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DE Digital Engineering

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by Jamie J. Gooch

Killing the Killer App

THE FIRST ELECTRONIC MESSAGE transmitted from one computer to another over an inter-connected network was sent more than 40 years ago. Ray Tomlinson, one of the engineers working on the Advanced Research Projects Agency Network (ARPANET)—a pre-cursor to the internet—sent a test message from one computer via the network to another computer sitting beside it in 1971. When asked about it later, he couldn't remember what it said.

I'm old enough to have worked in an office that did not have email. Times have certainly changed. As of this writing, I have 7, 113 messages in my inbox. I'm not ashamed. Most of them have been read. Reading and responding to email is the first thing I do every workday morning and often the last thing I do each evening. My email client is always there on my laptop screen and just a tap away on my phone. It's the original killer app. It's hard for me to imagine working without it.

> "Email is a communication platform, but it has been pressed into service as a collaboration platform and task management tool."

But there are people with bigger imaginations than mine who envision a workplace that does not revolve around email. They say email saps our productivity by distracting us from our real work and is an inefficient way to collaborate. I just stopped writing this column to make sure no one had emailed me since I began writing it, so they may have a point.

Communication vs. Collaboration

We're focusing on collaboration in this issue and email is getting a bad rap. On page 8, Chad Jackson asks: "What is the most widely proliferated technology used to enable collaboration?" He answers his own question: "Yes. I did hear you groan. And yes, you are correct. The answer is email." On page 22 Randall Newton writes: "Even with a PLM (product lifecycle management) system in place, most of the dialog takes place in email."

I get it. Email is a communication platform, but it has been pressed into service as a collaboration platform and task management tool. Attached files are not a single source of truth. Judging by how many times I have to resend an email "just to make sure" the recipient has the latest file, it's easy to lose emailed files or get confused about which version is which. And I can't count how many times I have searched through my inbox to forward a message on to someone who is lost on a project because they were inadvertently not copied on an email.

There are plenty of social collaboration tools available. From general-purpose tools like Google Drive, Slack and Facebook's new Workplace app to engineering-specific applications that offer various forms of collaboration and product data management. All of them compete with, or complement (depending on your point of view), different overarching PLM approaches.

The Status Quo

There is no question that working in an application designed specifically for collaboration is more productive. So why do so many people continue to use email to collaborate? Habit, ubiquity and costs have a lot to do with it. Everyone is used to email, everyone they want to work with has email, and its costs generally don't come out of their budget.

Making the move to something better requires a coordinated effort across an entire company, not only to invest in the software, but to take the time to train employees on its proper use, suggest efficient workflows and follow up to ensure it's being used. Like many technological shifts, cultural norms are bigger barriers than the availability or functionality of the technology itself.

The good news is, social collaboration software is becoming as accepted today as email was 20 years ago. Most students I know work on and turn in their assignments via the cloud as a matter of course. My daughters roll their eyes when I ask them if they read an email I sent them. "No one uses email anymore dad," they say without looking up from their Snapchat app. DE

Jamie Gooch *is editorial director of* Digital Engineering. *You can contact him, via email of course, at de-editors@digitaleng.news.*

DE

Digital Engineering

TECHNOLOGY FOR OPTIMAL ENGINEERING DESIGN

INSIDE

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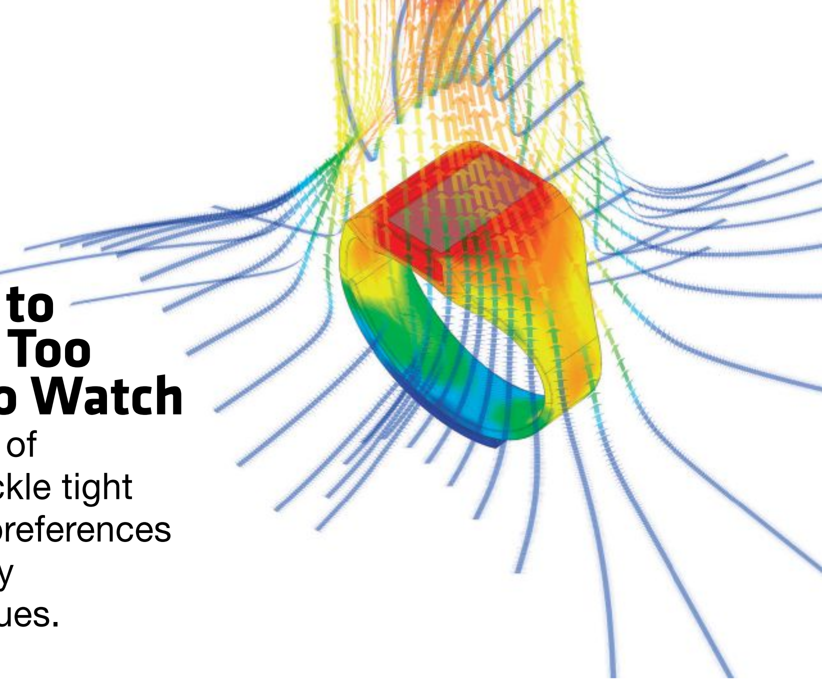
ON THE COVER: Image courtesy of *Mentor Graphics*

COVER STORY



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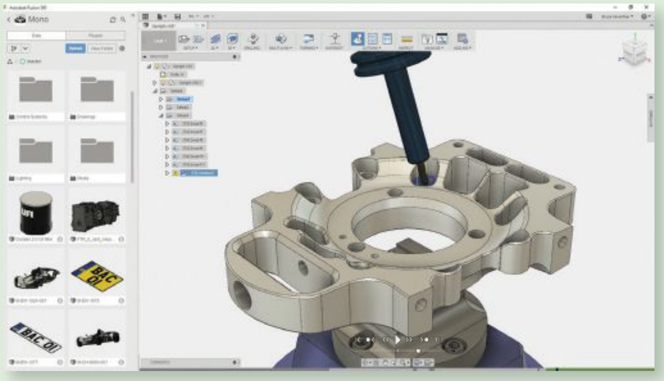

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BPA WORLDWIDE

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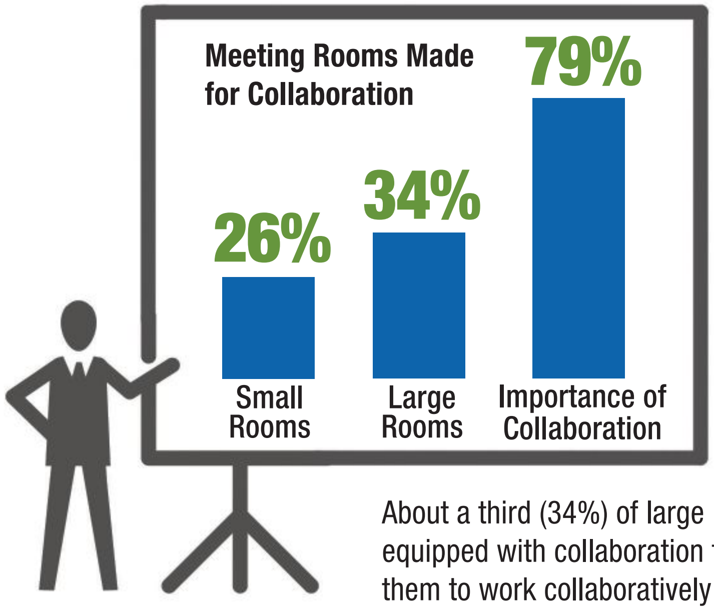
Room for Improvement in Collaboration



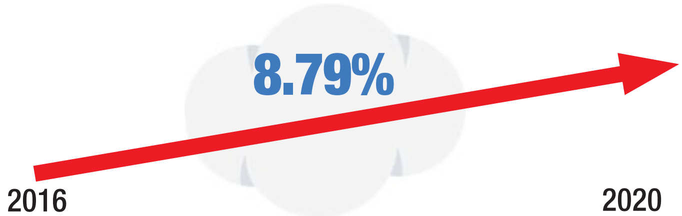
Improved communication and collaboration via social technologies could provide a productivity increase of 20% to 25% among high-skill knowledge workers.

— McKinsey Global Institute, "The social economy: unlocking value and productivity through social technologies," July 2012

About a third (34%) of large meeting rooms and 26% of smaller rooms are equipped with collaboration tools, but 79% of workers say it is important for them to work collaboratively with others in person.

— A commissioned study conducted by Forrester Consulting on behalf of Microsoft, June 2016

PLM Predictions



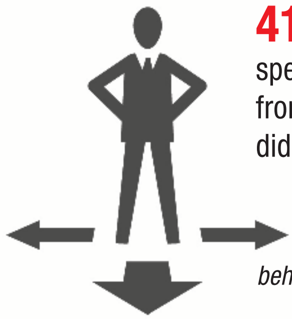
The global cloud product lifecycle management (PLM) market is expected to grow at a compound annual growth rate of 8.79% between 2016 and 2020.

— "Global Cloud Product Lifecycle Management Market 2016-2020," Technavio, May 2016

$76 Billion

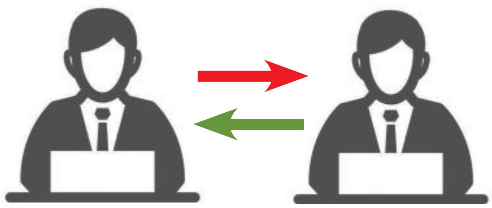
The global PLM market is anticipated to reach $76 billion by 2022.

— "Global Product Lifecycle Management (PLM) Market Analysis & Opportunity Outlook 2021," Research Nester, January 2017



41% of employees spend more time away from their desk than they did two years ago.

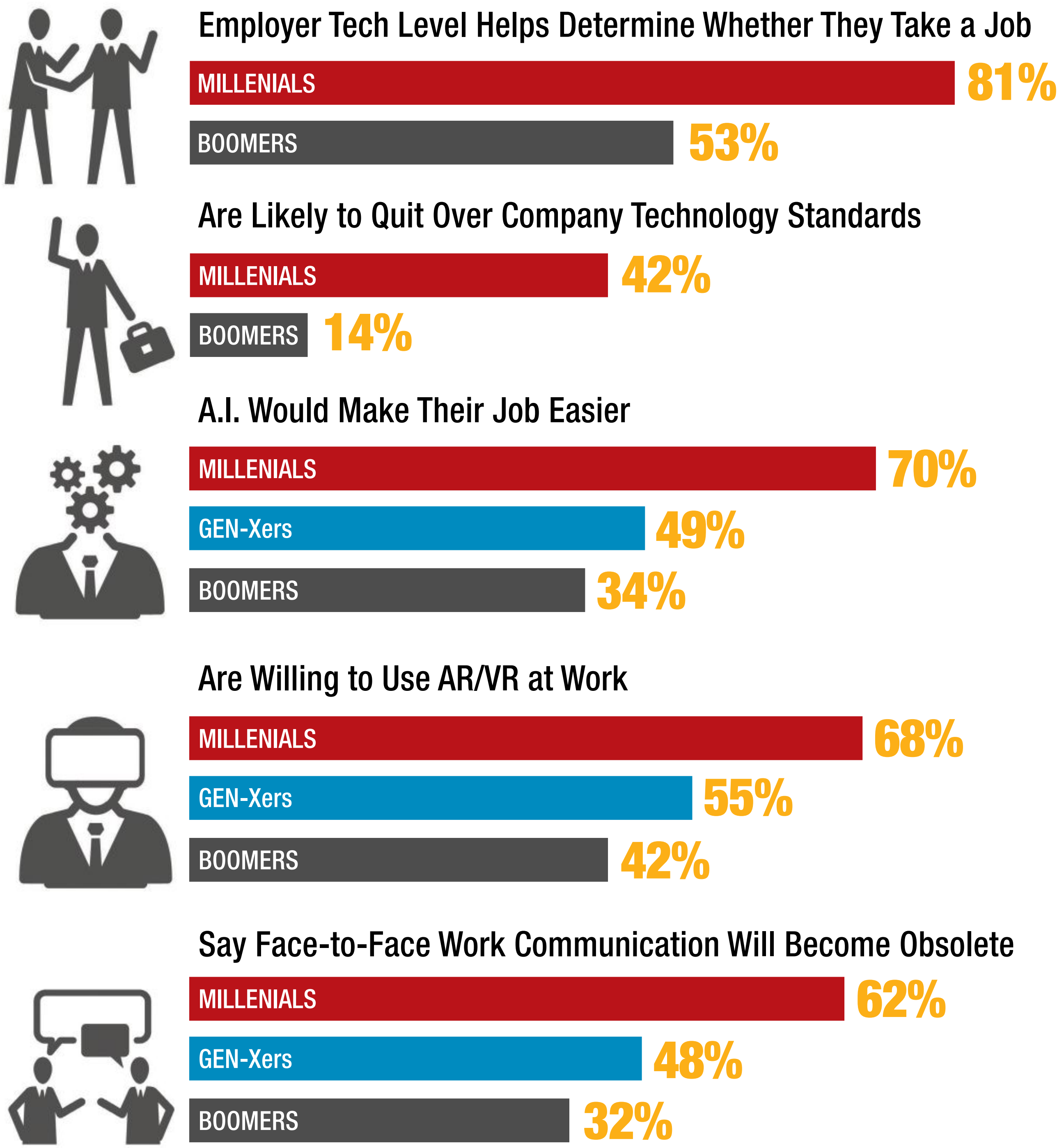
— A commissioned study conducted by Forrester Consulting on behalf of Microsoft, June 2016



The majority of workers cite collaboration solutions that integrate with the applications they use for work as important (62%), as are collaboration tools dedicated to work (60%).

— A commissioned study conducted by Forrester Consulting on behalf of Microsoft, June 2016

Collaboration Differences By Generation



— *Dell & Intel Future-Ready Workforce Study U.S. Report, July 15, 2016 (Dell.com/workforcestudy)*

| CONSULTANT'S CORNER |

CLOUD COLLABORATION

by Chad Jackson

Email: The Enemy of Collaboration

LET'S FACE IT: Design by its very nature is an iterative and collaborative process. In any design project, you will often try one thing to see if it works. When that fails, you try a different approach and eventually (hopefully) meet success. This happens again and again, day after day, as engineers develop new designs. The effort includes problem solving, trade offs and exploration. Iteration sits at the core of almost any design process.

That, however, doesn't happen in a vacuum. A change to your design will often affect the components connected to it. That's where collaboration comes into play. As you explore new options, you have to make sure your design is compatible with everything else around it, which most often involves collaborating with your peers.

That's the reality of engineering today: It is fundamentally about collaborative design iteration. Now, what is the most widely proliferated technology used to enable collaboration?

Yes. I did hear you groan. And yes, you are correct. The answer is email.

Practically every functional department in a company is utterly reliant on email. It is used to communicate with suppliers, the manufacturing floor, the quality department and many more. It's everywhere.

Email's Killer Issues

Now, email suffers from many general issues. It piles up quickly, especially if you're out of the office. When you return, you might have to wade through a hundred or more unread missives, most of which aren't relevant to your work. Time-sensitive tasks can easily get buried. Important emails triaged into folders can easily get lost. These are the issues that foul up the collaborative and iterative process of design.

There are other even more problematic issues. Email threads often include attached files, which provide the context of the engineering design discussion. Unfortunately, within hours of receiving the email, that file might be outdated as other thread participants mark it up with their thoughts or even make suggested changes. Even more disturbing, *multiple people* make their separate changes *at the same time*. That means there are different iterations of the file, each with different additional content. Keeping up with those changes, much less aggregating them back into one file, is a digital nightmare. For design, this is one of the worst-case scenarios. Suddenly, engineers already hard pressed for time must fight through the challenges of getting coherent feedback.

Gaining access to the file is only part of the picture, however. Another question is how to open that file. When we're talking about 3D models and drawings, there are plenty of free viewers, but they take time to install.

A Single Source of Truth in the Cloud

It is in this context where cloud-based computer-aided design and product lifecycle management solutions make a lot of sense. Let's explore why.

An important advantage when using any kind of product data management (PDM) or PLM system is that it offers a single source of the truth when it comes to managing different versions of a file, including 3D CAD models and drawings. Point someone at a design, even a specific version, and there is no room for confusion. The PDM or PLM system offers a unambiguous definition of that file.

When it comes to viewing and marking up design files, like 3D models and drawings, some cloud-based PDM or PLM systems offer a significant advantage: viewing and markup in the browser. There is no application to install. Once open in your browser, your changes are saved automatically as a markup. There is no need to send it back.

Lastly, there's the need to textually provide feedback. Cloud-based solutions now offer the means to add comments to specific versions of designs, right alongside their markups. In this way, it works more like a discussion on a social media site, where everyone can see each other's comments, allowing truer iterative collaboration.

Design by its very nature is an iterative and collaborative process. Using emails and installed 3D viewers have presented significant challenges to date. But the good news is that PDM and PLM systems, in particular those based in the cloud, offer significant advantages to improving the process. **DE**

Chad Jackson *is president of Lifecycle Insights (lifecycleinsights.com). Send email about this commentary to de-editors@digitaleng.news.*

| CONSULTANT'S CORNER |

DIGITAL TWINS

by Amy Rowell

Next-Gen PLM: Collaboration in the Age of the Digital Twin

"Twin? What is your current status?"
"In the past six months, my number of start-stop cycles has increased by 27.5%, and a change in my mission is causing damage to my T-11 rotor."
"Tell me about your rotor damage."
"My rotor damage has increased by over 4.0 times over the past six months. If this continues, I will lose nearly 69.9% of my useful life."
"Give me options for mitigating that rotor damage."
"Running diagnostics now, sir."

Sound far-fetched? It may—but this is where technology is taking us. As GE's Vice President, Software Research, GE Global Research Center, Colin Parris depicts in his presentation, "Meet the Digital Twin," such an exchange is an example of a human working collaboratively with a digital twin of an industrial machine.

By virtue of its digital twin, industrial machinery now has a voice of its own—powered by machine intelligence that promises to take the man-machine interface to a whole new level. Enabled by physics-based data, embedded sensors, the Industrial Internet of Things (IIoT) and real-time analytics—this modern-day version of the "intelligent machine" is transforming manufacturing and improving collaboration between man and machine.

Defining the Digital Twin

But what exactly do we mean when we say "digital twin"? According to author, professor and product lifecycle management consultant Dr. Michael Grieves, who credits his colleague John Vickers of NASA for coining the term as early as 2001, a digital twin is more than just a virtual representation of a product or asset. At its core, a digital twin includes three key elements:

1. the physical product in real space,
2. its digital twin in virtual space, and
3. the connections of data and information that tie the virtual and real products together.

And there-in lies the key difference between the traditional definition of a virtual product model and its "digital twin." The digital twin is actually a hybrid model—it shares all the same performance characteristics as its physical counterpart—but it lives in a virtual world. Supercharged by real-time or near real-time sensor data, the digital twin can serve as a means to more accurately evaluate and predict how well a machine or product is likely to perform based on a combination of historical data, real-time data, advanced analytics and predictive models.

Three Stages of Operation

According to GE's Parris, the twin operates in three stages. During the first stage, the "seeing" stage, it is actually gathering data—e.g. operational data and environmental data. During the second stage—the "think" stage—the twin runs simulations based on historical data, fleet data, forecasts for revenue and costs, etc. and comes up with recommendations. The third stage is the "do" stage, which is all about executing, whether manually or via an app.

Invaluable as a visual, data-driven collaboration tool for decision makers—this digital twin can also be readily shared among key stakeholders regardless of location for collectively evaluating asset or product performance, predicting failure rates and identifying optimization strategies. The digital twin can ultimately pave the way for greater product and process innovation, performance enhancements and increased profitability. Taking things a step further, paired with augmented reality (AR) environments, the digital twin can be used as an overlay onto a view of the actual object or asset, enabling the virtual and real worlds to come together.

Such capabilities have put the digital twin on Gartners' list of top technologies to watch in 2017. Coupled with Big Data analytics, the potential power of the digital twin is compelling—not just in manufacturing, but in medicine, transportation and more. As noted in its "Top Ten Strategic Technology Trends for 2017," Gartner predicts that "within three to five years, billions of things will be represented by digital twins."

The bottom line? PLM has come a long way—we have moved from paper to digital designs, from 2D to 3D, from physical to virtual prototypes, and now to digital twins that can leverage both AR and advanced analytics. How quickly will we see this approach gain traction? That depends. After all, in spite of the "cool factor," many still find technology like virtual reality headsets cumbersome. And as for all that data? Well, data isn't intelligence. It will all come down to the ability to collect, filter and analyze the right data. But the age of the "intelligent" digital twin has arrived. DE

Amy Rowell *(linkedin.com/in/aarowell) is an industry analyst with a passion for researching topics related to innovation in next-gen product design and manufacturing. Contact her via de-editors@digitaleng.news.*

SOLIDWORKS World 2017: "Optimize and Manufacture"

BY KENNETH WONG

A FEW MINUTES into his keynote at SOLIDWORKS World 2017 last month in Los Angeles, SOLIDWORKS CEO Gian Paolo Bassi faced a deadly and dangerous question. It came from not the press but the illusionist Justin Flom, part of the conference's opening act.

