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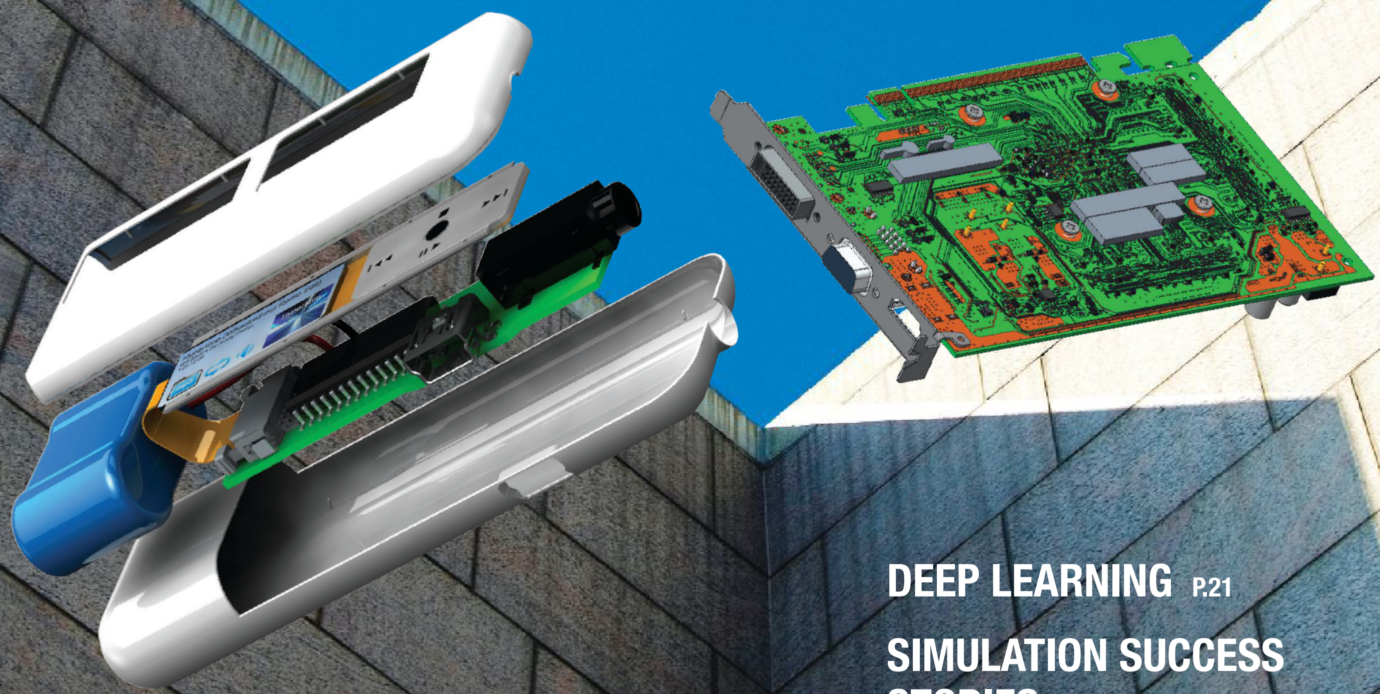


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Degrees of Freedom

by Jamie J. Gooch

Security vs. Convenience

I am the IT department for my family and extended family. When my father-in-law's monitor began displaying everything upside-down, he called me. I told him to stand on his head and then hit the Ctrl+Alt+Up arrow keys. When my brother-in-law clicked on a sketchy browser pop-up window that said "Your computer is infected with a virus, click here to remove it," thus infecting his computer, he called me. I told him he should have called sooner. When my mother-in-law bought a new cellphone, she didn't call me; she stopped by before turning it on so I could show her "how to text smiley faces."

Things have gotten better. The calls are fewer and further between now that most consumer technology vendors are focusing on making their products easier to use, even for consumers who are not technically inclined. My sister called me the other day after buying a new router, not to bribe me with dinner if I would come and set it up, but to brag that she did it herself. I asked if she changed the admin password.

How can companies design products that are easy to use and secure? Collaboration.

Security Isn't Easy

Technology may be easier to use than ever, but that's a detriment to security. Manufacturers want to make it easy for people to use their products, not burden or scare them with layers of security. That can mean default passwords with no requirement to change them and logging in via unprotected sites. If the goal is to a make a high-tech product easy enough for a kid to use, what does that mean for security? Headlines calling out security lapses in Mattel's Hello Barbie Wi-Fi connected doll and hackers stealing the personal information of 6 million customers from V-Tech are the most recent answers.

Stealing a child's pictures and chat logs is one thing, but with the explosion of the number of connected devices collectively referred to as the Internet of Things (IoT), more products will be collecting personal information, connecting to local networks and controlling everything from coffee pots to cars, which means hackers have more targets. ABI research predicts the number of "active wireless connected devices" will reach 40.9 billion by 2020. According to Gartner, there will be 250 million connected vehicles on the road by then. Many of those connected devices will be used in industrial settings like factories and power plants, which leads us to imagine all kinds of nightmare scenarios that could happen as the result of a security breach.

How can companies design products that are easy to use and secure? It will require bringing even more expertise into the product development pipeline. I don't mean just bringing together electrical and mechanical engineers or even making software developers part of the design engineering team. Seemingly simple collaborations like those can be incredibly difficult to pull off, but that won't be enough. I mean hiring and collaborating with hackers, technology suppliers and standards bodies to develop and maintain products that fit into a secure ecosystem. It's a daunting task.

Designing Systems, Not Just Products

The good news is, like my family with their technology issues, there is somewhere to turn for help. In addition to security firms and security focused technology vendors, a number of organizations are taking on the challenge of IoT security.

For example, the Internet of Things Security Foundation (IOTSF, iotsecurityfoundation.org) describes itself as a non-profit, international initiative with the goal of helping to secure the IoT. In its "Insecurity in the Internet of Things" report, it writes: "The concept of security by design must be given a higher priority in order to avoid security flaws being compounded as the IoT matures ... The IoT will be a transformational, disruptive technological movement, but carries a spectrum of risks that affect more than just the IT department."

The Industrial Internet Consortium (IIC) has released a reference architecture (iiconsortium.org/IIRA.htm) intended to provide a common language for the elements of Industrial Internet systems and the relationships between them. "The Industrial Internet Reference Architecture is an important first step toward establishing new IoT capabilities in the industrial space, enabling developers to operate faster," said Bradford Miller, senior scientist at GE and co-chair of the IIC Technology Working Group. "With the IIRA (Industrial Internet Reference Architecture), we are creating new ways to organize industrial applications that move toward a usage-driven, rather than a design-driven approach. We believe collaboration is essential to achieving Industrial Internet success, and organizations like the IIC help drive best practice sharing through global partnerships with industry leaders."

We're in the early days of IoT security, but it's already clear that collaboration with more stakeholders than ever is the key to keeping up with demand for easy-to-use, smarter products. DE

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

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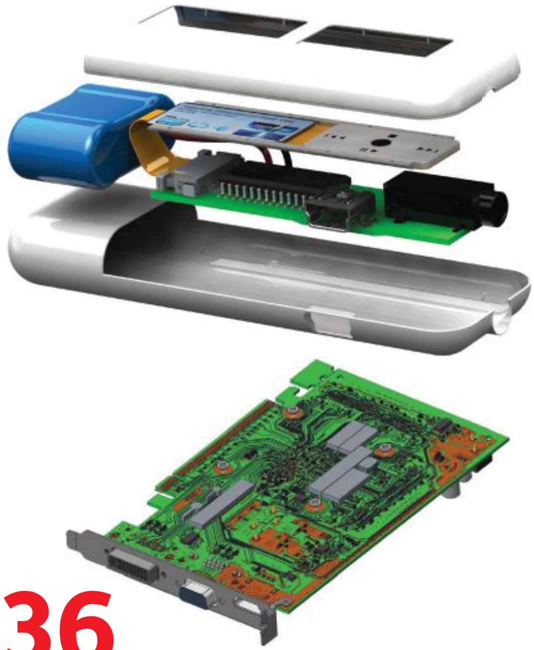

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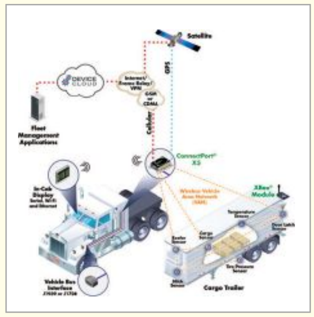

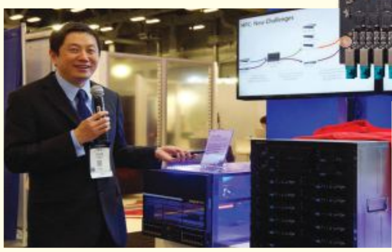

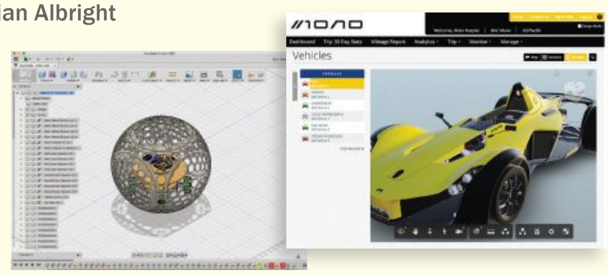

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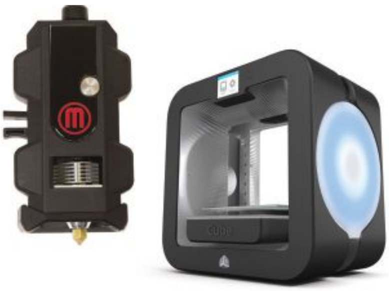

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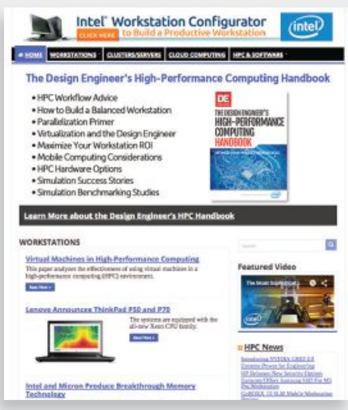

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Reengineering CAE

Computer-aided engineering is a world in transition: The whole environment is becoming faster and more seamless; the line between design and analysis is disappearing.

BY MARK CLARKSON

Editor's note: *The January/February 1996* Desktop Engineering *cover story has been reproduced here, in part, as we celebrate 20 years of publishing* DE. *To read the entire article, visit* *deskeng.com/de/CAE1996*.

A realization is sweeping through business: *Speed is life*. With products changing so much more dramatically and more often than ever before, time-to-market pressures have become as profound as material costs, market share, and overhead. In some especially fast-paced fields, such as computers, turn-around time can be as little as six months or less. Fail to meet that grueling schedule just once, miss one generation of product ... and you're dead. The whole process — design, analysis, prototyping, testing, and manufacturing — has got to go much faster.

In this environment, computer-aided engineering (CAE) is coming into its own.

Farewell Real World

When people talk about computer-aided engineering, they usually mean analysis, the most common form of which is finite element analysis (FEA). Finite element models are used to estimate how stress, or heat, or vibration propagates or accumulates across a structure.

In years past, analysts would construct finite element models based on the product design, or painstakingly recreate the CAD geometry in their FEA packages. Today, they don't have that time, says Michael Bussler, president and CEO of Algor, an analysis software manufacturer. "People want to have a link between their CAD software and their analysis software."

That link is auto-mesh converting, the process that turns a 3D CAD object into a "mesh" of hundreds, thousands, or even millions of elements — as if the model had been constructed with Lego building blocks. Algor's Houdini program provides just such a link, converting geometry from CAD files in STL (stereolithographic) or IGES (Initial Graphics Exchange Specification) format into 8-node brick meshes that are digestible by analysis packages available from Algor, ANSYS, MacNeal-Schwendler, and others.

This kind of auto-meshing, which is now available in CAD and FEA programs, as well as in in-between programs such as Houdini, makes a days-long chore into a comparative breeze. Throw in ever-faster computers and increasingly powerful and reliable analysis software, and you dramatically increase the speed of your design/analysis cycle, as well as the number of cycles you can afford to run. And the more design and analysis cycles you run through, the faster you learn and the more valuable you become to the company. Software analysis has virtually eliminated physical prototyping from a number of industries. Boeing's new 777 jetliner, designed primarily in IBM's CATIA, went straight from computer to the production floor. **DE**

Mark Clarkson *has been contributing to* DE *since its inception. He now serves as* DE*'s expert in visualization, computer animation and graphics. Visit him on the web at MarkClarkson.com or send e-mail about this article to DE-Editors@deskeng.com.*

Topology Optimization Issues

Topology optimization is attracting a lot of fans! Last month's *DE* showed many great applications. This month, I review what topology optimization is and some of the practical issues it raises.

Topology optimization is not new; the origins are usually attributed to Bendsøe and Kikuchi from 1988.[1] There is rejuvenated interest now that implementations are more accessible to engineers. There is also a natural alignment sensed between topology optimization and additive manufacturing processes.

Topology optimization is unique within structural optimization methods: It can take empty design space and produce a configuration. Other forms of optimization have to start from an initial configuration; either mesh or geometry based:

- Sizing optimization varies physical properties of 1D elements (cross-sectional properties of rods/beams) and 2D elements (shell thicknesses). It works on the FEA mesh, not geometry.
- Shape optimization comes in two flavors. One distorts the boundary shape of a 2D or 3D structure by distorting the mesh. The second allows parametric variation of geometry dimensions.

The "Free Spirit"

So topology optimization can be considered the "free spirit" of the optimization world! But what is it actually doing, and does it really deliver optimum solutions?

Mathematically, the method fills design space with continuous material, then punches voids. The FEA implementations knock out individual elements from a fixed mesh. However, it is not practical to literally delete elements, so density and Young's modulus of each element parent material are lowered to form a chewing gum type material. Any element can be modified.

The objective of the optimization is usually to minimize the compliance or strain energy of the overall structure. This in effect drives up its stiffness. However, a constraint is needed to give any meaningful solution. Commonly this is the target volume. There are some practical issues here:

- It is difficult to evolve chewing gum and steel regions with no transition. Fake materials between them are used. There is a tradeoff between an abruptness of transition, and convergence.
- Gentle transitions are difficult to interpret. Large amounts of "shades of gray" transition material will defy physical interpretation of the structural boundaries. A visually well-defined configuration with a relative density boundary of say, 0.85 is useful. A fuzzy outline shape evolving above a value of 0.3 is nebulous.
- Without special controls, the solution may appear checkerboard-like; with adjacent elements flipping hard between steel and chewing gum. Hence, foam-like regions are generated which are not physically realizable.
- As the mesh is refined, more root-like or branch-like configurations occur. In the limit, the stiffest optimum solution will look very fibrous.

Traditionally, these trends are unacceptable, but rapid prototyping may make this a useful area to explore!

Tough on Strength Constraints

Strength constraint in topology optimization is a tough challenge for program developers and methods are only recently evolving to include this in a rigorous way. Issues include:

- As element stiffness reduces toward zero, local stress levels may approach a singularity.
- Intact elements will form a Lego brick-like surface. If unsmoothed stresses are used, many artificial local stress concentrations will result and require additional intact material.
- Contours of density or Young's modulus can be plotted and smoothed to give a clear indication of the evolving configuration. However, it is very difficult to assess what stresses would be present in the surfaces of such a notional structure.

The best that can probably be achieved is to use a stress constraint as a global guiding constraint for the optimizer. It is not a rigorous limit, as found in more traditional methods.

The Idea Machine

So what does this leave us with? Well, topology optimization is an incredibly powerful tool that can give great insights into potential configurations. It opens up ideas that are not intuitive. However, it must be clearly seen as an idea machine! The configuration is not particularly optimum from a traditional strength or even stiffness perspective. Transitioning the somewhat fuzzy mathematical material boundary into a true geometric configuration will mean moving off the mathematical optimum. The transitioned geometry will need to be formally checked for adequate strength and stiffness – this may rule out the configuration. Alternatively shape and/or sizing optimization studies can flow from this.

Topology optimization is always a great starting point. That is the way the tool should be used, (and heavily re-used) as we explore design space. In many ways, lightweighting is an ideal use case: not optimum, but better! **DE**

[1] Bendsøe and Kikuchi. Generating optimal topologies in structural design using a homogenization method. Computer Methods in Applied Mechanics and Engineering 71 (1988)

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 e-learning classes. Send e-mail about this article to DE-Editors@deskeng.com.*

by Beth Stackpole

The New Face of **STEM**

As the mom of a high school senior in the throes of applying to engineering schools, I'm in awe — and more than a bit intimidated — when I see what's in store for my son during his first year of study. Calculus, physics, sustainable engineering principles, even statistical methodologies is on the docket, regardless of whether it's his safety or reach school.

Combine the rigor of the course load with the fact that many of these classes are taught in large lecture style, and it's no wonder so many first-years are turned off by the engineering curriculum and switch out of the major. Past studies have shown than upwards of 40% of engineering students switch to other majors or drop out of school not just because of the difficulty of the engineering curriculum, but because of the way it has traditionally been taught.

Kids like my son, fresh out of small high school classes with personalized teaching and lots of interaction, need more than book learning and lectures to stay engaged and embrace tracks in science, technology, engineering and math (STEM). They need to get their hands dirty, working on projects in collaborative teams and learning cross-discipline skills — much like they will when they're out there in the real world on their first engineering job.

To engage the next generation of engineers, schools need to integrate hands-on curriculums.

Getting Hands On

Luckily, more and more universities are getting that message loud and clear. Not only are they promoting student participation in competitions like the DARPA Robotics Challenge or ASME (American Society of Mechanical Engineers) Student Design Competition, but they are actively retooling their curriculum to foster more hands-on and project-based learning.

Take a look at what's happening in Ohio State University's First-Year Engineering course, ENGR 1181: Fundamentals of Engineering. To ensure students don't get discouraged by the slog through core science and mathematics courses, the department has introduced a final project that tasks students with developing a controller for an N-scale train set using MATLAB technical computing software and an Arduino microcontroller. In preparation, students learn measurement, graphing, data analysis and other core engineering concepts along with a basic class in MATLAB programming. Then in the 10th week of the course, they get to roll up their sleeves and dive into the project, working in groups of four. The higher-level classes build on this hands-on training, requiring students to build an advanced energy vehicle as well as other collaborative project work. Since adopting the new course sequence, OSU says a higher percentage of its students are continuing on in the engineering program.

Some engineering students at Purdue University are gearing up for their own hands-on engineering adventure. The university is offering a design class specifically focused on building a component of the Hyperloop, a space-age-like transportation system proposed by serial inventor Elon Musk. Hyperloop is a pneumatic tube-based transportation system built around reduced pressure tubes and pressurized capsules or pods that would transport people and cargo between destinations at speeds up to 700 mph. Purdue's Hyperloop course will require students to create a passenger capsule or pod for the vacuum-based transportation system, and some of those will be entered into SpaceX's Hyperloop pod competition later this year. The course is based on SpaceX's contest requirements and is taught by a professor in the School of Aeronautics and Astronautics.

More Changes on the Horizon

This is just the tip of the iceberg in what's happening in college engineering programs around the country. Group collaboration, hands-on learning opportunities and labs stuffed with the latest in engineering technology — from 3D printers to CNC (computer numerically controlled) milling machines and robotics tools — are being mainstreamed to help universities shift to a more experiential learning style.

