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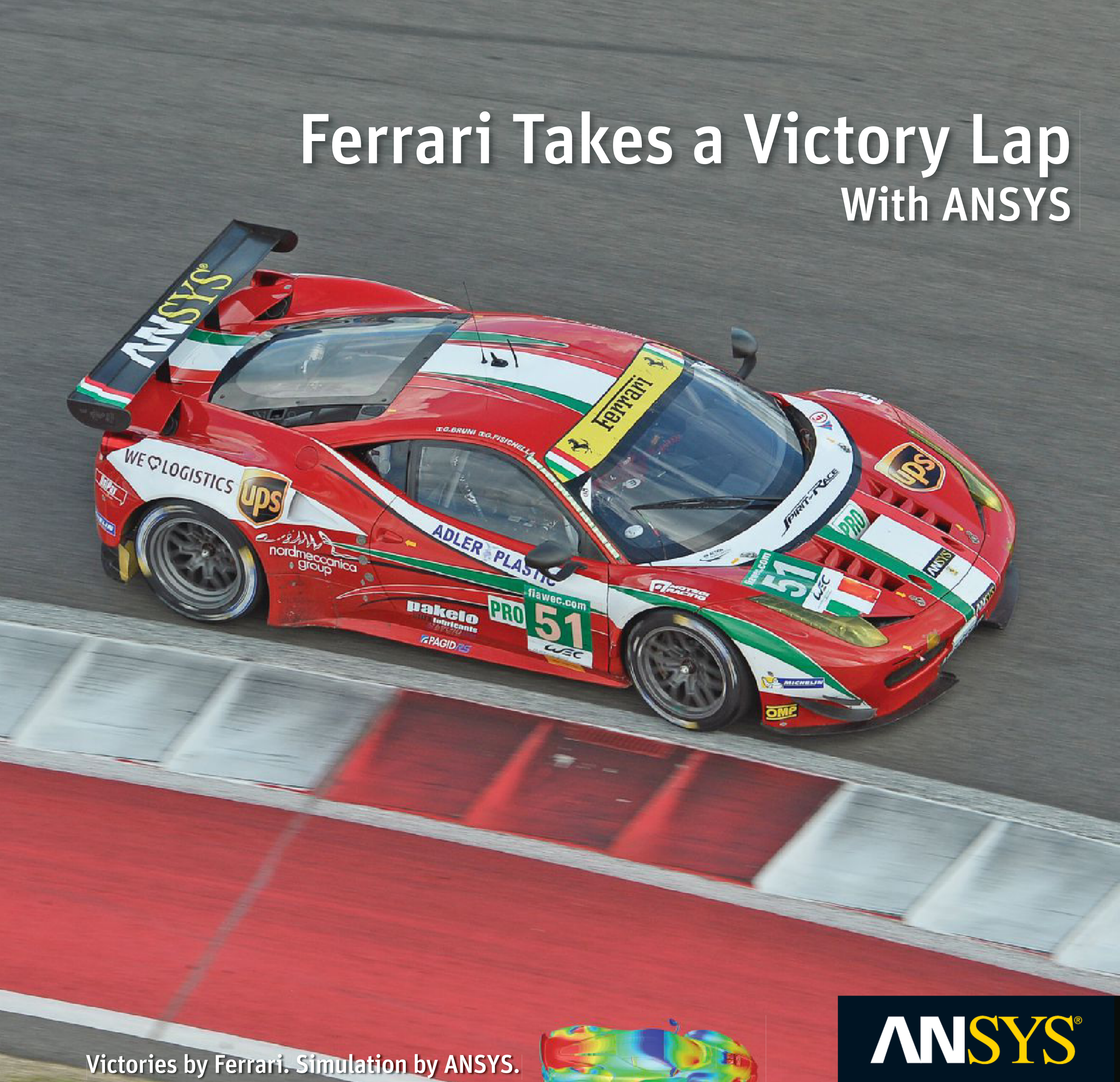

Ferrari Takes a Victory Lap
With ANSYS
Victories by Ferrari. Simulation by ANSYS.

by Jamie J. Gooch

More Data Collection, More Data Protection

It seems like the only topics getting more media attention than the Internet of Things (IoT) these days are privacy and security (once the latest reality TV star headlines are removed from contention). Target, Home Depot, Sony Pictures and Anthem are the latest high-profile company names that have made headlines for hacks and data breaches. As more manufacturers deploy connected devices capable of collecting and sharing data, they also need to ensure that data is well protected. No company wants to see its name connected to a breach of customer data, whether those customers are consumers or business partners.

One sure way to protect private data is to not collect it in the first place. In a report released earlier this year, "Internet of Things: Privacy & Security in a Connected World," the Federal Trade Commission (FTC) promoted the concept of "data minimization." The report is full of what you'd expect — designing security into IoT products from the start, training employees and monitoring connected devices over their lifecycle — but the idea of just collecting the information you need, and then only keeping it for as long as it's needed jumped out at me.

One sure way to protect private data is to not collect it.

Data minimization made me think of overengineering. Many design engineers used to think "if a little material on a stress area is good, a lot of material is better" (before simulation and testing provided more guidance). Likewise, the hype surrounding Big Data has a lot of people thinking "if a little data is good, a lot is better." After all, you never know what information might be useful a few years down the road.

Not to harp on reality TV, but it's that kind of thinking that makes the show *Hoarders* possible. Keeping what you don't need runs the risk of "just-in-case" data being left unsecured or stolen. It's rarely worth the reward of having it.

"Data minimization can help guard against two privacy-related risks," according to the FTC report. "First, larger data stores present a more attractive target for data thieves, both outside and inside a company — and increases the potential harm to consumers from such an event. Second, if a company collects and retains large amounts of data, there is an increased risk that the data will be used in a way that departs from consumers' reasonable expectations."

The report goes on to recognize business' need to balance future "just-in-case" uses of data with privacy protection by advocating a flexible approach to data minimization efforts that take into account the sensitivity and of data being retained, and whether it identifies people.

Privacy vs. Security

Its an approach some in the government might want to take themselves. At last month's White House Summit on Cybersecurity and Consumer Protection — held at Stanford University as a nod to the importance of Silicon Valley companies in the fight against hackers — a number of big names were conspicuously absent. Google, Facebook and Yahoo! CEOs were reportedly invited to the summit in which President Obama signed an executive order to promote more information sharing between government and industry, but declined to attend. It's no secret that many of the tech giants have been at odds with the National Security Agency's spying practices brought to light by the Edward Snowden leaks, and have made it more difficult for the government to access their customers' information.

Apple's Tim Cook was among the high-tech CEOs in attendance. He used the occasion to promote Apple's take on data minimization in a not-too-subtle jab at competitors.

"We have a straightforward business model that's based on selling the best products and services in the world, not on selling your data," Cook said. "We don't sell advertisers any information from your email content, from your messages or your web browsing history."

He went on to stress the importance of keeping data that is collected safe, and the importance of privacy: "If those of us in positions of responsibility fail to do everything in our power to protect the right of privacy, we risk something far more valuable than money — we risk our way of life."

As the IoT continues to expand and new companies find themselves in the data collection and analysis business, more and more people will be in those positions of responsibility. A little planning on what data is needed, how it will be used and how long it will be retained can go a long way toward enhancing its value, as well as the privacy of customers and business partners. DE

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

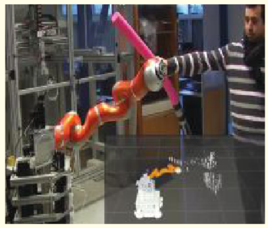
DE March 2015 VOLUME 20/ISSUE 7

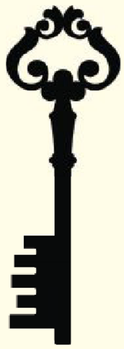
Design Engineers and the Internet of Things

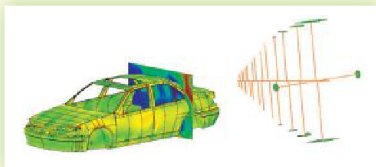
The movement to create a network of smart, connected devices is changing how engineers work. Read how companies are addressing new ways of designing, testing and securing IoT products.

PROTOTYPE

FOCUS ON THE INTERNET OF THINGS







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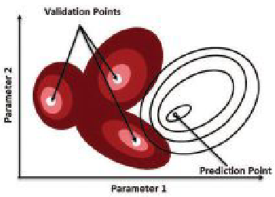

ENGINEERING COMPUTING

ON THE COVER: The IoT connects all kinds of devices, creating challenges and opportunities for design engineers.
Images source: Big Stock Photo

Dell recommends Windows.
DELL
Perfection takes time.
Going to market shouldn't.
Screen images simulated. Monitors not included.
Trial and error is the essence of engineering and universal design. The key is to ideate, design, test, make changes and repeat that process quickly and accurately. That's why OXO trusts Dell Precision workstations with Intel® Xeon® processors and their expert design software to accelerate product development. So while it still takes hundreds of iterations to make the perfect water bottle, OXO can now drive their innovative household tools to market faster than ever.
See how companies like OXO partner with Dell to engineer some of the most-loved products at Dell.com/CAD
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*Measured by SPECviewperf 12.0.1 running Windows 7 Professional (64-bit, SP1), comparing sw-03 on the Tower 5810 (Intel® Xeon® processor E5-1680 v3, Windows 8.1, Quadro K620, 32GB (8x4GB DDR4 2100) memory) & a T3500 (Intel® Xeon® processor W3680 CPU, Windows 8.1, Quadro 600, 12GB of memory).
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Onshape, a New Startup Headed by SolidWorks Veterans, Champions the Cloud

If the same group of people who developed SolidWorks in the 1990s were to go into business together today, what would that company look like? For the answer, you should turn to the new startup Onshape.

The team behind Onshape looks like a small army of SolidWorks defectors, beginning with John McEleney and Jon Hirschtick, former CEO and cofounder of SolidWorks, respectively. Other former SolidWorks staff include Scott Harris, cofounder and former VP of new product concepts; Dave Corcoran, former executive VP of R&D. Joe Dunne, former director of product strategy and Darren Henry, former marketing team member are also in the mix.

In the 1990s, SolidWorks broke new ground as an affordable CAD program for Windows desktops. It was a departure from the dominant design software titles that cost significantly more and required server-class hardware to operate.

Onshape has not yet revealed its product to the public, but blog posts published by McEleney and Hirschtick indicate they'll break new ground once more, this time by challenging the desktop design software industry with a cloud-hosted, mobile-friendly alternative.

CAD Only Halfway Done

On January 7, under the title "Why we started from scratch (again) in the CAD business," Hirschtick wrote, "CAD systems still aren't fast enough, they're not easy enough, they're not robust enough or reliable enough. All of the core issues in CAD are still there — and I think as an industry, maybe we're halfway done."

Personal desktops, once a challenger to the data centers, are now the established norm, threatened by shifting consumer behaviors. "Younger people have grown up in a post-desktop world and have different expectations about computers … They walk in with their laptops and their tablets and their mobile phones. They expect computing to be modern and available anywhere, anytime on any device. Cloud, Web and mobile technologies are our exciting new raw materials for creating CAD," Hirschtick wrote.

Former SolidWorks talents return to challenge the CAD industry with a new venture, Onshape.

On January 21, under the title "Business software has dramatically changed — it's time for CAD to catch up," McEleney observed, "As the giants of other industries are becoming more nimble, our own industry seems to be lagging behind. Many question whether the cloud will have a place in engineering. The CAD industry is one of the last major application sectors to embrace the cloud."

Going Direct via the Cloud

On its distribution plan, Hirschtick said the company is betting on the SaaS (Software-as-a-Service) model. "We will work with CAD resellers," he said in an email to *Desktop Engineering*, "but not in the traditional software license model way. In our case, resellers will provide services only — training, support, customization, etc. And we will also have direct sales to users over the Web."

"Internet connectivity availability is nearly ubiquitous and our mobile solution will work on 4G/LTE networks. With respect to performance — we have architected our system to take advantage of the extensive compute resources available in the cloud," McEleny wrote in response to a post comment. "Current desktops are not getting faster as they have reached clock-speed limits; however, we know that bandwidth is increasing every day. Onshape is the first system that you literally will see improvements in performance without having to do anything — no new system required, no new updates."

Of the new product he's now building at Onshape, Hirschtick said, "We have built an artful blend of parametric and direct editing. We also have some other modeling innovations that we will be unveiling. We are using the Parasolid geometry kernel and are very pleased with it."

Autodesk has begun the migration to cloud-hosted CAD with the launch of Autodesk A360 (the brand includes Autodesk Fusion 360, previously Inventor Fusion), delivering some functions through thin and thick clients, others straight from the browser. Many newer collaboration solutions, like GrabCAD Workbench, deliver project management, file management, version control and markup features from the browser.

Hirschtick said Onshape will be ready to reveal its product to the media later this year. Whatever that product is, it's bound to go up against SolidWorks, invented two decades ago by much of the same talent pool.

—K. Wong

by Kenneth Wong & Beth Stackpole

Autodesk Doubles Down on Software Subscriptions

Autodesk is drawing a line in the sand with a definitive cutoff for the availability of perpetual desktop licenses. "New commercial seats of most standalone desktop software products will be available only by Desktop Subscription beginning Feb. 1, 2016," the company announced in early February. The move is part of is transition to a subscription-only model.

"The move to cloud, mobile and social platforms for software companies is as profound as the move from mainframe to desktop computers," says Andrew Anagnost, senior vice president and industry strategist for Autodesk. "If we want to be relevant to our customers in the new world, we have to be moving toward a pure cloud-based, subscription-based company." He went so far as to declare, "*All* successful software companies in the future will be cloud companies."

Autodesk, best known for its flagship design and drafting software AutoCAD, once used perpetual desktop licenses as the standard approach for its design, engineering and animation software titles. But in 2009, Autodesk began experimenting with running cloud-hosted CAD programs remotely from thin clients and browsers.

Project Twitch, a technology preview at the time, let users remotely run Autodesk Inventor, AutoCAD and Autodesk Revit Architecture from a thin client, without installing the software locally. In early 2012, Autodesk launched its PLM offerings under the PLM 360 brand, delivering them as SaaS (software as a service) subscriptions. In late 2013, Autodesk introduced new licensing models, such as a monthly rental option, for some of its titles. These preceding moves prepared the company for what it ultimately wants to implement — cloud-hosted software offerings delivered as on-demand subscriptions.

Autodesk announces cutoff date for availability of desktop perpetual licensing.

The Path to Transition

Feb. 1, 2016, marks the end of "perpetual licenses for standalone desktop products," clarified Anagnost. "The suites [such as Building Design Suite, Product Design Suite, Entertainment Creation Suite] will continue to be available as standalone desktop products for some time, but that won't last forever."

Customers with perpetual licenses purchased prior to the cutoff date can continue to use their products with support from Autodesk. If these customers are on a maintenance contract, Autodesk is expected to keep their perpetual desktop titles current with updates.

The cloud-hosted subscription model allows Autodesk to deliver incremental updates soon as they become available, Anagnost pointed out. Customer preferences and customizations can also be stored online, he added. He said that over time, perpetual licenses with maintenance costs more than subscriptions. Enterprise customers who have built their workflows and processes around Autodesk products would have a year lead time to prepare for the transition.

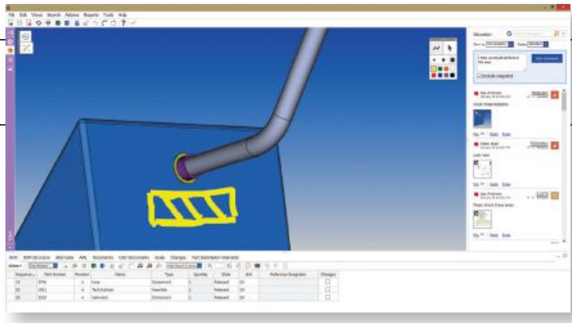
Anagnost said Autodesk subscriptions are month to month, with the option to cancel anytime.

"Paying month to month costs more [over time] than [an] annual subscription, but we're finding that some customers stay on that — 12, 13, 14 months, and so on — because it's just better for them," says Anagnost, "because, when the project stream dries up, they have the option to cancel."

Upon cancellation of the subscription, the desktop software becomes inactive in some cases and becomes viewing-only products in others. With a long history of desktop product sold under perpetual licenses, Autodesk currently has more customers on perpetual desktop licenses than subscription licenses, but the company expects the ratio to shift, eventually leading to subscription only.

—K. Wong

Aras Innovator 11 has new Visual Collaboration



Aras Innovator 11 delivers Visual Collaboration, adding discussion threads with embedded viewables and markups for collaboration. *Image courtesy of Aras*

In its latest upgrade to the Innovator PLM platform, Aras is attempting to address some of the long-standing shortcomings of product lifecycle management, particularly in the area of cross-discipline collaboration. Headlining the Aras Innovator 11 release is new Visual Collaboration and social technology. It's aimed at allowing engineering organizations to solve problems and communicate more effectively about products with an extended internal team as well as with external partners.

