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December 2015 / deskeng.com

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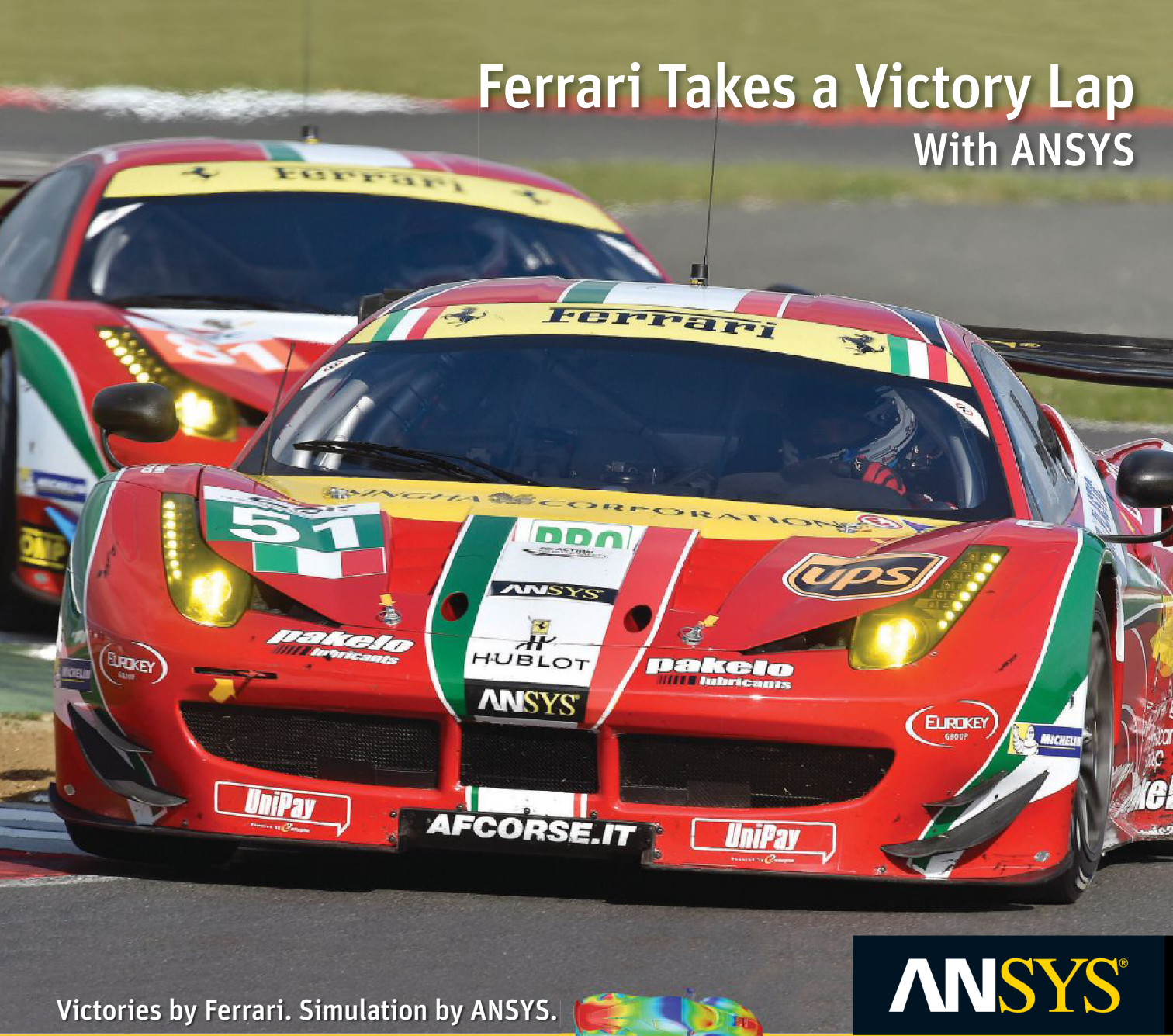

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by Jamie J. Gooch

Optimal Design Challenges

Engineer and author Henry Petroski once wrote: "Successful design is not the achievement of perfection but the minimization and accommodation of imperfection." I like that. It rings true with a practicality missing in "the relentless pursuit of perfection" mantras you hear in commercials.

A successful design is the optimal design for a given set of constraints and requirements. Among those constraints are often time and money. In fact, when asked to rank challenges to their day-to-day workflow, the nearly 900 *DE* readers who responded to our 2015 Reader Profile survey chose "short development deadlines" and "inadequate budgets" at their second- and third-most "extremely important" challenges. That's why bringing more technology to bear sooner in the design cycle is so critical. Simulation, optimization and real-time rendering — all accelerated by increasingly powerful computing — pays dividends in time and cost savings when they're performed early and often. Likewise, 3D printing for prototyping and — under increasingly expanding circumstances — end use parts, removes time and cost from product development, testing and manufacturing.

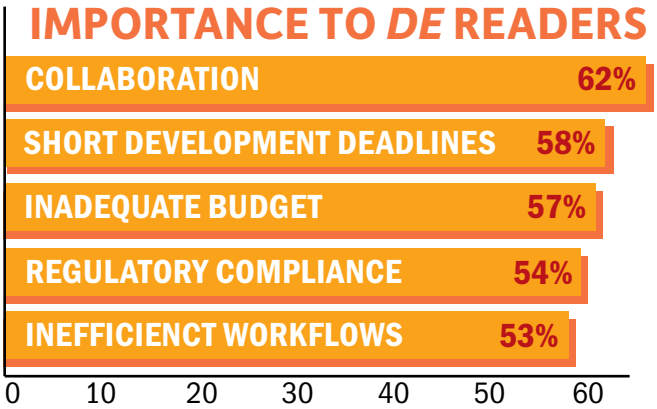
A successful design is the optimal design for a given set of constraints and requirements.

But, perhaps surprisingly, collaboration ranked a bit higher than challenges associated with time and budgets on our readership survey. Plus, "inefficient workflows," a challenge that combines both time and collaboration issues, moved into the top five "extremely important" challenge rankings.

Collaboration a Cause for Concern

As products become more complex and connected, designers, mechanical engineers, electrical engineers and software developers — who are often dispersed across the globe — need to work together more closely than ever to quickly get optimal products manufactured and to market. It's the market that ultimately determines whether a product is successful, so executives and marketing colleagues need to be brought into the product development cycle as early as possible to ensure all your design and engineering efforts aren't for not. And those go-to-market decisions are influenced by consumers' ever-changing wants and needs, which makes collecting, filtering, analyzing and incorporating usage data back into a design a top priority. That data can also be used to alert engineers to service records and part failures that can point toward design improvements.

The flow of information around the product development cycle and up and down the supply chain has been the subject of many nice flowcharts, but in the real world it's not so neatly done. Creating a product development platform or system that reaches across disciplines and industries, and integrates with other information management systems to keep everyone properly informed is no small feat. Just sifting through the data — especially the increased amount of data expected to come from the Internet of Things and Industrial Internet in the near future — is a daunting challenge.



***DE's* 2015 Reader Profile survey revealed the importance of collaboration, with 62% of respondents ranking it as extremely important to their day-to-day work.**

Optimal Design Technology Outlook

This year-end edition of *DE* addresses what we see as some of the top challenges facing design engineers in 2016, including expanding the use of optimization technologies, attempts to structure an approach to collaboration, combining real-world data with digital design processes, designing products for the Industrial Internet and consumer IoT, using 3D printing to achieve more design freedom, and more. These aren't far-off, future technologies; they're being used today.

As the philosopher Jeremy Bentham put it: "The age we live in is a busy age; in which knowledge is rapidly advancing towards perfection." That seems like an apt description of today's product development cycle, but he wrote that in 1776. It was, and is, a busy age, but our knowledge is still short of perfection. Until then, we can use technology to minimize and accommodate imperfection to create optimal designs. DE

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

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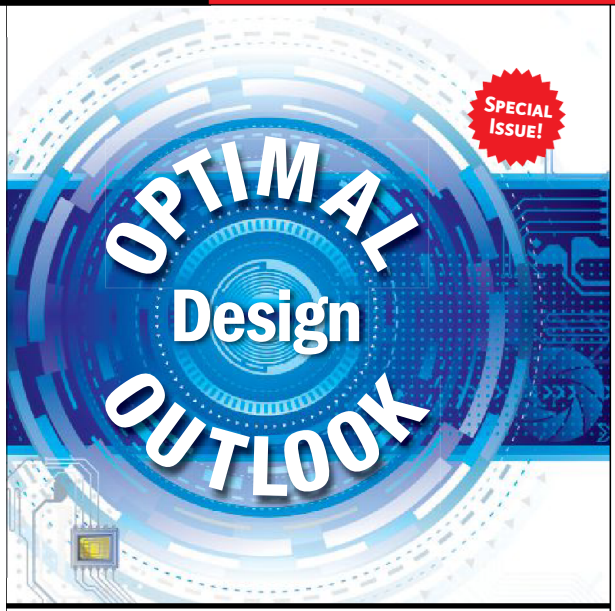

FOCUS ON OPTIMAL DESIGN

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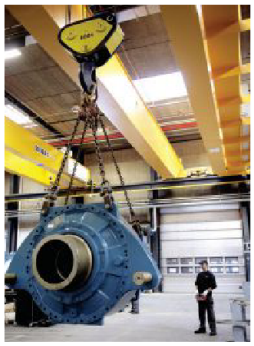

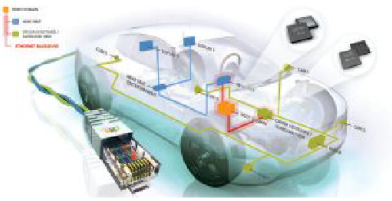

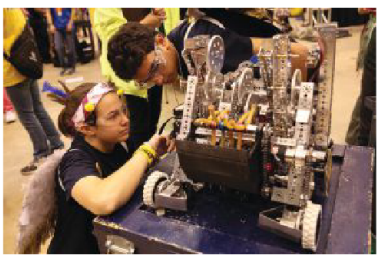

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BPA WORLDWIDE

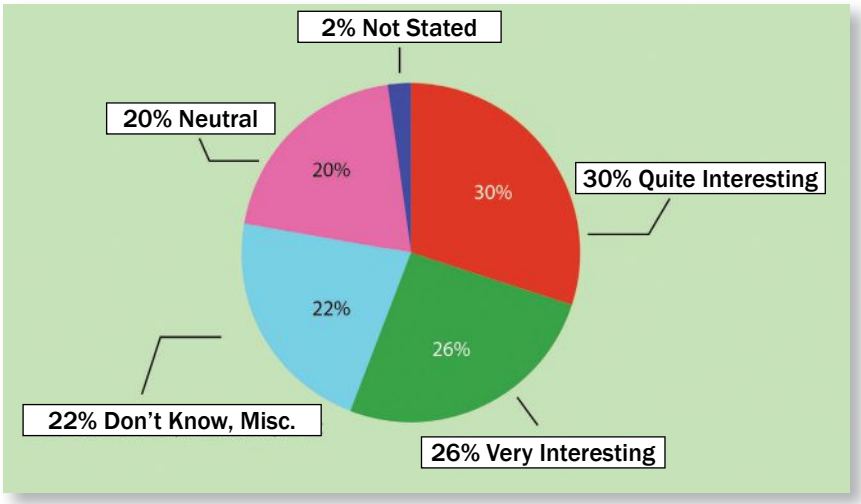
by Kenneth Wong & Beth Stackpole

Courting the Dedicated Workstation Users

The devout workstation users are the last stronghold that virtualization vendors have been trying to breach. Others — general consumers, knowledge workers and enterprise software users — have already embraced the freedom that comes with mobile devices and tablet clients. But the workstation crowd is different.

At October's Jon Peddie Research (JPR) Virtualize Conference, in a session devoted to "Best Practices for Large and Small Companies," Gary Radburn, Director of Workstation Virtualization at Dell, observed, "[Workstation users] are very proud of their workstations. A workstation-using engineer feels valued by the size of the box, the memory and the GPU (graphics processing unit) in it. If you change that with a thin client without telling them, they'd probably be upset."

The success of the campaign, as it turned out, depends as much on psychology as it does on technology. "Involve the users from day one. Don't suddenly go in there and, thinking you're doing them a favor, replace what's on their desk [with a thin client device]. You're trying to increase productivity, not to destroy their morale," Radburn said.



Interest in access to an office workstation on the road, as indicated by survey results from JPR, published in "Virtualization and Remote Graphics," a special report on the users and potential users of virtualized systems. ***Image courtesy of Jon Peddie Research.***

Virtualization Knowledge

JPR recently published "Virtualization and Remote Graphics: A Special Report on the Users and Potential Users of Virtualized Systems," based on survey responses from 350 participants. The goal, JPR states, is "to determine if the [senior] managers knew about virtualization, had tried it, or were planning to try it."

Remote graphics — graphics features generally available in physical GPUs made available remotely to virtual machines — is a critical issue in virtualization adoption among design and engineering software users who rely on digital prototypes to make critical decisions. If the quality of the visuals on virtual machines is not comparable to what the users are accustomed to on physical workstations, they'll most likely reject virtualization as a poor substitute for real workstations.

Survey responses suggest NVIDIA is leading the awareness campaign. Twenty-five percent say they are aware of the NVIDIA GRID virtualization solution. Fifteen percent are aware of offerings from Citrix, and 9% of those from Intel. More than a third — 33% — indicate they're not aware of any, suggesting providers need to do a better job with outreach and awareness campaigns.

Respondents also give virtualization vendors some encouraging signs. More than 70% think remote access to their office workstation from home is quite interesting, and more than 50% think it's very interesting. Similarly, more than 60% say remote access to an office workstation from the road is quite interesting, and more than 50% think it's very interesting. The survey also asks respondents to give a reason if they indicate they're not interested in remote workstation access. "The biggest reason for not adopting virtualization is listed as no productivity gain," according to JPR.

When asked, "If you were to employ remote graphics would it be for all of your applications or just one?" 32% say for all, 27% for one. The remaining 41% say they don't know. But a whopping 52% indicate that they're aware that GPUs could be shared in a virtualized setup — a key benefit of virtualization. An overwhelming 75% believe "there is, or will be a benefit to using a virtualized GPU/workstation."

By and large, IT departments are the gatekeepers that virtualization vendors have to convince. Thirty-one percent of the respondents reveal they'll acquire virtualized systems from their IT. Only 8% say they'll get it directly from the supplier. Only a fraction say they'll turn to systems integrators, VARs (value added resellers) and software providers.

Benchmarking Performance

At the conference, SPEC (Standard Performance Evaluation Corporation) led a panel discussion titled "Benchmarking Virtualized Processors." The session sought to find out the truth in "claims being made about performance," according to the organizers. Many workstation makers regularly cite SPECview-

perf scores as the hallmark of quality in their hardware. As custodians of widely adopted performance benchmarks, SPEC plays a role in establishing a set of fair, reasonable standards for assessing the capacity of virtual machines.

SPEC maintains the SPECvirt benchmark for evaluating virtualized data centers. It measures "the end-to-end performance of all system components including the hardware, virtualization platform, and the virtualized guest operating system and application software," according to SPEC.

"SPECvirt supports hardware virtualization, operating system virtualization, and hardware partitioning schemes. The SPEC workstation benchmark, SPECwpc, also measures virtualization based on specific business and industrial applications, as does SPECviewperf for graphics-intensive applications. The recently introduced SPECjbb2015 also supports performance measurement for virtualized hosts," said Bob Cramblitt, PR spokesperson for SPEC.

Because GPU sharing is one of the economic benefits of virtualization, the latency, interactivity and photorealism associated with virtual machines is expected to be a major factor shaping the user's experience. "No conclusion was reached [by the panelists] other than to acknowledge that this is going to be a thorny and probably contentious issue, but one that has to be dealt with," said Kathleen Maher, vice president of JPR.

Dell's Radburn offers an argument he thinks will persuade the workstation users to relinquish their cherished hardware: "Point outside their window the sales and marketing folks working in coffee shops, fields and beaches, then say, 'Wouldn't you like a slice of that life?'"

"We think that virtualization is the next step, and a very big one towards making the technology invisible. Normal humans were not born to become IT experts when they want to communicate with their friends, do their jobs or create art," said Maher.

— K. Wong

PTC Gets Real With Augmented Reality

In its latest move, PTC signed a definitive agreement to buy the Vuforia augmented reality business for $65 million, including its developer ecosystem, from Qualcomm Connected Experiences Inc., which is a subsidiary of the mobile giant Qualcomm. As it exists today, Vuforia is a mobile vision platform that currently has traction in the consumer world, helping to bring advertisements, toys and household items to life on a smartphone or tablet.

PTC's vision for Vuforia is to bridge the digital and physical worlds, a reality that PTC executives say is increasingly blurring as today's products meld both digital and physical components. "If you look at what's going on in manufacturing companies today, the BOM (bill of materials) is very different than it's historically been, and there's a lot more decisions about what lives in a digital form or what lives in a physical form," says Rob Gremley, executive vice president, Technology Platforms at PTC. "This whole mixed reality of the digital and physical living together has been a big theme of what we're doing."

A Mixed-Reality Model

With the Vuforia augmented reality technology, engineering organizations can gain access to digital information that exists about a product — in particular, the sensor data that depicts what's happening with a product in the field — alongside the physical product. This capability, bolstered with PTC's IoT (Internet of Things) and analytics platforms, unlocks new possibilities for designing products, monitoring and controlling products and facilitating service in the field.

By integrating Vuforia into the ThingWorx IoT platform, PTC plans to facilitate a mixed-reality model that blends the physical and digital worlds.

As an augmented reality technology, Vuforia will help PTC bridge the digital and physical worlds. ***Image courtesy of Vuforia.***

It can be used as a foundation to enable new applications and ways of working for both service and product design. Today, interaction with either the physical product or digital representation of that product is separate, but PTC aims to bring its technology portfolio to bear to deliver a mixed reality experience for interacting with those same representations, said PTC CEO Jim Heppelmann, in a webcast that highlighted PTC's plans for the acquisition.

"When you put augmented reality together with the other critical technologies we've acquired, it represents a new platform for the new reality of physical/digital convergence," he said, adding that PTC has invested over $600 million in the last 24 months to bring that vision to life, through both acquisition and organic development.

Beyond the Vuforia computer vision technology, PTC sees opportunity in the company's global developer ecosystem, currently the source for 20,000 augmented reality applications, representing about 76% of that market, Heppelmann said. "Vuforia is a gem that needs to be unlocked and exposed to a broader audience, and that's something PTC is in a position to do," he said.

— B. Stackpole

MBD Energizes Wave Farm

When you're designing something as groundbreaking and massive as the world's first and only operating wave farm, building a physical prototype is out of the question for a whole multitude of reasons, not the least of which is cost and scale.

That's the situation Carnegie Wave Energy faced during the design of CETO 5, technology that generates power from ocean swells using submerged buoys. CETO 5 is a cornerstone of the Perth Wave Energy Project (PWEP), which is currently the world's only operating grid-connected wave energy array. CETO 5 is a multidisciplinary system, converting hydrodynamic forces from the ocean to mechanical energy by the motion of the buoy, then to hydraulic energy through use of a pump, and finally to electrical energy using hydroelectric conversion devices.

Before physically building the CETO 5 system, Carnegie Wave Energy engineers needed insight into multiple variables, including how much load could be placed on the system's mechanical components so they could be sized properly. A design that incorporated components that were too strong or heavy would result in additional costs, while planning the system with less-than-robust components would put it at risk for failure in stormy seas. Building out a scale model of the entire system was not feasible so the team opted for a Model-Based Design (MBD) approach that would support a multidomain system along with simulations to explore a range of configurations, sea conditions, and faults.

Harnessing MathWork's MATLAB and Simulink MBD tools, Carnegie Wave Energy was able to iterate and test virtual prototypes of the CETO 5 design as opposed to building physical prototypes. It allowed the team to demonstrate the ability of a small CETO 5 array to produce and sell power reliably while also verifying the accuracy of the computational CETO system model against the measured project performance, according to Mathieu Cocho, analysis engineer at Carnegie Wave Energy.

Carnegie Wave Energy's CETO unit is the foundation for the grid connected Perth Wave Energy Project. ***Image courtesy of Carnegie Wave Energy.***

— B. Stackpole

Shape Generator Makes its Debut

It's a vision that Autodesk CTO Jeff Kowalski shared a year ago. Inside the Mandalay Bay hotel, speaking to the crowd at Autodesk University 2014, Kowalski said, "[It] starts with your goal. Then it explores all the possible permutations of the solution through successive generations, until the best one is found." That sums up what Autodesk calls "generative design."

A variant of generative design can be seen in Autodesk Within, which automatically generates lattice structures that fit user-defined geometric volumes. Another variant appears in the latest update to Autodesk Inventor as Shape Generator, a topology optimization function embedded in Inventor's CAD modeling environment.

Like Autodesk Within, Shape Generator relies on Autodesk Nastran as its simulation engine to perform stress analysis behind the scenes, then proposes the best — or optimal — geometry for the project.

"What's different about this is, it's integrated into a mainstream CAD platform," says Jonathan den Hartog, an Autodesk product manager for Autodesk Inventor. "Our approach is to put it in CAD so it can benefit the conceptual design phase."

