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THE MAGAZINE OF ASME

No. 01

138

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THE BEAUTY OF MOVEMENT

SURE, THERE'S PLENTY OF ART THAT REQUIRES A BIT OF ENGINEERING. Think of the pyramids, large-scale Jeff Koons sculptures, and epic movies. They all depend on someone who understands materials, movement, and energy. But when the two disciplines intersect, the engineering plays servant to the art. Rarely do they unite as one. The work of David C. Roy is that rarity. In his moving, mesmerizing, kaleidoscopic works, the engineering is the art.

A NEW ALLY FOR THE LIVER

LIVER SURGERY IS A TRICKY business: Patients sometimes end up with complications because surgeons inadvertently cut through a major blood vessel or bile duct. Researchers at the Cleveland Clinic are now using 3-D printed models of the human liver to assist with surgical planning. The models are held together with magnets so that doctors can pull them apart to examine hidden details.

For these articles and other content, visit asme.org.

3-D PRINTING AND THE JUMPING ROBOT

AS A POSTDOC AT HARVARD University, Michael Tolley, now an assistant professor at the University of California, San Diego, got in touch with people in chemistry who had been working on the idea of how to create soft machines. Then he became part of a team that decided to find the answer.

DEVELOPING FUEL CELLS // VIDEO

ASIM HUSSAIN OF BLOOM ENERGY talks about the development of solid oxide fuel cells, their use, and how engineers overcame the problem of high operating temperatures.

NEXT MONTH ON ASME.ORG

BOEING BANKS ON BIG DATA

Big Data offers huge potential for aerospace engineers and managers. Learn how Boeing is using predictive machine learning to improve various aspects of aircraft production.

VIDEO: INTEGRATING ELECTRONICS WITH 3-D PRINTING

An interview with Daniel Oliver, co-founder of Voxel8, a Massachusetts-based startup that's enabling designers and engineers to create three-dimensional parts with embedded circuitry.

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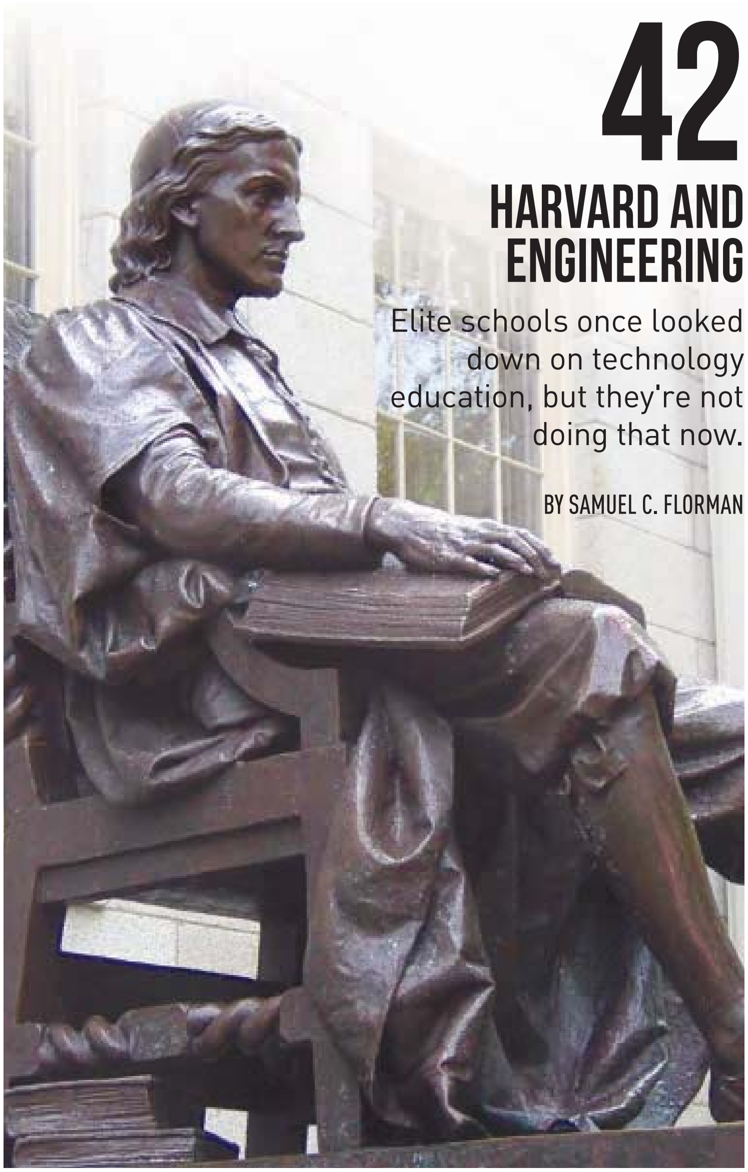

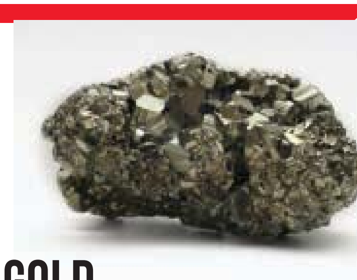

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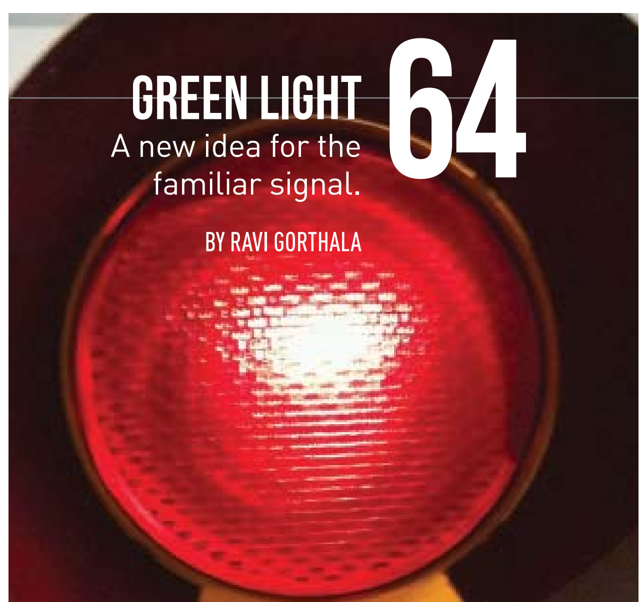

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Executive Editor
Harry Hutchinson

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Jeffrey Winters

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Art and Production Designer
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Contributing Writers
Michael Abrams, Benedict Bahner, Mark Crawford, Tom Gibson, Rob Goodier, Lee Langston, Bridget Mintz Testa, Ronald A.L. Rorrer, Kirk Teska, Evan Thomas, Jack Thornton, Michael Webber, Frank Wicks, Robert O. Woods

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Editor
David Walsh

Managing Editor
Chitra Sethi

Senior Editor
John Kosowatz

Managing Director Publishing Philip V. DiVietro

Managing Director Conformity Assessment & Publishing Michael Merker

Contact *Mechanical Engineering*

Mechanical Engineering
memag@asme.org
p. 212.591.7783 f. 212.591.7841
Two Park Avenue, New York, NY 10016

For reprints contact Jill Kaletha
jillk@fosterprinting.com
(866) 879-9144 ext.168

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ASME offices

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India Office NehruR@asme.org
p. +91.124.430.8413 f. +91.124.430.8207
c/o Tecnova India Pvt.Ltd.; 335, Udyog Vihar, Phase IV; Gurgaon 122 015 (Haryana)

Publisher
Nicholas J. Ferrari

Integrated Media Sales Manager
Greg Valero

Circulation Coordinator
Marni Rice

Advertising & Sponsorship Sales Representative
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Classified and Mailing List
212.591.7783

Advertising Sales Offices

East Coast Michael Reier
reierm@asme.org
p. 410.893.8003 f. 410.893.8004
900-A South Main Street, Suite 103; Bel Air, MD 21014

Northeast Jonathan Sismey
sismeyj@asme.org
p. 845.987.8128 c. 646.220.2645
Two Park Avenue, New York, NY 10016

Southeast Bob Doran
doranb@asme.org
p. 770.587.9421 f. 678.623.0276
8740 Glen Ferry Drive, Alpharetta, GA 30022

Central Thomas McNulty
mcnultyt@asme.org
p. 847.842.9429 f. 847.842.9583
P.O. Box 623; Barrington, IL 60011

West and Southwest Stephen Shuba
stephen.shuba@husonmedia.com
p. **212.268.3344 c. 407.928.3378**
Huson International Media
1239 Broadway, Suite 1508
New York, NY 10011

UK/Europe Christian Hoelscher
christian.hoelscher@husonmedia.com
p. +49 89.9500.2778 f. 49 89.9500.2779
Huson International Media
Agilolfingerstrasse 2a, 85609
Aschheim/Munich, Germany

James Rhoades-Brown
james.rhoadesbrown@husonmedia.com
p. +44 (0) 1932.564999 f. +44 (0) 1932.564998
Huson European Media
Cambridge House, Gogmore Lane, Chertsey, Surrey, KT16 9AP, England

Rachel Di Santo
rachel.disanto@husonmedia.com
p. +44 1625.876622
m. +44 7941 676014
Huson European Media
Cambridge House, Gogmore Lane, Chertsey, Surrey, KT16 9AP, England

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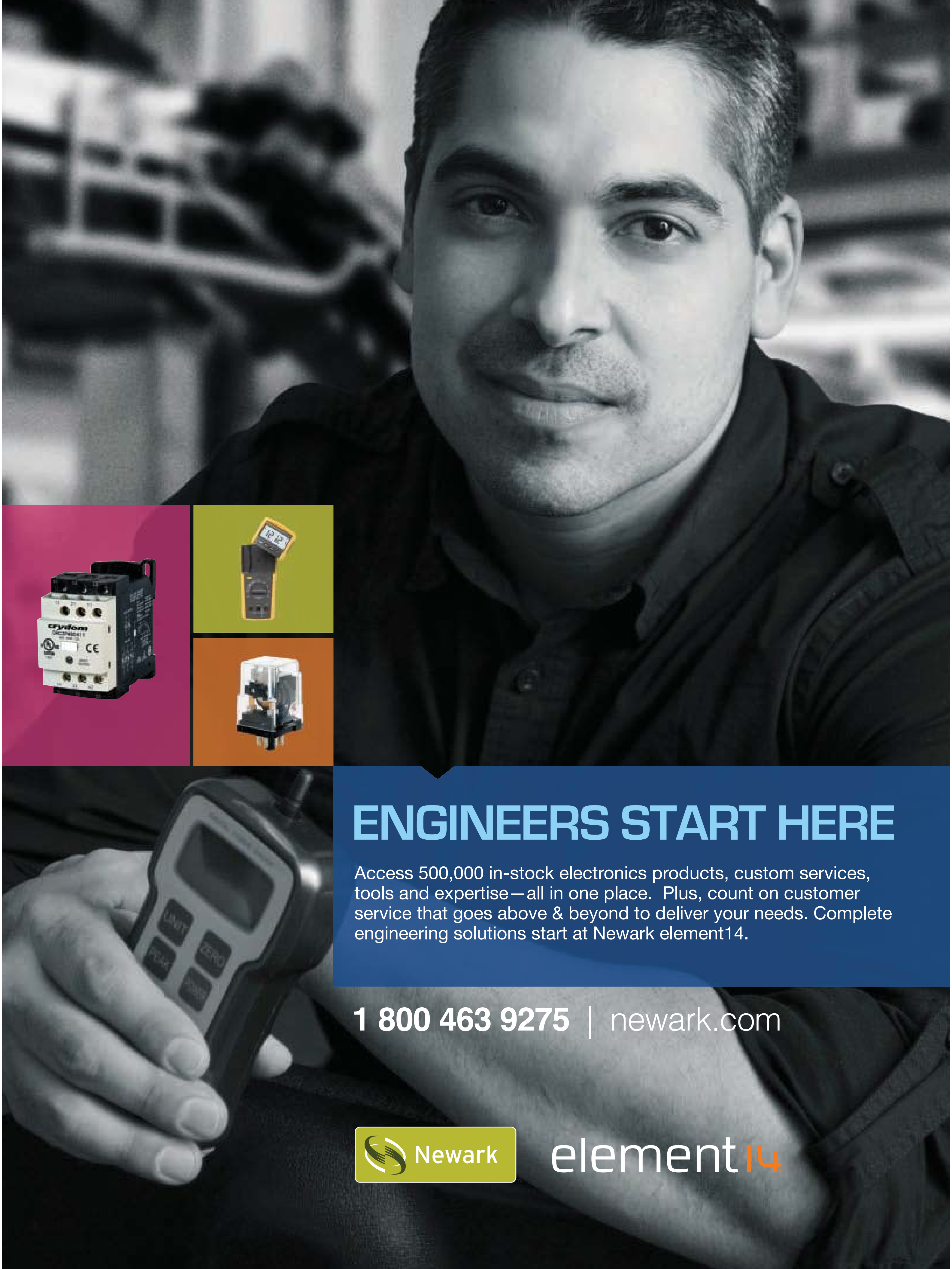
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John G. Falcioni
Editor-in-Chief

U.S. MANUFACTURING NOT SO LEAN ANYMORE

Not so long ago it was popular to mock U.S. manufacturing.

After all, global manufacturing competitiveness increased greatly as newcomers China, India, and Brazil made a big splash, while in the U.S. danger signs were difficult to ignore. Even as American high-tech manufacturers continued to lead the world in total output, their global share fell from 34 percent in 1998 to 28 percent in 2010. Over that period, the U.S. share of global high-tech exports declined from 22 percent to about 15 percent, according to government statistics.

But the days when manufacturers in other countries hold an advantage over competitors in the U.S. may be coming to an end. In large measure, this is due to a serious commitment by public and private sectors working together to change the trend and with it, they hope, also the public's perception of American manufacturing, once a source of national pride and optimism.

Americans believe that a high-performing manufacturing sector is imperative if the United States is to prosper in the 21st century. A survey by Deloitte Development LLC and The Manufacturing Institute shows that 85 percent of Americans said manufacturing is important to the country's standard of living and 77 percent said it is very important to national security. Consistent with this view, 79 percent said that a strong manufacturing base should be a national priority.

The drive to restore American leadership in manufacturing innovation is spurred by engineering and scientific advances that have given birth to cutting-edge materials and new processes. This technology has revolutionized ways to manufacture existing and new products in ways never before possible.

As traditional manufacturing processes continue, and even less traditional ones such as lean manufacturing evolve, advanced manufacturing has taken center stage. (Lean manufacturing is the focus of this month's cover story, "All-Out Lean," authored by renowned former General Motors executive Gary Cowger.)

The term advanced manufacturing points to innovation that is occurring in the manufacturing ecosystem, including the digitization of equipment and processes, 3-D printing, and new materials with custom-designed properties.

ASME's Industry Advisory Board and other representatives from ASME met recently at the Digital Manufacturing and Design Innovation Institute (DMDII) in Chicago—one of seven institutes developed under the National Network for Manufacturing Innovation—to begin a conversation on the role ASME might play in helping to support the growth of advanced manufacturing. The six other institutes focus on additive manufacturing, lightweight metals, semiconductors, composites, photonics, and flexible hybrid electronics.

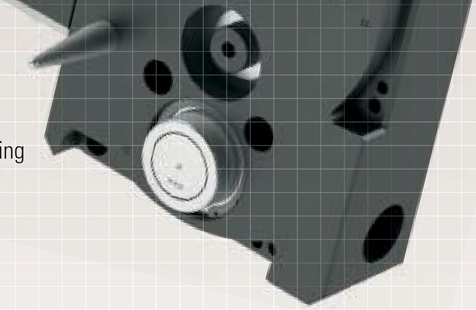
These institutes represent a government initiative linking industry, academia, and government partners to nurture manufacturing innovation and accelerate commercialization. Located throughout the United States, they bring together small manufacturers that could not otherwise afford to invest in advanced manufacturing research and expose them to cutting-edge technology. The Department of Defense supports the institutes because it views their areas of research as core competencies essential for the future of national security, said Adele Ratcliff, the director of manufacturing technology in the Office of the Deputy Assistant Secretary of Defense for Manufacturing and Industry Base Policy.

But there's yet another benefit. Government focus on national manufacturing will bring back enthusiasm for science, technology, engineering, and math education, argues Ratcliff. "There's a relationship between low STEM scores and manufacturing offshoring." As pride is restored in this country's manufacturing backbone, she said, scores will go up as more kids will want to be part of the revolution. *Viva la revolución!* **ME**

FEEDBACK

What is the one thing you would change to make U.S. manufacturing more globally competitive? Email me.

falcionij@asme.org



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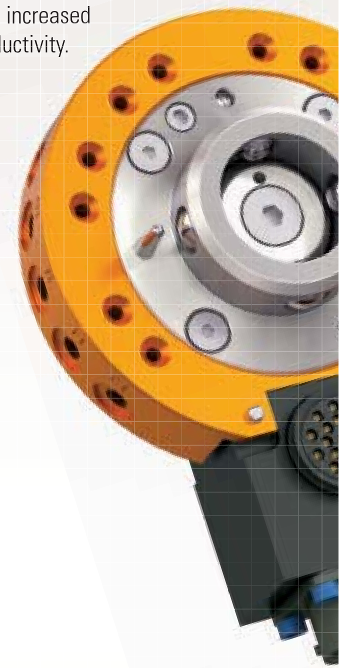

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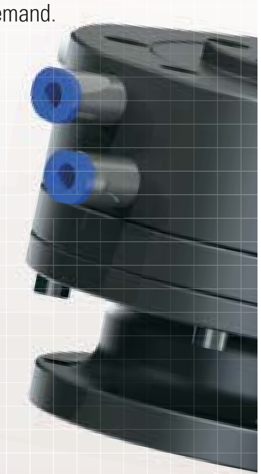

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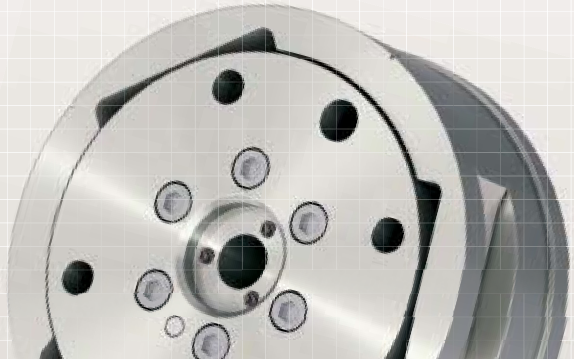

AUGUST 2015

Reader Willis differentiates between nameplate capacity and net generation.

« One reader reminds us of his invention. And in a comment, we learn about the future of turbine blade materials.

NAMEPLATE VS. AVAILABILITY

To the Editor: A review of the August 2015 article "Changing of the Guard" [Tech Buzz, Trending] reveals a very disturbing reduction in available power when the capacity factors are applied to the nameplate power of the proposed power generation additions. The actual increase in power is only about 9,365 MW, not 26,143 MW as stated in the article.

The 17,611 MW of coal and petroleum liquid power being retired are replaced with 15,775 MW of natural gas combined cycle and nuclear power. This produces a decrease of 1,836 MW. The capacity factors of 60 percent for coal and 10 percent for petroleum liquid are approximately balanced by the 50 percent for natural gas combined cycle and 90 percent for nuclear.

Since fossil and nuclear power retirements and replacements approximately balance out, the entire power generation addition will be renewable, wind and solar. Due to their unreliable and intermittent availability, the capacity factors are 35 percent for wind and 40 percent for solar. When the capacity factors are applied, the actual increase of generation power is reduced to 9,365 MW.

Frederick Willis, *Haddonfield, N.J.*

HIJACKED

To the Editor: Many thanks to Douglas Marriott for his letter (September

COMMENT

WHERE ARE GAS TURBINES HEADED?

New materials and manufacturing processes being developed by General Electric point to a 65 percent gas turbine/steam turbine combined cycle efficiency in the near future, according to Michael Idelchik, vice president of GE's advanced technology programs (One-on-One, October 2015). I would like to comment on what Idelchik has to say about advanced technology as it applies to gas turbines of all kinds. I also want to thank *ME* and the interviewer, Alan S. Brown, for writing and publishing the article.

That interview will be of particular interest to gas turbine engineers in the United States and around the world. Gas turbine output and efficiency levels continue to rise. Great progress has been made the past decade and even greater advancements are coming. As head of advanced technical programs for GE, Idelchik should know. He gives us a surprisingly rare peek of what to expect.

Idelchik starts out by telling us about the new lightweight (1/3 less than steel) titanium aluminide (TiAl) material being used for the power turbines of the GEX and Leap aero engines where weight was most important. TiAl has been known for some time to be a very good material for this blading, but it was difficult to cast or machine for gas turbine parts. GE spent a lot of time and money finding a way to make parts by powdering TiAl for 3-D printing. Parts, including advanced fuel nozzles for GE's new fan jets, now exist that could not be made any other way.

The next material to be used for gas turbine nozzle vanes and rotating blades will be ceramic matrix composites, which will raise combined-cycle efficiency from 60 percent to 65 percent. CMCs weigh half as much as TiAl, are very durable, and can withstand higher temperatures than single-crystal blades and vanes. I say it will be a gas turbine revolution.

Lighter blading makes it possible for the gas turbine disks and bearings to be reduced in size and weight. The fir tree connection of the blades to the disks can be simplified and less costly to manufacture. This year GE announced that it had been successful in running an advanced military jet, the GE F 414, with second-stage high-pressure turbine rotating blades made of CMC material. GE has also run an old J-47 non-air-cooled gas turbine with first-stage CMC nozzles and rotating blades

But the biggest advantage is that little or no cooling air will be required for a machine, thus leading to more gas turbine output and higher cycle efficiency for both aero and heavy-duty engines.

2015). Among many thoughts, he referred to my June letter, “Tool for Climatologists.”

He may be interested in my opinion that the original “global warming” science (the correlation of CO_2 records in historically dated Arctic ice cores with global mean temperatures over a period of 650,000 years) has been hijacked by the unscientific expression “climate change” following the 2013 hiatus. More the reason for statistical temperature analysis.

Gordon Rogers, P. Eng., Life Member, *Toronto*

CREDIT FOR A TURBINE

To the Editor: The recent article “Eiffel Tower Goes Green” (September 2015) describes the helical turbine, which is my invention, developed at Northeastern University in 1995.

The turbine brought me the 2001 Thomas Edison Patent Award from ASME. I would like you to mention my name relating to that article as a follow-up.

Alex Gorlov, *Boston*

FEEDBACK Send us your letters and comments via hard copy or e-mail memag@asme.org (subject line "Letters and Comments"). Please include full name, address and phone number. We reserve the right to edit for clarity, style, and length. We regret that unpublished letters cannot be acknowledged or returned.

GE has a pilot development plant in operation in Newark, Del., and a large plant ready to open in Asheville, N.C., to make stationary and rotating CMC parts for gas turbines.

The use of CMCs for combustion liners and for other fixed parts, as well as future rotating blades, sheds new light on the subject of the reheat gas turbine. ABB and Alstom developed land-based reheat turbines, but the extra cooling required for the second combustor and second set of hot nozzles and rotating blades has always been a stumbling block for aero gas turbines with sequential combustion.

Where do we go with gas turbines after full use of CMCs become a reality? Keep up with the gas turbine news and we will find out sooner than we think. ME

IVAN G. RICE is a retired turbomachinery engineer in Spring, Texas, and a former chair of the ASME International Gas Turbine Institute.

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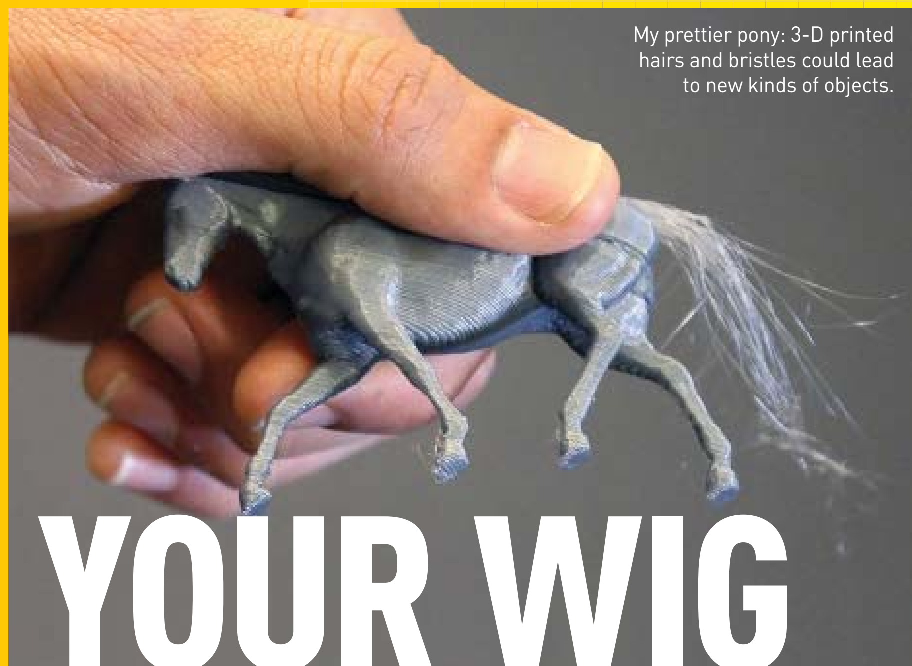

My prettier pony: 3-D printed hairs and bristles could lead to new kinds of objects.

PRINT YOUR WIG

3-D PRINTERS AREN'T JUST FOR MAKING PLASTIC CHESSMEN. A GROUP OF ENGINEERS HAS DISCOVERED HOW TO FABRICATE SOFT STRANDS AND STIFF BRISTLES.

Additive manufacturing machines are making industrial-quality parts, but hobbyist-grade 3-D printers have a decidedly mixed reputation. They are capable of producing all manner of small objects such as game tokens, but the finished products generally have a stiff, plasticky feel to them.

Three computer scientists at Carnegie Mellon University in Pittsburgh have developed a technique for printing up something decidedly softer. In November they presented a paper in which they showed how a conventional fused deposition modeling printer can produce strands in varied thickness and stiffness, from fine flowing hair to short bristles.

