DE
Desktop Engineering®

TECHNOLOGY FOR DESIGN ENGINEERING

May 2015 / deskeng.com

FOCUS ON: Medical Industry

3D Printing Medical Miracles
P.14

Degrees of Freedom

by Jamie J. Gooch

Customization is Crucial

Being able to design and 3D print your own, custom cellphone case is cool. Being able to have a pair of earphones designed exclusively to fit your ears and custom printed in a few days is amazing. But being able to create custom prosthetics, implants and patient-specific surgical models are life-changing, and in some cases, life-saving applications of 3D printing.

Every day, medical professionals are using 3D printers to create customized, personalized solutions for an array of medical problems, and there's more to come. Research firm IDTechEx expects the dental and medical market for 3D printers to expand by 365% to $867 million by 2025. Transparency Market Research predicts the medical 3D printing market will grow at a compound annual growth rate of 15.4% to reach $965.5 million in 2019.

Pushing the Boundaries

Researchers are already pushing beyond the initial medical 3D printing applications like spinal braces, knee implants and dental molds. For example:

- Oxford Performance Materials (OPM), which develops poly-ether-ketone-ketone (PEKK) materials used in 3D printing implants, is working with Yale University on 10 projects involving direct tissue attachment for cranial and facial surgery, prostheses for rib replacement, and 3D printed PEKK devices to deliver therapeutics and antibiotics.

3D printing enables patient-specific medical applications.

- A research team led by scientists at Dalhousie University and the Nova Scotia Cancer Center has investigated the use of 3D printing as part of modulated electron radiation therapy to create custom devices that shield some areas from the cancer treatment, but also to ensure an even distribution of radiation in the targeted area.
- Researchers at Brigham and Women's Hospital are developing a method that allows for the creation of viable blood vessels in 3D-printed organs.
- Researchers at Drexel University have begun to use 3D printers to artificially manufacture cancerous tumors. Doctors intend to use the tumors for medical testing and drug trials.
- A team of scientists used 3D printing to create a membranous sleeve that can surround a heart to provide monitoring and cardiac assistance.

The list of 3D printing medical research goes on and on. (See page 14 and rapidreadytech.com/category/medical for more.) To bring that research out of the labs and into hospitals will require the usual development cycle all new products go through, plus meeting extensive safety regulations. In the U.S., regulators are well aware of the promise of 3D printing.

Government Support

There are a number of online exchanges that allow anyone to download a model they can then 3D print. The National Institutes of Health (NIH) has launched the NIH 3D Print Exchange because "few scientific 3D-printable models are available online, and the expertise required to generate and validate such models remains a barrier," according to the site. The Exchange enables searching, browsing, downloading and sharing of biomedical files of cells, bacteria, viruses, molecules and anatomical models that can be 3D printed. The site also includes downloadable video tutorials and instructions on how to use 3D modeling software, and illustrated workflows to create 3D-printable models from data.

Last fall the U.S. Food and Drug Administration (FDA) hosted a public workshop called "Additive Manufacturing of Medical Devices: An Interactive Discussion on the Technical Considerations of 3D Printing." The workshop brought together representatives from the FDA, medical device manufactures, additive manufacturing companies and academia. The agency used the workshop to seek input on how to evaluate 3D-printed medical devices. (On-demand webcasts and transcripts are available here: http://goo.gl/GxQSyd).

At a medical conference last year, Steven Pollack, director of the Office of Science & Engineering Labs at the FDA, said the agency wants to be aware of the challenges involved in 3D printing and won't regulate things that don't need regulation, but does need to know where to "take a deeper dive."

The U.S. Department of Health and Human Services is awarding up to $3 million in grants in 2015 through the Eunice Kennedy Shriver National Institute of Child Health and Human Development to advance the use of 3D printers for the production of medical devices. The grants are specifically intended to support research to develop 3D printers, polymers and processes to produce premature- and neonatal-specific devices.

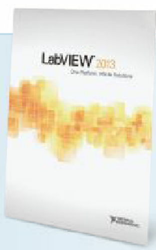
As with any innovation, government regulations can be a hindrance to widespread adoption or provide a boost to acceptance. The federal government's initial efforts show that it intends to support 3D printing as an avenue toward high-quality, personalized health care. DE

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

Smarter Embedded Designs,
Faster Deployment

The combination of NI LabVIEW system design software and reconfigurable I/O (RIO) hardware helps small design teams with varied expertise develop demanding embedded applications in less time. Using this graphical system design approach, you can take advantage of the same integrated platform to program embedded processors and FPGAs for faster application development in industries ranging from energy to transportation, manufacturing, and life sciences.

LabVIEW system design software offers ultimate flexibility through FPGA programming, simplifies code reuse, and helps you program the way you think–graphically.



>> Accelerate your productivity at ni.com/embedded-platform

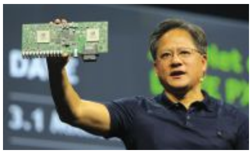
800 453 6202

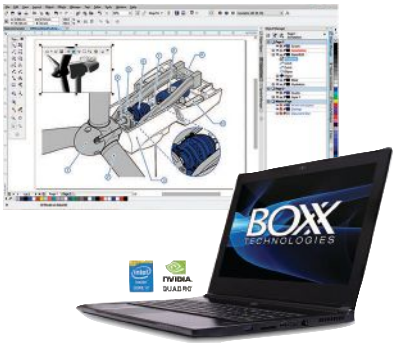
NATIONAL INSTRUMENTS

DE May 2015 VOLUME 20/ISSUE 9

ON THE COVER: A 3D model of a heart produced with Materialise's HeartPrint depicting the tissue in transparent material and the blood in white rigid material is pictured. *Image courtesy of Materialise, www.heartprint.materialise.com.*

DEPARTMENTS





EXECUTIVE EDITOR & PUBLISHER
Tom Conlon

EDITORIAL
Jamie J. Gooch | Editorial Director
Kenneth Wong | Senior Editor
Anthony J. Lockwood | Editor at Large
Jess Lulka | Associate Editor

CONTRIBUTING EDITORS
Tony Abbey, Brian Albright, Mark Clarkson, David S. Cohn, John Newman, Frank Ohlhorst, Beth Stackpole, Peter Varhol, Pamela J. Waterman

ADVERTISING SALES
603-563-1631 • Fax 603-563-8192
Erich Herbert | Sales Manager (x263)
Chris Casey | Sales Manager 847-274-5476

ART & PRODUCTION
Darlene Sweeney | Director 603-563-1631 (x257)

A PEERLESS MEDIA, LLC PUBLICATION
Brian Ceraolo | President and Group Publisher
Tom Conlon | Vice President

ADVERTISING, BUSINESS, & EDITORIAL OFFICES
***Desktop Engineering*® magazine**
Peerless Media, LLC
1283D Main St., PO Box 1039 • Dublin, NH 03444
603-563-1631 • Fax 603-563-8192
E-mail: DE-Editors@deskeng.com
www.deskeng.com

www.peerlessmedia.com

Kenneth Moyes | President and CEO, EH Publishing, Inc.

SUBSCRIBER CUSTOMER SERVICE
***Desktop Engineering*® magazine**
PO Box 677 • Northbrook, IL 60065-0677
847-559-7581 • Fax 847-564-9453
E-mail: den@omeda.com

***Desktop Engineering*®** (ISSN 1085-0422) is published monthly by Peerless Media, LLC, a division of EH Publishing, Inc. 111 Speen St., Ste. 200 Framingham, MA 01701. Periodicals postage paid at Framingham, MA and additional mailing offices. *Desktop Engineering*® is distributed free to qualified U.S. subscribers.

SUBSCRIPTION RATES: for non-qualified; U.S. $108 one year; Canada and Mexico $126 one year; all other countries $195 one year.

Send all subscription inquiries to *Desktop Engineering* 111 Speen St. Ste. 200 Framingham, MA 01701

LIST RENTALS: For information on list rentals, contact Statlistics, Danbury, CT: 203-778-8700.

Postmaster: Send all address changes to *Desktop Engineering*®, PO Box 1496 Framingham, MA 01701-1496.


MEDICAL MANUFACTURING • SLA • CNC MACHINING • ARCHITECTURAL MODEL MAKING • INJECTION
PRINTING • QUANTUMCAST CAST URETHANES • AUTOMOTIVE • POLYJET • MEDICAL MODELING • PROTOTYPING
Copyright ©2015 Stratasys Direct, Inc. All rights reserved. Stratasys Direct Manufacturing, FDM and PolyJet are trademarks or registered trademarks of Stratasys Direct, Inc. and/or its affiliates and may be registered in certain jurisdictions. Other trademarks are property of their respective owners.
SLA
PROJECT PRINTING HEARTS
CLIENT TCAI
PART ANATOMICAL HEART
DAYS 2
Learn how Stratasys is redefining manufacturing, download our recent white paper and explore more stories like Printing Hearts. STRATASYSTOGETHER.COM
Stratasys
DIRECT MANUFACTURING

by Kenneth Wong & Jess Lulka

Speeding Up Deep Learning with the GPU

In mid-March, NVIDIA Founder and CEO Jen-Hsun Huang greeted the crowd assembled at the San Jose Convention Center for the annual NVIDIA GPU Technology Conference (GTC). He said, "I'm going to tell you about four things: We'll talk about a new GPU (graphics processing unit) and deep learning. We'll talk about a very fast box, and deep learning. I'll show you our road map, talk about the exciting things we're doing at NVIDIA, and deep learning. And I'll talk to you about self-driving cars, as it relates to deep learning."

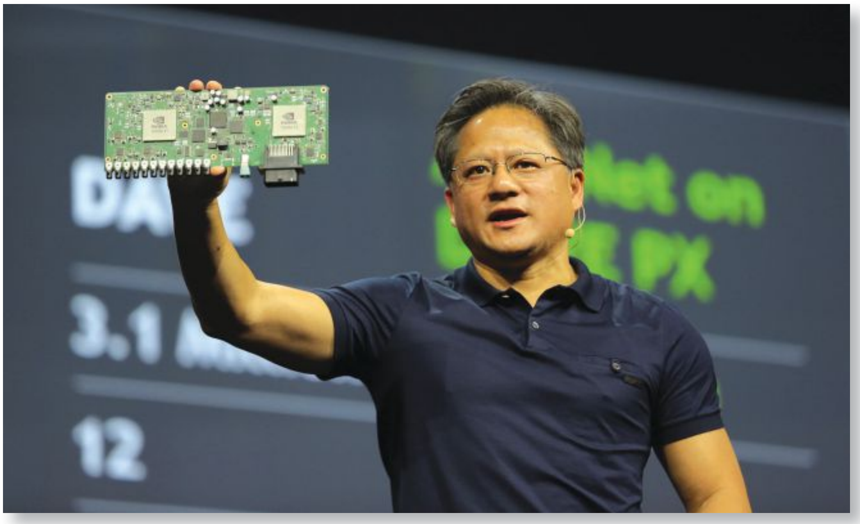
Huang's talk focused on:

- The GeForce TITAN X GPU, hardware for deep learning ($999);
- The DIGITS DevBox, aimed at re searchers interested in deep learning (available this month, $15,000);
- The plan to deliver 10X Maxwell's performance with PASCAL GPUs;
- The Drive PX developer kit for self-driving cars ($10,000).

Deep learning or machine learning — the theme that cuts across all four segments of Huang's talk — is better known as artificial intelligence (AI). Once the stuff of speculative utopian or dystopian films, AI hibernates today in the form of algorithms used in self-driving cars, face-recognition software and automatic-translation programs.

Another keynote delivered by Dr. Jeff Dean, a senior fellow in the Google Knowledge Group, picked up the same theme. "You can't write algorithms for all individual tasks, so you write programs that can learn from observation," he said.

The intense computation required in this specialized discipline is attractive to NVIDIA, which promotes the parallel processing power of its GPUs as a solution to the biggest high-performance computing (HPC) challenges. At this year's GTC, academics and data scientists strolled the corridors, talking about how GPU-outfitted appliances could accelerate different permutations of AI.



At the 2015 GPU Technology Conference, NVIDIA CEO Jen-Hsun Huang unveiled the Drive PX, a self-driving car developer kit. *Image courtesy of NVIDIA.*

Meet the TITAN

Huang called it "The most advanced GPU we have ever made." The TITAN X houses 8 billion transistors, running on more than 3,000 CUDA cores, capable of 7 TFLOP single-precision calculation. The GeForce product line may have originated as the ultimate gaming hardware, but the TITAN X, according to NVIDIA, is a good fit for researchers tackling deep learning. In building neural networks to ingest and understand large volumes of data, TITAN X's sheer horsepower may offer an advantage.

A Box to Train Your Machines

Few CEOs would introduce a product by explaining they intend to sell only a small volume of it. "The [DIGITS DevBox] is a box that we like not to sell in high volumes," Huang said. "The reason is it's really developed for the developers. It only comes with Linux, only comes with four GPUs, only in one configuration … It's priced at a level that hopefully all researchers can afford."

NVIDIA hopes it can capture smaller research teams with its modestly priced NVIDIA DIGITS DevBox.

The Self-Driving Car Starter Kit

The NVIDIA Drive PX is described as "a platform is based on the NVIDIA Tegra X1 processor, enabling smarter, more sophisticated advanced driver assistance systems (ADAS)." The Tegra X1's 1.3 gigapixels/second processing speed, the company points out, is "enough to handle 12 two-megapixel cameras at frame rates up to 60 fps for some cameras" — an important consideration for the autonomous cars that would rely on sensor data and camera-fed computer vision to make navigation decisions.

A Peak at PASCAL

Haung said PASCAL, the next-generation GPU architecture from NVIDIA, benefited from "a billion dollars' worth of refinement in R&D over the last three years." Pascal is expected to be the first GPU in NVIDIA's history capable of mixed precision.

Haung said this is the beginning of a whole new universe — "The Big Bang of self-driving cars," as he puts it. And if it were up to him, the GPUs will be an integration part of this AI evolution.

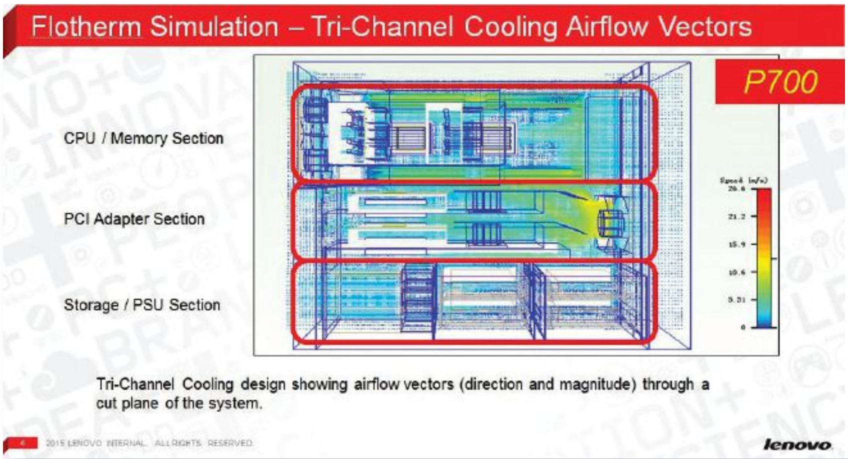
—*K. Wong*

How a Modern Workhorse Breathes

Some heavy computer users assume — in what seems to them like sound logic — that if their workstation is showing signs of extreme heat load (loud fan noise would be one of the symptoms), they can cool it off by opening up the side or back panel. That, Al Makley from Lenovo pointed out, can do more harm than good.

As director of Architecture and Technical Solutions at Lenovo's ThinkStation product line, Makley spent a lot of time thinking about what goes on under the hood of a computer. "The cover is an instrumental part of the machine's thermal regulation," he explained. "By removing the cover, you are removing the negative pressure inside the chassis. Without that negative pressure, you have no airflow on your hard drives, so they're now subject to overheat."

In older generation computers, the placement of components — CPUs, GPUs, motherboard, heat sinks, fans and hard drives — was much more forgiving, but the demand to pack a lot more into a smaller form factor in modern workstations leaves little space to waste inside the chassis. This calls for more sophisticated approaches to directing the airflow within the box.



Lenovo ThinkStation P Series uses a tri-channel cooling system to direct airflow and heat. The image here shows simulated airflow inside FloTHERM. ***Image courtesy of Lenovo.***

More Refined Design

In a standard computer housed inside a tower box, Makley saw what he called mixed airflow — "for instance, heat from the graphics adaptor influencing the dual inline memory modules (DIMMs) and the CPUs," he says. In the Lenovo ThinkStation P series, the company's patented tri-channel cooling system functions as a heat regulator. The design represents a more refined derivative of the system first introduced in the ThinkStation C20, which debuted in 2011.

"It segments the chassis into three separate compartments," says Makley. "One compartment works to cool the hard drives and power supplies, another to cool the memory and the CPUs, and the third to cool the PCI channel in the graphics adaptor. Within those compartments, we make sure there's clear front-to-back airflow to bring cool air in and pump warm air out, with no cross-compartment heat propagation."

With mechanical components, you can see their interactions with your naked eyes. Not so with the behavior of heat and airflow inside a computer's closed chassis, Makley pointed out. "Thermal design is very difficult to comprehend. That's where you need simulation," he said. "It tells you with clear vector arrows where the air is flowing."

Simulating Airflow

For thermal simulation, Lenovo uses FloTHERM, acquired by Mentor Graphics in 2008. With software-driven simulation, Makley believes he and his team can get to about 90-95% accuracy in predicting the airflow. The rest — the 5-10% margin — may be attributed to the approximation engineers must use. "For instance, with a real fan, the impeller shape would determine the airflow direction — it could be blowing at 40°, 45°, or 50° angle," he says. "In simulation software, you may have to guess that angle and use it as an input."

Lenovo uses physical tests — usually conducted with cardboard structures mimicking the chassis design — to verify the software's predictions.

"Of all the P series workstations, the P900 proves a lot more challenging to design because of the additional PCI-e slots that it must accommodate," Makley says. "So we added a highly efficient rare system fan to draw the airflow from the upstream pressure sources. It has an effective air baffle to deliver fresh air to both the upstream and downstream CPUs. The same airflow also cools the DIMMs adjacent to the CPUs — all accomplished with one self-contained air baffle."

Fans are the best solution to counteract the heat sources, but they're also additional risks for failure. As moving mechanical components, fans are prone to breaking; they also produce considerable noise when activated. So Makley and his colleagues wanted to design the P900 with as few fans as possible. "We managed to cool the entire system with only three fans," Makley says. "Our competition uses a lot more moving parts in their comparable product segments to do this."

—K. Wong

Ready, Set, Simulate

If simulation is in your job description, you won't want to miss the NAFEMS Annual World Conference (San Diego from June 21-24). The multi-day event has a packed agenda with over 300 presentations, training courses and an exhibition.

NAFEMS represents over 1,100 member organizations worldwide, including software vendors, global manufacturing industry representatives and leading academic institutions. The theme for 2015 is "A World of Engineering Simulation." The conference intends to initiate a discussion of how engineers and companies can keep up with the ever-evolving technology and concepts associated with simulation — from hardware to software and best practices. It also serves as a place for attendees figure out how their knowledge, processes, tools and corporate culture can take advantage of the continued evolution in simulation technology.

Training Topics

There will be an entire day devoted to training workshops on finite element analysis (FEA), computational fluid dynamics (CFD), and simulation process and data management (SPDM). Training provided throughout the convention will cover:

- Dynamic FEA
- CFD for Structural Designers and Analysts
- Introduction to Practical CFD
- Structural Optimization in FEA
- Simulation Verification & Validation for Managers

The congress has presentations focused on dynamics, multiphysics, composites, systems engineering, manufacturing, acoustics, high-performance computing and other simulation-related topics. Discussions will also be available for analysis management, stochastics, industrial applications, composites, emerging issues and more.

3D Printing Presentations

This year's lineup includes a forum on "Additive Manufacturing and 3D Printing in Design and Engineering." Exhibitors include the likes of Autodesk, CD-adapco, Dassault Systèmes, Mentor Graphics, MSC Software and Siemens PLM Software.

Keynote speakers include:

- Ferdinand Dirschmid, BMW Group, "The CFRP Lightweight Structure of the BMW i8"
- Klaus-Jürgen Bathe, Massachusetts Institute of Technology, "Advanced Finite Element Analysis and its Future"
- Zlatko Penzar, Continental AG, "How Small (but fine) Simulations can also Radically Improve Industrial Products"
- Peter Coleman, Airbus Operations, "Reflections on SPDM for Collaborative, Multidisciplinary and Agile Aircraft Product Development"

For more info, visit nafems.org.

—J. Lulka

On-demand HPC: Friend or Foe of the CIO?

Rescale, a Platform-as-a-Service (PaaS) provider that caters to simulation software users, was recently named one of the 20 promising HPC vendors for 2015 by *CIO Review*.

Since its quiet launch in 2013, Rescale has become a recognized name among the small simulation community, striking partnerships with Siemens PLM Software, Dassault Systèmes, CD-adapco, MSC Software and others. The software-hardware combo that lets simulation users create repeatable workflows distinguishes Rescale from other vendors who offer hardware alone. It's easy to overlook the company's role as the middleman to negotiate additional licenses or tokens where needed, but that feature adds enormous convenience for those who must add more licenses to simultaneously examine multiple design alternatives.

Traditionally skittish industries may be warming up to the idea of on-demand HPC. "Within the aerospace and automotive sectors, a large majority (over 70%) of our customers are large enterprises, including household OEMs (original equipment manufacturers), Tier 1 manufacturers and the rest of the supply chain. The larger the enterprise the bigger the benefit from transitioning to Rescale's cloud HPC simulation platform," says Joris Poort, CEO at Rescale.

Part of the anxiety with on-demand providers rests with reliability. A business that invests in on-premise HPC retains full control of the resources, 24/7, though the initial cost could be prohibitive. By contrast, a business that relies on on-demand HPC is at the mercy of the provider — or so the reasoning goes. But Poort points out, "Rescale's robust and proprietary infrastructure layer is extremely reliant where we guarantee 99% uptime (this is right in our service-level agreement). Due to the broad network of infrastructure provided by Rescale, at any single point in time, there will always be online capacity available."

The writing on the wall is clear, according to Poort: "Most organizations have already started the transition to cloud as part of the corporate IT strategy but these can take several years to execute on. Even for large organizations who may aggregate capacity for thousands of users, the economies of scale in purchasing, agility and elasticity of resources, power consumption optimization, and human resources expertise make on-premise HPC an unsustainable long-term solution."

—K. Wong

Functionalize Mixes Up Conductive Filament

What more could be accomplished if designers had the option of building an object using conductive filament?

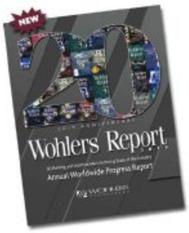
We'll soon find out the answer to that question. Functionalize recently announced the launch of its F-Electric filament. The filament is currently being produced in 1.75mm and 2.85mm, with a resistance of 0.75 ohm*cm, and a mechanical strength exceeding that of standard PLA (polylactic acid).

