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ENGINEERING

THE MAGAZINE OF ASME

No. 08
139

Technology that moves the world

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INTERNET OF HACKABLE THINGS

WHY MATERIALS MATTER IN DESIGN

SECRETS BEHIND HIDDEN DOORS

BIOENGINEERING MAY PROVIDE SOLUTIONS TO JOINT PAIN

THIRTY-TWO PERCENT OF AMERICAN adults experience some kind of joint pain, according to the Centers for Disease Control. And that number climbs as people age. With most Baby Boomers now over the age of 55, joint problems are getting attention in health care and research, and bioengineering may play a key role in treatment and prevention. Knee pain is one of the most common issues but researchers now have successfully grown a meniscus using a 3-D printer. It may help prevent arthritis.

ROBOTIC CATERPILLAR CRAWLS AHEAD

Researchers at the University of Warsaw have created a 15-mm soft-bodied robot that mimics the rippling way caterpillars move along flat surfaces. Designing soft robots calls for a new paradigm in terms of mechanics, power supply, and control.

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ORIGAMI PROVIDES UNEXPECTED INSPIRATION

When considering the inspiration for a new bulletproof shield for law enforcement, origami may not be the first thing you would guess. Yet that is exactly what inspired researchers at Brigham Young University.

MOBILE EYE CARE FOR THE DEVELOPING WORLD

Accessing medical care can be a challenge in remote or developing areas, and eye care is no exception. EyeNetra is creating a system that is both accessible and affordable.

NUCLEAR POWER: SAFETY AND RELIABILITY

Nuclear safety expert Jovica Riznic looks at the current state of nuclear power around the globe, with an added emphasis on his native Canada.

NEXT MONTH ON ASME.ORG

A 3-D-PRINTED SOLUTION FOR INFERTILITY

3-D printing has allowed researchers and doctors to create a number of body parts, including skin and ligaments. Now, it has created a prosthetic ovary that has allowed mice to conceive and give birth. This could be a major change in treating infertility.

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FEATURES

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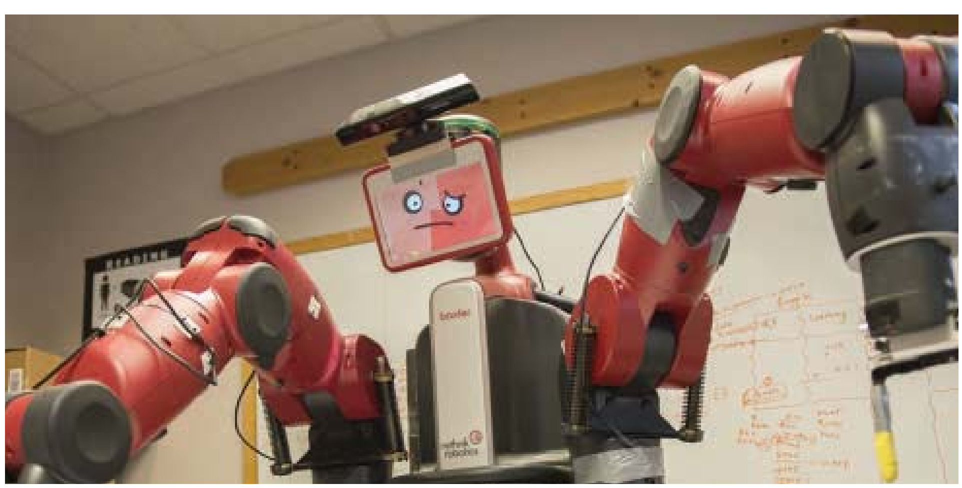

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Give me the place to stand, and I shall move the earth
—Archimedes

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John G. Falcioni
Editor-in-Chief

SMARTEST CITY

Singapore's brilliantly bold skyscraper landscape represents a grand stage where the star performers are the mechanical and electrical sensors, instruments, and controls that turn this island city-state into one of the smartest places on earth.

Under an ambitious Smart Nation program that began several years ago, Singapore has become a test bed for the application of Big Data and Internet of Things innovations and an incubator for technologies that are transforming the way our cities will work in the future.

Marina Bay, Singapore

The backbone of Singapore's increasingly smart infrastructure is a fiber network spanning the 276-square-mile island, bringing high-speed Internet to every home and office. It's no surprise that today Singaporeans average three mobile devices per person. But that is just the start.

The goal of the Smart Nation program is to turn Singapore into a living laboratory, a place to test smart solutions in crowded urban settings. In one Singapore neighborhood, for example, thousands of sensors were installed on individual apartments to measure energy draw, waste production, and water usage in real time. The neighborhood also has gone green with a vacuum waste-management system, solar panels, and a water-reclamation project.

In transportation, Singapore has been at the forefront of autonomous-vehicle testing. Its streets are open to self-driving cars and buses. Small-scale trials of shuttles began at Nanyang Technological University, and MIT spin-off nuTonomy began testing autonomous taxis on city streets.

Even as testing of self-driving vehicles continues, the family of sensors at the heart of Smart Nation is being used to track Singapore's bus fleet. The captured data enable the government to identify problems early on and find solutions.

The idea behind the Smart Nation is to meld technology incubated in the private sector with government efforts to ensure resilience amid turmoil linked to rapid urbanization, climate change, public health threats, unaffordability, and other challenges to national harmony.

Why has Singapore become a Smart City model? Singapore lacks the multilevel bureaucracies that stifle other major cities, engineers here told me during a recent visit. There's also a willingness to spend on infrastructure such as universal high-speed Internet with little or no opposition.

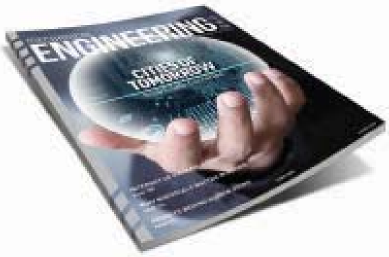
In the context of the IoT, constant connectivity, and complementary infrastructure it all makes sense. But because of Singapore's reputation as a chewing gum-averse, surveillance-happy state, factors surrounding smart city technology start to take on new gravity. With the prospect of sensors connecting homes, cars, infrastructure, and who knows what else in the name of efficiency and ease of use, cybersecurity and data privacy may be hard to preserve.

The glitter that shines off the majestic skyscrapers here hides the strong-arm of government. But as a social and technology experiment, Singapore is hard to beat. This month's cover story, "Building a Smart City" beginning on page 32, tells what one U.S. city—San Diego—is doing to get "smarter." **ME**

FEEDBACK

How much data about your private life are you willing to surrender to live in a smarter city? Email me.

falcionij@asme.org



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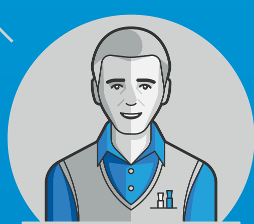

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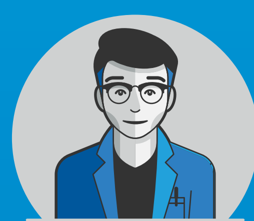

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LETTERS & COMMENTS

MARCH 2017

Reader Grist proposes exploitation of tidal power in the Severn Estuary.

« One reader compares waste-to-energy power plants across decades, while another makes the case for tidal power.

ROAD NOT TAKEN

To the Editor: While the details of the emissions control systems for waste-to-energy plants may have improved, all the various systems were available and considered for use in the 1980s. However, the industry as well as local and state officials often made economic and effectiveness arguments against their use. The result was that while most plants of that era had some post-combustion emissions control, few had the combination described in your February 2017 article on WTE technology ("Clean Power from Burning Trash" by John B. Kitto, Jr. and Larry A. Hiner).

That was shortsighted on the industry's part. If we had deployed the full suite of control systems, public acceptance likely would have been stronger and many more plants would have been built. Instead, by the end of the 1980s, the WTE industry was moribund.

Also, at one time under federal law, WTE plants were entitled to be paid the "avoided cost" for the power generated. In some states laws were passed requiring utilities to pay WTE plants the retail price of power; that is, what the ultimate customer paid. This was clearly a subsidy from the utility as it ignored the not insubstantial cost of transmission. Your article states that the Palm Beach plant sells its electricity to the utility "without a premium." It's not clear to me what this means. Do they sell at a wholesale cost of generation or at retail price without an additional premium?

Finally, I commend the project developers on the low emissions they have achieved. However, they may have overstated their case as compared to natural gas-fired gas turbine plants. While the

Palm Beach plant controls to extremely low levels of dioxins, furans, mercury, cadmium, and lead, gas turbine plants are not even required to control for these compounds as there is no source for them in fuel-grade natural gas.

No specifics were given for particle matter emissions. I expect that even with the SCR downstream of the baghouse filters, there will be some measurable carryover of particulate matter to the stack. While particulate matter can be measured in the stack of a gas turbine plant, it is typically lower than the ambient inlet air.

I spent much of the 1980s developing WTE plants in the Northeast and I wish it the best in resurrecting this technology. If I weren't happily retired, I might jump back in the game.

Brian D. Rodgers, ASME Life Member, *Bellaire, Tex.*

SCALE MATTERS

To the Editor: The March 2017 letter, "A Trickle at Best," draws attention to a perceived deficiency in the U.S. methodology adopted when the value of a relatively small amount of hydropower in future electricity generation is considered. My experience is similar at the other end of the electricity generation spectrum here in the United Kingdom.

The U.K. has the largest untapped source of tidal power in the world, the Severn Estuary. With a tidal range of up to 14.5 m (over 47 ft.) well over 4,000 MW is easily possible for four, six-hour periods each day; 3,000 MW could be produced continuously using "barrage" pier lagoons. Over 70 bidirectional water turbines are required to achieve this.

Such a project could tap experience from such diverse structures as North Sea oil platforms, wind-turbine support columns, and the Thames flood barrier closures—all proven 21st century technologies.

Beyond electricity generation, other possibilities arise. Upper estuary level control would prevent flooding; a nuclear submarine base at the recently decommissioned Oldbury nuclear power station would provide secure Atlantic access and materials storage.

So, when it comes to hydroelectric power generation, there appears to be a lack of engineering clarity on both when it is appropriate to upgrade existing assets and when modern proven designs and experience need to be valued, especially when benefits are multifunctional.

Edward Grist, ASME Fellow, *Congleton, U.K.*

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.

A sensor-filled glove provides doctors with a precise gauge of patients' muscle stiffness.
Image: UCSD

OBJECTIVE TOUCH

Like beauty, muscle stiffness is in the eye of the beholder. That revelation drove researchers at the University of California, San Diego, and Rady Children's Hospital to develop a sensor-filled glove that enables them to better evaluate and treat patients stymied by brain injury, stroke, and such debilitating muscle-control conditions as multiple sclerosis and cerebral palsy.

Doctors traditionally use touch and feel to assess the force and speed at which they can move a stiff muscle. The technique is highly subjective, and two doctors evaluating the same patient often reach very different conclusions.

The glove literally puts a sophisticated measurement instrument into the physician's hand. It uses hundreds of sensors to provide objective feedback about the force a doctor applies to an arm or leg, the speed at which the limb moves, and the threshold at which patients begin to feel discomfort. This information would help physicians prescribe medications more precisely and safely.

The prototype consists of more than 300 pressure sensors attached to the palm of a sports glove with an accelerometer on the back. Advanced signal-processing algorithms analyze and map the data these sensors send back in real time. The result is a numerical reading that more precisely assesses a patient's muscle stiffness.

It may sound simple, but it was anything but. "We thought we'd just put the glove on the doctor's hand and measure how much resistance they were feeling," said research scientist Harinath Garudadri, an associate researcher at UCSD's Qualcomm Institute who leads the project.

Garudadri's original plan was to calibrate the glove to a standard evaluation method known as the Modified Ashworth Scale, a six-point measuring system that doctors score as they move a patient's limbs with their bare hands. When Garudadri asked two specialists to assess the muscle tightness, or spasticity, of five cerebral palsy patients, their assessments agreed a mere 27 percent of the time.

"We didn't expect that," Garudadri said. "This scale was a lot more subjective than we had realized."

The researchers looked for a better

way to calibrate the glove. They ended up with an artificial arm that simulates how humans flex their muscles. Operators manually set the arm's resistance (using a mechanism that works like a bicycle's brakes) between 5 and 20 lb. When the physician moves the arm, onboard sensors compute its resistance, arm speed, and the amount of work the doctor performs.

Then Garudadri and his team played doctor. After setting the arm's resistance, they checked how well the glove measured the power needed to move the arm. The glove got it right 64 percent of the time.

A multidisciplinary team of scientists, students, technicians, and computer programmers has worked to boost the system's reliability by improving the glove's sensors, making them robust, and experimenting with 3-D printing them onto the glove.

Although nothing in medicine is foolproof, Garudadri believes that if the team can increase agreement to 90 percent, the glove would be reliable enough to provide doctors with additional information to supplement the Modified Ashworth Scale. That would be a giant step forward in assessing spasticity, and enable doctors to use the glove to guide treatment options and improve patient care, he said.

Garudadri plans further tests to make sure the doctors are comfortable with the glove's design and the information it provides. After all, he said, "they are the health care experts who make clinical decisions."

Going forward, Garudadri hopes to develop similar gloves for other procedures where doctors now rely on touch and feel to evaluate a patient's condition. These include monitoring spine health, assessing the severity of hip dislocations in infants, rehabilitation therapy, and physical therapy. **ME**

MEREDITH NELSON

BULLET-STOPPING GOO

A soft armor coating has the potential to withstand heavy-duty ballistics.

The stick-to-itiveness of an Air Force Academy cadet and assistant professor created the gooey secret ingredient in an innovative material that can stop a .44 Magnum bullet in its tracks.

Hayley Weir was a first-year cadet in 2014 when a basic freshman chemistry class project sparked her interest. She and fellow students were challenged to create a body armor using three materials: carbon fiber, Kevlar, and epoxy.

"The task to stop a bullet was very basic," Weir said, "but I thought that was really super cool and I wanted to continue research on it."

Weir envisioned a lightweight, flexible anti-ballistic material that wouldn't shatter. She took the advice of a chemistry adviser who suggested she replace the epoxy with a shear thickening fluid.

Air Force cadet Hayley Weir envisioned a flexible anti-ballistic material.
Image: USAF

Selling military and strategic studies professor Ryan Burke took some doing. A perfect fit to team up with Weir on the research, Burke is a Marine veteran who knows his body armor, particularly how bulky, confining, and, above all, heavy it is. But he was skeptical that "any kind of fluid would be able to stop a projectile in many cases traveling over 1,000 feet per second."

Weir pitched her idea using oobleck, a simple non-Newtonian fluid made of cornstarch and water and named after a substance from a Dr. Seuss book. Press gently and the oobleck yields easily, but when Weir told Burke to jam his finger really hard into the mixture, he nearly dislocated the digit. "That's when I understood there is a hardening property behind these fluids and that this was a pretty intriguing idea," Burke said.

In April 2016, Weir and Burke used a KitchenAid mixer and plastic knives to work with ingredients still under a pending patent. But when they began testing the prototype, 20 bullets whizzed right through it.

Frustrated, they began rearranging the layers of material until they hit upon a combination of components that had only been studied before individually. When the tweaked model stopped a 9-mm round, high-fives were exchanged. From there the flattened bullets piled up. In a later test, their prototype stopped three rounds from a .44 Magnum.

