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by Anthony J. Lockwood

Lockwood Looks Back

The way you found out what was going on in the design for manufacturing world was a different animal in 1995, and *Desktop Engineering* played a key role in the changes we now take for granted. Here's how *DE* got going and what affect it had.

I hired Ann Grummon, *Desktop Engineering's* first editor, as the premier issue—September 1995—went to press. I tossed some article printouts at her and told her to find typos. She dug right in, likely because I was cranky. Everything had to be just so, and the outfit I worked for cherished antique ideas about publishing. I derided them as "country club publishing." We battled. I won. Still, secretly, I fretted that, once again, I had shot off my mouth and got in way over my head. No one had seen an engineering trade magazine like *DE* before. But, wait. I'm getting ahead of myself.

Helmers Publishing—later Level 5 Communications—hired me in the summer of '94. Writing about computer stuff had been my gig since '79. I had logged in more than a dozen years at *BYTE* magazine, worked for an *InfoWorld* publication, and done freelance. Throughout the '80s, I was a key player developing BIX, *BYTE's* ill-fated online content offering—the first by a major publisher. BIX. Sheesh. One of the execs who sold it off commented to me as he showed me the door that "no one will ever be interested in the Internet." That was '92. He got the big bucks for such foresight.

We invested in the little guy who bet microcomputers were going to be the next big thing.

Defining *DE*

Anyway, Helmers hires me. Tells me that I'll soon run the editorial of a new publication for design and mechanical engineers and get the company's publications online. Now, just what this new rag was about was a mystery. One owner clung like a tick to the idea of computer algebra software; the other found nirvana in field computers. So, they sat me in a corner rewriting stuff on sensing technologies—accelerometers, LDVs, the whole shebang—for one of their existing pubs as they puzzled their data out.

Laura Hanson was the sorter. She researched the audience and advertising markets for the owners' ideas. Laura's data was excellent. Only, it showed that there wasn't advertising or audience interest in either of the owners' ideas.

What to Do?

So, it's January '95. I get called into a YAM (yet another meeting) with the owners, the CEO, and Laura. Our agenda: "What to do?"

Laura's research had revealed something interesting about the reading habits of engineers back then: You read the trade magazines of the day to learn about engineering. These were black, white, and stunningly dull. Reading them, you would have thought engineering went hand-in-hand with undertaking. But you also read flashy, full-color magazines like *BYTE* or *MacUser* to keep up on computing technology. (A lot of you read *Playboy* too, by the way.)

We dug a little. You weren't reading *PC World* for the centerfold. You hoped to find a tiny ad and an occasional article on engineering stuff.

On your desk, you had a 386- or 486-based PC on your desktop for "business" work. For engineering you had a dumb terminal connected to a mainframe somewhere and all sorts of black boxes scattered around. You hated the terminal and loved your PC. About a third of you, if memory holds, were online at work, with all the rest expecting to be so soon.

Engineering is Sexy

So, I'm in this YAM and I, devoid of a gatekeeper to censor whatever pops into my head, looked at this data and ralphed out some ideas in rapid, generally profane succession. Disclaimer: I had done some blue-sky dreaming with this guy John Hayes, my boss. So, I am not claiming total genius, but I am claiming that I was jumping up and down spouting off about what I wanted to do.

1 We'll do an engineering trade magazine that's as sexy looking as a newsstand magazine. This is the MTV generation, I argued. Give them media that looks like what they expect out of media, not 1960s reruns.

2 We're about PC-based engineering software and hardware. This was engineering word-weenieship heresy in '95. Everybody believed that engineering software meant "big iron" and that micros meant Windows. Windows and engineering? Double heresy.

3 Marry no technology, not even Windows. Technologies come and go like bad hairdos. But the world will forever turn to engineers to solve its big problems.

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by Anthony Lockwood

4 This was the tricky one: We'll look at engineering computing from the design and mechanical engineer's point of view. We'd inform you about the newest technologies, tell you what's in it for you, and show how these technologies help you solve problems.

5 Engineering is fun. One shall eschew ponderous third-person prose. Making things work, designing new things, having your work blow up a few times before it works is fun. Engineers are our people and passion. Let's entertain as we inform.

OK, now, Helmers did technology—think sensors and bar code readers. Grok robotics, not people. Dull gray, albeit informative, narrative suffused its DNA, so much so that one of its publications had a policy of no verbs in article titles. "One finds it too jarring" in the words of one long-time editor.

My diatribe elicited silence and blank stares from the owners. Yet, after an endless minute, we got the go ahead. "We" was John Hayes as publisher, Dan Harper as sales guy, Lee Ann Modestino as office manager/ad coordinator, and me as editor in chief of a staff of me. We shared Robin Haubrich in the graphics art department with the other businesses in-house.

We needed a name for this thing. Again, Laura's research came in handy. We identified *Cadence*, *CADalyst*, *CAE*, and *Personal Engineering & Information News* (*PE&IN*) as kind-of competitors. Only *CADalyst* survives today in a different form. We looked at these outfits and noticed one thing: They had little interest in the desktop computer. Oh, I can hear people I know who worked for them objecting. With the exception of *PE&IN*, they paid desktop computing lip service, unless it had something to do with Autodesk or National Instruments. The big money was in big iron.

So, we invested in the little guy who was betting that microcomputers were going to be the next big thing. This naturally led us to the "desktop" part of the title. Who blurted it out first, I do not know. I'll leave it you to figure out the "engineering" part.

Issue One

OK, now I had to make the editorial pudding set. I got an article on computer algebra systems (not that much of a dummy, eh?) for PCs that later grabbed worldwide attention. Another article reviewed programming PC-based data acquisition boards with LabVIEW from National Instruments, and a fun one covered using MCAD software to design whitewater rafts. FEA with 100k elements on a PC was a show-me piece that broadcast our intentions to cover the changing world of analysis. And I pieced together the thoughts of industry leaders for the cover story "Your Changing Desktop." That article's subtitle said it all: "Micros have forever changed engineering. But the big changes have just begun."

***DE's* first cover in September, 1995.**

So, anyway, Grummon, as well as Brian Vaillancourt, later to become *DE's* publisher, arrives right as I was finishing that first issue. Then we let our baby go out there to you, dear *Desktop Engineering* reader, and waited to see if we'd have a job come 1996. (Ever hopeful—or scared, depending on your point of view—we began building a website that went live soon after our first issue hit your snail mail address.)

Looking back over 15 years of this extraordinary resource for engineers, it's plain to see that our instincts were right then as they are now. News and information about products and technologies that you need never needed to be boring, as it was before *Desktop Engineering*. That's one reason why you now have a choice of exciting online information sources, some really lousy blogs as well as some good ones, and some truly good hard and digital copy.

We made our mistakes over the years, of course. Mine are legion. Still, in 1995, I believe *Desktop Engineering* changed the world of engineering trade magazines and how you get information forever. And knowing what little I do about *DE's* future plans, you haven't seen anything yet. **DE**

Thanks, pal. —Lockwood

Lockwood *is* Desktop Engineering's *Editor-at-Large. He helped start the magazine in 1995 and has edited it for years.*

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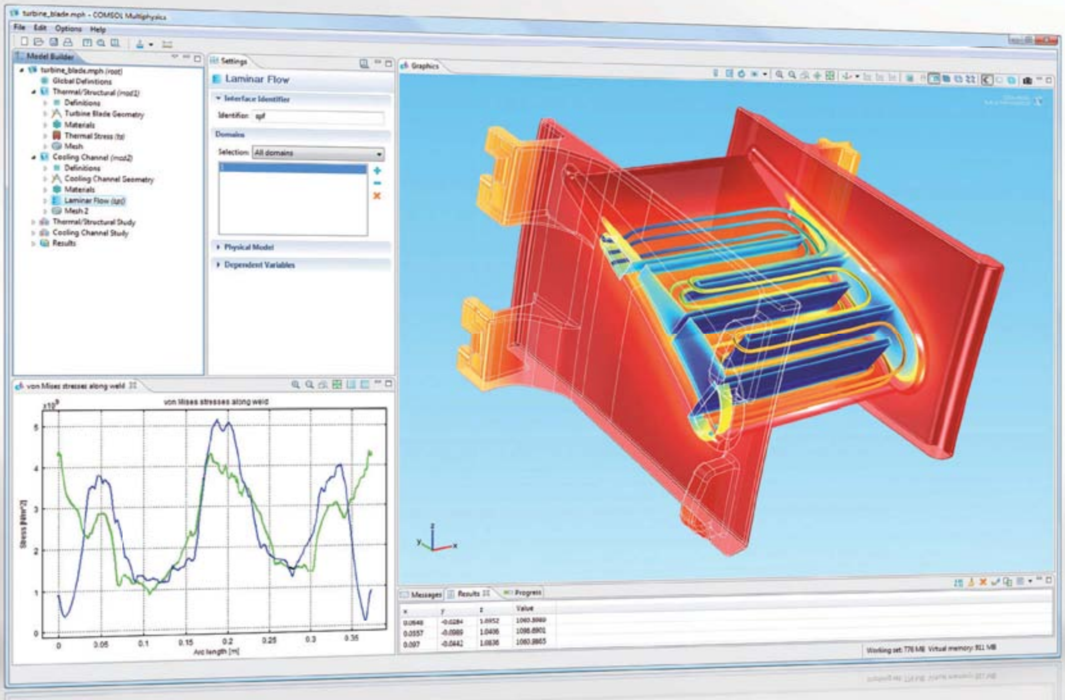

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COVER STORY

ON THE COVER: Computing technology illustrates the evolution of design engineering over the past 15 years.
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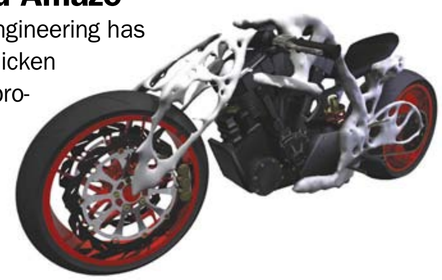

December 2010 VOLUME 16/ISSUE 4

VISIONARY VOICES

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VIRTUAL DESKTOP BLOG
Read Kenneth Wong @ deskeng.com/virtual_desktop for a closer look at lifecycle components via articles, interviews and video reports.

NEWSLETTER REGISTRATION
Newslink; Editor's Pick of the Week; Check It Out; Virtual Desktop; Focus on Analysis and Simulation; Focus on Engineering IT & Computing; Focus on MCAD; and Focus on Rapid Technologies.

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Peering into the Nano-Bio-Techno Future

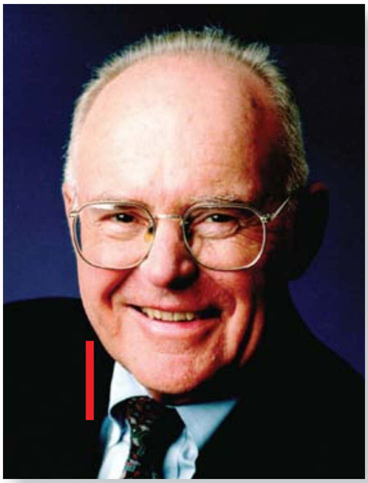
Moore's Law turns 45; *DE* turns 15.

BY KENNETH WONG

It was 1995: the year immediately following the debut of Netscape. It also marked the launch of DVD as new media; the birth of Yahoo! and eBay; and the passing of The Grateful Dead's Jerry Garcia. At the time, PTC's Pro/ENGINEER was in Release 15, Siemens PLM Software was still known as UGS, SolidWorks was getting ready to ship its first release, and the memorable AutoCAD R14 was still two years away. That year, at the end of August, just as Windows 95 (codenamed Chicago) hit the store shelves, the premiere issue of *Desktop Engineering* (*DE*) went off to press.

Fifteen years is but a blink in human history, but in the fast-evolving high-tech universe, that's more than enough time for a digital boom, a gold rush, and a bust, paving the way for a renaissance with new hopes and promises. Some might argue, having risen from the smoldering ashes of perished dot-coms and the financial crisis, the technology providers that remain on terra firma today are true survivors, much stronger for what they've endured.

This month, as *DE* turns 15, I check in with industry veterans and visionaries to figure out what's ahead. If technology has (to borrow Thomas Friedman's words) flattened the world, what risk and opportunities does the Brave New World have to offer? Some conversations take me into the cloud; others take me down to subatomic planes. Some experts argue that Moore's Law, whose days are predicted to be numbered, is merely gearing up for a Second Coming. Others direct me a treasure trove of Nature-inspired design ideas, ripe for plunder. While the experts don't always subscribe to the same views, they seem to be in agreement on one thing: The best is yet to come.



Gordon Moore, Intel's cofounder whose prediction of transistor count increases became known as Moore's Law.
Image courtesy of Intel.

Sustaining Exponential Growth

For a while, the cyclical computational horsepower increases were almost as reliable as death and taxes. As originally predicted by semiconductor researcher and Intel cofounder Gordon Moore in his paper ("Cramming More Components onto Integrated Circuits," April 19, 1965), the number of transistors embedded in a single integrated circuit kept doubling every year. (Moore later revised his calculation, asserting a doubling of transistor count every two years instead.) His prediction, now commonly known as Moore's Law, remained true throughout the '70s, '80s, and '90s. Many hardware and software businesses literally banked on the exponential growth promised by Moore. But Moore himself recently warned that the party may soon come to an

Engineering Technology Timeline

1995

First issue of *Desktop Engineering* is published.

1995

Microsoft releases Windows 95 and Internet Explorer 2.0.

1995

Intel releases the Pentium Pro processor, with clock speeds up to 200MHz.

end, alarming quite a few souls.

"In terms of size [of transistor] you can see that we're approaching the size of atoms, which is a fundamental barrier, but it'll be two or three generations before we get that far, but that's as far out as we've ever been able to see," he observed ("Moore's Law is Dead, says Gordon Moore," April 13, 2005, *Techworld*).

In a paper published around the same time, Intel scientists acknowledged, "The 30-year-long trend in microelectronics has been to increase both speed and density by scaling of device components (e.g., CMOS switch). However, this trend will end as we approach the energy barrier due to limits of heat removal capacity ("Limits to Binary Logic Switch Scaling–A Gedanken Model," June 2005).

Getting More out of Moore's Law

Anthony Neal-Graves, Intel's general manager of workstation group, cautioned that a eulogy for Moore's Law may be premature. "The semiconductor industry has ideas in place that may extend Moore's Law for the foreseeable future, past 2025," he explains. Shrinking the semiconductor's size beyond its current form (32 nanometer is what Intel ships today), he hinted the following progression could be expected in chip design, with approximately two years' interval for each generation leap: 22 nm in 2012; 18 nm in 2014; 12 nm in 2020 and smaller as we move along.

"[6.5 nm] means a dual processor workstation, which supports 158 Gigaflops today, could support in excess of 28 Teraflops," Neal-Graves points out. "But you need to recognize it is not all about flops. Delivered performance is all about system balance. That means you need to plumb it correctly in order to deliver the performance that is possible … What is needed is advanced memory hierarchies and greater capacities as well as system bandwidth. These components are at the foundation of delivered performance."

Some, like NVIDIA's chief scientist Bill Dally, have suggested Moore's Law could only be upheld by moving from serial processing to parallel processing. John Hengeveld, Intel's senior strategist, suggests, "R&D is in the DNA of our future. It enables new levels of performance and addresses areas such as energy efficiency, scalability for multi-core, many-core and heterogeneous architectures, system manageability and security, and ease of use. It helps us look at computing in new ways and enables us to explore new ways of delivering it."

Whether it's dubbed parallel processing or many-core architecture, this is the frontier where CPU makers Intel and AMD and GPU vendor NVIDIA will wrestle for market share.

Clouds Forecasted

Every individual engineer might not have access to a private computer cluster equipped with hundreds of cores, ready to do his or her bidding day or night. But with a high bandwidth connection, every engineer can easily tap into a remote cluster for their parallel processing needs.

For the most part, CAD modeling remains a sequential problem (it's not a computing task that can easily be broken into smaller chunks), but analysis and rendering, two of the most computing intensive tasks for CAD users, turn out to be ideal for parallel processing.

One of the many companies exploring the SaaS (software as a service) model for analysis is Dezineforce, a UK-headquartered company. Through what it describes as "HPC simulation on-demand," Dezineforce offers users a way to remotely access its HPC infrastructure from a browser and perform engineering analysis and simulation tasks.

Similarly, global engineering solution and service provider Altair has begun offering access to its own HPC infrastructure for clients who need additional computing horsepower through its PBS Works software suite. Altair is still assessing its pricing strategy for the on-demand HPC services. It'll most likely be a pricing model based on the number of computing nodes and time required by the customer.

In the near future, Autodesk 3ds Max users may simply push a menu button to render their scenes in the cloud, on a remote cluster equipped with NVIDIA Tesla GPUs. The new function is powered by the iray renderer from mental images, a wholly owned subsidiary of NVIDIA. Though Autodesk hasn't specified when it would be market-ready, the tool was demonstrated live at this years' NVIDIA GPU Technology Conference to an enthusiastic crowd.

"[Cloud-hosted GPUs] are all running exactly the same iray software that comes with 3ds Max," says Michael Kaplan, vice president of strategic development, mental images. "We

1995

First seat of SolidWorks 95 ships.

1995

Integraph releases Solid Edge.

1995

Stratasys purchases rapid prototyping technology from IBM.

21st Century Engineering Challenges

For the last half of the 20th century, JFK's words that crackled over the airwaves on May 25, 1961, summed up the simmering ambition of the postwar era. "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the Earth," he charged. It was a call to boldly go where no man has gone before. It was a presidential charge that held NASA engineers' feet to the fire throughout the Cold War.

Sixty years later, as the Red scare faded away, it was supplanted with the Green threat. Former vice president Al Gore launched a book, a movie, and a movement that would echo the anxiety of the times. Climate change spawned many sustainability—or green—initiatives, some more earnest than others.

A glance at the list of projects at The National Academy of Engineering's (NAE) Grand Challenges website (engineeringchallenges.org) reveals renewable energy and clean energy as people's top concerns. According to poll results published by the NAE (after tallying 25,000 votes), the three top challenges are:

1. making solar energy economical
2. providing energy from fusion
3. providing access to clean water

Surprisingly, securing cyperspace ranked 14, far below health informatics (9), carbon sequestration (6), and reverse-engineering the brain (4).

Analysis and simulation software makers found a place in the renewable market with thermal and fluid flow simulation packages. Green concerns also gave birth to life cycle assessment (LCA). CAD-embedded LCA tools are still in their infancy, beginning with SolidWorks Sustainability Xpress. Autodesk's recent partnership with materials data provider Granta is expected to produce another solution, possibly built around Autodesk Inventor. Independent browser-based software like Sustainable Minds (a partner of Autodesk) also gives engineers a way to evaluate environmental impacts.

What do you think is the next big engineering challenge? Visit *DE* Exchange (deexchange.com) or *DE* on Facebook (deskeng.com/facebook) to tell us.

can guarantee that the image that you get from [cloud-hosted iray renderer] is exactly the same, pixel for pixel, as what you would get from 3ds Max."

Autodesk is currently previewing a similar function for Autodesk users, called Project Neon. Hosted at Autodesk Labs, Project Neon lets AutoCAD users upload a scene with predefined camera views and render them remotely. Because remote rendering leaves your local machine's CPU and GPU free, you can continue to work on your machine while the rendering session is in progress.

The Machine is Your Silent Partner

Brian Mathews, vice president of Autodesk Labs, thinks cloud computing has been pigeonholed. Sure, the anticipated availability of web-hosted clusters at affordable rates will let you design "better, cheaper, faster," but he points out the trend also makes it possible for your machine to do what he calls "predictive computing" or "speculative computing."

"Instead of running one simulation over 12 hours, you might compress [the simulation time] down to a few seconds [by renting additional cloud-hosted cores]. Now, instead of looking at one alternative, you might look at three alternatives. In fact, you might automate those alternatives, using genetic algorithms," he says.

In the not-so-distant future, Mathews imagines, your design alternatives (say, two versions of a building with different window types) can be automated to cross-breed and spawn offspring, or derivatives. These derivatives can in turn produce more derivatives, thus multiplying the pool of design alternatives for as long as you can compute.

"You can analyze these variations by renting a massively parallel system," he says. "That way, instead of getting a better design, you'll arrive at the optimum design." The cloud, he feels, not only "amplifies your design imagination" but lets you "optimize your design to a level that wasn't possible before."

But going a step further, he imagines the machine (he means both the local machine and the networked cores accessible through it) performing heavy analyses in the background while you refine your design. While you're working, the machine can also be anticipating your next move (for example, anticipating an extrusion command from you when you finish sketching a 2D profile), and doing some of the required computing for the expected task before you demand it.

1995

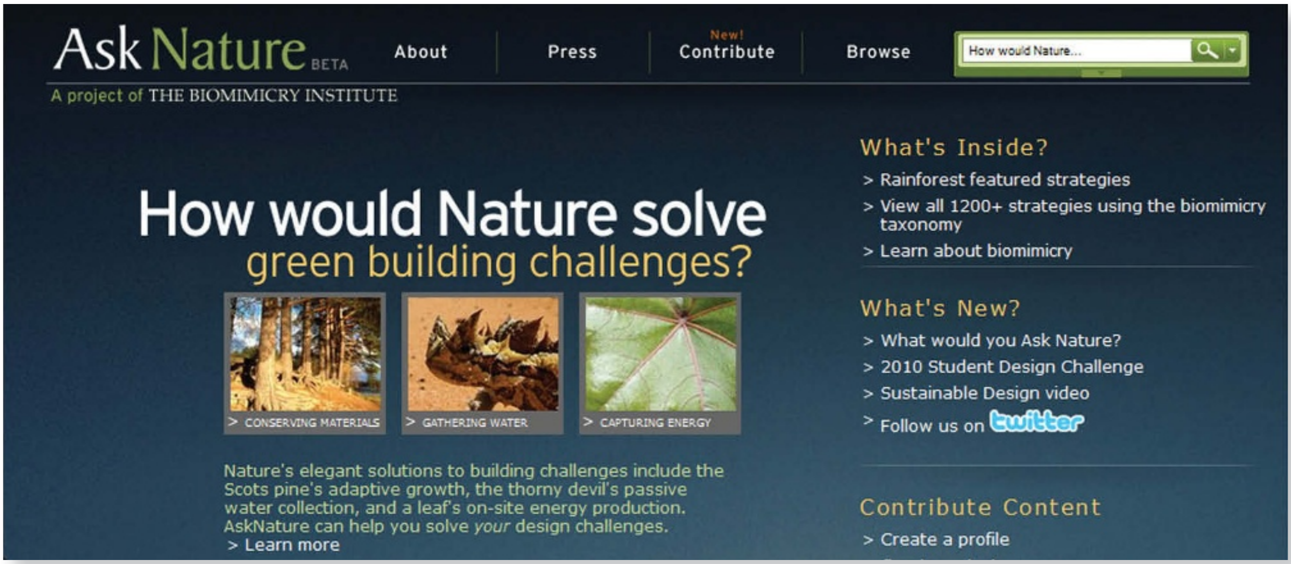
Delcam launches FeatureCAM.

