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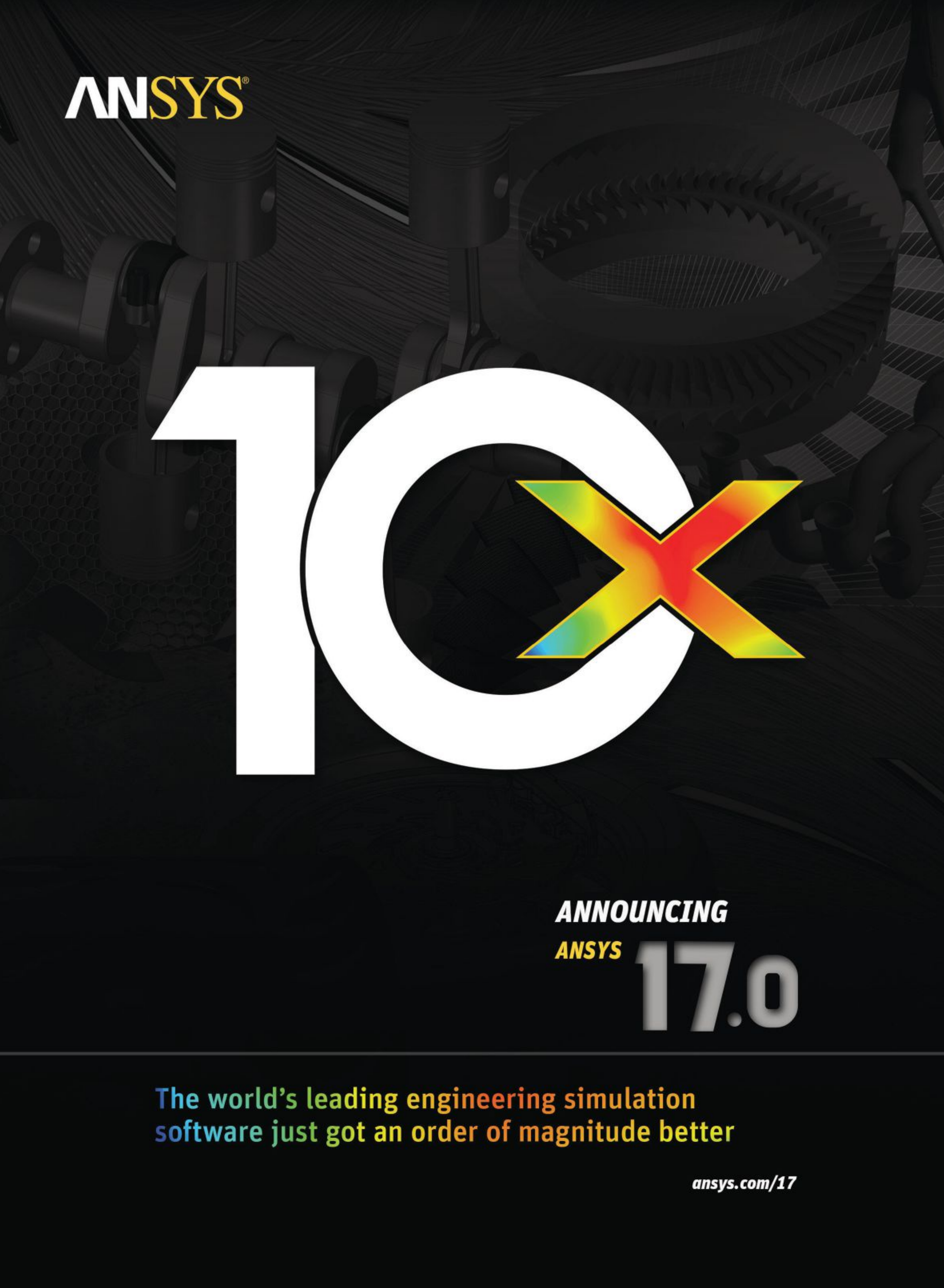
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by Jamie J. Gooch

Collaborating with the Crowd

The old line about the camel being a horse designed by committee is intended to cast aspersions at group decision making. "Too many cooks in the kitchen spoil the broth" is another one. Idioms like these stand the test of time because they're based on a grain (or maybe more) of truth. Many design engineers have gone into a meeting with a good, simple design that satisfies requirements and have come out with a mangled mess that tries to be all things to all people. If a room of people from different departments can derail the design process, then how does crowdsourcing work?

The term "crowdsourcing" describes any process in which a large group of people contribute ideas and/or services to a particular project. That project could be anything from helping NASA determine the age of star clusters to finding the perfect chocolate chip cookie recipe to designing a new automobile. Thanks to the Internet, the crowdsourcing community is global and could number in the billions. You would think that many cooks in the kitchen would create one nasty bowl of camel soup, but there are many examples of crowdsourcing successes; so many that it's often promoted as a key component in the design process of the future.

If a room of people can derail the design process, how does crowdsourcing work?

Rounding Up the Horses

XPRIZE is perhaps the most high-profile example of crowdsourced engineering. *DE* has covered the Google Lunar XPRIZE to land a privately funded robot on the moon and the Qualcomm Tricorder XPRIZE to foster the development of consumer devices to diagnose medical conditions, for example. Competitions, which often award cash prizes or lucrative contracts for winning designs, have become popular crowdsourcing formats. The Pentagon's Defense Advanced Research Projects Agency (DARPA) is using them to develop new ground vehicles and unmanned aerial vehicles, as well as to advance robotics. In this issue (see page 12), we cover SpaceX's Hyperloop Pod Competition, which taps the collective minds of the crowd to bring the idea of a tube-based, high-speed transportation system closer to reality.

Another blueprint for an open innovation platform comes from IDEO, the well-known design firm. It has created OpenIDEO, an online platform that guides organizations through design thinking, collaboration and project launches via a series of sponsored challenges — one of which happens to explore open innovation. OpenIDEO calls itself a "global community working together to design solutions for the world's biggest challenges." In the past five years, 100,000 community members have submitted 7,816 ideas via the site and related meetups.

Competitions and challenges avoid the usual design-by-committee pitfalls via a submission process where organizers choose the designs that advance to subsequent rounds, winnowing down the entries that aren't as viable without complicating the design process with an overabundance of differing opinions. Intel, Dell, IBM, HP and Microsoft are just a few of the companies who have sponsored crowdsourcing competitions. But other established companies are going further by trying to integrate crowdsourcing into their internal design processes.

GE, for example, has teamed up with Local Motors (known for its automobile co-creation model and microfactories) to launch FirstBuild, a startup style initiative to crowdsource appliance designs (see page 9). Many other big, instantly recognizable companies have promoted crowdsourcing efforts that have fallen by the wayside. Some were undoubtedly part of marketing campaigns — an attempt to cast the company in a cool, customer-focused light — that ran their course. Others no doubt failed because true crowdsourcing isn't business as usual. It requires a platform to collect and curate ideas, an infrastructure to manage the projects and a pervasive culture of collaboration — all requirements many companies are still wrestling with internally, without opening it up to a larger community.

The Search for Innovation

Technology platforms can help by enabling collaboration, visualizing ideas and tracking improvements in an integrated workflow that stretches from the conceptual stage all the way through production and end of life for the product. A truly integrated product lifecycle management (PLM) system could even avoid the camel-horse design problem by using real-world data to determine what will sell, what it should cost, how it would be maintained, how it would be recycled and more. In the future, the best design for all involved could be determined via algorithm, without committees.

Such a complete lifecycle may sound like science fiction, but so do many of the crowdsourced projects being developed. Perhaps we need a crowdsourced PLM challenge. Maybe the answers are already out there, just waiting to be shared. **DE**

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

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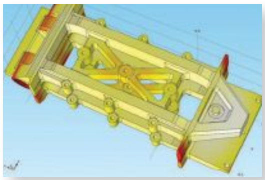

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Then & Now

A look at how technology was being used to solve problems in 1996 and how it is being used today, via the pages of *Desktop Engineering*.

As *DE* celebrates its 20th anniversary, it's nice to note that the mission of the design engineer hasn't changed. Today's design engineers still want to create the best product in the least amount of time. The technologies they use to accomplish that goal, however, have changed significantly. Below are just a few examples of how technology has transformed design engineering, torn from pages of the March/April 1996 issue of *DE*, and compared to the issue you're reading now.

Then: "One of our bottlenecks used to be plotting. You had to put a drawing on a floppy and carry it to the plotter. Now, you can sit at your desk and push a button. We have picked up five minutes per drawing, and when you're talking 75 to 100 drawings a day, that's significant."

— *David Lash, manager of Information Systems and Civil Engineering for Fink Roberts & Petrie*, an architectural, engineering and environmental firm. Lash was commenting on one of the productivity benefits of having a network version of AutoCAD in the March/April 1996 issue of *DE*.

Now: "If you are in San Francisco and you have a drawing you need to get to New York, you can scan the drawing and if you don't have a computer, you can use the phone or tablet to send it to the cloud. You are totally independent of a computer to run the scanner."

— *Steve Blanken, general manager of Contex Americas*

"We can take any kind of large-format drawing on board the hard drive, scan it to email and send it to somebody. You can do all of that directly from the printer's control panel."

— *Matt Kochanowski, product manager at Epson Professional Imaging* in "Scan, Print, Collaborate," page 43.

Then: "For the design engineer, more information, better information, and fast access to more and better information add up to a more valuable design. And if information access is the key to continuous improvement, then the promise of the Internet is that it is the key to vast amounts of information."

— *Kerry Newcom, president of Capital Equipment Corp.* on the relatively new idea in 1996 of giving away data analysis software via the Internet and then charging to customize it.

Now: "We can track a part from the time the product development team decides to do it to materials management, manufacturing, marketing, field support, etc. Anyone who has access can instantly see where a part is at any time."

— *Collin Fagan, project engineer at CNH Industrial/Reman*, on his company's use of Aras Innovator in "Next-Generation Collaboration," page 49. Aras Innovator is an open-source product lifecycle management software suite that uses a subscription model for technical support and updates.

Then: "If we are, in fact, making good parts, it's redundant to measure and measure again to verify that they are good parts. If you can build confidence in your system, and provide documentation to back it up, you can skip a lot of measurement. Then you've got a more productive system."

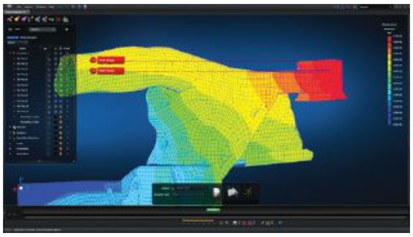
— *Floyd Gruver, quality control manager for Younger & Sons* on why the company moved to a DataMyte statisitcal process control system to cut down on measurement inspections.

Now: "They're holding things to micron levels, not millimeter levels. It's completely automated. Parts are presented, all the measurements are taken, and the parts are removed. It happens right in the assembly process."

— *Keith Gudeman, business development manager at Hexagon Manufacturing Intelligence* in "How to Measure Up Metrology Services," page 51. DE

MSC Releases Apex Eagle

According to MSC Software, the new Eagle release delivers innovative solutions for modeling and validating complex assemblies with the introduction of new part representations and connection types.



Support for shell element (2D) and tetrahedral and hexahedral meshing (3D) is now completed with support of discrete mass and rotary inertia (0D), as well as beam elements (1D). New connection types include rigid links, springs and mesh dependent tie connections, which extend existing mesh independent glue. With Eagle, MSC Apex users now create assemblies to support the rapid conceptual design of sub-assembly and vehicle level assemblies.

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Siemens to Acquire CD-Adapco

The 35-yer-old developer of CFD (computational fluid dynamics) software, STAR-CCM+ and Multidisciplinary eXploration (MDX) has a purchase price of $970 million. Last fiscal year, CD-adapco had over 900 employees and revenue of close to $200 million. Siemens expects this business will continue to experience strong growth in the future. CD-adapco will be integrated into the PLM (product lifecycle management) software business of Siemens' Digital Factory Division.

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SGI, HP Enterprise Enter OEM Agreement

The HPE Integrity MC990 X Server leverages the scale-up architecture of the SGI UV technology and provides HPE customers with a follow on solution to the eight-socket HPE ProLiant DL980 G7 Server.

Delivering up to 6TBs of coherent shared memory and featuring Intel Xeon E7-8800 v3 processors, the new eight-socket HPE system can be used in a variety of mission critical application environments.

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KeyShot 6.1 Announced

KeyShot 6.1 bridges capabilities introduced in KeyShot 6 with improvements to the KeyShot HDRI Editor, enhancements to Toon and Anisotropic materials and updated 3D software integration for KeyShot 6.

The HDRI Editor works by allowing a user to add light sources by adding 'pins' to the environment. With KeyShot 6.1, user may now create half-pins — half rectangular or half circular pins. Along with this capability, the HDRI Editor user interface has been updated.

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Objet Connex3 Updated

Updates to the Stratasys Objet Connex3 3D printer include Adobe color management and connectivity, and two updated materials: Vero PureWhite and VeroCyan.

Stratasys' Creative Colors Software links Photoshop CC with the Objet Connex3. The company is also linking Photoshop to Stratasys' direct manufacturing services.

"The Objet Connex3 is the only 3D printer on the market with the power to merge multiple materials and colors into one system alongside a highly streamlined and integrated workflow," said Josh Claman, chief business officer at Stratasys.

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SOLIDWORKS World 2016 Recap: IoT Makes its Mark

The ghost of IoT haunts MCAD companies. Once, the M in the MCAD was a mark of distinction. But in the era where software, circuits and chips account for a large part of the products and their functions, the capital M that — in many cases, unfairly — brands a program as strictly mechanical is an albatross around one's neck. This year, SOLIDWORKS takes dramatic steps to break the mechanical mold.

Last month, speaking to the SOLIDWORKS World 2016 (SWW16) assembly at the Kay Bailey Hutchinson Convention Center in Dallas, SOLIDWORKS CEO Gian Paolo Bassi said: "Innovation is an ecosystem of people, applications, and infrastructure"

Once associated with a single MCAD package, SOLIDWORKS is now home to more than 20 products. The latest product to debut at SWW16 is SOLIDWORKS PCB Design, the outcome of a partnership between SOLIDWORKS and Electronic CAD (ECAD) developer Altium. The new product is a standalone package for printed circuit board design, housed in a SOLIDWORKS-friendly interface. Altium's flagship 3D PCB design package, Altium Designer, is the engine behind SOLIDWORKS PCB Design.

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

Collaborating with Consumers

Natarajan Venkatakrishnan (Venkat) carries two business cards. One identifies him as director of R&D for GE Appliances. The other identifies him as director of FirstBuild. It gives the impression that Venkat is working for two employers. The truth is, Venkat's roles at GE Appliances and FirstBuild are interdependent. Each benefits from the other.

FirstBuild is a partnership between GE Appliances and Local Motors. It's intended to be, in FirstBuild's own description, "a new model for inventing, building and bringing the next generation of major appliances to the market." With a community of idea contributors and crowd-funded projects, FirstBuild looks and feels more like a startup than a traditional manufacturer.

Manufacturers don't always have the best ideas. Nor are they in a position to pursue good ideas that don't appeal to a broad spectrum. They revolve around mass production. They rely on failsafe, foolproof ideas for revenues. They lack an essential ingredient in innovation: an appetite for risk.

Through FirstBuild, GE wants to harvest the energy of a new kind of manufacturer — those driven by an entrepreneurial spirit, crowd funding and small-scale production.

Manufacturers lack an essential ingredient for innnovation: an appetite for risk.

Shifting Strategies

"Manufacturing used to be highly capital intensive. It doesn't need to be anymore," says Duleesha Kulasooriya, head of Strategy and principal author for Deloitte Center for the Edge. "A kid in San Francisco can come up with an idea, prototype it at TechShop [a membership-driven network of production facilities], fund it on Indiegogo and produce it in Shenzhen through HAX [a hardware production accelerator site]."

The change is also reflected in the R&D strategies of software vendors catering to manufacturers. "The range [of production] from zero to a thousand has been historically very difficult to fill," says Diego Tamburini, Autodesk's manufacturing industry strategist. "That has never been economically feasible. Everything has to be produced in at least several thousands [of units]."

Today, to accommodate low-volume production, Autodesk and other design software vendors have begun adding support for 3D printing in their mainstream CAD software. Leading PLM (product lifecycle management) system vendors are incorporating social media-style collaboration features into their framework, in a recognition that concept generation, brainstorming and idea evaluation must extend beyond the enterprise to include outside communities and enthusiasts. And many vendors are offering subscription software licensing models with lower upfront costs.

A Standard Bearer Falls

Enthusiasm for the new micro-manufacturing economy and maker movement is high. But the rise and fall of Quirky serves as a cautionary tale. Once hailed as a success story of crowd-sourced inventions, Quirky admitted defeat late last year with a Chapter 11 bankruptcy filing. In an onstage interview with *Fortune* magazine at *Fortune* Brainstorm Tech, former Quirky CEO Ben Kaufman attributed the failure in part to the company's over-reliance on big box stores for distribution.

"[Quirky products] were in so many retail stores — just last year, we were in 50,000 — that, just to fill the shelves, we were making tens of thousands of units," Kaufman said. "The very basis of Quirky — that we can prove an idea is good and stage-gate it in the development process — broke largely because of the traditional bounds of brick and motor retail."

Success is the double-edged sword that rewards and punishes promising ideas from the maker community. Without the supply chain and distribution strength of a traditional manufacturer, a crowd-funded project that succeeds could face scaling challenges.

"If you crowd-source a project, you get a lot of ideas, but [idea contributors] don't necessarily know how to turn them into products," Venkat says. "Your company's internal team has the domain knowledge, but they may not have the best ideas. The best approach is to pair crowd-sourced ideas and domain knowledge from experts."

According to "The Future of Manufacturing," a Deloitte Center for the Edge report co-authored by Kulasooriya, "While large-scale production will always dominate some segments of the value chain, innovative manufacturing models — distributed small-scale local manufacturing, loosely coupled manufacturing ecosystems and agile manufacturing — are arising to take advantage of these new opportunities."

In the past, engineers were responsible for innovation — to come up with breakthrough inventions and new products. The rise of crowd-sourced projects puts a new spin on their role. In the new co-creation model — a loose partnership between consumers with bright ideas and enterprises with prototyping and manufacturing capacity — engineers are innovation enablers. Whether this change is a blessing or a curse is up for debate. **DE**

This commentary is the opinion of **Kenneth Wong,** DE's *resident blogger and senior editor. Email him at kennethwong@deskeng.com or share your thoughts on this column at deskeng.com/facebook.*

Collaborative Design Optimization

Design space exploration and design optimization are rapidly becoming strategic competencies that engineering organizations must master to remain competitive. To have strategic and not just tactical impact, design exploration and optimization need to be adopted and deployed within the framework of a collaborative, enterprise-wide vision.

To date, however, the tools and methods are too often implemented at only the department or workgroup level, keeping their impact limited and localized. This deployment pattern is rooted in the early history of design optimization, when the discipline consisted mainly of abstruse mathematical methods that could only be applied manually by small numbers of Ph.D.-level specialists. But today the picture is different, thanks to the burgeoning number of software tools that make these powerful methods more broadly available to the engineering community.

Why should engineering organizations pursue collaborative, enterprise-level adoption of design exploration and optimization? Firstly, an enterprise-wide deployment makes the technology more readily applicable across disciplines and domains; the broader the span, the greater the impact.

Secondly, when they're broadly deployed, these tools and methods can foster more effective "systems thinking" across project teams, helping discipline specialists raise their visibility into a project — and their contributions to it — up and out of their silo of expertise, to the systems and whole-product level.

Enterprise adoption of optimization facilitates the capture and re-deployment of expert knowledge.

Thirdly, and possibly most important over time, is that enterprise adoption facilitates use of these tools to capture expert knowledge from across the organization, and then to synthesize it, digitally encapsulate it and re-deploy it enterprise-wide.

Automotive and Aerospace Lead the Way

Enterprise adoption of design exploration and optimization is an indicator of an industry's maturity level with these technologies and methods. On this measure, automakers and aircraft engine manufacturers are leading the way.

In the automotive industry, a prominent example is Ford Motor Company's adoption of ESTECO's SOMO software to enable what Ford calls an "enterprise multidisciplinary design optimization (MDO) system." One key to successful adoption is a strong internal champion for the cause. Inside Ford, the driving force behind this initiative is Yan Fu, technical leader of business strategy and engineering optimization for the automaker.

Why push adoption to the enterprise level? "When an expert leaves the company or is absent from work, the entire project can run into a bottleneck," Fu says. "The collaboration at an enterprise level guarantees the pooling of domain-specific know-how that would otherwise live inside the minds and computers of the experts themselves." According to ESTECO, key capabilities of SOMO include: "collecting domain-specific models; integrating them into a large-scale optimization workflow; preserving and versioning all of the data in a central archive, as well as sharing results with managers and decision makers."

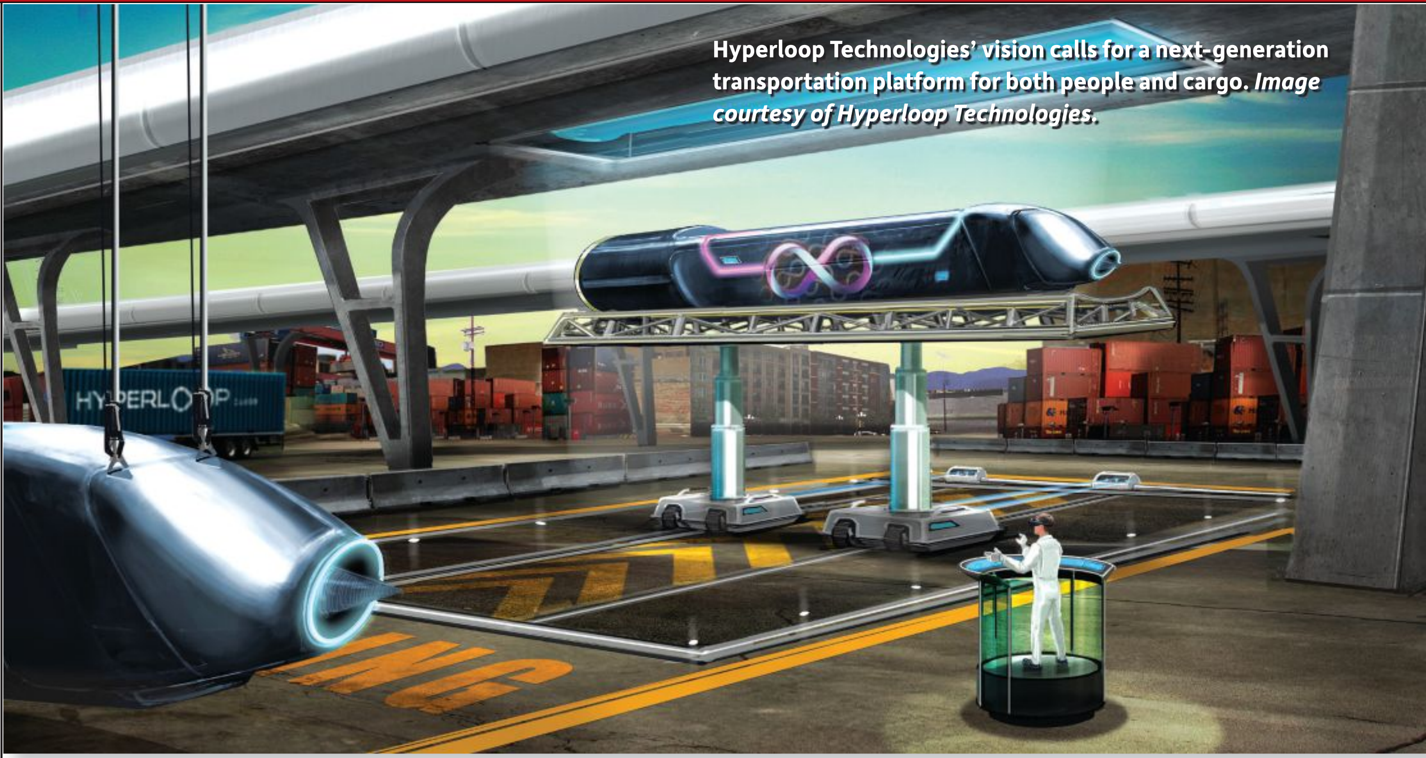
Another prominent automotive example is BMW, which uses Noesis Solutions' Optimus as its exclusive PIDO (process integration and design optimization) solution. With a large number of licenses installed and many trained users, the automaker standardized on Optimus because of its flexibility and its capability as an enterprise solution, reports Markus Zimmerman, director of research at BMW.