The new Visual Collaboration capabilities let stakeholders view content, add markups and make comments. The embedded viewables cover all data types, including many 3D and 2D CAD files along with schematics, layouts, Microsoft Office files and images. Each of the embedded viewables can be marked up, and stakeholders can make comments in the context of PLM items. Additionally, the marked-up viewables are linked with text comments into discussion threads, bringing a secure social aspect to the collaboration.

"Engineers want to be able to see what you're talking about, discuss it, and then make a decision," says Doug MacDonald, Aras' director of product marketing. "But one of the biggest challenges with product development today is that everything is in proprietary formats so colleagues can't easily view each other's work."

Aras 11's Visual Collaboration features make viewables accessible within the context of the product structure and processes, including the bill of materials, parts, models, drawings and change workflows. Because the viewing capabilities are a part of the PLM platform, the same permission model is employed to control access and that same security model also applies to social capabilities.

Aras 11's new social functionality lets users make comments and follow discussion threads. For example, users can opt to follow colleagues on a particular project or other people within the organization, but they will only gain access to their discussions and content if they have the proper access privileges.

Aras is also offering a new mobile app, Flow, which allows users to take advantage of Aras 11's visual and secure social communications when in the field.

—B. Stackpole

PTC Charges into the Cloud with SaaS PLM

In early 2006, PTC tested the SaaS waters with Windchill ProjectLink and Windchill PDMLink as on-demand solutions, hosted on IBM hardware. The conclusion was that market demand was lukewarm at best. So the company left the on-demand segment in the care of partners like NetIDEAS. Last year, however, PTC must have looked around and saw the SaaS market sizzling. It went out and bought NetIDEAS, laying the groundwork for a company announcement. In early February, with the launch of PLM Cloud, PTC jumps into SaaS with both feet.

"In the past, we've been a bit skittish with our answers about our cloud strategy," says Tom Shoemaker, vice president of product marketing, PTC. "Now, we can say, yes, we're here, we're all in!"

Other PLM and PDM (product data management) vendors like Arena Solutions and GrabCAD, which launched into the market with on-demand offerings and have no previous customer base dedicated to on-premise offerings, set up on a different pricing structure. Established PLM vendors like PTC, however, must deal with the inevitable conflict when introducing a SaaS option.

"We deal with this head on. We're offering the same pay-as-you-go licensing option to our existing customers," says Chris Bergquist, solutions manager, PTC PLM. What distinguishes PTC PLM Cloud, he explained, is the setup to "only pay for what you use."

PTC PLM Cloud is based on its existing product Windchill. It's available as Standard, Premium and Enterprise subscriptions. Under the PTC model, you make a commitment to a year and a minimum number of seats. In months when your project needs grow, you may pay for additional seats. The company also offers lower-priced subscriptions for Contributor seats and View-and-Print seats, which cost significantly less than Author-Editor seats (for those assigned to create, edit and add content to the PLM archive).

Bergquist pointed out that, with PTC PLM Cloud, strong CAD integration and management is included, with support for PTC products as well as rival products AutoCAD, SolidWorks and Autodesk Inventor. PTC isn't publishing the prices for its PLM Cloud. As standard practice, the company leaves its resellers and partners to negotiate the terms. Mobile device support for PLM Cloud is on the roadmap, Bergquist said.

—K. Wong

Senvol Launches Searchable Additive Manufacturing Database

As additive manufacturing (AM) continues to grow, the amount of information and documentation available also expands. This can make finding which AM system or material is best for your particular needs to be something of a challenge. With so many trending AM stories, even the Internet has become of limited help, unless you bear down on your Google search parameters.

Senvol, a consulting firm specializing in cost analyses, may have offered an easy way to cut through all the AM clutter with the launch of its 3D printing database. Currently, the database offers an option for searching for specific materials, and an option of searching for AM systems.

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Automakers to Increase Use of 3D Printing

While many may not go so far as to print an entire car, mainstream automakers are set to quintuple their use of 3D printing over the next five years. According to data from SmarTech, the auto industry's use of 3D printing will grow from $267 million currently to $1.25 billion by 2019. That's a compound annual growth rate of nearly 25% that could continue well into 2023.

Right now, the technology is used primarily for prototyping, but just as in the aerospace sector, printed parts are slowly working their way into finished vehicles. Parts can now be printed that can be used in prototype vehicles and in concept cars, which not only reduces the cost of making those vehicles, but also opens the door for putting printed end use parts into vehicles at some point.

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Could Microsoft's HoloLens be the Future of 3D Design?

The brains behind the Microsoft's Kinect have developed a new platform that might bring a simulated reality into our workplaces and living rooms. The new system is called HoloLens, and it takes the shape of a pair of goggles. Unlike Oculus Rift, HoloLens doesn't attempt to trick your brain into thinking it's someplace else, rather it uses augmented reality (AR) to overlay holograms into your everyday space.

HoloLens offers new opportunities for 3D design. Rather than sketching 3D images on a 2D surface, with the HoloLens, designers and engineers could design and develop 3D parts in 3D. Microsoft also realizes how much potential for design the new platform offers, and has included instances of 3D design in its demos and video marketing.

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3D Printing Fosters Marketplace Literacy

An Illinois educator is using business and marketplace education to help combat poverty around the world. Now his program has added AM to the curriculum. With 3D printing, participants can conceive of new

product ideas that they can quickly create and handle.

Madhu Viswanathan, a professor at the University of Illinois, conceived his marketplace literacy workshops and presentations as a way to educate the impoverished about commercial trading systems and help them identify new economic opportunities. The program is currently active in Tanzania, India and the U.S.

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Company Profile: RP Marketplace

Bring couples together and you're a matchmaker, connect buyers and sellers of services and you're a marketplace.

RP Marketplace aims to push the marketplace concept a bit further with its free online ecommerce platform that brings together buyers and sellers of commercial 3D printing and additive manufacturing services to work on rapid prototyping jobs.

Unlike competitive sites, which simply deliver a directory of rapid prototyping service providers, RP Marketplace serves up a roster of suppliers in addition to capabilities for transacting and managing projects, including the ability to post jobs, solicit bids, fund milestones and manage projects all from a single, browser-based platform.

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Following Nature's Lead

Engineering Solutions Balancing Performance & Efficiency

The shapes and configurations of nature are wildly complicated, often non-intuitive, yet completely amazing. The shapes and forms of a tree, a human skeleton, an insect or animal are the most efficient designs imaginable. To mimic the flawless balance between structure and strength of nature's most efficient shapes, a Michigan based Engineering Consulting Company, Engineering Technology Associates (ETA), offers unique product design optimization services. These engineering solutions incorporate a similar balance to product structures in terms of shape, material and thickness for heavy-trucks, buses, automobiles, aircraft and a variety of other structural products.

The Secret Recipe

At the heart of this offering is a patented process that ETA's Engineering Consulting Team developed and offers as a service to its client base worldwide. The Accelerated Concept to Product (ACP) Process® is a methodology which enables the structure of a product, such as the vehicle's body-in-white, to mimic "Nature's Way." Doing so creates the ultimate design efficiency, where structure and strength are perfectly balanced for the intended function. The results of this service are higher performing products combined with significant mass reduction. Achievable optimization results include:

- Significantly Reduced Product Development Costs
- Significantly Reduced Product Mass (20% to 40%)
- Improved Product Performance (stiffness, durability, NVH, Impact and crash/safety)
- Increased Fuel Efficiency

Background on the ACP Optimization Process

In June 2014, a US Patent was issued for ETA's ACP Optimization Process, which is a performance-driven, holistic product design development method based on design optimization. It incorporates the use of multiple CAE and CAO tools in a systematic process to generate the optimal design solution. This methodology provides solutions, which address the challenges facing the modern product development environment. It achieves this by synchronizing the individual facets of the product development process, resulting in an overall reduction in development costs and time to market.

Many industries

The transportation industry, and more specifically the automotive industry, is facing numerous challenges today. The product design and development process includes multi-dimensional issues, which often contradict each other. A central challenge is the need for cost reduction to compete in the global market while continuing to meet all new and existing requirements for quality and performance. The cost reduction objective is challenged by a few factors, including aggressive fuel economy and emissions standards. Other factors include new crash safety requirements, increasing customer demands and expectations for quality and performance and the availability of new energy sources such as electric/hybrid vehicles, plug-in technologies and fuel cells. These requirements indicate that new approaches are necessary.

The ACP Process Summary

To most effectively explore the design space (design volume, material and manufacturing process), while trying to reduce design cycle times, ETA engineers use the ACP Process. It can be described as a "search engine" that does not "invent" designs; rather it searches the predefined available design space for the best possible solutions, which meet all of the design constraints. It evaluates hundreds of design concepts, finding a set of acceptable design solutions, which also contains the optimal, or near-optimal design solution.

The holistic design process investigates the entire design space available and then defines the most robust design solution. The tools within ACP can greatly decrease the time required to identify a set of feasible, or even near-optimal, designs prior to building and testing the first prototype. Moreover, ACP can also compensate for the limitations of human intuition and provide design engineers with the freedom and power to seek creative solutions that are not always obvious to even the most experienced engineers.

The process analyzes multi-disciplinary loading, based on topology optimization and Geometry, Grade and Gauge (3G) Optimization. Using multiple CAE tools (modeling tools, application-specific tools, solver technology and optimization solutions) CAE, design and manufacturing are all synchronized. Once an optimal concept is identified, the ACP Process further generates the design, analyzes it and optimizes it using loading, manufacturing, material and cost constraints. It then outputs CAD data of an optimized concept design, suitable for detailed design and manufacturing.

The process can be applied to a wide variety of structural products and can be customized based on the client's ultimate goals. ACP can be implemented as a weight reduction strategy for current product refinement, starting with a current product design the client wishes to improve upon. Alternatively, it can be applied to a clean sheet design in order to develop a brand new product.

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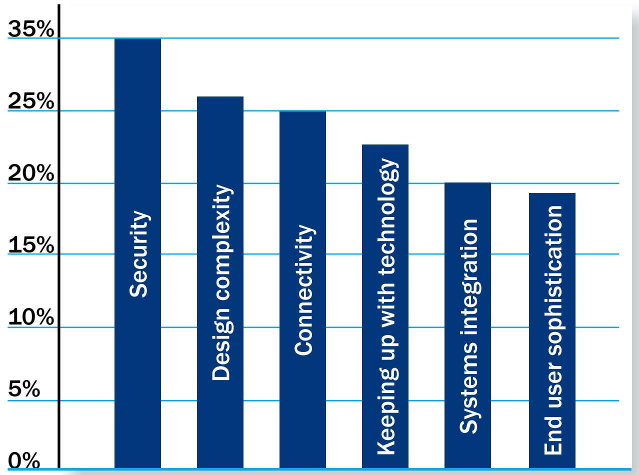
IoT Design Challenges

Reader survey reveals top hurdles to increased IoT development.

BY JAMIE J. GOOCH

Despite the current attention on the Internet of Things (IoT), the idea of sensor-enabled devices communicating with one another is not new. In 1926, famed electrical and mechanical engineer Nikola Tesla told *Colliers* magazine that "when wireless is perfectly applied," Earth would be converted into a "huge brain" via "amazingly simple" instruments that would be small enough to fit in a vest pocket. It has taken some time to approach that perfect application of wireless technology, and the devices are not always simple, but in a survey of *Desktop Engineering's* readers conducted earlier this year, most say the IoT is not hype. In fact, almost half of respondents are already involved or expect to be involved in IoT products and solutions.

Perfectly applying wireless technology is a high bar, and survey respondents admit they are struggling with connectivity. Of those respondents currently developing or expecting to develop IoT products, 52% said that they would like more training in communication technologies. That was the No. 1 training need cited. Connectivity was also in the top three IoT challenges respondents said they face, just behind "complexity of design and development." If Tesla was prophetic when it came to wireless technology, he might have been talking about ease of use, not engineering, when he called those future wireless devices simple.



SECURITY CONCERNS topped a list of challenges faced by *Desktop Engineering* survey respondents who were asked to note their top IoT design issues.

Security Tops Concerns

"I'm convinced that we are on the way to make almost everything connected," said one engineering manager who responded to the survey. "The cost is now low and the technology is there. If we can figure out how to make it secure and reliable, I can't see what will stop connecting almost everything to the Internet."

Many respondents (35%) see security as the biggest hurdle to future IoT development, and 42% say they need more training related to securing the IoT. We address many aspects of IoT design in this issue, including security (page 23-25) and the U.S. Federal Trade Commission's involvement. The FTC released a report titled "Internet of Things; Privacy and Security in a Connected World" in January. It provides steps businesses can take to enhance and protect privacy and security, according to the FTC.

"The only way for the Internet of Things to reach its full potential for innovation is with the trust of American consumers," said FTC Chairwoman Edith Ramirez in a statement announcing the report. "We believe that by adopting the best practices we've laid out, businesses will be better able to provide consumers the protections they want and allow the benefits of the Internet of Things to be fully realized."

But consumers are just one aspect of IoT acceptance. The Industrial Internet of Things kicks off our IoT coverage this month. According to our survey, manufacturing and industrial applications were the top IoT areas being addressed by respondents.

"As with most technical innovations, there is more behind the scenes work required than it would seem from first glance at the news and publicity," said one survey respondent. "Also there are so many options and the variety of protocols and equipment make it difficult to sort through and determine the optimal approach, as well as difficult to integrate disparate protocols or approaches."

Because of those difficulties, we'll continue to cover the IoT. Next month we explore IoT power requirements in the magazine and we're presenting a webcast on secure IoT design April 7. DE

Jamie Gooch *is editorial director of* Desktop Engineering. *Contact him via jgooch@deskeng.com.*

Webcast: IoT Security Begins with Design

Join us on April 7, 2015 for a discussion of best practices for designing a more secure Internet of Things. We'll review more results from our survey of *Desktop Engineering* readers and address the concerns revealed by the survey with industry experts.

Register in advance here: deskeng.com/de/IoTsecurity

The Rise of 'Intelligent,' Connected Machines

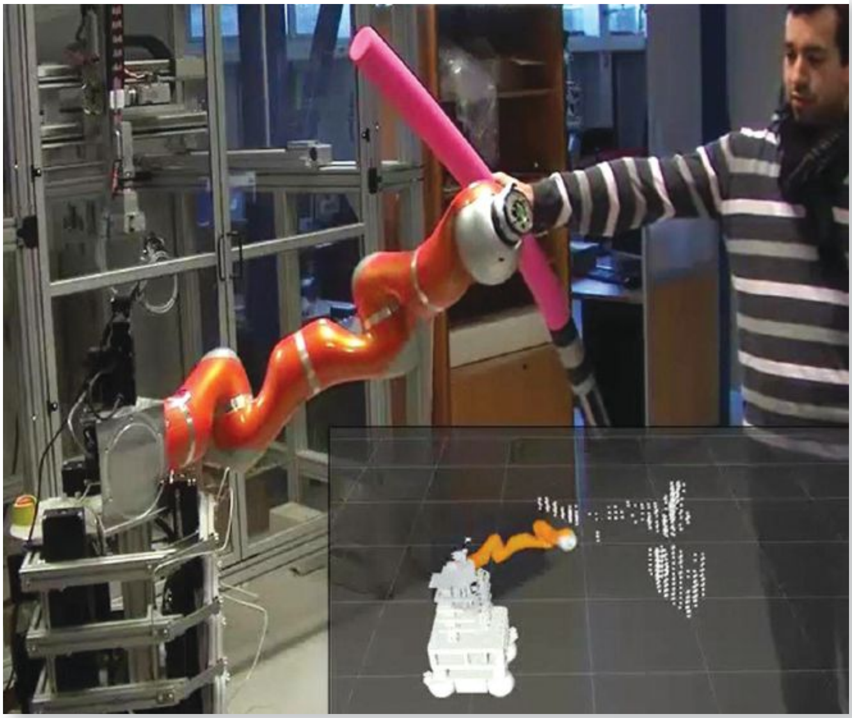
Early experiments to develop self-monitoring factories and semi-autonomous equipment are underway.

BY KENNETH WONG

Last August, Bernard Duprieu and Sebastian Boria from Airbus' manufacturing technologies research group got invited to be keynote presenters at NIWeek in Texas, hosted by National Instruments (NI). They decided to bring a prop, something that would demonstrate their vision for the factory of the future. They settled on a pair of goggles, which literally showed how Airbus engineers would see the cyber-physical systems in front of them.