1995

16 million people are using the Internet.

1996

The Internet has about 40 million users.



Ask Nature, a site that serves as a repository of Nature-inspired design ideas.

Natural Engineering

Arguably, Nature (that's Nature with a capital N) is the most seasoned engineer, as it has had millions of years to perfect its concepts and manufacturing through trial and error. So it's only natural that, prompted by the need for sustainable design, people turn to Nature for inspiration.

The movement to study and, when appropriate, duplicate Nature's best work is known as biomimicry. The best ideas in this field, or course, are to be found in the field: in the water-resistant texture of petals, in the flexible limbs of crabs, and in the water-storing cactuses in the desert. But you may also find a repository of biomimicry projects online at Ask Nature (asknature.org), a site maintained by the Biomimicry Institute (biomimicryinstitute.org).

Janine Benyus, cofounder and board president of the Institute, explained, "Imagine nature's most elegant ideas organized by design and engineering function, so you can enter 'filter salt from water' and see how mangroves, penguins, and shorebirds desalinate without fossil fuels. Now imagine you can meet the people who have studied these organisms, and together you can create the next great bio-inspired solution."

Though the archive is at the moment sparsely populated, you can read about a number of Nature-driven design projects, such as a London building with large panels of glass, inspired by the ribs and struts of the giant water lily; a car designed with a computer-aided optimization model, inspired by the structural strength of skeletal tissues; and many others. There's one clear advantage to stealing Nature's designs: they're not copyright protected.

Micro Management

Need to incorporate electrical component designs, such as circuit boards, into your CAD model? PTC offers an ECAD-MCAD Collaboration Extension for Pro/ENGINEER (now known as Creo Elements/Pro) users. SolidWorks gives you CircuitWorks, a partner-developed plug-in it acquired in 2008. Similarly, Siemens PLM Software recently announced Mechatronics Concept Designer, an NX-integrated package for those who work with mechanical and electrical components.

CAD software developers are widening their horizons toward the practice of modeling and simulating electromechanical interactions. But another area, one that requires a sharper focus on a smaller scale, remains a blind spot.

Nanotech, the study of material behaviors at the atomic

1996

Z Corp. makes its first machine sale.

1996

Geometric launches CAMWorks.

1996

Steve Jobs returns to Apple as a consultant.

Transistor Growth vs. Horsepower Increase

Anthony Neal-Graves, Intel's general manager of the workstation group, makes a distinction between the doubling of transistor count in a chip every two years (what Moore's Law says) and the doubling of computing horsepower every two years (what many assume would follow from Moore's Law).

"When we double the transistors, we introduce new microarchitectures that compute more instructions in a given compute cycle," he explains. "As we doubled transistors and increased the number of instructions, we also increased the clock cycles, but the physics of cooling ever higher frequencies has proven difficult. We can increase frequencies; we just don't know how to economically cool them."

This chip-architecture conundrum, he points out, gave birth to the era of multi-core computing, soon to be followed by many core architectures, as a way to further increase the number for instructions computed in a given compute cycle.

and molecular level, may hold the key to unlocking the next generation chipset design, expected to be stalled by the physical limitation of how small a transistor can get. Nanotech is also an area largely neglected by CAD modeling software vendors, possibly because it lies beyond their established expertise. Whereas current CAD programs are designed to replicate classical mechanical behaviors, nano-particle behavior may require different modeling engines and a different modeling principle altogether.

NanoEngineer from Nanorex is one of a handful of programs researchers and scientists currently use to model DNA structures and molecular gears. (For more, read "Nanotechnology Enables Real Atomic Precision" by Susan Smith, October 2009).

The Mac Effect

In October, when unveiling what he described as PTC's vision for CAD for the next 20 years, Brian Shepherd, PTC's vice president of product development, borrowed Apple's slogan for iPhone and iPad: "there's an app for that."

PTC's new product line, branded Creo, is replacing what was known as Pro/ENGINEER, CoCreate, and ProductView. They'll have to make way for Creo Elements/Pro, Creo Elements/Direct, and Creo Elements/View.

Contrary to Autodesk, PTC takes a more cautious approach to cloud computing. On more than one occasion, Shepherd had mentioned, "We're neither pro-cloud nor anti-cloud … We're ambivalent, or open, or agnostic about the way we deliver software."

Yet, Jim Heppelman, the company's CEO, has made an offhanded comment that "You'll probably see [a Creo app] on iPad before you see it on cloud." (He didn't say, however, how he might bypass the cloud as the traditional method for delivering applications to a web-connected device like iPad.)

"What Jim was talking about is the work-from-anywhere idea," explains Shepherd. "Product development is becoming a 24/7/365 activity. People don't want to have to go back to the office to their desktops … The beauty of the Creo architecture announced [in October] is that, we don't have to deliver an app for every operation on iPad."

Borrowing a page from Apple's iPhone playbook, PTC plans to break up professional CAD operations into smaller chunks, manageable in Apple-style apps (for example, a Creo app for surfacing, another for rendering, another for markup and visualization, and so on). This new approach, Shepherd points out, puts PTC in a nimbler position to respond to market and customer demands with OS-agnostic or OS-specific apps, which would take less time to develop than porting an entire CAD program to a new platform.

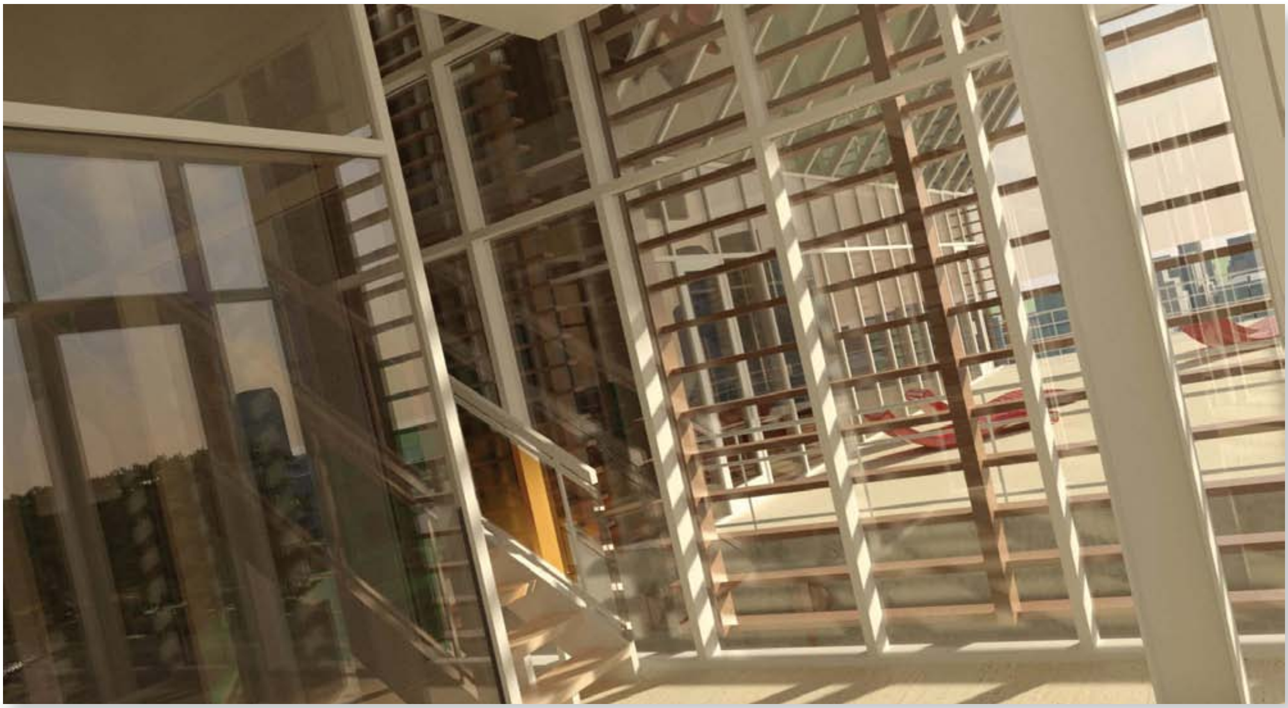
As portable devices like the iPad and iPhone become field crew's and road warriors' preferred communication method, traditionally Windows-focused CAD vendors are making their software Mac-friendly. Dassault Systèmes, for example, strives to deliver its 3DVIA software line to iPad users. Its 2D-specific drafting program, DraftSight, is now available for both Windows and Mac. Similarly, Autodesk has recently released a Mac-compatible version of its flagship 2D software, AutoCAD. The company also delivered iPad- and iPhone-compatible versions of AutoCAD WS, a 2D viewing and markup application.

1996 — **Dassault Systèmes' IPO.**

DASSAULT SYSTEMES

1996 — **Autodesk releases Mechanical Desktop.**

1997 — **Dassault Systèmes acquires SolidWorks.**



A building model rendered in the iray rendering engine. In the future, Autodesk 3ds Max users are expected to be able to produce the same type of rendering using a cloud-hosted cluster.

Lighter Apps, Heavier Computing

One of the first PTC Creo apps to be delivered, says Shepherd, is a simulation app, ideally suited for parallel processing. "That's a role-specific app [meant for an analyst] that can take advantage of distributed computing for certain types of analyses," he says. "For instance, in optimization studies, you'll need to solve the same analysis many times with different boundary conditions."

Another Creo app slated to appear in 1.0 is a rendering app, also suitable for distributed computing for faster results. "The engineering apps' appetite for more CPU cycles isn't going away," says Shepherd. "People want more realistic simulation, more realistic animation–more realistic everything."

If the engineering problem of this—and the next—decade is duplicating reality, perhaps the answer, too, is to be found in mimicking how people tackle complicated tasks in real life. Usually, they break up the task into smaller tasks, assign them to those best qualified to execute them, then collect the results at the end of the project—a perfect example of distributed workflow.

For more future engineering prognostications, visit *DE's* Virtual Desktop blog at deskeng.com/virtual-desktop and listen to recorded conversations with more industry veterans. **DE**

Kenneth Wong *writes about technology, its innovative use, and its implications. One of* DE's *MCAD/PLM experts, he has written for numerous technology magazines and writes DE's Virtual Desktop blog at deskeng.com/virtual_desktop/. You can follow him on Twitter at KennethongSF, or send e-mail to DE-Editors@deskeng.com.*

1997

ESI Group acquires Framasoft.

1997

Unigraphics Solutions started as a subsidiary of EDS Unigraphics.

1997

National Instruments launches PXI.

Cutting the Cord

Virtual and augmented reality tools are changing the human/computer interface. But will designers benefit?

BY BRIAN ALBRIGHT

For years, technology companies have been moving us closer to a "Star Trek" vision of the human computer interface, where computers respond to hand signals and voice commands, and people can interact with virtual objects.

Virtual reality (VR) has, well, *been a reality* in design and engineering for a number of years, often used in product development and design review. Users armed with sophisticated 3D glasses can interact with models on a PC, a powerwall or in a cave automatic virtual environment (CAVE). New advancements in ray tracing have made it possible to create highly realistic virtual prototypes, and major CAD and product lifecycle management (PLM) players provide visualization tools that can provide companies with a more realistic way to review designs before investing in a physical prototype.

This evolution has been enabled by the increase in computational and graphics power of design applications, and the hardware on which they run.

"What used to take hours now takes under a minute, and it can be completely interactive," says Phil Miller, director of product management for professional software at NVIDIA. "That's changing what's possible. Instead of waiting over lunch to see a rotation, you can play with the model and see the results interactively."

But while the technology used to generate virtual prototypes has reached new levels of sophistication, the way designers and engineers interact with these models hasn't changed much. New interface technologies have been developed in the VR space—haptic gloves, 3D headsets, motion control sensors—but for the most part, designers still work with a mouse and keyboard.

"The mouse and keyboard are quite powerful, that's the thing," says Austin O'Malley, executive vice president of R&D at Dassault Systèmes SolidWorks. "The entire office and desktop

Virtual reality is already being used by engineers to help make better design decisions by interacting with their designs *Image courtesy of NIAR.*

are designed around it. Most computer applications are not developed for use with other inputs, and they require a keyboard or mouse to augment those input devices if you need to input a lot of data or get a precise selection. They really don't blend well with other devices, and that's why other input devices don't get the kind of usage you might think they would. They are not good at inputting text."

That could be about to change. With gaming applications

1997

Alibre founded.

1998

Google is officially founded.

1998

Solid Edge acquired by EDS-Unigraphics.

and advanced mobile phones like the iPhone and Android devices driving down the price of the technology, and processing speeds increasing, more designers may be able to cut the cord on their mouse—at least some of the time.

By providing a more natural way to interact with models, designers could get a much better idea of how objects will look, feel and operate in the real world. They could also potentially spot design issues earlier in the process by seeing what impact an object will have on its real-world environment.

3D allows designers to see their designs in a different way. *Image courtesy of NIAR.*

"Can we review the design together and more naturally interact with it, rather than constantly walking over to a keyboard?" O'Malley says. "Touch devices and 3D viewing devices are interesting examples of how people could collaborate in the not-too-distant future."

What will ultimately drive adoption, however, will be a combination of low cost and utility.

"You have to offer a magnitude of difference in terms of efficiency to move away from that paradigm," says Sandy Joung, senior director, product marketing at PTC. "There has to be a compelling benefit, and from there it will come down to ease of use and interoperability."

Out of the Lab

James Oliver, professor of mechanical engineering and director of the Virtual Reality Applications Center (VRAC's) at Iowa State, says there is a significant opportunity for new interface technologies to improve the early stages of design work.

"There is an opportunity gap, from a researcher's point of view," he says. "Not a lot has gone into the front end of design, in particular conceptual design. We still have engineers using whiteboards and Excel spreadsheets and the backs of napkins."

At the VRAC, researchers are already testing some of the more outré human computer interface options, including haptics, touchscreens and motion tracking—sometimes using repurposed equipment from gaming applications. The U.S. Air Force, Boeing, Rockwell, John Deere and other companies leverage the VRAC for product development and manufacturing simulations.

A lot of this work is focused on simulations and prototyping, but Oliver says there is also a focus on that early part of design. Decisions made in the early stages of the process can lock companies into a lot of expense later in the process. At this stage, designers are usually more interested in whether option A is better than option B than in detailed analysis. But by allowing them to quickly manifest 3D renderings using a library of existing parts data, Oliver says designers "can keep more concepts alive in the pre-design process before they are cut into stone with a full CAD development."

Fernando Toledo, manager of the Virtual Reality Center at the National Institute for Aviation Research (NIAR), says VR tools are helping manufacturers work through design reviews by reducing the number of physical models that must be created.

"Using virtual reality, you can test different configurations of overhead bins, for example," Toledo says. "You can see different shapes and styles. These things would take too long if you had to build physical models. But it took awhile for engineers to see that it could help them to improve design decisions."

Beyond the Keyboard

Many of the interface tools used in VR and augmented reality

1998

Microsoft launches Windows 98.

1998

Guangzhou Chinaweal Longteng Technology Co., Ltd. (later to be named ZWSoft) is founded.

1998

Rhino 1.0 released by Robert McNeel & Associates.

Anytime, Anywhere Computing

Students at MIT's Media Lab have developed a wearable, motion-control mobile computing solution that will allow users to manipulate data using hand gestures in much the same way Tom Cruise did in the film Minority Report.

Dubbed SixthSense, the system uses an off-the-shelf digital projector and a Webcam to project images on to any surface and follow the user's gestures. Both units are built into a small, wearable device connected to a mobile computer. The entire system cost just $350 to build.

To take a digital photo, users snap their fingers. A drawing application allows users to draw on any surface by tracking their index fingers. The system also recognizes certain symbols to open applications—drawing a magnifying glass in the air with your fingers will open the map application, while drawing an @ symbol will open an e-mail program, for example. SixthSense also supports multi-touch and multi-user interaction.

The system could potentially provide a higher degree of environmental interactivity for users. By "snapping a photo" of a book, for instance, users can search for reviews or price information online.

Developed by student Pranav Mistry, the system is still in the developmental stages. Right now, users have to wear color markers on their fingers for the system to work, but Mistry plans to incorporate vision technologies that could eliminate that requirement.

For more information, see pranavmistry.com/projects/sixthsense/#ABOUT.

(AR) environments have become more sophisticated and less expensive. What used to require a $1 million investment in equipment can now be done 20 times faster for less than $20,000, thanks to PC clusters and other advancements.

"The gaming community drives the costs to a very reasonable level," Oliver says. "Who would ever guess that we'd be using Wii remotes and balance boards for interfaces to do real work?"

In the design review stage, companies sometimes use powerwalls or fully immersive CAVE systems to see how an object will look in 3D, using head-mounted displays (HMDs). "You can have a multi-functional team in the same room," Toledo says. "Car manufacturers and aircraft manufacturers like those environments, because they are very collaborative."

Although cost is still an obstacle, some lower-priced alternatives are now entering the market. Information can be transferred from a PC to an HDTV, for example, and viewed as a 3D image using stereoscopic glasses. Toledo says a company called RealD offers a product called the POD that can display images from a typical graphical card to an HDTV. Viewers can see the stereo 3D image by using the company's glasses.

"You can use an HDTV for a fraction of the cost of a powerwall," Toledo says. "You can have five or 10 people involved, and that lowers the cost and puts more companies in the game."

Interacting with those models, however, is another matter. Most of these systems still rely on the mouse/keyboard combo—although Oliver notes that VRAC students are using iPhones as an interface in these full-scale, immersive environments.

And then there are touchscreen systems and motion-capture solutions that promise to provide greater interactivity at a slightly smaller scale.

Several years ago, Microsoft announced Surface, a multi-touch technology that allows users to manipulate content using gesture recognition. Because it uses cameras for input, users can utilize their hands as input devices, or even other non-digital objects like paint brushes on the tabletop's acrylic display.

Surface failed to really take off, however, in part because it was expensive and bulky. Now, Microsoft has announced LightSpace, which takes the Surface concept further by projecting a display interface across an entire room, allowing users to "grab" a file or icon on one surface and drag it across the room to another area using their hands.

For design reviews or collaborative projects, technologies like LightSpace might provide less-costly alternatives to the CAVE or powerwall by combining vision, gesture and immersive computing.

As for commonly available touch interfaces, they can be used to manipulate existing CAD models and 3D prototypes, or to mark up drawings during review.

"You could use your finger or a stylus to create a geometry,

1998
DEC acquired by Compaq.

digital

1998
PTC acquires Computervision.

1998
CATIA V5 released.

and that may be faster than the keyboard/mouse combination," Joung says. "We have tablets that you can 'write' on that way now, but we need to have interfaces in the software so that what you scribbled can be understood by a CAD application."

But will designers use touch technology to develop digital models in the same way they use their hands to make clay models? Both touch and multi-touch have been demonstrated in a CAD environment. SpaceClaim, for example, announced multi-touch support for its 3D direct modeling software last year, adding gesture support that can replace toggle-key or keyboard shortcut commands. Last year, students at Cambridge University (working with SolidWorks) developed a touchscreen design application on the DiamondTouch table as part of a research project that allowed multi-user model construction without the benefit of a keyboard or mouse. But it remains to be seen whether designers will take their hands off the keyboard.

Sketching applications like Autodesk's SketchBook Pro, which supports the iPad and iPhone, are already available. It seems, however, that touch may have more utility in the design review and simulation process. Siemens, for one, has demonstrated its NX product running on an iPad via a client/server model. "You can pull up the model, and drill into the [product lifecycle management] data," says Paul Brown, director of NX marketing at Siemens.

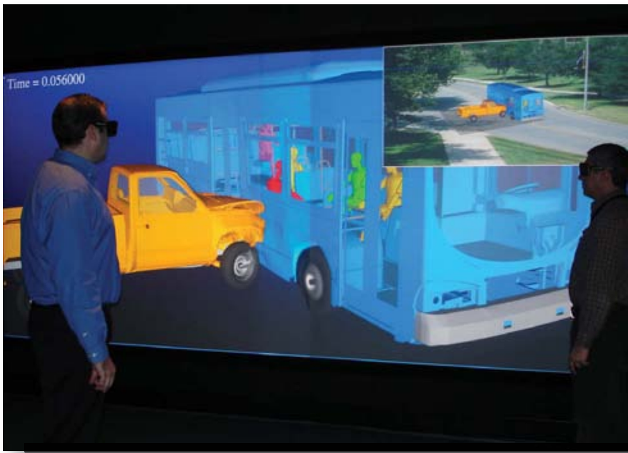
There are also opportunities in the mobile space, where small, touch-based phones could provide access to models for other applications.

"Right now, the key is getting access to data and repurposing it for other uses," O'Malley says. "If you can pair up the 3D output with a mobile device for people doing things like working on the shop floor, that would be quite useful."

Accessorizing in a Virtual World

Virtual environments employ a number of alternative interface technologies that allow users to interact with models in interesting ways, and VR-based gaming technologies have helped make these systems more accessible, easier to use and less expensive.

HMDs that provide stereoscopic 3D viewing are now much more comfortable to wear, and have improved graphics capabilities. Combined with wired gloves, these systems can allow users to manipulate models in real time.