That's when the enormity of what Burke called their

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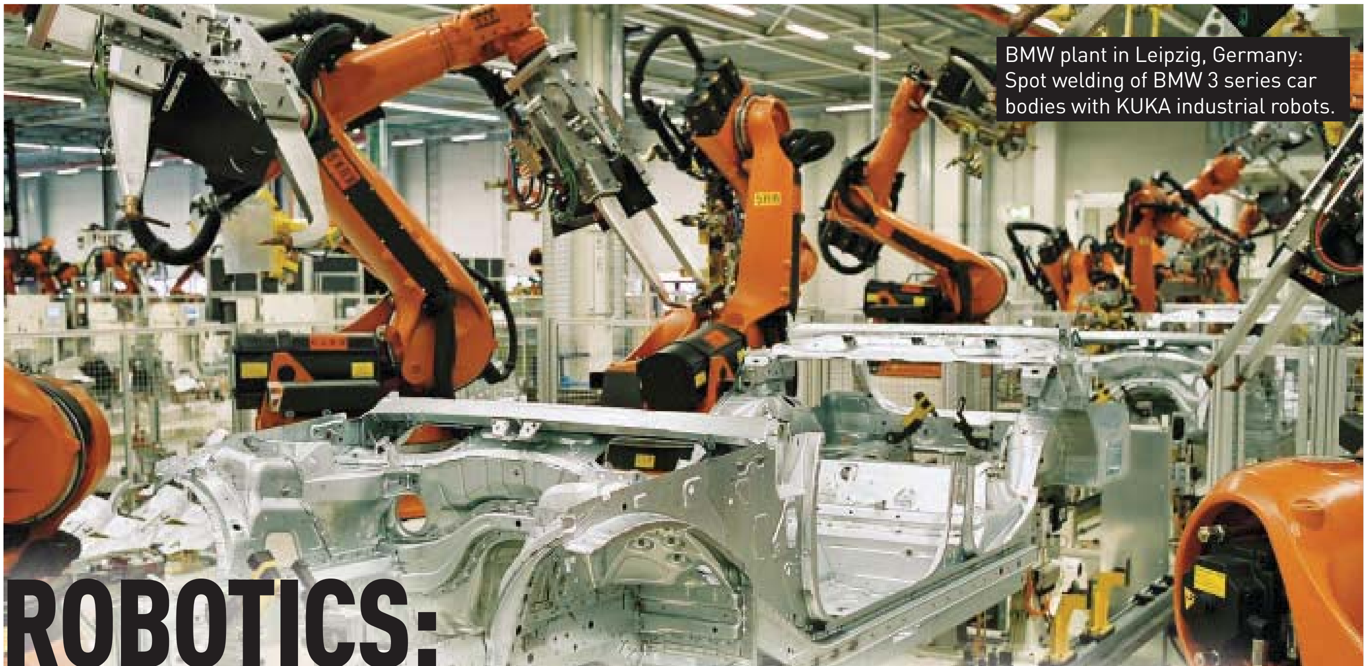

BMW plant in Leipzig, Germany: Spot welding of BMW 3 series car bodies with KUKA industrial robots.

ROBOTICS: THE SOFTWARE STAGE IS HERE

Robotic hardware has more or less arrived, and machines are currently hard at work in a wide range of industries including manufacturing, health care, and more. But the truth is, today's robots are not yet the stuff of science fiction dreams. They are only capable of performing rote, monotonous tasks, aren't good at adaptation, and still struggle with jobs requiring human interaction.

For robots to reach their full potential, then, the software that controls them must catch up with the capabilities of today's hardware. Researchers worldwide are working on this challenge right now, leveraging everything from artificial intelligence and machine learning to Big Data in order to better train robots and more seamlessly integrate them into daily life.

"It really does feel like robotics is exciting again," said Chris Roberts, head of industrial robotics at product development and design firm Cambridge Consultants. "Since the 1970s, there has been this general steady progression of robots getting bigger and more precise and more powerful and more expensive. This hasn't really been a revolution in technology, but lots of individual things getting a bit better. Processors getting a bit faster and sensors getting a bit cheaper. With labor costs going up I expect what we'll see in the next few years is more of the very low-skilled jobs getting automated."

According to Dezhen Song, a professor in the Department of Computer Science and Engineering at Texas A&M University, high-level intelligence for more advanced tasks is still probably five to 10 years off, depending on the task and the robot behavior involved. Simpler, more repetitive tasks—such as picking and sorting produce—could be outsourced far sooner.

"If you want a fully autonomous system that functions like a human, that's probably very far off," he said. "But if you have specifically set up a task you want them to do, then we are very close. We actually are already there for some tasks."

"IF YOU HAVE SPECIFICALLY SET UP A TASK YOU WANT THEM TO DO, THEN WE ARE VERY CLOSE."
DEZHEN SONG, TEXAS A&M UNIVERSITY

To become an autonomous part of the workforce, robots will need to become better at interacting and working side by side with humans, a process that robotics experts refer to as cobotics, literally human-robot collaboration.

"Imagine you've got a robot working at the same lab bench as you and the robot is helping you," Roberts said. "Say you both reach for the same test tube. The robot will stop and it won't hurt you, whereas the last generation of robots would have. That's cobotics. But it's still too hard for that robot to plan around you. So, when you both try to reach for the same test tube it will stop, it won't try to retry, it won't say you're reaching for that so I'll take a different route to get it."

The challenge of cobotics is the fact that humans and robots tend to have overlapping skill sets, so developers need to determine which tasks to assign to robots and which to leave up to humans. It isn't solely a question of creating machines that handle tasks for us, but rather making them flexible enough to know when to step in and help us and when to let us take over.

That's where artificial intelligence and

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SMART TRAPS PREVENT INSECT INVASIONS

A new bug trap in development applies artificial intelligence to the ages-old problem of pest control on farms. AgroPestAlert, a Spanish startup with roots in Chile and Venezuela, is a network of smart traps that capture insects and analyze their wing beats to identify their species and even their sex.

Placed throughout the fields, the traps communicate with the system to predict an imminent invasion. When complete, the system will send alerts to phones, tablets, and computers, and use an easy-to-understand visual tool to cue farmers instantly.

"Our traps use an AI algorithm which has already been lab-tested with a precision of about 90 percent," said Victor de Ponte, CTO of AgroPestAlert. "The data is sent in real time to our application in the cloud for its processing, firing alarms when the population surpasses the desired threshold."

The system could cut more than two weeks off the time it normally takes for farmers to become aware of an invasion. Today, farmers often use glue traps. Workers place glued boards throughout the fields, wait two weeks, then collect the boards of stuck insects to take to a lab for analysis.

"This gives enough time for flying insects to reproduce, and by the time the data is processed, the population may have grown a couple of generations, depending on the insect species," de Ponte said.

Better insect control could be a boon for crop producers. Worldwide, crop losses to animal pests and pathogens amount to as much as 18 percent, according to research published in February 2006 in the *Journal of Agricultural Science*.

At the same time, an automated system like this could reduce manual labor on farms by cutting the need for field visits. And with early alerts, farmers may be able to react quickly and reduce their use of pesticides, de Ponte and his colleagues say.

Louis Gerardo Holder, CEO of AgroPestAlert, displays the startup's prototype at Orizont.
Photo: AgroPestAlert

The traps employ a bi-dimensional laser beam and a suite of off-the-shelf, low-cost environmental sensors. When an insect crosses the laser, the interruption trips a photosensor battery that records the spectrum of wing beats. The traps communicate through GPRS mobile radio technology (2G and 3G mobile service), but that could change.

"Our goal is to make them communicate in a mesh-like topology, with gateways scattered over a certain number of traps, to reduce communication costs," de Ponte said.

The AgroPestAlert team is training the algorithm and experimenting with other metrics from its environmental sensor suite that can lead to better insect identification. Some of those include temperature, atmospheric pressure, wind speed and direction, soil pH, and relative humidity.

To reduce costs, the system is built with open-source technologies, with the exception of its proprietary algorithm, the preprocessing of the audio signal, and the communication protocol between the traps.

"This technology makes ours one of the cheapest automated solutions in the market for pest population monitoring," de Ponte said.

As such, the startup has attracted attention and assistance internationally from the private and public sectors.

Some of those include the Spanish Navarro Institute of Agricultural Technology and Infrastructure, the international food corporations Florette and Gelagri Iberica, and the accelerators Imagine Business Lab in Chile and Orizont in Spain. The team partnered with and received funding from SODENA, a government-operated business development agency in Navarra, Spain. Another accelerator, Orizont, provided funding and the team has an agreement with the Fruit Development Foundation in Chile, which provides lab-grown insects for testing and access to its entomologists.

Field tests of the wing beat algorithm are under way and the visual tool is in development. AgroPestAlert hopes to launch publicly in early 2018. ME

ROB GOODIER is Managing Editor at Engineering for Change. To read more about development engineering, go to Engineeringforchange.org.

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MATERIALS: BULLETPROOF GOO

"backyard scientist project" sunk in.

In its current state, a bulletproof vest is still quite a ways off. For now the focus is on developing the material for tents, armored vehicles, and aircraft casings. Engineers will work to improve it to withstand rifle rounds and other heavy-duty ballistics. The possibilities, Weir contends, are endless, including in the civilian world for emergency barricades and ballistic shields.

As for realizing her personal goal of fine-tuning the material to one day maybe save active-duty Marines, Weir, who graduated in May, is off to a master's program at Clemson University in South Carolina on a full Air Force scholarship with nothing but high hopes.

"I'm very optimistic that continuing the research we can find something," Weir said. **ME**

MEREDITH NELSON is a writer based in New York City.

BIG NUMBER

75%

FRACTION OF U.S. MANUFACTURING CAPACITY UTILIZED IN MAY 2017

CAPACITY UTILIZATION IS A KEY economic indicator tracked by the Federal Reserve Board. When times are good, very little factory floor space sits idle. Back in January 1989, for instance, manufacturing capex (as it is called) was 85.6 percent. Conversely, in the depths of the Great Recession, it fell to as little as 63.7 percent. Since then, manufacturing capex has recovered—settling into a narrow band between 74 and 76 percent—but it is still well below the long-term pre-recession average.

TRANSFORMING ASME AND ENGINEERING

Engineers must **leverage the transformative technologies** changing our profession today.

Engineers live in a world transformed by digital technology. In the past 20 years, everything from how we shop and learn to the way we pilot our planes and drive our cars has changed, often dramatically.

The pace of change is only accelerating as digital technologies, such as ubiquitous sensors, Big Data, and artificial intelligence, connect the physical and digital worlds in new and innovative ways. As mechanical engineers, we must reassess how we prepare for the future if we want to play a role in using these technologies to reshape our traditional domains.

Nowhere do these changes show up as vividly as in manufacturing. Factories have always been agents of societal change. More than 200 years ago, the First Industrial Revolution replaced muscle with water and steam power. This unleashed new mechanical devices that slashed the cost of manufactured goods and gave rise to modern cities.

The Second Industrial Revolution introduced electricity and mass production, bringing automobiles and other sophisticated products within the reach of the average consumer. The Third added automation and control, reducing factory employment while improving the quality of even the most intricate products.

The defining characteristic of the rapidly emerging Fourth Industrial Revolution is the digital thread of information that binds together factory products and processes, from design and production through use and final disposal. Smart machines are already mining this data to optimize throughput, boost productivity, and improve sustainability. Increasingly, they will regulate themselves and perform tasks that call for humanlike judgment.

Manufacturing is not alone. Similar changes are percolating through our economy and our profession. Today, engineers use AI to generate and test CAD designs, medical diagnostics communicate with our phones, and robots work side by side with humans.

ASME is evolving to support the engineering community as we wrestle with how to incorporate the virtual world of sensing, control, and data analytics into the physical world of machinery and mechanical devices.

On one hand, ASME is building on what we have always done: developing standards and certifications and helping engineers apply these best practices through courses, conferences, and publications. Today, ASME does this globally, operating offices in the United States, Beijing, Brussels, and New Delhi.

Yet, despite ASME's global reach, one organization cannot do everything. Instead, ASME's Board of Governors has chosen to focus the society's efforts on five core technologies that reflect our history and strengths. These are areas where ASME already sets standards, or has the potential to improve the safety, reliability, and availability of new technologies through new standards, best practices, and conferences.

These five areas are pressure technology (including the Boiler Code); manufacturing (from digital factories to additive production); bioengineering (for medical devices, prosthetics, and implants); clean energy (production and distribution); and robotics (from deterministic systems to autonomous and mobile robots).

Yet we cannot focus just on these five areas. Today's engineers must understand how to leverage fully the crosscutting technologies—we call them enabling applications—that will inform every design, machine, or product they touch going forward.

Some of these enabling applications are familiar, such as design engineering, sustainability, advanced materials, and nanotechnology.

Others have just begun to make an impact, such as the Internet of Things, Big Data analytics, artificial intelligence, and cybersecurity.

These technologies define the powerful transformative current running through our profession and our economy today. By embracing it, we, as engineers, will discover new perspectives, limitless possibilities—and a new fulcrum on which we can leverage our knowledge to make the world a better and safer place. ME

KEITH ROE, P.E., was the 135th president of ASME.

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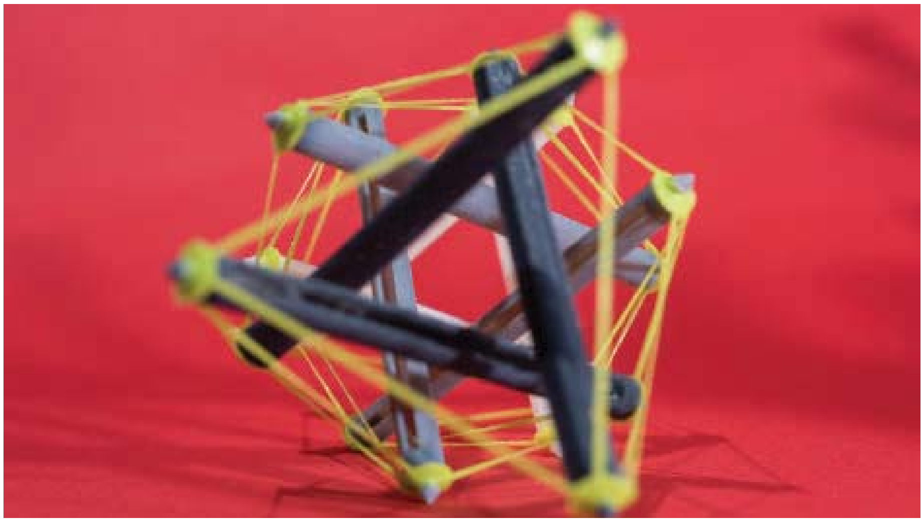


Researchers at the Georgia Institute of Technology in Atlanta have used 3-D printing to create structures capable of dramatically expanding and changing shape through the principle of tensegrity.

Championed by Buckminster Fuller in the 1950s and 1960s, tensegrity—a portmanteau of the words *tension* and *integrity*—is a concept whereby lightweight structures made of isolated rods are kept stable through the tension applied by connecting cables.

According to Glaucio Paulino, a professor of civil and environmental engineering at Georgia Tech, the goal of the research is to deploy a large tensegrity object that can be packed into a very small volume. To do that, the team needed to design struts that start off folded up and then expand one by one to push against the connecting cords.

The researchers hit upon printing hollow tubes from shape-memory polymers, a material that can be locked into a deformed shape when cool and then returned to its original when reheated. Printing the tubes and the connecting cables was relatively straightforward, but a bigger challenge was controlling the tensegrity structures' rate and sequence of expansion, to keep the whole process from becoming a tangled mess. The team was able to fine-tune the expansion temperature of each strut so that they would unfold one at a time.

"We believe that you could build something like an antenna that initially is compressed and takes up little space," said Jerry Qi, a professor in the George W. Woodruff School of Mechanical Engineering at Georgia Tech, "but once it's heated, say just from the heat of the sun, would fully expand." ME

Q&A CHARLA WISE

ASME'S NEW PRESIDENT, Charla Wise, has worked in a variety of capacities during her more than 25 years in the aerospace industry, including Vice President of Engineering and Vice President and Program Director for the F-22 Aircraft FW Team. Wise has served in numerous Society positions, including member of the ASME Board of Governors from 2011 to 2014, chair of the Strategic Growth Task Force from 2011 to 2013, chair of the Industry Advisory Board from 2008 to 2011, vice chair of the Committee on Honors from 2009 to 2011, and member of the ASME Foundation Board from 2005 to 2011. Wise is also the recipient of several ASME accolades, including the Henry Laurence Gantt Medal in 2006.

