DE

Technology for Optimal Design Engineering

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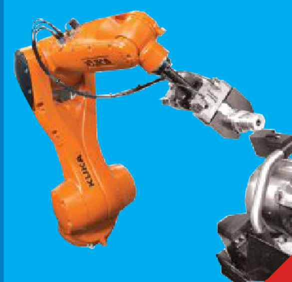
GOING VERTICAL



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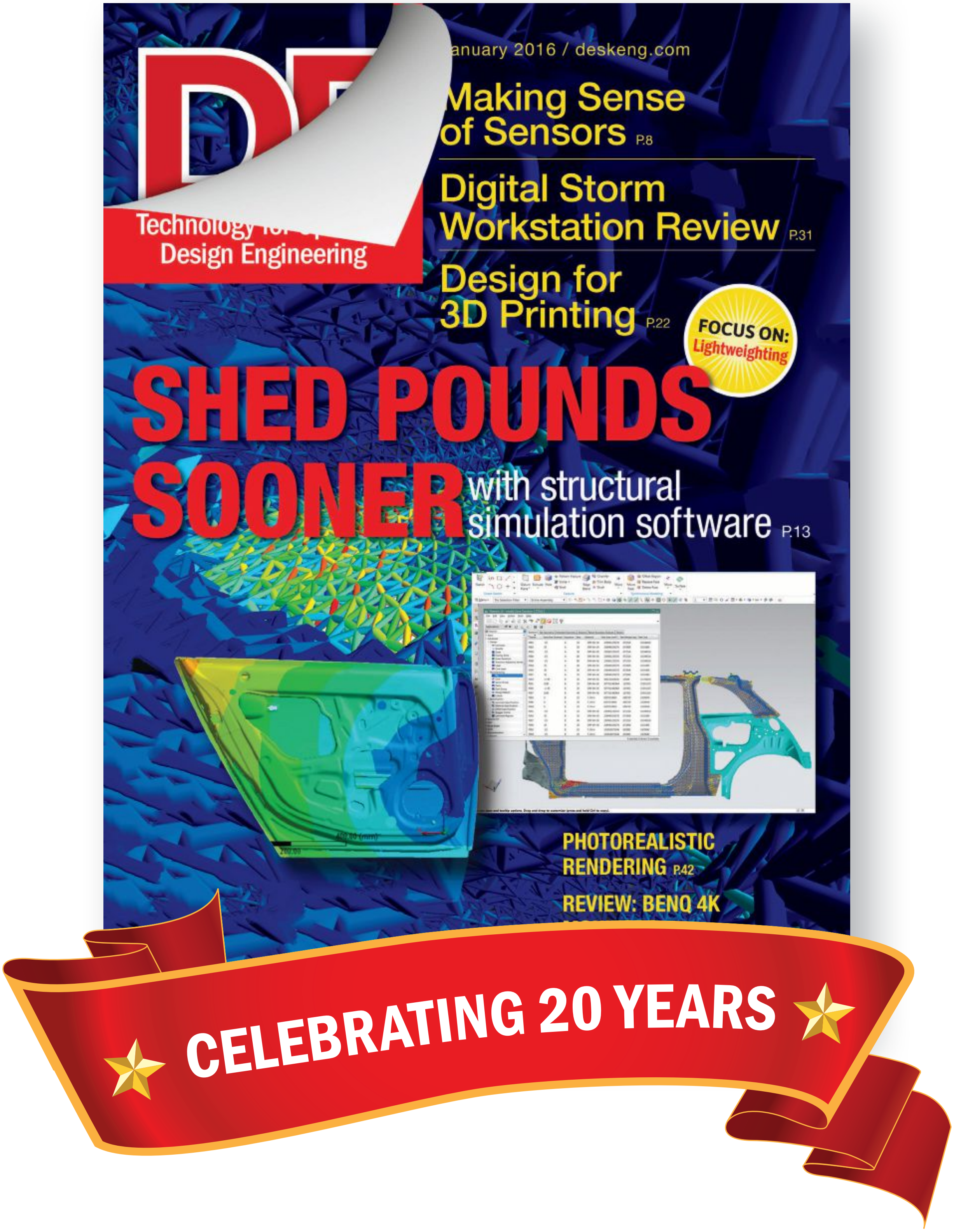
Coming Next Month:

New Look, New Name, Same Mission



by Jamie J. Gooch

Data and Democratization

I spent the last two weekends cleaning out my woodworking shop — or as my wife insists on calling it: the garage. I hadn't been out there to make anything for months. My lack of productivity wasn't because I didn't have the necessary tools to do the job — they were all in there, somewhere. The problem was I had too much stuff. Tool accessories I'll never use, jigs, board cutoffs I'm sure will be useful for an unknown future project, hardware left over from previous projects, schematics and not-quite-empty cans of paint were all mingled among my kids' sports equipment and bicycles. It was a mess, and it was preventing me from getting anything done.

Armed with a shop vac, trash bags and the dream of a better workflow, I began cleaning, decluttering and organizing. Likes went with likes — sandpaper with sanders, drill bits with drills, circular saws with hand saws hanging on the wall beside the table saw. I found tools I hadn't seen for years. I found duplicates of tools I had bought when I couldn't find the one I already had. I filled garbage bags, donation boxes and added considerably to the woodpile for our backyard fire pit. My children avoided me, afraid that I would enlist them in the great garage cleanup of 2016.

Having what you need where and when you need it is becoming more and more difficult.

When the sawdust settled, I looked around to see I had stations dedicated to different aspects of the job: designing, cutting, assembly, finishing. It was a beautiful thing. It was the way it should have always been, I just hadn't realized it as I added more tools and supplies little by little over the years.

Software Vendors Get Organized

Having what you need where and when you need it is a simple concept that becomes more difficult to implement as you acquire more — more stuff, more data, more tools. Many engineering software developers have realized the same thing. As they added features and toolsets over the years, the danger for clutter and complexity to trump productivity grew. New features make it easier for you to create the optimal design, unless you aren't able to find those features or don't understand how they can help. Specialized features for other disciplines and industries just get in your way.

It's an issue engineering software vendors are tackling primarily by three different means: creating platforms, supporting democratization and focusing on vertical markets.

The platform approach is intended to integrate all the tools design engineering teams need into a more efficient and collaborative workflow — from concept design to detailed CAD to simulation and analysis — via plugins and/or a standard user interface, for example. We'll look at the challenges associated with a platform approach, including interoperability, in our September issue.

When it comes to engineering software, democratization refers to various ways developers are making software easier to access by a larger pool of people. One popular method is via purpose-built apps that allow non-specialists to perform complicated simulations of specific phenomena. For example, a field rep can change a few variables to show a client a thermal simulation visual. The math is done in the background and the variable choices are constrained to avoid unrealistic results.

Democratization is a means to simplify a complicated task for a broader audience, but sometimes engineers need tools specific to their industry. Imagine if my woodworking shop was also filled with lug wrenches, spark plugs, floor jacks and other auto repair tools. It would be that much more difficult to get organized to do woodworking. That's the idea behind engineering software vendors' industry-specific approach. The challenge is knowing what tools and features engineering teams from different industries want and need. It requires a great deal of industry-specific knowledge to get right, as well as built-in flexibility to allow end users to further customize the software to meet their exact needs. Read more about going vertical on page 18.

Divide Data to Conquer It

Having the right software and workflow is only part of the solution. Like my wife asking me when I'm going to get that corner cabinet built for the dining room, there is a looming threat of repercussions to having unorganized and unnecessary stuff. When it comes to engineering, the boss might decide to finally let you kick simulation use into high gear, begin rolling out connected products or want better visibility into predicting when products are about to fail in the field. In any case, more stuff in the form of data is bound to be coming your way. Data will be given off by simulation runs and coming in from connected devices. Some of it will be data you need now, some will be data you might need someday. The challenge is to avoid hoarding data you'll never need while keeping the data you do need organized and easily accessible. **DE**

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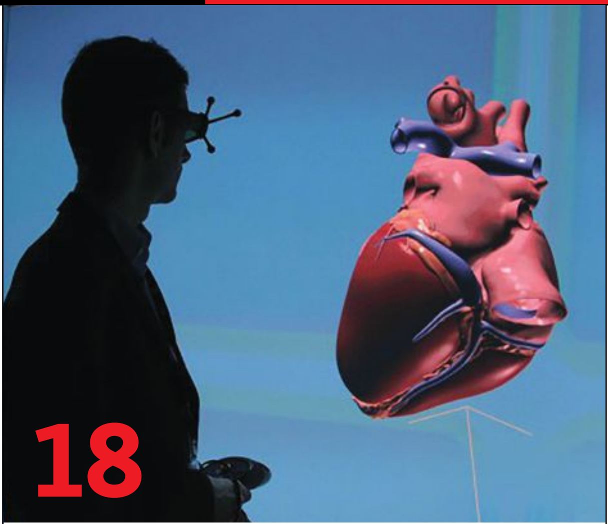

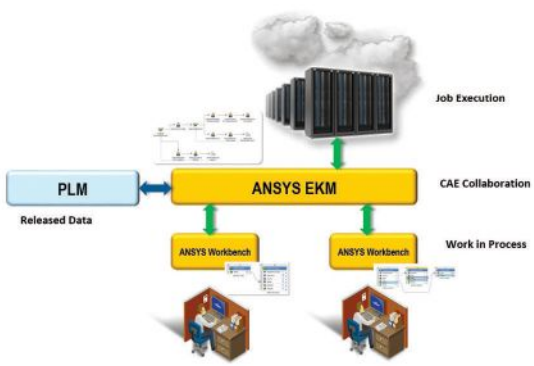

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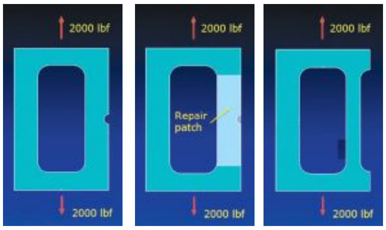

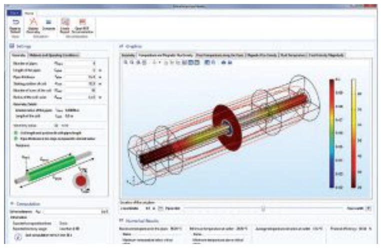

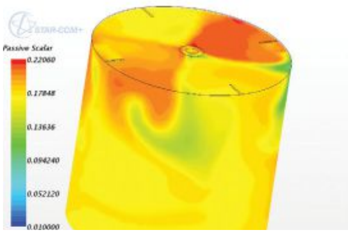

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A 3D Printed, Topology Optimized Motorcycle

A partnership between Altair and APWorks (an Airbus subsidiary) has provided a look at how the basics of motorcycle design might change in the digital design age. Light

Rider is the first 3D-printed motorcycle, and it's ready to hit the road.

Light Rider updates the classic look of a motorcycle with a high tech, almost organic design that is the result of an algorithm. Made of an aluminum-magnesium-scandium alloy called Scalmalloy, the hollow frame provides stability and durability while reducing the weight of the motorcycle by around 30%. Along with the benefit of weight reduction, the hollow frame allows for a cleaner overall look by allowing wiring to be hidden inside the frame.

The entire production cycle, from design to final product, took one year.

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Bioprinting for Reconstructive Surgery

American Process and Swansea University Medical School have entered into a joint agreement to develop new procedures for facial reconstructive surgery based on nanocellulose and 3D printing. Nanocellulose is a biomaterial generated from wood. Previous research by Swansea's ReconRegen group has shown nanocellulose is both compatible with human cells, and works well as a tissue support structure. Most importantly, for future research purposes, nanocellulose is hardy enough to survive 3D printing.

The joint research will attempt to use a mix of human cells and nanocellulose to build scaffold material, which will be 3D printed into tissues as part of reconstructive surgery. This would allow doctors to build new tissue for their patients that has been customized to fit with their appearance, while retaining enough durability to resist degradation.

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3D-Printed Solution to Scoliosis Developed

In some cases, scoliosis — curvature of the spine — requires bracing or monitoring by a physician to ensure the curvature doesn't increase. The worst cases require surgery using rods to straighten the spine. A new option has been developed by Medicrea, based on the flexibility offered by 3D printing. The company uses the technology to produce patient-specific fusion implants, helping prepare the patient for surgery.

Traditionally, when surgery is required to fix severe cases of scoliosis, doctors are required to bend the rods by hand and fit them in place as best they can. With recent FDA approval, Medicrea's UNiD system allows doctors to build spinal rods specific to each patient before surgery even begins with precision contouring.

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Siemens' Predictive Engineering Strategy

Simulation has landed a starring role in Siemens PLM Software's vision for how complex cyber-physical products are going to be built in the future as the company rolled out its new Simcenter CAE portfolio in concert with its predictive engineering approach.

If the concept has a ring of Big Data analytics and the Internet of Things (IoT), it's for good reason. With products evolving into smart systems while also leveraging new materials and manufacturing methods and embracing mass customization, Siemens contends that companies need to make significant changes in product engineering, including integrating use of simulation at every stage of the lifecycle. To turn the best practice into a reality, Siemens is pooling its simulation and test solutions — some organic, many acquired — into the Simcenter simulation suite, wrapping them with what it calls intelligent reporting and analytics capabilities. The result is a portfolio of simulation products that can be used to create a digital twin that will more accurately predict product performance throughout an entire lifecycle, according to Ravi Shankar, director, Global Simulation Product Marketing for Siemens PLM Software.

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ESTECO Releases modeFRONTIER 2016

New User Profiles in modeFRONTIER enable multidisciplinary engineering practices to consolidate specialized expertise and streamline teamwork by allocating software resources where needed. It is now possible to access different functionalities within the same installation through dedicated modules (modeSPACE and modePROCESS) or directly in modeFRONTIER, according to the profile of the user.

The profiles are divided into two categories: data space and process & optimization. ESTECO has also added a sensitivity analysis tool, RSM evaluation chart and improved RSM wizard. New capabilities for project complexity handling include a workflow setting, a design space node and a subprocess node.

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Insights from ASSESS

In the recent years, the CAD software business has gradually been shifting toward the subscription-based, pay-as-you-go model. A similar movement is also afoot in the simulation software market, a cousin of the CAD market.

But, based on discussions at the Analysis, Simulation and Systems Engineering Software Summit (ASSESS), Joe Walsh, CEO and founder of IntrinSIM, cautioned, “People over-emphasize the pay-as-you-go model as the be-all and the end-all of licensing issues. But the reality is, it only works with light to moderate usage; it doesn’t work well with heavy usage.”

Light to moderate simulation software users could benefit from pay-as-you-go licensing, because it bypasses the significant investment to acquire the software. But heavy users who use simulation routinely are economically much better off with perpetual licenses, for the same reason those who use a vehicle daily would favor perpetual ownership over rental.

ASSESS is billed as a “multi-industry initiative that began with the goal to expand the use and benefit of software tools for model-based analysis, simulation, and systems engineering.” It’s organized by Cyon Research, the technology consultancy and analyst firm that also produces the annual Congress on the Future of Engineering Software (COFES).

One difficult puzzle to solve in the usage-based model is cost. Walsh pointed out, “With the pay-per-use model, you know the rate at which you’re paying for your consumption. But it’s difficult to tell ahead of time how much you’ll consume.”

The software-as-a-service (SaaS) model swept across the business and productivity market because users can predict with relative certainty how long it would take to finish a project in, say, Microsoft Office or Adobe Creative Suites. Not so with simulation software.

Walsh explained, “Running simulation is not just setting it up perfectly, running it once, and getting an answer ... That’s why there are now several vendors looking at different models beside the consumption-based model.”

Pay-as-you-go simulation differs from the SaaS-style office and personal productivity software in one primary aspect — the need to add computing resources to the equation. With simulation jobs, the processing power you deploy (measured in CPU and GPU hours) affects the speed and accuracy of the task. Therefore, pay-as-you-go simulation vendors need to figure out a way to offer both software usage and processing power in an economically sensible bundle.

Democratization Not Up for Debate

ASSESS participants also put to bed the debate about wider access to simulation, or computer-aided engineering (CAE).

“We’ve gotten over that debate,” said Walsh. “We’ve accepted that democratization of simulation is inevitable. The discussions are no longer about whether to democratize or not. Now, we’re working out how to to do it.”

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Autodesk Hosts First-Ever Forge Developer Conference

On a sunny day by the San Francisco Bay, coders, hackers and developers began arriving at the Fort Mason Festival Pavilion for Forge DevCon, Autodesk’s first-ever developer conference.

“We’re probably not going to go after the shoe industry by building something called AutoShoe,” said Amar Hanspal, senior VP of products. “But perhaps one of you might.”

If you think you have a winning idea for a vertical market, you might try your hand at developing an app or a custom solution on Autodesk’s Forge platform. That was Autodesk’s proposition to the attendees.

Autodesk builds design software that are applicable to a wide user base. It focuses on three major sectors: product design; architecture and construction; and media and entertainment. The company usually doesn’t go after highly specialized verticals, like footwear comfort analysis. That leaves pockets of opportunities for app developers with sufficient knowledge in niche markets.

The Forge platform comes with the support and industry muscle of Autodesk. Perhaps more important, apps developed on it will find a ready-made market in the people using Autodesk products.

Hanspal said, “Forge is a set of APIs made especially for manufacturing and building industries. It’s made for the cloud. It spans modeling, drawing, visualization, simulation, IoT — all the data-centric operations people can assemble to build applications.”

The Forge developer program has three tiers: Explore (free); Build ($400/month); and Scale ($20K/month). These levels come with different consumption, storage, and usage allocations. To recruit, Autodesk is currently offering free access to the platform — that is, free until September 15.

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Stiffness or **Strength**?

At the recent NAFEMS Americas conference in Seattle, I had a chance to talk to analysts and designers about what role structural analysis can play in design. The need to distinguish between the influences of stiffness and strength was apparent. This was best summed up by an ex-colleague who recounted the tale of the "repair scheme death spiral."

The Repair Scheme Dilemma

Imagine two parallel vertical tubes, each connected at top and bottom between two stiff horizontal beams. The beams are being pulled apart vertically, so that equal vertical load is induced in each tube. A fatigue crack occurs in one tube and the repair scheme calls for a reinforcing strap to be bonded over this region. The net axial stiffness, (EA/L), of the reinforced tube is now higher than the undamaged tube. E is Young's Modulus, A is cross sectional area and L is effective length.

In a configuration like this, the load will be distributed between the two tubes in proportion to their axial stiffness. So the stiffened tube attracts the bigger share of the load. Eventually, this additional load results in further fatigue cracking and a new repair is called for. This repair adds further stiffness. This attracts more load to the repair, at the same time lowering the stresses in the healthy tube. You can guess how this goes: Eventually the massively stiff repaired tube is carrying the bulk of the load, while the healthy tube is made redundant.