Starting with full-vehicle early-phase concept optimization, the software is used throughout the product development process for system-level optimization as well as component optimization across NVH (noise, vibration and harshness), structural dynamics, crash, systems engineering, R&D and other areas of vehicle design and development.

Aircraft engines are another industry where leading manufacturers have achieved enterprise-level adoption. A prominent example is Rolls-Royce, well known for its longstanding institutionalization of design exploration, optimization and process integration based on the Isight software from Dassault Systèmes' SIMULIA. Alexander Karl, robust design lead with Rolls-Royce, explains how its robust design program emphasizes the role of design as the entry-point into its enterprise Six Sigma initiative: "We realized early on that the sheer size and complexity of the aircraft engine design and development 'problem' could only be mastered through a combination of simulation, process automation and optimization."

"We have been using Isight software as our main toolkit for robust design for almost a decade," Karl said in 2010. "At first, our management approached this new technology with caution, but our early successes with it convinced them of the value of standardizing on a single solution instead of growing lots of different solutions. Once it was realized that process integration and automation could be a cost driver for manufacturing, everyone was on board." DE

Bruce Jenkins *is president of Ora Research (oraresearch.com), a research and advisory services firm focused on technology business strategy for 21st-century engineering practice.*



Hyperloop Technologies' vision calls for a next-generation transportation platform for both people and cargo. ***Image courtesy of Hyperloop Technologies.***

Simulation-Driven Design Fast Tracks Hyperloop Development

Startups, crowdsourced communities and competitions are transforming Hyperloop design concepts into early prototypes.

BY BETH STACKPOLE

When Elon Musk, of SpaceX and Tesla fame, first released his 57-page manifesto for the futuristic "Hyperloop Alpha" in 2013, no one dismissed him as delusional, but plenty questioned whether the tube-based, high-speed transportation system would ever see the light of day.

In only three years, some serious groundwork has been laid to transform the Jetsons-like Hyperloop dream into a reality of the modern landscape. A pair of startups, each with different business models and Hyperloop design strategies, are building and testing critical components of the system and breaking ground on physical test tracks this year. Musk, who released his ideas to the open-source community declined, at the time, to spearhead Hyperloop development. However, he recently hired the construction giant Aecom to build a Hyperloop test track to host winners of a SpaceX-sponsored pod design competition later this summer.

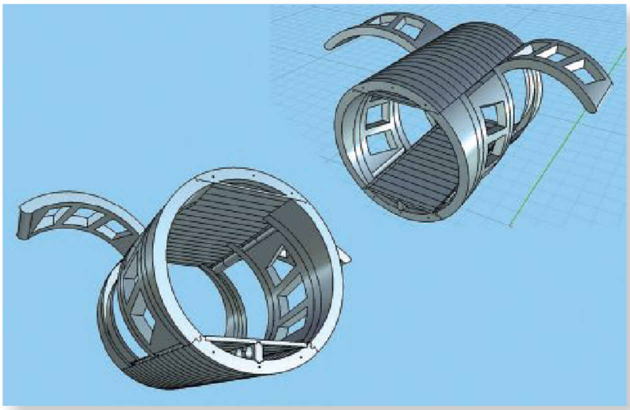
Across the country, student and professional design teams are gearing up for the Hyperloop race. Hyperloop Transportation Technologies (HTT), one of a pair of commercialized players in this space, is fostering an open-source community working on the design problem while forging relationships with UCLA architecture and urban planning students to throttle up its Hyperloop design efforts. Chief rival Hyperloop Technologies (HTI) is an active sponsor of the SpaceX pod design competition, ponying up $150,000 in prize money and a summer internship for the winner of the competition, held this January at Texas A&M University. Many universities, including UCLA and Purdue, are offering Hyperloop design classes as part of their engineering curricula.

While we're not there yet, this momentum is finally making the decades-old pipedream of a supersonic tube transportation system a reality more so than ever before, according to Sandeep

Sovani, director of Global Automotive Industry for ANSYS, whose simulation software is in the forefront of Hyperloop development with both commercial ventures as well as with the competition teams. "When Elon Musk published that white paper, it launched the Hyperloop into public attention given his stature," says Sovani, who has personally been actively involved in Hyperloop development prior to joining ANSYS. "This is the transportation technology of the future, and a significant amount of progress has been made."

A lot of that progress is thanks to the widespread use of simulation software — everything from FEA (finite element analysis) to CFD (computational fluid dynamics) and specialized optimization and analysis tools. Simulation has provided a much-needed means to iterate and test designs for levitation systems and pod capsules that pose key aerodynamic challenges that have never before been proven, Sovani says. In addition, the large-scale infrastructure such as the pylons and track systems that will serve as the foundation for the Hyperloop need to be put through its paces to test structural integrity along with the ability to withstand vibrations and earthquakes — all design challenges that can be effectively explored with simulation.

"There are so many different parameters and design integrations that need to be tested — the ability to do it virtually is what makes it possible," Sovani says. "It would be too cost prohibitive to do it all with physical prototypes."



Wing doors are featured in one of Hyperloop Transportation Technologies' capsule designs. *Images courtesy of Hyperloop Transportation Technologies.*

Space-Age Travel

The concept for tube transportation has been around for decades, but Musk advanced the idea with his vision of a pneumatic, tube-

30 Student Teams to Test Pod Design at SpaceX Hyperloop Test Track

More than 115 student engineering teams representing 27 U.S. states and 20 countries were at Texas A&M University in College Station, TX, Jan. 29-30, participating in SpaceX's Hyperloop Pod Competition Design Weekend. Thirty student teams were selected to test their design prototype at the world's first Hyperloop Test Track in California this summer.

The teams presented their plans for the overall pod design and were judged on a variety of criteria including innovation and uniqueness of design; full Hyperloop system applicability and economics; level of design detail; strength of supporting analysis and tests; feasibility for test track competition; and quality of documentation and presentation.

Student teams from all over the world took part in the SpaceX Hyperloop Pod Competition Design Weekend on the campus of Texas A&M. *Images courtesy of Texas A&M.*

The Top 5 student teams for the design and build category were:

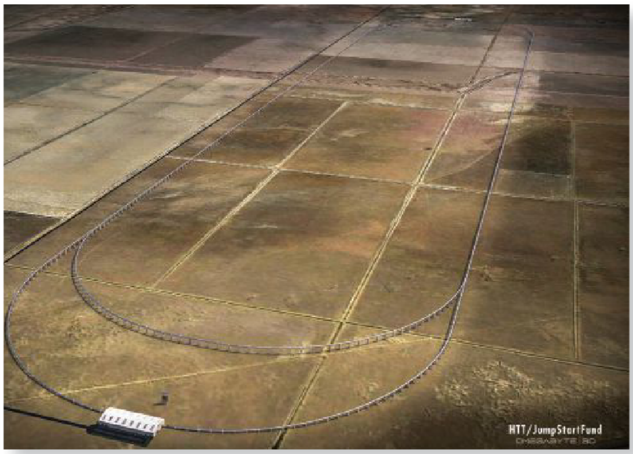
- **Best Overall Design Award:** MIT Hyperloop Team, Massachusetts Institute of Technology
- **Pod Innovation Award:** Delft Hyperloop, Delft University of Technology (The Netherlands)
- **Pod Technical Excellence Award:** Badgerloop, University of Wisconsin-Madison
- **Pod Technical Excellence Award:** Hyperloop at Virginia Tech, Virginia Tech
- **Pod Technical Excellence Award:** HyperXite, University of California-Irvine

Elon Musk, CEO and lead designer of SpaceX, made an unannounced appearance at SpaceX's Hyperloop Pod Competition Design Weekend.

Other student teams advancing to the competition weekend in California include:

- **uWaterloo Hyperloop:** University of Waterloo
- **UWashington Hyperloop:** University of Washington
- **University of Toronto:** University of Toronto
- **RUMD Loop:** University of Maryland and Rutgers University
- **GatorLoop:** University of Florida
- **Team HyperLynx**: University of Colorado-Denver
- **Hyperloop UC:** University of Cincinnati
- **UCSB Hyperloop:** University of California-Santa Barbara
- **bLoop:** University of California-Berkeley
- **TAMU Aerospace Hyperloop:** Texas A&M
- **WARR Hyperloop:** Technical University of Munich
- **Purdue Hyperloop Design Team:** Purdue University
- **Codex:** Oral Roberts University
- **Lehigh Hyperloop:** Lehigh University
- **Keio Alpha:** Keio University
- **Drexel Hyperloop:** Drexel University
- **Carnegie Mellon Hyperloop:** Carnegie-Mellon University
- **OpenLoop:** Cornell University, Harvey Mudd College, University of Michigan, Northeastern University, Memorial University of Newfoundland (Canada) and Princeton University
- **Bayou Bengals:** Louisiana State University
- **NYU Hyperloop:** New York University
- **VicHyper:** RMIT University
- **HyperLift:** St. John's High School
- **Illini Hyperloop:** University of Illinois at Urbana-Champaign
- **USC Hyperloop:** University of Southern California

In keeping with its emphasis on crowdsourcing, Hyperloop Transportation Technologies has enlisted UCLA architecture and urban planning students to design the Hyperloop passenger experience. *Image courtesy of Hyperloop Transportation Technologies.*



Mid-year is the target date for Hyperloop Transportation Technologies to start construction on its test track in Quay Valley, a planned solar-powered community between Los Angeles and San Francisco. *Image courtesy of Hyperloop Transportation Technologies.*

based transportation system that could transport people at speeds as fast as 750 mph — significantly faster than air travel. His idea, initially conceived as an alternative to a high-speed rail system connecting San Francisco and Los Angeles, calls for a network of elevated, reduced pressure tubes (for reducing drag) that transport aerodynamically designed pods using a levitation or air system that's driven by linear induction motors and air compressors. While the tubes are relatively low-tech, there's far more complexity in other parts of the Hyperloop system design, from the space-age pods and propulsion systems to the levitation mechanisms that create an air cushion on which the pods ride.

There's room to innovate and differentiate on the basic concept and that's where the two commercial ventures are focusing their efforts. HTI, which has catapulted from a few person garage startup in 2014 to 80-plus people in a facility in Los Angeles, including 65 engineers, envisions its Hyperloop as a next-generation transport for both people and cargo, according to Josh Geigel, vice president of Design and Analysis. Its Hyperloop design encompasses four main components: an ultra-lower pressure tube environment; a compressor that sucks in air instead of displacing it; a levitation system built on air bearings or maglev; and electronic propulsion.

A veritable "who's who" of simulation and optimization tools, including Fluent CFD, the full ANSYS suite, CD-dapco Star-CCM+ CFD, Red Cedar's HEEDS, MATLAB and a number of magnetic analysis tools are pushing the HTI Hyperloop effort along. The tools, Geigel says, are instrumental in helping the HTI team iterate design concepts faster while narrowing down the field so it can focus on the optimal results. "Simulation gives us a starting point to optimize and increase performance or reduce costs," he explains. "We know what the Hyperloop would cost now if we were to build it. We know moving forward, we have to get that cost even more competitive. Optimization, coupled with simulation, helps us target the low-hanging fruit on which to spend research dollars and will enable us to reduce the cost with a novel design."

Simulation, for example, is helping the team ensure that the low-pressure environment inside the tube can withstand safety standards and it will also ensure the team doesn't overdesign and spend excessive money on unnecessary steel. A free CFD simulation tool out of Stanford is helping with airflow optimization while multidisciplinary simulation is tackling problems like the proper placement of magnet arrays or the acceleration for the propulsion mechanisms, Geigel says.

For all of the simulation work, physical prototyping is still critical for this kind of large-scale, never-before-been-seen venture, Geigel says. This quarter, HTI plans to send an electric motor along a one kilometer track at speeds over 300 miles per hour (something it calls its Propulsion Open Air Test) and will follow up late this year or early in 2017 with its "Kitty Hawk moment," when it showcases the performance a full system, Geigel says. "Even the greatest simulation only gets you close — eventually you have to go out there and test something," he says. "It's especially important for a project that's going to exist in the real world."

HTT, which started its initiative back in 2013, has its roots in a non-profit incubator funded by NASA, which created a platform called JumpStartFund intended to help entrepreneurs leverage the collective power of community to build companies around their innovations and ideas. Dirk Ahborn, founder of the platform, lobbied to put the Hyperloop concept on the platform and from there, the company was born.

Today, HTT is evolving its Hyperloop design with a core team of 500 people in addition to a community of 20,000

A mock-up of what Hyperloop Transportation Technologies' Hyperloop might look like in the U.S. capital. *Image courtesy of Hyperloop Transportation Technologies.*

The first of Hyperloop Technologies' tubes for its test track are starting to take shape. *Image courtesy of Hyperloop Technologies.*

people. Yet there's a twist on HTT's model: Much of the core team, made up of marketers, engineers, social media people and others of varying backgrounds, devotes a minimum of 10 hours a week to the company and is paid stock options in return. It's not quite an open source development model, Ahborn maintains, because the company is building up its own valuable IP (intellectual property) while putting the best and brightest minds on the project. "We've got an aerospace engineer who worked on the Mars Rover, someone else involved in the Manhattan Project and people working at Boeing, Tesla, SpaceX and Faraday Future," Ahborn says. "Sometimes it's difficult to convince superstars to let everything go and come to a startup, but they are available for 10 hours a week and sometimes, that's all that's needed."

Along with its novel development model, HTT is leveraging scrum development principles and the usual litany of design tools — Autodesk virtual prototyping suite, collaboration platforms and a variety of simulation packages, including the xFlow next-generation CFD package — to iterate designs in the virtual world before building costly prototypes. "We're simulating a lot of different elements, from safety to airflow within the capsule to the most important part of the capsule — geometry," Ahborn says.

HTT has also made a lot progress on physical prototypes. The company has partnered to build a five-mile track in Quay Valley, CA, as part of a planned eco-community, and is scheduled to break ground in 2016 for public opening by 2018. The company also enlisted UCLA architecture and urban design graduate students to work on the pod and station design as well as how transportation options to and from Hyperloop stations would integrate into total user experience.

"What we've done from the beginning is to build a movement," Ahborn says. "When we started out, people looked at us and said this isn't possible,' and 'it can't be done.' Now people don't doubt it can be done — it's just a matter of time." **DE**

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

INFO → ANSYS: ANSYS.com

→ **Hyperloop Technologies:** HyperloopTech.com

→ **Hyperloop Transportation Technologies:** HyperloopTransp.com

→ **JumpStartFund:** JumpStartFund.com

→ **SpaceX:** SpaceX.com

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

Old and Busted vs. New Hotness

CHRIS MORLEY, *SR. PRODUCT MARKETING MANAGER, BOXX TECHNOLOGIES*

We're proud that the average life of a BOXX system is about seven years — and most are only set aside for faster models. A few years ago we did a contest to try to find the oldest BOXX workstation still in service. How old was the winner's system, still in use, by the original owner? Twelve years. Believe it or not, the runner up lost by only *seven days*.

Of course, it doesn't take 12 years for a BOXX to pay for itself. In about three years, on average, you've saved enough time, and gotten more done to more than offset the initial cost of a BOXX workstation. For some customers that ROI is a year, or for some of our rendering customers, it can be a matter of weeks.

See What You've Been Missing

Hardware changes quickly, and at some point it's worth considering an upgrade, even if your system is running fine. There comes a time when the newest hardware is worth the investment.

To illustrate this, we took one of our three-year-old systems — an Ivy Bridge-based 3DBOXX 4050XT featuring a Core i7 3770K overclocked to 4.5GHz — and compared it to an all-new APEXX 2 Model 2402 featuring the Skylake-based Core i7 6700K overclocked to 4.4GHz.

To further simulate a real-world comparison, we used a typical configuration from each generation. The 4050XT was outfitted with a Quadro 4000, mechanical hard drive, and DDR3-1600 memory, while the APEXX 2 Model 2402 was configured with a Quadro K4200 (since the testing was completed, the Quadro M4000 was released, which delivers more performance for the same price,) a speedy M.2 PCI-E SSD, and DDR4-2133 memory. Our goal was to design a real-world scenario where a customer with a typical BOXX configuration from three years ago could expect to get more done, faster, with an upgrade to a similar class of system using modern hardware today. We ran the same benchmarks on each system in order to be an apples-to-apples comparison — using different versions would make comparing the performance difference impossible.

Kick The Tires, and Light The Fires

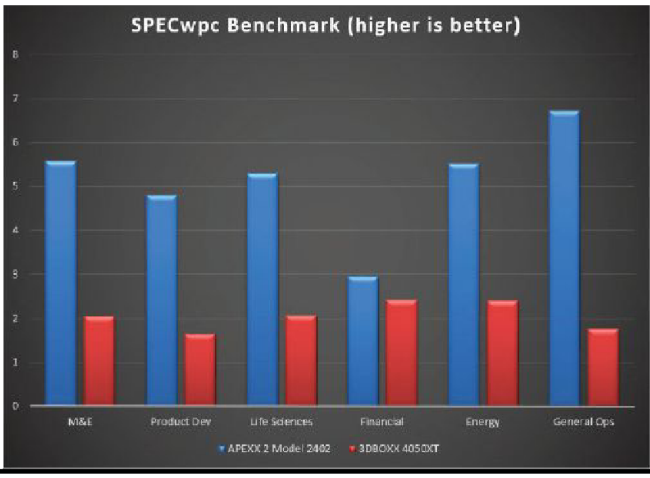
Roaring out of the gate, the APEXX 2 Model 2402 obliterates the 4050XT in SPECwpc, with increases of up to *283% faster*. Keep in mind, we're looking at the whole system. The APEXX 2 has advanced DDR4 memory, PCI-Express NVMe drives, modern GPUs, and a CPU that has such an advanced architecture (while being clocked 100MHz lower) that it outperforms a three-year old overclocked CPU in even CPU-centric benchmarks.

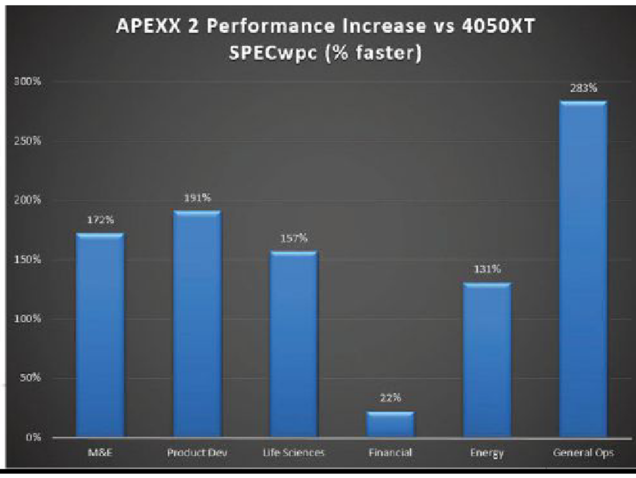
Next up, we'll take the SOLIDWORKS 2015 benchmark and put the two contenders through their paces. The APEXX 2 excels in every category, from graphics, to processor speed and I/O (HDD, memory). When your RealView performance is 28% faster and rendering is 24% faster, it's easy to see how the APEXX 2 Model 2402 is worth the upgrade. Plus, the I/O is 33% faster. This is critical for opening assemblies and doing rebuilds. This is a single-threaded activity that also relies heavily on storage speed. So it's not just all about the GPU and CPU!

Finally, we have the RFO Benchmark for Revit Users. With rendering performance up 20% over the 4050XT, and Viewport performance up 33%, you can imagine the productivity that can be had when your upgrade cycle is every three years.

We love knowing there are customers still using their BOXX systems for over a decade. That's an investment that's paid for itself several times over. But at some point, you have to look at how your hardware may holding you back. If it is, it may be time to say a loving goodbye and take a look at what the latest hardware can do for your workflow. (I'd like to apologize to the 3DBOXX 4050XT for calling it old and busted.)

To read more, go to: www.boxxtech.com/newhotness





Stress in Finite Element Analysis

Part 1

To study stress, engineers must first determine the best way to define it.

BY TONY ABBEY

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

One of the first issues when thinking about stress is defining the term. We use stress to mean something that is flowing through a structure and that we can use to compare against allowable values for strength assessment. However, it is difficult to visualize three-dimensional stress in a complex component. A typical post-processor stress selection pull-down menu might contain 30 choices, which just compounds the problem. If we are a bit hazy about what a stress really is, then what do these menu items represent? By the end of the article you should have a better idea of what some of the choices mean. A further installment will follow this article.

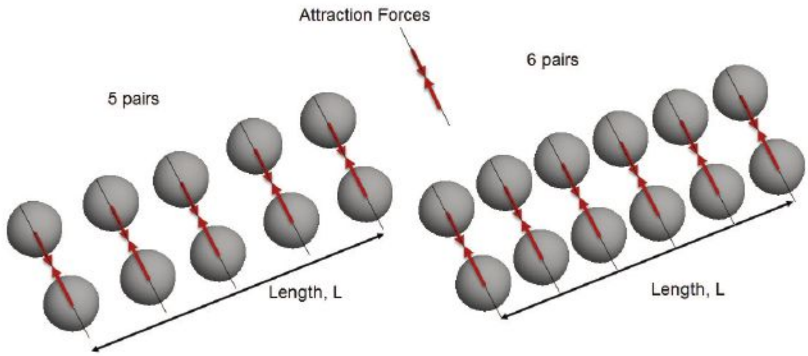


FIG. 1: Attraction forces between rows of atoms stretched by external loading.

