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Digital Engineering

February 2018

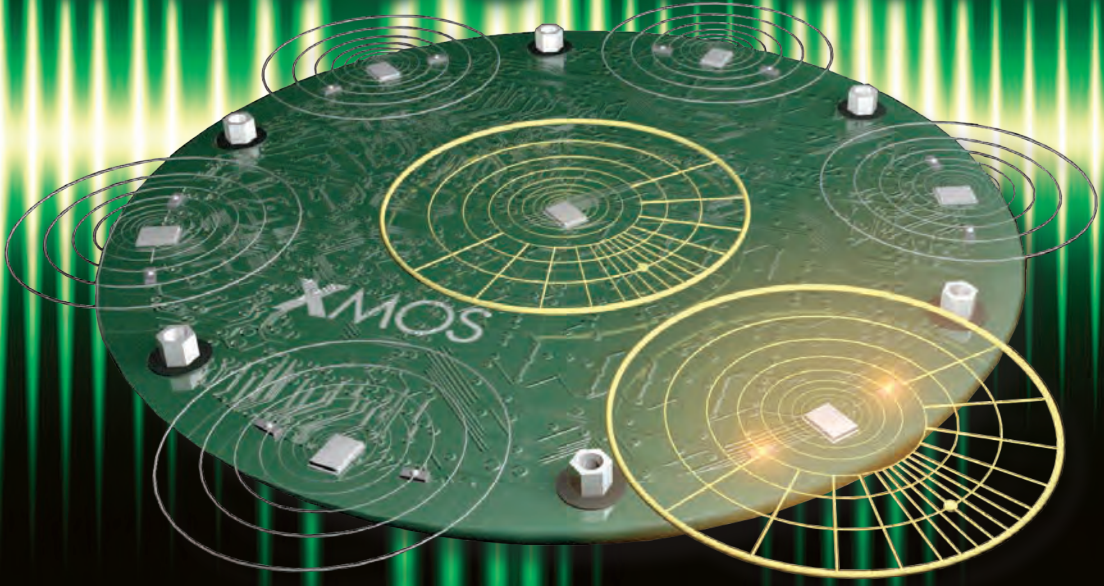
FOCUS ON: User Experience

CorelCAD Review

PNY Workstation Review

Siemens FEMAP with NX NASTRAN Overview

Voice Control



3D PRINTING POST-PROCESSING

COMPUTING CLUSTERS

PLM AND COLLABORATION

by Jamie J. Gooch

Experience is the Greatest Differentiator

MY DAUGHTER bought a used car to get back and forth to college. Her favorite thing about it is that it has buttons and knobs, as opposed to the touchscreens and voice commands that dominate the user interfaces (UIs) in the cars my wife and I drive. Is the younger generation yearning for an old-school tactile experience? Probably not.

The physical button vs. touchscreen interface battle was already fought by Apple and Blackberry. Buttons lost. My daughter, like most of us, has become accustomed to the relatively intuitive and responsive touchscreen UI on her smartphone. That is not the experience she had in my 2013 car. It was called "frustrating to use" in one of the more polite automotive reviews. The touchscreen in my wife's 2015 car from a different automaker fared slightly better, being described as merely "difficult to use," by the reviewer.

When shopping for our current vehicles, we paid attention to factors like acceleration, fuel economy and price. We did not focus in on how easy it would be to accidentally turn up the heater instead of the radio, how wearing gloves would prevent interaction with many of the cars' features, or how good they were at recognizing our voices. Rookie mistakes. They were our first touchscreen- and voice-enabled cars, and we just assumed they would work like our touchscreen phones.

Learning from Experience

My wife and I, like most consumers, know better now. I have no doubt that the test drives for our next cars will be dominated not by driving, but by interacting with infotainment systems, environmental controls and navigation systems. Nor do I doubt that the experience will be much improved. Automakers have long known how important user experiences are—from the weight of the doors, to the sound of the engine—the way a car feels differentiates it. Now that cars are essentially computers on wheels—and will soon be self-driving ones—the UI is the most important differentiator for many consumers, and automakers know it just has to work.

It's not just the automotive industry that has learned from its UI mistakes. Many industries are still responding to the opportunities created by integrating electronics and software into their designs, even as artificial intelligence opens up new possibilities for interactive user experiences.

Take the so-called smart speakers for example, which along with connected, self-driving cars were the talk of CES, the annual technology show that took place last month. We received an Amazon Echo smart speaker for Christmas. The voice recognition technology is impressive. The speaker can usually pick up commands even if we're in another room and even through background noise. The "smarts" used by the smart speaker are pretty impressive as well.

In time, the novelty of hardware being able to detect our voices and software being able to correctly identify what we want will wear off. We fickle consumers will quickly go from "I didn't think it would be able to do that" to "Why can't it always do that?" Already, my kids are disappointed that the Alexa-controlled Echo can't add milk and eggs to the grocery list with one voice command instead of two.

The Bleeding Edge

Software is hard, and great UI is even harder. The latest generation of smartphones, cars and speakers have set the UI bar high for products in other industries. When it comes to user experience, it's advisable to look before you leap into the latest interfaces.

For example, does the world need a smarter toilet? "Voice services and connected devices have become integrated into every facet of the home—with the notable exception of the bathroom," Kohler president and CEO David Kohler said in a statement announcing the Numi, its Alexa-enabled toilet that made its debut at CES 2018. "Until now."

He has a point and hopefully the research to back it up. It takes considerable engineering and consumer behavior knowledge to get the user experience right. Our cover story (see page 10) in this issue explains the complex and rapidly advancing technologies that are supporting voice-enabled products. We also take a look at how algorithms may soon be able to sense consumers' emotions (see page 18).

Someday your smart toilet may start playing "Splish Splash" when you tell your shower to begin running water, just because it senses your amusement. In the meantime, designers, engineers and marketers need to collaborate to decide when a button, knob or lever is still the best solution for a given application. **DE**

Jamie Gooch *is editorial director of* Digital Engineering. *Contact him via jgooch@digitaleng.news.*

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Digital Engineering

TECHNOLOGY FOR OPTIMAL ENGINEERING DESIGN

INSIDE

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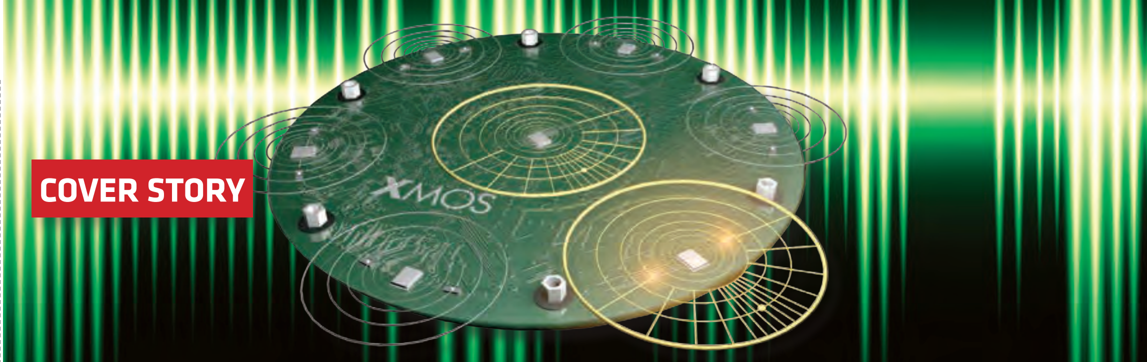

COVER STORY

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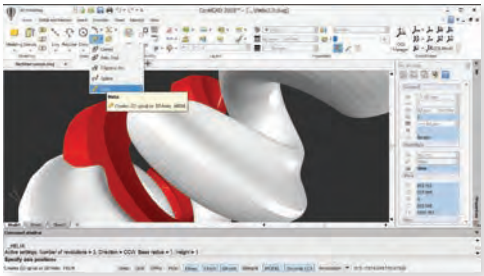

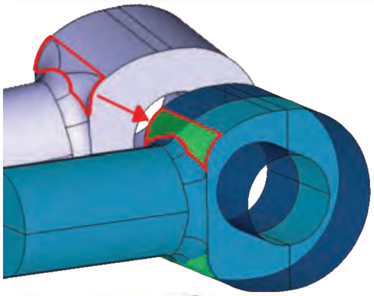

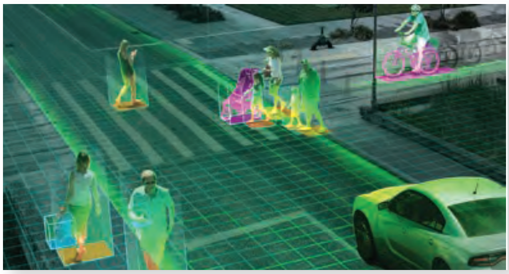

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Technology Drives the Auto Experience

Room for Improvement

44% of survey respondents were "very satisified" with their car's infotainment systems, which routinely rank as the least satisfying automotive feature in the survey.

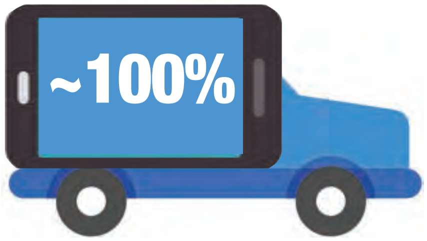
— Consumer Reports *subscriber survey, August 2017*

Sounding Off

More than half of respondents preferred to have a brand name car audio system in their next new vehicle. Among these, 81% indicated that it would influence their vehicle purchase decision and 53% wanted one to be standard on their vehicle.

— *"2017 Automotive Premium Audio Consumer Analysis," IHS Markit, August 2017*

Computing and Commuting



Nearly all consumers who had familiarity with replicating their smartphone system onto an in-vehicle display indicated they were interested or somewhat interested in having this feature in their next new vehicle.

— *"2017 Automotive Connected Services and Apps Consumer Analysis," IHS Markit, June 2017*

Back-Seat Movie Watchers

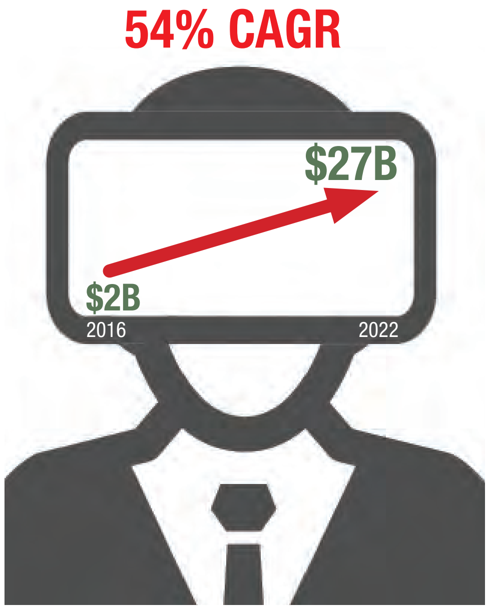
$640 Of all in-car technologies, consumers in the U.S. were most likely to pay for a rear-seat entertainment system, indicating they'd be willing to pay an additional $640 for it.

— *"2017 Automotive Connected Services and Apps Consumer Analysis," IHS Markit, June 2017*

The Future Interface?

The global virtual reality market size was valued at $2.02 billion in 2016 and is expected to reach $26.89 billion by 2022 with a compound annual growth rate of 54.01% between 2017 and 2022.

— *"VR Market by Hardware and Software," Zion Market Research, November 2017*



$3,000,000,000

Augmented reality and virtual reality broke investment records in 2017 with startups raising over $3 billion.

— *Digi-Capital, January 2018*

2,000

Apple says 2,000 apps are using its augmented reality software, ARkit, which was rolled out with iOS11 in September 2017.

— *Apple, January 2018*

Speaking to Speakers: The New UI

175 Million

Smart devices will be installed in a majority of U.S. households by 2022 (55%), with more than 70 million households having at least one smart speaker in their home. The total number of installed devices will top 175 million.

— "Digital Voice Assistants Platforms, Revenues & Opportunities 2017-2022," Juniper Research, November 2017.

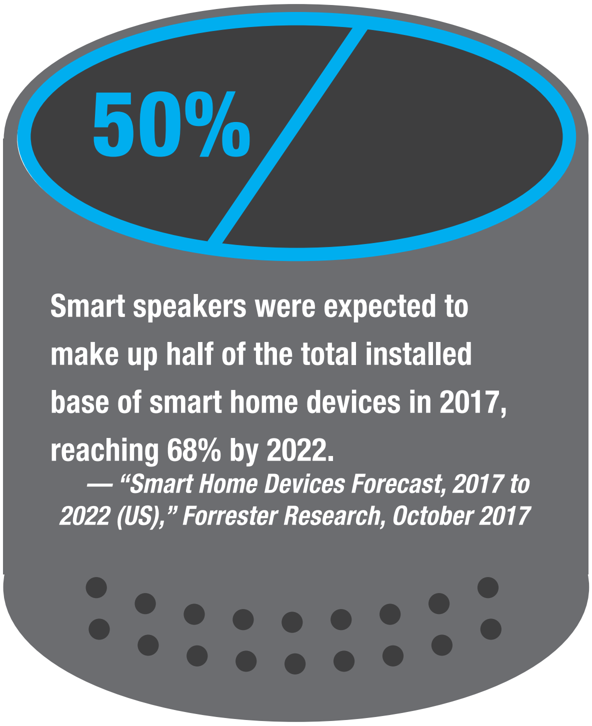
22 Million

Amazon sold over 11 million Alexa voice-controlled Amazon Echo devices in 2016, a number that was expected to double for 2017.

— "Smart Home Devices Forecast, 2017 to 2022 (US)," Forrester Research, October 2017

70.6% Amazon Echo accounted for 70.6% of all voice-enabled speaker users in the U.S. in 2017, followed by Google Home at 23.8%.

— eMarketer, April 2017



50%

Smart speakers were expected to make up half of the total installed base of smart home devices in 2017, reaching 68% by 2022.

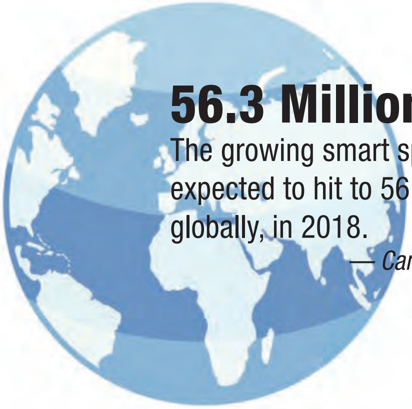
— "Smart Home Devices Forecast, 2017 to 2022 (US)," Forrester Research, October 2017

Look Who's Talking

- Millenials: 35.8M
- Gen X: 16.7M
- Boomers: 9.9M

In 2018, 38.5 million millenials are expected to use voice-enabled digital assistants—such as Amazon Alexa, Apple Siri, Google Now and Microsoft Cortana—at least once a month.

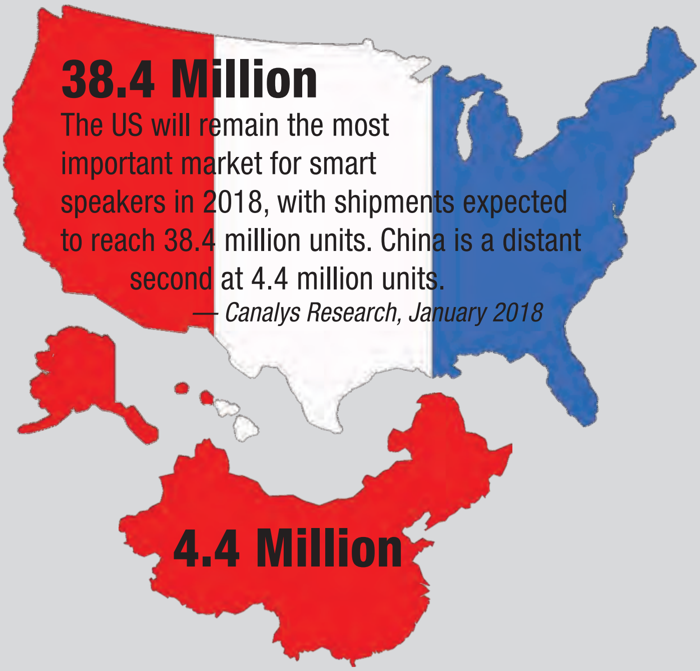
— eMarketer, April 2017



56.3 Million

The growing smart speaker market is expected to hit to 56.3 million shipments, globally, in 2018.

— Canalys Research, January 2018



38.4 Million

The US will remain the most important market for smart speakers in 2018, with shipments expected to reach 38.4 million units. China is a distant second at 4.4 million units.

— Canalys Research, January 2018

| MAKING SENSE OF SENSORS |

ENERGY HARVESTING

by Tom Kevan

A Power Source for Next-Generation Sensors

ENERGY HARVESTING promises to sweep aside a key impediment to ubiquitous sensing and, in the process, facilitate the realization of the internet of things (IoT). No longer dependent on powerline energy supplies and batteries, engineers can now use this technology to open the door to a broader field upon which to deploy all types of sensors.

In some cases, harvesting precludes the use of batteries all together. In others, it allows devices to operate for much longer periods of time without requiring engineers to replace batteries. This enables sensors and other electronic devices to function virtually autonomously in a broad range of applications, including remote and difficult-to-access locations.

The rise of energy harvesting is driven by advances that make the technology more practical and desirable for mobile and IoT applications. Energy conversion systems can now capture even trace amounts of energy from the environment and transform them into electrical energy, making the systems relevant in more use cases.

Another factor in play here is the fact that electronic systems have become more energy efficient, bringing the demand for power down into a range that harvesters can support. In particular, processor technology has achieved greater power efficiency, which reduces overall system power consumption. Growth of the number of low-power electronic devices—driven by demand for mobile and wearable products—also increases the number of use cases where the services of harvesting systems can be brought to bear.

The Basics

Before designers can take advantage of energy harvesting, however, they have to understand how power conversion works. The process begins with a transducer converting ambient energy—such as mechanical, thermal, light, electromagnetic energy, and chemical and biological energy sources—into harvested power. An example of this would be a piezoelectric generator transforming mechanical vibrations, strain or stress into electrical voltage or current that the system and the energy storage devices can use. This means matching the input impedance to provide maximum harvested energy, charging intermediate energy storage, routing power from a primary cell battery and generating the correct output voltage for the system.

In the final step, the energy conversion system buffers the processed energy in a storage device (such as a super capacitor or battery) to meet the device's ongoing power requirements. These include providing support for sensing, data processing and communications functions.

Design Tips

Designers have to consider a number of technical issues and variables when developing a harvesting system for a device. But perhaps the most fundamental lies in the nature of the energy source.

When designing a self-powered system, the engineer should start by estimating just how much power can be harvested from the available energy. For example, if the engineer is developing a thermoelectric harvester, the first step is to measure the temperature gradient that can be developed. If the designer plans to use vibration as the energy source, then the engineer must evaluate the acceleration level and vibration frequency. Once the available energy has been established, the designer can select the best harvester type for the application.

The next issue to consider is the energy-balance equation, where the engineer balances the harvester-enabled device's power demand with available energy. At this point, the development team may have to apply ultra low-power system design techniques to reduce the power requirements of the device, bringing power demand in line with available energy.

Designs may also require optional components to meet the application's requirements. For example, an application may call for an electronic interface module to condition the energy captured from a low-voltage source. This may take the form of a low-voltage step-up booster module.

The engineers may also have to include a supplementary energy storage device, such as a thin-film battery or a super capacitor.

Adding more components can often improve performance, but there's a catch: When considering the inclusion of optional components, development teams should remember that adding these new elements would likely increase the system's energy consumption. The best way to handle the cost–benefit trade-offs is by adopting a holistic view. DE

Tom Kevan *is a freelance writer/editor specializing in engineering and communications technology. Contact him via de-editors@digitaleng.news.*

CAASE Keynotes to Cover Engineering's Most Pressing Issues

CAASE18
The Conference on Advancing Analysis & Simulation in Engineering
June 5 - 7, Cleveland, Ohio

BY JAMIE J. GOOCH

THE CONFERENCE on Advancing Analysis & Simulation in Engineering (CAASE) will kick off June 5, 2018 in Cleveland. NAFEMS and *Digital Engineering* are co-hosting the event and have lined up some engaging expert keynote speakers to cover the issues you told us are most important to you.

Respondents to *DE's* recent Engineering Design Technology Outlook survey told us their top three day-to-day challenges were:

1. Collaboration,
2. Short deadlines, and
3. Regulatory compliance.

Meeting short product development deadlines without sacrificing product quality or innovation is one of the most cited benefits of simulation-led design. As simulation has become standard practice for many design engineering teams, the new workflow brings its own challenges. To help design engineering teams meet them, CAASE is assembling keynote speakers from government and industry.