F-Electric filament offers many new design opportunities. It is possible, according to the company, to literally print out, "complete electrical circuits, sockets, switches, buttons and connectors in your 3D printed structures with motors, active components and chips connected by plastic and placed with 3D printed precision, exactly where they make sense."

MORE ➜ rapidreadytech.com/?p=8523

20th Anniversary Edition of Wohlers Report Is Out

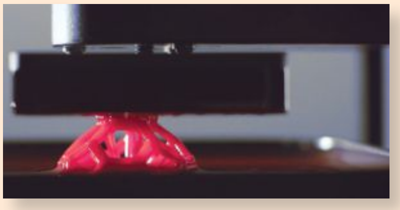
This year's 314-page report was compiled by 78 co-authors in 31 countries, and includes information provided by service providers and manufacturers. Information about 3D printing's history, applications, processes and materials are included. The report also looks at recent developments in R&D, investments by government and industry and provides a summary of the current state of AM around the world.



The 2015 *Wohlers Report* concludes that all sectors of additive manufacturing (AM) experienced growth. The market grew at a compound annual growth rate (CAGR) of 35.2% to $4.1 billion in 2014. Demnd for metal 3D printing has grown in medical and aerospace industries.

MORE ➜ rapidreadytech.com/?p=8529

Autodesk Invests in Carbon3D



Businesses and researchers have gone from using additive manufacturing (AM) mainly for prototyping or the occasional spare part, to full-scale production in multiple materials. You have to pay attention to keep up with what's going on in AM.

It seems that someone at Autodesk is paying attention. The company decided to invest $10 million into Carbon3D from the Spark Investment Fund. The fund had been set up to demonstrate Autodesk's dedication to launching the Spark program, including the Ember, as a tool for research and development.

Carbon3D has developed an AM system that uses a proprietary process called CLIP (continuous liquid interface production technology) that operates through photo polymerization. Unlike standard stereolithography, which builds an object one layer at a time by curing the topmost layer of a resin pool, CLIP projects light through the pool, encouraging the object to grow together simultaneously.

MORE ➜ rapidreadytech.com/?p=8539

3D-Printed Food That Grows on You

This cross between a pastry and a Chia Pet was thought up by food designer Chloe Rutzerveld. The printed snacks include a center made of agar — an edible goo that helps the seeds and spores grow.

According to her website: "Within five days the plants and fungi mature and the yeast ferments the solid inside into a liquid. The product's intensifying structure, scent and taste are reflected in its changing appearance. Depending on the preferred intensity, the consumer decides when to harvest and enjoy the delicious, fresh and nutrient-rich edible."

Rutzerveld developed the solution with Eindhoven University of Technology and TNO, a research company, as a way to 3D print fresh, healthy food. It could be another eight to 10 years, by her estimates, before the solution could be commercialized.

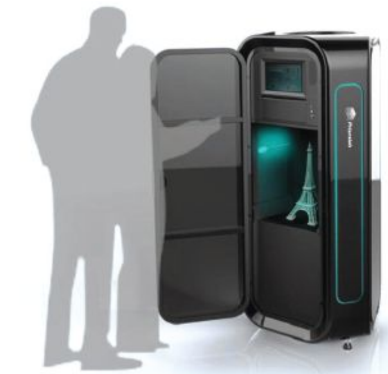
MORE ➜ rapidreadytech.com/?p=8411

Speeding Up 3D Printing

Speed is an area under constant development for additive manufacturing (AM). It is also of keen interest to Chinese AM companies looking to either catch up with, or surpass, their western counterparts in the AM business. Prismlab may well have achieved that goal with the development of multiple new AM systems. Each system is based on stereolithography (SL) technology, but, according to the company, operates up to 10x faster.

The Rapid series of AM systems represents Prismlab's first attempts at producing marketable 3D printers. If the final products look like the artist renderings, the systems will be sleek and thin, looking rather like a giant iPhone.

MORE ➜ rapidreadytech.com/?p=8505



➜ For more coverage of rapid technologies, visit RapidReadyTech.com

More from your Workstation

Overclocking is a safe, effective way to increase productivity.

Time is money. It's a cliché, but one that also happens to be true. Design engineers are well versed in the time requirements for working with large CAD models, running simulations and completing renders. The bigger the model, the longer it takes. Switching between daily office tasks like checking email and working in spreadsheets to more processor-intensive design engineering tasks can be frustrating. Waiting wastes money.

However, there's a safe, economical solution to boost your productivity when using professional design and simulation software packages.

Overclocking Overview

Maxing out cores and memory doesn't always deliver optimal performance improvements across the board, so instead of adding more hardware, one of the most productive ways to improve productivity is to get the right hardware and make it run faster.

Not every CPU is the same. A processor sold with a listed frequency of 3.9GHz may actually be fully and safely capable of running at 4.5GHz. Processor manufacturers identify the processors that are capable of running at a higher frequencies and BOXX Technologies overclocks them so that they actually run at these faster speeds. In fact, in order to ensure that their workstations are within the proper parameters of safe overclocking, BOXX works very closely with Intel.

Combining overclocked processors with high-performance components creates the most effective workstation. This includes power phase-matched motherboards, premium memory, efficient power supply units, and data-center quality cooling systems to maintain and extend the lifespan of the overclocked CPU.

In CAD applications like SolidWorks, if you're not doing frequent rendering, odds are that single-threaded performance is all that matters. This means that adding cores, or going to a dual CPU system will not give you better performance, nor will upgrading your GPU. Increasing processor frequency via overclocking is the only way to get that extra performance you need, and it's less expensive than you think.

Safe, Reliable, Powerful

Overclocking has been happening for years, especially in the computer game industry. At first, it was "unauthorized." These days, Intel is not only fully aware of the practice, it now proactively markets processors capable of overclocking.

When you combine these fully endorsed and authorized overclockable CPUs with the same processor cooling technology found in corporate data centers, you get quiet, reliable performance that's more than 20% better than out-of-the-box systems. Those productivity gains are possible while maintaining the same workstation lifespan backed by the same warranty and support that you'd get from a non-overclocked processor. So, it's never been safer to use overclocked processors. It's win-win.

The only way you'll know there's an overclocked processor in your workstation is the added performance you'll see every day.

For more information, visit boxxtech.com.

THE APEXX 2 2401 is well-suited for CAD users who don't need frequent rendering. It has up to: a 4.5GHz 4th Generation Intel Core i7 processor, 4 cores, 2 GPUs, and 32GB RAM.

THE APEXX 4 7402 is designed for local rendering without sacrificing single-threaded performance. It has up to: 4.125GHz 4th Generation Intel Core i7 processors, 8 cores, 4 GPUs and 64GB RAM.

THE GOBOXX 15 & 17 MXL laptops have the power of a desktop CPU. They are not overclocked, but use the fastest-frequency desktop processor to deliver performance beyond mobile processors.

3D Printing: *The Next Medical Miracle?*

3D printing is driving innovations in surgical training, implants, and prosthetic devices that are improving patient care while reducing risk and cost.

BY BETH STACKPOLE

One of the rising stars of the show "Grey's Anatomy" isn't any of the Emmy-nominated actors or McDreamy, the doc with the flowing hair. Instead, it's the 3D printing technology that has been used by the series' surgical teams over the last few seasons for such procedures as creating an infant portal vein and building customized heart and liver surgical planning models.

Grey Sloane Memorial might be a fictional hospital setting, but its use of 3D printing is the real deal. Hospitals, private physicians, dental practitioners, and researchers across the globe are both experimenting and using 3D printing and other 3D technologies to solve tough medical problems, turning what was once considered sci-fi into routine procedures now featured on primetime television.

3D printing got its start in the medical field nearly a decade ago, initially tapped in the dental space for building crowns, bridges, and a range of orthodontic appliances. Over time and with improvements, the technology started taking hold in areas that require custom design and quicker turnaround than traditional methods, including the production of hearing aid shells and the clear teeth aligners used in place of metal braces.

With the cost of 3D print technology continuing to decline and thanks to a bonanza of activity on the materials front, the technology has taken off in a number of new directions. 3D printers are routinely being used to design and build generic and custom orthopedic implants; create anatomically correct, complex models for training and surgical planning; and develop custom and cost-effective surgical guides. More recently, there have been major breakthroughs using 3D printing to produce patient-specific prosthetics for extremities, exoskeletons, cranio-maxillofacial surgeries, and full facial reconstructions. On top of that, bioprinting is in the early research stage, with efforts underway to explore how to harness 3D printing capabilities to grow live tissue and eventually, human organs. (See "Bioprinting is the New Frontier.")

The multi-color and multi-material bio-models created with Stratasys' Object500 Connex 3 multi-material 3D printer help surgeons uncover hidden tissues and blood vessels. *Image courtesy of Stratasys.*

Customization and Costs Savings

"There are inherent benefits to 3D printing technology when you are creating one-off or customized parts," says Todd Pietila, business development manager for Materialise, a provider of 3D printing software and services. "That has obvious benefits when applied to the medical field because every patient has a slightly different anatomy and every procedure can benefit from a customized approach. The technology is so powerful in the health care industry because it allows for personalized treatment that is tailored to the patient in order to achieve the best outcomes."

The continuing focus on rising health care costs is one reason why there is so much interest among the medical community in 3D printing technology. 3D printing offers a cost-effective way to produce personalized medical devices, especially in developing countries, where funding and resources for health care are scarce. While it's still early for the more innovative 3D printing medical applications, experts see huge market potential as the technology becomes more accessible, prices come down and early pioneers share success stories that get the broader health care community on board.

"We're starting to see 3D printing hit critical mass in the field as some of these experts apply the technology in exciting ways and get their peer groups to take notice," says Scott Dunham, senior analyst at SmarTech Market Publishing, a research company focused specifically on 3D printing. SmarTech Market Publishing is projecting the total market for 3D printing in the medical field (including software, hardware and materials) to skyrocket from around $268 million last year to nearly $1.3 billion by 2024.

It's not just 3D printing technology that's fueling the growth, Dunham notes. The convergence of existing medical imaging, 3D design software and 3D printing is creating a new category of medical solutions where the sum is greater than any of its parts, Dunham says.

"Medical imaging technology, 3D design software and 3D printing technology have all been around for a long time, but now people are figuring out the best ways to use them all together, and that is amazingly powerful for medical applications," Dunham says.

Creating A Digital Thread

Melding those core technologies is the key to 3D Systems' strategy for the medical market, according to Cathy Lewis, executive vice president and chief marketing officer for the firm. In addition to its wide-ranging line of 3D printers, the company has assembled many core capabilities through acquisition: virtual surgical planning and tactile medical imaging technology from Medical Modeling; solutions for converting CT scans into full-color 3D models for export to 3D printers from Bespoke Modeling; optical imaging technology from VIDAR Systems Corp.; virtual reality surgical

3D Systems and Rita Leibinger Medical are getting disabled dogs back on their feet fast with 3D-printed titanium implants. *Image courtesy of 3D Systems.*

Billy Crawford tries on a facial prosthetic created with 3D printing and Medical Modeling's software that matches his skin tone and texture. *Image courtesy of Student Society for Science.*

simulation and training from Simbionix; and direct metal 3D printing and manufacturing services from LayerWise.

"We're providing a beginning-to-end digital thread that allows physicians to learn, plan and provide higher quality procedures," Lewis says. "It's all about having all of the tools in place to have better patient outcomes."

3D Systems' SLA (stereolithography apparatus) production printers are being tapped to create detailed medical models along with the inner ear hearing aids and invisible teeth aligners, while the SLS (selective laser sintering) printers are employed by health care providers and practitioners to create fixtures and surgical guides. The company's LayerWise service and its line of ProX high-capacity direct metal 3D printers have also garnered a lot of traction in the medical market. They are used to create final implantable devices like knee replacements or dental appliances, Lewis says.

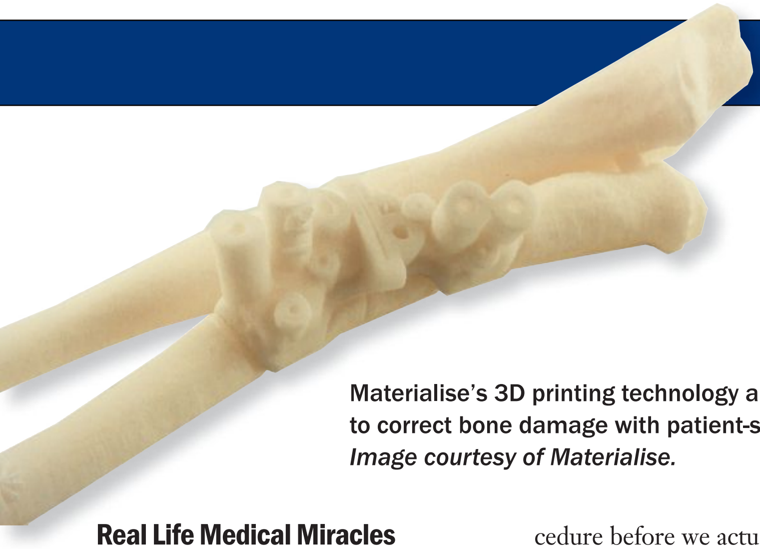
In one of the more recent and notable developments in this space, 3D Systems teamed up with Rita Leibinger Medical, a manufacturer of veterinary products, to design and 3D fabricate the patent-pending TTA RAPID, a titanium implant used in cruciate ligament repair in the hind legs of dogs. It promises faster recovery and less risk of infection and has been used on more than 10,000 dogs to date.

Stratasys' 3D printers are also behind innovative efforts in medical 3D printing. The company's line of Object Connex 3D printers has made significant inroads in this segment due to their ability to print in multi-materials and multiple colors at the same time, notes Scott Radar, general manager, Medical Solutions at Stratasys.

Radar says 3D printing technologies are having an impact on the medical field in three ways. For quite some time now, he says 3D printers have improved the design-to-manufacturing process, providing efficiencies and cost savings in how medical device companies make production-based jigs, castings and molds. There are also a lot of possibilities in leveraging 3D printing technology as a new production capability — whether that means printing products more locally or novel use cases like tissue printing, Radar explains. However, the area getting the most attention is using 3D printing to enhance the quality of patient care, which could include anything from realistic surgical planning models to the new generation of custom prosthetics.

The sheer variety of 3D printing technologies and new material choices are what is setting the stage for 3D medical printing to be a reality. For example, Stratasys currently offers over 1,000 different materials for 3D printers, including ULTEM 1010, an FDM (Fused Deposition Modeling) material with a certification for human contact, Radar says. As part of Materialise's HeartPrint service, physicians can now print a combination of flexible and rigid materials in one model to create calcifications in anatomy such as vessels or valves.

"HeartPrint models are quite realistic in terms of what you would find with atrial or cardiac tissue, so a surgeon can cut into it and bend a vessel out of the way as they would in the operating room," says Materialise's Pietila. "By better understanding exactly what approach they'll take, it saves time in the OR and it's less stressful for both the surgeon and the patient."



Materialise's 3D printing technology allows physicians to correct bone damage with patient-specific plates. *Image courtesy of Materialise.*

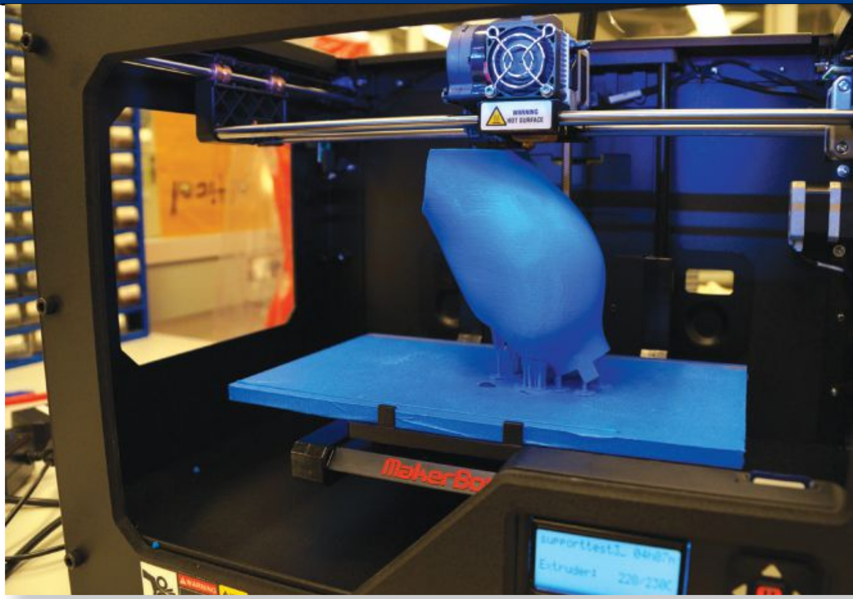
Real Life Medical Miracles

The anatomically correct, 3D printed surgical models are gaining traction across a range of surgical disciplines. At Miami Cardiac & Vascular Institute, doctors are using The PROcedure Rehearsal Studio from 3D Systems to create customized models to help them simulate, analyze and evaluate preoperative endovascular surgical treatment options for each patient. "We actually have patient-specific information and navigate or do a drive-through rehearsal doing a procedure before we actually do the procedure on the patient," said Barry Katzen, M.D., founder and chief medical executive at the institute, in a video interview. "By doing this, everyone knows what to do and when they're going to do it … which reduces the potential of error and improves the patient outcome."

At the Kobe University Graduate School of Medicine, Stratasys multi-material 3D printers are being used to aid in medical training and surgical preparation. Instead of the traditional approach where surgeons plan operations based on CT and MRI images, the students are using full-sized, 3D-printed color models of patient organs, which can help uncover hidden tissues and blood vessels that might be blocked by larger organs in 2D scans, says Dr. Maki Sugimoto, associate professor, in a case study.

Beyond medical models, there has been a lot of progress in 3D-printed prosthetics, particularly lower-cost technologies that can help patients in developing countries. E-NABLE, for example, is a global network of volunteers that is leveraging 3D printing technologies to make hands and fingers for disabled children around the globe.

CBM Canada, a nonprofit disability and development organization, is working with the University of Toronto's Critical Making Lab to develop a low-cost process for scanning, modeling, fabricating, and assembling lower-leg prosthetics for use in developing countries, says Mitchell



Thanks to 3D printing and specialized software, a collaborative team is designing a process to make affordable custom sockets for prosthetics patients in developing countries. ***Image courtesy of CBM Canada*****.**

Wilkie, director, International Programs for CBM Canada. The process, to be tested soon at the Comprehensive Rehabilitation Services for Uganda (CoRSU) hospital, pairs a MakerBot Z18 3D printer, scanning technology, and specialized software to allow practitioners in developing countries to inexpensively create the custom socket that is the critical part of a prosthetic in a matter of hours.

Still in the infancy stage is the work being done to apply 3D technologies, including 3D printing, to facial reconstruction and face transplants. Dr. Frank Rybicki, a radiologist and director of Brigham and Women's Hospital's Applied Imaging Science Lab, has a study underway exploring the use of CT and 3D printing technology to recreate life-size models of patient skulls to assist in face transplantation surgery.

While this team is exploring the merits of the technology for surgical preparation, a team of researchers at Texas A&M University Baylor College of Dentistry is employing software to design facial prosthetics for patients suffering massive trauma. The team, using 3D Systems' Medical Modeling software, among other technologies, was able to create a life-like facial prosthetic for a patient who was not a candidate for transplant surgery. Using CT scans taken prior and post trauma, they pinpointed anchor spots for a prosthetic that was 3D printed and painted to approximate the patient's pre-trauma face.

It's this intersection of 3D printing and other digital 3D technologies that is paving the way for these medical miracles. "This is the flexibility that designers, engineers and clinicians at the intersection of 3D printing have been looking for," says Stratasys' Radar. "The rapidly expanding universe of true engineering-grade materials and the enhanced functionality of printers to make structural products is encouraging greater use and opening doors for greater creativity." **DE**

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

Bioprinting is the New Frontier

The next big opportunity for 3D printing is leveraging the technology to create living human tissue and organs. Called bioprinting, the technology is still in the early research phase but Organovo began offering printed liver tissue to pharmaceutical laboratories for toxicity testing last year. It also announced a partnership with the Yale School of Medicine's Department of Surgery and the Yale School of Engineering and Applied Science to develop ways to print transplantable tissue, made from a patient's own cells, that could keep failing organs functioning longer while awaiting a transplant.

Ibrahim Ozbolat, assistant professor of Mechanical and Industrial Engineering at the University of Iowa's College of Engineering, has research underway to bioprint pancreatic tissue for use in both drug testing and potential transplantation.

For the short-term, bioprinting's greatest impact will be for drug testing, according to Scott Dunham, senior analyst at SmarTech Markets Publishing. "The biggest potential revolutionary area balanced with realism is using bioprinting processes to test drugs easier and more quickly rather than tissue engineering," he says.

INFO → 3D Systems: 3DSystems.com

→ **Brigham and Women's Hospital:** BrighamandWomens.org

→ **CBM Canada: CBMCanada.org**

→ **E-NABLE:** EnablingTheFuture.org

→ **LayerWise:** LayerWise.com

→ **Materialise:** Materialise.com

→ **Medical Modeling:** MedicalModeling.com

→ **Organovo:** Organovo.com

→ **Rita Leibinger Medical:** Leibinger-Medical.com

→ **Simbionix:** Simbionix.com

→ **SmarTech Medical Publishing:** SmarTechPublishing.com

→ **Stratasys:** Stratasys.com

→ **Texas A&M:** TAMU.edu

→ **Vidar Systems Corp.:** Vidar.com

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

Designing Space-Age Diagnostic Devices

Qualcomm Tricorder XPRIZE teams are creating medical devices inspired by "Star Trek" technology.

BY MICHAEL BELFIORE

Final Frontier Medical Devices. *Image courtesy of XPRIZE Foundation*

Emergency room visits in the United States are on the rise — up 34% between 1995 and 2010, according to the Centers for Disease Control and Prevention — even as the number of emergency rooms decrease (down 11% over the same period). It all adds up to overcrowded ERs and lower-quality care for patients as they wait longer to see a doctor and get tests that may or may not be needed.

Against this backdrop, the $10 million Qualcomm Tricorder XPRIZE seeks to foster the development of devices that would put the power to diagnose medical conditions into the hands of consumers, giving them more flexibility and faster access to the information needed to stay healthy.

The goal of the contest is a demonstration of not only what is going to be practical in the future, but also what can be learned "so that we refine these tools and processes so that it's scalable," says Qualcomm Tricorder XPRIZE Senior Director Grant Campany. The XPRIZE Foundation wants to jumpstart the development of a new class of products that give ordinary people unprecedented control over their healthcare.