The prototype eyewear Duprieu and Boria brought along could easily be mistaken for a pair of designer glasses. What distinguishes the device is its built-in image-processing capacity and connectivity to the tool in the engineer's hand. Much of the data and device integration happens in NI's technology, a mix of software and hardware.

"In a typical A380 airplane, there are about 400,000 holes to tighten, which requires over 1,100 basic tightening tools. So the operator would have to consult a manual, determine that he's in section A of the fuselage, that he has 40 holes to work on, that the tool should be set to a certain torque for the first 20 holes and a different value for the second set," says Andy Chang, senior manager of Academic Research at NI. "Airbus' prototype glasses use image processing to assess the environment and dynamically adjust the tool's settings to match the holes the engineer must work on."



A robot identifies an obstacle and calculates a safe motion path using visual target tracking and a control system with Kineo software onboard for collision-free path planning. ***Image courtesy of Siemens A.G.***

On the shop floor of STIWA Automation GmbH in Attnang-Puchheim, Austria, every eight seconds, the automation system collects 9MB of data in 150,000 data sets that describe noise, torque and other measurements. The engineers tweaked the system to invoke a MathWorks MATLAB algorithm every 10 seconds to analyze the collected data and adjust machine parameters, like trajectories, for optimum production.

At the international mining equipment manufacturer Joy Global, real-time data from 15 global mine sites, representing the output of around 1,000 machines and 1,000 real-time data points at sub-second intervals, steadily flows through PTC's ThingWorx software platform. The volume of accumulated data — too much for human consumption, but not impossible to process for computers — gives Joy Global the ability to anticipate equipment failures.

These are just a handful of examples of how the Internet of Things (IoT) is transforming the deployment of industrial machines in manufacturing. They illustrate that IoT on the industrial scale has to do more than sensing and collecting data; the machines must be trained to do a fair amount of thinking on their own.

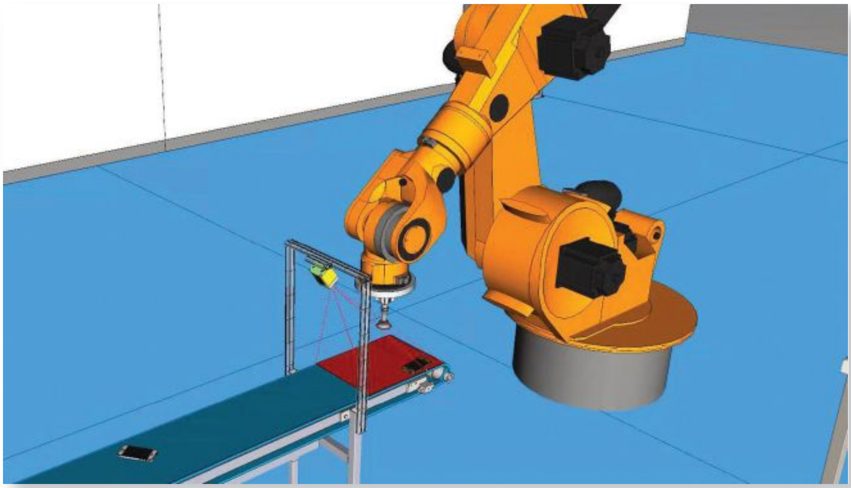
Machine Sees, Machine Learns

When STIWA Automation GmbH decided to add some automatic data-analysis and decision-making to its internal shopfloor management system, AMS ZPoint-CI, the company first experimented with writing algorithms using low-level programing languages, such as IEC 61131-3 Structured Text for PLCs (programmable logic controllers). The results were lackluster, as recorded in a case study published by MathWorks: "This approach was slow, and it became unworkable as the algorithms grew more complex. For example, the trajectory-planning algorithm calculates a path through four positions with joint constraints. Any change to the algorithm would require one day for PLC code implementation and a further day for error debugging."

Eventually STIWA engineers switched to MathWorks MATLAB to develop algorithms to automate data analysis and identify the best trajectories for robotic components. "The algorithms invoke [MathWorks'] Optimization Toolbox functions to calculate these optimal trajectories based on defined constraints, including velocity and space limitations," wrote MathWorks.

On workstations with up to six processing cores, the code written in MathWorks Parallel Computing Toolbox kicked in, speeding up the automated trajectory calculations. MATLAB Profiler helped identify the most time-consuming operations. MATLAB Compiler and MATLAB Builder helped turn the code into .NET components to drive the automation.

There are two areas of interest for IoT at the industrial scale: "The first is self-learning — the ability of the machine to read data, comprehend it and make self-adjustments. This is still in its early stages and the machines are limited to the extent of the learning algorithms," says Tony Lennon, industrial automation specialist, MathWorks. "The second is the incorporation of vision systems. Machine vision is not new in automation, but sensors and software keep advancing along



An integrated vision system detects smartphone color and position on the conveyor, allowing the robot to adjust its pick and place locations automatically. *Image courtesy of Siemens A.G.*

with computing power for a machine to incorporate some sophisticated computer vision systems, which can be used for inspection, recognition and navigation."

Using computer vision from an engineer's goggles to pinpoint the location of the engineer, as in Airbus' approach, at first seems unnecessarily complicated, since cellphone makers have figured out easier ways to add location-awareness to the device. "[Digital] cameras [which serve as the data source for computer vision] are very cheap, so it's very accessible as a mass-adoption technology," says NI's Chang. "Furthermore, the goggles themselves not only serve as a day-to-day protective gear, but can also be used as surveillance devices for the factory. That gives you the ability to monitor the factory floor through the human workers themselves."

In self-driving cars, the IoT and sensors give the car the ability to select alternate routes based on real-time traffic and weather data. In Industrial IoT, assembly machinery may begin to exhibit similar path-finding abilities using computer vision and accumulated data of the environment.

"Let's say a series of robots are supposed to pick up objects from point A and place them in point B. Typically they're confined to a safe zone, like behind a cage, to prevent collision with human employees. But to maximize space utility, some interaction with human workers is unavoidable. Some other devices may also intrude on the same paths. The way these robots detect interferences in real-time, change its trajectory, and navigate safely to their target positions could be an industrial application of IoT," says Chang.

Zvi Feuer, senior vice president of manufacturing engineering software for Siemens PLM, describes Industrial IoT as "still in an early phase. He adds, "We can already see many sensors on the shop floor. Many of these sensors sense the production resources, trying to identify dangerous situations (people that might walk into an active production cell) or monitor production equipment for different needs, such as maintenance, electricity usage, CO_2 emissions and more."

Feuer also foresees devices that come with its own repair and health-monitoring systems. For example, "a device that is attached to a batch of composite materials and is used to monitor life expectancy of the material (i.e., how much more time does this batch of composites have before it will be scrapped?) as well as to identify where each batch is located on the shop floor map," he says.

Facilities with App-itude

PTC was previously best known for its 3D mechanical design program Pro/ENGINEER, later rebranded as PTC Creo. But the company's 2011 acquisition of MKS, which caters to embedded software developers, marked a turning point. It was the first of a series of purchases to build a robust portfolio for IoT product development. In December 2013, PTC bought ThingWorx, which provides a platform for developing and deploying IoT-style applications, for $112 million. Then in August 2014, PTC acquired Axeda, a developer of solutions that securely connects machines and sensors to the cloud.

Though marketed as a rapid application development environment, ThingWorx and its principles originated from manufacturing, as evident in the history of its founders. Two of the founders — Russell Fadel, president and general manager, and Rick Bullotta, CTO — were instrumental in developing Lighthammer software for capturing manufacturing intelligence, later acquired by SAP.

"[Industrial IoT integration] usually starts off at the remote service level, like the ability to remotely diagnose products and systems. The value proposition is obvious. As businesses begin to understand the advantage, they move toward remote software updates, feature updates, and on-demand consumable replenishment. Some businesses change their business models. In the case of one of our customers, they went from selling medical equipment to charging for the use of test kits to get results," says John Canosa, PTC's chief strategist for ThingWorx.

What is crucial in the Industrial IoT, Canosa believes, is a collection of vertical apps. They provide factory and facility managers with a window into the data and intelligence collected by the equipment on the floor; perhaps more important, they initiate actions. "You won't realize the value of industrial IoT just by connecting the devices and schlepping some data on them. This isn't just pushing sensor-acquired data to some big data center in the cloud. The value is in connected apps, which are connected to the devices but also to enterprise resource systems and customer records," says Canosa.

The apps, in Canosa's view, are not the same as the virtual dashboards available in PLM, PDM (product data management), ERP (enterprise resource planning) and other enterprise systems. "A dashboard is static, just a visual display with flashing red lights and alerts," he said. "But an application is more than that. It's one thing to have information, quite another to be able to act on it."

Preparing for the Era of the Machines

When Airbus first showed NI its vision for its "factory of the future," the vision was no more than an animation clip depicting what it wanted to implement. Since then, some components of this so-called future factory have been tested and proven in research. Adding "intelligence" into factory tools, for example, is well underway. NI's Chang provided a rough roadmap for the project.

"The first phase is the smart tools," he says. "The second component is what we call the Open Robot Interface, a way for different industrial robots to communicate with one another. The third component is wireless communication through light, which is different from anything we have currently. [The] fourth component is a different form of robotics that could assemble and wield aircraft more efficiently. For example, a spider-like crawling robot is one wild idea. We're currently in the investigation phase for the Open Robot Interface initiative. It'll be a multiyear collaboration."

Siemens PLM's parent company, Siemens A.G., provides SCADA (supervisory, control and data acquisition) solutions, a large range of PLCs and sensors, and advanced software solutions to integrate, program and virtually commission Industrial IoT applications. "Siemens has two Showcase Plants, which are real production facilities for our automation product lines. Both plants — one in Erlangen, Germany and one in China — are used as test labs for advanced manufacturing technologies," says Feuer.

"In the future, we'll see sensors on every production device. These

STIWA's shopfloor management system, based on MATLAB, AMS ZPoint-CI, and AMS Analysis-CI is pictured. *Image courtesy of MathWorks.*

sensors will talk to one another and regulate themselves, define on the fly which production device should work and when, and information collected from these devices will be used to improve production quality, identify bottlenecks and report the changes that happened in the location of the equipment during the production. We can then take this information and recreate or update the virtual plant and line model," he says.

"The technology is not yet mature enough; we are still missing some capabilities needed," says Feuer. "Second, [we need] information security — deploying industrial IoT requires much better cyber security tools to help the plant manager secure their information, machines and production systems. The third challenge is skilled people to introduce these technologies."

Regulatory Roadblocks and Anxiety Ahead

Even if self-driving cars are technologically possible today, the cultural resistance will likely remain. In addition, current automotive regulations are not equipped to deal with a newer technology like semi-autonomous vehicles. For Industrial IoT, NI's Chang pointed out the companies with a vested interested in the area are forming the Industrial Internet Consortium (IIC) as a pre-emptive strike to address the cultural and legal concerns.

IIC's current members include GE, Intel, IBM, SAP and Siemens, among others. "There'll be lots of challenges, and companies would want to position their products in their own ways," says Chang. "The consortium is expected to steer us in the right direction, to focus on delivering the right technology to end users." Chang led NI's active participation in the consortium to establish standards and practices for semi-autonomous machinery.

The vision of intelligent industrial machines also spawns some fear and anxiety. Some may view this as an imminent threat to human workers' job security. "The objective is not to replace human workers, but rather to enhance their capabilities," says Chang. "There are so many critical tasks and procedures that require humans' attention, from assembling the components to final verification and validation. Factory of the future is the vision to leverage technology and connected devices to enhance our workforce's performance and reduce manual errors and risks in the production."

"As more automation is developed and deployed, the need for more skilled and technically educated labor rises to design, manufacture, test, install and maintain these more autonomous systems. The added benefit of more automation is that it takes people out of hazardous working environments and mundane repetitive tasks. Both government and industry need to invest in retraining existing workers in math, science and technology disciplines, which will enable workers to secure higher skilled jobs, provide improved job mobility, and boost economic productivity," says MathWorks' Lennon. **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 → Airbus Factory of the Future: AirbusGroup.com/int/en/story-overview/factory-of-the-future.html

→ **Industrial Internet Consortium:** IndustrialInternetConsortium.org

→ **PTC:** PTC.com

→ **NI:** NI.com

→ **MathWorks:** MathWorks.com/

→ **Siemens PLM:** Siemens.com/PLM

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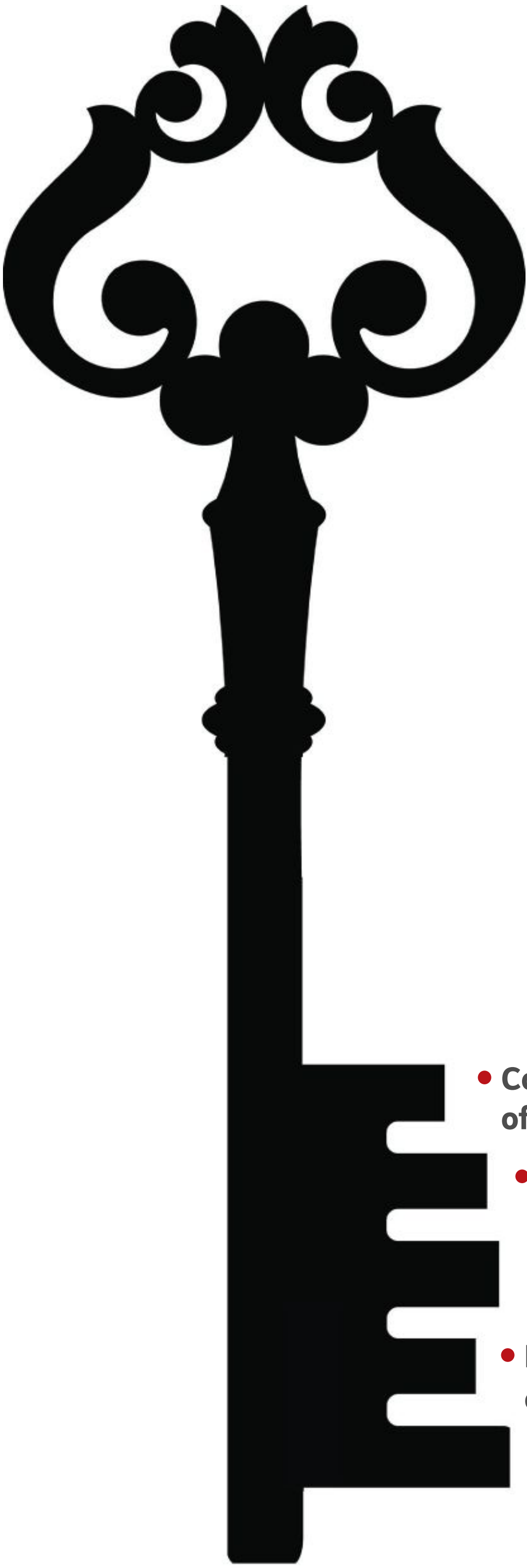

Keys to Security by Design

Security is a top concern for designing products for the Internet of Things. As outlined by Federal Trade Commission Chairwoman Edith Ramirez in a speech on privacy and IoT, here are the key security by design tenets:

- **Conduct a privacy or security risk assessment as part of the design process.**
- **Test security measures before a product launch.**
- **Use smart defaults — for example, requiring consumers to change default passwords in the set-up process.**
- **Employ encryption for the storage and transmission of sensitive data.**
- **Monitor products throughout their lifecycle and patch known vulnerabilities to the extent possible.**

Download the FTC report, “Internet of Things: Privacy and Security in a Connected World,” as well as its publication, “Careful Connections: Building Security in the Internet of Things” at deskeng.com/de/IoTresources.

Security: The New Frontier in IoT Design

The Internet of Things requires a new design approach to address security throughout a product's full lifecycle, including early-stage design.

BY BETH STACKPOLE

Designing products for the Internet of Things (IoT) is a little like being an explorer. In order to reap the benefits of this brave new world, engineers are finding themselves in uncharted territory, particularly when it comes to addressing security as part of the early design process.

With analysts projecting 50 billion connected devices (from wearables to industrial equipment to cars) by 2020, the IoT is big business, and manufacturers across industries are ramping up development efforts to become players in the IoT game. Yet in the rush to innovate new IoT offerings and services, companies are paying short shrift to the security aspect of these new smarter and connected products, opening the door to untold privacy and hacking risks that could have substantial financial ramifications and potentially put consumers in harm's way.

In a speech at the International Consumer Electronics Show earlier this year, Federal Trade Commision Chairwoman Edith Ramirez voiced concerns about security and data privacy in the age of the IoT. "Like traditional computers and mobile devices, inadequate security on IoT devices could enable intruders to access and misuse personal information collected and transmitted by the device," Ramirez said in her speech. "Moreover, the risks that unauthorized access create intensify as we adopt more and more devices linked to our physical safety such as our cars, medical care and homes."