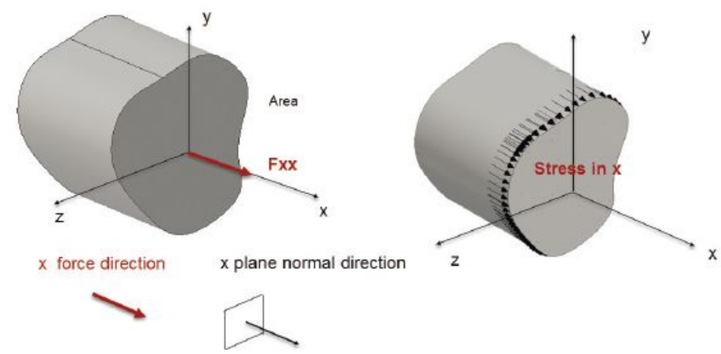


FIG. 2: Normal force and stress definitions in the x direction and x normal plane.

Understanding Forces

To understand stresses, it is easier to start by recapping on what we know about forces. A force is something we can sense and measure more directly. Right down at the atomic level, atoms are subject to mutual forces of attraction and repulsion. When a structure is in an unloaded condition, the atoms are in a neutral state where these forces balance. If a component is loaded externally, then the atoms are moved out of equilibrium and mutual internal forces are developed that balance the applied forces. Imagine an array of little rigid spheres connected together by springs. The springs develop a pattern of internal forces that balance the applied forces. Fig. 1 is a very crude schematic showing attractive forces developed between two instances of row pairs of atoms. The atoms are more closely spaced in one group (with six pairs) than the other (with five pairs) as shown. If each adjacent pair sees the same level of force, then one group will have a larger force developed internally over their local region: length

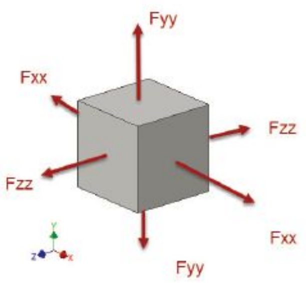


FIG. 3: Balanced 3D normal forces.

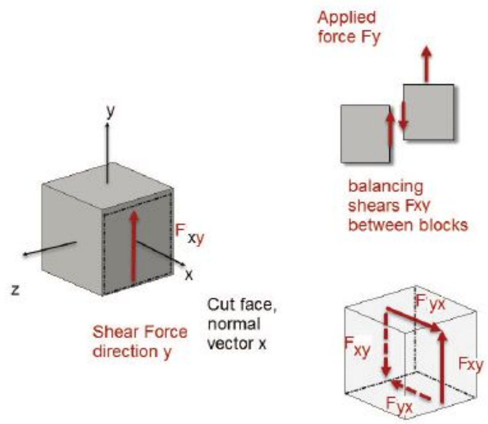


FIG. 4: Shearing loading generating F_{yx} shear force applied to cut face. Balanced shear force system shown.

L. We can describe the difference in the intensity of forces by using force per unit length, or in a more general sense, per unit area. In the limit as we approach small areas, this measure of intensity of the force is what we describe as stress.

Now consider a beam-like component of arbitrary shaped cross section as shown in Fig. 2. There is a net force F_{xx} applied across the cut face yz in direction x. If the force is evenly distributed across the face, and there are no local constraints and the material is continuous, then the stress is constant and is given by force divided by area. The terminology for the force is F_{xx}, the corresponding stress is S_{xx}. The notation is based on defining the cut plane in which the force is acting (the first subscript x). The second subscript x indicates the direction the force is acting in. The awkward thing here is

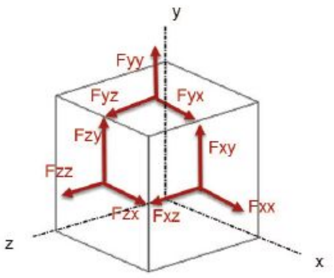


FIG. 5: Full set of normal and shear forces shown on visible faces. Complementary set exists on hidden faces.

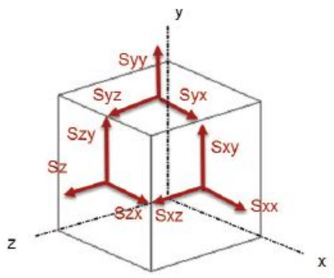


FIG. 6: Full set of normal and shear stresses shown on visible faces. Complementary set exists on hidden faces.

that the plane is defined by the vector that pierces it in a normal direction (x in this case).

The Force and Stress Cube

The reason for being pedantic about the indices is that we are going to extend the discussion from 1D uniaxial force and corresponding stress state to a general 3D state. This is usually done with reference to an infinitely small cube of material as shown in Fig. 3. The cube is so small that there is no variation in stress within the volume. It is all just one-stress state. Fig. 3 shows the remaining set of forces F_{yy} and F_{zz}. These are known as the normal forces that are acting normal to the respective cut faces. The force F_{xx} is traditionally abbreviated into just F_x. Forces F_y and F_z are treated in the same way. We will keep the full definition for now.

Normal forces result from force components acting perpendicular to the cut plane, which is why we can drop the second subscript. The other type of force is a shear force. This is not so intuitive as a normal force. Fig. 4 shows a section under a guillotining or shearing type loading. The cut face is defined by the yz plane (normal vector x). It has an external load applied, resulting in internal balancing force acting in the plane of the cut face. The applied force is a traction in the y direction. The definition of the force is F_{xy}; (x for the cut plane, y for the force direction). Also shown are the set of complementary internal balancing shear forces that must exist. For a cube with equal sides, the shear forces balance; $F_{xy} = F_{yx}$. I have tried to highlight the index lettering scheme in Fig. 4.

We can summarize the actions of the forces on a cube of material that is buried deep inside a component. If we pull apart two opposite faces of the cube, we develop a tensile normal force thorough the cube. If we squeeze the opposite faces, we develop a compressive force in the cube. If we apply in plane tractions to two opposite faces we develop shear forces in these faces, but also develop complementary opposing shear forces on the top and bottom faces. The complementary shear forces are puzzling at first. However, the cube must be in balance. If we only have shear forces on the front and back x vector faces, then we have a net moment. The complementary set of forces on the top and bottom y vector faces create an exactly opposite moment, and so complete the balance.

The general force situation is shown in Fig. 5. It is worth looking at the index convention to make sure it is clear (and also check my diagrams). If we imagine that the cube is small enough to have a constant force distribution on each face, then the stresses will be constant. I have used the full index notation for normal stress, so F_x is shown as F_{xx}. This shows the consistency in the scheme. There is a complementary set of forces on the hidden faces. I have not shown these for clarity.

Stresses Follow Forces

I always think it is easier to imagine forces acting on an object. We could imagine setting up an FE (finite element) analysis of the cube with the loads applied externally. The transition to the corresponding general stress state is shown in Fig. 6 and it is simply force per unit area for each force vector. Some of the stress terms in a typical selection menu are now apparent. The following common terms are identified from Fig. 6:

- Solid X-Normal Stress is S_{xx}
- Solid Y-Normal Stress is S_{yy}
- Solid Z-Normal Stress is S_{zz}
- Solid XY-Shear Stress is S_{xy}
- Solid YZ-Shear Stress is S_{yz}
- Solid ZX-Shear Stress is S_{zx}

The shear indices may swap on your post-processor, as $S_{zx} = S_{xz}$, etc. The order of the shear stresses in the menu may also change, which makes no difference to the data being selected. The normal stresses may be labeled S_{xx}, rather than S_x. Again these are referring to the same quantities.

Fig. 7 shows the arbitrary cross-section meshed with elements. The elements represent discrete areas where we can relate the local forces to the local stresses. In a rod element, for example, there is a simple relationship between the axial force and axial stress. For a solid element it is a more subtle relationship, the stresses in an element are not constant. The force balance is also occurring at eight, 10 or a higher number of nodes, in one element. However, I have indicated some notional forces balancing each element stress distribution. The idea here is to show the

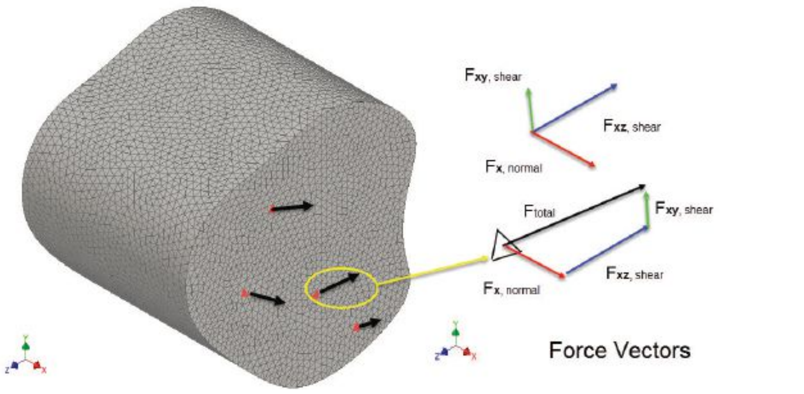


FIG. 7: Force vectors at a selection of elements, with one example of vector components shown.

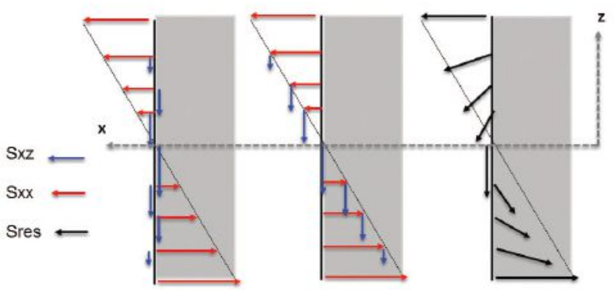


FIG. 8: Force vectors in a beam cross section subject to bending and shear.

forces at each element are a resultant direction and magnitude. It is easy to break down the force vector into its normal and shear components. One element is pulled out in Fig. 7 to show this. The sense of the approximate loading in that element region is clear. I think it helps to interpret the meaning of the corresponding S_{xx}, S_{xy} and S_{xz} stresses, which have to be plotted vector component by vector component.

I find it easier to imagine forces "flowing" through the internal volume of a structure. A vector plot of this type is a complete description of the local structural load path. It is very difficult to present stress vectors in such a concise way. We will discuss principal stresses in the next installment of this article, as they come closest to this concise ideal. There have been attempts to use the force vector approach in post-processing, but the implementation seems surprisingly difficult in a general 3D sense.

One significant issue is that element nodal forces are often not very meaningful in a physical sense. Their function is more of a mathematical balancing act than engineering. It is better to integrate stress distributions locally to estimate running loads and forces.

Fig. 8 shows a 2D view of forces at the cut face of a rectangular beam section under bending and shear loading. The axial normal forces are shown, with a classic engineer's theory of bending distribution. A parabolic shear force distribution is also shown. The shear distribution is interesting as it shows how the free surface shear force needs to be zero. No force can poke out of the top or bottom free surface. This helps visualize the same rule for shear stresses. They must be zero at the free surface.

The Art of Load Paths

The final strength assessment is made against peak local stress levels in most cases. So understanding stresses is important. In the next installment, we will look more closely at other stress components in a typical menu selector list. I will present a methodology for plotting a logical sequence of stress types to gain fuller understanding.

However, understanding load paths is also very important – and often neglected. How does the load get into, through and out of the component? It is very much more of an art than a science to do this effectively. The force vector diagram is very helpful in understanding the corresponding stresses. I tend to make rough load path sketches by turning local stresses into equivalent force vectors. The force vectors are then used to visualize the load paths through the structure.

I believe that visualizing both forces and stresses is a useful way to keep a clearer picture of how the structure is responding under static loading conditions. 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. If your company is interested in a customized training class on any topics discussed in this article, contact Tony via tony.abbey@nafems.org.*

Making Multiphysics Simulation **More Accessible**

Experts with multi-domain expertise are a rarity; multidisciplinary collaboration is the preferred approach.

BY KENNETH WONG

Life is multiphysics. The coffee maker that uses heat, steam and pressure to produce a delicious shot of espresso, the laptop that uses airflow to cool the scorching heat from the overworked CPUs, the chair that uses load balancing to support the constantly shifting human muscles — many everyday products involve a mix of structural, mechanical, thermal, electrical and fluid behaviors. But in simulation, these phenomena are often represented as single-physics events to make them more manageable. To identify the ideal temperature range for coffee brewing, the designer may reduce the problem to thermal physics alone. And to improve the comfort and stability of a chair, they may focus on the stress on the chair's surface area and leg-joints only.

But with some scenarios, the designers must take into account more than one type of physics. To study a radio frequency device's performance, for example, the design team would have to consider interactions between its electromagnetic and thermal behaviors. Multiphysics simulation packages are tailor-made for such design studies. The ongoing challenge in this branch of simulation has always been the rarity of multi-domain experts.

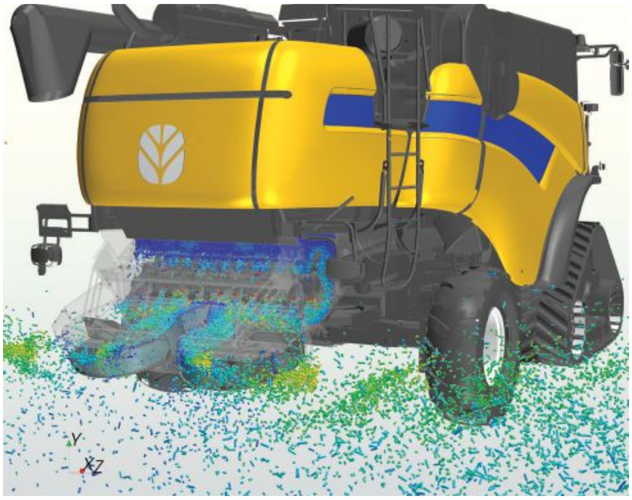


Illustration of the residue flow through the chopping and spreading mechanism of a New Holland combine harvester. The transient multiphysics simulation combines the DEM (discrete element method) and airflow capabilities of STAR-CCM+. ***Image courtesy of CNH Belgium N.V.***

Finding Multi-Domain Experts

Certain types of engineering software inherently promote multidisciplinary collaboration. Product lifecycle management (PLM) and product data management (PDM) systems are architected as digital repositories and communal dashboards for members of a project team to share ideas and track progress. CAD programs have historically been single-user software; however, some now have built-in tools to initiate collaborative design sessions. With such a feature, a mechanical engineer, electrical engineer and an industrial designer might come together to negotiate their respective preferences. In such multi-user environments, each user can take ownership of his or her functions without needing to learn the other domains.

Multiphysics software, despite its name, tends to be a single-user workspace to study coupled-physics phenomena. "We have multiphysics products, but they are typically for a single user," says Dale Berry, Dassault Systèmes' senior director of Technical Marketing for SIMULIA.

The burden on the multiphysics software user is thus a heavy one. "It's pretty difficult to set up multiphysics in most current tools. It requires that you learn at least one different environment [outside your domain]," says Christine Wolfe, ANSYS' lead product manager for Multiphysics. "If you're a fluid engineer, you might also have to know — perhaps more than you'd like to — about finite element analysis (FEA). In addition, you need not only expertise in both disciplines but also the software."

Bjorn Sjodin, COMSOL's vice president of Product Management, similarly notes: "Even if you're a simulation expert, you're an expert in your own area, not in your colleague's area. If your colleague hands you his simulation job, you still may not understand it or know how to set it up alongside yours."

Template-Based Workflow for Non-Experts

Over the years, the simulation software industry came up with different ways to make multiphysics more accessible to a broader usage base, with varying degrees of success. Berry says the industry needs to rethink how the function is delivered.

"This is true for single-physics tools. It's true for multiphysics. It has to be delivered in a way that's accessible to design engineers," he says. "We believe the key is a guided workflow. The software needs to have a framework that can build a guided workflow so designers can follow it step by step, without having to author the entire simulation. One benefit of this approach is, it standardizes the workflow for analyzing a valve, a pump and so on."

A guided workflow may be the outcome of the collaboration of various experts, each accounting for a type of physics involved in the analysis. But the user need not be an expert. With a basic understanding of the inner-workings of a valve or a pump, they could follow the sequence of inputs to complete the analysis. This is Dassault Systèmes' vision with its all-encompassing 3DEXPERIENCE platform. "Inside 3DEXPERIENCE, you have the capability to author a guided workflow and deliver it to the designers," Berry explains.

A similar approach is adopted by ANSYS in its product ANSYS AIM, described as an "integrated and comprehensive multiphysics simulation environment designed for all engineers." Wolfe says, "With AIM, a single analyst, let's say a fluid dynamics expert, can set up the mechanical portion of the multiphysics problem using the same tool, in the same environment, in the terms he or she is familiar with." The intent, says Wolfe, is to use "flexible guided workflows" that allow design engineers — a much wider user pool than the experts — to set up and perform multiphysics simulation.

COMSOL, which explicitly markets its offerings as multiphysics, has adopted an app-driven approach. In late 2014, the company introduced the Application Builder in its flagship product COMSOL Multiphysics. With Application Builder, someone well versed in sophisticated simulation can publish a repeatable simulation job as an app. With far fewer input fields and variables, the published app could be used even by those with limited exposure to general-purpose simulation software.

"With an app, you can make the simulation complex in the background but keep [the interface] lean and simple in the front, so the same simulation can be passed along and shared with others — even with people who don't regularly use simulation tools," says Sjodin.

Code-Coupling or Co-Simulation

Some simulation software offers prebuilt environments to study commonly combined physics types together. For example, Dassault Systèmes SIMULIA's Abaqus offers thermal-mechanical, thermal-electric and thermal-fluid-mechanical modules. COMSOL offers modules to study electrical, mechanical, fluid and chemical behaviors together. ADINA's Multiphysics package comes with solvers for fluid-structure interactions, thermo-mechanical events, thermal-fluid-structural events and more.

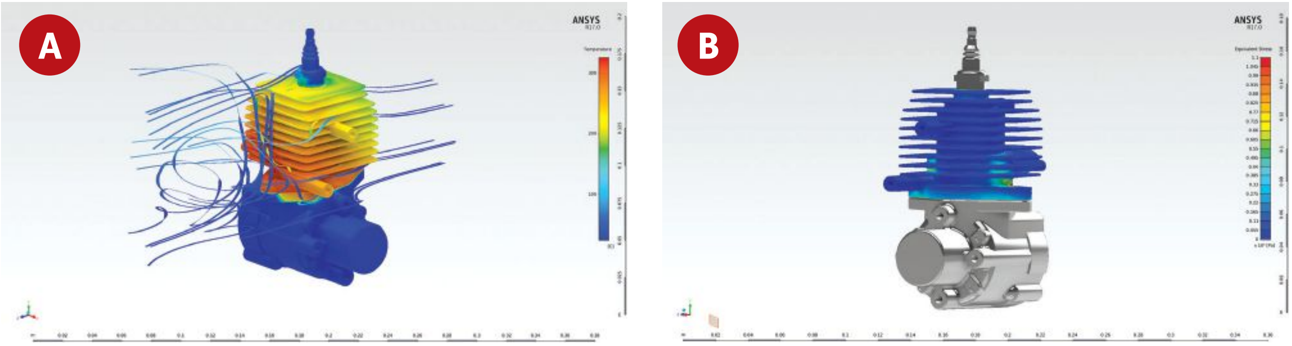
Some simulation packages facilitate multiphysics studies via code-coupling or co-simulation. For instance, CD-adapco's STAR-CCM+ allows users to combine its solvers with those from SIMULIA Abaqus. Commercial code-coupling is usually possible between products from simulation vendors that have a partnership and are willing to open up their APIs (application programming interfaces) to each other. With code-coupling, one package usually acts as the host, and the other as the plug-in.

"[Code-coupling] is pretty difficult to do," Berry says. "The disciplines are different, the mechanics are different, and the things you need to know to use each code and be successful in that domain are different." Consequently, such exercises are usually confined to the simulation experts, not generalists.

The Single-Physics Approach

With most simulation, reducing the scenario to a more manageable single-physics setup doesn't compromise the quality of the study. "A lot of the simulations we do today are single physics," ANSYS' Wolfe estimates. "I'd venture to say 80% of the time, single physics solves the problem to the level of fidelity acceptable to the engineers."

When engineers encounter problems that demand a multiphysics analysis, they may also break up the study into a series of single-physics studies. There's no simple way to decide what truly requires multiphysics and which can be broken up and tackled one at a time. Consequently, what constitutes "multi-



(A) Flow results for an air-cooled engine modeled in ANSYS AIM; (B) Equivalent stress results for an air-cooled engine modeled in ANSYS AIM. *Images courtesy of ANSYS.*

physics simulation" is sometimes up for debate.

David Vaughn, CD-adapco's vice president of Worldwide Marketing, says the emphasis should be on multidisciplinary simulation — a category that encompasses multiphysics, in his view. "I think it is really important to provide a multiphysics platform with a focus on enabling multidisciplinary simulation and design exploration," he says.

COMSOL's Sjodin says: "Several experts may collaborate on a single 3D model to run multiphysics. But they may also run a sequence of simulation on different types of physics. So, perhaps one expert performs heat transfer, another does acoustic and another does fluid, and they pass the model back and forth. That can also be a form of multiphysics."

The key "is to model the problem in multiphysics only when you need to. Otherwise, you waste resources. In some cases, you can feed the electromagnetic losses into your heat transfer simulation, then use the results as input to find out the structural deformation," Wolfe says. "That's a multiphysics study, even if you're not modeling all the physics together. Only a small fraction of the simulation we do routinely is the kind where two physics are working so tightly together that they cannot be pulled apart."

Multidisciplinary Collaboration

The current division of tools by specialty — one for FEA, another for structural analysis, another for thermal analysis and so on — seems to reflect the segmentation of engineering by discipline. But Vaughn argues the emergence of discipline-specific tools may have also contributed to the bifurcation of expertise.

"We believe we can bring engineers back together by offering a powerful tool," says Vaughn. "The physics you have to model is, no doubt, complicated, but that's the engineer's job. They have to understand the physics. We can't simplify the physics if we want the answers to be accurate. CD-adapco's goal is to provide a tool that's powerful, yet easy enough for engineers to use."

In January, Siemens announced its plan to acquire CD-adapco. When the transaction is complete, CD-adapco will become part of the PLM software business of Siemens' Digital Factory. The acquisition will bring together Siemens' NX design software and CD-adapco's simulation technology.

Because most multiphysics tools are currently set up as single-user environment, the collaboration occurs in the pre- and post-simulation discussions among the experts from different domains. "The multiphysics problem is what brings different experts together. The software can only facilitate the simulation," says ANSYS' Wolfe.

Dassault Systèmes' Berry says: "Most companies have different expert groups — FEA group, CFD (computational fluid dynamics) group and structural group, for example. One group may look at external styling, another may examine engine and suspension, and another deals with drag, and another noise and vibration ... Each group uses a different tool and the opportunity for these groups to collaborate is present in multiphysics simulation. But the issue is more organizational, not technological."