While virtual reality and 3D are now used for visualizing and simulating design, future technologies may allow engineers to easily access virtual front-end design tools. *Image courtesy of NIAR.*

"You can sense depth in the model and see what's there, instead of an abstract overlay or a 2D representation," Miller says. "That extra level of depth gives you insight into the model that normally would take multiple views. You can see it more quickly, and it's a more natural way to work."

Canon has done a significant amount of work on HMDs for virtual and augmented reality (in Canon's lexicon, mixed reality) applications, and showed off its headgear at the Canon EXPO in September. Canon's equipment is in use in Japan, where the National Museum of Nature and Science has launched a virtual dinosaur exhibit. The company also uses the technology in its own design processes.

"They've been quite focused on this idea of being able to mix virtual design with the physical environment to see how it all works," Brown says.

Haptics is another emerging (but somewhat expensive) interface possibility. At the VRAC, researchers are using haptics to simulate the manual assembly processes used by many large manufacturers. "It's a major effort to lay out a new line, so by assessing the ergonomics and feasibility of doing a particular process virtually, there are many issues that can be resolved digitally in the manufacturing process," Oliver says.

1999

Intel launches Pentium III and Pentium III Xeon processors.

1999

Autodesk launches Autodesk Inventor.

1999

ESI Group acquires Dynamic Software.

COMPUTERS THAT KNOW WHAT'S ON YOUR MIND

It remains to be seen what the human/computer interface of the future might look like, but researchers at Intel hope to someday eliminate that interface by allowing users to control their computers using brainwaves.

Over the summer, the chipmaker demonstrated software that uses brain scans to read minds. The software can determine with 90% accuracy which of two words a person is thinking by analyzing which parts of the brain are being activated while the subject concentrates on a specific word.

Right now, the system can only distinguish a limited number of words, and relies on a massive (and expensive) MRI scan to accomplish the task. The hope is that the technology can evolve and be used to help disabled people communicate, for example.

Intel joins Honda and the U.S. Department of Defense in the quest to develop thought-controlled computing technology. Honda's Brain Machine Interface (BMI) is a helmet that uses electroencephalography (EEG) technology and near-infrared spectroscopy to control robots using thought alone. Users concentrate on moving one of four pre-determined body parts, and the BMI system measures changes in their brain waves and cerebral blood flow. This information then triggers one of Honda's ASIMO robots to make the corresponding movement, such as raising an arm or a leg.

The Army, meanwhile, awarded a $4 million contract to researchers at the University of California at Irvine, Carnegie Mellon and the University of Maryland to help develop a helmet that would allow soldiers to communicate with each other using their minds.

Called "synthetic telepathy," the process would rely on a network of sensors that would allow direct mental control of military systems. Initially, the Army hopes to be able to capture brain waves that can be translated into audible radio messages, providing a silent method for troops to communicate with each other.

As is often the case, though, the first neurotech-based interface has come from the gaming community. NeuroSky released an EEG-based controller called MindSet in 2007, and is following up with a device called MindWave; OCZ Industries entered the market with a Neural Impulse Actuator in 2008, and Emotiv has also released EPOC, an EEG-based gaming headset the company claims will make it possible for users to control video games using their brain waves and facial expressions.

A number of other companies offer gloves for motion-capture applications and gaming, but haptic gloves that provide tactile and force feedback are also available. CyberGlove Systems, for example, offers exoskeleton-style equipment that can provide force and tactile feedback either as an add-on to its motion-capture gloves, or as complete armatures. The company supports Autodesk applications, and recently formed a partnership with haptic hardware and software provider HAPTION to provide real-time physics calculations for manipulation within a VR or CAD environment. HAPTION's support will enable the use of the CyberGlove with Dassault Systèmes' CATIA, Delmia, Virtools and SolidWorks systems.

VR has greatly improved the ability to evaluate and simulate objects and real-world environments, but augmented reality may prove to have even more utility for manufacturers and designers. In VR scenarios, users typically strap on a head-mounted display to see the virtual environment. "The problem with that is you essentially disassociate the users from the rest of their body," the VRAC's Oliver says.

With augmented reality, virtual elements are added to a real environment, typically by adding virtual objects to a photo or adding a 3D image into a real space via an HMD. In design, that could include adding a CAD model to a real piece of equipment to see how exactly how it would fit into a natural environment. One manufacturer the VRAC is working with, for example, wants to use a display on the assembly line showing a video feed of the employees' hands and with which components they are working. A "ghost" of the next part to be added can be placed in the image of the actual part, replacing the written workflow instructions currently used on the line.

1999 — Graebert launches PowerCAD CE.

1999 — NVIDIA releases first GPU in the Geforce 256.

2000 — Microsoft acquires Visio Corp.

InfiniteZ offers a visualization system called zSpace that allows users to interact with digital objects using natural movements. The system consists of head-tracking software, a stylus, glasses and a stereoscopic projector. Canon's mixed-reality project also falls into this category.

"There is a lot of opportunity with large structural work," Brown says. "Things like ships or planes—large infrastructure where there is a lot of piping and tubing, and you're trying to visualize how a new system would fit in amongst all of the existing infrastructure. How do you maintain the new equipment and remove it? Being able to do that without having to have special lighting conditions will be key."

Barriers to adoption remain

Other research is under way that could incorporate gaming-style motion control and eye tracking into business applications. Even further out is the work being done on computers that could potentially respond to human brainwaves (see "Computers that Know What's on Your Mind," on the previous page).

Oliver says there is also work under way to improve navigation within virtual environments like CAVEs.

"One of the hardest things to simulate is ambulatory capability, the idea of walking around a facility," he says. "If you are in a CAVE, you can walk in a square, but if you're designing a building, you want to keep going to the next room."

There are methods being developed to allow that type of motion—using omni-directional treadmills, for example.

But even for the technology currently available, hardware complexity and cost have kept many new interfaces out of the mainstream.

"The visualization systems are still costly," the NIAR's Toledo says. "That cost has dropped in the past few years, but it's still high enough to be a barrier."

The most likely technologies to gain ground in design are touchscreen/multi-touch systems, as well as more streamlined HMDs and other VR tools that can be used for prototyping and simulations.

The bottom line is that for any new interface to gain acceptance, there has to be a clear productivity benefit, the ability to enable new applications, or both.

CyberGlove Systems' products include support for a number of CAD applications.

"The ability to use design data in other contexts is a great thing," DS SolidWorks' O'Malley says. "People who buy CAD systems spend more money on their data than on their CAD software. If that data can be accessed through other devices, then rather than being locked up for the designers, it could be used for other things like marketing or assembly."

Of course, without a clear business case, some exotic new interface devices will remain on the toy shelf rather than the digital toolbox.

"Some things look really cool, but they are not financially viable," Brown adds. "They may look great, but they're a solution waiting for a problem." **DE**

Brian Albright *is a freelance journalist based in Columbus, OH. He is the former managing editor of* Frontline Solutions *magazine, and has been writing about technology topics for 14 years.*

INFO ➔ **Canon:** canon.com

➔ **CyberGlove Systems:** cyberglovesystems.com

➔ **NIAR Virtual Reality Center:** niar.twsu.edu/researchlabs/vr_overview.asp

➔ **NVIDIA:** nvidia.com

➔ **PTC:** ptc.com

➔ **RealD:** reald.com

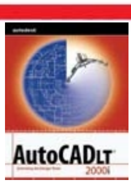
➔ **Siemens:** plm.automation.siemens.com

➔ **SolidWorks:** solidworks.com

➔ **VRAC:** vrac.iastate.edu

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

2000



Autodesk releases AutoCAD 2000i, the first Web-enabled CAD software.

2000

Intel launches Pentium 4 processor with 42 million transistors.

2000

Z Corp. launches Z402C a full-color 3D printer.

The Future of Green

Designers are increasingly being asked to take into account everything about their products, from the origins of the raw materials to the carbon released in their manufacture.

BY MARK CLARKSON

There is no such thing as a green product, asserts Sustainable Minds' CEO Terry Swack. "All products use materials and energy, and create waste. The best we can do is make products 'greener.'"

It's natural to think of green design in terms of end-of-life recycling, or maybe the use of recycled materials, but it goes a little deeper than that. To make products greener, designers must become eco-designers, paying particular attention to the environmental impact of a product throughout its entire lifecycle—from procurement through manufacturing, use and disposal.

Eco-design is bound with life cycle analysis (LCA), which attempts to compute what a product's environmental impact is in all its manifestations, from the discharge of toxic chemicals through to noise, vibration and social disruptions. The problem is, LCAs can be difficult, costly and time-consuming. They require plenty of obscure scientific expertise, and are somewhat ambiguous.

If you want to calculate the environmental impact of your product, you have to know where the parts and materials come from and what, exactly, is in them. You also need to know:

- how—and where—everything will be manufactured;
- how much electricity and water the processes use;
- how much pollution (and what types) is released;
- how and where the product will be used;
- how it will be packaged for shipment;
- how it will be transported, and
- what will become of that packaging once the customer unwraps it.

We haven't even gotten to the product's actual use phase, let alone what happens to it at the end of its life.

You might also want to add in any special tariffs your products will incur based on the materials they're made from and packaged in, and make special note of upcoming changes to pertinent government regulations.

That's a lot to ask of a designer who already has to worry about cost, strength, durability, safety and a thousand details inherent in their particular business and manufacturing processes—all the while trying to design a sexy new toothbrush.

2000 — **Knovel founded.**

2000 — **Dassault Systèmes acquires Spatial Technology and ACIS.**

2001 — **Intel ships Itanium processor for workstations and servers.**

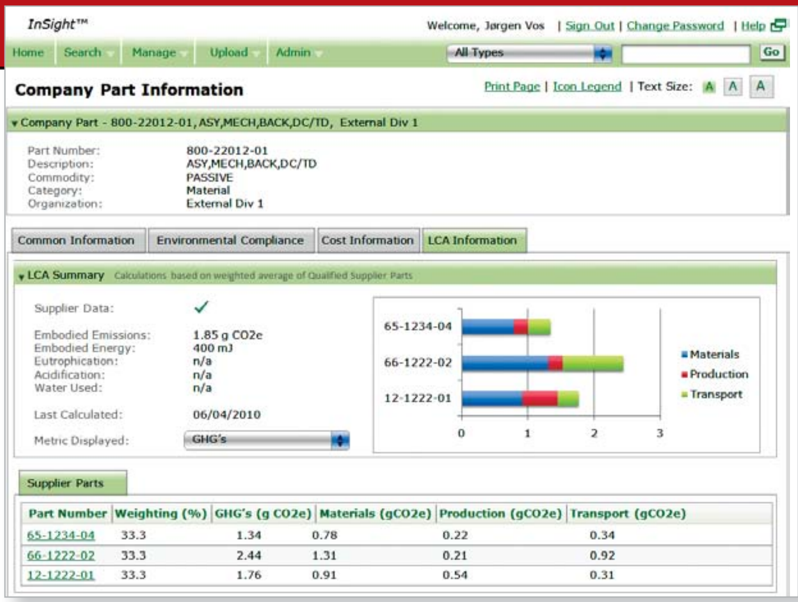
Time to Move up Front

Of course, software already exists that could help out, but it is mostly employed by management and special costing engineers. The results haven't been visible to the designer.

"Frequently, individual contributors go through the product development process largely unaware of how their decisions impact key performance criteria that ultimately determine the success of the product when it hits the field," says Howard Heppelmann, vice president of Product Analytics solutions for PTC.

In addition, analyses that are done are often done too late, he says.

"Most companies today are measuring and monitoring these activities once they get into production," he adds. "The designer finishes the design and passes it over the wall, and then somebody analyzes the production [bill of material, or BOM] for REACH compliance, or carbon footprint. That process needs to happen up front. Rather than managing risk once a product is designed and released into production, prevent risk."



The life cycle analysis summary of an assembly, generated by PTC InSight, shows the estimated embodied energy and emissions.

Everybody's Doing It

Moving LCA up front requires that designers and engineers have access to LCA tools as they're designing. And those tools are indeed appearing. In fact, LCA capability is becoming common in design software. Consider what are probably the Top three on the desktop: PTC, Autodesk and SolidWorks.

PTC, for example, acquired Planet Metrics (and its Rapid Carbon Modeling program) in January 2010. Planet Metrics adds LCA capability to the PTC's existing Product Analytics software, InSight, allowing designers to model the environmental cost of their product—carbon dioxide emissions, water used, etc.—along with its capital costs.

Autodesk has been in a special strategic relationship with the previously mentioned Sustainable Minds since late 2008. Sustainable Minds provides a Web-based LCA application that reads your BOM. With a little help, it models your product's environmental impact—complete with an Okala number (a measure of environmental impact derived from the Okala LCA methodology) and an assortment of graphs and tables that deconstruct your product's environmental impact.

Autodesk and materials information technology company, Granta Design Ltd., recently announced a new partnership, combining Autodesk's digital prototyping vision with Granta's materials information and eco design technology to help enable sustainable product design. The companies are co-developing software that will integrate Granta's eco design methods into Autodesk software, helping designers estimate the environmental impact of a product and make more sustainable design decisions.

With SolidWorks 2010, Dassault Systèmes incorporates SustainabilityXpress, the light version of its Sustainability LCA modeler, directly into the SolidWorks application. Sustainability evaluates the environmental impact of parts and assemblies (Xpress only works on parts) and displays the results in four simple numbers: carbon emissions, energy consumed, and air and water pollution. Accompanying pie charts break down each metric into material, manufacturing, region of use and end of life.

Each of these applications allows you to evaluate, in some way, the environmental impact of your product while you're still in the design stage. They also allow you to try different materials and manufacturing processes, to really dig down into your design and compare your options before actually committing to anything. It's often the case that 80% of your opportunity to improve rests in 20% of your components. Even a very basic

2001

Unigraphics changes its name to UGS.

UGS The PLM Company

2001

think3 announces GSM (global shape modeling), allowing push-pull editing of NURBS surfaces.

2001

Microsoft launches Windows XP.

CASE IN POINT: NUCOR STEEL

Nucor Steel Marion, Inc., of Marion, OH, melts and recycles scrap steel into new steel parts. Doing it right is a finicky process. You must carefully regulate the amount of energy based on the amount of scrap steel being melted. Overestimate the amount of steel going in, and you'll use too much energy and overheat your batch. Overheat the batch, and the resulting new steel won't be of acceptable quality.

When Nucor built a new reactor, it used National Instruments' LabVIEW software and Compact FieldPoint hardware to create a new scale. The device lets the team know exactly how much steel they're putting in, and how much electricity they'll need to cook it properly.

They can also now change voltage based on operator input using the software and field-programmable gate arrays without having to first take the load off the reactor. This eliminates the fluctuations in power that previously caused problems within the plant.

Nucor has also gained the ability to monitor and record the process in real time, allowing the team to react much more quickly to changing conditions. The end result is they're making a better product by using less energy, producing less waste and saving more money.

LCA will identify which 20% this is. You can focus your efforts where they'll do the most good, looking for alternative materials and processes for the most problematic components.

Mountains of Data

These applications rely on one or more huge databases of relevant life cycle data to perform their LCAs. There are several, but the largest is maintained and licensed by ecoinvent Centre of Switzerland, which has thousands of datasets on everything from metals processing to waste treatment.

Beyond that, each application works its own magic to transform your product's relationship to that mountain range of data into a few numbers and some easy-to-read graphics. The problem of reducing so much data to a few numbers is prodigious. And, it can be argued, it's oversimplified and misleading to do so.

On the other hand, there's a limit to how much data a product designer can process. It's important to be able to see, at a glance, the difference in environmental impact between an aluminum part and a plastic one, for example. But it's also important not to lose track of other important targets—consumers are generally unwilling to pay more for a product just because it's green.

"Designers need to be able to see across dimensions, and have some visual indicators of how a decision in one area complements or contradicts a desired outcome in other, equally important areas," says Heppelmann. " If someone has myopia toward only improving the carbon footprint, there's a chance they're going to veer off target on other things like cost, reliability or safety."

Compliance

There are a lot of reasons to go green: It looks good to your customers; your company gets credit for innovating and becoming more sustainable; and such deep analysis of your product's life will probably lead to cost savings. And if that those reasons aren't good enough, well, you've probably got no choice. Your customers and their governments may demand it. Companies have legal obligations to make sure they're managing the presence of toxic substances in their products. Failure to comply can cost you customers or even get you banned from the marketplace.

So since you probably don't have a choice, why not take this opportunity to make the world a better place? After all, there's an app for that. **DE**

Contributing Editor **Mark Clarkson** *is DE's expert in visualization, computer animation, and graphics. His newest book is "Photoshop Elements by Example." Visit him on the web at markclarkson.com or send e-mail about this article to DE-Editors@deskeng.com.*

INFO ➜ **Autodesk, Inc.:** usa.autodesk.com

➜ **ecoinvent Centre:** ecoinvent.ch

➜ **National Instruments:** ni.com

➜ **PTC:** ptc.com

➜ **SolidWorks:** solidworks.com

➜ **Sustainable Minds:** sustainableminds.com

2002

Hyper-Threading technology introduced by Intel.

2002

PTC launches Windchill and Pro/E Wildfire.

Windchill

2002

Microsoft introduces its tablet PC interface.

What's Missing in Analysis-Driven Design

Intel and the ISV community are working to close the gap in analysis driven design.

BY PETER VARHOL

Analysis and simulation in the product design process has been the domain of specialized experts since its beginning in the mid-1950s. While many design teams engage analysis and simulation, there is typically someone on the team with the expertise to set up the problem and analyze results. For smaller teams or individual engineering designers, these useful but complicated design procedures have often been out of reach.

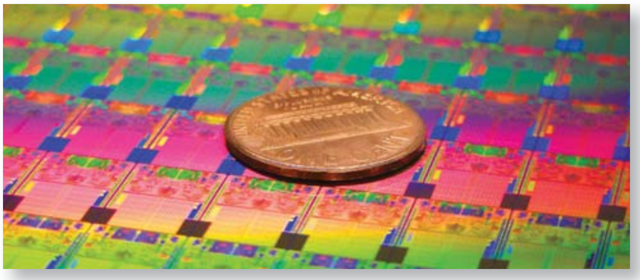
A large part of the problem is that software products supporting simulation and design have remained limited and difficult to use. Until recently, most required a deep level of understanding of the parameters used to set up the problem, and the ability to take numerical results and translate them to product characteristics.

The difficulty in creating analyses and interpreting results mean that products are being over-engineered as a precaution against failure, or are going through multiple physical prototype phases to meet requirements or iron out flaws. In either case, the result is increased costs and longer design cycles, which ultimately make the product less competitive than it could be.

A Revolution of Engineering Software

What is changing is the software. It's getting better, faster, more comprehensive, and easier to use. Software vendors such as ANSYS, Siemens PLM, SolidWorks, Autodesk, and others are focused on making digital analysis and simulation in design and manufacturing both easier to use and more affordable. They are democratizing the tools needed to perform sophisticated design engineering and they are helping small and medium businesses harvest the results from simulation based design.

Software vendors are able to achieve these goals thanks in large part to the increased power and capability of engineering workstations based on industry-standard processors. With the 64-bit Intel® Xeon®5600-series processor, systems have up to two processors, each supporting 6 computational cores and 12 computing threads. These processors, combined with recent software advancements, make it possible for engineers and designers to create, test and modify their ideas in near real-time. These workstations and work group clusters deliver the compute capacity of high-performance computers that were only available in the data center or on a supercomputer just a few years ago. What once took a rack of expensive RISC-based processors 15 minutes to solve can now be solved in less than 12 minutes on a much less expensive dual processor workstation that fits under a desk.



Intel's 300mm 45nm wafers like the one shown here are used to make it's newest dual and quad-core processors that are made up of hundreds of millions of the company's new 45nm transistors with Hafnium-based high-k metal gate silicon technology.

For complex and highly detailed analyses and simulations, server clusters can be employed to speed up computations further. Clusters can draw computing power from systems utilizing high-speed networking to create supercomputer-like performance. Because many high-end servers use Intel Xeon processors, Intel has an interest in ensuring that hardware from different vendors scales up well, and works with both components and software. Developed in conjunction with hardware and software partners, Intel Cluster Ready (ICR) systems let engineering design groups match engineering design applications to today's leading platforms and components. ICR systems include servers from Appro, Dell, SGI, and Super Micro, among others, and high-speed networking from a variety of network hardware providers.

Better, Faster, Cheaper Becomes a Reality

The combination of sophisticated and easy to use analysis and simulation software with the compute performance of Intel processors and Intel-based workstations delivers better and faster engineering processes at a significantly lower cost than in the past. Dynamic analysis and simulation are now engineering tools that are ready to be used on a wider range of products than before.