Ideally, a dummy repair patch would be added to the intact tube, so that the stiffness is always the same between the two, and hence the load is distributed evenly.

It is an exaggerated story, but illustrates the point that designs should first be assessed for relative stiffness of each load path. This will determine the load level in each path. The strength of the structure along that load path is then a function of the local stresses that will occur. Design for strength should come secondly as a local assessment. If the load path is under-strength, revising stiffness (perhaps reducing material) may be a more attractive option than increasing strength (by adding material). The only case where strength will dictate a load path is after material yield or local buckling, when it is too late!

An Example

The structure shown in Fig. 1 has a defect on the right hand side leg, which has been dressed out to a constant radius notch. This is the starting point for a repair. Two repair options are considered. In the first, shown in Fig. 2, a doubler repair patch of equal thickness to the original part is proposed. The patch is bonded to the original. In the second scheme,

Figure 1: Original damage dressed to a notch shape.

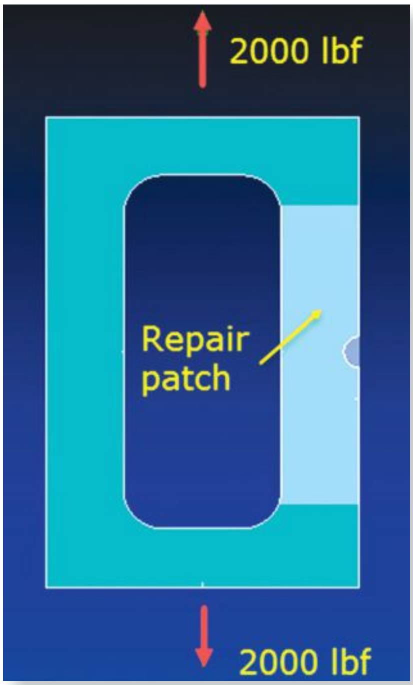


Figure 2: Repair scheme: doubler on right hand leg.

Figure 3: Repair scheme: flared right hand leg to eliminate the notch.

shown in Fig. 3, a reduction in the width of the right hand side leg (flared) is proposed. This eliminates the notch.

A series of FEA (finite element analysis) models were run to investigate the two schemes. The doubler patch is the most intuitive repair, based on strength consideration. We are putting back the same thickness of material across the defective region. However, the net area in the section increases, which increases the stiffness. This, in turn, attracts more load. The doubler repair forces remain constant at 800 lbf in the undamaged LHS (left-hand side) leg and 1200 lbf in the repaired RHS (right-hand side) leg.

The flared repair scheme on the other hand, has a reduced area in the repaired (RHS) leg. The reduced stiffness is due to this, over an effective length. Hence, load increases in the undamaged (LHS) leg. For zero notch, the legs are equal area. As the notch size increases the forces start to vary between the two legs. At a 0.3-in.notch, the forces vary as 1362/638 lbf.

The local stress concentrations around the notch, under the repair doubler patch are negligible. The LHS and RHS legs have the same stress values, at 1600 psi. The reduced force attracted to the RHS leg (stiffness effect) is offset by the reduced cross section area (strength effect).

The flared repair scheme has less overall cross sectional area than the doubler scheme. The datum zero notch stress for both legs is 2000 psi in the flared repair scheme. However, as the notch size increases two things are happening: the RHS flared leg is reducing in cross sectional area and attracting less load (stiffness). The reduced cross sectional area is increasing the stress (strength).

As the notch size increases, the net cross sectional area of both legs decreases, so both legs see an increase in stress. However, the stress distributions are virtually uniform across each.

It may well be possible with the example structure to have a successful repair scheme that works by reducing material, using a flared profile. This is perhaps counterintuitive and we would normally seek to add material to regain strength.

It can be useful in design to consider the influence of relative stiffness as a subtler way of changing load paths, rather than correcting strength directly by adding material. **DE**

Tony Abbey *is a consultant analyst with his own company, FETraining. He also works as training manager for NAFEMS, responsible for developing and implementing training classes, including a wide range of e-learning classes. If your company is interested in a customized training class on any topics discussed, contact tony.abbey@nafems.org.*

Using Industrial IoT Data to Drive Optimization

"The age of 'Big Data' is here: data of unprecedented size is becoming ubiquitous, which brings new challenges and new opportunities," observed Peter Richtárik of the University of Edinburgh's School of Mathematics and Zheng Qu of the University of Hong Kong. "With this comes the need to solve optimization problems of unprecedented sizes."

The two Big Data experts, organizers of an "Optimization and Big Data 2015" workshop (http://goo.gl/wByc1I), continued by writing: "Machine learning, compressed sensing, social network science and computational biology are some of many prominent application domains where it is increasingly common to formulate and solve optimization problems with billions of variables."

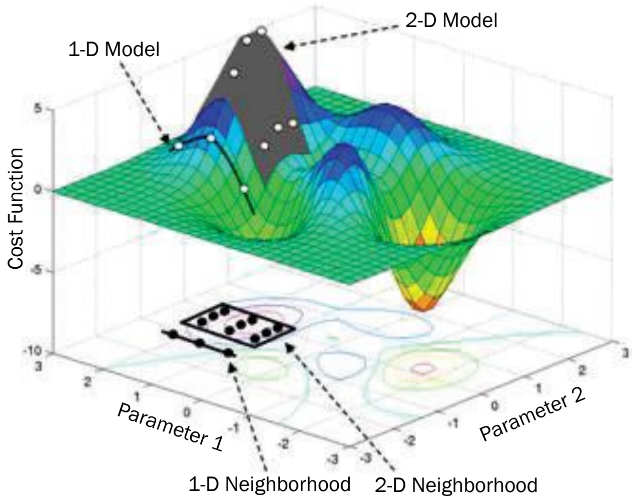
Product performance info collected from the IIoT holds great potential to fill in many regions of the design space.

In the engineering of discretely manufactured products, few topics today are more ubiquitous than how to prepare for the age of the Industrial Internet of Things (IIoT) and Industry 4.0. The largest effects of these developments, most centrally the resulting tsunami of data about product performance in service, have yet to hit. But when they do, the impact — and opportunity — for both users and developers of design space exploration and design optimization technologies could be transformative.

Higher Confidence in Design Space Exploration

Before optimizing a design, it can be useful to employ design space exploration — a family of quantitative methods that help engineers gain a better, more complete understanding of a new product's potential design space by discovering which design variables will have the greatest impact on product performance.

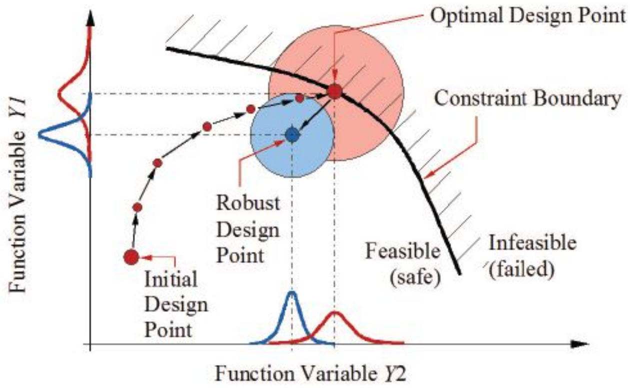
The essential quantitative method for design space exploration is design-of-experiment (DOE) studies. In a



Response surface model of a product's design space computed from results of a DOE study.
Image courtesy of Dr. Peter Hallschmid, School of Engineering, UBC Okanagan.

DOE study, an analysis model is automatically evaluated multiple times, with the design variables set to different values in each iteration. The results — often mapped as a 3D "response surface model" — identify which variable(s) affect the design the most, and which affect it the least. This information allows variables that are not important to be ignored in subsequent phases of the design process, or set to values that are most convenient or least costly.

How can IIoT-gathered Big Data help? In setting up and carrying out a DOE study, the methods used to sample the product's potential design space, and the confidence in the results delivered, are determined in part by how much is already known about the design being studied. Product performance information, collected in the enormous volumes promised from the IIoT, holds great potential to fill in many regions of the design space of an existing product with empirical data, thus giving higher confidence in exploring other regions of the design space for their performance parameters, and in the sensitivity and trade studies carried out on the DOE results. This will be invaluable for more efficiently and knowledgeably



Robust design optimization. ***Image courtesy of OptiY.***

developing future product models and variants, as well as for refining a current model in production.

Better-Informed Robustness and Reliability Optimization

Another area that will benefit from large volumes of empirical data about product performance is robustness-and-reliability optimization, aka stochastic optimization.

Product designs are nominal, while manufacturing and operating conditions are real-world finite geometric tolerances — variations in material properties, uncertainty in loading conditions and other variances encountered by a product in either production or use can cause it to perform differently from its nominal as-designed values. Therefore, robustness and reliability as design objectives beyond the nominal design are often desirable. Performance of robust and reliable designs is less affected by these variations, and remains at or above acceptable levels in all conditions.

To evaluate the robustness and reliability of a design during optimization, its variables and system inputs are made stochastic — that is, defined in terms of a mean value and a statistical distribution function. The resulting product performance is then measured in terms of a mean value and its variance.

Collected Big Data on a product's in-field behavior can be of great benefit in revealing where to center the robust optimum design point, either for refinement of a model in service or for development of a follow-on product. The same holds true for collected data on manufacturing variations. Both hold potential to increase the certainty of stochastic optimizations, and to reduce the number of variations needing study, through knowledge of where the bounds of the actual variations in manufacturing or performance have been shown to lie.

Impact on Technology Providers

What will all this mean for technology providers? As Big Data optimization experts Richtárik and Qu pointed out: "Classical algorithms are not designed to scale to instances of this size and hence new approaches are needed. These approaches utilize novel algorithmic design involving tools such as distributed and parallel computing, randomization, asynchronicity, decomposition, sketching and streaming."

Just as PLM (product lifecycle management) vendors are now engaged in sometimes radical overhauls of their product lines in face of the IIoT and Big Data revolution, developers of today's design exploration and optimization software products — often designed specifically to help engineers draw reliable conclusions from sparse data sets — may elect to modify, or even re-architect, some of their products to make the most of the Big Data revolution, and to help their users do the same. **DE**

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

Simulation Data Management Takes New **Twists** and **Turns**

As simulation takes a more prominent role in complex product design, SDM is becoming an integral part of the process.

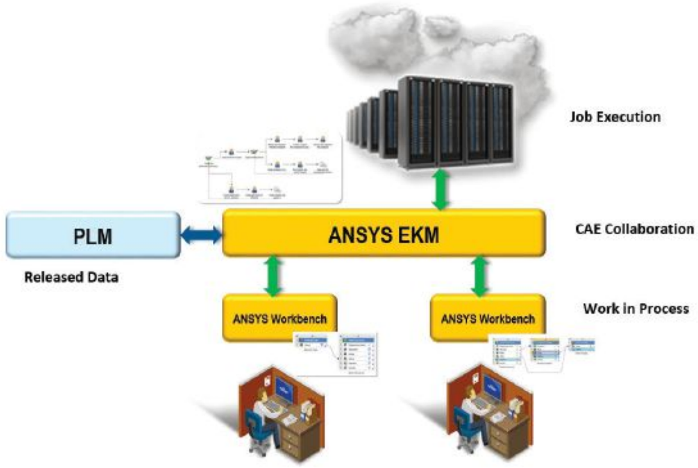
BY BETH STACKPOLE

For all the talk about the democratization of simulation, here's how much of the work still gets done today: A highly trained expert, often with an advanced degree, toils away on a local desktop, gathering data, building models, running simulations and then circulating a report that sums up his/her findings to colleagues throughout the design process.

The increasing complexity of products — more reliance on cyber/physical systems and especially software — calls for more pervasive use of simulation, performed regularly throughout the design cycle, not just at the back-end for validation. In the new model-based design approach, simulation data and results need to be widely and continuously shared with the rest of the engineering organization, even if the skilled analyst remains the epicenter of simulation work. The requirement is prompting renewed interest in simulation data management (SDM), not just as a separate enterprise hub for managing simulation data and processes, but as an integral part of the broader product development lifecycle.

"It gets to what is the strategic value of simulation as a whole in the product development process—that's what's changing," says Don Tolle, director of the Simulation-Driven Systems Development practice at CIMdata. "People are seeing business cases that support the need to do simulation early and often. If you're going to get value out of all this simulation work, you have to manage it. Otherwise it's just chaos."

While the market for SDM is still relatively small — CIMdata sizes it around $50 million — the category is becoming more popular and expanding from its roots in the automotive sector as a repository specifically used to manage car crash simulation data. Heightened interest in the Internet of Things (IoT) and the debut of the digital twin concept, which made a splash this year as a way to create a mirror image of a product that bridges the digital and physical worlds and captures behavior, is also encouraging more widespread use of simulation.

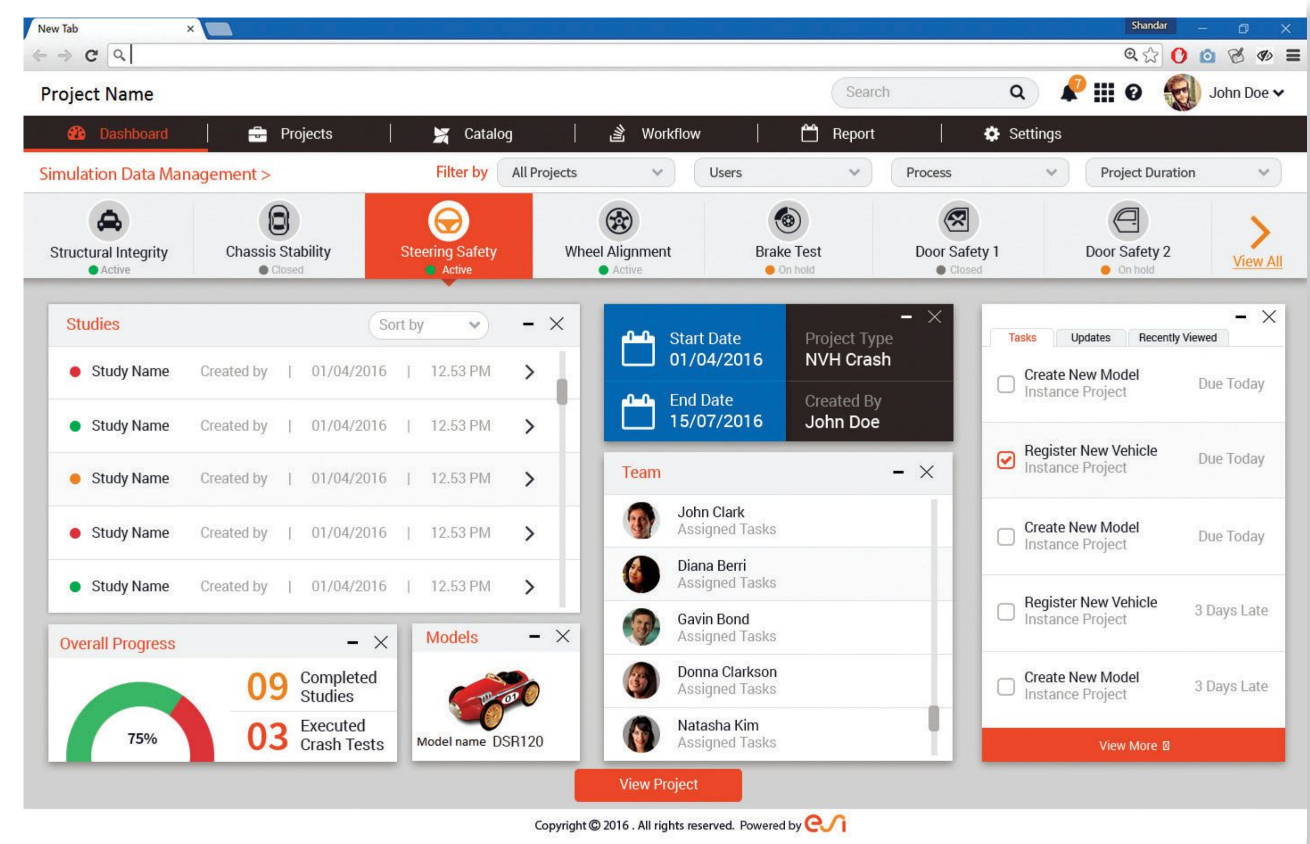


Through a web-based interface, ANSYS Engineering Knowledge Manager (EKM) is designed to facilitate seamless data exchange between expert and non-expert simulation users, providing them bi-directional connectivity with PLM and other business process management systems. *Image courtesy of ANSYS.*

As a result, engineering organizations are increasingly open to finding new ways to manage simulation data and processes, not as an isolated silo, but rather as part of the overall development process and design platform, Tolle says. "The old design paradigm moving to a model-based paradigm is what is getting us over the hump," he says. "It's not quite a wave, but [adoption] is building."

Knocking Down Barriers to SDM

For years, SDM has remained a fairly niche offering, especially when compared to other design and engineering-



centric enterprise platforms like PLM (product lifecycle management) and PDM (product data management). One of the big barriers has been cultural in that the people in charge of simulation aren't open to technology that centrally manages their data or moves it out of their control. "Simulation folks are very independent and are not used to having their data managed by Big Brother," Tolle says, adding that most prefer to maintain models and simulation data in their own shared drives, which doesn't support a very traceable or repeatable environment.

Also, because simulation work is iterative, involving a lot of tweaking of models and rerunning of simulations, analysts have balked at enterprise platforms they see in direct conflict with their longstanding workflows. "The idea of automatically archiving something the way you might do with CAD is not the way a lot of simulation work happens today," Tolle adds. "That's been a challenge that's been recognized by vendors."