Multidisciplinary collaboration in multiphysics simulation is inevitable because it's the most sensible way to study designs that can benefit from the inputs of several domain experts. There's a limit to how much such complex studies can be simplified; the only way such a study can be performed by a non-expert is under the guidance of an expert — or several domain experts, as the case may be. Because it's impractical to assemble a multidisciplinary team on the fly for every study, the next best alternative is to follow a guided workflow, a repeatable template collaboratively designed by multidisciplinary domain experts. **DE**

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

INFO ➜ ANSYS: ANSYS.com

➜ **CD-adapco:** CD-adapco.com

➜ **COMSOL:** COMSOL.com

➜ **Dassault Systèmes SIMULIA:** 3ds.com/products-services/SIMULIA/

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

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SENSORS

DE
Technology for Optimal Design Engineering

A SPECIAL SUPPLEMENT
March 2016 // deskeng.com

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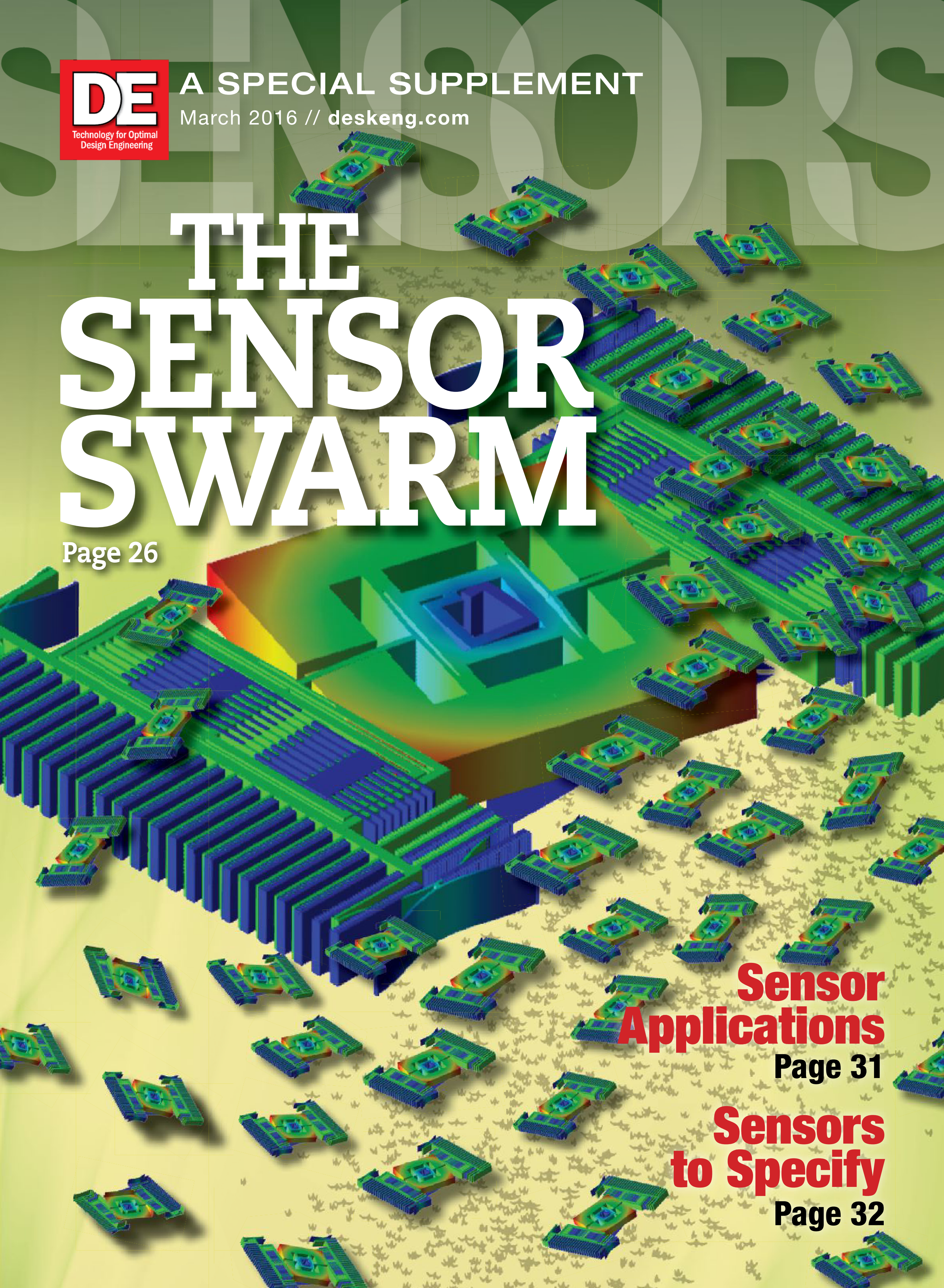


The **Sensor Swarm** Arrives

New design tools and workflows are needed to expand the limits of MEMS design.

By Tom Kevan

It all started with smartphones and airbags. Design engineers began to integrate sensors in growing numbers into such systems to enable smarter performance. These applications mark the prelude to what Alberto Sangiovanni-Vincentelli, a professor at Univeristy of California, Berkeley, describes as a "sensory swarm" — a flood of heterogeneous sensors interfacing the cyber and physical worlds. By 2025, experts predict that the swarm could number as many as 7 trillion devices.

One of the first stages in the realization of this sensor-dominated world, the Internet of Things (IoT) requires technologies that can take on smaller form factors and operate on miserly power budgets. In their search to find sensing devices that can meet these requirements, designers have turned to micro-electromechanical systems, or MEMS. Before they can take full advantage of the miniaturization the technology offers and expand its role in the marketplace, engineers must be able to bridge the gaps between the MEMS, analog and digital design worlds. To do this, they will require a new set of tools.

The Devil is in the Differences

Unlike traditional integrated circuit (IC) components, such as resistors and transistors, MEMS mechanisms consist of highly calibrated physical structures (see Fig. 1), such as gears and screws. The difference between these fundamental building blocks translates into two distinct sets of design requirements.

MEMS layouts must support a broad variety of irregular geometries, unlike conventional IC layout shapes, which usually take the form of rectangles, rectilinear polygons or polygons with 45° edges. Accommodation of these irregular shapes becomes a critical differentiator between MEMS tools and conventional IC tools.

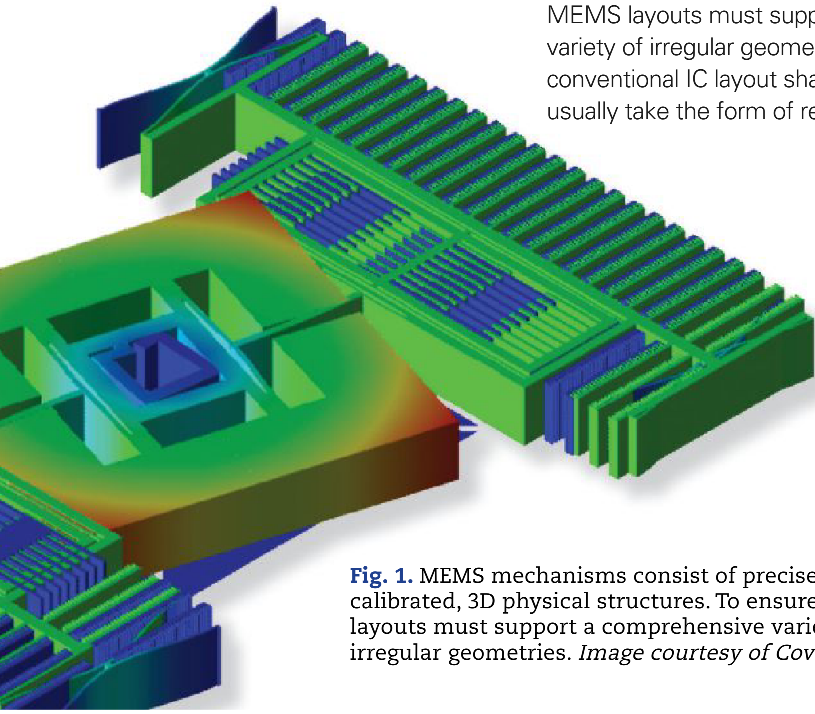


Fig. 1. MEMS mechanisms consist of precisely calibrated, 3D physical structures. To ensure accuracy, layouts must support a comprehensive variety of irregular geometries. *Image courtesy of Coventor.*

The difference between the two design domains, however, goes beyond the form and shape of the layout elements. Fabrication of these structures requires techniques like surface micro-machining, bulk micro-machining and deep reactive ion etching. In addition, MEMS devices traditionally have been manufactured with processes customized for each device. The variety of these fabrication processes increases production costs and extends the time to market — trends that run counter to the demands of the IoT.

The Crux of the Problem

The elemental differences between the IC and MEMS domains represent the chief hurdle for designers of IoT devices, because by definition these designs require analog/mixed signal, digital and MEMS components to live and function together in one device. Success demands that engineers design these devices with a process that blends all three domains, ensuring that they work well together, whether they reside on a single chip or multiple dies.

As market pressure drives the integration of MEMS devices into high-volume complementary metal oxide semiconductor (CMOS) IC manufacturing, MEMS providers must find ways to shorten development time, reduce costs and deliver increasingly complex performance and greater reliability. Incorporating MEMS design directly into the CMOS design flow provides the most efficient way to achieve this goal, but this will take some work on the part of MEMS design tool providers because the gulf between the two domains remains significant.

"The current design practice at many MEMS industry leaders still involves disparate tools for MEMS and CMOS design," says Steve Breit, vice president of Engineering at Coventor. "MEMS designers rely on conventional finite element analysis (FEA) tools to do their design, while CMOS designers rely on electronic design automation (EDA) tools. There is no automatic bridge between FEA and EDA tools. MEMS designers spend lots of time and expertise manually creating behavioral models for the CMOS designers. With all the manual effort, it's easy to introduce errors or for models used by CMOS designers to get out of sync with an evolving design."

Greater integration of the two design environments is needed. MEMS designers must be able to share design databases, models and results with CMOS colleagues and analyze the interactions between the two technologies. They also have to be able to maintain design database integrity and communicate design data across a variety of tools. For example, MEMS designers should be able to pass data directly from the CMOS layout environment to emulation and simulation tools, maintaining design integrity so that they simulate what they build.

"I would call it a MEMS-CMOS co-design flow," says Mary Ann Maher, CEO of SoftMEMS. "A tool suite can be constructed that allows MEMS and CMOS designers to use the same tools, but their flow through those tools may be different, and the MEMS designers may use some tools not used by the CMOS designers and vice versa."
One of the steps required to achieve this co-design flow is to enable MEMS designers to easily create or export models compatible with commonly used environments like MATLAB, Simulink and Cadence Virtuoso. "That is not the case today for MEMS designers who use conventional FEA tools with proprietary solvers to simulate their designs," says Breit. "The common practice is to handcraft a behavioral model that runs in the system and circuit design environments based on expert physical insight. Hand-crafted models are often over simplified and quickly get out of sync with the design."

Integrating the design flows of these two disparate domains calls for a more structured strategy. "A structured flow will help you use a top-down design process, where you can focus more on optimizing the complete system instead of optimizing the individual components of the design," says Nicholas Williams, product marketing manager for Mentor Graphics.

This structure can also take the form of standardization, which many aspects of MEMS design lack. "A structured design flow can take advantage of standard rules and design checks in an organized manner that prevents mistakes and overall can take less time," says Maher.

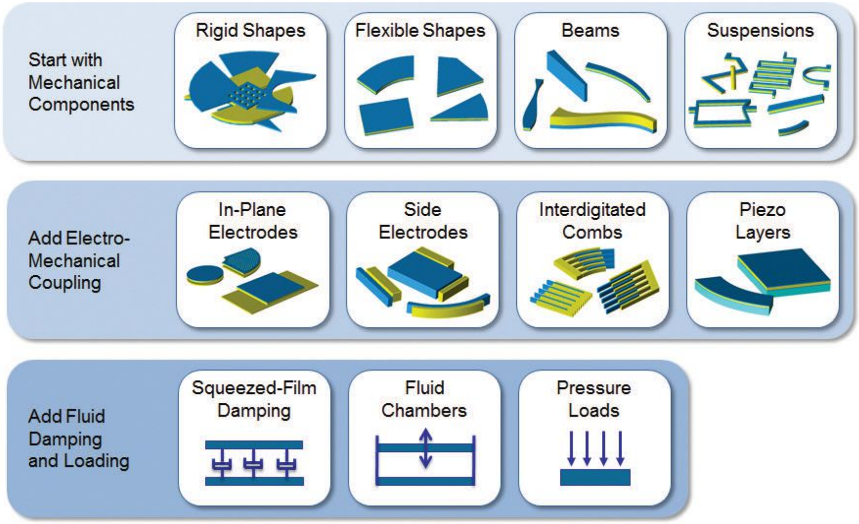


Fig. 2. Just as IC designers use SPICE model libraries to assemble electronic circuits, MEMS engineers rely on component libraries for physical primitives to create layouts. These building blocks include an underlying model that captures the mechanical and electrical physical behavior of the mechanism. *Image courtesy of Coventor.*

MEMS Building Blocks

One way MEMS design automation providers promote standardization is by providing libraries of proven, physical and scalable parameterized primitives, as well as test structures and packages (see Fig. 2). Each primitive should have an underlying model that captures mechanical and electrical physical behavior. The library's primitive models should support multiple simulators — such as SPICE, Verilog, MATLAB and 3D analysis — and different simulation types, including transient, frequency domain, optimization as well as noise and statistical analyses. These models must simulate fast enough to provide for design optimization and manufacturability studies.

Much like IC designers assemble an electronic circuit by selecting components and building models from a SPICE model library, MEMS designers select fabrication-ready components from the library, define parameters (e.g., length, radius and thickness), and assemble them in a layout, significantly reducing the design process. The designer can also use the library to supply material properties to simulations.
"The MEMS component library should be constrained by the process technology, but flexible enough to

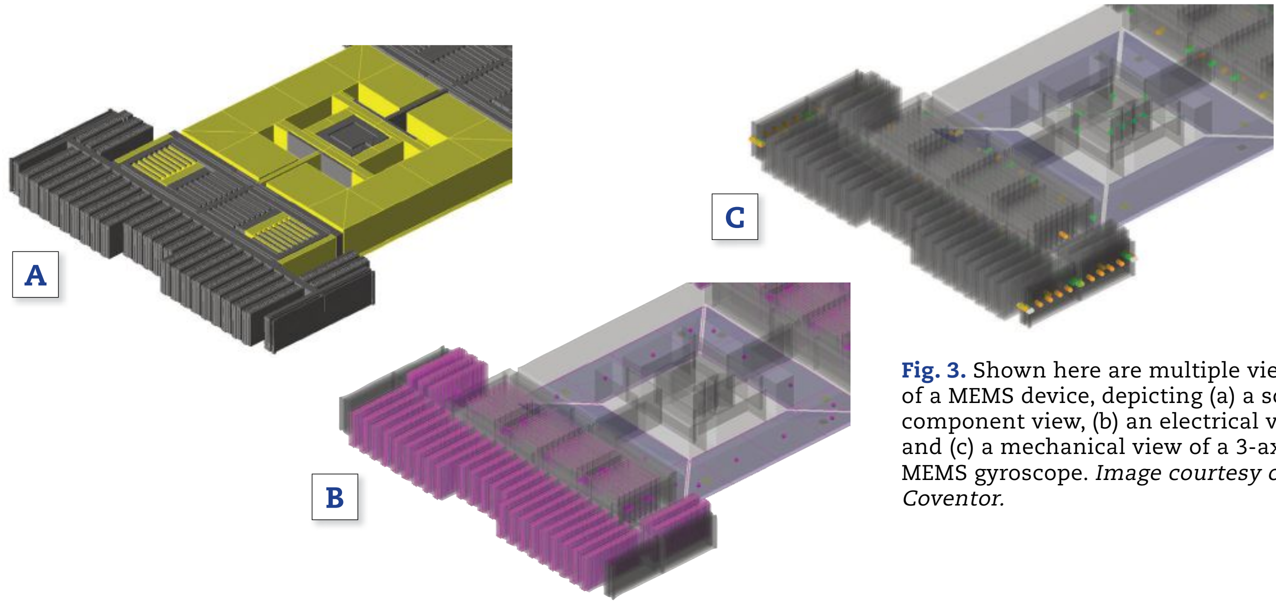


Fig. 3. Shown here are multiple views of a MEMS device, depicting (a) a solid component view, (b) an electrical view and (c) a mechanical view of a 3-axis MEMS gyroscope. *Image courtesy of Coventor.*

describe a wide range of complex, real-world MEMS sensors," says Breit. "Users should be able to create sensor models that are parametric with respect to key design, manufacturing and environment variables. The model must also include physical effects, such as electrostatic fringing fields and gas damping, and nonlinear effects such as electrostatic and mechanical nonlinearities." (See Fig. 3.)

Visualization also plays a key role. "The component library should provide multiple views of a device at various levels of abstraction, ranging from schematics, multiple simulation views, layout, layout abstract, 3D geometry and mesh views if appropriate," says Maher. (See Fig. 4.)

Design Glitches and Fixes

Problems can occur even when engineers assemble a design using the predefined building blocks of a component library. Some complications arise if the complex geometries of the components have not been handled correctly.

For example, MEMS layouts can contain curvilinear shapes, and these shapes should be correctly translated to mask output formats. Designers should be able to specify and manipulate curves in a natural way with direct curve representations, using intelligent methods that ensure that curves get approximated as all-angle edges to improve accuracy. Designers should be able to pass curves to process emulation tools in a direct curve representation for interpretation and meshing as opposed to a polygon format, which may not be the correct discretization size for efficient meshing. Also, design environments should provide a method of creating a hierarchy of different parts of the MEMS design to make it easier to assemble symmetrical MEMS devices.

Another area of the design process that can create problems lies at the point where design and manufacturability meet. Designers usually have multiple ways to construct a sensor model, and some construction approaches result in models that violate physical design rules or provide inaccurate simulation results.

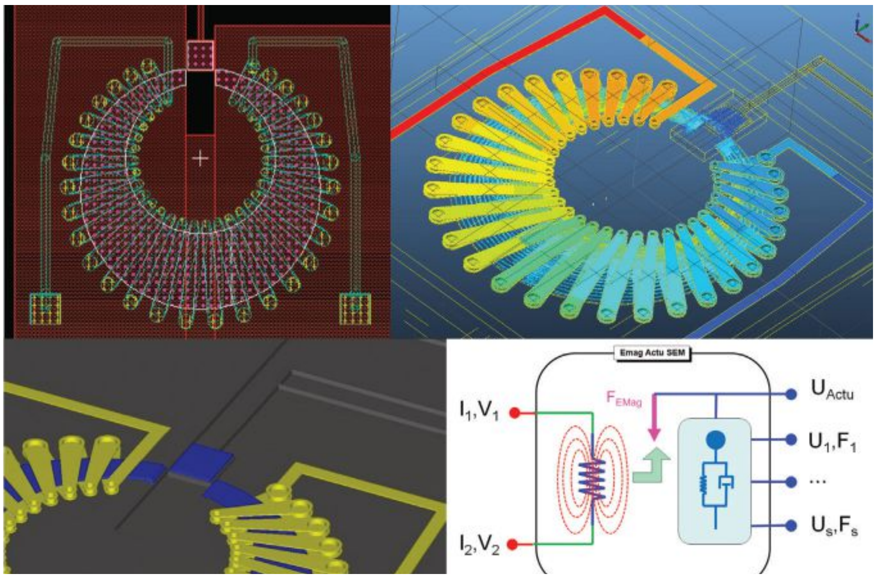


Fig. 4. A design platform should support multiple views of a MEMS or IC device at various levels of abstraction, ranging from schematics to 3D geometry and mesh views. IC and MEMS designers should be able to share these views to ensure design integrity. *Image courtesy of SoftMEMS/Mentor Graphics.*

"To reduce or avoid these issues, the design environment should provide a way to impose manufacturing and design constraints," says Breit. "For a given manufacturing process, some components may be excluded from the [component] library, and material properties, process parameters and geometric parameters of the remaining components may be constrained."

One solution is to select a design environment that offers a customizable component library. This provides a platform for creating MEMS process design kits that help ensure that the resulting designs can be manufactured and will behave as the designers expect.

Getting It Right

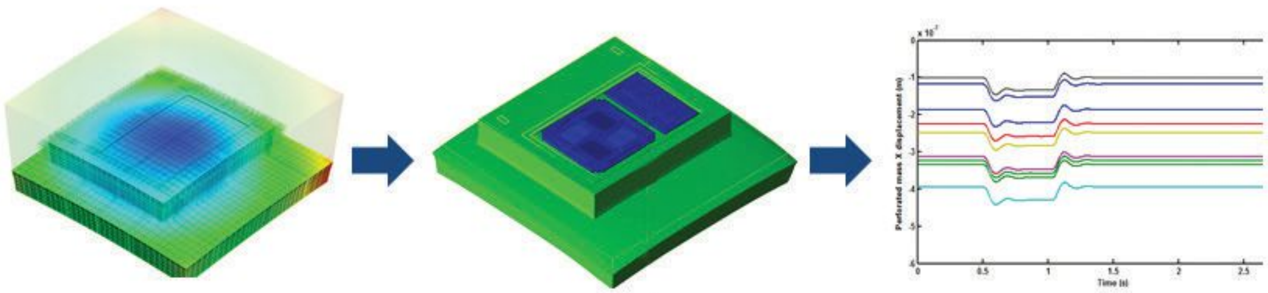
IC designers typically use a layout vs. schematic comparison and design rule checking (DRC) for physical verification. For MEMS devices, however, verification requires designers to depart from traditional IC verification techniques. MEMS designers also must perform DRC to confirm a design's manufacturability, but component structures typically have curved geometries and a variety of all-angled layouts, differing significantly from traditional IC designs.

As a result, MEMS designers must perform physical verification for the entire die, requiring two or more design sources that go into the complete die layout. One design source could be the layout of the active MEMS, generated from a MEMS component library or by a tool that supports true curves and all angles. The other design source could be the inactive parts of the design, such as interconnect wiring and bond pads, created in an electronic design automation (EDA) tool such as Cadence Virtuoso. The environment should automate, as much as possible, the combination of these two layout sources into a single layout that can be sent to an established DRC tool, such as Mentor Graphics' Caliber.

DRC should encompass manufacturing, context-sensitive and device-specific rules. Additionally, the technology should be able to handle curved structures efficiently without false errors.

"You need the ability to filter out false DRC violations that typically arise from DRC rules written for orthogonal layout," says Mentor Graphics' Williams. The ability to remove edges that don't project or only overlap by a small amount helps to remove false violations due to all-angle, curved edges and round-off. When a curved edge is approximated by multiple small edges, typical checks that assume a single edge intersects both sides of a box break down and cause false violations. This typically occurs in an extension check. The small edges that get created and don't intersect with the other layer can have reasonable projection lengths and, as a result, will not be filtered out based on projection. This can be handled by saving the results of an extension check as a polygon and checking the internal width of opposite or near opposite edges only.

While these practices have proven to be key elements of the verification and DRC processes, they represent the tip of a larger, more complex challenge. Increasingly, 3D modeling plays an important role in design verification.



Step 1: Use FEA to simulate package and die deformation vs. temperature.

Step 2: Attach MEMS device model to deformed die in Coventor MEMS+.

Step 3: Simulate sensor thermal stability in MATLAB or Cadence.

Fig. 5. This composite image depicts a methodology for predicting packaging effects on a MEMS inertial sensor. *Image courtesy of Coventor.*

Designing for Packaging

As the "sensory swarm" and the IoT increase pressure on MEMS design automation providers to enable greater levels of multi-technology integration, packaging increasingly affects the performance of the overall system. A good example of MEMS packaging effects can be seen in capacitive MEMS accelerometers and gyroscopes. These devices are relatively large — hundreds of microns across — and quite flexible, and they are attached to the substrate at a small number of points called anchors. Changes in ambient temperature cause the substrate to warp, which in turn causes tiny but detectable changes in the output capacitance of the sensor.