For straightforward designs, the combination of sophisticated but highly usable software with the power of today's intelligent workstations closes the gap in analysis-driven design. DE

INFO → Intel Corp: intel.com/go/workstation

→ intel.com/go/hpc

→ intel.com/go/cluster

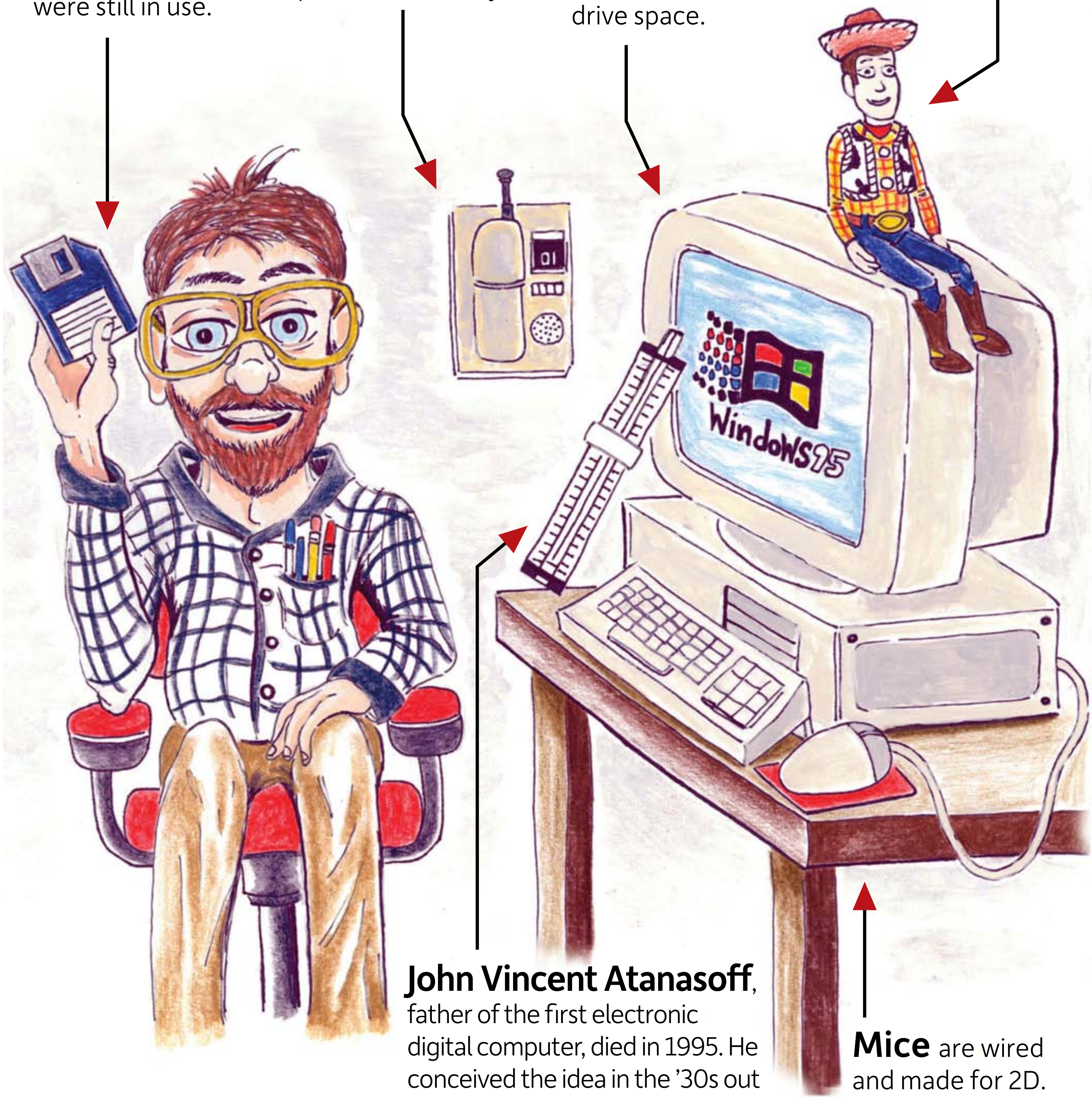
Engineers Then ...

3.5-in. floppy disks, capable of holding 1.44MB, were still in use.

CDMA cell phone systems were introduced, but the phones were larger than typical wall phones of the day.

Microsoft's Windows 95 ran on a *recommended* Intel 80486 or compatible system with 8MB of RAM and 120MB of hard drive space.

Toy Story, the first completely computer-generated movie, is released.



John Vincent Atanasoff, father of the first electronic digital computer, died in 1995. He conceived the idea in the '30s out of frustration with his slide rule.

Mice are wired and made for 2D.

and Now

Mobile workstations, capable of running Windows 7 with Intel i7-980X Extreme or Xeon processors, 24GB of RAM and 3.25TB of storage are capable of running today's most advanced engineering software.

Peripherals, such as 3D mice, allow design engineers to work more efficiently. Engineers can even create prototypes on desktop 3D printers today.

Smart phones have 1GHz processors, 512MB of RAM and 32GB of storage, multiple cameras, WiFi, GPS radios ... and they can make phone calls.

512GB flash drives are available, but expensive. Solid-state drives are being used in smart phones and computers.

Tablet computers hit the mainstream, with Apple selling 1 million iPads in 28 days and traditional engineering software makers releasing tablet apps.

ILLUSTRATIONS BY ERIC PETERSON

CAD's Come a Long Way

How we got to where we are, and where are we headed.

BY DAVID COHN

While they may seem new to some, many of the computer-aided design programs we use today have been around for more than a decade, and virtually all trace their lineage to work begun more than 50 years ago.

Modern engineering design and drafting can be traced back to the development of descriptive geometry in the 16th and 17th centuries. Drafting methods improved with the introduction of drafting machines, but the creation of engineering drawings changed very little until after World War II.

During the war, considerable work was done in the development of real-time computing, particularly at MIT, and by the 1950s there were dozens of people working on numerical control of machine tools and automating engineering design. But it's the work of two people in particular—Patrick Hanratty and Ivan Sutherland—who are largely credited with setting the stage for what we know today as CAD.

The Calma Digitizer workstation, introduced in 1965, allowed coordinate data to be entered and turned into computer-readable data.
Image courtesy of David Weisberg.

The Fathers of CAD

Hanratty is widely credited as "the Father of CADD/CAM." In 1957, while working at GE, he developed PRONTO (Program for Numerical Tooling Operations), the first commercial CNC programming system. Five years later, Sutherland presented his Ph.D. thesis at MIT titled "Sketchpad, A Man-Machine Graphical Communication System." Among its features, the first graphical user interface, using a light pen to manipulate objects displayed on a CRT.

The 1960s brought other developments, including the first digitizer (from Auto-trol) and DAC-1, the first production interactive graphics manufacturing system. By the end of the decade, a number of companies were founded to commercialize their fledgling CAD programs, including SDRC, Evans & Sutherland, Applicon, Computervision, and M&S Computing.

By the 1970s, research had moved from 2D to 3D. Major milestones included the work of Ken Versprille, whose invention of NURBS for his Ph.D. thesis formed the basis of modern 3D curve and surface modeling, and the development by Alan Grayer, Charles Lang, and Ian Braid of the PADL (Part and Assembly Description Language) solid modeler.

With the emergence of UNIX workstations in the early '80s, commercial CAD systems like CATIA and others began showing up in aerospace, automotive, and other industries. But it was the introduction of the first IBM PC in 1981 that set the stage for the large-scale adoption of CAD. The following year, a group of programmers formed Autodesk, and in 1983 released AutoCAD, the first significant CAD program for the IBM PC.

The CAD Revolution

AutoCAD marked a huge milestone in the evolution of CAD. Its developers set out to deliver 80% of the functionality of the other

2002 — **ZWCAD 1.0 released.**

2002 — **3D PLM Software Solutions Ltd. launched as a joint venture between Geometric and Dassault Systèmes.**

2002 — **Autodesk acquires Revit.**


CD-adapco
Engineering Success
CD-adapco enables innovation and reduces engineering time and cost.
"For over 30 years CD-adapco has been dedicated to engineering success. Our purpose is to provide software and services that ensure the success of our customers through the use of engineering simulation."
STEVE MACDONALD, PRESIDENT & CO-FOUNDER, CD-adapco
• STAR-CCM+ • STAR-CD • Engineering Services • Dedicated Support
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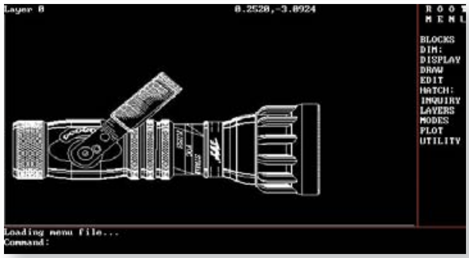
CD-adapco
www.cd-adapco.com

CAD programs of the day, for 20% of their cost. From then on, increasingly advanced drafting and engineering functionality became more affordable. But it was still largely 2D.

That changed in 1987 with the release of Pro/ENGINEER, a CAD program based on solid geometry and feature-based parametric techniques for defining parts and assemblies. It ran on UNIX workstations—PCs of the time were simply not powerful enough—but it was a game changer. The later years of the decade saw the release of several 3D modeling kernels, most notably ACIS and Parasolids, which would form the basis for other history-based parametric CAD programs.



The famous AutoCAD sample nozzle drawing was created by Don Strimbu with AutoCAD 2.18. ***Image courtesy of Shaan Hurley.***

By the 1990s, the PC was capable of the computations required by 3D CAD. In 1995, when the first issue of *Desktop Engineering* was published, SolidWorks was released. It was the first significant solid modeler for Windows. This was followed by Solid Edge, Inventor, and others. The decade also saw many of the original CAD developers from the 1960s acquired by newer companies and a consolidation of the industry into four main players—Autodesk, Dassault Systèmes (which acquired SolidWorks in 1997), PTC, and UGS (now Siemens PLM)—along with a host of smaller developers.

CAD Today, CAD Tomorrow

The modern CAD era has been marked by improvements in modeling, incorporation of analysis, and management of the products we create, from conception and engineering to manufacturing, sales, and maintenance (what has become known as PLM, product lifecycle management). But what of the world of tomorrow?

"Engineers and designers are being asked to create more, faster, and with higher quality," says Bill McClure, vice president of product development at Siemens PLM. He notes that CAD really hasn't changed much beyond adding more features and updating the user interface. "We need a new way of working to keep up with demands," he says. Siemens' synchronous technology "was developed to address this trend, as it combines the precision and control of feature-based design with the speed and flexibility of explicit modeling. The result is designers spend less time planning a model's construction, less time waiting for design changes, and less time remodeling imported or customer data for new uses."

PTC is taking a similar approach with the recent announcement of its Project Lightning, which was revealed as Creo in October.

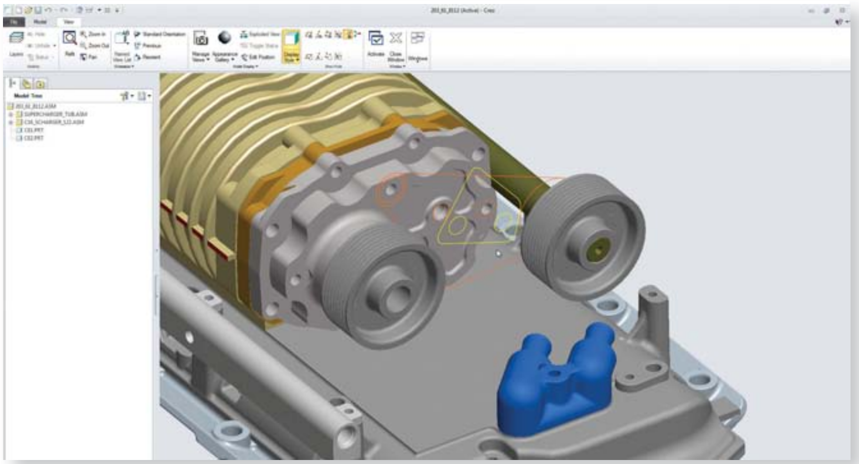
Brian Shepherd, executive vice president of product development at PTC, described Creo as "PTC's answer to this question about the next 20 years of CAD," and claims it will solve ease-of-use, interoperability, and assembly management problems with CAD.

2002

Stratasys introduces Dimension modeler

2003

ESI Group acquires EASi's CAE simulation design and control software environments.



PTC Creo, the company's new product line scheduled for 2011, will deliver task-specific applets (2D design, 3D parametric design, rendering, analysis, and more), an approach that's closer to Apple iPad and iPhone applications than to traditional CAD.

"Almost all CAD revenue has been through parametric modelers, following the paradigm that Pro/E invented," he says. But parametric modeling is an abstract approach for creating geometry. "You build a recipe and then the recipe creates the geometry. Direct modeling is much easier for people to understand," says Shepherd. "We think the right answer is a blend of parametrics and explicit modeling."

Creo promises to do just that by releasing a series of apps that allow users to design in 2D, 3D direct or 3D parametric modes, with the data updated and reusable in any of those modes. It also offers different user interfaces for different kinds of users, and promises to allow users to incorporate data from any CAD system.

"The feature-based paradigm will not get us to the next level," says Mike Payne. "Something like direct modeling is needed to attract a larger audience to CAD." And Payne should know. Over the years, he has been vice president of development at PTC, was a co-founder of SolidWorks, CTO of Dassault Systèmes, CEO of Spatial Corp., and co-founder and former CEO of SpaceClaim.

Robert "Buzz" Kross, senior vice president of the Manufacturing Industry Group at Autodesk, sees three technologies that will have the greatest impact on the future of CAD: "new, very friendly, very interactive interfaces, embedded simulation, and the cloud." The first, he explained, will attract new users and will support faster design iterations. Embedded simulations will enable users to analyze design data as they model, so that "designers will immediately know the result of any change before they commit to it." And the cloud, "will deliver immense compute power to everyone's device, even mobile devices."

2003

Intel ships its 1 billionth processor.

2003

Microsoft launches Windows Server 2003 and Windows Mobile.

The Mac and Low-Cost CAD

With Autodesk's recent release of a native Macintosh version of AutoCAD 2011, the Mac might be poised to gain market share as a technical workstation. Not surprisingly, Kross is enthusiastic. "Looking at the demographics of users, I see lots of Mac growth." But others are more cautious.

"Microsoft Windows still maintains over 90% market share of the client operating systems," says McClure. "Until this changes, native versions of CAD programs on other platforms will be interesting for some users, but will not represent a significant market share opportunity." He notes that the cost to develop and support multiple hardware platforms is daunting.

"There's no economy of scale in developing multi-platform applications," says Alibre Chairman and CEO, Paul Grayson.

Will low-cost CAD software take a bite out of the big companies' market share? It depends on who you ask. Grayson says it's already happening, while Payne notes that was what AutoCAD did in '83. "Once AutoCAD could do everything that the expensive systems could do, the game was over," he says. "The volume guy wins. Everyone knows that except big CAD companies."

But it appears that the "big" CAD companies have learned something. Shepherd says PTC's Creo will feature "role-based apps," with some of the company's new tools being "very low cost. Maybe free." But then he hedged, noting that the company needs to be able to fund innovation for its high-end users. For them, he says, "I think we're already at the price point that makes sense."

Even Mike Riddle, founder of Evolution Computing and a programmer instrumental in the earliest release of AutoCAD, doesn't see much viability in low-cost CAD. "When businesses start spending money on things like CAD after a recession, they start with low-cost CAD for the non-critical seats, but weaknesses in implementation and interoperability eventually drive businesses back to 'full-boat' systems—not for capability but for reliability."

Other Technologies to Watch

Utilizing the increasing number of CPU cores is essential to future implementations, while utilizing GPU cores will likely remain specialized. "Software that doesn't become massively multi-core in implementation will be left behind as our models become larger," notes Riddle. Yet McClure was quick to point out that "overall CAD performance is not limited by the CPU," and others concurred. Multi-threading provides great benefits for things like analysis and rendering, but most people want to see improved speed in geometry regeneration, which is fundamentally a serial process.

What about touch-based and gesture based interfaces? "Gestures will become more and more prevalent," says Kross. "Specific operations like pan, zoom, and rotate are particularly benefitted from touch-based interactions."

Kross sees touch as becoming mainstream, whereas McClure sees these technologies as "an excellent interface for handheld and tablet devices. However, it is not clear that the touch-based interface will have a big impact on engineering authoring applications." He notes that CAD generally requires high levels of precision and "touch-based gesturing has not proven to allow such precision."

Both McClure and Shepherd questioned the viability of working at an engineering workstation for long hours with arms extended to work at a touch-based display.

So other than these emerging technologies, has CAD become mature? "There is no such thing as a lack of ability to innovate for any design tool," says Riddle. "A mature technology is another way of saying that the current approach has been fully developed."

Are there any geometric forms we still can't model? "I think we can model virtually all shapes, but it is still way too hard," says Kross. And according to Payne, "It's not so much a question of whether we can or cannot model everything. It is more a question of whether all users can or cannot model everything. The systems of today require an expert to even remember how he built the model. We must put the smarts in the software, instead of needing people to be Top Guns."

As for what waits on the horizon, perhaps the wildest speculation came from Grayson: "Direct human to machine interfaces. Imagine searching Google by thinking of a search phrase and having the answer appear in your short term memory, or manipulating 3D objects in your brain while a computer manipulates virtual representations of those objects on its display."

Is that something we'll find in CAD systems of the future? If we do, remember that you read it first here. **DE**

David Cohn *is a computer consultant and technical writer based in Bellingham, WA and has been working with and writing about CAD since 1984. He's the technical publishing manager with 4D Technologies/CAD Learning, a Contributing Editor to* Desktop Engineering *and 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 ➜ **Alibre:** alibre.com

➜ **Autodesk:** autodesk.com

➜ **DS SolidWorks:** solidworks.com

➜ **Evolution Computing:** fastcad.com

➜ **PTC:** ptc.com

➜ **Siemens PLM:** siemens.com/plm

➜ **SpaceClaim:** spaceclaim.com

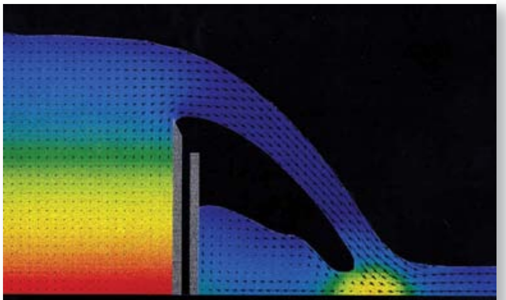
➜ **Spatial Corp.:** spatial.com

FEA and CFD: Getting Better All the Time

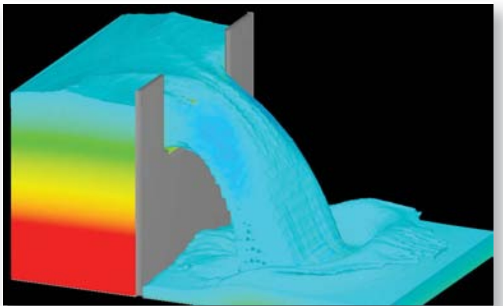
A 15-year perspective on growth in analysis software/hardware achievements.

BY PAMELA J. WATERMAN

What was your workspace like in 1995? Your PC probably ran on 640K of memory, your graphics displayed on a 15-inch CRT, and if you were lucky, your company let you upgrade from Windows 3.1 to Windows 95. But whether your focus was mechanical finite element analysis (FEA) or air or fluid computational fluid dynamics (CFD), you mostly did your "real" work on a workstation, mainframe or distant networked Cray. A mesh of 50,000 elements was state-of-the-art, and CFD was pretty much the realm of Ph.D.s.



Simulation of water flowing over a weir (a low overflow dam) performed with a 1993 version of Flow Science FLOW-3D CFD software. *Images courtesy Flow Science.*



CFD simulation of water flowing through a sluice in a weir, done with the 2010 version of Flow Science FLOW-3D software. More detail is now included in the model and the results.

The early 1970s and entire 1980s saw the birth and initial development of dozens of today's well-respected analysis software packages. However, the mid-1990s witnessed explosive growth as the personal computer's processing power, cache memory and graphics capabilities freed software developers from many computational bottlenecks.

FEA, Then and Now

Civil engineers led the way to developing FEAs. In the early 1940s, Richard Courant and Alexander Hrennikoff proposed two ways to discretize a continuous physical domain into subregions (finite elements, or FEs), approximating solutions to the complex partial differential equations (PDEs) defining mechanical vibration behavior.

By the mid-1950s, Ray Clough at UC Berkeley had coined the term "finite elements," and co-authored a paper establishing a broader definition of FEs to model stiffness and deflection of complex structures. Aeronautical applications for FEA in the '60s and '70s expanded the algorithms to include beams, plates and shells, and NASA funded the development of what became NASTRAN code, as both linear and non-linear algorithms emerged.

Although the first general-use PCs came out in 1985, desktop FEA applications were severely limited by both processing speed and RAM, a situation that persisted until

2003

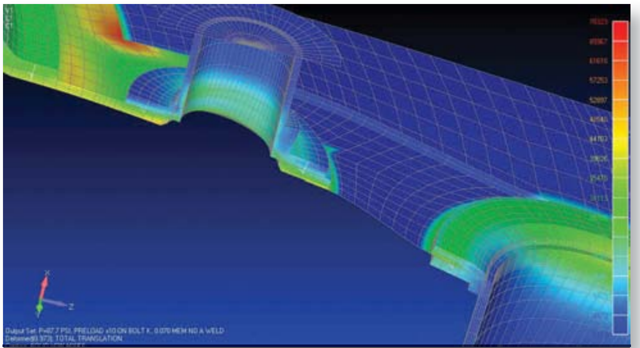
AMD releases Opteron processor for servers.

2003

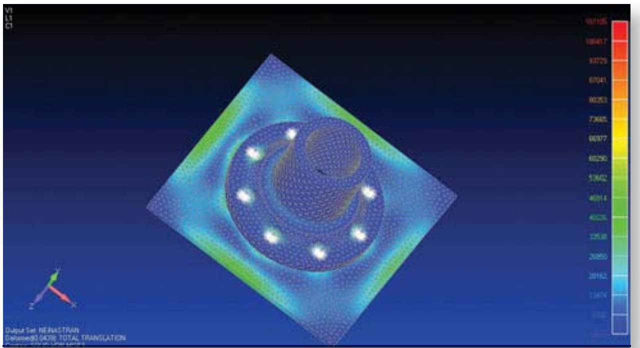
PTC releases Pro/ENGINEER WildFire.

2003

ESI Group acquires CFD Research Corporation's product division.



A typical structural mesh (c. 1990) generated by manually extruding elements in PATRAN 2.2. The bolted contact between parts in the assembly was created using bar/rod/spring elements and bolt-preload was created using a manually iterative process. This model took several weeks to complete and hours to run. *Images courtesy NEi Software.*



Today, a similar model of a fitting bolted to a pressure-vessel wall takes a few hours to build and minutes to solve using Siemens PLM Software's Femap with NEi Nastran. Meshing is done automatically and includes more detail of the geometry. Bolts with preload and true surface-to-surface contact were generated automatically and solved in a single linear static analysis.

the mid-1990s but also spurred software innovations. Major commercial players emerged in the field, developing software that produced meshes with 5,000 to 7,000 nodes. However, users still had to greatly simplify their models and make many load and material assumptions.