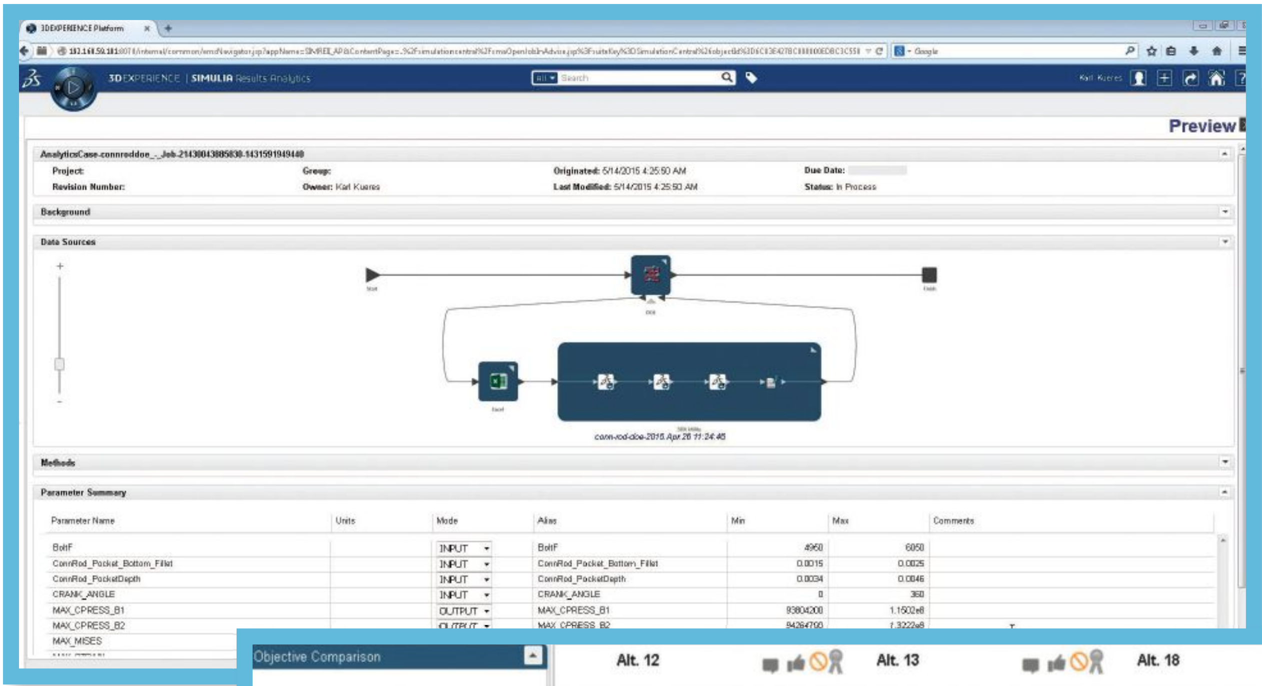
What's also been a challenge is SDM's traditional emphasis on managing documents and static reports, which leaves a lot on the table, according to Dale Berry, senior technical director, SIMULIA Growth for Dassault Systèmes. As opposed to managing a specific document or model, the real benefit of SDM comes with sharing the knowledge, learning, and methods surrounding the simulation so that others in the organization can benefit.

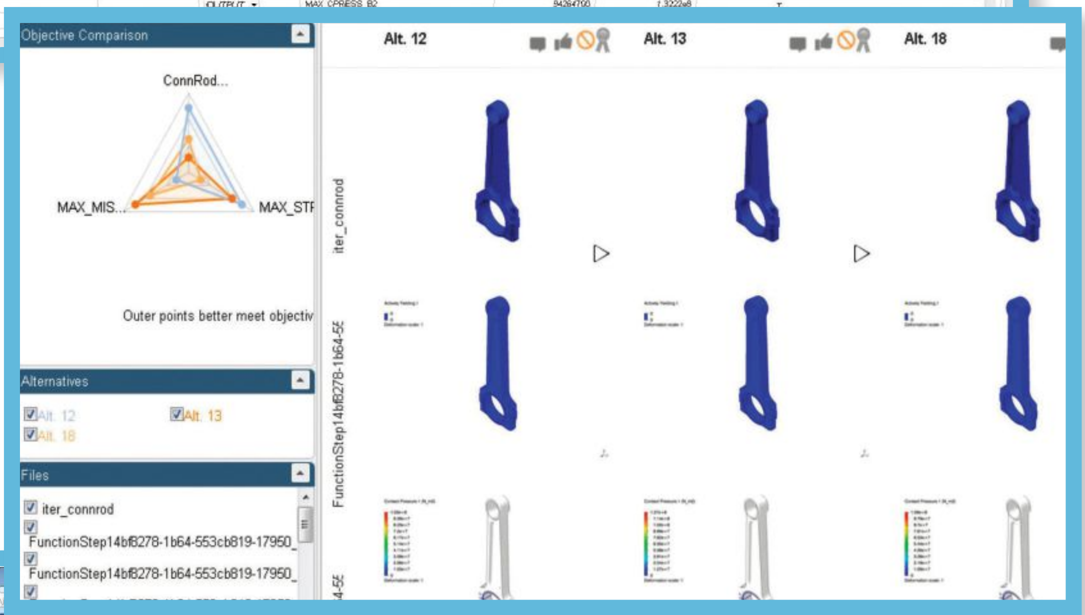
Dashboard view of projects and studies in ESI's cloud-based SDM application with quick status illustration required for projects and studies assigned to the engineer. *Image courtesy of ESI Group.*

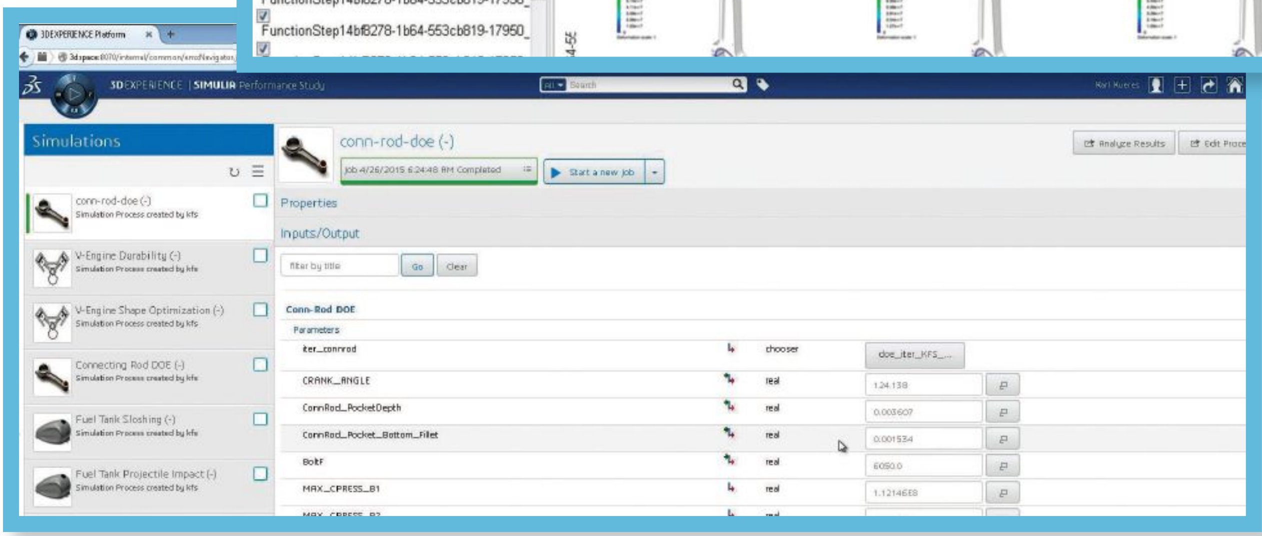
"When a model resides on someone's local machine, it's not a corporate asset," Berry explains. "The industry is at a tipping point where we are crossing over from thinking of SDM as document management to more like PLM. What's changing is the recognition that it's not the document that has value, it's the knowledge. We need to digitize the conclusion that this expert came to and make it available to everyone downstream."

Berry uses the example of an airline boarding pass in both PDF and mobile app form to illustrate his point. "The PDF is an electronic copy of the document and is not able to be updated or linked to other information or used in any way other than being a mirror image of a document," he explains. "In contrast, a mobile boarding pass is a living thing that can change any time a gate or flight time is updated."

To support this modern vision of SDM, Dassault, along with other SDM vendors, are making significant changes to their offerings. Dassault, for example, no longer maintains separate SDM and PLM offerings — it delivers simulation and SDM capabilities as an integrated part of the 3DEXPE-







These images show a captured simulation process for an engine-connecting rod (above), re-use of that process (right) and exploration of the resulting design space (below). ***Images courtesy of Dassault Systèmes.***

RIENCE platform. "When an expert sits down to build a simulation model on the 3DEXPERIENCE platform, everything they do is managed and digitized and becomes available for downstream use," says Sumanth Kumar, vice president, SIMULIA Growth at Dassault Systèmes. "That way the IT guys don't have to enforce it, it just happens naturally and is part of the paradigm shift taken in 3DEXPERIENCE."

Siemens PLM Software's vision for simulation and SDM also calls for the practice to be blended into the underlying data management of the PLM platform — not performed as a separate process. Its recently announced Simcenter simulation portfolio has a shared data management foundation and analytics capabilities at its core to set the stage for what officials are calling predictive engineering, a design approach that integrates simulation at every stage of the lifecycle to support the creation of a digital twin. "If companies want to take steps towards the digital twin vision, they have to consider tying together everything with an underlying data management system … so there's full traceability as to what's done and why," says Ravi Shankar, Siemens PLM Software's director for Simulation Product Marketing. "Data management is critical and SDM is absolutely going to be essential."

At ESI Group, increased demand for SDM capabilities are directly tied to its users' desire for automating simulation processes, according to Andrea Gittens, visual product marketing manager for VisualDSS.

VisualDSS, which ESI touts as a decision support system for CAE, collects the simulation content of virtual tests, facilitating the capture, storage and reuse of enterprise knowledge while also automating repetitive tasks in the simulation and virtual prototyping workflows, Gittens explains. The software, to be released later this year as a fully cloud-based platform, enables a seamless connection to CAD systems and PLM platforms so it functions as an integrated part of the design workflow, not as a separate silo, Gittens explains. "Our philosophy from the very beginning was not just SDM, but to deliver dedicated CAE applications through a cloud platform supporting engineering challenges like MDO, systems modeling, workflow management, and more," she says.

Yet SDM's applications can spread beyond simulation. ANSYS sees three use cases for its EKM (Engineering Knowledge Manager) platform: A core simulation data management function for searching, indexing, and mining CAE data; automating simulation workflows; and leveraging the tool to more efficiently submit and manage HPC (high-performance computing) jobs, according to Ray Miehm, ANSYS vice president, Enterprise Solutions and Cloud. The platform is now cloud-based, to support performance and scalability as use of simulation grows, and it's also designed with an open API (application programming interface) approach to ensure it integrates with mainstream engineering platforms. "The name of the game is to ensure an SDM platform is open enough to connect to PLM or to future big data systems and even existing big data analytics platforms," Miehm says. "If the SDM is open enough, there's no risk of becoming another silo."

Big Data Connections

SDM's connection with Big Data analytics seems to be where the category is headed next. Most of the major players in the category — ANSYS, Siemens PLM Software and Dassault, among others — see their investments and partnerships with Big Data analytics tools playing some role in SDM, whether as a tool for reducing the huge CAE data sets for more manageable access or for translating captured simulation knowledge into actionable insights that can impact future product designs.

As simulation becomes the bridge between the physical and virtual worlds, ANSYS believes in the power of analytics to help bolster the performance of smart machines in the field and to make predictions about future performance. In one example, the firm is working with GE Power Engineering to leverage the Predix Industrial Internet platform to deliver a "simulation as a service" pilot that blends physics-based simulation with Big Data analytics to help manufacturers reduce risk, avoid unplanned downtime and accelerate product development.

Siemens' acquisition of Camstar and its Omneo platform also points to Big Data analytics playing some sort of role in simulation and SDM. As engineers get simulation data under control, the next step is to perform some level of data mining to leverage data and knowledge in more meaningful ways, Shankar says. As its newly announced predictive engineering strategy spells out, simulation data, benchmark data, physical test data and even usage data collected from sensors will come together with analytics capabilities to help guide engineering decisions about how to evolve the product.

"We're looking at how to take all that data and use it in more meaningful ways to improve the next generation of products or in some cases, to improve the product as it exists in the field today," Shankar says. "It's a very exciting area, but we're in the early stages." DE

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

INFO → **ANSYS:** ANSYS.com

→ **CIMdata:** CIMdata.com

→ **Dassault Systèmes:** 3DS.com

→ **ESI Group:** ESI-Group.com

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

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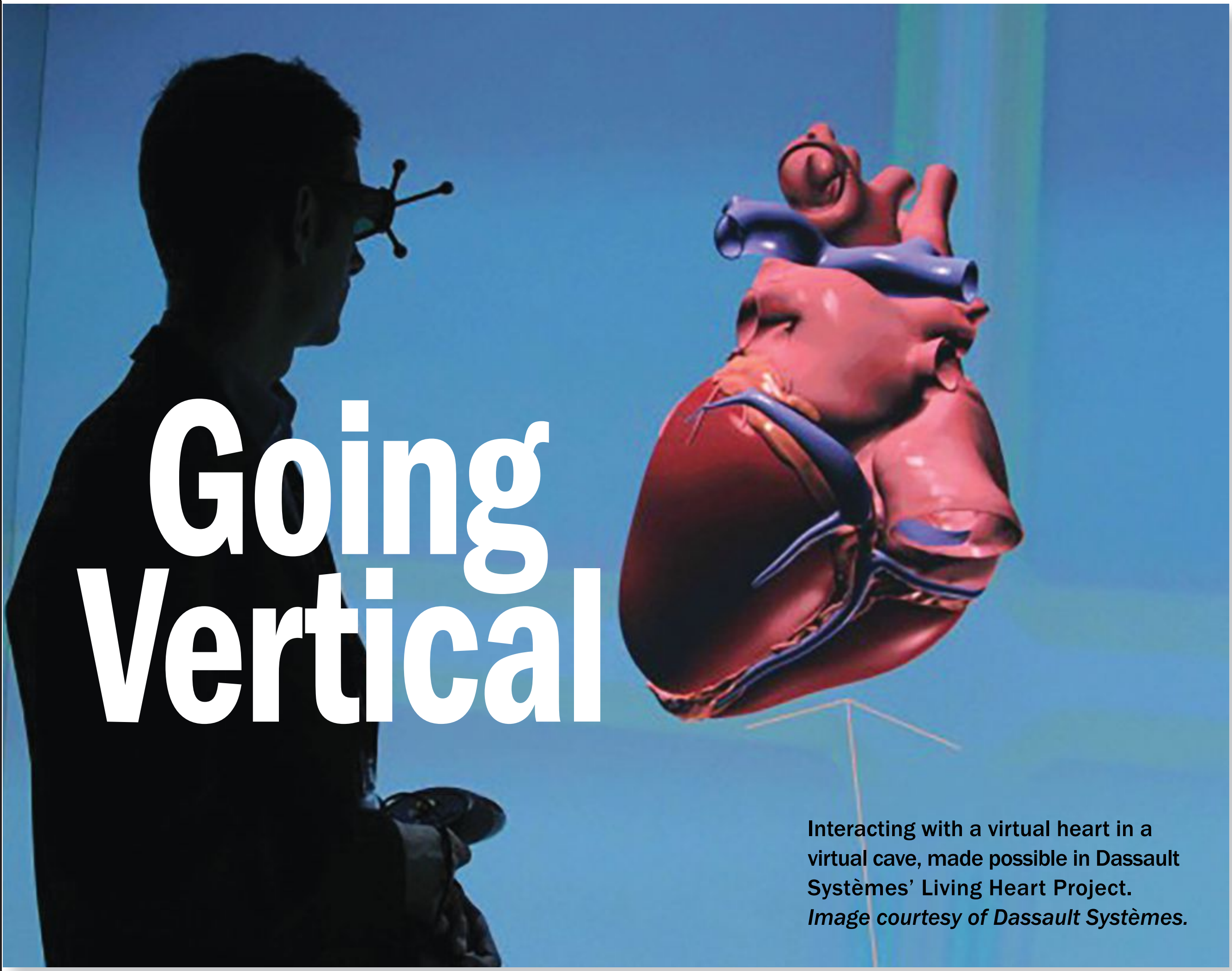


Going Vertical

Interacting with a virtual heart in a virtual cave, made possible in Dassault Systèmes' Living Heart Project. *Image courtesy of Dassault Systèmes.*

Industry-specific requirements and workflows reshape general-purpose software.

BY KENNETH WONG

In the beginning, AutoCAD was the same. Whether you used it for architecture, industrial design, mechanical design or electrical design, you used the same 2D drafting and drawing features. Working with a product built for the widest possible horizontal, you learned to come up with creative solutions (or clumsy workarounds) to accomplish the tasks unique to your discipline, domain or niche.

It's quite different today. The drawing environment for AutoCAD Architecture — the version that Autodesk markets to the architecture, engineering and construction (AEC) industry — is tailored to help you parametrically draw adjustable windows, doors and walls. By contrast, AutoCAD MEP — for the mechanical, electrical and plumbing systems designers — comes with blocks and orthographic symbols specific to the intended field. And AutoCAD Electrical has a layout environment designed for creating schematics with electrical connections, voltages and circuits. A timeline chronicling the first releases of these special AutoCAD versions would offer good insight into the moments Autodesk decided to expand into new verticals.

Design software makers like Autodesk constantly weigh the pros and cons of emerging markets to explore. Sometimes they acquire an established vendor in the target sector to use as their launch pad. Other times they spinoff a new edition or flavor of an existing product. When the needs of the new market are too eccentric (like the physics required to simulate fabrics in fashion and apparel, or the surface-modeling features needed to design prosthetics), vendors face a dilemma: Make radical changes to the core product to appeal to the new users, or leave the field open for someone else to tackle.

Forging a Path into New Verticals

Earlier this year, Autodesk decided its product offerings had grown too complex. The company offered a number of suites, each targeting a specific vertical: Building Design Suite for AEC; Product Design Suite for mechanical design and manufacturing; Entertainment Creation Suite for content creators, game developers and filmmakers; Factory Design Suite for factory designers; Plant Design Suite for plant managers; and so on. But many suites were also subdivided into Standard, Premium and Ultimate editions containing varying degrees of functionalities.

"[The suites] gave customers a lot of choices, but also created a lot of confusion," says Carl White, Autodesk's senior director of Business Models. The company's strategy was to reduce its bundles to three Industry Collections, reflecting the three core verticals it historically serves:

- Architecture, Engineering and Construction Collection
- Product Design Collection
- Media and Entertainment Collection

About the new collections, White says, "We're trying to put together the greatest number of relevant products at the right price point for most customers." The new Industry Collections are not subdivided into three tiers like the predecessor suites.

"We do go after verticals, but we tend to pick the broadest vertical we can go into," White adds. The company's acquisitions of HSMWorks in 2012 and Delcam in 2014 laid the foundation for its expansion into the computer-aided manufacturing (CAM) market, considered to be closely tied to the company's core businesses in CAD and computer-aided engineering (CAE).