"Here's the question of the day," Flom said, as he shepherded Bassi toward a mechanical contraption with a giant buzzsaw. "Would you trust your life to something made with SOLIDWORKS?"

Bassi predictably said, "Yes." Soon, he found himself kneeling in front of the moving saw, with his head locked in its path. Thankfully, the magic act worked; so did the machine. Bassi walked away with his head intact to continue his speech.

The CAD software industry is now embracing a new kind of magic-like process: optimization. The question that SOLIDWORKS users—and the CAD community at large—must soon confront is: Do you trust your project to something designed by optimization algorithms?

"Today, we expect the computing platform to anticipate your design goals," said Bassi. "This is why we're introducing topology optimization in SOLIDWORKS, in collaboration with our world-class engineers from SIMULIA [the company's simulation software] … The era of design and validate is about to end. We're entering the era of optimize and manufacture."

The Era of Optimization

According to Kishore Boyalakuntla, SOLIDWORKS senior director of product portfolio management, the optimization technology embedded in SOLIDWORKS desktop version is developed internally. The company has not yet determined its pricing. A similar function dubbed design guidance will be available in SOLIDWORKS Xdesign, the browser-based design software under development.

Boyalakuntla said there are some customers test-driving Xdesign now, but estimated it wouldn't be more widely available for trial until the third quarter of 2017.

Traditionally, engineers conceive what they believe to be the best shape for a product, then use simulation technologies to validate their idea—design and validate, as Bassi put it. But algorithm-driven optimization introduces a new paradigm. With optimization tools, engineers can specify the loads, stresses and pressures anticipated in the design, then let the software generate mathematically optimal geometry. The proposed method—going from optimization to manufacturing—speeds along product development dramatically.

The new approach also asks engineers to put their trust in the software's optimization algorithms. For many traditionalists, it may feel like putting their reputation and career on the line. Experts suggest it's not exactly blind faith, because you can use various means to double-check the software-proposed geometry's integrity.

Cloud Test, Cloud Tease

On the second day's keynote, Suchit Jain, SOLIDWORKS VP of strategy and community, announced that the software can be trialed in the cloud, without downloading the gigabyte-sized installation file. The online SOLIDWORKS trial is offered through the My SOLIDWORKS portal.

Currently, SOLIDWORKS doesn't offer its flagship mechanical package as SaaS (software as a service). Those who want to run it in the cloud may work with partners like EpiGrid or Fra.me to run the product from virtual machines, hosted in private or public cloud infrastructures. But things may change in the future.

"There's no reason why [cloud hosting] cannot be a commercial offering," Boyalakuntla said. "When the cost is right and the structure is right, you might see it … The fact that we're now offering the software for evaluation in the cloud tells you that we're confident of its performance."

Newcomers like Onshape, founded by former SOLIDWORKS employees, have proven that browser-based CAD is technically and economically feasible. It puts pressure on desktop CAD software developers to offer browser-based alternatives.

MORE → digitaleng.news/virtual_desktop/?p=12638

SOLIDWORKS CEO Gian Paolo puts his faith in the software at SOLIDWORKS World 2017. *Image courtesy of SOLIDWORKS.*

BRIEFINGS
News and New Products

Hexagon to Acquire MSC Softwarex

Hexagon AB, a provider of information technology, has stated it is in an agreement to acquire MSC Software for $834 million. The transaction is expected to be finalized this spring.

According to an MSC press release, the company will continue to run as an independent business unit within Hexagon's Manufacturing Intelligence (MI) division. MI's main businesses are in the automotive, aerospace, machinery, consumer electronics and other discrete manufacturing markets, and is increasingly focused on offering end-to-end solutions in these workflows.

According to Hexagon, the acquisition strengthens the company's ability to connect the traditionally separate stages of design and production.

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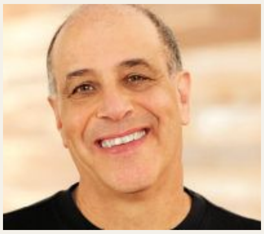
Autodesk CEO Carl Bass Has Stepped Down



The company's board has instituted a CEO search to consider candidates inside and outside Autodesk, and has formed an Interim Office of the Chief Executive to oversee the company's day-to-day operations. The Interim Office of the Chief Executive will be headed by Amar Hanspal, senior VP and chief product officer, and Andrew Anagnost, senior VP and chief marketing officer as interim co-chief executive officers. Bass will remain on staff as a special adviser to the company in support of the transition to a new CEO.

In a blog post, Bass wrote that he had been in discussion with the board about stepping down as CEO for years, and felt the time was now right. Bass has been with the company 24 years.

The company came to a new agreement with activist investors Sachem Head Capital Management LP that calls for two of Sachem Head's 2016 director nominees, Scott Ferguson and Jeff Clarke, to resign from the board of directors. When Sachem Head began acquiring Autodesk stock in late 2015, Bass and the board put discussions regarding a permanent successor on hold, determining that stable leadership was important to help Autodesk navigate investor negotiations while advancing its transition to cloud-based technologies and a subscription-only business model.

MORE ➜ digitaleng.news/de/?p=34767

Too HOT to Handle, Too BRIGHT to Watch

Thermal simulation of wearables must tackle tight corners, personal preferences and interdisciplinary communication issues.

BY KENNETH WONG

IN THE SECOND QUARTER OF 2016, shipments of wearable devices reached 22.5 million, according to International Data Corporation (IDC). "The overall market for wearable devices grew 26.1% year over year as new use cases are slowly starting to emerge," according to the firm.

While the market grows, the devices themselves are shrinking. The miniaturization adds a new layer of complexity to the design. "With wearables, the electronics are working hard to generate and collect all the data, so they're generating too much heat," says Akhil Docca, Future Facilities' corporate marketing & product strategy manager. Future Facilities develops engineering simulation software to quantify and qualify business decisions. "Now they're not only smaller, but also closer to the human body than before. That affects human comfort."

"It's all based on surface areas. To dissipate heat, the device needs to distribute it onto a surface area," says John Wilson, Mentor Graphics' technical marketing engineer. "In the case of a smartwatch, that surface area is not only small but also right next to the skin. It's important to get it right. Otherwise, people might think the device is too hot to wear and they'll return it. Or they might get hurt."

Getting it right means implementing thermal management strategies and cooling mechanisms that activate at the right moment. The solution usually belongs in the thermal engineers' territory. However, the fixes may affect the electrical layout and mechanical components. Experts believe it's time to address the shortage of efficient interdisciplinary communication tools.

"Thermal concerns can affect the electrical and mechanical performance of the electronic device as well', says Steve Pytel, lead electronics product manager at ANSYS. "You can have PCBs (printed circuit boards) delaminate or warp, causing the device to fail, and a thermal fix can also have an adverse effect on the electrical design. It is a completely interrelated design problem."

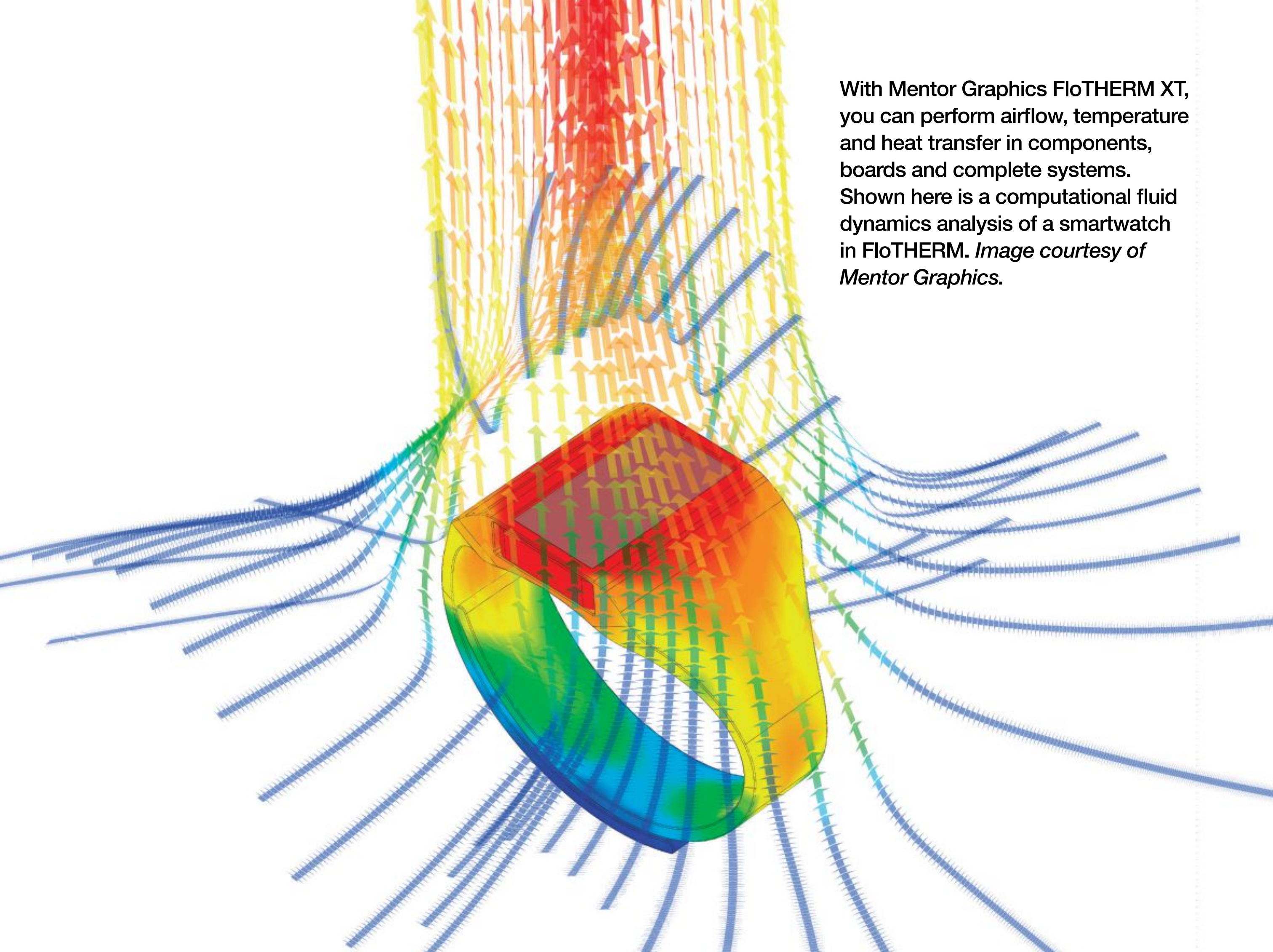
A Difficult Balance

Last September, Samsung recalled 2.5 million units of its Galaxy Note 7 after numerous reports of it catching fire. When some replacement units were also reported to suffer from the same hazard, the smartphone maker was forced to terminate sales of the model and launch an investigation into the root cause. The company is expected to take a $5.2 billion loss. According to a Reuters report, the fault rests with the battery ("Samsung Electronics probe finds battery was main cause of Note 7 fires," Se Young Lee, Jan. 2017). The whole incident revealed the delicate balance between battery life and product performance in connected devices.

"One of the issues with small IoT (Internet of Things) devices is the battery life," says Wilson. "Consumers want an extended battery life, but they also want more performance. More performance means more heat. One strategy for manufacturers is to insulate the heat-generating device or component, to isolate them from the surrounding parts. Air is probably the best insulator, because it's free, and it's pretty difficult to beat air when it comes to low thermal conductivity."

As another alternative, the designer may use molding to strategically spread the heat. "A mold makes a hot component cooler. It homogenizes the temperature because it spreads the heat out. Even a low-conductivity mold could have significant impact on the temperature," adds Wilson.

The components layouts and fine-tuning are usually done with the help



With Mentor Graphics FloTHERM XT, you can perform airflow, temperature and heat transfer in components, boards and complete systems. Shown here is a computational fluid dynamics analysis of a smartwatch in FloTHERM. *Image courtesy of Mentor Graphics.*

of special simulation software, because experiments and changes made in pixels cost less. However, relying on digital simulation alone is seldom adequate.

Calibrating the Simulation Model

A steady state simulation offers a snapshot of the product under a specific set of conditions. A transient simulation, on the other hand, offers the product's behavior within a slice of time, and is therefore more useful to engineers. But the latter is often more difficult to set up and taxing on the hardware needed to run the simulation.

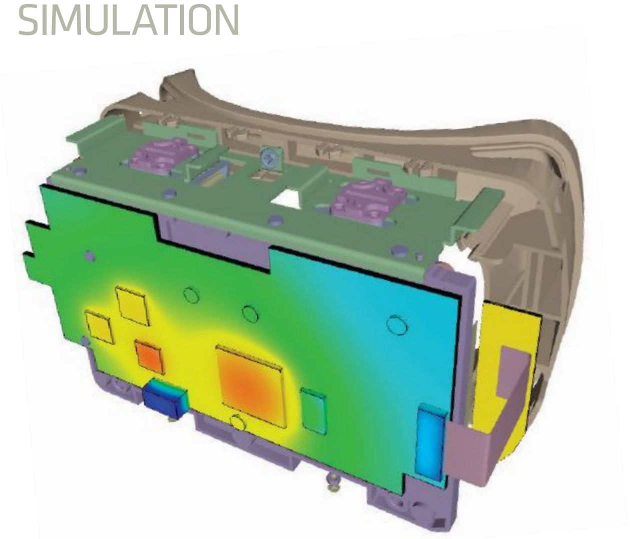
"Take, for instance, the smartwatch on your wrist," says Wilson. "While it's on standby, while you're not doing anything, it has a certain heat dissipation pattern. That's steady-state simulation. Now, let's say you start using Wi-Fi to communicate with something. Now the temperature will gradually rise. That's transient simulation. At some point the device would become too hot, so its performance has to be throttled [to give it a chance to cool down]."

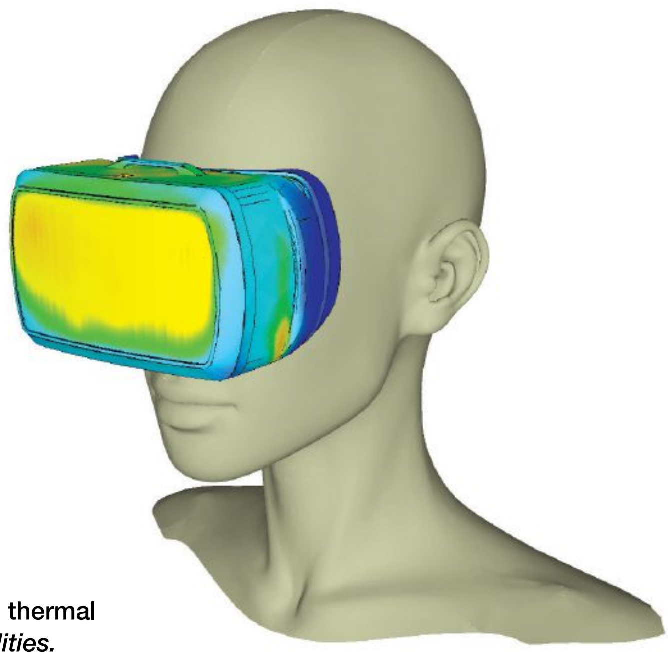
Transient simulation is much more reliable when it's calibrated to match the outcomes of a physical test. That means adjusting the input parameters in the digital simulation and experimenting with it until its behavior matches what's observed in a physical test. Thus calibrated, the simulation model becomes a much more reliable tool for making predictions. "You need to calibrate your model so it gives you accurate feedback on transient scenarios, but that makes building the model much more difficult," says Wilson.

FloTHERM from Mentor Graphics is a software package for simulating electronics component behaviors. The solver is capable of both steady- and transient-state simulations. "We invested a lot in transient simulation and thermal test calibration tools," says Wilson. "In FloTHERM, we added a feature to automatically calibrate the model with test data from T3ster [pronounced Tris-ter, a standard way to digitally describe thermal properties and behaviors in integrated circuits]."

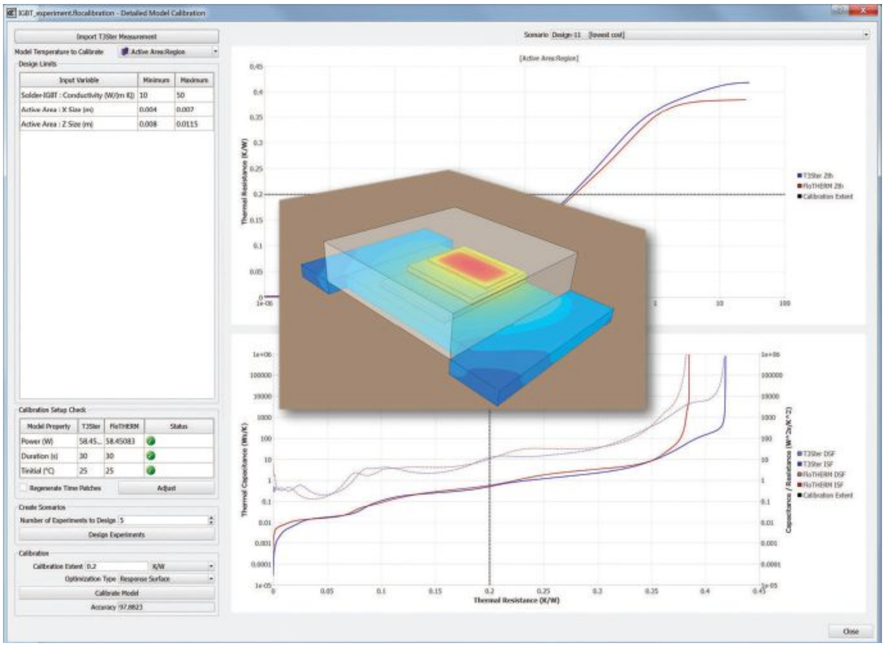
Encourage Early Thermal Studies

Formed in 2004, Future Facilities began by catering to the emerging data center industry with its thermal simulation software. It has since expanded into the electronics industry. The company now offers two distinct products: 6SigmaDCX software for data center performance prediction and 6SigmaET for thermal simulation of elec-





Future Facilities offers 6SigmaET software for simulating thermal behaviors in electronics. ***Images courtesy of Future Facilities.***



You can use FloTHERM's automated method to calibrate simulation models to match transient thermal measurements recorded with the Mentor Graphics T3Ster hardware. ***Image courtesy of Mentor Graphics.***

tronics. Because connected devices have a tendency to churn out large volumes of data, Future Facilities feels the impact of IoT on both ends of its businesses.

"Service providers like Apple or Fitbit have to store all that data somewhere, usually in large data centers" Docca points out. That means some customers are using Future Facilities' software not just to design and simulate their connected devices but also to manage the heating and cooling of their data centers.

"Manufacturers should get the thermal engineers involved very early on," suggests Docca. "They can run quick feasibility studies. At that point, there may be very little data available [for the new product], but there's enough historical data to work with [from older generation products]. It's very important to get that early layout right. Otherwise, you may need to move the heatsink or replace it later. Thermal engineers can help you reduce those costs or mitigate those risks."

In small, wearable IoT devices, the fitting is of paramount importance, because there is—quite literally—very little room for errors. Docca and his colleagues think it's a good idea to work in a software program that mimics the natural way in which objects fit together.

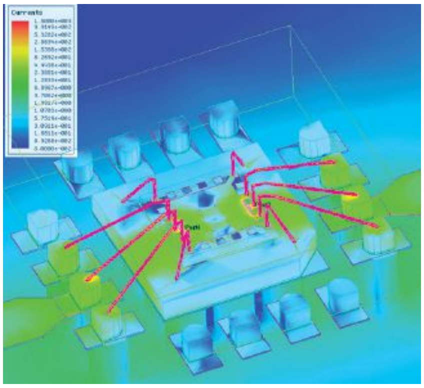
"The objects [in wearables] have a natural hierarchy," explains Docca. "A PCB fits inside a chassis; a component sits on the PCB; the heatsink sits on top of the component. We mimic that in our software. We reproduce that natural order."

One of the strengths of Future Facilities' 6Sigma software is its gridding or meshing technology, Docca points out. "We've made gridding completely automated, so a lot of our users just have to verify the model, then solve it."

HPC-Powered Simulation

With thermal simulation, the complexity of the scenario involved may increase the size of the job to the extent where it becomes no longer feasible to process it on a single workstation. In such cases, software written to take advantage of high-performance computing (HPC) clusters gives the user the option to employ additional computing cores, either from a company-owned cluster or on-demand cloud service providers.