Inspired by the 23rd century tricorder of the "Star Trek" universe, the prize offers $7 million, $2 million and $1 million to first-, second- and third-place teams, respectively. Winning teams will each have to create an easy-to-use system that weighs under five lbs. and can accurately diagnose a set of 13 core conditions (including an absence of conditions), along with three of 10 additional "elective" conditions. They will also have to measure and autonomously evaluate five vital signs, including heart and respiration rate and temperature.

Neatness Counts

Along with accuracy, developing a user-friendly experience is vital to winning the prize. In fact, evaluations of accuracy and usability will be equally weighted by judges in determining the winners — 45% of the overall consideration for each factor. The remaining 10% considered for determining awards will be given to the teams' explanations of how they intend to develop their entries into viable products.

In August 2014, a team of 22 independent judges helped pare down around 40 teams that had registered to compete to 10 finalists based on extensive documentation outlining their approaches. Now it's up to those 10 teams, which hail from across North America and Eu-

The DNA Medical Institute (DMI) is working on technology that can diagnose a patient via blood sample in an all-in-one unit.
Image courtesy of team DMI.

Final Frontier Medical Devices is headed by Basil Harris, an emergency room physician who uses his real-life knowledge to create algorithms and capabilities for the team's device.
Image courtesy of Russell Karten, MD.

Team Aezon is made up of students and faculty from Johns Hopkins University.
Image courtesy of Will Kirk.

rope, as well from India and Taiwan, to produce working prototypes — at least 30 per team — for evaluation by patients who have the conditions to be diagnosed. The prototypes are due in the XPRIZE offices this month. Researchers at UC San Diego's Clinical and Translational Research Institute (CTRI) will oversee the testing that will take place at CTRI as well as in the patients' homes over a six-month period from June until December. Winners will be announced in Los Angeles in January 2016 — the 50th anniversary year of the "Star Trek" TV series debut.

"He's not dead, Jim."

The competition looks almost tailor-made for team DNA Medicine Institute (DMI). DMI is headed by Eugene Chan, who also serves as CEO of the Cambridge, MA-based startup. Chan's experience as a working physician inspired him to found DMI with the goal of developing user-friendly medical devices. "The ability to be able to get diagnostic information as fast as possible started with seeing patients in the middle of the night," says Chan. In the absence of good, fast information, he says, "bad things happened."

Instead of having to rely on an outside lab that may not be open at a critical time, Chan longed for a device that could do the work of the lab, but would fit in his pocket. NASA became DMI's first client as it pursued its own quest to develop medical technologies for long-duration space missions.

DMI's approach to winning the prize hinges on blood analysis. After pricking themselves with a lancet, a patient can squeeze a drop of blood into a small receptacle, which then gets loaded into a portable diagnostic device, dubbed the rHEALTH X1. There, the blood mixes with microscopic test strips and other reagents. Illuminated with laser light, the reagents reflect the light differently depending on what's in the blood. An app running on a tablet docked with the machine runs an analysis and displays the results.

Chan says his team's small size is an asset. "Small is absolutely better," he says. "Right now, we've got 20 people working on this." That size, says Chan, fosters highly efficient communication. The team designs its prototype in Dassault Systèmes' SolidWorks and creates them with a 3D Systems V-Flash 3D printer. For designing printed circuit boards (PCBs), the team uses Altium Designer.

The Final Frontier of Medicine

Not every team has the backing of an established company. Basil Harris, a working emergency room physician, heads team Final Frontier. For Final Frontier, the competition is a family affair. Harris' brother, George, serves as lead programmer; their sister, Julia, works with friend Phil Charron on user experience design; while electrical engineer and physician brother Gus does signal processing for the project using MathWorks' MATLAB software. Ed Hepler designs the custom-made integrated circuits for the Bluetooth-enabled devices that comprise their entry. He designs the circuits using the open-source TinyCAD software package. George's daughter, Amanda, does graphic design for the team, and Andy Singer manages their finances. The team designs the devices themselves in the BlenderCAD open-source design package and creates prototypes using MakerBot Replicator 3D printers.

For Basil Harris, the challenge posed by the competition comes down to synthesizing his knowledge of emergency medicine, creating the right algorithms to codify it, and then spitting it back out in response to input from a patient. As far as he's concerned, data-collection devices like heart monitors are secondary in importance to the algorithms. "They're actually good in a number of categories," he says of the algorithms, which run on an iPad app. "They're not perfect across the board. But that's even without taking the objective data."

In other words, the artificial intelligence being developed by team Final Frontier can diagnose some conditions on its own simply by asking the right questions. The team has been able to fine-tune the system by conducting trials in the best possible environment — the ER itself.

With the team (including a handful of other specialists) spread out from Boston to Tennessee, the group places a premium on online collaboration. They also strive to make the best use of the face-to-face time they do have — typically in Basil's house in Pennsylvania, where MakerBot 3D printers churn out prototypes.

Team Final Frontier's design includes two electronics-laden patches to be placed on the patient's chest for heart readings, a thermometer, a spirometer for measuring respiratory flow, and a self-contained disposable urine tester, which is to be dunked in a sample provided by the patient.

Basil says he's amazed at what can be accomplished by a self-funded team of amateurs working part time. "I would encourage anybody to try to make stuff," he says. "It's the golden age of creation."

Nice Work if You Can Get It

The competition has also captured the interest of students and academic professionals. Biomedical engineering student Tatiana Rypinski heads a team of fellow undergraduates at Johns Hopkins University in Baltimore called Aezon. In addition to students, Rypinski has recruited faculty mentors as well as outside corporate partners. For designing its devices, the team uses SolidWorks and 3D prints prototypes on a MakerBot Replicator and a Stratasys Dimension BST 1200es. The team designs PCBs in Novarm DipTrace.

Rypinsk says the key to the success of team Aezon lies in the group's organization. Specialized teams within the larger group each work on a specific disease or piece of the software and hardware puzzle — the smartphone app at the heart of the system, the wearable vital signs monitoring device, or the lab box that processes biosamples.

Rypinski's biggest takeaway: "Don't be afraid to reach out for help if you have a great idea. You have nothing to lose by reaching out and pitching your project and trying to move it forward."

The range of approaches taken to win the Qualcomm Tricorder XPRIZE point to a major benefit of incentive prizes for solving technical challenges: they call forth a diversity of ideas that would be difficult to bring together by any other means. That's a boon to the XPRIZE Foundation, as well as, the foundation hopes, to future consumers. "Everything that we do is geared toward not only solving problems but building markets," says Campany. Even the seven finalists who don't win cash prizes should benefit. "You get an independent, objective evaluation of your platform relative to others," he says. And that feedback could enable teams that don't win the prize competition to win in the marketplace. **DE**

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

INFO ➜ 3D Systems: 3DSystems.com

➜ **Altium:** Altium.com

➜ **Basil Leaf Technologies:** BasilLeafTech.com

➜ **Dassault Systèmes SolidWorks Corp.:** SolidWorks.com

➜ **DNA Medicine Institute:** DNAMedInstitute.com

➜ **Johns Hopkins University:** JHU.edu

➜ **MakerBot:** MakerBot.com

➜ **MathWorks:** MathWorks.com

➜ **Novarm Ltd.:** DripTrace.com

➜ **Qualcomm:** Qualcomm.com

➜ **Stratasys:** Stratasys.com

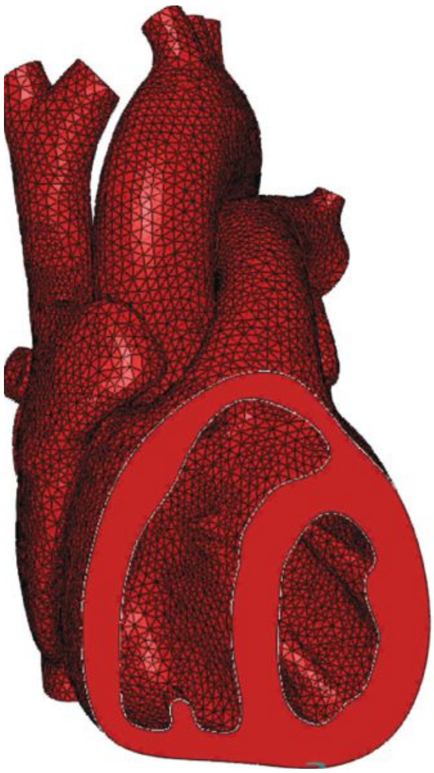
➜ **XPRIZE Foundation:** tricorder.XPRIZE.org

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

Diversity in Medical Simulation Applications

Computer analysis of man and machines is changing how we offer health care.

BY PAMELA J. WATERMAN



A vertical-cut view through the simulated working heart computer model developed by the Living Heart Project research initiative. The multiphysics simulation, launched by Dassault Systèmes, uses SIMULIA analysis software to account for mechanical, fluid, thermal and electrical interactions over time. *Image courtesy of SIMULIA.*

Did you brush your teeth this morning? Watch a sunset last night? Get a blood test a few weeks ago? Your ability to perform these everyday activities just may reflect the increasing ability of engineers to analyze the medical world, whether oriented toward human or mechanical systems. Good dental health, the best possible vision, accurate laboratory tests and more owe much to products developed through simulation software.

Both mechanical finite element (FE) and computational fluid dynamics (CFD) analysis packages offer a digital grasp of complex medically oriented systems, supporting ever more accurate functional analyses.

Implant Hardware: Refined

If your teeth brushing isn't quite up to par, you may find yourself exceedingly grateful that companies such as Biotec btk apply mechanical simulation software to their design workflow. In 2010, the company, based in Vicenza Italy, started using Siemens PLM Software products to move from 2D into 3D CAD and incorporate FEA in its design of dental implants. Now they can't imagine working without it.

A complete dental implant includes three sections: a threaded, machined titanium pin that goes into the jaw bone, a titanium or zirconium abutment that screws into the implant, and a custom porcelain-covered "tooth" (a coping and pin assembly that is screwed or cemented into the abutment). Biotec btk's move to Siemens Solid Edge 3D design software allowed them to readily identify matching and interference issues when sizing the small components (implants are generally 8mm to 18mm long).

Tapping additional benefits of digital design, Biotec btk started using Siemen's Femap FEA software to analyze stress and load distributions on the mechanical implant sections as well as on the jawbone. Stress occurs both when the abutment is screwed inside the implant, and during the chewing process. "Performing an analysis is mandatory, unless you are willing to spend a long time on mechanical tests, which would be difficult due to the tiny dimensions of our products," says Marco Zotto, Research and Development manager at Biotec btk.

Now, being able to simulate many possible design variations also lets Biotec btk engineers address design projects they might otherwise have dismissed as impossible. "Recently, we faced the challenge of having to make an ultra-short implant. Femap played an essential role as short implants don't seem to offer adequate load distribution at first sight," says Andrea Peloso, managing director at Biotec btk. Simulation of a new design predicted acceptable load distribution even on a 5mm part with few outer threads. Physical testing confirmed the predicted behavior, and the implant is now sold as their Nano model; the short height can eliminate the need for bone grafts in patients with eroded jaw structures.

As the population ages, another increasingly common implant procedure is a hip replacement. The patient receives a combination of femoral stem, femoral head, plastic liner and hip-socket insert (acetabular cup). The femoral stem, typically cast in titanium four at a time, must withstand the equivalent of more than 1 million cyclic loads per year of use, so its structural integrity is critical.

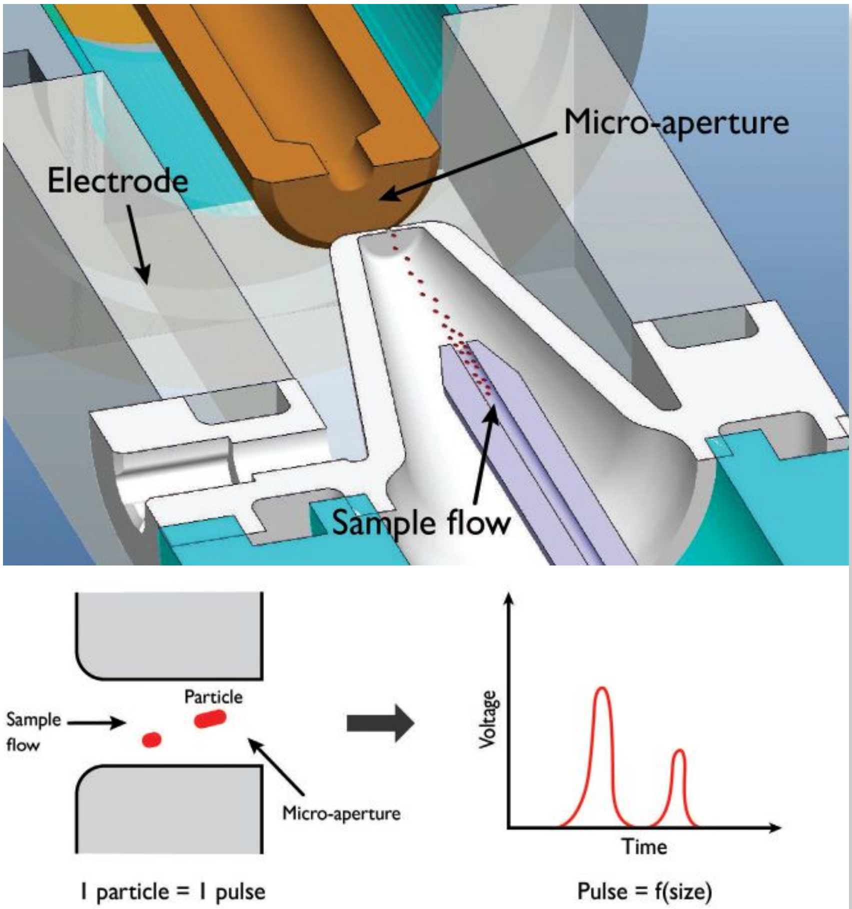
Investment casting such units requires setting the optimum temperature for both the molten metal and the pre-heated casting form, along with determining the best four-part filling geometry and sequence. Otherwise, uneven shrinkage during cooling can cause unacceptable voids and surface finish in the end product. The classic approach to identifying these parameters has been by trial-and-error via building numerous wax patterns and molds; the new way is through simulation.

Inegi, the R&D engineering and technology transfer group at the University of Porto, Portugal, has elected to use FE-based ProCAST software from ESI Group for its analysis work in this area. With the assistance of the Análisis y Simulación consulting company in Spain, Inegi first used ProCast's thermodynamic database to gather the high temperature properties of the Ti6Al4V alloy, then worked with the software to examine different approaches to the gating (filling) geometry and flow sequence. The results gave the group insight into the temperature gradients in various sections of the mold and the fill, and predicted the best combination to minimize shrinkage porosity.

Based on this information, the group designed a different gating system and a new external heater that wraps in a spiral around the outside of each femoral-insert mold, evenly distributing heat as the casting solidifies. X-rays of the finished product validated the porosity-free prostheses achieved through the improved manufacturing design.

Diagnostic Devices: Improved

Of the millions of blood tests performed daily, in both commercial



A micro-aperture section of a hematology analyzer from HORIBA Medical, showing individual blood cells (particles) streaming between sensing electrodes and the correspondence between particle size and voltage pulse determined by the changing impedance of the electric field. ***Image courtesy of COMSOL.***

and research laboratories, one of the most common is a complete blood count (CBC). Automated hematology equipment uses various technical approaches to analyze red cells, white cells and platelets, often processing more than 60 patient samples per hour. While laser-based optics perform cell sub-type identification, electrical impedance data is used to provide information about cell counts and individual sizes, the latter being on the order of 10 microns across or smaller.

HORIBA Medical, a division of HORIBA Ltd., Japan, markets a line of hematology and clinical chemistry instrumentation and is constantly working to improve the capabilities of its products. The CBC task generally relies on a process where the blood sample is mixed with an electrically conductive reagent, pumped through a narrow channel and passed through a gap between opposing electrodes. Changing impedance properties of particles in the flow induce voltage changes proportional to the size and number of particles.

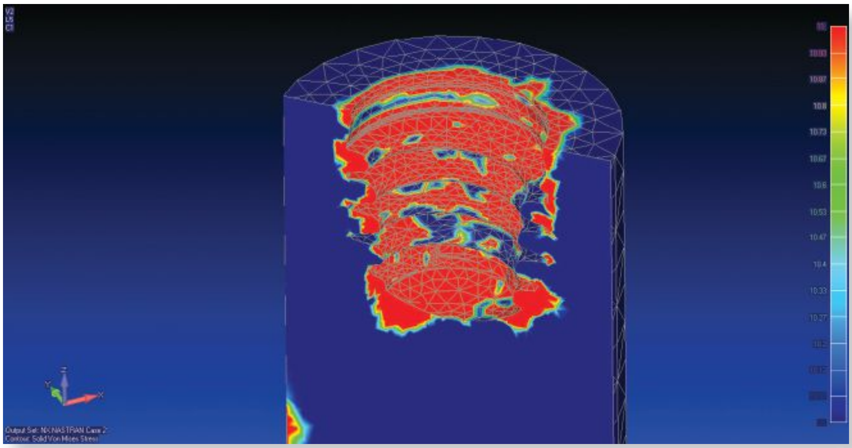
The instrument's complex physics interactions involve high fluid velocity, heat transfer, electric fields and pressure drop through the several-microns size gap. "We use COMSOL to develop a better understanding of how these physics interact. The simulation software automatically creates the fluid domain directly from the CAD model," says Damien Isèbe, scientific computing engineer at HORIBA Medical. One of the factors he investigated is the path taken by a cell as each traverses the tiny gap (micro-aperture) exposed to the electromagnetic field. If the cell's trajectory takes it near the gap's edges, instead of through the center, edge effects distort the field and result in overestimations.

Isèbe used COMSOL Multiphysics simulation techniques to account for varying particle trajectories and orientations. He also developed numerical models to prove that hydrodynamic focusing, which uses sheath flow to control and direct the sample as it passes through the micro-aperture, could be used to reduce analysis error. "Using these models," he says, "we can precisely compute the velocity field within the device and analyze the acceleration phase to determine which designs produce the most accurate results."

Human Systems: Understood

From the human body point of view, it's a great time to be involved in simulation. The level of detail and accuracy now possible for evaluating not only idealized but individual patient systems is amazing. Three such models are making headway for the eye, heart and skin.

If you ever took a course in anatomy, you were probably surprised by the complexity of the human eye. This highly specialized organ contains various types of tissue, pressurized fluid-filled compartments and an intricate neurovascular system. Physicians would like to better understand the effects of intraocular (IOP) and intracranial (ICP) pressures on the retina, optic nerve and ocular globe, with their corresponding impact on vision (e.g., glaucoma).



This finite element model shows stress distribution on the internally threaded half-section of a dental implant, due to mating with an abutment insert. Analysis performed with Siemens Femap and NX Nastran software. *Image courtesy of Siemens PLM Software.*

Researchers have developed various mathematical models to identify and evaluate working parameters, but tend to view just mechanical deformations, and only on portions of the eye. Adding CFD as well as fluid-structure interactions (FSI) analyses to these investigations is improving optical biomechanics understanding.

A few years ago, several scientists across the United States tackled this problem together using FLOW-3D fluid analysis software from Flow Science. The three — Edward Furlani (University at Buffalo), Anthony Nunez (Washington University in St. Louis), and Gianmarco Vizzeri (The University of Texas Medical Branch) — analyzed a 3D CAD eye model using FLOW-3D's TruVOF (volume-of-fluid method) and integrated FSI (FE-method based) to simultaneously model tissue deformation. This combined approach showed how an increase in pressure of an incompressible fluid in the eye's interior deforms the surrounding layers of tissue.

This simulation is particularly challenging not only due to the range in size of the eye's structures, measured in microns to millimeters, but also the range of properties of the tissue depending on the area being analyzed. For example, Young's modulus varies over several orders of magnitude where the optic nerve connects to the ocular globe. Preliminary results of stress and strain have recently been reviewed in more detail with the use of FlowSight, the new Flow Science post-processing package based on EnSight from CEI.

Continuing to make news is the Living Heart Project, begun in 2014 by Dassault Systèmes as a first step in offering software-based models to assist the medical device industry. The goal is to produce design-validation tools for the entire human body and a wide variety of issues, comparable to the use of simulation software for automotive product design. The initial focus is cardiovascular disease; tackling this worldwide problem could be greatly assisted with better models of the heart.

The company's SIMULIA division began with a simplistic, proof-of-concept model of a four-chamber heart, combining tissue-modeling techniques with thermal expansion models. Encouraged by the results, SIMULIA invited engineers, scientists and biomedical experts to help create a virtual 3D replica of a fully detailed functioning heart.

Using multiple elements of Dassault Systèmes' 3DExperience platform, including SIMULIA's Abaqus multiphysics simulation technology, SolidWorks CAD and 3DExcite realistic rendering, developers of the complete simulation started with scanned geometry data from an actual heart. They incorporated material property and fiber-orientation information on tissue, muscles and heart valves to develop a simulation that includes coupled fluid, mechanical and electrical effects as the heart contracts and pumps blood.

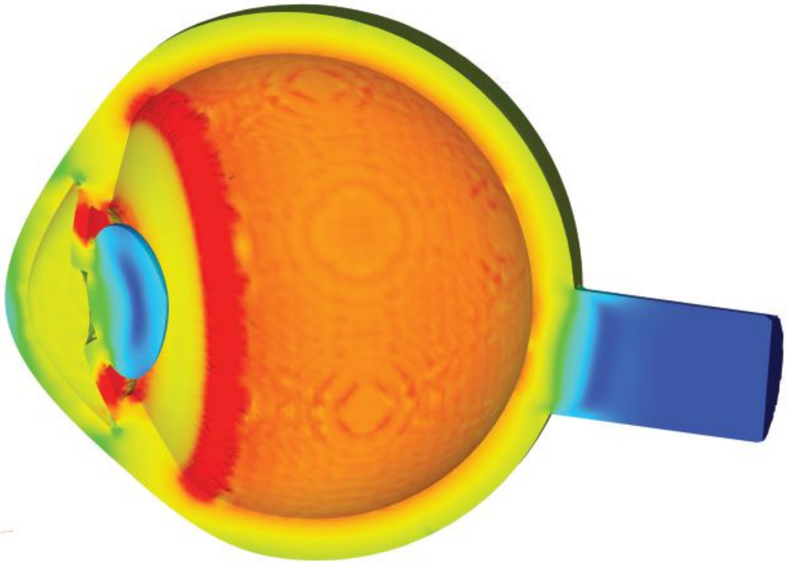
By making the Living Heart Project open for collaboration, the plan is to eventually produce patient-specific models that will help with designing and validating a wide range of medical products and procedures. The project is entering its second year, with the first commercial heart model in the beta stage. More than 45 member organizations are participating in the project, each working to improve a different aspect of the heart simulation. Current applications include adding heart disease effects, validating a heart valve assist device and virtually testing insertion, placement and performance of pacemaker leads. (For the current project status, see 3ds.com/heart.)