To address the concerns, Ramirez provided a framework for what she called "security by design" — the idea that companies design security functionality into the devices and the applications from the earliest stages while providing a mechanism for maintaining security throughout the entire lifecycle. She called on companies building products for the IoT to address security by leveraging a variety of technologies, including encryption, while also adhering to formal best practices, from risk assessments and new testing measures to monitoring products throughout their lifecycle so known vulnerabilities can be continuously addressed.

While the vision is clear, putting security by design principles into practice remains a bit more difficult. Many engineering groups don't have the right expertise at their disposal nor are they versed in security best practices as they relate to product development. Moreover, there's the very real issue of time-to-market pressures trumping the need to do the development work around IoT security, experts say.

"In the big push to get product out as fast as possible, design aspects related to security get cut first to comply with time-to-market pressures," says Donald Schleede, information security officer at Digi International, which provides machine-to-machine (M2M) products and services. "Moreover, many companies don't have the security credentials or training to build these functions into devices."

The danger of overlooking or underplaying security in IoT devices can be very real. Imagine a smart insulin pump that is hijacked and dispenses upwards of 50 units of insulin instead of what's prescribed, sending a patient into diabetic shock. The product manufacturer that finds itself in the epicenter of this type of breach will undoubtedly be held responsible, which could have severe financial, ethical and legal consequences.

Practicing security by design means employing the right technologies and considering the end-to-end security requirements for a product at the earliest stages of the design cycle, says Todd Pedersen, global director of sales and sales operation, Global Cyber Security division at CSC.

Digi, which offers IoT development and support services through its Etherios division, and CSC are among the growing number of providers building out IoT consulting practices to help companies understand the new design requirements of IoT products, with security being a top priority.

"Security by design means not building the product and then figuring out how to bolt on security on top of it, but rather building the product with security throughout," Pedersen says. "Manufacturers can use companies like CSC to augment their staff and teach engineers how to do this effectively, particularly as it relates to governance and focusing on security throughout the software development lifecycle."

The Optimal Security Mash-up

From a technology standpoint, there are a number of things engineering groups should consider when designing products for IoT. As cited in Ramirez's speech, encryption is critical, and in particular, designing an architecture that encrypts data as close as possible to the actual sensors to optimize the safeguards, says Digi's Schleede. Beyond encryption, IoT products require some sort of identity authentication mechanism to ensure that the device accessing or providing data is actually authorized to do so. In the case of the insulin pump, this would confirm that the device communicating its need for a specified amount of insulin is actually the device it claimed to be and not a rogue intruder, he says.

"There is a requirement for these devices to say who they are and prove who they are when connecting," says John Canosa, chief strategist at PTC's ThingWorx. "From an engineering standpoint, that means the team needs to understand encryption in flight and at rest. You really need someone with an overarching view into end-to-end security."

In that vein, companies need to consider security not just from the standpoint of locking down a device, but also ensuring that the device can't be tapped as a vector into a traditional TCP/IP network for wrong doing. "Most engineers focus more on the first problem than the second because that's where they are comfortable," says Brian Ray, CEO of LinkLabs, which provides M2M/IoT wireless network products and services. "They make sure their systems are following standard embedded protocols to keep unintended access out of the system, but they may not see the physical or wireless exploitation that can be used as a launching point for some sort of nefarious operation."

> "Security by design means not building the product and then figuring out how to bolt on security on top of it, but rather building the product with security throughout."
>
> *— Todd Pedersen, Global Cyber Security division, CSC*

Other steps for protecting the actual device include incorporating secure enclosures as part of a design and using methods like secure boots and encryption keys to protect the internal embedded software and silicon. A third pillar in an IoT security framework is managing and monitoring the devices throughout their lifecycle so known vulnerabilities can be addressed to the best extent possible.

IoT platforms like ThingWorx, Digi's Etherios Device Cloud, and Wind River's Edge Management System deliver a range of security management functions, including the ability to monitor and manage individual devices to keep security capabilities current and to apply regular patches. While these types of tasks are typical in IT organizations, they are unfamiliar to most embedded software developers, which means training and auxiliary services are likely necessary to help them get up to speed, says Tim Skutt, director of Wind River's security portfolio.

"Regardless of whether it's an automotive or industrial application, embedded systems developers are largely independent and they lack the skill set and mentality for evaluating risk and penetration testing on IoT devices," Skutt says. "We can provide services that can take them from early risk assessment all the way through an IoT product's lifecycle."

Security By Design Best Practices

As important as technology is to IoT security, so too is cultural and process change, particularly as it relates to security by design best practices. Conducting a privacy or risk assessment at the earliest stages of development is crucial to understanding the requirements and seamlessly integrating the right mix of security capabilities into a design as opposed to adding them later in the cycle, experts say.

Rigorous testing for security vulnerabilities is another best practice requiring engineering groups to establish formal processes as part of the design workflow, experts say. Most engineering groups test features and functions as part of their standard quality assurance practices, but they don't have the same formal processes in place as it relates to security, says Digi's Schleede. "It's a different level of thinking when you're testing devices for security," he says. "When you're testing features and functions, you don't do a lot of negative testing to see what can happen when you do things with a product for which it wasn't intended."

From a cultural standpoint, security by design practices shore up the ongoing emphasis on systems engineering, requiring cross-functional collaboration between the multiple engineering disciplines while also bringing IT into the fold — potentially for the first time for many engineering organizations. "Any company getting into this space needs to create a cross-functional team that looks at security design from a systems perspective," says PTC's Canosa. IT has the domain expertise in security issues like denial of service attacks and the corporate network infrastructure, so it's incumbent on organizations to make them an equal partner in the IoT design effort.

"Let's face it, there are few people out there with 10 or 15 years of IoT security expertise and you're more likely to find someone steeped in security architectures and challenges from the IT side of the house," Canosa says. "You have to bring IT into the mix and make them part of the cross-functional effort. You also need to come up with a common language and way to communicate about what these systems are to do, addressing it as a distributed system problem, not individual components." **DE**

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

INFO ➜ **CSC:** csc.com

➜ **Digi International:** digi.com

➜ **LinkLabs:** link-labs.com

➜ **PTC:** ptc.com

➜ **Wind River:** windriver.com

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IoT Design and Development

IoT development platforms help bridge software, hardware development gaps in the design workflow.

BRIAN ALBRIGHT

The Internet of Things (IoT) was one of the most pervasive tech topics in 2014 as more companies introduced smart, connected products. This included everything from cars and refrigerators to medical devices and even furniture. That growth is only going to continue (research firm Gartner, Inc. expects roughly 26 billion "things" on the network by 2020), and the impact on product design will be widespread.

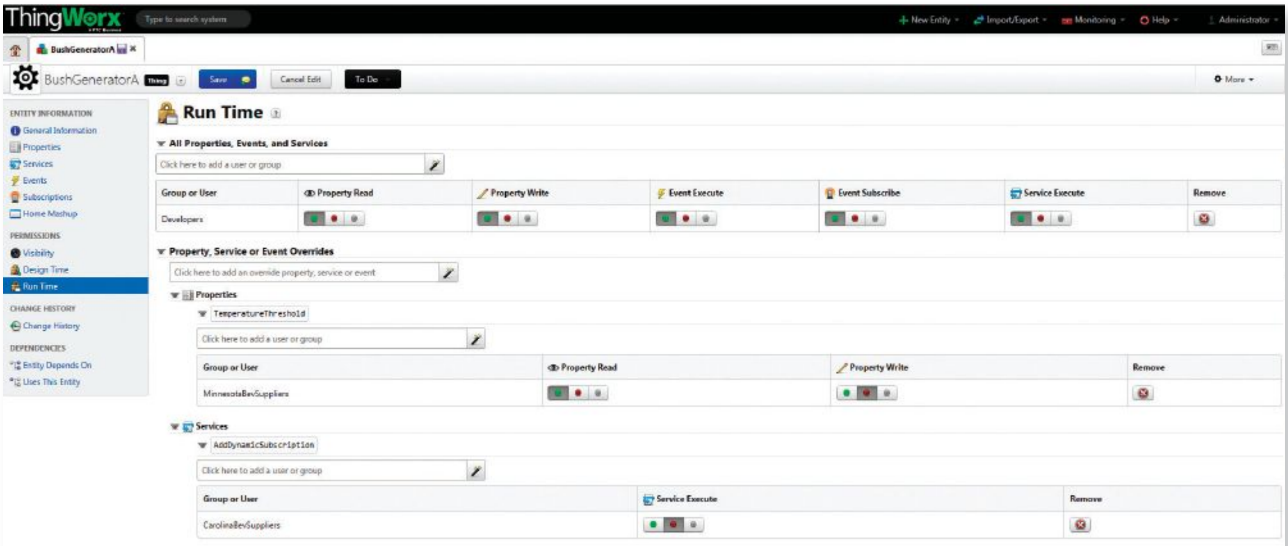
For designers and engineers, this will mean more than just adding a few sensors and radios to an existing product. IoT connectivity will affect how the software operating within these devices interacts with the hardware, what types of components can be used to gather data and enable communications, and will ultimately affect how the end product functions in the real world. More importantly, the IoT opens up a stream of real-time operational, usage and failure data that will give R&D departments, engineers and quality experts a previously unheard of view into how every component and material decision is playing out at customer sites.

"Design and development are being influenced by real-time feedback, which makes it imperative for designers and developers to be more agile and responsive," says Adi Pendyala, co-founder and head of Business Development at mnubo.

"How do you design a product that requires you to contemplate mechanical hardware, electronics, how to manage software on the product, and software that is in the cloud?" says Kevin Wrenn, division general manager of the ePLM (product lifecycle management) group at PTC. "We could see evergreen products that add features and functions throughout the entire lifecycle of the product."

In the IoT model, companies aren't selling products; they are selling services or outcomes. Developers and designers on both the hardware and software side have to work even more closely together to make that model work. Because the connectivity component is outside the domain expertise of many manufacturers, they are increasingly turning to IoT development platforms.

These solutions help companies accelerate development and design by making it easier to integrate sensors, microcontrollers, communications software, security and connectivity functions into products or machines. These tools can also be used to build the onboard and cloud-based applications required to run IoT solutions.



PTC's ThingWorx IoT platform offers a granular security model to enable data isolation and service execution at any required level, including user and device authentication. ***Image Courtesy of PTC.***

IoT Development Platforms

IoT solutions development has affected software and hardware development by simplifying the development process itself, lowering barriers to entry and increasing efficiency. According to Ilya Kretov, senior technology advisor at DataArt UK, in every IoT system, there is a point where hardware and software converge, blending design team responsibilities. IoT development platforms help speed development time and save costs by making it easier to extract value from the object data that is being generated.

"These systems are rather complex, so there are technical challenges in every part of the system," Kretov says. "That is especially true in the connection points between the systems."

Building computer-like connectivity, processing power and communications into products that have never had such features before will pose a number of challenges for designers and engineers. Smart, connected devices will require more personalization, support for ongoing product upgrades and accommodation of remote or predictive service models. Integration of hardware, electronics, software and connectivity technology will have to be more agile and flexible. There will be more design changes later in the process, as well as post-purchase changes and more rapid iterative work on those designs.

Even products that already included some level of embedded intelligence will be configured differently. Designers will need a new menu of boards, sensors, power supplies and actuators, along with a strategy for determining optimal computational load payoff between the local data processing and what happens in the cloud. Security and communications considerations will have even more impact on both the physical design and software development process for a wider range of products.

Designers will also have an entirely new view of how products are actually used. "These are things that designers never got to see before, because once they were finished with a product they didn't really know if it was being used in the way they anticipated, or if it was performing as expected," says Tom Shoemaker, vice president of the ePLM group at PTC. "That stream of information can now be made available to R&D (research & development) and the engineering team to give them better insight as to how the product is performing."

IoT development platforms make it easier to bake in the required connectivity without a lot of heavy lifting on the software development side. They also provide tools that can help guide hardware decisions at the board and sensor level, and APIs (application programming interfaces) that enable integration with data analytics, simulation, design and other software systems.

PTC entered the IoT market via its acquisition of ThingWorx in 2013 to complement its PLM and SLM (service lifecycle management) portfolios by offering a way to create secure product connections and to develop applications to leverage data generated by those products. "Existing design platforms have to get smarter to incorporate all of these new considerations," Shoemaker says. "We will need new libraries of sensors and other components that can be re-used and embedded in to the design process."

Wind River offers a development environment (Intelligent Device Platform XT), along with an Edge Management solution for connecting devices through a central console. According to Ido Sarig, general manager and vice president of the IoT Solutions Group at Wind River, the company has focused on creating ways to deploy embedded software to different hardware configurations quickly, without eating up lots of memory on the devices themselves.

"The whole paradigm of software development for embedded devices is undergoing a radical change," Sarig says. "It used to be you designed the software with a cross compiler for a particular target board, and then deployed it. That's very cumbersome and doesn't scale if you have more than one type of hardware. Ideally you would write once, and deploy everywhere."

Security Challenges

Securing the data generated by smart objects is a new challenge for developers. Devices that weren't previously connected to the network lack the common security capabilities found on a desktop computer, for example.

"There are new considerations in the design regarding identity and access," says Sean Lorenz, senior product marketing manager for LogMeIn's Xively. "You want to know what sensors are able to be read, how they are read, and who is able to access them. All of that information has to be determined in the design phase so that you can better understand the security issues."

"The type of software being developed in the past did not necessarily take all security issues into consideration, because the device was separated from the outside world," Sarig says. "They only thought about physical security. With the IoT, that changes. If you want to get data off of that device, how do you do that efficiently and securely? You have to work more closely with the developers working on the cloud side of the application to make sure the two parts interoperate. It's become a more complex development environment."

Security is just one area where hardware and software design are converging because of IoT requirements. "You have physical hardware and embedded systems designers, and software designers who build Web apps, and they've worked in completely different worlds," Lorenz says. "Now they are being thrust together in IoT. You not only have to understand the fundamentals of the hardware design, but also best practices for software, connectivity, data allocation and directories."

Developers that understand both halves of the process will be crucial players in re-organized design teams, and those teams will have to plan for the new ways in which customers use products and machines.

Real-Time Performance Data

The IoT will also lead to another significant change in the design process: closed-loop product lifecycle management. The data coming back from connected products will be more detailed and more granular, and provide a much better view of how customers are using products and how those products are performing.

This is a new concept for companies that have traditionally relied on historical data to determine failure rates and identify design problems. "You can understand how many button presses are occurring, and find out where the flaws

Every Samsung Product Will Connect to the IoT

To get an idea of what the Internet of Things might mean for future product designs, look no further than Samsung's recent announcement that by 2020, every product it sells will be connected to the Internet of Things and be able to communicate with each other. The company envisions everything from your phone and headphones to cars, mall maps and furniture interacting and providing feedback to users.

Samsung has opted to follow an open route to ensure device interconnectivity. It acquired a company called SmartThings last year that has created a smart home hub that effectively acts as a translator between different smart objects.

"Without this kind of openness, there won't be an Internet of Things because the things will not fit together," said BK Yoon, CEO, during his International Consumer Electronics Show 2015 (CES) keynote.

To make this possible, Yoon said that Samsung would need to develop smart components like sensors that can demonstrate understanding and context while the products are operating. Samsung is also investing more than $100 million in the developer community via accelerator programs worldwide.

Interoperability among what is expected to be billions of connected devices in the next decade will be a key challenge for the expansion of the IoT. In January, the Linux Foundation announced the preview release of IoTivity, an open source software framework that provides IoT connectivity.

are in real-time, and gather that data on a global scale," Lorenz says. "You then feed that back into analytics or whatever system you have to iterate on product design."

IoT platforms typically include APIs that make integrating this data into design software, analytics or simulation tools fairly straightforward. "And instead of doing traditional simulations, you now have real field data to show you what the actual fault tolerances are, for instance, in a real product," Lorenz says.

Currently, much of this smart object data exists in a silo at many companies, and that's where IoT development platforms also play a role. "What's going to happen for the next-generation OEMs (original equipment manufacturers) is there is going to be a business federation layer where business rules feed that data into existing processes," mnubo's Pendyala says.

Connected failure analysis can greatly accelerate the time it take to uncover and correct design problems, because companies will now have access to real-time performance and failure data.

"When properly instrumented, you can see the combination of environmental and operating conditions that lead to a failure," PTC's Shoemaker says. "That enables more rapid resolution of those types of problems and can also reduce costs by avoiding over-engineering certain products or features."