"If you have own hardware, you can scale anywhere from four to 32 cores in our software fairly easily," says Docca. "We also partner with Rescale so users who don't have hardware can solve the model in Rescale's clusters."



Electric currents on an electric component, generated in ANSYS Icepak software. *Image courtesy of ANSYS.*

ANSYS Icepak lets you perform transient and steady-state thermal behaviors. Shown here is the heat map of a PCB generated in Icepak. *Image courtesy of ANSYS.*

Rescale provides on-demand HPC for simulation. It's part of a growing segment that caters to simulation users who need additional computing power, but aren't prepared to acquire the necessary hardware. With on-demand HPC services, companies with fluctuating, irregular simulation workloads can complete their jobs in a timely fashion without the need to purchase additional hardware.

Multidisciplinary Design

Thermal, electrical and mechanical engineers often use different software packages—and that still remains a cause of communication hiccups. Many software packages now offer a free mobile or lightweight viewer for others to view the results. This approach partially addresses the problem.

ANSYS tackles the interdisciplinary communication issues with its ANSYS Icepak software. It performs heat transfer and fluid flow simulation, enabling engineers to analyze transient- and steady-state thermal conditions and develop effective cooling strategies. "Unique to ANSYS is that we provide a comprehensive, integrated electrical-thermal-mechanical simulation solution," says Pytel.

As he explains it, PCB power distribution problems include signal integrity, crosstalk and electromagnetic interference. Current flow in a PCB and through the electronic components causes power losses across the board and leads to power dissipation in the components, mainly the ICs. Power losses in conductors within the board and heat generated by ICs increase their temperatures, leading to thermal problems. Moreover, modern microprocessors can demand peak currents of 100 amperes or more. These high currents cause significant heat dissipation in the ICs and significant Joule or Ohmic heating in the connected power planes and traces.

"Even a small change in temperature can affect a device's performance due to the inverse relationship between electrical and thermal conductivities. This bending can cause solder joints to crack or even result in delamination of the board or traces on the PCB," Pytel says. "With the ANSYS design flow, you can perform DC analysis, calculate Joule heating, then produce temperature profiles and associated mechanical deformation and stress."

Mass Market with Personal Appeal

One of the challenges in thermal simulation is to come up with a set of values that are valid for most people. The wearables are fundamentally mass-market consumer items. Yet, they also demand an unprecedented level of personalization. What's too bright for some is still too dim for others. What's too hot for comfort for some may be tolerable for others. For the thermal engineer who must set a threshold, the acceptable range is difficult guesswork.

"About 10 or 15 years ago, it was common to design something to withstand the maximum thermal load," explains Wilson. "Now we're trying to design not just a device that works the same way in every environment—we need to design it so it works differently at cooler ambients, in warmer operations and so on."

The key to solving this dilemma may rest with better communication among the different engineering disciplines involved. "Thermal engineers need to work more closely with the electrical engineers to understand the device's power dissipation," suggests Wilson. "How long can a device stream video before it has to throttle or dim the display to prevent overheating? To decide that, you have to have a much better understanding of the materials involved—and beyond that, also the connection between the materials."

"Most thermal packages focus on allowing the thermal engineer to get all the data they need so they can build a good model and solve it," says Docca. "But the industry hasn't been addressing the need for a centralized way to communicate among everybody. That challenge is quite immense. It's ongoing, a learning process, and we are slowly moving in the right direction to address the larger communication problems." **DE**

Kenneth Wong *is* DE*'s resident blogger and senior editor. Email him at de-editors@digitaleng.news or share your thoughts on this article at digitaleng.news/facebook.*

INFO → ANSYS: ANSYS.com

→ **Future Facilities:** FutureFacilities.com

→ **IDC:** IDC.com

→ **Mentor Graphics:** Mentor.com

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Energy Efficiency for Always-on Sensing

Technologies and techniques to reduce energy use in mobile, wearable and IoT devices.

BY TOM KEVAN

NEW AND NOVEL WAYS OF HARNESSING THE POWER of sensors have begun to redefine the form and function of the latest generation of electronic products, changing the way people interact with and use these devices. Design teams now use terms like "natural," "interactive" and "hands-free" to describe the man-machine interfaces of sensor-enabled mobile, wearable and Internet of Things (IoT) devices.

A look behind the scenes reveals significant growth in the number, sophistication and variety of the components that allow developers to take full advantage of the information gathered by sensors. Next-generation systems sport a growing variety of specialized processors, large caches, enhanced memory and communication protocols.

To get an idea of the scale of this trend, consider Samsung's Galaxy smartphones. Launched in 2015, the S6 contains three times more sensors than the 2010 Galaxy S. In the same timeframe, the number of processor cores has grown from 1 to 8.

The rise of always-on sensing has opened the door for speech-based interfaces, dramatically changing the way consumers interact with everything from sports watches to automotive control systems. The challenge is: How do you design these systems in such a way that they don't drain the batteries that power their operation too quickly? *Image courtesy of InvenSense.*

The real change, however, is not the increasing power of sensing and processing resources, but the growing use of always-on sensing to enable voice- and gesture-activated interfaces, as well as context-, environment- or location-aware services. Implementing always-on applications often requires the design engineer to create systems that can operate within the meager power budgets of battery-operated devices.

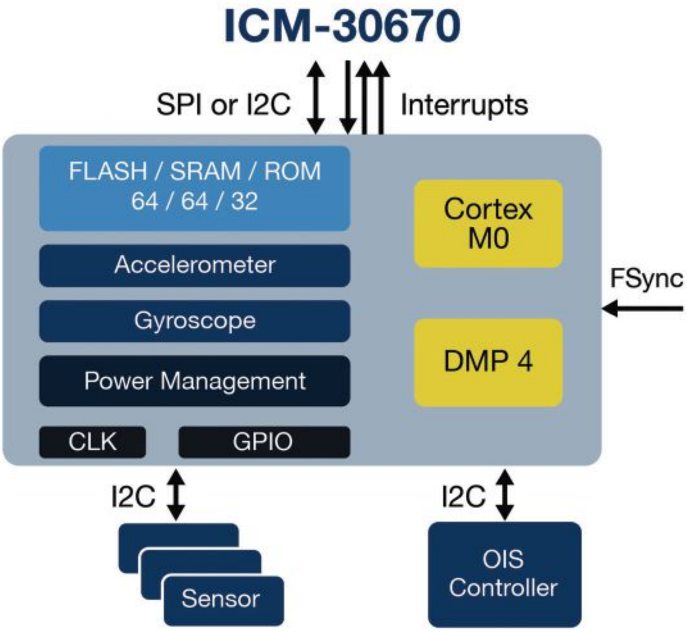
To address this issue, the design engineer has to do more than reduce the systems' energy budgets. Slashing power consumption often means sacrificing precision or increasing noise. "Simplistic brute-force approaches of 'let's just use a lower power sensor' may backfire," says Eitan Medina, vice president of marketing and product management at InvenSense. "Sacrificing performance parameters—such as the noise floor or sensitivity or other parameters—may actually hurt the ability of the [sensor] node to fulfill the end use case or address a portion of the system power that is actually negligible while causing a bigger waste elsewhere."

A more effective approach calls for tailoring sensor and processor operating parameters to minimize power consumption while ensuring precision measurements. Always-on applications cannot operate on power hungry general-purpose processors running high-level operating systems. The power consumption of these processors is simply prohibitive.

Start with the Big Picture

To effectively address the issues of precision and energy efficiency, engineers should begin their sensor design process by cultivating a deep understanding of the use case on the system level for the end product. "It is always important to see power consumption on the system level and optimize all components to achieve the maximum benefit," says Jeanne Forget, vice president of global marketing at Bosch Sensortec. "A variety of technologies can have a positive impact on power saving. It depends on the application and use case how much potential can be realized in the specific application."

Implementing a holistic approach calls for analysis in two areas: architectural analysis and actual measurements. The architectural analysis aims to understand the product's hardware architecture, identifying the key subsystems and obtaining from vendors as much information regarding the subsystems'



InvenSense's single-chip ICM-30670 combines gyroscope and accelerometer sensors with an ARM Cortex-M0 CPU and a DMP4 Digital Motion Processor. The specialized processors collect and process data from internal and external sensors, offloading processing from the application processor while reducing system power consumption. The Cortex-M0 CPU provides a programmable platform for software development, and the DMP4 is optimized for fixed-point processing and FFT (fast Fourier transform) generation, offloading math-intensive operations from the main CPU. *Image courtesy of InvenSense.*

power consumption in each of the key modes to be used by the end product. Once you do that, you come up with a power budget for each of the components in your design.

In the measurement phase, you are looking to correlate actual measurements with your architectural analysis to identify problems and areas best suited for power-optimization. You want to embed in your design prototypes the ability to measure power consumed by the biggest subsystems in the design. This will involve making sure you have test points that allow you to measure current by individual subsystems and chips.

If you have performed these steps correctly, the analysis and measurements will help identify the subsystems and use-case scenarios consuming the most power. You can then seek alternatives to the subsystems that consume the most power.

An example of this approach might involve finding a way to reduce the power required by a sports watch. In this case, the wearable incorporates a GPS system, 6-axis motion sensor and PPG (photoplethysmogram) sensor for measuring heart rate. In this example, the goal is to avoid needing to recharge the watch frequently.

If the primary element that limits the battery's operating life is the GPS system, then you could turn off the GPS subsystem intermittently, using motion sensors enabled by advanced algorithms to take over navigation functions, delivering a major power reduction on a system level. A side benefit of this holistic approach would be an improvement in the watch's ability to navigate when the user moves under trees or in an urban environment. If you focus on the components alone and do not adopt a top-down perspective, you can miss possible major power savings and potential expanded use cases.

Implementing this holistic approach requires designers to engage the full spectrum of disciplines, factoring in all aspects of the design. "InvenSense relies on an array of disciplines that work together to identify the right mix that would provide the sensor solution for the end product use case," says Medina. "The system and software insights influence the hardware and software partitioning of the capabilities and help prioritize tradeoffs in various levels in the sensor design and sometimes in the system design."

The Discrete Sensor

Working at the most basic level, the design engineer can take several approaches to optimizing the energy efficiency of the discrete sensor. Many development teams begin by fine-tuning the basic power control elements. "We achieve power efficiency through improvements in every element in the discrete sensor, including the sensing chain, drive chain and digital elements such as PLL (phase lock loop), LDO (luminescent dissolved oxygen), and charge-pumps," says Mahesh Chowdhary, director of strategic platforms and IoT applications for STMicroelectronics.

Optimization efforts also try to eke out energy savings using signal-sampling techniques like compressed sensing, a method of acquiring and reconstructing a signal from far fewer measurements than traditional methods. While this technique can reduce energy consumption, some consider its benefits to be limited. "Compressed sensing is getting a lot of press, but in practical systems, it only provides incremental benefits to energy efficiency," says Jim Steele, vice president of engineering, intelligent audio, at Knowles Corp. "A system solution with proper duty cycling is the best way to optimize energy consumption."

This approach periodically places various subsystems in the sensor system into sleep mode. The lower the duty cycle, the longer subsystems remain asleep, and the more energy they save.

In low-power, always-on applications, duty cycling becomes more complicated. The sensor must run when the system is asleep. This means the system clock is not available. Therefore, the sensor needs an internal clock to run during this time. After an event awakens the rest of the system, the sensor can resume using the system clock.

Duty cycling for this type of application requires a trigger that continuously analyzes incoming sensor data using minimal energy and memory resources, waking up a more powerful processor only when something significant happens. This is where the introduction of advanced software comes into play.

"The idea of duty cycling has been around for a while, but it is being realized now more than ever because more sophisticated algorithms are finding their way into the discrete sensor," says Steele.

Designers can take the role of software one step further by abstracting relevant context information from the raw sensor data. This opens the door for higher-level algorithms to use the abstracted results rather than the sensor data to obtain additional contextual insights. Adding the abstraction process further reduces the amount of data that must be processed, achieving even greater energy efficiency.

The downside of duty cycling, however, is that it can increase transmission latency and decrease the throughput. As a result, implementing duty cycling requires the design engineer to make tradeoffs between energy efficiency, transmission latency and throughput.

Advocates of duty cycling contend that the best results are achieved by adopting a hierarchical approach. In this technique, lower-power systems trigger successively higher-power systems to meet the required levels of accuracy. To do this, the designer must quantify the power requirements and available accuracy of each subsystem. Armed with this information, the design team can optimize energy efficiency and specify the desired level of accuracy required for the applications with full awareness of the impact of the tradeoffs being made.

Optimizing the Sensor Node

The sensor node presents a more complex arena than the discrete sensor for designers attempting to achieve greater energy efficiency. That said, many of the same techniques and technologies used to optimize the discrete sensor have proven to be relevant to the sensor node.

For example, developing an always-on, energy-efficient architecture for the sensor node also begins with a system-level assessment of the power budgets of the subsystems. As with the discrete sensor, designers can use this analysis to

STMicroelctronics LSM6DSM iNEMO inertial module incorporates embedded functions, using hardware blocks to enable such functions as motion detection, tilt detection and step recording. These embedded functions reduce energy consumption by offloading feature computations from the sensor node to the discrete sensor. ***Image courtesy of STMicroelctronics.***

target the most appropriate areas for optimization.

Duty cycling also plays an important role. In the case of the node, this technique can be challenging because of the array of subsystems involved and the complexity of their interactions. Even so, the rewards are significant.

These are a few general practices. Other optimization techniques seek to improve node architectures by specifically focusing on processor and data buffer resources that handle sensor data.

Processor Dexterity

One such approach builds on the principle that the designer cannot afford to run low-power, always-on applications on power-hungry, general-purpose processors running complex, high-level operating systems. This technique advocates developing architectures built on the use of small, low-power, specialized processors that can offload low-level cognitive functions from the general-purpose processor, providing appropriate performance within a sustainable power budget.

"When sensor devices are applied with general-purpose MCUs (microcontroller units), the MCUs often carry significant overhead," says Forget. "Instead, we [Bosch Sensortec] develop dedicated signal processors for sensor data fusion and sensor algorithms, optimized for the task with respect to instruction set, peripherals and performance. This way, we can achieve a perfectly optimized power budget."

Complex applications can require a series of processors, with each successive processor handling increasingly difficult functions. For example, a voice-based interface may require a digital signal processor (DSP) tailored for low-power voice detection. Downstream, more powerful processors run advanced voice-recognition algorithms for high-end functions.

Selecting an appropriate processor, however, may be easier said than done. The sheer variety of processing requirements for always-on applications precludes the adoption of a one-size-fits-all approach. There are, though, a few rules of thumb that can help with the selection process. Look for processors with efficient floating-point options for sensor data processing, scalable performance over a range of functionality, and an efficient instruction set with a low cycle count.

A Layered Approach

Another optimization technique called "cognitive layering" harnesses the power of parallel processing. In a white paper titled "Keeping Always-On Systems On for Low-Energy Internet-of-Things Applications" (https://goo.gl/H7WbbT), Gerard Andrews and Larry Przywara, of Cadence Design Systems, describe a technique of offloading tasks from the general-purpose processor to low-power, always-on DSPs. The idea is to have different layers of a software program run on specialized processors. The lower layers of the software are served by DSPs with just enough processing power to perform the tasks required by the system at a given point.

Andrews and Przywara describe how cognitive layering works using an example of a voice-recognition application on a smartphone. The bottom layer detects noise, which consumes only nanowatts of power. The noise detection triggers a series of actions further up in the processing chain, ranging from detecting a noise to recognizing a command to interpreting the commands in the context of the current application. Thus, each successive level of power consumption is triggered only when it is needed.

The developers of cognitive layering contend that, by using this technique, the designer can achieve optimal energy efficiency while still delivering acceptable latency and throughput. This technique can run on a single chip or include cloud-based processing for more complex applications.

Pushing Functionality to the Sensor

Another approach to optimizing energy efficiency of the sensor node takes the form of shifting more functionality to the discrete sensor. The idea here is that designers can improve performance across the board by beefing up local processing, memory and software assets. Again, the deployment of these resources has to be tailored to meet the specific needs of the use case.

Limited, targeted intelligence plays a prominent role in this strategy. "Knowles is working on improving the energy efficiency of sensor nodes by bring more intelligence into the discrete sensor itself," says Steele.

This intelligence takes several different forms. For example, Bosch Sensortec sees great potential in local signal processing and buffer memory in the sensor device. "Our sensors have internal FIFOs (first in, first out data buffers) that can be filled with sensor data," says Forget. "Some of our newer sensors also incorporate additional intelligence inside the sensor, allowing for limited data pre-processing without the need of interacting with the host MCU.

In addition to processors and memory, sensor vendors have expanded local logic by adding embedded functions. "In the sensor node, we reduce energy consumption by offloading some of the feature computation to the discrete sensor," says Chowdhary. "Discrete sensors from ST have embedded functions such as motion detection, step counting, tilt detection and orientation detection. Implementing these functions on the sensor produces significantly lower power consumption relative to the sensor node."

A Work in Progress

Growing demand for devices that deliver always-on functionality to support voice- and gesture-based interfaces places great pressure on design engineers to achieve optimum energy efficiency in sensor-enabled devices. While duty cycling, specialized processors, cognitive layering and embedded functions offer designers a variety of ways to reduce energy consumption, it is important to remember that each use case will likely have special requirements and demand its own unique architecture.

While current techniques and technologies have great potential, the coming years promise to bring a new class of design options. It's safe to say that the drive to build devices that can conveniently operate on battery power is only just beginning. **DE**

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INFO ➜ **Bosch Sensortec:** Bosch-Sensortec.com

➜ **Cadence Design Systems:** Cadence.com

➜ **InvenSense:** InvenSense.com

➜ **Knowles Corp.:** Knowles.com

➜ **STMicroelectronics:** ST.com

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Put Engineering Collaboration Front and Center

Social media and concurrent software development lead to collaborative engineering procedures.

BY RANDALL S. NEWTON

FROM THE EARLY DAYS of computer-aided design until today, Airbus has been intentional about pushing the possibilities of engineering technology. First there were electronic drawings; later digital mockups. In 1999 Airbus moved to concurrent engineering, creating methods, processes and tools to serve all functional design disciplines. Today Airbus is implementing collaborative engineering, which it defines as "the integration of functional and industrial design teams to produce a single deliverable, an industrial digital mockup (iDMU)."

Researchers at Madrid Polytechnic University recently studied the Airbus approach to collaborative engineering. They found management chose to break down "the wall between functional design and industrial design and to perform the design process with a unique team." The researchers found five elements that defined each transitional stage as Airbus moved from traditional to concurrent to collaborative methods.

Airbus is large enough to take a leadership role in creating a collaborative engineering environment; most companies depend on their software vendors to provide the new tools required to advance from traditional and concurrent engineering. Thanks to consumer-class social media and the use of concurrent engineering practices in software development, the pressure is on product design and manufacturing companies to adopt collaborative engineering procedures.

There is strong temptation to add social media tools and methods to existing engineering software and workflow. But there are significant drawbacks to borrowing consumer or enterprise software for engineering. Dropbox may make it easier to send a 3D model, but what happens to document control? Is it OK to use Skype or Facebook Messenger as a communications channel in product design? When it comes to collaborative engineering, there is a bit of the proverbial blind men describing an elephant feeling, but advances are being made around the themes of improving workflows, improving access to data and protecting engineering from time-wasting practices or technologies.

The PLM Underground

Significant conversations take place in product design, but do they always take place within the frame of product lifecycle management (PLM)? For most companies the answer is "no." Even with a PLM system in place, most of the dialog takes place in email. Such practices are part of what Aras Software calls The PLM Underground. "Do you have any Excel spreadsheets with 40 tabs and hundreds of macros? That's your PLM system," claims Peter Schroer, Aras CEO. "Look at the network bandwidth between your site and Dropbox. The PLM Underground is sending your corporate IP (intellectual protocol) via email, FTP and Dropbox to suppliers."

Aras, which develops the Aras Innovator PLM system, identifies three problem areas for engineering collaboration, according to product marketing director Doug McDonald.

1. Security: Email and other forms of direct communications are "potentially insecure ... it is important to keep these communications secure, even within the organization."

2. Context: If an engineer has a ques-

CHARACTERISTIC	TRADITIONAL	CONCURRENT	COLLABORATIVE
Timeframes	Sequential	Overlapping	Shared
Teams	No	A few	Unique
Deliverable	Drawings	Digital Mockup (DM)	Industrial Digital Mockup (iDMU)
Focus	Product Design	Reduce Time	Customer
Objective	Design for Functionality	Design for Assembly	Virtual Manufacturing

tion about materials, she might call up a model, but is it the right model? "Context is important in collaboration; engineers must be able to get answers from the right place at the right time." Too often such searches become "micro-level interactions using email or Dropbox," McDonald says, further weakening the security as well as potentially leading the engineer in the wrong direction.