A third bioengineering research field where simulation is making a difference involves killing cancer cells. In a treatment called photodynamic therapy, photosensitive drugs applied directly to the area of cancer react to irradiation of a very narrow frequency visual-spectrum bandwidth. The light source, which might shine either directly onto skin or, via some type of endoscope, onto an internal organ, has to supply uniform irradiance at an acceptable efficiency. Designing such a source requires understanding both the scattering properties within the applicator device itself as well as within the tissue (which can also absorb radiation).

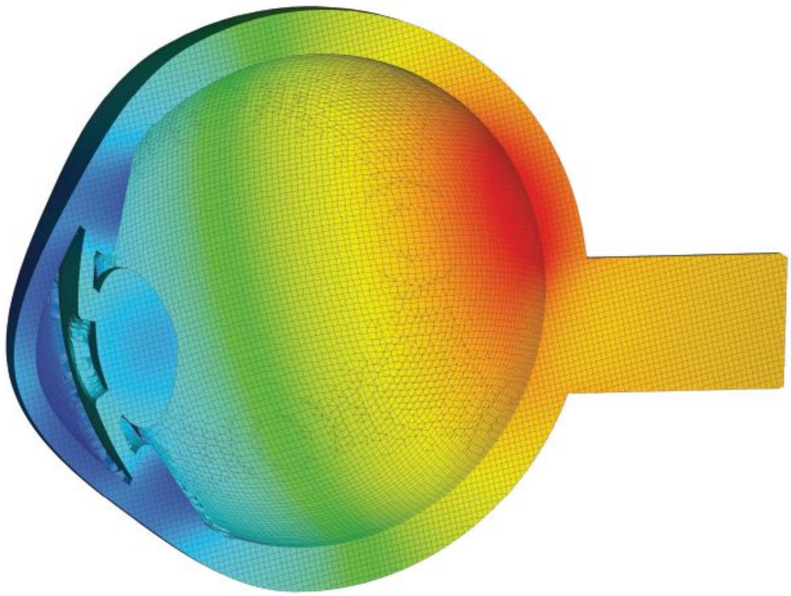
ASAP (advanced systems analysis program) non-sequential ray-tracing software from Breault Research Organization is well suited to this task. Continually improved for more than 20 years, the ASAP optical imaging package can handle both biological media and opto-mechanical system design. Different forms of interoperability are available with standard CAD packages such as SolidWorks, CATIA V5 and Rhinoceros, among others.

HORIBA'S Isèbe applauds the increasing use of multiphysics-based engineering software in the medical world. "Due to advancements in computational analysis and supercomputing capabilities, numerical simulation has become the third pillar of science, next to theory and experimentation," he says.

If these results and possibilities take your breath away, fear not — pulmonary system simulation is another hot topic. DE



An eye anatomy showing 3D fluid-structure interaction (FSI) is pictured. The simulation is done with FLOW-3D analysis and Flow Sight visualization software from Flow Science. Von Mises stress shows maximum values at and around the eye lens. *Images courtesy of Flow Science*.



Body-fitted conformal mesh in FLOW-3D software from Flow Science is used to resolve the intricacies of eye geometry during fluid-structure interaction (FSI) analysis.

Contributing Editor **Pamela Waterman**, DE's *simulation expert, is an electrical engineer and freelance technical writer based in Arizona. You can send her e-mail to DE-Editors@deskeng.com.*

Resources for the Medical Simulation Field

- Medical Device Innovation Consortium: mdic.org/
- CD-adapco – CFD Methods in the Biomedical Device and Diagnostics Industry webinar: https://youtu.be/DJcKiP9KXtI
- Granta Medical Materials Selection: grantadesign.com/solutions/medical/index.htm

INFO → Análisis y Simulación: analisisysimulacion.com

→ **Biotec btk:** btkthesmilesystem.com

→ **Breault Research:** Breault.com

→ **CD-adapco:** cd-adapco.com

→ **CEI:** CEISoftware.com

→ **COMSOL:** COMSOL.com

→ **Dassault Systèmes:** 3ds.com

→ **ESI Group:** ESI-Group.com

→ **Flow Science:** FLOW3D.com

→ **Granta Design:** GrantaDesign.com

→ **HORIBA Medical:** HORIBA.com/us/en/medical

→ **Inegi:** Inegi.pt

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

→ **SIMULIA:** SIMULIA.com

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

Building Bright Ideas

Proto Labs accelerates innovation by turning brilliant concepts into real parts in days.

Proto Labs uses proprietary computing technologies and automated manufacturing systems to produce custom prototypes and low-volume production parts in as fast as one day. We offer plastic, metal and liquid silicone rubber (LSR) parts through three distinct services: injection molding, CNC machining and additive manufacturing.

We blend automated design analysis on interactive quotes with accessible, live customer service engineers to help product designers and engineers arrive at the best possible 3D CAD model before any actual production begins. When a part is ready, digital instructions are sent to one of hundreds of in-house presses, mills, lathes and printers where we have the capacity to manufacture one design, or multiple designs simultaneously, without delays.

Proto Labs is a tech-driven, global manufacturer with production facilities in the United States, Europe and Japan. Customers from around the world can upload 3D CAD models, day or night, online at protolabs.com for a quote within hours. Our website is filled with additional resources like design guidelines and tips, material selection, comprehensive white papers and other helpful content.

Injection Molding

For customers who need low-volume production or bridge tooling, we can injection mold 25 to 10,000+ parts from hundreds of thermoplastic, liquid silicone rubber and stainless steel materials, in three weeks or less. That's a fraction of the time and cost of traditional mold manufacturers to produce custom parts across all industries.

CNC Machining

CNC machining can manufacture parts in as fast as the day they were ordered with engineering-grade plastic and metal materials for improved selection, part functionality and cosmetic appearance. We employ both three-axis milling and turning. Our three-axis milling process allows for milling from up to six orthogonal sides of the part to machine as many features as possible. Our turning process includes live tooling to create off-axis holes, flats, slots and grooves. Final milled and turned parts are used as high-quality prototypes, jigs, fixtures, one-offs and in end-use applications.

Additive Manufacturing

Our additive manufacturing service offers three rapid prototyping processes: stereolithography (SL), selective laser sintering (SLS) and direct metal laser sintering (DMLS). Whether small parts with precise geometries or large, highly detailed patterns are needed, Proto Labs provides another option during early prototyping. Get low quantities of SL, SLS and DMLS prototypes built in as fast as one day.

Interactive Quoting

The root of Proto Labs' process automation lies within our interactive quoting. Our automated system accepts customers' 3D CAD models and returns a detailed interactive quote within hours that contains free manufacturability analysis on parts as well as real-time pricing information that adjusts to quantity, material and turnaround time modifications. The design analysis addresses any potential molding and machining issues upfront, before production begins, allowing for quick iterations that save time and money. Once a design is ready and a customer submits an order, parts can be completed and shipped in one to 15 days.

Markets

Proto Labs is focused on providing product designers and engineers with fast, reliable and inexpensive ways to obtain low volumes of parts based on their 3D CAD design. We have a variety of processes that are used by those developing and producing parts for many industries, particularly automotive, medical, lighting, consumer product and aerospace segments.

Corporate History

Proto Labs began in 1999 as The ProtoMold Company, which specialized in the quick-turn manufacturing of custom plastic injection-molded parts. In 2007, the company introduced its CNC machining service, and soon after changed the corporate name to Proto Labs, Inc. Since that time, Proto Labs has opened facilities in Japan (2009) and Europe (2011), gone public on the New York Stock Exchange (2012) and added rapid additive manufacturing as a third flagship service.

Hybrid 3D Printing: What You Need to Know Now

Long-time technology rivals subtractive and additive manufacturing now partner to enable design engineers to break through traditional constraints.

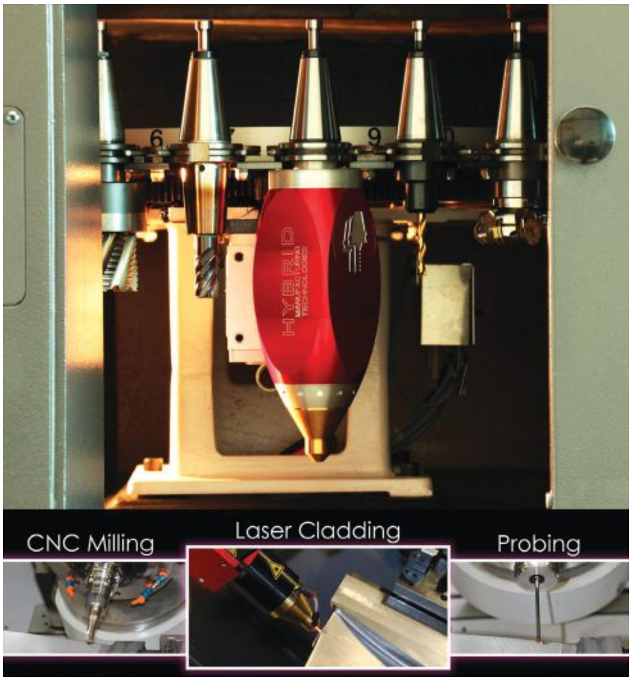
BY LAUREN GIBBONS PAUL

The concept of merging additive and subtractive techniques in one machine, a so-called hybrid 3D printer, has been around since the 1990s. Slow commercialization of the technology left hybrid 3D printers mostly off the radar of design engineers.

That may be changing as vendors from small startups like FABtotum to large, industrial players including Matsuura, Mazak, and DMG Mori are beginning to announce hybrid 3D printers, though few are on the market just yet. Combining the benefits of milling and 3D printing in one unit, these machines may break through barriers experienced by design engineers working in metals.

"Combining [additive and subtractive technologies] on the same platform and having the same set-up operation — that is a breakthrough," says Todd Grimm, principal at additive manufacturing consulting firm T. A. Grimm & Associates.

Grimm cites Matsuura as the first hybrid 3D printer player, custom building a machine for a mold-making client near the end of the1990s. That process used powder-bed fusion as its additive technology. Since then, several other vendors including EOS and SLM Solutions have also employed powder-bed fusion for the additive piece with the addition of milling technology as the subtractive mechanism.



The system developed by Hybrid Manufacturing Technologies is able to complete the pictured tasks with one machine.

Advantages of Hybrid 3D Printing

Additive manufacturing (AM) carries inherent limitations in terms of surface finish, according to Grimm. The resulting metal part usually has some texture to it. "It's not as smooth as a finely milled part," he says. The addition of milling overcomes the two chief drawbacks of AM. First, the final product is ready to go right out of the machine — no need for a separate milling operation. And, the part has greater dimensional accuracy — always a weakness of AM alone. In-process inspection can assure quality that is otherwise impractical or impossible to evaluate.

The use of additive and subtractive technologies was once an either-or consideration for design engineers. But their marriage holds promise for design engineers who work in metals, according to Jason Jones, cofounder and CEO of Hybrid Manufacturing Technologies. Hybrid Manufacturing sells a kit that enables a computer numerically controlled (CNC) machine to be outfitted for AM.

"Design engineers need to know it is now possible to mix metals, which can reduce costs significantly," says Jones. For example, assume the end product was nickel-based alloys. Normally, you would start by adding that material to Inconel. But the cost of substrates is not insignificant. Jones discovered he could just add Inconel onto a cheaper mild steel base.

"You can also use exotic materials much more easily — those sorts of things where you might just want a coating," says Jones. "You can use those exotic materials sparingly so the technical benefits are not cancelled out by the increased manufacturing costs."

Hybrid 3D printing has other advantages, adds Steve Griffiths, manager of Software for Additive Manufacturing at Materialise, a 3D printer manufacturer. For instance, there are more options for surface-finish levels. Also "parts will have strength and heat-resistance characteristics close to plastic injection parts," he says.

Design engineers will be interested in the possibilities, says Grimm. With additive and subtractive working together, they will be able to design something like a metal orb with a hole on the top that you can peek into. "With AM I can make that, no problem, but I can't get a smooth service inside the orb. But if you can hand off some additive and some subtractive operations, you can make the inside surface smooth.

"It does open the door to more production applications," says Grimm. "That is driving interest."

Tradeoffs

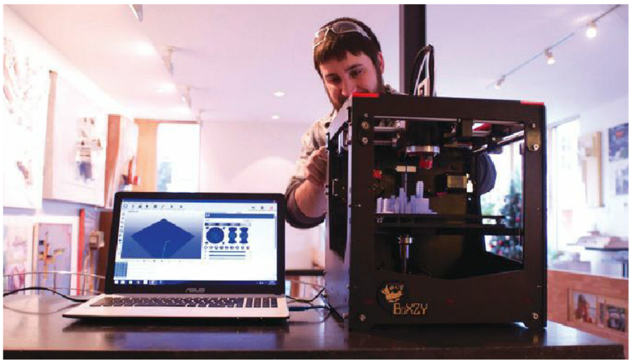
The first hybrid 3D printing technology carries the potential trade-off of excessive tool swapping, cautions Grimm. "Every time I'm doing additive [manufacturing] and I want to stop and do some milling work, I have to stop, put the tool away and then start the process again. You could potentially lose a lot of time there, so designers should be aware of that," he says.

Mazak's INTEGREX i-400AM melts metal powder using fiber laser heat. Cladding heads (additive manufacturing nozzles) apply the molten material layer by layer, each of which solidifies as the desired shape grows. It also provides full 5-axis milling.

A new technology, called automated welding or directed energy deposition, does not have this issue. This technique, used by DMG Mori and Hybrid Manufacturing Technologies, adapts welding processes to build parts.

"It's a little like using a hot glue gun. You're trying to shape parts based on the metal being extruded," says Jones. These operations are performed inside a CNC machine. "We have patented heads that fit inside the tool changer. You have multiple different drill bits and tools that you will need. Excess changeover time is not an issue."

Jones believes hybrid 3D printers will be used to make prototypes to some degree. "It's not necessarily the cheapest way to do it. Usually we would produce a plastic prototype first and then we would move on to a metal prototype."



Aimed at the Maker market, Boxzy combines a 3D printer, CNC mill, and laser engraver, according to its Kickstarter fundraising page where it has surpassed its $50,000 fundraising goal by almost $1 million as of press time.

But he is seeing metal prototypes increase. “Designers will use hybrid printers for prototypes,” says Griffiths. For now, most design engineers are in “wait-and-see” mode. There aren’t many machines readily available yet, though blade repair is a hot area for early adopters, says Jones.

“Most design engineers should have this on their radar to start to understand this. They don’t have to rush out and do it because there is not that much availability right now,” says Grimm.

But the promise is clear: It overcomes the limitations of AM by producing a ready-to-use part that meets all specifications. The design considerations will become clearer as hybrid 3D printing takes hold.

“You can’t ignore it. You can’t safely assume that the way you design things today will work on one of these machines in the future. You don’t want to be trying to come to grips with this at the 11th hour,” says Grimm. “Be aware and start to understand the possibilities.” DE

Lauren Gibbons Paul *is a Boston-based freelance writer. Contact her via de-editors@deskeng.com.*

INFO ➜ DMG Mori: us.DMGMori.com

➜ **EOS:** EOS.info

➜ **Hybrid Manufacturing Technologies:** hybridmanutech.com

➜ **Materialise:** materialise.com

➜ **Matsuura:** matsuurausa.com

➜ **Mazak Corp.:** Mazak.com

➜ **T.A. Grimm & Associates:** tagrimm.com

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

High-Definition Point Cloud Collection

What's Cool

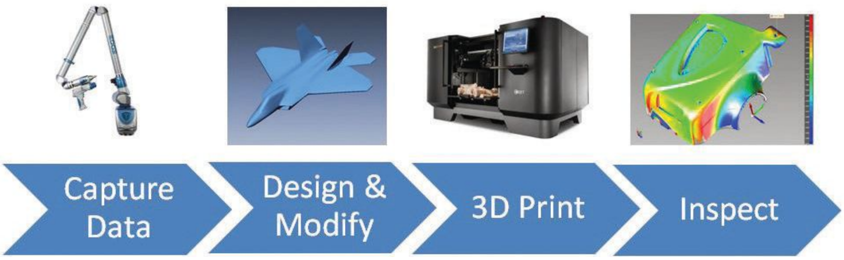
The FARO Edge ScanArm HD delivers rapid point cloud collection with high-definition scan data and precise accuracy — all in a compact, easy-to-use, and affordable system.

The integrated system combines the trusted FaroArm for tactile probing with all of the advantages of a groundbreaking laser line scanner – creating the most versatile contact/non-contact 3D measurement system on the market.

It is the ideal tool for rapid prototyping as it enables the fast collection of highly accurate and detailed 3D scan data that can be designed and modified to easily produce a water tight, 3D printable mesh or wrap. Additionally, the system is heavily utilized for many other product development, inspection and quality control applications, and offers capabilities such as point-cloud comparison with CAD, reverse engineering, and 3D modeling of free-form surfaces.

Who's It For

Manufacturing and engineering professionals interested in maximizing efficiencies in their production and quality assurance processes.



Features and Benefits

Rapid Scanning Speed

- The extra wide scan stripe and fast frame rate boosts productivity by increasing coverage and reducing scanning time.

High Definition Data

- Intricate components can be captured in fine detail as a result of the 2,000 actual points per scanline from the new blue laser, featuring noise reduction technology.

Scan Challenging Materials

- Seamlessly scan across diverse surface materials regardless of contrast, reflectivity or part complexity without any special coatings as a result of the improved HDR (High Dynamic Range) Mode and advanced software algorithms.

Compact, Lightweight, and Simple to Use

- Dramatically reduce required training time with the new crosshair feature and existing LED Rangefinder functionality which provides real-time scanning feedback.
- The small size and friendly user-interface result in a versatile and intuitive tool.

Highly Accurate and Repeatable

- Reliable, repeatable and highly accurate measurement data is delivered with confidence as a result of superior optical performance.

Specs

- **Accuracy:** ±25μm (±.001in)
- **Repeatability:** 25μm, (.001in)
- **Stand-off:** 115mm (4.5in)
- **Depth of Field:** 115mm (4.5in)
- **Effective Scan width:** Near Field 80mm (3.1in), Far Field 150mm (5.9in)
- **Points per line:** 2,000 points/line
- **Minimum Point Spacing:** 40μm (.0015in)
- **Scan Rate:** 280 frames/second, 280fps x 2,000 points/line = 560,000 points/sec
- **Laser:** Class 2M
- **Weight:** 485g (1.1lb)

“The FARO Edge ScanArm HD delivers high-definition data with superior speed and surface coverage at an affordable price, enabling our customers to reduce on-site measurement times, to scan very challenging materials, and to meaningfully improve their products and processes.”

— Kathleen J. Hall, FARO Technologies Senior Vice President and Managing Director, Americas

For more information visit: www.faro.com

Visit FARO at RAPID 2015 in Booth #574

Rapid Profile /// SLM® 500HL • *Sponsored by SLM Solutions*

Achieve Faster, Cost Efficient Builds for High Volume Metal Part Production

What's Cool

The Selective Laser Melting® System SLM®500HL's large 500x280x320 mm build envelope and unique twin laser technology enhances additive manufacturing production capabilities for complex metal parts. With the option of high performance quad lasers (4x 400W or 2x 400W and 1000W), the beam profiles may be used independently or simultaneously parallel in the process to significantly increase your build speed.

Features & Benefits

The SLM 500HL is built to optimize metal part production, ensure operator safety, and lower overall operational costs. Likewise, the newly integrated SLM Build Processor and open software architecture offers the freedom of controlling system parameters to meet strict production needs.

Additionally, SLM's patented closed-loop transport of metal powder increases operator safety and eliminates time consuming manual fills and powder handling. To further reduce ancillary times, an automatic powder sieving procedure does not interfere with the parallel-running build process. The finished build cylinder is transported out of the system and the cooling process takes place inside the unpacking unit, so that the next build process can begin immediately.

Achieve greater component quality and control your performance of each powder layer with the next generation SLM 500HL.

Who's It For?

SLM Solutions focuses on the development, assembly and sales of machines and integrated system solutions in the field of Selective Laser Melting®. These additive manufacturing systems are used worldwide by customers in the aerospace, energy, healthcare and automotive industries who benefit significantly from best-in-class operator safety and greater recoating speed.

Materials

The SLM 500HL covers a wide range of metals such as Stainless Steels, Tool Steels, Cobalt Chrome, Inconel, Aluminum and Titanium. You may use metal materials from SLM Solutions or another material provider without any risk to the machine warranty.

Specs

- **Build Envelope Volume (x/y/z):** 500 x 280 x 320mm
- **Laser Power:** 2x 400W; or optional 2x 1000W or 4x 400W Yb-Fiber-Laser
- **Build Speed:** 105 ccm/h
- **Pract. Layer Thickness:** 20 – 200 µm
- **Min. Scale Line / Wall Thickness:** 160 – 180 µm
- **Operational Beam Focus:** 80 – 120 / 700 µm
- **Scan Speed:** 10 m/s
- **Inert Gas Consumption in Operation:** Ar/N_2, 5.0 L/min
- **Inert Gas Consumption Venting:** Ar/N_2, 2500 L @ 100 L/min
- **Compressed Air Requirement:** ISO 8573-1, 30 L/min @ 1.5 bar
- **Dimensions:** (B x H x T) 4000 x 2200 (2500) x 1100mm
- **Weight:** approx. 2600 kg
- **E-Connection / Consumption:** 400 Volt 3NPE, 64 A, 50/60 Hz, 8 KW/h – 10 KW

> "From design and prototype to part production, our flagship SLM®500HL system provides companies the chance to optimize their production in a more efficient and independent way. Thanks to its multi-laser technology, this is the most productive laser melting system on the market – and clearly, the news is spreading."
>
> *— Dr. Markus Rechlin, CEO, SLM Solutions Group AG*

For more information visit: www.slm-solutions.us

Stratasys Direct Manufacturing's Fused Deposition Modeling (FDM) Services

What's Cool

Fused Deposition Modeling (FDM) is one of the only professional 3D printing technologies that uses production-grade thermoplastics.

Who's It For

- Design engineers
- Manufacturing engineers
- Aerospace, automotive, medical and energy companies
- Design and engineering services
- Packaging companies

Compatible Materials

- ABS
- ABSi
- ABS-M30
- ABS-M30i
- ABS-ESD7
- ASA
- FDM Nylon 12
- PC
- PC-ABS
- PC-ISO
- ULTEM 9085
- ULTEM 1010

Recommended System Requirements for Software

Stratasys Direct Manufacturing requires an STL file for FDM services. The most common CAD software systems have functionality to convert CAD files to STL.

Service Options

Stratasys Direct Manufacturing does not sell machines, it sells 3D printing services. As a part of the Stratasys organization, Stratasys Direct Manufacturing has the widest variety of available FDM services.

The following are the FDM service options offered by Stratasys Direct Manufacturing. Stratasys FDM printer options differ.