ME: Tell me about your early years, when you were a child.

CW: I grew up in Michigan as the middle child with two sisters. My favorite subjects were math and science. Some of my closest friends today are the friends I made back in kindergarten and in high school. My dad was an entrepreneur who owned a grocery store and later a mobile copy service. He fought in World War II and taught me how to fight for what's important and to keep trying even when things go wrong. My mom was both a stay-at-home mom and later a career woman. She was math- and science-oriented and a pilot. She encouraged me to pursue engineering and made me believe I could do anything I set my heart to.

ME: What would your high school teachers say about you, and what did you do outside of class?

CW: In high school, I was studious and somewhat quiet. My high school counselor encouraged me to pursue engineering. Outside of school, I was involved in Junior Achievement, I worked in a guitar studio, and was a bank teller.

ME: Tell me about your career. Did you move into leadership roles quickly?

CW: My first engineering job was with General Dynamics, which is now part of Lockheed Martin, working on the F-16. I eventually moved into program management and into leadership. I became Program Director for the F-16 USAF program, then I became Vice President and Program Director for the F-22 in Fort Worth. Thereafter, I became Vice President of Engineering for Lockheed Martin Aero and then moved to work for corporate and other sectors.

ME: What did you have to learn about leadership that helped you along the way?

CW: There's a long list. Having integrity is first, then to be fair, to listen, to invite everyone to contribute their thoughts and talents. Also, don't avoid addressing the hard issues. Don't let things fester. Be civil and polite. Recognize others' contributions. Say what you'll do and then do what you say.

ME: What do you want to accomplish during your year as ASME President?

CW: First, I'm honored to hold this position and am looking forward to an exciting year. My focus will be on moving ASME along our important strategic path and toward fulfilling our vision to be the essential resource for mechanical engineers and other technical professionals throughout the world for solutions that benefit humankind. We will also continue to communicate the excitement of engineering whenever we can. It's a great career choice!

ME: What advice do you have for early-career engineers?

CW: Many of the same things I would advise anyone else. Work hard and strive for excellence. Maintain your integrity. Seek help or guidance often. Be a team player, but speak up. We all take chances in life, we all fail, so learn from your mistakes.

JOHN G. FALCIONI

HERMES AWARD GOES TO SMART GRIPPER

The Hannover Fair has presented the €100,000 Hermes Award to Germany's Schunk for an intelligent, inherently safe gripping system that mounts on the end of a robotic arm and interacts directly with humans. The award, given by Germany's Hannover Fair trade show, is one of the world's most prestigious industrial technology awards. Schunk is a large manufacturer of machine gripping systems.

The new Co-act Gripper JL1 is fully sensored and designed to recognize and manipulate parts while working safely around people. It is, in many ways, a logical extension of the inherently safe and easily programmed collaborative robot arms pioneered by Rethink Robotics and Universal Robots.

"Manufacturing operations with small production runs, high component diversity, and frequent retooling are only possible if every part of the manufacturing system is intelligent, right down to the end effector level," said Wolfgang Wahlster, CEO of the German Research Center for Artificial Intelligence and head of the awards jury. "Schunk's JL1 is a perfect example of a state-of-the-art, smart end effector."

Schunk's JL1 robotic gripper was recognized for being both smart and safe.

According to Schunk, there are three critical requirements for safe human-robot collaboration: A robot must never lose its grip on an object. It must always detect contact with humans. It must never cause injury when gripping.

The company seeks to satisfy those requirements in several ways. First, the gripper has a positive drive that maintains its grip even if a process is interrupted. Second, it uses data from several different types of sensors to continuously monitor its environment. If the gripper makes unintentional contact with a human, it immediately limits its gripping force. Finally, the gripper itself is all smooth contours without the types of angles and edges that can snag a shirt or hand.

The sensor array is impressive. This starts with a 3-D camera between its opposed jaws. Similar in concept to the camera mounted on the arm of Rethink's Baxter robot, it provides the visual information needed for JL1 to detect a workpiece and plan how to grip it. There are also capacitive sensors to prevent collisions and tactile sensors that differentiate between workpieces and humans.

These redundant systems provide overlapping safety protection. They also help the gripper handle a variety of tasks very flexibly. In fact, the JL1 can identify and manipulate components using defined machining areas, RFID tags, or visual codes.

An integrated touch screen switches smoothly into teaching mode, so workers can grab and manipulate the gripper to show it what they want it to do. A machine learning program then optimizes the routine to make its movements more efficient. The gripper uses either a parallel or angular grip, enabling it to handle a wide range of objects.

Four other products were nominated for the 2017 Hermes Award. One of the more intriguing came from Germany's AGS-Verfahrenstechnik. It developed a system that can lay up to 2 km of power line in a single run. To do this, it encases the power line in a plastic pipe, then pulls the pipe through a water-filled duct. The buoyancy of the plastic in water floats the pipe, reducing tensile loading and making longer runs (and fewer junction boxes) possible.

Other nominees were: Finland's Augumenta, whose software creates augmented reality industrial control panels that technicians can manipulate using hand gestures; Austria's Linz Center for Mechatronics, which developed a sheet metal bending machine that recognizes how metal responds to pressure and automatically adjusts its operation to take advantage of those properties; and Switzerland's Noonee, which developed an exoskeleton chair that enables workers to sit wherever they want.

This year, Hannover Fair gave out a new Robotics Award for the first time. It went to Xstructures, a 2011 startup that developed optimization software for the lines of robots operated by automakers. Instead of improving the precision of an individual robot, the software harmonizes the movement of the entire line so that all the robots work with one another more efficiently. **ME**

ALAN S. BROWN

POWER TRANSMISSION BREAKTHROUGH COULD UNLEASH ELECTRIC VEHICLES

On road trips of the future, drivers might only need to stop for the restroom.

Stanford University scientists have demonstrated the continuous wireless transfer of electricity to an object in motion, paving the way for electric cars that recharge even as they're zooming along the highway.

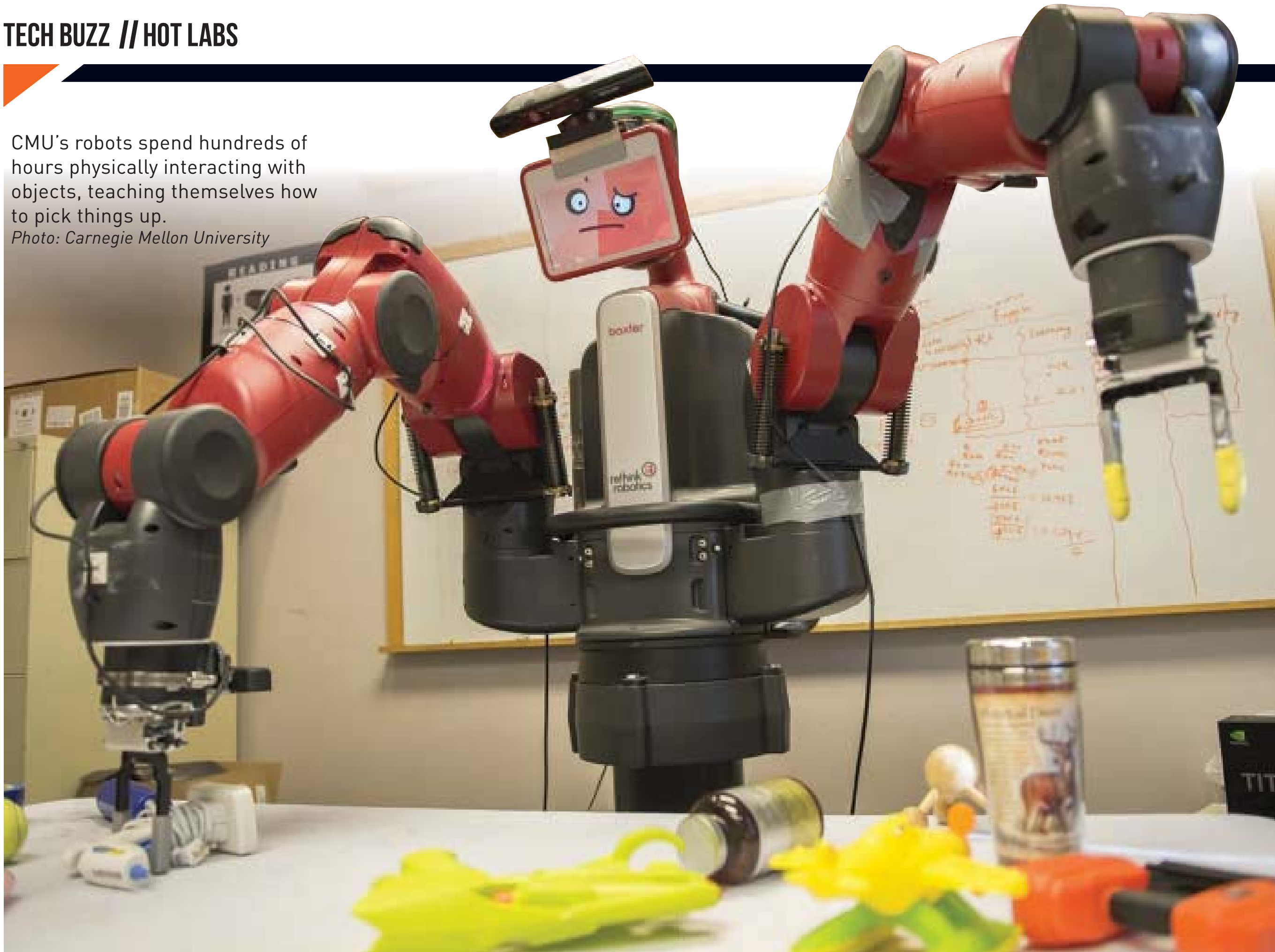
The breakthrough began with magnetic resonance coupling, which was first used at MIT in 2007 to transfer electricity wirelessly over a distance of a few feet to a stationary object. But the researchers found that as the object moved, the steady flow of power could only be maintained if some aspects of the circuits, such as the frequency, were manually tuned—a cumbersome process.

The Stanford team, led by electrical engineering professor Shanhui Fan, solved that problem by replacing the radio-frequency source in the transmitter with a store-bought voltage amplifier and feedback resistor. The system automatically figures out the right frequency for different distances without the need for human intervention.

Researchers demonstrated using two large discs: a stationary source coil generating a magnetic field and a moveable receiving coil fitted with an LED. As the receiving coil moves along a rod toward or away from the source coil, the light maintains a constant brightness over the range of about a meter.

The breakthrough could be a potential boon to manufacturing, enabling factory robots to roam across the shop floor indefinitely. Its greatest promise, however, lies in overcoming the largest obstacle to switching automobiles over to electric propulsion.

Present-day electric vehicles, which store energy in battery packs, have a range of around 200 miles before they must stop for several hours to recharge. A network of smart roadways with charge-as-you-drive coils embedded in the asphalt would allow vehicles to draw electricity continuously from the power grid. Such vehicles would be limited only by the extent of the electric power infrastructure. ME



CMU's robots spend hundreds of hours physically interacting with objects, teaching themselves how to pick things up.
Photo: Carnegie Mellon University

BIG DATA SUPERCHARGES ROBOTIC GRASPING

ROBOTS HAVE PROBLEMS GRASPING and holding everyday objects. The more diverse the objects' shapes and orientations, the more difficult it is for robotic grippers to pick them up without dropping them. Thanks to innovative combinations of Big Data and artificial intelligence, this month's Hot Labs demonstrate that this could be a year of big breakthroughs in grasping.

Infants quickly learn to grasp cups and balls without dropping them, but artificially intelligent robots need tens or even hundreds of thousands of training examples to master the same tasks. Abhinav Gupta, an assistant professor at Carnegie Mellon University's Robotics Institute, has shown he can reduce robot learning times by emulating how babies learn to grasp.

Working with Google, Gupta first tried self-supervised learning, where robots grasp a variety of objects and AI software analyzes the results to improve performance. This takes tens of thousands of training examples, and provides only limited data on whether a grasp is robust or weak.

Infants also test grasps, but with a critical difference. Babies will shake an object they pick up, which makes it less stable. They pull, push, or grab things from people's hands. By constantly testing their grip against opposing forces, they learn what makes a strong, robust grip, Gupta said.

FIGHTING TO LEARN

THE LAB Robotics Institute, Carnegie Mellon University, Pittsburgh. Abhinav Gupta, assistant professor.

OBJECTIVE Leveraging what we understand about cognitive development to improve robotic learning in vision, language, and manipulation.

DEVELOPMENT Improvements in the quality of robotic learning by giving them an adversary that challenges them.

Taking inspiration from infants, Gupta decided to challenge his robots using a technique called adversarial learning. Sometimes, the adversary is a second robot that tries to push or pull the object from the robot's vise grips. Other times, Gupta programs the robot to become its own worst enemy and shake the item it has grasped to see if it falls. With each challenge, the robot improves the quality of its grasp.

The result is faster learning. Gupta initially trained his robot to grasp using 40,000 samples. After 9,000 additional adversarial shaking samples, the robot successfully grasped 58 percent of novel objects, compared to only 47 percent after 16,000 non-adversarial samples.

Gupta plans to expand his research by adding more adversarial challenges, such as changing an object's orientation or hiding it. He is also applying adversarial models to training robots to walk.

"We apply random forces to the heel of a walker to try to destabilize it," Gupta said. "As the robot learns to defeat those forces, it becomes more stable."

His lab is also using supervised learning to improve how robots can work together, and to enhance autonomous drone flights.

"We've crashed into 15,000 walls and use that data to teach drones how not to fly," he said. ME

A robot that trained on virtual models successfully picked up (and shook, to show the grip was solid) 98 to 99 percent of novel objects—and averaged 0.8 seconds per grasp doing it. The work sets new benchmarks for accuracy and speed, and University of California, Berkeley's Ken Goldberg and graduate student Jeff Mahler are discussing the technology with several robotics firms.

The secret behind this performance lies in massive databases. The researchers scoured the Internet for 14,000 open-source CAD files, put them into a consistent format, and made them large enough for a robot to grip. Then Goldberg and Mahler turned to the physics of screw theory, which describes how pairs of 3-D vectors (such as a gripper's two jaws) act on a body.

"If you show me two points on an object, physics will tell me if I can lift that object," Goldberg said.

Yet robots can never grab those two precise points because sensors and controllers always accumulate a few millimeters of error. So Goldberg and Mahler used statistics to vary the grasp points on the object.

"A typical part has 1,000 pairs of facets that I can grab, or 1 million candidate grabs," Goldberg said. "We did 1,000 sample points around each candidate, for 1 billion calculations per object, and we had 14,000 objects."

After several days of computing, his software spit out an ordered ranking of the best places to grip each object. Mahler then converted each object into a map of points, the way a robot's camera would see them. To train their gripper, they simulated dropping each object onto a flat surface. The robot looked at its point cloud and used the ranked grasps to try to pick it up.

This produced 6.7 million samples, by far the most ever used to train an artificial intelligence system to grasp objects. This accounts for the robot's high success rate and speed, Goldberg said.

This system frees robot trainers from the arduous task of physical data collection. It also shows how simulations sharing CAD models and data from working robots could train and improve the performance of future robots. ME

LEARNING FROM VIRTUAL SIMULATIONS

THE LAB Laboratory for Automation Science and Engineering, University of California, Berkeley. Ken Goldberg, director.

OBJECTIVE Improving robot performance, dexterity, and surgical performance through cloud robotics and sophisticated deep-learning methodologies.

DEVELOPMENT A robot trained entirely through simulation rapidly grasps and holds more than 98 percent of all novel objects.