Expensive processing time, charged by the minute, inspired existing companies and newcomers to write FEA codes for desktop PCs. For example, Dave Weinberg, founder and president of NEi Software (formerly Noran Engineering), used his NASTRAN experience at McDonald Douglas to create a version that would run on PCs instead of "billable" workstations. The result was NEi Nastran. Its basic pieces were running by 1986, and really advanced in the mid-1990s as RAM expanded and processing speed increased.

By 2000, a 3D shell model that would have taken a month to prepare in the 1970s could be done in a few hours. Algorithms could now handle surface contacts, sliding contacts and extreme (plastic) deformations, plus flexible and composite material properties.

Robert Taylor, an FEA expert at SIMULIA who studied under Clough at Berkley, points out that two other areas of development proved critical to the advancement of these tools.

"The ability to have graphical editors and to start solving larger models with interacting parts brought a lot of benefits," he says. "We could visualize results all over the computer model, going beyond the limits of sensors on physical models."

At the same time, parallel processing became available to the general user, allowing the possibility of even larger and more non-linear models.

Perhaps most significantly in the past decade, automating mesh generation—a task which often took longer than the solution itself—expanded FEA beyond the non-analyst expert. Preprocessors became part of the software package, and post-processors also simplified understanding and sharing results.

Lastly, making the entire process less expensive and more user-friendly (without diminishing its accuracy) meant suppliers, consultants and small companies could tap the power of FEA.

The Evolution of FEA

Over the past 15 years, enhancements to FEA programs have appeared so continuously it's hard to keep track of results. Multiphysics applications have expanded far beyond the first fluid-structural interactions. Enormous increases in memory and processing power support analyzing models with more

2003

National Instruments introduces NI CompactRIO.

2004

2004 Dantec Dynamics introduces FlowMatch.

2004

Oracle acquires PeopleSoft.

NAFEMS AS VISIONARY

What group has its finger on the future of both FEA and CFD analyses? That would be NAFEMS, the international organization dedicated to promoting the effective use of engineering simulation methods such as finite element analysis, multibody system dynamics and computational fluid dynamics. Check out NAFEMS.org for its publication list and the activities of its technical and regional groups to find like-minded people shaping the future of analysis and simulation.

than a million degrees of freedom. And today's computers even handle the explicit dynamics of relatively long-term events—as well as those taking place in milliseconds.

The variety and sophistication of element types has also greatly enhanced model fidelity. In fact, each of these improvements has helped skeptical engineers accept the value and validity of computer-based mechanical analyses to the point where industries such as the medical device world are moving to certification by simulation, a concept unheard of 20 years ago.

However, engineers being engineers, we know we're never satisfied. Running codes on parallel processors is still tricky (do you get the same answer if you run it on one CPU or two?), and I/O bottlenecks still slow down the fastest solvers. In other words, there's plenty of room for innovation.

Weinberg says he expects FEA will evolve to hide more of the internal computational complexities, so that users just input loads and conditions, yet obtain credible results. Taylor says he sees multiphysics expanding to include cyber-physical conditions, adding the effects of closed-loop software controllers into mechanical operations, and even getting down to the level of molecular dynamics as coupled to finite elements. He says he also believes that in the next decade, analysis and simulation in general will incorporate aspects of manufacturability and maintenance, allowing trade-off studies to cover a complete life-cycle analysis.

From Ancient Waterworks to Modern Fluid Flow

Fascination with moving fluids is a recurring theme throughout history, from the waterworks of ancient Rome to da Vinci's plans to cast his Horse statue from molten bronze. Mathematicians such as Bernoulli and Euler proposed fluid-flow equations that formed the basis of work done first by the Frenchman Claude Navier, and later by the Irishman George Stokes. The end result was the set of now-famous Navier-Stokes differential equations that are the basis of modern CFD.

Computers were the key to applying finite difference methods and finite volume methods for solving the closely coupled Navier-Stokes equations. The 1960s and '70s finally witnessed solutions in acceptable timeframes for these non-linear equations (defining fluid flow, heat and materials transport), and commercial CFD codes overtook the use of proprietary in-house solutions.

David Gosman, founder and vice-president of technology at CD-adapco, began working with computer-based CFD in the late '60s. He points out that working with Cartesian-coordinate-based geometry imposed great restrictions on accurate solutions. For example, any curved surface to be meshed could only be represented by a stair-step approximation. In 1987, CD-adapco developed tools to create body-fitted meshes, and by 1995, all CFD codes had been generalized in this way to handle different shapes of elements.

In the early days of personal computers, limited memory size also made it flatly impossible to work with highly detailed CAD geometry. Even as available RAM increased, Gosman found that management still preferred results from the traditional build-and-test approach. Eventually, the same improvements in memory, processing speed and user graphics that boosted FEA code usage tipped the scales to encourage more detailed, accurate and practical CFD analyses.

CFD: The '90s and Now

Aerospace and automotive engineers came to see CFD as a tool to thoroughly evaluate a wide variety of operating conditions impossible to test physically on complex designs. Still, many of the challenges with adopting CFD in the early 1990s were not directly connected to the analysis software itself.

For example, Gosman found that customers didn't like spending extensive time on three necessary tasks outside of the solver: CAD data "cleanup," meshing the model in

2004

EDS sells UGS PLM Solutions.

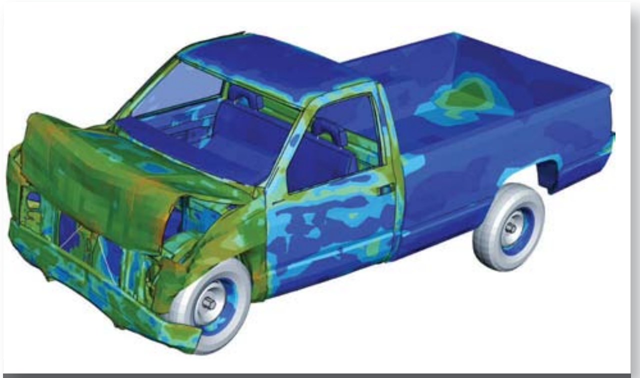
2005

CD-adapco launches STAR-CCM+.

2005

Z Corp. becomes a subsidiary of Contex.

Although Abaqus FEA software produced good-correlation component models in the early 1990s, automakers' full-body vehicle models were very coarse and used little FEA. *Image courtesy SIMULIA.*



Current Abaqus FEA models from Dassault Systèmes' SIMULIA can simulate full-body vehicle motion, crash, noise and vibration, rolling tires and crash dummies. *Image courtesy of FHWA/NHTSA National Crash Analysis Center.*

proper detail and post-processing steps such as report generation. Time spent on the actual analysis was generally a small part of the process.

The next improvement, then, was to integrate these tasks and do them automatically, which opened the analysis process up to the concept of optimization. Including an optimization function in the design process—for example, by coupling a CFD package to an optimization code such as SIMULIA's Isight—is very much a current growth area in this field.

As in the structural analysis world, multiphysics capabilities, whether in a single code or between well-communicating codes, are expanding throughout the CFD realm. Michael Barkhudarov, vice president of R&D at Flow Science, says hardware improvements, as well as advances in the capabilities of programming languages and software, have enabled developers to better couple FEA and CFD models. He notes that the new FSI capabilities have expanded to include such industrial processes as those found in micro-electro-mechanical systems (MEMS) and nanotechnology.

Whether one approaches multiphysics analysis by adding CFD capabilities to mechanical (FE) analysis or vice versa is still an open question. Either way, the analysis community must improve user education at both university and corporate levels to encourage using a coordinated set of tools.

CFD's Future

As Gosman so puts it, "the boundaries are not very porous" among today's typical CAD, FEA and CFD departments. "This (increased use) will happen, but not very quickly," he says—pointing out, however, that one encouraging movement is greater access to parallel clusters and cloud-computing resources.

In the next decade, increased automation will be the dominating factor as CFD analyses move deeply into the design world.

"With the increased time constraints and market pressures for developing new products, the demand for fast, accurate and easy-to-use simulation tools is higher than ever," Barkhudarov says. DE

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INFO → **CD-adapco:** CD-adapco.com

→ **Flow Science:** Flow3d.com

→ **NEi Software:** nenastran.com

→ **SIMULIA:** simulia.com

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2005 — **Dassault Systèmes acquires ABAQUS.**

2005 — **Graebert begins developing ARES.**

2005 — **IMSI's TurboCAD and TurboCAD 3D released for the Mac.**

Putting it all Together

Configuring the HP Z800 Workstation for ANSYS

Carefully configure workstations for optimum performance with ANSYS simulation software.

BY ANDREW PRIESTLEY

ANSYS software demands a great deal of a workstation, and can quickly overwhelm an insufficiently prepared computer. Key components that need to be addressed are the processors, memory, hard disks and graphics cards.

Choosing the Processors

Processor choice should be slanted heavily towards maximum performance, with dual sockets filled with six-core processors which take full advantage of the HP Z800 Workstation 3-channel memory capabilities. The on-die intelligent memory management capabilities of the latest selection of Intel® Xeon® X5600 and E5600 processors can make a big difference with ANSYS, especially when dealing with very large files. Users often select Intel Hyper-Threading Technology [1] capabilities, but performance benchmarks show that this choice is counterproductive, and actually slows down the performance. So more processing cores are desirable, but hyper threading is not[2].

Memory

Memory is the next key item, more memory is better. You should have more physical memory available than the largest file you can see yourself working with, and then add memory to account for the OS and other concurrently running applications. Then check HP’s memory configuration guidelines as you want to fill the slots in the method that gives the maximum performance configuration, balancing channels and processors without losing performance.

Storage

Next, after your memory choices have been made, you need to consider your hard drives. Spindle speed can be very important, so you’ll want to choose a drive(s) with a minimum speed of 10K rpm, and for best performance you may want to consider Solid State Disks.

Graphics Choices

Graphics cards are your final hardware configuration issue. You’ll want to choose a compatible mid- to high-range graphics card for good visualization, and you may want to consider the use of a graphics card to take advantage of the recently announced GPU-based acceleration of the ANSYS Mechanical solver. This selection can be critical, so check into benchmark data for the latest graphics cards performance info.

Tuning is critical

One thing that you can only get with HP, that makes all of these things work even better, is the HP Performance Advisor, a free utility that comes pre-installed on all HP workstations. It tunes and optimizes your workstation for maximum performance with the applications you use most, such as ANSYS. Even more important it monitors and displays system resource use, processors, memory, disks and even graphics usage so you can understand if you have any performance bottlenecks. Getting the best possible performance out of ANSYS requires a high performance workstation, and a bit of homework. You can find detail configuration guidelines on the HP website. **DE**

For more information on an HP and ANSYS Solutions please go to www.hp.com/go/solver or call 800-888-0261.

Powerful. Intelligent.

1. Intel HT Technology (HT) is designed to improve performance of multi-threaded software products and requires a computer system with a processor supporting HT and an HT-enabled chipset, BIOS, and operating system. Please contact your software provider to determine compatibility. Not all customers or software applications will benefit from the use of HT. See http://www.intel.com/info/hyperthreading for more information.
2. “Hyper-Threading data is based upon standard ANSYS benchmark tests run by HP Technical Marketing”.

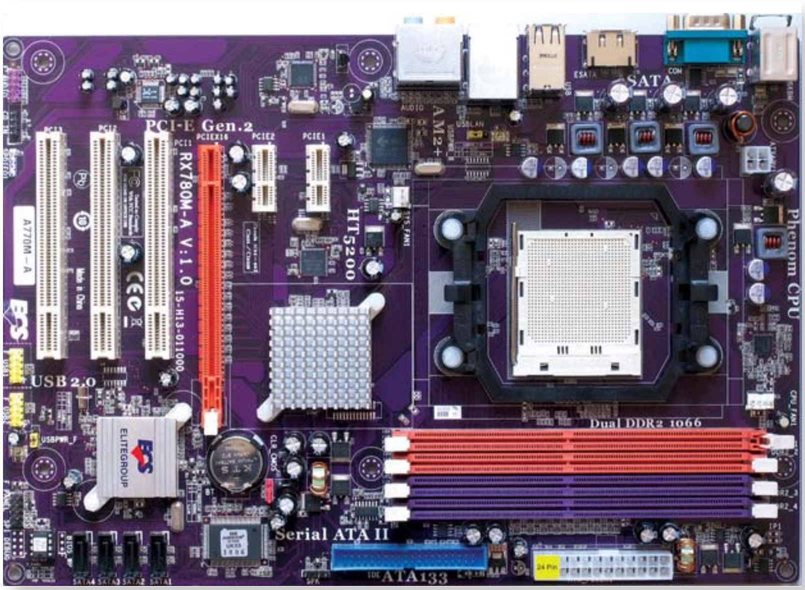
Data Center **Power** on the Desktop

We live in a Golden Age of design engineering on powerful desktop computers.

BY PETER VARHOL

Engineers always knew personal computers would become powerful enough to do serious design, modeling, analysis and development work. When Intel introduced the 32-bit, 80386 microprocessor in 1986, engineering software firms such as Autodesk raced to bring their products to PCs through extended DOS or one of the PC-compatible UNIX distributions.

Expense was a factor: Systems configured with the memory, graphics, processing power and disk storage to support modest engineering applications cost between $10,000 and $20,000—not including the software license. But even that cost was much better than the only slightly more powerful workstations and minicomputers from the likes of Digital, Apollo, Sun and HP. The era of desktop design engineering had begun.



Since its origin, the PC has incorporated an expansion bus that enables engineers to seamlessly combine graphics, networking, storage, and other peripherals.

The early 1990s heralded the origins of inexpensive desktop engineering computing. With the emergence of 32-bit operating systems like Microsoft Windows 95, running on Pentium processors, software had access to multitasking and virtual memory, which made it possible to run applications larger than the available physical memory.

The primary roadblock to faster software at this time became the bus speeds—the ability to get data from the peripheral to memory, disk to the memory, and from memory to the processor. To maintain PC compatibility, these busses ran at a sedate speed for far longer than was technologically feasible. Fortunately, advances in bus speeds eventually made it into the standard PC architecture, leading to memory bus speeds of more than 1GHz today.

Networking was another key innovation that brought desktop computing closer to engineers. Sun Microsystems (acquired by Oracle) was founded on the premise that “the network is the

2005

Geometric acquires TekSoft Inc.

2005

UGS acquires Tecnomatix.

2005

SpaceClaim is founded.

SPACECLAIM CORPORATION

computer," meaning that network resources made the desktop workstation (or X-Windows terminal) more powerful than the resources in a single box. PCs followed slowly, first with file server networks based primarily on Novell NetWare network software, then using Windows networking.

A third innovation was cache memory. Cache is used at several different stages of the execution pipeline—on the processor, on the disk controller, and on the graphics controller. Cache is fast memory that holds recently used code and data with the expectation that it will be used again soon. While that principle isn't universal, it is common enough so that cache greatly speeds up most applications. While the processor is much faster than memory, the bus from main memory to the processor slows it down, so having some memory adjacent to the processor makes it run more efficiently.

Last but not least, 64-bit processors have all but replaced 32-bit chips in all systems, and have been in engineering workstations for some time. Sixty-four bit processors have the potential to be faster, because they can carry more than one value per clock cycle. More importantly, they can address more memory than their 32-bit counterparts. They are able to work with much larger applications and data sets; 32-bit processors are generally limited to an application and data address space of between 2 and 3GB, an amount increasingly inadequate for engineering applications with large data sets or computations.

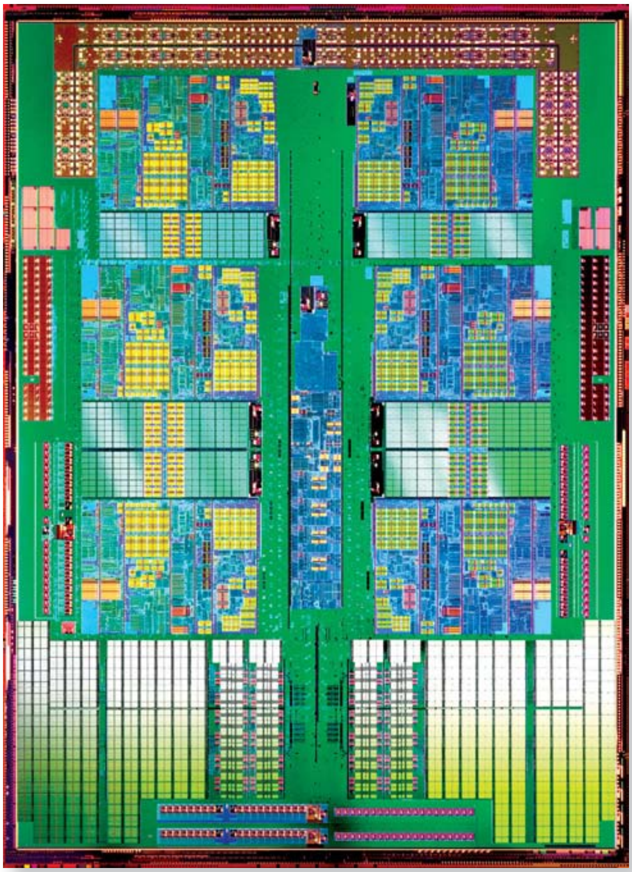
Where We Stand Today

These and other innovations have combined to produce engineering workstations under $5,000 that support full-featured design processes using a variety of software. These systems are using complex CPUs that consist of multiple individual processors, plus additional on-chip caches that provide the ability to keep multiple process threads directly on the chip.

Today, engineers have as much power at their deskside as they did in the data center five years ago—and on a supercomputer 10 years ago—at a fraction of the cost. Because that power is spread among multiple processors, multiple cores and multiple threads per core, high-end engineering analysis applications that are multi-threaded run very well.

For design engineers, there is additional capability in the form of special-purpose peripherals. Plotters and large-format printers make it possible to deliver output that accurately reflects the product being designed. Digitizers enable drawing draftsman style, or scanning from an existing diagram, and using that as a basis of a new design. In some designs, rapid prototyping inkjet devices are even capable of formulating a prototype from an on-system design.

The combination of inexpensive computing horsepower, large amounts of memory and storage, lifelike graphics, powerful applications and a growing array of sophisticated peripherals make the personal computing workstation a



Sixty-four bit processors, such as this six-core AMD Opteron, bring supercomputer-level performance to desktop engineering computations.

2006

Apple releases Intel-based Macs.

2006

Autodesk acquires Alias.

2006

ESI Group acquires branch of IPS International for digital simulation services in CAE.

staple for engineering work. Today's tools are inexpensive enough so that any engineer can do professional and sophisticated work with a relatively small investment.

But it will get even better.

On the Horizon

The most significant trend for future innovation is not increasing CPU horsepower, although that is certainly happening. Instead, it is the ability to leverage distant power with an increasingly diverse collection of devices—netbooks, tablets and even smartphones. Engineers won't create a design on a phone interface, but they can check on simulation data, kick off new simulations, and show designs to colleagues, among other things.

The emergence of graphics processing units (GPUs) as more of a general-purpose computational processor also promises to improve the performance of certain types of computations. For engineers requiring supercomputing-class computational power, GPUs such as the NVIDIA Tesla line have the potential to deliver far higher levels of computational power than conventional CPUs. Intel is also pursuing development work on GPU technology, with the intent of building GPU-type computation performance into its industry-standard CPUs.

Cloud computing will offer engineers more alternatives on how to work. Design software can run in the cloud, making it possible for engineers to access their designs and work anywhere with fast Internet access. They may also be able to work using other devices, such as tablet computers and smartphones, delivering a mobility that hasn't been available before.

More from an immediate standpoint, cloud computing will enable engineers to rent time on high-end applications they can't justify buying licenses to use on their own systems. Because systems in the cloud are often high-end servers, they are likely to offer better performance than the same software running on a desktop.

Special-purpose peripherals are also emerging to make designs easier to create and more realistic. Tablet computers in particular may be a boon for engineers who do measured drawings. Instead of drawing on a digitizing tablet and having the results appear on the computer monitor, for example, tablets such as the Wacom Cintiq let engineers draw on a tablet-like device monitor, just as they would on a sheet of paper.

3D mice, made by 3Dconnexion and others, are also changing how engineers interact with their computers. 3D mice provide the ability to manipulate a 3D drawing on the screen through all three axes, letting engineers pan, zoom and rotate the model or camera as if they are holding it in their hands. This approach is about as close as it is possible to get to actually touching the product being designed.

Only Time Will Tell

We cannot forget the fact that Moore's Law still holds, after a fashion. The popular interpretation says that processors are doubling in speed every 18 months, and for a long time, that's pretty much what happened. It still is, and may continue to do so in the future, providing engineers with ever-faster systems for more comprehensive activities.

In time, engineers won't have to offload work to supercomputers or server clusters for high-end analysis or dynamic simulation. The vast majority of work will be done directly on the computer in front of them. For the diminishing amount of work beyond the scope of the desktop, the engineering workstation will serve as a portal to cloud systems that have the software or added horsepower for occasional needs. In effect, most engineers will end up having the equivalent of a supercomputer on their desks.

Of course, nothing about the future is guaranteed. Engineering computing could be poised for advances in an entirely different direction. But at the very least, computers, peripherals and software will be the engines that drive a continuing revolution in engineering design. **DE**

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INFO ➜ **3Dconnexion:** 3Dconnexion.com

➜ **Intel Corp.:** Intel.com

➜ **Microsoft:** Microsoft.com

➜ **NVIDIA:** Nvidia.com

➜ **Wacom:** Wacom.com

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2006

IMSI/Design LLC created to continue development and marketing of TurboCAD.

2006

Punch Software acquires CADSoft Solutions.

2006

PTC acquires Mathsoft.

Sensor Systems Advance

Better sensors and embedded systems development tools enable better design. That trend has brought us far, and it will continue. Here's why, and how.

BY BARBARA G. GOODE

Dramatic. That word describes not only the evolution of sensor and embedded systems technologies over the past 15 years, but also the impact that this evolution is having on design engineering. Furthermore, it characterizes the influence that current and imminent developments pose for the future of design.

The growth of sensors and embedded systems technologies "is nothing short of amazing," says Tom Ales, a Kimberly-Clark Corp. research scientist. Fellow research scientist Shawn Sullivan concurs: "And this is just the tip of the iceberg."