Design tools must be able to accurately predict these miniscule effects so that designers can mitigate their impact or at least know whether the resulting design will perform within specifications (see Fig. 5). MEMS and CMOS tools should interoperate with specialized packaging tools and interface with models provided by package vendors.

Moving Forward

Over the next five years, MEMS design automation providers will focus their efforts on bringing the design process more in line with high-volume, consumer product delivery demands while enabling greater multi-technology integration. "We will see more and more design re-use tools to reduce time to market with design kits, libraries and IP (intellectual property) tools for proven designs on proven processes," says Maher. "But at the same time, we will see tools to manage the design of devices using new materials and manufacturing processes, as device designers take advantage of flexible materials, low-cost substrates and printed devices."

As MEMS play a broader role in the marketplace, you will see design environments tailored for IoT designers who may not have MEMS experience, allowing them to use off-the-shelf parts to design systems. "There will be MEMS PDKs [process development kits] based on the MEMS component library approach available from independent foundries for proven MEMS processes," says Coventor's Breit. "We don't expect the IoT device designers to delve into detailed MEMS design, but rather to customize reference designs to suit their needs. The MEMS PDKs will make it much easier to customize and integrate MEMS and CMOS at the package and wafer levels."

For MEMS designers, the component library approach will continue to evolve to address more complex designs and advanced physical effects. The libraries will provide automated links with front- and back-end layout tools. On the front end, it will be easier to import a MEMS layout and construct a MEMS model. On the back end, the level of automation for combining active and inactive portions of the die layout will improve. There will also be advances in automated design optimization and manufacturing sensitivity studies, enabled by widespread availability of powerful computing resources through public and private cloud computing.

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INFO:

Coventor: Coventor.com

Mentor Graphics: Mentor.com

SoftMEMS: SoftMEMS.com

University of California, Berkeley: Berkeley.edu

Robots Get A Grip

Robotiq and Universal Robots implement their sensors and systems in product design testing.

A leading manufacturer of operator controls, non-contact sensors and safety devices is using the Robotiq FT 150 force torque sensor in its manufacturing loop.

Joystick bases and control sticks are a main product group from the manufacturer. These products must go through a variety of qualitative and quantitative test procedures. The joysticks are sold as a principal control device for vehicles, and they are a critical component for their customers. The quality assurance team has to verify the conformance of the electronic and mechanical components before they get to final packaging. The quality control team used to test their production manually, which allowed the workers to adapt their verification tasks to dozens of different joystick models including custom configurations.

The goal was to monitor the performance, full functionality and sensitivity of the joystick components. With everything being done manually, the company strove to minimize the work-in-progress at the different workstations, but didn't want to jeopardize its quality by implementing random sampling. Over the long term, they couldn't afford to assign more workers or increase the production pace; either might lead to worker fatigue and increased mistakes. These non-value added operations within their quality control functions represented the perfect opportunity for their quality and engineering team to automate their testing through the addition of a robot and gripper.

To automate its product testing, a leading manufacturer used Robotiq sensors and components with a Universal Robots arm. *Image courtesy of Robotiq.*

Determining Devices

The goal was to have the most flexible robotic cell they could have. From this optic, they could test a very wide range of products with the same cell. Besides that, they wanted to have easy to integrate and easy to use devices that would all mesh together. To meet these goals, they used three main devices.

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Collaborating on Prototype Refinement

Minnetronix partners with Karten Design to address aesthetic and functionality concerns on a tight timeline.

In partnership with Karten Design, a product design and innovation consultancy, Minnetronix was charged with designing and producing a working prototype that looked and functioned like a finished device for a wearable acoustic emission monitoring product that assessed orthopedic joint health. The project included internal and external design of the full device, a rolling console, as well as a redesign of the wearable sensor.

The client had already engaged with Karten Design and was seeking a partner with electromechanical expertise and extensive experience in the medical device industry who could collaborate effectively with Karten. Minnetronix and Karten were asked to deliver a near-commercial prototype in less than six months so that it could be demonstrated at a major tradeshow.

The collected data on the rolling console was designed to aggregate data in real time. *Image courtesy of Minnetronix.*

The Solution

Karten Design led the human factors, usability and industrial design of the rolling console. They designed the look and feel of the device, developed a user interface design concept and developed the outer housing. The intent was to create a system that would add value to a physician's practice while eliminating any barriers to learning a new device.

Minnetronix, leveraging its expertise in electromechanical engineering, focused on the inner workings of the console. They developed the single board computer, software, custom electronics and custom display with a touchscreen.

MORE: deskeng.com/de/?p=28604

SPECIFY NEW SENSORS

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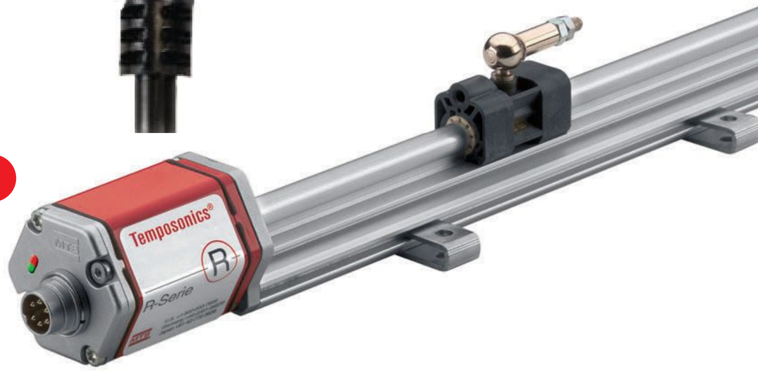

1 Ophir Photonics Announces High Damage Threshold Sensor

Part of the 3A-P family of laser sensors, the 3A-PF-12 is an ultra sensitive sensor that can measure powers from as low as 15µW up to 3W and energies from as low as 20µJ to 2J, according to the company. The new sensor replaces the P-type absorber with the high damage threshold PF type, giving it the industry's highest energy density damage threshold for repetitive pulses, Ophir Photonics says.

Designed for use with YAG and its harmonics and excimer lasers, the 3A-PF-12 is a thermal power/energy sensor with low noise of 4µW and low drift of 5-30µW. It delivers one of the highest energy density damage thresholds in the industry, up to 1.5J/cm^2 for repetitive ns pulses, the company states. The sensor features a 12mm aperture and broad wavelength range of 0.15 – 20µm. ophiropt.com

2 MEMSIC Announces MTLT Sensor Family

According to the company, the MTLT family of tilt sensors are appropriate for a range of static and dynamic applications in construction and industrial markets such as boom tilt monitoring, bucket loader roll back protection, PV/CSP solar tracking systems and others. Currently available for evaluation are the MTLT110S-R, MTLT105S-R and MTLT105D-R.

All three products are IP67 rated inclinometers with an integrated RS-232 interface and flying lead cable operating from a 9 V to 32 V single supply. The MTLT105S and MTLT110S are designed for applications needing < 0.5 degree and < 1.0 degree accuracy, respectfully, over the full operating temperature range. The MTLT sensors also include programmable tilt alarms for tilt safety applications. The alarm can be programmed to be triggered to activate when the tilt exceeds a specified threshold. The tilt alarm can also be used to lock out controls or trigger an alarm or warning light. memsic.com/index.cfm

3 MTS Enhances R-Series Portfolio

MTS Sensors, a subgroup of MTS Systems Corporation, has enhanced its R-Series of high-performance magnetostrictive sensors for absolute position measurement. The series now conforms with the latest version of the Ethernet/IP communication protocol with device-level ring (DLR) compatibility, having recently re-certified against the ODVA Ethernet/IP Composite Conformance Test revision CT12. Through this, interfacing with a wider array of Ethernet/IP compliant hardware across numerous industry sectors has been made possible.

According to the company, these sensors are better equipped for industrial networking implementation. Their DLR capabilities permits direct connection to a ring topology without using external switches. They are offered in a choice of rod style, profile style and flex

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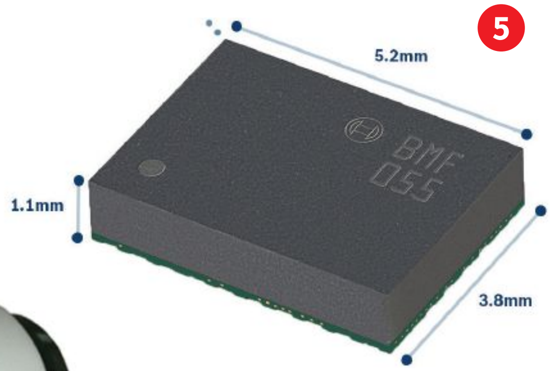

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style configurations, with stroke lengths of 25mm to 7620mm (1 in. to 300 in.), 25mm to 5080mm (1 in. to 200 in.) and 255mm to 10,060mm (10 in. to 396 in.) respectively.
mtssensors.com

4 TE Connectivity Releases IH-492 Series

The new IH-492 series features a glass-encapsulated NTC thermistor potted in a copper housing for stable and accurate measurement in high moisture and freeze/thaw applications. It has a 5x20mm copper housing radius and operating range of -40ºC to + 105ºC.

The rugged sensors integrate several features including a 36-in., AWG#24 PVC-insulated wire that provides signal integrity. A radius-shaped housing minimizes external environmental effects and maximizes contact against the pipe. A proprietary molding process produces an extremely dense NTC ceramic that provides exceptional and stable measurement and has passed severe environmental testing to confirm the sensors withstand some of the harshest real-world applications, the company states.

The sensor assembly is available as standalone or with a custom-designed, copper-clad steel clip that facilitates easy installation onto the copper refrigerant tubing. Clip sizes include ¼-in., $^3/_8$-in., ½-in. and ¾-in. Standard resistance is 10 kOhm at 25ºC with up to ±1% resistance and a Beta value of 3976K (25ºC/85ºC).
te.com

5 Bosch Sensortec Launches BMF055

The BMF055 sensor is suited for customers developing advanced application-specific sensor fusion algorithms, adding sophisticated motion sensing capabilities and replacing multiple discrete components with a single package, the company states.

Target market segments include robotics, gaming, remote controls, navigation systems, drones and human interface devices for Internet of Things (IoT) projects.

The new sensor from Bosch Sensortec's Application-Specific Sensor Node (ASSN) family combines an accelerometer, a gyroscope and a magnetometer with a Cortex M0+ processor from Atmel's SAMD20 microcontroller family. In a compact single 5.2×3.8×1.1 mm^3 package, it provides this high level functionality in a "one stop shop" solution, making integration easier for the customers, the company states.

With the BMF055 sensor, Bosch Sensortec provides a Software Development Package that includes a precompiled BSX Lite fusion library with integration guidelines, API (application programming interface) source files for individual sensors and example projects as a plugin for Atmel Studio.
bosch-sensortec.com/en

6 Ceramic Media Isolated Series Released

All Sensors Corporation has released new media isolated pressure sensors.

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The company's first line is the ceramic CPM 602 series. These sensors offer performance for various applications such as hydraulics, automotive, medical, energy and more.

The CPM 602 series offers piezoresistive monolithic ceramic pressure sensors. According to the company, Product highlights include excellent chemical resistance and easy mounting. Using thick-film technology, the measuring bridge is printed directly onto one side of the ceramic diaphragm. The structure-free backside can be directly exposed to the medium to be measured. Due to a high resistance to chemicals, additional protection is not necessary.

Devices are available in 30, 75, 150, 300, 750, 1500, 3000 and 6000 PSI.
allsensors.com

7 Novotechnik's New Angle Sensors

The RSX-7900 series of angle sensors provide up to IP69K ingress protection, life of >100 million movements and ISO13849 PL-d safety compliance in a non-contacting design, according to Novotechnik.

The sensor is available in six standard measuring ranges with angles from 0 to 60 to 0 to 360° with unrestricted rotation. Resolution is 12-bit across a 4 to 20 mA output with linearity to ±1% at ≥ 90°. Repeatability is 0.2° and update rate is 5kHz.

Single and dual redundant versions are available and the life specification is valid even under high shock and vibration conditions up to 50 and 20 g respectively. The RSX-7900 Series is available with a CANopen interface.

The RSX-7900 Series sensors offer anodized aluminum housing with a stainless steel shaft for enhanced corrosion protection with salt and spray resistance. Axial and radial shaft loading is up to 300N thanks to a double row angular contact ball bearing design. The 70mm diameter sensor has a nominal length of 35mm and is available with a wide choice of shaft styles for maximum installation flexibility.

The RSX-7900 Series angle sensors operate from 9 to 34V DC supply making them suited for 12V and 24V off-highway vehicle and construction equipment applications.
novotechnik.com

8 Himax Imaging Launches CMOS Image Sensor

The HM01B0's ultra-low power consumption allows the sensor to be placed in a constant state of operation, enabling "always on," contextually aware, computer vision capabilities such as feature extraction, proximity sensing, gesture recognition, object tracking and pattern identification.

According to Himax, the sensor's reflowable chip scale package measures less than 5 mm² and requires only three passive components to support a highly compact camera module and miniature wafer level module assembly that can be easily integrated into next-generation power-efficient devices for context sensitive computer vision applications.

"Our image sensors for notebook and smartphone applications, such as our ¼ in. 8MP MIPI sensor, have been among the lowest power in the industry," stated Jordan Wu, CEO of Himax Technologies.
himax.com.tw

TMR Switch Sensors Now Available from Multi-Dimension Technology

MultiDimension Technology (MDT), a supplier of magnetic sensors, has released a series of ultra-low power, small hysteresis TMR (tunneling magnetoresistive) switch sensors.

The TMR1340/TMR1341/TMR1343/TMR1345 feature a switching point from 14 Gauss to 72 Gauss with small hysteresis, ultra-low power at 1.5microAmperes in high-speed operation, with open-drain output and an ultra-compact 2×1.5mm LGA package, MDT states.

According to the com-

pany, they are an ideal choice for industrial proximity switches, pneumatic cylinder switches and liquid level switches that require precise measurement of position and displacement, excellent temperature stability and versatility to adapt to different types of magnets and stroke lengths.
dowaytech.com/en

9 Hoffmann + Krippner Release Inelta IZAL Series of LVDT Sensors

These devices are designed to ensure precise path length measurements in applications with highly confined spaces, the company states.

According to a company press release, the 4mm diameter housing of these Linear Variable Differential Transformer (LVDT) sensors are barely larger than a matchstick, though their interior provides a complete and powerful differential transformer measuring system with a core and coils.

The contact, wear-free sensors for displacement and position detection have a linear tolerance of ±5% and are designed for measuring ranges of 1, 2.5 and 5 mm. They are housed in nickel-plated steel and have a temperature range of -25 to +85°C (-13 to -121°F).
hoffmann-krippner.com

Sensata Technologies Develops New Pressure Sensors

Sensata Technologies, a manufacturer of sensing, electrical protection, control and power management solutions, has developed a new line of smaller, lighter Micro-Fused Strain Gage (MSG) pressure sensors. These components are ideal for next-generation brake systems for hybrid, electric and conventional vehicles, the company states.

Sensata's automotive MSG pressure technology will now be offered at less than 5g, with a body diameter less than 7.8mm and a height less than 30mm, including the company's spring contact system. The new XFF (eXtra-small form factor) platform utilizes a modular port design, catering to a wide-range of system pressures and a modular circuit architecture offering high-fault-detectability enabling system manufacturers to meet technical safety requirements associated with ISO26262, the company states.

The sensors offer analog and digital integrated pressure and temperature signal conditioning over an operating temperature (-40° to +140° C) and various pressure ranges.
sensata.com

10 Moxa Ships Smart Remote Data Acquisition Devices

The new ioLogik 2542-WL1 and ioLogik 2512-WL1 are designed to help collect and share sensor data in different environments. Both feature 802.11a/b/g Wi-Fi connectivity, which will serve the growing number of devices and machine-to-machine (M2M) applications that require wireless communication. The ioLogik 2542-WL1 supports analog I/O connections over Wi-Fi, whereas the ioLogik 2512-WL1 supports digital I/O connections over Wi-Fi.

Both ioLogik units feature automatic tag generation and reporting for connected sensors and devices. This enables operators to monitor a large number of field devices with great efficiency. This function can also work in conjunction with Moxa's MX-AOPC UA Server on the cloud to minimize network bandwidth and latency. Data communication is protected with the highest commercially available security (WPA2/802.11i), which features advanced encryption and authentication.

In addition to Wi-Fi, the ioLogik 2542-WL1 and 2512-WL1 both feature a 4-port unmanaged Ethernet switch and two serial ports for a seamless connection to a variety of field devices.
moxa.com

Dassault Systèmes' Integrated Plant Engineering solution helps develop a virtual twin of an actual plant before it's built or modified. *Image courtesy of Dassault Systèmes.*

When Reality Becomes Virtual

Engineers are gaining more access to virtual and augmented reality thanks to cheaper technology.

BY JIM ROMEO

Part of Disney Enterprises' preparations to launch "Star Wars" attractions in its theme parks, included creating them digitally and using projectors and 3D glasses to see what they'd be like in reality — virtual reality that is.

Disney has worked with Dassault Systèmes and its virtual reality (VR) technology as a tool to prototype designs to help accurately create the product virtually before they invest in the real deal. For many companies, virtual reality is one of the next big things to embrace. For design engineers, it provides a means to greatly improve the effectiveness of large-scale designs, while reducing risk and total cost of ownership.

Reduce Time and Cost

David Nahon is the director of the Immersive Virtuality Lab at Dassault Systèmes in Paris. He says over the past two decades, we have seen a majority of virtual reality (VR) adoption in the automotive or aerospace industries as a way to replace physical prototyping processes, reducing time and cost spent in development.

Nahon says that these industries have spent millions in purchasing and maintaining immersive VR rooms, otherwise known as cave automatic virtual environments (CAVEs). With the high cost of building CAVEs, the return on investment hasn't always aligned with the needs of certain industries. Very soon, design engineers, like those using Dassault Systèmes solutions, could enjoy an affordable virtual environment.

Moving forward, designers may begin to rely on VR simulations to build prototypes and test new products to reduce time and cost. VR can also drive a stronger return on investment as headsets are used to view simulations, rather than using the large, more expensive CAVE environments.

"Virtual reality is ideal for manufacturing industries using product lifecycle management (PLM) applications — specifically on the actual plant and in workbench simulations," says

Nahon. "Virtual reality is also an important tool for industries that require training. Companies that have complex operations need to be able to train employees before going out into the field — this means they must be able to create an interactive environment that provides a realistic atmosphere."

Howard Schimmoller is a technical fellow with Kalypso, an innovation consulting firm in Media, PA. He knows the value of virtual reality and says that it is about to make a big step into the mainstream as an engineering and design tool. However, he believes it will do so in a selective manner.

"In the past it has been successful where model data was sufficiently realistic and accurate," says Schimmoller. "For example, in aerospace — where missions have a very small margin for error — VR has been used to effectively retire risks that cannot or should not be tested on Earth. The basic tenets that must be met [are if] model fidelity and accuracy is appropriate, risk can be eliminated, and the associated simulation of characterizations is trusted."

Jason Milo, a solution architect with Kalypso, points out that virtual reality is not a new technology; it has been used for decades in scientific research, aerospace, defense and automotive industries to provide a lower-cost method of visualizing designs and performing true simulation, where iterating multiple physical prototypes for physical testing would be impractical.

He says that these industries have embraced the model-based enterprise and that 3D models are integral at almost every stage throughout the entire product lifecycle. The model-based enterprise concepts allow these industries to use VR because their 3D models are accurate.

Accuracy is also key in avoiding numerous iterations before the final product or assembly line is developed. Dassault Systèmes' Nahon says VR is ideal for manufacturers to prototype products in 3D to see what works and what doesn't. The drivers behind this are cost and time savings. Companies can eliminate the process of having to build a number of models just to find one that works. Virtual reality allows for real-time design adjustments without risking resources and overhead costs.

Depicting Large-Scale Objects and Processes

Mitigating risk and reducing cost are key advantages for large-scale projects that would otherwise be difficult to prototype to scale. While smaller objects have been prototyped well, large objects such as a theme park, gas turbine or automobile, haven't been so easy to depict.

"I do believe that large-scale products are a perfect use case for virtual reality," says Anthony Duca, director of Invimage LLC in Carlsbad, CA. "Scale objects are really hard to visualize on a computer screen. With virtual reality you can really get a sense of actual scale, as well as be able to interact with it. Being able to walk around large objects makes it so much more real and tangible, your brain really gets tricked into thinking the object actually exists."

Milo says that the advantage of being able to test and try many different features and variables without a physical prototype is key. VR provides a picture that designers can tweak and vary.

"Many other 'traditional' manufacturing companies are at various levels of maturity when it comes to model-based enterprise as many design engineers are using 3D models as a method to make pretty pictures on a drawing, create rough 3D-printed prototypes, perform basic simulations and use as an aid in manufacturing instead of being directly used for manufacturing," says Milo. "The quality and fidelity of their 3D models limit the usefulness of VR technology unless they shift from their current design methods and fully embrace model-based enterprise concepts, especially where simulation is used instead of relying on the physical testing."

Milo adds that companies will continue to leverage or adopt VR as a way to improve efficiency and effectiveness for any process in the product lifecycle to lower the cost of development and increase the success of their products in the market.

"This is why it has been adopted in the past and will continue to be adopted as long as the benefits of using VR outweigh

PTC Draws on Augmented Reality to Round Out IoT Offerings

A short three months after its $65 million acquisition of the Vuforia augmented reality platform, PTC is showing how crucial that technology is to its future vision for reinventing itself as a core Internet of Things (IoT) platform provider.

While the Vuforia technology lies at the heart of some pretty compelling consumer product marketing initiatives and some cool kid's toys from LEGO, PTC believes there's a more promising enterprise value proposition. Using an augmented reality (AR) platform to overlay digital data — such as real-time temperature readings off a sensored product or design data stored in a PLM platform — companies can elevate interaction with a product, providing service operators with detailed instructions or facilitating design reviews for engineers

"The digital/physical worlds are converging with products existing in both at the same time, comprising both hardware and software, part on-premise in the field with customers and part digital up in the cloud," said CEO Jim Heppelmann at its recent ThingEvent in Boston. He sketched out a new corporate positioning to "take a fresh look at things," with a significant emphasis on augmented reality. "PTC has invested more than $700 million to transform its portfolio with new technology for connectivity and cloud-based capabilities."

Heppelmann and the PTC crew outlined a range of enterprise use cases, including validating products against the original design, facilitating more efficient and insightful design reviews, and as a means for better product training.

Sysmex is exploring the Vuforia AR platform to help customers get instruments back up and running quickly.