Special software like solidThinking Inspire lets you perform topology optimization. Certain simulation and analysis packages also offer the function. However, it's rarely integrated in general-purpose CAD programs. In that respect, Autodesk Inventor may be breaking new ground with the introduction of Shape Generator. Introducing optimization at the CAD design phase brings the art of lightweighting closer to the conceptual design phase. In the initial incarnation, Shape Generator focuses on "structurally efficient lightweight parts," explains Hartog.

Since Shape Generator is embedded inside Inventor, the user can overlay optimized geometry proposed by the software to the original part, making it easier to identify the regions where further trims and cuts can be made without affecting the part's structural integrity. The way Shape Generator works is consistent with the way you'd use topology optimization in specialized CAE software, but with a simpler interface.

For more information, see page 12.

— K. Wong

Avi Reichental Departs 3D Systems

3D Systems (3DS) has announced the departure of Avi Reichental, who was president, CEO and a director of the company. Reichental's departure comes on the heels of a serious downturn in 3DS' share price, and amid various lawsuits targeting the company, some of which name Reichental directly.

Although it seems likely that a large drop in 3DS' stock share price could have resulted in Reichental's departure, other factors may also have played a role. A group of shareholders expressed their dissatisfaction with 3DS and Reichental's leadership with the launch of a lawsuit in August. The suit claimed that Reichental and other members of 3DS's leadership had overestimated the company's ability to fulfill printer orders, leading to a loss in profits.

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Stratasys Invests in Desktop Metal

Stratasys was recently part of a group of investors backing a new startup called Desktop Metal. The company has $14 million in funding and the stated goal of producing a desktop metal AM system that can run in an office space with no muss or fuss.

Desktop Metal is led by CEO and co-founder Ric Fulop, who has been involved with a number of other companies, including MarkForged, developer of a 3D printer that can produce carbon fiber parts. Fulop said he believes AM is still in its infancy, and that metal AM is one area lacking serious progress that would allow for a wider scale adoption.

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Local Motors Debuts LM3D

Local Motors has been wowing the tech world with its 3D-printed vehicle concepts. It printed an entire Strati at several different conferences over the past two years, and now it's showing off the LM3D Swim vehicle, which was on display at the Specialty Equipment Market Association (SEMA) 2015 show in November.

Unlike the Strati, the LM3D is now undergoing crash testing as part of Local Motors' efforts to create a road-ready 3D-printed car for release in 2017. The estimated retail price for the car will be around $53,000, not including special subsidies for electric vehicles. The design for the LM3D emerged out of the Project REDACTED challenge. Kevin Lo submitted the winning design (which was modified by the Local Motors team), and the first model was produced just a few months later. Local Motors used Siemens Solid Edge for product development, and printed the vehicles using materials from SABIC.

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Recording Shipwrecks with 3D Technology

Part of the University of North Carolina Coastal Studies Institute's mandate is to preserve and record shipwrecks wherever they are found, both on land and in the sea. Generally, a shipwreck that washes ashore faces destruction both from the pounding of the waves and the slow drying out process that leeches preserving water from the structure. In the past, UNC teams have had to race against the clock to capture images of beached wrecks, but advances in 3D technology have made documenting such finds easier and faster.

In 2009, winter storms uncovered the remains of a ship built in the 1600s. Rather than leave the find to be destroyed by the elements, UNC removed the wreck from the beach. The drying out process left behind a mass of twisted lumber that can only vaguely be recognized as a ship and left UNC with a desire for a better method of recording the past.

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Canon to Enter 3D Printing Market

During the Canon Expo held in Paris, the company revealed plans to enter the 3D printing market with a brand new system developed internally. While the actual printer wasn't on display, Canon showed off parts built by the prototype system, and discussed some of what it hopes to accomplish.

Canon says it would employ a new (unspecified) additive manufacturing process based on general use resins to offer customers material diversity. According to the company, its 3D printer will reduce post-processing requirements, and include water soluble support material.

The company wants to create an entire digital environment with what it calls a "3D Integrated Software" solution. This includes 3D scanners, AM systems and digital design tools.

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Democratizing Simulation

COMSOL Conference Boston 2015 gave attendees a first-hand look at some of the software's new features, a host of use cases and the chance to directly provide feedback on its Multiphysics platform. The company also offered plenty of traditional and on-hands learning courses with a pre-release of version 5.2.

In 2014, COMSOL introduced the Application Builder and Server to the simulation community with Multiphysics 5.0. This year, the company has been working to make Application Builder and Server's main capabilities more robust and accessible to users. The goal is to be able to provide Multiphysics "modeling and simulation to everyone," according to Svante Littmarck, CEO of COMSOL.

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A New Product Lifecycle

At this year's Autodesk Accelerate conference, presenters and attendees made good use of buzzwords as they predicted "The Future of Making Things." With the emergence of smart, connected devices and the shift to a service-oriented economy, it's no secret that the way engineers design products is rapidly changing. But how does this new design process fit into current practices, such as PLM (product lifecycle management)?

In his keynote, Scott Reese, VP of Cloud Platforms at Autodesk, said, "We're seeing a lot of disruption, a greater amount than we've ever seen ... We're seeing the little guys take on the big guys." Reese also cited Big Data and smart products as contributors to disruption.

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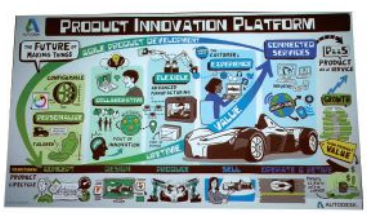

Digital Disruption

This year, Siemens PLM Software's main strategy could be summed up in one word: digitalization. The fact that the virtual world is colliding with the physical world is nothing new. What is new to some is the disruption the shockwaves of that collision are causing to every aspect of the enterprise.

Unlike its competitors, Siemens PLM Software is owned by the largest engineering company in Europe, Siemens AG. The multi-national parent has hundreds of production and manufacturing facilities, including what it calls "lighthouse plants" in Germany and China that are highly automated. Siemens PLM Software took advantage of that expertise at this year's Industry Analyst Conference by inviting Dr. Horst J. Kayser, chief strategy officer, Siemens AG to keynote.

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Casting a Positive Global Vision for 3D Printing

Speakers at this year's 17th annual International Wohlers Conference and Euromold Exhibition took on the state of 3D printing, as its stockmarket prices were taking a beating.

Keynote speaker and Autodesk CTO Jeff Kowalski said the biggest changes will not come from the 3D printers, but from the software used to design products and provide the data to the printers.

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AutoCAD Alternatives

Autodesk remains the market leader for 2D product design and manufacturing, but it is not the only player. Two developer conferences held in Germany brought together a range of small third-party developers and a few well-known brands that share a common interest in supporting the DWG-compatible CAD market independent of Autodesk. Graebert Software and Bricsys both create software that supports the DWG format popularized by Autodesk.

Graebert is a CAD vendor that some might say has an identity problem. There are more than 1 million active users of its software, yet only a small percentage knows the vendor behind it. Most of them are SOLIDWORKS and CATIA users who take advantage of free or paid versions of DraftSight CAD distributed by Dassault Systèmes.

Bricsys believes the continued impact of Autodesk's bifurcated strategy has given it an opportunity. Bricsys has built an international dealer network by being the core CAD engine for 1,200 development partners who create hundreds of genre products, such as mechanical modelers in most European languages, plant design software and many products for AEC (architecture, engineering and construction) and GIS (geographic information systems).

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Automation in Aerospace

This year's Global Product Data Interoperability Summit (GPDIS) 2015, had a leading-edge "something for everyone." The event covered model-based manufacturing, the factory of the future, wearables, sensors, cloud topics and, of course, standards.

Jay Ganguli from The Boeing Company was the first of many presenters to update attendees with ongoing standards committees' activities including the implications of some of the current directions. He notes that future influential and disruptive activities include the Internet of Things (IoT), Industrial Internet and Industry 4.0.

MORE ➜ deskeng.com/virtual_desktop/?p=11083

➜ For more engineering conference coverage, visit deskeng.com

A Crash Course in Workstation Configuration

Configuring the ideal workstation for your specific workflow can be a daunting task. With that in mind, BOXX Technologies has assembled a mini buyer's guide designed to help engineers sort through processor, GPU and hard drive configurations, and make a custom workstation match.

Processor Cores and Threads vs. Frequency

Aside from budget constraints, the most significant consideration is CPU cores — specifically, how fast and how many. Modern workstations range from four to up to 18 cores, and many include hyper threading, which theoretically doubles the system's ability to process threads (but does not double its performance).

Frequency-bound applications, including 3D modeling tools like SOLIDWORKS or Autodesk 3ds Max, benefit from CPU frequency more than cores. That's why BOXX offers safe overclocking, which provides up to 25% more performance by unlocking the built-in frequency headroom found inside Intel CPUs. Our maximum frequency workstation is APEXX 2 Model 2401.

Highly threaded applications, such as rendering or simulation, can benefit from multiple cores, thus we recommend Intel Xeon processors with high thread counts such as the APEXX 4 Model 7901. If a workflow requires both higher frequencies for interactive activities *and* high thread counts for rendering or simulation, the optimal solution would be to combine an APEXX 1 Model 1401 with a BOXX renderPRO 1, a desk-side rendering and simulation solution.

The GPU

The graphics processing unit (GPU) is primarily responsible for what you see on your screen. GPUs come in a variety of flavors from NVIDIA and AMD. 3D design and modeling applications rely on the GPU to keep frame rates up for smooth panning, zooming and rotating when creating and manipulating 3D objects. However, these applications are frequency bound and can't take advantage of multiple GPUs. For good viewport performance in these applications, we recommend a minimum configuration of an NVIDIA Quadro K1200 GPU

For certain rendering and simulation applications, the GPU can work in the background, operating exponentially faster than a CPU. Examples include GPU rendering engines like V-Ray RT, Iray or Octane, and simulation applications such as CATIA or ANSYS. In most of these cases, higher end GPUs will result in linear performance gains.

Hard Drives

The unsung hero in system responsiveness is a workstation's storage technology. While the basic functionality of mechanical hard drives hasn't changed in over a half century, the technology used to increase performance and storage size has evolved, all while delivering smaller and more innovative form factors. Despite such advancements as migration from Parallel ATA (PATA) to Serial ATA (SATA) and new technologies like Native Command Queueing, onboard caching, faster on-board processing, denser platters and increased spindle speeds, the mechanical hard drive still has inherent limitations that can be detrimental to your workflow.

It's safe to assume that all solid-state drive products (especially the Intel 750 SSD) will outperform mechanical drives in booting up a system, opening programs and any other bandwidth-intensive applications. Mechanical drives are only recommended for storing and archiving data and not for active projects.

RAM

Open up your task manager and look at your RAM usage while working. If during your most intensive tasks, you're not coming within 30% of the maximum RAM amount, you're probably in a safe range. However, more RAM means more room for multitasking, so investing in additional memory can be beneficial to your overall workflow. The minimum recommendation is for 16GB of RAM, while large data sets for simulation, large scenes with lots of polygons and textures, and complex parts in engineering applications will benefit from additional memory.

For an in-depth version of the BOXX guide, click here: www.boxxtech.com/DEhardwareguide.

Find the **Optimal Design**

Design exploration and optimization strategies expand the benefits of simulation.

BY BRUCE JENKINS

Recognizing the largely untapped value of digital simulation in new product development, more and more engineering organizations are leveraging their existing CAE assets with new, complementary investments in design space exploration and design optimization — technologies and methods that automatically exercise simulation, analysis and modeling applications to rationally and rapidly search through large numbers of design alternatives to identify the best possible designs.

These technologies began much the same as CAE, used chiefly by an elite group of experts for their most critical problems. But today, advances in usability, off-the-shelf connectors to all widely used modelers and solvers, and built-in (or easily captured) knowledge that guards against errors and misinterpretation of results are transforming these tools into practical, everyday engineering aids.

solidThinking Inspire 2015 supports assembly optimization. ***Image courtesy of solidThinking***

Topology Optimization Boosted by Additive Manufacturing

Of the technologies available for automated design exploration and optimization, the most widely used is likely structural optimization. Applying algorithms to solve structural problems by means of finite element analysis (FEA), this software optimizes some aspect of a product's geometry — most often topology, shape, size, topometry or topography — to satisfy operating limits imposed on the response of the structure, and limits on the values that the structural parameters can assume.

Among the different kinds of structural optimization, topology optimization is currently the focus of greatest effort by software vendors to make it more accessible and easily applied by non-specialists.

An important driver of efforts to make topology optimization accessible to as many users as possible is the surge of activity around additive manufacturing. Often used to identify a conceptual design that best meets specified design requirements, topology optimization works by optimizing material layout within a given physical design volume for a specified set of loads and boundary conditions, so that the resulting layout meets prescribed performance targets. It frequently yields biomorphic-like shapes suited to additive manufacturing. These can then be modified for production by conventional subtractive manufacturing, if required.

Autodesk Within Generates Lightweight Designs

One vendor leading the move to democratize topology optimization is Autodesk. Autodesk Within, released in July 2015, is a set of generative design software solutions to help engineers create and 3D print lightweight designs for the automotive, aerospace, industrial equipment and medical implant industries. "Generative design, advances in material science, and new fabrication techniques are allowing engineers to deliver components that were never before possible. Autodesk Within enables designers to create high-performing parts while enforcing design rules and adhering to additive manufacturing constraints," says Mark Davis, senior director of Design Research at Autodesk.

Based on technology from Autodesk's 2014 acquisition of London-based Within Lab, Autodesk Within is built around an optimization engine that takes input parameters such as desired weight requirements, and maximum stress and displacement, then generates designs with variable-density lattice structures and surface skins to meet those specifications. The aim is to produce components that are both more high performance and lightweight, which are then refined for production by additive manufacturing.

Shape Generator Integrates Topology Optimization into Inventor

Another Autodesk initiative is Shape Generator, a new feature in Autodesk Inventor 2016 R2 (released October 2015)

that provides topology optimization integrated directly into Inventor. Shape Generator is a conceptual design tool that generates a lightweight, structurally efficient 3D shape in response to a specified load case, using finite element methods to optimize material for the defined criteria. The user specifies boundary conditions, loads and target, then Shape Generator generates a 3D shape that can be used as a conceptual guide for preliminary design of a lightweight part.

Autodesk says that over time, generative design features will be incorporated into still more of its software portfolio. Much of this technology will come from Project Dreamcatcher, an initiative by the Autodesk Research organization to explore and expand the limits of generative design using cloud computing, natural-language input, pattern-based problem description and AI-assisted design space visualization.

Inspire 2015 Expands Structural Optimization to Assembly Models

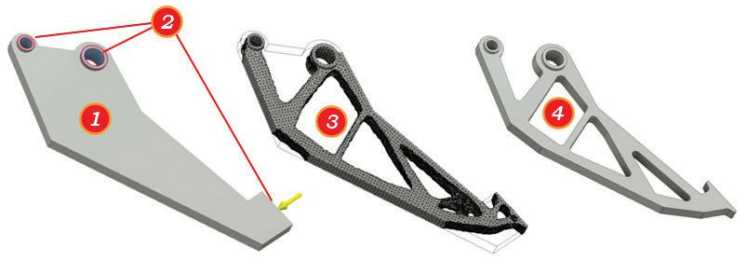
Another product bringing structural optimization into conceptual design is solidThinking Inspire from solidThinking Inc., an Altair company. This software helps engineers, product designers and architects create and investigate structurally efficient concepts quickly and easily.

solidThinking Inspire 2015, released in June, significantly expanded the scope and complexity of problems the software can address. Most notably — and unlike many other volume-market optimization solutions — Inspire can now model, optimize and analyze product assemblies, not just individual components. "With support for assembly optimization, users can now incorporate a surrounding structure into their optimizations and gain a deeper understanding of the relationship between multiple components," says Andrew Bartels, program manager for solidThinking Inspire.

OptiStruct Adds Lattice Structures, Advanced Materials

In addition to solidThinking Inspire, Altair continues to advance OptiStruct, one of the industry's longest-established solutions for structural design and optimization. A structural analysis solver for linear and nonlinear problems under static and dynamic loadings, OptiStruct uses finite element and multibody dynamics technology, together with analysis and optimization algorithms, to help designers and engineers develop lightweight and structurally efficient designs. Recent releases offer novel solutions for design and optimization of 3D printed lattice structures and advanced materials such as laminate composites.

In keeping with OptiStruct's 20-year history of introducing new capabilities,



Shape Generator workflow: (1) Create a build volume or approximation of the part model; specify requisite contact points such as the two pin locations and the contact surface where force will be applied. (2) Specify preserve (keep out) zones that will not be modified when creating the guide shape; apply constraints and forces that the part may encounter in use. (3) Run a Shape Generator Study; receive back a mesh in response to the criteria. (4) Use the mesh as a guide for making modifications to the build volume model — user edits transform the model from an approximation into a design. *Image courtesy of Autodesk.*

new functionality in the recent 13.0 release includes support for poroelastic (Biot's equation) material properties, large-displacement nonlinear analysis, nonlinear heat transfer and more, according to the company.

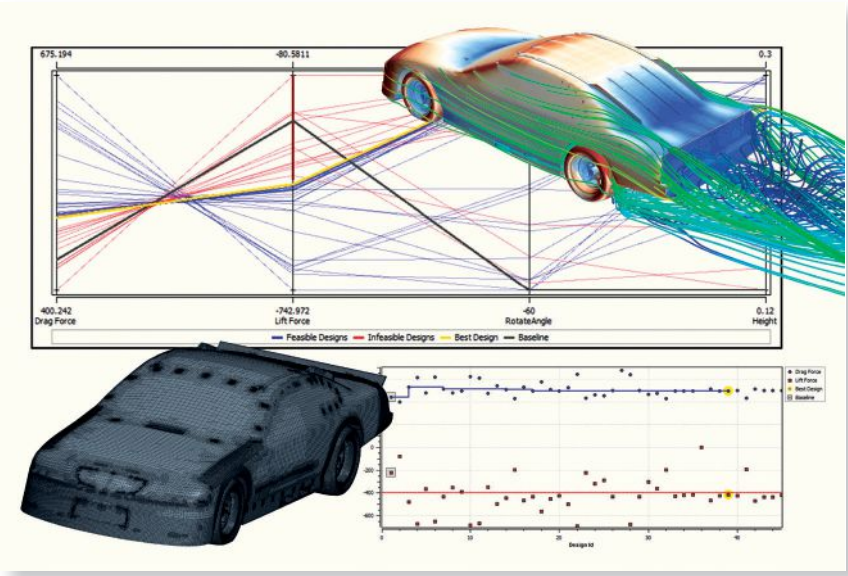
The current OptiStruct 13.0.210 release features a new solution for design and optimization of 3D-printed lattice structures, which can provide design concepts for a blended solid-and-lattice structure or a lattice-only structure. The lattice structure can be fine-tuned through size optimization techniques to meet various performance requirements.

Design Space Exploration Software Speaks the Language of Engineers

Structural optimization is far from the only area of progress in leveraging simulation with powerful layers of intelligent automation that offer engineers more complete, higher-fidelity visibility into product performance earlier than was possible with older approaches. Equally important advances are coming in design space exploration — a category of software and methods that are beginning to radically advance the capabilities of engineers and multidisciplinary engineering teams to discover an array of feasible design concepts early; rapidly and fluently evaluate sensitivities, variants, and tradeoffs; then select the best candidates and optimize them. These include design of experiments (DOE), parameter and sensitivity studies, multidisciplinary optimization (MDO), multi-objective (Pareto) optimization and stochastic (robustness and reliability) optimization.

A focus of development across the industry is to make these tools easily and safely usable without requiring expert knowledge of the quantitative and algorithmic methods that underlie them. For example, users long had to know a fair amount about the array of statistical sampling methods to perform a DOE study — full factorial, fractional factorial, Latin hypercube and others — to choose one best suited to the particular problem being studied. In setting up complex multidisciplinary optimization runs, they needed some understanding of gradient-based vs. deterministic vs. heuristic solution methods, the issues involved in searching for local vs. global optima, and more.

Today, developers are removing these complexities by building in intelligence that lets their software make more and more of these decisions autonomously, based on the user's description of the problem in engineering terms — in effect, making design exploration software speak the language of engineers and not mathematicians. This is a prime focus of development for Altair's HyperStudy, CD-adapco's Red Cedar Technology HEEDS MDO with its SHERPA search method, Dassault Systèmes' SIMULIA Isight and the Design Optimization Roles in its 3DEXPERIENCE platform, ESTECO's modeFRONTIER with its new pilOPT one-click self-adapting optimization algorithm, Exa's PowerFLOW Optimization Solution, Noesis Solutions' Optimus with its new Adaptive DOE techniques, and others.



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

71% of *DE* readers surveyed "strongly agree" that design optimization will revolutionize the design process.

— DE *2015 Reader Profile*

Overcoming Market Development Constraints

Despite these technological advances, however, many more engineering organizations could be taking advantage of design space exploration and design optimization than do today. One reason is simply the constrained marketing and sales resources of some of the small, independent software developers that make up much of this industry segment. An example of what expanded market development resources can accomplish is Red Cedar Technology, which grew its billings more than 80% and tripled its customer base less than a year after its 2013 acquisition by CD-adapco.

Another constraint on adoption is that design exploration and optimization are not part of the standard work process at enough engineering organizations today. Too many still rely on intuition-based, hit-or-miss engineering practices, not recognizing how these new technologies for systematic, rational, software-enabled design discovery, exploration and optimization deliver benefits well beyond the costs of bringing them into the organization.