Chris Harrison, assistant professor of human-computer interaction at Carnegie Mellon, attributes the inspiration for the new technique to a very common annoyance for people making handicrafts. "Our work was inspired by the phenomenon that occurs during the operation of a hand-held glue gun," Harrison wrote on his blog. "When a person extrudes hot glue material and moves the gun away, a 'string' of residue often forms unintentionally."

Glue guns and FDM-type printers both work the same way: a material is heated until it softens, then it is extruded through a nozzle in a long, thin bead. What's more, some hobby-grade 3-D printers also produce strings by accident as the molten plastic trails behind the moving print head.

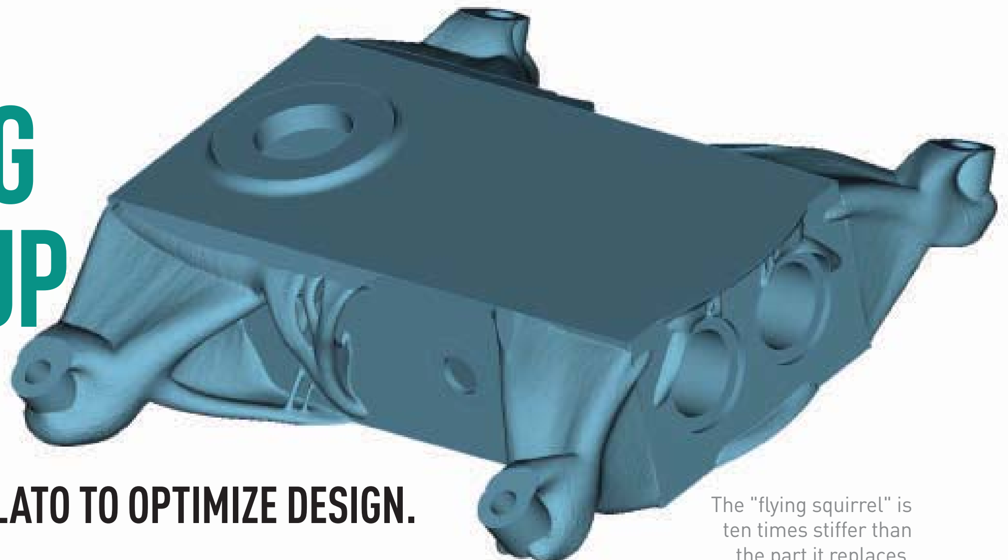
According to the researchers, the way to create hairs using a cheap printer working in polylactic acid filament (a common plastic) is to slowly extrude a tiny bit of plastic and then quickly move the print head away. Controlling the speed of the print head can determine the thickness and texture of the printed hair.

The team admits it is a painstaking process to print hair, thanks to the slowness of the hobbyist-style printer. And the heat of the print head will melt the hair, which limits the density that can be printed. The demonstrations they presented tend toward the wispy.

But the process opens up the possibility of new types of objects that can be produced by 3-D printers. Whether homemade plastic toupees are actually advisable remains to be seen. **ME**

JEFFREY WINTERS

Changing filaments and design parameters can control hair color and texture.



RETHINKING THE MAKEUP OF PARTS

A NATIONAL LAB ENLISTS PLATO TO OPTIMIZE DESIGN.

The "flying squirrel" is ten times stiffer than the part it replaces. *Image: Sandia National Laboratories*

When engineers at Sandia National Laboratories in Albuquerque needed to redesign a part for a weapons systems, they used to start with an idea of what shape would work, then redesigned the part using CAD software. But recently they tried software that could rethink the part entirely.

The engineers fed critical data on the part into the new software: the part's desired volume, the material it could use, the location of its attachment points, how much force it needed to withstand.

Then they let the software, which they call Platinum Topology Optimization, or PLATO for short, determine the shape that worked best. The original part resembled a low platform supported by four legs, but the redesign resembled a partially melted and resolidified version of the original. "We call it our flying squirrel," said Ted Blacker, who manages the lab's simulation modeling efforts.

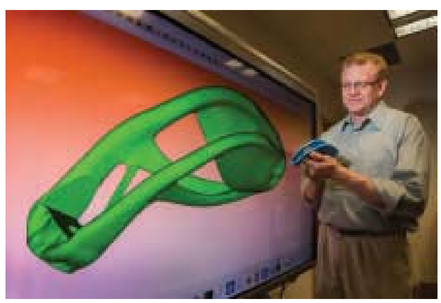
When they built a prototype of the squirrel with additive manufacturing and tested it, it used no more material than the original, but it was ten times stiffer.

By marrying topology optimization and additive manufacturing, engineers can now create parts that are simultaneously lighter, stronger, and often cheaper to make. Often a single part can replace separate parts that had to be built and assembled. The married methods could produce ultrareliable parts for national security, aerospace, medical, and other vital applications.

"What's exciting is that now additive manufacturing can make all these things that we couldn't make before," said Blacker. "This is a fundamental change in how we approach design."

Topology optimization software, which has been commercially available for about 15 years, starts with a part's physical constraints, such as volume and attachment points, and its desired functions, such as stiffness or thermal load. Then it calculates the shape that best achieves them. Often the software comes up with flowing, fluid shapes like those in nature.

Such shapes often can't be made by typical machining methods, but additive machines can build them by translating the flowing, organic designs into concrete instructions to deposit material exactly where it's needed.



Sandia's Ted Blacker, with a uniquely shaped bracket designed by topology software. *Photo: Sandia National Laboratories*

Combining the two methods means fast prototyping as well. "We can do more design iterations faster and cheaper than we could before, so we can better optimize designs," said Mark Smith, a Sandia engineer who coordinates the lab's additive manufacturing initiative.

Before they even build a part, PLATO can validate its design to ensure it will function as the engineers hope. For that the Sandia team developed automated meshing functions that help PLATO simulate the complex physical demands on the part, much as finite element analysis software helps validate conventional parts.

"That's where meshing is very powerful. It can handle these very weird shapes," Blacker said.

The engineers have begun building into PLATO ways to alter a material's mesostructure—effectively designing the material itself. They design a part from a multitude of small cubes, each with an internal lattice. By adjusting the thickness of the lattice's supporting members, for instance, they could control an object's stiffness, porosity, density, and heat conductivity.

Sandia engineers are also honing PLATO's process simulation, which determines whether additive manufacturing can actually make a part. In the future, they hope to create parts with a carefully graded mix of two or more materials—for example, one that's ductile and resilient inside with a hard surface, or another that is electrically conductive at one end but insulating at the other, Smith said.

"It's a really important tool in our toolbox," Smith said, "that allows us to do things we couldn't do before." **ME**

DAN FERBER

FEELING IN A SECOND SKIN

Zhenan Bao's team at Stanford developed a two-ply plastic construct that translates electrical imputs into biochemical stimuli compatible with nerve cells. *Photo: Bao Lab*

A team of Stanford University researchers is moving closer to a new goal in the sophistication of prosthetic limbs: To make an artificial limb feel objects and allow a user to react to touch. The team is developing artificial skin made of very thin plastic layers containing a sensor, which detects pressure and delivers an electric signal to neurons.

"We want to communicate information or stimulus in a way the brain can understand," said Alex Chortos, a doctoral candidate in materials science and engineering who is part of a team led by Zhenan Bao, a Stanford professor of chemical engineering.

According to Bao, "This is the first time a flexible, skin-like material has been able to detect pressure and also transmit a signal to a component of the nervous system."

The work involves three components: the sensor, a flexible circuit to transmit a signal, and a neurological recognition of the signal.

The sensor has two thin rubber-based plastic layers. The top layer creates a sensing mechanism based on earlier work by Bao's team that showed how to use the "spring" of the molecular structures of plastics and rubber that compose the sensor. The sensitivity was increased by fabricating the plastic with a waffle pattern, which compresses the plastic's molecular springs even further. The team added billions of carbon nanofibers throughout the plastic to increase pressure sensitivity even more. The nanofibers are pushed closer together during touch, enabling them to conduct electricity.

> **"THERE'S A LONG WAY TO GO TO GET TO FULL FUNCTIONALITY.... TO BE ABLE TO FULLY MIMIC SKIN WE HAVE TO IMPLEMENT A NUMBER OF DIFFERENT SENSORS."**
>
> **ALEX CHORTOS, DOCTORAL CANDIDATE IN MATERIALS SCIENCE AND ENGINEERING**

"The response is very complicated," Chartos said. Human skin transmits pressure information in short electrical pulses, similar to Morse code. As pressure to the sensor changes, electric pulses ebb and flow.

Moving the electric pulses to nerve cells is the next step. To accomplish that, the team worked with colleagues from PARC, a Xerox company, using the firm's inkjet technology to print flexible circuits onto plastic. For sensitive artificial skin to become practical, a large number of sensors must be able to be deposited over a large

continued on p.14 »

HELP WANTED: ASTRONAUTS

NASA is accepting applications for the next class of astronaut candidates.

The agency will accept applications until mid-February. It expects to announce its selection in the middle of 2017.

The recruitment is in preparation for the return of human spaceflight launches to American soil and for a possible mission to Mars. The next class of astronauts may fly on any of four different classes of vessels during their careers: the International Space Station; two commercial crew spacecraft currently in development by U.S. companies; and NASA's Orion deep-space exploration vehicle.

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Astronaut candidates must pass the NASA long-duration spaceflight physical.

More information and application requirements are available online at www.nasa.gov/astronauts.

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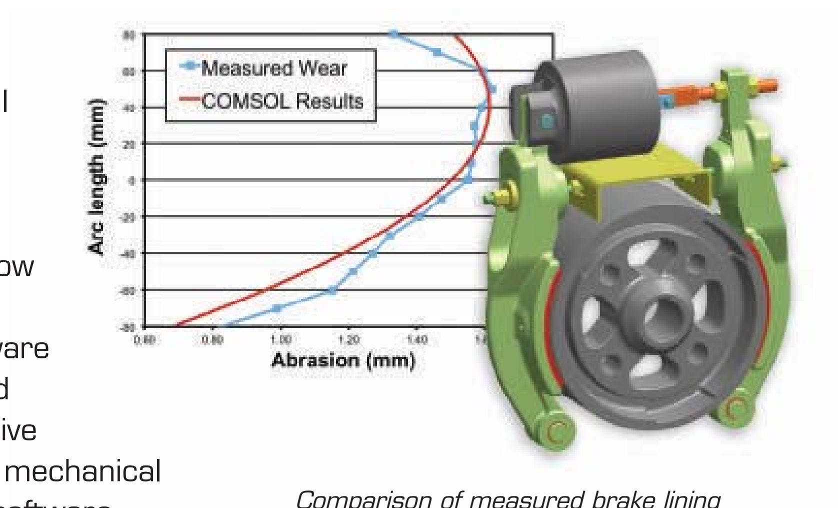

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TEENAGE INVENTOR TO THE RESCUE

One device provides emergency transport; another delivers protective gear to people in danger.

At age 15, Alexis Lewis has designed and patented a bamboo rescue travois, applied for a patent for a pod to deliver safety gear to people caught in burning buildings, and has created designs on paper for a plasma rocket, a shaped charge, and a railgun power source.

The award-winning inventor has advice for other young people and for schools: Inventing should be part of the grade-school curriculum.

Alexis Lewis with her rescue travois.
Photo: Alexis Lewis

When she was 12 years old, Alexis Lewis upgraded the travois, which is a kind of triangular stretcher, a wheelless cart that is traditionally dragged along the ground. She gave her prototype wheels and a lightweight aluminum frame so that it could be shipped or even air dropped to refugee families. The year was 2012 and Lewis figured that Somali refugees escaping the drought and famine in their hometowns could use the machine to carry their kids and belongings on the long trek to the refugee camps.

She designed, prototyped and tested the travois, then sought expert advice for improvements, doing the work that college engineering students 10 years her senior engage in. And she hasn't stopped.

Lewis (formerly Chase Lewis) has fielded advice from three engineers, one of whom is her grandfather, and from global development experts. In 2013, the Rescue Travois won the Spark! Lab Invent It Challenge. It caught the attention of Meg Wirth, CEO of Maternova, a distributor of maternal health technology in developing countries.

"She told me that the Rescue Travois was needed in remote, rural parts of Africa to help the sick and women in delivery distress reach doctors in bigger villages," Lewis said. "Other health professionals who have been in Africa have told me that the travois-on-wheels is needed for this purpose."

Following the principles for design in emerging economies, she swapped out all of the parts of the prototype for materials that can be found locally in sub-

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ARTIFICIAL SKIN

surface, Chartos said.

But the electronic signal still must be recognized by the brain through a biological neuron to complete the chain. Researchers worked with Stanford bioengineering professor Karl Deisseroth's lab to leverage Deisseroth's work in optogenetics, which combines optics and genetics. Cells are bioengineered to make them sensitive to light frequencies. Light pulses can then be used to switch cellular processes on and off.

The team engineered neurons to represent the human nervous system and translated electronic impulses from the artificial skin into light pulses. Those pulses activated the neurons. The work is detailed in a paper published in *Science*.

"There's a long way to go to get to full functionality of skin," Chartos said. "We've demonstrated that a single pressure receptor acts in a certain way. But to be able to fully mimic skin we have to implement a number of different sensors."

The team feels its approach lends itself to adding sensors for other sensations—temperature or texture, for instance—supported by inkjet fabrication to lay down a network of sensors over a plastic layer that would cover a prosthetic hand or arm.

The density of receptors in real skin is very high. Chartos estimates that, right now, researchers could only put down 10 to 20 artificial sensors.

There also are other challenges. "There are other limiting factors for a real prosthetic hand," Chartos said. "For instance, on the biological side, there are a number of peripheral nerves you have to make contact with."

Other methods of stimulating nerves may also be used in future prosthetics. The team has worked with other Stanford professors on direct simulation of neurons with electrical pulses. Last year, a team at Case Western Reserve University in Cleveland developed a system for attaching a prosthetic hand to surgically implanted electrodes in a patient's forearm to allow a user to feel what the fingers were doing.

Also, a new DARPA initiative called the Hand Proprioception and Touch Interfaces Program is working with private companies and universities, including Case Western Reserve, to develop technology to send signals back and forth to the brain. DARPA's goal is to ready an FDA-approved system for testing within four years. **ME**

JOHN KOSOWATZ, ASME.ORG

Saharan Africa. The aluminum struts are now bamboo poles, the parachute cloth platform is now a rope mesh, and the axle is held in place with concrete.

Lewis received a patent for the invention in 2015, as well as a write-up in the U.S. Patent and Trademark Office's *Inventor's Eye* newsletter. In June, the Smithsonian Museum of American History placed a photo of Lewis and the travois in a new exhibit. And the *Smithsonian Magazine* profiled her, her work on the travois, and other projects she's developing. She's now arranging field-testing trials with organizations working in Sub-Saharan Africa.

Lewis's next invention was the Emergency Mask Pod, an American football-shaped container that stores a smoke mask, goggles, and an LED stick.

In a research paper she wrote on the pod, Lewis explains that 40 percent of the 2,500 people who die in fires each year in the United States succumb to smoke inhalation before they can be rescued. The pod is her answer.

"When a first responder arrives at the scene, and sees someone stuck on the second floor, he would tell them to open their window and that he will throw a smoke mask up to them," Lewis said.

Before settling on the football, Lewis tested an interesting set of ideas, from a tennis ball canister shot out of a pneumatic t-shirt cannon to a hand-thrown aerosol "stick grenade" that clears smoke, inspired by the early 20th century German weapon. The football gave the best performance after hours of testing with volunteer firemen.

"The EM Pod would be particularly useful in rural areas supported by fire departments relying 100 percent on volunteers," Lewis said. "In these cases, a civilian firefighter is likely to arrive at the scene of the fire before the fire engine."

Lewis has designs for a portable railgun power source, a plasma rocket, and a shaped charge, none of which she can prototype or test without funds and laboratory access. For those, she is resigned to wait until she is in graduate school, she said. But she believes that inventing should begin in grade school. She laid out her case for Inventing 101 courses in a TEDxUNC talk last year.

For other young people aspiring to make great things, Lewis has this advice: "Making your idea is the easy part, and it's probably the part you are going to like. Once you have a working invention, unless you have astronomically great luck, you will almost certainly have to do a lot of legwork to get it off the ground." ME

ROB GOODIER, ENGINEERINGFORCHANGE.ORG

ONE SIDE IS NO DISCUSSION

If you are a manager, **telling your subordinates your view of the world** is a non-optimal use of your position.

I am finally starting to understand the world around me. Perhaps someone can learn from one of my observations: Literally, it is not a discussion if only one side gets to talk.

One would think, as I did before switching from industry, that decision making in a university would involve intellectual brainstorming, with the best or near-best idea holding sway. Over time, though, I realized that most of my conversations with other faculty, especially with those up the food chain from me, were not conversations, but monologues. Their ideas were solidified well before our interaction (in some cases, years in advance), and it was clear that my attempting to have a fruitful discussion was a waste of time for both of us. I could have probably gone back to my office answered a few e-mails and returned without the speaker's noticing.

As I replay the video in my head of these past interactions, predominantly with managers, I realize that this has happened quite often over my career. And there are a few aspects of this for everyone to consider.

If you are a manager, telling your subordinates your view of the world is a non-optimal use of your position.

Most meetings should in essence be sessions where you and your people consider alternatives to the proposed path forward. Some of these alternative paths could be potentially positive, disruptive, or revolutionary.

If it becomes clear to those who work for you that you are only pursuing your ideas, they stop proposing their ideas to you. In fact, they often sever the flow of much higher-level information.

REGARDLESS OF YOUR POSITION, INSTITUTION, OR INDUSTRY, IT CAN BE ARGUED THAT IT IS THE INFORMATION THAT IS AVAILABLE TO YOU THAT DETERMINES BOTH YOUR PERSONAL SUCCESS AND THE ORGANIZATION'S.

This is not the routine information that employees have to transfer within an organization in order to fulfill the expectations of their employment. Instead, it is many other things, often those less tangible than simply the substandard performance of a product. It can be the mood of the troops, when mass discontent, revolt, or defection is on the horizon. It can be ideas for disruptive technologies for your organization.

Regardless of your position, institution, or industry, it can be argued that it is the information that is available to you that determines both your personal success and the organization's.

As an individual working for a manager or even a ladder of managers whose ideas are not subject to modification or discussion, one has to decide how to act. First, regardless of your level of frustration, you must fulfill the expectations of productivity for your employment.

Second, I actively start avoiding any conversation with the individual and only interact when absolutely necessary. (Continued tilting with the windmill can start a spiral of frustration that rarely has an upside.)

Third, wait it out. There is a saying about poor administrators that goes: "I was here when he arrived; I will be here when he leaves."

If necessary, move on to another situation, either in your current organization or in a new one, because I have seen managers drive subordinates to overt insubordination or even madness with this behavior. ME

RONALD A.L. RORRER, P.E., is the director of motor sports and an associate professor in the department of mechanical engineering at the University of Colorado, Denver.

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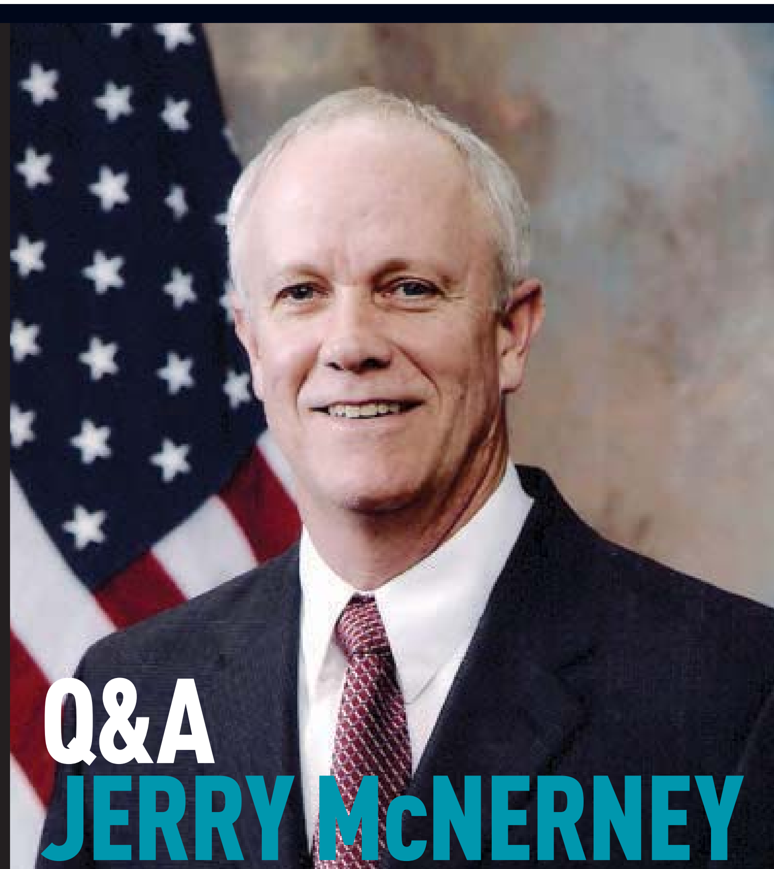

Q&A JERRY McNERNEY

NOT ONLY IS U.S. REPRESENTATIVE JERRY McNERNEY of California one of the few members of Congress with a technical background, he is an ASME Fellow. McNerney earned a Ph.D. in mathematics and has held engineering-related positions at Sandia National Laboratories, U.S. Windpower, and Kenetech, and formed a start-up company to manufacture wind turbines. He is a member of the House Committee on Energy and Commerce, and together with Rep. Renee Ellmers of North Carolina, he has worked to highlight the problem of outdated utility grids and how to update them using smart technology.

ME: What is the biggest issue affecting energy use and development in the U.S.?

J.M: I think energy efficiency is probably the biggest issue. I was looking at some statistics that showed a $1.1 trillion savings through energy efficiency in the next 20 years or so.

Secondly, I think energy storage is very important. We need to develop energy storage and implement it. Then we can create more energy from renewable sources and have it integrated into our system in a very transparent way.

ME: Another issue you've worked on is the electrification of the economy. This is all moving rather quickly and a lot the public doesn't understand it. Do members of Congress?

J.M: There is a general understanding of how important the electric grid is to our economy. I started a bipartisan caucus with Renee Ellmers, a member from North Carolina, called the Grid Innovation Caucus. We have about 20 members. So folks are becoming more and more aware of how important this is.

There's a growing trend for electrification of our power systems and that's going to continue. You see that with electric vehicles. A lot more vehicles will be depending on electricity for their mode of power. We need to make sure that the electric system is reliable. We want to make sure it provides power at low cost so that we can continue to grow our economy.

ME: What can be done on the national level to help utilities meet this challenge?

J.M: There is an opportunity at the national level do something and that is to create legislation to encourage investment and create a stable environment so that investors and utilities can see what's going to happen in the next five to 10 years on the regulatory side. We also need to make sure we have workers that know what to do, and have a diversity of workers, so that we don't leave any particular ethnic group behind.

ME: The workforce is very important and the shortages of kids graduating from U.S. universities with engineering and science degrees is pretty well documented. How do you build on that? Does the visa program for foreign students and foreign workers need to be modified?

J.M: What we need to do in terms of providing for a workforce, our first priority, is make sure we educate our own children. We do that through good education programs, encouraging STEM, reaching out to women and minorities, and so on.

But there's a cultural issue here. Going into STEM means you're going to be working hard through college. There has to be a reason that these young men and women would be motivated to go into that field. Part of it is that you're going to get a good education; part of it is that you're going to get a good job, and part of it is that it's culturally something that's cool to do. We want to make sure that people see that.

The larger immigration issue is very important and needs to have a solution on a bipartisan basis. Certainly, if we're not producing students and technologists to meet the needs of Silicon Valley, or the biotech industry, or the automotive industry, then we will have to make sure we can have students and graduates coming from other countries, but our first priority is to educate our own. ME

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This nanosub has only 244 atoms.

TINY SUB DRIVEN BY LIGHT

The 1960s film *Fantastic Voyage* featured a miniaturized submarine that carried a wetsuit-clad surgical team into a patient's brain. That raised a question: Did the sub's atoms shrink in size, or did some mechanism remove most of them?

A team at Rice University in Houston has found a way to answer that question. Researchers there have built a nanoscale submarine out of just 244 atoms.

The thing is so small that a single turn of its whip-like propeller moves the sub just 18 nanometers—a small fraction of a wavelength of ultraviolet light that makes the propeller spin. But since the propeller is turning at more than a million revolutions per minute, those nanometers add up.

According to the chemist James Tour, whose lab built the nanosub, they are the fastest-moving molecules ever seen in a solution.

Scientists have created microscopic machines with motors over the years, but making these objects move involved the use of toxic chemicals. Tour's lab decided to try out a motor that was developed by a Dutch research group. The motor, which is energized by the application of light instead of chemicals, was synthesized via a multistep chemical reaction. Such motors have been used to propel nanoscale "cars" in laboratory settings.

The motors operate like a bacteria's flagellum and complete each revolution in four steps. When excited by light, the double bond that holds the rotor to the body becomes a single bond, allowing it to rotate a quarter step. As the motor seeks to return to a lower energy state, it jumps adjacent atoms for another quarter turn. The process repeats as long as the light is on.

For comparison tests, the lab also made submersibles with no motors, slow motors, and motors that paddle back and forth. Researchers were able to track the subs via their pontoons, which fluoresce red when struck by laser light.

The developers hope that this sort of research will lead to more complicated nanomachines, including some that could carry medicines to specific cells for precision medical treatments. No word on whether a miniature Raquel Welch will also be developed. ME

FEDERAL BIOFUEL MANDATE UNDER FIRE

Two subcommittees of the House Science, Space, and Technology Committee have held a hearing on the effectiveness of the Renewable Fuel Standard, which sets requirements for introducing liquid biofuels into the automotive fuel supply.

The proceedings, led by Jim Bridenstein of Oklahoma, chairman of the Environment Subcommittee, and by Barry Loudermilk of Georgia, chair of the Oversight Subcommittee, were largely in favor of repealing the standard.

In his opening remarks, Bridenstein said, "The RFS is an example of the federal government picking winners and losers by forcing the use of renewables in transportation fuels." The law that set the current standard, the Energy Independence and Security Act, passed with broad support in 2007 because it promised to yield environmental benefits and support U.S. energy security. But Bridenstein added, "These promises have yet to materialize."