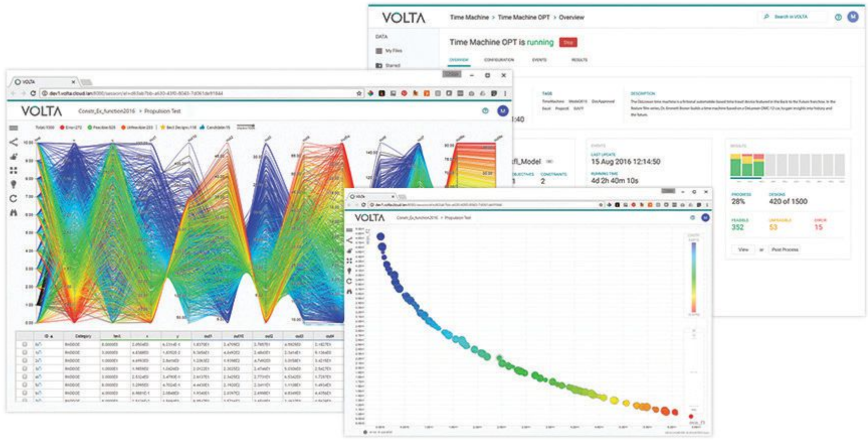
3. Verification: There is no consistent, automated way to store, access and verify communications outside the PLM system. This makes it impossible to establish an audit trail, crucial in some industries.

Electronic vs. Digital Collaboration

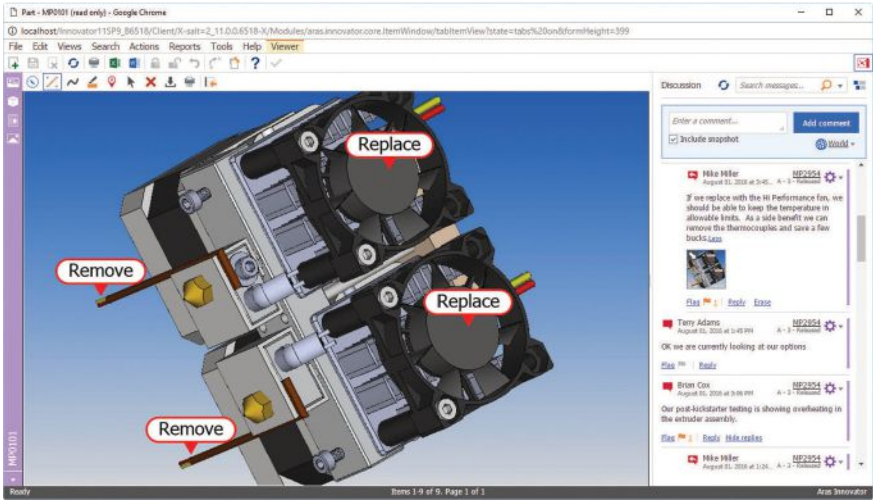
Data in collaborative environments needs to be granular; accessible at its most fundamental level. At the same time, not everyone in the value chain needs the same level of data granularity.

Dassault Systèmes' Ramesh Haldora, VP of Strategic Consulting for the 3DEXPERIENCE platform, says granularity of data is an important reason to move from electronic engineering documents to a single digital platform. "Consider the boarding pass," he says. "Ten years ago we had paper documents, five years ago we would check in online and download a PDF. Today we have a digital boarding pass; if there is a gate change the boarding pass updates." With each improvement the granularity changed and utility increased. The PDF was an electronic document, the boarding pass in the app is a digital display connected to the flight database. The passenger may only need to read gate and departure information, but the bar code with the digital boarding pass tells the airline gate agent everything she needs to know to allow the passenger on board. Each person in the value chain can access the data they need at the level of detail required, and it the data is always current.

Haldora says the digital platform Dassault has built based on its core applications—CATIA for modeling, SIMULIA for simulation, and ENOVIA for data management—provides the single data model approach, moving on from electronic sharing to digital access. "We have



ESTECO Volta is a new web-based simulation collaboration application, designed to encourage collaborative engineering and knowledge management for the dispersed enterprise. *Image courtesy of ESTECO.*



Aras Innovator PLM software includes Visual Collaboration, a browser-based environment for model and document review. *Image courtesy of Aras Software.*

been on the digital platform for almost nine years; the technology is robust. CATIA engineers can now work directly with simulation engineers. They work at the same time on the same version of the truth," he says. He calls the ability to do 256 iterations on four parameters—instead of one at a time as in the serial workflow of traditional engineering—"a quantum difference" in the engineering workflow.

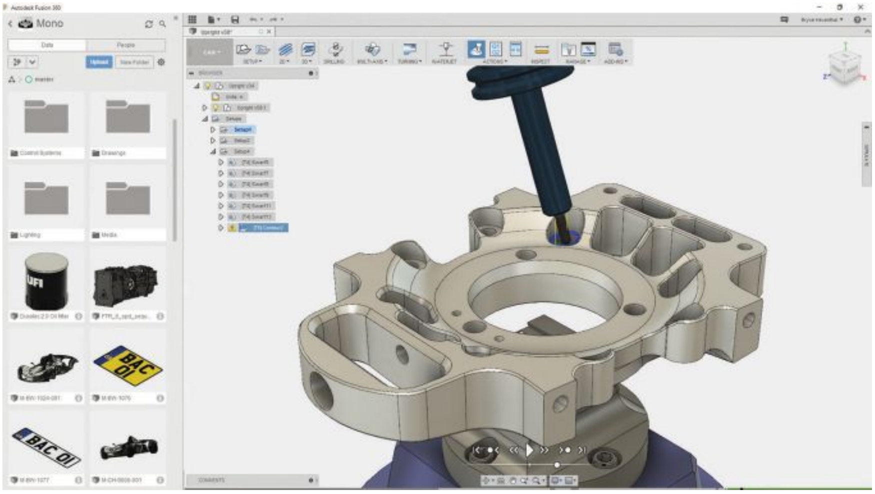
Granularity is vital, but the need for it "varies massively," says Leo Kilfoy, general manager of MSC's Engineering Lifecycle Management Business Unit. "Often, drawings or models are the key focus. But at other stages it might be a reserve factor or a margin of safety that is the focus."

What matters is the pedigree of the data, adds Keith Dunlop, a senior technical consultant with MSC, "[to] ensure there is a clear audit that connects these data islands during the development phases and often well after the product is in service."

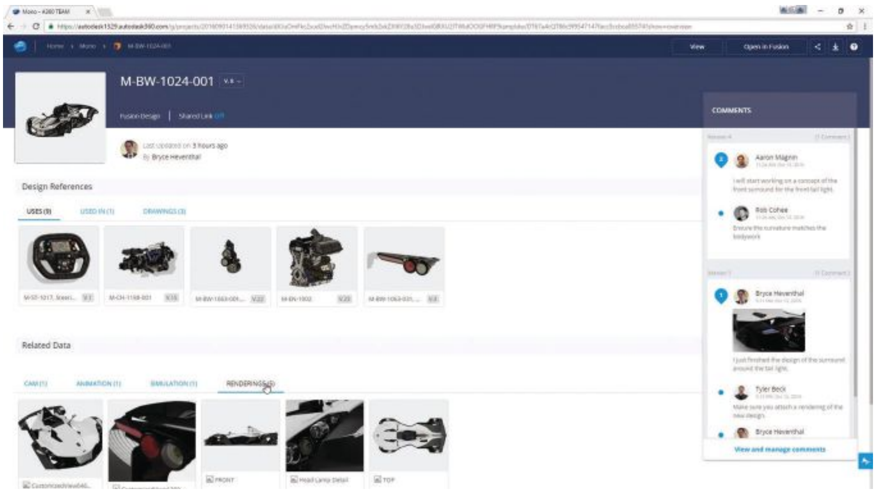
But if all information is accessible, are engineers inundated with too much data? "The key to managing information overload is to create semantics and meaning, giving context to the data for engineering change," says Dassault Systèmes' Haldora. If you don't do that, users will create their own meaning from data.

Synchronous or Asynchronous?

Not every engineering software company is working to provide real-time collaboration as the norm. "We make a distinction between synchronous and asynchronous collaboration," says Dan Staples, VP of Product Development for the mainstream engineering division of Siemens PLM Software. "Most people prefer asynchronous work; it is working on their own timeline: 'Tell me what you think of the model; mark it up and send it back.'" The synchronous



Autodesk Fusion 360 is a cloud-enabled collaborative product development platform that offers CAD, CAM and simulation features in a concurrent access environment. ***Image courtesy of Autodesk.***



Autodesk Fusion 360 includes shared visual access to all project data in a common data model, and an activity stream that connects all team members. ***Image courtesy of Autodesk.***

model is "nice but can be overused," says Staples. "It is the yappy dog. Fundamentally, engineers need asynchronous collaboration at the bottom of the pyramid and synchronous at the top. It's not as important."

ESTECO approaches its role in engineering as providing for a team approach. "No single expert can do the entire simulation; this pushes engineers to work together," says Matteo Nicolich, the ESTECO engineering solutions product manager. "We use collaboration to give simulation experts a way to build processes and connect with PLM apps, and to give visibility to managers and others in the process, to deliver their expertise."

ESTECO sees democratization of engineering data as a crucial piece of creating a collaborative environment. "Collaboration in general is not easy," notes Nicolich. "It can't be free, but as you lower the cost the more they collaborate. People are in charge of sharing directly. Yet we support structure at an enterprise level so the company has its standards."

Agile as the Next Frontier

Some engineering vendors see Agile processes as the next step in product development collaboration. As practiced by software developers, Agile engineering is a set of collaborative methods in which solutions arrive via self-organizing, cross-functional teams. Early delivery, continuous improvement, and rapid and flexible responses to change are important to the Agile method.

"We push Agile processes for engineering," says ESTECO's Nicolich. "Early review helps to improve design and reduce costs. The idea [of Agile] is collaboration and constant review and transparency of information for all engineers. Agile is already disruptive in software development; we will bring it to engineering and change the way old-school engineers work."

Cloud-based CAD vendor Onshape is also pushing Agile as a game-changing extension of collaborative engineering. "The serial workflows of traditional CAD and PDM [product data management] systems are anti-Agile," claims Onshape founder Jon Hirschtick, who also co-founded SOLIDWORKS. Onshape's cloud architecture makes all the data available to all team members all the time, Hirschtick says, making it a natural for a design philosophy of rapid change and continuous delivery. "Cutting out all that dead time—the waiting, the copying, the syncing, the worrying—makes everyone on the team less stressed and more likely to explore new ideas. That's time for innovation vs. rushing just to get things done." **DE**

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INFO → **Airbus:** Airbus.com

→ **Autodesk:** Autodesk.com

→ **Dassault Systèmes:** 3DS.com

→ **ESTECO:** Esteco.com

→ **Madrid Polytechnic University:** upm.es

→ **MSC:** MSCsoftware.com

→ **Onshape:** Onshape.com

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

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Out of Classroom Curriculum

Student competitions prepare up-and-comers with the hands-on experience necessary to meet the challenges of next-generation engineering.

BY BETH STACKPOLE

OSU's EcoCAR team gets a crash course in real-world engineering disciplines, including advanced testing. ***Image Courtesy of The Ohio State University.***

ANDREW HUSTER, A SECOND YEAR ELECTRICAL ENGINEERING graduate student, can't wait to step into his first professional gig at General Motors working on active safety features and integration. Yet before coming on board this August, The Ohio State University (OSU) student has already begun building out an impressive resume that includes internships at dSPACE, Ford and GM, along with carefully honed skills in hardware-in-the-loop testing and other advanced competencies.

How was Huster able to amass such marketable skills and hands-on experience while still knee deep in his studies? He spent five years on the OSU team competing in the EcoCAR challenge. Participation in the student competition helped fortify his technical acumen while building invaluable leadership, project management and collaboration skills that Huster contends is just not possible through traditional classroom learning.

"The engineering curriculum was a lot of theory and not a lot of practice or application," he says. "EcoCAR taught me a lot of technical skills and how to apply them along with how to work with and manage groups of people. I don't think I would have gotten this far without that experience."

Huster and many other university-level students are getting a significant jumpstart on their careers through participation in student competitions like EcoCAR, Formula SAE and the Solar Car Challenge. Beyond the automotive space, there are competitions targeting a range of industries, including civil engineering (the AISC Steel Bridge Competition, for example), robotics, and even next-generation transportation like Space X's Hyperloop Competition. While typically not a formal part of most university-level engineering programs, extracurricular student competitions are increasingly playing an important role in preparing up and coming engineers to apply what they've learned to better handle the complexities and unknowns of real-world design problems.

"If you put students in a classroom and throw equations at them all day, they don't necessarily understand," says Patrick Currier Ph.D., an associate professor in the Mechanical Engineering department at Embry-Riddle Aeronautical University and the lead adviser for the school's EcoCAR team. "If you give them an opportunity to participate in one of these student competitions, they get a chance to apply what they've learned, see how it works, and it creates a feedback loop—the classroom gets easier and the competition gets easier and they feed off each other."

A lot of what the students learn is practical stuff that isn't born out through the traditional course curriculum, Currier says. For example, students need to learn that just because something can be drawn in CAD doesn't mean it can be produced cost effectively. Similarly, just because there is an opportunity to spend three weeks optimizing a part doesn't mean that's the most efficient use of time or the best possible design strategy. "It's the kind of stuff you don't really get through the classroom unless you have a chance to work on one of these projects," he explains.

Thinking Outside the Lecture Hall

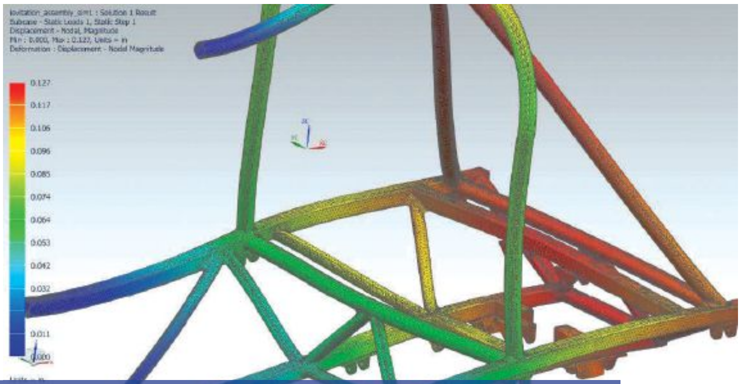
Given that most university-level engineering curriculums are dense and tightly scripted to cover maximum ground, there is limited time for students to explore specialty areas or immerse themselves in experiential learning, notes Shawn Midlam Mohler, associate professor of Practice, Mechanical & Aerospace Engineering at OSU. Student competitions, on the other hand, provide an outlet for students to put what they learned in class to practice while engaging in more free-range thinking and creative problem solving, he says.

In addition to sparking outside-the-box problem solving, competitions also give students an opportunity to develop soft, non-technical skills that are essential to success in the workplace. Working on a project like EcoCAR, for example, exposes students to situations that require communications skills and show them how to collaborate effectively with other team members. Student participants are also forced to roll up their sleeves and get immersed in standard business practices in areas such as balancing budgets, project management, meeting deadlines, and of course, Midlam Mohler says, competing in high-stakes competitions.

"These students are running vehicle programs like a small business with responsibility for several hundred thousand dollars to cover parts, testing, even machining services," he explains. "Students are functioning in an environment where they lead teams and have decision-making authority—that makes them mature so quickly."

Practicing creativity and learning how to function effectively as a member of a team are the two areas where Harvey Bell sees the greatest impact. Bell, a 39-year veteran of GM, is now professor of Engineering Practice and the co-director of the Multidisciplinary Design Program at University of Michigan's College of Engineering. One of his primary objectives is to integrate more hands-on style applied learning into the university's curriculum.

Unlike classroom learning and projects where students function mainly as "sole proprietors," student teams thrust them into situations where they have to be creative and figure out how to operate as a well-oiled machine, Bell says. "No one gets fired be-



University of Maryland students participating in SpaceX's Hyperloop competition are leveraging Siemens simulation software to model their dynamic test rig. *Image Courtesy of University of Maryland.*

A team of international students present their Reconfigurable Shared-Use Mobility System in a future mobility competition at the PACE Annual Forum. *Image Courtesy of Siemens PLM Software.*

cause they can't crank out a spreadsheet or do analysis—they get fired because they flunk Sandbox 101 and don't play well with others," he explains. "On competitions, students have to learn how to intellectually disagree with each other and still remain friends and be respectful."

As part of UofM's Multidisciplinary Design Program, Bell says that students are encouraged to participate in any number of student competitions for which they can receive course credit. At OSU, students are encouraged to participate in these competitions as an extracurricular activity for their freshman and sophomore years, but if they stick with it beyond that, there are ways to integrate it into their senior capstone design project and receive course credit, adds Midlam Mohler.

Hands-on Learning

Along with university professors, the leading design tool vendors are also playing a key role in promoting and supporting student competitions. In addition to providing student teams competing in challenges with training and its modeFRONTIER optimization software, ESTECO Academy is partnering with Aprilia Racing to expose students to multidisciplinary tools and practices, notes Enrico Nobile, a co-founder of ESTECO, a professor of mechanical engineering at the University of Trieste, and the scientific adviser for the team. As part of the competition, students design a four-stroke single cylinder engine for a motorcycle using multidisciplinary optimization—a discipline that isn't readily covered in most engineering curriculum, Nobile says.

"The design competitions help students think outside the box and learn how to apply a true multidisciplinary approach unlike standard coursework, which considers them mostly separate," he explains.

Siemens PLM Software also takes an active role in supporting a range of student teams, including EcoCAR, PACE, Greenpower, Formula Student, and more recently, the Hyperloop competition along with FIRST Robotics and a number of other programs aimed at the K-12 level. The PLM provider delivers software, training and sometimes financial backing for the teams, according to Dora Smith, Siemens' global director of its academic program. She says competitions are an instrumental component of preparing students for real-world engineering challenges.

One example is early exposure to the tools used on the job, which can deliver a leg up, Smith says. "When you have a single course, you might be introduced to CAD or simulation, but you're not applying it in an actual project," she explains. "This is about bringing it all together."

MathWorks has been involved the Advanced Vehicle Technology Competitions (ATVC) series, sponsored by the Department of Energy, for more than 15 years, according to Paul Smith, director of consulting services, MathWorks. Its sponsorship has changed from software donations and small contributions to mentoring and training for the student teams. "We

The EcoCAR competition gives engineering students at Embry-Riddle Aeronautical University a chance to apply multidisciplinary design principles. ***Image Courtesy of Embry-Riddle.***

provide software to the main part of the competition for simulation," he says. "In large part, what these students are doing with our tools is what automotive engineers are doing with our tools at the leading companies worldwide. Student competitions like EcoCAR helps create a strong talent pool to draw from."

Student participants in competitions typically have an advantage over fellow students when it comes time to compete for an internship or even that first job. For example, the typical mechanical engineering student might get a fluid dynamics lesson in how to determine the flow of fluid through pipes. In comparison, a student who has worked on a competition team understands how to apply that knowledge to generate the best result. "We might teach how to calculate how fast fluid flows through a pipe and what size pipe to use, but without reducing it to practice, they have no idea how to make fluid connections," Midlam Mohler says. "Recruiters can tell within two or three minutes of talking with a student whether they have experience like this."

Christina Kuwabara, a junior at OSU majoring in mechanical engineering and a member of the EcoCAR team, says the experience gave her exposure to processes and tools (MathWorks' MATLAB and Simulink, in particular) that she wouldn't get in day-to-day classroom learning. This in turn landed her a multi-year internship at Honda where she's working on controls, system modeling, simulation and testing. "During the interview, they asked me questions about EcoCAR—what test procedures I worked on, how we validated our results—not about what I learned in class," she says. "It was like I already had a job and we were talking about experience."

Same deal for Huster, who says his five years with the EcoCAR team and his ability to learn advanced skills like hardware-in-the-loop testing set him apart from his student peers and made the multi-hours a week time commitment well worth it.

"Participating in these competitions isn't necessary per se, but it's definitely a really good way to put yourself above the rest of your class when you start applying for jobs and you want to stand out," Huster says. "My advice is to get involved—it's well worth the extra time and effort." **DE**

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

INFO ➜ AISC Steel Bridge Competition: aisc.org/education/university-programs/student-steel-bridge-competition

➜ **dSPACE:** dSPACE.com

➜ **Embry-Riddle Aeronautical University:** engin.umich.edu

➜ **ECOcar:** ECOcar3.org

➜ **ESTECO:** ESTECO.com

➜ **FIRST Robotics:** firstinspires.org

➜ **Formula SAE:** students.sae.org/cds/formulaseries

➜ **Formula Student:** imeche.org/events/formula-student

➜ **GreenpowerUSA:** GreenpowerUSA.net

➜ **MathWorks:** MathWorks.com

➜ **PACE:** pacepartners.org

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

➜ **Solar Car Challenge:** solarcarchallenge.org/challenge

➜ **Space X's Hyperloop Competition:** spacex.com/hyperloop

➜ **The Ohio State university:** OSU.edu

➜ **University of Michigan:** engin.umich.edu

➜ **University of Trieste:** units.it

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Understanding Load Paths

Diagram to help determine the nature of the load.