KTM sees huge potential in augmented reality as a way to help address service challenges. ***Images courtesy of PTC.***

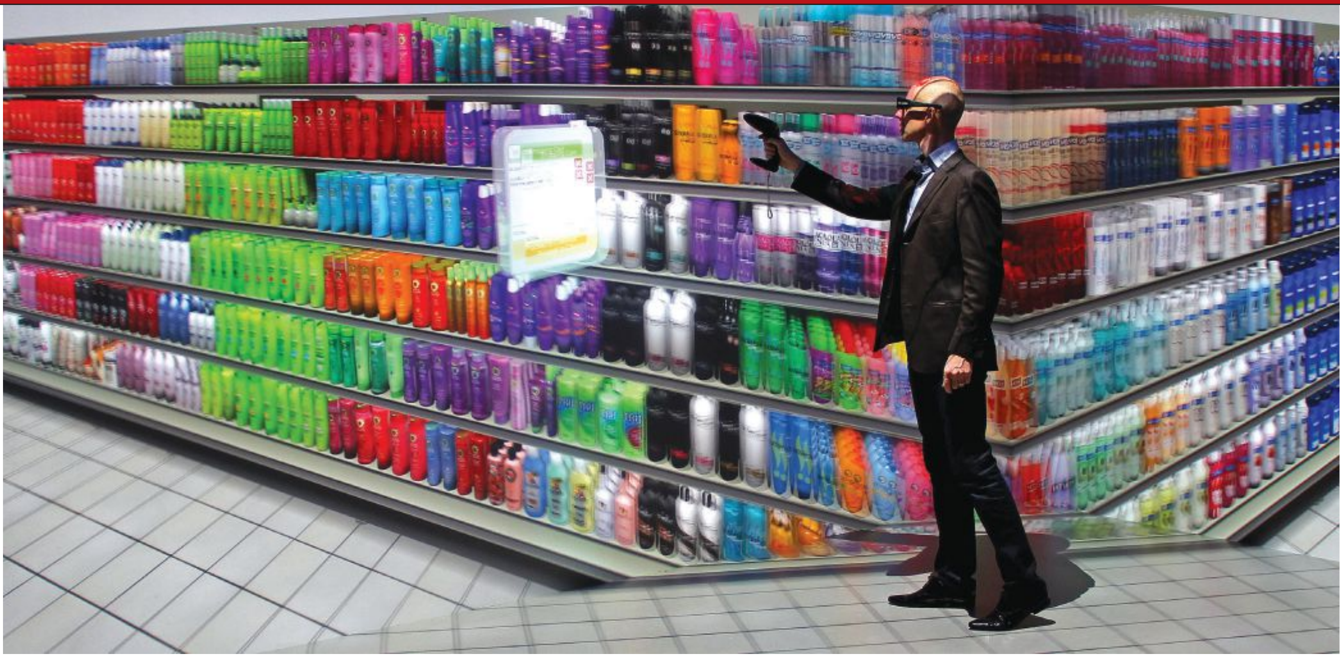
However, service was the main event as PTC and a handful of early AR customers talked about how AR is "the killer capability" that will transform service operations.

For example, KTM, a maker of high-end motorcycles, described an iPad service dashboard, built with ThingWorx and Vuforia, that lets field technicians perform faster diagnostics and deliver a more consistent level of service. By overlaying the 3D CAD geometry on the physical bike, technicians can see how to how to remove a panel and check a particular connection, streamlining the procedure. Similarly, Sysmex America, a maker of medical instruments, plans to marry IoT and AR capabilities to make its field staff more efficient and to help customers perform more self-service operations and improve medical equipment uptime.

Beyond showcasing real-world customer examples, PTC unveiled a number of enhancements designed to shore up Vuforia's enterprise game, including adding support for Windows 10 devices, as well as VuMark, which officials dubbed a next-generation bar code. Like a QR code, the VuMark designates an AR experience to a particular product or thing, encoding data like URLs or product serial numbers. The difference is that VuMark provides greater design freedom, allowing engineers and designers of the AR experience to incorporate a custom look.

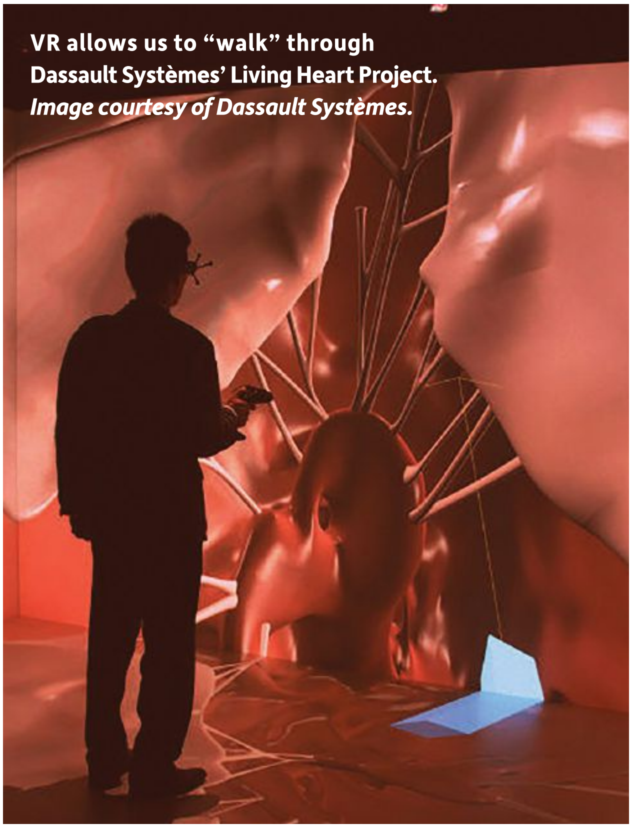
PTC also previewed several critical ThingWorx announcements it plans to detail this summer at its upcoming ThingWorx conference. As part of an expanded strategy it's calling ThingX, PTC plans to release ThingBrowser, a universal browser for recognizing and interacting with smart, connected products in lieu of disparate apps; ThingBuilder, a drag-and-drop environment for building IoT experiences that integrate data from PLM and SLM (service lifecycle management); and ThingServer, akin to a Web server, but for managing and serving up all relevant data specific to a particular "thing."

— Beth Stackpole



Dassault Systèmes' Perfect Shelf solution simulates retail settings inside immersive, life-like 3D virtual environments to help consumer packaged goods companies and retailers design attractive displays. *Image courtesy of Dassault Systèmes.*

its cost to implement," says Milo. "I expect to see sales and marketing departments driving the adoption of using lower-cost VR solutions for visualizing concepts that will require industrial designers and design engineers to have easy access to VR tools. In the very near future, I expect that every mechanical design department will have these tools, and many departments will have every design engineer outfitted with this technology."



VR allows us to "walk" through Dassault Systèmes' Living Heart Project. ***Image courtesy of Dassault Systèmes.***

According to Schimmoller, the barriers to entry have been lowered, making VR available to a wider set of users and industries. Virtual reality is turning the corner as a high-value technology tool that is more than a novel design application. It is becoming valuable intellectual property that is both cost effective and also reduces engineering design risk.

"The tenets that make the VR use valuable remain true: model fidelity and accuracy must meet expectations; the associated simulation of physical characterizations must be trusted; and risk must be cost effectively eliminated," says Schimmoller. "New users should be clear if their business process maturity, organization and management are ready for the change. Design engineers and management professionals must act as a model-based enterprise. They must recognize the investment represented in the VR model data. The data must be managed as the high-value intellectual property it is." **DE**

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INFO → Dassault Systèmes: 3ds.com

→ **Invimage:** Invimage.com

→ **Kalypso:** Kalypso.com

→ **PTC:** PTC.com

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The Growing Demand for On-Demand Licensing

New CAD users' behaviors and preferences offer clues to subscription's appeal.

BY KENNETH WONG

"When people are leasing a car, they tend to get a model that's much nicer than what they can afford to buy," says Cristiano Sacchi, co-founder of the online design software reseller Novedge. He suspects the same might be true of people renting software. "People might get a more sophisticated software package when the barrier of entry for cost is much lower."

Perpetual licensing was once the only way to buy CAD. The buyers paid an upfront cost of a few thousand dollars, along with an annual maintenance fee to get regular updates. Even when Salesforce.com's pay-as-you-go offerings were sweeping through the enterprise, CAD held out. But now that is changing.

At the end of January, Autodesk stopped selling perpetual licenses for its individual software titles. In July, it plans to stop selling perpetual licenses for its popular software bundles, such as the Autodesk Product Design Suite and Building Design Suite. (The perpetual licenses already sold prior to these deadlines remain valid; owners will continue to receive upgrades as long as they continue to pay their maintenance fee.)

Autodesk's rivals aren't discontinuing their perpetual models, but they have begun offering subscriptions. In 2013, Siemens PLM Software put its mainstream CAD program Solid Edge on subscription. Last November, PTC put its entire portfolio on subscription. Dassault Systèmes SOLIDWORKS is only available for perpetual licensing. However, the company began offering SOLIDWORKS Conceptual Designer and Industrial Designer under shorter-term (quarterly) licenses. This January, it previewed X-branded products — X Drive and X Design — also to be made available in short-term licenses.

Dan Schulist, general manager of Autodesk reseller MasterGraphics, feels the pressure subscriptions are having on resellers. "The customers now have an easy out," he says. "They're no longer obligated to put down a huge investment and figure out how to make it work. We need to help them make it work."

With perpetual licensing, the customer and the reseller are in a committed relationship once the transaction is processed.

Desktop Subscription vs. Perpetual +Maintenance

Three-Year Price Comparison, North America

	AutoCAD LT	AutoCAD	Maya
Three-year desktop subscription	$1,080	$5,040	$4,410
Perpetual license plus three-year mainenance	$1,740	$5,830	$5,530

A subscription to Autodesk products is initially cheaper, but unlike perpetual licenses, the software will not continue to operate if the subscription is not maintained. *Information courtesy of Autodesk.*

With a subscription, the customer can walk away without the loss of an initial investment; therefore, the reseller must continually prove its value to retain the subscriber. "CAD technology is very complex. Most customers only use a fraction of the software's capacity," Schulist says. "We can help them discover the full extent of the software's potential."

It's not clear what the long-term ramifications of subscription CAD software will be. "The truth is, we're learning, figuring out things as we go," Sacchi says. Resellers continue to be the frontline of CAD sales. Their strategies to weather the transition from perpetual to subscription economy could have profound effects, not only on their own future but also on the user experience.

The Number Game

At about $100 per user per seat, subscription licensing is a departure from the previous model. For a start, the reseller's profit margin is much smaller; the surefire way (perhaps the only way) to remain competitive is to become efficient at volume sales.

Franco Folini, co-founder of Novedge, compares selling CAD subscriptions to selling SOLIDWORKS student editions, currently listed for $86 on Novedge's online catalog. "We don't expect to make a lot of money on them," he explains. "But we can't subsidize the operations at a loss either. We just make a little bit of profit on each sale. For this kind of product, we need to have a super-efficient, highly automated system."

A Case Study in Mobile Usage

Once a machinist, Mitch Free founded MFG.com, an online manufacturing marketplace, in 2000. After nurturing MFG.com to its success and selling it off in 2013, Free decided to setup shop and began offering CNC machining, 3D printing and plastic molding services as ZYCI. "We thrive on low volume — not mass production, but on doing one to 100 pieces, with a high degree of customization, with very quick turnaround," he says of his new business.

From his previous role at MFG.com, Free was well aware of the talents behind the SOLIDWORKS CAD program. When he found out a group of SOLIDWORKS veterans had developed a browser-based CAD program called Onshape, he decided to become a beta tester. Eventually Free became one of their first paying customers — or, rather subscribers.

Onshape subscriptions are available at the Free (with a cap on private data storage), Professional ($100 per month) and Enterprise (price unpublished) levels. "This was perfect," Free says. "I was running a startup business, needed cash flow. I didn't want to spend $5,000 to $7,000 on a CAD license tied to a single machine in an office. Wherever I happened to be, home or office, I should be able to fire up the program."

Mitch Free uses browser-based CAD software Onshape, also available as a mobile app (shown here on an iPad app).

Free relies on Onshape for 90% of his CAD operations, and the rest on Kubotek KeyCreator. He currently owns five Onshape subscriptions. Since Onshape sells subscriptions directly from its site, Free deals directly with the software vendor with no reseller in-between.

"I use Onshape primarily to issue quotes," he says. "Wherever I happen to be, I want to be able to respond as quickly as possible. I've learned that the faster I can issue a quote, the better my chance is at winning the business. If a customer needs something urgent and I can't get back to them, they'll call someone else."

With Onshape, Free can inspect the CAD model submitted by the customer from virtually anywhere, so long as he has a device with a Web browser.

Read more: deskeng.com/de/?p=28613

The Exploratory Buyers

MasterGraphics' Schulist estimates that 60% of its business comes from the manufacturing sector, the rest from architecture, engineering and construction. The company has been selling Autodesk products throughout the Midwest since the 1990s. It is currently a platinum partner of Autodesk.

Schulist recalls some existing customers stocking up on perpetual licenses before Autodesk's cutoff date arrived. "These are established businesses that know they'll be using the software indefinitely, and prefer to own the software perpetually," he says.

While subscription dramatically lowers the cost of entry, some see the cumulative monthly or yearly subscription fees over time as an economic disadvantage. By Autodesk's own calculations, a three-year desktop subscription of AutoCAD comes to $5,040, whereas a three-year maintenance and a perpetual license of AutoCAD comes to $5,830. Keep in mind, however, that the subscription fee of $210 a month or $1,680 a year (current published price for AutoCAD) will continue indefinitely. By comparison, someone who owns a perpetual license of AutoCAD could continue to pay the nominal maintenance fee (not published, available through resellers) to continue receiving upgrades. Therefore, over a period of six, seven or 10 years, the total spent on subscription could add up significantly higher than the perpetual license and maintenance combo.

Responding to *DE*'s Virtual Desktop blog post "Autodesk Will Only Sell Subscription Licenses for Desktop Products After February 1, 2016," (deskeng.com/virtual_desktop/?p=9888) one reader commented: "I had considered upgrading our AutoCAD platform that complements our use of SOLIDWORKS for design, but we'll definitely pass on the cloud-centric subscription model and just stick with their legacy software as long as we can make it work. This one-size-fits-all pricing is simply impossible for us to justify for continued use."

While some users are leery of the subscription model, MasterGraphics is also uncovering new markets. "Our newer customers are younger startups," Schulist says. "They want a lower cost of entry. They don't want to shell out a lot of money for a program only to find out later that's not what they need."

A Case Study in Project-Driven Usage

Good ideas from scientists and independent inventors might not see the light of day if they don't have the experience or the equipment to produce a prototype. Even if they're willing to pay for it, making one sample unit isn't worth some machine shops' time.

Ryan Spoering hopes to cater to these underserved inventors with his prototyping business. An organic chemist and a teacher by profession, Spoering also happens to have a knack for prototyping, engineering and metalworking. Last year, he decided to launch a Boston-based consulting business dubbed Lab Machinist Solutions.

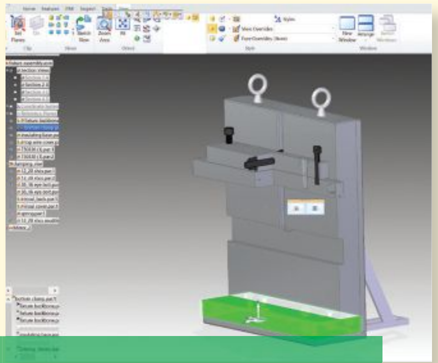
To choose the CAD program that would become his business' backbone, Spoering spent 45 days (the typical free trial period for CAD software) modeling parts and assemblies in several different programs. One of the major draws was the subscription licensing option. "This was important, especially in the beginning of my business," he says. "I needed to be able to start without a huge investment in software."

In the end, he picked Solid Edge from Siemens PLM Software. The multi-tiered licensing model lets subscribers choose if they want the Design and Drafting ($100 per month), Foundation ($230 per month), Classic ($290 per month) or Premium ($420 per month) edition. Higher-priced editions come with advanced modeling functions, data management and analysis tools not found in the basic editions.

"I began at the Design and Drafting level," says Spoering. "After a few months, I switched to the Foundation level." The commitment-free licensing scheme functioned as an extended trial period for Spoering to figure out the features he needed. "If I were to purchase the software, I'd need to know how much of those features I'd be using regularly, and I had no way to know that in the beginning. So I'd have to take a gamble and live with my choice."

If Spoering needs higher-end functions for a new project, he can subscribe to the Premium edition for a month, then move back down when he's done.

As a one-person startup, Spoering relies on on-demand products not just for 3D CAD, but also 2D conceptual design (Autodesk SketchBook Pro), accounting (Quickbook online) and data storage (Dropbox). Even if his business grows to a small company and his CAD workload becomes predictable, Spoering predicts he'll keep a few subscription licenses in addition to perpetual seats. "I like having the flexibility for expansion and contraction based on projects," he says.



Ryan Spoering, who runs consultant business Lab Machinist Solutions, uses Solid Edge on subscription to turn his clients' ideas into 3D CAD for prototyping. *Image courtesy of Ryan Spoering.*

Novedge is having a similar experience. "We're starting to see smaller, newer customers," Sacchi says. "If you can't afford to buy a professional package like Maya, you can't produce work with a certain kind of quality. But now, you can subscribe to it at a much lower price. Ideally, we'll see people who couldn't afford to buy the professional software packages becoming subscribers."

Monthly or quarterly subscriptions can be adjusted to match the rise and fall of project needs; by contrast, perpetual licenses are permanently installed, with a fixed cost for annual maintenance even when the licenses are not in use.

Catering to the On-Demand Crowd

MasterGraphics' value-add offerings mirror the changing attitude. "We give customers the flexibility to choose what they want, when they want it," Schulist says. "We've always offered classroom training, but we now produce more online and offsite trainings. We also break longer trainings into smaller modules."

Novedge's Sacchi says subscription licensing is a precursor to a new kind of CAD software. "Right now, when you subscribe, you're essentially getting the same product as the perpetual software," he points out. "But I think over time the products will include much more add-on services. With more timely upgrades, products will become alive."

Both vendors and resellers recognize the move to subscription comes with certain risks. But the risk of abstaining from subscription licensing may be far greater. "This is the way the market is going, the way software will be sold, what the customers demand and want," Schulist says. "We need to get in line with it." DE

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

INFO → **Autodesk:** Autodesk.com

→ **Dassault Systèmes SOLIDWORKS Corp.:** SOLIDWORKS.com

→ **Kubotek:** Kubotek3D.com

→ **Lab Machinist Solutions:** LabMachinist.com

→ **MasterGraphics:** MasterGraphics.com

→ **Novedge:** Novedge.com

→ **Onshape:** Onshape.com

→ **Siemens PLM Software's Solid Edge:** SolidEdge.com

→ **ZYCI:** ZYCI.com

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Scan, Print, Collaborate

Mobility and cloud computing have augmented the next generation of offerings.

BRIAN ALBRIGHT

Epson's new SureColor T-Series line of large-format color printers comes in 24-, 36- and 44-in. sizes. *Image courtesy of Epson.*

Printers were once highly localized technologies, either relying on a one-to-one connection with a computer or a LAN connection in a facility. Large-format printing and scanning was even more limited, with large equipment stationed at service centers providing prints to engineers that would sometimes take days to turnaround.

Mobility and cloud computing have changed that equation, and enabled new efficiencies for engineers. At the same time, smaller and less expensive all-in-one large-format printers/scanners with onboard computing power have made it easier for design teams to print and share documents.

In the increasingly digital design environment engineers still have to do plenty of printing and scanning. Most paper documents are printed for collaborative purposes, and because not every stakeholder in the process can use the software required to access digital schematics, drawings, specifications and other documents. In fact, many of those documents might be difficult to interpret on a screen given the amount of panning and zooming necessary. And once those documents get marked up in a meeting, they have to be scanned and updated. Scanning also provides a way to retain iterations of changes, which can eliminate confusion down the line.

This is all happening in a highly mobile and faster-paced environment where many more iterations of a design are possible in a shorter amount of time, and users need to be able to print more quickly from a wider variety of devices.

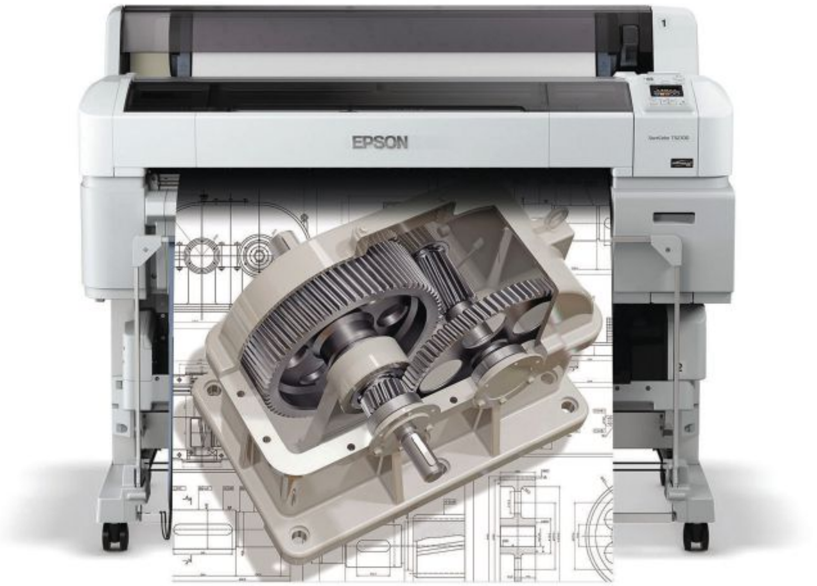
"It's become more challenging because of the speed at which designers are asked to develop and transition to manufacturing," says Gregg Kockler, product manager at HP for the PS Design organization. "These tools give them the ability to capture changes, and drive them back via scanning so they can collaborate and maximize communication. That drives workflow efficiencies."

It also makes it easier to work with customers and get changes approved. "It's hard to look at a rendering on screen and catch any problems that way," says Matt Kochanowski, product manager at Epson Professional Imaging. "With the cost of these printers falling, and the fact that they have an internal hard drive, you can actually have a printer at a customer site and output those prints much faster than in the past."

Enhancing Collaboration

Mobility and cloud-based services have made it easier to print in multiple locations and to collaborate across departments, within a network of multiple locations, or with clients around the globe. Networkable scanners make it easier and faster to scan drawings and quickly share them with an entire workgroup.

Onboard intelligence, in fact, has made collaboration via a networked scanner much easier as the nature of large-format scanning evolves in engineering firms. "Scanning is much more convenience focused now," says Steve Blanken, general manager of Contex Americas.



Sometimes printing schematics and technical documents can help engineers identify details easier. ***Image courtesy of Epson.***

"Our customers are really focused on convenience and portability instead of production issues."

Contex offers software called Nextimage that makes it easier to both share scan on a local network and to scan directly to email. The company's PageDrop cloud-based scanning functionality leverages smartphones or tablets to send documents to cloud destinations like Dropbox or Google Drive.

"If you are in San Francisco and you have a drawing you need to get to New York, you can scan the drawing and if you don't have a computer, you can use the phone or tablet to send it to the cloud," Blanken says. "You are totally independent of a computer to run the scanner."