The law was passed in a time of heavy dependence on foreign oil and high gas prices. According to Loudermilk, "Back then gasoline consumption was on the rise, America relied on foreign oil, and renewable fuels were just starting to become an option for consumers. Fast forward to today where the demand for gasoline is decreasing, our country is now considering exporting crude oil, and we now know ethanol and biofuels are not as clean as we once thought."

Terry Dinan, senior advisor at the Congressional Budget Office, presented a CBO study that cast doubts on whether the goals of the Energy Independence and Security Act can be met at all. One of the act's provisions is a schedule for phasing cellulosic biofuel into the fuel stream. Production of cellulosic ethanol is complex and costly, and production levels fall short of the targets set by the law.

Another obstacle is the so-called "blend wall." Blends with more than 10 percent ethanol will damage older vehicles. As demand for gasoline declines, the volume of ethanol sold will decline with it, and increasing the proportion of ethanol is not an option.

Dinan said about 40 percent of the U.S. corn supply is used to produce ethanol, which raises the price of corn-based food. The overall effect on a household food budget would be about 0.1 percent, according to the CBO.

Ed Anderson, chief executive officer of Wen-Gap LLC, which operates 11 Wendy's franchises in Virginia,

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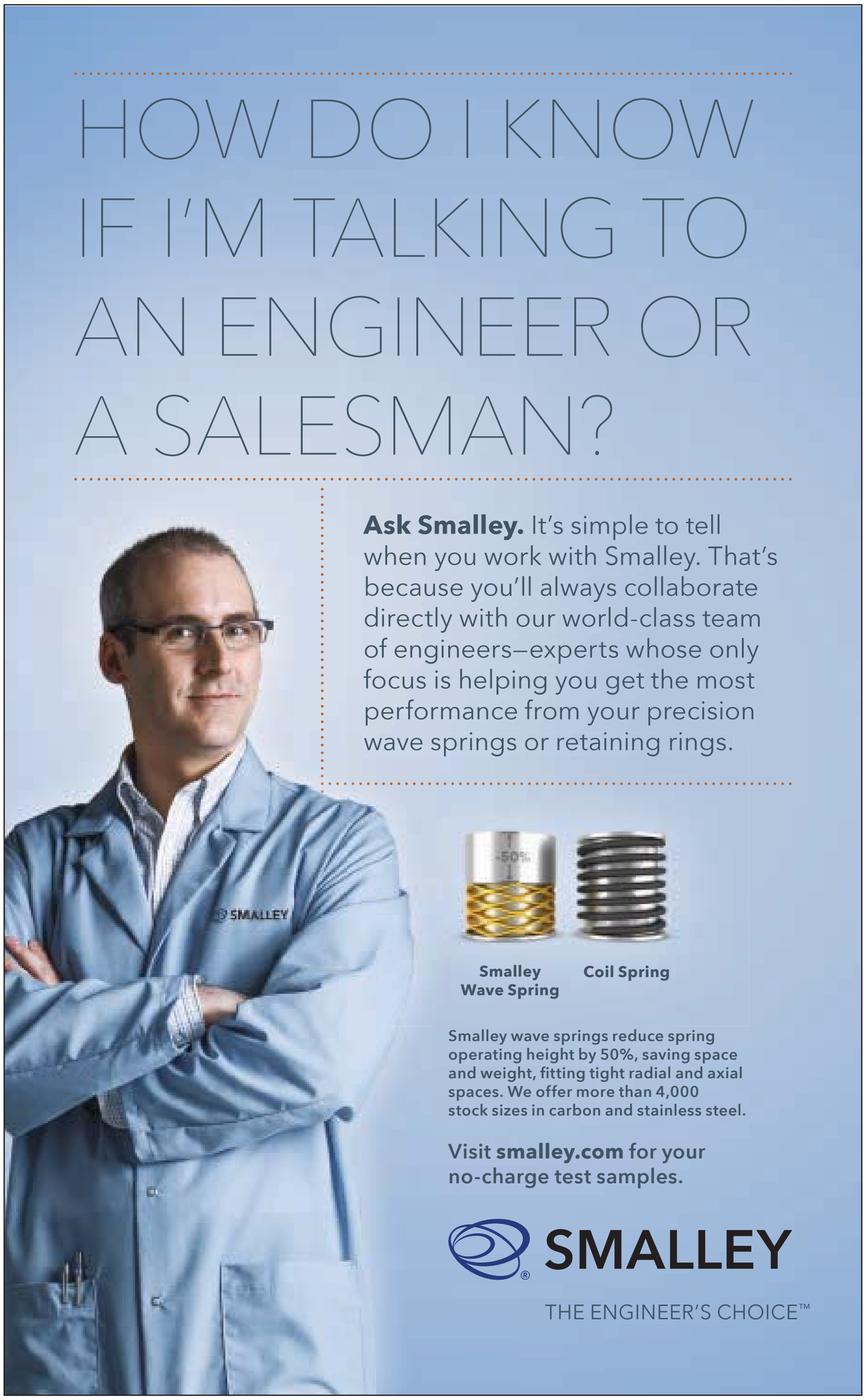

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BIOFUEL: UNDER FIRE

appeared as the representative of the National Council of Chain Restaurants.

"My own analysis," Anderson said, "is that the RFS is costing my small company up to $34,000 more in higher food costs, per restaurant, each and every year. For our family business, that's up to $374,000 a year in additional cost."

John M. DeCicco, research professor at the University of Michigan Energy Institute, challenged the idea that ethanol burned with gasoline reduces carbon dioxide emissions. According to DeCicco, production of ethanol releases more carbon than gasoline refining does, enough that using gasoline containing 10 percent ethanol will put more, not less, carbon into the atmosphere.

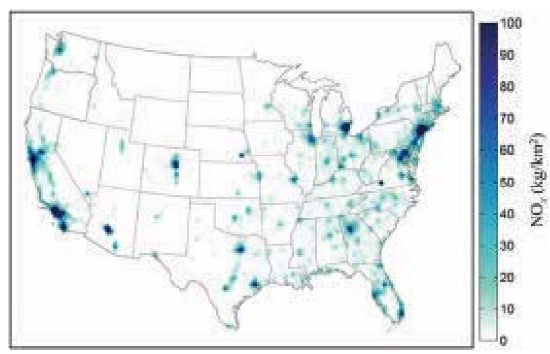
The only voice in support of the fuel standard was Brooke Coleman, executive director of the Advanced Biofuels Business Council, which represents those involved in developing and commercializing advanced and cellulosic biofuels. Coleman argued that the fuel standard is meeting its goals—petroleum conservation, energy independence, greenhouse gas reduction—and should stand.

The U.S. has policies that encourage innovation in biofuels, Coleman said. Besides the Renewable Fuel Standard they include tax credits and allowances, and energy title programs in the farm bill. The policies, however, are not dependable, and are often at risk of expiration, Coleman said. On the other hand, the federal government supports the fossil fuels industry through the tax code, infrastructure, and other policies, and that support is almost always permanent.

Charles Drevna, distinguished senior fellow at the Institute for Energy Research, a think tank that supports free energy markets, said, "The results of the RFS are a failure for America. We have greater energy security today—not because of vast improvements in cellulosic biofuels as envisioned in 2007—but because of much greater domestic oil production coupled with a leveling off of demand. It is time we look at the actual results of the RFS and act accordingly." ME

THE COST OF EMISSIONS CHEATING

It made international news when Volkswagen admitted to installing software in its emissions control systems that would detect when the cars were being tested—and then would produce falsely low readings. These so-called defeat devices were able to mask the fact that for 2-liter light-duty diesel cars in model years 2009 through 2015—the ones first noticed by the U.S. Environmental Protection Agency—the real-world emissions of nitrogen oxides were as much as 40 times as great as EPA limits.



Excess pollution produced by Volkswagen 2-liter diesel engines (below) was concentrated in certain regions.

Given that more than 480,000 vehicles of that sort were sold in the U.S., what sort of effect would that have on air quality? A team of researchers from Harvard University and the Massachusetts Institute of Technology, both in Cambridge, modeled the impact by running two VW diesels—a 2012 Jetta and a 2013 Passat—through their paces under different sorts of driving conditions and measured their real-world emissions. They then determined the difference between the actual emissions and the EPA goals for each kind of road, then calculated where those extra emissions would be distributed.

The extra pollution in the U.S. is found in the Northeast and California, as would be expected, but there are also pockets around Detroit and Phoenix that are also very high.

The team, led by Steven R.H. Barrett, a mechanical engineer who is the director of the Laboratory for Aviation and the Environment at MIT, also calculated that exposure to the excess pollution, especially particulates and ozone, is already responsible for 59 early deaths due to respiratory illness, and has caused $450 million in damages. Unless the cars are recalled and the emissions problem fixed, the ongoing impact of the defeat devices would run to an estimated 140 early deaths and between $140 million and $2.5 billion in costs.

Subsequent reports suggest that many more vehicles with Volkswagen engines than at first suspected were equipped with defeat devices, meaning the pollution was even greater.

The Harvard-MIT paper was published on October 29 in the journal *Environmental Research Letters*. ME

QUANTUM DOTS MAKE A BETTER BATTERY

Lithium ion batteries are found in just about every cellphone, laptop, and hybrid-electric vehicle on the planet. But all those batteries are limited by the pace at which they can be recharged. Engineers have known for some time that adding nanoscale crystals called quantum dots to the battery will enable the batteries to recharge much more rapidly, but the improvement lasts for only a few recharge cycles.

Iron pyrite, also known as fool's gold, the most common of the sulfide minerals.

Recently a group of mechanical engineers at Vanderbilt University in Nashville, Tenn., reported a breakthrough. Using quantum dots made from iron pyrite—the mineral also known as fool's gold—the researchers were able to increase the recharge performance of a lithium ion battery by around a factor of ten. That isn't enough to make a commercially viable rechargeable battery, but it points toward a promising path for research.

Assistant professor of mechanical engineering Cary Pint and graduate student Anna Douglas started looking at iron pyrite because it is one of the most common minerals and is already used in single-discharge lithium ion batteries. And they are proven to be charging boosters: a lithium ion cellphone battery containing iron pyrite quantum dots will fully recharge in about 30 seconds.

"Researchers have demonstrated that nanoscale materials can significantly improve batteries, but there is a limit," Pint was quoted in a Vanderbilt press release. "When the particles get very small, generally meaning below 10 nanometers (40 to 50 atoms wide), the nanoparticles begin to chemically react with the electrolytes and so can only charge and discharge a few times."

Pint worked with Douglas, who had experience synthesizing nanoparticles, to see what would happen if they used very small particles. They added iron pyrite quantum dots of various sizes to standard lithium ion button-type batteries (such as those used to power watches) and tested them to see if one size of dot was more durable than the others. It turned out that quantum dots that were about 4.5 nanometers across showed a marked improvement, with both a better recharge rate and cycling durability.

The researchers believe that these quantum dots are small enough that when the lithium or sulfur ions in the battery react with the nanoparticles, the iron within the pyrite can migrate to the surface of the dot. The movement of the iron enables a faster and more durable recharge.

Pint believes that understanding the chemical storage mechanism and how it behaves at nanoscale dimensions is critical to developing batteries that can support the transition to electric vehicles.

"The batteries of tomorrow that can charge in seconds and discharge in days will not just use nanotechnology; they will benefit from the development of new tools that will allow us to design nanostructures that can stand up to tens of thousands of cycles and possess energy storage capacities rivaling that of gasoline," Pint said. "Our research is a major step in this direction." ME

MOTORS, BIG AND SMALL

VEHICLE MOTORS HAVE COME A LONG WAY since the Model T. Our increased knowledge about combustion has led to more powerful and efficient engines and advanced ignition technologies, fuels, and pollution controls. Engines are also getting much smaller—in fact, down to the nanoscale, where they are built from molecular parts like amino acids and have hundreds of potential applications in medicine and other fields. This month we touch base with two university labs that are doing groundbreaking research on motors—both large and small.

Former graduate student Bethany Sparn checking out instrumentation on a John Deere diesel engine installed at the Engines and Energy Conversion Laboratory. In the background is a 16-cylinder, 2,300 hp Caterpillar 3516C natural gas engine. *Photo: Dan Bihn*

Engines that run on natural gas promise better efficiency and lower emissions, and the Engines and Energy Conversion Laboratory at Colorado State University is researching ways to meet that promise.

For instance, the lab has pioneered high-pressure fuel-injection technology for large natural gas engines, such as those used in the natural gas pipelines. The system improves fuel and air mixing to increase fuel efficiency and reduce emissions. According to Anthony Marchese, the lab's director, "The technology has now been commercialized by multiple companies and today is responsible for preventing 100 million pounds of nitrogen oxide pollution and has saved over 2.5 billion cubic feet of natural gas."

EECL has recently developed an exhaust after-treatment three-way catalyst system that simultaneously reduces NO_x, HC, and CO. The three-way catalyst research has focused on stationary natural gas engines used primarily for power generation and gas compression. These engines must maintain emissions compliance for 24/7 operation, which is one requirement that distinguishes them from automotive systems. An innovative feature of the EECL technology is development of a control algorithm that uses a post catalyst NO_x sensor to maintain

GAS POWER

THE LAB Engines and Energy Conversion Laboratory, Colorado State University in Fort Collins; Anthony Marchese, director.

OBJECTIVE To create innovative energy solutions and entrepreneurial models that benefit the human condition and achieve global impact.

DEVELOPMENT Emissions reduction systems for large engines, improved dual-fuel diesel engine technology.

optimal engine equivalence ratio.

"A single NO_x sensor responds to both NO_x and ammonia, which is a key enabling technology for this system," said EECL co-director Daniel Olsen.

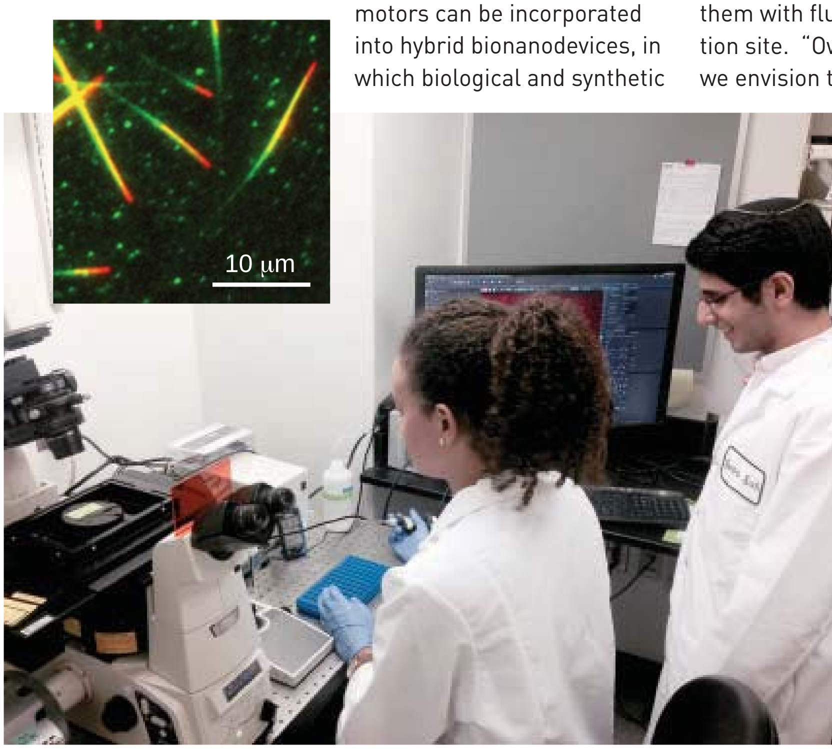
The lab is also involved in developing new sources of gaseous fuels, including both synthetic natural gas and biomass derivatives.

Ongoing research explores the use of alternative gaseous fuels in dual-fuel diesel engines. The challenge with dual-fuel engines, which run on both natural gas and diesel fuel simultaneously, is increasing the substitution rate of natural gas to the highest amount possible (to minimize cost to the user), while still delivering the needed torque and power.

"Over the past five years, we have found creative ways to maximize natural gas substitution," Marchese said. "Also, in doing this research, we have discovered a new mode of engine knock that occurs in dual-fuel engines and developed ways to avoid it." ME

Henry Hess, (pictured, right) director of the Laboratory for Nanobiotechnology and Synthetic Biology at Columbia University, often turns to the natural world for inspiration. For example, nature provides sophisticated nanomotors in the form of motor proteins that actively control the delivery and assembly of materials within cells, and generate large forces by acting in arrays—such as in muscles.

Hess and his colleagues have successfully developed "molecular shuttles" that use motor proteins to transport nanoscale cargo. Motor proteins are molecules that can convert the chemical energy released from the hydrolysis of adenosine triphosphate, or ATP, directly into useful mechanical work. These motors can be incorporated into hybrid bionanodevices, in which biological and synthetic materials are synergistically combined.



Graduate student Megan Armstrong and undergraduate researcher David Verdi using a fluorescence microscope to observe protein motors in action.

MINI MOTOR

THE LAB Laboratory for Nanobiotechnology and Synthetic Biology, Columbia University in New York City; Henry Hess, director.

OBJECTIVE To develop a broad range of engineering applications for nanoscale motors, including biosensing, drug delivery, molecular assembly, and active materials.

DEVELOPMENT Nanoscale actuators for molecular motors.

The research team recently built and successfully operated a hybrid microdevice that is powered by ATP and relies on protein motors to capture target analytes from an aqueous solution, tag them with fluorescent particles, and deliver them to a detection site. "Owing to their small size and autonomous function, we envision that large numbers of these biosensors can be inserted into organisms or distributed into the environment for remote sensing," Hess said.

The hybrid lets techniques, materials, and devices unique to biology or technology merge into a novel combination. Applications particularly suited to hybrid systems are found in medicine and biotechnology, where biocompatibility is critical and the environmental conditions are favorable for biological nanomachines.

"We can dynamically assemble hundreds of molecular motors into teams to transport a larger structure, similar to the way ants come together to carry a large piece of food," Hess said. "This ability allows engineers to envision applications, such as adaptive materials, where huge numbers of these tiny motors are required. To be successful, however, these nanomotors must have energy conversion efficiencies comparable with large engines." ME

MARK CRAWFORD is a geologist and independent writer in Madison, Wis.

THE VITAL NEED FOR GREATER FINANCIAL SUPPORT TO PURE-SCIENCE RESEARCH

BY HERBERT HOOVER, SECRETARY OF COMMERCE

Three years before he was elected president of the United States, Herbert Hoover delivered the first Henry Robinson Towne Lecture at ASME's winter annual meeting in December. The text of his speech was published in Mechanical Engineering *a month later.*

LOOKING BACK

The issue of funding basic research was a topic of discussion for the Secretary of Commerce 90 years ago in January 1926.

Research in the biological and physical sciences takes two forms, industrial research (which is the application of science) and research in pure science. Obviously there must first be a pure science before there can be an application. I am aware that there is a twilight zone between them, but no scientist has difficulty in finding the borders.

While we have in recent years developed our industrial research upon a scale hitherto unparalleled in history, we have by no means kept pace in the development of research in pure science. We have an increase in some ten years from 100 to over 500 laboratories engaged upon search for applications of known scientific fact and law. These results have been magnificent. But all these applied-science laboratories are dependent upon the raw material which flows from the laboratories and men engaged in pure science. ...

Compared with other expenditures of far less importance to human welfare, the amount of money annually devoted in the United States to the aid of investigators and investigation in pure science is absurdly small. It is less than one-tenth what we spend on cosmetics. We have indeed some fine foundations for pure scientific research. The Carnegie Institution, the Smithsonian Institution, the Rockefeller Institute, and the many other research activities of much more limited but special endowments, the work of our universities, together with the work of the National Research Council and our government agencies, have shown fine accomplishment in this field. But the whole of the income available from these sources for research in pure science certainly does not exceed $10,000,000 a year, whereas in the professional schools of our universities, in technical and agricultural colleges and experiment stations, in industrial laboratories, and in our government bureaus we probably expend today $200,000,000 a year upon applied-science research.

The wealth of the country has multiplied far faster than the funds we have given for these pure-science purposes. And the funds administered in the nation today for it are but a triviality compared to the vast resources that a single discovery places in our hands. Men of science know from their own experience how seriously scientific work has been impeded by lack of resources, and they will appreciate how great, in the aggregate, must be the resulting loss to the nation and to the world. ME

DOLLARS FOR SCIENCE

As the text of Hoover's lecture appeared in this magazine, the journal *Science* ran a notice in its Jan. 1 issue that the National Academy of Sciences was leading an effort "to secure larger resources for research in pure science" through research professorships and other support for colleges and universities. Known as the National Research Endowment, the effort brought together representatives of foundations and other public figures. They included Albert Michelson, president of the National Academy, and John Merriam, president of the Carnegie Institution of Washington. Herbert Hoover chaired the new initiative's board of trustees.

Hoover: Pure science shortchanged.

WIDE GAP IN TRANS-ATLANTIC FLIGHT EFFICIENCY

Commercial aircraft are an underappreciated source of carbon dioxide emissions, and one that is difficult to account for. Should the emissions on international flights be charged to the country of the carrier? The destination or origination points? To the nationality of the passengers themselves?

The International Civil Aviation Organization has been grappling with that issue, and with developing market-based measures for controlling CO_2 emissions from commercial aircraft, but disagreements over how to equitably distribute reduction targets by country or carrier have led to a stalemate.

Anyway you assign it, a recent report by the International Council on Clean Transportation, an independent nonprofit research organization, signals trouble while it also offers hope.

Looking at the carbon intensity of trans-Atlantic flights by 20 major carriers, the council found that the gap between the most and least efficient was 51 percent. That is, while Norwegian Air Shuttle is able to squeeze 40 passenger kilometers traveled per liter of fuel (about 94 passenger miles per gallon), British Airways can get only 27 passenger kilometers traveled.

The ICCT points out that the three least fuel-efficient airlines in the study—United, Lufthansa, and BA—together accounted for about one-fifth of the available seats on trans-Atlantic flights. That means their inefficiency is producing a lot of extra pollution and greenhouse gases.

On the other hand, the report suggests that the wide range of fuel use per passenger is an opportunity. Bringing the least efficient airlines up to the standard of the most efficient would cut down on the more than 700 million tons of CO_2 emitted by airlines each year.

The ICCT found two major factors drove down the efficiency of the lowest-rated airlines. First, airlines that predominantly flew older planes were less efficient than those which had invested in new, more advanced planes, such as the Boeing 787-8. Newer aircraft feature engines and other technologies designed to cut the rate of fuel use. When other airlines switch over to newer planes, they should see an increase in efficiency.

But the type of service is also a factor, and one that might be harder to change. Premium seating, such as those in first and business classes, accounted for only 14 percent of available seat kilometers flown on trans-Atlantic routes but produced around one-third of total carbon emissions. "For carriers such as British Airways and Swiss," the report stated, "premium seating was responsible for almost one-half of their total emissions from passenger travel."

Unfortunately, those premium seats are also the most profitable for the airlines.

Seating configuration, the report found, accounted for 46 percent of the variation in airline fuel efficiency, with aircraft fuel burn rate coming in second at 35 percent. But while burn rate is subject to technological fixes, changing the seating configuration will require talking the high rollers into sitting in economy-sized seats for eight or more hours at a time. The ICCT had no recommendations for how to accomplish that. ME

NEWER AIRCRAFT [SUCH AS THE BOEING 787-8] FEATURE ENGINES AND OTHER TECHNOLOGIES DESIGNED TO CUT THE RATE OF FUEL USE.

BY THE NUMBERS: TAKING THE PLUNGE

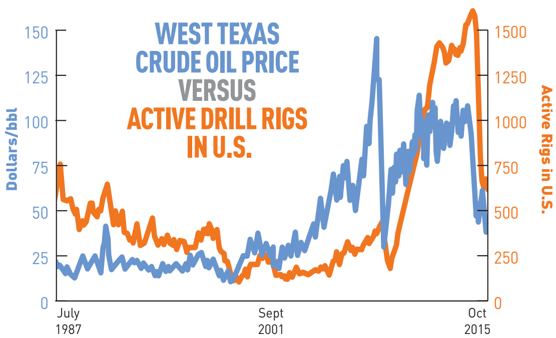
ROCK-BOTTOM OIL PRICES HAVE SLOWED DOWN THE U.S. DRILLING BOOM.

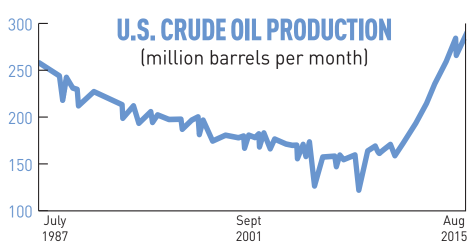
When North Dakota's underlying shale formations became a leading U.S. source for oil production, the inrushing workers were left living in old recreational vehicles and prefabricated "man camps." Buying into talk of a decades-long oil boom, home builders started slapping up luxury apartments and homes.

Now those half-finished structures look to be largely vacant when they are completed. The oil drilling boom in North Dakota and elsewhere suddenly has gone bust.

The petroleum has always had troubles with cycles of high prices leading to oversupply and inevitably to underinvestment in new wells. The oil crises of the 1970s illustrate this perfectly: In April 1973, there were about 1,000 rotary rigs operating in the U.S., according to Energy Information Administration data. But after a series of price and supply shocks, domestic oil companies sought resources close to home and by the end of 1981, there were more than 4,200 oil and gas drilling rigs at work onshore in the U.S. But when oil prices collapsed in the late 1980s, so did oil drilling, and the number of rigs bounced along between 400 and 1,000 for more than 15 years.