BY TONY ABBEY

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

HOW DOES LOAD GET INTO a component and how does it get OUT? Knowing the answer to these questions will help in setting up a good finite element analysis (FEA) simulation. Free body diagrams are one of the most useful tools in understanding load paths.

A free body diagram is a picture that shows all the external balancing loads acting on a component. It includes the set of applied forces and reaction forces and is used to check that all forces are in balance. For a 2D representation in an xy plane, there are three balancing equations developed:

1. Summation of forces in x (Fx);
2. summation of forces in y (Fy); and
3. balance of moment about z at some convenient point (Mz).

For a 3D representation in xyz space, there are six equations developed:

1. Summation of forces in x (Fx);
2. summation of forces in y (Fy);
3. summation of forces in z (Fz);
4. balance of moment about x at some convenient point (Mx);
5. balance of moment about y at some convenient point (My); and
6. balance of moment about z at some convenient point (Mz)

The general definition of what is a reaction force and what is an applied force is debatable. In an FEA model definition it is clearer, in a sense, as reactions are defined by constrained degrees of freedom and applied forces are defined through loading actions. So why the confusion? Well, the free body diagram is a more philosophical approach that tries to define the fundamental nature of the load path through the component. Figure 1 explains this idea.

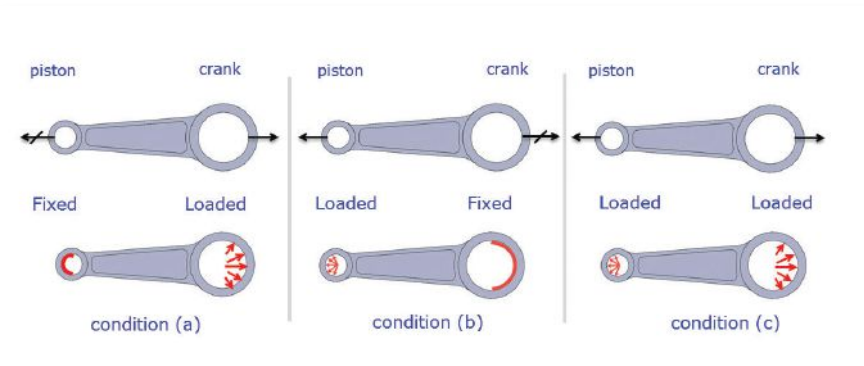

FIGURE 1: **Alternative free body diagrams and FEA model sketches.**

In Figure 1, condition (a), upper diagram, shows a conrod with an applied force at the right end (connected to the crank) and a reaction force at the left end (connected to the piston). The crank force is transmitted from the crank. The piston reaction is transmitted through the piston. The force and reaction vectors are drawn in a natural sense here, following their intuitive directions. Many industries also indicate a reaction by an oblique line through the arrow. The FEA model is shown in the lower diagram and uses the same boundary conditions.

Condition (b) shows a different interpretation of the same physical situation. The load is now applied at the left and reacted at the right. Both the free body diagram (upper) and the FEA load and boundary condition sketch (lower) shows this action. From a free body diagram point of view, it doesn't matter which way we setup the action and reaction. However, from the point of view of a finite element analysis, it will make a big difference. Local stresses in the

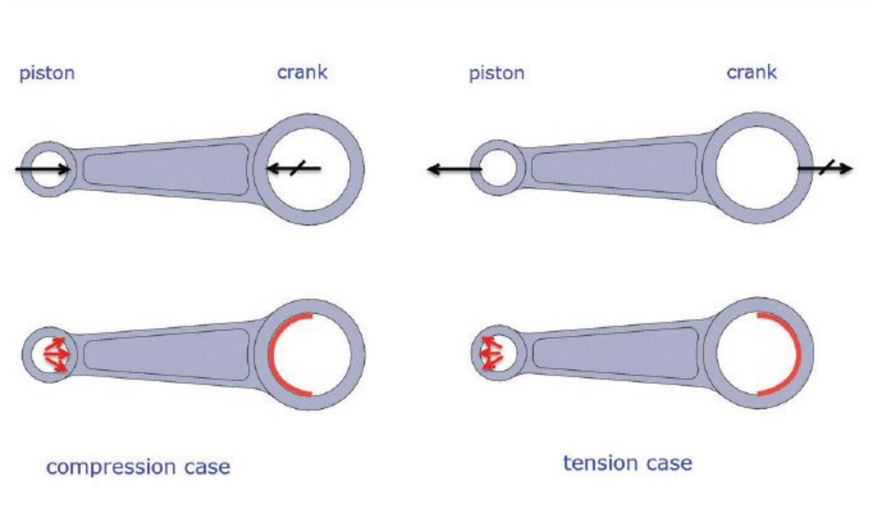

FIGURE 2: Compression and tension load cases in conrod.

constrained regions for condition (a) or (b) will be very different and both will be inaccurate. A previous article, ("Free-Floating FEA Models," February 2015, digitaleng.news/de/free-floating-fea-models) discussed the minimum constraint approach, and this is shown in condition (c). The FEA model sketch in Figure 1 clearly shows the load applied at both the right and left ends. The free body diagram shows the corresponding loads as actions, rather than reactions. In this case, the FEA model constraints are not shown. To stop rigid body motion, the minimum set of constraints (the '321' set) must be applied.

All the free body diagrams shown in Figure 1 are correct: They show balance in the horizontal sense. Notice that a free body diagram does not include internal forces. We can look at internal forces separately, but the intention of the free body diagram is to show overall state of balance.

Conrod Basic 1D Equilibrium

So far, we have looked at the conrod component in a simplistic way. Loading is applied at one end and the opposite end is fixed, or we can use a minimum constraint approach. The first approach is used very commonly in basic FEA tutorials. A more realistic assessment looks at the overall physics of the piston and crank system and sets objectives for the analysis. The job of the conrod is clearly to transmit loading between the piston and the crank. There are two basic scenarios that occur. At the start of the power stroke, maximum gas pressure is exerted on the piston face. This is transmitted through the conrod and reacted at the crank. For now, we can assume the crank is locked against movement and hence will provide a complete reaction path to the piston force. This will be a compressive load path. On the return stroke, we can assume the gas pressure has dissipated and the piston is being accelerated with no resistance. Newton's second law tells us that a force will be developed in the conrod as the crank resists this motion. This will be a tensile load path. Figure 2 shows these two scenarios.

A stiffness and strength assessment can be made based on these two loading scenarios. Fatigue analysis can also be carried out, assuming the stress range of each power cycle is defined by the compression and tension loadings. There are some more subtleties that could be applied, including inertia relief and friction effects. However, this is a common starting point.

Inertia Loading and 2D Equilibrium in the Conrod

There is, however, a big limitation in this method. We cannot get anything other than a one dimensional (1D) load balance from this system. The crank will rotate through 720° in a full power cycle, so it will spend most of its time in an off-axis configura-

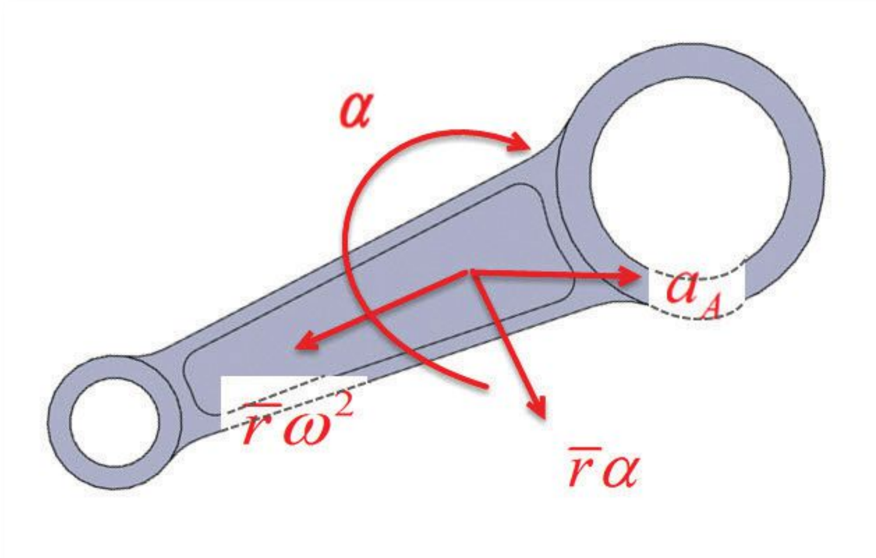

FIGURE 3: Conrod accelerations at arbitrary crank angle.

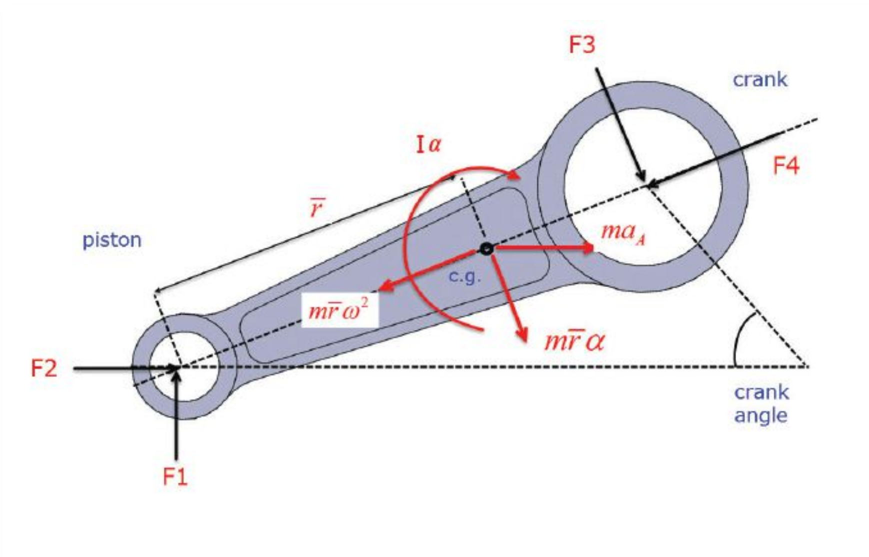

FIGURE 4: Conrod force balance at arbitrary crank angle.

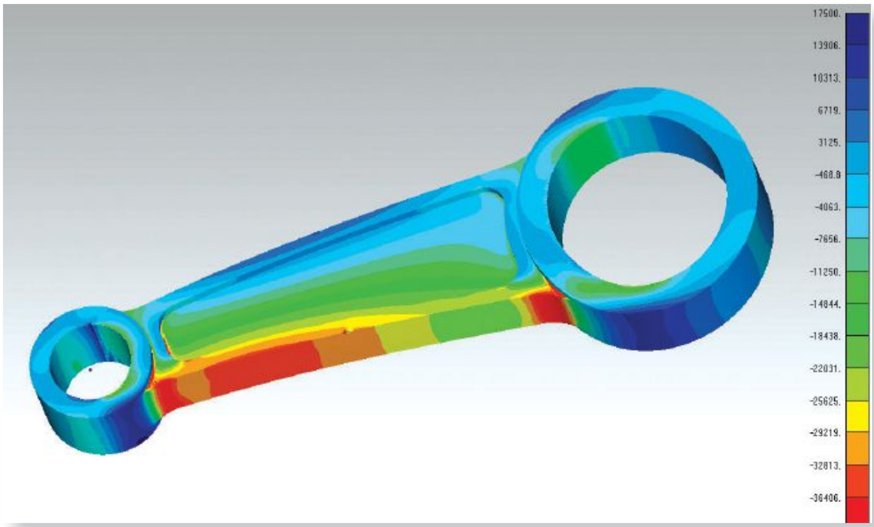

FIGURE 5: Axial stress in conrod at 60° crank angle

tion. We have only simulated top dead center and bottom dead center positions. How can we derive a free body diagram for an arbitrary crank angle?

The key here is to be able to define the inertia loading. That is quite tricky to achieve, and it is easiest to define both an acceleration diagram and a corresponding force balance diagram. Figure 3 shows the acceleration diagram of the conrod at some arbitrary crank angle. The accelerations are drawn relative to the conrod center of gravity (c.g.). The c.g. is at length r, along the conrod. The conrod sees an instantaneous rotational acceleration, alpha and longitudinal acceleration aA. There is also a centrifugal acceleration, r*w2, along the axis of the conrod which is due to the instantaneous angular rotation, w. Finally, there is a linear acceleration r*alpha. If the angular acceleration is ignored, then only the linear acceleration, aA, and the centrifugal acceleration, r*w2, exist.

This example is well documented in reference 1 at the end of this article.

Having established the accelerations, the corresponding inertial forces can now be described. These are shown in Figure 4. The balancing forces at the piston and crank interfaces are also shown as forces F1 through F4. For convenience, the piston forces F1 and F2 are shown in the piston local axis system. The crank forces F3 and F4 are shown in the conrod local coordinate system. Any coordinate system can be used as long as balance is maintained in the free body diagram. The forces are balanced horizontally and vertically, and moments are taken about the piston end. All forces can now be calculated for this crank angle, given the gas pressure load, crank rotational speed and crank rotational acceleration.

What is interesting now is that we have reaction forces at right angles to the conrod axis—therefore bending loads can be sustained in this system of loading. The resultant bending stresses can be important in strength, stability and fatigue assessment. It is usual in this type of analysis to do a finite element analysis at positions all around the power stroke, spread throughout the 720° range to assess worst-case positions. It is also likely that a full kinematics analysis would be used with a multi-body dynamics simulation tool to provide the balancing forces, and accelerations for a given gas pressure history and crank RPM.

Figure 5 shows the axial stress distribution under the loading case shown. All loads have been applied as pressure distributions, or body inertia loads under translational and rotational accelerations corresponding to the acceleration diagram in Figure 3. The '321' minimum constraint method has been used as described in the February 2015 "Free-Floating FEA Models" article. The crank angle is 60° from top dead center. There is significant bending overlaid on top of the compressive axial response. The use of a free body diagram allows the balancing forces and moments to be investigated and applied correctly. Without this, the conrod can only be analyzed with simple axial load cases.

Sign Conventions

There are two main alternative conventions for loading on a free body diagram. Figure 4 used the natural orientations of the loads. This implies that we can predict the orientation and sense of the loading, and the sense of the vectors follows this. Consider the conrod under horizontal balance in Figure 6 (a). We can draw an applied load due to gas pressure coming into the small end and a force reacted at the crank through the big end. This puts the conrod into compression and we can write an equation where F1 equals F2.

Another approach is to take a fixed sign convention where we ignore any preconceived ideas about loading direction. This is useful when we are unsure of the loading or reaction sense. It avoids a situation where we've assumed a compressive reaction that turns out to be tensile load and we can end up with a double negative in the diagram! Figure 6 (b) shows F1 and F2 in a positive sense to the right. We then sum F1 plus F2 to zero: balance in the horizontal direction. F1 will equal minus F2.

Checking Load Paths

Many engineers are familiar with free body diagrams from their college days. The task then was to carry out a hand calculation and evaluate all the forces in a structure. One of the reasons that we typically avoid doing this in practice is that most structures have redundant load paths (i.e. are statically indeterminate).

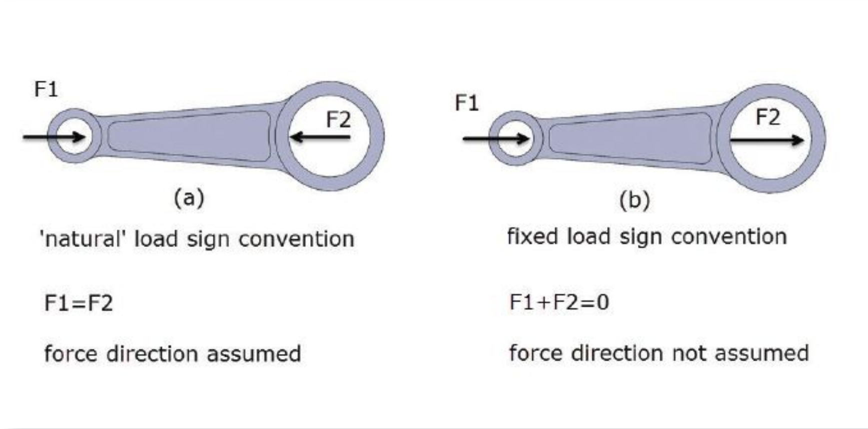

FIGURE 6: Load and force sign conventions.

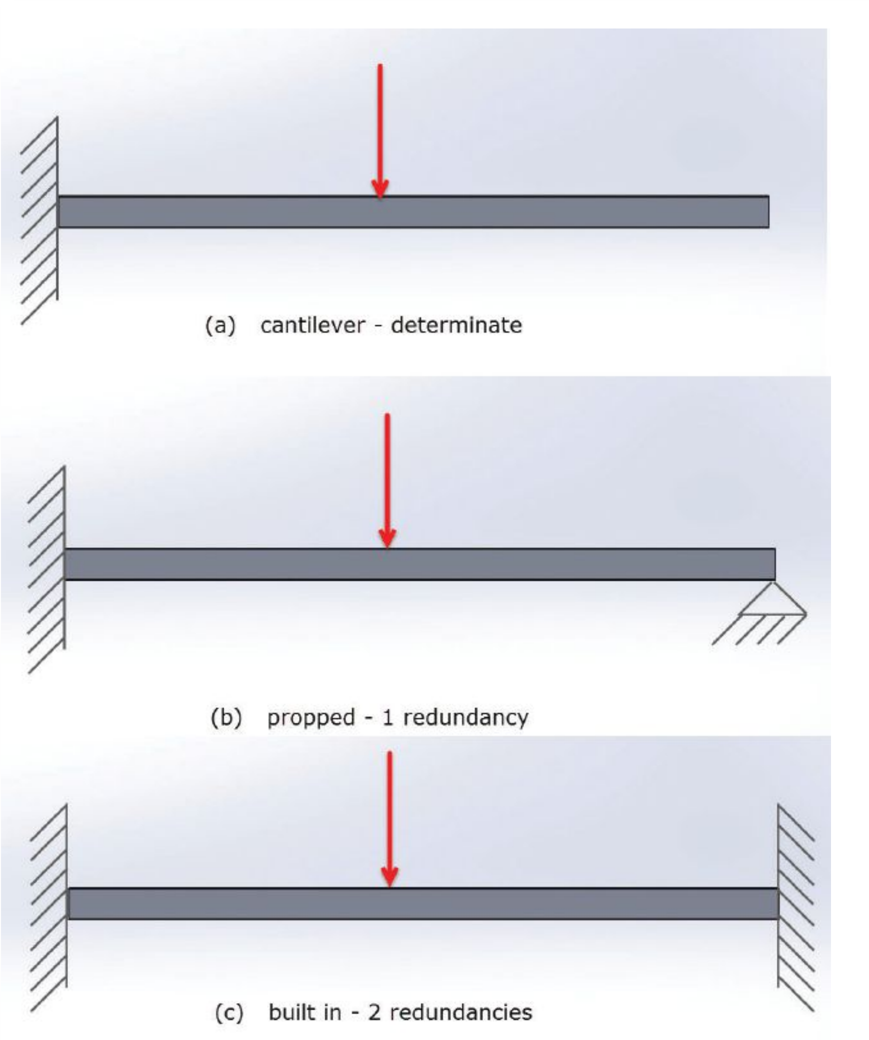

FIGURE 7: Beam free body diagrams.

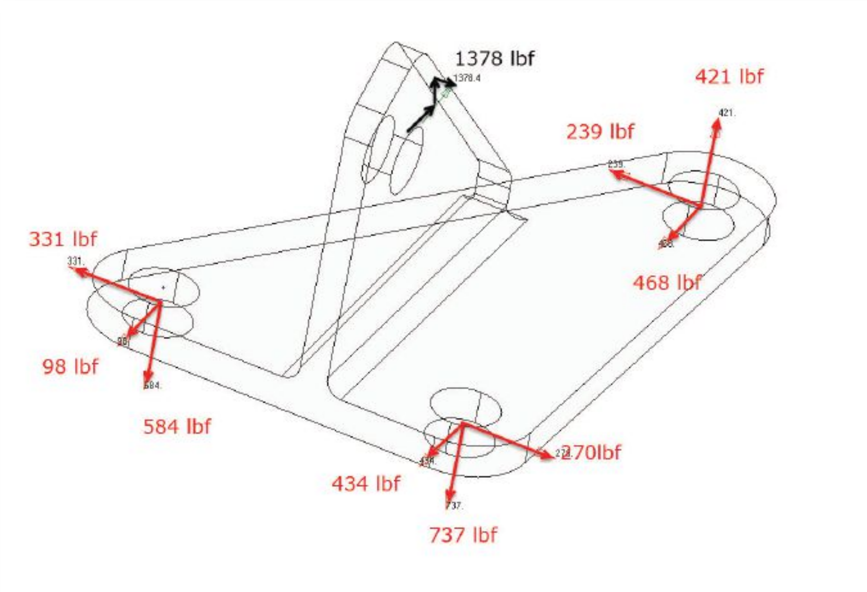

FIGURE 8: Free body diagram of reaction and applied forces in bracket.