Though the company shows no interest in straying too far from its core competency, it has begun to encourage others to develop products for the underserved industries using Autodesk Forge, a set of cloud services that connects design, engineering, visualization, collaboration, production and operation workflows. Forge is a set of APIs (application programming interfaces) that allow developers to tap into the modeling, drawing, visualization, simulation, and data-management technologies from Autodesk. It's the same platform used by Autodesk to build its own products. (*Editor's note: See page 7 for more information.*)

The Heart of the Strategy

Historically a CAD and product lifecycle management (PLM) company, Dassault Systèmes took bold steps to expand its life sciences footprint into the biomedical field with the acquisition of Accelrys in 2014. The San Diego-based Accelrys specializes in biological, chemical and material modeling, simulation and production domains. Among its 2,000 customers were Sanofi, Pfizer, Unilever NV and L'Oreal SA. In May of 2014, Dassault Systèmes launched its new brand BIOVIA, described as a combination of its "own activities in BioIntelligence, its collaborative 3DEXPERIENCE technologies, and the leading life sciences and material sciences applications from the recent acquisition of Accelrys."

This is expanding into new territories for Dassault Systèmes, mostly known for its solutions and experience with automotive and aerospace manufacturers. "We offer a full range of solutions to support innovation from pharmaceuticals to medical device to healthcare companies, leveraging the power and collaboration benefits of the 3DEXPERIENCE platform and the integration with BIOVIA applications," says Jean Colombel, VP of Life Sciences at Dassault Systèmes.

One of Dassault Systèmes' notable offerings in this field is The Living Heart, a 3D digital realistic model of a human heart. "We have partnered with over 100 medical experts in the field of cardiology, working in collaboration with clinicians, designers and regulators," Colombel says. "The first model we built is based on a healthy human adult and we can create other models from this one. You can use The Living Heart straight out of the box. If you're a medical professional or a medical device researcher, you could use it, for example, to develop a new kind of cardiac valve and test it in silico. We provide a predefined set of characteristics related to the human body. You can then also customize [the digital heart] further with results from your own research."

For blood flow and muscle movement simulation, The Living Heart uses SIMULIA, the same Dassault Systèmes technology deployed by car and plane manufacturers, but with a twist. "On top of SIMULIA, we put a layer specific to the design of heart valves and medical devices. And we make sure we use the right medical properties," says Colombel.

In November 2014, Dassault Systèmes signed a five-year collaborative research agreement with the U.S. Food and Drug Administration (FDA). The joint announcement explained the company and FDA "will initially target the development of testing paradigms for the insertion, placement, and performance of pacemaker leads and other cardiovascular devices used to treat heart disease."

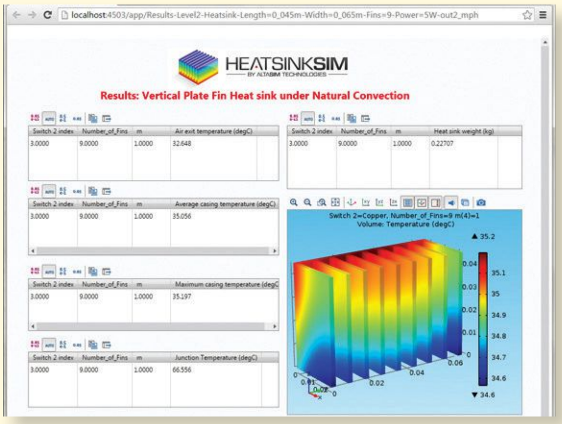
Targeting a specialized industry like medical device makers requires a good understanding of their workflow, and tailor-made features to meet their regulatory needs. "Medical device manufacturers have to organize knowledge around what's called a design history file (DHF) when they ask for market registration to comply with regulatory demands," says Colombel. "The same type of information exists in the software for automotive or aerospace, but it has to be organized, named, captured, collected and presented in a specific way for Life Sciences DHF filing."

DHF change management is part of Dassault Systèmes' project management offerings under the 3DEXPERIENCE platform. It's described as "advanced project management capabilities for medical device companies to … coordinate project activities and deliverables to ensure completion of design control deliverables and automatically populates the resulting DHF."

Another Way to Combat Complexity

Traditionally, the use of simulation revolves around general-purpose simulation software packages. The level of expertise required by this approach limits the pool of candidates who can use the technology. Focusing on specific industries allows software vendors to cut through complexity and focus on the features engineers in those trades use most, but there's another way to simplify software. The "app-ification" of simulation — the movement to encapsulate repeatable simulation tasks as simple, template-driven apps — broadens the playing field. It also leave room for simulation app developers — a new type of vendor.

AltaSim's HeatSinkSim exemplifies this trend. It also illustrates the complex relationships and partnerships that must exist to support the new usage paradigm.



In the creators' own words, the app analyzes heat transfer "using conduction, convection and radiation. Two levels of analyses are available: Level 1 analyzes a range of heat sink designs to identify optimum heat sink designs; Level 2 provides a detailed analysis of the optimum heat sink design and is automatically recommended when predicted temperatures approach component operating limits."

HeatSinkSim is an app — a repeatable simulation operation — built to run on COMSOL Multiphysics. When a user puts in the input parameters, the app uses COMSOL software to compute the answer in the background. This allows novice users with limited multiphysics simulation software expertise to bypass the need learn COMSOL software to set up the problem correctly.

COMSOL, the company behind the popular COMSOL Multiphysics software, also encourages the app-ification with the release of its COMSOL Server, which functions as the host for simulation apps.

Sailing into Energy and Shipbuilding

Siemens PLM Software, a division of Siemens, uses what it calls Industry Catalysts as launch pads to move into specific verticals. "Eighty to 90% of the product is exactly the same; but that remaining 10-20% has to tailor to the specific industry. We have expertise in many core industries; in others we leverage our partners," says Tony Hemmelgarn, executive VP of Global Sales, Marketing and Service Delivery for Siemens PLM Software.

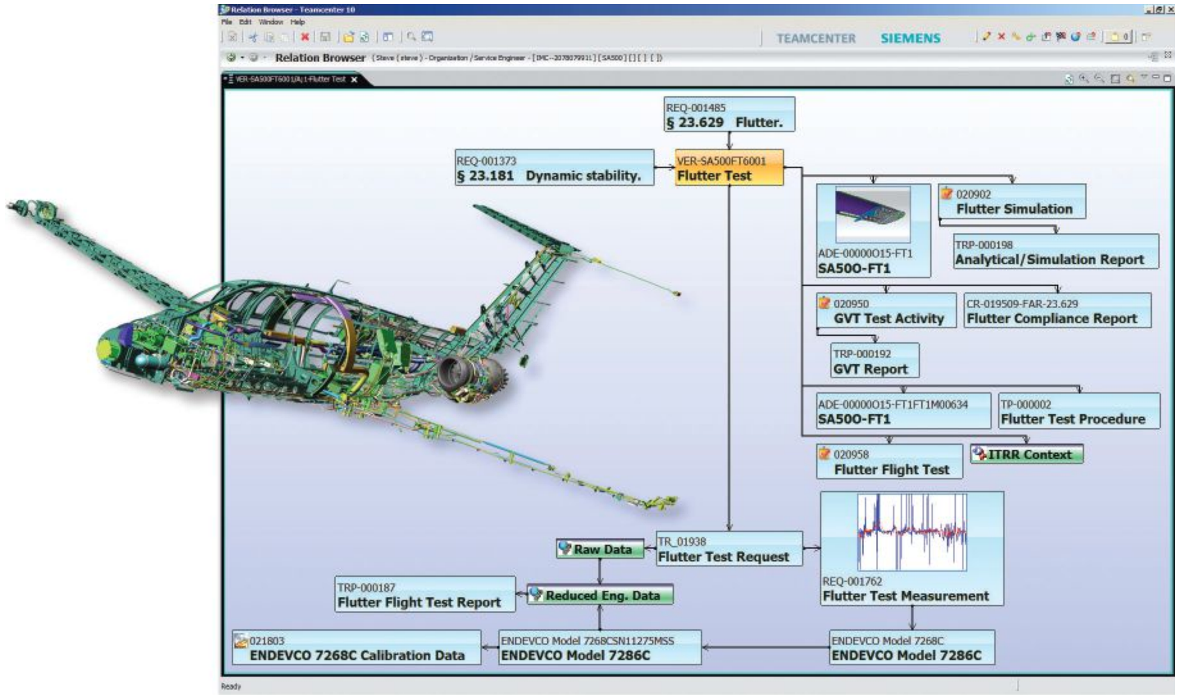
When the company wanted to offer a bid response solution to the energy sector, it chose Accenture as its partner. "When an energy company wants to respond to a bid, there are lots of documents they need to pull together. The terms they use and the way they do that is different from other industries. Our partner in that area is Accenture," Hemmelgarn explains.

In May 2015, Siemens PLM Software announced "a new PLM software and services solution aimed at enhancing efficiency for the global Energy & Utilities industry." The solution is part of Siemens' Industry Catalyst Series offerings. The company writes: "it leverages Siemens' Teamcenter portfolio to digitalize key capital project management processes, such as bid response management, and is specifically tailored to critical Energy & Utilities industry business processes." Siemens praises project partner Accenture for its "deep industry knowledge and implementation experience."

Another Industry Catalyst from Siemens PLM Software targets the shipbuilding industry. "Most Industry Catalysts are an integration of our products. But for shipbuilding, we added capabilities to track and consume weight information along the lifecycle of the ship configuration. This data is then submitted to the weight computation specialists for shipyard-specific weight calculations," says Hemmelgarn.

The company writes: "The shipbuilding catalyst delivers industry best practice models that function as references for PLM across the entire product lifecycle. Deployment accelerators include recommended product selections, network design decisions, configuration procedures, deployment best practices and user training. Open and configurable shipbuilding software allows you to control the appearance and behavior of a Siemens PLM implementation. These include data model extensions, data structures, and validation checks."

The more eccentric the workflow, the more effort is required to tailor the code and user interface (UI). "It's easy to put a thin layer or a wraparound [on a product]. But that won't get you want you want," recalls Hemmelgarn. "When we did a process for airplane certification, we had all the required technology components. But we'd never linked a process together from a manufacturer's point of view. It required leveraging people in the industry to help us get it right. In that case, we had to have full traceability, facilitated through Teamcenter requirements management, with linkages to CAD authoring tools."



Teamcenter's relationship browser provides a snapshot of requirements verification, offering traceability from requirement to compliance. ***Image courtesy of Siemens PLM Software.***

Open Opportunities for Partners

Some verticals will inevitably be too vertical, too narrow a niche for industry leading vendors to pursue. "If we have to make radical changes to the way our product work, and the market is so small, then it doesn't make sense to us," Hemmelgarn says. So pockets of opportunities are left to third-party developers and software partners with sufficient domain knowledge.

For example, OPTIS, a Deluxe partner of Siemens PLM Software, offers light simulation and prototyping solutions that "help businesses and people to optimize perceived quality and visual signature of their future product." The software's integration with NX, Siemens PLM Software points out, offers "advanced light and optical simulation directly integrated in their overall product design process." Most people don't associate Dassault Systèmes' CATIA design program with architecture, but it is the foundation for Gehry Technologies' Digital Projects, an architectural modeling program.

Sandip Jadhav, CEO of simulationHub, develops and markets a series of simulation apps based on Autodesk's Forge APIs. The selection is currently available as beta versions. It features ventilation analysis for conceptual houses, flow simulation for butterfly valves, and turbulent flow analysis for cyclone separators. The preconfigured templates allow people with limited expertise in simulation to conduct specific types of analysis without learning or purchasing a general-purpose computational fluid dynamic (CFD) package.

As a general-purpose design product gains widespread adoption in a certain industry, the industry's special needs and eccentricities begin to reshape the product itself. Thus, many CAD, CAM and CAE software vendors find themselves at a crossroad as they begin exploring industries beyond their principal domains — automotive and aerospace manufacturing. The opportunities in emerging fields like IoT, biomedical, life sciences and medical devices beckon. But to pursue them, developers would need to put in significant code refinement and UI changes.

"We think it absolutely requires tailoring the software to specific industries. We really got down to the nomenclature and verbiage," remarks Siemens PLM Software's Hemmelgarn. **DE**

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

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➜ **Autodesk:** Autodesk.com

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

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Deliver Engineer Ready Desktops Remotely & Securely

Virtual workstations are ready for demanding engineering use cases. Here's why you should get ready for them.

Some gauge their value to an organization by the size or location of their office. For engineers, the measuring stick has long been their workstation specs. The more bells, whistles and horsepower under their desks, the higher their rank in the pecking order. Those days are rapidly fading as engineering teams realize mobility and collaboration not only improve their productivity, but unchain them from their desks. Thin and light have become the new bragging rights, but engineers still require high-octane workstation muscle. That's where virtual workstations come in.

All the benefits of mobile computing and collaboration without their computing and security compromises are now available to engineers. Thanks to a slew of new technology advances, including virtual GPUs, compression capabilities and next-generation secure endpoints, organizations can finally tap into the benefits of virtualized environments for hardcore engineering work as an alternative or a complement to traditional workstation hardware.

Freedom and Security

Similar to other workloads migrating to a virtualized environment, virtual workstations centralize compute and graphics processing on a single platform or appliance, allowing users direct access to its resources through a thin client, entry-level laptop or even their old tower or mobile workstation.

This computing model has a number of advantages particularly well suited for engineering workflows. In a virtualized environment, engineers are no longer tethered to their desks to work with CAD and simulation models or other critical intellectual property (IP). Instead, they can tap into powerful centralized infrastructure resources and collaborate from wherever they are working as long as they have an internet connection. For engineers, the flexibility to conduct design reviews or iterate concepts from a client site or from home is a boon to work-life balance and effective communication.

Because everything in a resides in a centralized location rather than dispersed individual engineering workstations, critical IP, such as product designs, remain in sync in a virtualized environment, ensuring that all contributors have access to the most current information, regardless of where they are working. This simplifies data management and eliminates version control issues.

Along with the promise of mobility and better collaboration, enhanced security is another upside. In a virtual workstation environment, secure compressed pixels are being streamed to endpoints, which are sending back secure compressed keystrokes and mouse movements. There is no data

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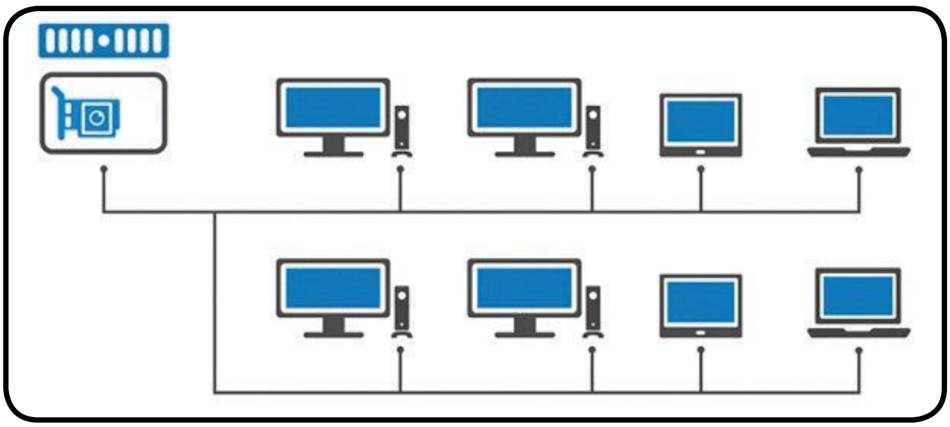


resident on the endpoint itself, so if it is lost or stolen, valuable data is not compromised. In addition, data centralization enables organizations to establish need-based access to IP based on enterprise governance and security policies, further ensuring that critical IP is properly safeguarded.

Ready for Engineering Work

Unlike early virtualization environments that weren't fully equipped to handle the robust graphics requirements of 3D design and engineering software, new technologies such as virtual GPUs and compression techniques now ensure that virtual workstations perform on par with their traditional, physical counterparts. In addition, the leading independent software vendors, including Autodesk, Dassault Systèmes, Siemens and PTC, have taken steps to certify and optimize their CAD and PLM software to run on virtual workstations. As a result, engineers will find it difficult to distinguish between a virtual and physical workstation environment, stamping out any lingering concerns about system degradation or a compromised user experience.

Despite these well-documented benefits, many organizations will still bump up against cultural and organizational challenges as they contemplate a move to virtual workstations. Some engineers will dig in their heels, not wanting to give up what they perceive as more control and better performance with the familiar physical workstation environment. Top level execs have to budget for an initial upfront expense even though they are clearly convinced of the ROI resulting from streamlined IT management, improved worker productivity and greater IP protection.

A smart virtualization strategy, led by the right business champions, can allay cultural concerns and conquer organizational challenges. By moving to virtual workstations, engineers get the horsepower they need to streamline complex product development and design on a global scale with all the flexibility, security and simplicity of a modern computing experience.

To help explain the benefits of virtual workstations for graphic-intensive engineering work, *DE* has produced "Making the Case for Virtual Workstations" with support from Dell and NVIDIA. It answers common questions about virtual workstations, exposes myths associated with them, and outlines the return on investment opportunities. You can download it for free at **deskeng.com/de/virtualworkstations**.

Burns Engineering Fires Up Productivity

Burns Engineering Inc. is 200 employees strong, and its pipeline is mighty with more than 500 projects going at any one time with CAD designers, structural engineers and project managers collaborating across the company's Philadelphia headquarters and 10-plus remote branch offices.

With projects and people spread out across the country, maintaining control over design data and making it easily accessible to project teams was a constant challenge, according to Bill Coffield, IT manager for the engineering and construction management firm. Moreover, each branch site (whether an individual job location or a full office) required its own IT infrastructure to support engineers and project managers, which meant that Coffield was constantly deploying gear to individual sites and connecting everything back through an internet router to the main office. The hardware alone cost about $50,000, not to mention, the weeks of travel time and expenses associated with deploying the on-site hardware.

Maintaining all this disparate IT infrastructure was also a burden. Coffield and his limited team were always on the run, patching, updating, issuing new licenses and replicating data across all of the sites. As the amount of data managed by the system swelled, so did the scalability problems. Users working at remote locations or from home were constantly frustrated by file replication latencies, which resulted in incomplete or inaccurate data. "I never knew if someone else was working on a file," recalls Alex Krause, CAD operator. "If they made file changes needing replication across servers at headquarters and the branch sites, the file wouldn't be synched for a long time."

Working with Dell partner BOLDER Designs, Burns Engineering turned to a virtual workstation approach — the Dell Precision Appliance for Wyse. The platform delivers a cost-effective, end-to-end virtual desktop infrastructure that has dramatically eased the company's IT burden, while providing greater scalability and business agility. The near-zero latency of the solution, which features PC-over-IP technology to transfer compressed display pixels over a LAN or WAN as opposed to actual CAD files, means engineers and project managers get the same experience as they have previously experienced with physical workstations — even those that have slow internet connections.

"One person who works from his home in the Virginia mountains, hundreds of miles away from the company headquarters, has just a 1Mbps connection, but he is using the Dell Wyse 5030 zero client for VMware there to run AutoCAD as if he is sitting in the office," Coffield says.