A related constraint is that design exploration and optimization are too often implemented at only the department or workgroup level. To have the greatest impact, the technologies and attendant work processes need to be recognized and given backing as enterprise capabilities. Achieving adoption at the institutional level:

- Eliminates burden of re-justifying tools and methods on every new project.
- Mitigates the problem of software and work processes falling into disuse between projects.
- Makes the technology more readily applicable across disciplines and domains — the wider this span, the greater its impact.
- Fosters systems thinking across project teams, helping discipline specialists raise their visibility into the project — and their contributions to it — up and out of their silo of expertise, to the systems and whole-product level.
- Facilitates capture and synthesis of expert knowledge from across the enterprise, then re-deployment of that knowledge enterprise-wide.

Prominent examples include Ford's adoption of ESTECO's SOMO to enable an enterprise MDO system, BMW's use of Noesis Solutions' Optimus as its exclusive PIDO (process integration and design optimization) solution, and Rolls-Royce, whose aircraft engine development process is known for its long-standing institutionalization of design exploration, optimization and process integration based on SIMULIA's Isight. Buoyed by these proof cases, and by the technology's ever-increasing ease of implementation and use, design exploration and optimization use should continue to accelerate in the future. 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.*

INFO
- **Altair:** Altair.com
- **Autodesk:** Autodesk.com
- **CD-adapco:** CD-adapco.com
- **Dassault Systèmes:** 3DS.com
- **ESTECO:** ESTECO.com
- **Exa:** Exa.com
- **Noesis Solutions:** NoesisSolutions.com
- **Red Cedar Technology:** RedCedarTech.com
- **solidThinking:** solidThinking.com
- **Within Lab:** WithinLab.com

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

Optimize Your Design Process

Speed simulation-driven design by 6.9-17.7X with Altair's optimization software and the latest hardware.

Some things are more than the sum of their parts. In the complex world of engineering, simulation software closely coupled with optimization capabilities makes for a dynamic duo that radically redefines design workflows. When simulation and optimization are powered by modern workstations, the benefits are multiplied, allowing design engineering teams to boost innovation, lower costs and speed time to market.

Embracing Simulation and Optimization

While many organizations have embraced simulation software, fewer have adopted optimization, and an even smaller number have melded both disciplines into a single, integrated workflow running on the latest computing hardware. The barriers to adoption are many. A majority of these software tools are still oriented toward an expert audience, making it difficult for the average engineer to tap into their full set of capabilities. Most organizations, under pressure to compress development cycles, cut back on the number of iterations and delay hardware investments to save time and short-term costs. Finally, simulation and optimization tools often hail from different vendors, introducing layers of complexity and incompatibilities that hinder the synergies of the two design technologies.

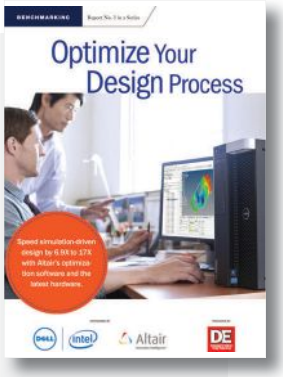
As a result, simulation and optimization are often put to work later in the design cycle, and often on older computing hardware. Doing so means design teams have already gone too far down the path to fully benefit from using the winning combination of simulation, optimization and current hardware. This late-in-the-game approach puts engineering organizations at risk of missing out on the promise of streamlined workflows and deep design exploration that gives way to higher quality products that might not have otherwise been discovered.

Benchmarking Altair OptiStruct

That's not the case with Altair's OptiStruct, a modern structural analysis solver for linear and nonlinear problems under static and dynamic loadings. Based on finite-element and multi-body dynamics technology, and through advanced analysis and optimization algorithms, OptiStruct promotes the development of innovative, lightweight and structurally efficient designs through tightly coupled use of simulation and optimization at each stage of the process.

Compared to conventional solvers, OptiStruct employs intelligent memory management techniques to gain added performance from its solution algorithms for linear, nonlinear and modal analysis problems. The tool can take advantage of the latest computer hardware advances to simulate structures with millions of degrees of freedom (DOFs) without any model size restrictions, providing more flexibility for extensive design studies.

More than 17X Faster Simulation and Optimization



To learn more about how the latest Dell Precision workstations and software combine to speed your simulation and optimization workflow, download "Optimize Your Design Process," the third in a series of *DE* benchmarking reports sponsored by Intel, Dell and independent software vendors.

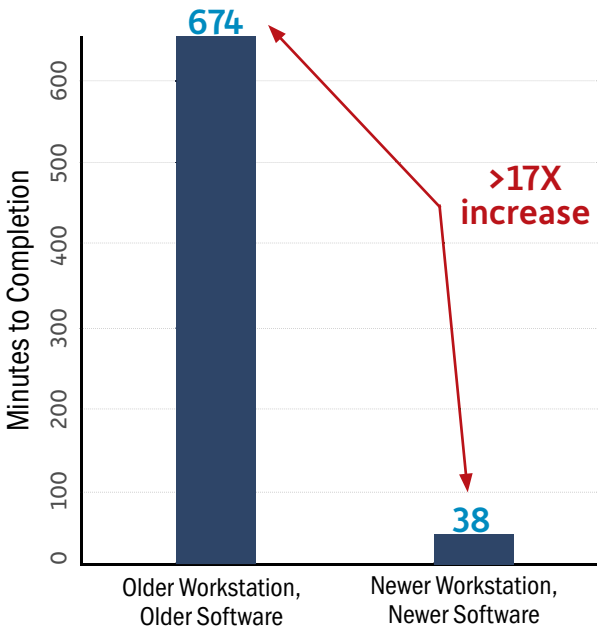
Each benchmarking study pits three-year-old workstations and simulation software against their modern-day equivalents to see how much time can be saved by updating both your hardware and software. In Altair's case, the new hardware and latest software completed some tasks more than 17X faster.

Download "Optimize Your Design Process" here: deskeng.com/de/benchmark3.

Accompanying its robust solver portfolio are highly advanced optimization algorithms, enabling OptiStruct to solve complex problems with thousands of design variables in a short period of time. The optimization engine lets users combine topology, topography, size and shape optimization methods to create alternative concepts for structurally sound, but lightweight designs.

To attain the optimal performance out of OptiStruct, our benchmarks suggest organizations should consider investing in the latest release of the software and pairing it with the latest workstation hardware. Our benchmark tests show that OptiStruct version 14.0 running on a current Dell Precision tower 7910 workstation powered by Intel processors is up to 8X faster for some operations compared to running its predecessor, OptiStruct 11.0, on comparable three-year-old hardware using the same number of cores. When OptiStruct 14.0 was given access to all 16 of the current workstation's cores, some simulations were completed more than 17X faster.

For more information, download the full "Optimize Your Design Process" benchmarking report for free at deskeng.com/de/benchmark3.



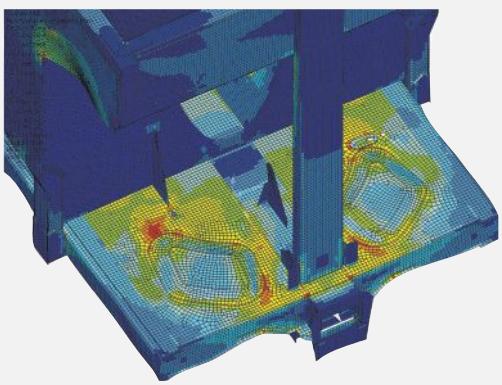
The most impressive results were seen when running a contact analysis of a train rail car (see below) using the newer software and the newer workstation's 16 cores vs. the older workstation's 8 cores.

Upgrades Get Results

Altair, Intel and Dell collaborated with DE to explore the impact of outdated software and hardware on present-day simulation studies. The partners conducted a benchmark study to test vendor claims that a combination of state-of-the-art hardware and simulation software upgrades make a big difference in the scope and performance of simulation-driven design and optimization. Below is the most impressive result of the benchmarking study, but all five of the analyses studied showed significant reductions in run times — from 6.9X to 17.7X.

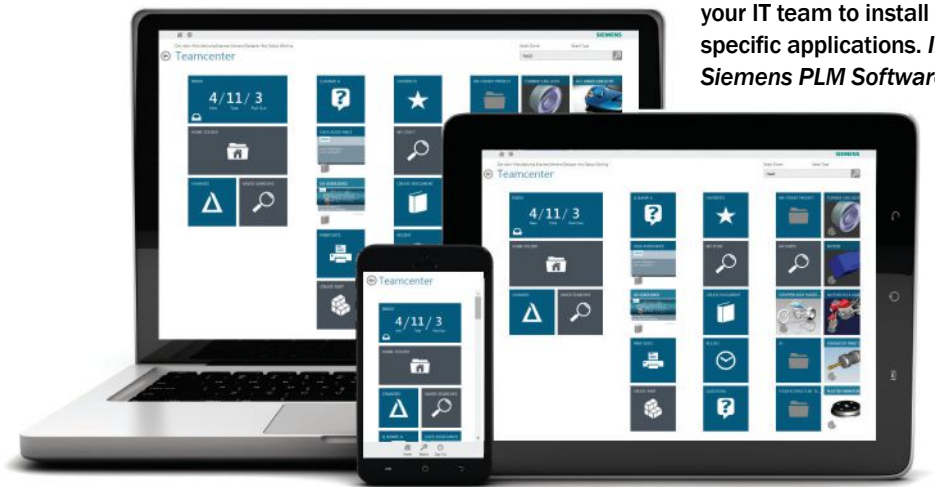
Contact Analysis of a Train Rail Car

Degrees of Freedom: 5.3 Million
Contact Pairs: 10,060
Subcases: 1
Solution time:
Three-year-old workstation and three-year-old software: 674 minutes
Current workstation and three-year-old software: 284 minutes
Hardware speedup alone: 2.4X
Current workstation and current software: 38 minutes
Software speedup alone: 7.5X



Current hardware and software speedup: 17.7X

Contact analysis is used to determine the state of contact between multiple bodies. This is done by setting up contact pairs between the nodes of one body and the elements surfaces of the other body. This nonlinear analysis is iterative and can be very slow as each contact pair affects the other. With the old workstation and old OptiStruct software, this analysis takes over 11 hours. Newer hardware speeds things up, requiring just five hours of run time with the old version of OptiStruct. With OptiStruct 14.0 and taking advantage of the new system's 16 cores, along with a new algorithm designed for contact analysis, the analysis time drops to just 38 minutes.



Active Workspace provides an identical user experience any time, anywhere, on any modern computing device without requiring your IT team to install and maintain device-specific applications. *Image courtesy of Siemens PLM Software.*

End-to-End Engineering

Comprehensive platforms let users design, simulate and manage a project from one software suite, but they also raise concerns.

BY JESS LULKA

Consumers want to be able to access whatever they'd like to at their fingertips — from restaurant recommendations to the weather. While engineers are creating products that help provide an "all-in-one" experience to consumers, they're also realizing that product complexity is requiring them to find platforms that can manage multiple workflows and different data sets to collaborate across an entire enterprise. To aid this, companies are developing centralized ecosystems that can integrate CAD, CAE and PLM (product lifecycle management) capabilities within one space. Yet there's concern that trying to connect data sets and files that aren't necessarily interoperable could either mean long implementation times or closed ecosystems.

To address these concerns, companies are creating platforms that can give end users and industry customers the ability to address multiple stages of the product lifecycle while also being able to interpret each stage individually — all while adding features to improve the user experience and ease collaboration among departments.

"What matters to buyers is that the solutions they rely on most work well together," says Monica Schnitger, president of Schnitger Corporation, a market analysis firm that specializes in engineering software. "For some, that's CAD and CAE; for others, it's the different flavors of CAD throughout their supply chains; for many, it's managing significant amounts of data from varying sources and controlling the work processes that create that data. Because these needs change over time, as businesses evolve, these platforms must be open and able to accommodate new solutions, data types, business models and partnerships." To make this possible, companies are charged with making engineering environments that are large enough to offer end-to-end engineering while also providing scalability.

Dealing with Data

Despite what functions engineering teams decide to use within an immersive platform, it's imperative that data is presented in a way that can be used throughout multiple points in the design process and beyond to the large enterprise.

"One of the main things that users and customers are looking for is a way to streamline the way that people are getting to data," says Bill Lewis, marketing manager for Teamcenter at Siemens PLM Software. "If you consider the implications of having an environment where it's a single source that includes multiple components, you're talking about a lot of data and a lot of different types of people interacting with that data." This makes it important for software companies to figure out ways to help multiple users connect with the right context and people for the data that they work with, he says.

At Dassault Systèmes, the company's 3DEXPERIENCE platform supports outside file formats to make data integration

easier. "Studies have shown that engineers spend up to 40% of their time engaged in non-value added activities (looking for information, check-in/check-out, duplicating design information, etc.). The data-driven infrastructure of the 3DEXPERIENCE platform enables engineers to focus on innovation rather than administrative tasks," says Andy Kalambi, CEO of ENOVIA at Dassault Systèmes. Because the environment is centered around design data, Kalambi notes that users can share CAD data with each other "irrespective of the original CAD authoring system, so that information can not only be stored and accessed, but [also] leveraged in the context of a virtual prototype."

By bringing data to the center of the platform's infrastructure, and increasing interoperability with outside applications, software companies are easing the need for data translation and helping multiple departments collaborate on a project. It also gives a stronger correlation of raw data and project management capabilities — letting users see the entire scale of a project.

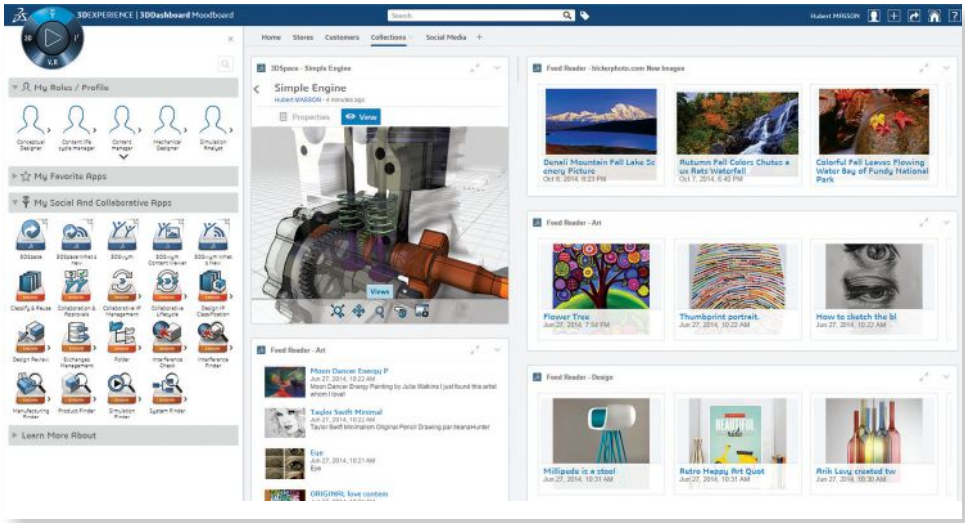
"[With 3DEXPERIENCE], project management becomes data-driven by being linked with the product portfolio," Kalambi says. "When the two processes are disconnected with different technologies, there are multiple projects being defined and tracked, but they are not grounded in the reality of the product data that is being created as part of the project. Now, suppose a single technology is used to permanently associate the definition and development of the product portfolio with the tracking of the projects used to govern it? The implications of portfolio decisions can be quickly assessed against project schedule. As a result, a project manager is taking action to resolve issues with a full understanding of the impact on the product portfolio."

6 The average number of months in the design cycle of *DE* readers surveyed, not including the plan or build stages, which averaged 4 and 7 months, respectively.

— DE's 2015 Reader Profile

Bringing Work on the Go

In an age of social media and cloud capabilities, engineers are seeing more technology to help them gain ubiquitous access to their models and data. Mobility is becoming more apparent through Web-based software access and even smartphone and tablet applications. At this year's Autodesk Accelerate event,



Dassault Systèmes' 3DEXPERIENCE environment has a data-centered infrastructure and role-based profiles to help users access specific projects and customize their own dashboard. *Image courtesy of Dassault Systèmes.*

presenters discussed what technology would enable engineers to address product complexity across multiple, worldwide teams. "Innovation and globalization are major drivers for business and complexity. We need a new set of tools and what's really enabling it is the IT," says Marc Halpern, research vice president at Gartner Research, an IT research company. "The four major trends that are driving product innovation platforms are mobility, social networking, Big Data and the cloud."

To bring design and simulation into an infrastructure where engineers can access their data at any time, more companies are creating specific applications and Web-based portals. Dassault Systèmes offers its own 3DPlay app, where engineers can manipulate product data and check simulation results. At Siemens PLM, the company's Active Workspace enables PLM management from a Web-browser. By offering engineering software in mediums that are similar to what designers use as consumers, it can remove some of the technical overhead. "With Active Workspace, we're trying to take lessons on how users are interacting and working with the online world in their day-to-day life [and apply that to PLM]," says Lewis.

The 4 Trends Driving Product Platforms

1. Mobility
2. Social Networking
3. Big Data
4. The Cloud

— *Gartner Research*

Filling in the Gaps with Partnership

With these environments offering multiple roles and personas for engineers to access data, how are companies able to create a program that is simultaneously both general and specific? Corporate collaboration is one answer because it helps to increase interoperability among different platforms via integrations and plug-ins.

"I don't think anybody has deployed an all-in-one kind of solution, and there are going to be requirements to leverage what the customer already has. While we offer a broad footprint, we also have to have the ability to work with other tools and other systems," says Lewis. Having this compatibility with other software has also led Siemens PLM Software to grow its partnership programs to help provide toolsets for all the use cases Teamcenter supports. "[When creating a platform like Teamcenter, we ask:] 'What are people already deploying and how can you fit into those systems that they already have?'" says Lewis.

Lewis' sentiment isn't uncommon. Partnerships to help create a more encompassing design environment are appearing elsewhere in the industry. For example, Autodesk, National Instruments and the University of California, Berkeley have launched a partnership to help connect and streamline the tool supply chain. The goal of this collaboration, is to "take the output of Autodesk Inventor, put it together with Modelica [an object-oriented system modeling language], and feed it into the simulation and control design module in [NI's] LabVIEW," according to Dave Wilson, academic marketing director at National Instruments. (For more, see deskeng.com/virtual_desktop/?p=10948).

Cause for Concern?

While a more complete design environment can offer a central access point for multiple project stages, companies also need to address concerns of scalability, interoperability and long implementation times. As a solution, environments will often have a certain amount of customization available to add-on to the main infrastructure.

"The modular architecture of the 3DEXPERIENCE platform provides the flexibility to enjoy the collaborative benefits of the base solution and add role-based apps, as needed. The available apps span design, simulation, manufacturing and more, and are available tailored for specific industry challenges," says Kalambi. He also notes that to help more industries, the company has expanded its base beyond manufacturing to newer sectors such as life sciences and packaged goods.

Lewis says that Teamcenter has developed Rapid Start, a preconfigured solution that includes some common industry best practices and features for PLM. By providing an out-of-the-box foundation, customers can start using the software's capabilities more quickly and then decide if it needs to be expanded or customized.

However, even with larger end-to-end engineering environments, it's rare that a company decides on a complete switch to a new platform. "It's usually a more organic process, where a division or product line selects a new tool because it has capabilities that the legacy solution doesn't provide, and proves out that this approach works — only then is the new platform rolled out on a wider basis. Today, the platforms more often need to mold to the enterprise's needs. Today's incremental approach is faster, less disruptive and can build success a bit at a time," Schnitger says.

Despite the idea of the design platform becoming more apparent in industry, engineering teams still need to have software that is scalable and accessible. By creating platforms that offer customization beyond a main infrastructure, mobile and Web portals, and the ability to integrate outside niche software, companies are setting a new standard for collaborative engineering. DE

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

INFO ➜ **Autodesk:** Autodesk.com

➜ **Dassault Systèmes:** 3ds.com

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

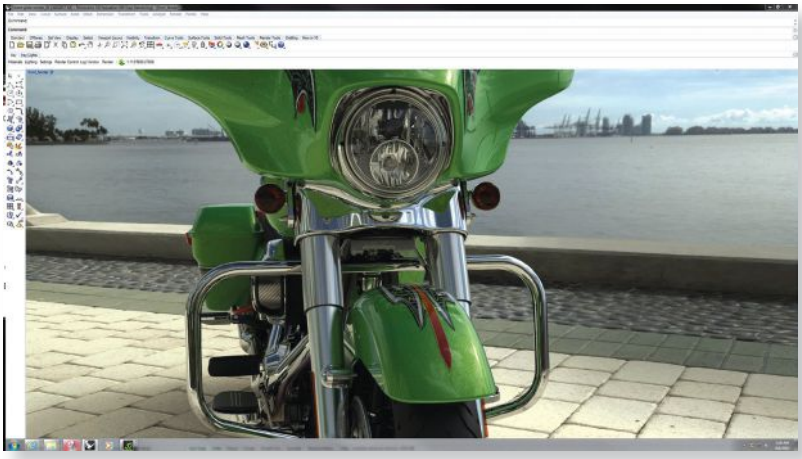
➜ **Schnitger Corporation:** SchnitgerCorp.com

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

Fast, Predictive Rendering

Unambiguous and fast iteration transforms design workflows.