FDM High Definition 7 (HD7)
- **Maximum build resolution:** Z = 0.007", X/Y = 0.028"
- **Build size**: 16"x14"x16"
- **Materials:** ABS-M30, ABS-ESD7, ABSi, ABS-M30i, ASA, PC, PC-ISO, PC-ABS

FDM Standard Definition 10 (SD10)
- **Maximum build resolution:** Z = 0.010", X/Y = 0.040"
- **Build size:** 16"x14"x16"
- **Materials:** ABS-M30, ABS-ESD7, ABSi, ABS-M30i, ASA, PC, PC-ISO, PC-ABS, ULTEM 9085, ULTEM 1010

FDM Standard Definition 13 (SD13)
- **Maximum build resolution:** Z = 0.013", X/Y = 0.052"
- **Build size:** 16"x14"x16"
- **Materials:** ABS-M30, ABSi, ABS-M30i, ASA, PC, PC-ISO, PC-ABS

FDM Xtra Large Definition 10 (XD10)
- **Maximum build resolution:** Z = 0.010", X/Y = 0.040"
- **Build size:** 36"x24"x36"
- **Materials:** ABS-M30, ABS-ESD7, ABSi, ABS-M30i, ASA,PC, PC-ISO, PC-ABS, ULTEM 9085, ULTEM 1010

FDM Xtra Large Definition (XD13)
- **Maximum build resolution:** Z = 0.013", X/Y = 0.052"
- **Build size:** 36"x24"x36"
- **Materials:** ABS-M30, ABSi, ABS-M30i, ASA, PC, PC-ISO, PC-ABS, ULTEM 9085, ULTEM 1010

FDM Prototype 7 (Proto7)
- **Maximum build resolution:** Z = 0.007", X/Y = 0.028"
- **Build size:** 24"x20"x24"
- **Materials:** ABS

FDM Prototype 10 (Proto10)
- **Maximum build resolution:** Z = 0.010", X/Y = 0.040"
- **Build size:** 24"x20"x24"
- **Materials:** ABS

FDM Professional Finishing Services
- **Hand finish services**
- **Surface treatments**

"With the broadest selection of engineering thermoplastic materials from ABS to ULTEM small, Stratasys Direct Manufacturing has helped customers apply the FDM process to a wide variety of product development and manufacturing needs."

— Chuck Alexander, Director of Product Management, Stratasys Direct Manufacturing

For more information visit:
www.stratasysdirect.com

Find Engineering Services Fast

The Engineering Services Directory arranges a host of companies to assist with the design workflow.

BY JESS LULKA

The Engineering Services Directory from *Desktop Engineering* is a source of outside expertise from design to production. It covers areas such as conceptual design, analysis and simulation, industrial design, IT, product testing, rapid prototyping and educational services.

It's All About the Benefits

Engineering service companies can add value to a firm's existing capabilities, or even introduce new ones into the workflow. So what are some of the perks of collaboration?

"One [benefit is] the availability of resources at any time," says Akbar Farahani, vice president of Global Engineering at Engineering Technology Associates. "Outsourcing to a company like [ETA] gives you the ability of working with flexible costs instead of working with fixed costs in planning and budgeting."

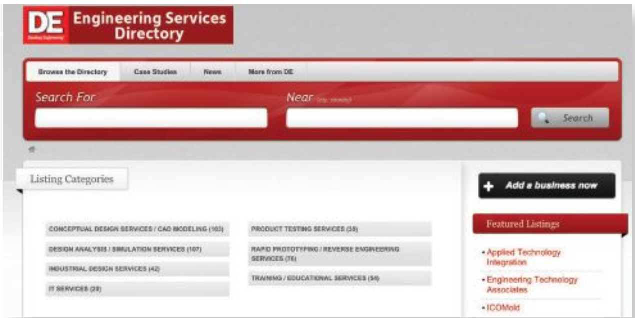
For manufacturing, equipment and materials is "where a service bureau can bring a lot of value, because as an engineering firm … it's hard to basically have every type of process in-house. Particularly some of these processes like SL (stereolithography), SLS (selective laser sintering) or DMLS (direct metal laser sintering)," says Robert Bodor, vice president and general manager, Americas at Proto Labs. "As a service bureau, we're able to offer [clients] a breadth of different technologies to serve whatever their needs are."

Efficiency is another benefit to collaborating with a service provider. For example, Proto Labs helps automate the quoting and design process. With its software, the company can respond to clients faster and help them bring their products to market.

Outside Thinking

In addition to expanded resources, companies can also bring added expertise to the engineering workflow. TotalCAE, a high-performance computing service bureau, offers a range of consulting, management and implementation services.

"The main difference between us and the other technical providers is that we are a full-service provider that manages the complete engineering environment," says Rod Mach, principal at TotalCAE. "So we're not trying to sell a customer something and leave it there, we actually end up managing that for them." TotalCAE is versed in practices that other IT departments might not be familiar with or are just starting to learn, Mach says.



THE DIRECTORY includes more than 100 engineering service providers, arranged by category.

Picking and Choosing

When deciding on what service bureau to work with, it's important to consider several factors: company history, knowledge of customer applications and capabilities.

"There's a number of things you want to think about," says Bodor. "One is what's it like to interact with them — from quoting to customer service." He also says firms should evaluate whether a service provider has the breadth of capabilities to support what is required, and how well they can scale if needed.

Farahani notes that firms should look into experience when selecting an organization to work with. Researching how long the company has been in its field, if the project team has worked together before and their knowledge of required materials are all items to know, he says.

How can engineers get the most out of working with a services company? "Good preparation for outsourcing," says Farahani. "It could be CAD data, finite element models or a BOM (bill of materials). All that needs to be prepared well, because as soon as you outsource, that's the first thing that is required." When it comes to working with an engineering service company, the possibilities can be endless. But finding the right organization doesn't have to be difficult with *DE's* Engineering Services Directory. Start looking today. **DE**

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

INFO → **Engineering Services Directory:** deskeng.com/services

→ **Engineering Technology Associates:** ETA.com

→ **Protot Labs:** ProtoLabs.com

→ **TotalCAE:** TotalCAE.com

Engineering for **Everyone**

Intelligent web-enabled applications (Smart Apps) allow everyone in your organization to safely create product designs.

EXPERT
NON-EXPERT

What would it mean to a manufacturer, if anyone who wanted to create a product design could do it per company standards, within minutes and with reduced reliance upon the company's experts? What if the product design and simulation knowledge of the engineering experts in your organization could be tapped on-demand through the use of intelligent web-enabled "virtual expert" applications?

Imagine how your company's product development processes and go-to-market strategy would change. Designers could configure products with the assurance that their designs would be engineering validated. Sales reps could engineer products, on the fly, and in front of customers based on their requirements. Junior engineers would be able to generate product designs and perform analyses without bogging down your company experts.

Intelligent Automation

Juan Betts, Managing Director of Front End Analytics says, "Back in the early 1900s, during the infancy of the automotive industry, one needed to have deep knowledge of how a car worked in order to drive a car. Today the automotive industry is a $1.5 trillion industry because, through intelligent automation and controls, someone who has no clue how a car works can drive a car. The engineering design and simulation industry is still in the 1900s requiring the developers of engineering models to be the same persons as the users of these models. In the same way you don't need to be a mechanic to drive a car nowadays, our Smart Apps enable folks who are not experts to use engineering expertise to create a product design through intelligent automation methods."

Front End Analytics helps companies transform how they create, sell and service product via the use of intelligent web-enabled Smart Apps. These applications imbed design rules, engineering practices and experts' knowhow, thereby allowing anyone enterprise-wide to safely create a product design.

Smart Apps have five major characteristics. They:

1. Leverage the company's existing intellectual property (rules, knowhow, previous designs, etc.)
2. Work across a wide range of design changes and product families
3. Speak the language of the intended user and prevent non-expert users from creating invalid designs
4. Automate an entire workflow (i.e. should work for both CAD creation as well as analysis automation)
5. Can be employed for different levels of model abstraction (i.e. from 1D functional-centric conceptual design to 3D parametric CAD and FEA/CFD analysis in detailed design).

To create these Smart Apps, Front End Analytics leverages the company's existing IP and tool set (Excel spreadsheets, MATLAB scripts, in-house codes, CAD/CAE tools, databases, enterprise systems, etc.) and intelligently links them in an automation platform. A platform that Front End Analytics often uses is called EASA, a cloud-computing platform for rapid application development, process automation and enterprise-wide software accessibility.

These Smart Apps can be safely tucked away behind a company's firewall or accessible through the web. Different Apps or functionalities within Apps can be made available via user permissions following each company's IT policies.

The Process

Front End Analytics works closely with companies to assess their workflows, engineering challenges, design practices, expert knowhow, etc. to diagnose the best course of action that would lead to desired outcomes. "We always diagnose before we prescribe," says Betts.

"We meet with companies as a neutral third party, staying focused on the facts as part of our education. Extracting the deterministic rule sets needed for the automation leads to their own discoveries about what they did and did not know," says Mark Walker from Front End Analytics. "In the end, it's their consensus that makes the solution successful."

Once a company's core design process and engineering rules are codified, various applications can be created to help streamline product development. "We make the application speak the language of the intended users across the enterprise and add intelligent controls to prevent non-expert users from creating an invalid product design," Walker says.

Many companies begin with a small pilot and then scale up.

For more info on how Front End Analytics can help automate your engineering workflow, visit www.feasol.com.

Front End Analytics (FEA)
Delivering Business Advantage

Prices for HP's Z230 entry-level workstation, shown here in tower format, begin at $799.

Professional Machines at Consumer Pricing?

Entry-level workstations are challenging the notion of unaffordable professional hardware.

BY KENNETH WONG

Workstations are more expensive than consumer PCs — that's the general assumption among hardware buyers. The former is specifically designed for professionals, running 3D applications used in automotive manufacturing, aeronautic engineering and commercial building projects. The latter is for balancing checkbooks in Excel, editing family photos and typing up résumés. The price difference reflects the disparity in performance between the two classes of machines. So some budget-conscious buyers come up with what seems like an ingenious strategy: Buy a decent consumer PC, spend some extra on CPU, GPU (graphics processing unit) or RAM upgrades and use it to run CAD applications. Even though hardware makers discourage it and software vendors don't sanction it, the truth is, you can do it.

You can, but you don't have to. Five or six years ago, the price gap between a workstation and a consumer PC was significant, so the approach was understandable. But today, with the availability of sub-$1,000 workstations, the practice no longer makes economic sense. Lenovo's ThinkStation P series entry-level workstations begin at $656. Dell's entry-level workstation, the Dell Precision T1700, begins at $679. HP's Z230, starts at $799. These prices are well within the range of consumers who might consider the Lenovo IdeaCenter K450 performance desktop ($679 at Best Buy online) or the HP ENVY 700 desktops (beginning from $749 at HP online). The ideal professional hardware has become as affordable as the compromise. Therefore, the previous cost-benefit equation should be, at the very least, revisited.

High-end PC vs. Entry-level Workstation

If there's no difference in price, what are the differences between entry-level workstations and consumer PCs? Plenty, according to computer and engineering software vendors.

"A surgeon doesn't wake up in the morning and pick up a kitchen knife and go to work to perform brain surgery. They use a scalpel. The two things are both knives, but one is a professional tool for a professional job," says Andy

Rhodes, executive director of Dell Precision workstations. (For more on this, read the white paper titled "Making the Case for Professional Engineering Workstations" at deskeng.com/de/making-case-professional-engineering-workstations.)

Even high-end consumer systems are not ideal for professional engineering work, according to Richard Runnells, director of Marketing for Solid Edge at Siemens PLM Software.

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

HP's Jeff Wood, vice president of Product Management for Workstation & Thin Client Business at HP, agrees with Runnells' conclusions.

"Buyers are missing a huge benefit in productivity when they opt for the consumer PC, certainly versus our Z workstations," he says. "The workstations have been highly tuned for professional applications. Another consideration is [that] many of the CAD software vendors are unwilling to provide software support for non-certified consumer PCs."

That's because certification is a rigorous process that involves hardware and software vendors working together to find and solve any compatibility issue before the workstation is released.

"Independent Software Vendor (ISV) certification ensures the system is qualified and supported by the ISV for workstation software applications," says Al Makley, director of ThinkStation Architecture and Technical Solutions, Lenovo. "Desktop PCs do not have ISV certification."

In some workstations, utilities that cater to the professional software user base enhance the experience. "With Dell Precision Optimizer, an automated software tool installed on all Dell Precision workstations that fine-tunes your system beyond standard factory settings, professional engineers can achieve the best possible application performance while running software from leading vendors like Autodesk, Dassault Systèmes, PTC and Siemens," says Rhodes.

"We certify workstation-class graphics cards as part of our hardware certification program," says Justin Kidder, director of SolidWorks Graphics and Architecture. "What this means is, we know what to expect in terms of graphics drivers and their interactions with the workstation. While some customers may choose to run on consumer or gaming PCs, we do not certify them for use with SolidWorks, and do not recommend that our customers do this."

Prices for Lenovo's entry-level workstation P300, shown here in small form factor, begin at $656.

Even if the software vendor is willing overlook the unsanctioned use of a consumer PC and gaming graphics, the resources available may be limited. "Autodesk doesn't recommend or certify these systems/cards. However, if an engineer encounters a problem with running Autodesk Inventor on one of these configurations, Autodesk will try its best to provide support for that issue. Diagnosis and solutions are frequently dependent on us having the configuration available as well as a vendor's willingness to support a potential problem within their driver/hardware," says Tom Rang, senior quality assurance manager at Autodesk.

Processor and Graphics

Geometry editing, the core function of CAD, is primarily CPU-driven. Most mainstream CAD vendors are making efforts to parallelize their CAD so the software can take advantage of more than one CPU, but they have succeeded only to a limited extent. Therefore, despite widespread availability of workstations with multiple CPUs, a single fast CPU remains the best configuration CAD users.

"We recommend a fast single CPU and, if your budget allows, multiple fast CPUs. There's a slight benefit using multiple processor/core machines, but only for certain operations within Autodesk Inventor (e.g. 3D view manipulation, like panning, zooming, and rotation; ray tracing; Inventor Studio rendering; mass property computation; and 3D faceting)," says Rang.

Mainstream CAD packages usually offer built-in rendering and visualization tools. Some of these tools may benefit from the GPU's massively parallel processing power; however, the degree of GPU acceleration possible varies. SolidWorks, for example, comes with PhotoView for rendering 3D models into photorealistic imagery. But it relies on the CPU only and doesn't benefit from GPU acceleration. By contrast, an independent rendering program like Bunkspeed SHOT is designed to tap into the GPU's horsepower.

"We recommended you use a graphics card with a minimum of 1GB of memory or more. It's important that the card support DirectX11 if running Autodesk Inventor 2015 or newer. Most Inventor graphic features are implemented based on DirectX11 APIs (application programming interfaces)," says Rang.

"CAD and CAE applications typically don't tax the graphics sub-system much, unless they are utilizing 3D rendering for fly-through," says HP's Wood. Such usage would go beyond typical CAD rendering; it's much closer to the type of visualization done in specialized animation and rendering programs like Autodesk 3ds Max.

If you work primarily in design programs that benefit from GPU acceleration, your choice should be a professional graphics card certified for your preferred CAD program. They tend to offer certain advantages over uncertified gaming or consumer graphics. "Professional-level graphic cards provide additional performance benefits over gaming cards, since they are designed to handle the workloads often encountered while working in a CAD environment," says Runnells.

Memory and Hard Disk

For CAD users who must open, edit, tumble and rotate large assembly files, a generous memory allocation is essential. If the system's random access memory (RAM) is insufficient to accommodate the size of the assembly model, the system must tap into the hard disk itself to "borrow" space. This process is often the culprit in decreased software performance.

"Memory is the most important factor to consider when it comes to Autodesk Inventor's performance. Inventor requires a minimum of 8GB; 12GB is recommended. The more RAM installed in the machine, the better the performance a user will experience, particularly when designing very complex components and/or working with large assembly datasets. Consult the specifications of the computer's motherboard to understand how much RAM it supports and be sure to invest in faster RAM chip sets," says Rang.

"You can never go wrong with too much memory. Prices have come down to the point where you can buy more RAM than you'll ever think you'll need, and you'll still find a way to use it," says SolidWorks' Kidder.

Most workstation vendors offer both traditional hard drives and solid-state drives (SSD) in the configuration options. Experts tend to advocate SSD, for the advantage it offers in data reading, writing, and retrieval speed. "Make sure you have at least one SSD in your workstation. The performance boost you'll see when loading and saving files will be worth it," says Kidder.

Virtualization and Workstations

One alternative previously unavailable for CAD users is remote desktops or virtual machines. Server-hosted workstations have always been around as on-premise solutions, but remote access to the workstation (for example, accessing the workstation from a client's site using a lightweight laptop or tablet) was hampered by bandwidth issues and the limitation of virtualization technologies. But in the last few years, virtualization has made great strides, spearheaded by Citrix, VMWare and NVIDIA. (The GPU maker offers NVIDIA GRID appliances for hosting virtual machines, each allocated with its own virtual GPU.) This has given birth to Desktop-as-a-Service (DaaS) vendors, offering virtual machines hosted in the private or public cloud, delivered on-demand to users. The business model could compete with traditional workstations.

"Investment in on-premise virtualization can be cost prohibitive for smaller businesses without dedicated IT services. Utilizing on-demand virtual solutions can be an advantage for these businesses, but many are still concerned about data security and integrity. Most businesses will continue to deploy discrete workstation solutions under the desk until the industry is ready to provide a secure solution at a competitive cost," says Wood.

Lenovo's Makley agrees. "Depending on the size of the customer and the workload required, entry-level workstation may still provide a better return on investment than remote (virtualized) workstation deployment," he says. "Data security and remote collaboration are the leading factors that drive professionals to remote (virtualized) workstation deployment. As remote (virtualized) workstation capabilities increase, we may see an offload of traditional high-end workstation requirements (design visualization, rendering, simulation) to the data center, leading to more entry-level workstations at the professional's desk."

Gary Radburn, head of workstation virtualization at Dell, says the company thinks of virtualization as extending the reach of a workstation, rather than as a replacement.

"Some companies may want to implement centralized control, centralized manageability, and have a flexible working policy [facilitated by virtual machines]; however, there will also be those who have not considered workstations before or have not had the opportunity to experience their value firsthand, but who can now implement fully certified, virtualized systems," he says.

While the cost differences between consumer PCs and entry-level professional workstations have disappeared, the line between virtual and physical hardware is still blurring. It's not clear whether entry-level workstations will eventually give way to virtualization, or whether the two will continue to co-exist by fulfilling different users' needs. What is clear is that engineering teams have more choices than ever when it comes to professional, workstation-class computing. **DE**

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

INFO → **Citrix:** Citrix.com

→ **Dell:** Dell.com

→ **HP:** HP.com

→ **Lenovo:** Lenovo.com

→ **NVIDIA:** NVIDIA.com

→ **SolidWorks:** SolidWorks.com

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

→ **VMWare:** VMWare.com

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

A Q&A with ETA

Company's patented Accelerated Concept to Product Process® is inspired by the efficiency of shapes in nature.

Q: What services do you provide to design engineers, and engineering and IT management?

A: Following nature's lead, ETA provides product design & development solutions, which offer the *optimal balance of performance and efficiency*. The shapes and forms of a tree, a human skeleton, an insect or animal are the most efficient designs imaginable. To mimic the balance between structure and strength of nature's most efficient shapes, ETA engineers have developed the patented Accelerated Concept to Product (ACP) Process®.

The process incorporates similar balance to product structures in terms of shape, material and thickness for automobiles, aircraft and a variety of other structural products. The results are lightweight, yet higher performing designs.

ETA's product design & development solutions include full vehicle development, CAE/FEA analysis, design optimization for cost & weight reduction and on-site engineering support. A long time tier-one supplier to the global automotive industry, ETA offers expertise in all aspects of structural analysis including durability, NVH, metal forming, crashworthiness, occupant safety and optimization.

Q: What are the top challenges being faced by the engineering teams you serve?

A: The transportation industries in particular are facing numerous challenges today. The product design and development process includes multi-dimensional issues, which often contradict each other. A central challenge is the need for cost and mass reduction to compete in the global market, while continuing to meet all new and existing requirements for quality and performance.

The cost and mass reduction objectives are challenged by a few factors, including aggressive fuel economy and emissions standards.

Q: How can you help engineering teams cope with those top challenges?

A: These design requirements indicate that new approaches are necessary within the modern product development environment. To address the challenges head-on, ETA applies its ACP Process®, which views product development in a completely holistic way. It synchronizes the individual facets of the product development process including concept design, material selection, CAE and manufacturing. Results offer an overall reduction in development costs and time to market.

For ETA's clients, the methodology offers four key benefits, namely a demonstrated capability to:

1. **Reduce Product Development Costs by 40%**
2. **Reduce Product Mass by Approximately 40%**
3. **Improve Product Performance (durability, stiffness, NVH, crash/safety)**
4. **Increase MPG Based on the Mass Reduction Results**

About ETA

ETA is committed to the delivery of processes, tools and services of consistently high quality, and to continual improvement. ETA strives to be innovative and excels at providing new technology and multi-disciplinary expertise by developing new processes to help reduce cost and increase quality.

Contact Information:
Email: etainfo@eta.com
1133 E. Maple Rd, Suite 200, Troy, MI 48083 USA
+1.248.729-3010

For more information visit:
www.eta.com

Practical Dynamic Response Analysis

Hints and tips to solve transient analysis and use the data it produces.

BY TONY ABBEY

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

There are two ways of solving response analysis: direct and modal methods. The direct method uses physical degrees of freedom (DOF) of the model. A structure modeled with 200,000 DOF has stiffness and mass matrices of this order. On the other hand, if we use a modal method then the DOF are represented by the number of modes — say 50. This reduces the size of the mass and stiffness matrices to this order. The computing cost of solving modal-based solutions is much cheaper than using a direct method. We can also reuse a modal database that reduces the cost even further.

However, as with all things, we don't get something for nothing. The big danger in a modal method is reliance on finding all the modes needed to describe the dynamic response. In some cases, the number of modes can be very high and modes may be missed or difficult to calculate accurately. So, in general, the direct method is more accurate — but more expensive. In practice we will use both methods, rather than just focusing on one. A modal-based analysis can get us answers quickly and help us to understand the physics of the problem. A follow-on direct method can confirm the accuracy.

Please remember that whichever method you use, a physical understanding of the important modes in the structure is the key. The real structure will respond based on its inherent modal characteristics, so we should know as much about these as possible. You should always do a preliminary normal modes analysis, even if you are aiming for a direct transient analysis that does not strictly need them. This was stressed in the previous article (deskeng.com/de/?p=810) and the sermon continues.

Transient Analysis Time Step

In real life, the structure will see a continuous response to any form of input loading. The finite element analysis (FEA) method discretizes this into a set of finite time steps.