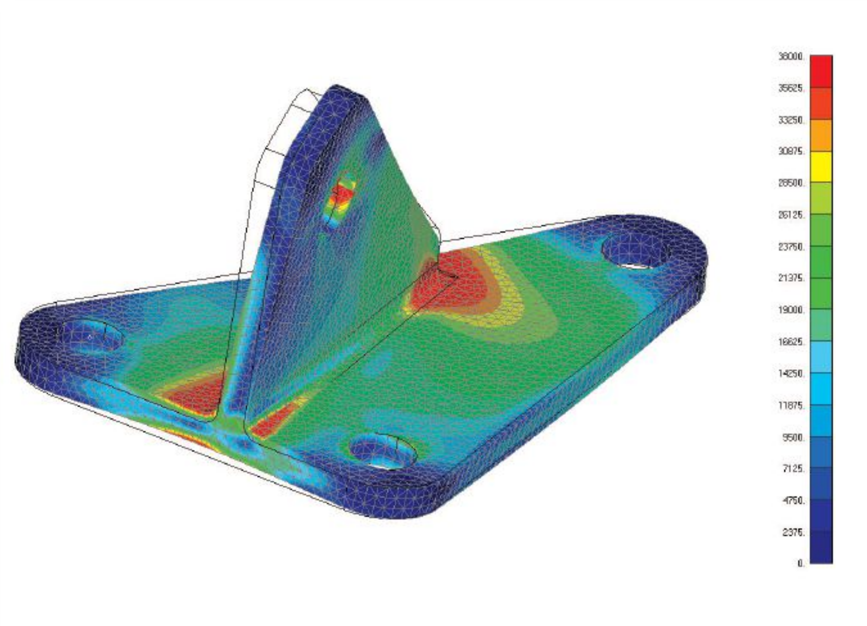

FIGURE 9: Von Mises stress distribution in bracket.

The equilibrium equations: three in 2D problems six in 3D problems are not enough to solve the structures, so we use energy methods, such as FEA. Figure 7 (a) shows a cantilever beam, which is determinate and can be solved by hand. However, if we introduce one redundancy as shown in Figure 7 (b), then we must use energy methods to solve. Adding a moment restraint in Figure 7 (c) means there are two redundancies—and more tedious work to do.

For a typical component, we are not attempting to do the stressing by hand—we use FEA. Now the free body diagram acts as a very useful tool to check the load balance. The actual distribution of loading will depend on the relative stiffness of the load paths. The bracket shown in Figure 8, is loaded with 1,378 lbf resultant vector acting in an off-axis direction. The load is reacted at three bolting positions. The assumption is that only translational forces are reacted. A free body diagram tool is used to post process the results and show the nature of the reaction forces.

One observation is that the two rear bolts act to resist the load in axial tension (584 lbf and 737 lbf), the front bolt resists with axial compression (-421 lbf). The model would be improved if an attempt was made to model the bracket bottom plate bearing footprint under the front bolt region. Bolt shear actions can also be checked and design decisions made. The free body tools can be complicated to set up in a post processor, but they are worth pursuing as they give definitive answers. The Von Mises stress distribution is also shown in Figure 9.

It is important to understand the nature of the loads that a structure carries. We can consider them either as applied loads or reaction forces. Drawing the diagram manually, or from FEA results, permits a clear picture of the load balance—both for checking and for design assessment.

In a future article, I will look at checking internal load balance, using typical FEA post processing tools. **DE**

Reference

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Tony Abbey *works as training manager for NAFEMS, responsible for developing and implementing training classes, including a wide range of e-learning classes. Check out the range of courses available: nafems.org/e-learning.*

New Lenovo ThinkStation P410 Offers Xeon Processors

Mainstream performance at an entry-level price.

DAVID COHN

LENOVO FINISHED OUT THE YEAR much the way it began, with the release of yet another new workstation. The latest system to arrive at our lab is the ThinkStation P410, an entirely new entry in the company's P-series workstation lineup. Built for businesses involved in engineering, architecture, finance and media & entertainment, the P410 also caters to individuals involved in rendering, simulation, game development, animation and 3D CAD modeling. The new ThinkStation P410 offers mainstream power at what had formerly been an entry-level price.

The new Lenovo ThinkStation P410 delivers mainstream workstation performance at new affordable price points. *Image courtesy of Lenovo*

The Lenovo ThinkStation P410 comes housed in a tower case with a red touch point marking its integrated handle. The case measures 6.89x14.8x16.77 in. (WxHxD) and our evaluation unit weighed just 21 lbs. The front panel features a pair of Lenovo Flex Bay modules that can support either a standard drive or an ultra-slim optical drive, media card reader and FireWire (IEEE 1394) port. The system we received included a standard 5.25-in. DVD +/-RW dual-layer drive in one of the two Flex bays. The space below these bays contained a 9-in-1 media card reader, two USB 3.0 ports, headphone and microphone jacks and a power button.

(continued on page 38)

INFO → Lenovo: lenovo.com/thinkstation

Lenovo ThinkStation P410

- **Price:** $2,515 as tested ($1,043 base price)
- **Size:** 6.89x14.8x16.77 in. (WxHxD) tower
- **Weight:** 21 lbs.
- **CPU:** 3.6GHz Intel Xeon 6-core E5-1650 v4
- **Memory:** 16GB DDR4 ECC at 2400MHz
- **Graphics:** NVIDIA Quadro M4000
- **Hard Disk:** 1TB SSD SATA
- **Optical:** 16X DVD+/-RW
- **Audio:** integrated Realtek ALC662 audio (front panel: headphone; rear-panel: line-in, line-out, microphone)
- **Network:** integrated gigabit Ethernet, one RJ45 port
- **Other:** Six USB 3.0 (2 front/4 rear), two USB 2.0 ports rear, PS/2 mouse and keyboard ports, four DisplayPorts on NVIDIA board, 9-in-1 media card reader
- **Keyboard:** 104-key Lenovo USB keyboard
- **Pointing device:** Lenovo USB optical wheel mouse
- **Power supply:** 450 watts, 92%, 80 PLUS Platinum qualified
- **Warranty:** 3-years parts and labor

Single Socket Workstations Compared	**Lenovo ThinkStation P410** one 3.6GHz Intel Xeon E5-1650 v4 6-core CPU, NVIDIA Quadro M4000, 16GB RAM, 1TB SATA SSD HD	**Dell Precision 3620** one 4.0GHz Intel Core i7-6700K 4-core CPU, NVIDIA Quadro M4000, 32GB RAM, 512GB PCIe SSD and two 1TB SATA drives in RAID 0 array	**BOXX APEXX 2 2402** one 4.0GHz Intel Core i7-6700K 4-core CPU over-clocked to 4.4GHz, NVIDIA Quadro M5000, 16GB RAM, 800GB PCIe SSD	**BOXX APEXX 1** one 4.0GHz Intel Core i7-6700K 4-core CPU over-clocked to 4.4GHz, NVIDIA Quadro K1200, 16GB RAM, 512GB PCIe SSD	**Xi Mtower CX** one 3.0GHz Intel Xeon E5-1660 v3 8-core CPU over-clocked to 4.1GHz, NVIDIA Quadro M5000, 16GB RAM, 256GB PCIe SSD and 1TB SATA HD	**Digital Storm Slade PRO** one 3.1GHz Intel Xeon E5-2687W v3 10-core CPU, NVIDIA Quadro M4000, 32GB RAM, 400GB PCIe SSD and 2TB SATA HD
Price as tested	$2,515	$2,860	$5,806	$3,711	$4,997	$6,187
Date tested	10/26/16	8/5/16	1/30/16	1/30/16	1/25/16	10/18/15
Operating System	Windows 10	Windows 10	Windows 10	Windows 10	Windows 10	Windows 10
SPECviewperf 12 (higher is better)						
catia-04	89.66	86.07	133.05	34.95	126.16	78.54
creo-01	76.93	72.47	108.03	33.45	107.44	65.60
energy-01	6.34	6.33	11.44	2.56	11.65	6.31
maya-04	63.31	69.94	101.53	31.22	97.68	63.79
medical-01	26.62	26.54	45.12	11.41	45.78	25.99
showcase-01	46.58	45.77	60.37	18.99	61.65	42.26
snx-02	125.39	72.93	121.01	28.47	219.48	74.62
sw-03	106.37	108.73	158.22	70.56	149.88	110.74
SPECapc SOLIDWORKS 2015 (higher is better)						
Graphics Composite	8.08	8.23	7.65	5.17	5.89	n/a
Shaded Graphics Sub-Composite	4.87	4.95	4.19	2.86	3.16	n/a
Shaded w/Edges Graphics Sub-Composite	5.97	6.36	5.57	3.92	4.22	n/a
Shaded using RealView Sub-Composite	6.43	6.35	5.45	3.56	4.32	n/a
Shaded w/Edges using RealView Sub-Composite	9.99	10.19	9.01	6.17	7.20	n/a
Shaded using RealView and Shadows Sub-Composite	7.23	7.07	6.77	4.15	4.97	n/a
Shaded with Edges using RealView and Shadows Graphics Sub-Composite	10.47	10.57	10.29	7.20	7.67	n/a
Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	16.01	15.04	14.87	7.78	11.94	n/a
Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	22.75	21.89	21.17	11.63	17.69	n/a
Wireframe Graphics Sub-Composite	3.26	3.88	4.19	4.17	2.98	n/a
CPU Composite	5.08	4.96	6.09	6.75	5.87	n/a
SPECwpc v2.0 (higher is better)						
Media and Entertainment	2.84	3.22	3.52	2.84	3.84	3.67
Product Development	2.79	2.75	3.06	2.46	3.38	3.89
Life Sciences	3.03	3.25	3.65	2.96	4.19	4.46
Financial Services	4.60	1.40	1.54	1.53	2.59	2.55
Energy	3.11	2.77	3.17	2.70	4.37	4.57
General Operations	1.14	1.58	1.99	1.93	1.78	1.47
Time						
Autodesk Render Test (in seconds, lower is better)	50.10	58.20	41.70	46.30	25.30	47.33

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

A Perfect Pairing

As part of our review of the new ThinkStation P410, Lenovo also sent us its new ThinkVision P27 monitor. This 27-in. monitor offers a crystal clear borderless IPS (in-plane switching) display with a native 4K (3840x2160) resolution and what the company says is a 100% sRGB color gamut along with built-in stereo speakers.

The P27 weighs 15.12 lbs., including the stand. It took just a few minutes to assemble the stand and attach the panel, or you can use any other mount using the standard 100mm VESA mounting holes. The panel itself measures 24.19x15.63x 0.75 in., has a height adjustment range of 18.59 to 21.59 in., and needs a space 11.81 in. deep for the large circular base. The stand provides a very stable support and allows the panel to be swiveled 45° left and right and to be tilted from -5 to 30°. The panel can also be pivoted 90° from landscape to portrait mode.

All of the ports and controls are very conveniently located. Power is provided via a small external power adapter that routes to a port on the rear of the panel. Adjacent to the power connection are both DisplayPort and HDMI video inputs, a USB 3.0 input, and two USB 3.0 output ports. Two additional USB 3.0 output ports plus a headphone jack and volume control are located on the lower-left edge. A pair of 3W stereo speakers are located in a narrow strip below the panel while five buttons in the lower-right corner of the bezel enable you to control basic monitor functions or access the on-screen display.

The monitor has a vertical viewing angle of 178°, features a brightness of 300 cd/m2, a contrast ratio of 1300:1, and response time of 6 milliseconds gray-to-gray. The DisplayMate test patterns (displaymate.com) did not reveal any picture quality problems or video artifacts.

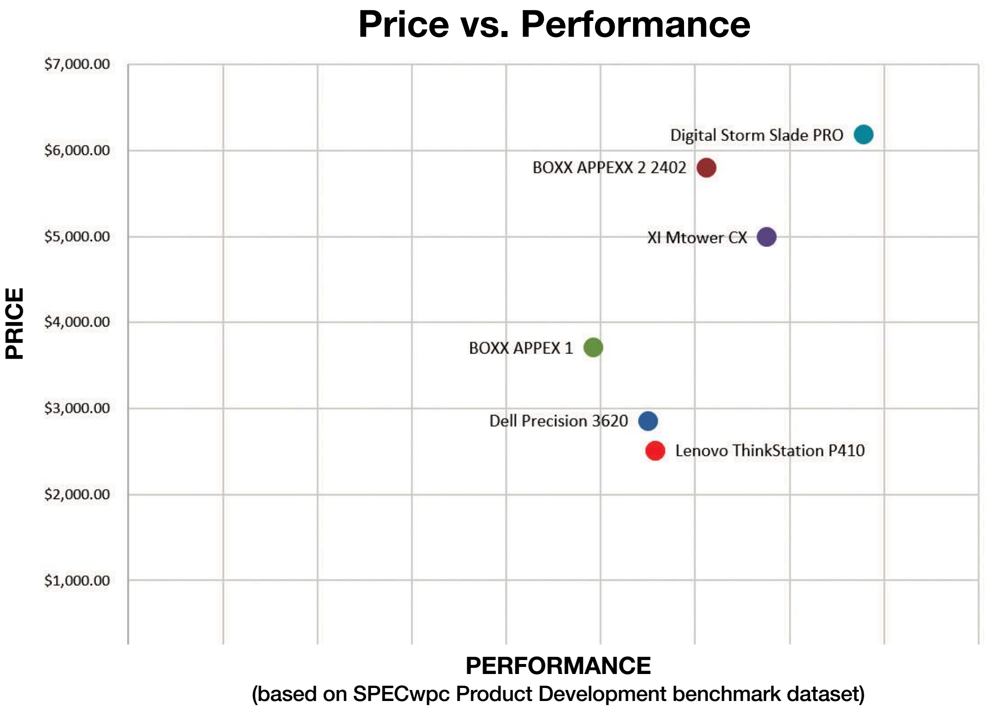
In addition to the power adapter, Lenovo provides a DisplayPort cable, mini DisplayPort to DisplayPort adapter, and a USB 3.0 input cable, but no HDMI cable. The system is backed by a three-year warranty. With a street price of just $517, the Lenovo ThinkVision P27 is priced right and pairs perfectly with the new Lenovo ThinkStation P410 workstation.

The new Lenovo ThinkVision P27 monitor is a great choice to accompany the new ThinkStation P410 workstation. *Image courtesy of Lenovo*.

INFO ➜ Lenovo: lenovo.com/thinkstation

Lenovo ThinkVision P27 27-inch IPS Display

- **Price:** $579 MSRP ($517 street price)
- **Size:** 27 in. (diagonal)
- **Display type:** IPS LED backlit
- **Screen dimensions without stand (WxHxD):** 24.19x15.63x 0.75 in.
- **Physical size with stand at highest setting (HxWxD):** 21.59x 24.19x 11.81 in.
- **Weight:** 15.12 lbs.
- **Native resolution:** 3840x2160 pixels @ 60Hz
- **Display Area:** 23.49x13.2 in.
- **Horizontal frequency range:** 24kHz – 140kHz
- **Vertical refresh rate:** 23 - 80 Hz
- **Aspect ratio:** 16:9
- **Pixel Pitch:** 0.1557mm
- **Dot/Pixel per Inch:** 163.18
- **Brightness:** 300 cd/m2
- **Contrast ratio:** 1300:1
- **Response time:** 6ms (gray to gray)
- **Number of colors:** 1.07 billion
- **Color gamut:** 100% sRGB
- **Power consumption:** 40 watts typical, 0.5 watts standby
- **Video input ports:** DisplayPort, HDMI
- **I/O ports:** USB 3.0 in, four USB 3.0 out, headphone jack
- **Other features:** tilt/swivel base, portrait/landscape pivot, built-in 3W stereo speakers, Kensington lock slot
- **Cables included:** Power adapter and AC power cord, DisplayPort, USB 3.0, mini DP to DP adapter
- **Warranty:** Three years parts and labor



(continued from page 35)

The rear panel provides PS/2 keyboard and mouse ports, four more USB 3.0 ports, two USB 2.0 ports, an RJ45 network jack, and audio jacks for line-in, line-out, and microphone. The NVIDIA GPU in our evaluation unit included four DisplayPorts.

Enhanced Expandability

To access the interior of the P410, you must remove two non-captive screws and press a round button to release the left side panel. Unlike other models in the P-series, not all components in the P410 can be removed without tools. For example, the 450-watt power supply is attached to the metal chassis with four screws.

The motherboard features four full-height PCIe expansion slots: two PCIe 3.0 x16 slots, a PCIe 3.0 x8 slot, and a PCIe 2.0 x4 slot. There are also four DIMM (dual in-line memory module) sockets flanking the CPU and a pair of internal hard drive bays. Cooling is provided by a pair of fans.

At $1,043, the base P410 configuration includes a quad-core 3.1GHz Intel Xeon CPU, but that's just the starting point. Lenovo offers a choice of four different Xeon processors. Our evaluation unit came with a 3.6GHz six-core Intel Xeon E5-1650 v4 processor. This Broadwell CPU has a maximum turbo speed of 4.0GHz, 15MB SmartCache, and a 140-watt thermal design power (TDP) rating, adding $340 to the base price.

The base configuration also comes with 8GB of RAM, installed as a single 8GB module. Our system included 16GB of RAM, installed as a pair of 8GB 2400MHz ECC (error correcting code) DIMMs, a $126 upgrade. The ThinkStation P410 can accommodate up to 64GB using 16GB modules.

The base configuration includes one 1TB 7200rpm SATA hard drive, but the P410 supports up to four internal SATA drives and up to three PCIe M.2 drives. Our unit came with a single 1TB solid state 6GB/second SATA drive, which added $430 to the price. The system also supports RAID 0, 1, 5 and 10 arrays.

The system we received also came with an NVIDIA Quadro M4000 video adapter in lieu of the NVIDIA NVS315 included in the base model, a $725 upgrade. Based on the Maxwell GPU, this graphics card features 8GB of GDDR5 memory and 1664 CUDA parallel processing cores. Although the M4000 takes up just a single PCIe slot, its 120-watt maximum power consumption requires an auxiliary power connection. The M4000 can support up to four 4K displays.

Midrange Performance

Thanks to its six-core CPU and NVIDIA Quadro graphics, the Lenovo ThinkStation P410 did quite well in all of our benchmark tests. On the SPECapc SOLIDWORKS benchmark, the ThinkStation P410 was at or near the top on all aspects of this test, compared to other single-socket workstations. On the very demanding SPECwpc benchmark, however, the results were more of a mixed bag, with some results at the top, some at the bottom, and most falling midway between those extremes. The P410 completed our AutoCAD rendering test in just 50.1 seconds. The system remained nearly silent throughout our tests.

Lenovo pre-loaded Windows 10 Professional 64-bit. Windows 7 is also available. Like other Lenovo workstations, the new ThinkStation P410 comes with a 3-year on-site warranty. The ThinkStation P410 is independent software vendor certified for applications from Adobe, Autodesk, Dassault Systèmes, PTC, Siemens and others. Customers can also download the recently released Lenovo Performance Tuner (LPT) to optimize the performance of their P410 workstation for specific applications.