Collaboration and Certification

The FDA's Tina Morrison will address collaboration among government and private companies when it comes to advancing the use of simulation to meet regulatory compliance. Morrison is deputy director, Division of Applied Mechanics, Office of Science and Engineering Laboratories, Center for Devices and Radiological Health at the U.S. Food and Drug Administration. Her keynote, titled "Priorities Advancing Regulatory Science and In Silico Medicine at the FDA," will be of interest to anyone involved in complying with government regulations, not just medical device designers, because it illustrates how government agencies are beginning to view simulation as a critical component of compliance.

To get an in-depth look at simulation in aircraft certification, the Federal Aviation Administration's Patrick Safarian will present "Requirements of Certification by Analysis." Safarian is fatigue and damage tolerance senior technical specialist with the FAA. Prior to FAA he was at the Boeing Company for 11 years. He'll explain how the FAA interacts with the industry in developing and applying simulation tools.

Caralynn Nowinski Collens, CEO of UI LABS, will explain how the innovation accelerator "leverages a network of hundreds of partners from university and industry, along with startups, government and community groups, to address problems too big for any one organization to solve on its own." Nowinski Collens' keynote is titled "Accelerating Innovation through Collaboration." UI LABS and the Department of Defense work together on the Digital Manufacturing and Design Innovation Institute (DMDII), a manufacturing hub based in Chicago.

The Future is Coming Fast

DE's Engineering Design Technology Outlook survey respondents also predicted these technologies would have the biggest impact on product design and development over the next five years:

1. Additive Manufacturing/3D Printing,
2. Simulation, and
3. Artificial Intelligence/Machine Learning

These technologies are already disrupting business as usual and providing new opportunities across industries. At CAASE, the keynotes and conference sessions will address simulation's role in the digital disruption affecting businesses today.

Jerry Overton, data scientist at DXC Technology, will present "AI in Manufacturing: How to Run Longer, Run Better and Keep Relevant." In his keynote, he'll explain how AI can be used to anticipate equipment service needs in advance and make smarter production design decisions that optimize the overall manufacturing process. Overton leads the strategy and development for DXC's Advanced Analytics, Artificial Intelligence and Internet of Things offerings. An author, systems model innovator and trainer, he is also is the principal data scientist for the strategic alliance between DXC and Microsoft known as Industrial Machine Learning.

Perhaps no other industry is experiencing digital disruption as acutely as the automotive industry. Ford Motor Company's Piero Aversa will explain how simulation is helping the industry meet recent advancements related to the electrification of powertrains, the reinvention of the battery and the advent of fully autonomous vehicles. Aversa is chief engineer, Global Powertrain NVH and CAE at Ford. His CAASE keynote is titled "Providing the Transformational Means to a New Era of Sustainability and Mobility."

CAASE will cover all of those topics and more. Learn more here: nafems.org/caase18. **DE**

Jamie J. Gooch *is editorial director of* DE. *Send e-mail about this article to de-editors@digitaleng.news.*

Sensors Empower Voice Interfaces

The convergence of smart microphones, new digital signal processing technology, voice recognition and natural language processing has opened the door for voice interfaces.

BY TOM KEVAN

Many market watchers contend voice interfaces will usher in an age of streamlined human-machine interactions. *Image courtesy of XMOS.*

A device the size of a pencil point has brought the voice interface to the verge of mainstream consumer electronics, with the control mechanism poised to transform the way people interact with machines. Smart microphones have opened the door for interfaces that adapt to human behavior better than any previous technology—surpassing both touch- and gesture-based interfaces.

Advances in acoustic sensing and signal processing techniques now enable these tiny devices to support human–machine interactions across rooms. Smart microphones represent the fundamental technology upon which voice interfaces are built. To understand and interpret speech reliably, the interfaces must hear just as clearly as people do. This means that the devices must be able to filter out extraneous noise and emulate the directional hearing that people do naturally.

A scan of today's market reveals the microphone's strong presence in products ranging from smartphones and wearables to smart appliances and home hubs. To see the extent of their market penetration, consider the statistics: Amazon Echo already resides in 4% of American households; Apple's Siri responds to more than 2 billion commands a week; and 20% of Google searches on Android smartphones in the U.S. are done via voice commands.

Part of a Larger System

When people talk about "smart microphones," they are actually referring to an array of microphones, supported by special signal processing hardware that helps to locate and isolate speech. With each new generation of voice-recognition technology, the number of microphones in the arrays has increased. For example, the first iPhone had one microphone, but the iPhone 5 had four sensors. Devices like Amazon Echo use as many as seven microphones.

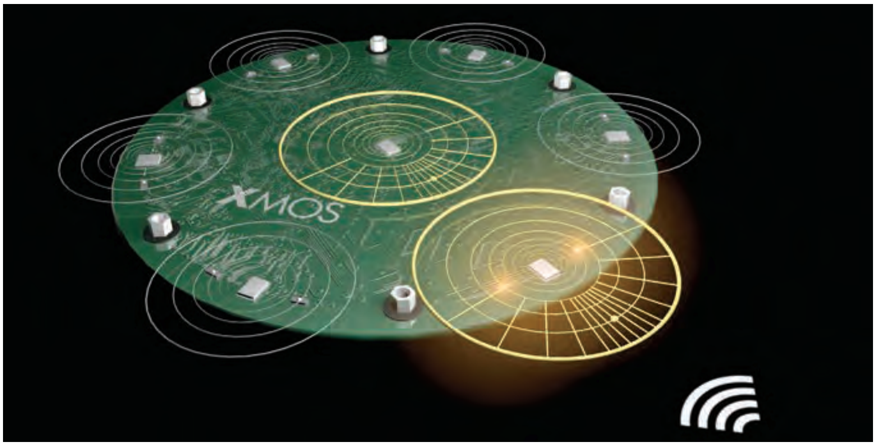
These microphone arrays can be made up of omni-directional microphones, directional microphones or a mix of the two, distributed in a variety of configurations. As a sound wave passes over an array, the wavefront reaches each microphone at a slightly different time. The system uses the time difference to triangulate the origin of the sound.

But there is much more to the process than triangulation. Voice-recognition systems begin with the microphone array converting acoustic waves to electronic and then digital signals. The array passes the digital signals to a digital signal processor, where speech enhancement is applied via specialized algorithms. This processing involves locating the direction of sound and contending with a number of factors that can compromise the acoustic signal. Finally, the enhanced signal goes to a conventional acoustic model for speech recognition.

To achieve optimal performance from a microphone array, the designer must closely match the sensitivity and frequency response of each microphone. Differences in these two parameters among the various microphones can cause a breakdown of the array's desired response.

Two Sensing Approaches

Current microphone technology includes old and new approaches. Capacitive micro-electro-mechanical system (MEMS) microphones have traditionally populated micro-



Smart microphones use direction-of-arrival, beamforming, echo cancellation, noise suppression, and gain control techniques to focus solely on the target speaker and eliminate unwanted noise. This enables the microphone to provide the interface with a signal suitable for voice recognition and natural language processing. ***Image courtesy of XMOS.***

phone arrays. This type of microphone uses a diaphragm and one or two back plates to form an air-gap capacitor that has a high bias charge. When the diaphragm moves in response to sound waves, the capacitance changes and the resulting voltage increases.

High-performance capacitive analog MEMS microphones deliver 63–65 dB SNR, as well as clear audio pickup, and the device offers a small footprint. On the negative side, however, these devices often succumb to the wear and tear of harsh environments. Capacitive microphones tend to be easily damaged by contaminants like water and dust. If even one microphone's performance is compromised by environmental conditions, the performance of the entire array deteriorates.

Despite this flaw, capacitive microphones have long dominated the market, and most major microphone vendors rely on the technology. On top of that, leading device manufacturers like Apple use capacitive MEMS microphones in their mobile products.

Recently, however, vendors have begun to introduce piezoelectric MEMS microphones, which offer impressive advantages. The developers of these devices have replaced the diaphragm and back plate found in capacitive sensors with a design that allows the sensing device to withstand harsh conditions without workarounds to ensure high reliability.

Piezoelectric MEMS microphones are relatively new to the market, but the strengths that they bring to the table have captured the attention of major developers like Amazon. Last year, Amazon's venture capital arm, the Alexa Fund, announced that it had contributed to Series A funding for Vesper, an early provider of piezoelectric MEMS microphones.

In Search of Clarity

Whether the microphones rely on capacitive or piezoelectric technology, the arrays enabling voice interfaces still have their work cut out for them. Typically, voice interfaces operate in noisy environments, cluttered with competing speakers, background noise and audio system reverberation that masks or corrupts the desired speech signal. Before the interface can process natural language, the microphones must sift through a flurry of acoustic signals, identify the source of interest, determine the direction from which it is projected and mitigate the effects of undesired signals and noise.

One of the most useful technologies in the developer's toolbox for addressing these issues is "beamforming," a process that extracts sound from a specific area of space. The beam usually takes the form of a plane or cone-shaped segment of space. Engineers measure beamforming's effectiveness by how much of the signal outside the beam is eliminated and how well the microphones focus on a speaker's voice by steering the directivity pattern toward the source. So not only does beamforming allow the microphone array to focus on the desired voice, but it also eliminates unwanted noise.

Voice interface designs must also contend with acoustic echo and reverberation. Acoustic echo stems from audio-playback paths often found in voice-recognition systems. The echo occurs when microphone elements of the array pick up the playback audio and feed it back into the system. This problem becomes particularly bad when the audio playback volume is high or when the speakers and microphones are close together.

Reverberation, on the other hand, occurs when audio-signal reflections from furniture and structural elements—such as walls—are fed into the microphone.

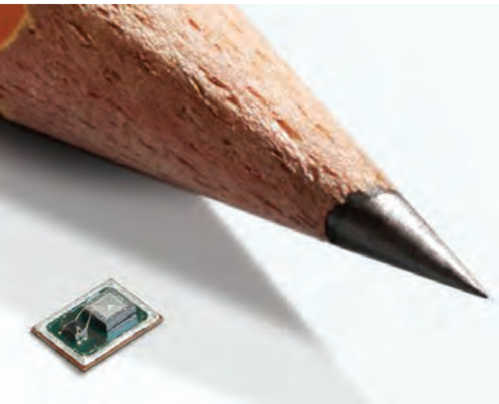
To mitigate the effects of these conditions, designers use acoustic echo-cancellation algorithms and de-reverberation filters. Recent efforts to eliminate interfering noise, however, have moved beyond these traditional approaches. Increasingly, voice interface designers rely on machine learning to clean up the noise clutter and drive further enhancements. They achieve this by using deep neural networks to block all but the desired signal.

From Design Parameters to System-Wide Concerns

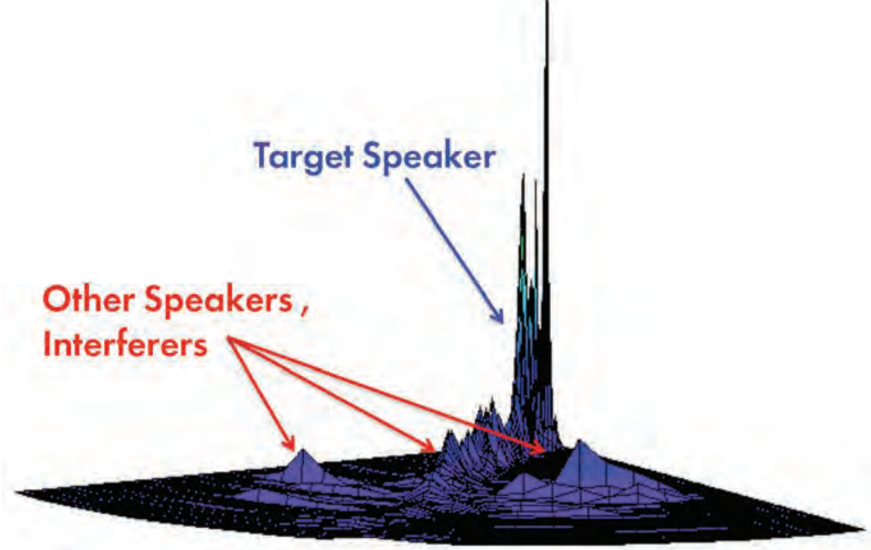
The relevance of beamforming, acoustic echo-cancellation algorithms, de-reverberation filters and deep neural networks depends on the operating environment in which the microphone array must function. As you might expect, for these applications, that translates into parameters of space and operating distance.

There are two broad types of voice-based interfaces: mobile and wearable device interfaces, which typically have to function over short distances, and smart home hubs like Amazon's Echo or Google's Home, which must function over longer distances.

"To date, yes, these two types dominate, and maybe there will be even longer distances in the future," says Matt Crowley, CEO of Vesper Technologies.



Smart microphones have made it possible to incorporate voice interfaces in mobile and wearable devices, dramatically changing the way users interact with computing systems. *Image courtesy of Vesper Technologies.*



Setem Technologies developed blind source signal separation algorithms, enabling consumer devices to focus on a specific voice or conversation within a crowded audio environment. *Image courtesy of XMOS.*

"The design requirements of mobile and wearable lend themselves more toward ruggedness and high acoustic overload for things like wind noise because it's associated with outdoor environments. The design of a hub-type device also demands good far-field performance—since the audio source may be far away—and also high acoustic overload for things like barge-in if the hub is playing music at the same time. There is a large amount of overlap in desirable acoustic specs, but the driving reasons are slightly different."

That said, some parse voice interface applications into more subcategories. "There are three different types of voice interface: hand-held, hands-free and far-field," says Huw Geddes, director of marketing for XMOS. "Hand-held includes wearables, mobiles, etc., where users [are] in the 10–50 cm range. Designers can make informed judgments on the position of the voice source and predict the relationship of microphones and voice source. Hands-free includes devices like an intercom or speakerphone, where the user is in the 100 cm range. Like hands-free, designers make informed judgments on the position of the speaker. Then there are far-field interfaces, which need to be able to capture voice across the room in the 2 to 5+ meter range, and in environments where the voice source can be in free space and moving. In this case, designers cannot make judgments about the relationship of speaker and microphones."

Short-Distance Interfaces

As you can see, the operating range of short-distance interfaces sets some of the design parameters for products that include smart microphones. But development teams must also consider other short distance-specific and system-wide issues.

For example, noise cancellation plays a large role in the effectiveness of the interface and the quality of the user's experience. Smart microphones should be able to cancel all known noise sources encountered by mobile, wearable and hands-free products. To this end, the designer should bear in mind that microphone placement—which affects frequency response and directivity of any beamformer—greatly determines a microphone array's ability to effectively eliminate noise. This task poses unique challenges in space-constrained designs exposed to demanding physical environments.

But perhaps the most unique challenge encountered in the design of this group of products is power management. For smart microphones, this issue is often linked with always-on functionality. "Power consumption in mobile and wearable devices is critical," says Todd Mozer, CEO of Sensory Inc. "Low-power, sound-detection circuitry creates an ultra-low power consumption for always-on, always-listening devices by awakening the recognizer only when interesting audio is present and then following with a very low power recognizer."

Another factor that plays a key role in ensuring a seamless user experience is latency—how quickly the interface responds to the user. "Existing digital signal processing subsystems on the SoC (system on a chip) for noise suppression and cloud communication already add to the overall latency," says Crowley. "Therefore, a smart microphone, if needed, should be chosen to optimize the latency of the system."

In addition to these two issues, speech processing must also be tailored to the applications. This raises a number of questions that the designer must address. For instance:

- What type of signal processing is required? Are multiple input channels needed for speaker localization, beamforming or noise profiling?
- Is the audio quality sufficient for speech processing? For example, nonlinear processing may negatively interfere with voice user interfaces.
- Are any speech-processing related functions available on the smart microphone hardware, such as speech-activity detection? Are any of these, or lower-level functions like an FFT (fast Fourier transform), implemented in silicon?

These are just some of the issues development teams must factor into their designs. And because it is still the early days for voice interfaces, the systems will only become more complex.

Far-field smart microphones enable manufacturers to offer voice interfaces that function from across the room. *Image courtesy of XMOS.*

Far-Field Smart Microphones

Designers of far-field microphone arrays face a different set of problems than those encountered by developers of short-distance arrays. Many of the differences emanate from the acoustic properties with which they must contend. At the same time, developers have the option of using different techniques from their short-distance counterparts. As a result, design engineers beginning a far-field project must take a different perspective.

"It's important to remember that sound behaves differently over different distances," says Geddes. "Sound waves near a hand-held or hands-free device are spherical, which makes it easier to identify the location of a sound source. With far-field microphones, the sound wave is usually assumed to be planar, which means that different simpler algorithms can be used to identify the source location. In addition, voice sources distant from the microphone are quieter and often have to compete with other surrounding noise sources, including other electronics and people."

In addition to these issues, design engineers need to be particularly aware of the placement and decoupling of speakers relative to the microphones. The output volume is limited by the acoustic echo cancellation's ability to remove the speaker signal. Preprocessing can help, as well as better speakers with less total harmonic distortion.

Designers should also pay attention to the impact of the system's enclosure on acoustic performance. The positioning of the microphones has a significant effect on the ability of the device to cancel out bouncing signals and reverberation, identify direction of arrival of the voice signal and capture the loudest possible signal.

The number of microphones in the array and the use of automatic gain control also affect performance. "More microphones are needed for better sound processing," says Mozer. "Also, the microphone should allow for real automatic gain control, either with hardware amplification or with 24–32 bits of information that allow shifting up or down for the 16-bit window that represents the target audio."

Beamforming also plays an important role in this class of application. Smart microphones based on beamformers enable arrays to identify real human voice sources (as opposed to voices on the TV) within a noisy soundscape at a distance of several meters. There are, however, types of smart microphones based on different mathematical algorithms that can deliver similar results.

Given the scale of the geography within which far-field arrays must perform, smart microphones in these applications must be able to function well in all kinds of conditions. "The ability of the system to adapt to different environments and climatic conditions is important," says Geddes. "Devices often work differently in winter vs. summer conditions, or even in the same location at different times of the day. A device optimized to handle reverberation well might work efficiently in an office environment, but much less effectively in a room with many soft furnishings as the voice signal is not strong enough. So the solution must be flexible and able to be re-tuned, maybe using some type of AI."

Looking at the Big Picture

It's important to remember that smart microphones do not operate as discrete systems. Optimal design or selection of smart microphones cannot solely rest on the issues outlined. A more holistic view of the increasingly complex and interconnected components and subsystems making up voice interfaces must also be considered.

This broader view requires designers to consider other factors. Speech and language applications can vary in many aspects, some of which are listed below.

- Does the application run on the device or does the cloud come into play? Is it a hybrid, leveraging onboard and server-based speech and language technology?
- Is the interface an embedded unit or a larger one? Is it battery operated or does it have a constant power supply? Can parts of the speech processing be done on dedicated hardware, such as a DSP or neural network hardware acceleration unit?
- What part of the world does a speech recognition service cover? Is it limited to a dedicated domain, such as transcribing radiology reports, or is it a voice assistant with large coverage? Is it available in a single language or in multiple languages?
- Is the interface a command-and-control system, with a small set of distinct commands (e.g., a set of commands for warehousing that can be understood robustly even in adverse acoustic conditions), or is it a natural language application like a virtual assistant that needs to deal with flexible, natural language?

Balancing these elements to meet design requirements means making the inevitable tradeoffs. "If the device will be used in noisy environments, microphone arrays can deliver multichannel audio that can be used for beamforming to home in on the speaker's voice," says Holger Quast, senior principal product manager, Nuance Communications. "If this is used in an always-on recognition mode like with a wake-up word application, power consumption may be an issue if it's a small battery-operated device, so possibly DSP hardware solutions may help. If other modalities like a visual channel (camera) are available, that information may also be used to locate the user and set the beamformer." **DE**

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INFO ➜ Nuance Communications: Nuance.com

➜ **Sensory Inc.:** Sensory.com

➜ **Vesper Technologies:** Vespermems.com

➜ **XMOS:** XMOS.com

CAD UI in Metamorphosis

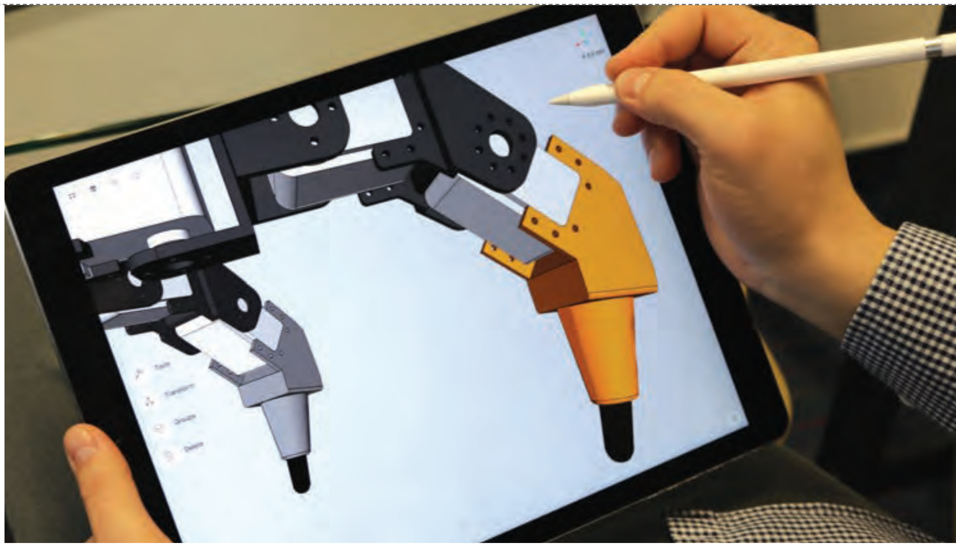
Desktop-centric CAD user interfaces are transforming to keep up with touch displays and AR-VR gear.