ALAN S. BROWN

DOE AWARDS NUCLEAR GRANTS

THE U.S. DEPARTMENT OF ENERGY in June announced nearly $67 million in awards across 85 projects that look to advance nuclear power technologies. The awards will provide funding for nuclear energy-related research through the Nuclear Energy University Program, Nuclear Science User Facilities, and Nuclear Energy Enabling Technologies programs.

In addition, a number of nuclear technology developers will receive access to research capabilities and other assistance.

The DOE is awarding more than $31 million through its Nuclear Energy University Program to support 32 university-led nuclear energy research and development projects in 23 states. Additionally, 19 universities will receive approximately $6 million for research reactor and infrastructure improvements providing important safety, performance, and student education-related upgrades to a portion of the nation's 25 university research reactors as well as enhancing university research and training infrastructure. **ME**

CHINESE COMPANY CREATES LARGEST DRONE SWARM

Chinese technologists have set a record for largest number of aerial drones flying in formation.

The China Electronics Technology Group Corporation announced in June that it had tested 119 fixed-wing unmanned aerial vehicles, launching them via catapult-assisted takeoff and flying them in predetermined patterns.

The previous record for a drone swarm was 67 UAVs.

The UAV industry in China has grown rapidly in recent years. The drone market in China is expected to reach 75 billion yuan ($11 billion) by 2025, according to the Xinhua news agency.

CETC told Xinhua that its goal was to develop artificial intelligence systems to help foster the growth of unmanned aerial systems.

Low-cost and multi-function UAVs enhanced by AI could be used in a variety of tasks, including emergency search and communications. **ME**

continued from page 12 »

ROBOTICS: GETTING SMARTER

machine learning come in. Deep Learning is a neural network-based approach to machine learning that makes use of today's massive sets of data to train machines on behavior. By using these large data sets, programmers are now able to improve robots' object recognition skills, their natural language processing, their image classification, and more, resulting in smarter machines.

According to Jesse Clayton, senior manager of product management for intelligent machines at Nvidia, three factors have enabled this new approach to machine learning: Big Data, so there is more data available to train neural networks; new training algorithms that are far more efficient than previous generations; and advanced new graphic processing technologies, enabling robots to "see" and perceive more about the world around them.

"The key part is training," he said. "This is where you're exposing a neural network to the sort of data that you want it to learn. So, if you want it to learn to detect people, or you want it to learn to detect cars, or if you want it to learn to detect widgets in a factory, you simply show many, many instances of that data and through that process it learns how to distinguish between cars or people or different types of widgets in a factory."

This is the process by which artificial intelligence becomes "intelligent," and thanks to Big Data and cloud computing, it is accelerating.

"Right now, robots know to pick up a widget from this spot, move it over to this spot and put it back down," Clayton said. "They can't deal well with things like dynamic lighting, changing environments, or changes to a manufacturing line. So, there's a lot of opportunity to automate so many more things throughout the entire industrial supply chain, if robots could be smarter about dealing with more dynamic situations, and also smarter about being able to work with humans."

"IT'S GOOD TO BE OPTIMISTIC, BUT IT'S NOT GOOD TO BE OVERLY OPTIMISTIC ABOUT THIS TECHNOLOGY."
DEZHEN SONG, TEXAS A&M UNIVERSITY

Clayton says he expects Deep Learning to start making real changes to robotics in the next five years, affecting not only manufacturing but a whole host of other industries as well.

Of course, no discussion of Deep Learning and "robots teaching robots" is complete without addressing the risk factors associated with having sentient, autonomous robots in close proximity to humans. By definition, machines are stronger and more resilient than the average person, and that creates a potential danger in the case of a malfunction or other breakdown in the cobotics working relationship.

This has not gone unnoticed by researchers.

"With robots, we're going to have situations where they might work in some environments, situations where I can control the environment, but might not work when we are in an environment where we cannot anticipate of all the possibilities," Song said. "So, we will have to be very careful. We have to have a fence, and within the fence we know the robot can work safely. The problem is it's not always possible to establish that fence, especially as robots start getting closer and closer to humans."

Autonomous driving is a very good example of this, he explained, because in a self-driving car a person is essentially sitting inside a robot that is fully in control of the situation and is driving very close to other people out on the road. This is a car, and it can do real damage—to the occupant as well as others around it—in the event that something goes wrong. The possibility of any sort of accident, then, is unacceptable, and many layers of safeguards must be built in to protect the humans that are interacting with these machines.

This is a process that takes time and careful effort, meaning that the transition to fully interactive robots is going to be slow and methodical.

"It is good to be optimistic," Song said, "but it's not good to be overly optimistic about this technology. We have many years of work to do." ME

TIM SPRINKLE is an independent writer. For more articles on robotics, visit ASME.org.

EFFICIENT ROTOR SAILS SET FOR TRIAL

FINDING AN ENVIRONMENTALLY FRIENDLY SOLUTION in a century-old engineering innovation isn't easy. Finnish company Norsepower has rediscovered rotor sail technology, unveiled in 1924 by the German engineer Anton Flettner, to harness wind energy for electricity aboard large ships.

Norsepower recently announced that it will install and trial Flettner rotor sails onboard a Maersk Tankers-owned vessel.

The company says the project will be the first installation of wind-powered energy technology on a product tanker vessel, and will provide insights into fuel savings and operational experience.

The rotor sails will be fitted during the first half of 2018, before undergoing testing and data analysis at sea until the end of 2019.

Initial estimates from Maersk and Norsepower expect the rotor sail technology to reduce average fuel consumption by 7 to 10 percent on routes with favorable wind conditions. ME

THE APPLICATION OF MACHINERY TO AGRICULTURE

BY O.B. ZIMMERMAN, ASSISTANT TO MANAGER, EXPERIMENTAL AND ENGINEERING DEPARTMENT, INTERNATIONAL HARVESTER COMPANY, CHICAGO, ILL.

An engineer discusses the design challenges of manufacturing farm implements—and how those machines affect not only farmers, but also the wider economy.

LOOKING BACK

The mechanization of agriculture was accelerating when this article was first published in August 1927.

The title of this paper, "The Application of Machinery to Agriculture," furnishes the explanation of how and why it is that the United States outranks the world in agricultural production per man; of why and how, with so small a part of the world's population, it produces so large a part of the world's supply of foodstuffs.

These same six words also help to explain how the United States has achieved and maintains its conspicuous world supremacy in practically all departments of manufacturing industry. A generally accepted estimate shows that if we were compelled to feed and clothe our own population—to say nothing of our vast exports of farm products—by the means and methods available three-quarters of a century ago it would require the presence and labor on our farms of 20 million more workers than are now so employed. In other words, the application of machinery to agriculture sets free from the soil 20 million workers for the service of manufacturing and other industry.

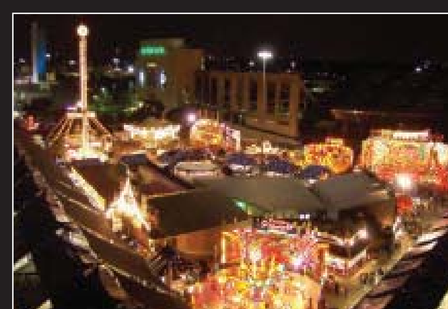
Broadly and practically speaking, the mechanization of agriculture is a new art. It is difficult now to realize that eighty years ago there were virtually no farm-implement factories. Making the few and simple tools that agriculture then knew was the job of the blacksmith, the wheelwright, and the farmer himself; even the farm wagon was often homemade. The contrast between then and now is both striking and significant. Today there is hardly a town too small to have its farm-implement dealer, distributing the widely varied, highly specialized, and constantly improving tools and machines whose range provides some means of dealing effectively with every phase of farm operation.

Again, speaking broadly, the mechanization of agriculture is now passing into its third major phase. First was the period of hand farming that began when, before the dawn of history, the first man scratched the soil with a sharpened stick and planted the seed of some edible wild plant—a period that lasted until the advent of the reaper and the steel plow about the middle of the last century. After that came the period of farming with animal power, and with a rapidly developing line of machines to cover all operations from the making of the seed bed to the harvesting of the crop. Now we are at the beginning of the age of mechanical power farming; we are witnessing today a change almost as revolutionary as that which marked the transition from hand to animal power on the farm.

The effects of these two great advances in agriculture have often been measured in economic and sociological terms. The purpose of this paper is to deal with them rather with a view to outlining some of the mechanical problems involved which may be somewhat unfamiliar to engineers engaged in other fields of industry. ME

THE STATE FAIR

One of the best ways to witness the mechanization of agriculture that Oliver Zimmerman wrote about in 1927 is to attend a county or state fair. The first agricultural fair in North America was held in Manhattan of all places, under the aegis of the Colony of New Amsterdam in 1641. The idea grew and spread widely through the 18th and 19th centuries as farmers shared ideas, competed for prizes, and examined displays of farm machinery for sale. This month, millions of people will attend state fairs in Iowa, Indiana, Minnesota, and elsewhere, but the biggest fair in the U.S.—the Texas State Fair in Dallas—kicks off in late September and runs through most of October.



The Texas State Fair at night.
Credit: Wikimedia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BY THE NUMBERS: BORN TO RUN

There's no need for a tradeoff. Today's cars are able to be both powerful and efficient.

With a base engine output of more than 450 hp, the Chevrolet Corvette gets 29 highway miles per gallon of gasoline.

PERFORMANCE HISTORY OF THE HONDA CIVIC

	Gen 1: 1972–1979	Gen 2: 1979–1983	Gen 3: 1983–1987	Gen 4: 1987–1991	Gen 5: 1991–1995	Gen 6: 1996–2000
Engine Displacement:	1,170 cc	1,335 cc	1,187 cc	1,343 cc	1,343 cc	1,343 cc
Power:	59 hp	44 hp	54 hp	74 hp	74 hp	90 hp
Unladen Weight:	625 kg (1,378 lb)	730 kg (1,609 lb)	785 kg (1,731 lb)	835 kg (1,841 lb)	925 kg (2,039 lb)	940 kg (2,072 lb)
0-100 kph (0-62 mph):	12.5 s	17.5 s	13.3 s	11 s	11.3 s	11.4 s
U.S. Fuel Economy:	28.4 mpg	30.1 mpg	33.9 mpg	36.5 mpg	33.6 mpg	34.8 mpg

Data source: Automobile-catalogue.com

During the oil crises of the 1970s, American car buyers were left with the option of either a powerful but gas-guzzling full-sized car or an economy model that had a hard time reaching highway speeds. Hardly anyone was happy with that choice.

Today, it's much easier to have it all. Thanks to advances in automotive engineering, the average light vehicle sold in the U.S. is larger, nimbler, more powerful, and more fuel efficient than ever before.

According to data from the Office of Energy Efficiency and Renewable Energy, part of the U.S. Department of Energy, the sales-weighted average fuel economy for model year 2016 light vehicles (which includes cars, pick-up trucks, and sport-utility vehicles) is 25.6 miles per gallon. That compares quite favorably with the 19.2 miles per gallon posted by model year 1980 vehicles and the 19.3 mpg for cars in 2004.

There's been no commensurate tradeoff in terms of size or power. Since 1980, when the average car sold weighed 3,228 lb. and sported 104 hp engines, vehicles have bulked up to an average of nearly 4,000 lb. with 230 hp engines.

The average time to go from 0 to 60 miles per hour has also dropped considerably. In 1980, the average car sold accelerated from 0 to 60 in 15.6 seconds; today, it can reach that speed in just 8.2 seconds.

That average is obviously affected by the sales of SUVs and pickup trucks, which now make up more than 60 percent of light vehicles sales. The best-selling vehicle in the U.S. is the Ford F series pickup, which weighs 4,647 lb. and has a 282 hp engine. While the fuel economy for the F series pickup isn't stellar, it is still equal to that of the average vehicle sold in 1980. And some SUVs do quite well. The Honda CR-V, for instance, ranks eighth in U.S. sales and gets 27 mpg and can accelerate from 0 to 60 in under 8 seconds.

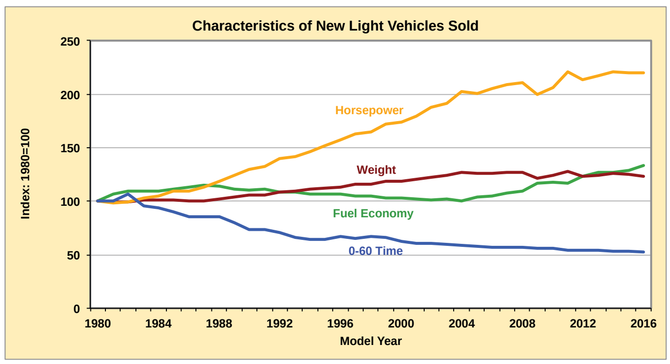


Chart courtesy: Office of Energy Efficiency and Renewable Energy

The recent improvements in fuel economy were shaped by gasoline prices and government mandates, both of which look to be reduced in the coming years. But vehicles like the CR-V show that powerful rides don't need to be gas hogs. ME

JEFFREY WINTERS

Gen 7: 2000–2005	Gen 8: 2005–20011	Gen 9: 2011–2016	Gen 10: 2016-Pres.
Engine Displacement: 1,396 cc	**Engine Displacement:** 1,339 cc	**Engine Displacement:** 1,339 cc	**Engine Displacement:** 988 cc
Power: 89 cc	**Power:** 82 hp	**Power:** 99 hp	**Power:** 127 hp
Unladen Weight: 1,092 kg (2,407 lb)	**Unladen Weight:** 1,165 kg (2,568 lb)	**Unladen Weight:** 1,225 kg (2,701 lb)	**Unladen Weight:** 1,200 kg (2,645 lb)
0-100 kph (0-62 mph): 11.6 s	**0-100 kph (0-62 mph):** 14.6 s	**0-100 kph (0-62 mph):** 13.4 s	**0-100 kph (0-62 mph):** 10.8 s
U.S. Fuel Economy: 37.3 mpg	**U.S. Fuel Economy:** 39.8 mpg	**U.S. Fuel Economy:** 43.5 mpg	**U.S. Fuel Economy:** 59 mpg


The first-generation Honda Civic.

BUILDING A SMART CITY

Cities must master the flow of information to create a digital infrastructure that makes life better.

By John Kosowatz

It was going to be a gleaming ghost town, shimmering amid an arid expanse of southeastern New Mexico. Energy and infrastructure consultant Marble Arch Partners proposed building The Center for Innovation, Testing and Evaluation to do full-scale testing of the smart cities systems and technologies that will define the future of urban development.

The ambitious plan called for spending $1 billion to build an uninhabited city large enough for 35,000 people, fitted with intelligent building, transportation, and energy systems. Without human drivers on the road or children playing in the streets, engineers could test new systems without worrying about disrupting everyday life. Drones could hover over autonomously operated vehicles while streetlights watched buses to see if they were running on time.

Five years after the announcement, ground still has not been broken and the window may be closing. Instead of running tests in the middle of nowhere, cities are installing smart systems at an increasing pace, beginning with pilot projects and expanding them as the results prove out. Using their own infrastructure as a test bed, their results promise to change how cities manage utilities and services while providing citizens with tools to exploit the information they generate.

“THERE ARE SO MANY DIFFERENT TECHNOLOGIES, BUT LIGHTING IS ONE OF THE BIG GROWTH AREAS. LED LIGHTING IS BECOMING THE GO-TO REPLACEMENT TECHNOLOGY.”