Thanks to the virtual workstation approach, Burns Engineering has reduced deployment costs by $50,000 per branch site while streamlining IT management by cutting back desk-side visits. Virtual workstations have also bolstered engineering productivity by improving collaboration and positioned the company for modern-day engineering workflows by allowing for mobility. "I can confidently say our company is ready for the future," Coffield says.

When Customization is Critical

Naked Prosthetics uses 3D printing to create biomechanical prosthetic fingers, such as the PIPDriver, pictured here. *Image courtesy of Naked Prosthetics.*

Engineers, designers and the medical world are using 3D printing and sensors technologies to create innovative prosthetics.

BY JESS LULKA

Today's prosthetic applications are an example of the intersection of design, technology and science. Going beyond traditional molding techniques and labor-intensive processes presents new opportunities for medical device design and patient data collection.

Despite its long history, 3D printing is just now flourishing in the medical sector, especially for generating prosthetics. Engineers and medical professionals are collaborating on a new generation of technology and design processes based on the quick customization enabled by 3D printing.

"With the use of 3D printing, a designer and prosthetist can work together to design a prosthetic using modern tools in combination with age-old techniques like plaster casting, to create prosthetics faster and more efficiently at a lower cost," says Ava DeCapri, industrial designer at FATHOM, a Stratasys 3D printer reseller and service provider.

For example, Travis Bellicchi, Maxillofacial Prosthodontic resident at Indiana University's School of Dentistry, is working with a host of students and faculty to develop a new mandible prosthesis for a patient. They're using a new digital workflow that includes 3D printing.

Knowing the final product would be produced with FDA-grade silicone, Bellicchi and his team decided to integrate 3D printing as part of the design process. "It's easily iterative. If you're working with plaster in the lab to make your molds, it's quite easy to crack, fracture [or] get totally destroyed. There's a real delicacy to a mold." Additionally, there's a higher resolution quality to some of the printing materials, which is especially important when figuring out how to place a prosthesis near a jaw or under skin.

To develop a new mandible, Bellicchi collaborated with the School of Informatics and Computing: Department of Media Arts and Science, School of Mechanical Engineering and Herron School of Art. Their work not only created a new mandible, but also produced a digital workflow that combined 3D scanning, CAD and 3D printing — something that's relatively new to the field. "In the past, our work felt very traditional and bogged down in this analog process," he says.

By being able to gather digital data and print multiple prototypes, Bellichi says his team was able to automate a lot of the time-consuming lab work by referring to patient data every time they wanted to tweak the design, instead of starting from scratch.

Comfort is Key

When addressing form, fit and function in prosthetic design, "fit" is king for creating a device that will be used every day.

"We get a lot of customers who [have gotten] prosthetics developed and they just end up sitting in a drawer," says Tony Peto, senior engineer at Naked Prosthetics. "That's not what we want."

3D printing allows the fit to be customized for each patient. Peto says engineers at Naked work on a patient-to-patient basis to ensure that the design will be beneficial to its user once it leaves production.

Movement is another key requirement, especially for more advanced prostheses, according to Travis Bellicchi, Maxillofacial Prosthodontic resident at Indiana University. When generating solutions that are integrated into the jaw or face, for example, part of the patient experience is how movement affects the prosthetic material and positioning.

The form of the design is also important, but it's not as challenging from a design perspective. "The aesthetic needs are actually quite [streamlined] for a prosthesis," Bellicchi explains. "Both for internal characterization and external characterization, making it look lifelike is relatively straightforward."

Making prosthetics look cooler than lifelike is also an option with 3D printing. For example, Open Bionics has teamed up with The Walt Disney Company to provide Frozen, Marvel and Star Wars inspired prosthetic hands to kids. Others are using the technology to create artistic prosthetics that are both lightweight and customized.

Collaboration is also helping to drive lower costs. "The largely open-source prosthetic 3D printing community shares designs and concepts at high speed, constantly 3D printing, testing and improving available designs … leading to faster innovation in the industry as a whole," FATHOM's DeCapri notes. This type of open-source design can be seen through organizations such as e-NABLE, The Helping Hand Project, Open Bionics and others who are focused on providing affordable and free 3D printed prosthetics to those in need.

While one of the main benefits of using 3D printing for prosthetics is reduced cost, there are other benefits that might not immediately be considered. "There is less risk and lower cost involved in designing and creating 3D printed prosthetics vs. traditionally fabricated prosthetics, so the technology allows for greater exploration of unprecedented design concepts. For the many people who have unique cases, traditional options [which may require surgery] can seem overwhelming," says DeCapri.

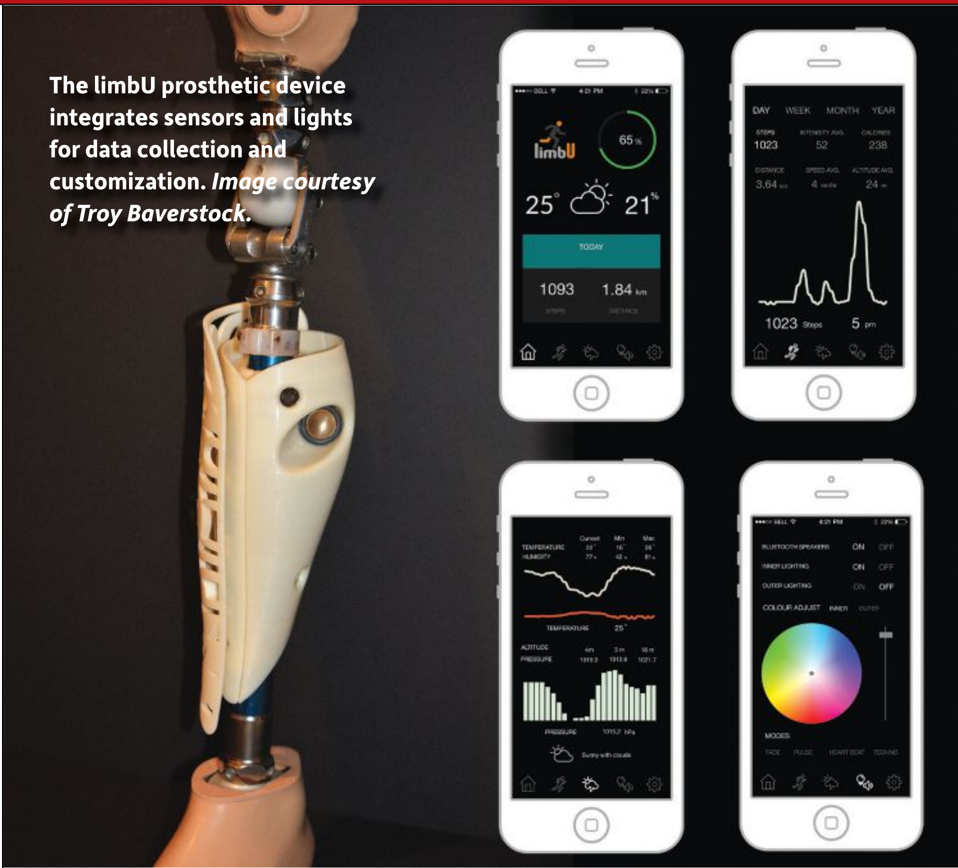
Beyond the cost and time savings for digital development, Bellicchi hopes using tools such as 3D printing and basic design software could also help medical professionals directly within hospitals. "There's a missing link in healthcare [when it comes to] digital design. Day-to-day, there's a need for more simplistic rapid prototyping that doesn't necessarily justify the thousands of dollars of design support, but still can be beneficial for patients."

Getting Technical

3D printing is just the beginning of offering customized medical devices. Affordable, accessible technologies are also ushering in an era of prosthetics and medical devices that integrate sensors for smart prosthetics and tailored feedback. Some examples include the BOOMcast from FATHOM and the limbU design. Both of these applications focus around connecting technology and augmenting the patient's use of a prosthetic or cast.

"With BOOMcast, the FATHOM team saw the opportunity as a challenge," DeCapri explains. "How can we rethink a medical cast? What are the possibilities that haven't been tapped into? What if this leg cast could actively facilitate the healing process and give doctors additional medical data?"

Some of the technology that was used in the BOOMcast



The limbU prosthetic device integrates sensors and lights for data collection and customization. *Image courtesy of Troy Baverstock.*

was implemented to gather technical data — including an accelerometer, gyroscope, magnetometer and an Intel Edison compute module. Because the wearer, Mike North, was constantly moving around the globe for his job, having connectivity allowed doctors assess his medical state from afar and make adjustments as needed.

While the technology helped doctors monitor patient statics, it also served as a bigger part of the user experience. Bluetooth-enabled speakers and LED lighting added a new layer of customization. But, it wasn't entirely decorative; the speakers emitted low-frequency tones that researchers concluded did ultimately help heal the bone, says DeCapri.

The integration of different technologies such as 3D printing, sensors and computer processors is just the beginning for prostheses.

"Despite promising advances in medical technology, prostheses that can match their biological counterparts are currently confined to the realms of science fiction. This limitation, however, does not restrict us from exploring new forms and functions for which the prosthetic limb is uniquely situated," says Troy Baverstock, designer.

Baverstock has designed limbU to push the boundaries of prosthetics and advance the current offerings. The device, which is a prosthetic add-on, currently sports a USB charger, stereo amplifier and speakers, GPS, microcontrollers, barometer, accelerometer and gyroscope. Ultimately, the wearer will not only be able to monitor daily activity, but also their environment around them. "limbU seeks to redefine a wearer's relationship with their limb by allowing the opportunity to cocreate its form and function to suit their personal lives," he says.

But, even with these advanced devices, Peto says that the technology for truly advanced prosthetics right now is currently ahead of the implementation. Still, with the lower costs of 3D printing methods and the trend toward connectivity, it's helping more patients get better devices and paving the way for even more innovative prosthetics. **DE**

Get Involved

Because open source is a large part of the 3D-printed prosthetic movement, organizations have popped up to take advantage of the technology for philanthropy. If you're interesting in helping, check out these causes:

- **e-NABLE:** One of the largest groups in the community, e-NABLE delivers prosthetics globally and its Raptor hand design has become mainstream for similar charities: enablingthefuture.org.
- **The Helping Hand Project:** Based out of UNC Chapel Hill, the group can make a prosthetic hand design for less than $40: helpinghandproject.org.
- **Open Bionics:** Going beyond 3D printing, this company has a developer community for users to help shape prosthetic designs and devices: openbionics.com.

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INFO ➜ FATHOM: StudioFATHOM.com

➜ **Formlabs:** Formlabs.com

➜ **Indiana University:** IU.edu

➜ **limbU:** TroyBaverstock.com/design/limbU

➜ **Naked Prosthetics:** NPDevices.com

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SENSORS

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Sensor Week P.30

Human-Robot Interaction P.38

AI, Sensors and Data Analytics — the Unsung Heroes of IoT

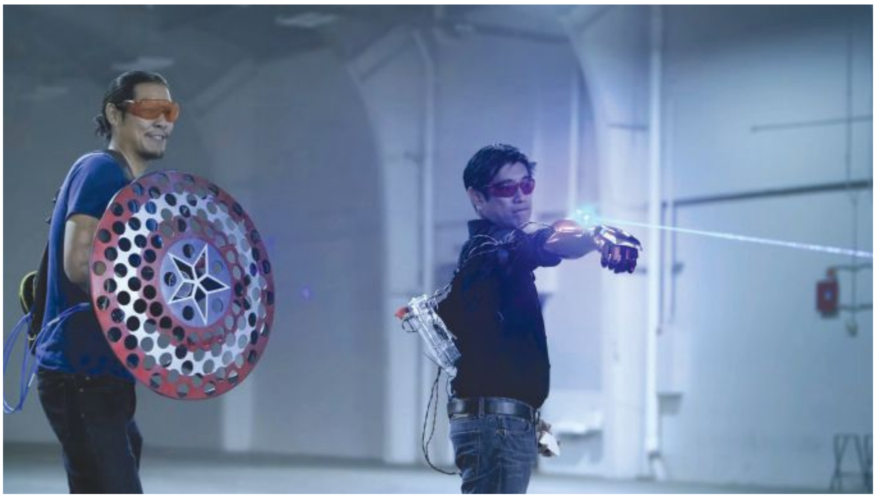
By Kenneth Wong

Iron Man's laser-shooting glove, Captain America's flying shield — can such imaginary superhero devices be created using today's technology? That's the challenge taken up by the web TV show "Project Heroes."

Standing 5' 7" in his trademark long-sleeved black shirt, Grant Imahara, the host of "Project Heroes," looks more like a startup executive than a superhero. In fact, any hardware startup would be lucky to have him in a leading role. Imahara's TV and film career includes roles on "Mythbusters" and "Battlebots," He's also the inventor behind well-known robotics, such as the Star Wars prequel-era R2-D2. In the first two episodes, Imahara and his cohost Allen Pan showed step by step how to use the electrical components available in the market to duplicate technology imagined by Marvel Comics writers.

Factory for the Superheroes

Without access to Tony Stark's research lab, Imahara built the laser-shooting glove with 3D-printed components and the highest powered laser he could legally buy. Pan couldn't get the mythical Vibranium Steel alloy to mold Captain America's shield, so he built a replica using aerodynamic foam pieces. A potentiometer and accelerometer made it possible for Pan to control the shield's flight using hand gestures. Imahara and Pan's sponsor is Mouser Electronics (not Stark Industries). They used components from Molex, Analog Devices, Cypress, Kemet and other participating electronics suppliers.



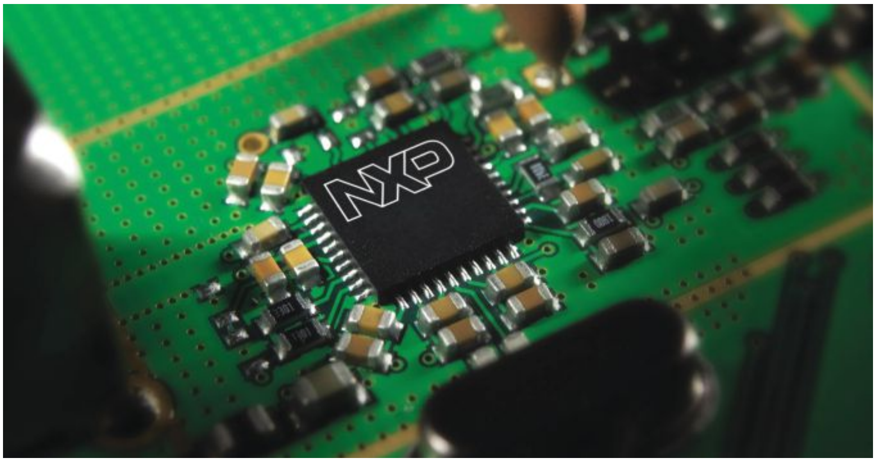
"Project Heroes" cohosts Allen Pan (left) and Grant Imahara (right) face off against each other with their own versions of Captain America's shield and Iron Man's glove. *Image courtesy of Mouser Electronics.*

Entertainment value aside, Project Heroes offers insights into the unsung heroes of modern gadgets — the microcontrollers, microprocessors and sensors that have long since supplanted the clumsy mechanical apparatuses. At the recent Sensors Expo (June 22-23, San Jose, CA), Mouser and other sensor makers showcased their accelerometers, gyroscopes, magnetometers and other components. The talk on the show floor was mainly about IoT (Internet of Things) risks and opportunities.

IoT by the Numbers

Christopher Rommel, executive VP of IoT and Embedded Technology for the analyst firm VDC Research, presented findings from the 2016 IoT Survey, conducted on behalf of Sensors Expo. Forty-one percent of the survey participants state they're consolidating sensor functionality into more intelligent/centralized hubs. Thirty percent revealed they are integrating more sensors of different types in their current projects. Thirty-six percent indicated they intend to integrate more sensors of different types in the next three years. Rommel and his colleagues believe "predictive maintenance will drive need for traditional sensor types," and "new use cases will drive need for machine vision solutions."

When ranking IoT market inhibitors, participants put security challenges and concerns at the top, followed by end-customer demand and readiness, lack of common standards, and maturity of available commercial products. "By and large, businesses don't delay or postpone IoT projects due to security concerns," Rommel said. One reason may be the cost of the fix. "If the fix is at a component level, the cost may be too prohibitive," he added. Another is time-to-market and competitive pressure. "People are always fighting to meet deadlines; they're already late. They also know their competition is rapidly making progress," he said.



NXP chip on board: Semiconductor maker NXP and other sensor makers can expect IoT to drive growth. *Image courtesy of NXP.*

Enter AI and Machine Learning

Semiconductor maker NXP equipped a double-decker trailer with its technology to demonstrate how it can power smart homes, smart appliances, gyroscopes and 3D printing. Telit promoted its IoT factory solutions, powered by its deviceWISE platform. Developed to operate within an enterprise's premise, deviseWISE "connects and integrates production machines and processes with existing enterprise resource planning (ERP) and manufacturing resource planning (MRP) systems and supervisory control and data acquisition (SCADA) applications," the company says.

China-based INMOTION SCV (sensor-controlled vehicles) is known for Segway-like unicycles and personal mopeds. At the expo, it promoted its 3D depth camera line as "high performance robot navigation and positioning solutions."

VDC Research's Rommel said: "[IoT] fundamentally changes how you go about monetizing your product, how you derive value." One way IoT changes the connected device industry is to shift the emphasis from the device to the data. Gadget makers are quickly coming to the realization that a connected device that merely collects, transmits and receives data adds very little value. Only a device that adapts and anticipates — for example, a heartrate monitor that recognizes symptoms of pending cardiac issues and can send warnings, or a home thermostat that can sense when the occupants are absent and turn itself off — may truly be considered IoT-enabled. Such AI-like intelligence can only come from data — lots of data.

Therefore, data analytics and machine learning solutions are expected to become an integral part of the sensor-driven future.

One real-world example comes from Horse Sense Shoes, which uses NXP's accelerometers, magnetometers and air pressure sensors to look for deviations from a horse's normal routines — signs of deteriorating health in the animal. "If the horse is usually laying down for two hours a day, and now, all of a sudden, it's laying down four hours, that's a flag, so [the app] sends a text message to the owner or the vet," said Roger Roisen, CTO of Horse Sense Shoes, in a TV interview with NWCT.

One of the exhibitors at Sensors Expo was RealityAnalytics, which claims its software "[uses] advanced, patented artificial intelligence techniques to detect real-world events in sensor and signal data so apps and devices can take action." It currently offers two products: Reality AI for IoT and Reality AI for UAV.