BY KENNETH WONG

IF WE CONSIDER JOHN WALKER'S founding of Autodesk in 1982 and the launch of PTC's Pro/ENGINEER in 1987 as the approximate origins of what's generally referred to as CAD today, then CAD is now celebrating 30-something years. In the disruption-filled technology timeline, each decade sees tremendous evolutionary activities: the arrival of new blood, the maturity and extinction of some household names and the survivors' metamorphosis.

Throughout all, CAD user interfaces (UIs) have remained surprisingly consistent, preserved by the stability of the user's choice of operating system and hardware: Windows-based workstations. For example, the way you extrude a 2D profile into a 3D solid, the way you apply blends to sharp edges and the way you create holes on surfaces—they're nearly identical in competing programs. Although these protocols are easy for industry insiders, CAD UIs still remain a barrier to newbies.

Now that classic workstations are evolving into professional tablets, and touch displays and all-in-one systems are becoming the norm in design studios large and small, CAD UIs are overdue for a transformation. The emerging AR-VR devices, too, put pressure on CAD to get more creative.



Shapr3D is among the developers who believe there's a need for a full-scale CAD design application for mobile devices and pen input.

The Expanding CAD Universe

Perhaps CAD software didn't need to concern itself with ease of use when it was the exclusive tool of engineers and architects. But those in the thriving maker community—inventors, tinkerers, artists and hackers—are now beginning to rely on CAD to produce digital designs that can be 3D printed. The DIY crowd, driven by irregular bursts of inspiration and inventive energy rather than year-long projects, is less tolerant of software with a steep learning curve. To attract them, CAD software makers need to offer something else.

"Dassault Systèmes SolidWorks [CAD program] is easy for people with engineering background, but there are also people with innovative product ideas without engineering background—people with English literature backgrounds, for example," says Kishore Boyalakuntla, VP of product portfolio management and brand user experience, Dassault Systèmes SolidWorks. "Parametric modeling is not straightforward to them. That's why we developed Xdesign."

Xdesign, a new product unveiled at SolidWorks 2016, is still in development. Designed as a browser-based program, Xdesign is expected to appeal to new users who prefer SaaS (system as a service) style interaction. "There's a whole universe of people who casually consume 3D data and make changes to the design," says Boyalakuntla. "For them, the zero-install, browser-based Xdesign is much better."

The Mobile Gold Rush

Jon Hirschtick was part of the small team that launched the Windows-based parametric CAD movement in the '90s with SolidWorks. The former SolidWorks co-founder came out of retirement in 2012 to remake CAD for the modern era, as a cloud-hosted, browser-operated program. The new product, Onshape, was released commercially in December 2015.

"One in eight Onshape sessions are on phones and tablets," reports Hirschtick. The statistics challenge the notion that full-scale CAD design work is not feasible on mobile devices.

"We have a lot of customers who tell me: 'I never thought I'd use your mobile apps, but then I was in the airport, at a client meeting or in the shop, and I had to make a design change and tried your mobile app and wow! I was actually able to model and do version control on it!' It's really cool when a customer can do extrude, filleting, draft angles, shelling, assembly mates and even version control on their phone or tablet, and of course it's all real-time collaborative, just like all Onshape clients," adds Hirschtick.

As this article goes to press, mobile app developer Shapr3D announced the release of its CAD app for iPad Pro, developed in collaboration with Siemens PLM Software and Tech Soft 3D. The app is designed for an iPad Pro's stylus input.

"[The app integrates [Siemens PLM Software's] Parasolid and [Tech Soft 3D's] HOOPS Exchange [software developer kit] to allow solid modeling and data translation locally within the app … By integrating these two technologies with Shapr3D's precision touch screen interface, engineering and design professionals now have the power of desktop modeling on a tablet, the iPad Pro," the company says.

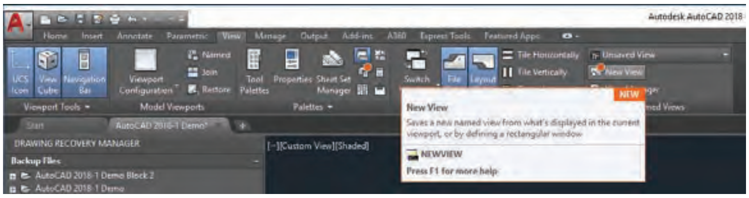
The free version of Shapr3D has a three-workspace limitation. The Pro version, at $149.90 per year, offers unlimited workspaces.

Finish My Sentences for Me

AutoCAD, one of the most widely used digital drawing programs in the engineering community, is not necessarily the model for ease of use. The steep learning curve is perhaps the price for the robustness of the program itself.

"AutoCAD is one of those do-anything-with-it programs. So there's no denying there's learning involved," says Marcus O'Brien, senior product line manager, Autodesk. "It's quite easy to get to the basic level proficiency, where you can start drawing lines, arcs and circles. But getting to the expert or elite level takes time." In each new release, many of the AutoCAD UI enhancements are designed to nudge the newbies and casual users toward acquiring expert skills, he reveals.

Whereas most newbies may feel more comfortable with the familiar Windows-style menu bars, many AutoCAD veterans—including O'Brien—believe typing in a text command is much faster than hunting for a menu icon to perform the same operation. For some, it's not just a skill but a matter of pride. The ability to run AutoCAD through text command is a sign that their relationship with the program is so intimate they can speak to it in



Autodesk uses orange dots to mark new features added to the latest release. *Image courtesy of Autodesk.*

its own programming lingo.

Suggestions to remove the command line to modernize the UI have met with fierce and vociferous resistance in the past. The AutoCAD community's online forum still houses the history of such a controversy in the discussion threads on Lachmi Khemlani's review of AutoCAD in the December 2001 *Cadence* magazine (now defunct).

"In 2012, AutoCAD introduced the command line autocomplete feature," recounts O'Brien. "If you only remember the beginning letters in a command, you start typing it, and the software completes it for you."

The feature was subsequently extended to include mid-string search, where typing chunks of letters belonging anywhere in the command text string would bring up the possible command line options to select.

In 2017, AutoCAD began marking new features with an orange dot, to help CAD managers distinguish new features added to the software. "We know CAD managers like to update [their CAD workforce] about every two years. The orange dots in the ribbon show you the new features that are added. So you can choose when to learn and adopt them," explains O'Brien.

Limit my Choices

PTC's behemoth all-in-one program called Pro/ENGINEER went through a dramatic overhaul in 2010. The program got rebranded as Creo, and was divided into a suite of smaller modules: Creo Parametric for classic parametric modeling; Creo Simulate for simulation; Creo Direct for direct modeling and so on. Today, the Creo product family also encompasses Creo Design Exploration Extension for concept design; Creo Interactive Surface Design Extension for industrial design; and more.

One of the concerted efforts made to simplify the Creo UI is not to give the user more choices, but less—fewer choices of operations, but more relevant choices based on context. "In Creo 4.0, we introduced the mini toolbar," says Paul Sagar, VP of product management, PTC. "So if you select a specific surface on a 3D model, you'll get a mini toolbar that shows the operations possible on that face. If you select a spline, Sweep is one of the options; if you choose a face, Chamfer may be an option."

A Modern Touch

One of the major challenges that CAD developers confront is the adaptation of touch-driven operating systems and devices. Experimentation with CAD on touch devices began almost as soon as the hardware became powerful enough, a few years before CAD software companies were ready to support them.

Boyalakuntla confesses that he installed the SolidWorks CAD program on a Microsoft Surface Pro before his company officially sanctioned the usage. "Before [SolidWorks chose to support touch interfaces], functions like Zoom would not scale on touch devices," notes Boyalakuntla. "With touch, you could use your fingertips; sometimes you use two fingers. Sometimes you drag objects with your finger. If the icons and buttons don't automatically scale, you can't tell what your focus area is."

In SolidWorks 2018, the company officially began supporting touch devices. "If you install SolidWorks 2018 on a system without touch interface, the touch-activated commands will be hidden. But if you have a touch-capable laptop or a tablet, like Microsoft Surface Book, you'll be able to take full advantage of the touch-based features," says Boyalakuntla.

Sketching has always been an awkward experience on mouse and keyboard, but with touch devices with pen input, the operation is expected to be much more efficient and natural. The ease of use comes as a result of the R&D team's observations of the touch device users' behaviors.

"If you use your fingertip, your point of focus is much larger, but if you use the pen, your pen tip has a very precise focus point. When you draw a line in the sketch mode, then try to rotate the model, how does the software know you're not trying to draw another arc [with your rotation action]? We had to build various prototypes and collect feedback to get these things right," adds Boyalakuntla.

Formerly dubbed AutoCAD WS, AutoCAD Mobile is a tablet-friendly version of AutoCAD. "When you draw a line with a mouse, you tend to click on the start point, then click once more at the end point. With a touch interface, it's very different," observes O'Brien. "When drawing with your fingertip, when you put your finger on the surface for the first time, you're actually selecting the rough area where you want to start the line. So you need to zoom in closer for details. It's by lifting the finger that you indicate the precise point where you want to start the line."

It's important to note that AutoCAD Mobile is a subset of the desktop version. The two are not comparable, feature for feature. "We didn't want to put all of the features of desktop AutoCAD into the mobile version, so it's a purposeful subset of features," says O'Brien.

Many existing parametric modeling paradigms, such as the steps involved in applying blends to selected edges, evolved over time to become the norm, and thus considered intuitive. Adapting 2D and 3D CAD interfaces to touch devices is an ongoing process. Some stumbles and failed experiments are inevitable. But the natural interaction's rewards outweigh the inconveniences.

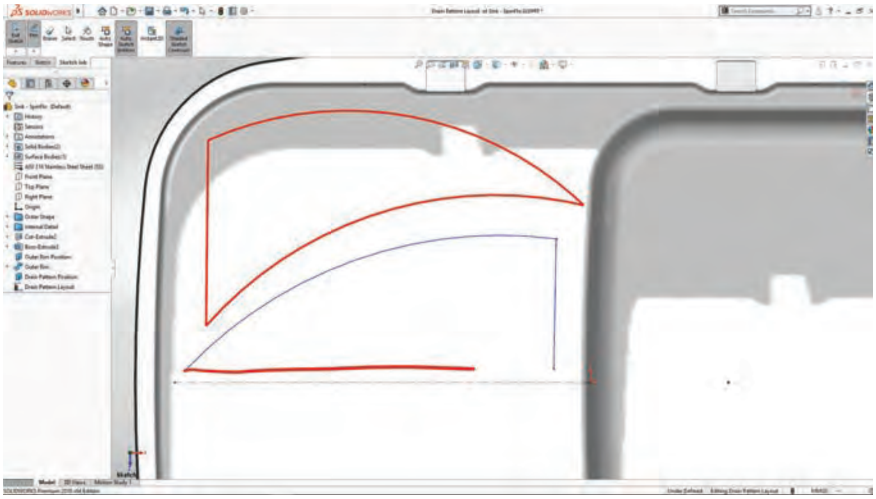
Augmented CAD Reality Check

Onshape's pure-cloud architecture eliminates what is arguably one of the biggest headaches for CAD adoption: the installation. Because it houses the users' work in progress in the cloud, Onshape gives project teams a way to collaborate without the worrying about accidentally overriding one another's work. Like Google Docs, Onshape automatically saves changes and keeps a version history; therefore, reverting to a previous version is much easier, compared with the same operation in desktop-run parametric CAD.

One area Hirschtick is watching closely for Onshape collaboration tools is the emerging AR-VR (augmented reality, virtual reality) hardware. "As of today, I haven't seen any that change the game, yet," says Hirschtick. "But these devices will be very important to our world in the future. You'll see mixed reality applications [where digital objects and physical objects coexist in the device's display]; you'll see CAD programs and real-time collaboration on these platforms, not just 3D file viewing. When that happens, it'll be profound. Our cloud architecture makes it easy for us to offer a mixed reality client."

In 2015, PTC acquired Vuforia from telecom giant Qualcomm. This made Vuforia's AR technology stack part of PTC. Vuforia can power AR viewing experiences where product views can be augmented with real-time sensor data and 3D CAD data. It's a critical component to PTC's digital twin strategy. AR function is now included as part of PTC Creo.

"The way our customers experience these digital twins may not necessarily be through a CAD program like Creo," says Sagar. "It may be through ThingWorx View [a mobile app from PTC, developed using the Vuforia SDK]. With it, you can let others experience your design. Further down the road, you might use it not just for review and collaboration but actually design something in it."



SolidWorks 2018 marks the debut of a touch-based sketching interface. *Image courtesy of SolidWorks.*

Quite a Workout

Supporting AR-VR for viewing and collaboration is fairly straightforward. Many mainstream CAD programs have already implemented this feature through a simple exporting or publishing tool that lets you bring your CAD data into widely used AR-VR devices. But AR-VR for design may demand a whole new UI. Repackaging the current desktop-centric UI to AR-VR would be ill-advised.

At Autodesk University 2017 conference, the company put AutoCAD Mobile on Microsoft Surface Hub, a 55-in. touch-enabled wall designed for collaboration. The software ran smoothly, and the installation attracted quite a bit of foot traffic. "The Facebook video clip was widely circulated. It was viewed more than one million times, shared thousands of times, with nearly 3,000 comments," notes O'Brien.

But it also inadvertently revealed one of the challenges of CAD on large displays, and by extension, CAD in AR-VR, where the display is virtually limitless. On a desktop display, the mouse travel to access a menu button is minimal, but with a giant display like Hub, you need to use big arm movements to reach for the same menu items and commands. Working the whole day in this mode may be the equivalent of a six- to eight-hour Yoga workout.

"Some people commented that, if they have to work like that all day, they'd be exhausted," recalls O'Brien. "So, I think AR-VR is important, but we need to first make sure we get the touch interface right."

In 2013, SolidWorks introduced AR functionality into its free viewer eDrawings, available both as desktop and mobile applications. "I can tell you we have customers using AR-VR in their production environment, for collision detection, ergonomics checks for service technicians and so on," says Boyalakuntla. "The device is the customer's choice, not ours to make. So our approach is first to create a format that all [AR-VR devices] can read."

Like Autodesk, O'Brien says he, too, takes a more cautious approach when it comes to design creation in AR-VR. "To actually design in AR-VR, to wave your hands and build objects in it—that's certainly a dream for many," says Boyalakuntla. "But in that area, the technology is still in its infancy." DE

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INFO → **Autodesk:** Autodesk.com

→ **Onshape:** Onshape.com

→ **PTC:** PTC.com

→ **Sharp3D:** Shapr3D.com

→ **SolidWorks:** SolidWorks.com

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Emotion as a Design Parameter

New technologies emerge to let engineers monitor, interpret and incorporate human emotions into product design.

BY KENNETH WONG

CONSUMERS don't expect products to possess emotional intelligence. They don't expect their car to calm them down in a traffic jam; nor do they expect their smartwatch to realize the last text message they read on it was a devastating piece of news. But the emergence of emotion-detection technologies, riding on the wave of sensor-equipped wearables and machine learning, points to a new kind of man-and-machine interaction—one that involves emotions.

For designers, it's both a blessing and a burden. Being able to design products that are not only emotive but also emotion-aware opens new doors. But it also adds new parameters to include in system design that few have previously considered.

The Feel of a Brand

What exactly is the Jaguar feel, BMW feel or Audi feel? The mix of luxury, comfort and prestige associated with a certain brand is difficult to define, even more difficult to measure. Some of it comes from the consistent marketing campaign that makes you associate the logo and the vehicle with a certain lifestyle or personality. Others come from years of engineering to ensure the brand's recognizable form and emotive details are preserved.

"The automotive brand feel is quite subjective," observes Ulrich Raschke, director of human simulation products, Siemens PLM Software. "Over a decade ago, car companies became in-

Emotion Research Lab uses webcam-detected microexpressions to identify human emotions and moods. *Image courtesy of Emotion Research Lab.*

Automakers may deploy Siemens PLM Software's Tecnomatix Jack in immersive AR-VR environments to understand consumers' subjective feelings associated with certain brands. ***Image courtesy of Siemens PLM Software.***

terested in designing the brand's feel. To capture the characteristics of that feel, some of them used Siemens PLM Software's Tecnomatix Jack to immerse someone in the digital vehicle model to collect the test subject's subjective responses."

Part of the collection of human simulation solutions overseen by Raschke, Tecnomatix Jack can be used to simulate and analyze the assembly workflow in plants and factories. Jack and his female counterpart Jill can be configured to match the target population's size attributes.

Their range of motion is restricted to match real human capacity. Therefore, if Jack and Jill are required to adopt unnatural postures to perform a certain task, they'll show signs of distress (registered as torques in the affected regions in their virtual bodies). Simulating assembly routines with Jack and Jill could reveal certain work-related ergonomic issues and injury risks. With the emergence of affordable augmented reality and virtual reality (AR-VR) hardware, software like Tecnomatix Jack enters the realm of immersive simulation.

"With the test subjects sitting in the virtual vehicle, the car manufacturer tracked their movements," explains Raschke, recounting the use of Jack in automotive brand design projects. "Could they reach the mirror, the gear shafts and the radio controls? Was it comfortable to reach for them? How did that feel?"

Siemens PLM Software's rivals—Autodesk, Dassault Systèmes and PTC—are also aggressively exploring AR-VR incorporation as part of the design workflow. An immersive simulation made possible with AR-VR gear offers a new level of understanding previously not possible with desktop computer-based simulation.

"You can measure not only the pressures and forces exerted on the test subjects, but also ask them if they can imagine doing this job this way for eight hours a day," Raschke points out. "The reporting tool might say numerically it's OK to do this task, that there's no risk of injury, but the test subjects' feeling might be that they don't want to work that way."

Measuring Emotions

Industry analysts expect the wearable medical device market to grow rapidly by 2025. The market is spawning many new types of connected devices catering to health-conscious consumers.

Among them is Feel, a wristband described as an "emotion sensor and mental health advisor." The company states: "The wristband monitors a variety of physiological signals throughout the day to recognize changes in your emotions." The device can detect emotional patterns including joy, stress, distress, contentment and sadness, as made evident by the consumer's heart-rate variability, skin temperature and other physiological changes.

Feel is designed mainly using SolidWorks 3D CAD program, according to Olga Labutina, Feel's product & marketing manager. "We have five sensors in the wristband," she explains. "The most important one is the custom sensor. Making that custom sensor, placing it to make sure the user can easily keep the device on 24-7, to make sure the sensor touches the skin properly to get good readings—these were the technical challenges."

The centerpiece of Feel's wristband is a GSR sensor that captures differences in skin conductance as an indicator of fluctuating emotions. Feel uses machine learning to analyze the changes to develop its proprietary algorithm for emotion recognition.

"In our controlled in-house tests, we use VR hardware, mainly Homido and Samsung Gear VR. Feel engineers let testers view multimedia content developed in-house with psychologists, then verified if the emotional states detected match what the test subjects were experiencing in a certain point in time. While in the uncontrolled environment, the user goes through [the] Feel experience of emotion recognition and self-reports via Feel Mobile App," says Labutina.

Because it's a wearable, Feel engineers also had to ensure the device is discreet and sleek, and won't disrupt the daily domestic tasks people tend to perform. The product is now going through validation tests, says Labutina.

Monitoring Moods

Maria Pocovi, CEO of Emotion Research Lab, has the technology that she believes is changing the way people do market and brand research. Forget the focus groups and telephone surveys. These take too much time and money to organize. Pocovi prefers to work with webcams and algorithms. Though the technology was initially developed with market researchers in mind, Pocovi now thinks it can also be incorporated into IoT devices and autonomous vehicles.

"We developed an emotion-recognition algorithm based on microexpressions in people's faces," Pocovi explains. "That's why we can work with just a webcam."

In onsite deployment, a retailer might mount a webcam next to two versions of a product to understand the consumer's

The Feel wristband's built-in sensors can detect human emotions and mood. ***Image courtesy of Feel.***

receptiveness for one over the other. In online deployment, a marketer might let survey participants look at prepared content (for example, a TV ad campaign), then measure the basic emotions and moods generated (Neutral, Exuberant, Dependent, Relaxed, Docile, Hostile, Anxious, Disdainful, Bored) based on their reaction as detected via the webcam.