Design is the key differentiator among products in today's economy, but predictability and iterative speed are key differentiators in the economics of design. At its heart, design engineering is the process of iteration: An idea is visualized, critiqued and refined, until it is ultimately delivered. More iterations mean more chances to try new ideas, to catch mistakes, to polish concepts into ever better designs. It's not enough, however, to have a beautiful design. Speed to market and cost of production are both essential in the creation of a competitive, profitable product. While it's important to do enough design iterations, the changes need to happen quickly and with the confidence that the final product will emerge as the designer intended.



By incorporating physically based rendering into the upfront design process, design engineers can iterate in real time and see how modifying a part's shape or material will affect the look of the final product.

Interaction via Physically Based Rendering

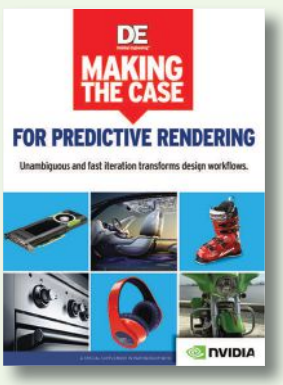
Rendering has long been an important tool for visualizing 3D designs. Real-time display renderers, such as OpenGL, lend themselves well to rapid iteration. However, such rendering can only approximate the appearance of materials and objects. It is often useful for working with the mechanical components of a shape, but it cannot accurately predict the appearance of a finished product, meaning the designer can only make educated guesses. Various forms of ray tracing, and other CPU-based rendering methods that simulate light more realistically than OpenGL have been available to designers for years, but these have been difficult to use and too slow to fit well into rapid iterative design. As a result, many designers have simply learned to do without realistic rendering, or they have saved it for special occasions.

Interactive, predictive, physically based rendering (PBR) is poised to change the way such designers work. It combines easy-to-use physically based lighting, verifiable realistic materials and reliably accurate photorealistic results, with the computational performance of graphics processing units (GPUs). Not only can a designer see how the product will really look, he can see it in his application's interactive viewport, while he designs it. Just as hardware-accelerated OpenGL became the standard mode for working interactively in 3D, GPU acceleration turns physically based rendering into an interactive design mode that will become an essential part of iterative design workflows.

Making the Case for Predictive Rendering

This new paper produced by *DE* on behalf of NVIDIA makes the case for using physically based rendering early and often in the design process to transform your iterative design workflow. Thanks to the power of GPUs, modern rendering software is capable of producing realistic visuals in real time, allowing you to immediately see the results of design changes without costly prototyping and manufacturing.

"Making the Case for Predictive Rendering" explains the key concepts and benefits of predictive design, and includes real-world examples to show how Harley-Davidson and Renault are using it to get better products to market faster. Download the paper for free at deskeng.com/de/predictive.



4 Reasons for Predictive Rendering

A predictive design approach that leverages realistic, iterative rendering can accelerate the design workflow, help designers identify flaws earlier in the process, increase creativity, save costs and provide a platform for better decision making and collaboration with non-engineers during the product development process. GPU-accelerated, physically based rendering (PBR) ultimately improves the end product.

To convince your team to incorporate predictive design into your overall product development workflow, focus on these four points:

1 Easier, faster rendering allows you to make better use of your time, completing your work faster. With Iray-enabled PBR, designers can explore more concepts in less time, and have confidence that what they see in the photorealistic rendering accurately reflects what the design will look like when it is built.

2 Potentially catastrophic design flaws can be identified earlier in the process through visualization. This saves expensive re-work down the road and improves client satisfaction. Having access to a lifelike representation earlier in the design process ultimately results in better products, because engineers can make design decisions faster and more effectively.

3 Managers and clients can clearly see the impact of a design change, or better understand the intent of a design idea in real-time. This improves collaboration, saves time and further speeds the development cycle.

4 By enabling the design engineering team to create realistic digital prototypes on demand, you can save the cost of creating physical models and prototypes. Reducing or eliminating the number of physical models/prototypes required can result in significant savings.

Learn more by downloading "Making the case for Predictive Rendering" via deskeng.com/de/predictive

"SWITCHING TO IRAY RAY TRACING WAS LIKE A DREAM — WE CAN GO SO QUICKLY FROM 'IDEA' TO 'RENDER.' THERE'S NO PRE-PROCESSING REQUIREMENT. MATERIAL AND GEOMETRY CHANGES ARE MADE EXTREMELY EASY TO HANDLE INTERACTIVELY AND IN NEAR REAL-TIME."

— RENAULT DESIGN DIGITAL VISULAZATION'S GUILLAUME SHAN

"IT USED TO TAKE FOUR PEOPLE ON OUR TEAM A FEW MONTHS TO DEVELOP A NEW BIKE DESIGN. NOW, TWO PEOPLE CAN DESIGN A FULL MOTORCYCLE IN TWO WEEKS."

— HARLEY-DAVIDSON SENIOR SURFACE DESIGNER MATTHEW GUELLER

Avatars Land a Role In Product Design

The concept of a digital twin is gaining traction as companies look at connecting the physical product to its virtual counterpart.

BY BETH STACKPOLE

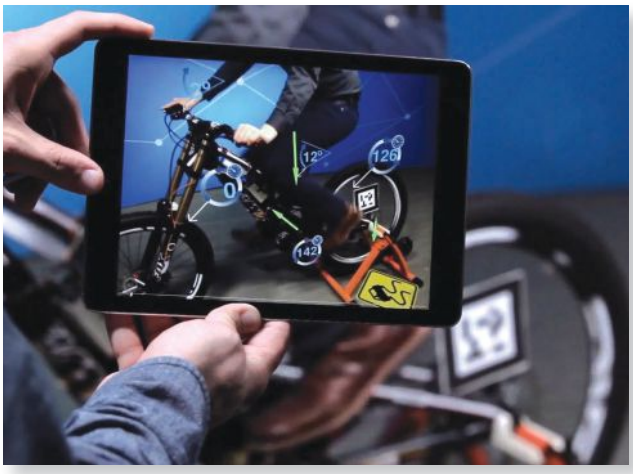
Given the ever-increasing complexity of today's multi-domain products, the practice of digital prototyping is evolving with the digital twin — a concept that carries the traditional 3D representation of a product into the new reality of a converged physical and virtual world.

While definitions vary, the digital twin is increasingly being used as a way to describe a means of connecting information about the physical product and its behavior in the real world with the 3D digital representation so commonly employed by engineering and other areas of the business. The requirement for viewing, interacting and getting information about the product in a blended virtual and digital world is in part being driven by the Internet of Things (IoT) and the rise of connected products.

"Product complexity is driving a need to bring multiple people together more efficiently to collaborate and that is accelerating the need to create convergence between the real and virtual worlds," says Eliane Fourgeau, CATIA Systems' senior director of Sales at Dassault Systèmes. "It's critical because you need to make sure the product you're putting on the market is the right product and is delivering the right services."

That's one company's view of why a digital twin is important. Dassault's primary competitors in the CAD space — PTC, Siemens PLM Software and Autodesk — are also bullish on the concept and its potential benefits, but they all have different ideas of what constitutes a digital twin and alternative plans for where it fits best in the scheme of a product's lifecycle. All are in agreement, however, that a digital twin can deliver efficiencies to the design and production processes, improve product quality and innovation, and foster better serviceability of products, ultimately benefitting customers.

For Dassault, the concept of a digital twin (or a virtual twin, as the company prefers to call it) is an extension of its systems engineering strategy, enabling design teams to conceive and architect a cross-disciplinary product that combines mechanical, electrical, electronic, hydraulic and control capabilities, among other domain properties. As part of its 3DEXPERIENCE strategy, which is an environment for engineering a system or a product in the context of its whole experience, the concept of virtual twin will enable design teams to experience a product before it exists. In this way, engineering teams see not just static mockups of a product or system (the traditional 3D digital mockup driven by CAD), but rather provide insights into physical behaviors like stress and vibration as well as behaviors associated with the software and control systems, Fourgeau explains. "In a sense, think of it as creating an avatar that behaves as something would in real life," she says.



PTC's vision of a digital twin involves a one-to-one representation of an individual product. *Image courtesy of PTC.*

Essential to Dassault's strategy are model-based design capabilities for modeling, simulating and validating complex engineering systems. As part of its systems engineering portfolio, the 3DEXPERIENCE platform uses the Modelica language and Functional Mockup Interface (FMI) standard so multi-physical systems can be modeled and easily composed, promoting reuse and cross-domain exchange while supporting an open ecosystem, Fourgeau says.

Creating and leveraging this virtual twin at the beginning of the process — not later on in the detailed design stage — is one thing Dassault says sets its strategy apart from competitors. "Take the example of an energy efficient building — you can wait until you build it, put sensors in, and have an IoT system

Using Autodesk's SeeControl technology, real-time sensor data from a robotic arm is collected, analyzed and displayed in an easy-to-digest format. *Image courtesy of Autodesk.*

tell you if it's efficient or not, or you can create a virtual representation of that building and experiment, putting double pane glass here or changing the exposure of the building with regards to sun," Fourgeau says. "In that way, you continue to play what-if scenarios until you are satisfied and then start the detailed development of the building."

Siemens PLM Software sees the concept of the digital twin as the intersection of four different worlds coming together: Product design, manufacturing planning, factory design and the real world — with an emphasis on production. "The digital twin does something very unique by merging the virtual and real worlds of production," says Aaron Frankel, senior director of product marketing for Siemens PLM Software. "Now you can take the as-designed model and all the information you are collecting from the production environment about performance and quality, overlay them on a digital model, and compare the as-designed and as-built worlds to see if there is a difference," he says.

This view advances the concept of digital prototyping by taking into account all that can happen with production processes, full proofing a product design by eliminating the possibility of failure, according to Zvi Feuer, Siemens PLM's vice president of Manufacturing Engineering Software. "The digital twin is the avatar of the product process and the factory all together," he says. "If you can take failure off the table, companies will be willing to be bolder and take bigger risks."

The underpinning of Siemens' digital twin concept is the Teamcenter data management and collaboration platform along with various other components, some from its simulation and factory optimization tools and others from its Manufacturing Execution System (MES) and factory automation suite.

Autodesk's digital twin vision spans both the factory and product, making use of augmented reality technologies borrowed from its media and entertainment software line as well as capabilities from SeeControl, an IoT cloud services platform provider it acquired in August. "SeeControl is the underpinning of our digital twin," says Diego Tamburini, manufacturing industry

Using the Tecnomatix process planning and simulation tools, Comau is able to create a digital twin to validate production lines. ***Image Courtesy of Siemens.***

strategist at Autodesk. "It allows you to quickly connect to a sensored device and get data, which can be overlaid on a 3D model."

Viewing that data overlaid onto a real physical product using augmented reality technology is where the rubber meets the road, Tamburini says. "There's an obvious advantage to looking at data at the source — for example, looking at temperature or stress values in the exact location of the product," he says. "That's very intuitive and you don't have to do any mapping in your head. If you're looking at a 3D model, it takes too much black magic to get the sensor data displayed there."

20% The profitability and productivity gains GE hopes to achieve via its digital twin wind farm concept .

— *GE Power*

Augmented reality will be part PTC's digital twin vision in light of its acquisition of the Vuforia technology (*see page 7*). For now, however, the company is talking about the concept in the context of product development, but more vociferously in the area of field service and operations, according to Mike Campbell, PTC's executive vice president, Digital Twin.

Unlike the traditional CAD model used in virtual prototyping, which is a general representation of a multitude of products, Campbell says PTC sees the digital twin as a one-to-one representation of a unique physical product already out there in the real world. "A digital twin associated with a specific product is the key idea here," he says. "It's this one-to-one mapping that makes it different than CAD and different from what some of our competitors are doing."

A 3D CAD model is highly valued during the design process, but loses utility once the product leaves the manufacturing floor. In contrast, a digital twin of a smart, connected product can provide insight into how the product is behaving in the field, helping to steer product design and provide intelligence for successful service calls, Campbell says. "People design products all the time against idealized requirements — they over- or under-engineer things or products and miss the mark entirely because they didn't understand real-world use cases," he says. "The connectivity and digital twin provide an opportunity to understand how a product is used and leverage that insight to make the product better."

PTC is planning a January launch of its official digital twin strategy. While Campbell declined to discuss the specifics, he said that the company is assembling a portfolio of technologies, which will include augmented reality capabilities, tools for managing the one-to-one relationship, mechanisms to collect relevant data from sensors, and a way to integrate information from other enterprise systems.

Sysmex, a manufacturer of clinical diagnostic equipment, sees potential for the digital twin for both field service and product design applications. On the service front, field technicians might receive a digital picture flashing warnings to flag conditions that exist with a particular medical instrument rather than trying to discern something from data in a table view.

For Sysmex product designers, the digital twin will provide essential feedback on non-tangible information that can help drive future development. "By having a digital twin, field service technicians can provide detailed information about what exactly they adjusted, cleaned or lubricated rather than just providing general guidance," says Steve Postma, enterprise architect at Sysmex. "Now engineering and development teams have a clear serviceability picture of what's happening with the product and can leverage that in future designs." DE

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

INFO ➜ **Autodesk:** Autodesk.com

➜ **Dassault Systèmes:** 3Ds.com

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

➜ **PTC:** PTC.com

➜ **Sysmex:** Sysmex.com

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Optimal Design Leaders

Optimize Your Performance

Workstations customized for engineers improve productivity.

BY SHOAIB MOHAMMAD, *Vice President of Marketing and Business Development*

For today's engineers, the computer workstation is their most important tool, yet it also presents one of their greatest challenges. The proper solution optimizes productivity, but this is where commodity PC makers, with their "one size fits all" approach, usually fail to deliver. They don't understand professional applications and the specific configurations needed for workflow optimization, often resulting in misinformation. To further complicate matters, engineers face an increasingly competitive marketplace. If you rely on inaccurate information from your hardware provider, and as a result, are saddled with an expensive system that doesn't maximize your productivity, you're behind the curve—and your competition.

Knowledge is power, and as a solution provider, BOXX customizes systems to optimize workflows because our expert performance specialists, engineers, and legendary technical support not only know everything about our Autodesk and Dassault Systèmes certified hardware; they also have an intimate understanding of these applications and workflows. And because BOXX designs and manufactures in the U.S., we're more agile, quickly adopting leading technologies in response to customer needs. Our unique offerings, with features like safe overclocking, liquid cooling, and multiple GPUs backed by a full, three-year warranty, have all become BOXX trademarks—just like customer satisfaction.

Enfinity Engineering's Richard Howard, discussing simultaneous jobs, each with a critical deadline, says (without his BOXX), "There's no way I could have done all the crunching, the reloads, the opening and closing, popping back and forth, and still make my deadline."

Two-time SOLIDWORKS International Design Competition winner Bill Gould credits his BOXX workstation for a productivity increase of at least 30 percent. "I don't have to wait for anything in SOLIDWORKS," he says. "More importantly, it has opened up new possibilities because what I can do now, I can do faster."

Working faster and more efficiently is the key to any engineering team's success. BOXX understands this and that is why we are uniquely positioned to help you meet your engineering challenges and maximize your productivity.

BOXX TECHNOLOGIES

About BOXX Technologies, Inc.

BOXX is the leading innovator of high-performance workstations and rendering systems for engineering, product design, architectural visualization, visual effects, animation, and more. Combining record-setting performance, speed, and reliability with unparalleled industry knowledge, BOXX is the trusted choice for creative professionals worldwide. Hear what our satisfied customers have to say: www.boxxtech.com/whyboxx

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10435 Burnet Rd #120, Austin, TX 78758
(512) 835-0400
www.boxxtech.com

Discover Better Designs, *Faster*

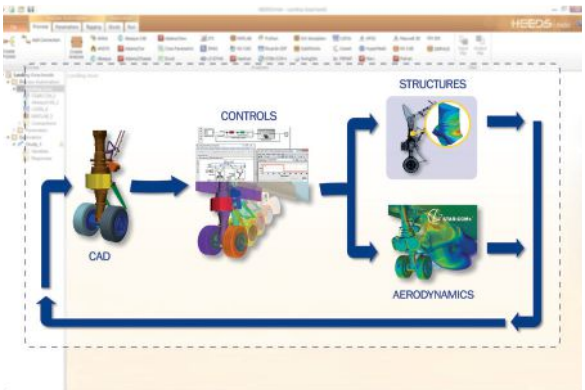
Multidisciplinary Design eXploration speeds product innovation.

DAVID L. VAUGHN, *Global Vice President, Marketing*

To design better products, engineers need to be able to quickly predict the outcome of design changes on the real-world performance of the product. To be most effective, these predictions should be delivered early and often, providing a constant stream of data that influences the product from the very earliest point in the design process. In short, the ongoing challenge in engineering is to discover better designs, faster.

Engineering Across Disciplines

Multidisciplinary engineering simulation provides the most reliable flow of information into the design process, while providing comprehensive predictions that are usually more accurate and always less expensive than the experimental testing. Deployed effectively, simulation can be used to improve a product or design by providing a stream of engineering data to drive the design through multiple design iterations. In addition, engineering simulation opens the door to intelligent and automated design exploration and optimization. Ultimately, the implementation of this Multidisciplinary Design eXploration (MDX) process results in higher quality and more robust products that exceed customer expectations.



Innovative Solutions Backed by Experts

CD-adapco is an engineering simulation company with a unique vision for MDX. Our flagship product, STAR-CCM+, along with our other multidisciplinary engineering simulation technologies, predict the real-world performance of products accurately and robustly. They can be used to explore and evaluate product performance throughout a range of design configurations and operating scenarios. They provide timely solutions by employing efficient algorithms and automated and repeatable CFD and CAE processes that are optimized for modern parallel and cloud computing.

Our solutions are backed by a staff of engineering simulation experts located around the globe. The company provides unprecedented support through our designated support engineer format, along with the Steve portal that provides online resources 24/7.

CD-adapco is synonymous with innovation. Indeed, we pioneered much of the software technology that makes engineering simulation possible, and we also led the market in offering innovative licensing options to make MDX affordable. The Power Session license revolutionized the industry by offering unlimited parallel computing access for a fixed price. We then brought engineering simulation to "the cloud" with our Power-on-Demand licensing, which gives users a "pay-as-you-go" option. Now, Power Tokens complement the MDX vision by enabling affordable licensing for design exploration.

About CD-adapco

CD-adapco is an engineering simulation company with a unique vision for Multidisciplinary Design eXploration (MDX). Our purpose is to facilitate innovation and to lower product development costs through the application of multidisciplinary engineering simulation and design space exploration. Put simply, our mission is to allow our customers to "discover better designs, *faster.*"

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CD-adapco®

Spreading Virtual Prototyping and Design Optimization Through Simulation Apps

Simulation specialists can extend versatile multiphysics simulation design capabilities to an entire organization via apps.

BY VALERIO MARRA, *Technical Marketing Manager*

Modern product design tools are indispensable to the engineer, enabling virtual testing of your first idea to the verification and optimization of the designs and processes necessary to manufacture high-quality products. The advantages of a simulation-led workflow extend throughout an organization or company by allowing your design teams to innovate with reduced risk, cutting the cost and time associated with physical prototyping, while meeting time-to-market goals.

Eliminate the Workflow Bottleneck

Your organization or design engineering team could face significant challenges in implementing such a workflow, despite their numerous advantages, because highly trained specialists are required. Additionally, a small group of experts often have to serve an entire organization while covering a diverse range of simulation needs. A bottleneck results, limiting the pace of the product design cycle and innovation, which in turn affects competitiveness and future revenue.

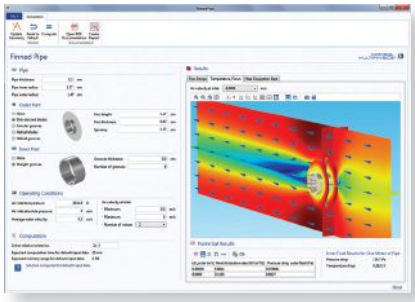
The latest version of COMSOL Multiphysics® software and its Application Builder provide you with the tools needed to turn detailed physics and mathematical models into easy-to-use simulation applications for use by everyone in your organization and beyond. Thus, the workflow bottleneck is bypassed.

Design Optimization with Simulation Apps

To continue addressing your most critical workflow challenges, COMSOL is committed to providing engineers with easy-to-use, affordable simulation and application design tools as well as access to highly skilled support engineers. With COMSOL Multiphysics, engineers from a diverse range of technical areas can solve systems of equations representing coupled physics effects as they would occur in nature; hence you can base your design decisions on highly accurate data.

Running your design optimization based on this real-world model is a great competitive advantage. COMSOL provides add-on products such as the Optimization Module as well as products for interfacing with CAD software to enable topology optimization, inverse problems, and time-dependent optimization analyses.

A simulation application can be developed for a specific design optimization task, and presents only those parameters, results, and reports that may be of interest to the user. There is no learning curve to run simulation apps, and users won't require previous experience in using modeling and simulation software.



The thermal properties of a finned pipe are derived from a conjugate heat transfer simulation app.

COMSOL specifically developed COMSOL Server™, a software that makes it possible to run apps in a readily available COMSOL Client for Windows® or in any major web browser. With its generous license, costs for large-scale deployment are minimized, and apps can run on local hardware or on the cloud for worldwide use. With Application Builder and COMSOL Server, you can bring easy-to-use simulation apps to everyone.

About COMSOL, Inc.