I'm confident that engineering is a great track for my son. Yet, I have to admit there's a chance he'll be discouraged without an opportunity for an immersive experience that depicts what real-world engineering is like. That said, I couldn't be happier about the coming changes — for him and for all of those upcoming engineers who are so critical to driving next-generation innovation. **DE**

This commentary is the opinion of **Beth Stackpole** *a contributing editor to* DE. *Email her via beth@deskeng.com.*

SABIC Releases Large Format Touch Sensor

SABIC has introduced a transparent, conductive polycarbonate film that constitutes a new class of display materials. It is suited for large formats with 2.5 and 3D formability.

The film combines SANTE nanoparticle technology from Cima NanoTech over SABIC's LEXAN film for sensitive touch screens. SABIC's transparent, conductive polycarbonate film — available in gauges from 800 micrometers to 125 micrometers — provides considerable weight savings, which can support thin wall designs as well as potentially reduce transportation costs, the company states.

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Altair Opens Enlighten Award Nominations

The program, according to the company, is focused on recognizing lightweighting achievements in the automotive industry. This year's competition is offering two distinct submission categories: full vehicles and modules.

"As pressure continues to increase on the industry approaching the 2016-2018 mid-term review, we expect to see significant new innovations to be showcased in this year's competition," said Dr. Jay Baron, president and CEO at the Center for Automotive Research. "We look forward to the 2016 nominations highlighting exciting new approaches to automotive engineering and design contributing to further reductions in weight, fuel consumption, and emissions for light-duty vehicles."

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Tecplot 360 EX 2016 Release 1 Launches

Tecplot Inc.'s update of its data visualization and analysis software includes easier license management, expanded polyhedral data support, improved animation methods, an all-new macro debugger and more Mac support.

"The CFD community is gravitating to polyhedral element types largely due to their tendency to increase the rate of convergence," says Scott Fowler, product manager at Tecplot. "We've spent considerable time improving our algorithms and rendering to better support polyhedral cells. Many of these algorithms have been made parallel while simultaneously using less memory, which allows our users to visualize and analyze larger datasets, faster."

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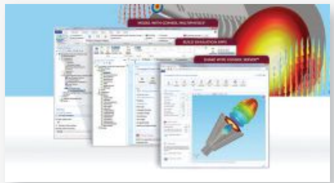
COMSOL Multiphysics Available on Rescale



Engineers now have more access to simulation applications on the Rescale platform with the addition of COMSOL Multiphysics.

Overall, COMSOL Multiphysics users can run computationally demanding analyses on high-end hardware that matches the power and flexibility of their solvers. Users submit simulations using their existing Multiphysics licenses with on-demand high-performance computing (HPC) hardware. The new Rescale and COMSOL collaboration allows users to accelerate their COMSOL Multiphysics analyses using Rescale's pay-per-use HPC platforms, leveraging built-in administration and collaboration tools designed to improve and speed-up the simulation process, a company press release states.

"For customers seeking HPC resources for bigger analyses, this important initiative with Rescale allows our users to take full advantage of both the COMSOL Multiphysics software and Rescale's secure and flexible simulation environments," says Phil Kinnane, vice president of Business Development, COMSOL.

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Maplesoft Adds MapleSim CAD Toolbox

The MapleSim CAD Toolbox is an add-on that allows engineers to bring their designs directly into MapleSim. By being able to import models, the company states, users can learn how their designs will behave as part of a larger, multidomain system and apply advanced analysis tools for optimization.

Capabilities of the MapleSim CAD Toolbox include feature detection, letting users add points of interest and coordinate frames between separate bodies. It can handle files from Inventor, NX and SOLIDWORKS, as well as STEP and STL file formats. Models can be saved to the MapleSim Server, making file sharing easier across engineering teams.

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Cube 3D Printer is Discontinued

Citing efforts to expand its professional line, 3D Systems will no longer be offering its consumer 3D printer, the Cube 3D. All associated retail products were also discontinued.

"In connection with our ongoing review of our business and industry, we believe that the most meaningful opportunities today are in professional and industrial settings, from the product design shop to the operating room to the factory floor," said Andy Johnson, who is interim chief executive officer while the company searches for a replacement to Avi Reichental, who resigned his position as president and CEO in October.

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GE Ventures, Autodesk Invest in Optomec

Money from the Autodesk Spark Investment Fund will further development, promotion and deployment of Optomec's solutions for production applications.

Optomec supports additive manufacturing in areas such as 3D-printed sensors, advanced electronics packaging and 3D-printed metal. The goal of the company's collaborations with GE and Autodesk is to reduce barriers of additive manufacturing adoption.

"The Spark Investment Fund aims to push the boundaries of additive manufacturing and we believe a connected ecosystem between hardware and software is key in spurring innovation and collaboration," said Samir Hanna, vice president and general manager, Consumer and 3D Printing, Autodesk. "We're excited to have a shared vision with Optomec in enabling additive manufacturing technology to be seamlessly integrated into conventional production platforms to advance the overall design and fabrication process."

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MakerBot Announces Smart Extruder+

The Smart Extruder+ features improved key components to ensure reliability, such as an enhanced thermal management system and an extended PTFE tube to feed the filament into the nozzle, according to MakerBot. Additional improvements include faster print startup and refined build plate leveling, the process of calibrating a 3D printer.

The Smart Extruder+ sensor system communicates with MakerBot Desktop and MakerBot Mobile to keep users informed about the status of a print wherever they go. For example, the filament detection sensor notifies users — on their computer or mobile phone — when filament is absent and automatically pauses a print to enable print recovery.

The previous extruder in MakerBot's fifth generation of 3D printers allegedly suffered a high failure/replacement rate and is at the center of an ongoing class action lawsuit against the company.

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Eurocom Releases Sky DLX7 Laptop

The Eurocom Sky DLX7 uses an Intel Z170 Chipset, socket LGA 1151 for support of up to Intel Core i7-6700K processors, which have 4 cores and 8 threads running at 4GHz, with turbo boost up to 4.2GHz. The 14nm Intel Core i7-6700K is overclockable for maximum control and performance.

Five Terabytes of storage is possible through four storage drives for a host of capacity, configuration and upgrade options. Two 9.5 mm HDD or SSD (solid-state drive) bays and two M.2 SSD PCIe x4 SATA drives are supported with RAID 0/1/5/10 availability.

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AMD Announces New Polaris Architecture

At this year's Consumer Electronic Show, AMD showcased its upcoming Polaris GPU (graphics processing unit) architecture. This version, according to the company, has a range of architectural improvements such as HDR monitor performance and enhanced performance-per-watt.

According to a company press release, AMD's Polaris 14nm architecture-based FinFET GPUs deliver a generational jump in power efficiency. Polaris-based GPUs are designed for fluid frame rates in graphics, gaming, VR and multimedia applications running on small form factor and thin-and-light computer designs.

AMD expects shipments of Polaris to begin mid-year.

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SimManager 2015 Now Available

The newest release of MSC Software's SimManager provides full Adams/Car Portal Data Management integration, providing a platform for storing, retrieving and managing vehicle dynamics models and enabling improved cooperation among design teams. Support includes ability to work on local models, retrieval and publishing of these models from/to SimManager and sharing models with a global team. The Adams/Car Plug-In for Adams/View provides support for publishing and retrieving Adams/Car models from the GUI, improving ease of use and productivity. SimManager 2015 also includes support for the newly introduced token-based system, MSC One licensing.

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Aras Innovator Goes to the Cloud

Aras, a provider of product lifecycle management (PLM) software, and CloudSAFE, an infrastructure company enabling business in the cloud, have announced the availability of the CloudSAFE PLM Appliance with cloud-based back-up and disaster recovery. Aras says this is the first in a line of pre-packaged PLM infrastructure appliances powered by Aras Innovator that provide a scalable, ready-to-run PLM solution.

The platform is offered as a monthly subscription and powered by Aras' Innovator framework. Organizations an choose to implement a private or

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hybrid cloud configuration without needed extensive knowledge of setup, configuration or maintenance.

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Contex Ships HP PageWide XL Driver

Contex, a provider of wide format scanning and imaging solutions, announced that its Nextimage Repro scanning software now supports the HP PageWide XL portfolio.

By supporting the HP systems, Contex's software is now compatible with over 60 printers. Exclusive to Contex wide format scanners, these drivers are suited for high speed and ease of use, especially with variable large formats.

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HBM Expands SomatXR Portfolio

The new SomatXR systems from HBM are suited for rugged applications, environments and operating systems.

The MX840B-R Universal Module was developed for measurement tasks that require multiple transducer types. The measuring amplifier has eight channels for connecting more than 16 types of transducers. The MX411B-R Highly Dynamic Module is suited for dynamic acquisition and analysis of mechanical measurement quantities. It has 24-bit resolution and four channels with a maximum sample rate of 100 kS/s per channel, which increases to 200 kS/s in two-channel mode. The MX471B-R CAN Module is designed for connecting the SomatXR data acquisition system to a CAN network.

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Keysight Technologies Adds New Test Formats

GSM, GPRS, EGPRS and TD-SCDMA, HSPA test capabilities are available on the E7515A UXM wireless test set from Keysight Technologies. Developers can validate multi-format LTE devices in a single UXM test set.

The new GSM and TD-SCDMA test applications allow fast switching between W-CDMA, GSM and TD-SCDMA formats in a single UXM with one transceiver hardware set. The new test applications also include the GSM and TD-SCDMA X-Series measurement applications for RF testing.

MORE ➜ deskeng.com/de/?p=27866

modeFRONTIER 2016 User Meeting Set

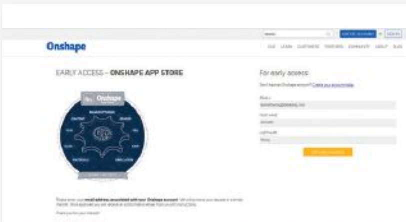
This year's international ESTECO modeFRONTIER user meeting will take place May 17-18 in Trieste, Italy. It is an opportunity for users from different, industrial sectors, academia and research to exchange ideas. Users of ESTECO technology will discuss the versatility of the software and provide starting-points for future applications and innovations.

The conference is open to contributions showing how modeFRONTIER can accelerate product innovation. Authors have until February 26 to submit abstracts.

MORE ➜ deskeng.com/de/?p=28009

Onshape Opens App Store

It's the Apple model adapted for CAD. The crew behind Onshape has been busy laying the groundwork to launch an app store, featuring a collection of products to augment the flagship Onshape CAD program. It's now ready to go.



In December, the Beta announcement for the Onshape App Store went live, with an online form to solicit early access.

Other CAD software vendors have their own partner networks, but the Onshape partner apps are characterized by their alignment with Onshape's distinct features: They all have the free trial option and they all recognize the Onshape credentials.

Joe Dunne, Onshape's partner manager, pointed out: "This is a big ecosystem launching with us. We have 24 partners. Those are just the ones who are ready today. In the simulation category alone, we have five partners. Billing is consolidated. Onshape has a freemium offering; every partner is required to embrace this model."

Onshape has a free version with a limit on storage. Commercial licenses require a monthly fee or subscription.

Among the first simulation partners to launch Onshape apps in the app store are Simscale, Simsolid, and Simlab. CAMWorks and Mastercam fill in the spot for computer-aided manufacturing. TraceParts has launched the 3DX Certified Models app, which allows users to find products from over 400 suppliers by graphically navigating to specific products, using tag-based product search, or searching across multiple certified catalogs. Selected parts provide a real-time 3D product preview and a summary of BOM (bill of materials) attributes.

The partners select the type of licensing or billing method that works best for their offerings. Therefore, under the current setup, some apps are sold as subscription, just like Onshape itself. Others may be on the pay-per-usage model.

Onshape is built to run in the cloud, but not all partners have the same capacity or are ready to devote themselves exclusively to this strategy. Onshape apps are offered as connected cloud apps, integrated apps and connected desktop apps.

MORE ➜ deskeng.com/virtual_desktop/?p=11289

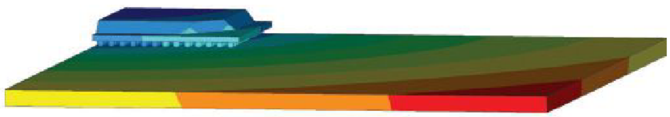
ANSYS Release 17 Redefines Simulation Performance

The push for higher performing simulation is not just about the need for speed. Faster simulation delivers real business value to engineering organizations, allowing them to explore more design alternatives earlier in the process while being able to evaluate much more complex and complete designs against myriad multiphysics criteria.

ANSYS, always in the forefront of driving high-performance simulation, has upped the ante once again with the latest release of its CAE portfolio. With ANSYS Release 17 comes a modern HPC solver architecture designed to harness the horsepower of the latest Intel processor technologies to deliver unparalleled simulation performance and return results faster, whether the software is running on a desktop, a workstation, an HPC cluster or in a cloud environment.

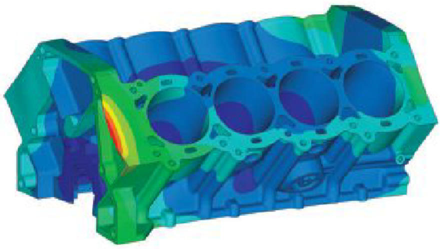
The bar was already set pretty high. In a previous benchmark study conducted by ANSYS, *Desktop Engineering*, Dell and Intel, ANSYS Mechanical R16 running on a state-of-the-art Dell Precision 7910 workstation equipped with 3.2GHz

Sparse Solver Model



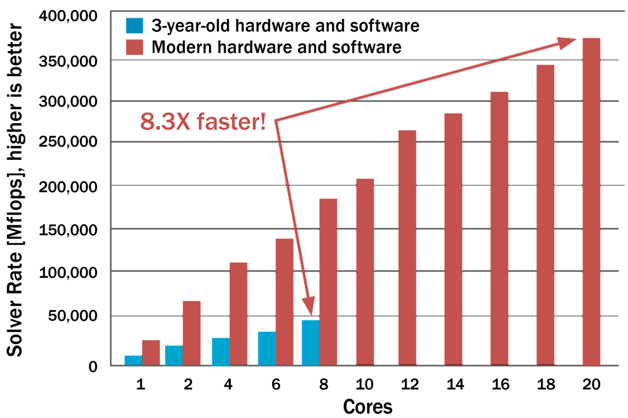
A transient nonlinear structural analysis of an electronic ball grid array. **Model Characteristics:** Sparse solver, symmetric matrix, 6 million DOFs

Iterative Solver Model



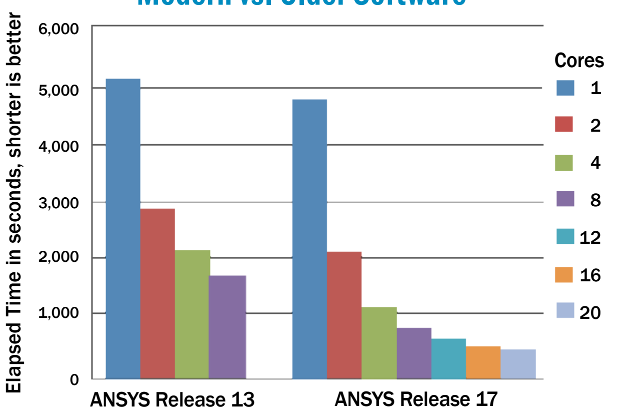
A static, linear structural analysis of an engine block without the internal components. **Model Characteristics:** PCG solver, symmetric matrix, 14.2 million DOFs

Modern vs. Older Hardware and Software



ANSYS release 17 performed a transient nonlinear structural analysis of an electronic ball grid array 8.3X faster than ANSYS release 13.

Modern vs. Older Software



ANSYS release 17 running on a current Dell workstation showed significant reductions in solver times on a linear structural analysis of an engine block as core counts increased.

dual E5-2667 v3 processors and 16 cores increased simulation performance on one model by more than 6X compared to that same simulation exercise conducted with three-year-old hardware and software. (See deskeng.com/de/benchmark2.) That same model, running on a comparable Dell workstation (with 3.1GHz processors and 20 cores) and with the new ANSYS R17, achieved a speedup of 8.3X, underscoring the ANSYS upgrade's ability to throttle up simulations by leveraging higher core counts.

ANSYS R17's improved robustness and scalability comes in part from leveraging a number of Intel Software Development products to optimize the software for the Intel Haswell processor architecture, including adopting the latest Intel AVX-2 compiler instructions and the Intel Math Kernel Libraries. ANSYS has also implemented a completely new algorithm that optimizes the matrix factorization stage of the sparse solver — which may account for a significant portion of the total solution time — along with other software code optimizations that contribute to the accelerated performance.

Beyond those enhancements, ANSYS R17 supports more robust Distributed Memory Parallel (DMP) processing capabilities at higher core counts (32+ cores), enabling a complex simulation to be divided up into portions that are computed on separate cores and processors. The latest release changes up the default Message Passing Interface (MPI) software — the communications channel that lets each ANSYS process exchange data with other processes involved in the DMP simulation — to Intel MPI, further accelerating performance. These improvements have enabled ANSYS to make DMP the default standard for ANSYS Workbench instead of Shared Memory Parallel (SMP) processing, delivering more efficient performance for simulations involving more than four compute cores running in parallel. Moreover, new DMP features, including a new version of the Block Lanczos eigensolver as well as a support for spectrum analyses such as the PSD method, lead to faster performance, especially at higher core counts.

Iterative Solving Gets a Huge Boost

ANSYS R17's performance gains are not limited to the sparse solver. Because today's highly complex structural systems require analysis of a wide range of physics, multiple solving solutions are required, each a beneficiary of R17's enhanced performance. In one such example, iterative solvers, well suited for the current trend toward larger models with solid elements and fine meshes, has also been greatly enhanced to deliver faster solution solving in the new ANSYS release 17.

Consider the Preconditioned Conjugate Gradient (PCG) iterative solver, one of the various solvers in the ANSYS portfolio, as an example. Iterative solvers like PCG use a different approach to solving large systems of linear equations compared to sparse solvers. The PCG starts with an initial guess and goes through an iterative process to update the solution vector in every iteration using the system matrix and a preconditioner matrix to converge the solution. Thanks to improvements made in the PCG solver in ANSYS R17, simulation models now converge faster to the correct solution.

ANSYS R17 sets the standard for high-performance simulation, helping engineers navigate mounting product complexity and giving manufacturers an edge.

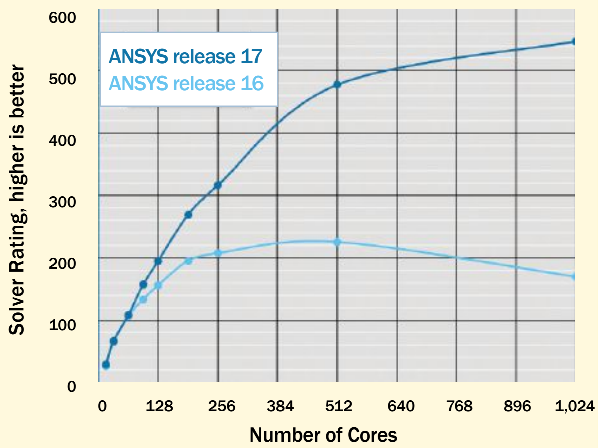
For more information about ANSYS release 17, please visit ANSYS.com/StructuresHPC.