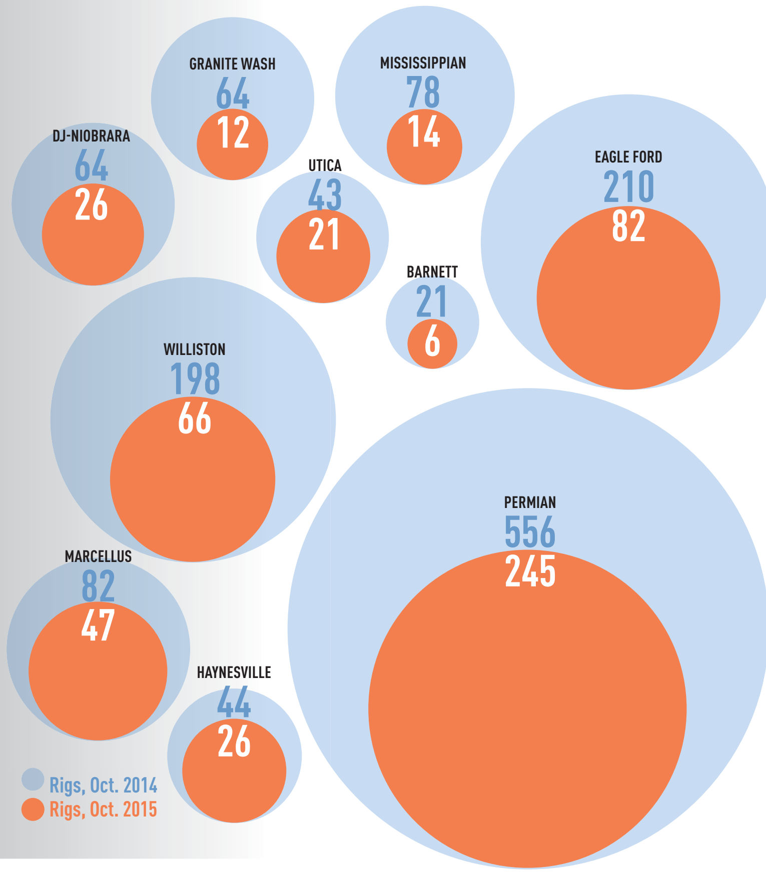
Starting in 2002, oil drilling began a long, steady drive upward, spurred on by production techniques able to get at oil locked in tight reservoirs. Aside from a slowdown in the aftermath of the global financial crisis of 2008, there had been more than 1,500 oil and gas rigs in operation since 2006, and





THE BOOM GOES BUST, FOR NOW

Oil drilling activity in the U.S. is sensitive to the price of crude oil, though there is a lag of several months between oil price crashes and oil field slowdowns. In 2015, many of the production basins in the U.S. have seen oil and gas drilling cut by half or more (below). Even with less drilling, U.S. oil production has remained at near-record levels.



U.S. oil production had reached levels not seen in 45 years.

Thanks to a determination on the part of Saudi Arabia and other oil exporters to keep their production levels high in the face of a growing glut, the price of crude oil has dropped precipitously since the middle of 2014. And U.S. drillers responded almost immediately by cutting back on drilling new wells. According to data from Baker Hughes, the oil services company, the number of oil rigs in operation dropped from 1,550 in early October 2014 to 590 just one year later. (Gas drilling has seen a similar, but smaller, plunge.)

The bust is most keenly felt in the Eagle Ford and Permian basins in Texas, and the Williston Basin, home of the Bakken Formation in North Dakota, where the rig count has gone from 198 to 66.

Drilling tends to grow slowly and stop suddenly, so even after the prices start climbing again it will be a while before workers start swarming the shale fields. At least the housing will be there when they return. ME

JEFFREY WINTERS

HOUSING

Privately owned housing starts authorized by building permits: 1-unit structures for North Dakota

Source: Federal Reserve Bank of St. Louis

Unfinished apartment complex in Watford City, North Dakota.

F30

All-Out LEAN

HALF MEASURES GET LESS THAN HALF RESULTS.

By Gary Cowger

Many people have campaigned incessantly about the advantages of lean manufacturing. Now, thanks to a 2013 U.S. Bureau of Census survey, we have some objective data to back up our enthusiasm.

Census surveyed 30,000 manufacturing facilities about a subset of lean-related practices, including performance monitoring, target setting, and management incentives. The leaner the company, the faster it grew and the more profitable, productive, and innovative it became.

The top 10 percent of lean implementers outperformed the bottom 10 percent by 12 percent in value added per employee, 9 percent in productivity, 6 percent in employment, and 2 percent in profitability per sale. This held true even after accounting for factory age, industry, and employee education.

A similar survey of 300 British manufacturers found that leaner companies were 17 percent less energy intensive.

I believe these numbers are wrong.

Based on my career at General Motors, I think they are too conservative. Far too conservative.

SYSTEMS FOR BIG IMPROVEMENTS

Census measured only a small subset of lean practices. Companies that fully implement complete lean *systems* do much better. Lean systems enabled U.S. automakers to raise the time line workers spend doing value-added tasks—mounting a part, tightening a bolt, doing something related to assembly—above 90 percent, up from 15 to 30 percent in the 1970s.

Other companies achieved similar results. GE Appliances, now part of Electrolux, used lean practices to reduce the time needed to assemble refrigerators to roughly 2 hours per unit, from the U.S. average of 9 to 10 hours. Lean practices were a key factor in returning refrigerator manufacturing to the United States, from South Korea.

Toyota created lean manufacturing as we know it. James Bonini, who works for Toyota, showed other companies how to make their facilities lean. In a recent National Academy of Engineering report, *Making Value for America: Embracing the Future of Manufacturing, Technology, and Work,* he argued that many companies do not believe they can reduce U.S. operating costs even 10 percent. Bonini found companies where he implemented lean systems slashed costs by 40 or 50 percent.

These are powerful competitive advantages. And since lean is an ongoing process, they are sustainable. The Census Bureau found that just 18 percent of factories had adopted 75 percent or more of the lean practices mentioned in the survey, *Management in America*. Another 27 percent of factories had adopted fewer than half of them.

I don't think those numbers are accurate, either.

My own experience is that many managers confuse lean practices with lean systems. Practices do not become systems until they work together to produce synergistic results.

So, what is a lean system? It is a constellation of interrelated processes that improves productivity and reduces waste through continuous monitoring, evaluation, and improvement. It gives front-line workers, the people nearest to the work, the tools to spot waste and quality problems and address them. Each practice reinforces the others, and together they make dramatic cost reductions possible.

One example is the Andon cord, which assembly workers pull to stop the line so they can address a defect before it leaves the station.

But what if that factory has a truckload of defective parts in inventory? What if workers have to wait until a supervisor or engineer shows up to take action?

To function properly, Andon requires small teams of trained workers with the tools to solve problems on the spot. It demands single-part flow, so factories do not make large batches of bad parts. It relies on vendors who use similar systems to prevent defective parts from shipping. Andon works best when it is part of a larger system.

Viewing lean as a mix-and-match collection of practices rather than an interlocking system should be a red flag for anyone who cares about U.S. manufacturing. This misunderstanding keeps U.S. factories from making better products at lower costs, and encourages companies to look abroad when they could meet their financial goals at home.

> VIEWING LEAN AS A **MIX-AND-MATCH** COLLECTION OF PRACTICES RATHER THAN **AN INTERLOCKING SYSTEM** SHOULD BE A **RED FLAG** FOR ANYONE WHO CARES ABOUT **U.S. MANUFACTURING**.

It also leaves U.S. manufacturers vulnerable to overseas competitors. In emerging nations, managers and workers do not carry decades of mass production practices and mindsets. These people are adapting lean practices to build sustainable competitive advantages that go beyond low wages and artificially depressed currency. They are smart and hard-working, and they want to win.

WHAT'S TAKING SO LONG?

It has been 25 years since James Womack, Daniel Jones, and Daniel Roos of the Massachusetts Institute of Technology's International Motor Vehicle Program published *The Machine That Changed the World,* which introduced Toyota's lean manufacturing processes to a broad audience. Why is it taking so long for manufacturers, especially small and medium-size enterprises, to get the message?

One reason may be confusion. Everybody seems to have a different definition of lean. A Google search for "lean manufacturing" generates more than 8 million hits. Ask for a definition and you will get 800,000 pages.

There are so many experts, consultants, courses, books, online training programs, and software packages. It takes a lot of time to unravel all the claims and decide what to implement. This is a real burden for smaller firms that do not have the people, time, and resources to throw at the problem.

Moreover, lean brings out the skepticism in many engineers and owners of small and medium-size businesses. They got where they are by knowing what works. It takes a lot to convince them to invest the time and money needed to transform even a modest factory into a lean operation.

Many question the rewards they will reap for their effort. Often, their suspicion is justified. Not every company has had a great experience going lean. Projects may fall short of goals. I won't say lean overpromises because 40 and 50 percent cost reductions are possible, but partial implementations will not get us there.

It takes a real commitment to make lean happen. I know this from first-hand experience. It took GM, and me personally, a long time to get it. But once we did, the results were striking.

I started hanging doors on a GM line as a co-op student at General Motors Institute (now Kettering University) in 1965. There was little automation, no assist devices, and little regard for noise or ergonomics. The factory produced an industry standard 220,000 cars annually and employed more than 5,000 people. There were 120 classifications for workers, and, as I already mentioned, the average worker spent only 15 to 30 percent of his time doing value-added work. We spent the rest of our time reading manifests, searching for parts, walking between stations, adjusting for variations in parts, and the like.

Today, my old plant still produces 220,000 cars. It has expanded to include a large, labor-intensive stamping facility, yet it employs only 3,200 men and women working in flexible teams. They spend more than 90 percent of their time doing value-added work, and take less than half the hours to build each car.

CAFE AND THE DEFECT CHALLENGE

The changes began in 1975, when the federal government enacted Corporate Average Fuel Economy mileage standards for domestic cars to cope with rising gasoline prices. To meet those targets, U.S. automakers had to slash vehicle weight.

That meant changing how we built cars. At the time, we used a technique called body-on-frame: We con-

A Cadillac ATS sedan on the assembly line at GM's Lansing Grand River Assembly plant in Michigan.

structed a chassis frame and set a welded body of underpan, rear compartment pan, and front end sheet metal onto it. Body-on-frame is very forgiving. If a part was off a few millimeters, a skilled assembler could push and shove to fit.

To shave weight to meet CAFE standards, we switched to a front body integral design, which integrates the body and frame into one unit. It had none of body-on-frame's give and take. We needed tighter tolerances. GM invested in new machinery and robots to achieve them.

We soon realized that our investment in technology was not paying off as well as it should. We had moved to robots, but we were still making and assembling parts as if we were building cars manually.

Our workers, for example, used welding guns up to 8 feet long. This limited their range of motion. Instead of changing our assembly process to take advantage of robots' speed, reach, strength, and precision, we simply replaced people with robots.

The parts we fed those robots had the same type of variations our workers had learned to work around. So we added skilled tradesmen—lots of them—to adjust the robots to those variations. As a result, productivity took a double hit: too much downtime and too many people.

This was in the 1980s, and we could not help looking at our Japanese competitors. They were impressive. Our factories were surrounded by yards of cars that needed defects fixed before we could ship them. Japanese factories had hardly any cars in final repair.

Clearly, they were building cars without defects, but how?

This was our introduction to lean. W. Edwards Deming, the father of statistical quality control, once said that you can walk through all the factories in the world, but unless you have a profound knowledge of the philosophy behind them, you won't make sense of what you see.

That was us. We saw lean practices, but not how they fit together as a system.

IT TAKES **A REAL COMMITMENT** TO MAKE LEAN HAPPEN. I KNOW THIS FROM **FIRST-HAND EXPERIENCE**. IT TOOK GM, AND ME PERSONALLY, A LONG TIME TO GET IT. BUT ONCE WE DID, **THE RESULTS WERE STRIKING**.

WE PUT **DESIGN ENGINEERS** ON THE FACTORY FLOOR, SO THEY COULD **ASSEMBLE THE PARTS** THEY DESIGNED. ... IT WAS SIMPLY AMAZING HOW MANY **DESIGN CHANGES WE SAW** IN THE WEEKS THAT FOLLOWED.

STARTING WITH DESIGN

Still, one lean lesson we learned was that productivity and efficiency start with design. In our system, engineers designed parts and threw them over the wall. Fabricators made those parts, and if they didn't hit specifications perfectly, the workers could make the necessary adjustments. We assumed this was the natural order of things.

Still, even though design accounts for just 5 percent of a part's lifecycle cost, it determines 75 to 85 percent of total costs. We had to stop building cost into our designs and begin integrating them with factory workflow, processes, and our new robots.

We changed how we designed parts. We invested in CAD/CAM and design for manufacturing and assembly software. We optimized designs for our machines and made parts simpler and easier to assemble. We redesigned body assemblies to take advantage of our robots' capabilities.

At Cadillac in 1988, we put design engineers on the factory floor, so they could assemble the parts they designed. We called them "Blue Jeans Days." It was simply amazing how many design changes we saw in the weeks that followed.

GM went back to school. In 1984, GM and Toyota opened a joint venture, the New United Motor Manufacturing Inc. plant in Fremont, Calif., to make cars. Through this venture, GM truly learned the principles underlying lean. In fact, the very word "lean" was coined by John Krafcik, a NUMMI quality engineer, in a 1988 article in MIT's *Sloan Management Review*.

At NUMMI, we saw how lean systems made operations more productive by exposing defects so we could correct them.

This is what makes Andon so powerful. Stopping the line when there is an issue makes problems visible. But it works only within a system where employees are trained to identify and respond to defects and managers support stopping a line to eliminate defects, even if it upsets production schedules initially. We also needed a better way to make and manage parts, so we caught problems early, before we built up inventories of defective goods. .

We also learned why small teams are important. I admit that I was a skeptic initially. Small teams at NUMMI had extra workers, and I thought we were wasting money on labor. When I looked closer, I noticed that when each worker understood the others' jobs, they could adjust to everyday workflow variations and jump in and deal with Andon problems on the spot.

I also saw an unanticipated benefit. Small teams bonded, and no one wanted to let their teammates down by not showing up. We had fewer absences. When someone was out, a trained teammate stepped in. We rarely had to shift untrained workers to new tasks and teach them the job on the fly.

It took years to get it, and even longer to implement. At first, we sent NUMMI managers to other GM plants. But one or two people, by themselves, were not enough to create changes.

Our new truck plant in Silao, Mexico, proved a turning point. The workers knew little about old-style mass production. If we said lean was the best system, they bought into it very quickly and the plant performed outstandingly. Then we replicated our success at our new Grand

Lessons learned from NUMMI have been applied to all GM plants including Silao, Mexico, which produces full-size trucks.

NUMMI plant in Fremont, a joint venture between General Motors and Toyota, with Mission Peak behind it.
Photo: Ellen Levy Finch

River plant in Michigan.

By the late 1990s, GM plant managers saw what we were doing at Silao and Grand River, and wanted to learn more. Instead of sending one or two NUMMI grads to their plants, we sent entire teams. Together, they had the critical mass to turn things around.

We began looking harder at first-time quality, the number of cars that did not need final repair. When plants did not meet their targets, we would send in lean teams to help. In many cases, the problem was not in the plant but in a vendor, so we worked with our vendors.

Our managers had spent years developing ways to work around manufacturing problems. Lean made those issues visible and challenged managers to solve them. It took time, but as managers saw our successes, they began to buy in.

NO STANDING STILL

By 2003, GM had cut the hours needed to make a car or truck in many plants by nearly half. Because GM and its peers continuously monitor performance, evaluate processes, and improve operations, our factories are even more flexible and productive today. Lean has the potential to continue to reduce costs every year, year after year.

Many small and medium-size enterprises now face a landscape similar to the one I surveyed three decades ago. Offshore competitors that once needed low wages, depressed currencies, and government support to succeed now compete with the best. They learn and implement new ideas as fast as you. Some are just as innovative.

Small and medium-size companies cannot afford to stand still. Lean systems could provide sustainable advantages, but only for companies willing to commit.

Having managed a giant manufacturer, I know I can offer only a limited amount of advice to smaller companies. Still, let me make some suggestions.

First, lean is not just for big companies. Even small job shops with 10 workstations can ask fundamental questions about waste and productivity: Does everyone have the right tools? Do they follow the best processes? Are some layouts better than others? How much time is spent on productive labor? Where are the quality issues? Lean addresses waste and productivity, even in the smallest factories.

Second, lean is a journey. It took Toyota decades to develop its system. We looked over Toyota's shoulders at NUMMI, and it took us more than a decade. No one goes lean in a few months. It will take years.

Third, you are going to have your pick of many first-rate consultants and software firms. Ask them about philosophy and strategy. Verify their results. Pick partners you will want to live with.

Fourth, pick partners that take a systems approach. Look for practices that reinforce one another. After all, why disrupt your plant for incremental advances?

Fifth, expect roles to change. Workers are going to have to take more responsibility for outcomes, and managers are going to have to treat workers like partners. This might unsettle established practices.

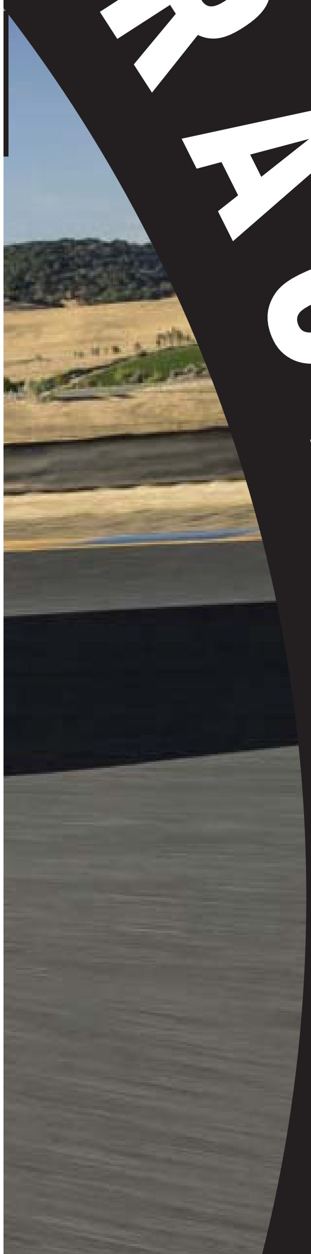
And, finally, remember that lean is not a flavor of the month or an end-point. It is a philosophy of continuous improvement. Learning how to expose and fix problems creates sustainable advantages that will continue for years to come. **ME**

GARY COWGER is professor of engineering practice at the University of Michigan and chairman of GLC Ventures, a management consultancy. He is a former president of General Motors North America and group vice president of General Motors Global Manufacturing and Labor Relations. He is the 2010 winner of ASME's M. Eugene Merchant Manufacturing Medal.

OFF TO THE

Who better to teach cars how to drive themselves than the professionals who race for a living?

HANDS FREE
Robby, an Audi RS7, is based on Stanford University research that applied the skills of race car drivers to computer-driven vehicles. It took only 2:01 minutes to complete the 2.5 mile Sonoma Raceway circuit.
Photo: Audi

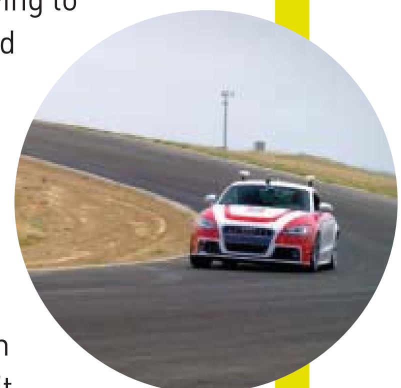


RACES

BY DAN FERBER

ON A FALL MORNING AT CALIFORNIA'S THUNDERHILL RACEWAY, David Vodden dons a white helmet and racing suit, straps into the driver's seat of an Audi TT sports car, revs his engine, and tears across the starting line.

Vodden, a longtime amateur racer who also happens to run the race track, roars around the curves, taking them on the inside again and again, trying to slice off some distance and outpace his opponent. But his opponent is relentless, almost robotic, in its tactics. On the long straightaway approaching the final turn, his opponent, also an Audi TT, tops 110 mph as it takes a commanding lead—which it holds through the final turn to the finish.



Just like that, Vodden became the first driver in history to lose a race to a car without a driver.

There was no shame in Vodden's loss. In fact, it was an engineering milestone. And in reality, the Audis racing each other were one and the same car. Their race was virtual, with animations of two runs superimposed on one another. After overcoming one engineering hurdle after another, the self-driving sports car, named Shelley, could finally keep up with a skilled amateur racer.

Despite its newfound racing prowess, the autonomous Audi, which was built by Stanford mechanical engineering professor Chris Gerdes, was not designed to win races at Le Mans, or even at Thunderhill Raceway, a curvy three-mile road course north of Sacramento. In designing Shelley, Gerdes and like-minded colleagues aimed instead for autonomous cars that can navigate traffic jams and make quick maneuvers to avoid accidents.

"The goal in my lab is to design self-driving cars

90% OF AUTO CRASHES *INVOLVE DRIVER ERROR, A FEDERAL STUDY SAYS.*

that handle emergencies even better than the very best human drivers," Gerdes said. "And the first step to doing that is to make sure they have phenomenal driving skills."

The stakes of such research are high—both in dollars and in human life. Of the 5.7 million motor vehicle accidents in the United States each year, 30,000 are fatal. What's more, 94 percent involve driver error, according to a three-year study by the National Highway Traffic Safety Administration.

Statistics like these have propelled Gerdes, and his counterparts at Google, Audi, Tesla, and other companies to build autonomous cars. "Just about every manufacturer is developing automated parking or driving or both," said Brad Stertz, communications lead for Audi's piloted driving project.

When they succeed, self-driving cars will handle emergencies better than you do.

RACING FOR SAFETY

The dream of self-driving cars dates back at least to 1939, when General Motors showcased the idea in its Futurama exhibit at the World's Fair in New York. But when Gerdes was growing up in Concord, N.C., in the shadow of Charlotte Motor Speedway, that dream was light years away.

FUTURAMA WORLD'S FAIR, 1939

As a kid, Gerdes dabbled in go-kart racing, but gravitated more towards math than motorsports. Math led to physics and engineering. "To me the magic of physics and engineering was that you could work out the mathematics and describe how things move," Gerdes said. "And cars are one of the most interesting things in terms of figuring out how they move."

As a graduate student at the University of California, Berkeley, in the early 1990s, Gerdes worked on a now-defunct U.S. Department of Transportation program to create automated highways on which closely spaced platoons of automated vehicles would draft each other. The lead cars would pull followers into their slipstreams, saving fuel and giving their drivers a break. He then worked at Daimler-Benz for three years, where he developed mathematical algorithms and computer simulations to model how the company's heavy trucks would maneuver on the road.

After joining Stanford as an assistant professor in 1998, Gerdes wanted to program cars to control themselves in an emergency. But after funders balked, he began working on automating vehicles for less dangerous situations. It took another decade before Gerdes could again pursue automation that might keep drivers safe when things go wrong—when they hit a patch of ice, for example, or when a deer darts into the road and they steer away too fast and lose control.

To make cars safer in such emergencies, Gerdes looked around for people who drove well, especially with their cars pushed to the limit. That led him to professional race car drivers.

Miles Collier, a Florida real estate baron and son of an auto racing pioneer, helped found an automotive research program at Stanford and also owns one of the world's greatest collections of vintage race cars. Collier let Gerdes's team record how the vintage cars handled, and introduced him to veteran race car drivers such as John Morton, Roger Mandeville, and Gunnar Jeannette.

As it happens, race car drivers don't drive like the rest of us. Most of us try to force our car to hew to the path we want it to drive. But race car drivers see driving as more of a dialogue.

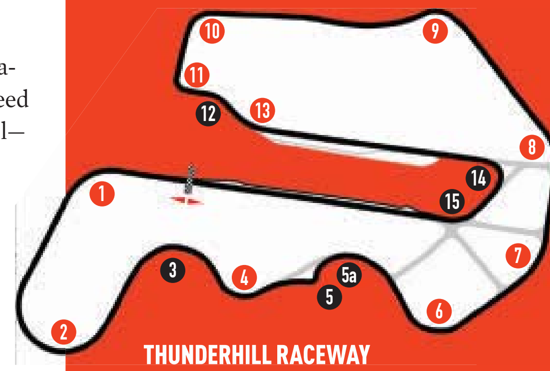
As they race, Gerdes said, "they're feeling out the capacity of the car and letting it reach its limit." When cornering, for example, they actually let the car sideslip a bit so they maintain as much speed as possible through the turn. They guide their car around the track rather than forcing it.

In an epiphany, Gerdes realized that if his team could figure out the underlying math, they could one day program a self-driving car to drive this way—to drive as well as the very best human drivers.

THE ROAD TO THUNDERHILL

A few years earlier, Gerdes had organized a brainstorming session with engineers from Audi and its parent company, Volkswagen, to come up with research ideas to push the capabilities of self-driving cars. The engineers, who met in San Francisco in late 2007, agreed that to make ordinary self-driving cars safer, it would be invaluable—not to mention cool—to build an autonomous race car.

Gerdes took on the task. Within 15 months, this time with Nissan's support, five Stanford engineering students on his team had designed and built a programmable self-driving, all-electric car. The car, named P1, had rear-wheel drive and a front-wheel steer-by-wire system, but it looked more like a dune buggy than a Chevy Volt or a Nissan Leaf. Yet despite its scraggly appearance, it did something no previous self-driving car could do. It drifted as it cornered with such control that it never spun out, just like a cornering race car driven to its limits by a pro.



MORE ON THE FLOOR

Racing with no driver takes high-speed computing, and Shelley is well equipped. The car's original processing system, which takes up most of the trunk, rapidly tracks and corrects its location by comparing data from its inertial measurement system with data from its GPS. The system must make these calculations fast enough to control the balance of the car as it approaches it's cornering limits during high speeds turns.

Photo: Gerdes Lab, Stanford University

In 2009, working with Audi engineers, Gerdes added sensors and extra computing power to an Audi TT that enabled it to drive itself. Over the next year, the autonomous car, now named Shelley, had zipped singlehandedly up switchback after switchback to the top of Colorado's 14,000-foot-high Pikes Peak, and sped to more than 130 mph on Utah's Bonneville Salt Flats.

Two years later, Gerdes approached Vodden about renting time at Thunderhill Raceway.

"They came into my office and saw all these trophies and pictures, and they were impressed that I was a real honest-to-gosh race car driver," Vodden said. "With my title of president and CEO, they didn't know I went out and crashed cars and ran into rivals and pushed them off the track and did all the things race car drivers do so well. They began to believe that I was good, and I was *not* going to correct them."

The Stanford team wanted to learn how experienced drivers think as they race, and asked Vodden if they could monitor the electrical activity of his brain. "They wanted a car to think like a race car driver," Vodden said. "They had me driving a car, put little electrodes in my brain, and interpreted them somehow."