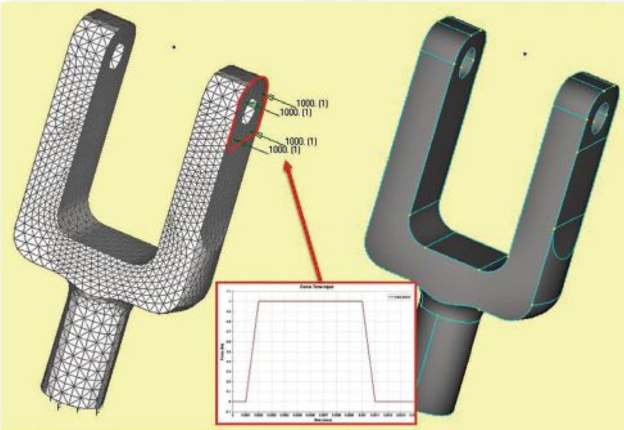
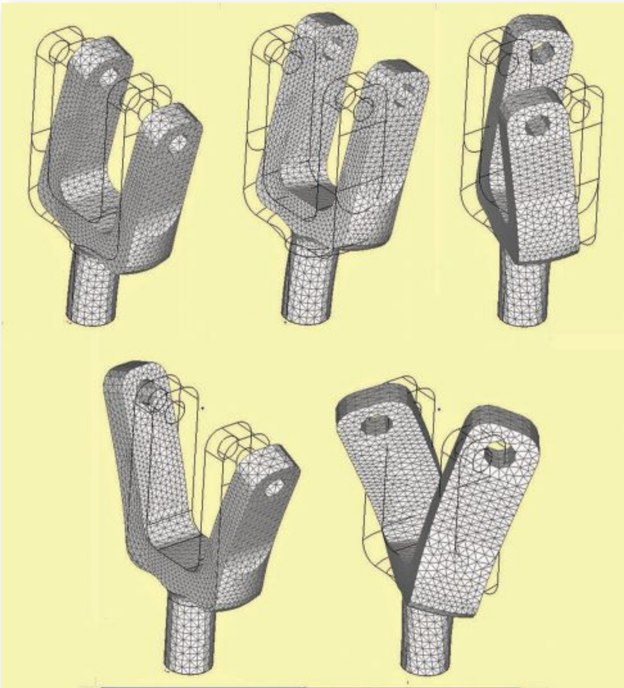


FIG 1: Geometry, mesh and loading of a yoke structure.



Mode	Freq (Hz)	Description
1	451	sway in y, arms in phase
2	491	sway in x, arms in phase
3	941	torsion about z
4	1088	sway in y, arms out of phase
5	2301	2nd torsion about z

FIG 2: Mode shapes, with description table.

This article is a follow-up on the May 2013 article in *Desktop Engineering* that covered the basics of dynamic analysis, including normal modes and natural frequencies (see deskeng.com/de/?p=810). Then, an emphasis was made on having a good understanding of the modal content of a structure. Two types of dynamic response analysis were reviewed: transient (i.e. time-based) and frequency-based analysis. This month's article focuses on transient analysis, introducing more of the background and providing practical hints and tips.

For many applications, this is a fixed-time step interval. The response through time is evaluated by a "time-marching" approach. The traditional FEA method solves for displacement, and so velocity and acceleration have to be estimated at each time step.

Force and displacement are "smeared" over three adjacent time points in this method. This has an important implication: If we make the time step too coarse, we will get very poor results. This leads us to our first practical point: What size of time step should we consider? We use the highest frequency of interest to us in the response analysis. To determine that will require engineering judgment, but we should have some clues available. It may be defined as an input specification, or equipment operating frequencies. If you are uncertain, use a safety factor of 1.5 or 2.0 on the upper value.

I am using the model shown in Fig. 1 to illustrate the methods in the article. This is a yoke, grounded at the base, but with no center component or connected shaft yet. The mode shapes, with associated frequencies, are shown in Fig. 2. The task is to check the structure dynamically up to 1,000Hz input spectrum. With a safety factor of 2.0, that means considering modes up to 2,000Hz, and we will use the first five. The next requirement is to investigate a 1,000 lbf pulse shown, applied over .001 seconds.

Modes 1 and 4 are the likely contributors under the loading shown. However Fig. 3, the Modal Effective Mass contribution, shows Mode 1 is dominating. Also of interest is that modes 1 and 2 are very close at 451Hz and 491Hz. We want to characterize the highest frequency (2,301Hz) accurately and typically assume 10 points on each sinusoidal time period (T). To capture a reasonable fidelity, calculate T, where T is 1/Frequency and divide by 10. In our case this gives a time step of 43.5E-6 seconds. It is often easier to think and work in terms of milliseconds (ms) rather than seconds to avoid cumbersome numbers. The time step is therefore 0.0435 ms. Be careful to input all of the data into the FEA solver in seconds.

The highest frequency may not be the dominating factor, so we also need to consider the loading. A sad case is a sharp shock input and a calculation time step that is bigger than the duration of the loading event. The FE analysis starts at the first calculation time step, and sadly it is all over before it has begun. This is a common beginner's error. I have done it many times and wondered why no response occurs even though the FEA model and spatial loading are correct. (I reran our model with time step value for ms, not seconds, and so missed the loading.)

In general we must be careful to make sure that we capture the fidelity of the loading input. The peaky nature of a triangular or square input actually implies very high-frequency content. Remember the Fourier Series? It takes lots of sine terms to match these shapes. The load smearing effect described implies that using just a few points to follow the triangle will transform its shape and amplitude. It is better to be conservative with the time step in this case, using 50 or so time steps for the duration of the shock. Check the response at the input point to make sure the fidelity is preserved. Similarly, if the loading point is being driven at 1,000Hz, we need at least 0.1 ms time step size.

If inputting a sine or cosine time-based loading form, look for a direct analytical definition in the solver, rather than a data table. The data table input relies on interpolation. Imagine five points used to describe a half-sine pulse. The FEA solver linearly interpolates between each point, so we get a poor definition of the input signal. An analytical input definition means that the interpolation is being done inside the solver to the accuracy of the time step.

The smaller the value of time step, the more accurate

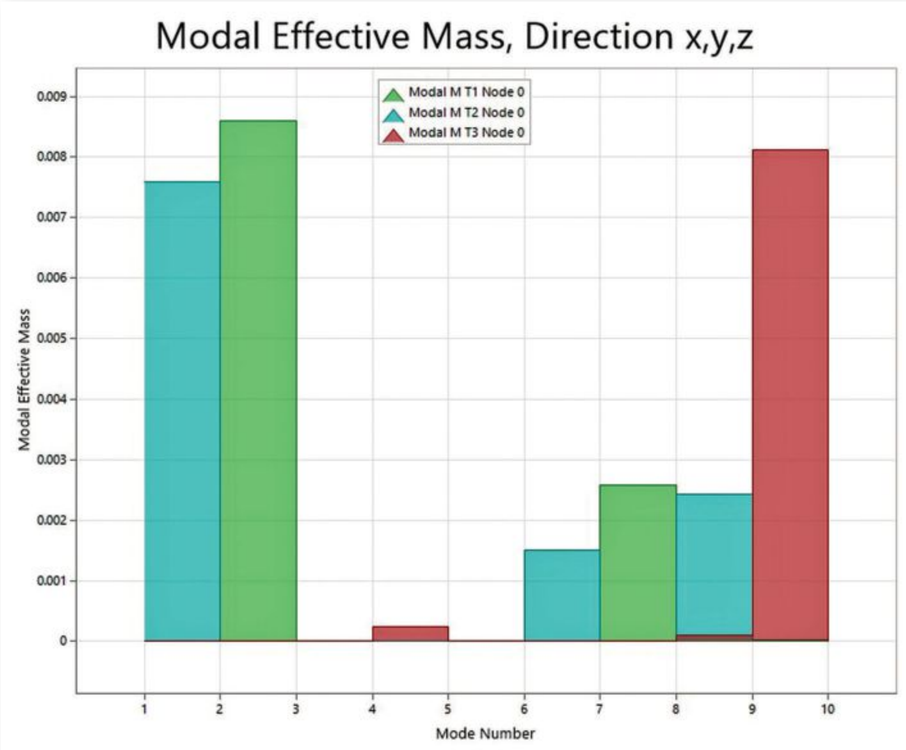


FIG 3: Modal Effective Mass table (translational).

the numerical displacement differentiation will be, which may override the previous considerations. In a large model, decrease time step at a period of critical interest (say under impulsive loading) and increase it later. However, for linear transient analysis, changing time step can be CPU expensive. Normally it will take a few runs to tune the model overall, and the effectiveness of the solution technique can be investigated.

Number of Time Steps, Duration of Analysis

The number of time steps to be used in the analysis is important. Don't guess on this or the time step size, as there is a logical approach. We want to capture enough of the response time history to make sure that any secondary swings after the initial response are captured. With complex mode shapes and phasing, it may be that the peak response occurs at some point in the history. Our aim is for the response to be clearly decaying at the analysis cutoff point, with no surprises later. Typically three or four free cycles of the lowest frequency content should be allowed to occur. The lowest frequency in the model and its time period should be straightforward to assess. From this, and the loading duration, the total duration of the analysis can be calculated. Knowing the time step size, we can calculate the number of time steps. In our case the lowest frequency is 451Hz , so each cycle is 2.22 ms; we need four cycles, so the free response should take 8.88 ms; the loading was on for 1.0 ms, so the total duration is 9.88ms. With an analysis time step of 0.0435 ms, this gives 227 steps. We can round this to 0.04 ms and 250 steps.

Data Output

The modern FEA trend is toward very large numbers of DOF. A transient analysis may have thousands of time steps. The potential to output Big Data is considerable. A useful approach is to consider two streams of output. One stream is for the big picture, an animation of the full response. Only a relatively few number of plot states are required to visualize this. If we have four cycles of a dominating low frequency response, with five plot states per cycle, then we can get down to a reasonable 20 complete sets of data. We probably need displacements at all nodes, but only need stresses on the surfaces of critical components. Careful consideration like this can make significant reductions in the amount of data stored and the time taken to transfer and display for post processing.

The second data stream is for detailed investigation by use of XY plots. There are key areas where we need a high fidelity to interrogate the frequency content and damping levels, frame these as if planning a physical test setup with data output channels. Requesting thousands of channels would be unpopular, so we settle for several hundred and probably focus on a few dozen. FEA is similar: Using engineering judgment and knowledge of the modal responses, we can predict the key points. Debugging a model using 20 output DOF, with 1,000 deflection and stress data points is extremely efficient. Investigate your post processing options carefully to see how you can set up these two data streams.

Response Investigation

The three key dynamic characteristics to investigate are listed below.

1 Check input loading. Enforced motion analysis (applying displacement or acceleration directly) allows an exact comparison between input and response at the driven point. It is more difficult to check arbitrary external forces. We can, however, apply an equivalent static loading and check the level of displacement. This will give us a correlation to the dynamic response shape and dynamic magnification factor. At the very least, we can check the order of magnitude and duration of applied loading. In our model, the static deflection is 0.0465 in. laterally. The peak dynamic amplitude is 0.065 in. when loading ends at 1.0 ms.

The dynamic magnification factor is 1.4, which is reasonable for a short pulse with a time duration less than the dominant frequency time period. The response is shown in Fig. 4.

2 Check frequency content. We want to make sure that the model exhibits the correct modal characteristics under the loading actions. Many certification authorities demand this kind of evidence. Use key points in convenient directional responses to measure the dominant frequencies from the time history plot. This is done by picking off peak-to-peak time periods. One major advantage of using the modal method is that we can directly filter the modal content in the analysis to understand which modes are contributing. Fig. 5 shows the response of our structure with Mode 1 dominating and being tracked accurately.

3 Check damping levels. We must confirm that the levels of damping defined in a model have been properly calculated during the analysis. There are several forms of damping simulation. Some of these can be problematic or error prone; Rayleigh damping depends on two coefficients in a quadratic equation, errors easily occur. Structural dumping relies on correct dominant mode identification because errors can badly affect damping levels.

We aim to find clean dominant modes showing decay after the loading is complete, under free motion. The log decrement method uses successive peaks to estimate the damping. The calculation for our structure is shown in Fig. 6, and the damping agrees with the input 2% critical value.

A Dynamic Story

The input parameters required for transient dynamic analysis can seem somewhat arbitrary, but there is a logical approach to estimating the time step size and the number of time steps.

There is a tendency to output an enormous amount of data in dynamic analysis, but with some planning you can keep the data down to a level required to do the job effectively.

Checking the dynamic response of the structure is vital. By using the key data point approach, we can investigate more deeply the structural response to loading input. Ultimately, we want to be able to "tell the story" of the structural dynamics. **DE**

Tony Abbey *is a consultant analyst with his own company, FETraining. He also works as training manager for NAFEMS, responsible for developing and implementing training classes, including a wide range of e-learning classes. Send e-mail about this article to DE-Editors@deskeng.com.*

INFO → NAFEMS Dynamics Class:
nafems.org/events/nafems/2015/el122

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

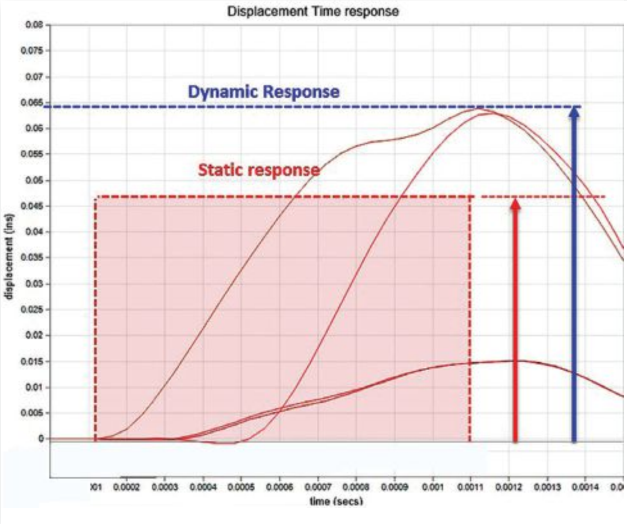


FIG 4: Dynamic and Static response at loaded point.

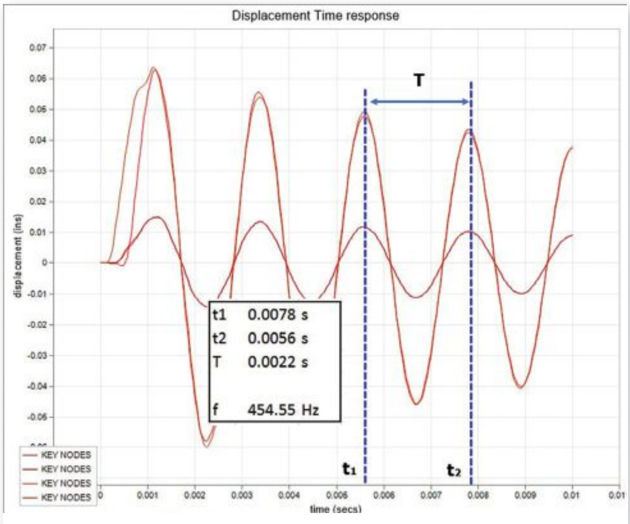


FIG 5: Checking the dominant natural frequency.

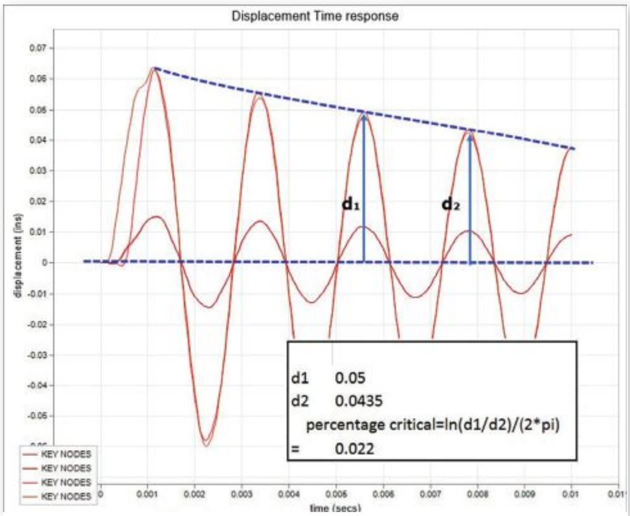


FIG 6: Checking the damping level.

Solar Impulse 2 preparing for flight. *Images courtesy of Solar Impulse.*

Around the World in 12 Legs

Solar Impulse's solar-powered aircraft is designed to circumnavigate the globe.

BY BRIAN BENTON

The Swiss-based company Solar Impulse SA, led by aeronaut Bertrand Piccard and Swiss engineer André Borschberg, has set out to circumnavigate the globe in an airplane that runs on solar energy. They are flying the plane, in multiple stages, a total of 35,000 km (21,000 miles) for over 500 hours of flight.

On March 9, Solar Impulse 2 took off on the first leg of its journey from Abu Dhabi, UAE, to Muscat, Oman. Borschberg landed after a 13 hour and 1 minute flight running on nothing but electricity generated from the sun. He flew Solar Impulse 2 to a maximum altitude of 6,383 m (20,941 ft), over a distance of 441 km, at an average speed of 33.88 km/h.

Solar Impulse SA started with a prototype plane that first flew in 2009. In 2010, it flew for 26 hours in July — including nine hours at night. The design team was able to gather a lot of data from this prototype and applied what they learned to create Solar Impulse 2, the aircraft that would attempt to fly around the world.

Designing a Solar-powered Aircraft

The task of designing an airplane that runs on solar power has myriad challenges. Minimizing the weight was the most crucial design challenge they faced.

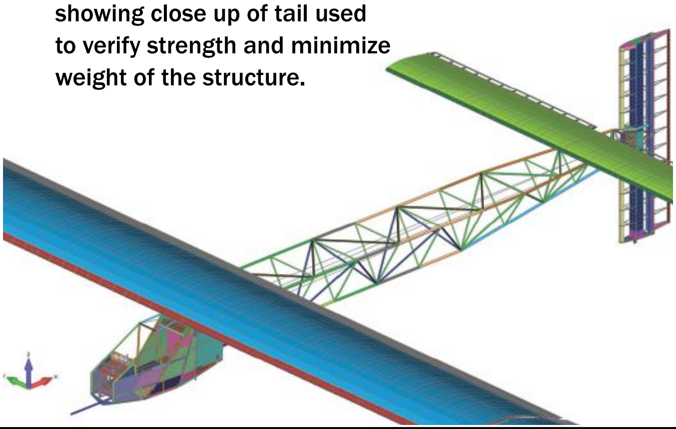
"The plane needs a lot of batteries, and batteries are heavy," says Geri Piller, head of the structural analysis team at Solar Impulse. "It has to be really light."

Engineers had to optimize the plane's design so that it was strong enough to carry the load of the batteries and still be as light as possible. The batteries make up nearly half the weight of the plane at about 2,007 lbs. They opted to use a composite sandwich structure made of a Kevlar paper honeycomb core.

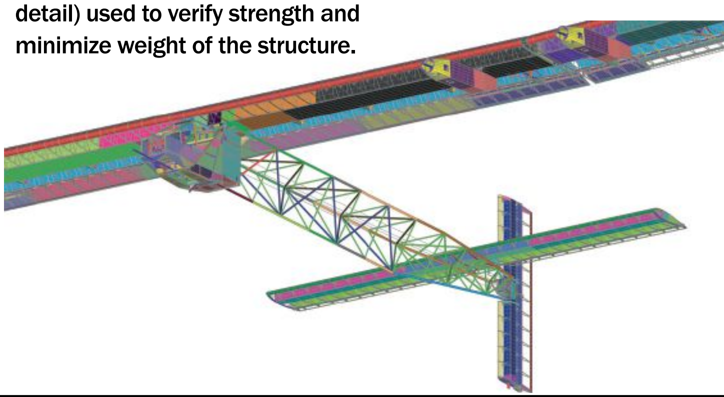
The Tools for Flight

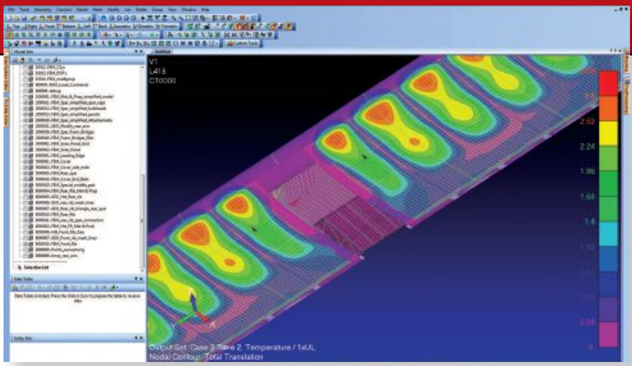
The design team for Solar Impulse used two main modeling tools for this project: CATIA from Dassault Systèmes for the 3D design and Femap with NX Nastran from Siemens PLM Software for analysis. Because CATIA was the primary design platform,

Complete simulation model showing close up of tail used to verify strength and minimize weight of the structure.



Simulation model of wing (with lower skin removed to show internal structural detail) used to verify strength and minimize weight of the structure.





Simulation predicts structural deformation experienced as a result of temperature loading.

the team felt that Femap was a natural choice as it easily accepts STEP and IGES files from CATIA. Once the 3D model was imported from CATIA, Femap could use that geometry as the basis for its finite element (FE) modeling.

"Ply definition is really easy. We were able to jump into that topic very quickly using Femap," he says. He also said that it was especially easy to simulate the composite materials in Femap, and they make up the majority of the plane.

Once the 3D modeling and design work was finished, Piller and the engineering team ran simulations and analysis to fine-tune the design. They choose Femap because it fit their needs, they were familiar with it, and it could conduct the many different types of analyses (strength, buckling, large deformation and more) they needed to run on the digital model.

CATIA was used to create the base 3D model, but once those files were imported, Femap modeling tools allowed the team to add 3D solid elements to the wings that represented Kevlar aramid paper honeycomb core. They did this to conduct analysis for local and global buckling effectively. Their FE models for the metal components ranged from 50,000 to 500,000 elements and the model of the wing contained 2 million elements. Their endurance analysis looked at 160 load cases.

Femap has an API (application programming interface) that allowed engineers to create custom scripts. One script applied the company's strength criteria to the composites in order to verify the laminate strengths. A second script helped evaluate the results. They were able to quickly identify where the laminate or sandwich structures failed, allowing for optimization of their design.

Lighter, Stronger, Faster, Bigger

The main challenge to designing the Solar Impulse 2 was the task of lightweighting the new plane. The plane needed to be bigger that the first iteration, and be able to carry a heavier load. To do this efficiently, Solar Impulse decided to use lighter materials. Solar Impulse, the prototype, used a material that weighed 100 grams per square meter. Solar Impulse 2 used a material that weighed only 25 grams per square meter on the wings.