Episode 3 of "Project Heroes" brought the faceoff between Imahara's version of the Iron Man glove and Pan's version of the Captain America shield. Most people saw a sleek, shiny glove that shoots laser beams hot enough to melt its target; and a shield that flies through the air, slices off the target and returns to its owner. Only engineers see the true source of these technical marvels — the sensors, microprocessors and electrical components under the hood.

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:

Mouser Electronics: Mouser.com

NXP: NXP.com

Project Heroes: Mouser.com/empowering-innovation/superhero-technology-project

RealityAnalytics: Reality.ai

INMOTION SVC: IMSCV.com

VDC: vdcresearch.com

Battle Tested

Sensor Week helps DoD, contractors prove out new sensor/seeker technology in a large-scale testing environment.

By Brian Albright

Testing defense and military systems can pose a significant challenge. These systems have to perform under battlefield conditions that are harsh and unpredictable. Because you can't test in an actual operating theater, simulating field conditions is the next best scenario. However, it can be difficult and expensive if you need to test a sensor solution that requires the participation of a fighter jet or a convoy of tanks and trucks.

From May 16 to 27, more than 50 U.S. Department of Defense (DoD) organizations and private companies arrived at Eglin Air Force Base near Valparaiso, FL, for an event that marries product testing, research and battle simulations: Sensor Week. Participants were able to test new sensor and seeker technology on a testing range with more than 400 vehicles and aircraft, including everything from Air Force jets to Russian fuel trucks and missile launchers.

During the event a host of different sensor-based solutions are tested using actual Air Force planes and military ground vehicles and equipment so that manufacturers and system designers can capture data that would otherwise be expensive and difficult to gather. They can then share that data with other participants and with the DoD.

"Customers come to Sensor Week to measure seeker/sensor data using their equipment on various scenarios such as ground threat vehicles or improvised explosive device scenarios," says 1st Lt. Keegan George at Eglin. "They usually have a new system or new software for seekers and sensors. We also have some more operational guys who were doing tactics development. Without going into too much detail, there are radar systems on the range and we can fly against those and see how the aircraft perform, when the radar can see them, and how the different ways they can fly will affect that."

Sensor Week is hosted every two years by Project Chicken Little as part of the 46th Test Squadron's Sensor and Defensive Systems Test Flight. The event is sponsored by the Air Combat Command (ACC), and costs are shared between the government and participants – a key feature of the event because having each organization or company conduct such testing individually would be prohibitively expensive and present logistics challenges.

Eglin also hosts the complementary event, Acoustics Week, which is held in odd-numbered years. That event focuses on acoustic sensors with more of a focus on ground testing for moving vehicles.

Cost-Effective Testing

Cost sharing is one of the primary benefits of the joint event. "We have 400 vehicles out for Sensor Week," George says. "To get all of those out and get the data would cost one system more than $1 million just for one test. This spreads out the cost. Chicken Little provides the scenario development, ground truth data, and test engineers and analysts. All the customer has to do is show up with the sensor suite and the test team to operate it, and a platform to fly it on."

The event helps reduce risk for the Air Force Materiel Command, and provides a significant return on investment in testing funds because so much data generated at one time.

Participants this year included a variety of DoD organizations including the Air Force Research Laboratory and the Army Research Laboratory, along with MIT, Lockheed Martin, Northrop Grumman and a host of other private companies.

Participants tested a number of electro-optical/infrared (EOIR) sensors, visual sensors, infrared systems, airborne radar and other technologies. They test their sensor systems for a variety of scenarios, including radar detection, aircraft detection and ground threat vehicle and improvised explosive device scenarios.

"The organizations are looking at trucks, tanks and radar systems on the range and trying to correctly identify them," George says. "The main objective is identifying different vehicles and making sure they can tell the difference between a tank that's a threat, for example, and a school bus."

The Eglin range is broken into different sections with a variety of static arrays (including boats, trucks, tanks and radar systems), along with moving assets like convoys of vehicles and radars that are actively emitting. "The sections are broken up into things that might be grouped together in an operational environment," George says. "We also had 15 types of aircraft flying as well."

Various vehicles are part of Sensor Week, allowing participants to test their sensor systems against a variety of ground threats to, for example, try to correctly identify a radar system (top) vs. an M5 tank convoy (bottom). *Images courtesy of USAF.*

Data Sharing

Many defense systems have benefited from the Sensor Week data over the years, including the Hellfire missile and the AGM-88E Advanced Anti-Radiation Guided Missile (AARGM), an Air Force manned reconnaissance platform.

The types of sensors tested are typically used on aircraft and for tracking foreign and domestic ground assets, vehicles, bombs, and for defensive purposes. The data generated during these tests winds up being used across the services. "The data isn't specific to one platform or one system, but gets

Radar systems are key to surveillance and deployment of weapons for offensive and defensive applications. At Sensor Week, Air Force planes can fly against various radar systems to collect and share performance data. *Image courtesy of USAF.*

A Height Finding Radar was used for seeker/sensor testing during Sensor Week at Eglin Air Force Base this year. *Image courtesy of USAF.*

used by the Navy, Coast Guard, Air Force and Army," says George.

One unusual test this year was an airbase recovery operation. "That customer simulated damage to a runway, and they were interested in collecting data to see if they could estimate how extensive the damage was," George says. "They didn't have a platform to collect on, so they set up the array and got buy-in from other customers to collect the data. It was a collaborative effort."

At the end of the event, data is shared with the Eglin Signature Data Center. Project Chicken Little also provides ground truth reports to participants that include data points, photos, vehicle parameters and other information that help stakeholders evaluate and analyze the data.

The compiled data is available to any user within the DoD, and can be used to improve sensor systems.

George says the database incudes several terabytes of data going back several decades. The information is categorized by the type of asset on the range; for example, all of the truck data would be grouped together. "If an organization or a Department of Defense contractor requests that data, we can send it out to them o they can come here and access it," George says.

For the DoD, the data provides a wealth of information that can be used in multiple different projects and systems. "The data can be applied to algorithm development for seeker tracking or different identification software applications that are far reaching to all corners of the DoD," George says.

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

INFO:

Department of Defense: Defense.gov

Eglin Air Force Base: Eglin.af.mil

Harnessing the Power of Sensor Fusion

Hubs, application specification and new technology help advance human-machine interaction.

By Tom Kevan

Accurately tracking complex user motions requires input from a variety of motion sensors, including gyroscopes, accelerometers, compasses and pressure sensors. Sensor fusion combines the sensor outputs into a single, accurate data stream for use as input commands in consumer electronic devices. *Image courtesy of InvenSense.*

Peel back the layers of the technology that has brought the Internet of Things (IoT) to life, and you will find a growing network of sensing devices that take human-machine interaction to a whole new level. To take advantage of this opportunity, design engineers increasingly turn to sensor fusion with an eye on implementing greater intelligence in their user interfaces.

The challenge for developers is to create a blend of hardware and software that can efficiently and accurately aggregate and interpret the mountains of sensor data now available to consumer devices. To select the right components for their system, designers must understand the unique features of their fusion use cases. Ultimately, the fusion process aims to produce application-ready information that provides real insight into the user's behavior and movement, thus opening the door for next-generation content and services.

"Consumers demand ever more intelligent applications that can take natural, intuitive commands from users," says Ian Chen, director, System Architecture, Software and Algorithms at NXP. To meet these expectations, the design engineer must be able to manage an ever-increasing number and variety of sensors and use those sensors to understand the application's variables, environment and context.

Fusion Basics

While the basic concept of sensor fusion has long been established, the techniques that enable the process vary and constantly evolve. Generally speaking, sensor fusion is the incorporation of data from multiple sensors observing the same event, each taking advantage of its own unique perspective. The sensors may reside in different locations or sense different physical properties, so the noise captured by each sensor is independent of, and different than, that of the other sensors. As a result, information present in all the sensor data streams must then be associated with the event of interest, and information that is present only in one sensor data stream is noise. In this way, the combination of the data gleaned by disparate sensors captures the true event better than a single sensor.

One of the most common techniques of combining data from multiple sensors is the Kalman filter, an adaptive, linear filtering algorithm. There are, however, other ways of combining sensor data to better understand the underlying event. These include nonlinear methods, such as particle filters, and statistical methods, like neural networks and

MotionFusion firmware algorithms from InvenSense enable designers to integrate inputs from a 3-axis gyroscope, 3-axis accelerometer and a pressure sensor to create motion interfaces for devices, promising to reduce development costs and time to market. *Image courtesy of InvenSense.*

machine learning algorithms. All of these approaches perform sensor fusion.

The Magic is in the Software

With all these software options, the real challenge becomes identifying the best algorithm for the application. Remember, the quality of the user experience depends on how well the algorithm translates sensor data into useful, application-ready information. So designers must find the software that delivers the best data aggregation accuracy, compute efficiency and power conservation within the context of the application at hand.

To convert these general goals to actual performance, engineers must consider the nuts and bolts of the fusion process. "To select an optimal algorithm, designers must consider both the signal and the background noise of the sensing environment," says Chen. "The signal can vary because of the installation environment, temporary unavailability of the sensor data in the case of a sensor network, or variations in the user population in the case of human-machine interface applications."

The application may introduce other issues that must be considered, as well, such as latencies, synchronization with other events in the application, types of error that must be accommodated, and run-time workload distribution. In the case of the workload distribution, the designer must know if the algorithm runs as part of an embedded system, in a network access point or gateway, or on servers in the cloud.

All these elements must be considered within the context of the hardware environment. "The sensor framework will need to be scalable to fit the hardware architecture of the current product, and it will need to be modular and scalable for future products," says Eitan Medina, vice president of Marketing and Product Management at InvenSense. "This means that the algorithm must come with a complete tool chain that will allow fast prototyping, experimentation, correlation and integration into applications."

A Starting Point

To jump-start the algorithm development process, sensor fusion providers often offer code libraries. The idea is to help designers unfamiliar with the technology to avoid having to re-invent the wheel and to minimize the time to market. Some vendors have taken this concept one step further by offering open source sensor fusion libraries. To get the most value of these resources, designers should not see these libraries as an alternative to developing their own code, but rather as a point to begin the creative process.

"Open-source libraries are like any other open source code base – it will get you started," says Medina. "Do not expect it to necessarily meet your product goals. In fact, expect it not to. Your engineers will need to own it [the library code] to make it work for you. If you decided to do your own fusion library, the open source will get you a good starting point in your development."

The problem with relying too heavily on open-source libraries is that sensor fusion cannot be a one-size-fits-all proposition. "Today's applications are so specialized that an unfocused approach no longer provides data accurate enough to meet the increasing demands of the marketplace," says David Sohn, China Sales & Marketing liaison manager at PNI.

Things to Look For

Designers should remember that the use of a library — whether it is open source or proprietary — does not absolve them of the need to verify their code against the actual use case of the application. They should be sure that they understand the parameters of the fusion algorithm they get and how it is validated.

When choosing a library, here are a few issues that designers should keep in mind:

- What is the system bandwidth?
- What are the sensitivities to various input noises?
- What physical interactions are, and are not, modeled by the fusion library?
- Every algorithm makes tradeoffs between efficiency and accuracy of the model. Are these tradeoffs compatible with the application?
- With which sensor hardware and under what environments is the algorithm validated?

The Intelligent Sensing Framework (ISF) from NXP/Freescale executes on Kinetis microcontrollers and enables embedded applications to subscribe to external sensor data, reading the data at various rates. ISF allows the microcontroller to act as a sensor hub for external sensors and manages the data for the host processor. *Image courtesy of NXP/Freescale.*

Tools and Testing

When choosing a development environment, be sure to select a platform that will accommodate algorithm modeling. "Focus on the development platform that will allow you to collect data for algorithm development and choose a tool chain built around a proven sensor framework, a graphical user interface and a wide set of algorithm building blocks so that you can focus on differentiating your application rather than building everything from scratch," says Medina.

Keep in mind that ensuring that you have the right test coverage for the algorithm can be time-consuming. The effort ranges from using simulated inputs to verifying the implementation to capturing data in the real world and comparing the sensor algorithm output with the truth.

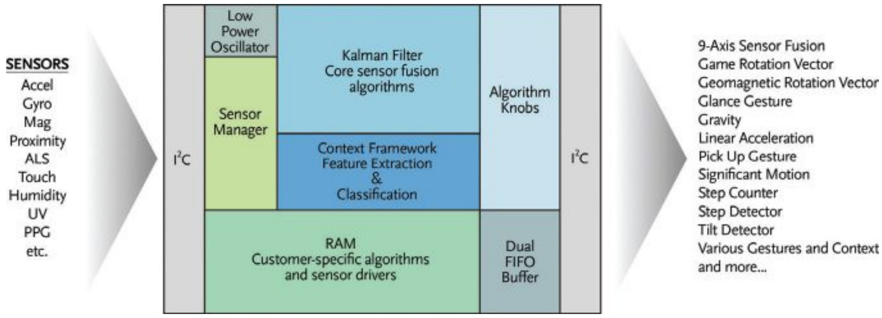
Sensor and chipset providers offer a variety of tools to help with these processes. "In addition to publishing our open source sensor fusion [Kalman filter] implementation, NXP also includes utilities for designers to generate simulated sensor data," says Chen. "We have created a series of hardware platforms and software utilities around our sensors and MCUs to allow designers to quickly capture and visualize sensor data so that they can focus on creating value with their sensor algorithms and applications."

The Changing Role of Sensor Hubs

Working hand in hand with the algorithms, sensor hubs represent one of the key enabling technologies of the fusion process. A specialized microcontroller, the hub helps to integrate and process data provided by the system's various sensors, off-loading computing tasks from the main application processor and thus reducing power consumption.

Just as fusion technology has evolved in recent years, so too has the role of the sensor hub. A lot of this transformation has been driven by the proliferation of mobile devices and the growing implementation of context-aware services enabled by machine learning.

"The exciting thing over the past five years is that the term 'sensor fusion' is evolving in mobile," says Jim Steele, vice president of Engineering, Intelligent Audio, at Knowles. "With the advent of machine learning techniques, context awareness of the user is becoming more and more possible. Knowing not only the location of a user, but also why he is there and



The SENtral-A2 low-power coprocessor from PNI Sensor includes a broad algorithm feature set and development framework. This combination aims to streamline algorithm creation for wearables and smartphones, providing designers with a faster way of delivering personalized, contextual experiences on devices. *Image courtesy of PNI Sensor.*

The "always-listening" VoiceIQ Smart Microphone from Knowles integrates an audio processing algorithm and acoustic activity detection directly into a digital microphone. As a result, the microphone recognizes when the audio chain should be awakened and when it should remain in sleep mode, delivering both power savings and effective noise suppression. *Image courtesy of Knowles.*

what he is doing feeds a multitude of new applications."

One aspect of the rise of context-aware applications is increased demand for always-on services, which has changed the operating requirements of the sensor hub. Always-on performance often translates into greater energy consumption. As a result, fusion algorithms have had to incorporate new ways of reducing energy consumption.

This rise in the hub's energy consumption has also been exacerbated by moves to incorporate more and more sensors into the mix. Consider, for example, the growing use of GPS and gyroscopes. While these technologies provide fast and accurate results, they also consume excessive amounts of power.

New Technologies for New Demands

To accommodate these demands, design engineers have begun to adopt new hub technologies. These take the form of processors tailored to achieve greater energy efficiency.

For example, instead of merely aggregating sensor data, sensor hubs now process sensor data to enable context-awareness. As the workload of hubs has increased, designers have turned to multi-core processors. Using this approach, a smaller, more power-efficient core performs sensor data acquisition, while a second core processes sensor data, staying in a low-power state as much as possible.

Another power-saving device is the digital signal processor (DSP). "As more complex use cases come about, the compute efficiency of a DSP is often preferred," says Steele. "Knowles provides DSP cores with additional hardware accelerations for sensor fusion and audio processing, which is essential for the low-power, high-compute performance necessary for the next generation of sensor fusion algorithms."

Perspectives and Tools

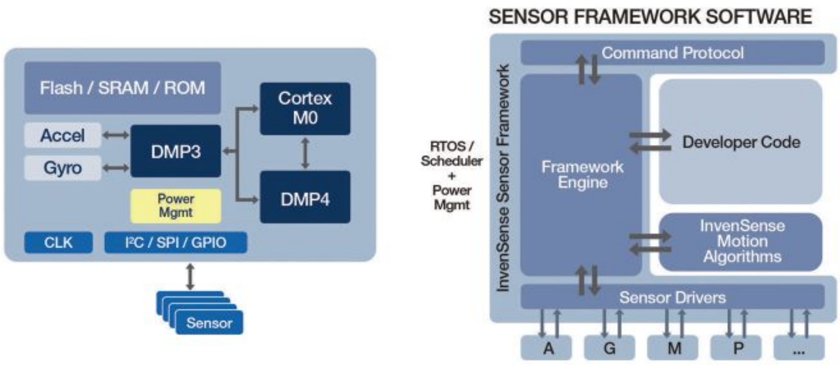
All these new demands on sensor fusion systems drive home the importance of understanding the use case. This includes making sure the algorithm is not wasting computing power to achieve precision where no accuracy can be gained because of limitations imposed by noise embedded in the sensor data.

An example of this can be seen in handheld applications where the natural hand tremor limits the meaningful resolution. In cases like this, designers can reduce trigonometric functions to lower order terms, using fixed-point math with a simplified floating-point library without compromising the application.

It is important for designers to recognize that there is no benefit to running sensor fusion at a sampling rate faster than the application demands. Real system power reduction comes from running the algorithm only when the input from the sensors is valuable. The tradeoff here is added system latency and the risk that the lower power trigger could cause the system to miss an important event.

"Given that power consumption has become one of the primary criteria in specifying a sensor hub, designers should always evaluate sensor hub power consumption for their expected workload," says Chen. "To help with this, some IDEs (integrated development environments) like NXP's LPCXpresso allow programmers to estimate the power consumption of their program."

At the very least, sensor hubs should come with a proven sensor framework and dedicated sensor application development tools. "By itself a bare-bone sensor hub without the supporting software is going to require significant software development," says Medina. "In many cases, great hardware specs of the sensor hub — especially around power — may not matter because inefficient sensor framework software may end up consuming excessive amounts of power."



InvenSense single-chip ICM-30630 supports 6-axis motion tracking, integrating a tri-core processor, sensor framework software, a gyroscope and an accelerometer. The chip serves as a sensor hub, supporting the collection and processing of data from internal and external sensors. *Image courtesy of InvenSense.*

Making the Right Connections

Another area critical to sensor fusion's success requires design engineers to choose the optimal interface linking each sensor to the hub. Keep in mind that individual sensor types have their own constraints in terms of frequency, latency, and power requirements. So the challenge is to match each sensor's requirements with those of the application.

With mobile and wearable applications, where battery life is a major concern, designers must minimize the static power consumption of the interface. For example, the pull up resister found in I2C interfaces draws constant power and can be a significant drawback. On the other hand, I2C requires only two signal pins and therefore is economical for the microcontroller.