The brain emits theta waves when it's working hard, especially at visual processing, and alpha waves when it's resting. By measuring the ratio of theta to alpha waves, Gerdes and his colleagues learned that Vodden and other experienced race car drivers don't have to think particularly hard when cornering on a track. Even as the car careens around a corner at the edge of its capabilities, a professional driver will calmly adjust, making quick changes to the steering, throttle, or brake to stay on the track.

"It's extraordinary," Gerdes said. "They're concentrating on the other vehicles around them. Controlling the car has become automated."

PIERO TARUFFI

SAFETY AT ANY SPEED

To design automated vehicles that drive as well as race car drivers, Gerdes also drew on a 1959 book he'd discovered by Piero Taruffi, an Italian Grand Prix champion.

In the 1950s, racing was extremely dangerous for drivers, and crashes at the track would occasionally take out groups of spectators as well. Taruffi led the fight for safety in the sport, even penning an article in the *Saturday Evening Post* titled "Stop Us Before We Kill Again."

Taruffi eventually earned a Ph.D. in industrial engineering at the University of Rome and wrote a classic book that discusses the physics of racing.

"Even though he wasn't going into any equations, you could see that the equations and the mathematics were part of his thinking," Gerdes said. "His insight was phenomenal. I don't think I've seen clearer explanations since that time."

Gerdes's team, like other autonomous car designers, had initially programmed their cars to compute and follow a particular path. On the streets and the freeways, that meant staying in lane, turning at the right place, and not driving off the road. For race car drivers, it meant finding the best path around the track—the best racing line.

Taruffi realized there was no single ideal racing line. Instead, the trick was to find a good line and drive it at the limits of the car. Human race car drivers use their brains, conditioned by years of experience, to calculate those lines. Computers directing autonomous cars would have to rely on math.

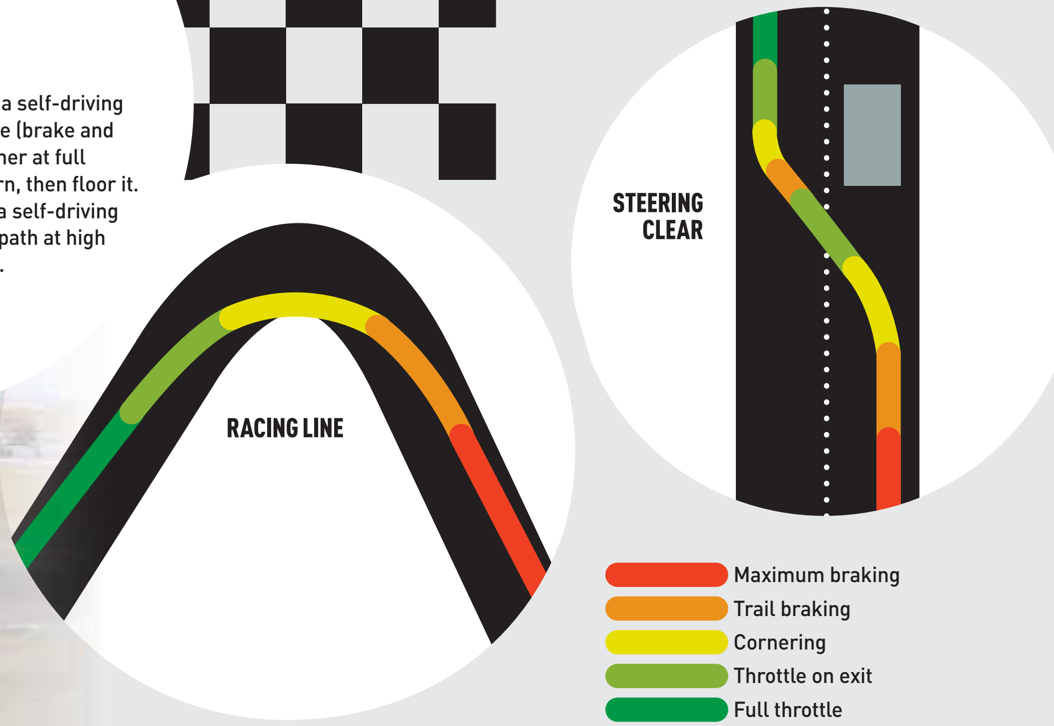
All cars have a limited amount of friction between their tires and the road. To win races, drivers need to make the most out of it. For this reason, they floor it on straights, brake hard at the last minute as they near a turn, ease up on the brake during the first half of the turn, release the brake entirely, and gradually step on the gas as they ease out of the turn and back to another straight.

In his book, Taruffi had drawn clear diagrams that explained how to break down racing lines into straights, arcs, and a curve representing how drivers steered into or out of turns. Inspired, Gerdes looked for a mathematical way to represent these three elements.

THEY TAUGHT THE CAR TO DRIVE LIKE A RACE CAR DRIVER— TO CALCULATE WHEN TO BRAKE BEFORE A TURN, HOW MUCH TO LET UP ON THE BRAKE ENTERING A TURN, HOW MUCH TO THROTTLE COMING OUT OF IT.

DODGING DISASTER

To navigate a racing turn, a self-driving car must brake, trail brake (brake and turn simultaneously), corner at full speed, throttle out of a turn, then floor it. Similar algorithms allow a self-driving car to drive an S-shaped path at high speed around an obstacle.



The straights and arcs were easy, but the transition curves posed a challenge. Eventually, Gerdes learned to represent those curves mathematically, using segments of a teardrop-shaped curve called a clothoid. Using those same three elements, he and former Stanford graduate student Paul Theodosis came up with an algorithm that represented a complicated racing line at Southern California's Laguna Seca raceway.

By programming Shelley with that algorithm, they taught the car to drive like a race car driver—to calculate when to brake before a turn, how much to let up on the brake entering a turn, how much to throttle coming out of it. And when they ran Shelley at Laguna Seca in a virtual race against driver Bruce Canepa, the world-record holder of the Pikes Peak Hill Climb, Shelley drove an aggressive racing line almost identical to Canepa's and drove it fast enough to give Canepa a run for his money, they reported at the ASME Dynamic Systems and Control Conference in 2012.

LESSONS FROM THE TRACK

Gerdes's team drew another lesson from the way race car drivers make the most of friction to maintain maximum speed on the track. "Their purpose in doing that is to be fast, but in fact the specifics are the same if you're trying to use all the friction between the tire and road to be safe," Gerdes said. And you might need every bit of friction if a mattress falls off the truck in front of you or a deer darts in front of your car.

To see if they could program Shelley to dodge such obstacles, Joe Funke, a graduate student in Gerdes's lab, derived an emergency lane change algorithm using the same underlying math the team had used at the race track. In tests at Thunderhill, Shelley calculated a new path on the fly and steered while easing off the brakes like a race car driver heading into a turn, shifting lanes smoothly and quickly.

The Stanford team borrowed yet another tactic that race car drivers use to avoid crashes. Say you're driving on a dry road and you hit a patch of ice, just as the car in front of you brakes hard. The lane to your left is open, so you steer left, but your rear end fishtails right. Race car drivers face the same risk as they corner. To control the car when they veer off course, they bend their path toward their desired racing line and return to it gradually.

Ordinary drivers face the same challenge during an emergency lane change. If you steer too abruptly, you could spin out. But if you read the situation and bend your path slowly into an adjacent lane, you can maintain control and avoid an accident. Last year, Gerdes, Funke, and two other team members used racing-derived algorithms to program another one of their vehicles, an all-electric rear-wheel drive car called X1, to do just that. When it had to, it quickly shifted two lanes over, swerving off course briefly, but adjusting.

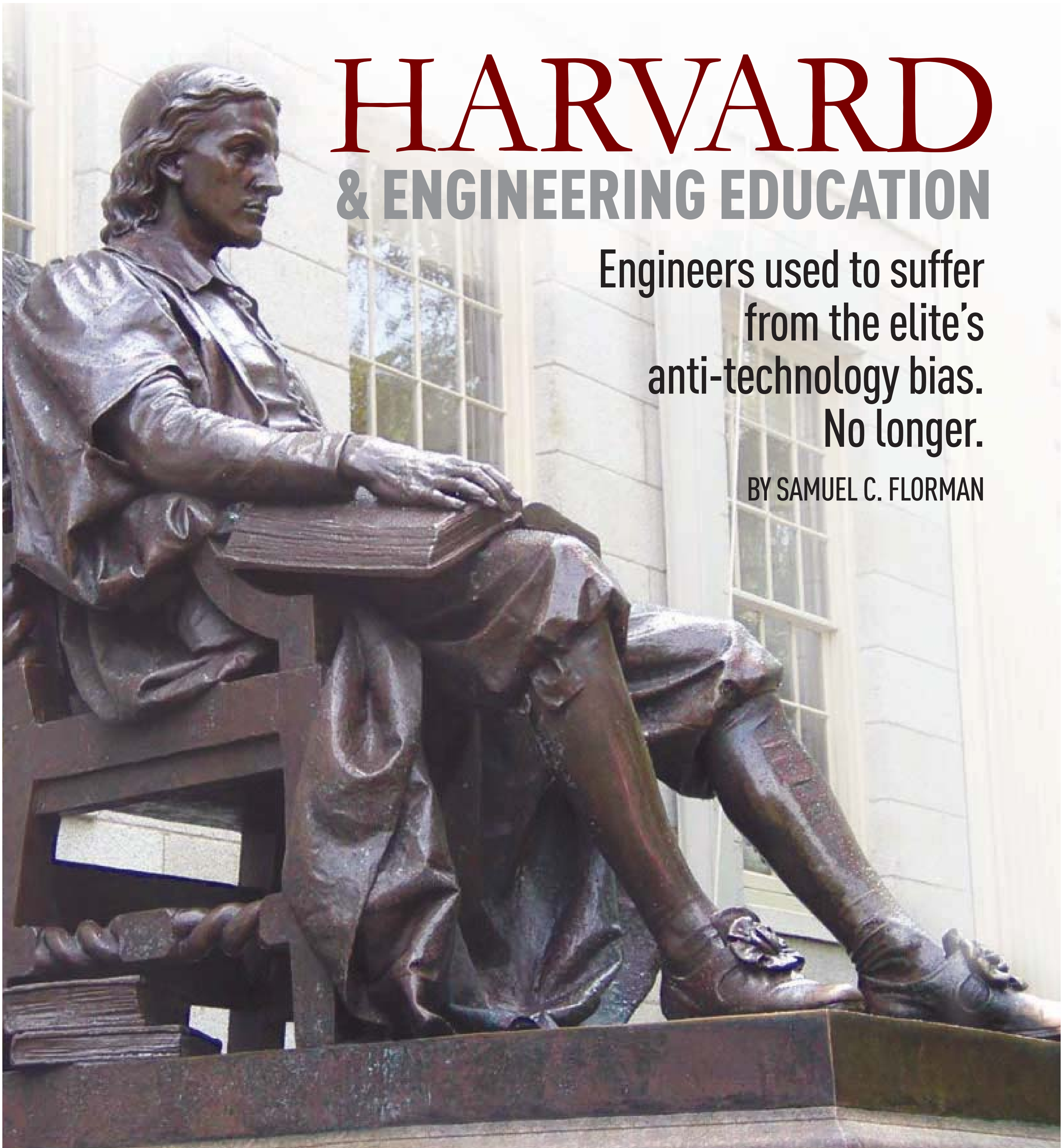
Impressive for a car with no driver, but Gerdes wants to up the ante. So far, the team's autonomous cars have operated alone on tracks or roads. Now, Gerdes is ready to test them in traffic and on icy roads that will force Shelley to adapt driving tactics midstream.

Long before driverless cars cruise down our freeways while we text, surf, and relax, carmakers will quietly add more automatic safety functions to complement the active cruise and electronic stability controls that already partly automate our driving.

More than a few of those inventions might come by watching how experienced race car drivers fly around a track and incorporating their skills in autonomous systems.

As Gerdes told us, "We keep finding that the things that make human drivers faster are the same things that we need automated vehicles to do." **ME**

DAN FERBER is a journalist based in Milwaukee who writes about science, engineering, and technology. He is the co-author, with Paul Epstein, of *Changing Planet, Changing Health: How Climate Change Threatens Our Health and What We Can Do About It.*



HARVARD
& ENGINEERING EDUCATION

Engineers used to suffer from the elite's anti-technology bias. No longer.

BY SAMUEL C. FLORMAN

I was astonished to learn recently that a billionaire hedge fund manager, John A. Paulson, is giving $400 million to Harvard in support of the university's School of Engineering and Applied Sciences. Ordinarily one is not surprised to find Harvard linked to big money, even this amount, the largest gift in the history of the institution. But the joining together of Harvard and engineering education—well, to this engineer the announcement was scarcely credible.

Only twenty-nine years ago—September 4, 1986—a crowd of Harvard dignitaries initiated a celebration of the university's 350th anniversary with cheers for a speech condemning the spread of the engineering enterprise. Prince Charles of Great Britain, "resplendent in a silk academic gown heavily embroidered with gold," according to *The New York Times*, "warned the audience of 16,000 people that the Western world was in danger of letting technology triumph over man." In the part of the speech that was most widely quoted, he pronounced that "We might have forgotten that when all is said and done a good man, as the Greeks would say, is a nobler work than a good technologist."

This widely disseminated—and seemingly gratuitous—critique of engineering education was warmly received at Harvard but was not regarded kindly by some of the folks at Harvard's Cambridge neighbor, the Massachusetts Institute of Technology. In those days I was writing a column for *Technology Review*, published at M.I.T., and the perceived putdown was a natural topic for my next essay, scheduled for January 1987. I wrote what I thought was a rather lighthearted riposte supported by a few pertinent historical facts. But then the editors added a touch of sparkle by making the title of my piece "A Good Technologist is a Noble Work," and drafting a sub-title that said "An anti-technology bias seems to have tainted Harvard's 350th celebration." Then, for emphasis, they added an illustration: the drawing of a nattily dressed man standing atop a classical stone column that is crumbling. The gentleman smilingly holds a Harvard shield, but the traditional VERITAS inscription has been replaced by the word VANITAS.

No lasting harm seemed to be done by this touch of journalistic jousting, yet the challenge remained for all of us to ponder. What right had the aristocrats of the Ivy League to disparage, indeed belittle and insult, engineering, one of the great professions of Western civilization? Well, come to think of it, this was more or less in tune with the aristocrats of American society who, although their fortunes were mostly founded in technological prowess—notably steel, oil, and the railroads—had developed a high society modeled on that of the British aristocracy. Engineers, as a class, were low on the social ladder, not likely to have attended Harvard. Herbert Hoover, a successful mining engineer before becoming president, related the tale of meeting a lady on a Transatlantic cruise, telling her he was an engineer only to have her reply "Oh dear, but I thought you were a gentleman."

The roots of engineering professionalization are to be found in France where as early as 1675 the government organized a corps of military engineers to oversee construction of fortresses and harbors.

It seems a strange quirk of history that although Britain sparked the Industrial Revolution with the steam engine and ironworking, one would have to give credit not to the nation's leaders but rather to the British working classes—individual geniuses of invention, and also talented families who

This statue, in the courtyard of the school, commemorates the cadets of L'Ecole Polytechnique who rushed to the defence of Paris against the foreign armies in 1814. A copy was installed in West Point as a symbol of brotherhood between the two nations and schools.

created and managed efficient factories. In the upper classes elder sons inherited titles and oversaw their family estates. Many younger sons sought careers in the church or in the army. Classical education remained dominant. There was no government support of technical education until 1889 when Parliament authorized grants to city universities for the purpose of technological training. Cambridge and Oxford followed reluctantly, with Cambridge introducing a minor program in "mechanical science" in 1890 and Oxford a chair of "engineering science" in 1909.

The roots of engineering professionalization are to be found in France where as early as 1675 the government organized a corps of military engineers to oversee construction of fortresses and harbors. This was followed in 1716 by a civilian engineering corps in charge of bridges, roads, and canals. Formal education for the profession can be dated to 1747 with establishment of the Ecole des Ponts et Chausses, followed in 1794 by the legendary Ecole Polytechnique. Converted to a military academy by Napoleon in 1804, the Polytechnique has played a unique, one must say historic, role. In France it became a selective and prestigious source of leadership, political and economic as well as scientific and technological. And throughout the 19th and 20th centuries it was a beacon for emulation by most of the developed and developing nations.

In the United States early colonial leaders, prominently Jefferson, were impressed by the French example, and the Military Academy founded at West Point in 1802, became the major source of American engineers for several decades. There followed Rensselaer Polytechic Institute and a few other private efforts. MIT, supported by the Massachusetts legislature, was formally established in 1861. And then came the great breakthrough of the Morrill Land-Grant Acts passed by Congress in 1862. This legislation, awarding federal aid to the states for founding colleges of agriculture and mechanic arts, saw the number of schools teaching engineering grow to eighty-five by 1880.

Harvard, the first college in the American colonies, was founded in 1636. John Harvard, the College's benefactor and namesake, was a clergyman who had received his M.A. from Cambridge University. Classical education prevailed through the colonial days and into development of the new nation. "Applied science" was introduced at Harvard in a very small way with the founding of the Lawrence School in 1847—endowed by a manufacturer of woolen goods. But that school graduated only forty nine men prior to the Civil War, and this, according to an engineering educator quoted in Charles Raborg Mann's *A Study of Engineering Education*, "in the face of an unconcealed disdain on the part of the regular faculty."

In 1985, the academic year preceding Prince Charles's condescending remarks, Harvard awarded only 38 undergraduate degrees in engineering science, plus six master's degrees and eight doctorates.

The Harvard celebration of 1986 seems like only yesterday, but obviously a lot has changed since then. I guess that I wasn't looking, certainly not at Cambridge, Mass., where Harvard engineering had been making its way into the silicon age. The newly named John A. Paulson School of Engineering and Applied Sciences can already point to a number of accomplished graduates and distinguished faculty. It currently has more than 400 graduate students and more than 800 undergraduates, and with this enormous new grant, prospects for the future certainly look bright.

Ironically, Prince Charles's warning of 1986 cannot be totally written off. There is still a danger that the successes of modern science and technology might "triumph over man." (Today he would say "over humankind.") I say that there is still a danger since a very big worry in today's academic world is the precipitously declining interest in the liberal arts. We cannot see clearly where this may be taking us.

TOP 20 U.S. MECHANICAL ENGINEERING GRADUATE PROGRAMS

Derived from data from the National Research Council (2010) In alphabetical order.

- Brown University
- California Institute of Technology
- Cornell University
- Duke University
- Georgia Institute of Technology
- Johns Hopkins University
- Massachusetts Institute of Technology
- Northwestern University
- Penn State University
- Princeton University
- Purdue University
- Stanford University
- University of California at Berkeley
- University of California at San Diego
- University of California at Santa Barbara
- University of Colorado at Boulder
- University of Illinois at Urbana-Champaign
- University of Maryland at College Park
- University of Michigan at Ann Arbor
- University of Minnesota-Twin Cities

Of course, Sylvanus Thayer, superintendent of the United States Military Academy from 1817 to 1833, and known as the "Father of West Point," in his later years, gave funds to found the Thayer School of Engineering at Dartmouth College, where he expected young men to be prepared "for the most responsible positions and the most difficult service." In connection with this he conceived of a two-year graduate program to follow a four-year college course. Dartmouth eventually reduced the six-year program to five years; but the Thayer School (confession: my alma mater) is an engineering school that requires the student to earn a B.A. prior to earning a B.S.

But that is a topic for another day. **ME**

SAMUEL C. FLORMAN, a civil engineer, is chairman of Kreisler Borg Florman General Construction Co. He is the author of *The Existential Pleasures of Engineering* and six other books. In 1995 he was elected to the National Academy of Engineering.

2015 ARTICLE INDEX

THE FOLLOWING IS A LIST OF FEATURE ARTICLES THAT APPEARED IN MECHANICAL ENGINEERING IN 2015.

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MC138 Workshop: Using ASME RAM Standards to Establish a Reliability, Availability & Maintainability (RAM) Program for Critical Systems and Power Plants* **NEW!** — 14 Feb

MC104 Bases and Application of Heat Exchanger Mechanical Design Rules in Section VIII of the ASME Boiler and Pressure Vessel Code — 14-15 Feb

MC136 Developing Effective Bolted Flange Joint Assembly Procedures Using ASME PCC-1* **NEW!** — 14-15 Feb

MC132 Run-or-Repair Operability Decisions for Pressure Equipment and Piping Systems Using ASME PCC-2* **NEW!** — 16-17 Feb

MC137 Creating and Implementing Effective Inspection Plans for Pressure Equipment and High Energy Piping Systems Using ASME PCC-3* **NEW!** — 18 Feb

MC127 Bases and Application Design Requirements for High Pressure Vessels in ASME Code Section VIII, Division 3* **NEW!** — 18-19 Feb

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PD539 Bolted Joints and Gasket Behavior — 15-16 Feb

PD467 Project Management for Engineers and Technical Professionals — 15-17 Feb

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PD765 Gas Turbine Engines – Controlling Pollutants — 15-17 Feb

PD014 ASME B31.3 Process Piping Design **ASME STANDARDS COURSE / TOP SELLER** — 15-18 Feb

PD394 Seismic Design and Retrofit of Equipment and Piping — 15-18 Feb

PD632 Design in Codes, Standards and Regulations for Nuclear Power Plant Construction **ASME STANDARDS COURSE / TOP SELLER** — 15-18 Feb

PD675 ASME NQA-1 Lead Auditor Training — 15-18 Feb

PD679 Selection of Pumps and Valves for Optimum System Performance — 15-18 Feb

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FEBRUARY 2016 – SAN ANTONIO, TEXAS USA (Continued)

PD386 Design of Bolted Flange Joints — 17 Feb

PD496 Preparing for the Project Management Professional Certification Exam — 18-19 Feb

PD577 Bolted Joint Assembly Principles Per PCC-1-2013 **ASME STANDARDS COURSE** — 18-19 Feb

PD457 B31.3 Process Piping Materials Fabrication, Examination and Testing **ASME STANDARDS COURSE / TOP SELLER** — 19 Feb

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PD706 Inline Inspections for Pipelines — 7-8 Mar

PD190 BPV Code, Section IX: Welding, Brazing and Fusing Qualifications **ASME STANDARDS COURSE** — 7-9 Mar

PD231 Shock and Vibration Analysis — 7-9 Mar

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PD441 Inspections, Repairs and Alterations of Pressure Equipment ASME STANDARDS COURSE — 10-11 Mar

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PD721 Optimization of Plant Layouts Utilizing 3D CAD/CAE Systems — 10-11 Mar

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PD467 Project Management for Engineers and Technical Professionals — 13-15 Mar

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PD643 B31.3 Process Piping Code
ASME STANDARDS COURSE — 13-17 Mar

PD725 BPV Code, Section VIII, Division 1: Design and Fabrication with Inspections, Repairs & Alterations of Pressure Vessels
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PD723 B31.4 and B31.8 Liquids and Gas Pipelines — 20-22 Mar

PD642 ASME B31.1 Power Piping Code
ASME STANDARDS COURSE — 20-23 Mar

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PD146 Flow Induced Vibration with Applications to Failure Analysis — 14-16 Mar

PD442 BPV Code, Section VIII, Division 1: Design and Fabrication of Pressure Vessels
ASME STANDARDS COURSE / TOP SELLER — 14-16 Mar

PD621 Grade 91 and Other Creep Strength Enhanced Ferritic Steels — 14-16 Mar

PD616 API 579 /ASME FFS-1 Fitness-for-Service Evaluation — 14-17 Mar

PD643 B31.3 Process Piping Code
ASME STANDARDS COURSE — 14-17 Mar

PD679 Selection of Pumps and Valves for Optimum System Performance — 14-17 Mar

PD716 BPV Code, Section 1: Power Boilers
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MC113 Techniques & Methods Used in API 579-1/ASME FFS-1 for Advanced Fitness-For-Service (FFS) Assessments* — 16 Mar

MARCH 2016 – COPENHAGEN, DENMARK (Continued)

MC104 Bases and Application of Heat Exchanger Mechanical Design Rules in Section VIII of the ASME Boiler and Pressure Vessel Code* — 17-18 Mar

MC135 Using ASME Codes to Meet the EU Pressure Equipment Directive (PED)* NEW! — 17-18 Mar

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PD622 BPV Code: Plant Equipment Requirements
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PD192 BPV Code, Section XI: Inservice Inspection of Nuclear Power Plant Components
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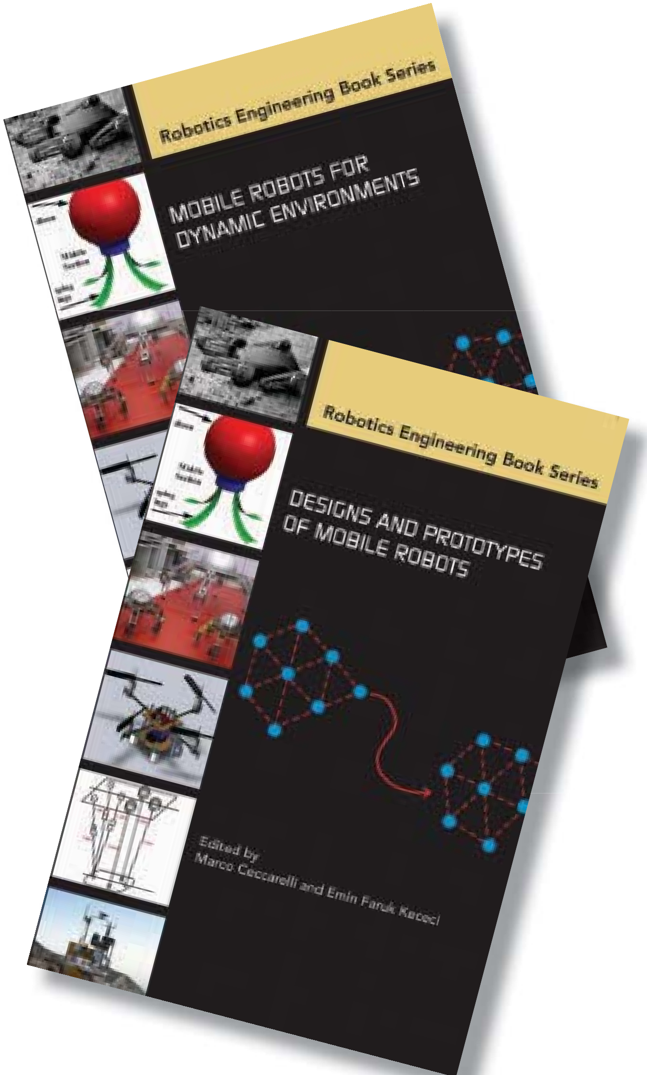
- In-Line Inspections for Pipelines

Check our website for program updates. For information and to register, go to go.asme.org/pipelinetraining



ROBOTICS ENGINEERING BOOK SERIES

VLADIMIR VANTSEVICH, SERIES EDITOR

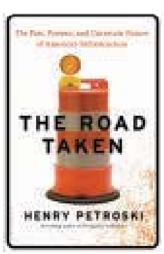
ASME Press Books,
Two Park Avenue, New York, NY 10016-5990. 2015.