That type of mobility integration is also more common in large-format printing and scanning. Rather than requiring a connection to a desktop or laptop PC, users can leverage their phones and tablets to print or scan to and from any location via email or the cloud. In cases where there are concerns about security or intellectual property protection, this type of printing can be secured via PIN protection. HP offers NTLMv2 (Network LAN Manager Version 2), a protocol that authenticates a user on the network and can be controlled via PIN printing

Likewise, users in different locations can also print directly from files housed in the cloud. "Design and manufacturing are often handled by different companies, so this type of collaboration helps bridge the gap between those different organizations as well," Kockler says.

Canon's Océ ColorWave 500 printing system is a multi-function unit with cloud connectivity. It also includes a touchscreen interface that lets users view live document previews, check positions and organize files. The printer can also be accessed from any location using a smartphone or tablet. Canon's imagePROGRAF printers for large workgroups are also available as multi-function units, and include cloud portal software.

"What is important is that this functionality be platform agnostic, and not tied exclusively to any single vendor," says Andrew Vecci, director of Large Format Solutions for Canon Solutions America. "For example, the Océ PlotWave and ColorWave family of products can integrate into any WebDAV compliant cloud, whether public or private, allowing users to access documents directly at the device's UI (user interface)."

In addition to mobile device support, users are also able to do more work on the printers/scanners themselves. The Océ ColorWave 500 printing system consolidates output in a single device. Technical users working via project portals or in the cloud can access documents directly at the printer using the Océ ClearConnect touch panel. The unit also supports user authentication, e-shredding and removable hard drives.

HP offers its HP All-in-One (AiO) Printer Remote mobile app that allows users to print or scan from an iOS or

Technical users working via project portals or in the cloud can access documents directly at the printer using the Océ ClearConnect touch panel. ***Images courtesy of Canon Solutions America.***

Android phone or tablet. The solution includes wireless printer discovery and email printing. The company's new HP DesignJet T730 Printer and HP DesignJet T830 Multifunction Printer include Wi-Fi Direct, a built-in Wi-Fi network for direct mobile printing.

All-in-One Convenience

Another boon to collaboration has been the ability to scan, copy and print large-format documents on a single device. While some high-volume production environments require stand-alone scanners or printers, most companies are upgrading to integrated solutions. In some cases, users can purchase a printer with the option of adding a scanner module later.

"When we talk to customers today about replacing their existing technology, they are very interested in being able to print, scan and copy," Kockler says. "That's a very attractive proposition from them in terms of acquisitions cost."

For Contex, that has meant a shift in the way its products are used by designers that are less interested in stand-alone scanners. "The advent of all-in-one devices has changed the way we make our products," Blanken says. "We have created scanners that we can connect to any type of large-format printer."

Contex supports more than 60 printers via its Nextimage Repro scanning software, allowing users to plug a printer into the scanner or the network. It has a built-in Ethernet port, and the option of an internal print server or an Adobe PostScript 3 Hardware Module for PDF and batch printing directly from the printer.

"With the continued trend of decentralization, more and more users generate their prints at the point of need," Vecci says. "This translates to the need for large-format printers to integrate into office environments much in the same way a cut sheet network copier does."

Epson's new SureColor T-Series line of large-format color printers comes in 24-, 36- and 44-in. sizes, with a SureColor Multifunction Module available for the 36- and 44-in. varieties for scanning and copying. "Some of our customers use that scanner to collaborate with their customers by being able to scan a drawing or rendering," says Epson's Kochanowski. "We can take any kind of large-format drawing on board the hard drive, scan it to email and send it to somebody. You can do all of that directly from the printer's control panel."

The new HP DesignJet T830 Multifunction Printer includes Wi-Fi Direct, a built-in Wi-Fi network for direct mobile printing. *Image courtesy of HP.*

Standard drivers have made it easier to print just about any type of file from any computer. "There's no special rendering needed," Kochanowski adds. "We have an optional PostScript module for very complex PostScript files so you can move all of the rendering to the printer. It's much less expensive to do that than in the past, when you would have needed an expensive PC for that type of job."

Speed is also critical in a more fast-paced design environment. "In a manufacturing render, there will be multiple layers with different design components, and as you build that out you create a very sophisticated print," says HP's Kockler. "One thing customer are looking for is not only the speed of the print, but also the transition from the workstation to the print so it can get started faster."

Faster color printing from these devices has also improved collaboration by allowing engineers to clarify of highlight components of complex drawings to reduce mistakes in the production process. "Making this an even more attractive proposition is that more advanced color devices have such high print quality and can use a wide variety of media types, that the printer's usage can be extended beyond simple technical drawings to a wider range of graphics applications," Vecci says. "It is easy to load multiple rolls of media of different sizes simultaneously to use across departments in the organization for a variety of projects."

Scanning and printing large-format documents will remain a critical part of the way designers collaborate. As the hardware becomes easier to use and support, that collaboration will extend beyond the design and engineering departments.

"I think in general there needs to be more awareness of wide-format printing and what you can do with it," Kochanowski says. "You can print to different substrates and use the printer to do more than just print plans or renderings. Other departments can leverage the printer, and that improves your ROI." **DE**

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INFO → **Canon:** CSA.Canon.com

→ **Contex:** Contex.com

→ **Epson:** Epson.com

→ **HP:** HP.com

A True Desktop Replacement

The Eurocom Sky X9W delivers desktop workstation-like performance. *Images courtesy of Eurocom and Dassault Systèmes SOLIDWORKS.*

The Eurocom Sky X9W delivers desktop power at a premium price.

DAVID COHN

Eurocom has consistently delivered exceedingly powerful mobile systems. Last year, the Canadian company sent us its P5 Pro mobile server (deskeng.com/de/?p=24638), a computer that delivered blazingly fast performance at a premium price. To start off 2016, Eurocom sent us its new Sky X9, a system the company says is the most powerful mobile workstation ever made. With a claim like that, we couldn't wait to put the Sky X9 through its paces.

Eurocom sells three versions of the Sky X9: a basic version using NVIDIA GTX graphics cards, the X9W and the X9E Extreme Edition with an unlocked BIOS for overclocking. All based on an Intel Z170 Express Skylake chipset, the $2,585 base configuration includes an Intel Core i7-6700K CPU, NVIDIA mobile GPU (graphics processing unit), 16GB of RAM, a 1920x1080 display, and 1TB SATA hard drive, but no operating system. All three versions are housed in similar sculpted charcoal gray cases.

We received the Eurocom Sky X9W, which measures 16.8x12.1x1.6 in. and tips the scales at a hefty 10.8 lbs. This makes the Sky X9W one of the largest and heaviest mobile systems we've tested in years. Its huge 330W external power supply (7.7x3.8x1.7 in.) adds another 3 lbs. to the total package. At a time when most modern portable systems are thin and light, the total Eurocom Sky X9W package weighs nearly 14 lbs.

Raising the lid reveals a gorgeous 17.3-in. UHD 4K (3840x2160) IPS (in-plane switching) display with a non-glare surface and 1000:1 contrast ratio, and a backlit 102-key keyboard that includes a separate numeric keypad. A 4.25x2.5 in. touchpad with a pair of buttons and a built-in fingerprint reader is centered below the spacebar. Centered above the display is a 2-megapixel webcam and microphones. There are also a pair of 2.2 watt FORSTER speakers for the Sound Blaster X-Fi MB5 sound system located in raised panels above the top corners of the keyboard, with a subwoofer on the bottom of the case. A round power button is centered above the keyboard and flanked on the left by a panel with LEDs to indicate airplane mode and hard drive activity, and on the right with a similar panel containing the caps lock, scroll lock and number lock indicators. Users can control the intensity, color and effects of both the keyboard backlight and logo illumination on the case lid.

Lots of Ports But Closed Interior

The right side of the case offers an SD card slot, a USB 3.0 port, a USB 3.1 (Type C) Thunderbolt 3 port, a pair of mini DisplayPorts and a Kensington lock slot. The left side provides a pair of RJ-45 network ports, three more USB 3.0 ports (including one that is powered), and audio jacks for line-in, microphone, headphone and S/PDIF-out. The rear panel hosts an HDMI port, an additional USB 3.0 port, and the connection for the external power supply flanked by a pair of air vents. There are lots more air vents along the front and on the bottom of the case. We found it puzzling that a system this big lacked an optical drive bay. The Eurocom Sky X9W is also a closed system: Users are not meant to get inside, although it is possible to open the case from the bottom (after removing a bunch of screws).

Our evaluation unit came with an Intel Core i7-6700K, a 4GHz quad-core CPU with 8MB cache, a maximum turbo frequency of 4.2GHz and a thermal design power rating of 91 watts. This 14nm Skylake processor also includes Intel HD Graphics 530. Several other less expensive CPUs are also available. Eurocom also equipped our system with an NVIDIA Quadro M5000M mobile GPU, with 1536 CUDA (compute unified device architecture) cores and 8GB of GDDR5 memory, increasing the system cost by an $1,379. The base-level Sky X9W comes with an NVIDIA Quadro M3000M.

Although 16GB of system memory comes standard, you have

Mobile Workstations Compared

	Eurocom Sky X9W 4.3GHz Intel Core i7-6700K quad-core CPU, NVIDIA Quadro M5000M, 64GB RAM	Dell Precision M3800 G2 2.3GHz Intel Core i7-4712HQ quad-core CPU, NVIDIA Quadro K1100M, 16GB RAM	HP ZBook 14 G2 2.6GHz Intel Core i7-5600U dual-core CPU, AMD FirePro M4150 and Intel HD Graphics 5500, 16GB RAM	BOXX GoBOXX G1980 2.8GHz Intel Core i7-4980HQ quad-core CPU, NVIDIA Quadro K1100M, 16GB RAM	Eurocom P5 Pro 4GHz Intel Core i7-4790K quad-core CPU, NVIDIA Quadro K510, 32GB RAM	MSI WS60 2.5GHz Intel Core i7-4710HQ quad-core CPU, NVIDIA Quadro K2100M, 16GB RAM
Price as tested	$6,781	$2,109	$2,115	$3,365	$4,489	$2,600
Date tested	1/23/16	5/25/15	2/20/15	2/4/15	2/4/15	1/17/15
Operating System	Windows 10	Windows 8.1	Windows 8.1	Windows 8.1	Windows 7	Windows 7
SPECviewperf 12 (higher is better)						
catia-04	102.23	15.16	15.09	21.26	64.64	21.26
creo-01	84.55	15.36	16.57	20.28	48.70	19.98
energy-01	10.52	0.34	0.06	0.32	2.61	0.32
maya-04	75.56	13.85	9.09	18.20	48.84	17.90
medical-01	40.75	4.30	2.70	5.71	23.93	5.71
showcase-01	45.87	8.55	7.58	10.35	27.86	10.63
snx-02	87.30	15.30	20.06	22.10	58.41	22.05
sw-03	121.63	25.41	29.21	34.53	97.38	32.32
SPECviewperf 11 (higher is better)						
catia-03	104.72	32.18	32.53	47.85	80.24	45.66
ensight-04	142.29	17.38	17.51	24.55	86.39	24.09
lightwave-01	82.57	60.00	65.87	77.62	94.51	64.37
maya-03	156.70	62.83	61.30	81.14	178.55	77.78
proe-05	19.05	13.92	9.70	21.57	22.67	18.26
sw-02	71.69	39.91	43.45	52.31	81.17	47.80
tcvis-02	77.67	28.59	13.38	37.24	70.60	36.95
snx-01	146.18	23.77	23.55	31.76	89.35	31.85
SPECapc SOLIDWORKS 2015 (higher is better)						
Graphics Composite	6.07	1.85	1.75	n/a	n/a	n/a
Shaded Graphics Sub-Composite	4.36	1.70	1.30	n/a	n/a	n/a
Shaded w/Edges Graphics Sub-Composite	5.58	2.27	1.32	n/a	n/a	n/a
Shaded using RealView Sub-Composite	5.07	1.57	1.16	n/a	n/a	n/a
Shaded w/Edges using RealView Sub-Composite	8.36	2.76	1.88	n/a	n/a	n/a
Shaded using RealView and Shadows Sub-Composite	5.17	1.38	1.39	n/a	n/a	n/a
Shaded with Edges; RealView & Shadows Graphics Sub-Composite	8.11	2.29	1.61	n/a	n/a	n/a
Shaded using RealView & Shadows & Ambient Occlusion Graphics Sub-Composite	6.81	1.12	2.90	n/a	n/a	n/a
Shaded with Edges using RealView & Shadows & Ambient Occlusion Graphics Sub-Composite	10.28	1.74	3.40	n/a	n/a	n/a
Wireframe Graphics Sub-Composite	3.76	2.36	2.27	n/a	n/a	n/a
CPU Composite	3.03	2.41	3.14	n/a	n/a	n/a
Time in Seconds						
Autodesk Render Test (lower is better)	64.90	79.38	124.28	55.39	56.88	63.60
Battery Test (higher is better)	2:17	5:34	7:28	2:15	2:17	3:13

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

There's room inside for up to 5TB of storage, but the interior is not easily accessible, not even to replace the battery.

lots of choices. Our evaluation unit came equipped with the maximum capacity of 64GB of 2133MHz memory, installed as four 16GB DDR4 260-pin Micro SODIMMs (small outline dual-inline memory modules), which added $1,095 to the system price.

There are also lots of storage options. The base configuration includes a 1TB 7200rpm Hitachi Travelstar SATA hard drive, but there are actually two 2.5-in. drive bays and Eurocom offers standard drives of up to 2GB capacity and solid-state drives (SSDs) ranging from 128GB to 2TB, both with RAID array capabilities. There are also two internal slots for SSD M.2 card-based drives ranging from 120GB to 512GB. Our evaluation unit came with a pair of 256GB Samsung SSD PCIe drives in a RAID 0 array hosting the operating system and a pair of 2TB Samsung 5400rpm drives in a RAID 1 array for data. This drive configuration added $1,206 to the total system cost.

While a 2-in-1 802.11a/b/g/n/ac WLAN+Bluetooth 4.2 plus Intel Wireless-AC 8260 card is included in the base configuration, Eurocom also offers both higher- and lower-end network cards. An eight-cell lithium-ion battery and 330 watt auto-switching worldwide power supply come standard.

You would think that the absence of an optical drive would leave room for a larger battery. But with all those hard drives, a power-hungry CPU and high-end GPU, our evaluation unit managed just 2 hours 17 minutes before shutting down. Throughout our tests, the Sky X9W ran relatively cool and quiet, averaging just 33dB at rest (compared to 29dB ambient background noise). The noise level climbed to 46dB under heavy compute loads (about the equivalent of an office conversation).

Desktop Performance

Thanks to its fast CPU, abundance of memory and high-end graphics card, the Eurocom Sky X9W turned in the best performance we have ever recorded for a mobile workstation. On the SPECviewperf test, which focuses solely on graphics, the Eurocom Sky X9W beat all competitors, often by a wide margin, even surpassing the performance of many desktop workstations.

For our SOLIDWORKS tests, we have recently begun using the new SPEC SolidWorks 2015 benchmark. This new evaluation performs nine graphics tests and two CPU tests. Although this marks the first review in which we are publishing these new results, we did go back and retest several other systems we previously reviewed. With its fast CPU and high-end mobile graphics system, the Eurocom Sky X9W turned in great results on this real-world performance evaluation.

We also ran the SPECwpc benchmark and the Eurocom Sky X9W beat the competition on nearly every aspect of this demanding test. Although the 64.90 second average rendering time on the AutoCAD rendering test was 8 seconds slower than last year's Eurocom P5 Pro, that still placed it near the top of the field.

Of course, all this power comes at a hefty price. As equipped, our Eurocom Sky X9W priced out at $6,781 (including $172 for the Microsoft Windows 10 Professional 64-bit operating system that came preinstalled), just $19 less than the most expensive mobile systems we've ever tested. Eurocom also offers other operating systems, or you can order the system without an OS and install your own. The price also includes a one-year warranty with return to depot service, but you can extend the warranty to two or three years for $151 or $323, respectively.

The Eurocom Sky X9W is meant to replace a desktop workstation for power users on the go, and it delivers on this promise. But its weight and price will likely make it a niche product, a super portable for those willing to carry both the weight and the cost that all the power demands. **DE**

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INFO → Eurocom: Eurocom.com

Eurocom Sky X9W

- **Price:** $6,781 as tested ($2,585 base price)
- **Size:** 16.8x12.1x1.6 in. (WxDxH) notebook
- **Weight:** 10.8 lbs. as tested, plus 3.0 lb. power supply
- **CPU:** 4GHz Intel Core i7-6700K quad-core w/8MB cache
- **Memory:**64GB 2133MHz DDR4
- **Graphics:** NVIDIA Quadro M5000M w/8GB memory and 1536 CUDA cores
- **LCD:** 17.3 in. diagonal (3840x2160), non-glare, IPS
- **Hard Disk:** Two 256GB PCIe SSD drives configured as a single 512GB OS drive as a RAID 0 array; two 2TB 5400rpm SATA3 redundant data drives configured as a RAID 1 array
- **Optical:** None
- **Audio:** Line-in, microphone, headphone, S/PDIF-out, plus built-in microphone and speakers
- **Network:** Integrated Gigabit Ethernet (10/100/1000 NIC) with two RJ-45 ports, 802.11a/b/g/n/ac wireless LAN, and Bluetooth 4.2
- **Other:** Five USB 3.0 (one powered), one USB 3.1 (Type C) Thunderbolt port, two mini DisplayPorts, HDMI-out, 2MP webcam, SD card slot
- **Keyboard:** 102-key keyboard with keypad
- **Pointing device:** 2-button touchpad and fingerprint reader

Next-Generation Collaboration

Digital transformation demands the sharing of data with non-engineers, both inside the organization and out.

BY LAUREN GIBBONS PAUL

Collaboration has always made the business world go round. And electronic tools for sharing information — everything from email to videoconferencing to PDF documents — have advanced the art of sharing data exponentially in the past 20 years. Now, in the age of digital transformation of manufacturing enterprises, collaboration is becoming turbocharged. Next-generation product lifecycle management (PLM) and other enterprise systems are enabling advanced collaboration.

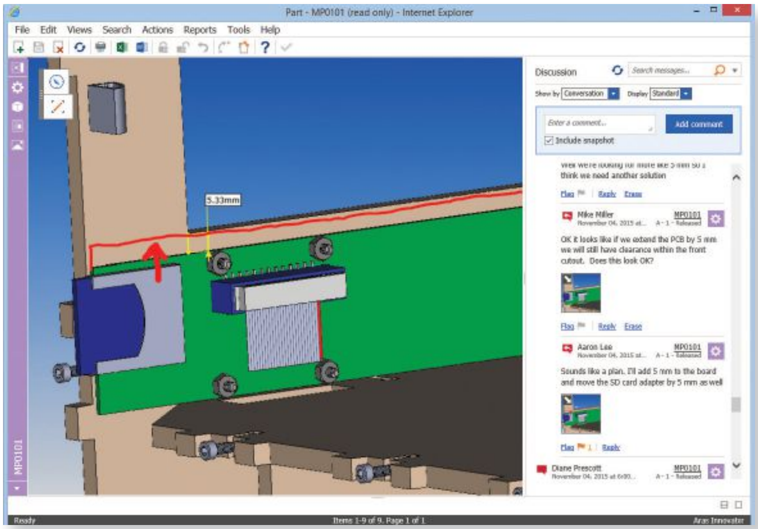
The dirty little secret: The sharing of data related to areas such as requirements management, project management, quality and production is still done largely via spreadsheets. Communication is still spread across multiple largely disconnected channels and tools, resulting in barriers between different disciplines (including mechanical, electronics and software) and business functions such as engineering, manufacturing, quality, testing and procurement. These barriers are particularly evident when attempting to collaborate across the extended enterprise with suppliers and customers as is required in today's business environment.

Top-name PLM vendors including Siemens, Dassault Systèmes and PTC are boosting their collaborative capabilities to ensure engineering can share data effectively with other groups, says to Marc Halpern, vice president of Research at Gartner.

For example, Siemens provides change management and bill of material (BOM) management capabilities via Teamcenter, according to Chris Pattioni, marketing director for Siemens. "With Active Workspace in Teamcenter, you now have the ability to assess the impact of a change, how it impacts data, people and processes in terms of cost, timing and commitments," he says.

Different parts of the enterprise including design, engineering and procurement, typically maintain their own representation of the BOM. With all of those disparate representations, it can be difficult to understand what is out of scope or out of date. Teamcenter provides a single product definition for all who interact with the BOM, says Pattioni, eliminating the need for standalone spreadsheets and systems.

Aras' Innovator has "visual collaboration" capability embedded in its PLM platform, allowing secure threaded discussions and for view and markup of assorted formats including 3D, 2D, PDF and Microsoft Office.



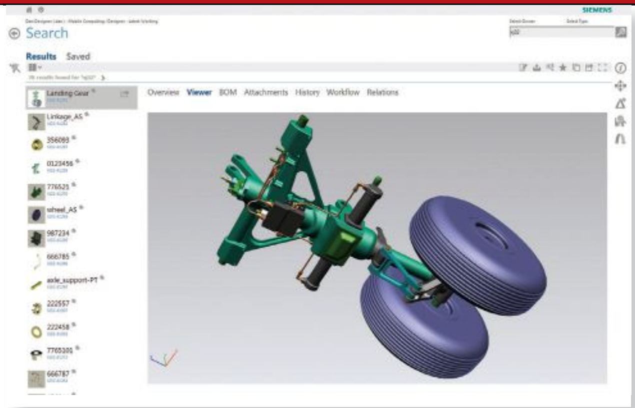
Visual collaboration lets users mock up models for easier cross-discipline collaboration. *Image courtesy of Aras.*

"This is about taking key processes in the manufacturing organization and making sure they are digital from end to end and that all of the people involved can get access to the information they need in a consistent manner," says Doug Macdonald, product marketing director for Aras.

Most manufacturers have mastered electronic collaboration for processes such as the management of CAD information. Macdonald calls this realm the "science of engineering." But many other cross-functional processes such as requirements management, quality and BOM management are fragmented and run on spreadsheets. He calls this area the "business of engineering."

"That's where we are starting to solve the collaboration problem. Everyone in the enterprise needs access to all of this product information. Each department needs to be able to define and support their processes, and get everyone on the same page," he says.

PLM analyst Monica Schnitger cites warranty information as an area that could be transformed via better collaboration. Assume a car company is seeing a lot of claims for a certain issue on a particular model. "What other models might be using that same component? If they could access that information easily, they could get ahead of that situation and give that information to dealerships and the repair shop



The Active Workspace main user interface lets users visualize the model while sporting tabs for BOM, attachments and other assemblies. *Image courtesy of Siemens PLM Software.*

network," says Schnitger, president of Schnitger Corp.

"A lot of companies have not connected the dots," she says. "The information is there, but it is not connected such that people can access it and take actions." Next-generation PLM systems, product innovation platforms, design optimization tools and collaboration hubs all seek to enable collaboration.

Collaboration By Any Other Name

CNH Industrial/Reman remakes parts used in agricultural equipment at its 300-person Springfield, MO, plant. As a small unit of a large conglomerate, CNH has not yet invested in major enterprise systems such as ERP (enterprise resource planning) or MRP (materials requirements panning). Four years ago, it implemented Aras Innovator for PLM. According to project engineer Collin Fagan, the need to share information more easily was the top driver for the purchase.