COMSOL is a global provider of modeling and simulation software. Its COMSOL Multiphysics and COMSOL Server™ products offer an integrated software environment for creating physics-based models and simulation apps that can be readily deployed and accessed by users in design teams, manufacturing departments, and test laboratories, as well as by customers throughout the world.

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From Solve to Innovate

Capture the Power of Simulation to Optimize Product and Business Performance

BY SUMANTH KUMAR, *VP, SIMULIA Portfolio Management*

With shorter timelines, reduced budgets, more stringent regulations and greater technical complexity product developers are relying more heavily on a range of simulation technologies.

Dassault Systèmes has responded to this industry demand by making technical breakthroughs in solver performance, accuracy, scalability, material modeling, assembly modeling, contact analysis, fracture and fatigue, multiphysics co-simulation and efficient optimization technologies. These technologies are all easily accessible through Extended Packaging for Abaqus, Tosca, Isight and fe-safe, which provides efficiency, flexibility and scalability to access the technology you need when you need it.

A Holistic Approach

However, robust technology on its own is no longer sufficient. The issue facing most companies is not only how to use more simulation "solver" technology, but how to integrate the technologies and leverage the benefits of simulation and optimization to power innovation. Companies need to bring simulation out from the back corner of the engineering department and onto center stage in their business processes.

Dassault Systèmes is leading the way by providing integrated simulation technologies as well as a platform for collaboration and management of simulation intellectual property. The **3D**EXPERIENCE® platform transforms the way products are designed, produced and supported. With our platform, industry-focused solutions, and expansive partner ecosystem we are empowering companies to make the transition from "solve" to "innovate."

The platform enables simulation to be an integral part of the cross-disciplinary workflows tailored to each specific industry. Entire development processes — with requirements, design variants, simulation models, and results — are maintained as part of the same single source of truth for product and experience-related data. Any changes are automatically reflected in the system of record, which makes it possible for everyone to be fully aware of their colleagues' contribution at each stage of development.

The integration of realistic simulation, process capture, automation, optimization and analytics within the platform enables companies to democratize simulation by sharing best practices. It also accelerates exploration of multiple options and supports collaboration across multidisciplinary teams to zero in on alternatives that may have never been considered with traditional methods.

The **3D**EXPERIENCE platform, combined with the breadth of SIMULIA applications, enables simulation to be essential for achieving optimal processes and designs. This helps companies deliver high-performing, innovative products while reducing cost, time and risk.

About Dassault Systèmes

Dassault Systèmes, the **3D**EXPERIENCE Company, provides businesses and people with virtual universes to imagine sustainable innovations. Its world-leading solutions transform the way products are designed, produced, and supported. Dassault Systèmes' collaborative solutions foster social innovation, expanding possibilities for the virtual world to improve the real world. The group brings value to over 190,000 customers of all sizes, in all industries, in more than 140 countries.

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DASSAULT SYSTEMES
The **3D**EXPERIENCE® Company

Design Products as a Whole

Optimize engineering collaboration with the enterprise.

BY CARLO POLONI, *President of ESTECO*

The dynamic nature of modern markets has radically changed the way manufacturers approach product design, and so far technology has risen to the occasion by providing tools to improve and innovate products. The challenge today and for the future is enabling collaboration, where sharing knowledge and decision making go hand-in-hand with technology to speed up design processes and engineer better products.

ESTECO meets this challenge by providing tools that manage the interaction between different engineering disciplines, enabling companies to design products as a whole rather than as a set of individual components. Our software automates the design process and gives our customers advanced data mining capabilities: designers can use an array of leading-edge post processing tools to extract relevant information and transform it into insightful and actionable analyses.

Pioneering Technology Recognized

Our strategy at ESTECO has always been to be better than everyone else – to create something new and different from what is currently available – that's why we are considered a pioneer in our field. What distinguishes ESTECO is our long history in, and experience with, traditional technology through the engineering of products and our ability to anticipate the future of IT technology. It's no coincidence that Gartner, the IT consulting company, singled us out in their 2015 Product Design and Life Cycle Management Cool Vendors Report when we moved from a very technical desktop solution to an enterprise solution where interaction with IT is the prime focus. In the beginning, our customers were individuals designing a single component on their PC. Nowadays, we are moving toward a scenario where our technology is used throughout the company and accessible to managers and different experts within the company. This means that the judges of our software are no longer specialists working at their desks, but the very companies themselves. Convincing companies of our technical prowess is no longer enough, we also need to prove we are a stable, reliable and innovative company, and Gartner's endorsement goes a long way toward doing that.

It's not obvious to those who don't know us, but wherever I look, wherever I go, I see things designed using our technology. Now, the world gets to know what we do, and I find that incredibly exciting. Being a Gartner Cool Vendor will make our lives a bit easier by raising awareness of ESTECO to companies that may not be aware of us and what our technology can do.

ESTECO Insights

As a pioneer in numerical optimization, ESTECO provides innovative technology that enables engineers to make the most of their expertise while giving free rein to their creativity. As design complexity grows and demands for time and cost-effective tools rise, so does the need for technologies that effectively manage complexity — simply and rapidly. For over 15 years, ESTECO has been at the forefront of optimization technology and continues to provide industry with best-in-class solutions that makes life easier for engineers.

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Rave Computer Resolves New Design Engineering Challenges

High-performance computing power for digital workflows.

BY MIKE LAJOICE, *Commercial Business Unit Manager*

Design engineers are up against new challenges, and Rave Computer is ready to help. Modeling a design in its real-life behavior is now a common expectation. Physical characteristics and photorealistic results give the customer an interactive real-world result. This evolution has been expedited by advancements in software vendors' products that provide tools to quickly move from design concept to product manufacturing with fewer people and greater digital quality. Digital design with realistic rendering reduces the need for multiple physical prototypes, saving both time and money.

Optimized Hardware

Advances in engineering design and simulation software have put a strain on computer hardware, IT infrastructure and IT overhead. At Rave Computer, we work directly with the software vendors to provide computer hardware that is optimized for their software requirements.

Rave Computer brings high-performance computing power to your desktop with the Beast product line. Putting power at the fingertips of engineers improves their productivity, reduces traffic to offsite clusters, and minimizes IT overhead as they support simpler desktop workstations instead of complicated computers in server rooms. When the addition of cluster computing is needed, Rave Computer complements its high-performance workstations by delivering condensed, optimized, high-performance racked systems that can be portable and installed in engineering rooms or racked into existing server rooms.

Rave Computer has been delivering high-performance, whisper quiet, semi-rugged computer solutions to the Defense and Commercial industries since 1988. Rave Solution Architects are onsite at engineering and design facilities, working through technology issues to ensure that we are always developing and delivering current and advanced technologies to the industry. Sales, Product Develop, Warehouse and Product Build are all housed in the same 35,000 sq. ft. facility, allowing for efficient transfer of new product ideas through production to the customer.

About Rave Computer

Founded in 1988, Rave Computer is a technology consultant and computer manufacturer providing commercial-off-the-shelf and custom engineered solutions optimized for specific customer requirements. Driven by a focus on long-term relationships with customers, Rave continues to grow in recognition throughout the Defense, Simulation and Training, Commercial, High-Performance Computing and OEM/Custom Hardware markets.

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Getting on Board with the Industrial Internet of Things

Although the Industrial Internet of Things, or IIoT, is still in its infancy, standards and best practices for security and interoperability are already emerging.

BY MICHAEL BELFIORE

The 10-ton cranes that moved around pieces of stamped and welded metal to be sent to an auto plant from Kalida Manufacturing in Ohio were burning through parts. Motors, switches and brakes had to be serviced or replaced every couple of months — keeping maintenance costs high and plant managers unable to figure out why. Adding to the mystery: Brand new cranes supplied by Konecranes also went through parts at an alarming rate.

But those new cranes had a feature the older models lacked: they were connected to the Industrial Internet of Things (IIoT), which meant that they continually reported operational data to a central database.

All it took was a look at that data to pinpoint the problem: Each crane was logging more than 20,000 motor starts and stops every single week. "This is basically 167 times an hour," explains Jim Skowron, regional vice president of sales at Konecranes. "That's an incredible amount of stress on that hoist motor." Using the data, plant managers were finally able to trace the maintenance problem to simple operator error.

Previous generation cranes ran on just one speed; to slow one down as it was rais-

Konecranes has been involved in the lift industry for more than 80 years. It now has almost 12,000 employees in 47 countries. ***Images courtesy of Konecranes.***

ing or lowering a part required the kind of rapid starts starts and stops the operators were doing, even though both the new Konecranes machines, and their immediate predecessors in fact, had two speeds.

Solving the maintenance problem was a simple matter of training the operators at the plant to press motor switches halfway in for a lower speed, and all the way in for a faster one. Practically overnight, the motor starts and stops were reduced by more than half. Maintenance became more of a biannual affair than a bimonthly one. And with the simple application of relatively inexpensive training sessions, maintenance costs were cut more than in half.

Konecranes' IIoT solution, called TRUCONNECT, provides just one example of how the IIoT is transforming industry by providing never-before-achievable insight into industrial processes. Everything from manufacturing and transportation to energy production and agriculture will benefit from the IIoT revolution now underway, according to a report released by the World Economic Forum in January 2015 titled "Industrial Internet of Things: Unleashing the Potential of Connected Products and Services."

47% of *DE* readers surveyed were already involved or expected to be involved in developing Internet of Things products.

— January 2015 DE Reader Survey

But significant risks also loom ahead, as increasing numbers of machines and processes going online expose themselves to the wider Internet, warns the report.

Along with security, Richard Soley, Executive Director of the Industrial Internet Consortium (IIC), also cites interoperability as a major challenge that need to be addressed by engineers and managers building IIoT systems in order to realize the full potential of the Industrial Internet of Things.

Interoperability

Most technologists focus on the wrong problem, Soley says of the effort to address the challenge of interoperability — that is, getting machines and other devices of different types to share data. "They focus on the middleware: How do I get the bits and bytes moved around," says Soley. "That's an easy problem, and it's in fact been solved a long time ago." The harder challenge to overcome, says Soley, is that the bits and bytes are all

Konecranes' TRUCONNECT suite of remote service products that connect data, machines and people via the Industrial Internet of Things.

coming from devices of different types that use different protocols to communicate. In other words, they speak different languages.

It might be tempting to suggest the creation of a common protocol that all future devices could share, says Soley, but he cautions that this would only add to the problem. He says such a solution would simply add yet another standard to the protocol soup as manufacturers continue to support old protocols and also continue to develop new ones to take advantage of emerging capabilities. Instead, says Soley, the best solutions to the interoperability problem will be systems that can act as translators between devices using different standards.

And the best way to iron out any interoperability glitches in a given system, says Soley, is to build a testbed to see what works through testing.

AT&T, Cisco, GE, IBM and Intel founded the IIC in March 2014 to do just that. Each member company contributes expertise, personnel, and other resources in the service of developing best practices and standards for the emerging IIoT through the creation of testbeds. Even more than that, says Soley, the IIC is charged with developing entire new business models that will make even greater use of the IIoT than is currently envisioned.

42% of Konecranes' total sales comes from providing services, much of it driven by data from its connected machinery.

— Juha Pankakoski, Konecranes' chief digital officer, at the 2015 Siemens PLM Software Industry Analyst Conference

For example, in February 2015, the IIC announced a track and trace testbed that Soley says will change the way factory managers manage their plants. In addition, says Soley, "it's going to increase safety on factory floors in ways that nobody could possibly see coming."

Another IIC testbed in progress, launched in May, is a micro-grid project designed to do for a connected electric grid what the track and trace testbed is doing for the use of the IIoT in manufacturing. As this article went to press, the micro-grid project was finishing the first of three phases and had the participation of IIC members Real-Time Innovations, National Instruments and Cisco.

Designing reference architectures and running them first in laboratory conditions and then in field trials is the best way to determine how to get disparate devices and systems to play nicely together, agrees Nick Butler, group manager for Embedded Systems Product Marketing at National Instruments.

For the first phase of the micro-grid testbed, engineers have assembled a small-scale prototype in a National Instruments lab. The setup incorporates a pair of National Instruments CompactRIO control and monitoring systems and takes up the space of one or two desks. For Phase Two, the testbed will move to a hardware in the loop (HIL) facility for further testing and development with similar electrical loads as it would experience in actual use. The third and final phase of the testbed project, to be completed by the end of 2016, will deploy an IIoT-connected solution to an electrical substation that will bring a new level of control and monitoring to grid operators.

The standards architectures produced in the IIC's testbeds will be available to IIC members and any organization that partners with them.

Security Tops Concerns

Of course, all of these new things going online represent potentially many more points of vulnerability where data can be accessed without authorization or malicious code introduced.

Godfrey Chua, Principal Analyst at Machina Research, an Internet of Things advisory firm, says that his company's research confirms that for current and potential users of IIoT-connected systems, security is one of the biggest concerns. "If we are to continue to maintain the momentum and accelerate the growth of IoT, it's really incumbent upon the industry to address the security concerns

Konecranes' motto: "Not just lifting things, but entire businesses" is supported by connections to sensors on over 9,500 of its customers' devices, and its use of Siemens PLM Software's Teamcenter.

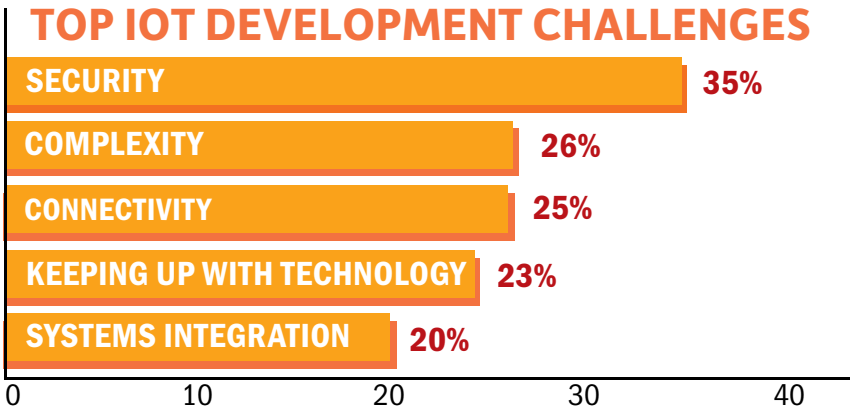
that potential customers have." Much of the concern among IoT users, says Chua, comes from a shortage of the expertise needed to address potential risks.

As for addressing those risks, Chua says that it's important to look at entire IoT architectures rather than to focus solely on individual components. "The fundamental challenge of security and IoT is that if you look at any IoT solution there are many pieces," says Chua. These pieces include the network itself, individual applications, and devices running the applications. "The many doorways through which a malicious actor may find its way into your solution just makes it harder to keep up," he adds. For that reason, Chua recommends taking what he calls a holistic approach to security for any given IoT solution, by building security in from the start of the design process, and not to try to address it piecemeal for each piece of technology involved.

The good news, says Chua, is that the technology already exists to build secure IoT systems. The biggest impediments to IoT security that he and his colleagues at Machina Research see are errors of oversight. "It could be as simple of forgetting to implement authentication," says Chua.

To ensure that nothing is overlooked, and because a given IoT system may touch many different business functions — including IT, operations, sales, and just about every other department of an organization — Chua envisions the creation a new executive position that would report directly to the CEO. "One of the big conversations right now in the industry is whether or not it's time for a chief IoT officer in the organization," says Chua.

Even with standards and best practices still emerging, the benefits of the IIoT are already clear. Biased though he may be, Konecranes' Skowron probably speaks for many when he says: "You'd be nuts not to make sure that the equipment that you're buying has this technology on it." DE



When asked to pick three of the top challenges they face when developing or planning to develop IoT products, *DE* readers said security was their No. 1 concern. *Source:* DE *reader survey, January 2015.*

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.*

INFO

- **Cisco:** Cisco.com
- **Industrial Internet Consortium:** IIConsortium.org
- **Konecranes:** Konecranesusa.com
- **Machina Research:** MachinaResearch.com
- **National Instruments:** NI.com
- **Real-Time Innovations:** RTI.com
- **Siemens PLM Software:** Siemens.com/plm

CHAPTER 4 EXCERPT

Virtualization Gets Real

Virtual computing can complement engineers' local workstations.

The Dell Workstation Virtualization Center of Excellence helps software providers and customers move high-end workloads into a virtualized workstation environment. ***Image cortesy of Dell.***

The term virtualization refers to the practice of creating, maintaining, and deploying digital counterparts — or virtual versions — of hardware, operating systems, networking environments and storage systems. Constructed largely in software code, these virtual entities have one clear advantage over their physical siblings: They can be remotely accessed from anywhere. One type of virtualization that has been steadily gaining ground in the engineering community is desktop virtualization — duplicating the functions of powerful professional workstations in a virtual environment.

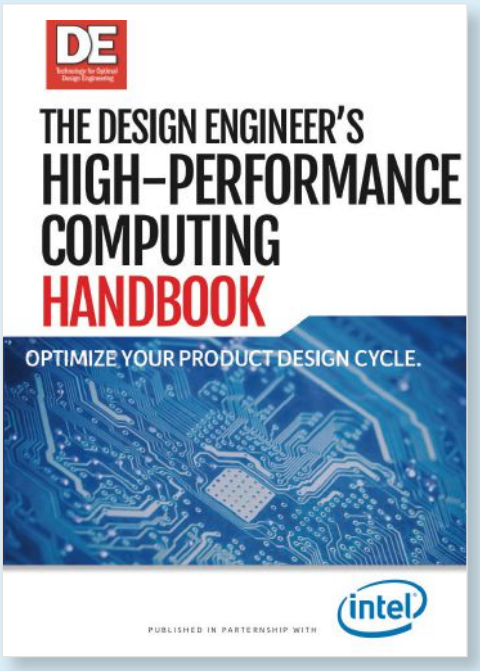
By and large, professional design and engineering workload demands workstation-class hardware. Such systems are configured with the right balance of processing power, graphics and memory to run industry-standard CAD, CAM and CAE software. They have also been tested and certified by independent software vendors (ISVs); therefore, they're guaranteed to deliver optimal performance in the chosen software's modeling, design and visualization environments. The drawback, however, is restricted mobility. Workstations — especially the desktop variety — are not designed to be easily portable. They're designed to remain fixed in a des-

How the HPC Handbook Works

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

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

Check it out at hpc.deskeng.com.



ignated location. Widespread connectivity has freed many types of workers from the offices and cubicles so they can work from home, from a cafe, on a train, at the airport—virtually anywhere they can find a reliable web connection. But this luxury eludes those in engineering who have computing needs that cannot be met with mobile workstations. Reliance on powerful desktop/deskside workstations means users must remain physically close to the hardware.

However, in a virtualized environment, an engineer can work with a virtual machine, configured to deliver the same computing capacity of a physical workstation. The decoupling of the backend hardware from the frontend access point is one of the primary advantages of virtualization. In such a setup, an engineer can experience workstation-class performance remotely.

The other big benefit of desktop virtualization is realized by IT management. Because the virtual machines are all under the direct control of IT, it's easier to apply updates, ensure security and quickly fix any issues that might arise. While some enigneers may balk at losing direct access to their physical machines, there are a number of enterprise-wide benefits that could tip the scales toward virtualization.

Driven by Server-Class Hardware

Contrary to what the name suggests, the virtual desktop infrastructure (VDI) is not exactly a hardware-free environment. Quite the opposite. The VDI has to be built on top-of-the-line server hardware, supported by a stack of robust virtualization software and reliable connectivity. Otherwise, the subpar experience of the virtual machine would be a compromise to the engineer who's accustomed to a workstation's responsiveness.

If you think hardware vendors might shun the virtualization movement, you'd be wrong. Despite their vested interest in workstation sales, Lenovo, Hitachi, Fujitsu, HP, Dell, Samsung and other major hardware providers are regular sponsors of the annual VMworld conference, an industry event dedicated to virtualization. In March 2014, Dell launched a new Workstation Virtualization Center of Excellence and Dell Wyse Datacenter for Virtual Workstations solution, two initiatives that anticipate the growth of VDI.

"We are seeing a change in the way users of data and graphics-intensive applications are able to securely access their data outside of the office," said Andy Rhodes, executive director of Dell Precision product line. "The idea of the fixed location-based workstation has changed as users need to be mobile and collaborate efficiently with others both within and outside of their organization. Furthermore, the notion of a 1:1 relationship between a user and a piece of hardware is going away, as an increasing number of IT managers see desktop virtualization as a viable means of providing users with a secure, manageable and resource efficient way to access their desktops and applications."

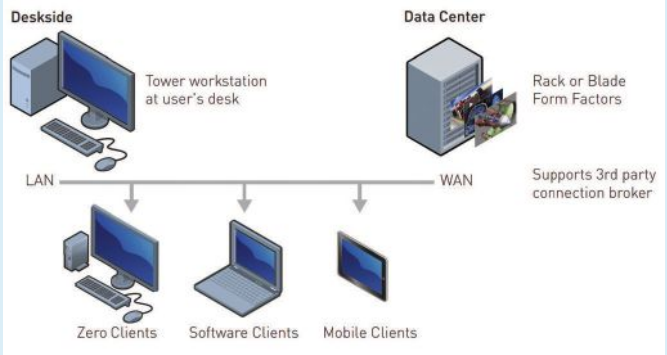
Every virtual machine in the private or public cloud is powered by a piece of physical hardware with enough computing resources to support it. VDI isn't seen as the death knell for workstations. It could be the prelude to an era where you can access your workstation from any connected device.