IoT development platforms can help companies quickly implement direct connectivity with products, and support the type of open communication among different types of products that IoT boosters have always touted. More of these tools are entering the market every month, and they will play a key role in product development as the demand for connected products increases. **DE**

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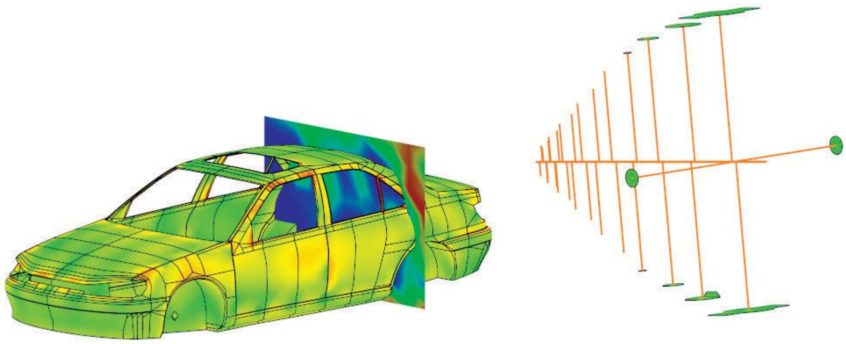
Taking the IoT's Electromagnetic Pulse

Embedded sensors and device connectivity increase the need for EMC verification.

BY KENNETH WONG

By the latest count of the International Telecommunication Union (ITU), the UN agency for IT and communications technology (ICT), the world's roughly 7 billion people were connected via 6.9 billion cellular subscriptions in 2014 ("Key 2005-2014 ICT Data for the World," published by ITU). The developed world accounts for 5.4 billion devices, and the developing world 1.4 billion. Regardless of the uneven distribution, the device density suggested by ITU's statistics is astounding. Inevitably, the electromagnetic transmissions from hundreds of smartphones will come in close contact and possibly clash with one another.

Remcom, formed in 1994 by Raymond Luebbers and his graduate students H. Scott Langdon and Christopher Penney, creates electromagnetic simulation software with an emphasis on handling large, complex problems and fast calculations via GPU (graphics processing unit) acceleration. "Generally speaking, if you put two cellphones next to each other, you do not want the electromagnetic energy from cellphone A's circuitry to interfere with cellphone B's operations. You want both to work. EMC (electromagnetic compatibility) is about measuring, testing and setting limits on the energy and transmission from the devices," says Jeff Barney, product marketing manager at Remcom.



Automotive EMC measurement installation, simulated in Altair's FEKO. *Image courtesy of Altair.*

"With miniaturization of connected devices, EMC concerns increase dramatically, because now you have to take into account the clash factors both internally on the device itself, and externally with other devices," says Humair Mandavia, executive director of the Zuken SOZO Center.

One of the challenges for design engineers in the age of the Internet of Things (IoT) will be to teach their devices to confine their electromagnetic energy to their own personal spaces — a task made harder by a lack of expertise.

Playing by the EMC Rules

In 1994, after completing his Ph.D. at the University of Stellenbosch, South Africa, Gronum Smith co-founded EM Software & Systems, a consultancy firm that focuses on electromagnetic-related problems. Realizing the fast growing need for EM simulation, they started working with Dr. Ulrich Jakobus on the code for FEKO software. By December 2013, FEKO's popularity caught the attention of Altair Engineering, a simulation software developer. So a deal was struck: Altair would buy 100% of EM Software & Systems. Smith is now Altair's country manager for South Africa and Jakobus is VP of Electromagnetic Solutions.

"Sensitive electronic equipment, which may or may not have intentional receiving capabilities, are highest on the susceptibility list," says Smith. "For example, high-power radars can damage sensitive electronic warfare

(EW) receivers, which are used to listen to enemy communications. Mobile phones are, due to their high mobility and uncontrolled use, potentially dangerous where they can interfere with, say, medical equipment, navigation systems (of aircraft), control systems and radios. Immunity to lightning and other EM pulses is often an industry requirement in, for example telecommunication masts, ship masts, buildings and aircraft."

This realization has prompted governments, industry leaders and regulatory institutions to set up some rules about how transmission-capable devices should behave around one another. You may have noticed the CE label inscribed on the back of wireless mice, smartphones and Bluetooth devices. The marking indicates the device complies with the EMC directive set by the Conformité Européenne, required for selling in the European Union countries. "That CE label assures you that, at a certain frequency range, the device's electromagnetic emissions are below the threshold set by the CE regulatory body," says Remcom's Barney.

"Not only are there different standards for different product types, but there are also different standards for different countries," Smith says. "The consequences of failure are an important consideration in the development of EMC standards for different products: For example, long-term effects on the health of mobile phone users, failure of systems that could lead to a crash or failure of medical equipment. For many consumer products, susceptibility is less important, since the consequences of failure are more annoying than catastrophic. A TV failing is annoying, whereas a pacemaker failure can be fatal to the patient."

In addition to safety concerns, running afoul of government regulations concerning EMC can be expensive. For example, last month U.S. Department of Transportation's Federal Aviation Administration (FAA) proposed a $900,000 civil penalty against Alaska Airlines, Inc. According to a statement from the FAA, it alleges that the airline installed systems to pulse external aircraft lights "without conducting required ground and flight tests to determine whether the systems caused electromagnetic radio frequency interference with aircraft radios, navigational systems, or other electronic equipment."

Specialized EMC Solvers

Zuken's 3D PCB (printed circuit board) design software CR-8000 and CR-5000, for example, include a feature called EMC Advisor, which gives users a way to conduct rule-based probes of signal integrity and shield structure effectiveness, among others. It's aimed at non-experts, according to the company.

"You may have EMC experts who are doing simulation and analysis, working with other gurus," says Zuken's Mandavia. "But the time required to do that kind of validation affects your lead time. With [EMC Advisor], anybody — PCB designers to engineers — can run some tests based on experts' guidelines and rules. So you can, for example, spot that traces are going over a split plane, and get feedback on how to fix it." For the more advanced EMC simulation, Zuken partners with ANSYS, CST, AWR and other developers who specialize in the field.

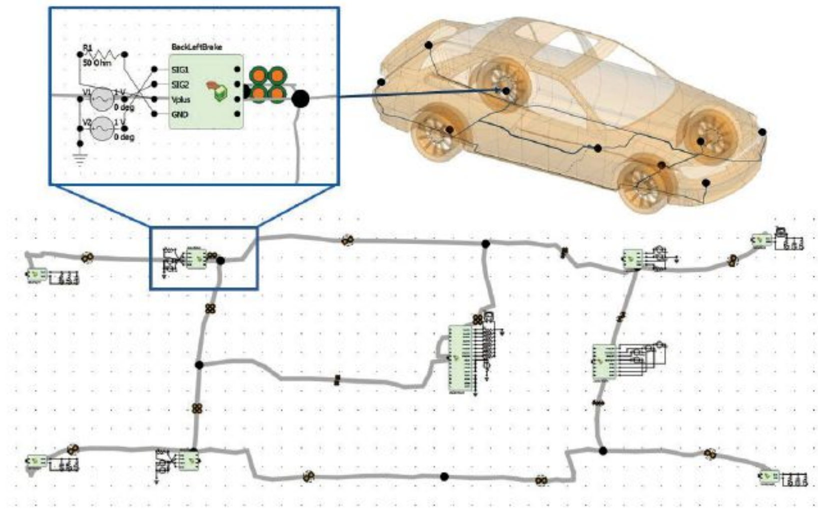
For example, CST EMC STUDIO is a product for EMC and EMI analysis that was launched earlier this year. According to the company, engineers can use the product to "study effects such as radiated or conducted emissions in consumer electronics devices, or susceptibility to electrostatic discharge, lightning strike and high-intensity radiated fields."

The CST software includes general and specialized solvers.

"Sometimes, the person in charge of EMC is treating the problem like a mechanical engineering problem, whereas it really should be treated like an antenna issue, because that's what emission is," Remcom's Barney says. "To analyze EMC, you need a solver that is specific to electromagnetics. These solvers look at radiation at various frequencies — different from solvers for thermal, structure, stress and strain, or heat transfer calculation."

One example of how vendors are making specialized EM simulation available to generalists can be seen the ANSYS Electronics Desktop, which was part of the January release of ANSYS 16.

"This single-window, highly integrated interface brings electromagnetic, circuit and systems analysis into a seamless working environment to maximize productivity and to ensure users are following simulation best practices," according to the company.



Analyzing cable harness and connected circuits in an automobile with Altair's FEKO. ***Image courtesy of Altair.***

It features ANSYS HFSS software for simulating 3D full-wave electromagnetic fields and what the company says is the industry's first 3D electromagnetic component library. Users can create 3D components to share with colleagues and/or integrate them into larger electronic assemblies.

Software products developed for EMC simulation and testing can all be traced back to a handful of leading EMC solvers, belonging to either time domain or frequency domain, according to Barney. Remcom's XFdtd, for example, is based on the finite-difference time-domain method (hence, the acronym FDTD).

Closely Guarded Materials and Wisdom

Usually EMC simulation begins (just like fluid or thermal simulation) with a CAD model. The geometry, in this case, will most likely be a detailed view of the circuitry, along with the screens and buttons it interacts with. The source CAD model may come from a combination of mechanical and electrical CAD assemblies. Because the types of conductive materials determine electromagnetic energy behavior, engineers need accurate material data (crucial values are permittivity and conductivity) to simulate the scenarios.

Running the simulation is the easy part, but tracking down the material data and compliance information proves much more difficult. "For example, if you purchase a certain type of plastic from a supplier, you may not know the electromagnetic properties of that plastic," says Barney.

"Some suppliers consider [material information] their intellectual property. Some treat it as sensitive data. Some think of it as their secret sauce, which lets them control their costs. So if you're trying to do a system-level simulation with multiple supplier components, getting that information could be difficult," says Mandavia.

If a product fails upon EMC testing, the next challenge is to identify a fix. The most common fixes are to reconfigure the circuitry layout to weaken resonances, improve shielding structures to contain the radiation, or redesign the grounding structure (to ensure good return paths). All these are worth considering, but identifying the magical combination of these approaches could be something of a black art, Barney notes. "Sometimes, our customers have an experienced engineer who instinctively knows the right fix," he says.

In the absence of such an EMC wizard, many rely on the ability to try out different combinations of fixes using simulation software. Still, the number of iterations you need to simulate to arrive at the best approach is not to be underestimated.

"Because the frequencies or the source of emission might not be known, it is necessary to cover a very broad spectrum, which in turn requires simulations at many frequencies or many time steps for time-domain simulations," says Altair's Smith. "Not only is it necessary to simulate individual components, which can be complex in itself, but the more challenging problem is simulating the complete assembly, including connection of several devices through cables. Although engineers aim to simplify and solve only the essential components and structures, these can still be very challenging to validate: for example, cable bundles supporting several circuits and devices in a car. The simulation and data processing time can become prohibitively long if many configurations have to be considered."

No Replacement for Real-World Tests

The IoT Gold Rush — the move to integrate wireless transmission, circuitry and sensors into everyday household items and consumer goods to make them appealing — is expected to increase the demand for EMC simulation.

"As you create more of these transmission devices, you'll have a greater need to make sure they comply with local standards," says Barney. But he cautions that "simulation is a design tool that is accurate enough to predict whether or not you'll pass the test. But at the end of the day, you still must go out and run the test to become certified."

"Although EM simulations would not replace the need for [real-world] measurements, their analytical use plays a major part in reducing the cost of obtaining EMC compliance," says Smith. **DE**

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Test Methodologies for IoT Success

To properly vet Internet of Things devices, companies must combine traditional hardware, software and procedures with new advances.

BY RANDY FRANK

Keysight Technologies hardware as well as N5978AIFT scripts and N6061A protocol logging and analysis software for LTE-A work together to analyze a variety of IoT testing issues in wireless applications. ***Image courtesy of Keysight Technologies.***

The software, sensing and connectivity requirements of Internet of Things (IoT) devices bring new complications to testing. Design engineers have several options to consider. IoT testing approaches include technology-specific testing, traditional automated test equipment (ATE) that uses different hardware to conduct specific tests, software-centric approaches and vendor-specific testing resources. Testing services provide yet another option.

Testing is performed to verify that something works as expected and it is within specifications to debug software. It also confirms the ability to meet industry standards, such as interoperability and others. In addition to ATE, development platforms and testbeds enable these activities.

Vendor-Specific Testing

Formed in 2014 by AT&T, Cisco, GE, Intel and IBM, the Industrial Internet Consortium (IIC) has a goal to utilize existing use cases and create new industry use cases and testbeds for real-world applications. As the IIC explains on its website, "A testbed is a controlled experimentation platform, conforming to an IIC reference architecture, where solutions can be deployed and tested in an environment that resembles real-world conditions."

In fact, testing is the key to IoT growth.

"Innovation is the ultimate goal of IoT. Technology, interoperability, security, data privacy — those are obviously important but they are just the enablers. Testbeds help expedite and validate those aspects and more," says Lynne Canavan, program director for the IIC. "The real ROI (return on investment) will come from innovative new products and services plus huge efficiency gains that represent the third revolution in modern industry: the Industrial Internet."

As a member of the IIC, Fujitsu has made an IoT platform in collaboration with IQP Japan Corporation, a developer of applications and platforms. With the platform, Fujitsu provides up to six months free use of application development and execution via the Fujitsu Cloud.

"To realize our vision of 'Human-Centric IoT', Fujitsu has launched an IoT platform to enable rapid development and testing of impactful and innovative new products and solutions," says Jane Yin, vice president, Marketing & Open Innovation Group, Fujitsu Laboratories of America Inc.

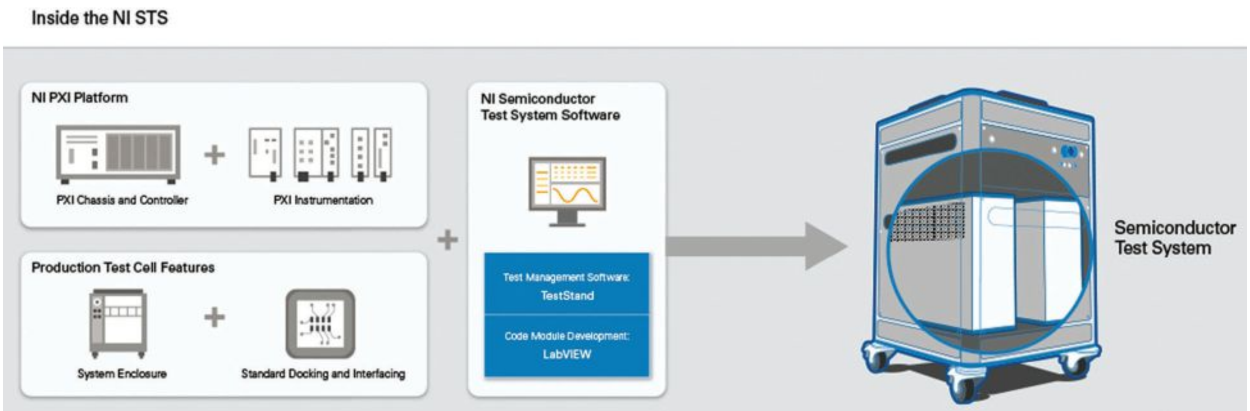
A Software-Centric Approach

National Instruments' (NI) approach to IoT testing consists of a hardware platform and software for testing in both the design and manufacturing phases. The Semiconductor Test System, or STS, provides a single technology-specific package for easy integration into a semiconductor production environment. Commonality was a major goal of the test system design.

"As much as you can get commonality around the physical way of making the measurement, as well as the software algorithms that are processing the bits that you are bringing in from the physical world, the better," says Luke Schreier, director of Automated Test product marketing at NI. "Because then you spend less time debugging the test system or simulation system and more time focusing on the thing you are building."

Integrated Device Technology (IDT), a semiconductor manufacturer and a lead user of the STS, discussed its success with it at NIWeek 2014. Reducing the cost of test was a major goal and common test platforms were pursued as a solution.

"It gives us the flexibility to address the need of various business units," said Rebecca Jimenez, vice president for Worldwide



Based on the PXI platform, NI's Test System Software provides a flexible IoT test solution that can change with the changing requirements of users that are addressing the IoT. ***Image courtesy of National Instruments.***

Test Operations at IDT. "By keeping this in mind during the initial hardware stages, we have been able to stay with a standard configuration, which is key for manufacturing. We already have three systems running in production."

Technology-Specific Testing

Achieving seamless connectivity and transitions such as 3G to 4G and performing 4G to 5G investigations and studies also require the use of platforms and testbeds. Qualcomm has created an Internet of Everything (IoE) Development Platform so users have hardware and software for designing and building machine-to-machine (M2M) devices with built-in cellular connectivity and an IoE Wi-Fi Development Platform.

Mike Stauffer, senior director of business development for IoE business at Qualcomm says the experts for the enabling IoT connectivity technologies typically provide tested and compliant subassemblies for the lowest levels.

In the software stack, other tests are required, particularly those that ensure interoperability at the application level.