New HPC Milestone Achieved: ANSYS R17 Scales to Over 1,000 Cores

Thanks to a modern HPC solver architecture that leverages the latest Intel processor technologies, ANSYS R17 has the ability to scale to over 1,000 cores — a milestone for pushing simulation performance beyond workstation capacity to corporate cluster levels.

For example, consider a ball grid array involving a nonlinear transient analysis with creep material properties (no contact). The sparse solver is used to solve the 4 million equations, and there is one load step with 12 substeps, resulting in 22 iterations to reach convergence in the nonlinear analysis. As a point of comparison, the model was run with the latest ANSYS R17 release and the previous R16 release on the same system — the Intel Endeavor cluster with each compute node featuring a pair of Intel Xeon E5-2696v3 (Haswell processors), 64GB of RAM, local SSD storage, and RHEL6.5. Mellanox InfiniBand FDR interconnects were also part of the configuration.

DMP Scaling Comparison



When run on the system with ANSYS R16, performance topped out at approximately 300 cores (see chart). With ANSYS R17, performance continued to improve to 1,024 cores. This results in significantly reduced solution times, helping engineering teams in their quest to perform more complex and complete simulations within reduced product development schedules.

Decoding the IoT Development Platform

The broad technology stack required for IoT product development dictates that engineering teams rely on multiple development platforms.

BY BETH STACKPOLE

Even as the concept of the Internet of Things (IoT) crystalizes and so-called smart, IoT-enabled products begin to take shape, the notion of an IoT development platform remains fuzzy — primarily due to the broad sweep of functionality behind this new phase of product design.

Unlike other disciplines such as embedded software development or electronics design, there is no universally established platform like application lifecycle management (ALM) or electronics design automation (EDA) to help engineers jumpstart development efforts. Everyone from chipset and sensor manufacturers to software vendors and consortia have different definitions for what constitutes an IoT development platform — yet most are marketing these offerings as a catch-all solution for development, despite probable gaps in functionality.

The reality of today's market, according to IoT experts, is that most current solutions only address a fraction of the wide swath of functionality required for full IoT product development, creating a host of confusion in what's still a pretty undefined yet undoubtedly complex market.

"IoT development is a broad, diverse, and ever changing landscape," notes Brian Bedrosian, senior director of product Marketing for Broadcom, a networking and communications electronics maker. "There are a lot of components to it — it's a big systems engineering project to develop a cloud-connected product."

The IoT's Technology Stack

The full technology stack for IoT development traverses a lot of terrain. At the physical hardware level, there are the traditional 3D design and analysis tools for modeling and simulating design concepts virtually with the very important addition of sensors — specifically the need to determine the kind, sensor orientation and collection of requisite data points.

Windchill 11's mash-up capabilities will enable users to see quality data collected by products in use in the field within the context of the traditional PLM product structure. ***Image courtesy of PTC.***

The connectivity piece, for getting sensor data to the cloud, is a major component of an IoT-enabled product and an area where many platform vendors are focused. Most provide tools to support a variety of wired and wireless connection options and in many cases, additional security and management components for safeguarding those connections.

Also critical to the IoT development stack are application and user interface capabilities for designing the IoT systems that leverage data from the cloud-connected products, analytics capabilities for parsing the data for insights, and integration capabilities for syncing up with core business systems.

"Very few people talk about the complete tool chain that it takes to develop IoT apps," says Stefan Jockusch, vice president, Strategy at Siemens PLM Software. "When most people talk about an IoT platform, they're really referring to the integrated development environment that makes it easier and faster to gather sensor input and communicate that

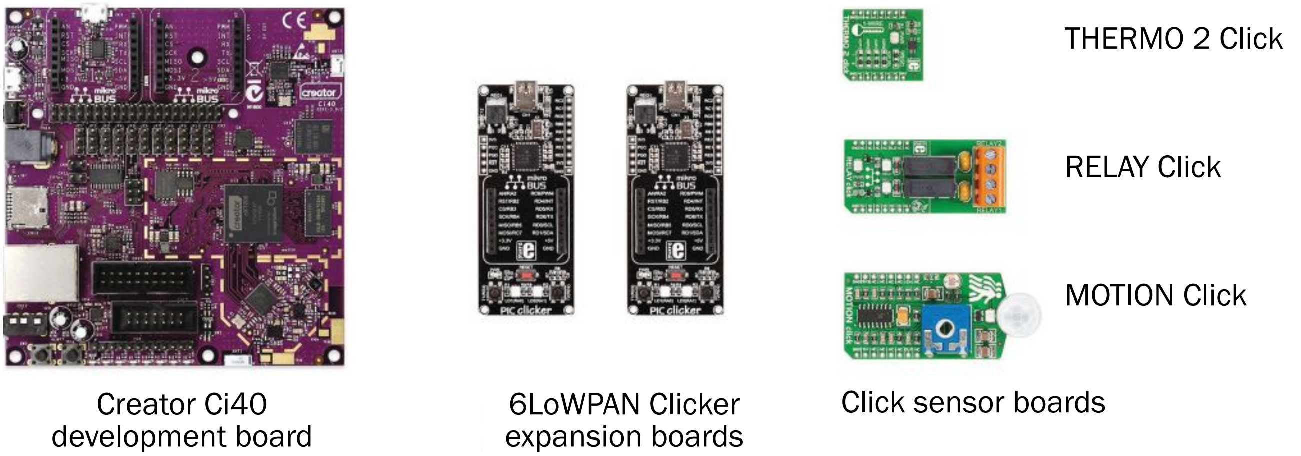
The Digi Device Cloud's support for open APIs positions the platform as part of a broader ecosystem for IoT development. *Image courtesy of Digi.*

Broadcom's WICED development system delivers Wi-Fi and Bluetooth connectivity for a range IoT applications, including home appliances and automation and logistics. *Image courtesy of Broadcom.*

to a database in the cloud. However, there's a big set of technology required in addition to that to build a complete application."

Jockusch makes that case that traditional design tools like CAD and CAE should have equal footing in the IoT development stack, and this broader definition underscores the importance of a systems engineering approach to design. While sensor data can deliver insights into what's happening with a product in the field, Jockusch says that data on its own is far less valuable if engineers can't directly compare it to a virtual model of how that system was designed to work.

"The data itself in only rare cases will give you a clue of what's happening — if something is serious and alarming or within normal design parameters," he explains. "In order to make IoT apps meaningful and enable people to take the right action, the IoT application needs to be rationalized against a virtual representation of a product."



Imagination Technologies' Ci40 toolkit is designed as an IoT hub to help jumpstart the development of IoT-enabled prototypes. *Image courtesy of Imagination Technologies.*

That's where CAD and simulation fit into the IoT development picture, Jockusch says, providing a "digital twin," or virtual representation of a product, that will provide the complete picture of how design teams expect that product to work. Siemens is evolving its IoT development capabilities by leveraging the Omneo analytics tool, brought under the company's umbrella via last year's Camstar acquisition, as part of a systems analytics bus that will help connect data collected from products in the field to the product design data managed by Teamcenter.

"This connects the analysis you do in the CAD and CAE world to the analytics you get out of actual product so that you can get a more accurate understanding of whether what you're measuring is within design parameters or outside," he explains. "The key thing you're trying to do is to extract something of business value out of the raw data to make designs and products more reliable. We see people focused on gathering the data, but the important part is to make sense of the data."

Given the scope of the IoT development stack, interoperability will be an ongoing issue, Jockusch says. However, Siemens is mitigating those challenges by filling in pieces of its platform — its recent acquisitions of Omneo and the Polarion Application Lifecycle Management (ALM) applications are key examples — as well as better integration with other applications. "We are building a fish bone of applications that will cover the whole process, well aware that there will be many situations where customers will be using different apps and we'll need to connect to them in the same way," Jockush explains.

PTC, hands down the most active in IoT development, has also relied heavily on acquisition to build out a comprehensive IoT technology stack. Its ThingWorx IoT platform provides a foundation for building and deploying enterprise IoT applications; the Axeda Machine Cloud provides cloud-based services for managing, securing, and connecting products and machines; ColdLight delivers analytics and automated machine learning capabilities for gaining insights into all that raw data; and Vuforia, its latest purchase, will deliver augmented reality capabilities.

Along with its new areas of focus, PTC is infusing IoT development capabilities into its traditional design platforms, including Creo and Windchill. The company is evolving the concept of a digital twin — a broader representation of a digital product — so engineers can stay in tune with what's happening with a specific product in the field. And the latest version of Windchill 11 includes an embedded ThingWorx adapter, which will allow the platform to connect to another "thing," either a piece of equipment in the field or an enterprise software platform, providing engineers with even more data points and insight on which to direct design decisions.

"Because Windchill is now smart and connected, it can do things like connected quality or have a mashup of quality and product structure data in the context of the product structure," explains Kevin Wrenn, PTC's divisional general manager of PLM. "That lets engineers connect to real data from a piece of equipment and look at it in the context of Windchill, which will enable them to make better decisions on what to design in the next version."

Key to Windchill's ability to do this is new mash-up capabilities, borrowed from ThingWorx and some of its other newly acquired tools. Arena, a provider of cloud-based PLM, plans to leverage mash-up and integration capabilities to evolve its platform in a similar direction to bring IoT-type data into the engineering fold, providing teams with better design intelligence. "Say you have a product that has 10 buttons and one is used three times as much as the others, this capability would let you design in a higher quality button in the next redesign," says Steve Chalgren, Arena's chief strategy officer and executive vice president of Product Management. "If you don't deliver that kind of information right to the engineer's eyeball in the context while they're doing work, you won't get to make such changes as often."

The Broader IoT Ecosystem

Beyond their traditional vendors, design engineers taking the plunge into the world of IoT will also need to expand their horizons to a broader ecosystem of platform players, especially on the connectivity front. A company like Broadcom, for example, offers the WICED connectivity platform for embedded devices, which provides secure Wi-Fi, Bluetooth, and Bluetooth Low Energy (BLE) capabilities along with security libraries, cloud connection agents, and a host of other tools, empowering engineering teams to build IoT-enabled products such as home appliances, automation equipment, smart meters and various other devices.

For Broadcom, partnerships will be key to building out its IoT platform and development strategy. "To accomplish our goal of providing end-to-end services, we choose to align with an ecosystem of partner companies that will provide all the services that are outside of our area of expertise," Bedrosian says. "Industrial companies might make great electromechnical systems like heat pumps while semiconductor guys like us are not as proficient at that, but do robust networking. We will focus on our core competency and use our partner network to provide the other components."

Digi International is also cultivating an ecosystem and opening up its Device Cloud APIs (application programming interfaces) to ensure its M2M (machine-to-machine) connectivity solutions integrate seamlessly in a larger IoT technology stack. "There's no way one company is ruling IoT all by itself — it's too complicated and too interesting," says Rob Faludi, Digi's chief innovator.

Imagination Technologies, on the other hand, is taking a completely different approach, offering up a soup-to-nuts starter IoT development platform that targets engineers just starting out on the IoT journey, who are looking for a way to fast-track design of early prototypes. The Ci40, geared toward smaller enterprises or entrepreneurs, is billed as an "IoT hub," and includes sensors; MIPS-powered boards that incorporate memory, security capabilities, and a range of wireless standards from Bluetooth to ZigBee; along with cloud connectivity; among other features.

"Because IoT [development] is so broad, it requires a lot of different skill sets and engineering disciplines that smaller companies may not have," explains Paul Evans, business development director for Imagination Technologies. "The kit has something from each discipline so companies can get started building a prototype or putting products into low-volume production."

Even while IoT opens the door to new areas and companies outside of the traditional design engineer domain, experts say core systems like PLM will remain essential to the design of smart connected products. "IoT provides a connection point to bring business value to customers, and PLM is a key part of that," explains Matt Sheridan, PTC's director of PLM. "It provides the opportunity to take information coming from the design world and leverage it across a product's whole lifecycle." DE

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

INFO → Arena Solutions: ArenaSolutions.com

→ **Broadcom:** Broadcom.com

→ **Digi International:** Digi.com

→ **Imagination Technologies:** ImgTec.com

→ **PTC:** PTC.com

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

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

More New IoT Platforms Just Announced

With the projected growth of the Internet of Things and its reach across the product development lifecycle, it's no wonder so many vendors are throwing their hats into the IoT platform ring. Below are just a few of the most recent announcements.

• **Renesas Electronics Corporation**, a supplier of semiconductor solutions, announced the commercial release of the Renesas Synergy Software Package (SSP) version 1.0.0. SSP is a "complete and qualified platform for the development of embedded and IoT applications," according to the company's press release. "It was designed to provide engineers with a platform that already has basic system elements implemented, configured and tested, so engineers can eliminate the time normally needed to implement and integrate base-line functionality and move almost immediately to product design, potentially reducing time to market by months."

renesas.com

• **Afero** is a stealth startup that just "uncloaked" last month to announce its IoT platform that consists of a Bluetooth Low Energy connectivity module with adeveloper board, a software developer kit and tools, a cloud platform and application programming interfaces. It is intended to help developers with secure IoT connectivity.

"Our platform unlocks smart capabilities for any device and allows smart devices to work together," the company claims on its website. "The possibilities are endless."

afero.io

• **Amazon Web Services**' IoT Cloud Services for Connected Devices exited its beta phase in December and has officially been launched. The platform is designed to make it easier for IoT devices to connect to AWS, which can be used to store and analyze data.

"We built AWS IoT because connected devices are proliferating," according to a post on the company's blog. "When we talked to our customers and to our own engineers, we learned quite a bit about the pain points that add complexity and development time to IoT applications. They told us that connecting devices to the cloud is overly complex due to the variety of SDKs and protocols that they need to support in a secure and scalable fashion."

ws.amazon.com

• **Wind River** has introduced an automotive software platform for the connected car called Helix Cockpit. According to the company, Cockpit was designed to meet the intersecting needs of the automotive and IoT landscapes.

"Wind River Helix Cockpit provides carmakers with the framework to fully own the software environment and realize their vision," said Marques McCammon, GM of connected vehicles at Wind River in a company press release. "By turning to Wind River's decades of embedded software leadership and rich technology expertise in mission-critical industries such as aerospace and defense, the auto industry can quickly become software savvy and begin their IoT transformation."

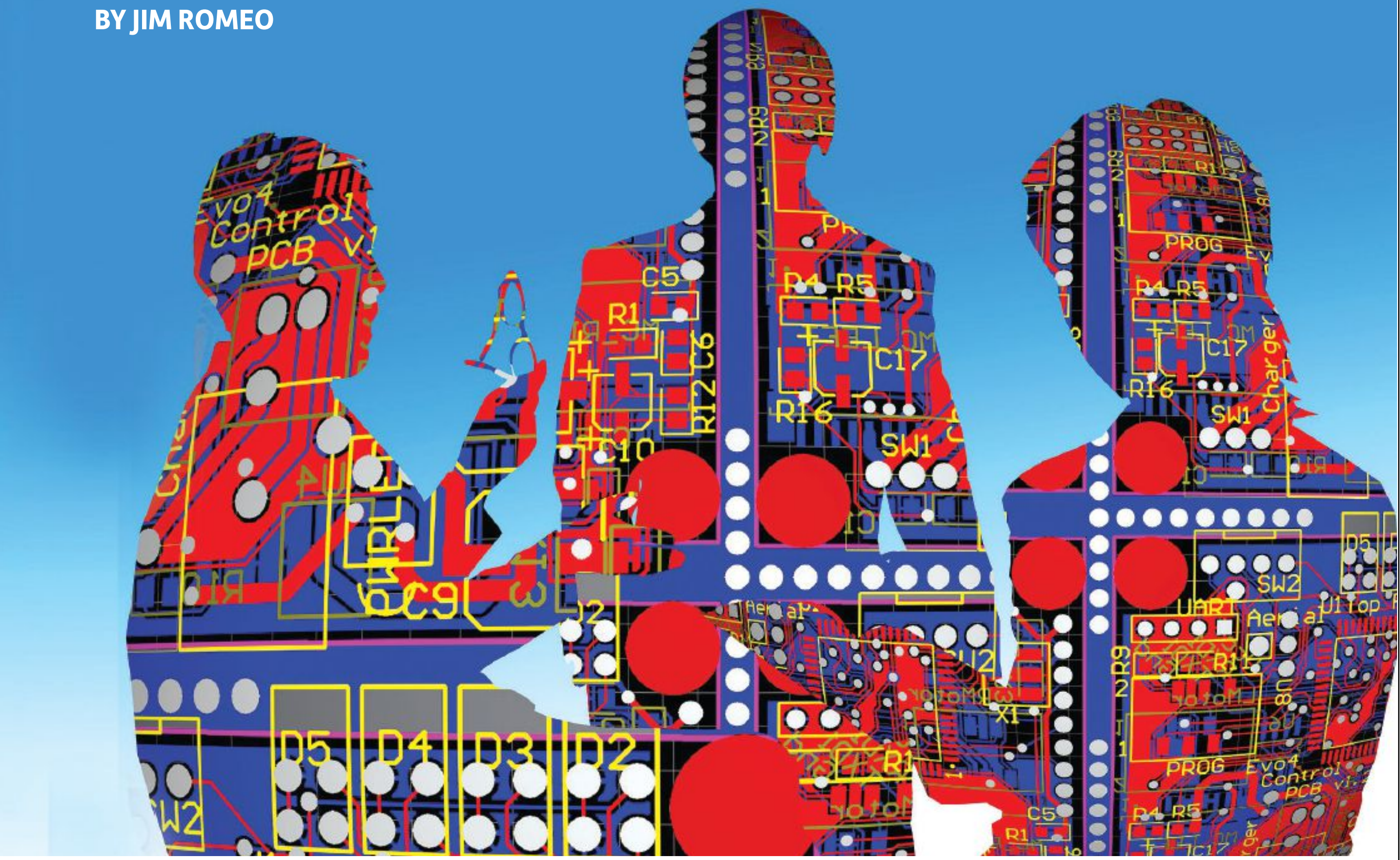
• **Thin Film Electronics ASA**, a provider of printed electronics and smart systems, has been awarded a grant from the European Commission to fund the "TagItSmart" project, through which Thinfilm will partner with technology, consumer packaged goods and smart-products leaders to create what the company calls "the world's first Internet of Things platform featuring open-source, open API architecture."

thinfilm.no

The Emergence of Deep and Machine Learning

Increased research is paving the way for the next generation of smarter products.

BY JIM ROMEO



Imagine a host of products that can incorporate such applications as superb and accurate language translation from multiple platforms, forecast weather with pinpoint accuracy and learn chess within 72 hours — and play at the Master level.

Such applications have arrived, but many more sophisticated and complex applications are on the way, thanks to the panache of deep and machine learning that is finding its way into product development and applications.

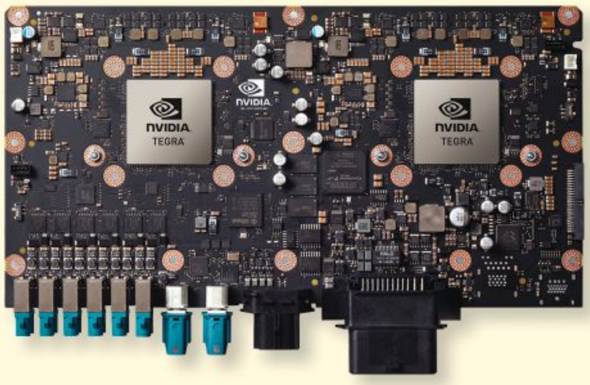
The application of machine learning is widespread: Many different applications stand to benefit from it.