Many Reasons for More Sensors

Smaller size and more modest power requirements, combined with improved reliability, greater capability and ease of use and better integration, add up to more sensor options for designers.

"Sensors are much smaller … and also more integrated," says Alex Gomez of Boston Engineering, whose company provides design engineering services for customers in a range of application areas. "In the past, you needed three accelerometers to measure in three dimensions. Now you can get all three in one package."

Fig. 1: The 657HT Isotron accelerometer—which senses acceleration in three directions and withstands temperatures to 347° F—is an example of the ability to pack increasing functionality and performance into the same small package.

An example of this is the Endevco Model 657HT Isotron triaxial accelerometer with low-impedance output. (See figure 1.) But according to Scott Mayo—who, as applications engineer for Meggitt Sensing Systems, supports the Endevco brand—this product represents another important advance: the ability to withstand extreme environmental conditions.

"Traditionally, this type of sensor has been limited to a maximum temperature of 248°F because of the electrical components," Mayo says. "Now, we are able to continuously operate at 347°F." The effort to push the boundaries on temperature is tied to the fact that jet and gas turbine engines can run efficiently at higher and higher temperatures, he explains. Mayo says that a lot of research continues to go into this effort, and into making sensors easier to mount, install and interface with.

Sullivan calls attention to the importance of the IEEE

2006

Z Corp. ships 3000th 3D printer.

2006

AMD acquires ATI.

2006

ANSYS acquires Fluent.

ANSYS

1451 standard, which had a goal of developing network- and vendor-independent sensor interfaces. The effect of this, according to Jamie Smith, director of industrial and embedded product marketing for National Instruments, is that because components can work together more cleanly, people doing monitoring and control "can take off-the-shelf components and integrate them into a system with easy-to-use software."

This, Smith says, "is all driven by advances by sensor and semiconductor companies for consumer and general-purpose applications." As an example, he points to video game remotes, chock-a-block full of sensors and able to communicate with the game console in multiple ways. Designers of such systems, he notes, have taken advantage of small size, low cost and low power requirements.

Indeed, says Dan Spohn, regional sales manager for Kaman Precision Products, some sensors are actually decreasing in terms of features to reduce prices "enough to get selected for the next iToaster." (See Figure 2.)

Smith says the iPhone is a good example of a device that incorporates multiple sensors, including haptics controls, "that would never have been possible 15 years ago."

Gomez characterizes the effect of these developments as a "luxury"—meaning he can afford to add more sensors to a design than he otherwise would. In addition, he adds, sensors have improved in terms of reliability. Many incorporate controllers, communications and various peripherals on board (think system on a chip), and can regulate their own power. In fact, some can even supply their own power. These characteristics allow civil structures to reap the benefits provided by low-power sensors placed under the pavement of roads, or embedded into the concrete in bridges, to detect properties such as vibration and strain.

"Scientists and engineers are measuring more and more parameters—because they can," Smith says.

Mayo agrees. "Engineers are starting to realize that the more information they have, the better the view they have of operations," he says, noting that massive system failures—he uses the example of the space shuttle—can prompt a move to add more sensors to gather additional information. Embedding sensors into the wing of the craft enabled better-informed decisions, he says. In this case, the cost of the sensor was not the driving issue, and neither was the novelty of the technology, which actually wasn't new. It's just that nobody had previously considered the sensor for that specific use, but once they did, it seemed a worthy addition.

Fig. 2: This "portable toaster-printer" is envisioned to download news from your computer and toast it into your breakfast. This finalist in the Electrolux Design Lab 2008 competition hints at the outcome enabled by inexpensive sensor options. By adding in-demand features without adding cost, manufacturers can keep ahead of the competition.

Easy does it

Smith says engineers are adding sensors not only because they can, but "because doing so is easier, with automated measurements triggered by smart software."

Spohn agrees. "The cost of implementing an embedded system design has decreased, which has opened up the potential to apply embedded systems into more—and less costly—products," he adds. "The competition is fierce in the lower-priced products, so a small edge like an additional feature can be the key to a large market share."

Part of the reason the implementation cost has decreased is that embedded system design and programming is so much easier to accomplish.

"The tools for developing embedded systems are vastly

2007

PTC acquires CoCreate.

PTC

2007

2007 Siemens AG acquires UGS.

2007

Autodesk acquires PlassoTech.

PLASSO TECH

THE DIGITAL EFFECT, AND MORE

For applications such as robotics, in which weight is a critical factor, minimal wiring is just as important as miniature sensor size, says Boston Engineering's Alex Gomez. He mentions "1-wire"—a name trademarked by Maxim Integrated Products—as technology that allows him to avoid using a large wiring harness. The advance is dependent on digital operation.

Digital offers other advantages, too, says Gomez, including an improvement in accuracy. Whereas sensors once generated analog serial output, today's sensor output is digitized on the chip and goes directly to the controller, without the need for a converter. This means not only a cost savings as a result of fewer components (and simpler design), but also less noise, and less opportunity for data to become corrupted.

Another nice aspect of digital domain, says Gomez, is that you can plan for expansion. "It's never as easy as 'plug and play,'" he adds, but it's no longer such a big deal to add on, to supply more functionality with additional sensors.

improving," says Sullivan, who notes that even low-end CAD systems are offering embedded systems capabilities. He adds that verification systems are more powerful and accurate, and far more efficient.

"Fifteen years ago, a specialized software engineer was required to do the programming, and everything was done in assembly language," he says. "Now, even a junior engineer right out of college can do that."

Whereas prototyping and analog systems adjustment used to require a lot of effort, now it is easy and "not frightening for someone, even if they are not well-versed in embedded systems," Sullivan explains, adding that this fact "enables the use of more sensors."

Ales states that earlier in the decade, within just a couple of years, a number of low-cost kits ($200 or less) became available that opened embedded systems creation to the world. "People realized how easy it was to construct their own code," he says, adding that "reference designs exploded—whereas this had been very niche."

Everything—signal conditioning, calibration, error correction—became "so much easier, and it was a very short hurdle to learn the ins and outs," Sullivan says. Lego's Mindstorms has even brought embedded systems development to grade schools, he points out.

The trend of what National Instruments calls Moore's Law for Instrumentation and Control will continue, says Smith, because "the size and power of some measurement and control systems has dropped by greater than 90% over the last decade." Another trend that will continue is functionality enabled by wireless communications—game consoles with the ability to update their own firmware is just one example.

"We get a lot of requests for wireless," says Mayo.

The Future is Bright

In fact, wireless is an integral part of the future evolution of sensors and embedded systems—which touches everything from personal products to vast systems and structures.

For starters, says Gomez, "the home automation market seems ready to explode."

Sullivan agrees, noting that in general, home products fall into two categories:

- Essential needs—This includes medical devices and similar products, to help people in areas of disability.
- Richness—This includes interactive TVs, audio systems and similar devices that people can live without, but that help them to better enjoy their lives.

These two can overlap. For example, when a continuous glucose monitor flags your blood sugar as being too low, a popup reminder on the TV could suggest proper action. This kind of pervasive healthcare, paired with "smart home" capabilities (that also provide an alert when the stove is left on, for instance) promise to help people remain independent longer.

As an extension of this, Ales says further connectivity could allow people to wirelessly access their information—including, perhaps, health records—from wherever they are. The data cloud exchanges information with sensor-based systems to learn your routines and predict your needs.

2007 — **Intel announces new 45nm process technology.**

2007 — **Alibre 3D Publisher for Google SketchUp released.**

2007 — **Dassault Systèmes acquires Seemage.**

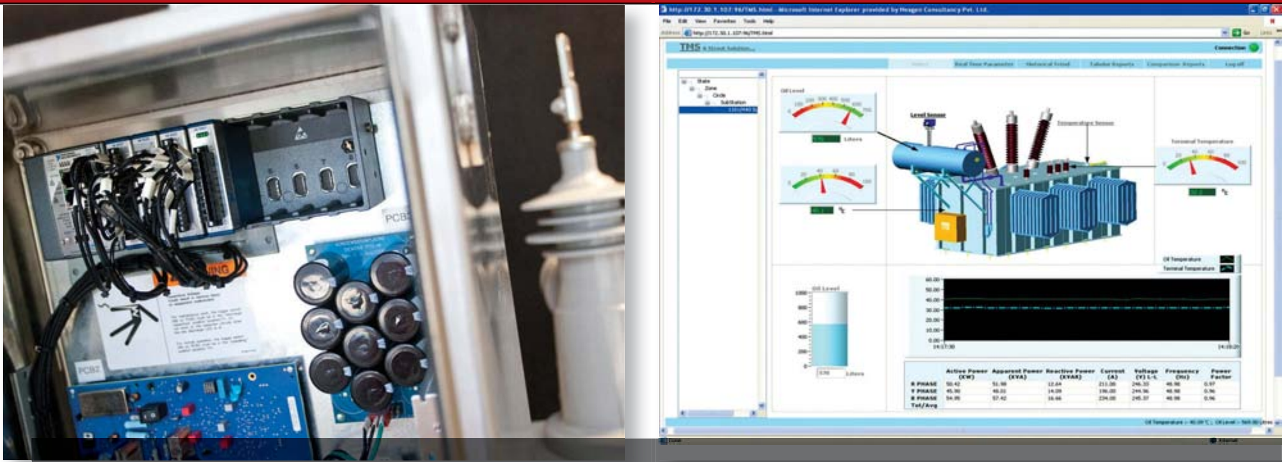

Fig. 3: Smart grid switches and reclosures aim to make the electrical grid as robust and self-healing as the Internet. To achieve this, they must automatically detect problems, isolate faults and redirect power. An NI CompactRIO embedded system (left), the "brain" of the switch, provides a field reconfigurable platform for smart grid R&D by performing multiple measurement, signal processing and control processes in parallel and in real-time. On the right is the output of a CompactRIO-based transformer monitoring system.

For this future to take shape, though, consumer acceptance is vital. So while Ales notes that while today's older population may shy away from such technology, those now in the 30 to 45 age bracket are accustomed to adopting gadgetry and will see the benefits. For younger generations, there will be even more acceptance; this is the generation that Spohn predicts will be turning appliances on and off, watering the lawn, etc., from their hotel rooms while on travel, for example.

Gomez foresees a big push in the clean energy sector—a push evident in the work of WindLift, LLC, developer of low-cost, next-generation "tethered airfoil" wind turbines. Airborne wind energy systems have potential advantages over traditional turbines, including the ability to capture more of the available wind energy; the ability to scale to larger sizes and output ratings; and heavier duty, less-expensive transmission/generation systems (which can be located on the ground instead of a tower).

Though the tethered airfoil concept was patented in the late 1970s, it has not been in production before because the necessary component technologies were not previously available at reasonable prices. These include:

- advanced wireless sensor networks and instrumentation;
- real-time computing for the autopilot system;
- reconfigurable, field-programmable gate hardware that eliminates the need for expensive and costly custom circuit board designs; and
- sophisticated software algorithms for controlling power generation and grid synchronization.

WindLift is found in National Instruments' CompactRIO, a "convergence platform" that integrates these technologies and combines them with system-level software development tools. According to WindLift controls engineer Matt Bennett, the platform provided the needed power, flexibility and functionality—and the ability to seamlessly transition from prototype to production with the same hardware and software.

NI's Smith adds that renewables are an important part of the power generation and distribution area, which he identifies as one of the top frontiers for sensors and embedded systems. He describes, for instance, an electric grid that continuously monitors itself and effectively integrates energy being generated by traditional means, along with that being produced by new, renewable sources. Such a vision, he says, is "only possible if smart grid analyzers are able to monitor the grid, talk to each other, and make changes dynamically." (See Figure 3.)

Further ahead, Smith sees such systems able to sustain themselves indefinitely by harvesting the solar, thermal or

2007

Dassault Systèmes adds 3DVIA Composer.

2007

Palm introduces Foleo, an early netbook.

2008

ANSYS acquires Ansoft.

vibrational power that is now wasted.

Smith calls life sciences another important frontier, pointing out that embedded systems and sensors are key to the operation of advanced medical equipment.

Gomez adds that long-term environmental and structural monitoring will be in increasing demand—for detecting seismic activity from within buildings and bridges, and for tidal wave detection from buoys, to name just two examples. This application will depend on low-power, "green" sensor systems, as will the "smart dust"—sensor systems that can be sprinkled from helicopters and instantly create ad-hoc sensor networks on the ground.

"That will happen soon," Gomez says.

Spohn suggests that with automated manufacturing—an application in which sensors are already established—there will be no downtime, because sensors are becoming inexpensive enough to enable redundancy in design. He says an embedded system will handle switching and notify technicians to change out the bad parts, which will then stand as the new backups.

"What will be important in the future with sensors, I believe, are things like resolution and repeatability—aspects that are inherent in the sensor design," says Spohn. This is in contrast, he adds, to things that change with the environment and for which an embedded system can compensate.

Smith says that increased performance will require parallel or multi-core processing.

"What will continue to make it all work is a stable software interface," he says. He admits that architecture changes will pose continual challenges for systems design and operation, but middleware that effectively abstracts the complexity of these advancements will make their benefits accessible to an ever-broader audience of engineers, who will harness that power to further innovate in their own fields. **DE**

Barbara G. Goode *served as editor-in-chief for* Sensors *magazine for nine years, and currently holds the same position at* BioOptics World, *which covers optics and photonics for life science applications. Contact her via de-editors@deskeng.com.*

INFO ➜ **Boston Engineering:** boston-engineering.com

➜ **Kaman Precision Products:** kamansensors.com

➜ **Kimberly-Clark Corp.:** kcc.com

➜ **Lego (Mindstorms):** mindstorms.lego.com

➜ **Maxim Integrated Products:** maxim-ic.com

➜ **Meggitt Sensing Systems:** meggittsensingsystems.com

➜ **National Instruments:** ni.com

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Navigating the Rapid Waters

The rapid movement is now characterized by a move to rapid manufacturing of end-use parts and the evolution of 3D printing to the desktop.

BY SUSAN SMITH

3D Systems' first additive manufacturing system (inset) and a low-cost 3D printer from Bits from Bytes, which 3D Systems recently acquired.

The promise of rapid technologies is obvious: instant, affordable prototyping. The evolution of rapid technology is characterized by rapid growth, and a definite asset to manufacturing, promising to move beyond prototyping to actual finished, manufactured parts in some cases. But where has it come from, and where is it going? How long will it be before there is a 3D printer on every engineer's desktop?

Rapid Technologies, Then and Now

Originally, rapid prototyping was developed to give manufacturers a way to test out parts or prototypes before embarking on the costly process of manufacture. In the beginning, the parts were not designed for actual manufacture, but now some high-end companies offer processes that can actually produce manufactured parts—thus the "rapid manufacturing" term was coined to encompass this new direction.

The first rapid prototyping company, 3D Systems, developed stereolithography (SLA) in 1986. This was followed by the invention of the .stl file format, spearheaded by Charles Hull, who is still chief technology officer and executive vice president at 3D Systems.

Brian Ford, director of strategic marketing for Quickparts, notes that when the technology was first introduced, materials were very brittle, not visually appealing, and generally had a rough finish. SLA materials were amber-colored, and would yellow and age over a short period of time.

The first machines were large, unreliable, expensive and required dedicated operators. Bruce Bradshaw, director of marketing for Objet North America, says the industry started in the back room—with messy processes and big open vats of carcinogenic liquids. Today, most vendors offer machines that fit in an office environment and are environmentally safe to use there.

According to Cathy Lewis, vice president, global marketing for 3D Systems Corp., while system size varies from small footprint to extra-large, high-productivity platforms, these units are easy to operate, provide long, unattended operation and are reliable.

2008

Bill Gates resigns as CEO of Microsoft.

2008

ESI Group acquires Vdot and Middleware Engineering.

2008

Geometric launches DFMPro.

The modern uPrint from Stratasys Dimension 3D Printing is compact enough to fit on the desktop, inexpensive and easy to use.

Stratasys' first commercial machine, the "3D Modeler," was introduced in 1991.

"The additive manufacturing systems today also offer a wide material portfolio, high-definition capabilities, efficiency and can handle far more complex geometries," says Lewis. "The two most notable changes are the move to rapid manufacturing of end-use parts and the evolution of 3D printing, where almost any size business or educational institution—or even an individual—can afford to invest in their own 3D printer for in-home or in-office use."

Stratasys' Joe Hiemenz says the Stratasys fused deposition modeling (FDM) process became known for its ability to make acrylonitrile butadiene styrene (ABS) parts suitable for functional testing.

"In the early years, our accuracy wasn't as good," he admits. "Over the years we've added several varieties of thermoplastics, such as polycarbonate, [polyphenylsulfone, or PPSF], and Ultem, as well as industry-specific formulations, such as ISO versions for medical use. And some of our systems now rival injection molding by producing highly toleranced parts with accuracies as high as 0.003 inch."

Today, Stratasys has a robust quality control system in place and is in the process of ISO Certification.

"Our raw components, subassemblies and finished products go through stringent performance testing, so we're confident when we ship product," Hiemenz says. "Our high-end product lines that are used for production have each had exhaustive studies on output repeatability, showing that part-to-part, their output is on par with injection molding."

That kind of performance wasn't always there. In the early years, additive system manufacturers may have introduced products a little faster than they should have. The technology was new, and there was a strong demand from major industries like aerospace and automotive that saw an advantage that competitors didn't have.

"Stratasys learned our lesson with an early model of a 3D printer called the Genisys, which launched before it was a whole product," says Hiemenz. "It was a multi-million dollar lesson in making sure your product is ready before you launch."

Z Corp.'s vice president of product management, Joe Titlow, says the company's first machine was the ZCorp 402, introduced in 1996. At the time, it did not have color, and it was much more expensive. It was also very complex and not nearly as reliable as the company's current products.

"Overall, every dimension that is meaningful to a customer has improved since then," says Titlow. "Cost of machine and operations has gotten better. The machines have become much easier to use, and overall, materials have improved significantly in terms of their accuracy and material properties. The improve-

2008

Autodesk acquires Moldflow Corp. and iLogic Software.

2009

Autodesk acquires ALGOR, Inc.

2009

SolidWorks Sustainability Xpress launched.

REVERSE TECHNOLOGIES

In the last five years, 3D laser scanning has advanced—and has greatly helped 3D printing.

"The more 3D scans that are out there, the more 3D prints will be out there," says Bruce Bradshaw, director of marketing for Objet North America. Scanning leads to prototyping, in other words, and has advanced to a point where it is used in automotive, medical, aerospace and architecture, among other uses.

In the future, it may be possible to have a 3D scanner at home, then take the scan to a local copying and printing service shop to do a 3D print. As scanners become higher resolution and easier to use, more flexibility and 3D prints will follow.

Joe Titlow, Z Corp.'s vice president of product management, says his company sees reverse engineering as an interesting adjacent market not core to 3D printing. Although Z Corp. "benefits significantly" from having the ZScanner line in its portfolio, Titlow says, "the target application is sometimes overlapping. I separate it from rapid prototyping. It's another way to gather the 3D information you need. It is at the front of the process that the customer goes through to get something that they want to print."

ments in color performance have been very dramatic since our first color 3D printer came out in 2000. It helps to make them less expensive and easier to use, but the key is really trying to simplify the technology and make it more robust."

Some of the most important changes are reliability and repeatability, according to Hiemenz.

"Most additive system makers are no longer content with just prototyping," he adds. "Many are pursuing the production industry. The requirements are more stringent, and system makers have stepped up their quality efforts."

Materials research continues to be an important area of ongoing R&D, and investment for rapid manufacturing companies will continue to grow in rapid manufacturing and medical applications. Materials are currently available in a range of colors and consistencies. There are brittle, delicate materials, very strong materials and those that are designed to be used as actual parts. The vulnerability to temperature, moisture and general exposure in materials has lessened over the years, but new stronger, more resilient materials are constantly being developed. There is a lot more to choose from today, and advantages with each rapid manufacturing process.

According to Lewis, today the materials offered by 3D Systems have grown from a single resin that was quite brittle to "a full complement of robust plastic materials, to almost indestructible powders used in our selective laser sintering [SLS] process and metals resulting from selective laser melting [SLM]."

Two Major Trends

Two major trends characterize the growth in rapid manufacturing:

1 In the low-price, 3D printer market, there is a continuing trend of prices coming down, while quality goes up. Even better, the market grows larger as the price comes down. Rapid technology manufacturers are approaching this potential in different ways.

"Our agreement to be an OEM for Hewlett-Packard 3D printers tells you they believe there's a growing market for 3D printers at the right price," Hiemenz reports.

"We are currently seeing substantial growth in rapid manufacturing applications as the systems and materials have matured," says Lewis. "These applications range from industrial to medical and all manner of artistic endeavors."

Lewis notes that because of this growth, 3D Systems has recently acquired one of the early 3D printer kit companies, Bits from Bytes, to address the low-end 3D printer market that may want the technology for small prototyping operations or for art or hobbies.

"At price points well below $5,000, with the benefit of lower-cost materials, we believe there will be an explosion in 3D printer adoption over the next few years," he adds.

Z Corp. has also come out with two low-cost machines in the last year: the Z150 and Z250. The company has incorporated the same ease of use of its higher-end machines into these units.

Bradshaw of Objet North America said they will move into the volume space at the low end of the market, with their Alaris low-cost machine, for customers who may buy

2009 Dassault Systèmes acquires IBM PLM.

2009 IMSI/Design releases DoubleCAD XT.

2009 MSC Software — STG acquires MSC.Software.

Z Corp. debuted its first machine, the ZCorp 402, in 1996.

Z Corp.'s highest-resolution, largest build size, premium-color 3D printer: the ZPrinter 650.

several small desktop printers to do early prototyping before getting to more complex prototyping.

"The high-volume market is really matching the 2D printing space, where the value proposition of the printer grew with inkjet technology followed by low cost laser technology," Bradshaw adds.

2 At the other end of the spectrum, more manufacturers are moving to additive systems for low-volume production needs. They're opting for "3D production systems," such as those produced by Stratasys and laser-sintering systems from EOS.