While the base configuration costs just over $1,000, that buys you an entry-level graphics board, mechanical hard drive, and 8GB of RAM. As equipped, the system we received is currently available for $2,515. At that price, it delivers a level of performance that should result in the Lenovo ThinkStation P410 finding a welcome home on the desks of many *DE* readers. **DE**

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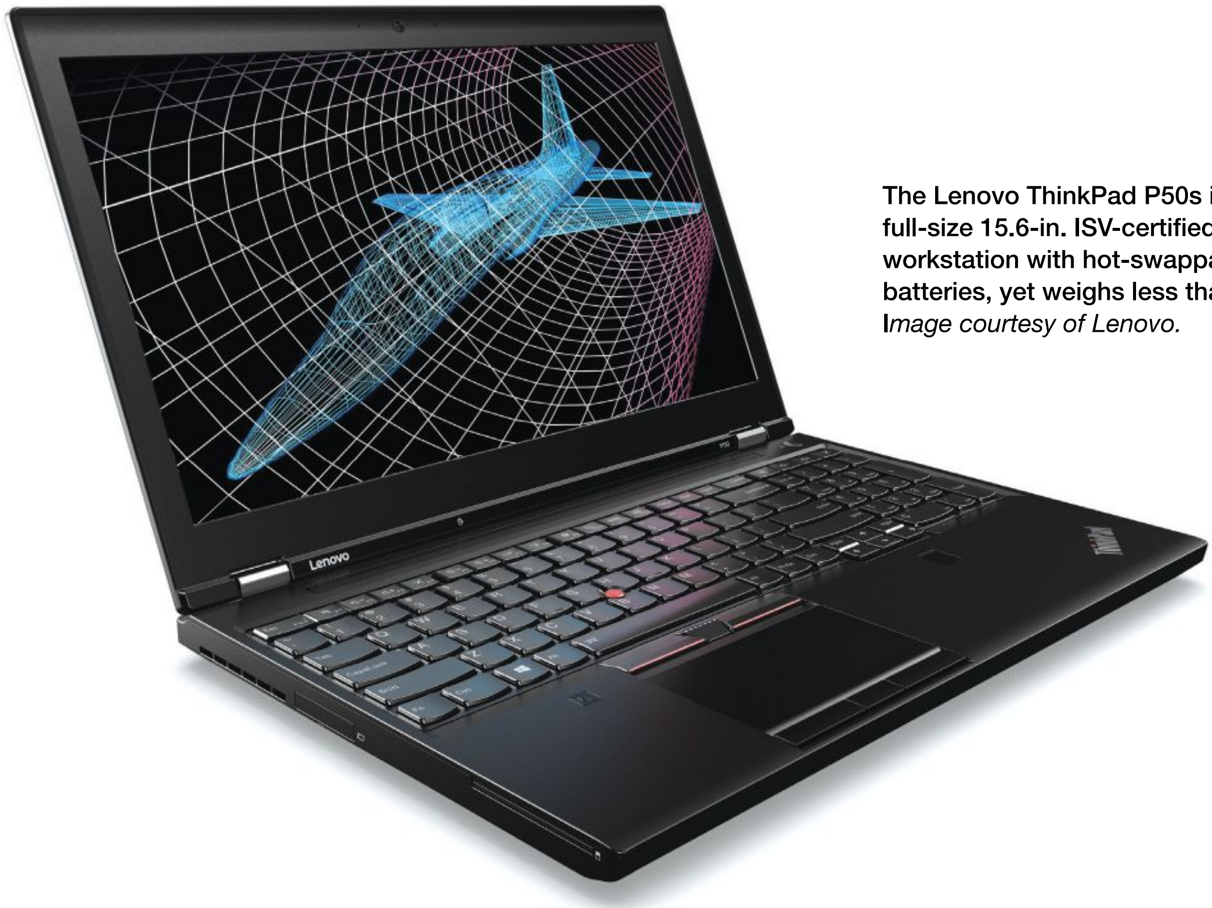


The Lenovo ThinkPad P50s is a full-size 15.6-in. ISV-certified mobile workstation with hot-swappable batteries, yet weighs less than 5 lbs. *Image courtesy of Lenovo.*

Portable & Affordable

The lightweight 15.6-in. Lenovo ThinkPad P50s mobile workstation features incredible battery life.

DAVID COHN

IT HAS BEEN A BIG YEAR FOR LENOVO, with updated workstations across its entire product line. No sooner had we finished reviewing the beautiful ThinkPad P40 Yoga (digitaleng.news/de/convertible-computer-for-cad) then yet another Lenovo mobile workstation arrived in our office. The ThinkPad P50s is an all-new system aimed at content creators looking to balance workstation-class power with extensive battery life in a compact form factor. With its 15.6-in. screen, the P50s is similar to the ThinkPad P50 we recently reviewed (digitaleng.news/de/sibling-rivalry-lenovo-thinkpad-p50), but thinner and lighter, with prices starting at $769.

Mobile Workstations Compared	Lenovo ThinkPad P50s 15.6-inch mobile 2.6GHz Intel Core i7-6600U dial-core CPU, NVIDIA Quadro M500M, 16GB RAM, 512GB PCIe SSD	MSI WT72 6QN 17.3-inch 2.9GHz Intel Core i7-6920HQ quad-core CPU, NVIDIA Quadro M5500, 32GB RAM, 256GB PCIe SSD RAID 0 and 1TB SATA HD	Lenovo P40 Yoga 14.1-inch 2.6GHz Intel Core i7-6600U dual-core CPU, NVIDIA Quadro M500M, 16GB RAM, 512GB PCIe SSD	Xi PowerGo XT 17.3-inch 4.0GHz Intel Core i7-6700K quad-core CPU, NVIDIA Quadro M5000M, 32GB RAM, 256GB PCIe SSD	Eurocom Sky DLX7 17.3-inch 4.0GHz Intel Core i7-6700K quad-core CPU, NVIDIA Quadro M5000M, 32GB RAM, 512GB PCIe SSD	HP ZBook Studio G3 15.6-inch 2.8GHz Intel Xeon E3-1505M v5 quad-core CPU, NVIDIA Quadro M1000M, 32GB RAM, 512GB PCIe SSD
Price as tested	$1,427	$4,999	$1,705	$4,423	$5,223	$2,999
Date tested	10/10/16	9/15/16	7/27/16	5/27/16	7/26/16	3/9/16
Operating System	Windows 10	Windows 10	Windows 10	Windows 10	Windows 10	Windows 10
SPECviewperf 12 (higher is better)						
catia-04	21.75	128.73	19.98	109.37	99.74	35.30
creo-01	25.34	103.28	24.34	94.91	93.00	32.36
energy-01	0.52	16.25	0.61	7.02	7.60	3.08
maya-04	13.27	81.64	12.25	79.26	64.78	29.50
medical-01	9.68	61.03	14.03	31.90	33.66	14.46
showcase-01	6.97	58.88	6.81	51.57	52.93	21.04
snx-02	31.85	120.83	26.46	165.04	90.15	28.55
sw-03	37.24	118.06	35.31	121.39	116.72	55.23
SPECapc SOLIDWORKS 2015 (higher is better)						
Graphics Composite	2.67	5.99	2.65	8.78	8.59	2.92
Shaded Graphics Sub-Composite	1.96	3.69	1.78	5.07	4.90	2.27
Shaded w/Edges Graphics Sub-Composite	2.52	4.84	2.40	6.54	6.31	3.05
Shaded using RealView Sub-Composite	2.01	4.77	2.00	6.65	6.49	2.32
Shaded w/Edges using RealView Sub-Composite	3.43	7.80	3.42	10.72	10.45	4.03
Shaded using RealView and Shadows Sub-Composite	1.96	5.16	2.03	7.40	7.26	2.13
Shaded with Edges using RealView and Shadows Graphics Sub-Composite	3.14	7.97	3.22	11.21	10.92	3.49
Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	3.02	9.15	3.38	18.10	18.11	3.19
Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	4.53	13.57	5.07	25.69	25.53	4.62
Wireframe Graphics Sub-Composite	2.61	3.20	2.20	3.91	3.86	3.16
CPU Composite	1.89	2.39	1.95	4.96	4.95	2.82
SPECwpc v2.0 (higher is better)						
Media and Entertainment	1.04	2.64	0.99	2.37	2.93	2.29
Product Development	1.28	2.65	1.11	2.28	2.77	2.22
Life Sciences	1.25	3.08	1.25	2.40	2.98	2.46
Financial Services	0.49	1.24*	0.49	1.39	1.39	1.15
Energy	0.96	2.61	0.87	2.34	2.69	2.22
General Operations	0.87	1.37	0.85	1.06	1.06	1.36
Time						
Autodesk Render Test (in seconds, lower is better)	172.50	73.20	149.00	53.10	65.70	76.80
Battery Test (in hours:minutes, higher is better)	11:44	3:09	9:10	2.30	2:28	5:18

Numbers in blue indicate best recorded results. Numbers in red indicate worst recorded results. ** results provided by MSI*

Housed in the now familiar ThinkPad charcoal gray case—this one comprised of polyphenylene sulfide and glass-fiber reinforced plastic—the system measures 14.98x10.17x 0.88 in. and weighs just 4.95 lbs. The small (4.19x1.75x1.12-in.) 65-watt external power supply adds a scant 0.64 additional pounds, bringing the entire travel weight to just over 5.5 lbs.

Raising the lid reveals the anti-glare display panel and a spill-resistant 105-key keyboard with separate numeric keypad. (Backlighting adds $30.) As we have come to expect from Lenovo, the keyboard ranks as one of the best laptop keyboards we have ever seen. Lenovo offers a choice of three different IPS (in-plane switching) displays, including FHD (1920x1080) with or without touch. The 3K (2880x1620) panel in our evaluation unit added $150 to the base price. A standard 720p webcam flanked by a pair of microphones is centered above the display.

A touchpad with three dedicated buttons is centered below the keyboard, while a red Lenovo pointing stick is nestled between the G, H and B keys. Our system also included a fingerprint reader (a $20 option). A round power button is nearly centered above the numeric keypad; the red dot over the "i" in the ThinkPad logo on both the palm rest and outer lid is illuminated when the system is powered up.

Ample Options

Like the other new ThinkPad P-series mobile workstations we have recently received, the P50s is built around one of Intel's latest 6th generation "Skylake" processors, although in the P50s, the choices are all dual-core. The base configuration uses the 2.4GHz Core i5-6300U, while our evaluation unit came with a 2.6GHz Intel Core i7-6600U, adding $140 to the price. That CPU has a 4MB Smart Cache, a frugal 25-watt thermal design power (TDP) rating and a maximum turbo frequency of 3.4GHz.

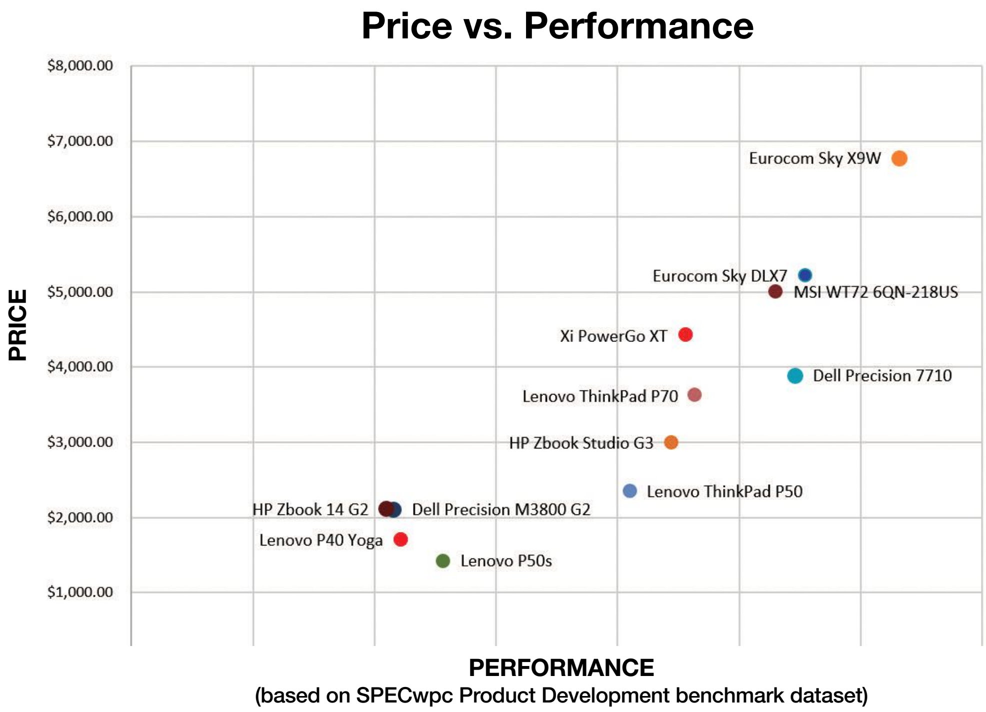
Although the CPU includes integrated Intel HD Graphics 520, all versions of the ThinkPad P50s also incorporate an NVIDIA Quadro M500M discrete graphics card with its own 2GB of GDDR3 memory. This 30-watt mobile GPU offers 384 CUDA cores, a 64-bit interface and a bandwidth of 14.4 GB per second.

While the CPU and GPU in our evaluation unit were the same as those in the ThinkPad P40 Yoga we recently reviewed, the P50s includes two memory sockets and can therefore accommodate up to 32GB of RAM. The base P50s comes with 4GB of memory. Our system included 16GB of 1600MHz DDR3L memory installed using a single SODIMM and adding $200 to the cost.

Our evaluation unit also came with a 512GB SATA3 solid state drive (SSD), a $360 upgrade from the 500GB 7200rpm SATA3 hard drive provided in the base model. A 1TB 7200rpm drive as well as several OPAL2.0-compatible SSD drives are also available, but as was true for the P40 Yoga, a more modern PCIe M.2 drive is not offered. Intel dual band wireless-AC 8260 and Bluetooth 4.1 come standard and integrated mobile broadband is available as an option.

There are also an ample number of ports. The right side includes two USB 3.0 ports, one of which can charge USB devices whenever the computer is connected to AC power. There is also a mini-DisplayPort and a security lock slot. The left side houses the AC power connector, an additional USB 3.0 port, an HDMI port, an audio jack, a 4-in-1 Smart Card reader (a $10 option), and an RJ45 Ethernet jack. The bottom of the case features a docking connector and an easily removable battery.

The battery configuration in the ThinkPad P50s is unique because there are two separate batteries. The P50s comes with a built-in 44 watt-hour battery. The removable battery is actually a second battery that can be hot-swapped without ever having to power down the computer. When the low battery warning comes on, you can simply swap out the removable battery with a new one. The system always draws power from the swappable battery first. When connected to AC power, the system charges the internal battery first, so that the computer never has to shut down when swapping batteries. Lenovo offers a choice three different capacities for



the removable battery: 23.2, 47, or 72 watt-hour. While the larger capacity batteries cost just $5 and $15 more than the standard 23.2 watt-hour battery, extra batteries range from $110 to $120. The pair of batteries kept our system running for an incredible 11 hours and 44 minutes—the longest we have ever recorded. The Lenovo ThinkPad P50s remained cool and silent throughout all of our tests.

Portability Over Performance

With its dual-core CPU, SATA3 SSD and entry-level Quadro GPU, we did not expect the P50s to set any performance milestones, but its benchmark results did place it ahead of the Ultrabooks and some of the other small, lightweight systems we have recently tested.

On the SPECviewperf benchmark, which focuses on graphics, the results ranked near the bottom of the pack. The same was true on the SPEC SOLIDWORKS 2015 benchmark, including a last-place CPU Composite score. On the very demanding SPECwpc benchmark, the performance of the ThinkPad P50s was also well below that of larger laptops. And on our AutoCAD rendering test, the P50s took nearly three minutes on average, even slower than the P40 Yoga.

Our evaluation unit came with Windows 10 Professional 64-bit, a $30 upgrade from the Windows 10 Home operating system included in the base configuration. Although the standard warranty covers the system for just one year, warranty extensions of three or four years, as well as on-site service, accidental damage protection, priority technical support and a sealed battery warranty that offers a one-time battery replacement within the first three years of ownership, are also available.

The ThinkPad P50s is ISV certified for a wide range of professional applications. It is also MIL-SPEC 810G tested for ruggedness. What it lacks in performance, it more than makes up for in portability and price. At just $1,427 as tested, the Lenovo ThinkPad P50s will run most CAD and design applications—and keep them running through even the most demanding road trip. **DE**

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David Cohn *is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA and has been benchmarking PCs since 1984. He's a Contributing Editor to* Digital Engineering *and the author of more than a dozen books. You can contact him via david@dscohn.com or dscohn.com.*

INFO ➔ **Lenovo:** lenovo.com/thinkstation

Lenovo ThinkPad P50s

- **Price:** $1,427 as tested ($769 base price)
- **Size:** 14.98x10.17x 0.88 in. (WxHxD) notebook
- **Weight:** 4.95 lbs. plus 0.64 pound power supply
- **CPU:** dual-core 2.6GHz Intel Core i7-6600U w/4MB Smart Cache
- **Memory:** 16GB DDR3L at 1600MHz (32GB max)
- **Graphics:** NVIDIA Quadro M500M w/2GB GDDR3 memory
- **LCD:** 15.6-in. 3K 2880x1620 IPS
- **Hard Disk:** 512GB SATA3 SSD
- **Floppy:** none
- **Optical:** none
- **Audio:** built-in speakers, audio jack, built-in microphone array
- **Network:** Intel Dual-Band Wireless-AC (2x2) 8260, Bluetooth 4.1
- **Modem:** none
- **Other:** three USB 3.0 (one always on), mini DisplayPort, HDMI, media card slot, 720p webcam
- **Keyboard:** integrated 105-key backlit keyboard with numeric keypad
- **Pointing device:** integrated touchpad with 3 buttons, pointing stick, fingerprint reader

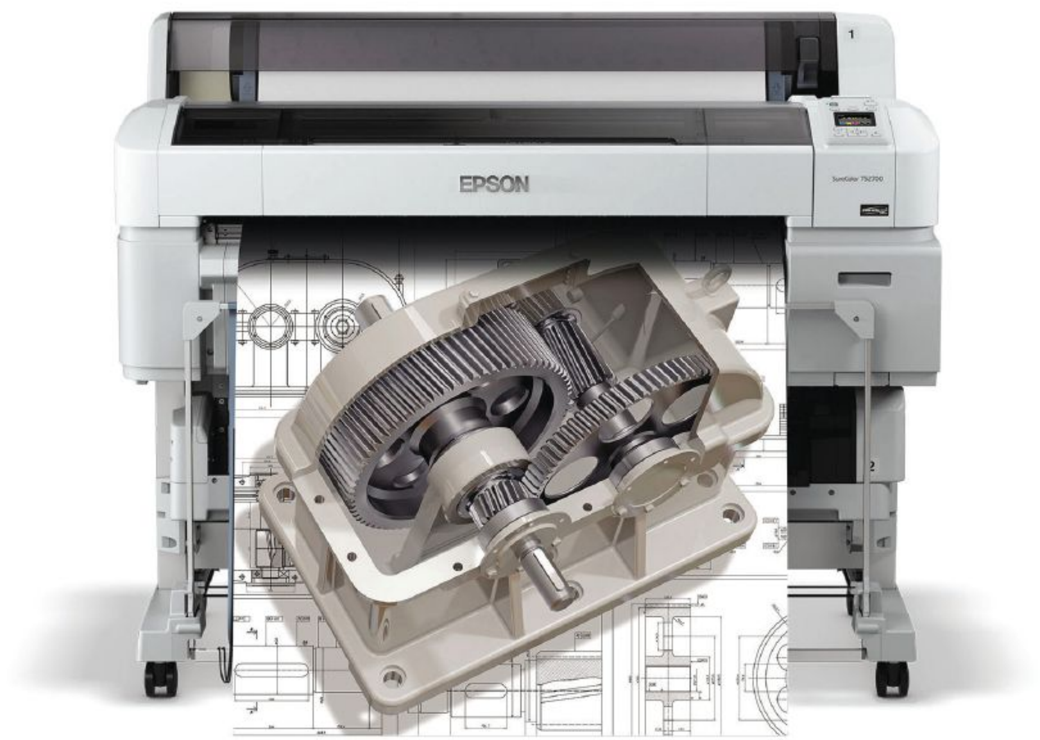
Large-Format Printing Gets an Upgrade

Industry providers are finding new ways to help businesses integrate the technology into their engineering workflow.

BY JESS LULKA

YOU MIGHT BE SURPRISED to find a connection between Crosby, Stills & Nash with large-format printing, but in fact, one member of the folk rock supergroup helped advance the technology. Graham Nash's work with the Iris Graphics 3047 inkjet printer for reproducing some of his photographs in the 1990s served as an early indicator of market demand and a springboard for technology improvement and quality. Ultimately, Nash's work with inkjet printing helped to launch a new market for large- and wide-format printing hardware in partnership with companies such as Epson.

Though applications have expanded far beyond art imaging for large-format systems, companies continue to create systems that are more affordable, have increased ease of use and offer connectivity beyond the device itself. This is setting up small- to mid-sized businesses (SMBs) for a new workflow that efficiently combines digital files



Epson's SureColor T-Series printers are available in both single- and dual-roll configurations. ***Image courtesy of Epson America.***

Canon's Océ ColorWave 500 can print with bond, film, waterfast Tyvek, recycled paper and other media options. *Image courtesy of Canon Solutions America.*

and traditional hard copies.

"We see more and more customers looking to maximize their investment by moving beyond a single-purpose printer [CAD only] to something that is more versatile in its application capacity," says Andrew Vecci, director of Marketing at Canon Solutions America. "To that end, not only has the convergence of color in the CAD workflow driven adoption of color printers, but also to have the in-house ability to print high-quality renderings, posters, event signage [and more] on the same device and across a wide variety of media."