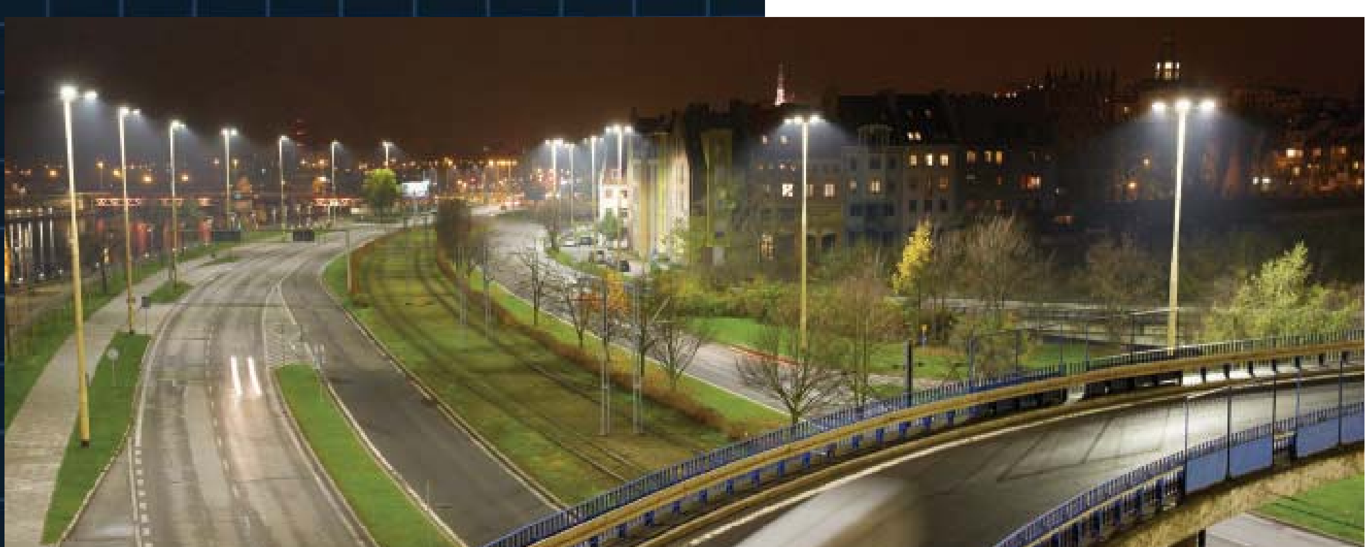
—RYAN CITRON
NAVIGANT ANALYST

According to a report by Navigant Research, smart cities are a global phenomenon. There are 250 projects underway in 178 cities worldwide, with Europe leading the way because of its aggressive climate change policies. The research firm estimates the global market for smart city technologies and services to be worth $40.1 billion in 2017, with growth expected to reach a whopping $97.9 billion by 2026. Barriers to entry are falling as sensors improve and smart technologies grow more efficient, more capable, more interoperable, and less expensive.

In a smart city, wireless motion and flow sensors, low-cost video cameras, temperature and noise monitors, and air quality devices feed data continuously into systems, which use them to control traffic lights, streetlights, pedestrian displays, power distribution and more. Cities use them to monitor traffic, mass transit, pedestrian flows, and crime. All these devices link with rugged wide area networks that send data to the cloud, where powerful analytic engines the data to make cities efficient and safer.

“There are so many different technologies, but lighting is one of the big growth areas,” said Ryan Citron, a Navigant analyst who co-authored the report. “LED lighting is becoming the go-to replacement technology.”

There are two key reasons why LEDs have become the foundational technology of smart city networks, Citron said. First, they offer energy savings of up to 80 percent and a fast payback period. Second, each light carries a microprocessor, making it a potential node in a system that is ideal for setting up a wireless wide area network.



These networks create a scaffold that supports the buildout of future smart system capabilities.

LEVERAGING DATA

San Diego officials are spending $30 million to make their city smarter. The effort, the most ambitious in the world, involves replacing 14,000 streetlights with LED lights and 3,200 sensors. Those sensors will gather information on everything from vehicular traffic and pedestrian movement to changes in air quality. The data will enable the city to reroute emergency vehicles around congestion, smooth the flow of the daily commute, and point drivers to vacant parking spaces as they come available.

Just as important, San Diego's emerging open-source platform will put raw, anonymous data in the hands of entrepreneurs searching for new opportunities and citizens looking for ways to make city life better, said David Graham, the city's deputy chief operating officer.

San Diego has both an educated population and a strong tech startup community, and Graham is actively courting two-way interaction with them by sponsoring hackathons using city data. A favorite that has emerged from those sessions will tell food trucks where people are congregating and where they can park.

Entrepreneurs could also use the data for more traditional market research, analyzing pedestrian traffic to decide where to locate a new retail store or how much rent to charge for commercial property. The system was developed by GE, which now is deploying it through a spin-off, Current. It retrofits existing lighting infrastructure by installing energy-efficient LED lights that are fitted with sensors, controls, wireless transmitters, and microprocessors.

"By repurposing light poles, you can transform to a digital infrastructure," said Austin Ashe, general manager of Current's intelligent cities program. "This becomes a digital engine that extracts metadata from the environment."

Of course, smart hardware needs equally smart software. GE believes that it has a proven system in its Predix software platform, which is already used by industry to generate operating data from factory machines and devices.

In cities, the networked system extracts "very granular" data in real time, and retains historical data it can use to predict trends in the movement of people, traffic, or whatever topic city officials identify.

"It also creates an opportunity to leverage the data with the broader software development community," Ashe said. "It allows the broader community to take the data and transform it into an appropriate application."

In fact, smart city applications generate more data than most cities can use. The volume of data is intimidating, said Ken Thompson, global technology leader for smart cities and sensors for engineering giant CH2M. "It scares a lot of people to death about how to process all of that data," Thompson said.

As a result, many industries and cities today use only a small fraction of the data available to them, he said. In one internal survey, Thompson found that water clients process only about 10 percent of their data. That is not efficient, though it is driving the development of faster analytics engines that can process large volumes of data more quickly.

"That data crunching ability is important," Thompson said, "but when you're developing the technology, you must have a subject matter expert involved." While IT professionals can develop all sorts of algorithms, it takes a subject matter expert—someone who understands city traffic or water distribution—to make sure they are capturing the information needed to make intelligent decisions.

WHILE IT PROFESSIONALS CAN DEVELOP ALL SORTS OF ALGORITHMS, IT TAKES A SUBJECT MATTER EXPERT TO MAKE SURE THEY ARE CAPTURING THE INFORMATION NEEDED TO MAKE INTELLIGENT DECISIONS.

DATA-DRIVEN DECISIONS

GE first approached San Diego when city officials were dealing with the result of years of underinvestment in infrastructure.

"Looking forward, rather than replace what we had with something that was just a little better, it became a conversation about building an intelligent platform," Graham said. The two parties decided to build a pilot network using 40 streetlights in San Diego's East Village neighborhood.

"After putting the sensors in the lights, we developed enough information for a parking application," Graham said. The city found there was a value proposition with parking, and that it could use sensors to identify abandoned vehicles and other roadway threats.

Just by themselves, the upgrade to LED lights made a lot of sense, Graham said. "With 2,000 lights, we found we could save a quarter-million dollars and cut energy use up to 60 percent."

Overall, the city expects a 13-year payback period for the entire project.

Yet the networked smart lights gave San Diego a new way to provide better and more site-specific neighborhoods services. For example, it could dim lighting around the nearby Palomar Observatory and in areas where people need "dark sky," Graham said. At the same time, the city could intensify the lighting elsewhere, depending on pedestrian and vehicular traffic data provided by their sensor.

Like GE, Mumbai-based Tata Consultancy Services provides real-time data and predictive models. It claims that its Intelligent Urban Exchange platform's machine learning technology cuts the payback period for LED lighting almost in half. It uses machine learning to build models that customize the operation of individual streetlights based on such historic data as crime patterns and pedestrian and vehicular traffic. The platform will suggest optimal streetlight brightness and the most cost-effective schedule to save energy.

Tata is using the same platform to optimize public transportation in Belfort, a city of 50,000 in eastern France. Belfort operates 100 buses along five bus routes. Tata's system gathers data such as the number of bus tickets sold and bus speed and location. It is using the data to help Belfort optimize bus schedules to reduce crowding, determine the savings from new road construction projects, and discover ways to reduce costs.

Senthil Gunasekara, who heads corporate development and strategy for Tata's Digital Software & Solutions Group, said his company developed the lighting and transportation applications as part of a staged rollout of smart city applications on a common software platform.

Adding new application modules enables cities to phase in the expansion of their smart city capabilities within a single platform. The software acts like a lingua franca, enabling it to access, exchange, and analyze different types of urban data, from streetlights and transportation to water and electrical systems.

That is a critical capability because most cities already collect a voluminous amount of information. Much of it comes from sensors and reporting systems that have been in place for years. These range from weather stations and traffic loggers to footfall data and crime videos. The software can integrate this data to help city managers make better day-to-day decisions, and to help them manage emergency response during a crisis.

"It can take data from any source, analyze it, and present solutions," Gunasekara said. "The platform is quite open."

SECURING THE NETWORK

Although cities want an open platform, they also want a secure platform to keep hackers from tampering with urban infrastructure, Ashe said. After all, in a system designed to respond automatically to sensor data, every LED light is also a portal into the city's digital control processes.

Most systems use proven methods to discourage tampering. Predix, for example, monitors individual devices and applications for signs of intrusion. It encrypts communications between devices, networks, and the Cloud. The system allows only authorized users to log in and will shut down any user who tries to do something if he or she lacks permission.

New security standards are emerging to bring better security to every device on the smart network. The recently released ISO/IEC 18598, for example, governs the security of the physical elements of automated infrastructure management systems. AIM components include computers, computer rooms, sensors, devices, cables, and all other hardware.

The standard sets out a list of defined features AIM systems must have, said Hans-Jurgen Neithammer, who led the ISO/IEC 18598 project. He is an expert on data center architectures with CommScope, a New York-based firm that builds and manages communication networks.

Under the new standard, AIM systems must know the location of all devices and cabling, and

WHEN A CITY BUILDS A ROAD OR A BRIDGE, IT CONFIDENTLY EXPECTS IT TO LAST FOR 50 YEARS OR MORE. THAT IS NOT THE CASE WITH DIGITAL INFRASTRUCTURE.

be able to identify and block viruses or intrusions at the level of those components. It must also monitor cable ports for "unauthorized changes," even something as mundane as the accidental disconnection of a cable. "When a critical circuit or element is removed, the system sends an alarm to a manager," Neithammer said.

The new standard also mandates secure but interoperable interfaces for software from different vendors. "The software interface is now defined, so no longer does a user have to rely on one vendor," Neithammer said.

This plug-and-play capability will allow cities to integrate new devices and technologies into existing infrastructure without having to worry about the compatibility of proprietary systems or equipment. "That is the biggest advantage from the user side," Neithammer said.

"Interoperability is really important," agreed San Diego's Graham. It gives the city more flexibility in how it deploys future systems, and it also reduces cost, since it opens the door to greater competition.

Yet smart cities will require significant investments that go well beyond the initial build. With digital infrastructure evolving so quickly, municipal officials will probably need to update software frequently to improve capabilities.

Cities will also need new types of professionals to manage and interpret the data. San Diego, for example, has hired a chief data officer to coordinate the integration of its smart infrastructure with various city departments, and a data scientist to monitor artificial intelligence and other technologies that it may one day want to incorporate it into its system.

Cities will also have to rethink what they know about utility service lifecycles. When a city builds a road or a bridge, it confidently expects it to last for 50 years or more. That is not the case with digital infrastructure.

"Everyone needs to understand the lifecycle," Thompson said. "There's a three-to-five year lifecycle for communications systems."

All of this requires significant investments, yet more and more cities seem willing to take the plunge.

In many ways, they have no other choice. The buildout of a private digital infrastructure points the way toward even greater connectivity, and it is happening rapidly whether cities are leading the way or not.

"Everything is moving toward everything within cities being connected," Ashe said. "In ten years or sooner, autonomous cars will be traveling on city streets and they need to know not only where they are going, but what is coming at them and what is around the corner. Drones will be flying overhead. People will have wearable devices constantly communicating."

Cities must learn to master those flows of traffic, energy, and information to create a smarter city that makes life better for those who are connected and those who are not. Either that, or they will descend into digital—and perhaps physical—chaos as independent smart devices create their own ad hoc networks and fight for their own piece of turf.

It is too soon to tell how this will all work out. Yet one thing is certain: Smart city technology is moving so fast, it has no time to wait for a mock city in the desert. It is happening now. ME

JOHN KOSOWATZ is a senior editor at ASME.org.

EFFICIENCY IS EASY TO HACK

As we embed Internet of Things-enabled devices through our physical world, we need to remember to secure them against cyberattacks.

BRIAN DAVID JOHNSON

Connecting an appliance to the Internet provides not only the opportunity for added functions and efficiency but also the potential for hackers to exploit security lapses.

West Point is a strategic location, a high bluff overlooking an S-shaped bend on the Hudson River. During the Revolutionary War, the army that held that spot controlled commerce and communication between Albany and New York City. In 1780, the British were willing to give Benedict Arnold a small fortune to deliver it to them.

Today, West Point is the home of the United States Military Academy. But just south of the academy, in the town of Highland Falls, is a new addition to the country's security infrastructure. The Army Cyber Institute is a think tank chartered to explore the future of cyber threats and what it will mean to the Army five to ten years in the future. It is part of a larger web of institutions and military commands across all the U.S. Armed Forces dedicated to understanding and countering the threat from cyberattacks and information warfare.

We expect the U.S. military to be a lean, mean, fighting machine, so cybersecurity may seem like an esoteric thing for it to be concerned with. But the Armed Forces are grappling with many of the same cybersecurity threats that private companies face. Indeed, part of the mandate for the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Sunday brunch
Water

Cybersecurity experts have demonstrated that Internet-connected vehicles are vulnerable to attack by hackers.

Army Cyber Institute is to bring together military commanders and experts from private industry to discuss and assess these threats and evaluate potential countermeasures.

Last summer, I led an event that tasked a diverse group of thought leaders with envisioning future digital and physical threats. The threatcasting process we followed is a conceptual framework designed to enable multidisciplinary groups to envision and plan in a systematic fashion against threats ten years in the future. From a wide array of multidisciplinary research, groups craft possible visions for the future of digital and physical security.

The goal of event was not only to model multiple future threats, but also to imagine clear next steps that organizations could take to avoid these coming threats. The event provided a platform for thinking and discussing the future, so that all the attendees could continue to process new information and developments.

One of the key findings from the event was that the technological, cultural, and economic shifts and advances in the next decade will bring about a different threat landscape than the one we are used to. To borrow a term from military thinkers, cyber and data security represents a widening attack plain that includes more private citizens, an increasing number of targets, and ultimately a fundamental change in the very nature of security and threat.

More intriguing to me, however, is the unique vulnerability that engineers are unintentionally creating when they build artificial intelligence into highly automated systems.

Globally there is no norm or accepted practice for human oversight of those systems or how—or whether—the "human remains in or on the loop." Humans are slow, error-prone, and costly, so the more a system can operate without human oversight and input, the more potential it has to provide a level of efficiency and productivity that could prove to be disruptively profitable.

As more physical systems undergo a wave of AI-driven automation with the driving factor being efficiency, those systems become increasingly vulnerable to attack. It turns out that efficiency is easy to hack.

The Calculus of Risk

Lt. Col. Joshua Bundt is a computer scientist who has spent 16 years as an officer securing communications and computer networks for the U.S. Army. Today, he is a researcher at the Army Cyber Institute and a professor at West Point, where he teaches program analysis and digital forensics.

"When we're designing for efficiency we try to streamline specific areas like a manufacturing processes, time to market, or a better user experience," Bundt explained. "When we do this we might succeed in making these areas more efficient, but then they are not secure. Because typically systems that are secure are not efficient."

It is possible to design a simple system that is both efficient and secure, but keeping it that way is a challenge. A successful system will face pressure—from internal stakeholders or market forces—to expand. For instance, in the early 2000s industrial and medical equipment began shipping with Windows XP rather than purpose-built operating systems. That made it easier to train new users, but even lightweight versions of a PC operating system are more complex than is absolutely necessary to run industrial equipment. And that increasing complexity creates the opportunities for vulnerabilities to creep in.

Security is an almost unwitting victim of efficiency.