"Our technology computes and extracts the emotions in real time, so the camera footage doesn't need to be recorded and archived," Pocovi points out. This resolves some privacy concerns and eliminates the need for costly storage servers—on premise or in the cloud—to keep hours of webcam footage generated.

"Our vision is to enable machines to understand human emotions, so our API now allows designers to create products that can understand human emotions and interact in real time," Pocovi says. "For example, detecting the emotional pattern of the driver is one step more to increase the security and avoiding accidents because people's mood affects their capabilities. Designers can integrate our technology in their IoT device or vehicle to make it more human"—that is, a smartphone or a car that knows how you feel and can issue helpful prompts.

The advancements in AR-VR gear make it possible for designers to study and understand how the consumer might feel about a product—a subjective parameter that may have nothing to do with product quality or performance. The emotion-detection technologies point to autonomous vehicles that could recognize signs of road rage or distractions in the driver, or smartwatches that could tell if their owners are in distress. Incorporating these into the product development cycle and system design might become a standard practice in the not-so-distant future. **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 → **Autodesk:** Autodesk.com

→ **Dassault Systèmes:** 3DS.com

→ **Emotion Research Lab:** EmotionResearchLab.com

→ **Feel:** MyFeel.co

→ **Homido:** Homido.com

→ **PTC:** PTC.com

→ **Samsung Gear VR:** Samsung.com/global/galaxy/gear-vr

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

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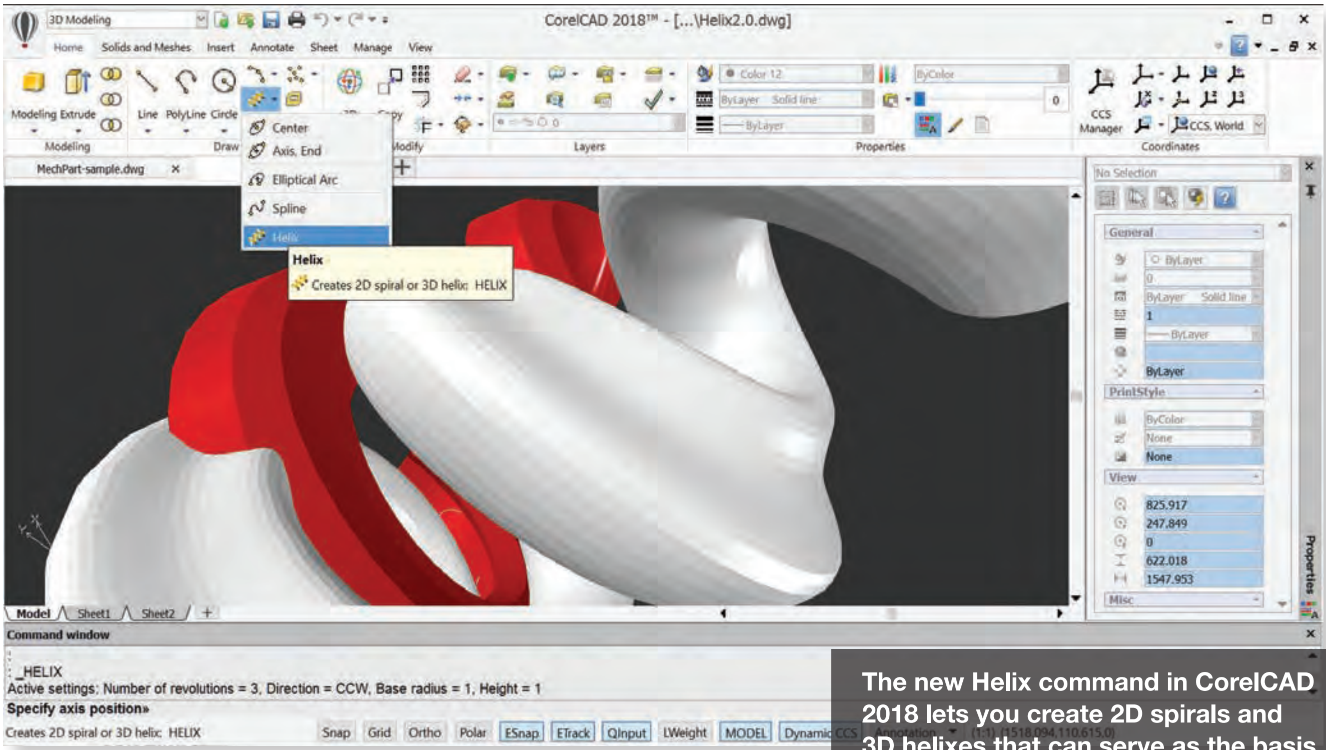


The new Helix command in CorelCAD 2018 lets you create 2D spirals and 3D helixes that can serve as the basis for creating more complex objects.

CorelCAD 2018: An Affordable AutoCAD Alternative

Seventh version of software offers DWG compatibility and is built using the ARES CAD kernel.

BY DAVID COHN

AT ONE TIME, Corel was one of the biggest software companies in Canada. Its flagship product, the widely popular CorelDRAW, was one of the first graphics programs for Windows. More recently, Corel Corp. acquired numerous programs in markets ranging from design and illustration to photo and video editing. In December, the company introduced CorelCAD 2018, the seventh version of its 2D/3D CAD software.

Unlike many of its other programs, however, CorelCAD is not an acquisition. Instead, it is built using the ARES CAD kernel from German developer Graebert. That same CAD engine powers Graebert's own ARES Commander and Dassault Systèmes' DraftSight software.

CorelCAD is positioned as a more affordable alternative to AutoCAD and uses DWG as its own native CorelCAD file format. With this latest release, CorelCAD can now open drawings saved in the latest AutoCAD 2018 DWG format, although CorelCAD still saves DWG files to the older 2013 format. CorelCAD 2018 is available for Windows and Mac OS, with an updated version of its CorelCAD Mobile app for Android devices as well as its first-ever CorelCAD Mobile app for iOS scheduled to be released in early 2018. CorelCAD 2018 offers new tools and enhancements aimed at improving its 2D and 3D capabilities.

Similar Look and Feel

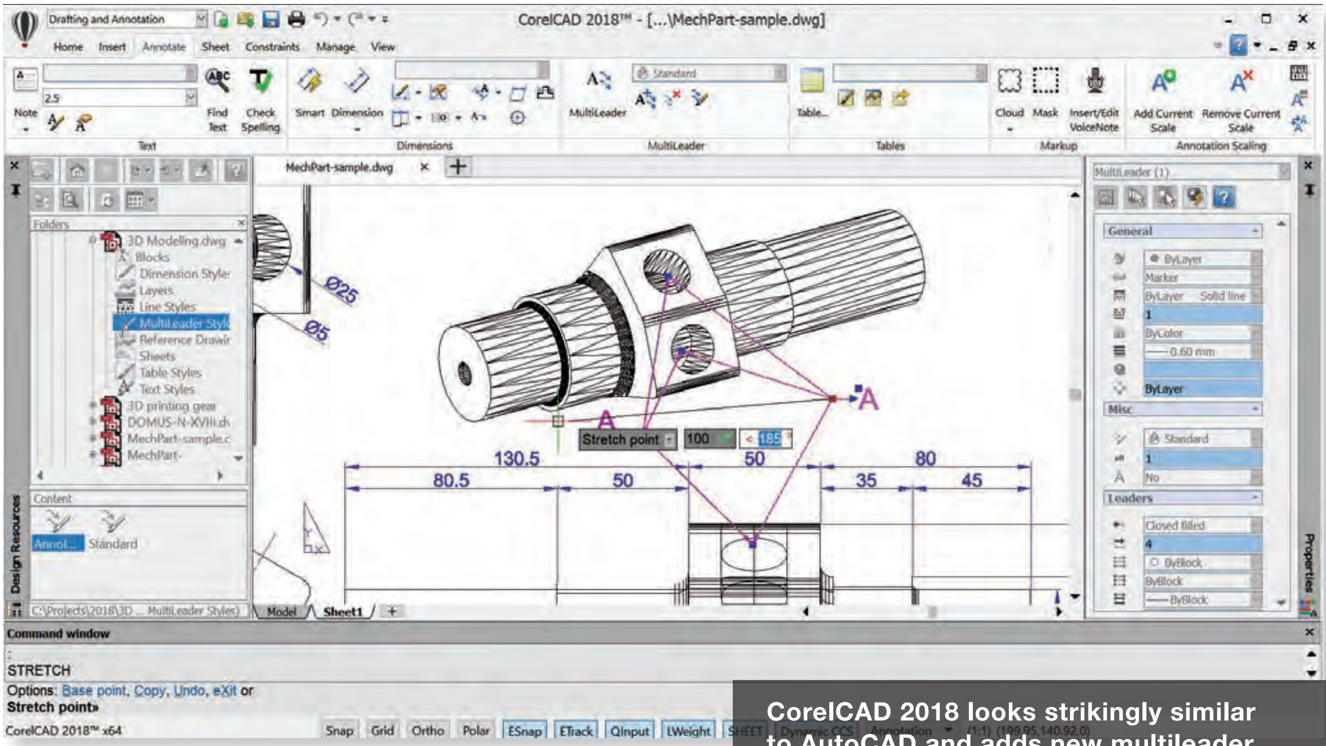
When you first start CorelCAD, the program displays its "Classic" user interface that includes pull-down menus and a host of toolbars with icon-only buttons docked around the perimeter of the screen, much like old versions of AutoCAD. But as soon as you switch to the "Drafting and Annotation" or "3D Modeling" workspaces—equivalent to similarly named workspaces in AutoCAD—CorelCAD changes to a ribbon interface quite like that of the AutoCAD of today.

Like AutoCAD, each drawing appears in its own window, identified by a file tab across the top of the drawing area. You can use the drawing file tabs to easily switch between drawings or start a new drawing, and use tabs in the lower-left corner of the drawing window to switch between model space and multiple sheets—equivalent to paper space layouts in AutoCAD.

Other aspects of CorelCAD are eerily similar to AutoCAD. For example, CorelCAD has a command window and you can start commands by typing, just like AutoCAD. A few commands have different names—such as PATTERN instead of ARRAY—but thanks to command shortcuts (like aliases in AutoCAD), you can type the AutoCAD command name to start almost any CorelCAD command.

Mostly Similar Functionality

Although CorelCAD does not include every function found in AutoCAD, with the last several releases, the list of



CorelCAD 2018 looks strikingly similar to AutoCAD and adds new multileader capabilities much like those in AutoCAD.

missing features has gotten smaller. For example, last year CorelCAD 2017 gained a Quick Input feature (like AutoCAD's dynamic input), command auto-completion (nearly identical to the feature first introduced in AutoCAD 2012) and context-sensitive grips (similar to extended tooltips) when working with 2D objects.

With the release of CorelCAD 2018, that trend continues. The new version includes a Smart Dimension command similar to the feature introduced in AutoCAD 2016. Although CorelCAD still offers individual commands for creating specific types of dimensions—such as linear, angular, diameter and ordinate dimensions—the new Smart Dimension tool automatically suggests the most appropriate dimension type. But unlike AutoCAD, this new tool in CorelCAD can only be used to dimension individual objects. You cannot specify extension line origins, you cannot use it to place ordinate or baseline dimensions and you cannot use it to place parallel (aligned dimensions). The new Smart Dimension tool in CorelCAD also lacks many of the "smart" features found in AutoCAD. For example, it can only place dimensions on the current layer (not on a specific dimension layer). CorelCAD also does not prompt you to move, break up or replace dimensions if you attempt to place a new smart dimension that overlaps another similar dimension.

CorelCAD 2018 also gains a new multileader tool that enables you to draw, edit and configure callouts with multiple leader lines and adjust existing callouts by adding and removing leader lines. Again, this new feature matches most of the capabilities of AutoCAD's MLeader tool that first appeared in AutoCAD 2008. The new release of CorelCAD also adds the option of pasting content from the clipboard to the current layer rather than the source layer.

Tables in CorelCAD have also been enhanced. You can now add formulas to cells using arithmetic operators as well as sum, average and count functions. In addition, once a table has been created, you can export it as a comma-separated format (CSV) file for subsequent import into Microsoft Excel or a database application. This, too, duplicates a function that has long been available in AutoCAD, but AutoCAD can additionally save table data directly to an XLS or MDB file and can link Excel spreadsheets to tables within drawings—abilities that CorelCAD still lacks.

Improved 3D Tools

With the 2018 release, CorelCAD's 3D capabilities get a significant boost. For example, in previous versions, you could create primitives such as solid boxes, wedges, cylinders and spheres as well as some solid mesh objects. But once created, it was very difficult to change the size of those primitives. Now, in CorelCAD 2018, when you select a solid primitive, the program displays grips that enable you to move faces and vertices. You can also use the Properties palette to alter the size and rotation of solid primitives. Unlike AutoCAD, however, solids in CorelCAD cannot retain their history. That means that once you perform Boolean operations, you can no longer modify the subobjects that were combined into the composite solid.

CorelCAD 2018 also now provides dynamic Custom Coordinate System capabilities (CCS) similar to the dynamic UCS feature that first appeared in AutoCAD 2007. Now, when you move the cursor over the face of a 3D solid in CorelCAD, the cursor automatically realigns the XY-plane. You can then draw new geometry on that face and use that geometry for editing and adding elements to the 3D model.

A helix tool has also been added to CorelCAD 2018, enabling users to create both 2D spirals and 3D helixes. Once you have created a helix, you can use it as the basis for creating 3D solids by sweeping a 2D or 3D curve along the helix path. Again, this feature has been available in AutoCAD since 2007.

Beyond AutoCAD Compatibility

CorelCAD continues to provide good support for AutoLISP and ARX and uses the same hatch patterns, linetypes and text files as AutoCAD. Users should therefore have few compatibility issues when exchanging drawing files, although when opening a DWG file saved using CorelCAD, AutoCAD will warn that the file was not saved by an Autodesk program.

CorelCAD also offers some capabilities not found in AutoCAD. For example, you can insert audio recordings into a drawing and play them back later. Although AutoCAD does not support these VoiceNotes, it has no problem opening drawings containing them.

CorelCAD also supports other industry-standard formats, including SVG, ACIS and SAT, enabling users to import files from other CAD programs. You can also export to PDF and include PDF files as underlays, but CorelCAD still lacks the ability to import PDF geometry into a CorelCAD drawing.

Because it was developed by Corel, it makes sense that CorelCAD also provides links to other Corel software. You can import CorelDRAW (CDR) and Corel DESIGNER (DES) files as model space objects and export CorelCAD drawings to both formats, but only in the Windows version. The CDR and DES formats are not supported in the Mac version of CorelCAD.

Despite the latest improvements, there are still many AutoCAD features that are not available in CorelCAD, including sheet sets, dynamic blocks and model documentation. But with the release of CorelCAD 2018, that list has gotten shorter.

At $699, CorelCAD is much less expensive than AutoCAD or even AutoCAD LT. You can also upgrade from any previous version of CorelCAD for $199. The fact that your purchase of CorelCAD gets you a perpetual license whereas AutoCAD and AutoCAD LT are now only available on a subscription basis is also quite attractive. But that may be changing. Corel is now also offering the Mac version on a monthly subscription basis.

Once the new mobile version is released, you will also be able to download CorelCAD 2018 Mobile for both Android and iOS tablets and smartphones. A subscription version of the mobile app will offer 3D viewing and 2D editing of any DWG file while a free version will allow viewing and annotation of drawings.

Although CorelCAD still lacks many of AutoCAD's more advanced features, its low cost and similar look and feel continue to make CorelCAD an attractive alternative for certain budgets. **DE**

David Cohn *is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA. He is a contributing editor to* Digital Engineering *and is the author of more than a dozen books. You can contact him via email at david@dscohn.com or visit his website at dscohn.com.*

INFO → Corel: corel.com

CorelCAD 2018

- **Price:**
- Full version (includes one-year mobile license): $699
- Upgrade (from any previous CorelCAD version): $199
- Subscription (via the Mac App Store): $35/month

SYSTEM REQUIREMENTS

Windows:

- **OS:** Windows 10, Windows 8 or Windows 7 (32-bit or 64-bit)
- **CPU:** Intel Core 2 Duo or AMD Athlon x2 Dual-Core or higher
- **Memory:** 2GB minimum (8GB or more recommended)
- **Disk Space**: 500MB
- **GPU:** 3D graphics accelerator with OpenGL v1.4 (OpenGL v3.2 or higher recommended)
- **Display:** 1280x768 minimum (1920x1080 recommended)

Macintosh:

- **OS:** Mac OS X v10.10 (Yosemite) or higher (including macOS Sierra)
- **CPU:** Intel Core 2 Duo processor (or better)
- **Memory:** 2GB minimum (8GB or more recommended)
- **Disk Space**: 500MB
- **GPU:** 3D graphics accelerator with OpenGL v1.4 (OpenGL v3.2 or higher recommended)
- **Display:** 1280x768 minimum (1920x1080 recommended)

Part 1

Siemens FEMAP with NX NASTRAN Overview

The first in this series of simulation and analysis software walkthroughs looks at the pairing of FEMAP and NX NASTRAN from Siemens.

BY TONY ABBEY

Editor's Note: *Tony Abbey teaches both live and e-Learning classes for NAFEMS. He also provides FEA consulting and mentoring. Contact tony@fetraining.com for details.*

This is the first in a new series of overviews that looks at finite element analysis (FEA) software products. Each overview will take the format of a walkthrough using a simple structural example. The full capabilities of each product can't be covered in a few pages, but the intention is to give you a feel for the basic workflow required for each product.

Each overview represents my independent assessment. Please note that the companies developing the products do not sponsor the overviews. However, in many cases, I am indebted to the companies for supplying temporary licenses to allow the walkthroughs to be carried out.

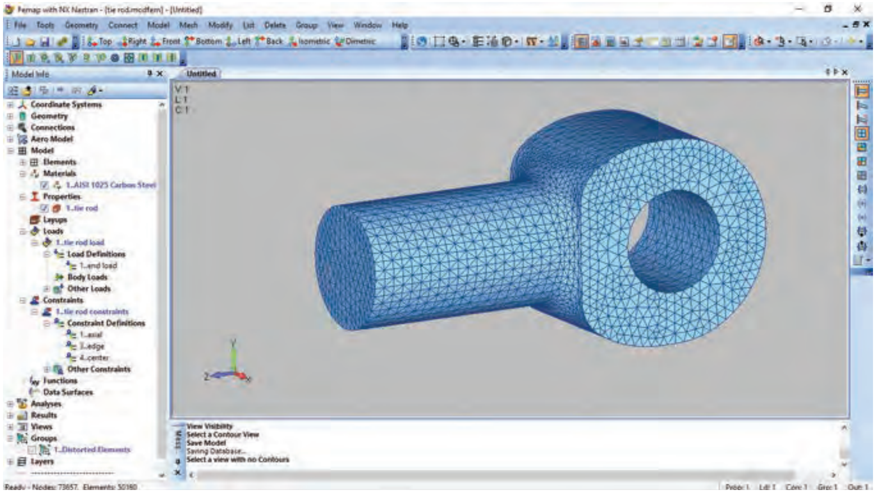


FIG. 1: The main FEMAP interface.

FEMAP with NX NASTRAN Intro

The first overview in the series looks at the pairing of FEMAP and NX NASTRAN from Siemens PLM Software. The main emphasis will be on the FEMAP pre- and post-processing environment. The overview is in two parts. In this first part we will be covering the workflow up to meshing. In the subsequent part we will be completing the workflow through to post-processing.

You can view the complete model build in an online video at digitaleng.news/de/femapnx.

Fig. 1 shows the screen area, with a tie rod FEA model visible in the main graphics window. To the left of this is the Model Info pane. The "tree" view within this pane is currently showing the various FEA entities being built out that are ready for the analysis. At the top of the screenshot is a traditional drop-down menu that broadly follows the sequence of tasks in an analysis setup. You can either work exclusively from the drop-down menu, or use a hybrid approach with much of the functionality available in the more visual Model Info pane.

Below the main drop-down menu is the toolbar area with a variety of toolbars shown active. Again, you can work exclusively with the toolbars, or use a mix of these, the main menu and the Model Info pane in your workflow. A strong feature of FEMAP is the variety of approaches available. For an experienced user, this makes it a very rich environment. For the new user, it can be a bit bewildering; therefore, for the novices, the best advice may be to stay with the model info pane in the beginning.

However, even a new user will be tempted to set up tailor-made workflows very quickly, using a selection of the toolbars, or by beginning to create customized toolbars. The approach is similar to customizing toolbars in many Windows-based products.

The other default region in view is the Message pane below the graphics window. This provides continuous feedback for all actions you take, as well as various types of summary data.