PCoIP, FYI

PC over Internet Protocol (PCoIP) is also part of the broader trend freeing the workers from the hardware they were previously tethered to. Whereas VDI uses clusters to spawn and support a pool of virtual machines (VMs), PCoIP lets a user directly control a workstation via a network connection. VDI is designed to be one-to-many setup; PCoIP is intended as one-to-one setup. Currently, Dell offers PCoIP solutions in partnership with Teradici. The solution can be hardware-based (facilitated by a remote-connection card in the system) or software-based.

According to Teradici, the software-based remote experience is "ideally suited to small and mid-sized businesses (SMBs) in architecture, construction, engineering and manufacturing." Olivier Favre, Teradici's director of product marketing, reveals, "The target market for the [software-based solution] is small- and mid-sized companies with 50-100 workstations."

In the July 2015 issue *DE*, Contributing Editor David Cohn observed, "PCoIP offers numerous benefits, including remote access, security, application independence, local collaboration and high performance. PCoIP technology transmits pixels, not data, and even those pixels are encrypted. Because the software sends pixels from the workstation display, it works regardless of the applications being used and the types of content being generated."



PCoIP sends pixels from a deskside workstation to zero/thin clients over the network. *Image cortesy of Terdici.*

CHAPTER 5 EXCERPT

Investing in Workstations vs. Consumer PCs

You can't do your job if you don't have the right tools

All professional workstations are computers, but not all computers are professional workstations. If you are only running MS Office applications, you can use just about any computer. But engineers running CAD, CAE or rendering software, you really should not be using just any computer. You need a workstation certified to run your software. Yet many companies provide their engineering professionals with standard consumer-grade personal computers.

Why? It may be a cost issue. After all, workstations cost more, don't they? Not really. There is not that big of a difference in price between entry-level workstations and consumer PCs that seem comparable on paper, and even high-end consumer systems are not ideal for professional engineering work, according to Richard Runnells, director of Marketing for Solid Edge at Siemens PLM Software.

"While in some instances using a high-end consumer PC or even a gaming PC may work to meet the minimum requirements for desktop CAD applications, typically these systems are maxed out and provide little to no room for future expansion," he says. "The cost of an entry-level workstation, which comes pre-configured and certified to run CAD applications, such as Solid Edge, is in many cases lower in price than that of a top-of-the-line gaming PC."

Jeff Wood, vice president of Product Management for workstation and thin client business at HP agrees. "Buyers are missing a huge benefit in productivity when they opt for the consumer PC. The workstations have been highly tuned for professional applications," he says.

Calculating Return on Investment

The length of time it takes to pay off a new workstation via increased productivity will vary depending on the amount of time spent doing design engineering, the engineer's salary, the amount of time saved, and the price of the workstation.

While studies show a wide range of productivity improvements, let's use some conservative numbers and calculate the return on investment (ROI) one might expect to achieve by upgrading from a PC to a workstation. For this example, we will assume that our engineers are paid

What Makes a Computer an Engineering Workstation?

Engineering workstations are more than just the sum of their parts. A modern workstation is a balanced system based on the current processor, memory, storage and graphics technology needed to run today's CAD, CAE, and visualization software.

While a PC may have enough power to run CAD applications, doing so often pushes the PC to its limits. A workstation, by comparison, typically has power to spare. Computers typically classified as workstations have a number of features that set them apart from general-use PCs:

- Error correcting code RAM
- Dual processors and multiple processor cores
- Optimized graphics processing units
- Independent software vendor certification

Workstations are also designed for easy deployment, maintenance and expansion. Details such as sturdy handles, easy-to-access hard drives, and other tool-less features save money and headaches when it comes time to expand those systems or replace components.

Professional workstations are also designed to require less maintenance. Workstations can run 24x7, improving the efficiencies of design engineers by day and running complex analyses unattended at night, with less risk of failure

a salary of $80,000 per year and spend one-third of their time actually using CAD software. So $27,000 of their salary is devoted to time spent using CAD. We will also use a conservative estimate of a 30 percent increase in design productivity achieved by investing in a new workstation.

Workstation ROI Calculation

- *Cost of a new workstation:* $4,500
- *Cost of the engineer's time:* $80,000/year at 250 working days per year at 8 hours per day= $40 per hour
- *Time spent doing design work:* One-third of an 8-hour day= 2.64 hours each day
- *Time saved using workstation:* 33% of 2.64 hours a day = about 54 minutes per day at 250 working days per year = 225 hours per year

Based on these numbers, the amount that could be saved annually by upgrading to an engineering workstation can be calculated as follows:

- *225 hours per year at $40 per hour = $9,000 per year*

Clearly, the engineering workstation can pay for itself.

More Reasons to Upgrade

Even if you already use a workstation, you should seriously consider an upgrade if that workstation is more than three years old.

The larger the model the more time it takes to compute, manipulate and store on the same system. On older workstations, large models sap your ability to innovate and your company's ability to compete. By some estimates, CAD model sizes double every two years, yet most companies hold onto their workstations for more than four years and many only update core CAD software every fifth release.

Even if you do upgrade your software more often than that, you may be paying a huge performance penalty. Installing the latest engineering software on underpowered hardware can further decrease the speed with which you design. New versions of CAD, CAE, and visualization software typically offer improved productivity, but software designed to take advantage of the latest advances in hardware can run slower if you install it on an older computer.

In one study conducted by Lenovo, the company pitted two similarly equipped workstations against each other running SolidWorks 2013. Both systems had identical amounts of memory and solid state hard drives. The ThinkStation S30 completed the identical design task more than twice as fast as the three-year-old S20.

"Giving engineers a new workstation is really the foundation for innovation," says Tom Salomone, Engineering and AEC and Manufacturing Segment Marketing Manager at Lenovo. "You want them to compute as fast as they think. You don't want their computers slowing them down."

Similar results have been reported by customers. In a case study published by Lenovo, the McLaren Mercedes Formula One racing team upgraded the hardware it uses to run its CAD, engineering, and simulation software. The design team was expecting modest performance gains of about 2 percent, and they would have been happy with that. "We have come to realize that we may have massively underestimated this," said Alan Dueden, lead systems engineer at the McLaren Technology Center. "A figure 10 times that might be a little nearer to the mark." Their MIDAS simulations were 30 percent faster, assembly drawing changes improved 25 percent, and parametric updates were 60 percent faster.

Quite simply, the right tool for an engineer's job is a professional workstation. Without professional workstations, a company's innovation engine is stalled. The engineer's pace of work gets reduced to match the sluggish speed of outdated or inadequate hardware. Yet workstations are more capable and affordable than ever. Their return on investment is outstanding.

For design engineers, a professional workstation means more time spent creating new products and improving existing ones and less time spent waiting for large assemblies to load or simulations to run. For IT specialists, equipping power users like design engineers with professional workstations means less time spent diagnosing and fixing issues. And for executive management, investing in an affordable professional workstation can pay for itself in a very short time.

The decision to invest in a professional engineering workstation is not just about the bottom line. It's about making better designs, speeding up the design cycle, and growing the business.

Learn More

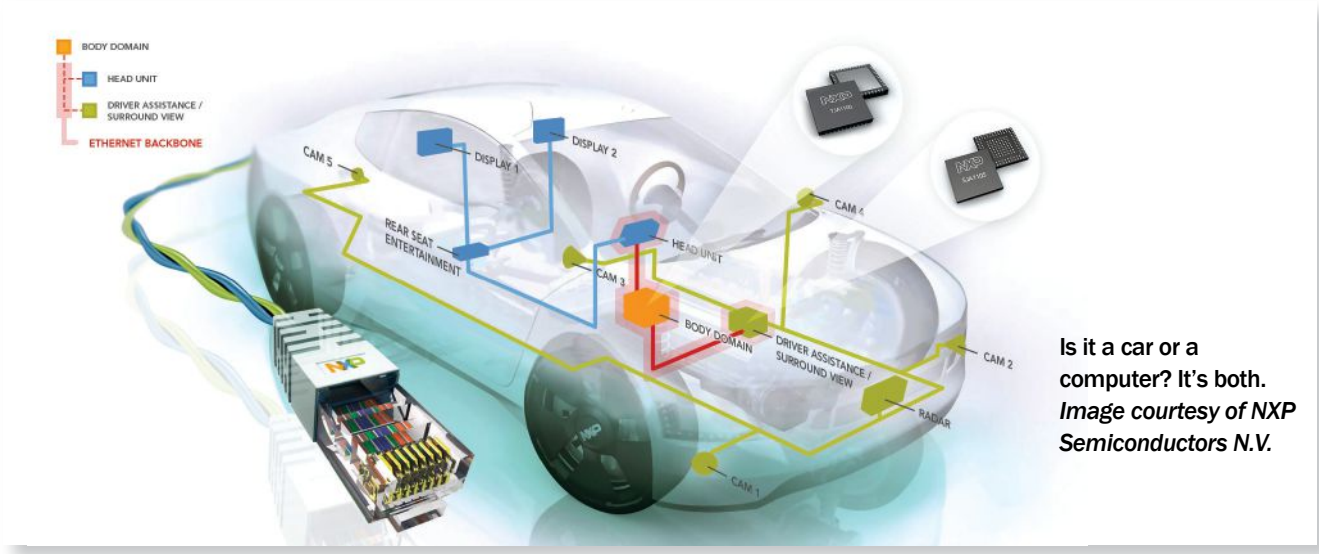
To learn more about building a balanced workstation and parallelization, download *The Design Engineer's High-Performance Computing Handbook,* which has just been updated with two new chapters covering those topics. The full version of chapters 4 and 5 include a discussion of the benefits of error-correcting code RAM, dual processors, GPUs, ISV certificatons, ROI justifications, definitions of terms and more.

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

Intelligence and the Connected Car

Networking, software and powerful processors continue to transform our primary mode of transportation.

BY PETER VARHOL



Is it a car or a computer? It's both. ***Image courtesy of NXP Semiconductors N.V.***

After decades of incremental improvement in visible technology, the automobile has undergone drastic changes in the last 10 years. Perhaps the most significant of those changes is the incorporation of connectivity, including Internet access and wireless data communications: the connected car.

The connected car includes music and audio, smartphone apps, navigation, roadside assistance, voice commands, contextual help/offers, parking apps, engine controls and car diagnosis functions. Further, driver assistance and even driverless cars are transforming the story of personal transportation. It will take a decade or more to approach that goal, but the fact that it is within reason is a testament to the tremendous advances in automated control and connectivity.

More vital uses of automotive intelligence and connectivity include diagnostics and prediction. By providing more detailed data and better ways of analyzing that data, automobile performance can be optimized and potential problems can be predicted. Further, automated decisions can be made in real time, enabling the vehicle to quickly adapt to changing technical or environmental situations.

Driving these changes is a combination of high-performance embedded processors, unique computing and software innovations, a vision of networking between previously separate automotive systems, and the addition of wireless communications to deliver engineering innovations to the driving experience.

Connected Systems in the Car

Just what is connected? It's useful to divide this phrase into three distinct categories: connected within the car; connected between car and a back-end computing infrastructure; and connected with other cars. These categories represent the major initiatives for the automotive industry in terms of connectivity, and also involve different goals and technologies.

Connected within the car is farthest along. Most current model cars have multiple processors, and are using the legacy CAN (controller area network) bus for connectivity. A CAN makes it possible to move data around reliably, so that data can be shared between automotive subsystems. For example, the engine emission sensors send data to instruments detailing

measurements of gasses, which are evaluated and presented to indicator lights and to instruments that are used in service facilities. This data is usually transmitted on the vehicle CAN bus between engine systems, emission monitors and displays.

The ability of cars to exchange data between different subsystems provides for greater analysis, information and reaction between systems that can work interdependently. The drivetrain would benefit from real-time data on engine operation. Different sensors at different points within the engine can provide a mixture controller with a finer degree of data on fuel consumption, providing for a level of fine-tuning that simply was not possible a few years ago. This type of control is enabling higher fuel economy, less engine wear and fewer emissions.

However, CAN is limited in bandwidth, and cars are in need of greater bandwidth and connectivity than CAN is able to provide. With an average of 50 or more processors on a car, the amount of data processed has grown enormously in the past few years. Some of these are standard embedded processors, while others are specially designed using FPGAs (field programming gate arrays) or ASICs (application-specific integrated circuits). It's not unusual for a new car to have hundreds of pounds of electronic components monitoring and controlling engine performance, fuel mix, brakes, power, drivetrain, and a host of other activities. Hybrid and electric cars have still more electronics.

250 million cars will include some form of embedded technology by 2020.
— Gartner Research, January 2015

Aggregating Data Off the Car

As off-car analytics become increasingly important in analyzing and optimizing auto performance, bandwidth needed to connect many cars to a central server infrastructure will likely operate alongside the CAN bus controlling in-car connectivity. Only a subset of auto data will be sent off of the car, and it is more likely that this connection will use protocols that better support traditional IT operations.

Car-to-server connectivity offers the best opportunity for near-term enhancement of automotive electronics, feedback, and improvements in car operations. Car-to-server refers to the ability of many individual cars to send data from the car to a central location in the cloud. The purpose of this data can be multifold. Data aggregated from many cars can be used for a variety of analytics. "Once we better understand events leading up to failures, we can use that data to predict failures in individual cars," says Wenis Jin, automotive industry manager at MathWorks.

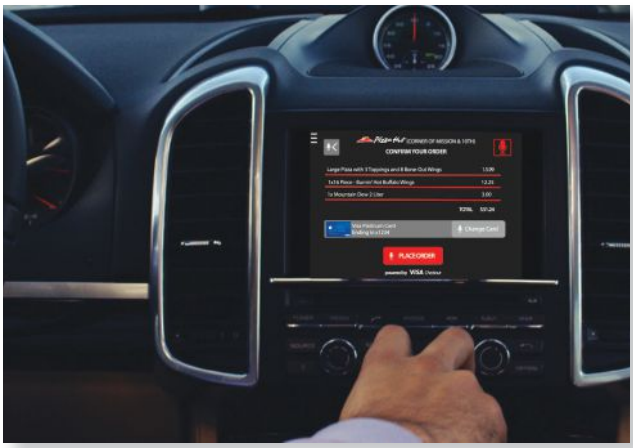
And data will go both ways. Once there are good data models, centralized applications can inform users to obtain service. "We could also make adjustments to systems, by downloading new software or changing parameters," says Jin. "Outright failures are uncommon, but they are drastic events for drivers. We can make them even less common."

Car-to-car connectivity may be the level of communication required to produce self-controlled (or driverless) cars. Today, the driverless concept cars on the road operate through a combination of real-time GPS updates and sensors on the auto's perimeter. Initial tests indicate that they may have safety advantages over cars with human drivers, in large part because they are able to detect and react to external activities, such as other cars and pedestrians. With highly accurate maps and GPS, cars navigate between points and avoid obstacles.

But car-to-car communication makes this possible on a much larger scale. Cars within proximity to each other can exchange sensor data as well as velocity and direction. Think of it as choreography, with many cars communicating constantly in order to navigate while avoiding each other.

Getting there will be a long and involved process. While sensors and high-performance processors make this feasible today, it could be decades before enough autos possess the technology to make it worthwhile to use car-to-car communications for practical purposes.

The Audi tablet includes gesture controls, 3D sound for a concert-hall atmosphere in the car, the Audi phone box and the seamless integration of smartphones into the car. *Image courtesy of Audi.*



Visa, Pizza Hut and Accenture are developing a connected car commerce experience to test mobile and online purchases on the go. *Image courtesy of Business Wire.*

Distracting, but Enhancing the Driver

One legitimate concern surrounding the connected car is that the many features enabled by connectivity might serve to distract the driver from his or her primary responsibility of driving the car. While it's true on one level, on another it's made driving safer by taking more decisions out of the hands of the driver and automating them, and making the cars safer by improving diagnostics and predictability.

That starts with collision warnings, based on sensors on the perimeter that detect close objects and those closing in on the vehicle. This involves the use of sensors on the perimeter of the vehicle. Collision avoidance follows, with cars having the ability to brake automatically, or turn to avoid obstacles. Multiply this by hundreds of cars in the immediate vicinity and you'll see how safety is being significantly improved.

Maintenance and optimal performance are also improved through the use of analytics. Cars can be made more efficient through monitoring and feedback of data from engines, drivetrains, brakes, and other systems susceptible to wear and eventually failure. Informing cars and drivers of impending failures — and even possibly downloading fixes — is fast transforming the transportation experience.

The Technology Behind the Automobile

What makes these innovations possible? One is the use of inexpensive multi-core processors that provide for multiple independent tasks to be performed by a single processor. This architecture provides a higher level of computational capability and performance, the ability analyze data, and respond in real time.

Graphics processors are also making a significant impact. The four-core NVIDIA Tegra K1 mobile processors are driving instrument and navigation displays, for example. NVIDIA processors can also be used for fast-floating point operations in general, expanding their use into data processing and decision making.

204% Amount that revenue from all digital auto content (entertainment, safety, vehicle management, etc.) is expected to grow between 2016 and 2021.
— PwC's Connected Car Study, 2015

Cloud computing is also contributing to auto connectivity. Virtually unlimited processing power on the back end makes it possible to gather data from cars, aggregate it and provide data for diagnostics, prediction and future car designs.

There is no turning back the clock on the connected car. Electronics, software and networking have only started to scratch the surface of what is possible. There will be new and different issues as our cars start looking more and more like computers, but the overall effect will be positive on both the industry and the user. DE

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3D Printing Clocks In

Additive manufacturing will be a part of more shop floors in the future, and it will change the design for manufacturing process.

BRIAN ALBRIGHT

Cincinnati Incorporated's Big Area Additive Manufacturing (BAAM) system has been used to produce Local Motors' Strati, a full-size Shelby Cobra automobile, a scaled fighter jet, a 12-ft. kayak, and more.

Most of the media buzz around 3D printing/additive manufacturing (AM) technologies has centered on the home or small-shop-based maker. But the biggest driver of what the *Wohlers Report* estimates to be a $4.1 billion market for AM services and products, has been its integration into traditional manufacturing workflows.

Manufacturers are moving well beyond rapid prototyping (although that is still an important application) and using 3D printing for fixtures, jigs, mold and die creation, tooling, and to create finished parts. That is happening across multiple industries, most notably in auto, aerospace and in the medical/dental markets.

"The accelerated growth that we've seen over the last several years has been the adoption of the technology on the production floor, and we see that as being the largest opportunity as we look out over the next five to 10 years," says Rich Garrity, vice president and general manager of vertical solutions at Stratasys.

In almost all of these use cases, 3D printing has been integrated into existing workflows, augmented by additional processes like machining, forging, molding, etc. "It's just like having another tool in your toolbox," says Patrick Dunne, director of industrial 3D printing applications at 3D Systems. "Like any manufacturing process, it will be part of a combination of different tools that are selected to make something."

It is also changing the way engineers design parts, assemblies and finished products. AM makes it possible to create complex geometries that either would have required multiple pieces in the past, or that weren't possible at all using traditional processes. Limitations on what can be fabricated are rapidly falling away, and that will require a new approach to design and the ability to incorporate more rapid iteration and optimization processes.

"For subtractive processes, a number of design rules are taught — and those don't apply to additive manufacturing," says Andy Snow, senior vice president at EOS. "There is a greater level of freedom of creation."

3D printing presents two key value propositions when it comes to manufacturing. First, it enables the mass production of custom pieces, although these are not always finished products. Orthodontics manufacturer Invisalign, for example, uses printers from 3D Systems to create thousands of custom aligner models. Those models are used for thermoforming the final dental aligners. "What they are doing is mass custom manufacturing of disposable tooling," Dunne says. "The largest adopters of 3D printing are not using the printers to make the final product, but are making an intermediate product in the manufacturing process."

Customization and Complexity

The sweet spot for AM now is in low-volume, high-complexity structures — an extreme example of which is the Strati, the 3D-printed concept car that Local Motors assembled at the International Manufacturing Technology Show (IMTS) in 2014 using

These direct metal laser-sintered parts, additively manufactured via an EOS M 290 system, have been "grown" onto small sub plates. This System 3R palletization concept allows parts created via AM to remain on sub plates through the balance of the machining process. ***Image courtesy Georg Fischer Machine Systems (GFMS).***

the Big Area Additive Manufacturing Machine (BAAM) from Cincinnati Inc. created at Oak Ridge National Laboratory.

The Strati demonstration simultaneously proved the notion that you can print an entire car (minus the tires, the powertrain, and a few other components) and highlighted some of the limitations of the technology. A Toyota factory is unlikely to churn out 50,000 vehicles per year using the same techniques.

But the Strati does represent an economical way to create a completely custom vehicle. Local Motors is turning its attention to what Alex Fiechter, head of product development at Local Motors, refers to as the "nitty gritty" of developing design rules and best practices for the additive processes used on the Strati. There will be more materials testing and crash simulations, for example, as well as investigating different production processes.

"We still have a lot of work to do on our printed vehicle, but it's very illustrative of what can be done," Fiechter says. "Even as we look at the possibility of embedding structural elements into the car, it's a much easier situation for us because we can embed the assisting componentry to create a full, enclosed part as the car is being created. You couldn't do that with another process."

Starting next year, GE Aviation will roll out its CFM LEAP engines — the first aircraft engines to include 3D printed parts. In this case: 19 fuel nozzles that the company says could not be produced using traditional techniques. The nozzles are 25% lighter than their predecessors, and will be made in a single piece (compared to the 18 parts previously required). A more intricate design also provides five times higher durability.