"There are proven applications of machine learning that will continue to grow as the underlying machine learning algorithms mature," says Joshua Saxe, senior principal research engineer at Invincea Labs. "These include application categories such as targeted advertising, recommendation systems, fraud detection, spam detection and the like. As academically oriented work improves the accuracy and efficiency of computer vision, natural language processing and network analysis algorithms (which these application areas depend on) these applications will benefit and improve. Firms that can improve upon the techniques used in these applications, either by gaining access to improved data quality and

Deep Learning Hits the Road

To help speed development of autonomous cars, NVIDIA launched DRIVE PX 2 at the Consumer Electronics Show last month.

According to an NVIDIA press release, DRIVE PX 2 allows the automotive industry to use artificial intelligence to tackle the complexities inherent in autonomous driving. It uses deep learning and NVIDIA's graphics processing units (GPUs) for situational awareness around the car.



"NVIDIA's GPU is central to advances in deep learning and supercomputing. We are leveraging these to create the brain of future autonomous vehicles that will be continuously alert, and eventually achieve superhuman levels of situational awareness," said Jen-Hsun Huang, co-founder and CEO, NVIDIA, in a press release. "Autonomous cars will bring increased safety, new convenient mobility services and even beautiful urban designs — providing a powerful force for a better future."

Some fast facts about DRIVE PX2 from NVIDIA:

- It provides processing power for deep learning that is equivalent to that of 150 MacBook Pros.
- Its two Tegra processors plus two discrete GPUs, based on the Pascal architecture, deliver up to 24 trillion deep learning operations per second.
- It has more than 10 times the computational horsepower than the previous-generation product.
- For general purpose floating point operations, it is capable of up to 8 trillion operations per second, which is four times more than the previous-generation product.
- It can process the inputs of 12 video cameras, plus lidar, radar and ultrasonic sensors.

NVIDIA has also released a suite of software tools, libraries and modules to help accelerate development and testing of autonomous vehicles. The DriveWorks suite enables sensor calibration, acquisition of surrounding data, synchronization, recording and then processing streams of sensor data through a pipeline of algorithms running on all of the DRIVE PX 2's processors, according to NVIDIA. Additionally, the company has a tool called DIGITS that enables deep neural network development, training and visualization.

quantity or leveraging achievements from academia, have an opportunity to achieve momentous results."

High-Performance Calculation

"The rapid development of machine learning provides development opportunities for many companies," says Hu Lei-Jun, vice president of Inspur – a multinational IT firm. "For the Internet industry, or even other industries of relevance to machine learning, machine learning's period allows these users to develop more intelligent products; and for hardware technology vendors, the demand for high-performance calculation will gradually rise. In the past, the highest demand for Internet companies was to meet the throughput rate, while with the development of machine learning large-scale servers are needed to meet computational demand."

For today's progressive enterprise, machine learning is providing significant opportunities to move forward. Information afforded by analytics and the subsequent deep learning that data analysis affords is helping to drive decisions and make positive changes for many industries.

Data is, of course, critical to machine learning. The Internet of Things, with its potential for collecting and communicating so much data, will surely accelerate the development and utility of machine learning. The concept of machine learning is almost as old as computers. While it has developed rapidly in recent years, its future development may be even faster.

"This trend is closely related to the massive data brought by the rapid development of the Internet," says Lei-Jun. "In 2015, global Internet users [reached] over 3 billion, which is nearly half of the world's total population. In 2015, the world's equipment connected to the Internet [reached] 4.9 billion units and this number will reach 26 billion by 2020. Only with such large data can the machine learning model carry out adequate training, which is the prerequisite for the development of machine learning."

A key pathway of machine learning will be to process the voluminous load of data by passing its computation through academia and into applications, and ultimately products. This path is most likely as the algorithms that deep learning uses are akin to the intellectual pursuit and brave challenge that researchers, students and faculty take on. But deep learning development needs to go further through the chain by instilling science and research into applications, and applications into products that the everyday world can use.

"Ideally, the slice of the technology industry that relies heavily on machine learning follows a simple progress model: Applications from industry and government help shape academic research, academic machine learning research improves or enables these applications, and businesses emerge that translate scientific achievements into successful products," explains Invincea's Saxe. "As in any major new field, there are risks to this model, such as large companies controlling access to lucrative datasets."

Globant uses artificial intelligence and machine learning to transform Big Data into highly intelligent products and services. The company works with some household names like Coca-Cola, American Express and Southwest Airlines.

"Building social integration between systems and machine learning models has become crucial in today's world because of greater user customization," says Gustavo Aguirre, head of Globant's Cognitive Computing Studio. "Companies must learn to monetize available data by extracting useful information using data science practices and extraction techniques based on Big Data platforms. As a result, this data can reduce financial risks, improve marketing campaigns, reduce operational costs and drive more engaging and personal connections with customers."

Aguirre says that in the future, machine learning processes will become the standard due to data volume increase; precise, complete and omni-channel customer data availability; more actionable customer behavioral patterns in near real time; an increase of non-structured data; and the need for automation and improvement of human tasks.

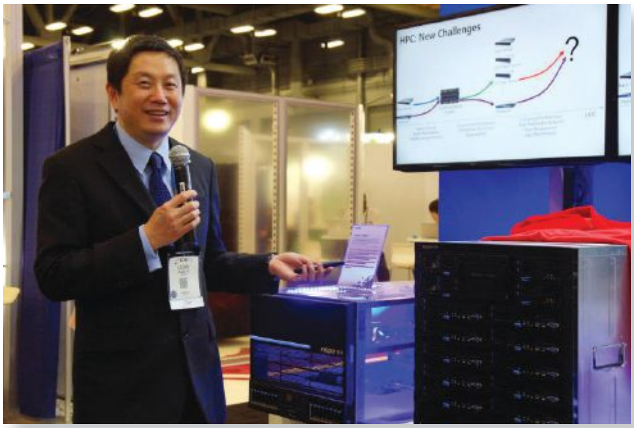
"We can imagine machine learning of the future more closely mimicking the human brain to detect visual patterns: It can detect pedestrians while a car is in motion, recognize a friendly face or voice among others in a crowd, read a text to understand meaning using contextual information. These examples of non-structured information are a field where machine learning opportunities will grow," says Aguirre.

Kitchen Robots to Cook Your Favorite Dish?

In the near term, expect machine learning to be at the forefront of priorities in smart design. Engineers and designers will likely incorporate the intelligence opportunity via machine design and systems design into product development at the earliest stages.

Saxe points out that there are some established applications of machine learning for which commercial markets are only just now emerging. These include self-driving cars, as well as areas like machine translation and machine learning based detection.

"There are also application areas of machine learning that perhaps have been conceived of and may become possible with big advances in the basic science, but are very 'blue sky' today," says Saxe. "This includes the litany of science fiction-like applications: Robots capable of mimetic learning from humans — a kitchen robot that learns to cook an owner's favorite dish — robots capable of performing psychotherapy, robotic teachers or robots that completely automate complex surgical procedures. There is always the possibility of 'black swan' innovations like these, but research in this category of applications will probably remain exploratory and academic for at least the medium-term."



Hu Lei-Jun displays Inspur's i9000 blade server at Supercomputing 15 (SC15). The technology is used for machine learning and supercomputing applications. ***Image courtesy of Inspur.***

Smarter Machines and the Road Ahead

As the Big Data revolution continues to mature, deep and machine learning will drive the development of products. Digital twins — the interchange of data between virtual and reality (see page 24) will be employed to produce a new chapter in the playbook of product lifecycle management. They will help pave the road ahead for "smart" machines.

"Over the coming years, you'll see greater correlation between the real and virtual worlds," says Eric Bantegnie, vice president, ANSYS' systems business unit. "Virtual reality is taking shape. The 'cyber-physical' systems will take advantage of the vast amount of collected data to optimize field-asset performance through the use of the 'digital twin' concept. The digital twin will also drive improvements in product design as the real-world data will be used to improve simulation models and create better performance next-generation products." **DE**

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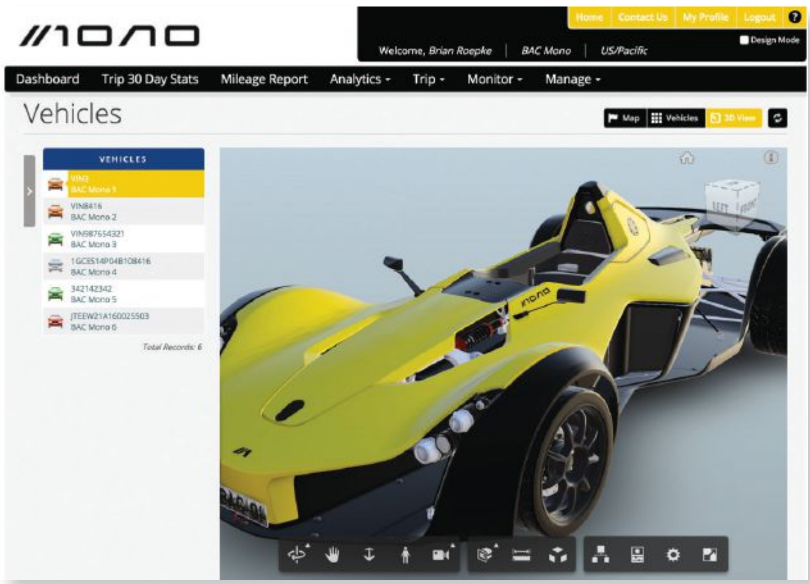
SEEING DIGITAL DOUBLE

Digital twins create an unprecedented design feedback loop thanks to the convergence of the Internet of Things, augmented reality and advanced simulation.

BY BRIAN ALBRIGHT

The line between virtual simulation and real-world testing is beginning to blur thanks to the Internet of Things (IoT), augmented and virtual reality technologies, reality capture, generative design software and advanced simulation technologies. By combining these capabilities, engineering software vendors are enabling the concept of the digital twin and taking simulation and testing in an entirely new direction.

A digital twin is a virtual or digital representation of a physical machine, vehicle, building or other object. "It's a model that uniquely represents a physical occurrence in the real world," says Mike Campbell, executive vice president, Digital Twin, at PTC. "This one-to-one mapping is important. You create a relationship between the digital data and a unique product occurrence from a variety of sources: sensors, enterprise data on how it was made, what its configuration was, its geometry, how it is being used, and how it is being serviced."



Sportscar maker Briggs Automotive uses Autodesk to create virtual models of its custom vehicles. ***Image courtesy of Autodesk.***

With the explosion in sensor-laden smart devices that have emerged under the umbrella of the Internet of Things, it is possible to "simulate" an existing physical product by using sensors and other technology to link the real object and the digital model.

The resulting avatars can be used to virtually test a system prior to physical validation, provide feedback for iterative design activities, and potentially improve service and maintenance operations. "We see a lot of interest in this digital twin idea coming from automotive, aerospace and defense, and machinery, yet we also hear some of our mid-market customers, such as Tier 1 suppliers, line builders and even job shops, talk about how the digital twin will help them become more productive," says Zvi Feuer, senior vice president of Manufacturing Engineering Software at Siemens PLM Software.

According to Brian Roepke, senior director for IoT and PLM at Autodesk, the primary markets for the technology so far include industrial machinery and specialty vehicle OEMs (original equipment manufacturers), but "there isn't a maker of a physical thing out there who isn't in some way or another considering it," he says.

The potential utility of a digital twin goes far beyond just the simulation and testing of new products. Smart systems that are meant to adapt to different environments or operating conditions. "For example, the automotive industry is doing a lot of investigation on developing self-driving cars. First of all, it will be a challenge to design those as a complex mechatronic system. But after development, the self-driving vehicle will need to interact with external systems that can change over time," says Jan Leuridan, senior vice president of Simulation and Test Solutions at Siemens PLM Software. "Manufacturers who want to manage this need digital twins to manage the entire lifecycle of such products."

Blurring the Lines Between Reality and Simulation

Exactly how the software vendors operating in this space define digital twin can vary. According to Siemens' Feuer, the digital twin is a full-scale virtual model of the product as it matures during the design lifecycle. "For the end user, this digital twin will provide the opportunity to evaluate the product by looking at its shape, fit and function, and analyzing some of its main features under different operational constraints," he says.

In some cases, this includes the ability to generate 3D models of multi-physical systems that can be run through simulations in advance of production. In others, a physical object is outfitted with sensors to provide data that is overlaid on a 3D model. Unlike a model used in virtual simulations or prototyping, in this case the model would not be a general representation of a product, but a digital avatar of a single specific item.

National Instruments doesn't use the term digital twin, but its hardware-in-the-loop (HIL) testing technology platform provides similar functionality for complex automotive and aerospace applications. HIL combines physical testing and simulation to ensure that systems will behave as expected prior to actual field testing.

"For an automotive or aerospace OEM, if you take all of these components out on the road not knowing if they work correctly and try to do physical testing, it can be expensive and dangerous if something goes wrong," says Noah Reding, principal product manager at National Instruments. "It can also delay the release of the product. With HIL, you can simulate the entire world around these different components and give it a level of validation before it goes into the field."

Subaru used HIL testing for its motor electronic control unit (ECU) in its first production model hybrid vehicle, the XV Crosstrek. The company built a verification system using the NI FlexRIO platform to replicate severe testing environments that could not be replicated on a physical test track. Engineers connected the ECU to a real-time electric motor simulation. The system included FlexRIO FPGA modules that executed a model representing the simulated operation of the motors. It was deployed using NI LabVIEW system design software.

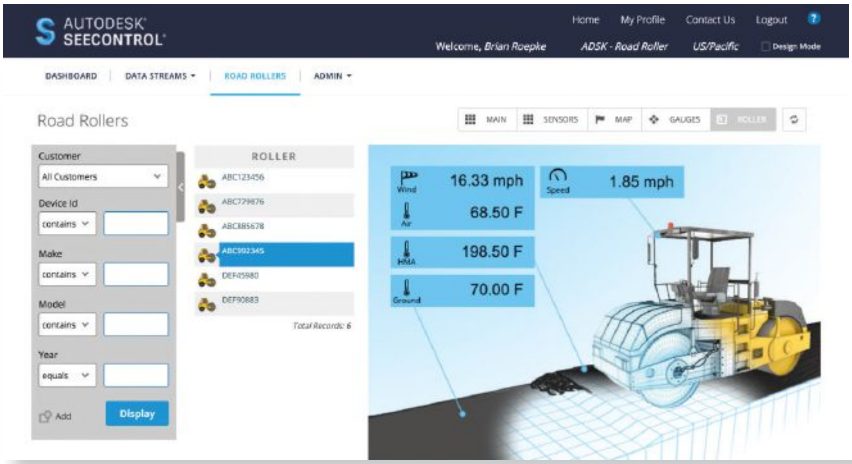
PTC has made digital twin technology a priority with its ThingWorx IoT platform. "Design and engineering teams suffer from a lack of understanding about what is happening with products in the real world," Campbell says. "We can simulate how we think a pump will be used, but most manufacturers don't really have any idea until something goes wrong."

With digital twins, engineers can access real-world performance data from a whole collection of unique product instances, and use that to inform their designs. "That's hard insight to get today," Campbell says. "In a digital twin environment, that's a benefit they would get that would allow them to make better products."

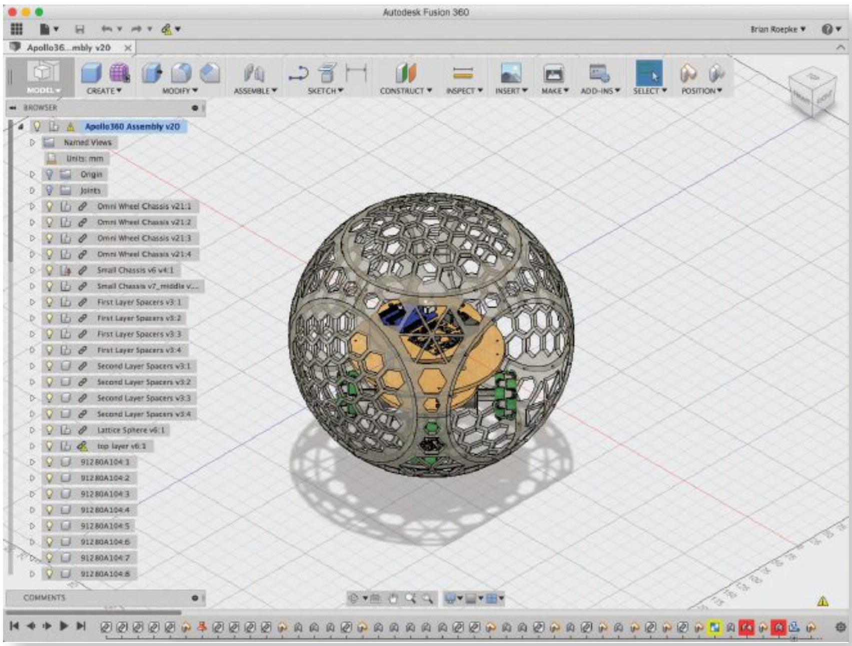
The Autodesk SeeControl platform allows users to build a data model of a physical object. Autodesk can also use live sensor data that can be attributed directly on the object representing the sensor on a 3D model.

"Users can walk through a machine or complex product and really investigate what is happening with it, and to it," Roepke says. "Many of us are visually inclined, so this is what we think of as the ultimate digital twin for the engineer. It helps quickly spot trends and patterns in how a machine performs."

At Siemens PLM Software, the digital twin is built in Teamcenter using NX CAD, NX CAE and the LMS portfolio for simulation. The company's new Polarion solutions support development of embedded software. Teamcenter Manufacturing and Manufacturing Engineering solutions are used to build the digital twin of the



Autodesk SeeControl allows users to build a data model of a physical object. *Image courtesy of Autodesk.*



With future integration of SeeControl, Fusion 360 users will be able to make design decisions based on real-world data. *Image courtesy of Autodesk.*

actual production system that will be used to produce the product.

Improving Design and Service

There are already a number of practical applications of digital twins emerging in different industries. A designer can bring live operational data into the digital model to help make better decisions while creating next-generation products, similar to the way a Web designer uses analytics to adjust the webpage UI (user interface) based on actual user experience patterns.

"By utilizing real world performance information, an engineer can optimize his or her designs based on how a product was actually used as opposed to the documented requirements that were assumed when the design first happened," Roepke says. "Most product engineers never get to see how their creations operate in the real world in real time — if at all."

The technology can also be used to accelerate and improve iterative design. For example, Autodesk and media company Bandito Brothers collaborated on the Hack Rod, which used artificial intelligence, sensors and machine learning to design a "perfect" car. The project leveraged Autodesk's reality capture technology, gathering data from laser scanning, photography and sensors to build 3D models. The team used a prototype vehicle chassis to gather data about the forces on the chassis, and then plugged that into the Autodesk Dreamcatcher design software. Dreamcatcher then generated a design for the new chassis based on that data.

Service and maintenance also stand to gain from digital twins. Transition Technologies recently demonstrated a solution that combines PTC Windchill PDMLink, PTC Servigistics, ThingWorx and the Vuforia augmented reality platform PTC recently acquired. The system combines CAD, PLM (product lifecycle management) and SLM (service lifecycle management) data with the ThingWorx IoT platform. Vuforia then visualizes the technical and service information using live sensor readings. It's a service application that provides detailed MRO steps and real-time feedback from the device itself during the repair.