There are a group of additional panes that can be opened to perform specialist tasks, such as meshing, post-processing and charting. We will be looking at some of these in the overview. The trend in FEMAP over the past few years has been to provide new or upgraded functionality via toolboxes located in these dedicated panes.

One thing to note in this overview is that I have changed many of the default entity and view colors to provide a clear set of images for the article.

Working with Geometry

Most users will be importing geometry into FEMAP. A wide range of formats is available, with advanced import settings for most of them. Fig. 2 shows the CAD model I have brought in, using the STEP file format. This CAD model is available for download at digitaleng.news/de/femapnx, in various formats.

Fig. 2 also shows the initial surgery applied to the CAD model. The component is symmetric, and the only area of interest from a structural analysis point of view is the fitting at the end. I have cropped the structure close to the end fitting. The stress state at the cut face is predictable, so this is a convenient approach to take. It avoids wasting resources on meshing and analyzing a large unwanted region of the component.

Fig. 3 shows the geometry after I carried out further manipulation. This provides surfaces on which to apply a bearing load. I also sliced the model vertically and imprinted a horizontal line on the cut face. The motivation was to provide better mesh control and allow clean edges for post-processing and a center point for one of the constraints.

The geometry manipulation took two forms: creating curves and projecting them onto surfaces, and then slicing the original body in two along a vertical plane.

Creating curves and projecting onto surfaces to imprint is quite straightforward. However, there are several actions that are key to doing this efficiently. The first is a global control on what type of entities are picked using the cursor. The default is a screen pick, but right mouse-clicking on the graphics window allows this to be changed to select nodes (FEA entities), points (geometric entities) and other features. Setting the cursor pick to select points allows parametric manipulation within dialog boxes. For example, in Fig. 4 a vertical curve is created.

Point 108 is shown highlighted and is used as the reference point. The first end of the curve uses the XYZ coordinates of this point, but the Y coordinate is modified by +0.5. The second end of the curve uses the same point's XYZ coordinates, but this time the Y coordinate is modified by -0.5.

Within any of the dialog boxes is a Methods option. This can change the way in which the dialog box operates.

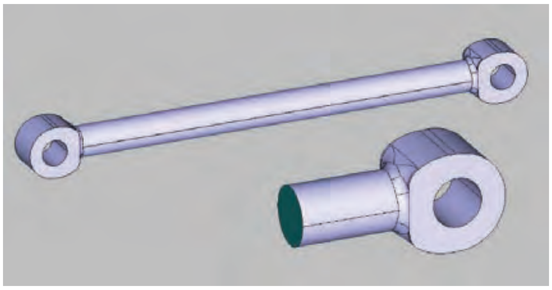


FIG. 2: Initial imported geometry and cut-out region.

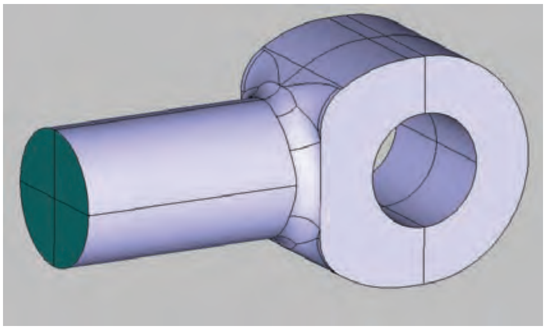


FIG. 3: Further manipulation of the geometry.

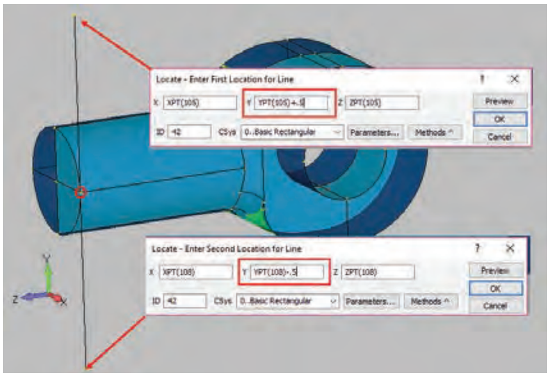


FIG. 4: Sequence of dialogue boxes to create a curve.

This provides a large variety of available techniques. In Fig. 4, the dialog boxes are asking for a location of each of the endpoints. For many dialog boxes, requesting a location will be the default Method. However, the Methods option can be changed to selecting the midpoint of the line, the center of an arc and many other shortcuts.

If another dialog box is used, such as deleting mesh, then the Methods options change and adapt to the task. In this case, useful Methods options include elements on specific surfaces, elements with a specific property ID and so on. This provides a workflow that is unique to FEMAP. Again, a newcomer to FEMAP will want to start exploring these options. Developing a personal set of tools from within this extensive toolbox is the goal.

At this stage, I carried out several trial meshes on the modified geometry. The transition region between the shaft and the end of the tie rod was very difficult geometry to work with. FEMAP has a powerful Geometry Preparation tool to address issues like this. This is essentially an automated geometry healing tool. Results of using the default settings are shown in Fig. 5.

The green colored surfaces, which I've highlighted, show a single surface created from the original surfaces. The thin slivers in the original surfaces were making them virtually impossible to mesh. The range of controls is shown in Fig. 6. Drop-down menus from this dialog box allow further advanced options.

FEMAP also has a dedicated Meshing toolbox that bundles together all the meshing controls and geometry manipulation controls found throughout the FEMAP menus. It also adds new functionality and provides an interactive view of geometry and mesh changes. It is evident from the functionality that the focus on geometry manipulation is to produce an improved mesh. An example of Meshing toolbox usage is seen in Fig. 7.

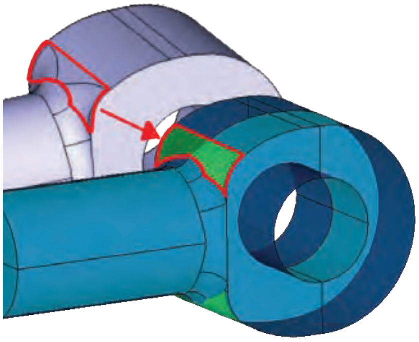


FIG.5: Geometry preparation, combining surfaces.

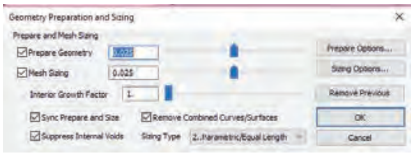


FIG.6: Geometry preparation controls.

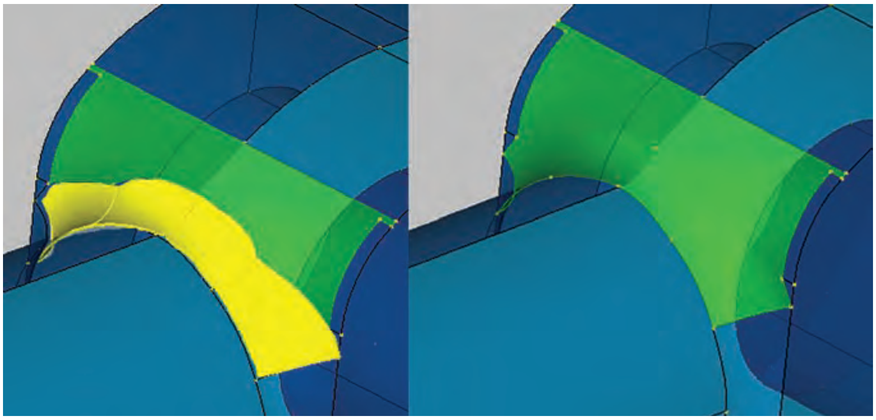


FIG.7: Interactive cleanup of geometry.

The left-hand side of the figure shows surfaces I've picked on the fly to combine together. I've also chosen the option to merge with existing surfaces. The right-hand side of the figure shows the result, with the surfaces now joined to the previous blended surfaces. Meshing is now much more controllable. FEMAP has a large buffer of undo levels, which can be increased if required. This means that exploring geometry changes and mesh changes gets easier. Users can undo mistakes.

Setting up Material and Physical Properties

Setting up material and physical properties to be used in the analysis is straightforward. Bear in mind that the traditional FEA data structure always links the material property to a physical property and the physical property is linked to each element. In the case of the beam or a shell element, this is intuitive. The physical property of a beam includes its cross-section and moments of inertia. The physical property of a shell will include its thickness.

The question becomes: What is the physical property of the solid element? Strictly speaking, it doesn't have one in the same sense as the beam or the shell. However, the same linking data structure is used. In fact, the physical property of the solid element can be used to describe integration level and material coordinate system. In FEMAP it can also be used to allocate a color to the element. The latter has no meaning when translated into an input analysis file (traditionally known as the input deck), but can be used in various ways to reference the element within FEMAP.

Fig. 8 shows how I have used the Model Info tree view to define the material and physical properties. The tree can be expanded and contracted easily using the plus/minus symbols. Right mouse-clicking on an entity type, such as materials, allows new material to be created, and an existing material to be edited, deleted and more.

For models with many materials, physical properties and other entities, it is a useful way to be able to quickly survey what is present in the FEMAP database.

FEMAP provides a set of default material libraries, and the user can select from metric or US options. One word of warning: FEMAP, like many traditional FEA tools, assumes that the user will define consistent units—there is no global units setting. It is straightforward to build your own user library from within FEMAP. Each instance of the material in a FEMAP database is copied from the library. The material library exists as a text file and can be positioned in any convenient folder on your computer. The directory path to that folder can be modified within the FEMAP preferences. Material libraries can be shared between users on the same network.

Setting up Constraints

Fig. 9 shows the constraint system that is used in the tie rod model. The shaft at the cut surface shown here is restrained axially, but should be free to contract under the Poisson's ratio effect. I have augmented the FEMAP screenshot with colored arrows to help identify the directionality of the constraints.

The constraint directions are color-coded with red as axial, yellow as vertical and blue as lateral. Three constraint sets exist: the first applies axial constraints to the four green surfaces, the second applies a single axial vertical and lateral constraint on the center point and a third applies a single vertical constraint on an edge point.

The three constraint sets are shown in Fig. 10. They actually exist as subsets within an overall constraint set. This hierarchy helps with advanced analysis setup. The dialog box shows the result of right mouse-clicking on the center constraint definition and then electing to edit the form of the constraint. Alternatively, I could have chosen to edit the location of the constraints. The dialog box shows X and Y directions constrained in the basic coordinate system. If I had needed a local coordinate system, that could have been set up and chosen at this stage.

The constraints are applied to geometric entities. That is the preferred way of working within FEMAP because it allows independence from any subsequent meshing. However, FEMAP does permit direct allocation of constraints to nodal entities as an alternative. This can be useful in complex situations, but it does mean that a subsequent remeshing will destroy those constraints.

This parallel approach is common throughout FEMAP workflows. For example, it is possible to create a mesh without using any geometry at all. In difficult models it is sometimes convenient to develop a hybrid approach. A typical scenario would involve 95% of elements being meshed on geometry, and a really stubborn 5% being directly meshed.

This approach will be unfamiliar to those accustomed to a CAD-embedded FEA environment, but it reveals the legacy of tools such as FEMAP that existed before viable geometry was available.

Setting up Loading

Loading is straightforward for the tie rod. There is just one axial bearing load applied at the connection end. The geometry was prepared for this, as described previously. The loading is created by right mouse-clicking on the tree view and creating an overall load set. From within this a subset is created. Fig. 11 shows the subset being created.

The option to use a bearing force has been selected, along with the magnitude of the loading and the angle over which the loading is going to be spread. In addition, it is confirmed that this load is a total value, rather than per surface. Load is defined as being normal to the surface. In addition to this dialog box, there is a further dialog box used to define the center point loading and the

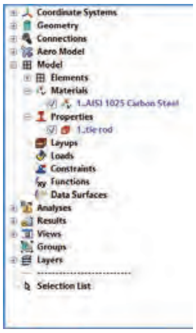


FIG. 8: Model Info tree view, showing Materials and Properties expanded.

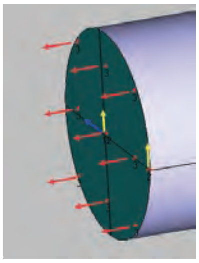


FIG. 9: The constraint system used in the tie rod model.

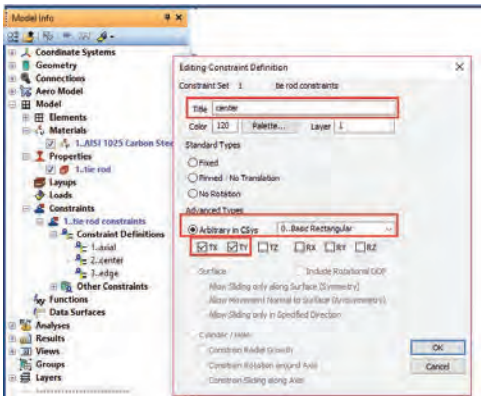


FIG. 10: The constraint sets and a typical dialog box.

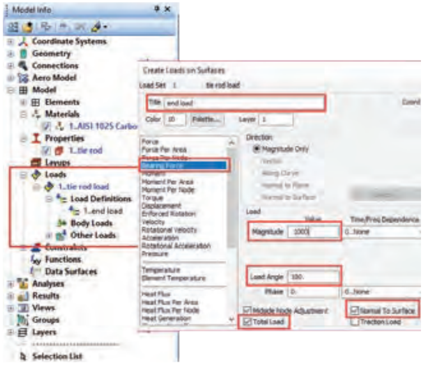


FIG.11: The model Info tree view and the loading dialog box.

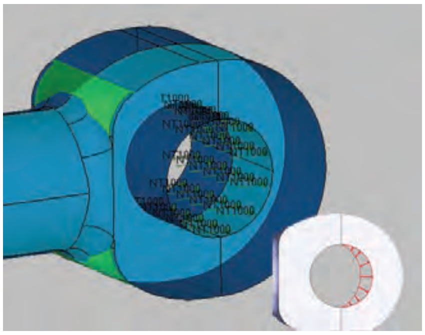


FIG.12: Loading distribution created with inset schematic.

direction of the loading.

Fig. 12 shows the leading distribution applied over the selected surfaces. I have emphasized the cosine distribution in the inset schematic.

Coming up Next

In the next article, we will complete the analysis by meshing the geometry, running, and post-processing the results. DE

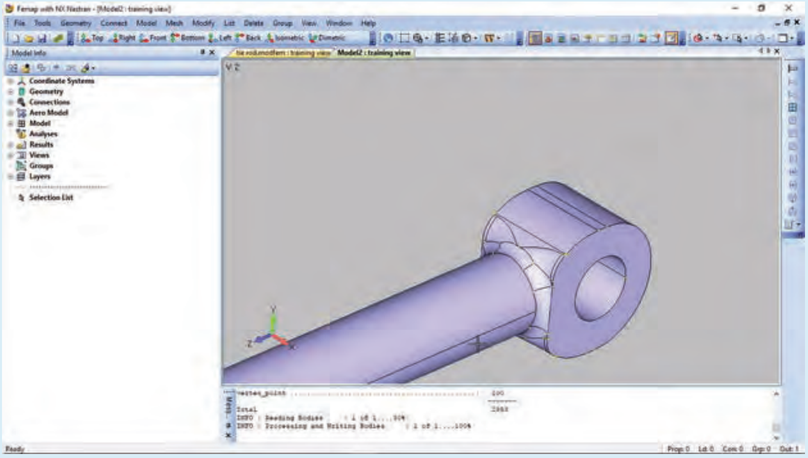
Tony Abbey *partners with NAFEMS, and is responsible for developing and implementing training classes, including a wide range of e-Learning classes. Check out the range of courses available: nafems.org/e-learning.*

INFO → Siemens PLM Software: Siemens.com/PLM

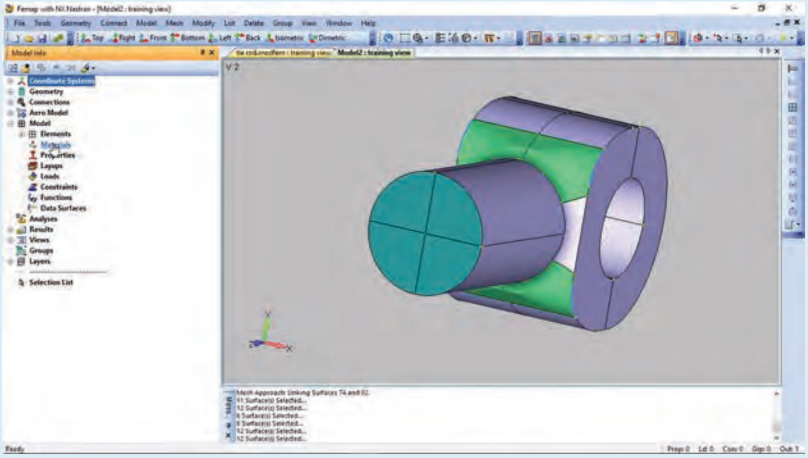
For more information on this topic, visit digitaleng.news.

Video Walkthroughs Available

Tony Abbey has created two videos to accompany part 1 of the Siemens Femap with NX NASTRAN review. The videos, along with a download of the tie rod model used as the example, are available at digitaleng.news/de/femapnx.



The first video provides an overview of the Siemens Femap with NX NASTRAN interface, importing the geometry and preparing it. Abbey shows how to slice along a plane to split the model, projecting curves on a surface, merging surfaces for meshing and more.



The second video for part 1 of the Siemens Femap with NX NASTRAN review focuses on creating materials, defining constraints and applying loading for the tie rod example.

The videos are intended to provide a visual overview of how common tasks are performed with the software.

— DE editors

VR-Ready from PNY: PNY PREVAIL PRO 4000

Check out the first mobile workstations from a familiar name.

BY DAVID COHN

PNY HAS LONG BEEN KNOWN as a manufacturer of flash memory cards, solid-state drives, memory modules and other PC accessories as well as a reseller of NVIDIA graphics cards. The company's product portfolio grew considerably this year, however, with the introduction of its first mobile workstations, the PREVAIL PRO P4000 and P3000. Initially announced in July at SIGGRAPH in Los Angeles, the systems became available in late November.

The company actually released three different models of its new 15.6-in. mobile workstation, all three of which are based on the same seventh-generation Intel i7 processor. The base P3000 ($2,499) comes with 16GB of memory, a 128GB solid-state primary drive, a 1TB 2.5-in. secondary storage drive and an NVIDIA Quadro P3000 powering a 2K display. The P3000 Upgrade Pro model ($3,499) includes 32GB of RAM, a 512GB SSD primary drive, a 2TB secondary drive and the same Quadro P3000 driving a 4K display. But for our review, PNY sent us its top-of-the-line PREVAIL PRO P4000 ($4,499), a VR-ready system equipped with 32GB of memory, a 512GB PCIe M.2 NVMe solid-state primary drive, a 2TB secondary drive and an NVIDIA Quadro P4000 GPU connected to a 4K display.

Thin and lightweight

Outwardly, all three PNY PREVAIL PRO mobile workstations look identical. The systems come housed in a charcoal gray chassis measuring 14.96x9.8x0.73-in. and weighing only 4.84 pounds. The 150-watt power supply (6.19x2.94x1.0-in.) adds another 1.37 pounds.

Although the CPU includes integrated Intel Graphics 630, all three PNY mobile workstations also incorporate an NVIDIA Quadro discrete graphics card, reduced to a single chip. The two P3000 models use the Quadro P3000 (with 6GB of GDDR5 memory and 1280 cores), but the PREVAIL PRO P4000 we received includes the NVIDIA Quadro P4000. This high-end GPU, based on NVIDIA's latest Pascal architecture, includes 8GB of GDDR5 discrete memory, 1792 CUDA parallel processing cores, a 256-bit interface and a bandwidth of 243 GB/second.

The Dell Precision 5520 packs a powerful 15.6-in. mobile workstation into a package the size of a 14-in. laptop.