Weight-saving steps were also taken in designing the motor gondolas. The Solar Impulse 2 needs to fly farther and longer than the prototype, so it had to have larger, more powerful motors that weighed more. In order to compensate for this weight, the engineering team switched to a sandwich structure from a framework structure. They used Femap to optimize the components (facings and spar caps as examples) to ensure that the new gondolas could hold the additional weight.

Sustaining Innovation

The Solar Impulse design is meant to demonstrate that sustainable power is possible. Solar Impulse 2 is using advanced material and construction techniques along with new battery technology to achieve its goals. Finite element analysis (FEA) made this design possible. Engineers were able to apply real world physics to their models without having to waste time and materials.

At presstime, Solar Impulse 2 is in China on leg six of 12 in its flight around the world, proving that solar-powered flight is indeed possible. **DE**

Brian Benton *is a freelance writer based in Florida. He writes the CAD-a-Blog website at cadablog.blogspot.com.*

INFO ➜ Dassault Systèmes: 3ds.com

➜ Siemens PLM Software: Siemens.com/plm

➜ Solar Impulse: SolarImpulse.comk

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

Form, Fit or Function?

Your choice of conceptual design tools should be guided by one of these three objectives.

BY KENNETH WONG

The cheapest conceptual design tool is the cocktail napkin on a bar counter. The tiny square invites your spur-of-the-moment bright ideas. Once you have drawn an intelligible schematic or sketch of your concept (not easy to do after the third pint), you can share it, revise it, expand on it and debate it with others. If it doesn't survive the what-ifs, you tear it to pieces and start again.

Finding the cocktail napkin's digital equal, however, proves much more challenging. Most mainstream CAD programs are for the detailed design phase, where you meticulously model the outer shape, internal parts and electromechanical components that make up your product. But engineers do not arrive at that stage by the same route.

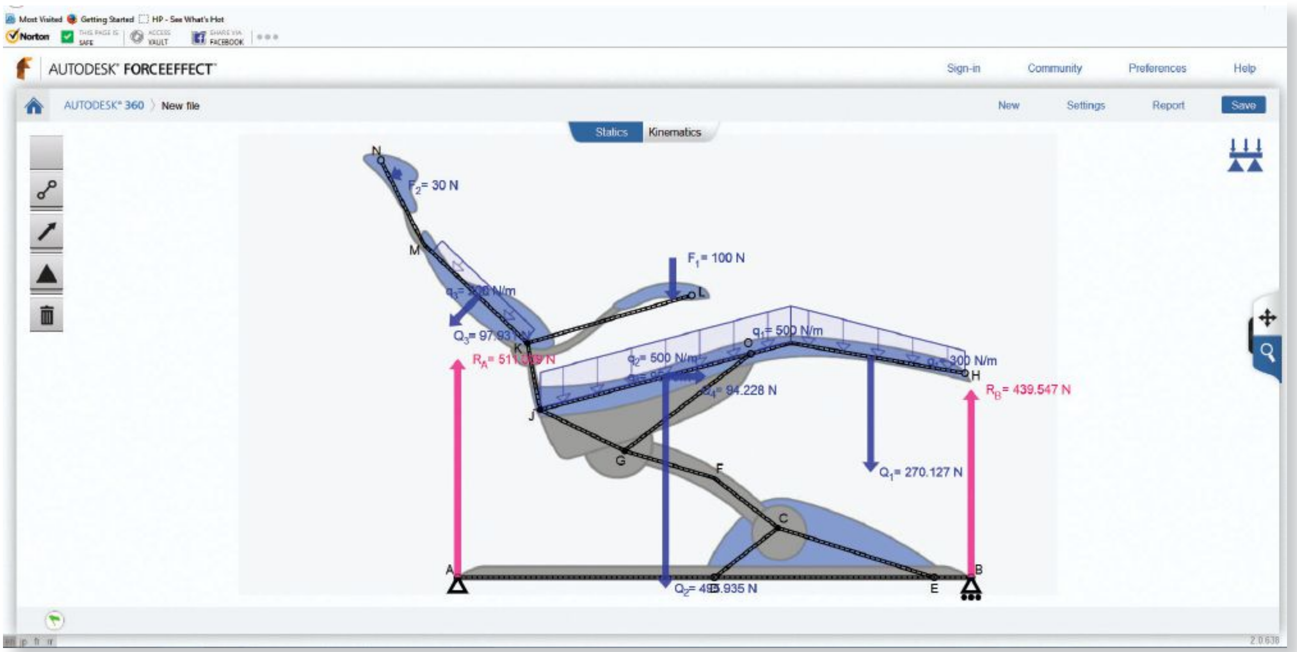
"People want to do slightly different things in the concept phase, depending on the kind of product they're trying to conceptualize," says Dr. Ken Versprille, executive consultant at CIMdata. Their priorities most likely will fall into one of the three classic design objectives: form, fit or function.

"If your major criteria is form [the shape or the look of the product], you would want easy geometry editing. If you want fit [a product that must connect, join, or fit into a predefined space], you may need a parametric modeler. If you want function [the operation of the product], you could explore simulation," says Versprille. Using these time-tested categories as a guide, looking for the right conceptual design tool is a bit easier.

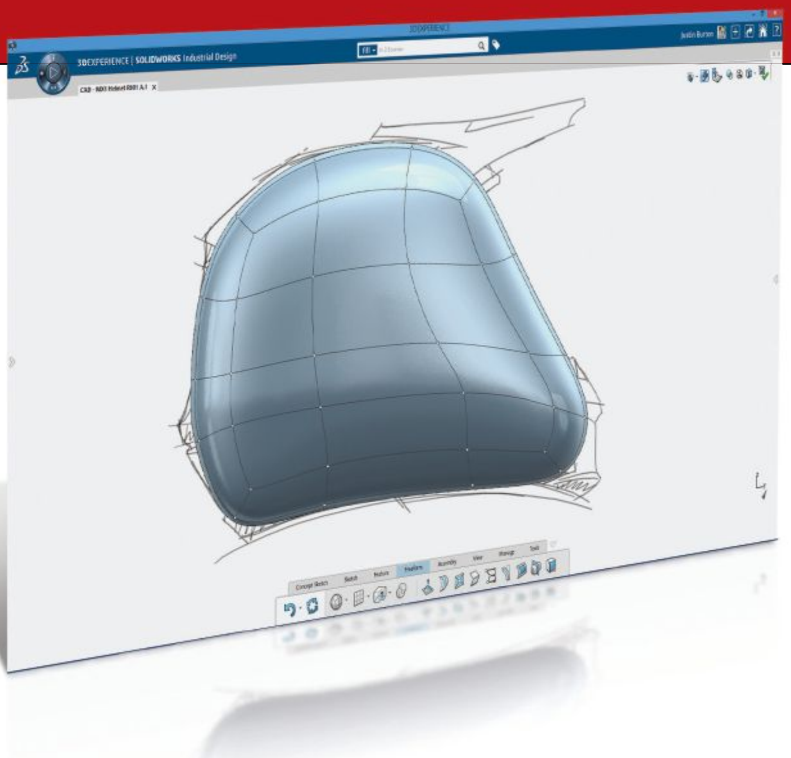
Digital Napkins

When used on a tablet with a stylus, apps like PTC's Creo Sketch, Autodesk SketchBook and CorelDRAW closely mimic the 2D pen-on-paper workflow, coming closest to a cocktail napkin. PTC Creo Sketch offers Spline tools in addition to painting tools; the product is meant to augment PTC's other 3D design apps, like PTC Creo Direct or Creo Parametric.

With digital brushes that reproduce the look of oil, watercolor, pastel and other mediums, Autodesk SketchBook offers a richer environment for artists and can function independently of other 3D design programs. Neither Creo Sketch nor SketchBook gives you the ability to draw with



From a Web- and mobile-friendly interface, Autodesk ForceEffect lets you calculate stress, loads and displacements using simple 2D diagrams that represent product structures.



With the introduction of SolidWorks Mechanical Conceptual and Industrial Design (shown here), the company hopes to tackle what it feels is an underserved segment. ***Image courtesy of SolidWorks.***

dimensions (the way you would typically do in 2D CAD), but that's not necessarily a drawback if you're mainly concerned with rough ideas. You can export the sketches as images into CAD programs for further development. With Creo Sketch, you can export Spline curves for further development in Creo Parametric. With art-centric SketchBook, you cannot export Spline objects; therefore, the use of the sketches created in it may be limited to background layers to guide your 3D modeling.

The CorelDRAW Technical Suite X7 includes CorelDRAW for vector illustration and page layout projects, Corel DESIGNER for technical illustrations, and the Corel Photo-Paint image editor. CorelDRAW and Corel DESIGNER files can be imported into CorelCAD as model space objects with a representation in a layout sheet.

One sketching program that bridges 2D and 3D is CATIA Natural Sketch from Dassault Systèmes. The program lets you use the traditional hand-sketching techniques, but on different working planes in 3D. You may also use the familiar extrusion and projection techniques in the sketching environment. With this approach, you can transform a 2D rough sketch into a 3D model with volume and mass.

Form

When SketchUp debuted as a product of @Last Software in 2000, it aimed to serve a number of industries, including civil engineering, architecture, industrial design and mechanical design. During Google's ownership (2006-2012), the program grew to become the de facto concept modeler for the architecture industry. With little to no learning curve, the program is ideal for anyone — even those without an engineering or technical background — who wants to sculpt out different concepts as 3D models. Like CAD programs, it offers tools to draw lines and arcs with precision; unlike CAD programs, it doesn't overwhelm the user with a slew of modeling menus and input fields.

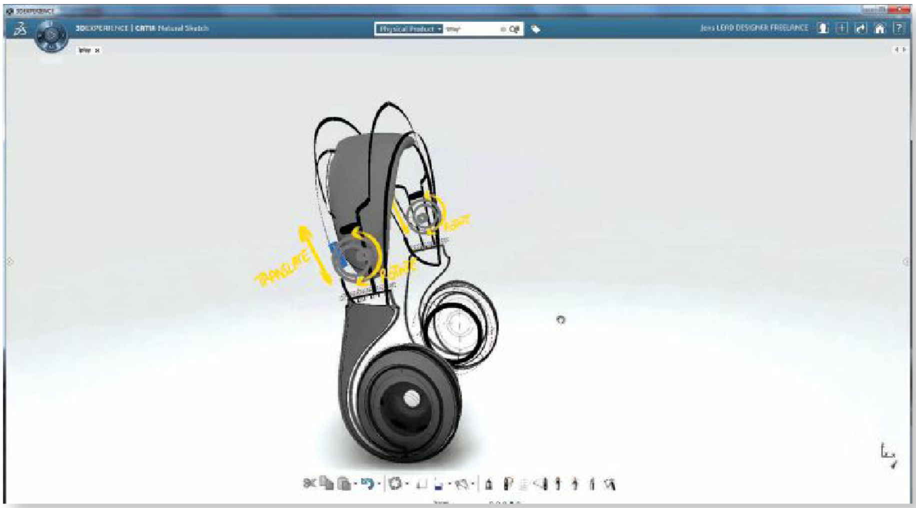
Currently, as a product of GPS and laser device developer Trimble, SketchUp still remains free, and can be adapted for mechanical design concepts, but its tight integration with architecture is evident in the preloaded content (like doors and windows). There is, unfortunately, nothing tailor-made for mechanical or industrial design that rivals SketchUp in ease of use and affordability.

For creating quick concepts involving classic mechanical shapes, direct-editing programs offer greater flexibility in editing, refining and revising geometry. In programs like PTC Creo Direct, Solid Edge with Synchronous Technology (SE with ST), SpaceClaim, IronCAD and Autodesk Fusion 360, the ability to move, rotate and delete geometric features with no regard for their construction history offers the freedom to explore design options beyond the realm of parametric logic. In some, direct editing and classic feature-based editing coexist. SE with ST, IronCAD, and Fusion 360 fall into this class. Used in conjunction with PTC's Flexible Modeling Extension (FMX), PTC Creo Parametric could serve the same purpose. Having duality is an advantage when transitioning from the concept phase to detailed design phase.

Anthropomorphic forms and organic shapes are the domain of high-end 3D modeling and animation programs like Autodesk Alias, Maya and Rhino. They're also the go-to packages for automotive design, where surface quality is of paramount importance. But their learning curve and comprehensive toolsets make them less than ideal for attempting quick form studies.

PTC addresses this segment with its Creo Freestyle module, built on subdivisional modeling techniques. It's part of Creo Parametric's modeling environment. The company believes their strategy of a common data model and geometry kernel shared by all of their apps, eliminating any data transfer and/or recreation of models, will significantly improve the handoff between concept and detail design.

With its upcoming product SolidWorks Industrial Designer (previously called Industrial Conceptual), SolidWorks aims to deliver, in its words, "a concept design tool



Straddling 2D sketching and 3D modeling, Dassault Systèmes' CATIA Natural Sketch offers a way to digitally develop concepts in a workflow that mimics pen and paper drawing. *Image courtesy of Dassault Systèmes.*

that allows you to quickly generate multiple industrial design concepts in response to a design brief. It offers unique tools for the rapid creation, manipulation, and modification of designs using native and imported geometry." In pre-release demonstrations at the SolidWorks World user conference, the software exhibits an intuitive NURBS and Spline editing system that allows you to push and pull on control points and vertices to create industrial design shapes.

Fit

Concepts with precise dimensions can easily morph into detailed designs; therefore, some of the classic parametric CAD programs — for both 2D and 3D workflows — may serve the same purpose. For 2D, choices include PTC Creo Layout, AutoCAD, AutoCAD LT, Solid Edge 2D (free), DraftSight (free), DoubleCAD XT (free), CorelDRAW Technical Suite and more. But many of those packages are intended for creating detailed 2D shop drawings with manufacturing dimensions. This means the learning curve and complexity of the software may stand in the way of quick concepts. "Ease of use is a difficult thing to achieve. As you add more capabilities, the program becomes much more complex," says CIMdata's Versprille.

PTC Creo Layout, the company explains, is developed specifically for creating 2D concepts that could drive subsequent 3D models. Currently it doesn't allow you to test load, stress and kinematic motions from the 2D sketches, like some others do.

SolidWorks, an established name in parametric CAD, hopes to address the conceptual phase for mechanical design with its SolidWorks Mechanical Conceptual. As a companion to SolidWorks, Mechanical Conceptual is expected to offer tools for developing concepts with dynamic 2D sketches and morphing them into 3D designs. Even in the 2D stage, the software will allow you to conduct motion and stress analysis. It will also offer direct editing for modifying imported geometry.

Function

Conceptualizing the function of a product (for example, the operations of a heart-rate monitoring wristband) usually falls into the realm of simulation software. But many general-purpose CFD (computational fluid dynamics) and FEA (finite element analysis) programs have the same steep learning curve that prevents detailed CAD programs from becoming effective concept design tools.

Autodesk's efforts to overcome the hurdle resulted in Autodesk ForceEffect, a Web- and mobile-friendly app that automatically calculates forces and stresses based on simple diagrams. With just a few lines and arcs representing structures (like bike frames, crane arms and bridges), you can verify the feasibility of your design before spending time developing 3D models.

Simulation software developer Altair, known for its HyperWorks suite, believes an easy-to-use duo of shape-creation and shape-optimization software could be the key to encouraging earlier use of simulation. It addresses the need with solidThinking Evolve (NURBS-based modeler) and solidThinking Inspire (for optimization). The latest version of Evolve, released in April, comes with more NURBS-editing tools and a photorealistic rendering option to help you visualize designs. In the Windows-dominated CAD software market, solidThinking's offerings stand out as one of a handful that support Mac OS, a platform favored by artists and designers.

Some direct editing programs like SE with ST and Autodesk Fusion 360 offer basic simulation tools, enabling engineers to conduct simple stress tests using rough geometric shapes. For those who are willing to employ advanced simulation programs, direct modelers may also serve as a tool to prepare the imported geometry for simulation. Without the shackles of a history-based modeler, a direct modeler allows you to edit CAD geometry with greater freedom. "Some of the direct modelers could be used for functional concept design, because they allow you to simply set things up for analysis," Versprille says.

Social Collaboration

With the increased popularity of Facebook and Twitter, the use of social media-inspired features — like chat windows, file sharing, discussion threads and group updates — also become part of engineering software, particularly in data management, project management and product lifecycle management (PLM) circles. On their own, these functions do not let you author design concepts; however, they play a crucial role in soliciting early feedback from internal colleagues, external experts, targeted demographics and even the general public.

Such features are the core of products like GrabCAD Workbench, a product spawned from the social legacy of the 3D content community GrabCAD. Traditional CAD vendors are also trying to catch up, by incorporating similar features into data management and design environments. In SolidWorks Mechanical Conceptual and Industrial Designer, the same social media-inspired tools are embedded in the 3D modeling environment. If built on cloud architecture, such tools are well-positioned to capitalize the rising popularity of mobile devices.

"Things are moving more and more toward mobile, toward the cloud," says Versprille. "Whether it's insurance or financial software, it has to ride that technology wave. The same with CAD. CAD has to go [to the cloud], because the rest of the world wants to go there."

The standard feature sets that appear in most mainstream mechanical CAD programs for detailed design are quite similar, an indication that the workflow for this phase is well-established. Not so with the workflow for conceptual design; hence, the elusive nature of a standard toolset for the phase. If someone asks CIMdata's Versprille to recommend a conceptual design tool, he says, "I'll have to ask them a bunch of questions to understand what it is they're trying to conceptualize." That is perhaps the best approach to tackling the design phase that has no clear definition. **DE**

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

INFO ➜ **Autodesk:** Autodesk.com

➜ **Altair:** Altair.com

➜ **CIMdata:** CIMdata.com

➜ **Corel Corp.:** Corel.com

➜ **GrabCAD:** GrabCAD.com

➜ **IronCAD:** IronCAD.com

➜ **PTC:** PTC.com

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

➜ **solidThinking:** solidThinking.com

➜ **SolidWorks:** SolidWorks.com

➜ **SpaceClaim:** SpaceClaim.com

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

Capturing Reality

New technologies are bridging the gap between digital and physical design.

BY BRIAN ALBRIGHT

The dividing line between the physical and the digital has blurred significantly thanks to advancements in 3D scanning, post-processing software and 3D printing. Metrology technology that was once used simply to measure objects or buildings can now be used to digitize physical items, transform them, incorporate them into visualizations, and then produce altered versions of those products or components in the real world.

Scanning has moved beyond metrology into what Autodesk is promoting as "reality capture" or "reality computing." Instead of just capturing measurement, companies are now leveraging the same solutions to create 3D point clouds for more realistic models or visualizations.

"We've seen all of these emerging technologies coming up and becoming more mainstream," says Elmer Bol, director of Market Development in the reality solutions group at Autodesk. "Laser scanning is nothing new, but it has become more mainstream. It was clear to us that our customers wanted to move this data into our solutions, but they weren't doing this just for the sake of doing it. It was a means to an end. They wanted to use that scan data to get some sort of deliverable that is valuable."

Companies are using these approaches in prototyping, reverse engineering, architecture, and even quality assurance applications. "The basic idea is that you 3D scan a real world object, make a comparison of the original 3D model that was used to produce the manufactured item, and perform a quality assurance," says Evgeny Lykhin, vice president of Product Management at Artec Group.

Unlike traditional metrology, the focus in many of these reality capture applications is less on precise measurement and more on scanning enough data to create viable digital models that can be manipulated and then built. "All of these uses just emphasize that people want to get three-dimen-

A 3D scan of a plant can help companies simulate production processes. It can also be used by design engineering teams to ensure new machine designs can easily integrate with existing equipment on shop floors. ***Images courtesy of Autodesk.***

sion data that provides a close enough representation of the object that they can do planning, preservation or re-create those objects," says Orlando Perez, director of Product Management at FARO Technologies. "The newer non-contact laser scanning methods do that quickly and efficiently."

Physical to Digital and Back Again

In the reality capture model, 3D scanning technology creates high-density point clouds that can be pre-processed then used in 3D design applications. The captured data can be manipulated, edited, analyzed, integrated with other model information, or used to simulate real-world operations. Laser scanned or even coordinate measurement machine-based metrology data can be combined with feature recognition software to convert point cloud and contact-probe data into a 3D solid model that can be used for inspection or reverse engineering.

The data can be turned back into both physical and virtual items. Visualization solutions can incorporate the digital objects, which not only helps provide context for the design, but can also help ensure that new designs fall within required specifications and tolerances. The data can also be fed to CAM systems or 3D printers to realize the new designs.

The scans can also be compared to original 3D design models of the object or structure for deviation analysis and quality control.

"It's a paradigm shift," Bol says. "We're seeing this more and more, and it can be scary for traditional designers."

Using scans for reverse engineering is an accepted practice in many industries. More intriguing is the idea that users can scan objects in great detail, and create new and upgraded designs for products, machine components and other items. Combining the scan information with design exploration or optimization solutions, users can digitally alter real-world objects. They can then simulate the results of using different materials and production methods, or alter the physical shape of the component.

"For example, in aerospace there is a push to make things lighter," Bol says. "So, a company can scan a component they want to replace, take those constraints for what they scan and fill it in with something else. You can generatively grow lattice structures that are lighter, and then those lattice structures can be fabricated using additive manufacturing."

The scanned object can be utilized in an augmented reality program to simulate its incorporation into an environment or another structure. Users can check for fit, make alterations, and then create a prototype via a 3D printer.

Autodesk Memento's user interface is designed to allow non-experts to learn how to use it without training.

Enabling this approach to design is scanning equipment that is much more intuitive than in the past. "We've created algorithms and features that make scanning as easy as possible," Lykhin says. "It's still not a fully automated process, though."

Enabling New Applications

Autodesk has teamed with a number of 3D scanner companies and other partners on reality capture projects. The company has also launched ReCap, its suite of reality capture software and services, and Project Memento, a toolkit that generates 3D meshes from photos and scans, and includes the capability to clean up the meshes, detect and fix mesh errors, and optimize the 3D models for publishing and other digital uses.

The concept has gained traction in the architecture and BIM (building information management) space. TURIS Systems, for example, used Autodesk ReCap's pre-processing functionality to help a client, Studio Gang Architects, renovate an existing building. The company scanned and modeled an existing power generation plant that was being converted to a student activity center. The company used a FARO scanner to capture 277 scans of the building. The point cloud files were joined in Revit to create a 3D model, providing engineers with an accurate documentation of the structure as they developed plans for the building conversion. TURIS reduced surveying time from months to days, and cut 15% from the cost of the project, compared to on-site manual measuring.

"We've also seen clients use this for synthetic biology applications, and in fashion where people are creating 3D-printed organic dresses," Bol says.

Volvo scans its existing assembly cells and uses the point cloud to create a digital plant; the company then uses model data and scan information to simulate and verify production processes for new vehicles. In aerospace, Autodesk says a maintenance company is scanning existing jet engine or turbine blades so that they can use machines and specialized welding techniques to repair portions of the worn blades and ensure they stay in balance.