ASME Press has released the first two volumes of a Robotics Engineering Books Series, *Designs and Prototypes of Mobile Robots* and its companion volume, *Mobile Robots for Dynamic Environments*. The series intends to examine technical issues, including mechanical design and control decisions, encountered in the development of advanced robotic systems. The initial texts, both edited by Marco Ceccarelli of the University of Cassino and South Latium and Emin Faruk Kececi of Istanbul Technical University, deal specifically with mobile robots. Topics covered by *Designs and Prototypes* include linkages for leg mechanisms, exoskeletons, and design challenges in prototyping rescue robots. The five chapters of *Mobile Robots for Dynamic Environments* include one each on robot swarms, underwater robots, and a lighter-than-air flying octopus. The editors see the books as suitable for use in graduate-level engineering courses and as guidebooks for practicing engineers.

FEATURED

DESIGNS AND PROTOTYPES, 202 PAGES. $119; ASME MEMBERS, $95.
ISBN: 978-0-7918-6047-2.

DYNAMIC ENVIRONMENTS, 180 PAGES. $119; ASME MEMBERS, $95.
ISBN: 978-0-7918-6052-6.

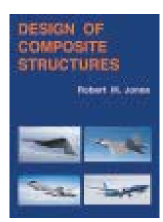


THE ROAD TAKEN

Henry Petroski
Bloomsbury Publishing Plc, 1385 Broadway, New York, NY 10018. 2016.

The subtitle of this book is "The History and Future of America's Infrastructure," and the author points out that the infrastructure is in woeful shape. Petroski looks at the problem as a matter of making choices: to repair roads or to live with potholes, to raise road taxes or to live with traffic congestion, or to find some reasonable compromise. He uses Robert Frost's "The Road Not Taken," a poem that deals with decisions and their consequences, as a metaphor for the infrastructure dilemma in the United States. Petroski points out that the decisions affecting public infrastructure—roads, railroads, bridges, tunnels, and the like—are influenced not only by economic realities, but also by politics and public perception. After all, we live inside the infrastructure, so we are likely to take it for granted, perhaps not notice it at all, until it breaks.

336 PAGES. $28. ISBN: 978-1-63286-160-7.



DESIGN OF COMPOSITE STRUCTURES

Robert M. Jones
Bull Ridge Publishing, Box 10698, Blacksburg, VA 24062-0698. 2015.

According to the author, this is a complex subject, and its more than 800 pages are intended, in the words of the subtitle, as "an introduction to the many aspects of composite structures design." Jones, who teaches a design course at Virginia Tech, writes that the book is intended for graduate-level university courses in the subject, and in industrial and government courses. Among the topics covered are a review of structural design processes, different uses of composite materials and how they are manufactured, alternative structural configurations, joint and attachment concepts, failure criteria, and a practical design philosophy for composite structures. The book discusses various applications in automotive, aircraft, space, naval, and other fields. Some, like the bridge in a backpack developed at the University of Maine, are conceptual, and others, like the all-fiberglass Windecker Eagle, were commercialized pace-setters.

816 PAGES. $120. ISBN: 978-0-9787223-3-3

GEOSPATIAL DATA

INTERGRAPH, HUNTSVILLE, ALA.

Intergraph Security, Government, and Infrastructure has released I/Map Editor for ArcGIS, a new product that works directly with Esri's ArcGIS Platform to migrate geospatial data into Intergraph's computer-aided dispatch software. Dispatch software systems are used by public safety agencies to answer emergency and non-emergency calls, create and update incidents, and manage multiple resources in real time. The new application is designed to minimize the number of different systems and steps required for ArcGIS users, offering them a one-stop shop for uploading data into their I/CAD system. It also permits the use of GIS data from third-party systems as the source of map graphics.

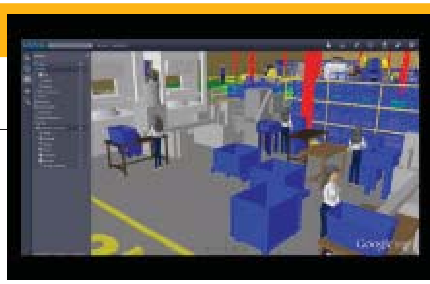
MANAGING MEASUREMENTS

HEXAGON METROLOGY, NORTH KINGSTOWN, R.I.

PC-DMIS 2015 is the new version of the company's software for the collection, evaluation, and management of measurement data. PC-DMIS is designed for Hexagon Metrology measurement devices and a range of other measurement equipment in the marketplace. The new release offers significant improvements for the inspection of point cloud data captured during scanning operations. Other enhancements have been developed for the tools, workflow, and overall user experience. Improvements include a redesigned execution timer that is more accurate and respects partial execution, improved probe animation to increase offline programming efficiency, and upgraded point cloud tools.

PLANT PLANNING

SIEMENS, MUNICH, GERMANY.



Intosite software is a cloud-based web application that maintains a 3-D representation of production facilities, enabling manufacturers to create smart maps of their worldwide sites. A mobile application for Microsoft's Windows 8.1 operating system, is now available at the Microsoft Store. Intosite provides access to information from any IT system, including manufacturing information from connected product lifecycle management systems. It allows users to virtually access information by clicking available visual tags on the map. The software lets manufacturers plan, resolve issues, and share best practices globally without the need for costly plant visits.

ROBOT PROGRAMMING

DELCAM, BIRMINGHAM, U.K.

The latest release of PowerMILL Robot enables manual and CNC programming of robots to be combined in a single program. Other enhancements include improved collision checking, automatic avoidance of wrist singularities, and the ability to generate robot programs from tape files produced in other CAM software. PowerMILL Robot also has enhancements made in recent releases of PowerMILL, in particular the Vortex strategy for high-efficiency area clearance. In addition, the range of robots supported by the system has been increased so that it now includes KUKA, ABB, Fanuc, Yaskawa Motoman, Stäubli, Hyundai, Comau, Kawasaki Robot, Nachi, and Universal Robots equipment, without a need for third-party translation software.

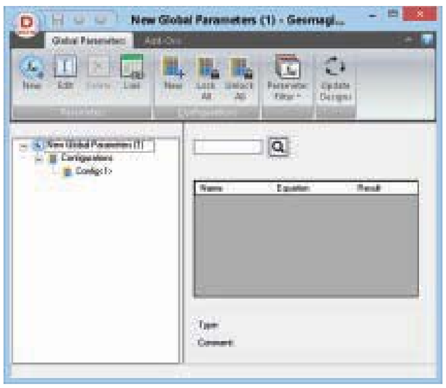
SUBMISSIONS

Submit electronic files of new products and images by e-mail to **memag@asme.org**. Use subject line "New Products." *ME* does not test or endorse the products described here.

SHARED EQUATIONS

CADDIT.NET, SYDNEY, AUSTRALIA.

The Geomagic Design 2015 V17 Release is a stability / bugfix release but with several new and important features requested by users in Australia and around the world. The most significant enhancement is the Global Parameters feature. A global parameter is a design value or equation which is shared across multiple parts or assemblies. The concept is very similar to SolidWorks global variables. Data is stored independently in the newly released ".AD_GLP" file format. Any part or assembly can be associated to the values stored in an AD_GLP file.



MANUFACTURABILITY ANALYSIS

PROTO LABS, MAPLE PLAIN, MINN.

Proto Labs, a custom prototyping and low-volume parts manufacturer, is making its online quoting system available within Autodesk's Fusion 360. Clicking the Proto Labs logo will offer an interactive quote within a few hours, along with a manufacturability analysis for injection molding or CNC machining. The analysis highlights potential manufacturability issues, allowing design modifications to be made early before any actual production begins. Plans are under way to implement similar quoting functionality for Proto Labs' additive manufacturing services.

JOB SCHEDULING

ALTAIR, TROY, MICH.

PBS Professional, a workload management and job scheduling system for clusters and supercomputers, has been upgraded to version 13.0. Altair says this is the largest release in the software's 20-year commercial history and provides faster job launches, a comprehensive health check framework, and scalability to millions of jobs per day. The company says the update has been designed for companies preparing for exascale computing, which is defined as systems capable of a billion billion calculations per second.

PCB DESIGN

ALTIUM LTD., SAN DIEGO.

PCBWorks is a new printed circuit board design tool created specifically for collaboration between electronic and mechanical design teams in SolidWorks. The design tool offers such features as support for SolidWorks' Parasolid file format, which allows the electrical designer to link directly to native mechanical models for enclosures and component bodies, and separate management for components within their respective design environments. PCBWorks also includes a number of PCB design features enabling electrical designers to complete their PCB designs in one unified design environment, tying together the schematic capture and the layout process.

CONSTRUCTION COMMUNICATIONS

ARC DOCUMENT SOLUTIONS, WALNUT CREEK, CALIF.

ARC Document Solutions Inc., which provides software for the construction industry, has introduced Skysite 2.0, an update to its cloud-based application for construction communication. Skysite manages and distributes construction documents and information via the cloud and mobile devices. It was designed to create a smooth and seamless workflow for construction projects by making communication simple, easy, and painless. Users with secure mobile access can consult project documents on devices that are small and light enough to fit into a tool bag. New features include tools for managing additional document types and tasks, such as request-for-information administration, photo management, and punch lists.

SCHEDULE MANAGEMENT

ASTA DEVELOPMENT, INDIANAPOLIS.

Asta Powerproject version 13 lets users analyze resource and cost center usage daily, weekly, monthly, or quarterly. They can link tasks automatically as they are created or selected, and show the location of subordinate tasks. Schedules can be created by entering basic project details in a dialog box. The software can exchange data with other systems. It will open files created in other formats and can save Powerproject files in various formats.

EXTRA COMPRESSOR WARRANTY

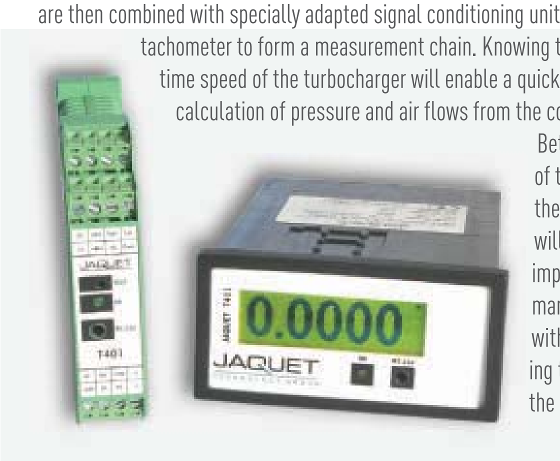
FS-ELLIOTT CO., EXPORT, PA.

The manufacturer is offering a separate warranty covering the air end assembly of its Polaris+ compressors. The warranty, called SteadiAIR 5, is in addition to FS-Elliott's standard warranty. SteadiAIR 5 covers the compressor air end assembly for a period of at least five years starting from the time of shipment. Polaris+ is a line of centrifugal compressors certified ISO 8573-1 Class 0 oil-free. Models range from 250 to 2,500 hp and deliver up to 150 psig discharge pressure.

TURBOCHARGER TESTING

JAQUET TECHNOLOGY GROUP, BASEL, SWITZERLAND.

TurboTach is designed for the laboratory testing of turbochargers. It is a modular system of the components needed to measure and validate the speed of turbochargers during engine design and development. Users can configure the system from a range of turbocharger speed sensors and connector cables, which are then combined with specially adapted signal conditioning units and a digital tachometer to form a measurement chain. Knowing the actual, real-time speed of the turbocharger will enable a quick and accurate calculation of pressure and air flows from the compressor map. Better utilization of the properties of the turbocharger will allow for improved performance of the engine without compromising the lifetime of the drivetrain.



TOOLS//HARDWARE

PROTECTIVE ENCLOSURES

AUTOMATIONDIRECT, CUMMING, GA.

The distributor has added more 360 NEMA 4/12 and 4/4X/12 enclosures designed to protect electrical and electronic components from harsh, dirty environments. The enclosures, the Ultimate series made by Hubbell-Wiegmann, include models with slope top, windows, and 1-point and 3-point latch heavy-duty handles. Models are available in heavy 14 gauge steel with ANSI gray light-textured or RAL7035 light gray textured finishes, and in 14 gauge 304 stainless steel with smooth-grain finish. The enclosures are constructed with plasma welded seams, poly-urethane poured-in-place gaskets, collar studs for mounting optional subpanels, concealed hinges, and increased tub openings to accommodate larger size subpanels. Prices start at $165.

HAZARDOUS LOCATION A/C

PENTAIR TECHNICAL PRODUCTS, ANOKA, MINN.

The Hoffman SpectraCool hazardous location air conditioner has a patented design that eliminates sources of ignition arising from the functioning of the A/C unit. There are two models: SpectraCool and SpectraCool Offshore. Standard models are available in Type 4 and 4X units with the option to monitor units from a control room or remote PC. SpectraCool Offshore units are Type 4X with 316L stainless steel body construction to resist corrosion and a Heresite coating for increased safety in harsh and hazardous environments. All models are rated for Class I, Division 2 Group B, C, D T4A applications and have a capacity range from 4,000 to 11,000 BTU per hour.

SEALED COMPRESSION LUG

AMPHENOL INDUSTRIAL PRODUCTS, SIDNEY, N.Y.

The SurLok Plus is a field-installable compression lug, using industry standard crimp, screw, and busbar termination options to eliminate the need for special torque tools. SurLok Plus is an environmentally sealed version of the company's original SurLok, and is available in smaller sizes. Its quick lock and press-to-release design incorporates Amphenol's proprietary R4 Radsok technology, which uses a high-conductivity alloy grid to produce low insertion forces and maintain a large conductive surface area. The unit is optimized for battery pack connections from 50 to 400 A using a touch-safe interface.

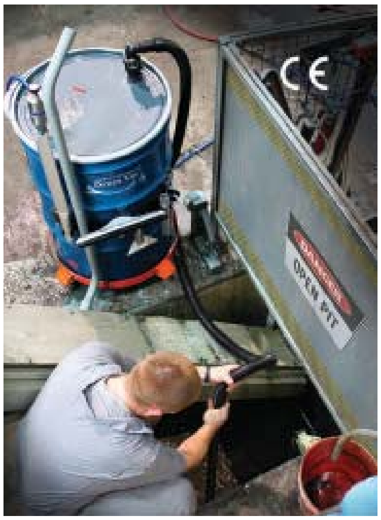
SUBMISSIONS

Submit electronic files of new products and images by e-mail to **memag@asme.org**. Use subject line "New Products." *ME* does not test or endorse the products described here.

FLUID RECOVERY

EXAIR CORP., CINCINNATI.

The high-lift reversible Drum Vac is designed for the recovery of fluids including coolant, hydraulic oils, sludge and chips, waste water, and tramp oil. The Drum Vac can recover liquids from below-grade sumps, wells, underground tanks, pits, and drains requiring up to 15 feet of lift. The unit can fill a 55-gallon drum in 85 seconds. Turning a knob reverses the process to empty the drum. The Drum Vac is powered by compressed air, and so has no electric motor or impellers. It is designed for continuous and heavy-duty applications and can also be used for lighter duty. It is not for use with flammable liquids.



LIGHTWEIGHTS FOR AIRCRAFT & AUTOMOBILES

SOLVAY S.A., BRUSSELS, BELGIUM.

Tegralite is a family of high-performance lightweight materials for the aeronautics industry. The manufacturer says the products can improve fuel efficiency and speed up the production and maintenance of planes at lower cost. Solvay works with partner companies to develop materials. Its alliance with 3A Composites has created a new generation of aerospace foams. Its partnership with JSP offers 3-D foam parts, a technology widely used in the automotive sector. Solvay and Aonix develop high- and ultra-performing prepreg systems as well as new sandwich materials and structures. Solvay complements the offering with its tailored multi-layer functional and decorative surfaces.

PRECISION GRINDERS

FIVES LANDIS CORP., HAGERSTOWN, MD.

The company has added a line of high-precision, high-production grinding equipment. The new line comes to Fives with the acquisition of Bryant Grinder from Vermont Machine Tool. Products include dedicated internal diameter and outer diameter grinders, universal bore, seat, and face grinders, and CNC operating systems. Bryant Grinder intellectual property includes round bar hydrostatic systems, in which a stiff, hydrostatic bearing controls the slide in all degrees of freedom. A very low coefficient of friction permits positioning accuracy of smaller than a micrometer.

TORMACH® Personal CNC

Shown here is an articulated humanoid robot leg, built by researchers at the Drexel Autonomous System Lab (DASL) with a Tormach PCNC 1100 milling machine. To read more about this project or to learn about Tormach's affordable CNC mills and accessories, visit www.tormach.com/mem.

PCNC 1100 Series 3

Mills shown here with optional stand, machine arm, LCD monitors, and other accessories.

PCNC 770 Series 3

www.tormach.com/mem

ASME STANDARDS & CERTIFICATION
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212.591.8500 FAX: 212.591.8501
E-MAIL: CS@ASME.ORG

If you are looking for information regarding an ASME code or standard committee, conformity assessment program, training program, staff contact, or schedule of meetings:

PLEASE VISIT OUR WEBSITE: WWW.ASME.ORG/CODES

COMMITTEE LISTING: For a listing of ASME Codes and Standards Development Committees and their charters, visit the Standards and Certification website at http://cstools.asme.org/charters.cfm.

CONFORMITY ASSESSMENT: For a listing and description of ASME Conformity Assessment (accreditation, registration, and certification) programs, visit the Standards and Certification website at http://www.asme.org/kb/standards/certification---accreditation.

TRAINING & DEVELOPMENT: For a listing and description of ASME Training & Development educational opportunities, visit the ASME Education website at http://www.asme.org/kb/courses/asme-training---development.

STAFF CONTACTS: To obtain the ASME staff contact information for a Codes and Standards Development Committee or a Conformity Assessment program, visit the Codes and Standards website at http://cstools.asme.org/staff.

SCHEDULE OF MEETINGS: Meetings of Codes and Standards Development Committees are held periodically to consider the development of new standards and the maintenance of existing standards. To search for scheduled meetings of Codes and Standards Development Committees, by date or by keyword, visit the Standards and Certification website at http://calendar.asme.org/home. cfm?CategoryID=1.

PUBLIC REVIEW DRAFTS
An important element of ASME's accredited standards development procedures is the requirement that all proposed standards actions (new codes and standards, revisions to existing codes and standards, and reaffirmations of existing codes and standards) be made available for public review and comment. The proposed standards actions currently available for public review are announced on ASME's website, located at http://cstools.asme.org/csconnect/PublicReviewpage.cfm.

The website announcements will provide information on the scope of the proposed standards action, the price of a standard when being proposed for reaffirmation or withdrawal, the deadline for submittal of comments, and the ASME staff contact to whom any comments should be provided. Some proposed standards actions may be available directly from the website; hard copies of any proposed standards action (excluding BPV) may be obtained from:

MAYRA SANTIAGO, Secretary A
ASME Standards & Certification
Two Park Ave., M/S 6-2A
New York, NY 10016
e-mail: ansibox@asme.org

ASME maintains approximately 500 codes and standards. A general categorization of the subject matter addressed by ASME codes and standards is as follows:

Authorized Inspections
Automotive
Bioprocessing Equipment
Boilers
Certification and Accreditation
Chains
Controls
Conveyors
Cranes and Hoists
Cutting, Hand, and Machine Tools
Dimensions
Drawings, Terminology, and Graphic Symbols
Elevators and Escalators
Energy Assessment
Fasteners
Fitness-For-Service
Gauges/Gaging
Geometric Dimensioning & Tolerancing (GD&T)
High-Pressure Vessels Systems
Keys and Keyseats
Limits & Fits
Materials
Measurement of Fluid Flow in Closed Conduits
Metal Products Sizes
Metric System
Metrology and Calibration of Instruments
Nondestructive Evaluation/ Examination-Nuclear
Operator Qualification and Certification
Performance Test Codes
Piping & Pipelines
Plumbing Materials and Equipment
Post Construction of Pressure Equipment and Piping
Powered Platforms
Pressure Vessels
Pumps
Rail Transportation
Reinforced Thermoset Plastic Corrosion Resistant Equipment
Risk Analysis
Screw Threads
Steel Stacks
Surface Quality
Turbines
Valves, Fittings, Flanges, Gaskets
Verification & Validation
Welding & Brazing

The ASME Standards & Certification section is published as submitted to Mechanical Engineering magazine by ASME's Standards & Certification Department.

VANDERBILT
School of Engineering

VANDERBILT UNIVERSITY FACULTY POSITION MECHANICAL ENGINEERING DEPARTMENT

The Department of Mechanical Engineering at Vanderbilt University invites applications for a tenure-track faculty position at the rank of Assistant Professor to begin in the fall of 2016. We are particularly seeking outstanding candidates in the area of nanomaterials, for solving critical energy issues, as part of the Vanderbilt School of Engineering's strategic growth initiative in Energy and Natural Resources. We strive for an active, culturally and academically diverse faculty of the highest caliber, skilled in both scholarship and teaching. The Department of Mechanical Engineering has 15 tenured/tenure-track faculty members with strong reputations in research fields including nanoengineering, rehabilitation engineering, and medical robots, with an annual research expenditure of $6.7 million. The successful candidate is expected to make significant contributions to the Department's research and teaching activities. Applications consisting of a cover letter, a complete curriculum vitae, statements of teaching and research interests, and the addresses of at least three references (include email address) should be submitted on-line at https://academicjobsonline.org/ajo/jobs/6048

Ranked in the top 20 nationally, Vanderbilt is a private, internationally renowned research university located in vibrant Nashville, Tennessee. The School of Engineering over the past decade has been on a strong upward trajectory in its national and international stature and prominence, and is entering a period of growth in terms of faculty and facilities. In the 2015 rankings of graduate engineering programs by U.S. News & World Report, the School ranks in the top three among programs with fewer than 100 faculty members. Vanderbilt University is an Affirmative Action/Equal Opportunity Employer committed to increasing the cultural and intellectual diversity of its faculty. The university aspires to become a leader among its peer institutions in making meaningful and lasting progress in responding to the needs and concerns of women and members of under-represented minority groups.

UNIVERSITY of HAWAI'I® MĀNOA

Assistant Professor (Thermofluids: Energy), position number 0085353, University of Hawaii at Manoa (UHM), College of Engineering (COE), Department of Mechanical Engineering, invites applications for a full-time, general funds, tenure track, faculty position, pending position clearance and availability of funds, to begin approximately August 1, 2016.

The University of Hawai'i is a Carnegie doctoral/research-extensive university with a strong emphasis on research and graduate education. The Department offers B.S., M.S., and Ph.D. degrees in mechanical engineering, and its undergraduate program is ABET accredited.

For more information on college research themes, please visit our college web site at www.eng.hawaii.edu. The department has active research programs in renewable energy systems & sustainability, combustion, boiling and two-phase flow, multidisciplinary design and analysis optimization, biotechnology, biomedical engineering, space and ocean science & exploration, robotics, control systems, dynamical systems, nanotechnology, corrosion, and high-performance computing.

This faculty could potentially work with UHM School of Ocean and Earth Science and Technology, SOEST (e.g., HNEI: Hawaii Natural Energy Institute and ORE: Ocean and Resources Engineering) and also contribute to the UH-iLab, Makers, VIP, and Entrepreneurship programs of the College. This faculty can also contribute to the COE Research Clusters such as Renewable Energy and Island Sustainability, etc.

Duties: Teach and develop undergraduate and graduate courses in the area of thermofluids such as renewable or alternative energy, energy conversion and storage, heat and/or mass transfer as related to thermal or fluid systems. Develop externally funded research programs that result in publications in leading scholarly journals; present research work in leading scholarly conferences; supervise graduate students; teach via various distance delivery modes as required; and serve on departmental, college, and university committees.

Minimum qualifications: An earned Ph.D. (All-But-Dissertation, ABD, cases will be considered) in Mechanical Engineering or a closely related field. The candidate should have a background in an emerging research area related to thermofluids with expertise in energy. Candidates must also show a strong commitment to teaching excellence and mentoring at the undergraduate and graduate levels.

Pay range: Commensurate with qualifications and experience.

To Apply: Only electronic applications are accepted. Applicants should follow the instructions at http://www4.eng.hawaii.edu/apply for submission instructions (The applicants should submit a cover letter specifying the position and the research area; a statement on their research interests, activities, and plans; a statement on their teaching philosophy, interests, and plan; a curriculum vitae detailing research and teaching accomplishments; copies of up to 4 relevant publications; and the names, addresses, e-mail, and telephone numbers of 4 references). For more information on the Department, please visit our website at www.me.hawaii.edu.

Inquiries: Professor Mehrdad N. Ghasemi-Nejhad, Chair, 808-956-7560, nejhad@hawaii.edu.

Review of applications will begin on February 1, 2016 and will continue until the position is filled.

The University of Hawai'i is an equal opportunity/affirmative action institution and is committed to a policy of nondiscrimination on the basis of race, sex, gender identity and expression, age, religion, color, national origin, ancestry, citizenship, disability, genetic information, marital status, breastfeeding, income assignment for child support, arrest and court record (except as permissible under State law), sexual orientation, national guard absence, or status as a covered veteran.

Individuals with disabilities who need a reasonable accommodation for the application or hiring process are encouraged to contact the EEO/AA coordinator(s) for the respective campus.