"We were managing our creation of parts from inception to launch by email and spreadsheet," says Fagan. "Parts would get stalled in different places and if someone wasn't at the meeting, you lost all visibility." Now, with Aras Innovator, "We can track a part from the time the product development team decides to do it to materials management, manufacturing, marketing, field support, etc. Anyone who has access can instantly see where a part is at any time," he says.

CNH has seen major savings of time and money. Fagan estimates use of the tool has eliminated 20 to 25 hours of meeting preparation every week, with instant answers accessible for the 125 staff and managers who use the system.

"Management can quickly see who has ownership of a process activity. This helps them identify staffing issues versus process issues," says Fagan. Managers can see the flow of parts through the pipeline at the weekly meeting, quickly identifying choke points and allowing for immediate corrective action. Under the old, spreadsheet-based system, problems may not have even been identified. Now, the users can see what other departments are doing without having to request data.

Cloud-based PLM is indeed enabling greater collaboration, says Halpern. "A lot of new PLM applications are being built to run on the cloud and existing apps are being rewritten for the cloud," he notes. The big advantage: Regardless of device and location, you can collaborate with growing bandwidth, greater accessibility and increasing performance.

Design Optimization

In addition to PLM, design optimization suites are getting in on the action, promoting better multi-disciplinary collaboration. ESTECO makes design optimization software that integrates simulation data with other enterprise systems in order to be part of the enterprise product development process. *(Editor's note: For more on ESTECO's workflow optimization concept, see page 8.)*

Users can set the parameters on the ESTECO SOMO collaboration framework to control for different variables, says Matteo Nicolich, enterprise solution product manager for ESTECO.

"The SOMO system generates information about the behavior of the product in different situations so you can monitor its performance," says Nicolich. SOMO generates the performance data and stores it where it can be mined.

Engineers are looking to multi-disciplinary process optimization as a way to speed up the design process, capturing data to be shared and reused rather than being left siloed, adds Nicolich.

"You can look at a component from different angles and points of view. You can have a structural analysis, a thermal analysis, an electrical analysis of the same component. Each of these requires a different knowledge base. They need to reach a point where they can track and ensure that everything works together," says Nicolich. "That's where our tool fits."

The demand for next-generation collaboration tools comes from gaps that remain post-PLM implementation, says Macdonald. Manufacturers still have process bottlenecks, miscommunication and lack of visibility. "They need a much more integrated approach" spanning manufacturing, engineering, supplier management, product support, quality, product development and product management, he says.

Traditionally, the IT organization working closely with the engineering department has driven the purchase of PLM. Now, with collaboration paramount, engineering is beginning to lead the selection process. "How well your supply chain works together is becoming a key differentiator," says Halpern. DE

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INFO ➜ **Aras:** Aras.com

➜ **CNH Industrial:** CNHIndustrial.com

➜ **ESTECO:** ESTECO.com

➜ **Gartner Research:** Gartner.com

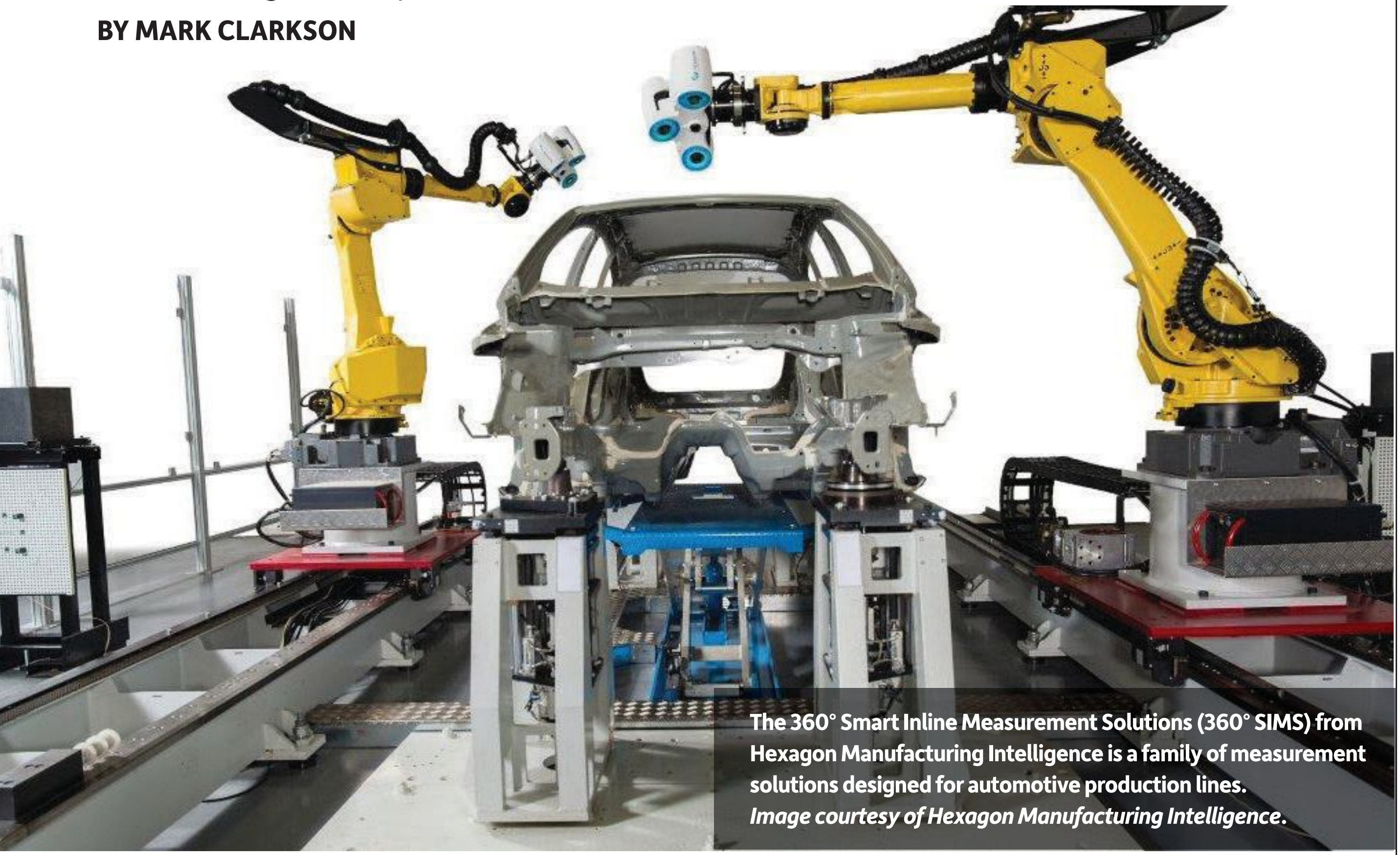
➜ **Siemens PLM Software:** Siemens.com/PLM

➜ **Schnitger Corp.:** SchnitgerCorp.com

How to **Measure Up** Metrology Services

Coordinate measurement machines, computerized tomography and 3D scanning can help address a host of measurement needs.

BY MARK CLARKSON



The 360° Smart Inline Measurement Solutions (360° SIMS) from Hexagon Manufacturing Intelligence is a family of measurement solutions designed for automotive production lines. ***Image courtesy of Hexagon Manufacturing Intelligence.***

Metrology service providers will do everything from recalibrating your calipers to helping set up automated aircraft assembly systems. They'll measure anything from tiny screws and stents to entire buildings.

"There are so many different [reasons why] someone would need metrology services," says Cali Schwartzly, marketing and business development manager at ECM Global Measurement Solutions. "We have customers that continuously ship batches of small parts to us because they need our CMM (coordinate measuring machine) and our lab to take the measurements. Or we can do months of automated airplane assembly integration, on-site, using laser trackers. We might come in, show them what needs to be done and do the work for them. In the long term, they might end up purchasing a piece of equipment and getting engineers trained to use it."

One thing potential metrology clients do have in common is a lack of time. "Usually, by the time someone [realizes that] they need contract measurement services, they're already behind," says Schwartzly. "They've tried every resource. They've been waiting for budget for a piece of equipment, or maybe they have the equipment but they didn't really think about the time it takes to hire and train an engineer to actually work it. Finally, they get so back-logged that they call us, and say: 'Can you come tomorrow?'"

That might not be possible. Providing contract metrology services can be more complicated than selling metrology equipment. "With some high-profile companies, there are so many hoops to jump through before they'll even let you into their facility to do any work," Schwartzly says.

Companies like Heidenhain Corp. provide inspection and gauging products for both end-users and original equipment manufacturers. ***Image courtesy of Heidenhain.***

Faster, Better, Faster

Manufacturers need more precise, and faster measurement than ever before, says Keith Gudeman, business development manager at Hexagon Manufacturing Intelligence. Among other reasons, today's assembly lines are often producing more intricate products at much higher production rates.

"Think of a flip phone 10 years ago," says Gudeman. "There were one or two measurements, max, made on the little piece of glass." But, while the glass in a flip phone serves as a simple protective shield for the screen behind it, the glass in a smartphone is an integral part of the phone's functionality and can require 20 or more measurements.

"They're checking for flatness," says Gudeman. "They're checking orientation once assembled. They're checking thickness in a number of areas. If you have inconsistent glass flatness and thickness, it's not going to function correctly."

All of these measurements can be made in-line, for every piece of glass on every phone, and at astonishing tolerances. "They're holding components to micron levels, not millimeter levels," says Gudeman. This is clearly not a job for technicians with calipers. Fortunately, there are newer technologies available, such as Hexagon's vision CMM systems. "It's completely automated," says Gudeman. "Parts are presented, all the measurements are taken, and the parts are removed. It takes place as part of the assembly process."

Industrial Computerized Tomography

Glass parts notwithstanding, high-speed vision CMM is really only good at measuring the outside of parts. If you need to look inside, consider industrial CT — computerized tomography. Like the more familiar medical CT, industrial CT scanning works by taking a series of X-ray images from different angles and building a 3D model from the resulting data.

CT can solve a host of difficult measurement problems. You can accurately scan a tiny fly's eye, or a delicate rose petal, but CT's primary benefit is the ability to non-destructively see inside things.

"You have full internal and external scanning capabilities," says Andrew Good, quality manager, JG&A Metrology Center, "and you don't have to section the part like you would with CMM, white light or lasers."

Those technologies are strictly line-of-site and require you to slice the object up (to section it) in order to inspect the insides. That's an especially big problem with really high-dollar parts and makes it impossible to inspect parts before actually using them. JG&A does a lot of work for aerospace and defense companies that require each part to be certified, and you can't slice parts up and then bolt them onto an airplane.

CT scans provide density information in addition to XYZ data to help distinguish between materials. "With something as simple as a sand casting," says Good, "you can see if there's any sand left inside the internal passages."

CT is a relatively new technology, at least it North America. CT scanning is expensive because the equipment is expensive and it's far from portable. But if you need to measure the insides of a part without chopping it open, it's really your only option.

Mobility and Metrology

CT scanners are amazing but they're big and bulky; and there's something to be said for portability. "We primarily use portable metrology equipment," says Mitch Fields, co-owner at TriMet. That equipment includes articulated arms, laser trackers and laser scanners.

"You can bring the equipment right up to the machine bed," says Fields. "The other day, we were at a lock and dam to measure gears that were binding. We were able to do that right on the spot. Obviously, there's no way you could take a stationary CMM into that area."

Laser scanning is becoming TriMet's forte. "We [might be] commissioned to go in and measure an assembly line tool while the workers are at lunch," Fields says. "We have 30 minutes to get in, scan everything and get out."

Laser scanning isn't quite as accurate, but it's getting better all the time, says Fields. "The accuracy delta between probing and scanning used to be quite large. Now they're virtually the same," he says. "Probing is still more accurate, especially with a stationary CMM, but the difference now is down to a couple ten-thousandths of an inch."

And scanning is more thorough. "If we probed everything and we forgot something we're out of luck, because the production line is back up," Fields says. "But if we scan, we can always extract all the dimensions we want. It's kind of foolproof in that sense."

> "Clearly, there's a disconnect between what customers think they want and what we know they need."
>
> **— *Cali Schwartzly, ECM Global Measurement Solutions***

Expanding Everywhere

Many metrology service providers are experiencing growth. Some firms are just receiving more calipers and multimeters to calibrate, others are expanding in whole new directions. TriMet is doing ever more laser scanning. JG&A reports an explosion in demand for structured light scanning. ECM is measuring larger and larger structures, from pipelines and factory buildings. Hexagon Manufacturing Intelligence is growing its focus and expertise to offer integrated measurement solutions.

"We do everything from medical stents to engine collars for jet engines," says JG&A's Good. "You'll have people asking you to scan statues, or dental implants or screws. It's a weird, diverse industry."

Some companies' offerings are overwhelming, seeming to provide every conceivable service, including several you might not recognize. "Clearly," says ECM's Schwartzly, "there's a disconnect between what customers think they want and what we know they need. It's all about the terminology. We think we provide contract measurement services or laser tracker services, but customers might type in 'aircraft measurements.' If [your search] doesn't include specific industry terms, it's going to be hard to find someone who does what you need." Be sure to include any required ISO, CMS or NADCAP certifications in your search.

If you already have metrology hardware and software on site, check with the vendor or manufacturer because they'll often be able to recommend metrology firms to work with you. **DE**

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

INFO ➜ ECM Global Measurement Solutions: EastCoastMetrology.com

➜ **Heidenhain Corp.:** Heidenhain.com

➜ **Hexagon Manufacturing Intelligence:** HexagonMI.com

➜ **JG&A Metrology Center:** JGarantMC.com

➜ **TriMet:** TriMetGroup.com

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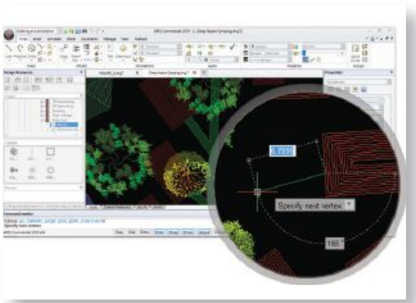
Editor's Picks

by Anthony J. Lockwood

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



Graebert Launches ARES Commander 2016

Productivity features are the highlight of the release.

ARES Commander 2016, which runs on 32- and 64-bit Windows, Mac and Linux workstations, offers a bunch of new productivity features. Two cool ones are Quick Input and LayerState Manager.

Quick Input provides a command interface and dynamic information at your cursor. LayerState Manager lets you create and name different scenarios for user layers.

The software also introduces a new set of productivity-driven tools for Windows users under a new XtraTools menu. Graebert states Mac and Linux users will have XtraTools soon.

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HBM Expands SomatXR DAQ Device Portfolio

The company now offers eight total devices in its product line.

General characteristics of all SomatXR modules include dust and water resistance (IP65 / IP67), an operating temperature range from -40 to +176°F (-40 to +80°C) and vibration resistance up to 10g and shock resistance up to 75g (MIL–STD202G).

All three new devices deploy with a Web interface. That means remote channel parameterization as well as remote monitoring of your measurement jobs and visualization of measured data.

The modules are suited for multiple transducer applications, dynamic data acquisition and CAN network connectivity.

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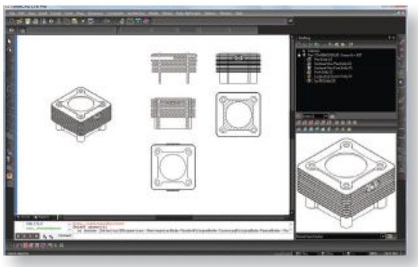

TurboCAD LTE Pro Now Available

Version 8 includes updates for drafting, detailing and rendering.

TurboCAD LTE Pro works a lot like AutoCAD LT: They have a similar user interface and command line, and both open and save DWG, DXF and DWF formats.

TurboCAD V8 updates read/write filters for AutoCAD 2013-2015 and debuts import/export of SketchUp 2015. V8 also brings Windows 10 support and an update of REDWAY3D's RedSDK rendering engine.

It also sees a new displacement shader for more realistic materials and a dynamic cutaway plane for looking inside a 3D model. The latter works in draft mode as well as in mixed draft and hidden line modes.

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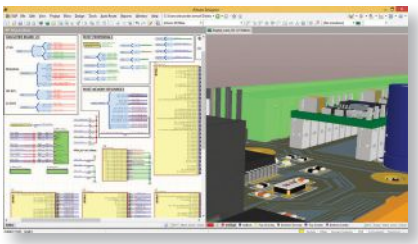

Altium Designer 16 Ships

Updates focus on automation for printed circuit board design.

The new features and enhancements in version 16 of the Altium Designer 3D PCB design and embedded system development platform focus on design productivity and snappier automation. Three in particular sound really cool: The Alternative Part Choice and Component Placement System and Visual Clearance Boundaries.

The software also debuts more features, including an Offline Design system to control what users share with their networked colleagues and a 3D STEP model generation wizard to make realistic and accurate 3D representations of a board.

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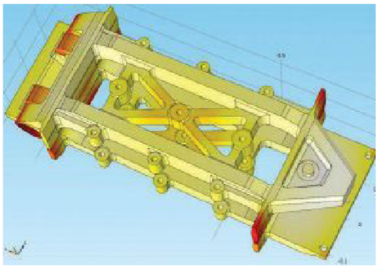
The Sweet Side of Simulation Behind the Scenes at Nestlé

Researchers at the Product Technology Centre in York, U.K., use simulation to perfect chocolate production at Nestlé.



Engineers at Nestlé's Product Technology Centre in York, U.K., (PTC York) work, among other things, on the research and development of three different products: a chocolate depositor for making candy bars; a wafer baking plate; and an extruder used to cook and sort cereals at the same time. At PTC York, which is home to the research and development of Nestlé's confectionery products, engineers rely on multiphysics simulation to optimize and streamline the production process.

Chocolate R&D

Candy bars, such as Kit Kat, Aero, Crunch and solid milk chocolate bars are produced using a chocolate depositor that fills a mold with molten chocolate. Chocolate enters the depositor via an arm at the top and exits into a mold through each of the nozzle tips.

"Ensuring that the amount of chocolate in every bar is consistent means that the flow rate and pressure of the chocolate exiting each nozzle must be the same," says William Pickles, a process engineer at Nestlé. "Not only do we need to make sure that each chocolate bar is the same weight for cost effectiveness and standardization, but we are also committed to guaranteeing that the calorie information on the package is correct as well. This allows us to deliver products with exact nutritional content that fit in with our customers' balanced diets."

To achieve this standardization, the uniformity in flow and pressure between each nozzle tip must be precise to within a narrow margin. Nestlé uses a combination of modeling and simulation tools to achieve this consistency, .

The chocolate depositor was first designed using SOLIDWORKS software and the geometry was then imported into COMSOL Multiphysics simulation software for analysis. Simulation was used to perform fluid flow optimization, test mechanical stress and analyze the thermal properties for a particular geometry.

"Every chocolate manufacturer has their own special recipe that produces chocolate with unique characteristics," says Pickles. "We were able to fully model the non-Newtonian behavior of Nestlé's signature chocolate by setting up a simulation where an experimental curve relating the shear rate to the shear stress of the fluid was imported into the software. This way, we were sure that we were modeling chocolate with the same fluid properties as the real product."

Using simulation, the team identified areas of high and low flow rates and determined the differences in flow between each of the depositor needles. Numerical probes in the flow channels and at the tips of the nozzles were used to analyze conditions at certain locations of the geometry.

"By optimizing the depositor design, we were able to achieve a flow rate through each of the nozzles that is consistent to within a tenth of a percent of the desired value," says Pickles.

Simulation Saves the Crunch

What would a Kit Kat be without the well-known snap of the wafer baked inside? When baking a wafer, uneven heating can cause different moisture concentrations within the wafer, ruining its crunchy texture or even causing it to spontaneously snap.

The wafer baking process at Nestlé uses two baking plates that compress the batter between them. During baking, the plates are passed above a series of about 40 flames.

Simulation is used to optimize the baking plate design by looking at the flow of hot air below and around the plates to ensure there is an even temperature profile across the plates' surfaces. The goal is to correct burner power and orientations to give the best wafer, while simultaneously reducing the amount of fuel used. This fits with Nestlé's policy of continually seeking to improve efficiency in all of its manufacturing processes.

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Commentary  Jonathan Wilkins

International Space Station Automation

You may have noticed the increasing number of space film releases over the past few years. From the renowned "Apollo" films to the 2014 release, "Gravity," everyone has a favorite. And you've surely heard of "Interstellar" by now. I didn't notice any industrial automation parts floating in the background, but if the film set was as true to life as it seemed, there should have been some. In the real world, industrial automation is already setting up camp on the International Space Station (ISS).

Layering on the Intelligence

Over the past 15 years, robotics and automation specialist TRACLabs has used its 3T robot intelligence software to perform inspection tasks for the ISS. Robots programmed with the latest software are able to search for, find and recognize people; hunt for underwater mines; and carry out repair and replacement tasks on Earth or in space. Impressive already — but wait — there's more.

Industrial automation plays a key part in humankind's exploration of outer space.

Layered intelligence can now be utilized by any computer-controlled machine, even stationary ones. TRACLabs has also been busy developing intelligent control for advanced life support systems such as biological water processors, oxygen generation and carbon dioxide recovery systems. The results of several of these efforts were used in human-related tests, including one with four people living and working in a NASA biosphere for three months. That's right; with a little more work, industrial automation might have the power to keep us alive in the un-friendliest environment imaginable.

OCTOPUS Aids Communication on the ISS

In terms of the types of technology industrial automation is contributing to the ISS, we've not even scratched the surface. Industrial networking technology supplier Hirschmann is also in on the action, providing the ISS with industry-proven managed OCTOPUS switches, used in data communication.

On the ISS, the OCTOPUS switches are subjected to electromagnetic radiation that is around 100 times higher than on Earth, mostly caused by high-energy protons. To ensure they were up to the job, the switches underwent extensive testing prior to implementation. Luckily, the radiation-sensitive integrated switch circuits proved their suitability for their sojourn in space.

After proving their worth in the communication system of the Russian segment of the ISS, the OCTOPUS switches have also been in use since 2011 in the American segment. This part of the ISS is the home of the Cupola, the observatory module used to conduct experiments, dockings and observations of Earth. In addition, the OCTOPUS switches transport data from the space station's joint local area network. In the future, videos in HD quality are to be transmitted from the Cupola to ground control.

Smaller Sensor Requires Less Maintenance

A leader in power and automation technologies, ABB is in the midst of developing a new industrial sensor that will be used to study planetary rocks from a Mars or moon rover. The new design is around half the size of its predecessor with better performance and lower service requirements. It includes a solid-state laser designed to operate in space, without any servicing for more than 20 years. Comparatively, its predecessor needed servicing every three years.

With the help of the new sensor, ABB hopes to advance understanding of issues such as global warming, ozone depletion and the impact of pollution on air quality, as well as weather prediction and climatology.

Apart from the latest generation of robots and industrial automation technologies, the ISS also relies on more traditional industrial automation components like motors and drives. The critical process of cooling, for example, is heavily dependent on liquid ammonia pumps.

It's fair to say that industrial automation plays a key part in humankind's exploration of outer space, and it's helping us go further every day. So there you have it, you are officially a part of the sci-fi craze. While I can't promise you'll become the next Buzz Aldrin or Valentina Tereshkova, I can assure you that this industry is making its mark in space. DE

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