"Complexity and security don't go together," Bundt continued. "It's a well-accepted fact that complexity is the enemy of security. When we try to design secure systems, the basic principles are to keep it as simple as possible. But when we introduce more and more complexity, it's harder to hold to this. It becomes almost impossible to be able to do a formal analysis and confirm that the system acts and behaves in a secure manner."

And while complex software is notoriously buggy, the problem extends to hardware as well. Over the past decade, for instance, our phones have morphed from simple voice transmitters and receivers to Internet-connected devices that form the nexus of personal and professional data networks, and payment by phone is beginning to replace cash in some places. The humble home thermostat and dimmer switch are being supplanted by smart devices that can be operated remotely, and some companies have prototype Internet-enabled refrigerators that would allow users to reorder groceries from a touchscreen panel on the door.

Those added features come at a cost. If the physical system is constructed with efficiency as its first priority, then that system is vulnerable to an individual or group that wants to disrupt, vandalize, or hijack that system. Already, hackers have compromised IoT devices ranging from fridges to toys, and security experts have shown that self-driving vehicles are open to cyberattack. The threat increases as we move into the future, since these bad actors can weaponize data and AI to heighten the intensity and efficacy of the attack.

Most systems today are designed with security as an afterthought. The shipping of an efficient product is rewarded by investors and consumers. At the moment, at least, security is not rewarded by the market, and complex digital systems accept a degree of risk as they take on more complexity or are designed solely for efficiency. If an organization's e-mail server or web application goes down, for instance, usually the organization doesn't shut down fully. Even if the organization faces a larger attack or breach of security, rarely are the consequences dire enough to change the calculus of risk.

"IT'S A WELL-ACCEPTED FACT THAT COMPLEXITY IS THE ENEMY OF SECURITY."

— Lt. Col. Joshua Bundt
U.S. Army

As we see more connected devices make their way into our work and home lives with the IoT, smart cities, and autonomous systems, this lack of awareness of how critical these systems are will become a major vulnerability. Today, these linked systems are not designed or designated as "critical systems." As they grow in sophistication and spread throughout the physical world, these systems will become an important part of our professional, medical, and educational infrastructure.

Unfortunately, until they are treated with the same severity and precautions for redundancy and security as other similar systems, such as the energy grid or water infrastructure, our reliance on IoT and smart systems will leave us vulnerable, exposed to threats, and primed for disruption.

Exploitable Vulnerabilities

The experts brought together for the threatcasting session I held for the Army Cyber Institute were incredibly diverse: not just Army cybersecurity officers, but leaders from the New York City Police Department, Citibank, various academic institutions—even one of the creators behind Marvel Comics' *X-Men*.

During the event, we explored a number of

MOST SYSTEMS TODAY ARE DESIGNED WITH SECURITY AS AN AFTERTHOUGHT. AT THE MOMENT, AT LEAST, SECURITY IS NOT REWARDED BY THE MARKET.

potential scenarios where the interface between the cyber and physical worlds—which allow for increased efficiency when all works as designed—creates an exploitable vulnerability. One scenario involved smugglers who activated malware to swamp the express package delivery system with orders of milk from smart refrigerators, leaving replacement parts for shipping container scanners sitting in the warehouse. With those scanners left unrepaired, contraband—even weapons of mass destruction—could be smuggled in.

The power of the threatcasting process comes from the combined perspectives and the wide variety of domain expertise gathered in the room. The multiple threat futures that were modeled pulled from private industry knowledge, law enforcement experience and best practices, and academic research, as well as military tactics and training. These small teams modeled a person who experiences the threat. The details of the effects-based models then helped the broader group identify how to disrupt, mitigate or recover from the threat. It was the military perspective that gave the group a new way of looking at security and efficiency.

The military is, by design, not efficient when it comes to securing a position. When a company of soldiers is dispatched to a position, they first attempt to make it secure or at least as secure as possible. Then each day the soldiers continue to make the position even more secure. Soldiers are trained to take the attackers' viewpoint, looking for vulnerabilities and guarding against them.

"Every day you're digging your foxhole and making it more secure," Bundt elaborated. "You're checking the perimeter of your defensible position. Then you send people out and they look from the enemy's point of view. They go through every position in your security area and try to detect if there's a vulnerability. Is there a spot where the enemy can approach unseen? We call that a dead zone. That's what makes things secure. We continue to improve our security posture. It comes through iteration."

That sort of intense focus on security has not been rewarded or encouraged in the private sector, where openness and ease of use are attributes that attract customers. As the attack plain begins to expand and digital attacks spread and become individual, physical, or even kinetic in nature, the calculus will change. When a digital hack or vulnerability can turn a trusted personal device—a laptop or automobile—into an improvised explosive device, the perception of vulnerability is radically altered.

How can designers strike the optimal balance between efficiency and security? As we know, complex systems are not just found in the world of technology, and it makes sense to look at older, more established complex systems to see how they have dealt with the issues facing today's designers.

What could we learn about efficiency from biology and life sciences?

"In biology every organism has evolved to a state that is efficient," said Kavita Berger, a molecular biologist at Gryphon Scientific, a small business that specializes in global health security, homeland security, preparedness, and science policy in Takoma Park, Md. "It is operating at efficiency in its environment, and when that environment changes, the organism changes. This is the driving force behind small and large genetic changes. Organisms adapt to new environments. But they have developed redundancies for essential functions to make sure the organisms survive."

That's the paradox of efficiency in biological systems. Evolution forces organisms to be efficient, but to survive organisms also must have some level of redundancy. Those redundancies are essential because naturally occurring mutations may damage certain essential pathways, or a changing environment may make certain functions obsolete. Latent abilities and redundant systems enable organisms to survive and reproduce even in the face of those internal and external challenges.

However, that redundancy by definition makes the organism less efficient.

"In agriculture, farmers grow crops as monocultures, meaning a single variety of plant all of which have the same traits," Berger said. "If you had a field that had different varieties, with inherent diversity, then a pest might affect one group of crops but not the rest. You still have the ability to recover crops. This applies to almost any biological system."

What Are We Optimizing For?

Adapting that notion of redundancy as an essential part of a highly efficient system to engineered products is something engineers are beginning to grapple with.

"In engineering efficiency is a perfectly good concept, but it's a bounded concept that might not apply to the future," said Braden Allenby, president's professor of sustainable, civil, and environmental engineering at Arizona State University in Tempe. "The old way of looking at engineering might apply if I need to create a widget and make it as inexpensive as possible. But that concept might not be applicable if I'm working in an environment that is highly complex and cyberattacks are an issue."

Allenby argues that the shifting focus between efficiency and security is analogous to the one physicists make when they investigate matter at different scales. At the macro scale, Newtonian physics explains the world quite well. But as physicists investigate at smaller scales or try to understand the interaction between minuscule bits of energy and individual molecules or atoms, they need to turn to the tool kit of quantum physics.

"WE NEED TO FIGURE OUT WHERE OUR TRADITIONAL IDEA ABOUT ENGINEERING AND EFFICIENCY IS APPROPRIATE AND WHEN IT'S NOT."

— Braden Allenby
Arizona State University

"We need to figure out where our traditional idea about engineering and efficiency is appropriate and when it's not," Allenby said.

As we prepare for the future we must ask ourselves: What are we optimizing for?

Traditional engineering has long optimized for things like cost, efficiency, or simplicity. But going forward, engineers are going to have to value security just as much. Internet-connected machines and IoT-enabled devices will allow systems to do amazing things, but they also create opportunities for bad actors to turn these systems against us. If we are going to get the full use from these connected machines, engineers must take that threat into account and optimize for security. ME

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MICHELIN
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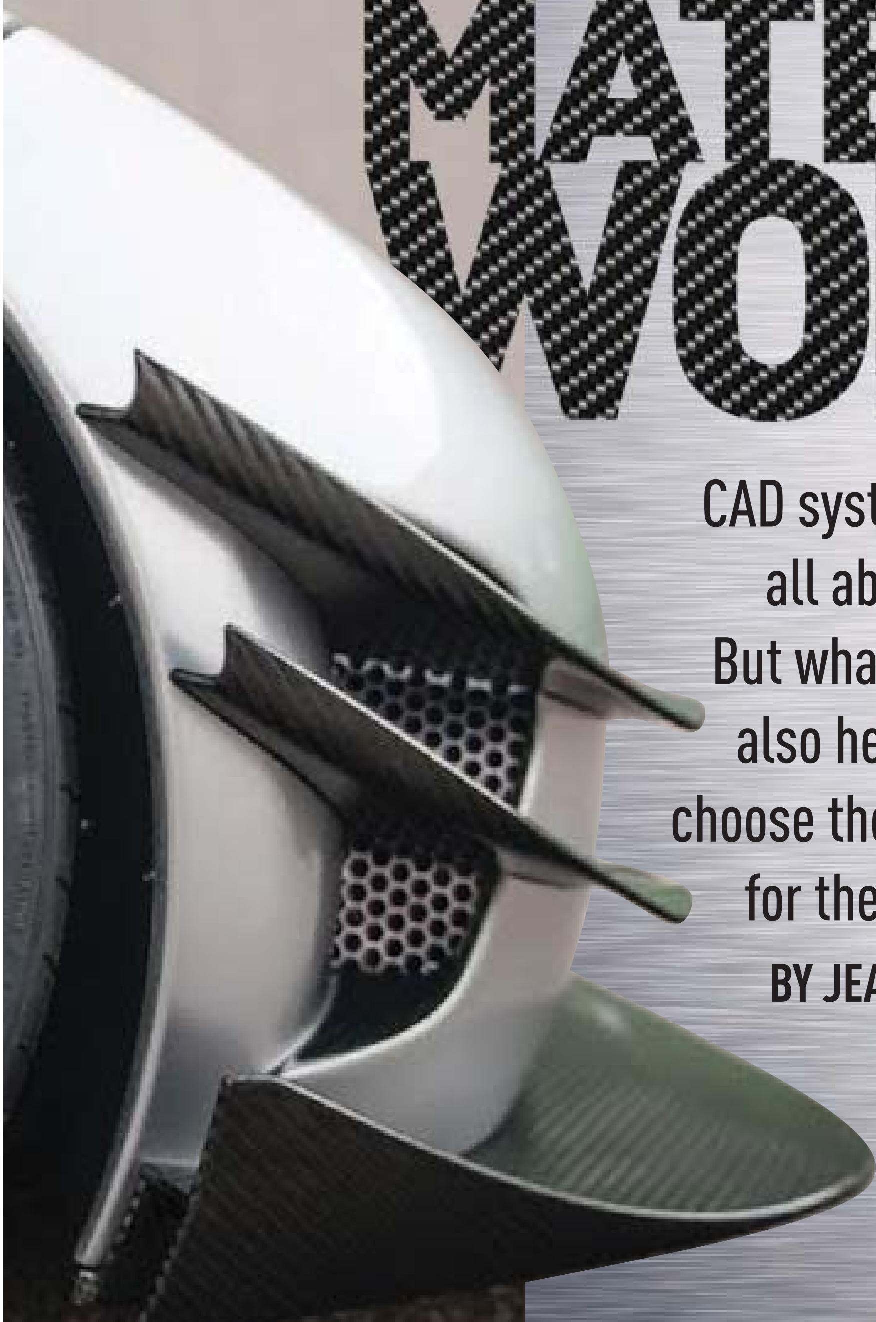
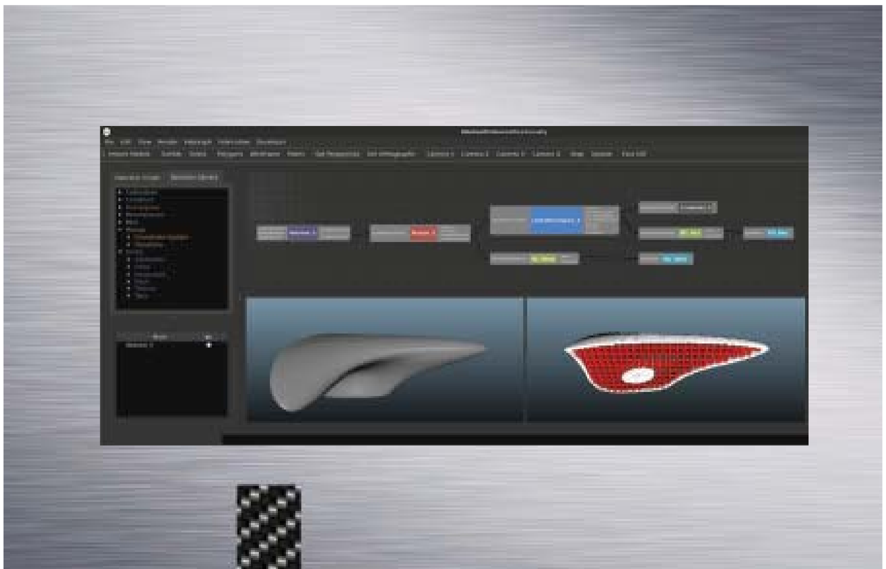
LIVING IN THE MATERIAL WORLD



CAD systems today are all about design. But what if they could also help engineers choose the best materials for their products?

BY JEAN THILMANY



Start with a function, then design structures and geometries to achieve the necessary performance.

LEFT: MIT's Foundry software lets engineers optimize properties by combining or blending several materials in a single object.

PREVIOUS SPREAD: Using CAD tools to simultaneously optimize materials and design could improve such everyday components as carbon composite and ceramic brakes.

Just as clothes make the man, materials make the part. When a material is perfectly suited to a design, the resulting structure holds up under heavy use, springs back into shape when bent, and handles high temperatures without buckling. It does exactly what we ask.

Yet engineers often fail to select the ideal material for their designs. This is not because they are lazy or do not appreciate the difference materials can make. Rather, it is because their CAD systems often push them in other directions.

CAD systems are essentially tools optimized for just one job, design. Only after engineers have completed their CAD models do they input the materials that give those designs their physical (and other) properties. But how do they know if they have selected the best material for the job? Or whether switching to a better but unfamiliar material might enable them to improve their design?

This is an important consideration, because for products to reach the next level of performance, materials need to become part of the design process itself, contends Yan Wang, an associate professor of computer-aided engineering and design at Georgia Tech.

"Materials discovery and integration is the key to the new products we want to make," Wang said. His research has explored that issue since 2000. It is a task CAD vendors are only beginning to tackle today.

Materials Selection Now

To appreciate how Wang and others want to change design, consider how engineers create products today. Essentially, they start with a function, then design structures and geometries to achieve the desired performance. After they complete the design they choose a material. Their goal is to pick one whose strength, durability, hardness, flexibility, thermal, and other properties best match the part's function.

Only then, drawing on simulation tools like finite element analysis (FEA), can they analyze the design's performance to see if they chose the right material.

This is an iterative and time-consuming process. Based on the limitations of the material, engineers might go back and tweak elements of their design. If those design changes make the part too large, heavy, or expensive, they might specify a different material. Back and forth they go, redesigning and simulating. Eventually, they reach an optimized design—or, to be realistic, a compromise they can live with.

Part of the problem is that most designers work from a very limited portfolio of materials, said John Downing, a technical communications specialist at Granta Design in Cambridge, England. "Designers rely on supplier recommendations or simply reuse what they have used before," he said.

Granta wants to expand their options. It does this by providing databases of materials and their properties, sometimes called libraries, that engineers can integrate into their CAD systems.

This starts with CES Selector, a stand-alone library of material property data that helps engineers screen materials based on design objectives and constraints. These criteria include not only materials properties, but also processing, economic, environmental, and other engineering constraints. Granta helps engineers wade through this data by graphically plotting these trade-offs, so engineers can see how the candidates measure up against the competing objectives of the application.

The tool is useful for identifying potential materials during the conceptual design phase and when searching for a replacement for a material that is not working out, Downing said.

Toward Integration

Although CES is an independent software program, it works with Granta's MI:Materials Gateway, an app designed to work within many CAD systems as well as some simulation and analysis software. The app enables engineers to create databases that combine the Granta data library with their own in-house materials database, and to narrow down choices by searching for properties within those materials, Downing said.