Large-format providers have been able to fine-tune the technology to not only be more affordable, but more scalable. Being able to select from a variety of sizes and add on additional hardware as the workflow expands makes them easier to fit into an office environment, says Matt Kochanowski, product manager for Professional Imaging at Epson America.

Bringing Printing In-House

SMBs have historically paid a high upfront cost for a large-format system or outsourced their technical documents to a specialty shop. But with the need-it-yesterday nature of product design, this can present some challenges for cost, time and quality control. It's also these factors that might encourage organizations to consider investing in an in-house system, notes Kochanowski.

One motivator for bringing large-format printing in house is print accessibility, he adds. "By having a wide-format printer locally in an office, you're able to print and have that file right away without any delay of printing, shipping and any transport cost," he says. This can be particularly useful during projects that require constant changes or extensive proofing both on and off the screen. It's also another way to collaborate with outside third parties that may not have direct access or licensing to the design software.

Jamie Sirois, PageWide XL Business Development Manager at HP adds: "As more AEC (architecture, engineering and construction) documents are being distributing electronically, it has become more important for the contractors and subcontractors to be able to access this critical information in-house. The benefits with in-house printing [include] convenience, and typically lower costs per print."

To Outsource or DIY?

In the past, companies would often outsource for large technical prints or specialized documents because of the expertise required for media selection, available hardware or specific printing applications. Outsourcing is still a viable option when requiring specific media or expertise for a print. Often printshops will not only have more flexibility in changing media options, but will be able to advise on the best fit for the type of project. For projects that require specific finishing options such as binding, laminating and mounting, firms can save time by working with outside experts instead of learning the techniques themselves.

Both Vecci and Kochanowski note that SMBs should evaluate how much printing is done within the office before purchasing a large-format system.

"One of the common starting points for a lot of organizations is: 'How much do I print?'" says Vecci. "And fortunately with a lot of devices today, there's a lot of flexibility when answering that question."

Kochanowski adds that users should also determine how wide they will need to print and if it's necessary to invest in either a single- or dual-roll system.

It's also wise for SMBs to decide if their needs are suited for black-and-white or color printing, if they need printers at multiple locations, what types of media they are expecting to work with, noise and emissions, and if there's a possibility of rightsizing in the future. Ultimately, Vecci says, printer providers want to ensure that the systems set up within businesses will help garner the right amount of utility—instead of being overworked or underutilized.

User Experience

One of the larger adoption hurdles with large-format printing and scanning is centered on learning the technology itself. As these systems become more capable, companies are working to streamline the introduction of new features and maintenance functions.

"The most desired characteristic from our view is ease of use. Even though we make printers and are in the printing business, most users of printers don't really care about printing … so the more we can design our systems so they can be easily deployed and used the better," explains Vecci.

For most systems, this has led to the introduction of touchscreen and graphic-based interfaces. At Canon, Vecci says the company went one step further to homogenize interfaces across its portfolio so that the user could walk up to any Océ Canon system and know how to operate it, both via the touchscreen interface and at a computer.

This improvement in user experience has helped offices move away from having the "in-office printer expert," explains Vecci. "Our systems are very automated from roll loading in the drawers to media detection and beyond."

On the software side, common interfaces for the systems, printer drivers and print management applications significantly reduce the number of necessary interfaces, which can help accelerate adoption. "It used to be that you would have to get specialized drivers and software in order to print to these printers. Now you can just load up the regular printer driver, hit print and it'll print out your file right there," says Kochanowski.

For a scalable hardware user experience, Epson is making it easier for SMBs to extend capabilities after their printer purchase, enabling users to modify their setups as needed. According to Kochanowski, it is now a lot more intuitive to add a scanner, second media roll or additional hard drive onto any of the SureColor printers. This takes the pressure off when deciding to make up-front decisions about scanning, drivers and post-script capabilities. "These are all things that our customers can scale their printers with down the road as their business grows," he says.

Another facet to the user experience is print management. With advanced connectivity to Wi-Fi and LANs, users no longer need to be near the system as it prints to monitor progress, or start and stop jobs. The introduction of mobile applications has set a new standard for printing, scanning and system management access. Canon, Epson and HP all offer mobile connectivity for both inkjet and large-format systems, offering control from phones, tablets and desktops.

Latest Market Offerings

In addition to technological advances, vendors are expanding their portfolios to include more variety.

"HP has gone to great lengths to make sure our wide-format printers are available in a wide range of features, benefits and cost points. This includes entry-level printer only and multi-functional devices from 24- to 40-in.," says Sirois. Some of the current offerings for SMBs include the DesignJet 830 MFP and PageWide XL 4000, which are equipped with Wi-Fi and increased printing speeds compared to previous offerings.

Canon has several portfolios within the Océ product line, including the PlotWave and ColorWave series for large-format printing. Not only are these systems formatted for a variety of media of sizes, but also include features such as true print preview, expandable media rolls and integrated security options for a cloud-based workflow.

The HP PageWideXL 4000 allows shops produce eight D/A1-size prints per minute, helping teams increase on-the-job productivity. ***Image courtesy of HP.***

Epson's SureColor offerings are the mainstay of its large-format systems. Its T-Series, which is most suited for printing technical documents, comes in 24-, 36- and 44-in. configurations that can accommodate either dual or single media rolls. Kochanowski also adds that the systems come with the UltraChrome XD inkset, which is designed to be water-, scuff- and scratch-resistant.

What's Next?

While some SMBs find themselves continuously going digital, many still need printing applications for design review, collaboration or sharing. Prints can offer a greater level of detail that may not be portrayed on a screen, or make it easier for multiple engineers to mark up a design simultaneously.

With these use cases in mind, industry providers are focusing their efforts on bringing faster print speeds, expanded applications, and improved connectivity for document production, storage and management—carving out a space for large-format systems within the office for the future. **DE**

Jess Lulka is DE's former associate editor. Send e-mail about this article to de-editors@digitaleng.news.

INFO → Canon Solutions America: CSA.Canon.com

→ **Epson:** Epson.com

→ **HP:** HP.com

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EDITOR'S PICKS

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

Markforged Releases Onyx Series of 3D Printers

Pro model has second printhead for continuous fiberglass for five times stronger material.

These 3D printers work with Markforged's Onyx filament, which has become the company's best-selling material. Onyx material is made of chopped carbon fiber within nylon. Markforged says this composition gives it twice the strength and stiffness of pure plastic.

The series has two models: The Onyx One and the Onyx Pro. Both have a 12.60×5.20×6.05 in. print volume and a 100-micron Z layer resolution. The difference is that the Pro version sports dual printheads.

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Agile Engineering Design System v8.5

New release focuses on improving turbomachine performance in less time.

Concepts NREC's Agile Engineering Design System is an integrated computer-aided engineering and computer-aided manufacturing suite for the turbomachinery design process. The CAE part of the suite provides toolsets for preliminary sizing, detailed and specialized design jobs, including 3D CFD (computational fluid dynamics) analyses, optimization, FEA (finite element analyses) and more. The suite's CAM tool kits offer a family of 5-axis milling tools and optional modules.

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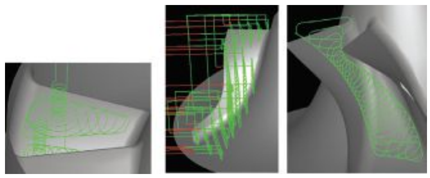

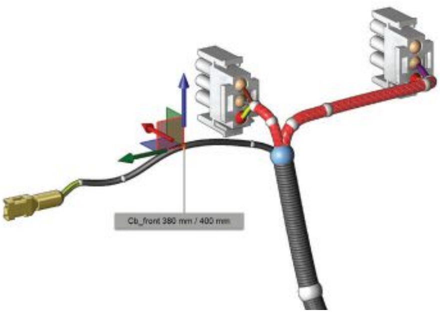

EPLAN Releases Harness proD Version 2.6

Wire harness design and documentation solution supports automatic cable dimensioning.

EPLAN Harness proD lets you use the 3D model of your mechanics and electrical schematics as well as a lot of automation to help make designing a wire harness more intuitive and less tedious.

It links in with the company's EPLAN Platform technology, which, among other things, means that everything gets documented neatly and that it's open to data from third-party MCAD and ECAD solutions.

Version 2.6 debuts a number of new features that make it convenient to use.

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Intelligent Light Updates FieldView

The CFD software has new functionality for creating MP4 movies for presentations.

By specializing on computational fluid dynamics (CFD) post-processing, FieldView eliminates lots of the overhead in an all-in-one CFD system. While this alone provides a good measure of efficiency, it also means the company's engineers can focus on the productivity tools designed to get you interactively exploring and presenting data quickly.

The line on FieldView from the trenches is that it's fast, easy to implement and easy to use.

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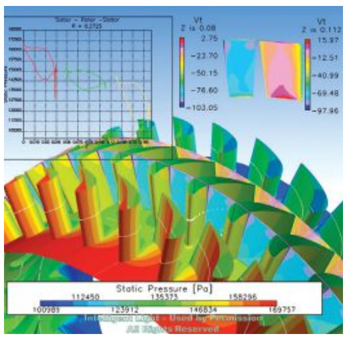

Next-Gen Engineers

Student Competition Profile: Fly Your Ideas

When Ideas Fly High

BY JIM ROMEO

AIRBUS sponsors the Fly Your Ideas global competition that challenges students to innovate with Airbus for the future of aviation.

The company launched Fly Your Ideas in 2008 with the aim of engaging universities and students around world and from all backgrounds. In 2012 it received patronage from the United Nations Educational Scientific and Cultural Organization (UNESCO) and achieved full partnership in 2014.

Gregor Achim Dirks is a Corporate Innovator for Airbus. We spoke with him to gain insight Fly Your Ideas.

***Digital Engineering:* Can you provide an overview of the program?**

Dirks: We want to inspire students to be creative and develop their skills with a leading global company on real-life challenges. The competition is an opportunity for students to build valuable employment skills like innovation, teamwork, project management and presentation skills. Teams get the chance to apply their classroom learning to real-world challenges, as voted for by Airbus employees. So they are genuinely tackling the same issues, and working with Airbus people who are immersed in the same areas.

Since Fly Your Ideas launched in 2008, over 20,000 students have registered to participate from over 650 universities and over 100 countries. Teams of three to five students advance through three progressively challenging rounds, and uniquely, get significant input from Airbus employees to help them realize their projects.

A record 5,499 students from around the world registered for this year's edition—we had ideas submitted by 356 teams in 89 countries.

Diversity is important to Airbus and we strongly encourage it in Fly Your Ideas teams too. In fact, every winning team to date has mixed nationalities, gender, profiles and disciplines.

***DE:* What becomes of the innovations that are presented?**

Dirks: The purpose of the competition is not to find commercially applicable ideas for Airbus, but over the four editions to date, we have shared many ideas with specialists throughout our business. We collaborate with teams and their universities to develop some of the proposals.

Let me give you a few examples.

We worked with 2011 finalists Team Msia on Mars from the Universiti Kuala Lumpur Malaysian Institute of Aviation Technology to further explore their idea for biodegradable materials from Kapok tree fibers for aircraft thermal and acoustic insulation blankets used for aircraft cabins.

Team Stanford ADG from Stanford University were finalists in 2009 with their idea on inverted V-formation flight, which hoped to reduce aircraft energy consumption based on the model of migrating birds. This led to a partnership and a collaborative research project into extended aircraft formations.

Finally, Team Retrolley, a team of five design students from the University of São Paulo in Brazil who won the second prize at the 2015 final, have witnessed their idea become reality. The Retrolley is a new cabin service trolley that enables the recycling of cabin waste. It is expected that the Retrolley can be delivered in the short term to airlines. **DE**

Team Multifun from Delft University of Technology, winners of Airbus Fly Your Ideas 2015. (From left: Dhamotharan Veerasamy; Ajith Moses; Sathiskumar Anusuya Ponnusami; Dineshkumar Harursampath, academic mentor Indian Institute of Science; Shashank Agrawal; and Mohit Gupta.

Jim Romeo *is a freelance writer based in Chesapeake, VA. Send e-mail about this article to de-editors@digitaleng.news.*

INFO → Fly Your Ideas website: airbus-fyi.com

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| COMMENTARY |

by Andrew Jones

Supercomputer Envy

MOST DIGITAL ENGINEERS are familiar with battling memory limits or processor speed on their workstations to get a simulation done. The desired simulation gets squashed down to fit what the computer can do in a reasonable time. Even if you have access to a high-performance computing (HPC) cluster, it's easy to be jealous of the simulations that could be done with the world's most powerful supercomputers, such as the Chinese Sunway TaihuLight supercomputer with over 10 million processor cores, or the U.S. Titan supercomputer with 18,000 GPUs (graphic processing units). However, most engineers must get the best out of much smaller scale HPC—that's their reality.

Despite repeated hype that one academic institution or vendor collaboration after another is leading the way and has "enabled industry to access HPC for the first time" or "opened industry's eyes to the opportunities of supercomputing," it turns out that industry has been using HPC for many years. While supercomputers in industry are big too (aerospace, automotive, and oil and gas companies are home to a few supercomputers with more than 100,000 cores), most industry HPC installations are much smaller—perhaps a few hundred to a few thousand cores.

Delivering More than Speed

Though, some of those "small" industry HPC services are way ahead of most academic or national lab counterparts in one aspect. Industry HPC users have become better at ensuring HPC facilities are properly measured by what they deliver to the company and how efficiently they do that against the budget and resources they consume.

They may be small compared with the world's fastest supercomputers, but successful HPC systems are big within that company's R&D agenda. The cost of every potential HPC technology or service innovation is assessed against the impact it will deliver to the R&D program and to the company's bottom line. Industry HPC services can only survive if they can prove that they are having a positive effect on the company goals, are value for the money, and are used as optimally as possible. Forget the flimsy metric of return on investment (ROI). Industrial HPC has a much more brutal metric: deliver critical capability to the company R&D goals or fail.

Demonstrating to senior management, users and stakeholders that their company's provision and use of HPC compares well with the best—in their sector or globally—is one of the key actions of successful HPC service managers. There are two ways to do this.

One: The HPC manager can take part in the external HPC community and discover ideas for improvement or cost reduction, possible collaborations, etc. It takes time and effort to be effective at this, but remains one of the best ways of ensuring continued business value from HPC.

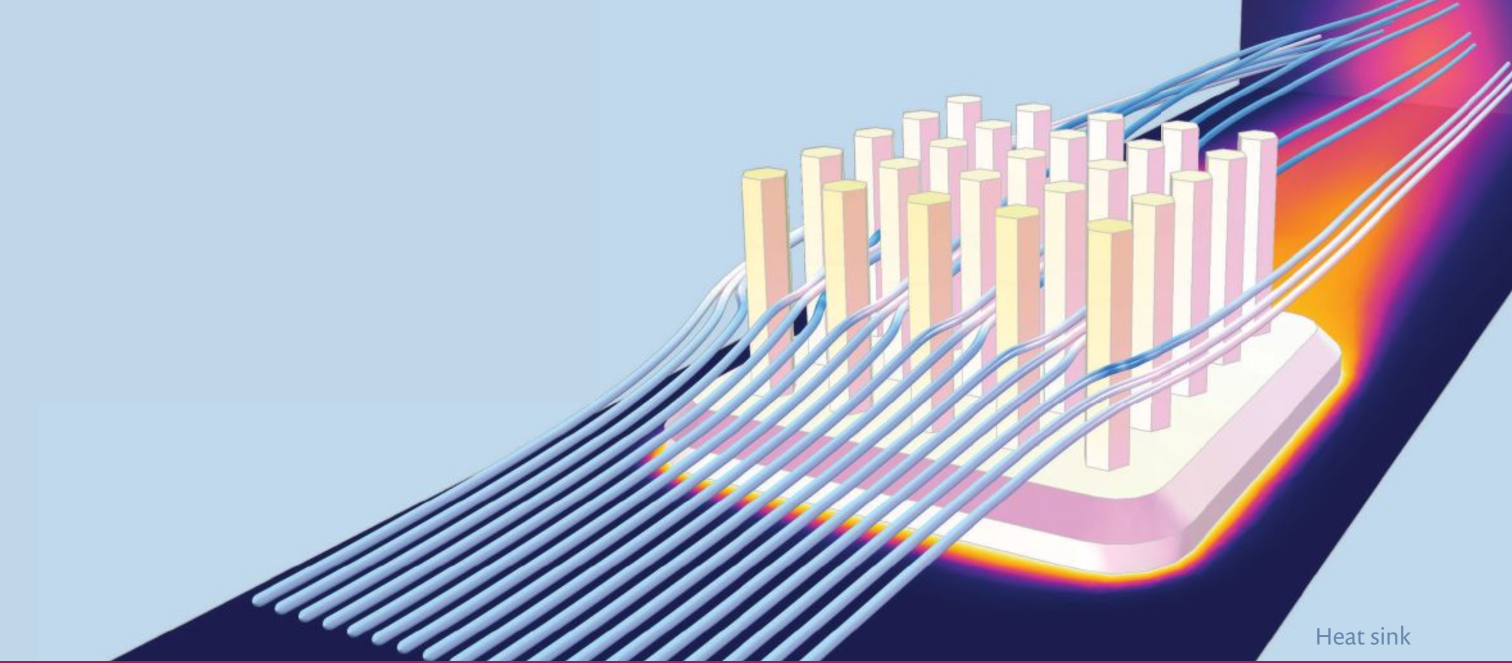
Or, second, the manager can call in the experts—specialists in HPC strategy and delivery who can assess how the company's HPC program stacks up against the best, can identify opportunities to improve performance and operational effectiveness, and help demonstrate value for money to stakeholders. Finding such a specialist—especially those who have experience in industry and not just academia, and understands both business and technology—could be invaluable in demonstrating that your HPC facilities are cost-effectively helping engineers deliver the best benefits to the business.

Value in HPC

When I undertake independent reviews of how companies get the best value from their HPC investment, I see that the best HPC managers pursue both approaches. They engage with the HPC community themselves, but they also bring in external expertise to confirm and challenge their own judgement, and provide an independent voice to their stakeholders. Some of these dual-approach managers have themselves become among the most informed, visionary and practical voices in the wider HPC community.

In short, the strongest way to ensure that engineers get the best advantages from HPC is not the size of the machine, but having an overall focus on ensuring impact, and getting the right balance of external and in-house expertise. You may not be burning the megawatts like TaihuLight or Titan, but if your engineering and HPC choices are on point, then your engineers' use of HPC can deliver the killer competitive edge to your company's R&D—and that is what really matters. DE

Andrew Jones *has 20 years of experience in scientific computing and HPC. He is responsible for NAG's (nag.com) HPC Services & Consulting business. Contact him via de-editors@digitaleng.news.*



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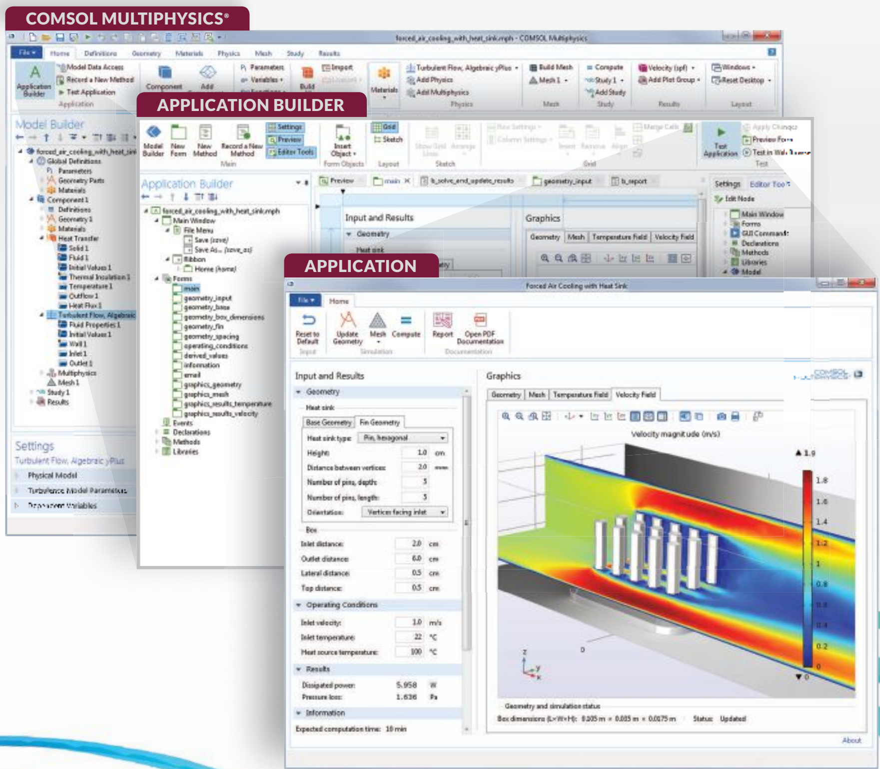

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