A New Approach to Simulation

Digital twins represent a new and more efficient way to test products. Siemens' Leuridan says that in industries such as automotive, digital twins enable time and resource optimization when it comes to testing. "For design engineers, it implies that they will have to collaborate much more across multiple applications and domains, and thus throughout the different stages of the development cycle," Leuridan says. "Fortunately for them, a common platform will allow them to do so. They will still

National Instruments' hardware-in-the-loop technology combines physical testing and simulation to ensure that systems will behave as expected prior to actual field testing. *Image courtesy of National Instruments.*

have their specialization, but they will be able to work with more accurate input, or within more realistic boundary conditions. They will be more effective and also gain more insight into their work considering the bigger picture."

The technology will also improve traditional simulation by providing real-world data to enhance simulations. "You are simulating the product based on how it is actually being used," Campbell says. "It adds more value to the whole simulation story."

Autodesk, for one, plans to surface the data from its SeeControl product into the Fusion 360 CAD/CAM/CAE platform so that users can take real-world performance data and use it in new designs. "Think about the physical forces on construction equipment or maybe the operating temperature in electronics," Roepke says. "If you knew exactly how hot something ran or the max and average loads of a front loader across all real-world uses globally, how much better would your simulations be?"

National Instruments' Reding says that there has been interest in the energy industry in this type of simulation for testing smart grid controllers. "Another area is in appliances and white goods," he adds. "Washers and dryers have embedded control systems. Designers can find defects in the software before it's deployed, which can save a significant amount of money when it comes to recalls or brand damage. It also provides improvements in development time and reductions in cost."

Manufacturers can also use these platforms to provide performance data to their own customers as a value-added service. Autodesk is offering SeeControl as a white labeled solution for manufactures that would otherwise have to spend a lot of time and money developing their own platform. "This reduces cost and risk, as well as dramatically decreases the amount of time it takes to get a solution to market — from years to weeks," Roepke says.

Too Much Data?

Companies utilizing digital twins beyond the testing/simulation phase will face data management challenges as they attempt to turn feedback from products into actionable intelligence for design. "This is truly a Big Data challenge," Roepke says. "A large piece of industrial mining equipment could generate up to 80GB per machine per day. That starts to stress the edges of networking technology. You start to look at processing that data on the machine instead of sending it all to remote servers to churn through."

In other cases, though, digital twins would leverage other existing data sources, which would mitigate the data management issue. "Our approach wouldn't replicate PLM or virtualization or service information," Campbell says. "You integrate with those systems via ThingWorx, and make the data available again, depending on the various use cases. You shouldn't think of this as creating a lot of duplicative data that has to be aggregated. The digital twin doesn't need to include every single piece of data about a product. It just needs to include information that is relevant."

With major PLM and design software vendors investing heavily in the technology, digital twins — by any name they're called — will have an impact on simulation and testing. The continued expansion of "smart" products and sensor-laden vehicles and components will make it even easier to create these digital doppelgangers. **DE**

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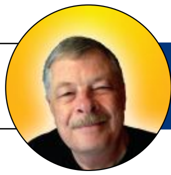


Multi-Layer Integration for the IoT

The Internet of Things (IoT) marks the latest stage of the sensor's evolution. This metamorphosis began with the sensor taking the form of a stand-alone, passive analog device and culminated with it becoming a critical element of a smart, mixed-signal system. The intelligence of these systems springs from the integration of data gathering, processing and communications. For the design engineer, this means meshing the analog, digital, MEMS (micro-electro-mechanical systems), and RF (radio frequency) design domains, which requires not only bridging the gap between the analog and digital worlds but also streamlining the design flow between the CMOS (complementary metal-oxide semiconductor) and MEMS environments.

The fundamental differences among these domains make the testing and verification of the designs one of the primary obstacles to bringing IoT devices to market quickly. What design engineers need now is a new set of design tools.

What design engineers need now is a new set of design tools.

Interfacing the Analog and Digital Worlds

One area in need of tools: The design of complex mixed-signal systems. Concurrent verification of the analog and digital portions of a design has proven to be a major challenge. Mixed-signal design environments, however, have evolved to support true mixed-signal simulations, using event-based digital simulators and analog solvers to verify complete mixed-signal systems on chip. Even so, verifying top-level mixed-signal systems can be a problem because of the time it takes to run analog simulations, and all too often, this prevents design teams from getting chips into production on time.

Design packages like Cadence's mixed-signal platform hope to address this issue using metric-driven, mixed-signal verification and standardized flow methodologies for generating and tracking verification coverage. This brings assertion-based verification to mixed-signal designs using automated analog behavioral modeling. The other piece of Cadence's solution lies in its support of behavioral models of the analog portion of the designs, using Verilog-A or Verilog-AMS with real-number models.

To streamline the process of generating behavioral models, Cadence offers a schematic model generator that produces analog/mixed-signal behavioral models using a schematic-like representation. Designers can take the schematic view and generate the behavioral model in Verilog-AMS.

Working with MEMS

The design of MEMS devices also presents unique engineering challenges when it comes to integration with CMOS-based platforms. Engineers have to wrestle with issues like nonstandard fabrication processes, multiphysics interactions and packaging requirements. To make matters worse, traditional EDA (electronic design automation) tools simply do not have the resources to take on these challenges. This disconnect between the CMOS and MEMS design processes inevitably results in much longer development cycles.

MEMS designers have traditionally relied on the time-consuming and costly build-and-test approach. With the emergence of the IoT, developers of MEMS design automation software have adopted a view of integration that includes the processes required to combine MEMS with CMOS electronics. To this end, MEMS design software must deliver models compatible with the tools of choice for electronics design, such as MathWorks' MATLAB and Simulink, and the Cadence Virtuoso suite.

An example of this can be seen in Coventor's MEMS design platform. MEMS+6.0 offers second-generation model reduction, with the ability to export to MathWorks Simulink or the Verilog-A format. The resulting reduced-order models promise to simulate nearly as fast as handcrafted models, but far more accurately. This enables system designers to incorporate nonlinear MEMS device models in their system- and circuit-level simulations. Coventor has simplified the inputs for model reduction, and the platform automatically includes critical dynamic and electrostatic effects. In addition, MEMS+6.0 includes an expanded MATLAB scripting interface for design entry and simulation control.

With Coventor's software, MEMS designers can combine ASICs (application-specific integrated circuits) and MEMS devices for full MEMS and IC (integrated circuit) simulation, producing a 3D model from the simulations augmented with details from FEA (finite element analysis). Designers can also run system simulations in the MATLAB/Simulink environment and perform co-simulations of sensor structure and sensing electronics by importing the MEMS+ model into Cadence Virtuoso.

Just the Beginning

While tools for analog, mixed-signal and MEMS design integration have begun to meet the needs rising from the emergence of the IoT, they are just that — a beginning. Design automation software vendors and fabrication process developers have miles to go before they sleep. **DE**

This commentary is the opinion of **Tom Kevan**, *a freelance writer/editor specializing in engineering and communications technology. Contact him via DE-editors@deskeng.com.*

by Emil Berthelsen /// IoT

How Enterprise IoT Changes Product Design

Enterprise IoT has emerged as a highly disruptive and transformational development for most industries. Enterprise IoT is all about smarter, connected industrial devices and products, capturing, sharing and processing data about the environment, and integrating this processed information in enterprise architectures and systems with the aim of producing real-time actionable insights and ultimately automated responses.[1]

Looking back, machine-to-machine (M2M) connections have predominantly been implemented by operational departments in enterprises. Through these connected sensors, operational performance could be monitored and managed. In IoT, this level of "connectedness," as illustrated in Fig. 1, extended from operational environments to include other forms of products such security systems, asset tracking devices, manufacturing tools, thermostats and/or field force solutions.

The scope has, unsurprisingly, moved from mainly operations to other key departments and business units such as product design, customer services and marketing. IoT, through continuous data connections, provides product designers with a host of new and exciting product and service innovations including:

- new product design process capabilities with augmented reality technologies;
- continuous monitoring of the usage, condition and quality of products;
- immediate product feedback;
- new pricing models and new value added service models;
- enhanced product and service lifecycle management; and
- closer interaction with end users.

Let's look in greater detail at several of these.

New Product Design Process Capabilities

Product designers will be acquainted with designing products with CAD solutions. Through these time-saving and highly flexible software tools, product designers have been able to create virtual prototypes, or at least define the necessary build of materials to complete the product. With IoT, this process remains the same but where the CAD solution stopped — and the physical product became a reality — we are now witnessing the next stage in product design.

Having "designed" the product virtually, it now goes into production as well as having a digital twin created for every single physical product. This digital twin, connected to its physical twin through IoT connections, provides real-time information about the usage, condition and quality of the product, and may be monitored, analyzed and acted upon by product designers as soon as the product has been activated.

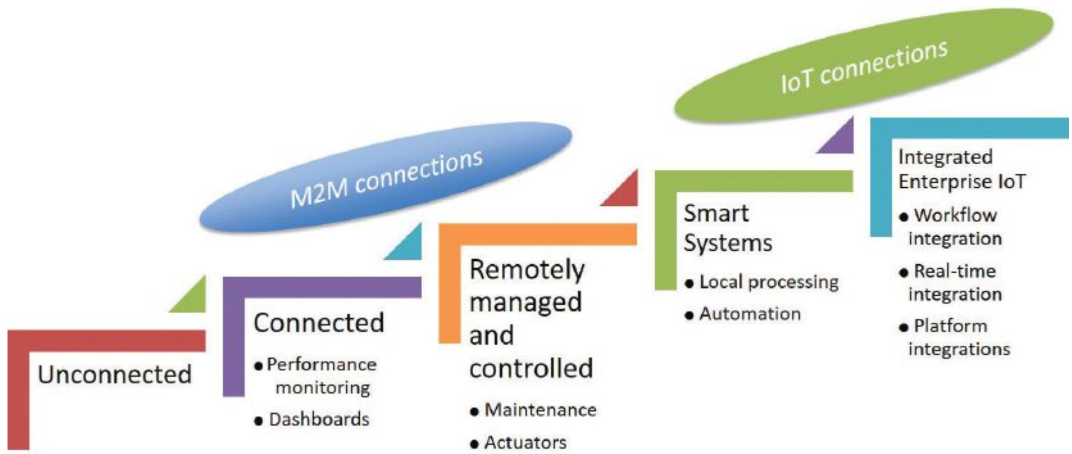


FIG. 1: From M2M to IoT connections: characteristics at each technology step. *Image courtesy of Machina Research.*

FIG. 2: Digital twin through the Vuforia Augmented Reality solution. *Image courtesy of PTC.*

Optimizing this real-time feedback of information, product designers are further able to enhance the analysis and interpretation of this data. One example is the adoption of augmented reality technologies that combine the digital twin (representation) of the physical product with augmented data information visually adhered to the product.[2] Fig. 2 illustrates the use of augmented reality technology on a physical product.

The opportunities from this connected product design space remain substantial. From immediate product feedback enabling enterprises to improve product design based on actual end-user usage, to identifying and addressing product faults before requiring significant product recall routines. Further enhanced with predictive analytics tools such as predictive maintenance, product designers as well as their customer service and operational colleagues will identify new and exciting opportunities from Enterprise IoT.

Exploring New Pricing Models and Value Added Service Models

As Enterprise IoT opens these new opportunities for product designers in the "physical" and design process sense, Enterprise IoT further enables a host of new possibilities in terms of pricing models and creating new services.

With real-time usage and condition information constantly available to manufacturers, products may be sold as services — priced on the basis of usage and condition of the product, and ultimately managed with reduced downtime, higher performance and improved safety parameters (through constant product monitoring). There may be new opportunities for more detailed and part specific warranty management, or for new trade-in models based on detailed condition management systems.

Enhanced Product and Service Lifecycle Management

And finally, with Enterprise IoT, product design needs to become a significantly more open and dynamic process, combining hardware and software. In hardware product design, improvements or replacements of models are key. In software product design, enabling updates and fixes are key. In Enterprise IoT with connected products, these two design processes will need to be combined. Traditional product designers will need to look at and plan for the extended lifecycles of the products and the associated services, and one of the most interesting developments with Enterprise IoT will be this merger of hardware and software designers.

Enterprise IoT is a disruptive technology and market force. Connected products with services are transforming industries and changing markets. Enterprises are actively going down this road, and product designers standing still or turning their backs on this transformation will find it challenging, if not impossible, to compete with this "next wave." **DE**

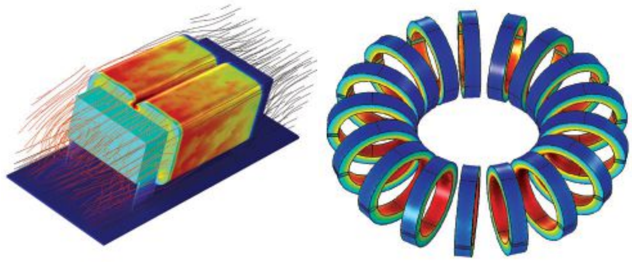
Emil Berthelsen *is a principal analyst at Machina Research (machinaresearch.com), leading the Enterprise IoT stream, and focuses on Big Data, data analytics, M2M and IoT Platforms and SLAs.*

1. For more information about Enterprise IoT, read Machina Research Strategy Report "Defining and implementing your Enterprise IoT strategy," September 2015

2. For a more detailed example of this new development of digital twins, see Machina Research's Research Note on "Digital twins bring IoT full circle within manufacturing design," November 26, 2015

CHAPTER 8 EXCERPT

Simulation Successes



Simulation of an air-cooled DC choke where temperature distribution and velocity streamlines are shown (left). Magnetic flux density in a toroidal choke (right). *Images courtesy of BLOCK Transformatoren-Elektronik.*

Throughout *The Design Engineer's High-Performance Computing Handbook*, we've covered the basic concepts, theories, industry statistics and hardware that support HPC. However, the best way to show the impact and versatility of these systems is through real-world applications. As the technology becomes more developed, and technology such as the cloud makes HPC more accessible, engineers will be able to leverage more processing and simulation power throughout the design process.

In this chapter, we've compiled five use cases so you can see how engineers benefit from simulation-led design:

1. BLOCK Transformatoren-Elektronik

A manufacturer of coiled products that are used in a variety of industries, especially for electronics applications, BLOCK expanded simulation resources with COMSOL Multiphysics and HPC. The company can run its simulations on a multicore workstation with no limit to the number of cores, as well as on a cluster with no limit to the number of compute nodes. This offers them improved efficiency regardless of whether a simulation is run on a workstation or a cluster; their R&D team can now quickly deliver the best products to customers.

"I'm currently using a cluster with 22 cores and 272GB of RAM and I can easily run my simulations remotely on it," says Marek Siatkowski, who is responsible for all of BLOCK's simulation activities. "COMSOL supports distributed memory computing where each node of a cluster can also benefit from local shared memory parallelism; this means that I'm getting the most out of the hardware available."

2. Pinnacle Engines Looks Into the Flames

Tony Willcox, director of simulation and controls at Pinnacle Engines, can gauge an engine's average performance characteristics such as torque, power, fuel flow and emissions via testing, but Willcox and the simulation team at Pinnacle Engines are also interested in what they cannot see or measure.

"There are things we can't measure in a test, but can mimic in simulation," Willcox says. "For instance, we could turn off heat transfer to see what the engine's efficiency would be without heat loss in the cylinder. Or we could turn off the leakages through the piston rings. With these options, we can better understand the impact of different factors on our design."

Pinnacle Engines' choice of software is CONVERGE CFD from Convergent Science. "When we need an answer, we need it in a matter of days," says Willcox. "We can't wait for weeks. There are too many parameters to sweep, so even if we had the hardware, we wouldn't be able to investigate all of them." Unless the design parameters can be calculated in parallel.

The answer is on-demand computing infrastructure, specifically designed for Design of Experiments (DOE)-type simulation. The answer, in this case, also turned out to be just 40 miles away from Pinnacle Engines' San Carlos, CA, headquarters. San Francisco-based Rescale, a cloud simulation supplier, offers a scalable on-demand platform — a combination of software and hardware — for those seeking to do precisely what Pinnacle Engines wants to do. The company makes its solution directly available in the web browser. It also has a partnership with Convergent Science, which simplifies acquiring additional licenses for parallel simulation runs.

3. UberCloud Team 171's Dynamic Study on Frontal Crash of a Car

Crash testing requires a number of test vehicles to be destroyed during the course of physical testing, which is time consuming and uneconomical. An efficient alternative is virtual simulation of crash testing with crash tests performed using computer simulation with finite element (FE) methods.

One study by an UberCloud team focused on the frontal crash simulation of a representative car model against a rigid plane wall. The computational models were solved using the FE software LS-DYNA that simulates the vehicle dynamics during the crash test. The cloud computing environment was accessed using a VNC (virtual network computing) viewer through a Web browser. The 40-core server with 256GB RAM installation was at Nephoscale, a cloud computing host. The LS-DYNA solver was installed and run on an ANSYS platform with multi-CPU allocation settings.

The representative car model was traveling at a speed of 80 km/hr (49.7 mph). The effect on the car due to the frontal impact was studied during which component to component interactions were analyzed and car impact behavior was visually experienced.

The LS-DYNA simulation was performed to evaluate the damage caused in the car assembly when it impacted with velocity against a rigid wall. The car was travelling at an average speed of 80 km/hr (49.7 mph). The following plots highlights the damage caused on the car.

The impact study on the car was carried out in the HPC environment, which is built on a 40-core cloud server with CentOS Operating System and LS-DYNA simulation package and is running on an ANSYS platform. The HPC performance was evaluated by building the simulation models with different mesh densities that started with a coarse mesh that was transformed into a fine mesh that had 1.5 million cells in the simulation model.

The advantage of the HPC cloud resource is that it increases the power of LS-DYNA to solve the simulation model in a shorter run time. The use of the HPC cloud has enabled simulations that include complex physics and geometrical interactions. The problems posed by these categories require high computing hardware and resources that are not possible using a normal workstation.

4. Farr Yacht Design

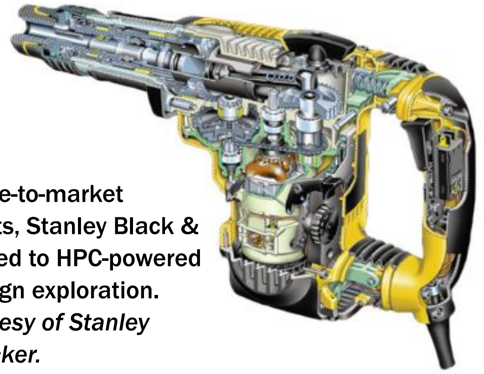
One of the top racing-yacht teams in the world, Farr Yacht Design collaborated with Penguin Computing and NUMECA on the company's extensive simulation needs.

"Because of the huge number of data points and the hundreds of runs required, if we had been running the NUMECA FINE/Marine CFD software exclusively on our inhouse HPC cluster, it would have taken us over six months," says Britton Ward, vice president and senior naval architect at Farr. "By being able to access POD (Penguin on Demand), we got our results in six weeks," he comments.

POD provides a persistent and secure compute environment designed specifically for HPC. Jobs are executed directly on physical systems and all systems are connected through a low latency QDR InfiniBand fabric for optimal application scalability. POD provides Farr with access to needed computational resources when the company's internal cluster, consisting of a number of standard x86-based servers, cannot provide the compute power needed to run complex simulations often involving computational fluid dynamics (CFD) and finite element analysis (FEA).