"It's great that you can hook up two devices that can actually send some packets back and forth, but you need to be able to interpret the meaning of those packets to do a lot of useful things for the IoE," says Stauffer.

Traditional Automated Test Equipment

No matter what type of testbed or platform is used, additional analytical equipment may be required. Keysight Technologies, a spinoff of Agilent Technologies, manufactures test equipment for a variety of measurement and testing situations.

One of the newest hardware tools for IoT testing is the E7515A UXM Wireless Test Set used for LTE-Advanced design validation and more. It is part of a test environment that can be configured with other Keysight products.

"The N6705B and N5978AIFT scripts work with the UXM to address complexity and other testing issues associated with the IoT," says Jan Whitacre, manager of the Wireless Technology Program at Keysight Technologies

Testing: At Your Service

Testing services help their clients get to market quicker and with greater confidence of interoperability. Testing services offer companies an alternative to acquiring and maintaining their own in-house assets. In the rapidly changing area of the IoT, it can provide a new option to users who are venturing into new territory.

One provider, CSC, has an IoT Testing Lab in Utah that works on IoT testing techniques, certification and creation of testing models. The facility focuses on interoperability of embedded systems with wired and wireless connectivity to the Internet.

"We are already implementing and developing IoT Testing using a TaaS (testing-as-a-service) model," says Manish Tomar, vice president and general manager, Applications Managed Services, CSC. "This is in line with CSC's vision of next-generation applications and service-enabled enterprise."

The IoT is all about connectivity. "When we think of the Industrial Internet, we are looking at transformational breakthroughs. We are, today, starting to make things happen in ways that couldn't happen before," says IIC's Canavan.

To do this, the way companies think about testing will be a key part of how things are done differently. **DE**

Randy Frank *is a contributor to* Desktop Engineering. *Send e-mail about this article to DE-Editors@deskeng.com.*

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→ **Keysight Technologies:** Keysight.com

→ **National Instruments:** NI.com

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Verification vs. Validation

How do these concepts help analysts create more accurate and realistic models?

TONY ABBEY

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

I was recently tasked with creating material to explain what Verification and Validation (V&V) are in relation to FEA (finite element analysis). To help guide me I listed some questions I felt an FEA engineer would want to ask and posted them as open questions in my LinkedIn Group (Finite Element Analysis Training).

- What are Verification and Validation?
- How are they different?
- How do I apply this to FEA in "hands on" work, not as a software developer?
- Doesn't Verification check against benchmark examples and Validation check against test?
- I check my work diligently, why do I need V&V?
- Shouldn't my manager be worrying about this, not me?
- Bottom line, how would V&V help my client and me?

Some of the questions were a little tongue in cheek, but they prompted a good discussion. The list also gave me a baseline to work from, which I hoped would address the processes from a bottom up perspective, rather than the usual high-level view.

What are Verification and Validation?

It was interesting to note in discussions with many FEA experts that it was difficult to define exactly what the "modern" definition of V&V brings to the FEA discipline that was not already being done. It doesn't help that both words, Verification and Validation, are synonymous in general usage. A cynic might argue that they neatly fit a classic system "V" diagram. The left hand side of the diagram represents the maturing design process from concepts down to frozen design, the right hand side represents the manufacturing, testing and evolving product verification and validation.

However, let's dive in and give a range of commonly agreed definitions for Verification and Validation in the FEA context. We start with a very practical definition set in the table below.

Verification	Validation
Making sure it works	Making sure it does what it's supposed to do.
Getting the math right.	Getting the physics right.
Providing an accurate FE analysis.	Checking the FEA against test.

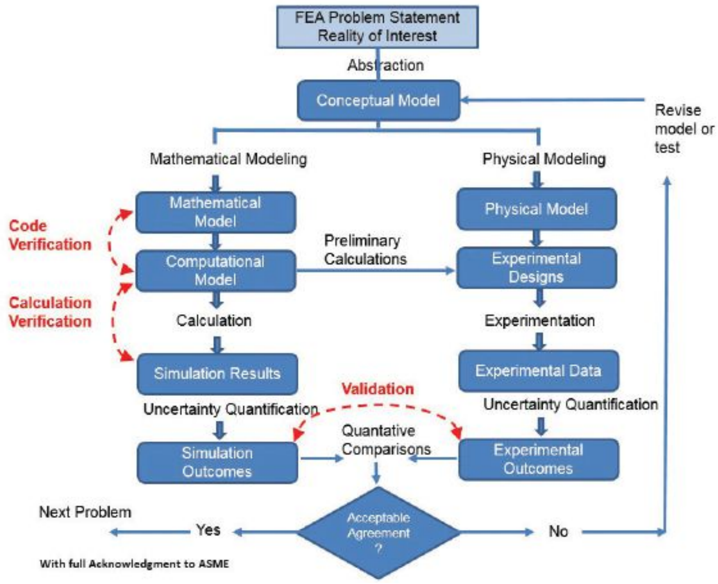

FIGURE 1: ASME V&V flowchart.

From these definitions, verification is very much to do with the typical checking process we should be going through when developing an FEA model. The validation process comes down to checking the FEA model against available test data.

The ASME, American Society of Mechanical Engineers, verification definition is: "The process of determining that a computational model accurately represents the underlying mathematical model and its solution." Similarly, The Los Alamos National Laboratory (LANL) defines verification as "concerned with identifying and removing errors in the model by comparing numerical solutions to analytical or highly accurate benchmark solutions."

This does not imply that verification is just a mechanistic set of checks on the FEA model. The checklist and checking process is a vital part of any traditional analysis plan, but we must do more than that. A further LANL verification definition gives an indicator of the wider task: "The process of determining that a model implementation accurately represents the developer's conceptual description of the model and the solution to the model."

So our early assumptions about the FEA model and its relevance to the actual physical structure, loads and boundary conditions are part of the verification process. Getting the physics right was attributed to validation in the table. However predicting the physics is an important part of verification in practice.

In contrast, ASME and LANL allocate the confirmation of the physics to a validation role: "Validation: The process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model." (ASME) LANL has an identical statement! The intention is to define this as an evaluation of the FEA model results against test evidence, but it should not be taken to mean we ignore any prior test evidence and experience.

A clearer positioning of validation in the process timeline is given by LANL: "[Validation]… is concerned with quantifying the accuracy of the model by comparing numerical solutions to experimental data."

Viewing the ASME process chart is a much better way of trying to understand the relationship between Verification, Validation, FEA and testing. A simplification of that chart is shown in Fig. 1.

The Verification and Validation Plan

A combined V&V plan, as shown in Fig. 1, brings to an FEA analysis the following key elements.

The early planning and assessment of the applicability of both the FEA model simulation methods and the test program to the real world structure and environment is done formally. It is also an integrated process between analysis and test disciplines. This is perhaps the biggest cultural change facing companies who want to take V&V seriously. I have worked with several companies where designers/analysts and test engineers have realized this fact themselves and have pushed their management to adopt this approach. It was noticeable that these were smaller organizations where good integration already existed and understanding of the physics, applicable modeling techniques and reasons for field failure all increased. Effective redesign and preventative new design capabilities improved significantly.

The comparisons between test and analysis are based on a set of metrics (the more the better). This means that the traditional single "big target" comparison (such as ultimate failure level, maximum deflection or peak acceleration) is supplemented by many incremental metrics. These give a broader validation between model and test and also provide a richer archive of legacy data.

Early program comparisons of test and analysis can help both plans and assumptions evolve. Many companies use FEA to predict test fixture strength and stiffness. In some cases, interaction between fixture and test article is inevitable and can be quantified (dynamic interaction or fixture flexibility).

The positioning of the verification step can be seen in Fig. 1. The lower Calculation Verification step relates to the FEA QA and checking processes we should be familiar with. Interestingly, Code Verification is included upstream of that. In many cases, repeating formal benchmarks of classical solutions to check the FEA Solver accuracy would be redundant. It is assumed to be covered by reference to the FEA Vendor Verification Manual (in at least one case confusingly called the Validation Manual). We won't discuss the Vendor Verification process in this article. However, as we move more into multiphysics, micro mechanics and other less understood areas, it may well be that Code Verification responsibility has to move away from the FEA Vendor.

Both the FEA and test paths have a step called Uncertainty Quantification. It attempts to bring some objectiveness to the maxim "Test evidence must be right, because it's real!" Are we comparing a highly accurate test result against a poorly modeled FEA, or are both subject to an unacceptable degree of doubt?

Uncertainty Qualification

I am not qualified to comment on Uncertainty Qualification in test, but believe it is an inexact science in FEA. We have methods of assessing mesh convergence to give confidence in FEA local stresses, but they are ad hoc. A simple automated metric can mislead here, without an understanding of load paths and stress distribution. The challenge to a good understanding of why stresses occur is that it is difficult for anyone, other than an expert, to picture. This is where FEA post-processing lets us down. There is a set of tools that could be developed to allow us to understand the results in a way which is required for effective verification.

A further shortfall of current FEA practice is the assessment of uncertainty over boundary conditions and loading. Accurate modeling of these aspects can be difficult. We can carry out sensitivity studies on loading levels and line of action, boundary stiffness and others, but it is tedious to do this manually. Again, if we are serious about V&V as an industry, we need FEA tools to facilitate this.

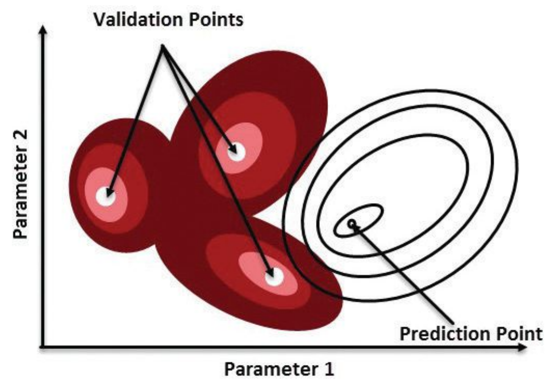

FIGURE 2: Validation uncertainty as described by the LANL.

Stages of Model Evolution

The various stages of model evolution shown in Fig. 1, can help clarify V&V planning. I will describe the FEA path, relying heavily on the definitions from the ASME and LANL.

The Conceptual Model is perhaps a misleading title, as it may not be a numerical model in any sense, but instead reflects the knowledge and information we have in our minds when assessing the structure to analyze and test (remember the integrated approach). Questions here would include what is the type of structural configuration, design objective, loading and constraint environment. Based on our experience, knowledge and training, we are going to make early decisions on modeling and test strategy. For a small-scale project this might come down to an informal plan for pre-analysis actions and data needed to be collected.

The Mathematical Model is where we commit ideas to preliminary calculations on paper, Excel, MATLAB and other programs. It may even be a simple exploratory FEA model.

How relevant is the Mathematical Model in modern FEA? Don't we just go straight from CAD to FEA? The key here is that structural analysis is knowledge, not just data transfer. Assumptions have to be questioned and the Mathematical Model provides that catalyst. Analysis target metrics can also be set, with ballpark comparisons against test. This could be a simple, thoroughly checked load balance diagram, with supporting calculations.

Finally we get to the Computational Model, which in our case is the FEA model. It is based on the thinking behind the conceptual model and the implementation and results of the mathematical model. The full battery of V&V checks are carried out.

Validation Uncertainty

If we are validating results between test and analysis and the range of validated designs is well populated, then we are interpolating data and would hope for good predictions. However, if we have to move outside our comfort zone, as shown in Fig. 2, the process becomes more difficult. A nice quote in discussion was "rewards come with risks, and risk goes hand in hand with uncertainty."

A judgment has to be made on whether the validation is acceptable based on:

- How complex are the physics and geometry involved;
- What degree of similarity is there between prediction point and validation domain;
- How well do test and analysis validations relate to each other;
- Is the model adequately representative.

One cautionary note: For some work the physics, problem complexity and hypothesis describing the phenomena can change, and our usual analysis method may not be appropriate. A challenging example for V&V is a commercial MEMS (micro-electro-mechanical systems) device design, electrically heating up an electrode that starts a chemical reaction in a fluid passing by, with a requirement to ensure structural, electrical and chemical integrity. Conversely, an aircraft structure analysis may not be required to demonstrate failure, but to show stresses within the elastic limit. If this level is exceeded, then a redesign is required as the limit load is established from extensive testing. This is an analysis exercise rather than a full simulation exercise.

An amusing analogy is to consider whether we have to model:

- An elephant reaching a cliff edge and falling off, so we can then predict the effect of reaching within a few millimeters (simulation).
- A demonstration that barriers stop the elephant getting nearer than 50 meters to a cliff edge we think may be there (analysis).

Key Takeaways

So what is my take on the V&V process? Don't get hung up on the words Verification and Validation in isolation, look at the process flow. Prediction and confirmation of the physics appear in Verification and Validation respectively. There is a need to make the concept of V&V more meaningful and practical at a practicing engineer/designer level. The ASME process plan is a great start. Build from existing FEA process and QA plans.

Test and analysis teams need to work together so that an integrated V and V plan can be developed; this may be a cultural challenge. Development of more generally accepted and easily applied Uncertainty Quantification in FEA is required.

Finally, the bottom line question: how does V&V help my boss, my client and me? An analyst with a V&V procedure can efficiently and effectively demonstrate his case in a consistent way. Validation against test is worth its weight in gold. The boss, who may have no FEA knowledge, has documented evidence to underwrite any go/no-go project decision. If all goes well the client should benefit from tighter and more objective decision making, if it doesn't – Plan B should be quicker in coming! DE

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THIN and POWERFUL

New mobile workstation from MSI delivers workstation performance in a lightweight package.

DAVID COHN

Thin is in. MSI (Micro-Star International) recently sent us one of its latest mobile workstation. The MSI WS60 20J 3K-004US clearly takes a page from Dell's playbook, sporting a thin, lightweight case reminiscent of the Dell Precision M3800 mobile workstation (deskeng.com/de/?p=15891) which in turn bore striking similarities to Apple's 15 in. MacBook Pro. While imitation may be the most sincere form of flattery, the thin, lightweight mobile market does carry some compromises.

For those not familiar with MSI, the Taiwan-based company — with offices in the U.S., Canada, Europe, the Middle East and Asia — was founded in 1986 as a motherboard and graphics card manufacturer. Today, it produces its own consumer and commercial electronics including notebooks, all-in-one PCs, servers, workstations, industrial PCs, household appliances, car infotainment products, multimedia systems and communication devices. In the U.S., MSI systems are sold by various national and regional distributors, and well-known retailers including B&H Photo, CompUSA, Fry's and Staples.

Last year, we reviewed the MSI GT70 20L mobile workstation, and came away impressed (deskeng.com/de/?p=12092). The new WS60 20J proved equally impressive.

The MSI WS60 comes housed in a thin, sculpted black brushed aluminum case with a glowing MSI workstation logo centered on the lid. The case measures 15.35 x 10.47 x 0.78 in. (W x D x H) and weighs 4.5 lbs. Its 6.5 x 3.25 x 1 in. external power supply is equally light, adding 1.5 lbs including all cables.

Unlike many other OEMs (original equipment manufacturers), MSI offers only two choices when configuring a WS60: a full HD eDP 1920x1080 display or a WQHD+ 3K display. The higher resolution adds $300 to the cost of the system. Otherwise, what you see is what you get, but what you get is a mobile workstation with a fast CPU, high-end graphics, a gorgeous display, lots of storage and plenty of memory at a very attractive price.

Both versions of the MSI WS60 mobile workstation are powered by a fourth generation quad-core 2.5GHz Intel Core i7-4710HQ CPU with integrated Intel HD Graphics 4600. This mobile processor has a maximum turbo boost speed of 3.4GHz, a 6MB cache, and a frugal thermal design power rating of 47 watts. The system also comes standard with 16GB of DDR3L 1600MHz memory, installed as a pair of 8GB SO-DIMMs in the two memory slots.