"Additive systems will probably never compete with traditional processes for high-volume production, but for low-volume, the additive process is ideal," says Hiemenz. "Direct digital manufacturing [DDM] brings enormous cost reduction and lead time reduction."

And if you think your operation doesn't need low-volume production because you're a mass producer, he adds, think again: "You probably use hundreds of custom assembly tools that are produced in low volume. There's loads of money waiting to be saved in this area."

Dr. Hans J. Langer, a pioneer of commercial laser sintering and CEO of EOS GmbH, agrees.

"In the coming years, additive manufacturing will see even greater integration into the manufacturing environment," he says. "Finely tuned quality assurance and standards for materials, processes and production parameters will continue to emerge. So will industry-specific standards. These advances will be driven by the desire of OEMs and their suppliers for cost reduction, increased productivity and complete design freedom that technologies like laser-sintering offer."

The demand for lower-cost machines, greater accuracy, better material properties, color, standards and other criteria to meet the design-to-manufacture process continues to drive the industry. DE

Susan Smith *has been working as an editor and writer in the technology industry for more than 16 years. She is a contributing editor for* DE. *She can be reached via de-editors@deskeng.com.*

INFO → Company Name: 3dsystems.com

→ **3D Systems:** uprint.dimensionprinting.com

→ **EOS:** eos.info

→ **Objet Geometries, Ltd.:** objet.com

→ **Quickparts:** quickparts.com

→ **Stratasys:** stratasys.com

→ **Wohlers Associates:** wohlersassociates.com

→ **Z Corporation:** zcorp.com

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2010

Microsoft Surface is available.

2010

Stratasys and HP deliver HP-branded 3D printers.

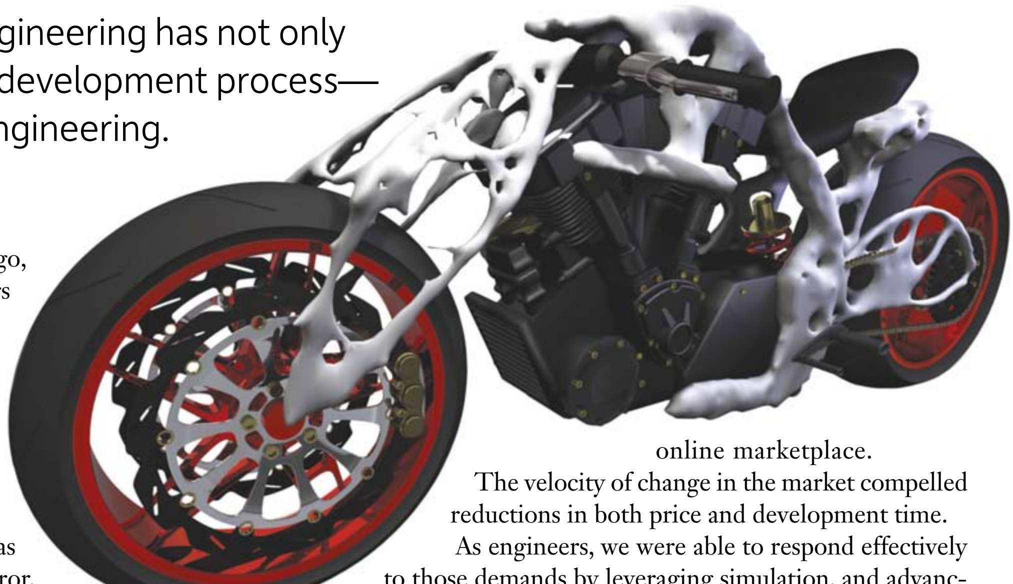
2010

Of all the computers running Windows 7, almost half are running the 64-bit edition.

CAE Continues to Assist and Amaze

Computer-aided engineering has not only helped quicken the development process—it's revolutionized engineering.

BY JAMES R. SCAPA



Less than three decades ago, the ingenuity of engineers was the primary force for improving the quality and reliability of products. Engineers conducted a great deal of performance testing, but they were restricted by slow and deliberate manual processes. Testing done by hand was largely a matter of trial and error, with knowledge accumulated over periods of months and years. It entailed exhaustive prototype testing, and failure in the field often was an unavoidable step in the validation process.

And then computer-aided engineering (CAE) came along. The art of finite element analysis (FEA) has evolved into a dependable computer-simulation science, and its limitless impact can be seen across the creation of everything from automobiles and airplanes to cell phones and golf clubs. Simulation is now in the driver's seat, pushing product development timelines, creating innovative concept designs, and improving product quality and reliability along the way.

A number of market factors helped push computer simulation to the forefront, including the increasing sophistication of consumers coupled with the emergence of the global online marketplace.

The velocity of change in the market compelled reductions in both price and development time. As engineers, we were able to respond effectively to those demands by leveraging simulation, and advancing the methods and application to improving design. We are seeing the convergence of four dynamics in the evolution of simulation: people, hardware, software and business models.

People and Ingenuity

The needs of engineers were always attuned to the evolution of simulation, notes Dr. J. Tinsley Oden, director of the Institute for Computational Engineering and Sciences at the University of Texas-Austin, and a legendary figure in the field of computational mechanics.

"Most of the models of physical events and behavior of systems are governed by partial differential equations on very complex domains. But these models remained out of the reach of engineers until the mid-20th century and the emergence of computers," Oden explains. "The nature of the engineering cul-

2010

Google has 85% of the global search market share and has expanded to offer advertising, cloud applications, browsers, cell phones and Internet-enabled televisions.

2010

ARES released for Windows, Mac and Linux.

2010

ZWSoft acquires VX Corp.

LEFT: Today's CAE software can be used to find the best design solution to meld creativity and product performance.
ABOVE: Simulation and analysis data now flows more easily among departments, allowing decisions to be made in the design stage that can drastically reduce a product's time to market.

ture was to study small components and then assemble them into a whole, and the nature of FEA dovetailed perfectly with this approach."

James Welton, former global CAE director at General Motors and now an executive consultant for Magna E-Car Systems, says he has seen engineers grow from data producers to professionals driving engineering through CAE tools. He has also seen the profound change in the application of these tools, navigating computer simulation upstream in the design and development process. These applications have helped to explore the design space, and drive designs more optimally with FEA—including non-linear solutions, virtual crash testing, computational fluid dynamics (CFD) and other disciplines.

Hardware Lays the Foundation

Today's simulation capabilities would have been inconceivable without advancements in microprocessor speed. As Welton asserts, "the substantial impact of computer simulation has ridden on the back of the speed of computing."

Computers evolved to handle larger problems, and models could be made detailed enough to capture results with more reliability and accuracy—without the need for as much "art" in the process. Some companies believed computers and simulation would replace test labs, but Welton points out that the smartest organizations realized the role of the test lab was simply changing, not dying. Now they could be used to test more exotic materials and other initial data before employing simulation for product design and validation.

Dr. Marc Halpern, vice president of research and lead analyst in product lifecycle management for Gartner, agrees.

"Engineering organizations have made tremendous progress in defining processes that align engineering simulation and physical testing," says Halpern, a former CAE software engineer. "In some industries, such as automotive and aerospace, development times for new products and acceptable cost of product development have been compressed so significantly that the products cannot be developed in the window of opportunity without these tools."

Software Meets Societal Needs

Equally important to the successful evolution of simulation was the advancement of modeling and analysis software, which were driven by both the government and the consumer.

On one hand, as safety became an increasing concern of regional and national governments in the 1980s and 1990s, automotive companies were compelled to find ways to build safer vehicles. This necessity propelled the opportunity for making crash-tests practical, from the standpoints of cost and development time, through computer simulation.

On the other hand, consumers wanted products that were safe, durable, recyclable or simply convenient. Engineers were called

2010

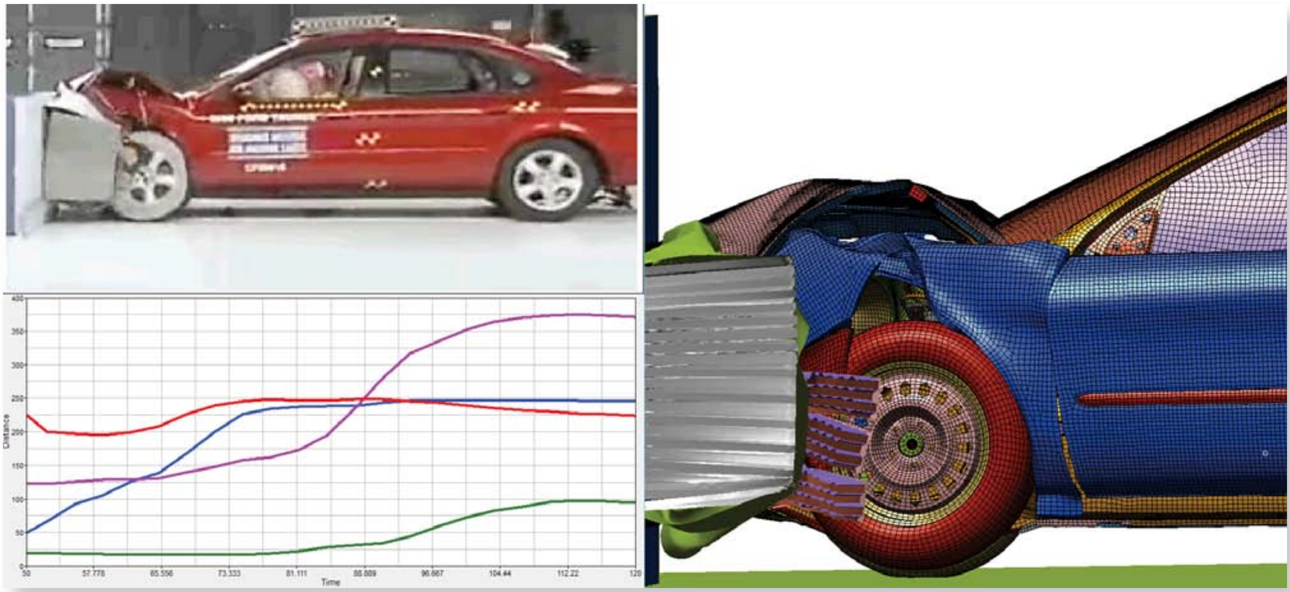
Dassault Systèmes releases DraftSight.

2010

Amazon launches EC2 Cluster Compute instances in the cloud.

2010

Apple launches the iPad and iPhone 4.



Altair HyperView's high-performance post-processing and visualization environment enables users to make informed decisions. *All images courtesy of Altair.*

on to incorporate those characteristics into product designs.

As a result, simulation software has helped to solve product design challenges by examining durability, noise and vibration performance, weight reduction, fatigue, sustainability, safety and manufacturability.

Today, we see computer simulation software employed at the front end of the product development process, creating the best design that couples aesthetics with performance at a target cost and quality level.

"The quality of the end product is higher," says Welton, adding that in the automotive space, "many of the upfront design decisions are made strictly from simulation input. It's changed the cost and speed of carrying out vehicle development programs."

Business Models Bring New Flexibility

Delivery models for simulation software have also changed over the last 25 years, but they must change even more to keep up with the rising demand—and to not inhibit the expansion of technology into broader applications.

For example, the traditional practice of buying "seats" that were locked to an individual computer have evolved slowly into trends like license serving and some basic token-based licensing methods.

Leveraging the power of the explosion in CPU affordability with "decay functions" for parallel applications, and using global license serving to mirror the globalization of engineering staff, has helped broaden the reach of simulation. Open architectures will also become even more important, as customers integrate applications from different vendors into complex design processes.

However, to really open the door for the expansion of simulation, future delivery models must be even more innovative. Advances such has software as a service (SaaS), clouds and on-demand computing, leveraged by other software industries, are finding their way into the simulation business.

The Future for CAE Engineers

"Higher expectations of the users of simulation, in terms of predictability of computer models, will eventually have a big impact

2010

Intel debuts 6-core Westmere EP Xeon processors.

2010

AutoCAD 2011 released for Macintosh.

2010

About 1.8 billion people use the Internet.

on engineering software and how engineers approach the problem of analysis and design," Oden predicts.

Citing Samuel Forman's 1976 book, *The Existential Pleasures of Engineering*, Halpern notes that engineers once were likened to individuals of the Renaissance era—the brilliant minds that put men on the moon, armed with the broad knowledge of many disciplines involved in their profession. After Sputnik, the pendulum shifted to specialization, with engineers focusing on math and analytical techniques.

"Now the pendulum is swinging back," Halpern notes. "Future engineers will need to think much more about social implications, manufacturability, cost and safety implications of the designs they are creating."

To be able to enlarge their considerations to these kinds of factors, many of the manual operations in the simulation process must be automated. Capturing and executing a company's best simulation practices in a batch process is an emerging and rapidly growing trend.

As in quality-based manufacturing engineering, these best practices will eventually include the impact of variability—likely to spawn hundreds of simulation runs nightly—in a perfect match for the expansion of compute power. We can also expect that, as CAE affects this realm of reliability-based design as well as driving the aesthetics of products, simulation will finally be elevated to the executive's desktop in key product decisions.

In addition, improvements to the usability and interactivity of simulation tools will greatly expand the usage to a broader market. Business models that encourage more simulation, because of its increasing value proposition, will further fuel this expansion.

More sophisticated user environments and automation will free engineers from the mundane tasks associated with simulation, and instead allow them to focus their time on extracting knowledge to make good decisions—and open their creativity in ways yet to be seen.

The design of our lives is increasingly driven by simulation. The real drivers of our future will be those engineers who use the lessons of the past 25 years as a catalyst to guide the design of currently unimaginable products to meet society's needs. **DE**

James R. Scapa *is chairman and CEO of Altair Engineering, a global provider of simulation technology and engineering services. Comments on this article can be directed to de-editors@deskeng.com.*

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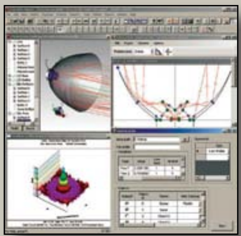

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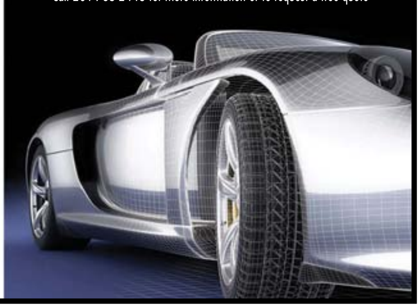

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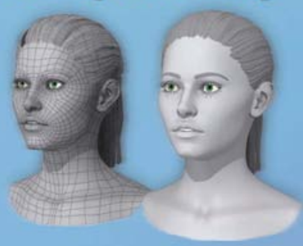

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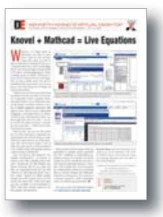

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Visionary Voices

It's not easy to foretell the future, especially when it comes to technology. You need look no further than Bill Gates' much-repeated quote, "640K ought to be enough for anybody." Of course, there's no hard evidence that Gates uttered those words and the Microsoft chairman denies ever saying them. The quote lives on as an urban legend because it illustrates how fast technology moves and how no one really knows what will happen next.

Who could have predicted, 15 years ago, that we'd have more megahertz in the smart phones in our pockets than we had on our desktops at the time? Or that a then-fledgling online bookseller would have a thriving business renting compute capacity in the "cloud"? Actually, there were people who could have predicted such amazing achievements—people with an inside track on the technologies in the pipeline and the vision to guess how those technologies would be used.

The brave souls who penned the following pages have such knowledge and vision, and they're going on record. If they're horribly wrong, there will be no denying it a decade or two from now. You can trust these predictions are their best bets. These visionary voices come from some of the vendors who are actively pursuing tomorrow's engineering technologies—from processors to rapid manufacturing to CAD, analysis and simulation. If anyone can make an educated guess about the tools that will be available in the next 15 years, it's the people making those tools.

Turn the page to read the details of how some of *DE's* advertisers think technologies such as high-performance computing, cloud computing, custom manufacturing and realistic simulations will impact engineering.

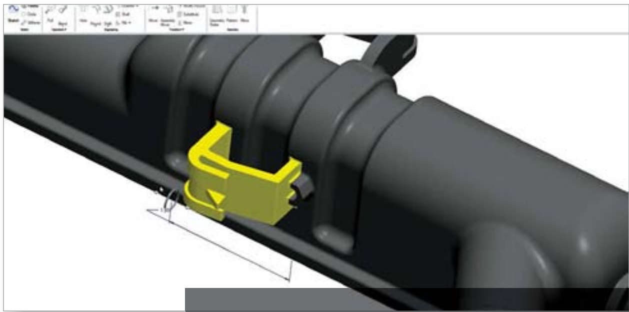
PTC and Creo *Solve CAD Challenges*

Introducing a new vision for CAD software and processes.

By Brian Shepherd

The 1990s were a period of rapid innovation with a lot of excitement over the advent of 3D parametric, solid modeling for product design. And while the market has become more mature and hence more static in the last 10 years, many significant unsolved problems still remain: ease of use, interoperability both within a company and externally with its supply chain, the complexities of "real-world" assembly modeling and technology lock-in.

PTC's vision and strategy addresses these issues with Creo, a scalable suite of interoperable design apps, helping companies unlock the full potential within product development



Design in any mode—2D, 3D direct, or 3D parametric knowing that data can be shared and edited across modes.

New Concepts for CAD

In manufacturing, product ideas are usually expressed with CAD designs. That's no problem if you're an expert who works all day with 3D software. But if you're not a 3D CAD expert, you may be out of luck, no matter how simple or elegant your proposal. Creo delivers easier to use design applications for everyone involved in product development, spanning the entire process, and addressing a broad set of needs and roles. For example, a product manager needing to create a rendering of a product no longer has to be an expert CAD user, or find an expert to generate the image. They can use a Creo design app that's focused on rendering, but still directly leverages the CAD model. This is a completely different approach: purpose-built applications, delivering just the right capabilities to get the job done. We call this breakthrough technology AnyRole Apps—the right tool for the right user for the right task.

We're introducing other concepts that are new for the CAD industry. The next is to support interoperability across the different apps and modeling approaches (2D, 3D Direct, and 3D parametric) that all too often are disjointed today. Clearly, the challenge is to preserve design intent across all apps and approaches. With AnyMode Modeling—participants in product development can pick the mode that meets their need and finally share and combine 2D, 3D Direct, and 3D parametric data. There is no loss of features or intelligence from one mode to another due to Creo's common data model.

For teams to be successful and productive, there must be a mechanism through which product data can be shared across the team as well as among various design systems, irrespective of the CAD tools in use. No product development exists in a vacuum. Manufacturers often need data coming from a supplier or from a customer, and those customers or suppliers might create data in another CAD system. AnyData Adoption is a breakthrough technology in Creo, enabling the use of design data that may not have been created with PTC products, but that can be consumed by, and used in, Creo. AnyData Adoption also frees companies from the CAD technology lock they typically face. Now they are free to look at new CAD approaches and tools without penalty.

Platform and modular design are sometimes described as the new frontiers of manufacturing. But they can also lead to data management headaches. With tens of thousands of product configurations possible from the presence of just a few options, many product variations are never modelled, tested, or properly documented. Our breakthrough in this area is AnyBOM Assembly. Teams now have the power and scalability needed to create, validate and reuse information for highly configurable products. Using BOM-driven assemblies and a tight integration with PTC's Windchill PLM software, companies can leverage the business logic that defines valid product configurations, use top-down visual navigation to select product options, and create the visual structure of a specific configuration. Companies can automatically generate 3D configurations of any desired variation, and develop related configuration-specific service and production plans.

Creo helps manufactures unlock the full potential within product development, enabling more people to participate earlier and more fully in the product development process, significantly improving creativity, teamwork, efficiency, and value. DE

Brian Shepherd *is executive vice president, Product Development, PTC.*

Computing Technology

A look at where the industry might be going.

By John H. Hengeveld

Congratulations, *Desktop Engineering*, on 15 years of helping your community of readers see how hardware and software technologies combine to create revolutionary opportunities. Job well done; here is to 15 more.

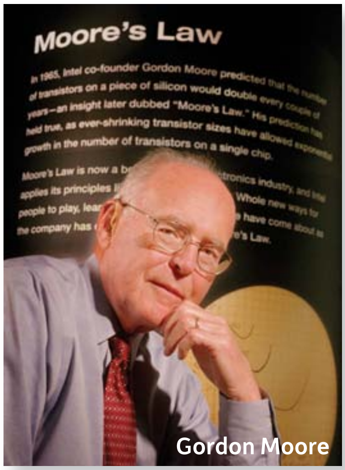
Today, silicon chips are everywhere. The task of making chips is no small feat. Designing them and the delivering the compute capacity demanded by our engineers is colossal. A modern "fab," a building where Intel makes its chips, has close to 1 million sq. ft. of space and is among the most technically advanced manufacturing facilities in the world. Our engineers continue to add new features and new instructions to the tiny silicon "engines" that drive an ever expanding and connected digital world. These silicon chips are powering the Internet, enabling mobile computing, automating factories, enhancing cell phones, and are found in the workstations and high-performance computers (HPCs) that engineers employ to create tomorrow's innovations. If you are wondering, it is estimated that about 10,000,000,000,000,000,000 (that's 10 quintillion) transistors are now shipping each year—that's about 100 times the number of ants estimated to be on Earth.

Computing in 2025

Let's look out 15 years. It's where we'll be in 15 years that shapes where we need to be in 5 years. Moore's law will be still in place, and we will probably see manufacturing processes that support 4.5 nanometers (nm) or smaller. I expect workstations will support more than 28 Exaflops and the king of the hill in the HPC world will be approaching 1 Zetto flop. Today's workstation delivers just over 150 Gflops.

High fidelity, multi modality, full system design and modeling on Intel Xeon based systems will be the norm. Agent supported simulation-based design will probably be celebrating its 10th anniversary, and automated design mediators will augment our opportunity to create, test and modify ideas at speeds that could be real-time. The mouse will disappear, and things like electronic clay and other haptics technologies will emerge.