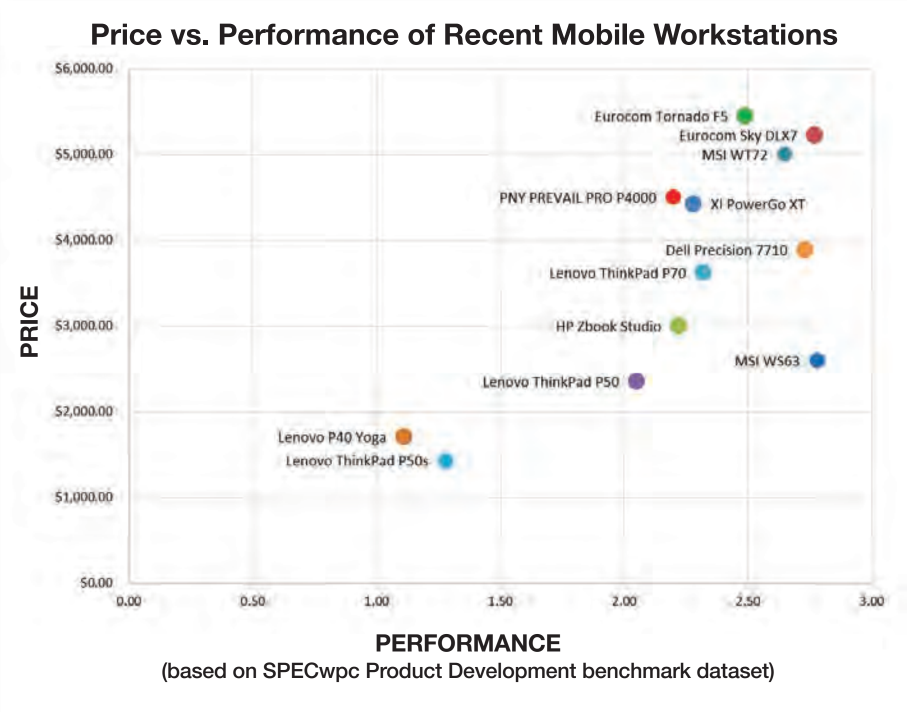
INFO ➜ PNY: PNY.com

PNY PREVAIL PRO

- **Price:** $4,499 as tested ($2,499 base price: P3000)
- **Size:** 14.96x9.8x0.73-in. (WxDxH) notebook
- **Weight:** 4.84 pounds plus 1.37-pound power supply
- **CPU:** 2.8GHz Intel Core i7-7700HQ quad-core w/6MB Smart Cache
- **Memory:** 32GB
- **Graphics:** NVIDIA Quadro P4000 w/8GB GDDR5 memory
- **LCD:** 15.6-in. UHD 3840x2160 wide view anti-glare backlit IGZO
- **Hard Disk:** 512GB M.2 NVMe PCIe and 2TB 5400rpm SATA drive
- **Floppy:** none
- **Optical:** none
- **Audio:** built-in speakers, built-in microphone
- **Network:** 10/100/1000 Base-T Ethernet; Intel Dual-Band Wireless-AC 8265 WiFi plus Bluetooth 4.2
- **Modem:** none
- **Other:** three USB 3.0, two USB Type-C, HDMI, two mini-DisplayPorts, six-in-one card reader, 2MP webcam, microphone jack, headphone/SPDIF jack, fingerprint-reader
- **Keyboard:** integrated 102-key full-size backlit keyboard with numeric keypad
- **Pointing device:** gesture-enabled multi-touch touchpad with two buttons

Mobile Workstations Compared	PNY PREVAIL PRO P4000 15.6-in. 2.8GHz Intel Core i7-7700HQ quad-core CPU, NVIDIA Quadro P4000, 32GB RAM, 512GB NVMe PCIe SSD and 2TB 5400rpm SATA HD	Dell Precision 5520 15.6-in. 3.0GHz Intel Xeon E3-1505M quad-core CPU, NVIDIA Quadro M1200M, 32GB RAM and 512GB NVMe PCIe SSD	MSI WT73VR 17.3-in. 2.9GHz Intel Core i7-7820HK quad-core CPU, NVIDIA Quadro P5000, 64GB RAM, 512GB PCIe SSD and 1TB 7200rpm SATA HD	MSI WS63 15.6-in. 2.8GHz Intel Core i7-7700HQ quad-core CPU, NVIDIA Quadro P3000M, 32GB RAM, 512GB PCIe SSD and 2TB 5200rpm SATA HD	Eurocom Tornado F5 15.6-in. 3.6GHz Intel Xeon E3-1270 quad-core CPU, NVIDIA Quadro M4000M, 32GB RAM, 2TB PCIe SSD	Lenovo ThinkPad P50s 15.6-in. 2.6GHz Intel Core i7-6600U dial-core CPU, NVIDIA Quadro M500M, 16GB RAM, 512GB PCIe SSD
Price as tested	$4,499	$2,759	$4,699	$2,599	$5.450	$1,427
Date tested	11/28/17	11/27/17	6/28/17	4/3/17	2/13/17	10/10/16
Operating System		Windows 10	Windows 10	Windows 10	Windows 10	Windows 10
SPECviewperf 12 (higher is better)						
catia-04	64.05	44.56	157.84	96.83	85.32	21.75
creo-01	61.16	45.88	129.89	87.28	80.21	25.34
energy-01	10.87	3.66	12.56	11.59	6.36	0.52
maya-04	32.83	34.47	100.99	66.22	60.58	13.27
medical-01	33.65	16.48	59.31	39.09	27.39	9.68
showcase-01	67.61	23.29	67.53	54.80	48.46	6.97
snx-02	47.11	34.93	185.13	71.52	78.14	31.85
sw-03	70.29	72.15	160.26	103.08	100.19	37.24
SPECapc SOLIDWORKS 2015 (higher is better)						
Graphics Composite	2.41	3.44	4.95	4.38	7.60	2.67
Shaded Graphics Sub-Composite	1.24	2.25	3.06	2.71	4.14	1.96
Shaded w/Edges Graphics Sub-Composite	1.81	3.27	3.89	3.50	5.46	2.52
Shaded using RealView Sub-Composite	1.63	2.70	3.54	3.14	5.64	2.01
Shaded w/Edges using RealView Sub-Composite	2.28	4.51	4.27	3.81	9.20	3.43
Shaded using RealView and Shadows Sub-Composite	1.86	2.31	4.07	3.61	6.44	1.96
Shaded with Edges using RealView and Shadows Graphics Sub-Composite	2.40	3.69	4.51	4.03	9.56	3.14
Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	5.53	4.55	13.46	11.77	16.22	3.02
Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	6.46	6.69	13.17	11.53	23.22	4.53
Wireframe Graphics Sub-Composite	2.74	2.96	3.91	3.33	3.65	2.61
CPU Composite	2.30	2.22	4.28	3.97	4.23	1.89
SPECwpc v2.0 (higher is better)						
Media and Entertainment	2.20	2.51	3.12	2.80	2.96	1.04
Product Development	2.37	2.52	3.13	2.78	2.49	1.28
Life Sciences	2.96	2.86	3.60	3.27	3.05	1.25
Financial Services	2.86	2.88	2.90	2.81	3.10	0.49
Energy	2.65	2.58	2.94	2.74	2.60	0.96
General Operations	1.35	1.64	1.45	1.37	1.37	0.87
Time						
Autodesk Render Test (in seconds, lower is better)	74.60	87.10	67.00	52.90	78.30	172.50
Battery Life (in hours:minutes, higher is better)	4:00	9:24	2:55	4:20	3:20	11:44

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



All three PNY PREVAIL PRO models provide a pair of SODIMM (small outline dual-inline memory module) memory sockets. The base model P3000 includes 16GB of RAM, installed as a pair of 8GB 2400MHz DDR4 modules while both the upgraded P3000 and the P4000 include 32GB of RAM, installed using two 16GB 2400MHz DDR4 SODIMMs. Similarly, all three versions include both a solid-state M.2 primary drive and a larger mechanical secondary storage drive. Our evaluation unit came with a 512GB Samsung PCIe M.2 NVMe drive plus a 2TB Seagate 2.5-in. 5400rpm secondary drive.

Lots of Ports

Raising the thin lid reveals the 15.6-in. display and a backlit 102-key keyboard and separate numeric keypad. A 4.25x2.37-in. gesture-enabled multi-touch trackpad with two buttons and an integrated fingerprint reader is located below the keyboard and a rectangular power button with a white LED is located to the upper right. The keyboard has a good feel with adequate travel, but lacks indicators to show when the caps lock or number lock keys are engaged.

Although the base model P3000 comes with a 2K FHD display (1920x1080), the upgraded P3000 as well as the P4000 include an anti-glare 15.6-in. 4K UHD (3840x2160). A very good 2MP (1920x1080) webcam and microphone are centered in the bezel above the display. Speakers for the integrated Sound Blaster X-Fi MB5 sound system are located beneath a grille located above the keyboard. Volume was lacking even at the highest settings and sounded quite “tinny.” Sound via headphones or external speakers, however, was of high quality.

All three versions of the PNY PREVAIL PRO provide a multitude of ports. The left side of the case houses a security lock slot, power connector, an HDMI port, two mini-DisplayPorts, two USB Type-C ports and a pair of USB 3 ports, while the right side provides an RJ-45 network port, a six-in-one card reader, a third USB 3 port, a microphone jack and a headphone/SPDIF jack. A set of four LED indicators along the left-front edge show power/charging status, battery status, hard drive activity and whether Airplane mode is enabled. The HDMI and DisplayPorts enable you to expand your workspace with up to three additional 4K displays.

All three new PNY systems also include built-in 10/100/1000 BASE-T ethernet as well as Intel dual-band wireless AC 8265 plus Bluetooth. The embedded four-cell 55Whr Li-Polymer battery powered our PNY PREVAIL PRO 4000 for exactly 4 hours in our battery run-down test.

Decent Performance

For our evaluation of the PNY PREVAIL PRO P4000, we ran our standard battery of tests, beginning with the SPECviewperf test of graphics performance. With the high-end NVIDIA Quadro P4000 GPU, we expected great results. And for the most part, the P4000 delivered, even achieving the best score we’ve ever recorded for a mobile workstation on one of the datasets in this benchmark. But other results lagged the similar MSI WS63 we recently reviewed (*DE*, September 2017), which had nearly identical specs as the P4000 but included the less powerful Quadro P3000 GPU and cost nearly $2,000 less. The same proved to be true when running the SPECapc SolidWorks benchmark.

On the very demanding SPECwpc benchmark, the PNY workstation delivered results similar to the Dell Precision 5520. And on our own AutoCAD rendering test, the PNY PREVAIL PRO P4000 averaged 74.6 seconds, again placing it behind the recently reviewed MSI mobile workstations, but well ahead of the Dell 5520. Though the system remained cool throughout our tests, its sound level reached 50dB under heavy compute loads.

PNY preloads Windows 10 Professional 64-bit and the PREVAIL PRO workstations are all ISV certified for AutoCAD, Inventor, 3ds Max, Maya, SolidWorks, Solid Edge and major products from Adobe. The standard PNY warranty provides one year of coverage (and only nine months for the battery), but systems purchased from the only PNY authorized reseller currently selling these new mobile workstations include a three-year warranty.

Based on our evaluation of the P4000, the less expensive P3000 models may be a better choice for many designers and engineers. That said, the new PNY PREVAIL PRO P4000 definitely establishes itself as the lightest weight and lowest cost VR-ready 15.6-in. mobile workstation currently available—a distinction likely to be very attractive. **DE**

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Clusters Shine through the Cloud

Autonomous driving and smart cities data integration will increase demand for dedicated engineering computing clusters. *Image courtesy of NVIDIA.*

BY RANDALL S. NEWTON

SOME YEARS AGO, there was speculation that the high-performance computing (HPC) segment of the computer industry might not be able to ride the Moore's Law acceleration curve for much longer. But when raw CPU processing speed began to slow down, the industry responded with more targeted and nuanced solutions to improve performance.

Intel delivered Xeon Phi, a next-generation CPU for HPC with considerable improvements in parallelism, vectorization and power efficiency. GPU capabilities from NVIDIA and AMD increased beyond expectation. HPC cluster connection standards such as Gigabit Ethernet and InfiniBand kept pace with improved performance and lower costs. Creative solutions such as "carpet clusters" became more common for getting the most computational bang for the buck.

The net result is that computer clusters for HPC continue to be a viable solution for engineering teams, along with workstations, virtualization, cloud computing and on-site data centers. Whereas a year or two ago there was talk that cloud computing might completely replace HPC clusters, today such clusters still play an important role.

Three Types of Engineering Computing Clusters

There are basically three types of HPC clusters in use today for engineering and manufacturing.

1. The first is the standard HPC cluster of several off-the-shelf workstations or servers, which continues to be an industry mainstay. They increase computer performance exponentially over the use of a single workstation, and they continue to pass on significant cost savings over SMP (symmetric multiprocessing) and MPP (massively parallel processing) systems, based on the use of lower cost hardware made for the wider professional market.

2. The second common engineering cluster today is assembled from linked GPU or Xeon Phi computers. These systems have become possible because of the combination of more powerful hardware options and better software for using GPU and Xeon Phi technology in clusters.

3. A third form of cluster becoming more popular in engineering is the dedicated visualization cluster, as more users realize there is long-term benefit in reusing visualization data, and market expectation for real-time simulation rises.

"I've never seen a visualization department in a manufacturing firm bigger than 20 users," says Chris Ruffo, the worldwide AEC and Manufacturing market manager for Lenovo. "They want small clusters within the company and they don't need the corporate data center."

HPC clusters are increasingly being viewed as a hub service, the central computing resource that centralizes the use of other computation sources such as commercial cloud or a separate in-house data center. The cluster is used for both collection and computation. (See also "The HPDA Buzz," *DE*, June 2017: digitaleng.news/de/the-hpda-buzz.) The in-house HPC cluster is also becoming the first platform for experimental work in such fields as machine learning and artificial intelligence. Engineering firms want to explore these new features but are discovering the cloud is a very expensive place for prototyping and learning how to use new computational technologies.

"The in-house cluster becomes a sandbox for exploration, without the expense of Amazon Web Services or Microsoft Azure," says Ruffo. Companies can then scale to the cloud or a larger in-house server installation as needed.

"It is all about managing costs," adds Scott Rupert, workstation portfolio manager at Lenovo. Carpet clusters—ad hoc HPC clusters created by linking department workstations—are for content creation, rendering simulation and machine learning. "A cluster in a back room may not be spun up all the time," Rupert notes, which means more expensive computing in the long run. Carpet clusters and workgroup HPC clusters can be assembled using less expensive hardware, and they can be more economically upgraded as technology improves. "The cloud is the safety net, not the primary resource," he adds.

Computer vendor Fujitsu continues to see a good market for cluster computing. Because it is an integrated software and hardware vendor, Fujitsu can add software layers into the cluster to fine-tune a cluster for each customer. Their HPC Gateway defines a model for each application a company desires to use, which can then be used on both individual workstations and clusters. HPC Gateway can also automatically attach to predefine on-demand computing resources.

"Customer requirements are increasingly driven by data intensity as much as compute," says Fujitsu's Bryan Hollar. "These days HPC may be viewed within a larger operational context." The size of the job changes much more often than the nature of the work to be done, making it easier for engineering groups to optimize clusters for a specific type of work, such as FEA.

Fujitsu says its internal market research shows that HPC-reliant economic sectors in the United States contribute around 55% of total gross domestic product. "We have seen the customer's appetite for performance and throughput never diminishes," adds Hollar. "They are always finding new processes or models that consume newfound power and then they push further with their modeling, looking for ever finer resolution, simulating more scenarios and identifying new domains of digitalization and virtual prototyping."

Like Lenovo, Fujitsu sees growth in the use of HPC for machine learning and related data intensive computing tasks not directly related to visualization. "Machine learning algorithms, accelerated with the latest generations of HPC technology, offer new potential for processing large data volumes more rapidly, be more adaptable to new forms of data and reveal previously hidden information," notes Hollar. Fujitsu predicts more engineering departments will explore the use of multiple small clusters, divided by task, whenever the cost/benefit gains of dedicated HPC hardware beat the use of larger but more distant options.

Fujitsu does not see much HPC/cluster market erosion due to cloud computing. "We can detect an increase in workload [on clusters] as more data-driven tasks and projects enter the engineering scope," Hollar says. Although some are investing in dedicated clusters, others are taking the hybrid approach to "build upon standard processes to explore new potentials" such as evaluating a multidisciplinary optimization problem.

A Bigger Computational Pie

Clusters remain a flexible and cost-effective way to deploy high-performance computing to small work groups, even as new solutions in corporate data centers and cloud computing come to market. Vendors are continuing to invest in cluster technology, even as they assemble new solutions designed specifically for software products like new ANSYS Discovery Live, which is designed for a single workstation equipped with NVIDIA GPUs.

Several vendors including Advanced Clustering Technologies still see a strong market in workgroup and small department engineering clusters. *Image courtesy of Advanced Clustering Technologies.*

Because GPU capability is increasing faster than CPUs, both hardware and engineering software vendors will continue to invest in HPC innovations that take advantage of the new massive parallelism coming to market. More software will offer multicore and multinode parallelism, as well as innovations in their use of neural network technology.

More than ever, it is data that will be the determinant of HPC deployment. The first generation of engineering clusters were driven by increased use of simulation applications. Now other departments are creating massive amounts of data, requiring specific solutions scattered throughout the manufacturing enterprise. New internet of things and digital twin applications will supply data in real time, driving new demand for predictive performance computing and requiring their own dedicated platforms. DE

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INFO → Advanced Clustering Technologies: AdvancedClustering.com

→ **Amazon Web Services:** AWS.Amazon.com

→ **AMD:** AMD.com

→ **ANSYS:** ANSYS.com

→ **Fujitsu:** Fujitsu.com

→ **Intel:** Intel.com

→ **Lenovo:** Lenovo.com

→ **Microsoft Azure:** Azure.Microsoft.com

→ **NVIDIA:** NVIDIA.com

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Post-Processing 3D Printed Prototypes

Post-processing a printed part is still a highly manual operation, but new technologies can help reduce both time and cost.

A finisher applies clear coat to a stereolithography part. *Image courtesy of Proto Labs.*

BY BRIAN ALBRIGHT

ANYONE WHO HAS USED additive manufacturing to create a part or a prototype knows that pulling the object off of the build plate is only the first step in post-processing. Depending on the material and technology, post-processing a 3D printed object can take as long—or longer—than the print process.

In fact, post-processing can contribute a significant amount of cost to each part through time and labor. In some cases, post-processing can double the time required to generate a finished part. For companies that are actually manufacturing larger batches of finished products, this can represent a significant expense.

But what about prototypes? These parts will typically require less post-processing depending on how they will be used, but secondary operations can extend lead times. Luckily, advancements in hardware, software and materials make it easier to produce quality prototypes with less post-processing.

The type of material and the print process used will ultimately determine just how much secondary work will have to be completed to get the prototype into finished form. Optimizing the design to reduce the need for post-processing and selecting a material and print process that best fit the part can reduce the cost of the prototype and increase turnaround time.

Getting to the Finished Part

Post-processing can be broken down into two general categories: Processes required to take the design from the CAD model to the physical component, and processes that affect the aesthetic or mechanical properties of the parts after they are printed.

For most 3D printing technologies, removing support structures is the most common post-processing step, usually accomplished through washing away water soluble supports or breaking them away. With stereolithography processes, this involves a wash or bath to remove excess resin and support structures, followed by sanding of down-facing surfaces and a grit-blast finish over the part. “That satisfies the majority of our customers,” says Andrew Rogers, machine maintenance supervisor and SL process engineer at Proto Labs.

Selective laser sintering, on the other hand, produces parts in a powder cake that has to cool before the parts are sifted out, the excess material is blown off and the parts go through a bead blast to even out the surface. Other 3D printing processes may require heat treatment, chemical baths, sanding or deburring.

According to Paul Heiden, senior vice president of product management at Ultimaker, the need for post-processing will depend on print technique, material and print settings. Fused filament printers require less post-processing than comparable stereolithography apparatus machines (that require resin removal), he says. By optimizing print profiles and materials,

This automotive dashboard vent is shown (left) as the initial piece directly from the Figure 4 production printer and (right) after plating directly onto the part. *Image courtesy of 3D Systems.*

Heiden says that many parts can be used immediately after printing, although dual-extrusion prints with support material do require post-processing. The company uses two types of support material: polyvinyl alcohol (which is water soluble and can be washed away), and a new Breakaway material.

For metal parts, Rogers says Proto Labs typically needs to grind off support structures, file or smooth down-facing surfaces and will then polish or peen the part to provide a consistent finish.

According to Allen Kreemer, senior manager, applications engineering for Stratasys, vibratory tumbling has emerged as an efficient means of finishing multiple parts at once, at least for Fused Deposition Modeling (FDM) printing. That process can take anywhere from 30 minutes to two hours, depending on the size of the parts and the geometry. "The technology allows you to build parts faster at a rougher layer setting," Kreemer says.

Another operation that can add time to the print process is sealing. Selective laser sintering and FDM printed parts usually require a sealant for testing. This is still largely a manual (and messy) process that Kreemer says hasn't seen a lot of automation. "There are a number of techniques for sealing pars, including dipping and coating, or brushing/spraying on various epoxies," he says. "There is definitely some room for improvement on that part of the process."

In addition to sanding or polishing, there are a number of other processes that may be applied to a prototype to improve its function or its overall appearance. "For post-processing that would [have an] impact on the mechanical or aesthetic properties, there are a lot of options," says Andy Richardson, senior director of sales and service at 3D Systems. "That can range from plating to anodization, silk screening, dying, etc. It's really dependent on the intent of the part."

Holes or internal channels are a functional feature that can require secondary operations after printing. Depending on the print process, the holes may not be accurately sized or may have a rough internal surface and need to be drilled out to meet customer specifications.