5. Stanley Black & Decker Optimizes Designs

Known for its tools, Stanley Black & Decker (SBD) is a diversified global provider of hand tools, power tools and related ac-



To meet time-to-market requirements, Stanley Black & Decker turned to HPC-powered CAE for design exploration. *Image courtesy of Stanley Black & Decker.*

cessories, mechanical access and electronic security solutions, healthcare solutions, engineered fastening systems, and more. When it came to optimizing a hammer mechanism design for their top-selling rotary hammers, SBD engineers knew they needed a computer-aided engineering (CAE)-based approach.

"Optimization by CAE is the only realistic way to achieve this; the requirements are just too complex to rely on experience based knowledge or pure physical testing," says Andreas Syma, director of Global Computer Aided Engineering at SBD. Previously SBD had been using workstations and CAE software with an optimization runtime of about three weeks, but Syma's goal was to reduce that to a weekend.

Altair introduced SBD to HyperWorks Unlimited, a fully managed HPC appliance for CAE. This turnkey appliance includes pre-configured HPC hardware and software, with unlimited use of all HyperWorks applications plus PBS Works for HPC workload management. SBD chose a 160-core HyperWorks Unlimited system, which Altair delivered and installed in just a few days. "The system just works," says Syma. "It's bringing up our utilization with no performance or maintenance issues to date."

Learn More

To learn more about mobile, desktop and cloud-based engineering computing options, download *The Design Engineer's High-Performance Computing Handbook,* which has just been updated with two new chapters. The full version of chapters 8 and 9 include more details on each of the simulation success case studies mentioned here, as well as a full explanation of how Intel and its partners are working to bring the power of supercomputing to more companies.

This free resource, brought to you be *DE* in partnership with Intel, is available at hpc.deskeng.com/download.

CHAPTER 9 EXCERPT

Opening Up HPC

Big names in hardware and software join together under the OpenHPC banner to democratize supercomputing.

Initially, high-performance computing (HPC) was exclusive to research institutions, government agencies, and large enterprises. It was the arsenal for climate analysis, genomic sequencing, and the search for intelligent life in the universe. Most small and medium businesses (SMBs), however, didn't engage in such ambitious projects. They didn't need the aggregated firepower from a server cluster. Nor did they routinely generate, store and examine terabytes of data. Professional workstations with robust processors and generous memory proved more than adequate for most operations. For them, HPC ownership and the associated IT responsibilities were more a burden than an advantage. If the need for HPC did arise due to special circumstances, they might approach a larger organization or a research facility for access to a cluster, perhaps for a nominal fee.

But the Internet of Things (IoT) is ushering in a new era. With the rapid growth of connected devices, Big Data is no longer a headache confined to big companies. It's now everyone's challenge.

With the capacity for massively parallel computation jobs, HPC is a natural fit for the Big Data problem. But implementation of HPC still proves a barrier to entry, even for those who're willing to bite the bullet and procure the necessary hardware. HPC management tools — especially the software components — were initially developed for large enterprises with big budgets and long lead times. SMBs need inexpensive — preferably free — tools that can get them up and running in a short timeframe. This has recently produced a flurry of HPC-related activities in the open source community. One of them is the Open HPC Collaborative Project, described as an initiative "to aggregate a number of common ingredients required to deploy and manage High Performance Computing (HPC) Linux clusters."

Unifying Open Source HPC Stakeholders

On November 12, 2015, just days before the Supercomputing 2015 (SC15) Conference, OpenHPC came online. The Linux Foundation announced, "For more than four decades, HPC has been used by universities and research centers for large-scale modeling and calculations required in meteorology, astronomy, engineering and nuclear physics, data sciences, among others. With unique application demands and parallel runtime requirements, software remains one of the biggest challenges for HPC user adoption … OpenHPC will provide a new, open source framework for HPC environments. This will consist of upstream project components, tools, and interconnections to enable the software stack."

Participants in the project pledge to:

- Create a stable environment for testing and validation
- Reduce costs
- Provide a robust and diverse open source software stack
- Develop a flexible framework for configuration

In the Open Source community, codes, plug-ins and software tools tend to develop and mature organically over time based on input and contributions from users. OpenHPC founding members expect their collaboration will avoid certain conflicts and duplication of efforts.

Open Source Momentum and Commercial Prospects

Linux, a champion of the open source movement, might have kicked off the project, but the current member roster features a long list of commercial software developers and systems providers, most notably Intel.

"We're entering a new era in which supercomputing is being transformed from a tool for a specific problem to a general tool for many," said Charlie Wuischpard, vice president and general manager of HPC Platform Group at Intel in a press release. "System-level innovations in processing, memory, software and fabric technologies are enabling system capabilities to be designed and optimized for different usages, from traditional HPC to the emerging world of big data analytics and everything in between."

Intel-supported versions of the open source HPC system software stack are expected to be available next year. Simulation software makers ANSYS, Altair, MSC Software, and Dassault Systemes are also participating in OpenHPC. So are leading hardware makers Dell, HP, Lenovo, and Fujitsu. Research giants Oak Ridge National Laboratory, Lawrence Livermore National Laboratory, and Dandiao National Laboratories round up the list.

Wim Slagter, director of HPC and cloud marketing at ANSYS, said, "While our engineering simulation software is optimized for HPC performance, many of our engineering customers are still slow to adopt HPC. The OpenHPC initiative enables them to reduce risk and to save valuable time with specifying, deploying and managing HPC systems."

The appeal of open source HPC is not lost on these commercial vendors. If Open Source lowers the barrier of entry for HPC, simulation software vendors stand to gain from the increase use of HPC-driven simulation. Large-scale simulation of complex systems is the a standard feature of aerospace and automotive design workflow; however, if HPC were easier to procure and deploy, other industries, such as consumer electronics and medical equipment, may follow suit, thus expanding the simulation software market. Hardware makers like Dell, HP, Lenovo, and Fujitsu have also made considerable efforts to bolster their HPC offerings, all in anticipation of HPC uptake beyond the top tier.

Jim Ganthier, Dell's VP and general manager of engineered solutions, cloud and HPC, said, "Community investment in open source frameworks and open standards is the right way to ensure the right capabilities are available to a growing HPC community. The new OpenHPC effort will greatly accelerate HPC adoption, productive usage, and innovation."

Scalable HPC

The cornerstone of Intel's strategy to capture the HPC market is its Scalable System Framework (SSF). Intel writes, "HPC has reached an inflection point with the convergence of traditional HPC and the emerging world of Big Data analytics. Intel's SSF enables an unprecedented level of system balance, performance, and scalability necessary to meet the demands of both compute- and data-intensive workloads."

The fabric component is Intel's Omni-Path Architecture (OPA), described as "an end-to-end fabric solution that cost-effectively improves the performance of HPC applications for entry level to large-scale HPC clusters" in Intel's announcement. Intel writes, "Current standards-based high performance fabrics, such as InfiniBand, were not originally designed for HPC, resulting in performance and scaling weaknesses that are currently impeding the path to Exascale computing. Intel Omni-Path Architecture is being designed specifically to address these issues."

Intel estimates that "OPA's 48-port switch enables up to 26% more servers than InfiniBand Enhanced Data Rate within the same budget and up to 60% lower power consumption for a more efficient switch and system infrastructure."

Intel OPA is currently deployed at the Texas Advanced Computing Center and the Pittsburgh Supercomputer Center. In the first quarter of this year, Colfax, Cray, Dell, Fujitsu, Hitachi, Lenovo, NEC, SGI, Sugon, Supermicro and other system providers are expected to begin shipping OPA-based HPC products.

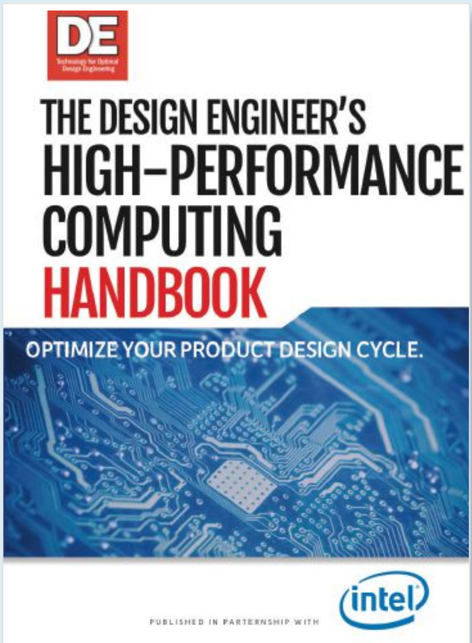
Learn more by downloading the complete chapter as part of *The Design Engineer's High-Performance Computing Handbook* at hpc.deskeng.com/download.

How the HPC Handbook Works

The Design Engineer's High-Performance Computing Handbook is a multimedia resource consisting of magazine article excerpts; the hpc.deskeng.com website that is full of videos, case studies and research; e-newsletters; and regularly released chapters that are free to download. Once you download a chapter, you'll be alerted when new chapters are ready. Each chapter takes a detailed look at a computing topic important to design engineers. The chapters include pictures, charts, definitions and links to additional information.

The HPC Handbook site is the hub of information for high-performance computing in design engineering. The HPC Handbook is available for download on the site, and the site is constantly updated to include the latest HPC educational resources that are pertinent to design engineering teams. It is divided into sections on Workstations, Clusters/Servers, Cloud Computing and Software, each of which contain the best information available on the Web from *DE* and beyond.

Check it out at hpc.deskeng.com.



MCAD and ECAD: Don't Throw It Over the Wall!

Connected devices redefine today's MCAD-ECAD co-design protocols.

BY KENNETH WONG

Gotta get all the air out! It's a mandate that Craig Armenti and his colleagues at Zuken have heard time and time again. In the era of smaller, lighter connected devices, wasted space is the greatest design sin. Conversely, the ability to pack all the necessary electromechanical components in the smallest possible space is a feature of optimal design. Therefore, in the way a device's housing unit and its internal circuits fit together, the room for error is much smaller — quite literally.

"Look at your mobile phone or the thermostat on your wall," says Armenti, applications engineer at Zuken. "More and more components are going into it. Your thermostat probably has Wi-Fi now."

In the past, the MCAD-ECAD collaboration headache was a simple communication problem: To come up with a neutral file format that lets each discipline transmit its respective design to the other. But to design a connected device, where the outer shell and the internal parts must fit like hand and glove, the two sides must work together closer than ever before.

Looking for a New Language

A format like IDF (intermediate data format), which is supported by most industry-standard software from both sides, removes the communication barrier between MCAD and ECAD disciplines, but many experts feel a new lingua franca is needed.

"The industry has matured in many ways, but the formats we've been using to exchange information with ECAD haven't really kept up. In the past couple of years, we've had some good interaction with MCAD and ECAD vendors to develop a standard called EDMD," says Ashley Eckhoff, senior product manager for NX at Siemens PLM Software.

EDMD (electrical design mechanical design) is a protocol championed by ProSTEP iViP, an international association that develops and defines standards for product data management and virtual product creation. "It's actively maintained, so we meet with other CAD and ECAD vendors monthly or bimonthly to develop it to include what the modern designers need," says Eckhoff.

"The technologies and design methodologies are changing very quickly, but IDF/IDX (incremental data eXchange) hasn't really morphed fast enough. We'll continue to support them, but we also work with ECAD companies to directly support custom standards," notes Lou Feinstein, senior portfolio manager at SOLIDWORKS.

SOLIDWORKS also plans to support the emerging EDMD format. "I actually sit on the board for EDMD at ProSTEP iViP," says Feinstein.

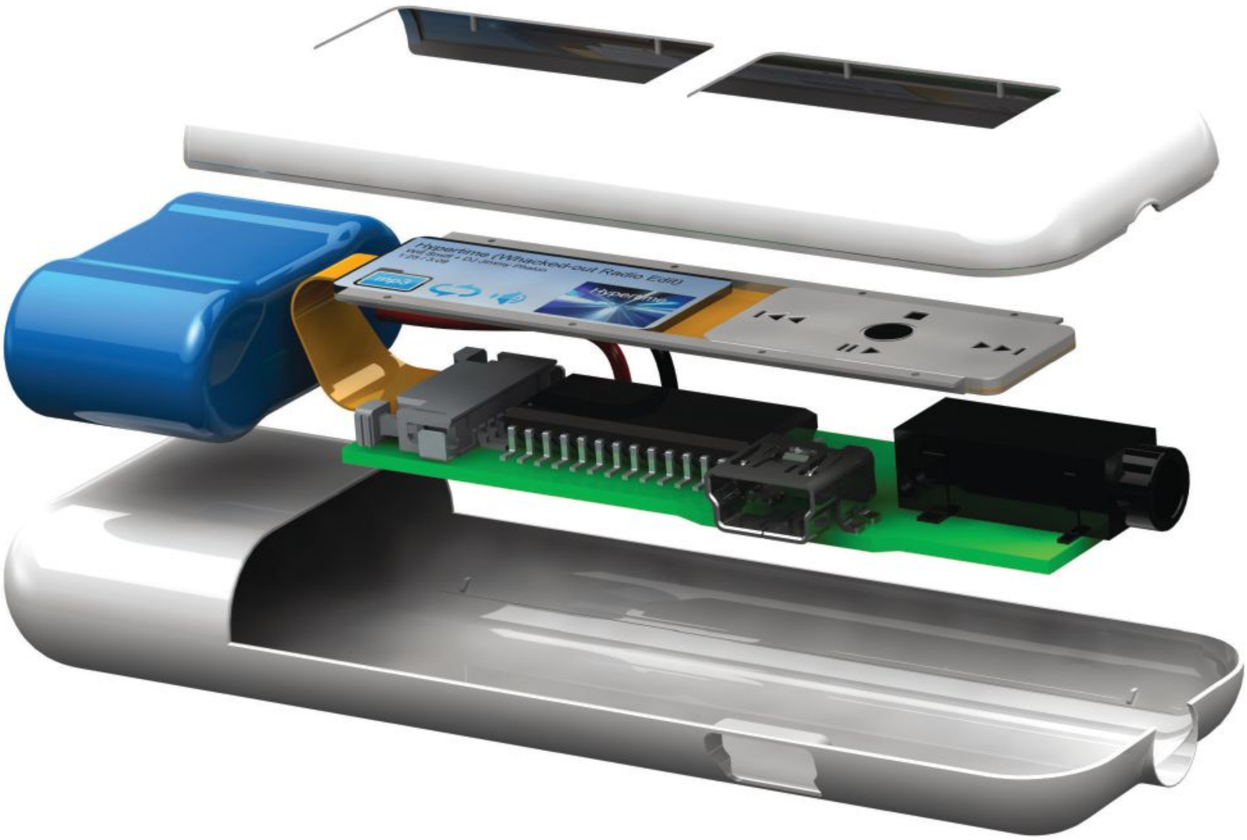
The Hot Topic

The connected devices of the IoT (Internet of Things) era are more than functional equipment. They're usually marketed as wearable gadgets that also double as fashion accessories (for example, smartwatches and wireless headsets). Because they're usually in close contact with the user's skin, the heat generated by the internal circuits is a critical consideration.

John Wilson, electronics product specialist at Mentor Graphics' mechanical analysis division focuses on thermal and airflow analysis of PCBs (printed circuit boards). His software arsenal includes FloTHERM, FloEFD and FloTHERM XT — CFD (computational fluid dynamics) packages from Mentor Graphics.

"The thermal design for a consumer product is not like a piece of hardware sitting in a server room. You certainly don't want the users wearing it to burn themselves. You don't even want them to think it's getting warm, because that's generally perceived as a defect or a flaw. They may call the manufacturer for replacement or to return it," observes Wilson.

The usual solution to eliminate hotspots, Wilson says, is to isolate the heat-generating component or to distribute the heat across a larger area. "In these devices, the mechanical shape is critical to the thermal performance of the device. Nobody cares about the shape of the chassis of



Even consumer electronics as simple as MP3 players can contain both rigid and flexible printed circuits, requiring tight cooperation between the MCAD and ECAD design teams. *Image courtesy of Siemens PLM Software.*

something sitting inside a server room, but the shape matters in consumer goods, and small tolerances make a huge difference in them. It's even more important for the electronics designer to work closely with his or her mechanical counterpart," he says.

Presenting the analysis results to clients and management teams, who are often nontechnical, also requires some tact, Wilson learned. When conducting software-driven analysis, engineers tend to remove minor details (like rounded edges and holes) that don't make a difference in the simulation. But that could make the analytical model look significantly different from the original product design in the screenshots and animation clips showing the simulation results.

"I learned that, even if certain design elements are irrelevant to the product's thermal performance, I should retain their geometry because they [the clients] are more likely to trust what I'm proposing if they recognize the product from its shape," says Wilson.

In the mechanical CAD industry, ANSYS is better known for its simulation and analysis products, but among electrical CAD designers, the company is known for ANSYS Icepak, a CFD package to simulate heat transfer and fluid flow inside integrated circuit (IC) packages. Icepak is based on an ANSYS Fluent solver. It's one of the products used by electronics and electrical engineers to develop cooling strategies. Such products are expected to become a critical part of the design workflow in the era of IoT.

The Origami Printed Circuit Board

Outsiders might not be aware of it, but in the PCB industry, flexible boards — PCBs designed with bendable plastic substrates — have emerged as an alternative to the traditional rigid boards. Their appeal comes from the ability to fit into tight corners and conform to oddly shaped products. Insiders refer to them as "origami boards."

"Camera companies have become the masters of PCB origami," says SOLIDWORKS' Feinstein. "The cameras have become really small, and a lot of circuits have to fit inside them. Even in cellphones, there are multiple circuit boards that are folded. So what you see is electrical design that's mechanical in nature. That adds new complexity."

The need for these flexible boards is not only seen in hardware design — it's prompting new software capabilities. "Flexible boards are so common that they prompted a significant investment to our ECAD module in the PTC Creo 3 Release to support them," says Brian Thompson, senior vice president of CAD, PTC.

Siemens PLM Software's Eckhoff points out: "They introduce new problems, like bend regions. The board flexes with certain operations, like opening and closing of a phone, so you can't place soldered components on the bend region."

"Consumer goods are usually defined by the enclosure, or the shape — not the board," says Zuken's Armenti. "So if there's going to be more than one board, usually [engineers] want to use a mix of rigid and flexible boards." Clearance for a rigid board is fairly straightforward, but figuring out the space constraint and thermal impact of a flexible board is much more complicated, especially when the bended board is expected to heat up the nearby mechanical features.