Custom surgical implants are another area where reality computing has shown immediate utility. Oakland, CA-based FATHOM, for example, has used a combination of 3D scanning and printing to help develop customized prosthetics.

Ease of Use Improving

The biggest challenge users face with reality capture is that much of the software is still hard to learn.

"The hardware is pretty easy to use but the software required to create deliverables is complex and expensive," Bol says. "The software is aimed at high-end professional users, and that's an inhibitor that the industry needs to tackle."

At Autodesk, that effort has involved creating a new type of user interface for ReCap. "With ReCap and Memento, we set out to create products that you can learn without training," Bol says.

The other barrier: cost. "The technology is not cheap," Bol adds. "But we've seen that, even though the cost of the software and hardware is high, once companies dive in and get the scanners, they can often earn their money back within the first project they use it on. That payback comes through reducing errors, finding problems and just being able to do things they couldn't do before."

Scanner companies are also working to make the scan process even easier.

"For our customers, the ideal would be to click one button, wave the scanner around an object, and get a scan — period," Artec's Lykhin says. "We're not there yet, but we need to do everything we can to be as close to that as possible."

"The optics still have to improve to the point that you can get the same amount of accuracy or better from a laser scanner than you could with a high contact device, so that's where a lot of the focus is these days," Perez says. "There are different techniques evolving to provide more precision, that can change the contrast on the object or use triangulation."

And while much of the action thus far has been on the architecture side, product design and manufacturing are still big opportunities for reality capture. "We're working with other product design teams, like Fusion 360, to integrate reality based workflows into the design side of things for mechanical parts and industrial parts," Bol says. "We can quickly and simply digitize components instead of designing from scratch, and look at better ways of manufacturing that product. It's still the early days, but that is getting a lot of attention." 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 since the mid-1990s. Send e-mail about this article to DE-Editors@deskeng.com.*

INFO → **Autodesk:** Autodesk.com

→ **Artec:** Artec3d.com

→ **FARO Technologies:** FARO.com

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

Helping Those with Hearing Loss

Micro 3D-printed middle ear prostheses is music to the ears of hearing loss sufferers.

3D printing is frequently in the news as a process for manufacturing prostheses to replace lost limbs. It's an obvious choice, especially when combined with 3D scanning, because it allows designers

to create prosthetics customized to each patient's unique physical requirements.

At Potomac Photonics, experts in micro-manufacturing solutions, they are finding unique applications to micro 3D print small implantable prosthetics using the ProJet 3500 3D printer from 3D Systems. In one recent project they were asked to make the tiny elements of the middle ear to help develop prosthesis for otosclerosis disease.

The ProJet 3500 uses MultiJet printing technology to deliver robust, durable, high-quality plastic parts. It has layer accuracy as small as 32 microns. The platform has a range of material choices including acrylonitrile butadiene styrene-like plastic; translucent, blue and black materials; and choices of high-strength, highly flexible and tough plastics. This makes it suited to highly accurate prototypes and end use parts of many kinds and sizes, including automotive, aerospace, and, of course, medical devices.

According to the American Academy of Otolaryngology – Head and Neck Surgery [AAO-HNS], 10% of the world's adult Caucasian population is affected by otosclerosis. There are no drug treatments and hearing aids only work in mild cases. Consequently, it is important to try to develop prosthesis solutions.

MORE ➜ deskeng.com/de/?p=23817

Artificial Heart Researchers Near Breakthrough with PTC Creo

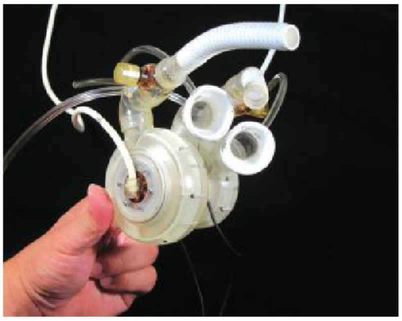
Application helps the team accurately model and simulate medical technology.

BY GEOFF HEDGES, PTC

According to the World Health Organization (WHO), almost 20 million people suffer from heart failure worldwide, with 2 million new cases added each year. Many of these patients could benefit from a new heart, but the sad truth is that there simply aren't enough donors.

So they wait.

Researchers at the Department of Radiology and Biomedical Engineering in the medical school at the University of Tokyo want to change that. In Japan, heart patients wait an average of 981 days for a transplant — that's more than two and a half years. If the Tokyo group could produce a man-made device that performed just as well as



the human organ, they could replace diseased hearts and return patients to good health, or, at the very least keep their circulatory systems running long enough for a donor to be found.

Using PTC Creo as their design software, researchers at the University of Tokyo began prototyping and testing a series of innovative mechanical models based on a hydrodynamic levitating impeller pump.

MORE ➜ deskeng.com/de/?p=23823

Life-Saving Transport Ventilator Developed via Model-Based Design

Weinmann used MATLAB and Simulink to generate code for MEDUMAT Transport.

The MEDUMAT Transport ventilator moves a mixture of oxygen and air into and out of the lungs of patients who require breathing support. Developed by Weinmann Medical Technology, MEDUMAT Transport is designed for use in emergency care and during transport. As an emergency medical device deployed in a range of operating conditions, the MEDUMAT Transport must be portable, versatile and exceptionally reliable.

Weinmann engineers used Model-Based Design with MATLAB and Simulink to develop the embedded software for MEDUMAT Transport. This approach not only streamlined production; it also helped Weinmann work with TÜV SÜD to certify MEDUMAT Transport to ISO/IEC 62304, ISO 10651-3, DIN EN ISO 13485 and DIN EN ISO 14971 standards.

"MEDUMAT is orders of magnitude more complex than earlier ventilators that we have developed," says Dr. Florian Dietz, head of Predevelopment Emergency Medicine at Weinmann. "Model-Based Design with MATLAB and Simulink enabled us to handle the increased complexity, and it was instrumental in our achieving compliance certification. Working with models instead of handwritten code makes the embedded software easier to maintain and reuse, and helps us explain the technology to a certification authority."

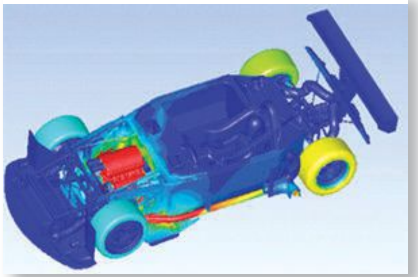
MORE ➜ deskeng.com/de/?p=23827

➜ For the complete application stories visit deskeng.com/de/fastapps

Editor's Picks

by Anthony J. Lockwood

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



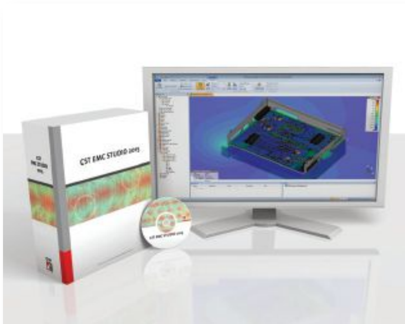
ANSYS 16.0 Launches

The engineering portfolio has enhancements for all applications.

Version 16.0 has something new throughout the entire range of ANSYS products from verification tools for connected electronic devices to simulation capabilities for the gamut of structural materials to extended modeling capabilities for model-based systems and embedded software development.

ANSYS says that version 16.0 reduces fluid dynamics simulation times by as much as 40%. A new adjoint designer tool should reduce your design optimization times by enabling you to perform multi-objective shape optimization, including constraints.

MORE ➜ deskeng.com/de/?p=22647



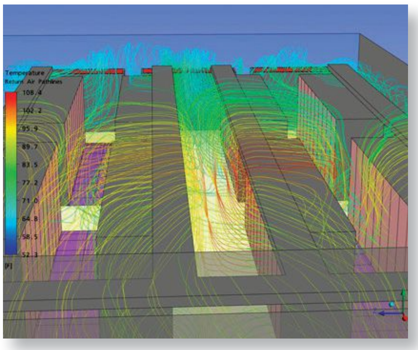
CST Releases EMC STUDIO

The application provides a toolkit of solver technologies for EMC.

CST EMC STUDIO offers general-purpose 3D modules for time and frequency domain simulation as well as specialized solvers, including a 3D transmission line matrix (TLM) method solver. The TLM solver is designed to help simplify your numerical EMC (electromagnetic compatibility) analysis by using octree meshing to reduce simulation time on complex structures.

Other tools you'll find in CST EMC STUDIO include a cable harness solver, rule checking and compact models for simulating vents and seams.

MORE ➜ deskeng.com/de/?p=22755



Software Optimizes Data Center Designs

The thermal modeling system is created for ease of use and thermal simulation.

CoolSim is a cloud-based engineering service, so you only subscribe to as much of it as you need to analyze and optimize the airflow in your data center. You can use it to understand your existing design or to analyze possibilities for a new design.

CoolSim version 4.4 sports a new model-building environment that lets you make your data center model using 2D and 3D views simultaneously. You can also use multiple display monitors for more on-screen real estate. Additionally, it has a new Ducting Tool for incorporating ducted supply designs.

MORE ➜ deskeng.com/de/?p=22959

Workstation Offers Ultra HD and 4GHz Turbo Boost

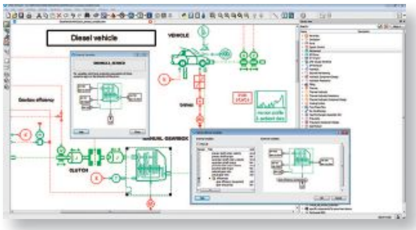
It sports a 15-in. display and weighs 4.36 lbs.

The GoBOXX 15 SLM appears ready to fit right into your engineering workflow, whether you're tossing something like Inventor, SolidWorks or Autodesk 3ds Max at it. Start with the CPU. You can get yourself a GoBOXX 15 SLM with either an Intel Core i7 4720HQ quad-core 2.6/3.6GHz Turbo Boost CPU or a high-performance Intel Core i7 4980HQ quad-core 2.8/4.0GHz Turbo Boost CPU.

It comes with a lot of memory, lots of SSD (solid-state drive) and disk storage, a bunch of ports for external devices, networking and other goodies.

MORE ➜ deskeng.com/de/?p=23075

Siemens PLM Software Introduces Imagine.Lab 14



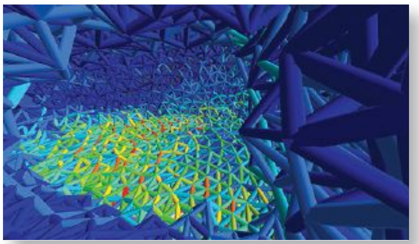
The suite is ideal for mechatronic simulation for model-based systems engineering.

LMS Imagine.Lab is particularly well deployed in the automotive/ground transportation and aerospace industries. For engineers in the former, LMS Imagine. Lab 14 offers capabilities that let you create engine maps from public data. There's automatic calibration of combustion models, and tools to help analyze tire behavior on soft soil. Other functionalities include valve definition and parameterization of after-treatment systems and an interface for gear parameterization.

This release also offers an assortment of enhancements such as 3D mechanical junctions for real-time simulations and a user interface for importing data from your finite element modeling software.

MORE ➔ deskeng.com/de/?p=23167

Altair Adds OptiStruct Solver for 3D Printing Optimization



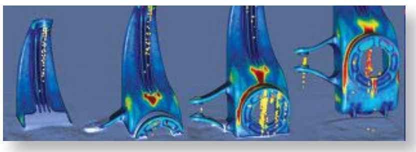
The technology can help users effectively place lattice structures in prototypes.

Altair Engineering recently announced that the latest release of its OptiStruct structural analysis solver has new features that extend topology optimization tools to designers working with lattice structures in 3D printing design.

This means you now have analysis tools that help you determine and optimize material distribution in designs intended for 3D printing. In part, it means you can figure out where your design needs more material and where it doesn't before you place lattice structures. The capabilities also let you study lattice performance.

MORE ➔ deskeng.com/de/?p=23319

CD-adapco Releases STAR-CCM+ v10.02



This version focuses on technology, productivity and user experience.

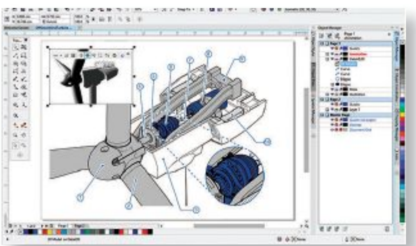
Among the technology improvements in STAR-CCM+ v10.02 are a new capability for the remote execution of a CAD client and an interaction model between VOF (volume of fluid), Fluid Film and Lagrangian models.

The user experience gets a new standalone collaboration and file-sharing tool called STAR-View+. You also have improved capabilities for adjusting the strain put on your GPU (graphics processing unit) while rendering.

CD-adapco also says that STAR-CCM+ v10.02 has 40 new features suggested by its user community alone.

MORE ➔ deskeng.com/de/?p=23492

CorelDRAW Technical Suite X7 Available



The program can create documents for print, online and mobile devices.

The skinny on the CorelDRAW Technical Suite is that it's a set of applications for technical design and illustration. It has tools for engineering drawing, page layout and photo editing. It imports and exports more than 100 vector graphics, bitmap images, documents and other data file formats like DWG.

The recently-released X7 edition of the suite sees such enhancements as a new 3D PDF publishing feature. Also added is connectivity to Translation Memory Systems (TMS) and an all-new Equation Editor, which turns mathematical and scientific equations into editable elements.

MORE ➔ deskeng.com/de/?p=23660

Commentary

by Kristian Debus

Simulation and the Future of Medicine

The group of industries known as Life Sciences, is experiencing an unprecedented change in how new medicines and medical technologies are being developed. Visionary companies in the sector are increasingly deploying modeling and simulation to reduce costs, mitigate risks and increase innovation. Ultimately, this results in better medicines, medical products and improved patient outcomes.

Medical Design and Simulation

In their day-to-day work, medical professionals are often required to provide fast and simple answers. The "yes" or "no" decisions doctors are forced to make could ultimately lead to the life or death of a patient. For example, when trying to predict whether an aneurism will rupture, doctors inspect blood flow patterns and wall thicknesses. CFD (computational fluid dynamics) and FEA (finite element analysis) could be used to run many simulations and provide correlations that suggest whether a particular set of circumstances might lead to a rupture.

> **Many Life Sciences companies are taking action; others will have to catch up later.**

While extensive research and development is required before modeling simulation is able to consistently provide a fast, accurate and reliable tool for clinical diagnostics, steady progress has been made recently, enabling some pioneering companies to begin offering these services to the medical community.

Where Are We Today?

To use computational modeling and simulation effectively, we need to close the gap between experiments, benchtop tests, clinical trials and engineering design, by automating the workflow process. For clinical trial support, that means direct import from major CAD packages, integrated with anatomical data sets from CT or MRI scans, followed by state-of-the-art meshing to enable rapid turnaround time of complex geometries.

From a software vendor's perspective, this requires the introduction of methods to enable integration of device and patient-specific data. In addition, software vendors need to offer visualization tools that help deliver simulation results in a way that is easily understandable by physicians and patients.

Most importantly, simulation-based product development and virtual prototyping are increasingly being recognized by the FDA as valid tools to supplement experimental testing and, clinical trials, and accelerate regulatory approval. Initiatives like the ASME V&V 40, MDIC or Avicenna drive and guide these efforts and lobby for the increased usage of simulation for the support of benchtop and clinical trials in the medical device industry.

Similarly, in pharmaceuticals, consortia like CSPOS are promoting the move from batch to continuous manufacturing. This represents a great opportunity to integrate the use of simulation early when redesigning processes, and offering the best possible chance of maximizing ROI.

When Will It Go "Mainstream?"

So how will this shared vision of a revolution in Life Sciences simulation become a reality? Part of the challenge is in developing solver technologies and process improvement tools. Another is the provision of advanced use cases that give potential users confidence in the technology for the particular applications.

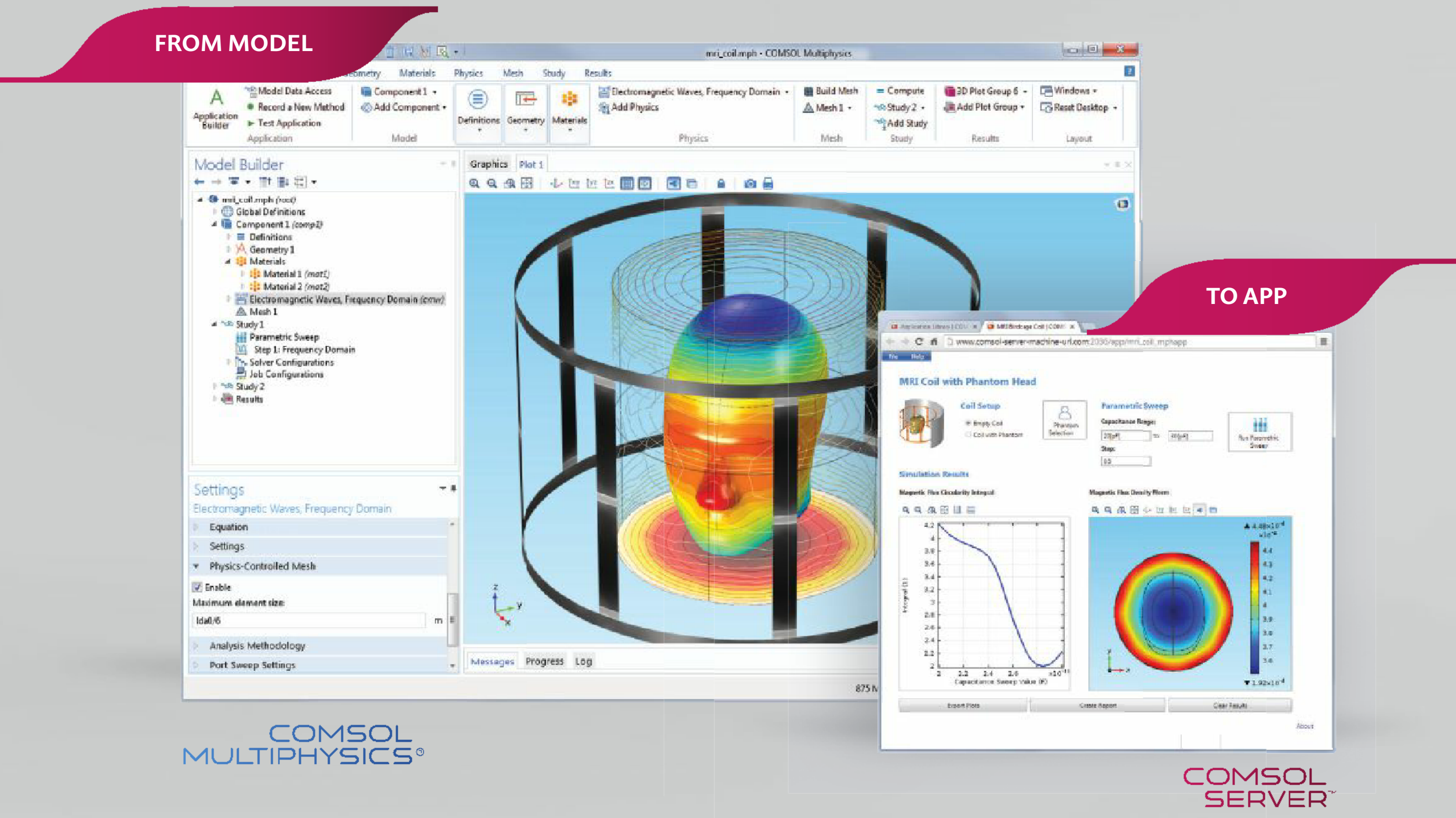
Yet, with the advancement of simulation technology, and following the buy-in and support by the regulatory bodies, the most essential ingredients — expertise and manpower — have to come from the customer. The leading medical device design and pharma companies have realized the investment is required in terms of recruitment as well as the technology. They also require the integration of modeling and simulation into clinical trial studies or the fine-tuning and modernizing of manufacturing processes in "big pharma."

To facilitate this substantial change in the industry, modeling and simulation expertise cross-pollinated from industry sectors such as automotive or communications and power will have to be considered. To maintain the momentum that MDIC or CSOPS have created, we need to reach out to the end-users to help overhaul process engineering in big pharma and integrate new design and testing modalities within medical device companies.

There has been a lot of planning, talking and investigating around modeling and simulation in the Life Sciences sector — many are finally taking action; others will have to catch up later. **DE**

Kristian Debus *is the director of Life Sciences at CD-adapco, cd-adapco.com. Send email about this article to de-editors@deskeng.com.*


Rapid Manufacturing with a Polite Disregard for Tradition
Tech-driven injection molding, CNC machining and 3D printing for those who need parts *tomorrow*
Proto Labs uses proprietary software and a massive compute cluster to accelerate manufacturing of prototypes and production parts for every industry.
Got a project? Get 1 to 10,000+ plastic, metal or liquid silicone rubber parts in as fast as 1 day.
Request your free Torus design aid at go.protolabs.com/DT5TB
ISO 9001:2008 Certified | ITAR Registered
Major Credit Cards Accepted | © 2015 Proto Labs, Inc.
proto labs®
Real Parts. Really Fast.™



How do you create the best design and share your simulation expertise?

THROUGH POWERFUL COMPUTATIONAL TOOLS.
WITH SIMULATION APPS THAT CAN BE EASILY SHARED.

comsol.com/release/5.1

PRODUCT SUITE

› COMSOL Multiphysics®
› COMSOL Server™

ELECTRICAL
› AC/DC Module
› RF Module
› Wave Optics Module
› Ray Optics Module
› MEMS Module
› Plasma Module
› Semiconductor Module

MECHANICAL
› Heat Transfer Module
› Structural Mechanics Module
› Nonlinear Structural Materials Module
› Geomechanics Module
› Fatigue Module
› Multibody Dynamics Module
› Acoustics Module

FLUID
› CFD Module
› Mixer Module
› Microfluidics Module
› Subsurface Flow Module
› Pipe Flow Module
› Molecular Flow Module

CHEMICAL
› Chemical Reaction Engineering Module
› Batteries & Fuel Cells Module
› Electrodeposition Module
› Corrosion Module
› Electrochemistry Module

MULTIPURPOSE
› Optimization Module
› Material Library
› Particle Tracing Module

INTERFACING
› LiveLink™ *for* MATLAB®
› LiveLink™ *for* Excel®
› CAD Import Module
› Design Module
› ECAD Import Module
› LiveLink™ *for* SOLIDWORKS®
› LiveLink™ *for* Inventor®
› LiveLink™ *for* AutoCAD®
› LiveLink™ *for* Revit®
› LiveLink™ *for* PTC® Creo® Parametric™
› LiveLink™ *for* PTC® Pro/ENGINEER®
› LiveLink™ *for* Solid Edge®
› File Import *for* CATIA® V5

COMSOL