From there, prototypes may be painted, dyed or metal plated to achieve a finished look. The emergence of color and multimaterial printing has helped streamline these final steps, however. The Stratasys J750, for example, provides realistic color mapping, printing with up to six materials and realistic textures.

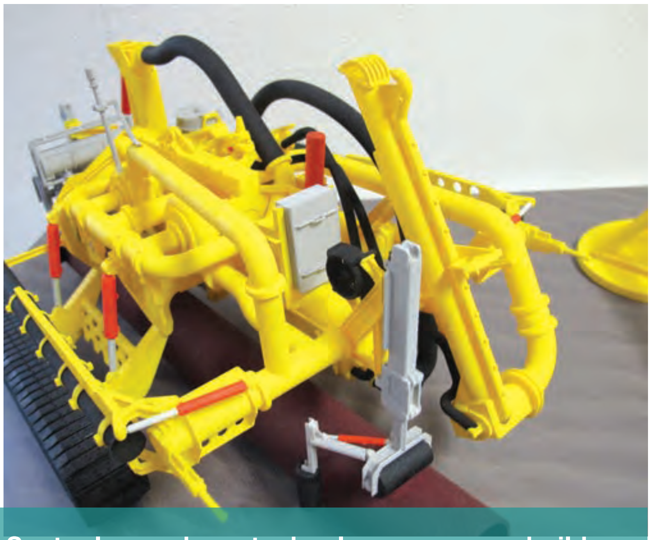
"That has really helped in the prototyping market," Kreemer says. "We've seen a huge market response for being able to closely match Pantone colors and specific things like wood grain or other patterns. We've even seen some customers use those parts for photo shoots. With a bit of sanding and clear coating, they look like the final product."

Multimaterial technologies can better represent the final part, and there has been an increasing demand for multimaterial printing according to Rogers at Proto Labs. "That's one of the reasons we launched our PolyJet service," he says. "We can do multiple hardness types, elastomerics and we offer overmold prototyping through the PolyJet service."

Customer Education is Key

To achieve a quality finished part, communication between the company that orders the prototype and the one printing it is critical. "You have to communicate to the customer service team what you are looking for," Rogers says. "If you need accuracy for holes, or smoothness inside of a hole, that has to be communicated."

Investigate the limitations of the printing process in advance.



Seatools, a subsea technology company, builds key scale models of its machinery designs using 3D Systems SLS 3D printing with the Duraform PA nylon materials. On completion of the prints, the models are sanded and painted for the company's trade shows and marketing. *Image courtesy of 3D Systems.*

Shown here is the Ultimaker Breakaway material, which makes it easier to remove support structures from a finished product with no additional sanding required. *Image courtesy of Ultimaker.*

That can save time because certain type of builds will lend themselves to specific 3D printing technologies.

"Over the past few years, new customers have been much more educated on additive manufacturing," Rogers says. "Ten years ago, no one knew any of the limitations. It has gotten easier as time goes by, but education has to happen. You need to ask questions and know what the parts are going to be used for."

Companies are also more likely to design for 3D printing. "You can create geometries that couldn't be made using other processes, and they are designed in a way that is complementary to the process being used," Richardson says. "People are getting more comfortable with the technology and learning how to use the software and other technology to enhance those designs."

However, there may still be tolerance requirements or finish requirements that cannot be accomplished within the print. "With direct metal, for example, we build parts and use CNC machining to post-machine them to get tolerances or features we need," Richardson says. That's why companies should also be prepared for additional cost, in both time and labor, that may be required for finishing each prototype. "The amount of time it takes to get to the finished print can be high and requires a lot of preparation," Richardson says.

Metal parts may require specialized secondary operations or post-processing that not every service provider offers. Chemical passivation or certified heat treatment, for example, may need to be handled in-house or farmed out to another contractor.

Kreemer at Stratasys says that establishing enough space to accommodate post-processing can also be a challenge for the companies creating these prototypes as print volumes increase. "Companies also struggle to find qualified staff," he adds. "Depending on what part of the country you are in, there is not a wealth of qualified model makers, and that's what you need for high-quality prototypes. Even when they have budget approval, these companies might not have the space or staff available."

New Tech, Practices Can Reduce Post-Processing

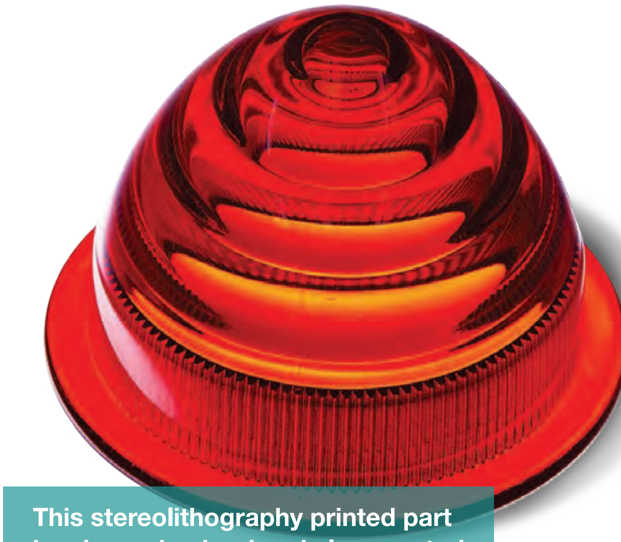
Many approaches can help minimize the need for post-processing, during the design phase, as the prototype is printed and—thanks to some new types of automation—afterward.

Design optimization for additive plays an important role. Designers can reduce the need for post-processing by taking into account the limitations of 3D printing when they create the parts or prepare for printing. One common example is tapering or eliminating overhangs to reduce the need for support structures.

The orientation of the part on the build plate can also be changed to reduce the need for supports. "If you orient round features in the draw plane, the hole will be the most round, smoothest—and require less secondary operations than something built on its side," Rogers says.

Holes can also be designed as squares and drilled out later, which will reduce the need for supports and additional material. This can also speed up the printing process.

"If you can design a part such that it can be built vertically



This stereolithography printed part has been dyed red and clear coated. ***Image courtesy of Proto Labs.***

and smoothly, you will need less post-processing," Roger says.

Also, prototypes don't necessarily need to be as "finished" as a final product. Can you live with a textured surface for the prototype to reduce the need for additional post-processing?

Additional automation being introduced in the post-printing phase will also help. Printer manufacturers and service providers are investigating new ways to integrate machining and other operations with the printing process, as well as developing ways to perform secondary operations on multiple parts at the same time.

"It's the most time-intensive part of the process, so we are seeing development of tools that do that more efficiently," says Richardson at 3D Systems. "For instance, we are creating equipment that allows us to send a platform of parts through a bath at the same time. There are also grinders and sanders that allow us to finish parts more quickly."

UK-based Additive Manufacturing Technologies (AMT) recently unveiled its PostPro3D system that can automatically finish multiple sintered nylon parts. Formlabs' new Form Wash and Form Cure were created to automate washing and post-curing for parts produced on the company's Form 2 printers.

The Stratasys Robotic Composite 3D Demonstrator presents another way to reduce post-processing requirements using an eight-axis motion system that does not require support material. "It orients the layer lines in such a way that it is not an issue on the part," Kreemer says. "[That system] separates the part features into different build zones that can build normal to the tip direction. You aren't slicing the entire part geometry into 2D layers. It gives you a nicer, smoother finish."

At Ultimaker, Heiden says the company has optimized print profiles for all of its materials in its Ultimaker Cura software. "That will make it much easier for users to print on an Ultimaker 3D printer with all the different materials and ensures that the print quality is good. Software and the right print settings can really help reduce the need for post-processing. So, it is not only about the hardware, but software, and the right print settings can really help reduce the need for post-processing."

The company also released its Breakaway support material for dual-extrusion printers that adheres to acrylonitrile butadiene styrene, nylon and other materials, and can simply be snapped off of the part and doesn't require sanding. Massachusetts start-up Rize Inc. has developed what it calls the augmented polymer deposition system, which uses a repelling ink with a medical-grade thermoplastic to create supports that can be easily snapped off.

The most important thing, though, is for designers to understand the technology they are designing for, and that 3D printer operators and finishers have a continuing education program in place to ensure that they stay up to speed on best practices. **DE**

Brian Albright *is a freelance journalist based in Ohio. He is the former managing editor of Frontline Solutions magazine, and has been writing about technology topics since the mid-1990s. Send email about this article to de-editors@digitaleng.news.*

INFO → **3D Systems:** 3DSystems.com

→ **Additive Manufacturing Technologies:** 3DHubs.com

→ **Formlabs:** Formlabs.com

→ **Proto Labs:** ProtoLabs.com

→ **Rize:** Rize3D.com

→ **Stratasys:** Stratasys.com

→ **Ultimaker:** Ultimaker.com

PLM Gets a Collaboration Makeover

Vendors are revamping platforms with new technologies aimed at democratizing engagement and facilitating collaborative workflows.

BY BETH STACKPOLE

For more than two decades, PLM proponents pushed the platform as the single repository for product design—the hub for an extended design team to share materials and engage in collaboration. Yet the reality was often notably different: Traditional PLM was far too unwieldy for many organizations and its functionality catered to the engineering department's specific needs, not necessarily to the broader enterprise or even to an extended chain of partners.

Enter the new age of PLM, where technologies like the cloud, improved visualization, lightweight sharing capabilities and role-based experiences are being leveraged to open up the platform to a far broader audience. In particular, many new PLM offerings, along with remodeled versions of the original behemoth PLM platforms, are introducing functionality aimed specifically at facilitating extended design chain collaboration—a necessity given the complexity of today's multidisciplinary products.

Whether you're talking about the latest vehicle design or a smart home device, the makeup of today's modern products demands different expertise and different workflows than in the past. Many in the extended ecosystem don't have access to enterprise PLM and even more don't have interest in learning how to use the complex systems. Moreover, downstream users in procurement or service, for example, need access to product-related data that often has never made its way into the core PLM backbone.

"There are a lot of partially developed PLM systems that are missing a lot of data," says James White, practice director, additive manufacturing at CIMdata. "A lot of what's required for product lifecycle management involves objects, documents, files and metadata that is outside of the engineering department. There's a recognition that much of the content is coming from other places."

Solid Edge Portal allows users to upload their designs and maintain fully associative parts lists for easy project accessibility and part visualization. *Image courtesy of Zumex Group and Majenta PLM.*

Traditional PLM players and newcomers are hard at work trying to change that dynamic by making it easier to tap into data silos and orchestrate collaboration workflows.

"The issue with traditional PLM over the last 10 to 15 years is that it's been focused on capturing and storing information related to product development—it's not been about sharing information," adds Francois Lamy, VP of solution management for PTC's IoT Solutions Group. "Most of the people accessing PLM are the people that put information into PLM. Because PLM has mostly been deployed on premise, behind the firewall, it's made it difficult to bring outside people in. It's possible, but it's not been easy."

New Technologies to the Rescue

At PTC, there is a multipronged strategy to make PLM more accessible to a wider audience. At a base level, the company now offers a subscription pricing model (see *DE* article here: digitaleng.news/virtual_desktop/?p=11640) to give customers more flexibility in planning PLM usage, Lamy says, and it's also seeing more of its PLM customers deploy the Windchill PLM platform in the cloud, which can optimize costs, facilitate deployment, and most importantly, make extended collaboration easier.

Beyond those steps, PTC has modified how it views PLM—instead of a single repository or one version of the truth (both old PLM catchphrases), it now views PLM as a system of engagement, which can tap into information from other systems. "As more of the organization gets involved in product development, the problem of collaboration becomes more important," Lamy explains. "That doesn't mean all the information has to be in one system. We are trying to make it easier for people to access information inside of different systems of record."

Those systems of record, ERP, CRM, MRP or even another PLM system, can be accessed through Navigate, a series of smartphone-style apps that make role- and task-specific PLM

Navigate leverages ThingWorx's connectivity and rapid development capabilities to tap into different systems of record. ***Image courtesy of PTC.***

data available to all participants in the product lifecycle. Leveraging ThingWorx connectivity and rapid application development capabilities, PTC Navigate provides a library of tasks, which can be configured to create workflows to support specific roles.

Given its stake in augmented reality (AR) via its acquisition of Vuforia (see *DE* article here: digitaleng.news/virtual_desktop/?p=11428), PTC is also exploring how to leverage AR in design reviews.

At Siemens PLM Software, another PLM giant, work has been underway to make PLM capabilities more accessible to smaller companies, particularly those that haven't had any PLM or product data management (PDM) systems, notes Dan Staples, Siemens' VP of mainstream engineering R&D. Although Teamcenter remains the Siemens PLM platform of choice for large enterprise customers, it's the smaller companies, many lacking full-time database administrators, that have been underserved by traditional PLM—exactly the constituency Siemens is targeting with Solid Edge ST9 version, according to Staples.

Solid Edge ST9 offers a cloud-based licensing option, built-in data management capabilities and the ability to leverage popular tools like Dropbox, OneDrive, Box and Google Drive as data storage options that offer cloud-enabled vaulting and anywhere access for sharing design data. Without a full-blown SQL database at its core, a requirement of most traditional PLM systems, smaller firms can get up and running quickly without requiring assistance from a database administrator, Staples says.

The compatibility with cloud storage and sharing tools, in particular, does a lot to facilitate collaboration. "An engineer in Huntsville, AL, can open a file for write access and it's immediately locked for a peer engineer in China for write access," he explains. "That means suddenly small businesses can get involved in collaborating on a geographically dispersed basis. Before with traditional PLM, it was expensive replication or a free for all. What we want to get to is managed collaboration."

Siemens PLM Software has also released the free Solid Edge Portal for cloud-based project collaboration. Users can upload CAD files to the cloud, organize them into projects, view and share 3D models securely and selectively with other engineers and partners, Staples says. The portal offers extensive 3D viewing capabilities like 3D pan, zoom and rotate, and 3D cross-sections.

Aras, a one-time fringe PLM player, has made its way into some of the largest OEM customers in the aerospace and automotive sectors because its open PLM platform is more flexible for engaging constituents beyond engineering in active collaboration, according to Doug MacDonald, product marketing director for the firm. Aras Innovator's model-based service-oriented architecture (SOA), which includes an open data model, open interfaces and open web standards, enables rapid implementation and easy configuration of specific workflows not to mention the ability to scale to accommodate large numbers of PLM users without degrading performance, MacDonald says.

Because of this flexibility, customers are overlaying Aras Innovator onto their existing PLM deployments, typically focused on CAD data management and related processes, to handle specific workflows, MacDonald says.

"We've optimized our architecture to make it flexible and easy to use rather than building in specific ways of doing things," he says. "So instead of us telling customers how to manage the lifecycle, the customer can define how to do those processes."

UpChainXLM, a startup in this space, is positioning its cloud-based platform specifically as a PLM alternative that allows engineers, designers, salespeople and procurement specialists to collaborate more effectively. The firm, initially a consultant in the automotive supply chain, developed its core technology to address the challenges suppliers faced trying to manage product development cycles involving large customers across multiple locations. Many of its customers were dealing with a lack of unified global systems, which made sharing engineering CAD files difficult and created obstacles as part naming conventions varied across the myriad systems and locations.

The UpChain XLM solution is based on a proprietary "decoder ring" that enables CAD files to be uploaded, stored and shared easily across users and projects, regardless of the file format, says John Laslavic, CEO and founder. UpChain also spent a lot of development energy on creating a user experience that allows users to be versed in the system within hours, he says.

With industry estimates that only a fraction of companies have deployed PLM, UpChain and other PLM providers see an opportunity to expand their ranks by focusing on collaboration. "Seventy percent of CAD users in the world need something for collaboration and don't have anything other than shared drives, Excel spreadsheets or functionality from their ERP systems to make it work," Laslavic says. "We think of it as the democratization of engineering and PLM—allowing people, no matter who they are or where they are working, to collaborate." **DE**

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INFO ➜ Aras: Aras.com

➜ **CIMdata:** CIMdata.com

➜ **PTC:** PTC.com

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

➜ **UpChainXLM:** UpChainxlm.com

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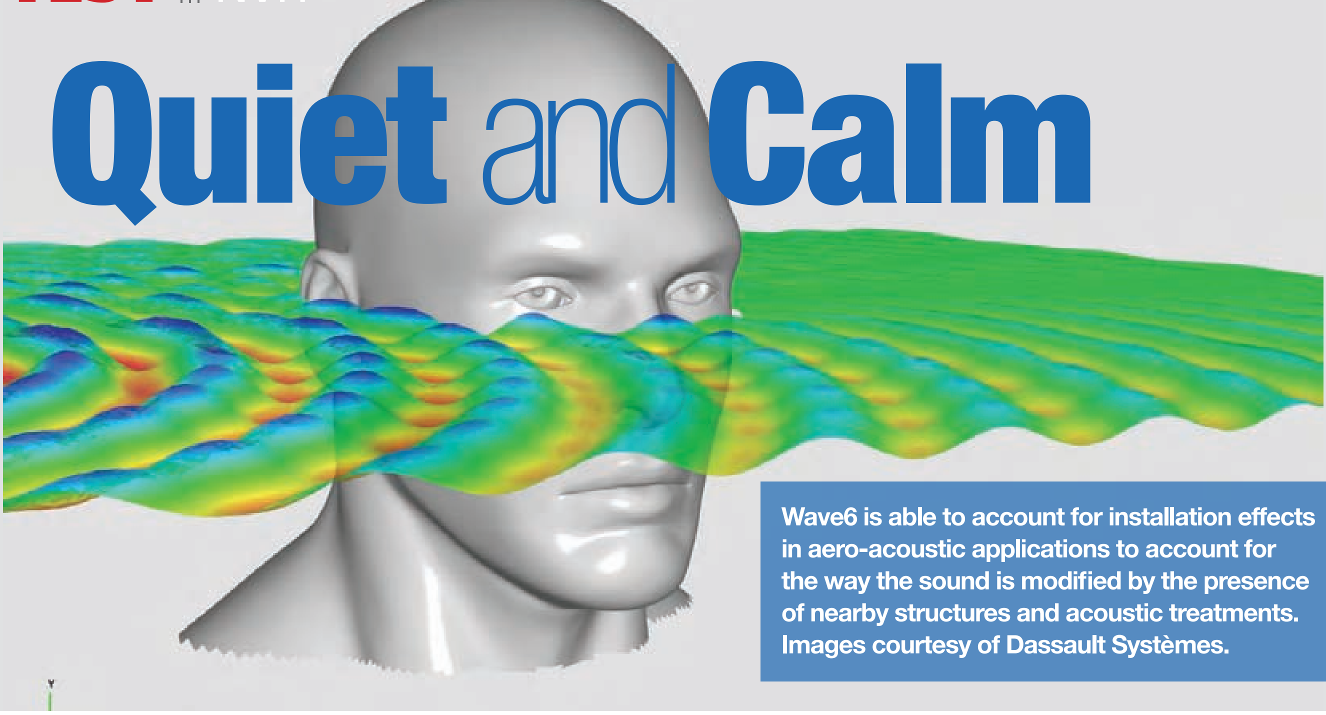
Quiet and Calm



Wave6 is able to account for installation effects in aero-acoustic applications to account for the way the sound is modified by the presence of nearby structures and acoustic treatments. Images courtesy of Dassault Systèmes.

Software helps engineers develop an ear for noise, vibration and harshness.

BY JIM ROMEO

When the Briggs & Stratton Q6500 QuietPower Series Inverter Generator was introduced at the Green Industry & Equipment Expo in November, dealers were impressed with the generator's sound—mostly because they couldn't hear it running.

The generator is more than 60% quieter, 30% lighter and 45% more compact than standard portable generators. Briggs & Stratton, like many product designers, has a rigorous process for testing noise, vibration and harshness (NVH), an area that is becoming increasingly important in product design for many industries.

Noise Abatement

Understanding noise and vibration performance is a key starting point in designing for improvement. Loudness may be a disruptive feature in many products, but the type of sound that is made can really irk users—sometimes quite negatively.

"Noise and vibration analysis is becoming increasingly important for our clients," says Phil Shorter, senior director, Dassault Systèmes SIMULIA R&D. "The need to understand noise and vibration performance can arise for many reasons. The way that noise and vibration affect perceived product quality—and the related field of 'sound quality,' [or] relationship between how humans perceive certain sounds and certain objective measures of those sounds—is certainly one of the reasons that our clients have an interest in noise and vibration. For example, our clients are sometimes concerned with issues such as the sound that a golf club driver makes when it hits a ball, the sound of an elevator door closing and the annoyance caused by squeaks and rattles in complex assemblies with many fasteners and whether this will affect industry standard Initial Quality Study (IQS) surveys for their products. However, perceived product quality, and the separate field of sound quality, are not the only reasons that our clients are interested in noise and vibration performance."