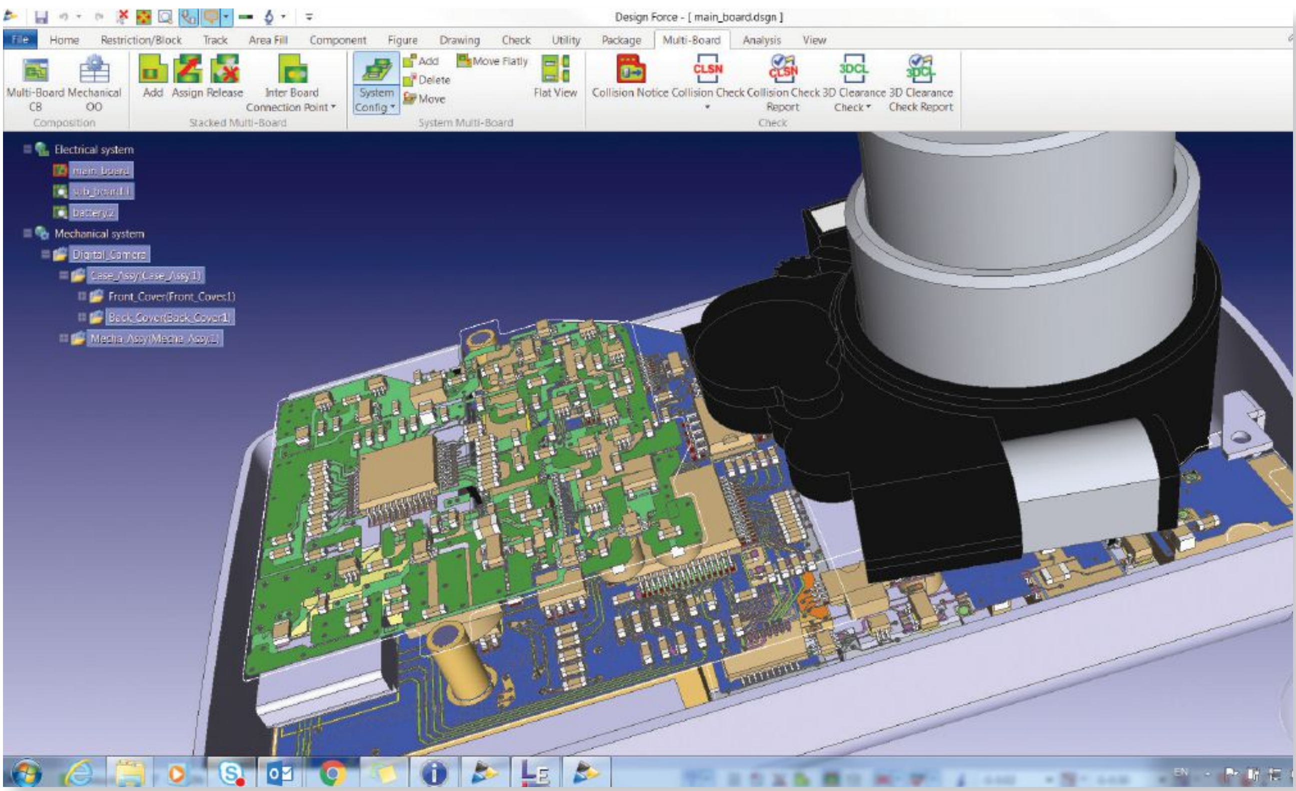
Previously, PCB designers could work efficiently in 2D space, in schematics representing the board layout, but the flexible boards demand a 3D workspace, with the option to visualize the boards both in flattened and folded states (as you would with sheet metal design). With its software CR-8000 already in 3D, ECAD developer Zuken is well positioned to tackle the flexible boards.

"As the designers try to get the air out of their products, they recognize that they need to be able to look at both [mechanical and electrical parts] simultaneously, look at the thermal characteristics together. They really need to be able to look at more than one board at a time, need to see things in 3D," says Armenti.

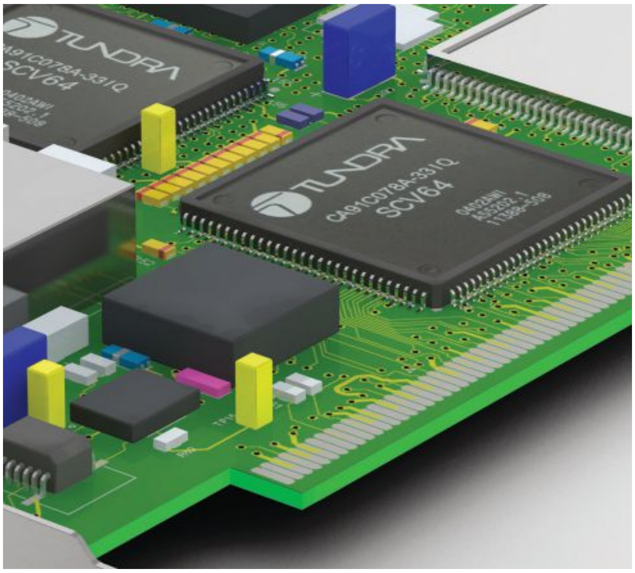
Embedded Software

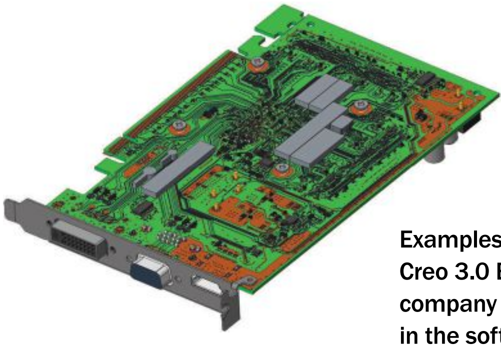
In most connected devices, software represents the invisible components — especially in IoT devices where software-triggered operations largely account for how a product works. "Verifying that the software will work correctly in conjunction with the hardware — that is a problem a lot of companies are struggling with," points out Dennis George, Teamcenter marketing manager at Siemens PLM Software.

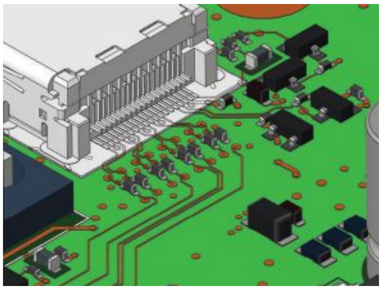
Over the years, PLM (product lifecycle management) software companies have had to include software management functions as part of the design workflow. Siemens PLM Software's Teamcenter can be used to manage software as a component of the project. For simulating software-triggered functions, its customers may turn to Siemens PLM Software's LMS, described as "model-based mechatronic simulation and advanced testing solutions." In anticipation



Zuken's CR-8000 Design Force supports displaying all three boards of a camera design along with the enclosure in an editable format. *Image courtesy of Zuken.*







Examples from PTC Creo 3.0 ECAD. The company has invested in the software to support flexible PCBs and struck partnerships with ECAD software developers to connect mechanical and electrical design disciplines via PTC Creo MCAD-ECAD. *Images courtesy of PTC.*

of the growing importance of software, PTC acquired the application lifecycle management (ALM) company MKS. Today, MKS' offerings are part of PTC's portfolio.

Building Bridges

CAD software developer PTC struck up partnerships with some ECAD software makers to jointly develop a bridge connecting the mechanical and electrical design disciplines. The outcome was the PTC Creo MCAD-ECAD Collaboration Extension (ECX), which allows the two sides to work in a shared environment.

"Not only can the design team better identify and resolve potential electromechanical issues, they can also record and manage the design change process more efficiently … PTC ECX is also compatible with popular electrical design software tools from Cadence and Mentor, and it's well suited to bridging the communication and collaboration challenges of geographically dispersed teams. Results include fewer errors, enhanced product quality and shortened product development time," according to PTC.

Siemens PLM Software offers NX PCB Exchange for Zuken, described as a plug-in that "provides direct data exchange between NX and Zuken's CR-5000 Board Designer." All these developments suggest the two sides' recognition of the need for closer collaboration and tools that accommodate bidirectional workflow with shared data — a departure from the previous way of doing things.

Erasing the Boundaries

Aside from the technology, territorial conflicts also tend to contribute to the MCAD-ECAD tension. "Most conflicts are about who owns what and which requirements get priority," notes PTC's Thompson. "Does form drive function? Or function drives form? The tension is a normal part of product development. Newer startups that specialize in consumer products tend to be much better at MCAD and ECAD teams working together."

In a specific project, MCAD, which defines the shape of the product, or ECAD, which defines the electrical inner organs, may take precedence. However, it's highly unlikely that one discipline can consistently dominate the other.

"The ECAD leaders are just as big as we are in their own space," says Siemens PLM Software's Eckhoff. "What we have now is cooperation between the equals. The good news is, in the past two or three years, I've seen an interest in the ECAD and MCAD vendors to cooperate to make the process much better."

SOLIDWORKS' Feinstein notes: "What I see is a unification of electrical and mechanical design. You can't throw the design over the wall like you used to." **DE**

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

INFO ➜ Cadence: Cadence.com

➜ **Mentor Graphics:** Mentor.com

➜ **PTC:** PTC.com

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

➜ **SOLIDWORKS:** SOLIDWORKS.com

➜ **Zuken:** Zuken.com

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

3D-Printed Electronics Charge Ahead

Small teams and big companies are developing a wide range of 3D-printed electronics applications.

BY PAMELA J. WATERMAN

Last year may have been the Year of Electronics 3D printing, as evidenced by activity with conductive inks, conductive plastics, conformal surface-deposition and multi-material 3D design. The building blocks for 3D-printed/3D structural electronics are popping up across a wide spectrum of cost and applications, from F-Electric conductive filament offered by Functionalize to direct-printed sensors made possible by Optomec's Aerosol Jet systems. This month, *DE* takes a look at grad students, individual innovators, system manufacturers and industry giants who are all contributing to this latest evolution in additive manufacturing (AM).

The 3D-printed BOOMcast was custom-created by FATHOM design studio to support Mike North's broken leg and supply electronic sensor information via Wi-Fi to North's doctor. As a bonus, the cast includes a Bluetooth sound system and LED sensor-feedback lights. *Image courtesy of FATHOM.*

The Mother of Invention

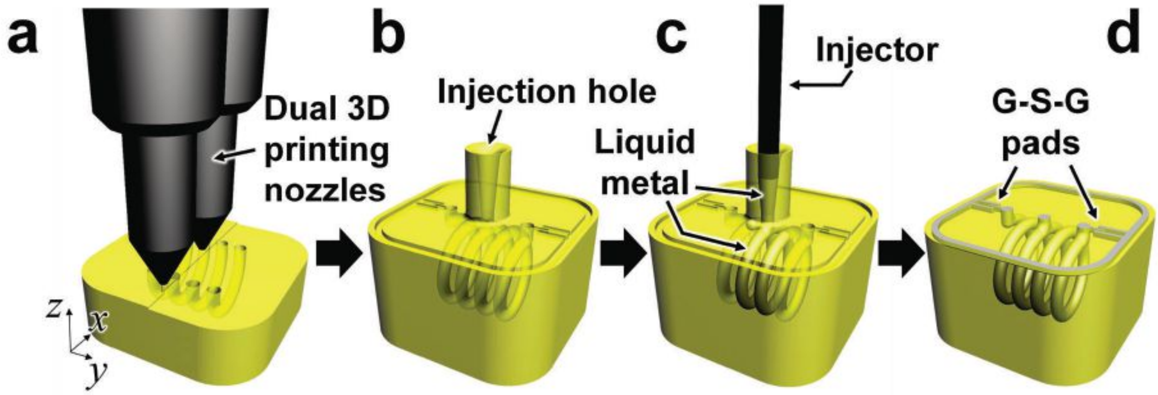
Sometimes the coolest product ideas come from everyday frustrations. How often do you grab a milk carton from the refrigerator and pour a glass, only to have the first sip tell you the milk is spoiled? That scenario inspired the SmartCap, a demonstration of 3D-printed sensor technology by Liwei Lin and his students at the Berkeley Sensor and Actuator Center at University of California, Berkeley.

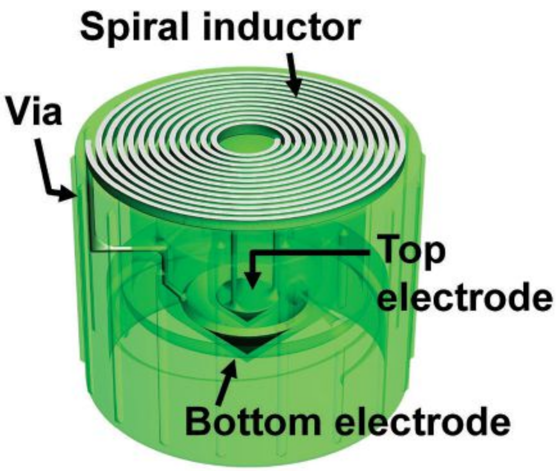
The proof-of-concept SmartCap (tested on a milk carton) was built on a dual-nozzle 3D Systems ProJet HD 3000, with alternating regions of polymer and sacrificial materials. By melting out the latter material and injecting the resulting tunnels with conductive metal paste that hardened, the team created an inductor-capacitor circuit with two electrodes separated by an air gap. Tilting the carton filled the gap with milk, whose dielectric constant determined the resonant frequency of the circuit as connected to a network analyzer. As the milk aged, bacterial growth changed the dielectric constant and shifted the measured frequency. Lin says the technology could have many applications in the health field.

Sensors embedded in 3D-printed parts have also played a key role in several additional projects aimed at medical applications. Affordable prosthetics is the goal of the multinational OpenBionics team. Recently they improved on their already successful open-source hand design by adding near-field communications (NFC)-ready fingers. Each finger is easily produced by a process termed hybrid deposition manufacturing (HDM). The novel HDM technique, proposed by Raymond Ma of Yale University, combines filament-based 3D printing (to create a mold) with casting of two-part urethane or resin epoxies. Individual fingers are cast from flexible material, and electronic components and wires are embedded during that process. Each finger can contain a different functional element, such as a force sensor, flex sensor or NFC tag, which could be programmed to interact with a touch-sensitive smartphone. This design was designated as a Hackaday 2015 award finalist.

Broken limbs served as another design stimulus. When scientist/TV star Mike North ("Outrageous Acts of Science") broke his leg, he asked the FATHOM Group of California to create a cast that would permit him to walk and travel with minimal inconvenience. FATHOM designers and engineers teamed up to 3D print the custom Boomcast, structured with adjustable clamps and loaded with electronics such as a gyroscope, accelerometer, magnetometer and force-sensing resistors. Combined, these sensors tracked leg movements and possible swelling, transmitting information via an embedded, Wi-Fi-enabled Intel Edison microprocessor. North received feedback via LED lights, and his doctor could also monitor the information to suggest more or less walking, or adjusting the fit of the cast. To increase the "cool factor," FATHOM integrated Bluetooth speakers controlled by a smartphone app.

Across the globe in Western Australia, Iain Murray and his team in the department of electrical and computer engineering at Curtin University have been working on a project with a related goal. To assist patients undergoing rehabilitation due to joint injuries or general mobility problems, the group 3D printed braces with embedded sensors that track acceleration and angular velocity due to movement. The information lets doctors know exactly how long the patient is doing an exercise as well as if the motion is being correctly performed.





Diagrams and elements of the SmartCap, a 3D-printed device that incorporates conductive metal traces to form an LC filter/spoilage sensor. When fluid such as milk enters and fills the capacitive gap, its changing properties (as the milk spoils) affect the resonant frequency of the filter, which can be electronically monitored. *Image courtesy of Berkeley Sensor and Actuator Center, University of California, Berkeley.*

Supporting Software: Designing 3D Electronics, Improving User Interactions

- **Project Wire** from Autodesk is a browser-based 3D electronics design tool that helps users lay out wiring, add components and communicate with the Voxel8 3D printer.
- **The Human Media Lab** of Queen's University, Ontario, addresses the need for software that helps designers add interactive elements (buttons, sliders, pressure sensors, touchpads) into model files for 3D printing. Queen's professor Roel Vertegaal led a group that created the PrintPut system to simplify standard and conductive dual-extruder printing.
- **ShareStation3D.com**, created and maintained by Graphene 3D Lab, is an online repository of functional 3D print projects. The site includes a free tool to convert 2D PCB drawings made with KiCad to models for 3D printing with conductive filament.
- **Capricate Fabrication Pipeline** software developed by a team at Technische Universitat, Darmstadt, Germany, enables users to design and 3D print objects with embedded capacitive multi-touch sensing on complex 3D surfaces. Applications include wearables (smart bracelets, rings, etc.) and tangible interactive computer interfaces. — *PJW*

A sample capacitive-touch part designed with Capricate touch-sensitive Fabrication Pipeline design software. Parts with complex surfaces were 3D-printed in dual materials (carbon-loaded ABS/black and PLA/blue) to produce capacitive, multi-touch, user-interactive sections. ***Image courtesy of Technische Universitat.***

Industrial Sensor Applications

Industrial giant GE Aviation has already made a name for itself by heavily investing in metal AM processes for 3D printing the fuel nozzles in production GE LEAP engines. Now the company has found an electronics-related 3D printing application that ultimately improves the long-term performance of another jet engine, the GE 90-94 model, originally built for the Boeing 777 aircraft. An existing sensor in front of the engine's air compressor takes temperature and pressure readings; however the current sensor housing configuration allows ice to build up and break off into the compressor, affecting durability. GE Aviation completely redesigned the housing with 3D printing in mind. Not only does the part work better, it was brought into production much faster (saving a year) by eliminating casting as the manufacturing process. The company is now in the process of retrofitting the sensors on 400 in-service 90-94B engines.

You can't talk about 3D-printed electronics without including Optomec. The company recently received investment funding from GE Ventures and Autodesk for general AM developments plus technology for the Industrial Internet of Things. "Sensors are finding their way into every aspect of the industrial sector, be it low-cost medical diagnostic devices or high-value components such as turbine blades. Printing sensors in 2D or 3D directly onto these target products, leveraging digitally-driven sensor patterns, enables mass customization and serialization. Having the ability to print (such) antennas on planar and non-planar, low-temperature substrates such as polycarbonate enables lower manufacturing and equipment costs and improved antenna design," says Mike O'Reilly, director of Aerosol Jet product management at Optomec.

In a perfect application of the Optomec technology, the Welsh Centre for Printing and Coating at Swansea University has been printing both creep and strain sensors onto jet compressor blades. By creating micron-level line patterns whose spacing can be read optically (non-contact), the degree of creep can be monitored in real time. In addition, because the Aerosol Jet material is conductive nano-silver ink, strain sensors printed directly on the blades can send information through connectors to microprocessor-based monitoring equipment for characterizing stress. The work shows the potential to simplify and improve maintenance inspections.

Although sensors are in use everywhere, one limitation has been their degradation due to corrosion, impact and overall wear. Fabrisonic has been addressing this problem with its ultrasonic additive manufacturing (UAM) process, licensed and developed by the former Solidica. This approach creates solid metal parts from metal-foil layers and can accommodate fully embedded electronics. Because the UAM process operates at low temperatures, it does not thermally damage such components as thermocouples, strain gauges, fiber optics or USB connectors. For example, Fabrisonic has built devices that combine layers of aluminum and copper with seemingly delicate, foil-based strain gauges. Also, fiber optic cables designed as Bragg laser-reflective gratings have been built into strips of layered metal, allowing strain measurements at hundreds of discrete locations along the length. If built into an aerospace component, such sensors could provide valuable, detailed stress data.

Conductive Materials, New 3D Printing Approaches

There's no lack of ingenuity and effort in both approaches and material choices addressing 3D-printed electronic functions. Because fused-filament printers are widespread and broadly affordable, Mike Toutonghi chose that general technology as the basis for developing F-Electric conductive filament, the first of a line of materials from his company, Functionalize. F-Electric, a blend of PLA (polylactic acid), carbon nanotubes and proprietary chemistry, can be used in single- and dual-head printers to allow direct 3D printing of such elements as circuits, buttons, sensors and power connectors. (See video: youtu.be/oYI4SVn63zg.)

"We are working on a new support material, and have just finished a plastic circuit design to be sold as a kit. It's an unconventional, yet simple two-layer circuit board that includes a common 555 timer IC with socket, resistance for on/off timing, battery holders and LED and capacitor clips," says Toutonghi. He adds that Functionalize is also working on adhesives and industrial materials including Ultem-blends targeted to aerospace and automotive applications.