That's a good example of the types of opportunities AM opens up for design iteration and optimization. "There's almost no correlation between cost and complexity," Dunne says. "You get step changes in efficiency and optimization of the product itself."

Manufacturing engineers have traditionally had to compromise on designs to make it possible to fabricate an assembly in a cost-effective manner. 3D printing allows engineers to design for pure functionality and ignore other constraints. "It's like putting accelerant on design optimization and iteration," Dunne says. "You can review a concept within hours of designing it."

Integrating Additive

Using 3D printing and additional manufacturing processes to complement each other is the way forward, according to Snow at EOS. The company recently partnered with George Fisher Machining Solutions (GFMS) to integrate additive manufacturing machines into the production of mold inserts. "We're integrating additive into the overall process chain," Snow says. "We're integrating what we call the GFMS System 3R approach, which is a highly accurate reference system that links all the machines in a workshop with a common reference, enabling seamless, automated transfers from machine to machine."

The two companies have introduced the AgieCharmilles AM S 290 system, which produces molds and dies using metal laser sintering. It allows mold makers to move thermal exchange closer to the surface of a mold. It can be integrated with other GFMS machine tools and measuring devices.

Alcoa, a company that has rested its fortunes on traditional manufacturing, is expanding an R&D center in Pennsylvania to accelerate development of 3D printing materials and processes. The company hopes to cash in on demand for complex 3D-printed metal parts for aerospace, automotive, medical, construction and other applications. Alcoa sees the integration of additive and traditional processes as a key strategy, exemplified by its Ampliforge process, which involves printing a near complete part and then treating it with a process like forging to increase part strength. The process is being tested at facilities in Pittsburgh and Cleveland.

Again, the key contribution of AM in these scenarios is the ability to create more complex parts as a single unit. "The power of additive manufacturing really starts in the design process," Stratasys' Garrity says. "If a company is looking to just replace a traditionally made part with a printed part with the same design, often it doesn't make sense."

Benefits come from freeing up the engineers to design better parts, regardless of the manufacturing process. "You can design structures with lattice interiors to get weight reduction," Garrity adds. "Aerospace and auto manufacturers are under pressure to meet weight requirements, so that is a big benefit for them."

Prototypes to Finished Parts

Even the idea of rapid prototyping, a longstanding AM application, is starting to work its way into finished products. According to 3D Systems' Dunne, automakers are using 3D printed components to help shave time from their go-to-market cycle. The long lead-time on creating injection mold tooling for nylon parts in a vehicle can add weeks to the launch cycle. By printing a run of those parts up front, they can launch the vehicle while the tooling is being produced. "Time is money, so while it's more expensive to create nylon parts on a laser sintering machine, there's still an economic justification for that type of bridge tooling because they get to market sooner," he says.

Jigs, fixtures, tooling and other secondary manufacturing equipment are another key area where 3D printing has flour-

55% of *DE* readers surveyed are using or plan to use 3D printing for end-use parts or products.

— DE's "The State of the 3D Printing Solutions Market" report, sponsored by Stratasys

ished. "We see it put ion the production floor to customize jigs or fixtures for a particular line process or for the ergonomic benefits of the line workers," Garrity says.

In aerospace, composite tooling and molding are allowing manufacturers to create more complex shapes and to more easily change or reproduce those shapes with less investment.

"That also adds to the direct part side of the equation, because that ability to make new geometries has an even larger impact. You are forced or encouraged by the technology re-evaluate how you've broken that product up," Fiechter says.

And the direct part side of the equation is getting bigger. The Airbus A350 XWB uses more than 1,000 3D printed parts, Honeywell International is testing a 3D printed heat exchanger, and GE Aviation, Pratt & Whitney and other companies are also putting printed parts on their planes. AM revenues in aerospace are expected to reach $1.7 billion in 2020 and expand to $3.3 billion in 2022, according to SmarTech Markets Publishing.

The United Launch Alliance, a joint venture of Boeing and Lockheed Martin, is testing additive manufactured parts for rockets. The venture's Atlas V and Delta IV rockets will include components printed on Stratasys Fortus 900mc equipment with ULTEM 9085 material.

Being able to produce limited access or blind geometries forces engineers to look at the functional duties of every element of a vehicle, for example, and divide those functions differently across a given part. "Instead of an exterior panel simply serving an aesthetic purpose, it can also provide ergonomics and include a body structure for crash absorption," Fiechter says.

Materials, Education Remain Obstacles

There are still challenges for firms trying to integrate AM on the plant floor. One obstacle is material selection. For some applications, there aren't always appropriate materials for the existing printing processes, or the processes are too slow.

"There is certainly metallic 3D printing, but the deposition rates are much lower than with polymers, so you butt up against that issue of speed," Fiechter says. "Cars are built on top of structural steels for safety and crash energy absorption. Now you have to rewrite the book, and find media that can be run through this process with a new type of machine and method of deposition — yet still functionally perform the same way."

There also needs to be more integration with manufacturing systems, as well as tools to can make it easier for designers to determine which parts make sense for additive.

The biggest barrier, however, is a lack of familiarity among engineers and manufacturing executives. "Designers just need more experience and familiarity with the process," Garrity says.

EOS has introduced its Additive Manufacturing Consultancy to provide that type of education to clients, including everything from simply introduction to the technology up to a complete assessment of the business. EOS is also working with Underwriters Laboratory on its AM educational efforts. DE

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- **3D Systems:** 3DSystems.com
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- **EOS:** EOS.com
- **Local Motors:** LocalMotors.com
- **Stratasys:** Stratasys.com
- **Underwriters Laboratory:** industries.ul.com
- **Wohlers Associates:** WohlersAssociates.com

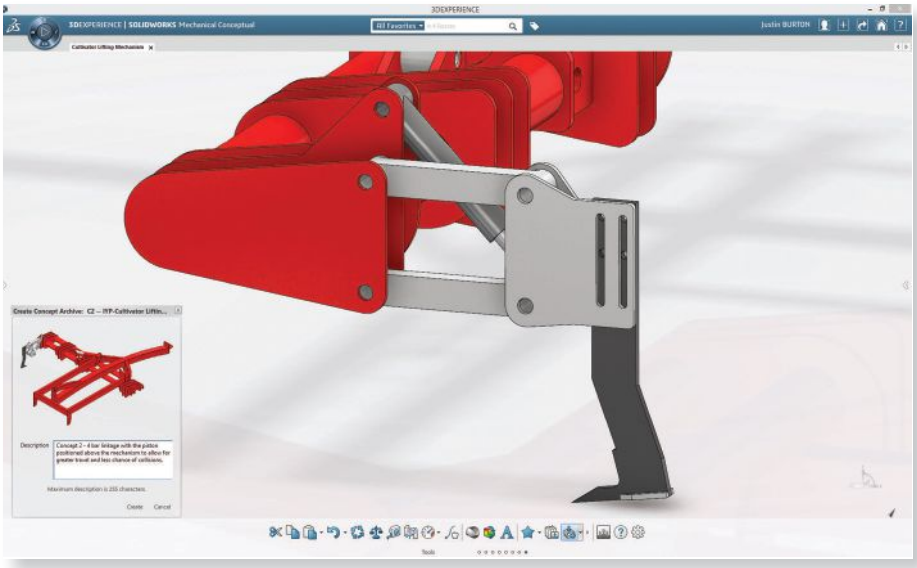
The Dawn of Pay-As-You-Go CAD

Does the shifting of CAD licensing signals the beginning of a new era?

BY KENNETH WONG

Earlier this year, just a week shy of Valentine's Day, Autodesk signaled the perpetual license's twilight: "New commercial seats of most standalone desktop software products will be available only by desktop subscription beginning February 1, 2016," the company declared. In doing so, it publicly crossed the point of no return.

In enterprise, consumer and product lifecycle management (PLM) software sectors, brands like Salesforce, Norton Antivirus and Arena Solutions have proven subscription licensing to be a viable, sustainable model. But in the design and engineering software market, the status quo is perpetual licensing. Here, "subscription" remains a touchy subject; it still raises eyebrows and blood pressure.



SOLIDWORKS Mechanical Design (initially introduced as Mechanical Conceptual) goes on sale via quarterly and annual subscriptions. The new licensing model is a departure from traditional perpetual desktop licenses. ***Image courtesy of SOLIDWORKS.***

Its opponents see subscription licensing as a way for some vendors to keep the users on a long leash, hold their proprietary data hostage, and collect fees indefinitely. Others may welcome the subscription model because the pay-as-you-go or pay-per-usage option gives them instant access to the software at a much lower cost.

According to Jon Peddie Research's 2015 CAD Report, Autodesk accounts for 29% of the $8 billion CAD market. As such, the company carries a lot of weight. When it makes a major policy shift, it tends to produce repercussions across the market. Its decision to fully commit to subscription is closely observed by its partners, customers, resellers and even rivals, because everyone has some skin in the game.

The Long Goodbye

In September, Andrew Anagnost, Autodesk's senior vice president of Industry Strategy and Marketing, began talking to the press to clarify how the company intends to handle the existing perpetual license owners. He assured them that customers who have bought perpetual licenses will continue to get updates "for as long as they are on maintenance."

Some buyers began stocking up on perpetual licenses to beat the imminent cutoff date, Anagnost acknowledged. "But not as much as we thought we might see," he says. In many regions, the opposite happened. "In Australia and New Zealand, we stopped selling AutoCAD LT [via perpetual licenses] last year. But what happened was that the number of people buying AutoCAD LT went up after that," Anagnost says. The implication is that the lower upfront cost in subscription is enticing more buyers to pick up the software.

Whereas Autodesk is jumping in with both feet, Dassault Systèmes took a more cautious approach. SOLIDWORKS, Dassault Systèmes' rival product to Autodesk Inventor, remains a desktop product for perpetual licensing. "The majority of our SOLIDWORKS customers want to buy perpetual licenses. Our customers prefer to own our best-in-class design software where they create their IP (intellectual property)," says Kishore

Boyalakuntla, senior director and leader of Product Management for SOLIDWORKS.

Adopting a hybrid approach, Dassault Systèmes began offering its two newer cloud-centric products — Industrial Designer and Mechanical Designer — as quarterly and annual subscriptions. The announcement was made at the SOLIDWORKS World 2015 user conference. "The Lighthouse customers [with early access] told us [Mechanical Conceptual] is not a tool they'll use for only one month or two. They'll do concepts all year long, so they're already committed to a yearly lease. [The subscription term requirement is] not an issue for them. But maybe we'll see other smaller customers and independent designers who're not like that. We're all going to learn from this, and we'll adjust if needed," said Bertrand Sicot, former CEO of SOLIDWORKS.

Going After the Non-Committal Buyers

In September 2013, Siemens PLM Software tiptoed into subscription by introducing a monthly licensing option to its mainstream CAD program Solid Edge. Prices range from $100 a month (design and drafting only) to $400 a month (comprehensive 3D CAD with support contract).

Kris Kasprzak, Siemens PLM's marketing director at the time (currently product manager for NX), explained: "A typical use case might be a government contractor who needs to work on a project for six months. They don't want to buy the software, but want to be able to pay for it for using it six months. Or start-up companies without a lot of money. They can use Solid Edge on subscription until they've made it and realized they'll need to use it perpetually. Or businesses that are cyclical, like toy manufacturers who're on fire during holiday seasons, then have less work later."

29% of the $8 billion CAD market is attributed to Autodesk.

— Jon Peddie Reseach's 2015 CAD Report

Solid Edge subscription and perpetual license options are still available from Siemens. "Some of our customers have a strong preference for one or the other type of license. We anticipate the interest level in subscription to be fluctuating in some of our core markets and intend to continue offering customers the choice of model," says Dr. Stefan Jockush, vice president of Strategy for Siemens PLM.

PTC's Windchill PLM products were previously available as software-as-a-service (SaaS) offerings through partners like NetIDEAS. But after acquiring NetIDEAS last year, PTC launched PLM Cloud. More recently, the company began offering a subscription option for all its software, including its CAD program Creo. According to the company's FAQ, initial subscription terms are one, two or three years, depending on the solution chosen.

Stan Przybylinski, vice president of Research at CIMdata, says, "There are still people who want to have the software forever, but we increasingly live in a subscription world now, driven by the Web and apps, so it is natural that people want to have that experience at work."

Offering subscription licensing does come with certain risks for the vendors. For one thing, customers are not obligated to remain on subscription once the project has run its course. "People can always walk away each year, but we know that in practice that does not happen often. Whether you like it or not, your information and business gets locked into the tools of your chosen providers," says Przybylinski.

Starting Over From a Blank Sheet

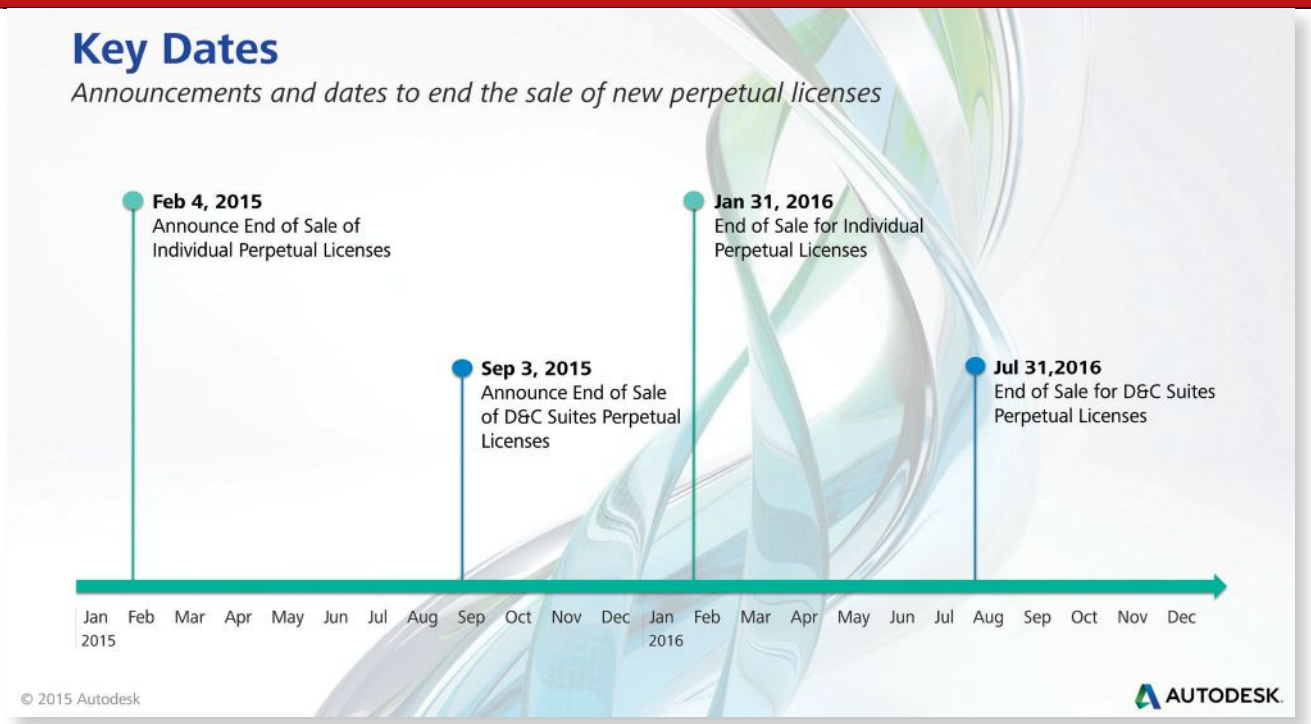
In March, a group of former SOLIDWORKS veterans launched a new CAD brand titled Onshape. As it turned out, being a newbie in a mature market wasn't a handicap but an opportunity. The company wasn't saddled with an existing customer-base entrenched in perpetual licenses; nor did it have a legacy code originally developed for the desktop PC environment. This allowed the startup to do what most established CAD vendors couldn't or wouldn't do. It architected its CAD package to run in the cloud; and it offers the product on subscription.

Jon Hirschtick, co-founder of SOLIDWORKS, now runs Onshape as the company's board chairman. On the company's blog, he wrote: "Younger people have grown up in a post-desk-

Subscription vs. SaaS

Almost all browser-based, cloud-hosted software-as-a-service (SaaS) offerings are sold as subscription software ... but not all subscription softwares are browser-based, cloud-hosted SaaS titles. Adobe has moved all of its individual titles and suites — such as Photoshop, Illustrator and Creative Suite — to the subscription model. But they're not delivered as browser-based software. Users install the software on a local machine to use it. As long as the subscription is active, the software remains operable.

CAD titles currently offered under subscription — like Autodesk products and Solid Edge from Siemens PLM Software — work the same way. They require a full installation; you cannot use them from a browser the way you would most SaaS products. Onshape, founded by former SOLIDWORKS veterans, stands out as an exception to this. The software is a full-fledged CAD program that runs in the browser (no installation needed). As a truly functional SaaS CAD product, it earns the right to introduce the acronym CaaS (CAD-as-a-service).



Autodesk began nudging its customers toward subscription licensing by announcing Feb., 1, 2016, as the end date for perpetual desktop licenses. *Image courtesy of Autodesk.*

top world and have different expectations about computers. They don't even think about having 'a computer.' They walk in with their laptops and their tablets and their mobile phones. They expect computing to be modern and available anywhere, any time on any device. Cloud, Web and mobile technologies are our exciting new raw materials for creating CAD." Onshape subscriptions begin at $100 per user, per month. A free version with limited private storage is also available for students and makers.

CAE Edging Toward Flexible Licensing

A handful of CAE or simulation software vendors currently offer SaaS. SimScale, for example, markets its browser-based simulation software to individuals for as little as €200 (about $215) per month. But the majority still sells perpetual licenses for desktop or server installations or uses a token-based system. If the CAD market gradually migrates toward subscription, will CAE follow in its footsteps?

"A lot of our customers, whether they're enterprise customers or small businesses, are interested in this pay-per-use or pay-as-you-go option — what we call elastic licensing. However, it's still very new in CAE," says Ray Milhem, vice president of Enterprise Solutions and Cloud at ANSYS.

Milhem attributed the change in software users' attitude toward subscription or on-demand licensing to the introduction of "remote computing and cloud computing." He says, "People are beginning to ask for elasticity not just in their compute capacity but also in their licensing."

ANSYS recently began offering its Enterprise Cloud option, which runs on Amazon Web Services (AWS). The company writes, "Customers who adopt the ANSYS Enterprise Cloud can scale their simulation capacity — including infrastructure and software assets — on-demand." It brings ANSYS one step closer to the on-demand model. Companies like Rescale also offer simulation infrastructure (software-hardware combination) available on demand, spawning the new term PaaS (platform-as-a-service).

"The leading and exciting offering we have right now at ANSYS is single-tenant cloud (STC) setup," says Milhem. "We're working on a new generation that will be multi-tenant cloud (MTC)." But SaaS for CAD and SaaS for CAE may not be identical, he cautioned. "For our industry, the elastic model we offer is SaaS-based, because you only use it for as much as you need to, and you pay per hour usage. Both STC and MTC are complementary and are targeting different markets," he says.

Milhem specified that ANSYS' elastic licensing will complement the company's existing offering of leased and paid-up licenses. "Our customer base and future customers have options and will choose what fits their needs," he adds.

Redefining the 'V' in VAR

When perpetual licensing was the default purchase option, CAD vendors relied heavily on resellers, or value-added reseller (VAR) networks. In addition to selling the software, VARs usually operate as first-level support providers. They also offer training, consultancy and complementary services. With perpetual licenses typically priced between $1,500 to $4,000, VARs stand to generate significant revenues by nurturing a pool of core accounts.

Subscription commerce, however, is drastically differ-

ent. The emphasis is on low prices (around $100 per user per month) and volume sales. Online software distribution sites like Novedge have proven that design and engineering software can be marketed just like books on Amazon.com. It challenges the conventional thinking that VARs are essential to the transaction. Therefore, the VARs' role in the new era needs to be calibrated.

"The VARs still adding 'value' will have a sustainable relationship with their customers. They may even have more opportunities to generate revenue because of the different types of cloud software customers will be deploying. Smart partners will figure out ways to help customers integrate products," says Anagnost.

Even with a hassle-free browser-based product like Autodesk PLM 360, VARs can still offer services, "because PLM requires an understanding of the customer's processes and what they're trying to accomplish. VARS can help them integrate [the PLM modules] with other enterprise systems and create templates," says Anagnost.

Anagnost suggests forward-thinking VARs should get ready for the volume-sales model. He asked, rhetorically: "What good is a high margin business if it's shrinking? Watch where the volume is going. The volume is moving toward the new model, not the old model."

Siemens PLM's Jockusch says, "Keep in mind that the purpose of a reseller is to add value to the product they are selling, thus, the term 'value-added reseller.' As long as resellers provide real added value to customers, such as services, training and consulting, their role doesn't fundamentally change with a subscription model."

Owners vs. Renters

Perpetual licensing is attractive to those who view software as an asset. For such buyers, the comparatively higher upfront cost is well worth the assurance that comes with lifetime ownership. The perpetual license ensures the software will remain in their possession even if the original developer's fortune falters or fails.