Technologies that are employed to solve complex problems composed of computationally intensive applications will probably be accessible in ways you only dream of today. You may have access to greater functionality and control from your pocket. It will be available in your office and larger, higher fidelity models will leverage the resources of either corporate or cloud-based assets. I expect to see a compute continuum from handheld systems through HPCs that will provide fast, efficient, easy and affordable access to compute capacities. If you need an immediate answer, you may use the cloud. If you can wait, you will use other resources that will provide more affordable results in an acceptable timeframe.



Gordon Moore

The Way Forward

There is no magic to delivering solutions found in workstations and HPCs. It is centered on delivering a balanced computing architecture that provides processing performance, memory and bandwidth capacity. It is the three-legged stool story. If the compute capacity outstrips the facility to access and store data, you end up with subpar performance. The way forward is through increased levels of integration enabled by manufacturing processes ensconced in Moore's law. Here is a near-term example: For years, CAD users looked to discrete add-in professional graphics cards to supply the performance they demanded to do CAD. However, integrated and optimized graphics solutions in 2011 on Intel Xeon processor-based workstations are expected to meet the demands of many 2D and 3D CAD applications in an even more energy-efficient design.

As the industry traverses from 32nm manufacturing technologies to 22, 18, to 12 onto 9, 6.5 and eventually to 4.5nm, expect to see not only more cores, but more cores that each process more instruction per cycle—that is a multiplier effect. Remember the three-legged stool. You can also expect to see heterogeneous architectures that combine vector, scalar and graphics architectures with new memory topologies and i/o infrastructures.

Back to the 5-year outlook: You will see increased levels of hardware integration and most likely the introduction of heterogeneous architectures that will deliver an unbelievable amount of performance from a balanced computing architecture. The trick is helping the ecosystem realize this performance without requiring vendor-specific software that limits end-user choice. Software needs to be portable and scalable to realize the vision of a design environment with access to agent supported simulation-based design or automated design mediators. **DE**

John H. Hengeveld *is director of Technical Computing Marketing, Intel Architecture Group.*

Stick Your Head in the Cloud

Get a view of tomorrow's 3D CAD.

By Jon Hirschtick

Every technology shift in the last 30 years has erased one or more of the limits on CAD. Cloud computing is a similar movement that removes many limits, from cost to processing power, features, functionality, time or space.

Mainframe-based CAD freed designers from paper and pencils. UNIX workstations made 3D CAD available to design teams everywhere. And Windows-based 32-bit computing made 3D CAD completely democratic, allowing anyone with a PC to design in three dimensions.

Now, we're in the middle of another major technology shift, where applications are moving from the desktop to the Internet, making it possible (in theory, at least) to design in 3D on any device with an Internet connection. Moving applications online means the eventual end to limits on processing power; of being limited to whatever features and functions you happen to have on your local hard drive; of sweating out the next virus, crash or data loss. It means collaborating with anyone, anywhere, at any time. It means using smart phones, tablets, and other mobile devices to access your designs directly from the job site or shop floor.

No Limits

This new shift is different than the ones that came before though—the Internet-as-platform model won't eliminate the desktop. It will make the desktop better. The computer at your desk becomes a gateway to more processing power, functionality, and collaborative reach than it could possibly provide on its own. By using the Internet, almost every hardware limitation that we deal with every day is removed.

Moving to an online computing model means we'll have to change our preconceptions and expectations about computing, at least in the short run. If you live in an area with an under-developed Internet infrastructure, you might have to live with some amount of latency before your local broadband provider catches up. But when you consider how many people (myself included) are already streaming live video and playing graphically intense games online, it's easy to envision bandwidth not being an issue for too long.

Safe and Secure

A lot of people also worry about the security of data stored on the Internet—specifically, a perceived lack of security. I don't buy it. We already entrust our money, credit ratings and personal information to online businesses because we trust that they have enough precautions in place to keep our information safe. Thousands of businesses already store sensitive customer data on Salesforce.com, and internal threats to data—primarily by employees inside the company firewall—are a bigger risk than things that can happen in a well-managed data center with layers of protection and backup.

Compared to the gains, the risks are minimal. When CAD moves online, you'll have access to computing power that will make your models rebuild faster. Complex simulations will be available on demand. You'll have access to rendering capabilities far beyond anything available for a desktop computer. Going online does away with the rigidity of packaged software. Forget about fixed cycles for upgrades. Do you need fluid flow analysis, but only once or twice a month to run one test? Rent it for a few hours instead of buying it and paying for it to sit on your hard drive 360 out of 365 days per year.

When we're running full crash simulations through our online desktops, or renting an expensive feature for an afternoon instead of buying it, we're going to laugh about how we used to be stuck on a box in the good old days of 2010. DE

Jon Hirshtick *is a co-founder of Concord, MA-based DS SolidWorks.*

DS SolidWorks

Simulation's New Age

Engineering simulation evolves.

By Josh Fredberg

ANSYS was founded 40 years ago to help product development companies reduce physical prototypes and testing, speeding product development while ensuring a high degree of confidence in product quality. Since 1970, ANSYS software has enabled customers to predict, with accuracy, that their products will thrive in the real world. Customers trust the suite to drive business success through innovation.

For four decades, we have witnessed radical changes in the world of product engineering—the most recent being the proliferation of smart products. In addition, market expectations for product performance continue to rise. Where once it was adequate to develop a design deemed "acceptable," it is now imperative to find not just a good design, but the optimal design. The increased complexity of products coupled with market demands is leading to a systems approach to design.

Taking a Holistic View

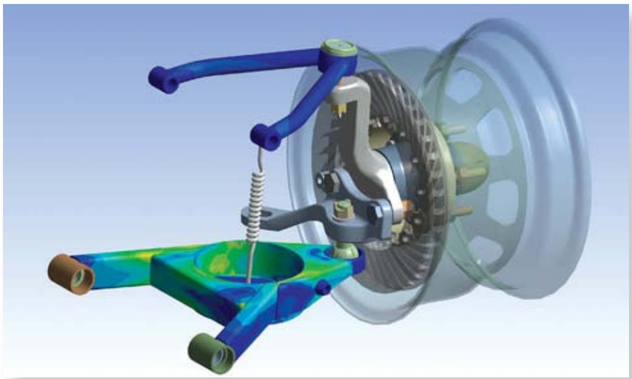
A systems approach requires a holistic view of how subsystems of a product interact with each other and in harmony with users and complex environments. The product must be tested against a wide range of usage scenarios, such as physical components cross talking over each other. This mandates new, more collaborative design processes.

Design engineering teams must be increasingly mindful of intended or unintended interacting forces governed by a range of physics from electromagnetic to thermal to mechanical to fluid dynamics. Today's products demand that engineering teams span traditional engineering silos. The academic realm has noted this, too, and is considering how best to incorporate multiphysics education as it prepares the next generation.

These systems engineering problems are complex. A key enabler to solving them is the ever-advancing computer power that every year makes unsolvable problems solvable. Arriving at a timely and accurate answer requires advances in high-performance computing (HPC) and the use of the cloud to drive compute capacity. As a result, today's engineers rapidly solve huge problems—sometimes system-level problems—that once were thought impossible. This cycle will continue.

ANSYS: Anticipating Evolving User Needs

As product engineering evolves, ANSYS continually introduces new simulation tools that anticipate this evolution. To address growing complexity, ANSYS has introduced smarter, broader, faster and more powerful solutions that mirror real-world results with an incredible degree of accuracy.



More complex products will require more powerful simulation solutions and a systems approach.

Our latest product release, ANSYS 13.0, enables greater simulation fidelity that reflects the changing conditions of dynamic performance environments. It also maximizes productivity through new automation and performance features, as well as HPC advancements that deliver speedup ratios dramatically higher than previous releases.

ANSYS 13.0 is also built for collaboration across multiple functional users, allowing groups of engineers to work together in a rapid, high-impact manner as they validate the functional design of new products. Engineers can identify and address any performance issues much earlier in their design processes—allowing the greatest return on product development investments.

The Changing Face of Innovation

The evolution of product engineering, and the corresponding evolution of ANSYS solutions, is changing the basic nature of innovation. While historically engineers focused on small, sequential design enhancements that improved products over time, today's powerful tools enable designers to create "clean sheet," breakthrough ideas with a few clicks of a mouse.

By minimizing the time, cost and risk of developing game-changing new product designs, simulation has made it easier to truly innovate—and this is a trend that will only pick up speed as more and more companies embrace engineering simulation.

For future releases of ANSYS, improvements are driven by real-world customer needs—but our primary goal will remain the same. We will continue to anticipate the changing needs of product development teams worldwide by taking engineering simulation, and product innovation, to the next level. DE

Josh Fredberg *is vice president of marketing, ANSYS, Inc.*

What's Ahead for 3D Printing?

Custom manufacturing goes mainstream as prices fall and material types increase.

By Jon Cobb

Like many successful technology products, 3D printers will become smaller, faster, less expensive and easier to use in the next five to 10 years. They will also be able to produce parts with a wider variety of materials. These drivers, in addition to simplified user interfaces from the CAD software, will increase acceptance of 3D printers and alter the way they are used.

Future Engineers

Today's students will become the users of tomorrow. Students in universities, high schools, middle schools and even elementary schools are being introduced to additive manufacturing. In Edina, MN, for example, eighth-grade students used the Dimension uPrint Personal 3D Printer in a project to model their design ideas for a new automobile cup holder. Cost, ease of use, and part durability were important to the teacher, who said the project generated tremendous enthusiasm from students and their parents.

Students will take their design and prototyping skills from school to the workforce, where 3D printers will be found in the engineering offices of manufacturing and architectural firms. Two types of products will emerge for these applications. Shared devices for three to 10 people will support higher demand, while individual printers will provide the personal use we see today with 2D printers. In the architectural and construction market, which is still largely untapped, we will see greater use of 3D printers for design and development, from initial concept models to detailed models for making final decisions on designs.

Custom Manufacturing

In the manufacturing world, 3D printing will continue to grow, as it can be used to produce custom-manufactured assembly tools quicker and more cost efficiently than traditional means. This trend will be bolstered by an increase in the plastic and metal materials that will become available for 3D printers.

We also will see an increase in additive manufacturing for end-use parts. Like the production of assembly tools, the use of 3D printers to make short run production parts is another growing trend. A significant percentage of manufacturers don't produce runs of millions or even hundreds of thousands. For those performing production runs of 5,000 parts or fewer, 3D printing is a viable process. I believe this trend will continue, along with the growing awareness of the benefits.

In the future, it will become more common for companies to employ large quantities of 3D printers for mass customization—making large quantities of products, each with features unique to a customer's need. These companies will delight customers with technology that builds single parts economically. As the price of 3D printers decreases and more people become comfortable with custom manufacturing, we will see more use in small- to medium-volume runs geared toward consumer markets. Even hobbyists and gamers will discover the benefits of 3D printing. Here, the availability of new software also will drive increased hardware usage.

We continue to drive the price down and deliver products that mimic how 2D printers operate. And we will do this while maintaining high quality standards for commercial applications.

Our relationship with HP will help us expand acceptance in the future. I believe HP's unmatched sales and distribution capabilities and Stratasys FDM technology are the right combination to achieve broader 3D printer usage worldwide.

The return on investment for organizations that purchase 3D printers is sound. Seeing is believing for users, and companies are amazed at how quickly they experience a payback on their investment. For many organizations, 3D printers are moving from "nice to have" to "mission critical." DE

Jon Cobb *is vice president of Global Marketing for Stratasys.*

Making Realistic Simulation an integral business practice

By Tim Webb

In 1978, David Hibbitt, a founding member of Hibbitt, Karlsson, and Sorensen, Inc. (HKS), put forward a view that engineers would want to get as close to real-world behavior as possible. While the majority of finite element analyses at the time were performed using a simplified approach, he believed that users of FEA software would need to solve engineering problems in the nonlinear domain. As computing power has become faster and less expensive, his vision has proven accurate, as many engineers in a range of industries are migrating from legacy (linear) methods to higher-fidelity nonlinear methods, using tools such as Abaqus FEA from SIMULIA.

During the same time period, Dassault Systèmes (DS) embarked on a strategy to help companies move from 2D to 3D design, providing digital mockups of complex products and introducing the idea of managing the complete product lifecycle. The DS strategy included the principle that as companies designed, collaborated and communicated in 3D—with the associated intellectual property managed within a product lifecycle management (PLM) solution—they would need to incorporate realistic simulation as a standard and integral business practice.

The acquisition of ABAQUS, Inc. (previously HKS) by DS, brought the mutual visions together. Today, SIMULIA is the DS brand for realistic simulation. Our commitment to strengthening Abaqus as the unified FEA technology with advanced materials and mechanics capabilities is as strong as ever. We are also responsible for developing solutions for multiphysics, process automation, design optimization, and simulation lifecycle management.

The Future Today

In terms of future significant changes to simulation in product development, it is important not to dismiss what is possible with today's technology. Many companies are just beginning to realize the ROI from the people and methods at their disposal. Their successful application of today's design analysis solutions will drive significant growth in the use of CAE.

For customers to truly realize the full business benefits of realistic simulation moving forward, we are providing analysis solutions to designers with the same robust capabilities found in our advanced simulation products.

DesignSight, our newest product suite and part of the DS V6 PLM 2.0 solution, enables CATIA users to take advantage of proven Abaqus technology to perform realistic simulations as part of their natural design experience. This product suite

Dassault Systèmes's CATIA V6 PLM 2.0 suite includes DesignSight, which uses Abaqus technology to perform realistic simulations.

provides powerful linear and nonlinear simulation capabilities in the design environment in a robust and easily accessible manner. By providing built-in checks and balances, DesignSight guides users to correctly set up and perform their analyses. DesignSight is fully integrated within the DS V6 PLM 2.0 platform, which enables analysts and designers to easily collaborate through the use of common technology and methods.

When combined with SIMULIA's Isight, engineers have access to a suite of visual and flexible tools for creating simulation process flow to automatically explore design alternatives and identify optimal performance parameters. This results in higher quality designs, with lower costs and faster time-to-market, making our customers more competitive in their respective industries. In addition, the DS V6 platform is allowing SIMULIA to provide a robust portfolio of solutions to manage simulation data, processes and applications, as well as collaborate.

We are very enthusiastic about the future of realistic simulation and feel privileged to be able to interact with so many talented engineers and scientists from all industries. There is so much value the simulation community brings to improve our society and help protect our environment. We are engaged with our customers on a daily basis to make realistic simulation an integral business practice, with the goal of accelerating exploration, discovery, and innovation.

For more on SIMULIA's solutions and customer papers, visit the Resource Center at 3ds.com/products/simulia. DE

Tim Webb *is director of Marketing & Communications, SIMULIA.*

Information *as You Need It*

Knovel serves today's leaner, geographically dispersed engineering workforce.

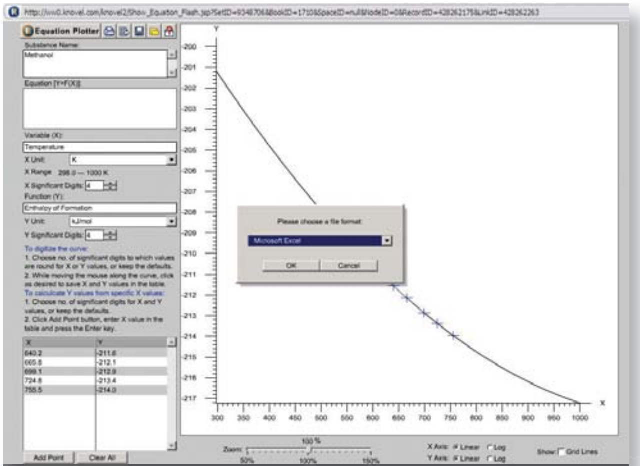
BY CHRIS FORBES

Ten years ago, Knovel began offering trusted technical references to engineers online. We surprised the industry by bringing reference data to life by making it interactive, empowering engineers to manipulate and incorporate it into their workflow.

Engineers embraced the convenience and power of Knovel from the start. Why? Because going to a physical library and skimming through books for answers, manually copying a source or an equation into a notebook and using calculators to solve it burns valuable time. Searching the vast Internet isn't much more effective. Consider how much time is wasted digging through a deluge of results to find usable information from sources that must be validated.

Today, Knovel offers content across 24 subject areas, and we have nearly 70,000 interactive tables, equation plotters, charts and graphs that can be manipulated and exported into other tools such as Excel or PTC's Mathcad. Using Knovel, engineers save time, avoid costly mistakes, and expand their knowledge base. Industry leading companies rely on Knovel as a source of highly regarded content engineers can use to justify design decisions.

Engineers using Knovel have powered towns with wind farms, rebuilt bridges, designed power plants, and introduced new products to market. We are proud to support design engineers as they research product development and design options, best practices, safety, compliance, and materials for a wide range of products across all industries.



With Knovel's equation plotter, engineers can use reference information to model results by entering their own test values.

Engineering Trends

We continue to be solely focused on the needs of the engineering community. In fact, engineers drive Knovel's content selection and product design; staying tuned into their business challenges is a priority.

At a high level, customers tell us they face intense global competition and tight margins. Engineering teams are leaner and less specialized requiring more interdisciplinary know-how.

Experienced engineers are retiring at an alarming pace and fewer are entering the field. Training and knowledge transfer are more important than ever.

We also see a rise of merger and acquisition activity in the market and an increase in remote and geographically dispersed teams. Companies turn to Knovel as they streamline resources to ensure employees/engineers have access to a common source of best practices and policies. This not only ensures engineering projects are properly and consistently documented, but it also helps to provide an efficient work environment.

Future Opportunities

With customer and industry challenges in mind, we see tremendous opportunities as technology continues to advance. Mobile devices and applications change the way we work and live. Collaboration has taken on new meaning with the adoption of Wikis, social networks, and crowd sourcing. The ability to access Knovel via mobile devices, collaboration, and integration into enterprise applications, such as content and knowledge management systems, are all part of our long-term strategy to ensure that we continue to increase the speed-to-solution for engineers.

Next year, Knovel will launch a new platform with enhanced ease-of-use including an intuitive search interface that improves the speed of search returns as well as the accuracy and relevance of results and even more content. Text and data searches will be unified to save time. The new interface will facilitate navigation and increase efficiency and visibility of our interactive tools. With Knovel, you'll know more and search less.

If you haven't tried Knovel, check it out and see what you've been missing. **DE**

Chris Forbes *is president and CEO, Knovel.*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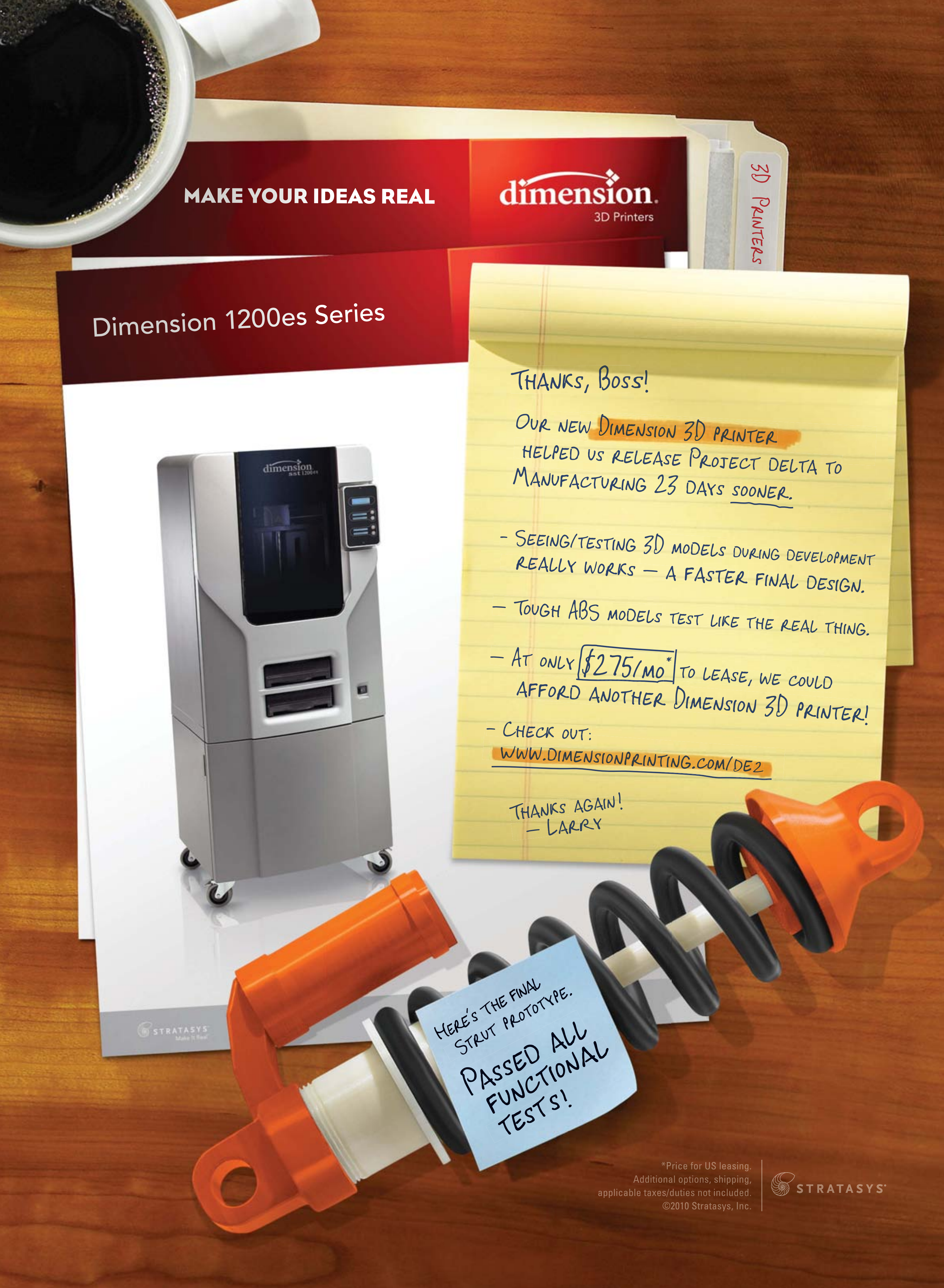
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