The new Sensewire interface — aka I3C — being proposed by the Mobile Industry Processor Interface Alliance attempts to capture both qualities. Unfortunately, it is not yet widely supported by the hardware market.

Commonly used in industrial applications, SPI (serial peripheral interface) consumes little standby power but requires more pins.

And for automotive applications, engineers can avail themselves of specialized interfaces like SENT, PSI and DSI. The industry has optimized these to deliver robustness to designs concerned with functional safety.

Looking Forward

As sensor fusion's role in applications expands, engineers can expect to see growing numbers and varieties of sensors incorporated into the process. Some of these may even take the form of ad hoc sensor networks.

Engineers will continue to use established software approaches, such as Kalman filters, implementing them in both traditional and emerging applications, such as in Active Driving Assistance Systems. At the same time, designers will increasingly include machine-learning algorithms to process both raw sensor data and results from sensor fusion. This will take sensor fusion into applications like context-aware computing and enable the delivery of more complex services and content.

Tom Kevan *is a freelance writer/editor specializing in engineering and communications technology. Contact him via DE-Editors@deskeng.com.*

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Driving While Blind: The Challenges of Human-Robot Interaction

First self-driving car fatality shines spotlight on the gap between robotic capabilities and perceptions.

By Michael Belfiore

In a comical YouTube video that has since been taken down, technologist Austin Meyer read aloud from a newspaper that blocked the entire view out the windshield of his Tesla Model S. The car is running on Autopilot, steering itself as well as keeping acceleration steady. But instead of demonstrating that hands-off control of self-driving cars is ready for prime time, Meyer was making the point that watching the road is still mandatory for safe driving, even in robotic cars. He in fact used a spotter in a pace car and drove on a sparsely traveled private road to pull off his newspaper stunt.

The interface is just one part of human-robot interaction. Pictured here is the design for the Tesla S. *Image courtesy of Tesla.*

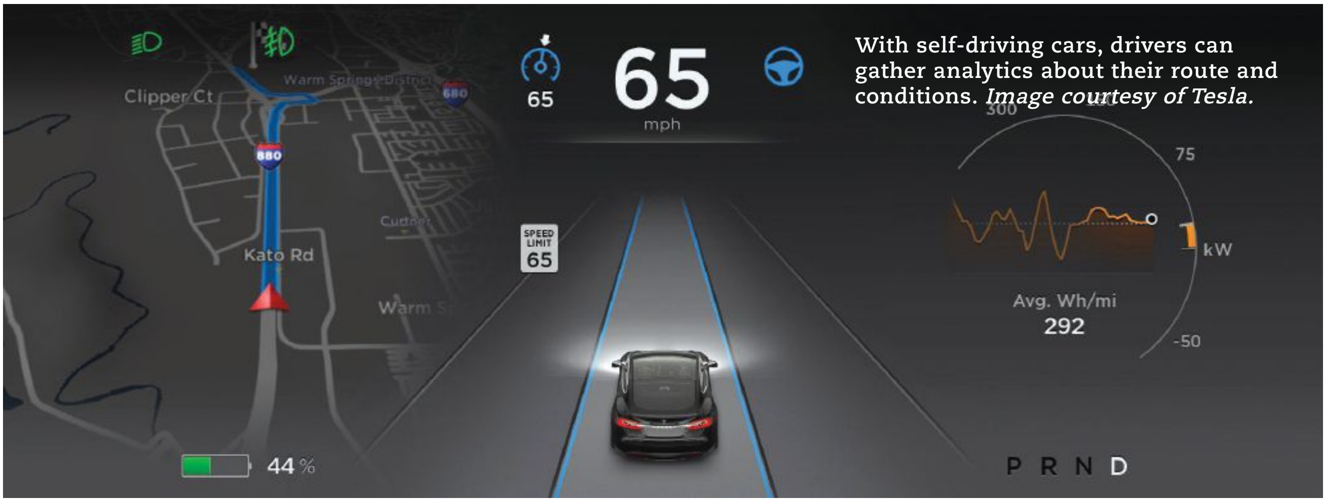
That's because vehicles with autonomous capabilities still aren't up to the task of everyday driving, as more recent and serious events have illustrated. On May 7, Joshua D. Brown died while driving his Tesla Model S in self-driving mode. Initial reports indicate that the car's cameras could not distinguish the white side of a turning tractor-trailer rig from the sky, or may have identified it as an overhead sign, so the car's brakes were not activated. The National Highway Transportation Safety Administration has launched an investigation.

The crash has called attention to what those working on human-machine interaction already know: Much more work needs to be done to line up human expectations with fast-evolving robotic capabilities. The study of how to optimize human-robot interaction, or HRI, is a central challenge now facing both robot designers and users.

The Perception Problem

Perceptions, both human and robot, are at the heart of the HRI challenge. On the human side, says Sanjiv Singh, a research professor at Carnegie Mellon University's Robotics Institute and CEO of drone startup Near Earth Autonomy, is a gap between the perceived abilities of robots like self-driving cars and their actual capabilities. "One of the dangers of automation," says Singh, "is that people sometimes ascribe more intelligence to the automation than is really there." And that can get people into trouble.

Singh cites a case where sponsors of an experimental autonomous lawn mower visited his lab at Carnegie Mellon to see a demonstration. After a few minutes of watching the mower, the sponsors grew comfortable enough with it to stop paying attention, even turning their backs to the golf-cart-size machine and its whirling blades as they excitedly discussed its potential. "We had to tell them," recalls Singh, "this is a piece of heavy machinery that's operating within feet of you. It could have an error." The tendency is for humans to get too relaxed too quickly around potentially dangerous robots if they



With self-driving cars, drivers can gather analytics about their route and conditions. *Image courtesy of Tesla.*

initially appear competent, which is something that Singh himself experienced while riding in an experimental autonomous car created by Google.

The limitation of software controlling autonomous vehicles, says Singh, is that although it may perform well in predictable conditions, it may not react so predictably — or at all — in unforeseen circumstances. For that reason a human has to keep a close watch and be ready to take over. And for a driver lulled into complacency, reaction may come too late to avoid an accident.

Thomas Sheridan, a professor emeritus of mechanical engineering at MIT, has studied human factors and HRI in a career going back to the 1950s, when he worked on airplane cockpit design in the U.S. Air Force. He cites studies showing that humans do not in fact react quickly enough to take over from misbehaving robots to prevent problems from occurring. "If there's too little to do, a person just loses interest," he says. This means human intervention won't occur until it's too late. "Keeping the human in the loop if the human's got nothing to do is a virtual impossibility."

Then, too, there is the problem of robot perception. "Right now we're using lidar, cameras, radar. These are the three sensing modalities that are most in use," explains Singh. All three are susceptible to errors caused by environmental changes. "A puddle on a road can create a complete black hole for a vehicle that's driving using lidar," for example, says Singh. "Water absorbs lidar and you will get no returns back from a puddle."

Moving Toward Solutions

Sheridan suggests task sharing as a good principle for human-robot interaction because it keeps humans in the loop and interested enough in the task at hand to be ready to take control if necessary. Rather than take over completely, says Sheridan by way of example, "a smart cruise control very precisely takes care of the longitudinal control for you while you steer."

Another advantage of task sharing, besides increased safety, is that it allows robotics developers to test their systems in the real world with fewer negative consequences. "It's a good way to mature the technology because you get to learn over long periods of time what the failure modes are," says Singh of systems that assist with the task of driving without taking control. "You can get started without actually having 100% reliability."

Overall, says Sheridan, more research is needed to learn not only how robots behave, but how people interact with them as well. As he puts in in his paper, *Human-Robot Interaction: Status and Challenges*, "With regard to mental models, that is, what operators are thinking, what they know, whether they misunderstand, and so on, research is critical as systems get more complex and the stakes get higher."

In the meantime, better catch up on your reading after you get home.

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

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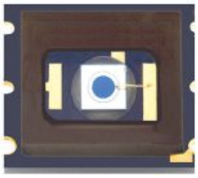
SPECIFY & APPLY

NEW SENSORS



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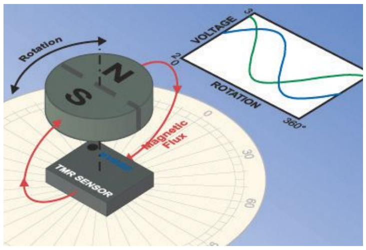

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1 First Sensor Announces Series 9.5 APDs

The new Series 9.5 avalanche photodiodes from First Sensor feature an increased sensitivity in the near infrared (NIR) wavelength range up to 950 nm. Due to their fast rise time and very low dark current, the company says the photodiodes are ideal for applications with low light intensities and high modulation frequencies such as laser range-finding and laser scanning. The slow increase of the amplification with the applied reverse bias voltage of the Series 9.5 allows for easy and precise adjustments of high gain factors, the company states.

The Series 9.5 APDs from First Sensor provide a quantum efficiency of more than 80% in the 730 to 930 nm range and have the option of equipping different band-pass filters, a press release states.

First-Sensor.com

MEMSIC Introduces New Acceleration Components

The MEMSIC portfolio has four new sensors: the MXD6240 and 41AU, and the MXC6244AU and MXC6245XU. These new sensors provide tip-over and acceleration sensing in a range of automotive, industrial and consumer applications, such as motorcycle and off-road vehicle tip-over detection, vehicle navigation and Digital SLR camera horizontal position detection, the company states.

The 624x family offers a range of functionality, features and performance to serve the diverse needs of different applications. The fully autonomous MXD6240/41 eliminate the need for a micro controller and can replace older mechanical pendulum solutions in motorcycles and off-road vehicles.

MEMSIC.com

2 NVE Ultralow-Power Angle Sensor

The AAT009 has six megohm device resistance for low power consumption, and can run years on a single button cell or on scant harvested power, according to NVE. Harvested power can be intermittent, and AAT-Series sensors are designed to detect and maintain absolute position information, and immediately power up in the correct position after power is restored.

According to the company press, AAT-Series sensors use Tunneling Magnetoresistance (TMR) elements for large signals and low power consumption. Also known as Spin-Dependent Tunneling (SDT), Magnetic Tunnel Junction (MTJ) or Tunneling Magnetic Junction (TMJ), it is a spintronic quantum effect that produces a dramatic resistance change in a normally insulating layer, depending on the magnetic field and thus the predominant electron spin in a free layer.

NVE.com

Hoffmann + Krippner Announce Printed Polymer Strain Gage

Hoffmann + Krippner is now shipping its new P-DMS Polymer Strain Gage. The solution is based on sensor paste technology on a PCB (printed circuit board) and is for measuring pressure.

Requiring no moving parts, the P-DMS can be accurate and long lasting, the company states. As the strain gage can be directly printed on the application's control board, it does not need to be connected by wires. This enables compact and affordable designs, as well as eliminating the failure points of wire failure and corrosion. It also eliminates electrical sparking as the key contacts come together.

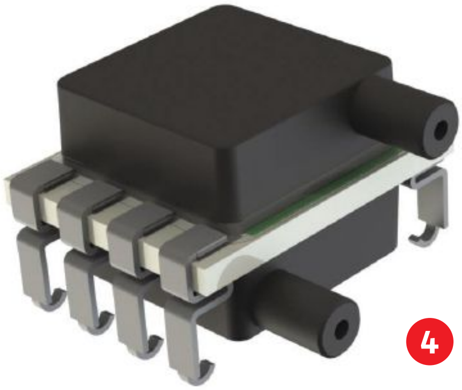
According to a press release, it is available in a variety of customized sizes and shapes.

Hoffmann-Krippner.com

3 New ToF Sensor Boosts Range and Speed

STMicroelectronics' VL-53L0X extends the ToF measurement range to 2 meters, and is accurate to within ±3%. It is also faster, measuring the distance in under 30ms, and highly energy-efficient, consuming 20mW in active ranging mode and drawing 5µA in standby. At 2.4x4.4x1 mm, it is also the smallest such device in the market, the company states.

Unlike conventional infrared proximity sensors, the VL53L0X gives accurate distance measurement in millimeters, and is reportedly unaffected by the color or reflectivity of the sensed target. Its fast-acting FlightSense technology, known from the laser-assisted camera auto-focus featured in several smartphones from top brands, can also distinguish



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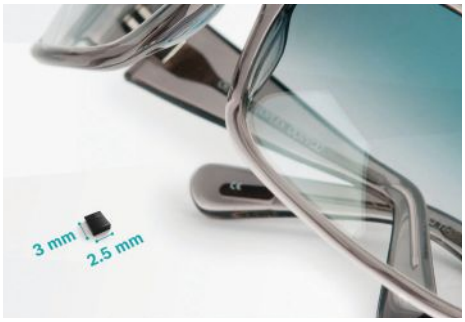

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movement toward or away from the sensor or from side to side. Distance is calculated internally and communicated over I2C thereby minimizing demands on the system host controller.
ST.com

Glucose Sensor Receives CE Mark
Maryland-based Senseonics received the CE Mark approval for its Eversense Continuous Glucose Monitoring (CGM) System, featuring an implanted glucose sensor that lasts up to 90 days.

The IDT sensing solution incorporates an LED driver, temperature sensor, photodiodes and other components in a compact package to drive glucose measurements, which are wirelessly communicated to an on-body wearable transmitter.

In developing the semiconductor for Senseonics, IDT engineers selected a technology usually used for hearing aids that can be operated at a voltage as low as 0.85 V.

"Senseonics' use of our novel technology to develop its Eversense CGM system is a great example of how miniaturized advanced electronics are contributing to improvements in medical care," said Uwe Guenther, director of Mobile Sensing at IDT.
IDT.com

4 Merit Sensor Systems' Low Pressure Family
The new LP Series pressure sensor assembly is a surface mountable (SMT), eight-pin design available in both uncompensated and compensated output configurations. The compensated LP Series versions include both high accuracy analog and digital ratiometric signal output options with each compensated option providing full compensation for offset, temperature and span variability. It can meet pressure monitoring requirements within a range as low as 4 in. H_2O.

"We are excited to add the LP Series family of ultra-low pressure sensor packages to our pressure sensor portfolio," said Rick Russell, president of Merit Sensor. "Last year we introduced the TR Series sensor solution to address a market need for harsh media pressure monitoring, and today we are adding ultra-low pressure sensing capability to our portfolio. We expect this product will give application and system engineers new levels of accuracy and pressure monitoring performance."
MeritSensor.com

Sensirion Launches Digital Humidity Sensor
The SHTW2 ultra-small humidity sensor comes in a flip-chip package and has a footprint of 1.3×0.7×0.5 mm. This makes it suitable for applications in the tightest space constraints, the company states.

The SHTW2 is based on Sensirion's CMOSens technology, which offers a sensor system on a single chip with a digital I 2 C interface. The sensor is fully calibrated and covers a humidity measurement range of 0 to 100% RH and a temperature measurement range of -30 to 100°C, with a typical accuracy of ± 3% RH and ±0.4°C. The operation voltage of 1.8 V and the low power consumption make the SHTW2 suited for integration in consumer electronics that run on tight power budgets, such as mobile phones, wearables and Internet of Things (IoT) applications.
Sensirion.com

5 Bosch Sensortec's 9-Axis Motion Sensor
The BMX160 is housed in a 2.5x3.0x0.95 mm3 package, making it the smallest 9-axis motion sensor in the industry, the company states. It is suited for applications such as smartphones, fitness trackers, virtual reality devices and smart jewelry.

By combining Bosch Sensortec's accelerometer, gyroscope and geomagnetic sensor technologies, the BMX160 is able to meet the more stringent low-power requirements demanded by wearable devices, according to a press release. The device reduces power consumption below 1.5 milliampere.

The accelerometer, gyroscope and magnetic technology in the BMX160 have been optimized for low offset, low noise and temperature stability.

"This device finally overcomes today's placement constraints in smartphones and directly addresses the demands of wearable devices, where PCB space and low power consumption are at an even greater premium," said Jeanne Forget, VP marketing, Bosch Sensortec.
Bosch-Sensortec.com

Flexible Assistance Without a Safety Fence

Siemens relies on a flexible KUKA cell for human-robot collaboration in electric motor production.

The motion control business unit of the Siemens Digital Factory (DF) division, with its headquarters in Erlangen, specializes in producing high-performance motors, inverters and controllers. With an extensive range of comprehensively integrated hardware and software as well as technology-based services, the DF division helps production companies all over the world boost the flexibility and efficiency of their manufacturing processes, and bring new products to market faster.

In the town of Bad Neustadt an der Saale, Siemens operates a lead factory for electric motors. There, among other items, the drives for numerous KUKA robots are produced. With the expertise derived from hundreds of thousands of electric motors and employing about 1,700 people, the lead factory is an innovative example for electronics with the "made in Germany" cachet.

For its stator manufacturing operation, the company was on the lookout for a flexible solution to automate the activity of passing on and positioning workpieces that had previously been done by hand — while retaining the high quality and continuous, barrier-free access to the working area for people. Together with the Augsburg-based company, KUKA Systems GmbH, and its Advanced Technology Solutions department, a flexible cell was developed for this application using KUKA's LBR iiwa lightweight robot. Its sensitive capabilities make this robot weighing less than 30 kg ideal for human-machine collaboration. With its seven axes, it is not only more agile and more mobile than most models of its kind, it also features torque sensors in all axes — as a result it can also detect obstacles and respond accordingly.

The "Knight concept" allows KUKA's robots to be implemented or removed as needed. *Image courtesy of KUKA.*

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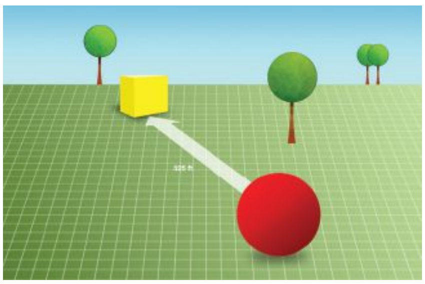
Phone-Based Laser Rangefinder Works Outdoors

Depth sensor built from off-the-shelf parts filters out ambient infrared light.

By Larry Hardesty

The Microsoft Kinect was a boon to robotics researchers. The cheap, off-the-shelf depth sensor allowed them to quickly and cost-effectively prototype innovative systems that enable robots to map, interpret and navigate their environments.



CSAIL researchers are presenting a new infrared depth-sensing system built from off-the-shelf components, that works outdoors as well as in. *Illustration courtesy of Christine Daniloff/MIT.*

But sensors like the Kinect, which use infrared light to gauge depth, are easily confused by ambient infrared light. Even indoors, they tend to require low-light conditions, and outdoors, they're hopeless.