Also standard is an NVIDIA Quadro K2100M mobile GPU (graphics processing unit) with 2GB of GDDR5 memory and

The thin MSI WS60 mobile workstation delivers excellent performance in an affordable, lightweight package, but suffers from fan noise and a somewhat quirky keyboard. *Image courtesy of David Cohn.*

INFO → Micro-Star International Co. Ltd.: msi.com

MSI WS60 20J 3K004US

- **Price:** $2,600 as tested ($2,300 base price)
- **Size:** 15.35 x 10.47 x 0.78 in. (W x D x H) notebook
- **Weight:** 4.5 lbs. as tested, plus 1.5 lbs. power supply
- **CPU:** 2.5GHz Intel Core i7-4710HQ quad-core w/6MB cache
- **Memory:** 16GB 1600MHz DDR3L
- **Graphics:** NVIDIA Quadro K2100M w/ 2GB memory
- **LCD:** 15.6 in. diagonal (2880 x 1620)
- **Hard Drives:** 128GB SSD x2 RAID 0 and 1TB 7200rpm SATA
- **Optical:** None
- **Audio:** Sound Blaster Cinema 2 with stereo speakers and built-in microphone, headphone-out and microphone-in
- **Network:** Intel Gigabit LAN (10/100/1000), Intel Dual Band Wireless-AC 7260, Bluetooth
- **Modem:** None
- **Other:** Three USB 3.0, Thunderbolt/mini DisplayPort, HDMI 1.4, 1080p webcam, SD (XC/HC) card reader
- **Keyboard:** Integrated 102-key backlit keyboard with numeric keypad
- **Pointing device:** Integrated touchpad with multi-touch

Mobile Workstations Compared

		MSI WS60 2.5GHz Intel Core i7-4710HQ quad-core CPU, NVIDIA Quadro K2100M, 16GB RAM	**Dell Precision M3800** 2.2GHz Intel Core i7-4702HQ quad-core CPU, NVIDIA Quadro K1100M, 16GB RAM	**MSI GT70 20LWS** 2.4GHz Intel Core i7-4700MQ quad-core CPU, NVIDIA Quadro K4100M, 16GB RAM	**Eurocom Racer 3W** 2.4GHz Intel Core i7-4700MQ quad-core CPU, NVIDIA Quadro K1100M, 16GB RAM	**BOXX GOBOXX G2720** 3.6GHz Intel Core i7-3820 quad-core CPU, NVIDIA Quadro K5000M, 16GB RAM	**Eurocom Panther 4.0** 3.1GHz Intel Xeon E5-2867W 8-core CPU, NVIDIA Quadro K5000M, 16GB RAM
Price as tested		$2,600	$2,887	$3,200	$2,172	$5,895	$6,800
Date tested		1/17/15	3/13/14	11/25/13	11/10/13	5/28/13	4/20/13
Operating System		Windows 7	Windows 7	Windows 7	Windows 7	Windows 7	Windows 7
SPECviewperf 12	higher						
catia-04		21.26	14.74	n/a	n/a	n/a	n/a
creo-01		19.98	13.37	n/a	n/a	n/a	n/a
energy-01		0.32	0.28	n/a	n/a	n/a	n/a
maya-04		17.90	12.79	n/a	n/a	n/a	n/a
medical-01		5.71	3.72	n/a	n/a	n/a	n/a
showcase-01		10.63	8.50	n/a	n/a	n/a	n/a
snx-02		22.05	14.74	n/a	n/a	n/a	n/a
sw-03		32.32	19.43	n/a	n/a	n/a	n/a
SPECviewperf 11	higher						
catia-03		45.66	33.56	72.47	28.97	73.23	65.87
ensight-04		24.09	17.50	50.62	17.38	61.24	61.01
lightwave-01		64.37	58.84	64.39	31.53	78.03	65.85
maya-03		77.78	61.83	112.33	51.20	111.58	102.18
pro-5		18.26	15.37	18.38	9.43	16.06	13.82
sw-02		47.80	39.48	55.00	24.95	63.26	55.06
tcvis-02		36.95	28.69	60.63	27.70	60.91	59.28
snx-01		31.85	23.76	59.76	23.17	63.57	64.62
SPECapc SolidWorks 2013	higher						
Graphics Composite		3.08	2.41	5.27	3.63	2.72	2.26
RealView Graphics Composite		3.23	2.71	6.27	3.97	2.93	2.42
Shadows Composite		3.23	2.34	6.26	3.95	2.93	2.42
Ambient Occlusion Composite		3.51	2.20	13.00	5.35	6.09	5.14
Shaded Mode Composite		2.96	2.31	5.78	3.83	2.66	2.41
Shaded with Edges Mode Composite		3.21	2.51	4.80	3.44	2.78	2.12
RealView Disabled Composite		2.55	2.40	2.62	2.55	2.02	1.72
CPU Composite		3.06	2.41	3.74	3.99	3.61	3.72
Autodesk Render Test	lower						
Time	seconds	63.60	71.42	60.33	55.83	79.20	57.33

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

576 CUDA cores. This mid-range mobile discrete graphics card enabled the WS60 to deliver some good graphics performance. The system also comes standard with Intel Dual Band Wireless-AC 7260 and Bluetooth.

Quirky Keyboard

Lifting the lid reveals a beautiful 15.6 in. backlit LCD display. Since we received the WS60 model with the WQHD+ 3K display, our system came with an IPS panel with a native resolution of 2880 x 1620. A 1080p webcam is centered above the display with a single microphone to one side. An LED adjacent to the webcam glows white when the camera is active.

The SteelSeries keyboard provides 102 backlit keys, including a separate numeric keypad. The main keyboard has large keys with an excellent feel, but unfortunately we found both the layout and the appearance of the keys themselves to be somewhat problematic. MSI used an overly-stylized font for the keyboard graphics, some keys were in awkward locations, and there was only one Windows key. Function key combinations let you quickly toggle between various power saving modes, control the webcam, toggle Wi-Fi, control the keyboard backlight, adjust speaker volume and so on. There's even a function key combination you can program to launch a user-defined application.

The touchpad also raised some issues. Rather than being centered below the keyboard, the 4 x 2.75 in. panel was shifted about 2 in. two inches to the left, resulting in less space to rest your left palm. The touchpad's multi-touch capabilities also did not feel as smooth as those on the Dell M3800 or MacBook Pro.

A pair of stereo speakers are located above the keyboard, beneath a perforated grill. A round power button centered above the grill glows white when the system is using the integrated graphics and amber when the discrete NVIDIA GPU is active.

Bright LEDs along the front edge of the case indicate the sleep state, hard drive activity, number lock, caps lock, Bluetooth, Wi-Fi and battery status. With its slim design, all ports are located on the sides. The right side of the case houses a USB 3.0 port that can continue to charge external devices even when the computer is in power off mode. Here you will also find an SD card reader for XC and HC cards, an HDMI port, an RJ45 connector for the Intel Gigabit LAN and a Thunderbolt Gen2 port that can be used to connect fast external storage or external displays.

The left side sports a pair of audio jacks for headphone and microphone for the built-in Sound Blaster Cinema 2 sound system, two additional USB 3.0 ports, a Kensington lock slot and the connector for the external power supply.

Ventilation ports are locked near the rear on both sides with additional ventilation ports on the bottom. The bottom of the case provides two additional stereo speakers. As is true with other slim systems, there is no battery compartment. While the bottom cover can be removed to access the fan, hard drive and battery, the slim manual (which we had to download from the MSI website) does not address any user-serviceable components.

While there is no optical drive, MSI does equip the WS60 with some impressive storage. Our system came equipped with a pair of 128GB SSDs (solid-state drives) in a RAID 0 array as well as a 1TB 7200rpm SATA hard drive, all standard in the base price.

In spite of the preponderance of solid-state components, the WS60 exhibited some pretty excessive fan noise. The fans are active all the time, with noise at a pretty constant 40dB, climbing as high as 56dB during compute-intensive tasks. In spite of this, the system ran quite cool, but battery life proved somewhat disappointing. The integrated 6-cell battery kept the MSI system running for 3 hours and 13 minutes on our battery rundown test. While that's not bad compared to most other mobile workstations we've tested, it pales in comparison to other thin, lightweight solid-state systems.

Winning Performance

The minor issues we encountered all but disappeared, however, once we began our benchmark tests. On the SPECviewperf test, the MSI WS60 outperformed the Dell M3800 on every dataset. In fact, on this graphics-intensive test, the WS60 was only beaten by mobile systems utilizing much higher-end GPUs and costing considerably more.

On the SPECapc SolidWorks 2013 benchmark, which is more of a real-world test, the MSI WS60 mobile workstation was even more impressive, turning in test results that placed it in the upper echelon of mobile workstations we've tested recently. In fact, only the MSI GT70 we reviewed last year surpassed all of its SolidWorks results.

We also ran the new SPECwpc benchmark. Although we still have limited results with which to compare, the WS60 outperformed the Dell M3800 on this test, and even beat out several desktop systems on many of the tests in this extensive benchmark.

Finally, on the AutoCAD rendering test, a multi-threaded test where the edge definitely goes to systems with fast, multi-core CPUs, the MSI WS60 turned in great results, completing our test rendering in just over 63 seconds.

MSI preloads Windows 7 Professional 64-bit and backs the system with a two-year limited warranty. And unlike many other lesser-known brands, this MSI mobile workstation is ISV (independent software vendor) certified for major CAD/CAM programs such as SolidWorks.

The price was also impressive. At $2,600 as configured, the MSI WS60-20J 3K-004US is one of the most affordable mobile workstations currently available. The same system with a 1920 x 1080 display is $300 less. At that price, we can forgive the few shortcomings. Once again, MSI has delivered a winning mobile workstation. **DE**

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3D-Printed Electronics Get Real

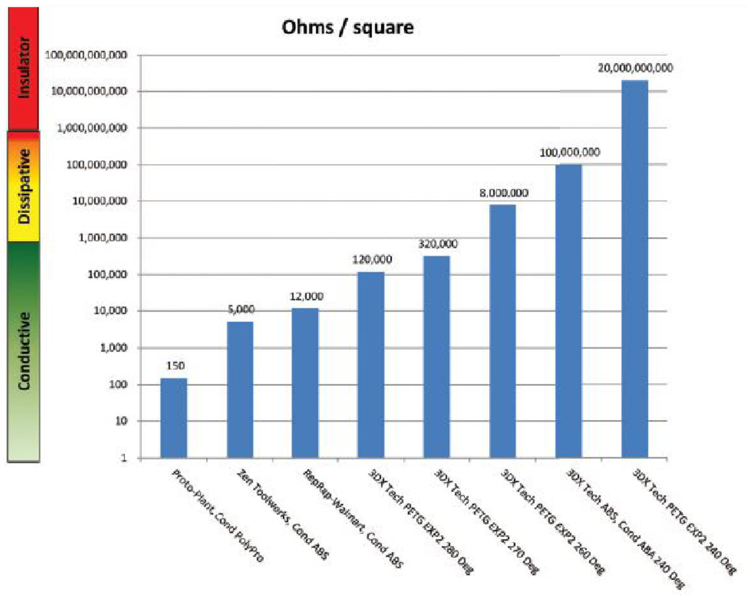
An oft-overlooked subset of the additive manufacturing world, 3D-printed electronics have a long history and a great future.

BY PAMELA J. WATERMAN

Light-sensor shield board (violet) attached to an Arduino microprocessor motherboard, with photo-sensor and LED connected by electrically conductive, 3D-printed F-Electric filament traces. ***Image courtesy Functionalize.***

Cool, amazing, useful or fun. Any one of these words may describe 3D-printed parts, but the conversation usually centers on end-parts with structural functions — not electrical. Or so you may think. Turns out the first commercially available 3D-printing system for electrical applications came out more than a decade ago and creative work has been escalating ever since.

But what defines 3D-printed electronics, as opposed to standard printed electronics? Does it refer to the materials, i.e., printing layers of electrically conductive plastic? Is it a process that can deposit silver traces alongside plastic in a single build cycle? Or are we talking about generating printed circuitry that conforms to 3D-surface topology, eliminating the need for separate printed-circuit boards (PCBs)? The answer is all of the above and more as new approaches crop up, suitable for applications both exotic and mundane.



Comparison of surface resistance values [ohms/unit square] for several conductive 3D printing materials. ***Image courtesy ProtoPlant.***

Benefits Now and Down the Road

Why might you want to apply 3D printing concepts to electronic circuits in the first place? A little perspective comes from TNO, an independent research organization based in the Netherlands. The group discussed additive manufacturing (AM) opportunities for electronics during the 3D Printing Electronics Conference, held in the Netherlands in January.

TNO points out that most electronics built today require environmentally unfriendly chemical processes to produce PCBs as well as multiple assembly steps to add discrete components. What if, instead, you could print circuits directly on a part, wrapping around it and completely eliminating a separate PCB, or even print an actual electronic component? Such capabilities will simplify today's electronics manufacturing and create totally new product solutions.

Pioneering 3D-Printed Electronics

If you start a Web search on 3D-printed electronics, you might find all roads seem to lead to Optomec. Though other groups and companies are working on relevant projects, Optomec, a 60-person New Mexico-based manufacturer, has more than 15 years of experience dedicated to this field. Known for its LENS powder-metal AM fabrication systems, Optomec is also the developer of Aerosol Jet technology, a process that creates electronic circuits and components on non-planar 3D geometry. Starting its program in 1999 under the DARPA Mesoscale Integrated Conformal Electronics initiative, the company now has 120 installed Aerosol Jet systems worldwide and works with customers on proof-of-concept efforts at its Minnesota Advanced Applications Laboratory.

There are four elements the company says are critical to making 3D-printed electronic technology a success. "With both our LENS and Aerosol Jet technology, we can certainly build a full end-product from scratch," says Ken Vartanian, vice president of marketing, Optomec. "But in addition, we can add material to an existing structure, which is very different from most 3D printing capabilities out there today. This requires the ability to print freely in 3D space in a conformal manner onto parts that were manufactured in some other way. Most 3D printing systems today cannot do this — you have to start with a flat surface."

The notion of applying printed materials on substrates to create electronics is not new: Current PCB production involves sophisticated forms of inkjet printing with low viscosity ink or screen-printing using high viscosity ink. So, replacing regular ink with functional ink is one approach. However, Aerosol Jet equipment achieves high precision with a different technology. Its systems use a secondary sheath-gas to aerodynamically focus a primary stream of atomized material and deposit it on non-planar surfaces, creating features as small as 10 microns wide. After low temperature (<200°C) sintering, the traces are fully conductive.

Vartanian lists requirement number two for 3D printing electronics: "When you want to move into high-volume production, the technology needs to be scalable and address various points of the product lifecycle, so you don't have to go through another process development stage. Change has got to be compelling from a cost and functional stand-point — it can't just be cool."

The third factor concerns the big picture of manufacturing. "We don't quite subscribe to the 'disruptive technology' notion of 3D printing," says Vartanian, "where factories will be a thing of the past. We look to see where we can add value to an existing manufacturing operation; the architecture must be open enough for 3D printing to integrate with existing processes and machines."

Vartanian notes that a successful open approach also requires working with a variety of low-cost materials available from multiple sources. "We don't sell materials but we certify them and provide customers with direct access to suppliers," he says. Aerosol Jet systems print with a wide range of commercial and custom formulations, including conductive nanoparticle inks (with metals such as silver, gold and copper suspended in solvents), non-metallic conductors (carbon nanotubes and conductive polymers), carbon-based resistor inks, dielectric adhesives, semi-conductive inks and even biologic materials.

Customer applications range from cellphone integral-antenna printing by three worldwide contract manufacturers, to thin film transistor (TFT) work done by the University of Massachusetts at Lowell and the University of Minnesota, to a breakthrough alternative to wire-bonding and through-silicon-via (TSV) operations in semiconductor packaging. The latter approach involves printing conformal interconnects directly up a 3D die-stack, with no risk of wires shorting or crosstalk. Aerosol Jet technology is also modular and scalable, supporting multiple print heads in a single system; Neotech AMT in Germany added a four-print-head version to its standard 5-axis CNC (computer numerically controlled) system, creating the AJ 45X, a material handling and deposition system that fits directly into existing manufacturing lines.

Functional Plastics, Functional Inks

An impressive aspect of the 3D printing industry is that it supports activity across a spectrum of organizations, from university research groups to grass-roots inventors to crowd-funded startups. Some projects' goals are to lay down conductive traces a millimeter or two wide; others are aimed at proving the concept of printing multiple materials for conduction, insulation and connectivity.

Two academic examples that exemplify this are flexible embedded sensors and functional LEDs. The sensor work was begun several years ago by Simon Leigh at the University of Warwick in England. His group used a multi-head Bits from Bytes BFB3000 fused filament system to print a PLA (polylactic acid) glove with embedded motion-sensing strips along the fingers. These strips, formed from a carbon black filled-polyester termed carbomorph, are piezoresistive; even a 0.25 square-micron cross-section was sensitive enough to detect finger-bending.

At Princeton University, Michael McAlpine, assistant professor of Mechanical Engineering, directed graduate students on a proof-of-concept project that 3D-printed a five-layer LED on a hard contact lens. (See "Princeton Combines Plastics and QLEDs in Prototype Contact Lens," rapidreadytech.com/?p=7965) The group modified a pick-and-place machine to deliver quantum LED dots (cadmium selenide nanoparticles coated with zinc sulfide) suspended in a mixture of toluene and dichlorobenzene. The system also deposited layers of four other materials, creating cathode, anode and connector functions in one run.

Controlling the nanoparticle fluid placement across a 2mm-diameter over a curved surface meant finely balancing surface tension vs. nozzle leakage. Using different sized dots created either orange or green LEDs, but at that scale, size difference required a tricky system recalibration. Bringing such technology into manufacturing would involve additional steps such as sintering for full conductivity; acceptable throughput times could be problematic.