Employment is contingent on satisfying employment eligibility verification requirements of the Immigration Reform and Control Act of 1986; reference checks of previous employers; and for certain positions, criminal history record checks.

In accordance with the Jeanne Clery Disclosure of Campus Security Policy and Campus Crime Statistics Act, annual campus crime statistics for the University of Hawai'i may be viewed at: http://ope.ed.gov/security/, or a paper copy may be obtained upon request from the respective UH Public Safety or Administrative Services Office.

ASME
SETTING THE STANDARD

PIPELINE TECHNOLOGY AND STANDARDS TRAINING WEEK

APRIL 11–14, 2016 | DENVER, COLORADO

A must attend training event led by pipeline experts and code authorities.

Courses and highlights include:

- **(Plenary Session)** Pipeline Safety: Implications of Proposed Rule Making (recent NPRMs)
- Onshore Pipeline Design and Construction – A Practical Approach
- **NEW!** Pipeline Stress Corrosion Cracking (SCC) Management
- **NEW!** Pipeline Defect Assessment
- **NEW!** Integrity Management of Natural Gas Pipelines Using ASME B31.8S Standard
- **NEW!** Pipeline Integrity Issues, Mitigation, Prevention & Repair Using ASME B31.8S Standard
- ASME B31.4 & B31.8, Liquids and Gas Pipelines
- ASME B31.3 Process Piping Code
- Bolted Joint Assembly Principles Per PCC-1-2013
- **NEW!** Integrity and Repair of Process Piping and Tanks
- Practical Welding Technology
- In-Line Inspections for Pipelines

Check our website for program updates. For information and to register, go to:

go.asme.org/pipelinetraining

MISSOURI S&T
MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY
Formerly University of Missouri-Rolla

MECHANICAL AND AEROSPACE ENGINEERING DEPARTMENT
Assistant Professor Position
(Job #18145, Position #00058753)

The Department of Mechanical and Aerospace Engineering at the Missouri University of Science and Technology (formerly the University of Missouri - Rolla) invites applications for a full-time tenure-track Assistant Professor position in the general area of robotics and automation, including but not limited to (a) human-robot collaboration; (b) control and coordination; (c) sensing, perception, and vision; (d) design, particularly using novel locomotion and materials; (e) innovative applications (factory, mining, surgery, space, harsh environments, etc.).

Applicants must have a Ph.D. in Mechanical Engineering or closely related fields. This opening is anticipated to be filled at the Assistant Professor level, although qualified applicants will be considered for appointment at a higher level. The successful candidate will demonstrate the potential to establish and grow a strong research program and will participate in all aspects of the Department's mission, which includes research, teaching and service.

The department currently has 41 full-time faculty members, over 800 undergraduate and approximately 200 graduate students, and offers the B.S., M.S., and Ph.D. degrees in Mechanical and Aerospace Engineering. The Department seeks to significantly increase the national visibility of its research and graduate program while maintaining its high standards of teaching. A recently completed $29 million renovation project has produced a state-of-the-art Mechanical and Aerospace Engineering complex with 144,000 square feet of teaching and research laboratory space. Details regarding the department can be found at http://mae.mst.edu/. In addition, details of research centers on campus can be found at http://www.mst.edu/research/.

Candidates should include the following with their letter of application: current curriculum vitae, statement of research plans, statement of teaching interests and philosophy, and names and contact information for at least three references. Review of applications will begin on February 1, 2016 and applications will be accepted and reviewed until the position is filled. All application materials must be electronically submitted to the Missouri University of Science and Technology's Human Resource Office at http://hr.mst.edu/careers/academic/. All submitted application materials must have the position reference number in order to be processed. Acceptable electronic formats that can be used for email attachments include PDF and Word; hardcopy application materials will not be accepted.

Missouri S&T is an AA/EEO employer and does not discriminate on the basis of race, color, religion, national origin, sex, sexual orientation, gender identity, gender expression, age, disability or status as a protected veteran. Females, minorities, and persons with disabilities are encouraged to apply. The university participates in E-Verify. For more information on E-Verify, please contact DHS at: 1-888-464-4218.

UNIVERSITY of HAWAI'I MĀNOA

Assistant Professor (Mechanics: Mechatronics), position number 0082783, University of Hawaii at Manoa (UHM), College of Engineering (COE), Department of Mechanical Engineering, invites applications for a full-time, general funds, tenure track, faculty position, pending position clearance and availability of funds, to begin approximately August 1, 2016.

The University of Hawai'i is a Carnegie doctoral/research-extensive university with a strong emphasis on research and graduate education. The Department offers B.S., M.S., and Ph.D. degrees in mechanical engineering, and its undergraduate program is ABET accredited.

For more information on college research themes, please visit our college web site at www.eng.hawaii.edu. The department has active research programs in robotics, control systems, dynamical systems, nanotechnology, corrosion, biotechnology, biomedical engineering, space and ocean science & exploration, renewable energy systems & sustainability, combustion, boiling and two-phase flow, multidisciplinary design and analysis optimization, and high-performance computing.

This faculty could potentially work with UHM School of Ocean and Earth Science and Technology (SOEST) & Institute for Astronomy (IFA) and also contribute to the UH-iLab, Makers, VIP, and Entrepreneurship programs of the College. This faculty can also contribute to the following COE Research Clusters: Autonomous Systems (e.g., UAS, AUV, etc.) and Robotics, Biomedical Engineering, Renewable Energy and Island Sustainability, and Sustainable Materials and Manufacturing Technology.

Duties: Teach and develop undergraduate and graduate courses in Mechanics, Mechatronics, and Engineering Design. Develop externally funded research programs that result in publications in leading scholarly journals; present research work in leading scholarly conferences; supervise graduate students; teach via various distance delivery modes as required; and serve on departmental, college, and university committees.

Minimum qualifications: An earned Ph.D. (All-But-Dissertation, ABD, cases will be considered) in Mechanical Engineering or a closely related field. The candidate should have a background in Mechanics and Electronic aspects of Advanced Systems (such as Robotics, Applied Controls, Biomedical, Design Innovations, Renewable Energy, Manufacturing Technology, and Internet of Things-IoT). The candidate should have experiences in design, analysis, fabrication, and testing of mechatronic systems. Candidates must also show a strong commitment to teaching excellence and mentoring at the undergraduate and graduate levels.

Pay range: Commensurate with qualifications and experience.

To Apply: Only electronic applications are accepted. Applicants should follow the instructions at http://www4.eng.hawaii.edu/apply for submission instructions (The applicants should submit a cover letter specifying the position and the research area; a statement on their research interests, activities, and plans; a statement on their teaching philosophy, interests, and plan; a curriculum vitae detailing research and teaching accomplishments; copies of up to 4 relevant publications; and the names, addresses, e-mail, and telephone numbers of 4 references). For more information on the Department, please visit our website at www.me.hawaii.edu.

Inquiries: Professor Mehrdad N. Ghasemi-Nejhad, Chair, 808-956-7560, nejhad@hawaii.edu.

Review of applications will begin on February 1, 2016 and will continue until the position is filled.

The University of Hawai'i is an equal opportunity/affirmative action institution and is committed to a policy of nondiscrimination on the basis of race, sex, gender identity and expression, age, religion, color, national origin, ancestry, citizenship, disability, genetic information, marital status, breastfeeding, income assignment for child support, arrest and court record (except as permissible under State law), sexual orientation, national guard absence, or status as a covered veteran.

Individuals with disabilities who need a reasonable accommodation for the application or hiring process are encouraged to contact the EEO/AA coordinator(s) for the respective campus.

Employment is contingent on satisfying employment eligibility verification requirements of the Immigration Reform and Control Act of 1986; reference checks of previous employers; and for certain positions, criminal history record checks.

In accordance with the Jeanne Clery Disclosure of Campus Security Policy and Campus Crime Statistics Act, annual campus crime statistics for the University of Hawai'i may be viewed at: http://ope.ed.gov/security/, or a paper copy may be obtained upon request from the respective UH Public Safety or Administrative Services Office.

The University of Mississippi
Oxford • Jackson • Tupelo • Southaven

Assistant Professor (Tenure Track) Emphasis in Computational Solid Mechanics

The Department of Mechanical Engineering at University of Mississippi, Oxford, MS is seeking to fill a Tenure-Track Assistant Professor position in Computational Solid Mechanics to start in Fall 2016. The computational mechanics topics include but are not limited to: micro/meso-scale solid mechanics, mechanics of biological systems, mechanics of composite materials for energy applications, and multiscale modeling. Candidates should have proven expertise in the development of advanced computational algorithms / theories / modeling of structural, biological, and/or energy systems that are complementary and synergistic with existing research areas in the School. The Mechanical Engineering department has recently built a new blast and impact facility with a high speed three dimensional digital imaging system for studying material/structural response. Modeling and simulation can be performed using computers at the state supported on-campus "Mississippi Center for Supercomputing Research."

The successful candidate is expected to make a significant contribution to the School's research activities and to build a strong, externally funded research program. The candidate should also have a marked interest in, and demonstrated talent for, teaching in both the undergraduate and graduate programs. The candidate is expected to foster a balanced program of research and instruction that integrates the perspectives of computational mechanics, structural dynamics, and materials science. The candidate is also expected to develop strong collaborative research in the area of computational mechanics with faculty performing experimental research in blast response of composite materials, multiscale modeling of biological materials, and energy harvesting systems. An earned Ph.D. in Mechanical Engineering or closely related field is required.

To apply, interested candidates should apply online at jobs.olemiss.edu. Candidates should include a current CV, statement describing research and teaching experience and interests, along with the names of three references and their contact information. In the research statement, the candidate should discuss research plans, possible funding sources, and laboratory requirements.

Review of applications will begin immediately and continue until the position is filled. Any questions regarding this position should be emailed to the Search Committee Chair, Dr. Tyrus A. McCarty at mccarty@olemiss.edu. Women and minorities are encouraged to apply. The University of Mississippi is an EEO/AA/Title VI/Title IX/Section 504/ADA/ADEA employer.

COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

Faculty Position in the "Sensors and Systems" in the Department of Mechanical Engineering

Columbia Engineering is pleased to invite applications for faculty positions in the Department of **Mechanical Engineering** at Columbia University in the City of New York City. Applications at the assistant professor, and in exceptional cases, at the associate professor and full professor levels, will be considered.

Applications are specifically sought in interdisciplinary areas related to the design, analysis, and fabrication of unique sensors, especially at small length scales; and deployment of such sensors into large scale monitoring systems utilizing big data analysis. Candidates must have a Ph.D. or its professional equivalent by the starting date of the appointment. Applicants for this position at the Assistant Professor and Associate Professors without tenure must demonstrate the potential to do pioneering research and to teach effectively. Applicants for this position at the tenured level (Associate or Full Professor) must have a demonstrated record of outstanding research accomplishments, excellent teaching credentials and established leadership in the field.

The successful candidate is expected to contribute to the advancement of their field and the department by developing an original and leading externally funded research program, and contributing to the undergraduate and graduate educational mission of the Department. Columbia fosters multidisciplinary research and encourages collaborations with academic departments and units across Columbia University. **This position particularly seeks candidates whose research focus intersects with the field of data sciences and can take full advantage of the Data Science Institute at Columbia University.** Opportunities exist for collaboration with a broad range of research centers and activities at Columbia University, including but not limited to centers in Materials Science, Photonics, and Neuroscience. The Department is especially interested in qualified candidates who can contribute, through their research, teaching, and/or service, to the diversity and excellence of the academic community.

For additional information and to apply, please see: http://academicjobs.columbia.edu/applicants/Central?quickFind=61656. Applications should be submitted electronically and include the following: curriculum-vitae including a publication list, a description of research accomplishments, a statement of research and teaching interests and plans, contact information for three experts who can provide letters of recommendation, and up to three pre/reprints of scholarly work. All applications received by December 31, 2015 will receive full consideration.

Applicants can consult www.me.columbia.edu for more information about the department.

Columbia is an affirmative action/equal opportunity employer with a strong commitment to the quality of faculty life.

Assistant Professor
Mechatronics/Mechanical Engineering Technology (Multiple Positions)

CUNY NYC College of Technology

New York City College of Technology of the City University of New York (CUNY), a comprehensive college of over 17,000 students in downtown Brooklyn, offering associate and baccalaureate degrees, invites applications for a tenure-track position in Mechanical Engineering Technology focusing on Mechatronics at the Assistant Professor level, to begin during the Spring or Fall 2016 semesters. The Mechanical Engineering Technology department has a full-time faculty of 8, supplemented with part-time faculty members. It offers Associate in Applied Science degrees (AAS) in Mechanical Engineering Technology and Industrial Design Technology and a Bachelor of Technology in Mechanical Engineering Technology. The department is developing a concentration in Mechatronics. The Mechanical Engineering Technology programs are accredited by ETAC/ABET. The successful candidate will be expected to develop and teach courses in areas such as control systems and mechatronics, instrumentation, and robotics, as well as conduct research, develop new courses, and engage in service activities. Teaching areas will include: mechatronics, instrumentation, robotics, design, and manufacturing processes. Performs teaching, research and guidance duties in area(s) of expertise. Shares responsibility for committee and department assignments including administrative, supervisory, and other functions.

QUALIFICATIONS - A PhD is strongly preferred. Prior teaching is highly desirable. A minimum of ten years of industrial experience in mechanical engineering, manufacturing, or a related field is essential, as is proficiency with CAD/CAM/CNC, and Finite Elements. Candidates with a minimum of a master's degree in mechanical engineering or mechanical engineering technology (or closely related field) plus a PE license who have strong industry experience can be considered. The candidate should be able to demonstrate a strong working knowledge of various elements of mechatronics design and fabrication including but not limited to control systems, control electronics, digital control systems, and mechanical systems. In filling this position, the Department seeks leadership qualifications and skills needed to formulate and direct a growing mechatronics program. Additional desired experience includes: proposal/grant solicitation and management skills, experience working in a collaborative multidisciplinary environment, and an interest in developing and fostering public-private partnerships and industry related student internship programs. Ph.D. degree in area(s) of experience or equivalent. Also required are the ability to teach successfully, demonstrated scholarship or achievement, and ability to cooperate with others for the good of the institution.

COMPENSATION - CUNY offers faculty a competitive compensation and benefits package covering health insurance, pension and retirement benefits, paid parental leave, and savings programs. We also provide mentoring and support for research, scholarship, and publication as part of our commitment to ongoing faculty professional development.

HOW TO APPLY - Visit www.cuny.edu, access the employment page, log in or create a new user account, and search for this vacancy using the Job ID, 13766, or Title. Select "Apply Now" and provide the requested information. Candidates should provide a CV/resume and statement of scholarly interests.

EO/AA Employer

CUNY The City University of New York

THE OHIO STATE UNIVERSITY

COLLEGE OF ENGINEERING

Faculty Position Announcement: Energy Conversion and Storage Systems

The Ohio State University Department of Mechanical and Aerospace Engineering and Center for Automotive Research invite applications for a tenure-track faculty position in energy conversion and storage systems. Candidates will be considered at any rank, commensurate with experience, with preference for a junior or early/mid career position. This position is partially funded by Ohio State's **Discovery Themes**, a significant faculty hiring investment in key thematic areas in which the university can build on its culture of academic collaboration to make a global impact. The position is specifically included in a cohort focused on energy conversion and storage, and related technologies that connect materials science with chemistry and systems. Successful candidates are expected to join a multidisciplinary group of faculty that spans multiple departments, including Mechanical and Aerospace Engineering, Materials Science and Engineering, Chemical Engineering, Electrical Engineering, Chemistry, and Physics.

This hire is affiliated with the **Ohio State's Center for Automotive Research** and is a key element in the creation of a new, multidisciplinary energy research hub. The hub is part of a world-class network of laboratories and centers supporting energy research including the Center for Electron Microscopy and Analysis, CEMAS (http://cemas.osu.edu) and Nanotech West (http://www.nanotech.osu.edu) as well as the many laboratory and test bed facilities of the Center for Automotive Research (http://car.osu.edu) where 50 staff support the research and educational activities of over 80 graduate students and faculty from five different colleges, with annual expenditures in excess of $10M.

In addition to demonstrating academic and scholarly excellence in his or her own field, the candidate is expected to participate in the development of new research programs, and to contribute to the growth of the Center and of the energy research hub by participating in research teams, and by developing new capabilities within existing facilities.

The Ohio State University College of Engineering comprises more than 320 faculty members, offers 16 graduate degree programs in engineering and architecture, and is home to a number of federally-supported research centers, state-supported research and commercialization centers of excellence, and industrial consortia. The College's annual research expenditures were $118M in 2014, and comprise a key component to the University's position as 10th among public universities nationally in research expenditures and 6th nationally in industrial research expenditures. Energy and transportation are among the top research and strategic hiring priorities in the College.

Candidates should hold a Ph.D. in mechanical engineering, or a related discipline. The candidate is expected to build strong collaborations with faculty across the college of engineering and the departments of Chemistry and Physics, to actively participate in multidisciplinary teaching and research activities, and to work closely with the Center leadership in planning and executing strategic initiatives. Experience in mentoring members of underrepresented groups is especially welcome. For consideration, please submit curriculum vitae, statement of research and teaching interests, and the names and addresses of at least three references, in electronic format. Applications should be forwarded to:

MAE-CAR Faculty Search: eng-carfacultysearch@osu.edu

The Ohio State University is committed to establishing a culturally and intellectually diverse environment, encouraging all members of our learning community to reach their full potential. We are responsive to dual-career families and strongly promote work-life balance to support our community members through a suite of institutionalized policies. We are an NSF Advance Institution and a member of the Ohio/Western Pennsylvania/West Virginia Higher Education Recruitment Consortium.' Ohio State is an EEO/AA Employer.

AUBURN UNIVERSITY

SAMUEL GINN COLLEGE OF ENGINEERING

AEROSPACE

Multiple Tenure-track Faculty Positions

The Department of Aerospace Engineering at Auburn University invites applications for **multiple tenure track faculty positions at the assistant or associate professor rank**. Exceptional candidates may be considered for the prestigious Walt and Virginia Woltosz Professorship. Applicants with expertise in all areas related to aerospace engineering are invited to apply. Applicants must have an earned doctorate in aerospace engineering, mechanical engineering, or a closely related field. They will be expected to fully contribute to the department's mission and the development of a strong, nationally recognized, funded research program.

Auburn's Aerospace Engineering has a long-standing legacy that begins at the turn of the twentieth century and extends rather seamlessly from the Wright Brothers to the Space Station, and from the Aeronautical Program that evolved under the leadership of Robert Knapp (1907) to the Aerospace Engineering Department, which took off under the direction of Robert Pitts (1942).

Chartered in 1856, Auburn's unique campus is fabled for its beauty (ranked seventh in the nation). The Samuel Ginn College of Engineering, the most prestigious engineering college in Alabama, produces more than one third of the state's engineering graduates. Its Fall'14 enrollment included 4,618 undergraduates and 921 graduates. The college was recently ranked 28th among public universities while its graduate programs were ranked 37th. Auburn is located 90 miles southwest of Atlanta on I-85, 50 miles of Montgomery.

Applicants can submit a cover letter, CV, research vision, teaching philosophy, and three references at: http://aufacultypositions.peopleadmin.com/postings/1247

Cover letters may be addressed to: Dr. Joseph Majdalani, Search Committee Chair, 211 Davis Hall, Auburn, AL 36849. The applicant review process will begin Dec. 14, 2015 and continue until successful candidates are identified. The candidates selected for these positions must be able to meet eligibility requirements to work in the U.S. at the time of appointment and continue working legally for the proposed term of employment. Additional information may be found at: http://www.eng.auburn.edu/aero/

AU is an EEO/Vet/Disability employer.

University of Nevada, Reno

Professor/Chair Opening in Mechanical Engineering

The University of Nevada, Reno (UNR) invites applications or nominations for the position of Chair of the Mechanical Engineering Department. The Department seeks candidates at the full professor level to lead this dynamic academic unit within a rapidly growing research university. The successful candidate will be expected to enhance the academic programs, advance sponsored research, bring a collaborative leadership style, and serve as a strong advocate for the Department to internal and external stake holders. This individual will lead the Department strategic planning efforts and foster an environment that promotes effective collaboration among the faculty and with other departments. In the last five years, the College of Engineering has witnessed an unprecedented growth in student enrollment and number of faculty positions. The College is positioned to further enhance the growth of its students, faculty, staff, and facilities as well as research productivity and graduate and undergraduate programs.

Mechanical Engineering is one of five departments in the College of Engineering and currently has 17 tenured and tenure-track faculty members. The Department offers B.S., M.S., and Ph.D. degrees in Mechanical Engineering, is ABET accredited, and has approximately 700 undergraduate and 40 graduate students. Over the last ten years, the Department has averaged $1.9 million/year in research expenditures, and placed emphasis on pursuing nationally-competitive grants, publishing in reputable journals, increasing the Doctoral program, enhancing collaboration with industry, and providing high-impact outreach and national professional service. For more information please visit http://www.unr.edu/me/.

Required Qualifications: The successful candidate must hold an earned doctorate in Mechanical Engineering or a closely related field. The candidate must have a record indicating a strong potential of professional and academic leadership, and a distinguished national and international reputation in research. The qualifications must be consistent with the rank of a full professor.

Applicants must submit a current curriculum vitae, a letter of interest that addresses qualifications, experience and expectations, and a list of five references. Nomination letters should include contact information of the nominee. Applications must be submitted online at: https://www.unrsearch.com/postings/19273. Review of applications will begin on February 1 2016. The position is available effective July 1, 2016. Salary, benefits, and startup package will be competitive.

The University of Nevada, Reno is committed to Equal Employment Opportunity/Affirmative Action in recruitment of its students and employees and does not discriminate on the basis of race, color, religion, sex, age, creed, national origin, veteran status, physical or mental disability, and sexual orientation. The University of Nevada, Reno employs only United States citizens and aliens lawfully authorized to work in the United States. Women and under-represented groups are encouraged to apply.

UC San Diego

Structural Engineering

THE UNIVERSITY OF CALIFORNIA – SAN DIEGO, Department of Structural Engineering (http://structures.ucsd.edu) has opened a search for a **faculty member at the Assistant Professor level** with demonstrated excellence in teaching, scholarship, and professional activity. Specializations in any of the primary research areas within the Department will be considered, with particular emphasis on: (1) Geotechnical Engineering, (2) Advanced Composites and Aerospace Structural Systems, (3) Computational Mechanics, and (4) Structural Protective Systems Against Extreme Events. A successful candidate will be required to teach high-quality undergraduate and graduate courses, develop an active and well-funded research program, and form synergistic connections with other areas in the department and university. An earned doctoral degree or advancement to candidacy in civil engineering, structural engineering, or a closely-related field is required at the time of application. For inquiries specific to the Department of Structural Engineering, contact the Chair of the Search Committee, Prof. Michael Todd (mdtodd@ucsd.edu).

The Department of Structural Engineering houses unparalleled large-scale testing facilities, including the NHERI@UCSD Large High-Performance Outdoor Shake Table, a blast simulation facility, a composite and aerospace structures laboratory, a rail defect testing facility, a high-bay structural systems laboratory and structural components laboratory, a large Caltrans 6-DOF shake table for testing structural response modification devices (SRMD), a 50 g-ton geotechnical centrifuge with shaking table, and multiple non-destructive evaluation/structural health monitoring (NDE/SHM) laboratories.

UC San Diego is an affirmative action/equal opportunity employer, and the Jacobs School of Engineering is committed to building an excellent, diverse, and inclusive faculty, staff, and student body (http://www.jacobsschool.ucsd.edu/diversity/). Candidates with experience with or willingness to engage in activities that contribute to diversity and inclusion are especially encouraged to apply.

For applicants interested in spousal/partner employment, please visit the UCSD Partner Opportunities Program website (http://academicaffairs.ucsd.edu/aps/partneropp/).

Salary: Level of appointment commensurate with qualifications; salary based on UC pay scales.

Closing Date: Applications received by January 15, 2016 will be given full consideration; however, the position is open until filled.

To Apply: The application (curriculum vitae, including a complete publication list, a list of four professional references with contact information, a cover letter which identifies the Department of Structural Engineering as the department to be considered for, a statement of research and teaching interests, and a separate statement describing past experience and activities that promote diversity and inclusion and/or plans to make future contributions), should be submitted electronically to the Jacobs School of Engineering at: (https://apol-recruit.ucsd.edu/apply/JPF00949). For further information about contributions to diversity statements, see: http://facultyequity.ucsd.edu/Faculty-Applicant-C2D-Info.asp

POSITIONS OPEN

ASSISTANT PROFESSOR OF INDUSTRIAL ENGINEERING (16-05) AT FRANCIS MARION UNIVERSITY IN FLORENCE, SOUTH CAROLINA, invites applications for a **TENURE-TRACK POSITION AT THE ASSISTANT PROFESSOR LEVEL** to start August 2016. Qualified applicants with diverse backgrounds and interests are welcome, but preference will be given to those applicants with a background and interest in Advanced Manufacturing and/or Materials Science who possess the ability to teach a variety of industrial engineering classes. PhD in IE or a related field required. Prior teaching experience in an ABET-accredited program preferred. For a complete job description and information on how to apply, please visit http://www.fmarion.edu/about/positions. EOE/AA

THE UNIVERSITY OF SOUTH CAROLINA, DEPARTMENT OF MECHANICAL ENGINEERING, is accepting applications for **A TENURE TRACK POSITION AT THE ASSISTANT PROFESSOR LEVEL.** The position is closely aligned with the SmartState™ Center for Multifunctional Materials and Structures (MFMS) and the McNAIR Center for Aerospace Innovation and Research. For a complete description see http://www.me.sc.edu/employmentopportunities.html . Position requires a Ph.D. in Mechanical Engineering or a closely related field with expertise in the development of design systems for multi-functional structures built from composite, multi-functional materials. Applications should be submitted by email to odonnemc@cec.sc.edu , in the form of a single PDF document, containing: 1) vitae, 2) statement of research plans, 3) statement of teaching interests, and 4) contact information for three references. For full consideration, complete application packet must be received by February 15, 2016. The University of South Carolina is an EO/AA Employer. Minorities and women are encouraged to apply.