Graphene 3D Lab is another company that entered this field with a conductive filament product and is expanding its offerings in multiple directions. The company already offers its conductive graphene filament (and many other filament materials) through its subsidiary Black Magic 3D; it has also recently filed a provisional patent application for a multi-functional 3D printer, dubbed the Romulus III. This printer technology is said to offer multiple deposition techniques and a robotic manipulator, as well as laser- and UV-curing capabilities.

Graphene 3D Lab's patent application includes a process for directly 3D printing an organic LED light source. "A primary mission of our company is to revolutionize 3D printing by making it capable of easily fabricating functional objects – things that work and can be used," says Daniel Stolyarov, co-CEO of Graphine 3D Lab. Work is already underway to 3D print a working battery; the prototype involves five different graphene composite materials, and may come on the market through a third party.

Inks, Wires and 3D-Printed PCBs

Taking conductive properties in a different direction are groups working with inks and novel building techniques. Examples of the former group are PV Nano Cell and Applied Nanotech; in the latter category is the W. M. Keck Center for 3D Innovation at the University of Texas El Paso (UTEP); and incorporating aspects of both areas are Voxel8 and NanoDimension.

The Nano Dimension dual-material inkjet DragonFly 2020 3D printer creates professional multi-layer printed circuit boards that include vias, without the need for drilling. The equipment deposits both dielectric and conductive inks and performs an integrated sintering process for curing both materials. *Image courtesy of Nano Dimension.*

PV Nano Cell was founded in 2009 to produce the Sicrys family of customized single crystal nano-metric conductive inks in silver and copper versions. Originally developed for 2D digital inkjet-printing applications such as photovoltaics, PCBs (printed circuit boards) and RFID (radio frequency identification) tags, the portfolio of inks has been expanded to include the newest product, the Sicrys I50TM-119, which offers greater environmental stability when exposed to water and humidity. Inkjet printing of these materials directly on 3D structures can create antennas on non-planar surfaces devices such as cellphones. The company was recently honored with the 2015 IDTechEx award for Best Development in Materials for 3D Printing.

Forward-thinking Applied Nanotech, a PEN Inc. company, has also been working to transform conductive nano-inks, developed for 2D applications, into materials suitable for additive manufacturing. The company offers a broad line of nanoparticle materials including aluminum, copper and silver conductive inks and pastes. It developed a copper material for Optomec's Aerosol Jet systems and has been working on additional inks and pastes that can be photo-sintered (UV-cured) at highly desirable room temperatures without the need for an inert atmosphere.

Zvi Yaniv, lead researcher at Applied Nanotech, says the new materials also require new systems to perfect building truly 3D layers. Noting that copper creates excellent traces at lower costs than silver, he explains: "Our sintering method utilizes a photo-curing Xenon 2000 unit operated sequen-

Desktop Electronics Printing in 2.5 Dimensions?

The world of printed circuit boards (PCBs) is witnessing a new production process that falls somewhere in between traditional 2D board production and 3D printing of parts that integrate electronics directly. Termed desktop electronics printing, the emerging field targets users who want to produce a PCB without the need for etching, milling or sending designs out to a fab house. In this arena are such consumer-friendly systems as the Argentum from Cartesian, a thermal inkjet-based printer that deposits a proprietary silver ink on rigid and flexible substrates and the Voltera V-One, developed by four engineering students from the University of Waterloo, Canada. — *PJW*

tially at each 5-micron-thick inkjet-printed copper ink trace." The company has already demonstrated using its copper ink material to form conductive metallic structures with a measured resistivity of 1.9x10-5 ohm-cm.

Part of the appeal of engineering in general and 3D printing in particular is finding more than one way to solve a problem. Since 2003, the Keck Center at UTEP has been working to include electronic functionality into 3D-printed parts; its early efforts involved interrupting a stereolithography (STL) process to introduce conductive inks and electronic components in select layers then completing the STL run. Unique demonstration parts were fabricated, including magnetic flux sensors, digital gaming dice, and a CubeSat module that was launched into low Earth orbit in late 2013.

UTEP has since started working with filament-based technology to fabricate electronic substrates and housings with improved mechanical and thermal properties. To realize the automated fabrication of 3D-printed electronics, the group is developing a system named the Multi3D with funding from America Makes. This work incorporates patent-pending tools that embed heated, bare-copper wires into any layer and on any surface during the process of building 3D-printed parts. By adding additional degrees-of-freedom to the process, the wire-embedding mechanism has been demonstrated on non-planar, curved surfaces.

At the 2015 Consumer Electronics Show (CES), Voxel8 made headlines introducing its dual-material dual-nozzle filament 3D printer. Currently marketed as a Developer's Kit, the system builds parts with embedded circuitry by alternating conductive silver ink (5x10-5 ohm-cm) with PLA; the company's website states that units will be shipping in Q2 2016 and an industrialized version is in the works. Voxel8 made a follow-up appearance at last month's CES 2016.

Also exhibiting at CES 2016 was Nano Dimension, a company founded in 2012 that says it is "bringing professional-grade 3D printing to the world of electronics." Its solution produces true multi-layer PCBs by combining three technologies: DragonFly 2020 3D printer hardware, control software that converts standard Gerber board design files to 3D-printable files, and nanotechnology-based dielectric and metal inks. Silver is in use, and a new copper ink was recently patented. This dual-material system, demonstrated in the U.S. in November at the Printed Electronics USA 2015 conference, creates boards with classic vias (two pads in corresponding positions on different layers of the board that are electrically connected by a hole through the board) as either blind, open or complete paths of conductive material, with no need for drilling.

The DragonFly 2020 deposits 2-micron-thick layers of material, alternating both types within a given layer to create the trace patterns; sintering and curing steps are built in. According to the company's website FAQs, trace widths are 80-100 microns and build time for a large, complex 10-layer board is several hours. PCBs created with the desktop, office-environment system are suitable for prototyping and one-off projects, bypassing the time needed to work with traditional board services. (See nano-di.com/3d-printer for a video representation of the 3D printing process.) **DE**

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

INFO → Applied Nanotech: AppliedNanotech.net

→ **Berkeley Sensor and Actuator Center:** BSAC.EECS.Berkeley.edu

→ **Cartesian:** Cartesianco.com

→ **Curtin University:** Curtin.edu.au

→ **Fabrisonic:** Fabrisonic.com

→ **FATHOM:** StudioFATHOM.com

→ **Functionalize:** Functionalize.com

→ **GE Aviation:** GEAviation.com

→ **Graphene 3D Lab:** Graphene3DLab.com

→ **Nano Dimension:** Nano-Di.com

→ **OpenBionics:** OpenBionics.org

→ **Optomec:** Optomec.com

→ **PV Nano Cell:** PVNanoCell.com

→ **University of Waterloo:** UWaterloo.ca

→ **Voxel8:** Voxel8.co

→ **Welsh Centre for Printing and Coating:** WCPCSwansea.com

→ **W. M. Keck Center for 3D Innovation:** Keck.UTEP.edu

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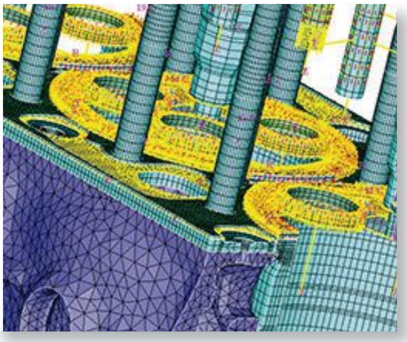
by Anthony J. Lockwood

Editor's Picks

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.



SimLab 14.0 Now Available

Software helps automate simulation and modeling.

Altair's SimLab provides a lot of automation for simulation-modeling tasks, which means it can help reduce the time spent plodding through manual FE (finite element) model creation. It interfaces with solvers like OptiStruct and Abaqus, and it can directly access native geometry from Parasolid-based CAD systems.

The key change in SimLab 14.0 is a completely redesigned graphical user interface (GUI). Altair says the redesigned GUI is based on its "Unity" framework.

It organizes functions into familiar ribbons, and commands and functions are grouped logically for the process at hand.

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EOS GmbH Debuts EOS M 100 3D Printer

System suited for small runs of complex parts.

The EOS M 100 has a 200-watt ytterbium fiber laser, a 40-μm laser spot and a scan speed of up to 23 ft. per second (7.0 m/sec). Translation: Users can produce high-quality, complex and delicate components in good time. Other characteristics of note include easy setup, material replacement and maintenance. The system's modest overall size and power requirements means users should be able to easily find a spot for it on the shop floor.

Right now, the EOS M 100 works with stainless steel, cobalt-chrome and other metals that are good for dental, automotive, aerospace and consumer products.

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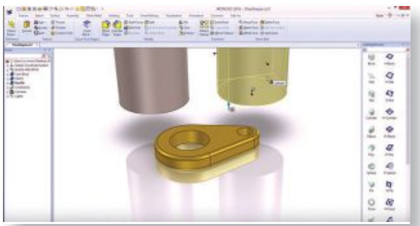

IronCAD 2016 Launches

The 2D and 3D design software continues to focus on collaboration.

The recently released 2016 edition of the IronCAD Design Collaboration Suite of 2D and 3D design, detailing, configuration and collaboration applications sees major enhancements for sheet metal and assembly work. There's also a new Mechanical add-in with utilities for design operations.

Also added to IronCAD 2016 are a bunch of new ways to create copies and links to select points, a new quick search that dynamically filters design variations, and capabilities that let users dynamically control part numbers.

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BOXX Technologies Overclocks the CAD Workflow

Its APEXX 2 workstation is ideal for 3D design and rendering applications.

BOXX Technologies has engineered the APEXX 2 2402 workstation for single-threaded applications in two key ways.

One, it's built with a quad-core Intel 6th Generation Core i7-6700K 4GHz processor that BOXX overclocked to 4.4GHz. Overclocked is a big deal here. It means a sustained 4.4GHz rate across all cores.

Two, a recommended APEXX 2 2402 comes with a CAD-friendly 16GB of DDR4 memory, upgradable to 64GB.

The recommended APEXX 2 2402 also comes with a 2GB NVIDIA Quadro K620 graphics accelerator, which handles a lot of compute-intensive work.

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Simulating Faster with Siemens PLM Software

American Axle & Manufacturing uses NX software to reduce time to market and warranty costs.

American Axle & Manufacturing Holdings Inc. (AAM) is a Tier one, global automotive supplier founded in 1994, but its manufacturing expertise goes back more than 90 years. AAM is a leader in driveline and drivetrain systems and related components for light trucks, sport utility vehicles (SUVs), passenger cars, crossover and commercial vehicles.

AAM's success can be measured with sales of about US$3.7 billion, more than 30 locations worldwide, and more than 13,000 associates serving over 100 customers. AAM attributes this success to its ability to provide value with a focus on quality, warranty, reliability, delivery and launch support.

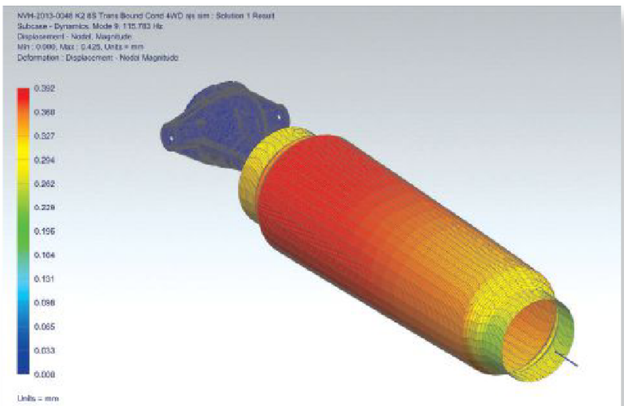
Delivering Power Anonymously

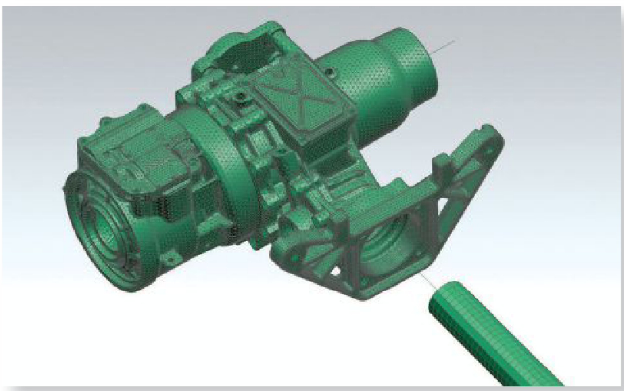
"The goal of AAM is to deliver power anonymously," says Glen Steyer, executive director of Product Engineering. What this means is that a driver cannot perceive how power is transmitted from the engine to the wheels, so they cannot hear or feel vibrations from the driveline. For an original equipment manufacturer (OEM), a quiet, vibration-free driveline is an attribute that can be tied directly to higher quality rankings and better customer satisfaction.

To meet standards for noise, vibration and harshness on drivelines, AAM uses simulation and physical prototyping. *Image courtesy of AAM.*

To facilitate meeting strict, industry-leading standards, AAM uses a combination of simulation and physical testing for its axles and drivelines.

"We heavily rely on upfront finite element computer simulation of the product performance and noise and vibration characteristics," says Steyer. AAM uses Siemens PLM Software's NX software for computer-aided engineering (CAE); NX Nastran software for noise, vibration and harshness (NVH) finite element (FE) simulation; and LMS Test.Lab software for data acquisition, physical testing and test-based engineering.





With Siemens NX, engineers state they can go from a CAD model to a simulation in just a day. *Images courtesy of AAM.*

Selecting NX CAE

Two years ago, AAM recognized it would need to migrate to a new CAE tool because its legacy simulation system software was being phased out.

"We wondered what we should do because we were so successful with [our legacy software]," says Zhaohui Sun, senior manager for NVH Engineering. "Moreover, we understood this may be a great opportunity to evolve and expand our capabilities."

To determine AAM's next steps, Sun's team needed to define the requirements it would need for its next- generation simulation software, including legacy capabilities that the team members liked and wanted to retain in the new simulation tool. The engineers also considered new capabilities that their current system didn't have but they would like to have in their future software.

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Bringing the Internet of Things Home

Lutron uses Xively to produce smarter lighting products for consumers.

Since its founding in 1961, when Lutron pioneered light dimmers for the home, the company has had an unwavering commitment to delighting customers and innovating top-quality products.

This is evident in Lutron's premium connected home solutions, which it has been selling through professional dealers since 1990. The solutions are a hit with high-end customers who want to remotely control lights and shades and require large-scale, complex installations. Reaching mass-market consumers, however, required a different approach.

"Customers love our connected home products. We knew if we could make them simple, reliable and affordable for the everyday homeowner, we'd have a winner," said Matt Swatsky, product manager, Caséta Wireless at Lutron. The challenge was that Lutron's premium solutions, built with a proprietary remote access technology, were more time-consuming and costly to develop, deploy and manage.

A Bright Solution

Lutron envisioned a connected home offering that could be set up in minutes and easily controlled through a smartphone app. The company turned to LogMeIn for its connected product expertise and Xively Internet of Things (IoT) Platform.

"We believe the IoT isn't just about connectivity. It's about making things work better for customers. LogMeIn shares this vision," said Swatsky. "LogMeIn's robust platform, Internet of Things expertise, and ability to deliver quickly on its promise were key selling points. In just four months, we went from concept to field-ready product."

Lutron Electronics is a provider of smart lighting technologies. *Image courtesy of Lutron.*

With the Xively platform, Lutron could create easy-to-use technology that consumers can control from their smartphone. *Image courtesy of Lutron.*

According to Swatsky, "LogMeIn was instrumental in helping us deliver remote connectivity to our mobile experience for the general consumer."

LogMeIn Professional Services leveraged LogMeIn's Xively IoT Platform to power the remote connectivity of Caséta Wireless. The Xively platform is built on LogMeIn's highly scalable, Gravity cloud infrastructure, which supports millions of secure connections between people, devices and data across the globe. Lutron Smart Bridge, a hub that connects and controls Lutron Caséta Wireless dimmers and Lutron Serena and select Sivoia QS remote-controlled shades, connects the customer's home to a smartphone, tablet or Apple Watch. LogMeIn consultants used Heroku to develop remote connectivity in the Lutron mobile app, enabling consumers to control Lutron devices via the Smart Bridge from any iOS- or Android-based phone or tablet, from anywhere in the world.

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Advertising Index

Commentary  by Walid Abu-Hadba

A Tenfold Revolution in Engineering Simulation

The Industrial Revolution began because innovators in all types of industries sought to use improvements in production processes and technologies to gain a competitive edge. Steam engines — and later combustion engines — made it possible to produce and distribute goods faster than ever before. Ford dominated the early automobile industry when it introduced the assembly line. Over the past few decades, computers and the Internet have triggered a revolution in virtual services. Each of these revolutions led to new businesses and revenue streams. Now the smart and connected devices that typify the Internet of Things (IoT) are igniting the next revolution. Success in this revolution will depend more than ever on a company's ability to innovate — and any winning strategy must be grounded in engineering simulation.

> **Using simulation to test and explore the design space early is the key to unlocking innovation.**

In the early stages of the product development cycle, the cost of making design changes is at its lowest. As the product development cycle evolves, there is more commitment and investment to design decisions and the cost to change rises by a factor of 10 with each phase. To verify engineering decisions and manage cost, leading engineering organizations in every industry have adopted engineering simulation.

While cost and efficiency gains provided by simulation are understood, its role to innovate and develop high-potential products is often overlooked. Experimenting early and frequently with computer models, simulating 10, 100 or even 1,000 design permutations, gives teams early insight into ideas that pose high risks but also offer potentially high profits. With the advent of trends like the IoT and increasingly smarter and more complex products, using simulation to systematically test and explore the design space early in the development process is the key to unlocking innovation while maintaining cost and schedule objectives.

Ten Times the Performance, Insight and Productivity

Our customers are constantly seeking to break new ground, developing products that are lighter, stronger and more efficient. The companies that enable their engineers to iteratively test their designs throughout the process are winning their markets. But to achieve these types of results, they need to be able to model simulations faster and capture results more effectively. ANSYS is helping its customers see magnitudes of innovation by taking advantage of advanced processor technologies, high-performance computing (HPC) architectures and cloud environments. These technologies are enabling our customers to run more simulations in less time. With our new release, ANSYS 17.0, we're incorporating new solver improvements and simulation workflows so that engineers can collaborate throughout the production process and achieve results faster. We're also helping our customers to create more reliable systems by introducing solutions that enable faster, more comprehensive simulations of products at the systems level.

As companies embed more and more smaller electronic components into products ranging from controllable toys to entertainment and safety systems in cars, they need to be able to test and make design decisions both for individual components and the assembled systems. New-generation printed circuit boards (PCBs), for example, have smaller form factors and contain chips with increasing power densities that give rise to thermal cycle failures, but accurately testing them for thermal stress, deformation and fatigue can be impractical given time and production constraints. With ANSYS, engineers can now import an ECAD geometry, model the intricate layers and traces of a PCB, and perform thermal, power integrity and cooling analysis in less time, allowing more frequent testing and ensuring more reliable electronics systems.

Given the evolution — or rather revolution — of technologies, the pressure on production design and manufacturing will not be slowing down any time soon. **DE**

This commentary is the opinion of **Walid Abu-Hadba**, *chief product officer at ANSYS (ANSYS.com). Send e-mail to him about this commentary via de-editors@deskeng.com.*