But a new class of software users trained on SaaS challenges this established notion. They view software as a means to an end, a digital tool to get the job done. For them, extending the cost of ownership beyond the usefulness of the tool doesn't make sense. (In the design and engineering software market, the cost of ownership comes in the form of annual maintenance fees and renewable support contracts, which can certainly add up over time.) Subscription advocates like Autodesk and Onshape are counting on the "I'd-rather-rent" crowd's growth to outpace the "I'd-rather-own" crowd. 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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Learning to Use the "Black Box" Correctly

Professors and employers discuss the role of software in STEM education.

BY KENNETH WONG

The engineering director of Simulation-Based Design at Whirlpool Corporation, John Mannisto, reveals what he looks for in new recruits. A Ph.D. isn't necessarily going to persuade him to give you a job. "The ones I'm interested in may only have a bachelor's degree or a master's, but they've had experience designing airflows in manifolds and engines," he says. "They don't necessarily understand how the computation works in the software code, but they can get the job done."

Mannisto's approach reflects the pragmatism of a hiring manager. He wants new hires who can hit the ground running. But university educators say they need to be teaching more than software skills in engineering curriculums.

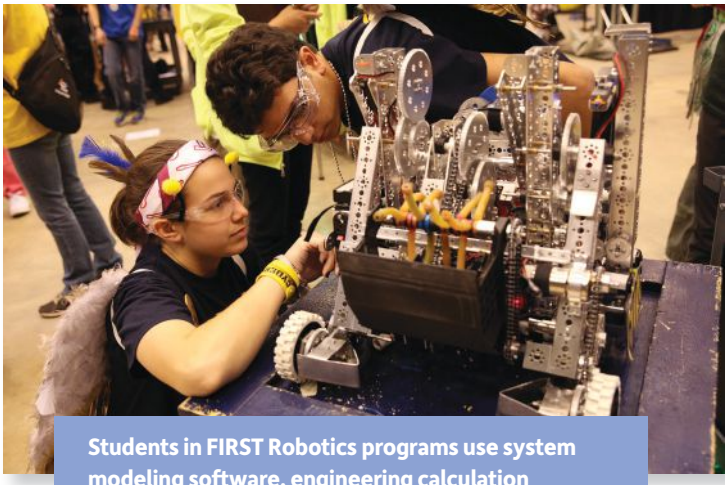
"Students are using numerically based software, but they're using them with very little numeric background," says David Auslander, professor of Mechanical Engineering at UC Berkeley. To him, that's a disconnect between the tool and the user. He'd like to teach students "to include numerical approaches from the beginning for such basics as integrals and derivatives" so they understand the underlying principles of simulation software.

Most employers prefer graduates with software mastery. But many educators feel that, without a thorough understanding of the mathematical principles and engineering rules, software mastery rings hollow, perhaps even dangerous. At the heart of this debate are the two different views of the software's role: Trust the software like a black box that can spit out the correct answer; or peek inside the black box to learn how it produces the answer.

Recalibrating the Curriculum

Auslander specializes in automatic control system analysis and design, computation for physical system simulation and for control system design and implementation, building energy management, and mechanical system control. He has served as associate dean and acting dean of UC Berkeley's College of Engineering.

"In the past, you needed ways to generalize and analyze problems because dealing with them purely with computation was too expensive," Auslander says. "In Newton's era, computation was expensive. In the Manhattan Project [1940s], they had to employ human computers — people who manually performed computing — to deal with the intractable calculation problems they encountered."



Students in FIRST Robotics programs use system modeling software, engineering calculation packages and CAD programs to solve engineering challenges. *Image courtesy of FIRST Robotics.*

However, the cost of computation drastically decreased once computers became widely available. Harvesting the horsepower of multicore processors, software like Wolfram Mathematica or MathWorks MATLAB can now compute what was previously considered impossible or impractical with hand calculation. Yet "basic engineering curriculums still feature largely a bunch of special cases for which computation was not available at the time. They're about 50 years out of date," says Auslander.

To realign engineering education with the type of complex problems students will likely be called upon to solve, Auslander suggests turning the curriculums inside out. The role of software training in engineering education is "a hot button issue," he says. "The curriculum is not preparing the students to know how to use these types of analytical software."

He'd like students to have an intuitive understanding of the math working behind the scene, the analytical algorithms in software. "You have to teach things that are numerically based from the beginning," he says. Otherwise, he asks, "How would they know when they're getting nonsense and when they're getting real results? How can they formulate a problem in numeric terms?"

Auslander's concern is echoed by Dr. Paul Lethbridge, academic program manager at ANSYS. "If you teach someone how to use the product only, you're teaching them the black box

approach," he says. "If they don't understand what's going on inside the black box, then it's garbage in, garbage out."

Teaching Skills While Remaining Brand-Agnostic

Most software vendors have outreach initiatives targeting colleges and universities. From the vendors' point of view, building brand familiarity among aspiring engineers is a worthwhile investment.

Autodesk, for example, offers free education licenses of its design and engineering software. Dassault Systèmes, Siemens PLM Software and PTC have robust educational licensing policies to provide their software to students at heavily discounted rates.

Despite access to commercial code, educational institutions have to narrow the number of software they teach in a course or the volume of software could overwhelm the materials. Some universities have adopted a brand they feel represents the norm.

"We have effectively adopted ANSYS as our CAE platform," says Dr. Rajesh Bhaskaran, senior lecturer for Cornell University's Mechanical and Aerospace Engineering department. "We're using it in about 11 courses, both at graduate and undergraduate levels. But we don't teach CAE as a separate course. It's integrated with everything, from solid mechanics and heat transfer to fluid mechanics."

Cornell University's SimCafe.org features a collection of simulation tutorials based on ANSYS software. The content is distributed via Creative Commons licensing. It's an e-learning portal to "integrate industry-standard simulation tools into courses and to provide a resource for supplementary learning outside the classroom," according to the site.

"I floated through quite a few toolsets in my career, everything from ANSYS to Abaqus [simulation package from Dassault Systèmes]," says Mannisto. "Generally, the concept of constraints and loads — where to hold the model, where to put the load, what a good quality mesh is — that's all the same. Those are the skills — not the peculiarities of specific software."

Mannisto looks at FIRST Robotics Programs as fertile ground for talent scouting. Here, throughout a series of robotic contests, Mannisto gets to observe how students with a knack for tinkering work together to solve their electrical, mechanical and software engineering conundrums. "It's like getting to interview a kid over the course of four [to] five years," he says.

Software as Learning Platforms

In a commentary for *DE* ("Make CAE Mainstream," deskeng.com/de/?p=25211), Mannisto expressed his opinion. He wrote: "It is my belief that there is too much emphasis on the inner workings of a computer program and not enough on the practical application." He recommended, "Teach CAE not as a course, but instead build it into the entire curriculum. Teach the beam equation, teach Mc/I, then apply it using finite element analysis. Teach continuity, momentum and Navier-Stokes, then show how to define an entrance condition and a pressure boundary in a computational fluid dynamics program."

Bhaskaran says studying the software can be an education unto itself. "You can use the software to teach the underlying math by relating it to user inputs and outputs. For instance, by meshing the model, the user is marking out the points where she or he would like the tool to compute displacements directly and is also setting the number of algebraic equations that need to be solved."

92% of traditional STEM jobs in 2018 will be for those with at least some post-secondary education and training.
— Georgetown University Center on Education and the Workforce's STEM report

ANSYS' Lethbridge said, "What Dr. Bhaskaran does is to use the black box and then teaches students to probe that black box so they understand what's going on and how to interpret the results."

"You don't need to know how to code, but you need to know how the tool is taking differential equations and converting them into algebraic equations. What strategies does it use? What are the errors introduced in that process? What is it calculating directly and what's derived through post-processing? When you do something in the software, you should know if you're affecting the boundary conditions, the governing equations, the numerical solution strategies or post-processing," Bhaskaran says.

The different views on how to treat the black box are not so far apart. In the end, both the hiring managers and the educators want the same thing: Aspiring engineers who can use the black box correctly. If there's a gap between the two sides, it's one that can easily be bridged with ongoing dialog.

Bhaskaran points out the crucial distinction between software expertise and engineering skills. "The software doesn't solve the physical problem for you. It solves a mathematical model of the physical problem. Students need to know what the mathematical model is — the governing equations and boundary conditions as well as the physical principles and assumptions embedded in the model," he says. DE

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

INFO ➜ **ANSYS:** ANSYS.com

➜ **Cornell University Sibley School of Mechanical and Aerospace Engineering:** MAE.Cornell.edu

➜ **Modelica:** Modelica.org

➜ **National Instruments:** NI.com

➜ **UC Berkeley Jacobs Institute for Design Innovation:** JacobsInstitute.Berkeley.edu

➜ **Whirlpool:** Whirlpool.com

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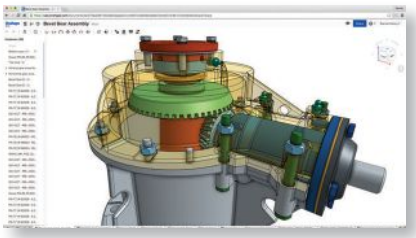
Editor's Picks

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.



Cloud-Native 3D CAD Adds 2D Drawings

Onshape is workstation and browser agnostic.

Onshape is a cloud-native, professional-class 3D CAD design and collaboration system. It's the brainchild of a lot of talented people who inspired much of the design and engineering software used today.

This update is a full 2D system with snap points, dimension and annotation tools as well as standard, projected, auxiliary and section views. If users need a kick to get started, Onshape has downloadable drawing templates.

Currently, Onshape is on a three-week update schedule, so it's always improving — often by user request.

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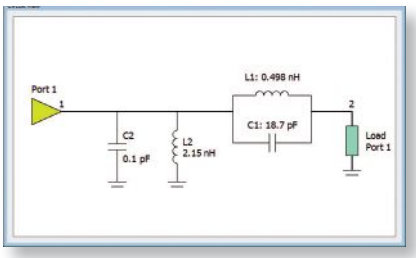

XFdtd Integrates with Optenni Lab

Simplify antenna matching circuit optimization workflows.

Remcom's integration brings together XFdtd's Circuit Element Optimizer add-on module with Optenni Lab. Optenni Lab provides automatic matching circuit generation and optimization routines.

Users can send XFdtd simulation data to Optenni Lab directly. It's a simple drop-down menu procedure to invoke Optenni Lab. Optenni Lab optimizes matching network topologies and component values based on the S-Parameter and efficiency results from the XFdtd simulation. It then returns a choice of optimized matching circuit topologies that meet user design criteria.

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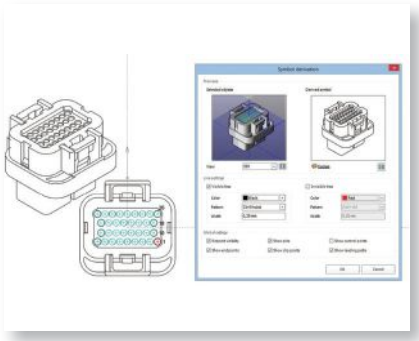

EPLAN Platform 2.5 Available

The release enhances parts management capabilities.

Version 2.5 of EPLAN Platform takes the company's project, process and data management focus further. Among the key enhancements announced are faster template creation and a new navigator functionality that makes it easier to create and edit electrical and fluid power engineering macros. Version 2.5 now also offers page- and area-specific revision management.

The Harness proD 3D system for wire harness design is now coupled with EPLAN Platform's central parts manager. This provides a single, integrated parts management system over the course of a project.

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HP Expands Workstation Portfolio

Its Z240 is available as a tower or single form factor system.

The HP Z240 workstations are an upgrade to the company's popular HP Z230 workstation with technological improvements like an integrated M.2 slot for expansion cards and connectors as well as a smaller, more efficient motherboard. The hard-drive cage in the HP Z240 SFF (single form factor) has been re-engineered to provide more efficient airflow.

The workstations accommodate up to 64GB of memory and a pair of HP's new Z Turbo Drive SSDs (solid state drives). They run 64-bit Windows or Linux, support eight USB 3.0 ports, Intel processors, as well as AMD or NVIDIA graphics.

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A Hands-on Look at Product Design and Development

DFMA tools from Boothroyd Dewhurst give one college student a firm grasp of the principles of product design and costing.

Patrick Bright was camping with friends in Northern Arizona when he came up with the idea for his class project. An engineering student at Embry-Riddle Aeronautical University in Prescott, AZ, Bright was in his junior year and had recently signed up for course ME 428: Design for Manufacturing and Assembly (DFMA). It was uncharted territory for Bright, but based on the syllabus he figured it would be a good way to learn more about manufacturing, a topic he'd long been interested in. He wasn't disappointed.

Before applying for admission to Embry-Riddle, Bright served in the Marine Corps. Through it all he had his sights set on a career in aerospace engineering, but thought he might not be talented enough for the grueling academic work required. Thankfully, he was proven wrong.

As he sat in front of his tent, roasting hotdogs, he noticed that the bench seat of his 2010 Jeep Wrangler wanted to tip over and he was concerned about rocks and dirt getting into the connectors on the bottom of the seat.

And so the focus for Bright's DFMA class project was born. Following the DFMA process, Bright began to outline the design requirements for his concept, now dubbed the Outdoor Bench Seat Attachment.

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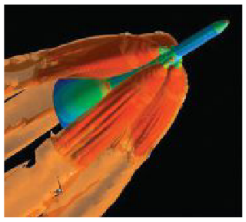
Simulation Success

NASA relies on Tecplot CFD and post-processing visualization software to perfect its Orion spacecraft heat shield.

America's commitment to deep-space exploration has been reignited. On Dec. 5, 2014, at the Kennedy Space Center in Florida, NASA conducted the first test flight of the Orion Program, launching a new chapter in human space travel. If all goes according to plan, the Orion spacecraft will put humans on an asteroid by 2025 and on Mars in the 2030s.

More than 1,000 onboard sensors recorded every detail of the flight. Launched aboard a United Launch Alliance Delta IV Heavy Rocket, Orion circled Earth twice and reached an altitude of 3,600 miles during the test flight, about 15 times higher than the International Space Station. To one day accomplish its ultimate mission — sending humans to Mars and bringing them back safely — Orion must withstand extreme speeds, intense radiation and searing temperatures.

To predict temperature and airflow around the heat shield during re-entry, a team of about 20 engineers analyzed heat shield materials in NASA Ames' Arc Jet wind-tunnel and then compared the results with those generated by CFD (computational fluid dynamics) simulations. They then used Tecplot 360 EX as a post-processor to analyze, visualize and understand the CFD results.



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by Cees Links

Design Smart Home Services, Not Connected Things

Are you designing for the smart home or for the new Internet of Things (IoT)? We all know it's going to be really, really big.

- According to World Economic Forum: "By 2020, more than 5 billion people will be connected, not to mention 50 billion things."
- Cisco says: "The IoT is a world where up to 50 billion things (or devices) will be connected to the Internet by 2020; or, the equivalent of six devices for every person on the planet."
- Gartner says: "4.9 billion connected things will be in use in 2015 (up 30% from 2014), 25 billion by 2020."

These organizations are all predicting amazing opportunities for the future growth of the IoT market. It all sounds quite rosy and bright. However, there is a growing undercurrent of industry grumbling and complaining that the IoT and smart home revolution seems to be taking a lot longer than it should. What is the problem? Maybe the industry is selling the wrong thing: a product instead of a service.

Maybe the industry is selling the wrong thing: a product instead of a service.

Engineering as a Service

It is time to take a new look at how our technology industry approaches and markets the potential of the smart home — the smart IoT. By giving consumers, as well as businesses, governments and corporations, what they want — effective service applications as well as complete managed solutions instead of DIY things — the tech industry can further accelerate the growth of smart technology, thereby making our lives safer, more efficient and more comfortable — all for less cost.

End users and consumers don't want to resource, purchase, install and program a variety of smart home devices. They don't want to be concerned with how these various devices will talk to each other, how these devices will connect to the Internet, and where and how they can be controlled. Consumers just want working, out-of-the-box products and services.

They also want secure homes. They want locks and alarms on their doors and windows that can be remotely controlled and monitored. They want locks that are smart enough to realize that when no one is home, the doors and windows should be closed and locked. Smart enough, even, to send a message to the homeowner asking for permission to lock the doors and windows, and go ahead and do so when the homeowner gives the OK.

End users want homes that are comfortable with control of the air conditioning and heating that are customized to how they live their lives. When no one is home, the HVAC does not need to be on, however, it should know the family's schedule and assess the temperature of the home and the weather outside to begin making the home comfortable as the family heads home.

With smart homes, engineers are applying old technology to emerging applications. These basic sensing and control technologies have been available for decades. What is new is the Web connection, and the smartphones and tablets that can talk to these home systems.

What is needed now are service providers to handle the installation, maintenance and operation of the system. Yes, early innovators and earnest DIYers can go to their local home improvement store and buy and install all of this right now. But mostly, people just want it to work easily.

So instead of spending all of this time, money and PR to convince consumers to buy smart home things, the industry should team up with service providers to enable them to cost effectively market and manage these systems. Wouldn't you be happy if a company like Apple or Intel decided to move into this space — instead of just selling products — and ran a smart home for you?

When we buy a car, most consumers really don't care how the engine works, how the brakes slow down the vehicle, how the transmission changes gears, or the fuel system adjusts the gasoline/air mixture. They just want the car to go where they want it to go. The less interaction, the better.

In the same way, homeowners want a service that makes their lives safer, more efficient and more comfortable; all for less cost and with minimal maintenance.

Quit selling things and start selling services. DE

Links *is CEO & Founder of GreenPeak, greenpeak.com. You may send comments to him about this article via de-editors@deskeng.com.*

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Contact Information

Abstracts & papers: papers@lstc.com
Participation, Registration: Marsha Victory, vic@lstc.com

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- **Deadline:** November 30, 2015
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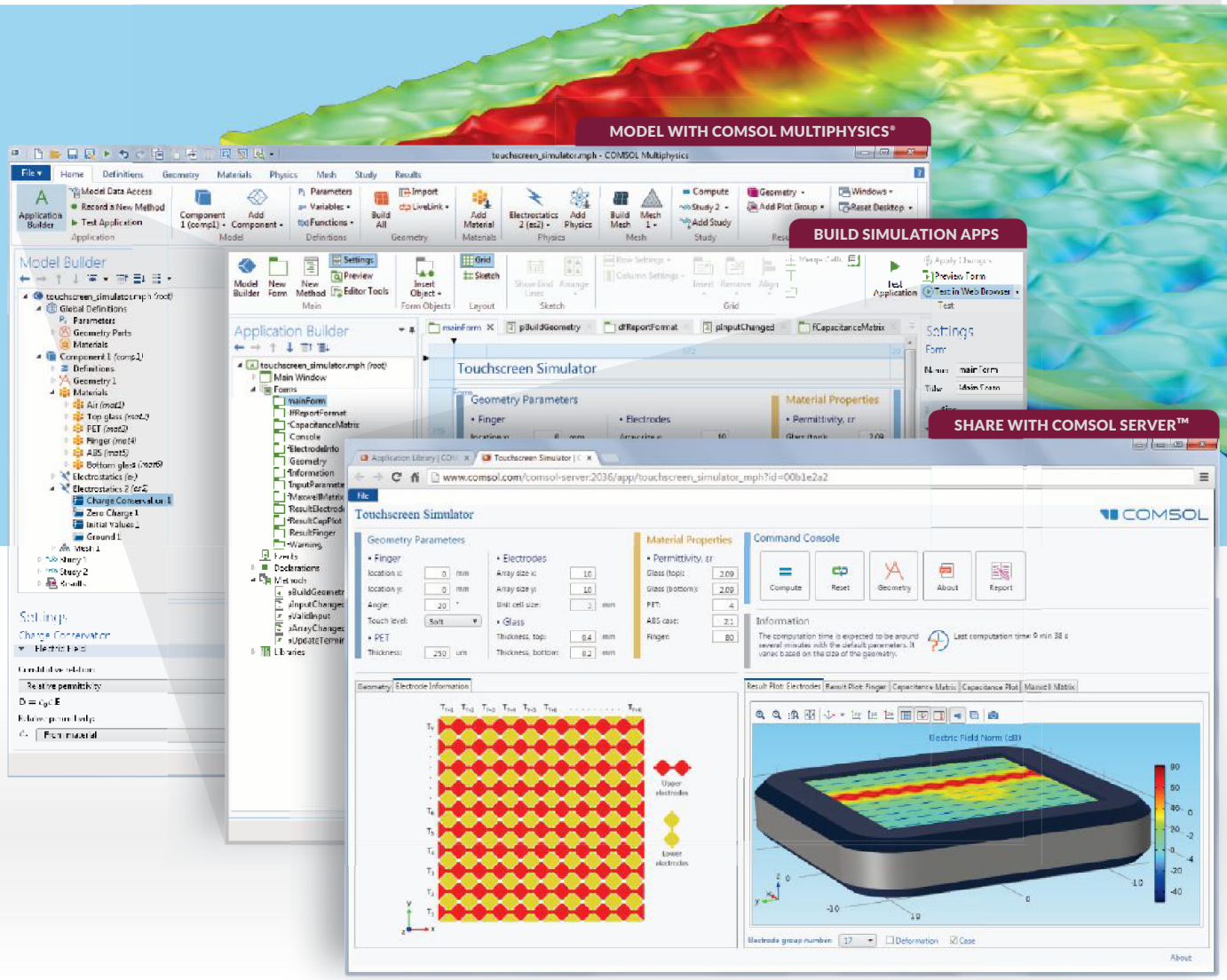

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