Having a materials library is a good start. In fact, for many engineers who make products for applications whose demands are well-characterized, it is probably enough. But engineers who want to move beyond the usual suspects may need something more. They may want to combine materials to achieve very specific performance goals, or perhaps design structural materials themselves.

While there is not yet an app for that—at least one fully integrated with CAD—several developers are moving in that direction.

One group of developers might come as a surprise: 3-D printer developers. Their customers often complain about their narrow range of materials choices. Yet additive manufacturing has become a hotbed of materials-design innovation. It gives engineers a way to combine polymers and reinforcing fibers, and even polymers and metals (to make circuit boards).

The MultiFab printer developed by MIT's Science and Artificial Intelligence Lab represents the extreme edge of this research. It enables engineers to print multiple materials at once and build objects whose segments have different properties, said Javier E. Ramos, a former researcher with the lab and a co-founder of Inkbit, a Cambridge, Mass., company that seeks to commercialize the technology.

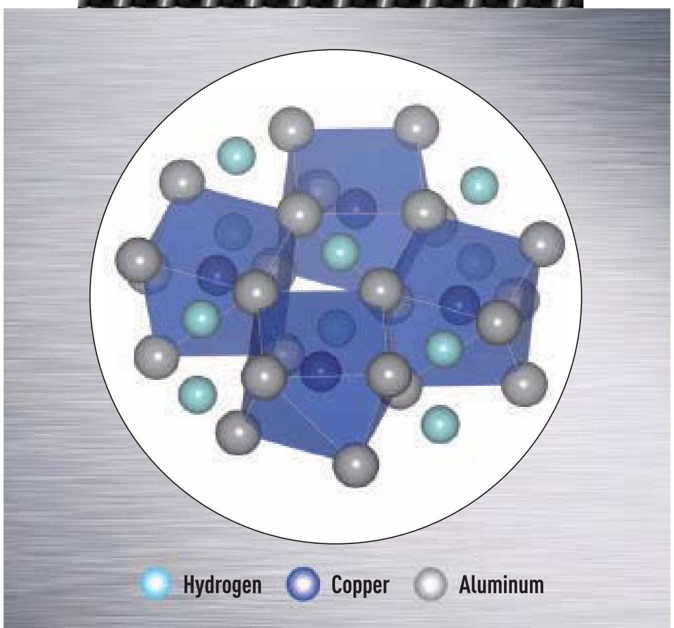
In fact, MIT's Foundry software enables MultiFab to control materials microstructures in ways that determine the material's structural properties. It is one way to achieve performance that was not possible before, said Kiril Vidimce, an MIT graduate student who helped create Foundry. The software, he said, is "Photoshop for 3-D materials."

Hod Lipson, director of the Creative Machines Lab at Columbia University, calls these intimately entwined materials "metamaterials." The term is often used to describe materials that are not found in nature. While most materials used in 3-D printing are not natural to begin with, playing with their microstructures endows them with very different properties than their starting forms. Lipson is currently creating a database of such materials and investigating how to predict their properties more accurately.

Dassault Systèmes, like many large purveyors of engineering software, has made no secret of its desire to create a soup-to-nuts buffet of engineering software tools. The company is best known for its SolidWorks and CATIA CAD programs and Simulia simulation and analysis program. Materials simulation is also an important part of its plans.

In 2014, Dassault bought Accelrys, a company that made software to help biochemists and chemical engineers understand and manufacture molecules used in pharmaceuticals. Dassault promptly renamed the business Biovia, and improved its materials simulation capabilities for structural materials.

Biovia's Materials Studio works a lot like the FEA



By simulating interactions with hydrogen atoms and molecules, the researchers identified the aluminum clusters, nanowires, and crystals best suited for storage.

tools mechanical engineers use to simulate designs. Just as engineers can see how a bracket or rotating part will affect the performance of a final product, Materials Studio shows how changes to the molecules and crystals that make up a material will determine the behavior of the bulk materials used to design structures.

To showcase how this works, Biovia researchers used Materials Studio to study how aluminum absorbs hydrogen. Aluminum is a promising candidate for storing hydrogen in fuel cells, said Alexander Goldberg, who was involved in the studies. By simulating interactions with hydrogen atoms and molecules, the researchers identified the aluminum clusters, nanowires, and crystals best suited for storage. The research will help engineers design structures that store more hydrogen at lower cost in new fuel cells.

This approach, modeling and simulating materials behavior at the smallest scales and using the information to predict the behavior of bulk materials, is called multiscale modeling. Several companies, including Toyota, Samsung, Boeing, and other aerospace and energy companies have bought into the concept. They now use Biovia to design new materials and simulate how they behave in engineering applications, Biovia CEO Max Carnecchia said.

Materials scientists have used simulation tools to do similar analyses in the past, but those programs were difficult to use. Biovia hopes to simplify the process and broaden the number of people who can use it. Ultimately, Dassault hopes to incorporate materials simulation into such engineering tools as CATIA, SolidWorks, and Simulia.

“This offers us an opportunity to substantially expand the range of what is possible,” Carnecchia said. “These joint solutions are needed to solve the most difficult problems in energy sustainability, resource utilization, and urban planning.”

Carnecchia’s boss, Dassault CEO Bernard Charles, reaffirms those thoughts. The most sophisticated designers are “moving toward using material as a variable, not a constraint,” he said. “And to do so, the ability to manage product information at the molecular level in a scalable manner is essential.”

That is Dassault’s vision. Clearly, most engineers will never need those advanced properties, and many of their employers will not have the means to create such unusual material variants. But others might.

It is probably too soon to determine if this technology will be adopted and used widely, said Marc Halpern, a vice president at technology research firm Gartner who follows product lifecycle management software.

After all, linking materials simulation with CAD modeling in ways that are useful to engineers is a big challenge. It is a problem Georgia Tech's Wang has been working on for the past 17 years.

Part of CAD

Wang and his team are looking for ways to enable engineers to design a part and the materials that comprise it at the same time, within a single software application.

The system Wang envisions would work something like a combination of CAD and FEA, but with one key difference. Today, CAD-FEA systems enable engineers to test structures as they design them, then play with materials and design to see what works best.

Wang's approach would give engineers tools to customize those materials at the microscale and give them just the right properties for the design. Engineers might, for example, start with a polymer that is close to what they want, then change its porosity and the size distribution of its pores to reduce mass and increase electrical resistance. Or they could alter the ratio of crystalline phases in a superalloy to strengthen it at high temperatures.

By integrating this into CAD design systems, engineers could alter materials at the microscale to achieve specific physical properties needed for the shapes and structures they design at the macroscale, Wang said.

"What we're envisioning is a way for engineers to define their own materials rather than use those already discovered," Wang said. "In this way, design engineers will be able to customize materials to their design in much the same way they select and change part geometries today.

"They'll be able to simulate the product with the selected geometries and materials in an all-in-one package, and create new materials while they are designing new products," he said.

This would truly make materials one of the top considerations within the design cycle, Wang added.

Jean-Bernard Bluntzer, an associate professor of mechanical engineering and design at University of Technology of Belfort-Montbeliard in France, wants to go even further. His design approach, Design for Materials, calls for using materials selection to help define CAD design allowables.

"The main objective of this new approach," he explained in a paper given at the 2016 Conference of the International Academy for Production Engineering, "is to allow the product geometry and structure to be driven by the material specifications with the help of new CAD tools. The morphology of the product should emerge from a primarily material-driven design process."

Bluntzer's concept calls for engineers to choose a family of materials, say plastics, when defining the part. Then, as they design, they'd drill down further, to define the type of plastic to be used. Finally, in the last engineering design step in which materials are ordinarily assigned, the engineer would refine the material even further, perhaps by choosing a reinforcement or filler material, Bluntzer wrote.

"Using this approach, the morphology of the product is driven by material requirements," he said. "Therefore, this approach allows the designer to design different product forms according to the material requirements of clients."

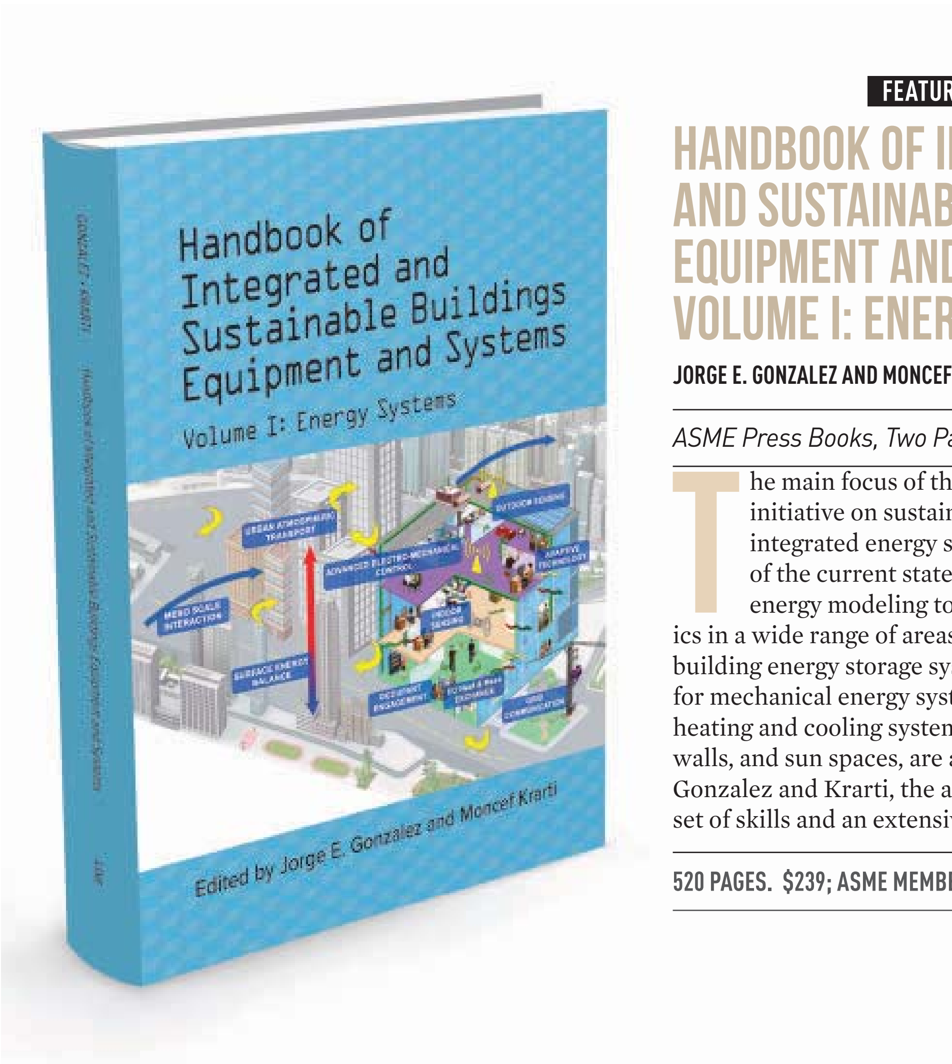
Clearly, materials and structure cannot exist without one another. Designers know this, and they often spend quite a bit of time doing iterative materials selection once they complete their design.

Materials-design integration would allow them to do this more fluidly. The tools Wang, Bluntzer, and others want to build would enable design to inform materials selection while materials inform design possibilities, all within a single process.

That process might give engineers and material scientists a way to do something they do not: communicate with one another. "There's a way to bring both of them together, and both communities are starting to see this," Wang said.

The result might be a new wave of innovation. Using a single system to combine materials specification with product design could unleash new types of materials and material combinations, and surprising structures with properties never seen before, Wang said. **ME**

JEAN THILMANY is an independent writer based in St. Paul, Minn.



FEATURED

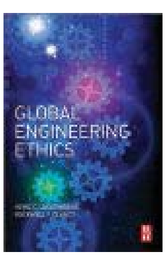
HANDBOOK OF INTEGRATED AND SUSTAINABLE BUILDINGS EQUIPMENT AND SYSTEMS VOLUME I: ENERGY SYSTEMS

JORGE E. GONZALEZ AND MONCEF KRARTI, EDITORS

ASME Press Books, Two Park Avenue, New York, NY 10016. 2017

The main focus of this volume, which grew out of an ASME initiative on sustainable equipment for buildings, is on integrated energy systems. Beginning with an overview of the current state of energy equipment and building energy modeling tools, the authors explore emerging topics in a wide range of areas, including combined heat and power, building energy storage systems, and advanced control strategies for mechanical energy systems in buildings. A number of passive heating and cooling systems, such as natural ventilation, trombe walls, and sun spaces, are also examined. Under the guidance of Gonzalez and Krarti, the assembled contributors have a diverse set of skills and an extensive experience in building engineering.

520 PAGES. $239; ASME MEMBERS, $191. ISBN: 978-0-7918-6127-1



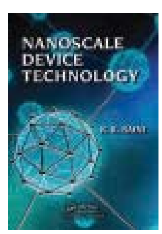
GLOBAL ENGINEERING ETHICS

Heinz C. Luegenbiehl and Rockwell F. Clancy

Butterworth-Heinemann, an imprint of Elsevier, Radarweg 29, 1043 NX Amsterdam, The Netherlands. 2017.

Culture influences what we consider ethical, but engineering increasingly takes place in global contexts, with industrial and research teams operating across national and cultural borders. That cosmopolitanism creates a layer of complexity to any ethical issue, which can be difficult enough to manage without the addition of cultural complication. Luegenbiehl and Clancy try to explore the fundamentals of ethics in a context specific to engineering without privileging any one national or cultural conception of ethics. Numerous case studies from around the world are intended to help readers see the relevance of design, safety, and professionalism to engineers no matter where they are from.

222 PAGES. $89.95. ISBN: 978-0-1281-1218-2



NANOSCALE DEVICE TECHNOLOGY

K.K. Saini

CRC Press, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487. 2017.

K.K. Saini, chief scientist at the National Physical Laboratory in New Delhi, starts his overview of microelectromechanical systems and nanoscale devices by looking back at the history of electronics, starting with the discovery of the vacuum tube through the emergence of solid-state electronic devices, including field-effect transistors. Now, teams of technologists are working to reduce the feature size and improve performance of minuscule devices, and Saini describes structures with diode- or transistor-like switching behavior exhibited by single molecules. Nanotechnology promises a major transformation in the near future and the book concludes with an introduction to tools, such as optical tweezers, for transporting extremely small particles or molecules.