At the International Conference on Robotics and Automation in May, researchers from MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) presented a new infrared depth-sensing system, built from a smartphone with a $10 laser attached to it that works outdoors and indoors.

The researchers envision that cellphones with cheap, built-in infrared lasers could be snapped into personal vehicles, such as golf carts or wheelchairs, to help render them autonomous. A version of the system could also be built into small autonomous robots, like the package-delivery drones proposed by Amazon, whose wide deployment in unpredictable environments would prohibit the use of expensive laser rangefinders.

"My group has been strongly pushing for a device-centric approach to smarter cities, vs. today's largely vehicle-centric or infrastructure-centric approach," says Li-Shiuan Peh, a professor of electrical engineering and computer science, whose group developed the system. "This is because phones have a more rapid upgrade-and-replacement cycle than vehicles."

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IoT Security: Smart Measures for Smart Devices

Early integration and testing is key for safer products.

BY JIM ROMEO

In 2015, hackers were able to tap into and kill the transmission of a 2014 Jeep Cherokee as it drove down a highway in St. Louis. The Internet of Things (IoT) allows many features and advantages. Its incorporation into sophisticated designs can achieve remarkable outcomes. However, IoT security presents a concern for the entire design team and all the stakeholders with whom they interact.

More and more engineering designs will incorporate IoT, however, the devices that are part of the design process may be the source of the risk. Katie Curtin, lead product marketing manager for Security Solutions at AT&T, cites AT&T's Cybersecurity Insights report *What Every CEO Needs to Know About Cybersecurity*. The report forecasts that 50 billion devices will connect to networks by 2020.

Vulnerability Scans of IoT Devices Increase

"The issue is that hackers are seeing this too," says Curtin. "Over the past two years, our Security Operations Center has logged a 458% increase in vulnerability scans of IoT devices."

The increase may be due in part to devices within the network not always having proper security measures set forth early. "We found that only 10% of organizations are confident that the devices on their network are secure," she says. "This underscores the importance of working to provide security in every device because of a breach's financial and reputation cost. Finding ways to help secure these new devices and the associated data is vital to managing security threats going forward. Since every new device creates a new entry point into the network — it is more important than ever to help make these endpoints highly secure."

Given the history of high-profile breaches, security is top of mind for consumers and needs to be a top priority for the companies building connected products. "In order for connected products — and the IoT overall — to succeed, security must be a key consideration in the design phase and built in from the get-go," says Calum Barnes, senior manager, IoT Products & Strategy, Xively by LogMeIn in Boston. "On average, companies building connected products spend almost 20% of their design effort on data and device security."

Incorporating security, however, is not so easy. Jeff Shiner, director of IoT Solutions, Micron Technology, says that when implementing IoT into design, security is one of the most difficult burdens for engineers to tackle. "This is primarily due to the fact that critical security elements on clients or nodes aren't currently native to these platforms and in most cases can be very costly to implement due to both the software and hardware elements required. In addition to the complexity of redesign, the approach can be fairly fragmented between different software and hardware vendors," he says.

"This, in turn, can translate into a long investigation cycle followed by a costly design cycle based on each organizations specific security needs," Shiner continues.

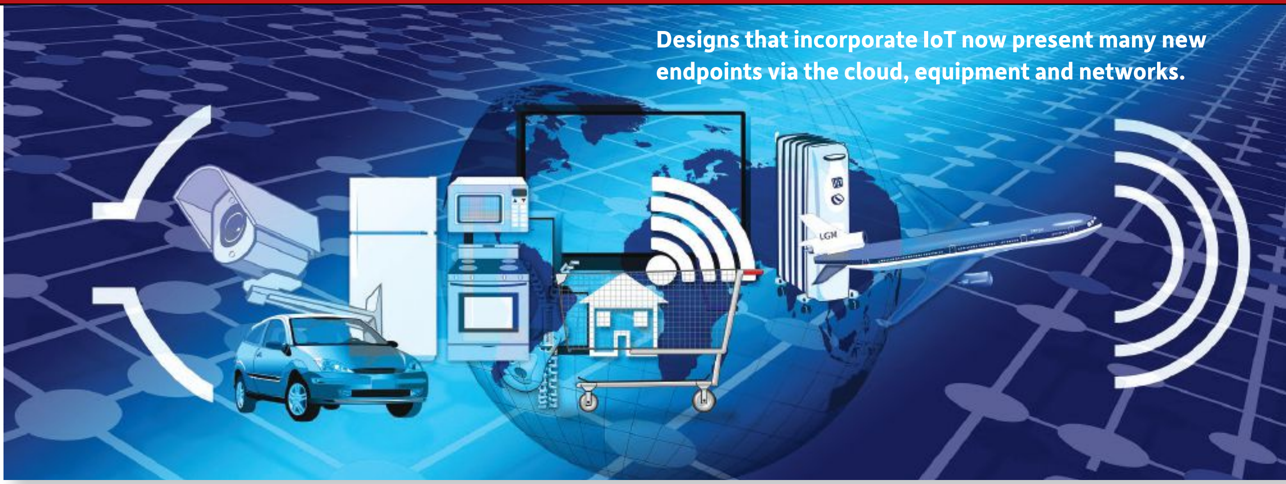
Implementation Strategy

Responsibilities within the design team will vary among entities. However, the roles of everyone, with respect to IoT security, must be clarified.

Barnes says that chief architects and security engineers are typically responsible for the end state of the security of the product. However, he emphasizes that to be successful, companies need to make security part of the overall product development process and have every developer take responsibility for building and delivering a secure solution. He cites Microsoft's popular Security Development Lifecycle method (microsoft.com/en-us/sdl) for constant evaluation of security posture during development as a great way to do this.

"With the awareness created by automotive, retail, industrial and medical breaches, organizations today are taking a more holistic view of how to properly implement security in a way that balances cost vs. risk," adds Shiner. "It typically starts at the CISO (chief information security officer) level and then trickles down into initiatives driven by individual engineering teams. More and more we are seeing the evolution of security taskforces or even formalized groups within these corporations to align software and hardware efforts to achieve the highest level implementation strategy."

There may not be one ideal time for IoT security concerns to be addressed. Smart designers will be vigilant early



Designs that incorporate IoT now present many new endpoints via the cloud, equipment and networks.

and flexible throughout the design cycle to ensure that any incorporation of IoT is swiftly addressed and met with proper security measures.

"It is crucial that security is addressed at every stage of design and development of an IoT system," says Barnes. "Product design engineers need to be constantly aware of security considerations when working with their engineers. However, it is even more important that product designers are aware of the security implications of third-party software being used in the system."

Joel Scambray, a principal IT security evangelist at Cigital, says security should be implemented "early and often."

He adds that it behooves engineers to consider security at the earliest phases of development, particularly in the design phase. There are already recognized practices around secure design, including processes like threat modeling that can help engineering teams clarify their designs to mitigate relevant risks, instead of just throwing in catch-all security controls.

"Another good resource for secure design is the IEEE Center for Secure Design, which has gathered some prominent organizations to collect data about and promote secure design principles," Scambray adds. "Beyond the design phase, it's important to integrate security into all the other key 'touch points' along the development lifecycle. Some of the most recognized touch points include secure code review and static analysis after code completion milestones, and penetration testing during the QA phase, and ideally again before release to production."

Be Prepared

Kurt Kokko, chief technology officer of Signal Sense, an IT security firm located in Seattle, cautions that you should not wait to instill security into your IoT designs. He says that engineering teams should be thinking of security throughout the design process but must be aware that breaches can happen at any time — including now.

"Fortunately, machine learning and neural networks are extremely good at monitoring IoT environments full of small, predictable, controller-based devices — just learning behavioral norms and noting deviations, all day, every day," says Kokko. "A network-centric approach to security that's powered by machine learning is very well-suited to keeping IoT devices from becoming a jumping-off pad for malicious behavior."

Barns points out that physical security is one of the hardest problems to solve in IoT. Product designers must use a measured approach and ensure there is just the right amount of security. If someone can break open their product and compromise just their own device, that's an acceptable level of risk for many OEMs (original equipment manufacturers). "If somebody can crack open a device and compromise every device, that's a major problem," he says. "It's all about setting what levels of risk you can accept as a business, and sticking to that no matter what."

If IoT security is properly accommodated and addressed, it opens up new avenues for designs of today and tomorrow. The data and information that IoT endpoints allow will change the impact that decision makers will have in utilizing such data.

According to Shiner, when analyzing your cybersecurity exposure, the most effective way to protect against a breach is to leverage hardware roots of trust. Use such roots as your base anchor within endpoints.

"If done correctly, this can make a system nearly impenetrable," says Shiner. "The most common belief among security professionals is that even their best security will be hacked. With this belief, the approach is different than just picking a solution. The solution in this case is multiple layers of security. As cybercrime evolves and new technology emerges to aide in these efforts, multiple hardware roots of trust provide the true in-depth defense needed to make the cost of the attack the deterrent." DE

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

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→ **Micron Technology:** MicronTechnology.com

→ **Signal Sense:** SignalSense.com

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Editor's Picks

by Anthony J. Lockwood

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

HP Refreshes Workstation Portfolio

The company's Z series offerings include the latest Intel processors.

The HP Z840, Z640 and Z440 now all feature Intel's next generation multi-core Xeon E5 series processors, and can be equipped with the newest AMD FirePro and NVIDIA Quadro graphics accelerators. All sorts of additional memory and storage options are available. And there's lots of room and connectivity for expansion.

One interesting tidbit here is that they can also be outfitted with HP's new, second-generation Z Turbo Drive G2. This SSD (solid-state drive) offers 1TB storage capacity, and HP says it has four times the read performance of traditional SSDs. It is also available in 256GB and 512GB capacities.

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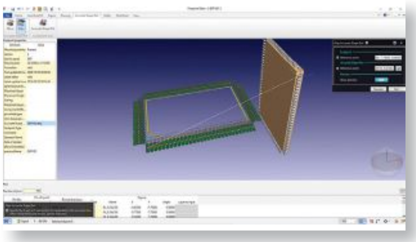

Zuken Launches CR-8000 2016

Concurrent multi-area PCB design capabilities are now integrated.

CR-8000 has the tools to optimize a design at both the product and PCB design level. Its all-in-one design process encompasses 2D/3D multi-board design and implementation, FPGA (field programmable gate array) I/O optimization and chip, package and board co-design as well as 3D MCAD integration.

The 2016 edition of CR-8000 has many cool enhancements, chief of which is concurrent multi-area PCB design. The gist here is that on-site or disbursed engineering teams can simultaneously work on and modify the same area of a design. Part sawpping has also been enhanced.

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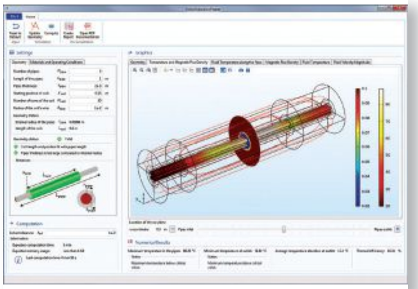

COMSOL Updates Multiphysics Suite

Version 5.2a of the software is focused on performance and productivity.

COMSOL Multiphysics 5.2a has three new solvers, all of which sound fast and memory efficient. First is SA-AMG (smoothed aggregation algebraic multigrid) for linear elastic and other analyses. Next is a domain decomposition solver for handling large multiphysics models. Finally, there's a new explicit solver for acoustics simulations.

Other enhancements introduced in version 5.2a include magnetic vector hysteresis for modeling transformers and ferromagnetic materials in the AC/DC module; and domain terminal boundary conditions for easier simulation of touchscreens and MEMS devices.

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Arena PLM Summer 2016 Now Available

A new Training Management module for Arena QMS has been added.

Arena already provides the ability to combine PLM and QMS in a single platform. The new Training Management module in this release automates, simplifies and brings training management and its components into that single platform.

The short of it is that all your employee training records — plans, history, electronic signatures — are tracked, securely stored, fully traceable and auditable.

All this data is maintained in context, easily accessible and ready for you to demonstrate to some auditor that your operations comply with your industry's regulatory requirements.

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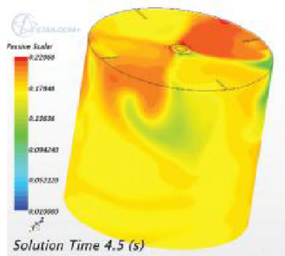
STAR-CCM+ Keeps Pierre Guerin on a Competitive Edge

CFD simulations provide a robust tool for modeling systems and manufactured equipment.

BY NICHOLAS CHASTAN



Like many successful entrepreneurs, Pierre Guerin founded a small family business of five employees for agricultural and dairy maintenance equipment in 1949. It took decades of evolution of products, brands, contributions and innovations to turn his startup into a successful corporation, which is now recognized as the major European supplier of stainless steel process mixing vessels for the chemical/food/beverage and pharmaceutical industries. For these industries, mixing is a key unit operation as the quality of products is highly dependent on how effectively and efficiently the components with different properties mix with each other to reach a uniform blend with desired attributes.

For Pierre Guerin to maintain its competitive advantage, it is crucial that it designs and manufactures equipment that guarantees the highest level of mixing quality while keeping operational time and cost low for its customers. A traditional scale-up approach from lab scale to production has never been an easy task. It involves time consuming and expensive experimentations to test and verify new ideas during the design process.

Computational fluid dynamics (CFD) simulations provide a robust tool for modeling the system in actual plant scale that also captures all key physics and required quantities in continuum space, explore the design space faster, and hence reduce the number of trials required for optimization of a stirred tank. In this way, engineers are able to submit only the most promising design to physical testing. In mixing vessel applications, some of the main targeted characteristics are the pumping number, the power number and the mixing time. To select the most efficient CFD tool to predict these numbers, mixing engineers at Pierre Guerin conducted validation studies using several CFD software tools, including STAR-CCM+.

STAR-CCM+ can be used to model different types of impeller/vessels manufactured by Pierre Guerin. In this study, the geometry is composed of a flat bottom vessel with four baffles, and a Pierre Guerin HTPG4 impeller. Vessel geometry and baffles were created using STAR-CCM+'s 3D-CAD modeler, and the impeller was extracted from a neutral CAD file format using the STAR-CCM+ surface wrapping functionality.

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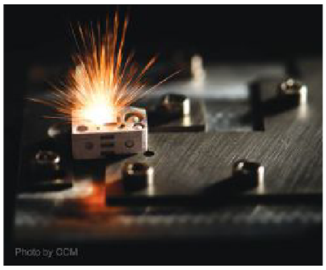
Validating a High-Performance Manufacturing Line

CADfix supports additive manufacturing processes for mass production of 3D-printed parts.

The goal of the Hyproline initiative is to design, implement and validate a flexible, high-performance additive manufacturing line for serial fabrication of customized high-quality metal parts. The initiative combines innovative component technologies for net shape manufacture, direct write structuring, inspection and intelligent automation. It began as a result of an EU FP7 Factories of the Future Program grant.

Hyproline endeavored to develop production lines designed to produce multiple, unique parts, while simultaneously adapting to the specific requirements of a given component on the same line. The solution featured an innovative combination of additive manufacturing and laser-based structuring, coupled with integrated process monitoring and metrology systems. The results were successful.



Program researchers focused on three metals: stainless steel 316L, titanium and copper, and on the serial production of customized parts in the order of 10mm with a goal of 10,000 parts a day.

One of the biggest challenges researchers faced was how to increase the quality of 3D printed metallic parts. ITI's CADfix contributed to the solution through improved slice generation from CAD and the processing of inline 3D scanning and laser ablation with real-time point cloud capture and 3D comparison.

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Commentary  by Monica Schnitger

Managing CAE from Black Box to Full Fidelity

Product design is often pictured as a linear process from first idea to detailed manufacturing instructions. In reality, it's a series of loops and false starts as the design team searches for and finds the best way forward.

One way that design teams are course-correcting is by using simulation, aka computer-aided engineering (CAE), during preliminary design. This helps discover good alternatives and sets the stage for targeted, detailed design. That's using CAE for innovation as well as validation and risk mitigation, to gain a deep understanding of the product. You'll learn how each design option influences the product's operation and be able to make decisions early, before change becomes too expensive.

If you're simulating that early and often, you're likely generating vast amounts of data — models, loads, material options,

> **How can you make the most of simulation data?**

outputs, visualizations and animations — that you somehow need to manage. Looked at one way, this becomes yet another pile of paper or bits to keep track of until the project ends, and then never referred to again. But looked at with a different lens, this is a huge intellectual property asset. The thought process behind each design and the analyses that led to decisions can help inform future designs. How can you make the most of that value?

In the early stages, simulations will have the lowest fidelity that can yield a meaningful result. You'll likely use black boxes as placeholders until you have more info. As more details about the system are known, the simulation fidelity improves. Eventually, you'll run component-level simulations to ensure each design element meets its requirements, as well as simulating the whole assembly. Keeping track of what was known and what was assumed at each stage isn't easy, but it is crucial if the team needs to backtrack during a design, or wants to jumpstart the next version.

Mining for Gold

All of that information is incredibly valuable, but only if you can find it. Many teams just print out reports summarizing the results of the simulations for their files. That's a time-honored approach, but imagine staring at a wall of filing cabinets, hoping to strike gold. Now consider having that information organized, with pointers to the gold nugget — a much more comfortable situation, no?

Others use some sort of digital filing system. Perhaps a shared drive for archiving — or a PDM/PLM system that can associate models, input and output decks, animations and other information. But there's another choice. Simulation data management (SDM) tools are purpose-built to manage simulation-related processes, models, documents and outputs. Some can also manage test data for correlations.

SDM FYI

Purpose-built SDM tools often run in the background, capturing data associated with every step in the simulation process. This makes sure everything is done to procedure and that it can be repeated from one design iteration to the next. That traceability can be very important as team members collaborate on designs and need to refer to other versions of the same concept. Some SDMs also enable automation to make it easier to import models and assemblies, create input decks, post-process and create reports.

If you're investing in simulation, consider using a digital solution to manage your workflow. There's too much value in knowing what worked and what didn't to file it away in paper form. Consider the metadata you use when you archive your projects, so that they can be searched and retrieved for future projects. Try to capture both the process and the inputs and outputs — you want to be sure that the next simulation is run the same way, so that the results are comparable. The correct setup will allow you to backtrack for internal traceability and regulatory compliance.

Adherence to procedures is important, but perhaps the biggest benefit of an SDM is that it jumpstarts future innovation. If you can refer back to other projects, you have access to their simulation plans and processes, what was tried and what succeeded. That enables you to make better and faster decisions because you'll be able to quickly reject alternatives that are proven to be unworkable — as well as areas of further exploration.

You simulate your product's performance to make sure it is reliable, safe and fit for purpose. Managing the data asset that you create along the way is just as important for your business. **DE**

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