UNIVERSITY of VIRGINIA
MECHANICAL & AEROSPACE ENGINEERING

The Department of Mechanical and Aerospace Engineering (MAE), School of Engineering and Applied Science (SEAS) at the University of Virginia (UVA) is seeking candidates (all ranks) in two particular areas: 1) cyber-physical systems and 2) energy transfer. Candidates must hold a PhD or Sc.D. in Mechanical or Aerospace Engineering or a closely related discipline, a record of excellence in research, a commitment to teaching at the undergraduate and graduate levels, and a dedication to service to both the research community and the university.

For cyber-physical systems, the focus is on intelligent, connected and/or autonomous platforms and all areas of mechanical and aerospace engineering will be considered, including but not limited to:

- **Robotics, autonomous drones and/or underwater vehicles**
- **Crash avoidance, automated vehicles and intelligent transportation**
- **Advanced manufacturing systems**
- **Digital communication and control of mechanical systems**
- **High-impulse autonomous launch systems**
- **Counter terrorism and homeland security applications**

Successful candidates will find a stimulating and nurturing academic environment within the department and an abundance of collaboration opportunities with other departments that have strengths in cyber-physical systems.

This search is part of an initiative by the SEAS and the Link Lab (http://linklab.virginia.edu), dedicated to collaborative and interdisciplinary research. In their research statement, applicants should discuss any experiences with or plans for collaborative or cross-cutting research.

To apply, in the area of Cyber-Physical Systems candidates must submit a Candidate Profile through Jobs@UVA https://jobs.virginia.edu, search on posting number 0617535.

For energy transfer, the focus is on computational and theoretical investigation of heat and mass transfer, which can range from the nanoscale to the microscale and to the mesoscale. A scholar will bring expertise to already existing Thermal Management strengths in SEAS and UVA, and will investigate fundamental thermophysics related to innovative solutions in societal challenges and national needs. This faculty hire will complement researchers in MAE and SEAS that examine similar scales in heat transfer, mass transfer, fluid mechanics, solid mechanics, as well as reacting flows and surfaces.

To apply, in the area of Energy Transfer candidates must submit a Candidate Profile through Jobs@UVA https://jobs.virginia.edu under the posting number 0617706.

Please attach a cover letter, statement of research interest, statement of teaching philosophy, CV/Resume, and contact information for 3 references.

MAE is nationally recognized for its active interdisciplinary research and superior education programs and has built up strong thrusts in biomechanics, automobile safety, high-speed propulsion and bio-inspired propulsion, rotating machinery, multi-scale heat transfer, and advanced manufacturing.

SEAS offers a vibrant research culture where innovative, interdisciplinary, and foundational research is conducted in a collegial atmosphere. It is committed to enhancing a culturally diverse community and strongly encourages applications from women, minorities, veterans and persons with disabilities; furthermore, the university is an active dual career employer. The University of Virginia is an equal opportunity and affirmative action employer and is actively boosting the participation of women faculty in science and engineering with the support of a National Science Foundation ADVANCE grant.

Screening of applicants begin on January 4, 2016 and will continue until the positions are filled. Questions about either position can be emailed to Jackie Slaughter-Scott at jls5bc@virginia.edu.

CASE WESTERN RESERVE UNIVERSITY EST. 1826

FACULTY POSITIONS AVAILABLE

The Department of Mechanical and Aerospace Engineering at **Case Western Reserve University** invites applications for two **tenure-track positions** with an anticipated starting date of August 1, 2016 or thereafter. The areas of interest include, but are not exclusive to, intelligent systems, structural and system dynamics, process automation and control, digital design and manufacturing with an emphasis on composite and light-weight materials, mechanistic modeling and simulation, additive manufacturing, smart materials, energy efficiency, and other emerging fields. A doctorate in Mechanical/Aerospace Engineering or a closely related field is required.

The positions will be at the Assistant or Associate Professor levels, although appointment to Full Professor may be considered for candidate with an excellent track record. Applicants should submit a cover letter, curriculum vitae, statements on teaching and research, copy of three representative journal papers, and the contact information of at least four professional referees to MAEfacultysearch@case.edu, in one PDF file. Evaluation of applications will begin immediately and continue until the positions are filled.

Case Western Reserve University is an equal opportunity, affirmative action employer, and is committed to providing employment opportunities to all qualified applicants without regards to race, color, religion, age, gender, sexual orientation, national origin, disability, or protected veteran status.

MECHANICAL ENGINEERING
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For all recruitment advertising opportunities, contact:

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(212) 591-8356
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ASME SETTING THE STANDARD

Assistant Professor
Mechatronics/Mechanical Engineering Technology (Multiple Positions)

CUNY NYC College of Technology

New York City College of Technology of the City University of New York (CUNY), a comprehensive college of over 17,000 students in downtown Brooklyn, offering associate and baccalaureate degrees, invites applications for a tenure-track position in Mechanical Engineering Technology focusing on Mechatronics at the Assistant Professor level, to begin during the Spring or Fall 2016 semesters. The Mechanical Engineering Technology department has a full-time faculty of 8, supplemented with part-time faculty members. It offers Associate in Applied Science degrees (AAS) in Mechanical Engineering Technology and Industrial Design Technology and a Bachelor of Technology in Mechanical Engineering Technology. The department is developing a concentration in Mechatronics. The Mechanical Engineering Technology programs are accredited by ETAC/ABET. The successful candidate will be expected to develop and teach courses in areas such as control systems and mechatronics, instrumentation, and robotics, as well as conduct research, develop new courses, and engage in service activities. Teaching areas will include: mechatronics, instrumentation, robotics, design, and manufacturing processes. Performs teaching, research and guidance duties in area(s) of expertise. Shares responsibility for committee and department assignments including administrative, supervisory, and other functions.

QUALIFICATIONS - A PhD is strongly preferred. Prior teaching is highly desirable. A minimum of ten years of industrial experience in mechanical engineering, manufacturing, or a related field is essential, as is proficiency with CAD/CAM/CNC, and Finite Elements. Candidates with a minimum of a master's degree in mechanical engineering or mechanical engineering technology (or closely related field) plus a PE license who have strong industry experience can be considered. The candidate should be able to demonstrate a strong working knowledge of various elements of mechatronics design and fabrication including but not limited to control systems, control electronics, digital control systems, and mechanical systems. In filling this position, the Department seeks leadership qualifications and skills needed to formulate and direct a growing mechatronics program. Additional desired experience includes: proposal/grant solicitation and management skills, experience working in a collaborative multidisciplinary environment, and an interest in developing and fostering public-private partnerships and industry related student internship programs. Ph.D. degree in area(s) of experience or equivalent. Also required are the ability to teach successfully, demonstrated scholarship or achievement, and ability to cooperate with others for the good of the institution.

COMPENSATION - CUNY offers faculty a competitive compensation and benefits package covering health insurance, pension and retirement benefits, paid parental leave, and savings programs. We also provide mentoring and support for research, scholarship, and publication as part of our commitment to ongoing faculty professional development.

HOW TO APPLY - Visit www.cuny.edu, access the employment page, log in or create a new user account, and search for this vacancy using the Job ID, 13766, or Title. Select "Apply Now" and provide the requested information. Candidates should provide a CV/resume and statement of scholarly interests.

EO/AA Employer

CUNY The City University of New York

R&D Engineers

Creare, a leader in cutting-edge R&D, conducts applied research, develops new technologies, and provides analysis, design, experimental, computational, product, and consulting services to industry and government. Project teams are small and engineer-led, and individuals have significant opportunity to pursue areas of technical interest.

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- **Combustion**
- **Applied Mechanics**
- **Manufacturing Processes**

We are looking for exceptional engineers with the passion, creativity, and skills to pursue varied technical research in a multi-disciplinary environment.

Professional requirements: Ph.D. with exceptional academic achievement and/or Masters with the same plus 5 or more years of relevant industrial experience. Engineering degree majors include: Aeronautical, Biomedical, Chemical, Electrical, Mechanical, and Nuclear.

This position requires U.S. Citizenship or U.S. Permanent Residency.

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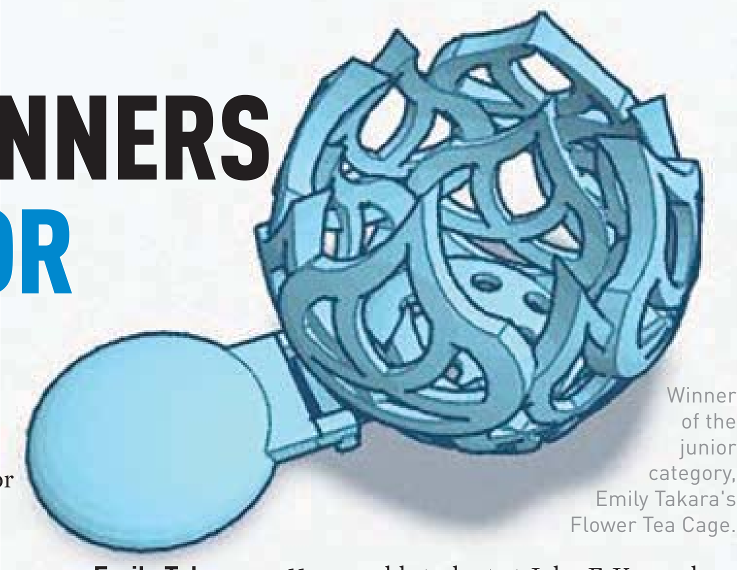
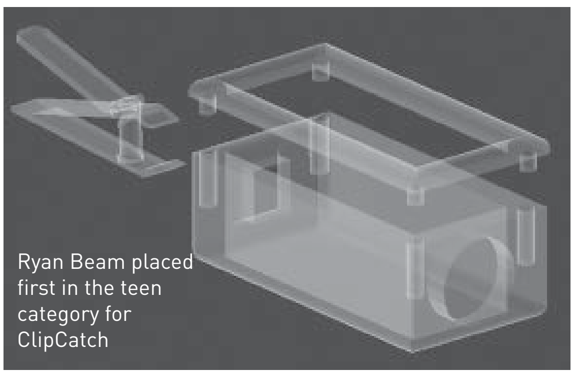


Winner of the junior category, Emily Takara's Flower Tea Cage.

Two middle school students from California developed 3-D models of containers that could be used for various purposes in a microgravity environment. In the process, the two won the Future Engineers 3-D Space Container Challenge, sponsored by NASA and the ASME Foundation.

Now in its second year, the Future Engineers 3-D Space Challenge series was created to inspire students to become young innovators and engineers by enabling them to design 3-D models that could potentially be manufactured in space.

FutureEngineers.org, a newly founded open innovation platform for K-12 student challenges, hosts the competition.



Ryan Beam placed first in the teen category for ClipCatch

Ryan Beam, a 13-year old student at Scotts Valley Middle School, was the grand prize winner in the teen category for ClipCatch, a small rectangular container designed to help keep fingernail clippings from floating throughout the cabin. The container has holes on either end to insert a finger and a set of clippers; the cut clippings are retained in the container for later disposal.

Emily Takara, an 11-year-old student at John F. Kennedy Middle School in Cupertino, was named the winner of the junior category. Her entry, the Flower Tea Cage, is a handheld, spherical plastic cage that astronauts could use to brew and drink tea in microgravity environments, where liquids naturally form spheres and adhere upon contact.

The judging panel for this year's Future Engineers Challenge comprised astronaut **Nicole Stott**; **Niki Werkheiser**, in-space manufacturing project manager at NASA; **Sanjoy Som**, systems engineer, Flight Systems Implementation Branch, NASA Ames Research; and **Mike Snyder**, chief engineer at Made In Space Inc.

For more information on the Future Engineers program, or to see each of the 3D Space Container Challenge entries, visit http://www.futureengineers.org. ME

MAJUMDAR NAMED ENERGY INSTITUTE DIRECTOR

ASME Honorary Member **Arun Majumdar**, professor of mechanical engineering at Stanford University, has been named co-director of the university's Precourt Institute for Energy. The institute supports research and education intended to make the world's energy systems less vulnerable to environmental, economic, and security threats, and more capable of extending modern energy service to billions of underserved people.

Majumdar, an ASME Fellow who is the first Jay Precourt provostial chair professor, joined the Stanford faculty in the mechanical engineering department in 2014. Majumdar is recognized as a leader in energy development and innovation, and his current research focuses broadly on energy conversion and re-engineering the electricity grid. In 2009, Majumdar was appointed the founding director of the U.S. Department of Energy's Advanced Research Projects Agency-Energy, where he carried out transformational R&D in energy efficiency, renewable technologies, and storage systems.

Majumdar serves as co-director of the institute with Sally M. Benson, professor of energy resources engineering at Stanford. ME

Arun Majumdar
Photo: U.S. Dept. of Energy

E4C WEBINAR LOOKS AT OFF-GRID ENERGY

Governments and large non-governmental organizations are working to improve energy access in the developing world, and social enterprises have become important in lighting up dark homes. An Engineering for Change webinar in September covered progress being made in providing energy to areas not served by the electrical grid.

Globally, over 1.2 billion people are without access to an electricity grid. More than 95 percent of them live in sub-Saharan Africa or developing countries in Asia, and 84 percent are in rural areas, according to the International Energy Agency.

Off-grid consumers pay a heavy price for this inequality. In East Africa, for example, a typical family can spend up to 20 percent of its annual income on lighting and cell phone charging.

The E4C webinar featured **Nakul Kadaba**, who manages the project portfolio in India for the Small-Scale Sustainable Infrastructure Development Fund and assists with expanding the organization's Social Merchant Bank Approach to other countries in Asia, and **Lesley Marincola**, the founder and CEO of Angaza, which provides pay-as-you-go energy technology to enable the purchase of solar power.

The webinar was moderated by **Gaurav Manchanda**, CEO of One Degree Solar.

The archive of this and other E4C webinars can be viewed at https://www.youtube.com/playlist?list=PLFC2D8180DF11AAAA. ME

THREE TITLES JOIN CONCISE MONOGRAPHS

ASME Press has published the three new entries in its Concise Monograph Series.

Toward Consistent Design Evaluation of Nuclear Power Piping by Nonlinear Finite Element Analysis by Lingfu Zeng, Lennart Jansson, and Nils-Erik Wiberg is part of the Nuclear Engineering and Technology for the 21st Century Monograph Series. The monograph is focused on commercial software and current practices for power uprate and life extension of aging nuclear power facilities.

Magnetic Bearings for Mechanical Cardiac Assist Devices is part of the Biomedical and Nanomedical Technologies Monograph Series. Written by Steven Day, Shanbao Cheng, and Arnold David Gomez, the text explores the typical structures of passive bearings, which are composed entirely of permanent magnets, and active magnetic bearings, which use electromagnets and position sensors to control the position of the rotor. It also discusses the components of a typical AMB system, including the actuator, position sensor, controller, and amplifier, as well as different structures of electromagnet actuators, coils design, and iron selection.

The third book, *Thermoactive Foundations for Sustainable Buildings*, is the latest monograph in the Technologies for Sustainable Life collection, which explores the interface between engineering and environmental sustainability. Moncef Krarti is the guest editor for this publication, which presents the latest multi-disciplinary advances in modeling, designing, and monitoring thermoactive foundations, also known as thermal or energy piles.

The price for each of the three new titles is $79 for ASME members, and $99 for non-members. To learn more about the books in these series, visit asme.org/shop/books. ME

SECOND ADVANCED MANUFACTURING FELLOWSHIP AVAILABLE

There will be two ASME Advanced Manufacturing Fellowship opportunities at America Makes, located in Youngstown, Ohio, this year. In addition to the position that was announced in 2015, the second one-year fellowship will start in mid- to late 2016.

The ASME Fellow will provide leadership and support in one of the key pillars of America Makes—workforce and educational outreach. Specifically, the fellow will help to develop education and training programs and resources for additive manufacturing implementation and serve as a liaison with partners and policymakers to help America Makes enhance its network of education and workforce development solution providers.

The fellow will also provide scientific, technical, curricular, and intellectual leadership, and analytical support contributing to the advancement of the institute's goals, particularly as they apply to workforce development and educational outreach.

America Makes was created in August 2012 to help the United States develop capabilities in additive manufacturing by facilitating collaboration among leaders from business, academia, non-profit organizations, and government agencies. The institute focuses on areas such as design, materials, technology, and workforce development.

ASME will provide a stipend of $60,000 for this one-year fellowship. All Fellowship Applicants must be U.S. citizens and ASME members at the time of application. The application deadline is January 31, 2016.

For additional information, including the online application, visit http://ppec.asme.org/washington-insider/new-asme-advanced-manufacturing-fellowship-america-makes/.

GREEN LIGHT

How many people does it take to change a traffic light bulb? I count three—one in the lift bucket, one in the truck, and another to direct traffic.

And when the local grid goes down, there is no light at all. And no recourse except to play a game of chicken with other cars until the power comes back up.

When a signal light stops working, it can make for complications—delays in obstructed traffic and an increased risk of accidents.

These are some of the observations that got me thinking about an alternative to conventional traffic lights. I am proposing a solution that will leave the light source away from the roadway and won't require grid electricity. It may also save money.

Instead of incandescent lamps, the design uses light-emitting diodes (which replaced the incandescent lamps in most traffic signals in the country), which can be placed anywhere that's convenient, because the light is carried to the fixture above the traffic lanes by fiber optic cables. The power source is sunlight. Photovoltaic panels power the lights during daylight hours and also charge batteries that keep the light on during the night.

The idea for the power source is not original to me.

Gloucester County in New Jersey has already installed a solar-powered traffic light, in Mantua Township. The power comes from a PV system with battery backup that can send electricity to the grid. The traffic signal power system incorporates six 170 W PV modules and is expected to save up to $550 per year.

In another field installation, University of Nebraska-Lincoln deployed a hybrid solar/wind power system for a traffic signal in its home town. According to a press release, the city of Perris in California was planning to install solar powered bus shelters to power traffic lights and street lights. So there is already a real trend towards bringing solar and renewable energy to traffic intersections.

Fiber optics: A pixelated display, above, and a traffic light mock-up using solid-core fiber.

Integrating fiber-optic technology with photovoltaics and advanced LEDs can develop a demonstrably new and renewable energy technology. After all, these individual technologies have gone through decades of development, so I believe the timing is right.

PV-powered fiber-optic traffic light systems offer significant advantages: minimized liability, ease of maintenance, and energy savings. By integrating PVs with battery backup, the need for utility power is minimized and hazards due to blackouts can be reduced.

Before I joined the faculty at the University of New Haven, I worked for Steven Winter Associates Inc., an engineering and architecture consulting firm in New York. During that time I built a mock-up of the fiber-optic traffic light system.

My colleagues at Steven Winter and I conducted a technical feasibility study funded by the New York State Energy Research and Development Authority. The analysis showed that a 1.5 kW PV system is suitable for a four-lane, four-way intersection. The estimated cost of a PV-powered, fiber-optic light system is about $14,000 with battery backup, and $9,000 for a system without battery backup.

If someone steps up to build a full-scale version for a real-world service, why, you could find yourself driving through an intersection that gives a new meaning to "green light." ME

RAVI GORTHALA is an associate professor in the department of mechanical and industrial engineering at the University of New Haven.

ABSTRACT DEADLINE: MONDAY, MARCH 7

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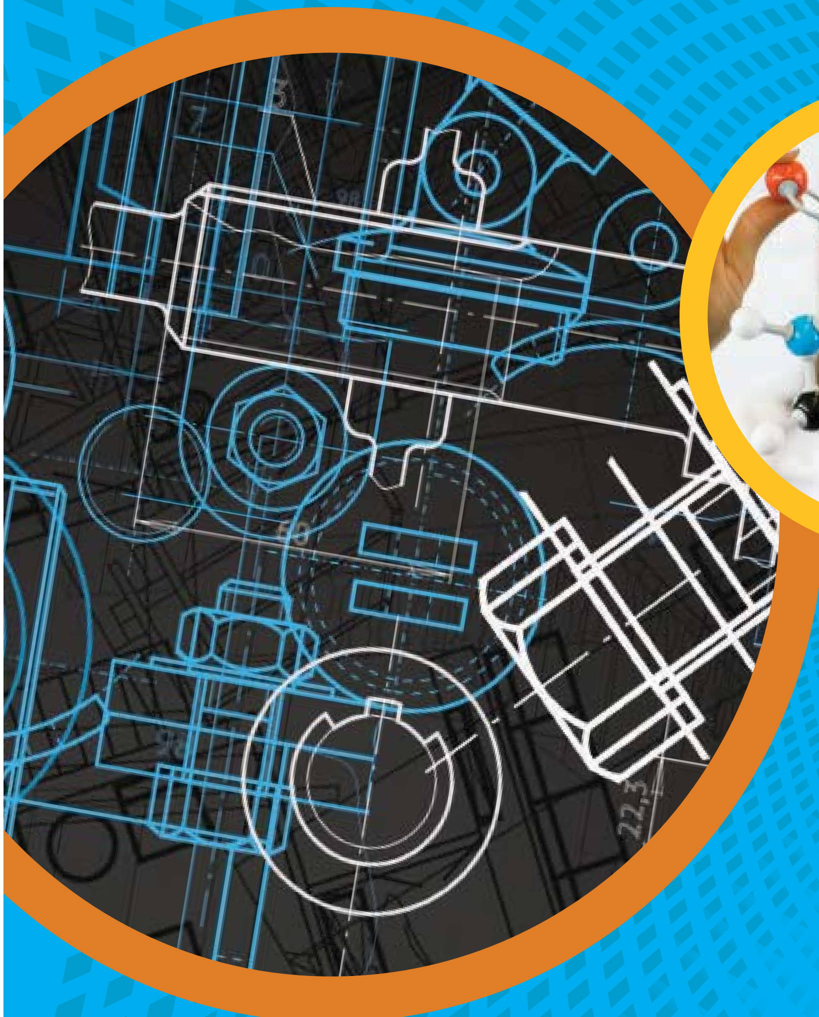

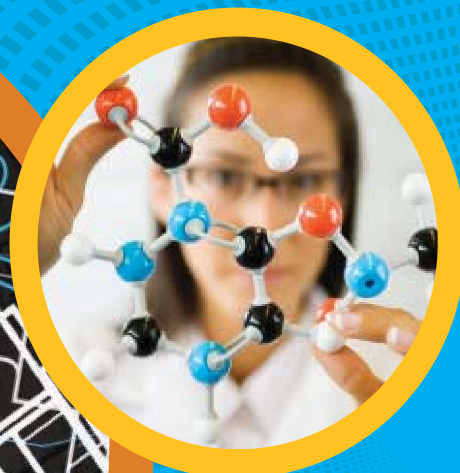

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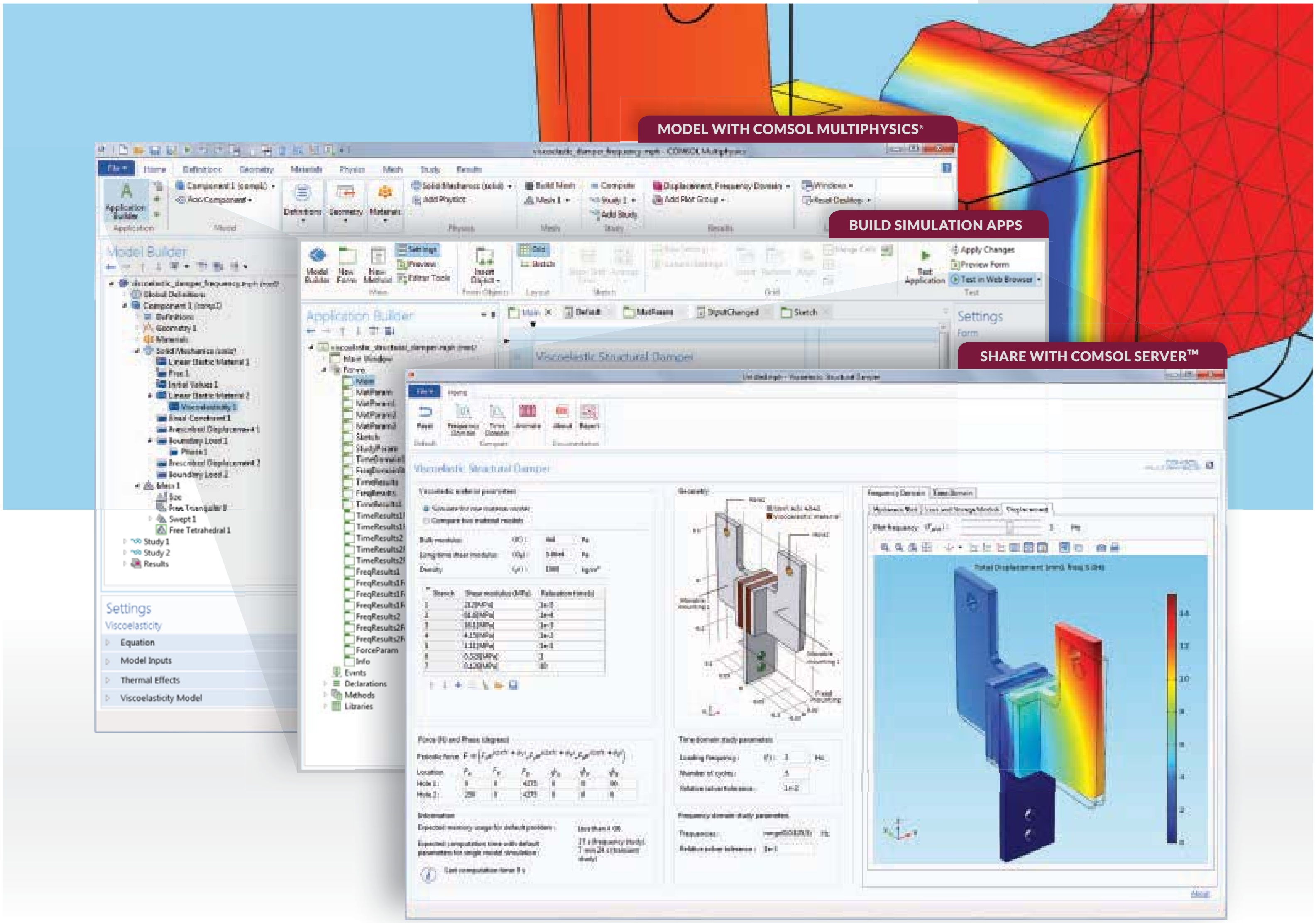

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