Shorter says that one of the big challenges when designing a product is that you often have a limited amount of time to make design decisions because of schedule and cost constraints.

"The earlier in the design cycle that you can make design decisions, the more likely it is that these design changes will have an influence on the final product," he says. "If you find a noise and vibration problem late in the design cycle you're often constrained in how you can respond and you can often end up with expensive band-aid fixes that may not be optimal in terms of things like cost and weight."

Design engineers are increasingly asked to answer questions about the expected noise and vibration performance of their products earlier and earlier in the product life cycle, Shorter says, often at the conceptual design stage. Those demands call for an increased use of noise and vibration simulation in the design of products, rather than at the prototype or testing stages.

Testing with Real-Life Insights

NVH testing can be challenging for design teams of today. "Modern engineering challenges impact testing teams," says Steve Dom, automotive solutions manager and simulation and test business segment manager for Siemens PLM Software. “The essence of testing today is to support the engineering process with real-life insights.” He identifies various needs that NVH testing teams need to address.

First, Dom sees a need for increased productivity: Testing teams today need to test more with less resources, while having fewer prototypes available. One test should deliver all of the necessary information on the first shot.

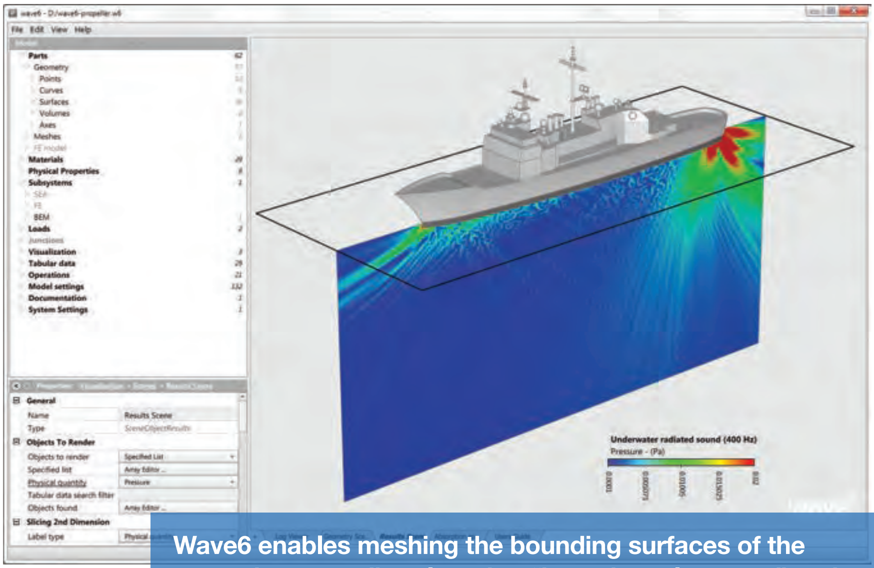
He also sees a need for more innovation: To remain competitive in the marketplace, manufacturers need to innovate. Tests remain an essential step of innovation and are mandatory to validate innovative designs—for example, to validate the acoustic properties of new materials.

Dom says NVH designs must deal with mission-critical safety and increased regulatory pressure. “In some industries, failures have dramatic consequences,” he says. “Test remains the only method to certify that the product will not fail and will behave according to specifications.

“Governments increase regulatory pressure and require test results as proof of compliance to the regulations. For example, in many industries, it is critical to quantify the sound power emitted by a machine so as to be able to limit the noise level. Sound power testing helps develop superior products that respond to the industry demands and the ISO certification while improving competitive advantage and supporting branding strategy.”

He continues, “In the transportation industry, pass-by noise testing measures vehicle noise emission levels on an exterior test track. Certification departments of vehicle manufacturers use the results of pass-by noise tests to confirm that vehicles comply with specific noise emission standards. This certification is required for all types of road vehicles—from trucks and buses to passenger cars and recreational vehicles.”

Brett Birschbach is the senior engineering manager of NVH for Briggs & Stratton in Wauwatosa, WI. The company uses state-of-the-art data acquisition and analysis software to efficiently test products and develop more effective noise reduction solutions.



Wave6 enables meshing the bounding surfaces of the acoustic space directly, using “boundary elements,” and coupling acoustic boundary elements subsystems to finite element structure and finite element acoustic subsystems.

“One area [where] we have spent a significant amount of time is utilizing sophisticated engine simulation and CFD (computational fluid dynamics) software to improve our muffler design,” he explains. “These tools provide greater insight during the muffler design process by proving the optimal trade-off between noise reduction and performance of the engine.”

User-Friendly NVH

Designing for noise, vibration and harshness suppression means putting the end user at the center of the product experience. What will they experience and how will they react? What can be done to accommodate their experience?

Designers need to incorporate these questions into their testing as well as materials selection and design.

To date, sound quality has generally been approached in one of two very different ways, according to David Bowen, director of the Noise and Vibration Group of Acentech in Boston.

“One way is to rely entirely on pre-existing computational metrics such as loudness, sharpness, roughness, etc.,” he explains. “The other way is to incorporate the use of jury or listener panels as the ‘instrument’ to provide quantitative feedback on a range of possible product or device sounds to help guide design modifications.”

He says that the former is much simpler but has a distinct disadvantage in that it leaves out product context, which can often be very important in how users judge, what he calls “acceptability” of product sounds—when users are actually using these products.

Sound is a distinguishing feature that can be used to separate brands, and as such, manufacturers want to “design” preferable sound profiles for their products.

Product manufacturers and their designers must be well aware of the user’s experience and incorporate a rigorous testing program where NVH greatly influences product quality and the overall ownership experience.

“We believe that low noise and vibration are key drivers for product improvement that will differentiate our brand and provide a competitive advantage,” says Birschbach. “Driving to the lowest possible noise and vibration characteristics will improve the perception of both the product and brand quality resulting in a positive ownership experience.” **DE**

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INFO → Acentech: Acentech.com

→ **Briggs & Stratton:** BriggsandStratton.com

→ **Dassault Systèmes:** 3DS.com

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

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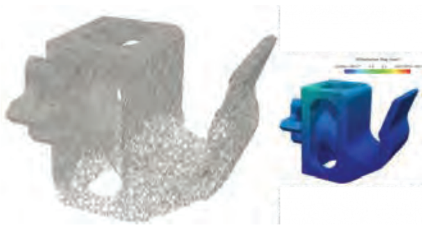
EDITOR'S PICKS

*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.*



Carbon 3D Print Software Updated

Cloud-based FEA simulates 3D print forces.

Carbon released a new version of 3D print software for its printer line. The software is an import, slice and monitor tool. It's really an intelligent enabler.

The software, called Carbon, lets you work with the company's continuous liquid interface production (CLIP) programmable liquid resins. It gives you control of the chemical reactions in the printing process. It runs in a browser. As long as the 3D printers and your workstation or iPad are connected to the same network, you can use it.

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SimulationX Version 3.9 Unveiled

Multiphysics system simulation platform sees new libraries and more.

ESI Group released version 3.9 of its SimulationX multiphysics platform for system simulation. Based on the Modelica standard, this customizable and extensible system offers a slew of model libraries from various physical domains and all sorts of analysis options.

It's engineered to slip right into your workflow with numerous interfaces for your preferred CAD and CAE tools. It deploys a graphical modeling interface to help beginners become productive quickly.

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Develop AR Apps for Glass and IIoT Devices

Software enables platform-independent industrial augmented reality development.

The Augumenta SmartPanel and Augumenta Studio are intended for developing and deploying AR applications in Industry 4.0 environments and to industrial internet of things (IIoT) devices.

Widespread availability means downloadables from a couple smart glass developers' app stores and it means cloud-based. You now have the capability to develop applications to replace or augment hardware-based control panels with AR-enabled 3D control panels.

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Desktop 3D Printer Built for Premium Performance

New production systems and updated software for network sites also debut.

EnvisionTEC says its entry-level Aria 3D printer is built to be a reliable, premium performer. A desktop-sized unit for a range of applications, the Aria 3D printer lets users set Z layer resolution at 25, 35 or 50 microns, depending on material.

This system, weighing just 35 pounds, is fast and capable of making accurate parts with real nice surface finishes. It has a touch-screen interface and supplied software for 3D print operations and STL file repair.

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Workstation Power To Go

NVIDIA Quadro graphics and Intel Core i7 power ultra-thin, light mobile systems.

PNY Technologies has a new series of ultra-thin, light engineering-class workstations called the PREVAILPRO. Ultra-thin means a 0.73-in. thick low-profile design. Light means 4.8 lbs.

The series offers two models—the PREVAILPRO P3000 and the PREVAILPRO P4000 Upgraded Pro. They run the four-core/eight-thread 7th generation Intel Core i7-7700HQ chip. Each has a 15.6-in. display. All come with multi-GB solid-state drive and multi-TB hard-disk storage.

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BOXX Unveils New Flagship Workstation

APEXX S3 debuts with updated chassis and 8th-generation Intel Core i7 processor.

The new flagship BOXX workstation is made for CAD, modeling and creative content professionals. At the heart of the APEXX S3 is an 8th-generation Intel Core i7 8700K processor.

It provides 12MB of cache, 12 threads, a 3.7GHz base speed and a 4.7GHz maximum turbo frequency. What they've done here is overclocked the Core i7 8700K CPU to 4.8GHz. It handles two dual-slot plus one more graphics cards and boasts up to 64GB of 2666MHz DDR4 memory.

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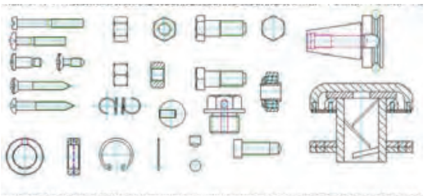
ZWCAD Mechanical 2018 Unveiled



Mechanical design system provides specialized tools for manufacturing.

Check out the latest release of a widely deployed 2D drafting solution.

ZWCAD is a professional-level DWG-compatible mechanical drawing system. It provides tools for just about every facet of the mechanical engineering and design process. In part, that means expected features like tolerance dimensioning, surface texture symbols, layer management and layer mapping. It comes with a library of standard parts and supports international drafting standards.

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Multiple New 3D Print Systems Unveiled

Also, new engineering-grade materials for MultiJet Printer platform are launched.

3D Systems has debuted multiple additive manufacturing systems, new build materials and software upgrades.

Among these are new 3D printing systems ranging from desktop size to full-scale, industrial production systems. First up is the FabPro 1000. It marks 3D Systems' entry into the desktop industrial 3D printing market. A unit for designers, engineers, artisans and the like, this unit handles various materials, including engineering plastics and castable resins.

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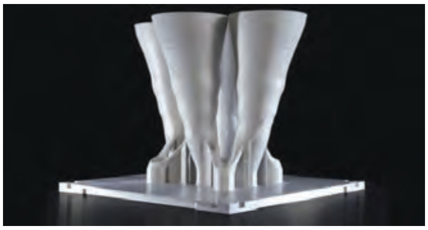


Next-Gen Engineers

Student Design Competition Profile: The Shell Eco-marathon

Building the Most Energy-Efficient Vehicle

BY JIM ROMEO

SHELL ECO-MARATHON Americas is a global competition that challenges students to push the boundaries of energy efficiency on the road by designing, building and testing the most energy-efficient vehicles possible.

Like many great ideas, the concept that later became Shell Eco-marathon started as a bet in 1939 between a couple of scientists at a Shell research facility in Illinois to see who could travel farthest on a gallon of gasoline. The winner achieved about 50 miles per gallon.

In 1985, the first formal Shell Eco-marathon student competition was held in Europe and since then it has expanded to the Americas and Asia, with more than 5,000 global student participants.

Pam Rosen is the general manager for Shell Eco-marathon Americas. We spoke to her to learn more about the program and the competition.

Digital Engineering: Can you provide an overview of the Shell Eco-marathon?

Pam Rosen: The event came to the Americas in 2007 with less than 20 teams registered to compete on the inside track of a Speedway in Fontana, CA.

2017 marked the 11th running of the competition in the Americas, which returned to "Motor City" in Detroit on April 27-30, as a featured element of a four-day festival of ideas and innovation—Make the Future. The festival celebrated bright energy ideas to inspire current and future energy solutions, offering free virtual reality experiences and hands-on science experiments for thousands of visitors from the Great Lakes region.

The intent of the competition is to inspire scientists and engineers of the future to turn their vision of sustainable mobility into reality. It also sparks a passionate debate about what could one day be possible for cars on the road.

There were approximately 114 participating student teams from the Americas, including Brazil, Canada, Colombia, Guatemala, Mexico, Peru, Puerto Rico and the United States—totaling more than 1,200 student participants. And a growing number of student participants were female. Among this year's student teams, 245 participants were women, including 16 team managers. This trend is encouraging.

DE: Can you tell us about some of the designs that are part of the event?

Rosen: The competition provides an arena for students to test vehicles that they design and build themselves. It aims to inspire young people to become scientists and engineers of the future by building prototype or urban concept vehicles that are powered by internal combustion engine fuels, electric battery or hydrogen.

The students have about a year to submit their designs and build their vehicles to global rules that set out requirements for size, weight, safety, propulsion and other technical specifications before competing in one of the annual global events.

We have seen students bring cars that utilize 3D printed components and lightweight carbon materials, as well as recycled components like parts of a windmill being used as a drivetrain.

DE: What drove Shell to sponsor the event and coordinate the event?

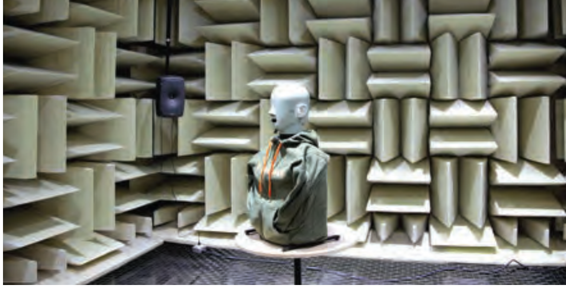
Rosen: At Shell, we believe that one of the biggest challenges facing the world is how to produce more energy for economic growth and human progress, while significantly reducing carbon dioxide emissions. We are committed to finding solutions to tackle this global challenge.

Make the Future, featuring Shell Eco-marathon, brings together brilliant minds, from different parts of society, that are developing new ways to help provide the world with the cleaner energy it needs. The festival provides a platform for the next generation of aspiring scientists and engineers to collaborate, and an opportunity for all ages to experience bright energy ideas in action. **DE**

Jim Romeo *is a B2B copywriter focused on business and technology topics. Contact him via JimRomeo.net or freelancewriting@yahoo.com.*

MORE → shell.com/energy-and-innovation/shell-ecomarathon/americas.html

More than 5,000 students compete in the Shell Eco-marathon event, worldwide.



FAST APPS

Engineering Case Studies

Moldex3D Helps Synventive Simulate Advanced Pin Movement

Sequential valve gating is a common practice that allows molders to manufacture large injection-molded parts with high-quality surface finishes. However, this creates defects such as pressure flow marks on unpainted parts, reflection marks on painted parts and hot spot marks opposite of direct gated nozzles. Synventive Molding Solutions manufactures hot runner systems for the plastics injection molding industry.

Its activeGate Technologies are a line of control systems that give molders using valve-gated hot runner systems control beyond the on/off ability of conventional valve gates. The molder can control the stroke, velocity and acceleration of the valve pins. Moldex3D is able to simulate this high-level control and allows molders to better predict and prevent common defects in injection-molded parts.

Project Objectives

The objectives of this project are to accurately identify the common molding defects in sequentially molded parts, to prepare a simulation that shows an area that has high potential of creating those defects, and to simulate the use of valve pin movement technology (controlled sequential valve gating system) called activeGate Technologies, as the solution to resolve the defects.

The whole model itself is a two-cavity mold that utilizes a two-valve gated hot runner system for each cavity. The second set of valve pins (Drop 2 and 4) is opened at full speed after the melt front from the first set of valve pins (Drop 1 and 3) passes Drop 2 and 4. When Drop 2 and 4 opened, the material inside, which has been compressed under high pressure, is released into the cavity.

At this point, a few things were detected. One, the melt front is pushed forward at a much faster rate than the first nozzle. This shows up as a large melt front advancement, which can be seen from large distances between iso-contour lines, and it can lead to pressure transition marks. Two, some material can flow backward and create dense areas, which can be seen from small distances between iso-contour lines. These two indicate large uncontrolled melt front advancements and melt front stagnation on the side of parts.

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Skullcandy Chooses Eckel to Build Anechoic Test Chamber

Project helps strengthen Skullcandy brand's R&D capabilities.

Headquartered in Park City, Utah, Skullcandy has grown into a global brand known for its lifestyle performance audio products. The modern company continues to grow, expanding its product lines and its R&D capabilities, while remaining true to its stated goal: "innovate to solve real problems and democratize amazing audio experiences with quality and style."

Skullcandy aims to achieve high audio standards with each step it takes in product development. That's why its leadership chose Eckel Noise Control Technologies (Eckel) of Cambridge, MA, to design and produce an anechoic chamber for product and component testing in the R&D area of its new headquarters. Skullcandy Director of Global Product Management Matt Windt said he went directly to Eckel because of the company's reputation for performance and value.

"From our first conversation, it was obvious that Matt was very knowledgeable about our anechoic chambers, which made my job that much easier," Eckel Vice President Jeff Morse says. "I met with Matt to discuss Skullcandy's needs and our capabilities. When I showed him the video of our world record-breaking Microsoft chamber, that seemed to seal the deal."

"It was great to have Jeff out to Park City to talk through our vision. He was able to quickly assess our needs and get the chamber specified within our performance and budget requirements," adds Windt.

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AD INDEX

by Michael LaLande

Why Cloud Technology is Driving the New Automotive Era

OVER THE YEARS, technological advancements in how cars are designed and manufactured have affected the automotive market. One such change is cloud-enabled platforms that are transforming how business is done, eliciting greater collaboration and integration within companies—and more interactive experiences with consumers.

The worldwide public cloud services market revenue is projected to grow 18.5% in 2017 to total $260.2 billion, up from $219.6 billion in 2016, according to Gartner (gartner.com/newsroom/id/3815165). Cloud-based technology is empowering start-ups to compete with legacy automakers, forcing traditional companies to adopt new business models to survive. Couple that with the fact that the cloud allows business to scale and maneuver quickly, and you have a catalyst that transforms how vehicles are being brought to market.

Platforms Disrupt "Business as Usual"

As the automotive market evolves, there remains one commonality across all companies—the use of platforms. With the right platform, companies can have an all-in-one solution at their fingertips, enabling once siloed departments to work in tandem. The platform is an integrated system that allows seamless communication and workflow across disparate departments, resulting in fewer production cycles, enabling faster speed to market.

Think of the platform as an iPhone and the various solutions that branch off of the platform as apps that can be tailored to individual auto departments. This digital thread connects engineers, project managers and product developers, enabling them to work more efficiently and collaboratively. This streamlined business model is allowing newcomers like Tesla to gain a competitive manufacturing edge.

Tesla has a mission to make electricity a viable alternative to petroleum-based vehicles. Using a platform solution, Tesla was able to efficiently and collaboratively manufacture its vehicles—connecting all aspects of the operation to eliminate data boundaries, compress lead times and reduce costs in development. Ultimately, using a platform removed confusion across the operation, allowing Tesla to deliver quality solutions to market quickly.

With information available in real time on one platform, automakers are able to continuously develop and share information to break down data silos and expedite the production process from concept to creation. This ultimately adds value for automakers to spend that time making more informed business decisions.

How Cloud Levels the Playing Field

The cloud is allowing the smallest companies to be nimble and compete with staid industry giants. With the digitalization of business, legacy companies that have manufactured cars the same way for 50 years must explore new models or quickly become outdated and outperformed by startups that are embracing digital transformation as a starting point. Because the cloud can be accessed from anywhere, automakers are able to work cohesively across departments and globally to deliver a more customizable and competitive experience for customers.

Built on a cloud-based platform, solutions like the Virtual Garage are allowing consumers to interact with virtual cars without ever seeing a physical model, allowing them to customize and tailor in real time. The Virtual Garage was developed in response to today's mass customization phenomenon, and the platform provides automotive companies like Peugeot and DS Automobiles with a dynamic new way to showcase their innovation.

Recently at the 86th Geneva International Motor Show, visitors to Peugeot's booth wore an HTC Vive headset and controlled a joystick to virtually view, explore and interact with its new DS 3. Viewers were able to change the roof and body colors and choose the trims and interior décor — all without stepping foot into a car. With each change, visitors "saw" their customized DS 3 updated in real time.

The automotive market will continue to undergo massive changes over the next few years. Today's manufacturers are enduring challenges that were not seen by their predecessors. As digital transformation continues to drive change across this industry, it's the manufacturers that have the right thinking, strategy and tools that will drive this industry forward.

Michael LaLande *is director of Americas Transportation & Mobility at Dassault Systèmes (3DS.com).*