"Time is a huge challenge," says McAlpine. "People can't figure out what's the killer app yet for 3D printing, which is still a serial process compared to microfabrication. There's probably some niche application — printing custom electronics on custom pieces on non-flat surfaces, maybe biomedical devices — some next-generation application that no one is yet sure of where slow throughput matters less than the need for customization."

Supplying the Filament World

In the past few years, the thought of creating conductive filament materials that bypass the need for PCBs has also appealed to creative private businesses. Such filaments combine plastic with embedded particles that allow 3D-printed parts to display electrically conductive properties. The printed-feature size does not compete with the industrial capabilities of Optomec systems, but the materials give new functionality to open-source equipment and are improving month by month.

MakerGeeks markets a 1.75mm-diameter conductive filament that is ABS (acrylonitrile butadiene styrene) based and contains a blend of carbon fiber and carbon black particles, with a stated resistivity range of 10,000 to 12,000 ohm-cm (See "Resistance, Resistivity and Surface Resistance" to the left); price is $23/lb. Online comments indicate if users are careful to print at low speed to avoid filament breakage, the material is useful for making an electronics case with an integrated ground. Because resistivity needs to be at least a thousand times smaller for behavior closer to that of metals, it's no wonder a lot more work is underway by a number of entrepreneurs.

Though little more than a year old, ProtoPlant now manufactures six types of (in their words) exotic filaments. The company recently announced funding of its second Kickstarter project, supporting the new Proto-pasta Conductive PLA. The material is a compound of conductive black, a dispersant and PLA, and is sold in both 1.75mm and 2.85mm versions. The volume resistivity of molded resin (not 3D printed) is 15 ohm-cm; for example, resistance of a 10cm length of 1.75mm filament is 1.8 Kohm. Conductivity is suitable for such applications as touch-sensor projects and simple circuits. Expected pricing: $48/500g spool ($43.50/lb).

Resistivity, Resistance and Sheet Resistance

You may need a refresher on the concept of resistivity as related to resistance. Resistivity (ρ) is a fundamental material property measured in ohm-meters or ohm-centimeters, and is therefore the property most often listed by vendors supplying electrically conductive material to the 3D-printing industry. It relates to classic resistance R [ohms] when a specific geometry is defined.

$$\text{Resistance [ohms]} = \frac{\text{Resistivity [ohm-cm]} \times \text{Length [cm]}}{\text{Area [cm2]}}$$

Conductivity, the inverse of resistivity, indicates how well the material conducts electricity; its units are seimens (S) per meter or centimeter. A converter of resistivity to conductivity for different units can be found at cactus2000.de/uk/unit/masscnd.shtml.

One way to compare resistivities is to use the concept of sheet resistance Rs [ohms/square]. This refers to the resistivity of a sample of a certain thickness, as designated across a "unit square." See ece.gatech.edu/research/labs/vc/theory/sheetRes.html.

Functionalize is another new materials company born out of the desire to readily 3D print circuitry. President and founder Mike Toutonghi, in looking for ways to assemble electronics without soldering, drew on his early interest in chemistry to set up his own nanotechnology lab. Several years of work led him to synthesize a conductive compound of PLA, carbon nanotubes and metal composite that displays resistivity of <1 ohm-cm. The company is now marketing its F-Electric PLA filament through ProtoParadigm, a manufacturer of basic, colored and specialty filaments.

Toutonghi says although F-Electric's pricing is about $140/lb, the filament's use can be validated when used as a small percentage of a 3D-printed part, with the majority of the part built from standard PLA for structural integrity. He's working on lower-cost formulations but is also exploring another intriguing property of the material, its signal frequency bandwidth of about 200 MHz. "This could be a challenge," he says, "but it's close to the ability to put gigabit/second data on it."

More Developments, More Directions

News related to printing conductive materials is now an almost daily event. AutoX3D, maker of industrial-grade personal printers, just announced a water-cooled extruder system that may address the nozzle clogging that can happen with conductive (filled) filaments. And a filament printhead add-on from RabbitProto will let users deposit conductive silver ink (Electric Paint) supplied by Bare Conductive; trace width is 0.84 inches from standard nozzles and surface resistivity is 55 ohms/square for 50-micron thick deposition.

Working on yet another inexpensive way to bypass traditional PCBs (even printing on fabric), Australia-based Cartesian obtained Kickstarter funding to develop the Argentum open-source 3D printer. The Argentum employs dual inkjet cartridges to lay down two-part material: the first deposits a silver-nanoparticle solution then the second retraces the same CAD-directed pattern with simple ascorbic acid. The two liquids combine to create a silver precipitate, which dries into conductive traces determined by nozzle size. Systems began shipping last summer; the site says batch four will ship this month.

Lastly, the 2015 International Consumer Electronics Show saw the debut of the Voxel8 dual material two-nozzle 3D printer from Voxel8 of Somerville, MA. Founded by Dr. Jennifer Lewis, Wyss Professor of Biologically Inspired Engineering at Harvard University, the company is based on more than a decade of university work. The system trades off depositing PLA filament with pneumatically dispensed conductive silver ink during a single build, supporting creation of embedded conductors, wires and batteries. Nozzle size for the silver is 250 microns; material resistivity is 5.0 x 10-5 ohm-cm, and other materials are coming. Voxel8 has worked with Autodesk to develop Project Wire software that lets users create a 3D mechanical design with embedded conductive traces for printing on the Voxel8 system. **DE**

The Optomec Aerosol Jet 3D printing system is capable of depositing materials freely on non-planar surfaces. The system can print traces as small as 10 microns wide, using various conductive nano-particle inks as well as non-metallic conductors, carbon-based resistor inks, dielectric adhesives, semi-conductive inks and more. *Image courtesy Optomec.*

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INFO ➔ Autodesk: autodesk.com

➔ **AutoX3D:** autoX3D.com

➔ **Bare Conductive:** bareconductive.com

➔ **Cartesian:** cartesianco.com

➔ **Functionalize:** functionalize.com

➔ **MakerGeeks.com:** makergeeks.com

➔ **Neotech:** neotech-amt.com

➔ **Optomec:** optomec.com

➔ **Princeton University:** princeton.edu

➔ **ProtoParadigm:** protoparadigm.com

➔ **ProtoPlant:** proto-pasta.com

➔ **RabbitProto:** rabbitproto.com

➔ **University of Warwick:** 2.warwick.ac.uk

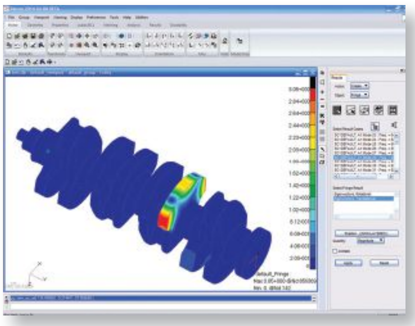
➔ **Voxel8:** voxel8.co

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

Editor's Picks

by Anthony J. Lockwood

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



MSC Nastran and Patran 2014 Launched

Improved nonlinear analysis capabilities added.

General performance enhancements are a common thread throughout this Nastran/Patran release. Take, for example, explicit nonlinear analyses. On multi-core configurations, the performance has improved by a factor of two. And the 2014 version of the Krylov solver, which reduces the number of matrix factorizations performed during frequency response analyses, sees improved performance with new DMP (distributed memory parallel) technology that enables it to run across multiple compute nodes. Frequency computations for non-symmetric systems are also three times faster.

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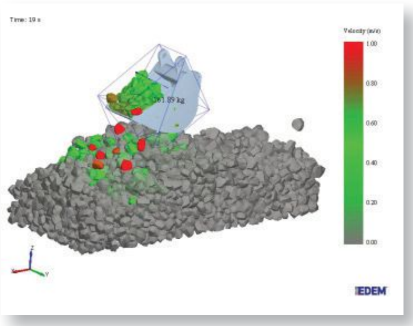

DEM Solutions Releases Co-Simulation Applications

Functionality links bulk material simulation to multibody dynamics platforms.

The EDEM software from DEM Software empowers you to simulate and analyze the flow behavior of bulk solid materials.

The new co-simulation solutions extend EDEM's couplings to multibody dynamics (MBD) software tools like MSC Software's Adams, Simulink from MathWorks and LMS Virtual.Lab Motion from Siemens PLM Software.

In hands-on terms, this means you can link EDEM's bulk material simulation and analysis functionalities with an MBD solver's ability to control the motion of interconnected and articulated equipment like a payloader's bucket and control arms.

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ARES Commander 2015 Available

Release adds new editing tools and more flexible licensing.

The 2015 edition sees the introduction of a bunch of new model editing tools. Among these are PowerTrim and Dynamic Blocks.

On the usability front, ARES Commander 2015 now provides a QuickModify command.

Also new in version 2015 is functionality for modifying the ribbon interface to group together the tools you use most often. Additionally, you can create your own workspaces.

The company has also launched a beta version of ARES Touch 2015, a mobile CAD solution for Android.

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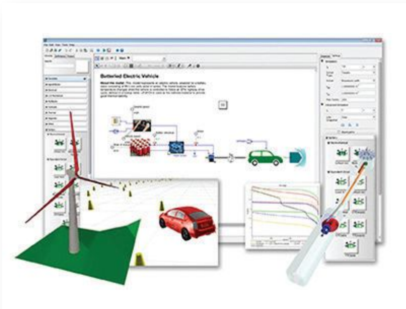

Maplesoft Adds Battery Library to MapleSim

Provides physics-based predictive models for electronics applications.

What the MapleSim Battery Library brings to your toolkit is the ability to incorporate physics-based predictive models of battery cells into multidomain models early in your design process

It supports both equivalent circuit and electrochemical battery models. Equivalent circuit models include Li-Ion, NiMH and lead-acid batteries. Electrochemical physics models have the chemistries for a variety of anode and cathode Li-Ion batteries as well as NiMH batteries.

Model properties include voltage profile, capacity fading and state of charge.

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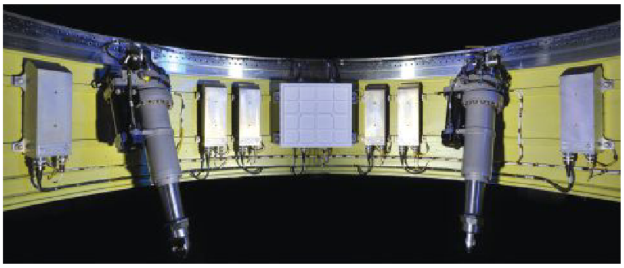
Stable Testing for Aerospace

SABCA uses Siemens LMS Test Lab and SCADAS for closed loop shaker control and data acquisition.

Just a few days before the maiden flight of the European Space Agency (ESA) Vega launcher, Marc Pitz, Testing, along with Product Engineer Marc Rigal at SABCA noted that they did not know if the electromechanical thrust vector actuation system from SABCA, which would be used to steer the rocket ship that took off from the French Guyana Space Center in Kourou, would



perform according to plan. A few days later, the first qualification flight of the Vega launch vehicle proved to be a success.

"The outcome of the Vega program is extremely important for us," says Pitz. "Vega will mark our future."

SABCA is one of the main aerospace companies in Belgium. It was founded in 1920 and is based in Haren, near Brussels, and Charleroi. Besides being a subcontractor for different aircraft manufacturers, such as Dassault Aviation and Airbus, SABCA just delivered its 100th Airbus A380 T-Shape: a large metallic structural assembly that carries high fuselage loads between the main wheel wells of the aircraft. The company also builds servo-actuators for the Ariane 5 launcher and the Interstage 0/1 skirt and the thrust vectoring systems for the four stages of the new Vega launcher.

This new Vega launcher has been developed by the ESA during the last nine years. It will be able to bring a 1.5-ton payload into low earth orbit. The technology on the Ariane 5 program goes back as far as the early 1970s, and the servo-actuators that were used to direct the rocket thrust and steer the rocket ship are still electrohydraulic systems: GAT (Groupe d'Activation Tuyère or Nozzle Activation Unit) and GAM (Groupe d'Activation Moteur or Motor Activation Unit).

For the new Vega launcher, SABCA developed a fully electrical thrust vector actuation system (electromechanical actuators, control, power electronics and the associated software). This system is based on a proprietary SABCA microprocessor hardened against space radiation. It will operate in a vacuum at very low temperatures and have to withstand the heavy shocks generated by the various stages of separation of the rocket.

Due to significant constraints, the thrust vector actuation system undergoes a very strict and severe qualification test program during development. But each subassembly also undergoes a set of predefined lower and shorter tests on the shaker just before rocket assembly.

Appreciating Versatility

Five years ago, SABCA decided to replace and update its first system, and now uses LMS Test.Lab software in combination with LMS SCADAS hardware for closed loop shaker control and data acquisition from Siemens PLM Software.

"We evaluated different suppliers, and the solutions of Siemens PLM Software offered far more possibilities and flexibility, mainly because of their modal capability," says Marc Pitz.

Two years ago, the test environment was further enhanced with a brand new 160 kilo Newton (kN) shaker, referred to by Pitz as "our big elephant."

"We use the same test setup for both qualification and production testing of the servo-actuators," says Pitz. "This built-in flexibility is considered a key advantage of the Siemens PLM Software testing solutions.

"Ease of use is very important to us because different engineers are using the system, and not everybody is a test software expert or can invest vast amounts of time studying the tools. Production engineers are no vibration experts, but once the configuration is set, they push the button and the test is done. These time savings are important for us."

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Commentary

by Tim Creasey

Manage Change for Success

According to Prosci's *Best Practices in Change Management – 2014 Edition*, 71% of companies expect to see significant change over the next two years, and 77% of those companies are already experiencing what is known as change fatigue. Companies are running into issues delivering on the expected value of these changes. Too often, organizations can check the boxes for on time and on budget, but fail to achieve project success because they are not working to catalyze employee adoption of desired solutions. That is where change management — the practice of planning for and actively managing individual transitions during the project — comes in.

A growing trend in project management is integrating change management within the project workflow. Both disciplines bring necessary structure for effectively implementing change; project management focuses on the technical side, while change management focuses on the people side. When the two are applied in unison, project managers are meeting objectives and achieving results at a higher level. In fact, 62% of project managers that were already integrating the two disciplines met or exceeded their project's objectives, compared to the 45% of project managers who were not integrating and met or exceeded their objectives.

Make change management meaningful and real.

The question then becomes how do you integrate the two disciplines and what are the most pressing roadblocks you will face?

Support and Buy-in

With change management still being a relatively new concept, some project leaders and managers do not see the value or importance of change management or perceive change management as overhead that slows down the project and eats into the budget.

Make change management meaningful and real by tangibly connecting it to what the project is trying to achieve. Ask project leaders to clarify the goals and objectives of a project, then have them identify what percentage of achieving each of those benefits depends on people adopting and using the solution the project brings. Pitch change management as an effective method of managing the people side of change, which makes projects more likely to be on schedule and on budget.

Another frequent problem involves making sure change management is involved early on and consistently throughout the project. Often change management is brought in when the project's solution is going live, or worse yet, after go-live when people are not adopting as hoped. This does not allow the time or endorsement needed to effectively apply change management and influence individual transitions.

Be structured in your change management approach and ensure that planning and strategy development take place in collaboration with the project team. By asking important change-management-oriented questions early on — such as, "How much of this project's success depends on adoption and usage?" "Who is being impacted by this change?" "How will their jobs be different?" — you can position change management as a success factor early in the project lifecycle.

Starting Integration

Even if the project team recognizes the value of change management, project and change managers often stumble when figuring out how and what to integrate between change management and project management activities, tools and roles.

When integrating project management and change management, consider these steps:

- Decide which tools and processes to combine;
- Make change management part of the project plan and charter;
- Maintain transparency and access to information;
- And create collaborative teams to include both change management and project management practitioners.

Begin by gaining foundational knowledge and insights into your organization's project management processes. Understand the function of the change practitioner's tools, and the project manager's tools. Then, you can identify connections, overlaps and similarities between project management and change management, which will uncover opportunities to integrate.

Role Clarity

Within some organizations, project management is sometimes considered change management or vice versa. This common struggle underscores the need to define and clarify the roles of change management and project management. Be preemptive about defining and clarifying roles. Identify activities that might result in overlap when it comes to which role carries out which task, and discuss these activities upfront with the project team.

Together, these needs show just how important it is to recognize and communicate that change management and project management are intrinsically and inextricably tied to the realization of organizational results and outcomes. DE

Tim Creasey *is chief development officer at Prosci. He co-authored the book* Change Management: The People Side of Change *and led Prosci's last six benchmarking studies. Send email about this article to de-editors@deskeng.com and learn more at prosci.com.*