180 PAGES. $99.95. ISBN: 978-1-4987-3428-8

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— President & CEO

April 17, 2017

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TODAY'S TECH BUZZ

Mass. institute opens center to speed up smart medtech development
A medical and technology development center called PracticePoint at WPI has been launched by Worcester Polytechnic Institute to accelerate the development of smart medical devices and therapies by providing manufacturers, researchers and engineers with several testing suites. The initiative has received $5 million from the Massachusetts Technology Collaborative, $2.5 million from GE Healthcare and $9.5 million from WPI.
WBUR-FM (Boston) (4/13)

NASA envisions the future of general aviation with X-57 electric aircraft

(Roberto Schmidt/AFP/Getty Images)

NASA's X-57 aircraft concept, dubbed Maxwell, could shape the future of general aviation aircraft design with its use of multiple electric motors. The conceptual aircraft uses 14 electric motors to increase overall efficiency while lowering noise.
KPCC-FM (Los Angeles) (4/13)

Apple seeks "holy grail" of noninvasive blood glucose monitoring
A team of biomedical engineers at Apple is reportedly developing sensors for use in noninvasive continuous blood glucose monitors. People familiar with the project say Apple is conducting clinical feasibility trials and has hired regulatory consultants.
CNBC (4/12)

GLOBAL WINDOW

Australia project scales up efficient geothermal energy
A geothermal energy project that scaled up the technology to the size of a small suburb was a first for a housing development in Australia. The Fairwater project began with a massive drill normally used on mining sites and employed a copper loop filled with refrigerant to tap the constant cool temperatures as much as 295 feet below the surface, adding up to about $3,800 to the cost of homes in the development.
The Age (Melbourne, Australia) (4/17)

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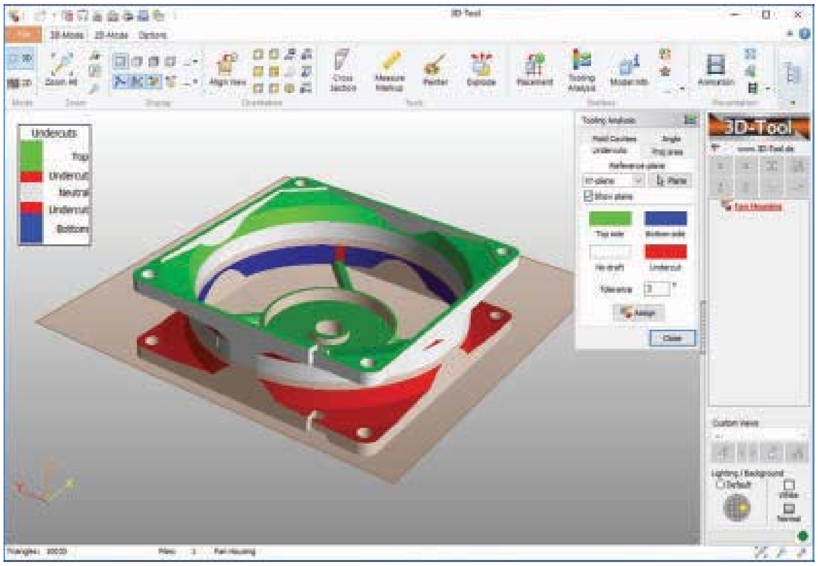
CAD VIEWER

3D-TOOL, WEINHEIM, GERMANY.

NOW OPTIMIZED FOR USE with 4k monitors and touch screens, version 12 of 3D-Tool CAD Viewer has updated interfaces for all major CAD programs. The premium version allows the conversion of native 3-D CAD models from Siemens NX 11, CATIA V6R2016, Creo 3, SolidWorks 2017, Inventor 2017, SolidEdge ST9, as well as the display of product and manufacturing information. New 3-D file format additions are JT, CGR, and 3DXML. For the evaluation of molded parts in toolmaking, drafts and undercuts are displayed in different colors. In order to estimate the clamping forces for molded parts, the projected area is calculated.



MACHINING SUITE

CNC SOFTWARE, TOLLAND, CONN.

Mastercam 2018, a new suite of programming tools focused on delivering speed, automation, and efficiency for all machining jobs, offers new 2-D and 3-D milling features. Stock awareness has been added to select 2-D tool paths and allows tool motion on the top, bottom, or both values of the stock. A new chip break control prevents problems by allowing the user to set length and time conditions, retract, and dwell options. Mill-turn machine definitions now contain tailstock and quill components, tailored to specific machines. A new set of turning strategies automate tool path generation and support for Sandvik Coromant CoroTurn Prime inserts and PrimeTurning method.

FLUID DYNAMICS

CRADLE, BEAVERCREEK, OHIO

Newly included features in the version 13 of scFLOW include a new preprocessor with navigation, part tree and property windows, and an scMoniter with visualization analysis that can be used on Linux OS. Conversion to polyhedral mesh is generated by converting tetrahedral mesh; one million elements in SC/Tetra is equivalent to 200,000 elements in scFLOW, the company states. Other enhancements include applying the VOF method to steady-state analysis, and using the FLUX method in combination with free-surface analysis function. The fan model has been enhanced with rotating wings, and the diffusive species function has been upgraded so that the mixed gas analysis and passive scalar can be analyzed simultaneously. In the CradleViewer, the Oculus Rift has been supported and the experiencing of flow can be enabled by virtual reality.

MECHANICAL DESIGN

AUTODESK, NEW YORK

Enhancements have been made to Autodesk Inventor 2017's core design tools to optimize performance from the outset. Improved interoperability can quickly bring design data together to build a complete definition of the product. Integrated communication abilities allow connection with anyone on the project team, and to share progress. Design enhancements include new 3-D sketch commands including 3-D Transform commands providing a rich set of geometry manipulation tools for moving and rotating geometry quickly and precisely. A new feature relationships tool identifies parent and child relationships between part features, while another new tool provides greater control when building surface geometry. Updates are also made in drawings, and shape generator.

MULTIPHYSICS SIMULATION

COMSOL, BURLINTGON, MASS.

COMSOL's update to LiveLink for SolidWorks is an add-on to its multiphysics software that allows a CAD model to be synchronized between the two software packages for launching and running simulation apps that can be used in synchronicity with SolidWorks software. Simulation specialists and analysts can now build apps with the application builder to let users, such as design engineers, analyze and modify a geometry from SolidWorks software right from the tailor-made interface of the app. A bike frame analyzer app has been added to the application libraries to enable interactive updates to the geometry while computing the stress distribution in the frame that is subject to various loads and constraints.

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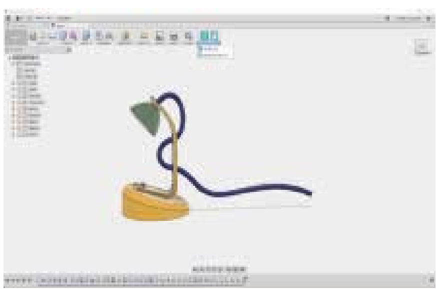
EQUATION LIBRARY

MICROSOFT, REDMOND, WASH.

Azeotrope is an add-in that introduces more than 40 physical property equations to Microsoft Excel in order to calculate thermodynamic properties. Upon installation, several constant and temperature-dependent functions are added to the spreadsheet function list that can be used to estimate physical and chemical properties of almost 5,000 chemicals. Azeotrope functions can be used as any other Excel function. Constant functions have one argument: substance ID; while temperature-dependent functions have two arguments: substance ID and temperature. Substance ID is a unique key used for retrieving properties. If the ID is unknown, it can be easily found using a search function accessible by a ribbon shortcut.

FILE EXPORTER

PROTOTECH SOLUTIONS, PUNE, INDIA.



The FBX Exporter for Autodesk Fusion 360 is a 3-D CAD, CAM, and CAE plug-in tool for Mac and Windows that combines industrial and mechanical design, simulation, collaboration, and machining in a single package. The tools in Fusion 360 enable fast and easy exploration of design ideas with an integrated concept-to-production tool set. Autodesk Fusion 360 supports both cloud and local export. Cloud files include Inventor 2014, IGES, SAT, SMT, STEP, DWG, DXF, STL, FBX, and F3D. Local files include IGES, SAT, SMT, STEP, F3D, and DXF. It exports solid bodies to an FBX file (.fbx), and supports face-level color, color, parts assemblies, and one-click export of multiple-part assemblies

ASSET MANAGEMENT

BLUECIELO, HOOFDDORP, NETHERLANDS.

BlueCielo's Meridian 2017 is intended to streamline centralized operational control for enterprise implementations. Organizations can reduce the number of servers and administrators needed by co-locating servers in a centralized deployment, lowering their implementation and administration costs, and ensuring consistent enterprise-wide processes and standards. Local caching servers at sites provide fast access to information for users worldwide. Users can perform concurrent engineering for building information management workflows. Shared work spaces enable users to share models, distribute design work in a controlled manner, and edit collaboratively in BIM. Meridian 2017 fully supports Revit models, including Revit work sheet management with property validation, approval workflows, 2-D sheet management, and automatic publishing of PDFs.

WORKFLOW AUTOMATION

BLUEBEAM, PASADENA, CALIF.

Revu 2017 boasts enhanced workflow automation tools that span the entire project lifecycle and maximize workflow efficiency in the architectural, engineering, and construction industries. Takeoff tools empower estimators to create higher-quality, PDF-based bids with greater accuracy and speed. Expanded batch-processing tools allow architects and engineers to quickly and efficiently apply digital signatures and professional seals across a batch of multiple files without opening, signing, and saving individual documents one at a time. New automatic form creation increases efficiency across a broad set of needs including RFIs, submittals, contracts, and permits. Other features include streamlined measurement and count tool enhancements and the ability to embed photos.

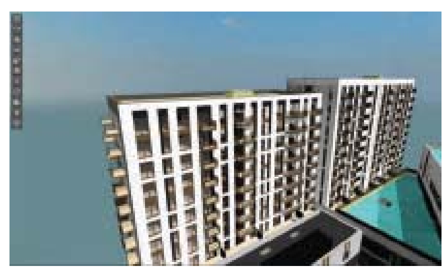
MACHINING SIMULATOR

FANUC, ROCHESTER HILLS, MICH.

FANUC Machining Simulator is intended to cover the complete manufacturing process from part design and engineering to CNC programming to virtual production simulation. The application comes with Autodesk's Fusion 360, a cloud-based CAD/CAM/CAE software platform that works on both Macs and PCs, as well as a custom machining simulation program designed by ModuleWorks. Students can use Fusion 360 to perform CAD/CAM work and the included post-processors will convert the designs into G-code (suitable for the included CNC) that commands the machine tool. A simple G-code editor makes modifications before the program is sent to the CNC. Students may also import their programs to the CNC using the FANUC FASBacCNC user interface or back up the CNC data.

3-D BUILDING COLLABORATION

DSI DIGITAL, PEACHTREE CORNERS, GA.



VIZZ 3D is a productivity tool that allows building project stakeholders to create 3-D visualizations, collaborate on the designs, and share renderings with an unlimited number of viewers. The application operates in a cloud-based gaming platform, empowering any user to virtually walk through and experience the building. Software installation is not required, and even new users will be up and running in minutes. Notes can be added and all the data behind any object can be revealed. For more immersive environments, VIZZ 3D offers compatibility with several virtual reality systems.

AUTOMATED GUIDED VEHICLE PLATFORM

COMAU, TURIN, ITALY.

THE AGILE 1500 WORKS ACROSS A WIDE RANGE of manufacturing and nonmanufacturing scenarios. Modular, scalable, and completely reconfigurable, it can carry up to 1,500 kg with a maximum speed of 1.7 m/s, facilitating core operations including just-in-time and just-in-sequence production. The platform works with multiple navigation systems that use both natural landmarks such as walls and predefined points marked with magnetic tape. Benefits include best-in-class payload in terms of size-to-speed ratio; compact design with on-the-spot rotation capabilities; powerful system-management software that handles transport orders, allocates vehicles, and monitors the entire AGV fleet; and it easily interfaces with other automation systems in the factory.

ANALOG MOTOR CONTROLLER

CROUZET NORTH AMERICA, IRVINE, CALIF.

BDE PRO is a high-performance external motor drive specifically designed to optimize operation of five of Crouzet's ultraquiet DCmind brushed motors ranging in size from 42-mm to 62-mm diameter and in power from 15 W to 100 W. The analog controller, suitable for use in a variety of applications including medical, access control, commercial, and industrial, is designed for rapid prototyping for new product development. The 84855104 BDE PRO controls motor speed and torque with extreme precision in a compact panel-mount package that measures just 5.1 in. x 3 in. x 1 in. Performance characteristics include a power range of 25 A peak current and 15 A continuous current while supporting both Hall-effect sensor and incremental encoder-type feedback.

MODULAR CONTROLLER

SIEMENS, MUNICH.

The Simatic S7-1212 modular controller performs standard and safety-related automation tasks in a single device, which may enable users to reduce wiring and save space. Using Siemens TIA Portal V14 engineering software and firmware V4.2, safety-related devices, including Siemens Sinamics drives, are easily networked with Profinet and Profisafe, reducing hardware and wiring requirements. It has 100 KB integrated program/data memory and a 2 MB load memory. It features integrated standard I/O, eight digital inputs, six digital outputs, and two analog inputs. The controller is expandable, with up to three communication modules, two signal modules, and one signal board.

ROBUST ROTARY ENCODERS

LEINE & LINDE, SCHAUMBURG, ILL.

Leine & Linde designed the FSI 800 series rotary encoders to be particularly useful in rugged motor drive applications. The encoders boast high-current HTL signals that make them suitable for high-disturbance environments. They are certified for use in SIL2/PLd applications. The company set out to replace the 1 Vpp encoder signal, which is not suitable for all installations, especially not for those with a need for long cables or those that are subjected to electromagnetic disturbance, which is often the case in heavy industry, by providing a single incremental HCHTL encoder. The FSI 800 takes up less space, needs less cabling, and lives up to the high-performance requirements needed for it to excel in heavy equipment.

HIGH-SPEED DATA CONNECTOR

MOLEX, LISLE, ILL.

Combining QSFP+, Impel, or near-ASIC connectors with thin Twinax cables, BiPass I/O, and backplane cable assemblies provide a low-insertion-loss alternative to PCB traces for high bandwidth speeds, efficiency, and proper thermal management for densely packed circuits. The integrated, one-piece design with board-mount connectors ensures easy installation in data communications, telecom, and networking for 56 Gbps PAM4, 56 Gbps NRZ, and 112 Gbps PAM4 applications. Molex's integrated electronic product development focuses on high-speed data connectivity solutions and next-generation technologies designed to meet rising data speeds and bandwidth in demanding networking and high-performance computing applications.

MEASURING COUPLINGS

VOSS FLUID, WIPPERFÜRTH, GERMANY.

Voss offers a versatile range of measuring couplings of different types, with various hoses and adapters, and protective caps in several colors for differentiation among hydraulic circuits. Designed for hydraulic systems requiring user-friendly and leak-tight measuring couplings so that measuring and testing devices can be connected and disconnected at any time or permanently installed, the couplings' caps feature a permanently elastic and tear-resistant plastic element that does not loosen, even when subjected to strong vibrations. The cap also protects against external environmental factors like dust and moisture. The different colors allow machine operators to recognize diagnostic points on the measuring couplings from a distance and label various hydraulic circuits, like high and low pressure, with separate colors.

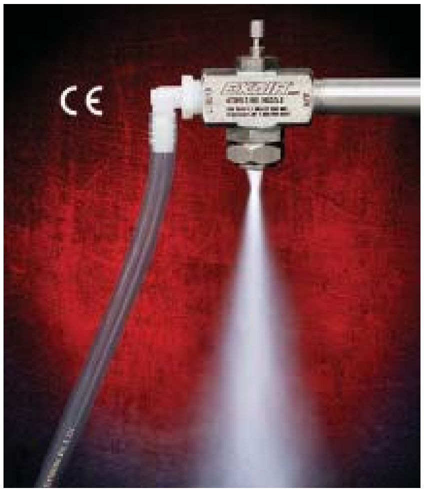
PALLET LOADER

SOUTHWORTH PRODUCTS, PORTLAND, ME.

The PalletPal Roll-On with turntable features a platform that lowers to floor height so that pallets can be placed and removed using a hand pallet truck. A built-in turntable allows users to effortlessly rotate loads so that they are always loading or unloading pallets from the near side. The unit's capacity is 2,500 lb. and its 44-in. x 48-in. platform accepts a variety of pallet sizes. The fully raised platform height is 30 in. In loading operations, a pallet is placed on the platform and the platform is raised by hydraulic power to its full-up position. As goods are loaded onto the pallet, the platform is lowered so that each succeeding tier of goods can be loaded at the same height.

SPRAY NOZZLE

EXAIR, CINCINNATI.



EXAIR's new 1/2 NPT siphon-fed atomizing spray nozzle atomizes a variety of fluids in a round spray pattern where no liquid pressure is available and heavy application of liquid is needed. This corrosion-resistant type 303SS nozzle draws liquid into the airstream and mixes it internally while providing up to 24 in. of suction height. Liquid can be easily adjusted to meet the needs of your application using the adjustment valve. The 1/2 NPT spray nozzle provides high liquid flow up to 68 GPH in a 6-in. diameter round pattern. With EXAIR's wide variety of atomizing spray nozzles, you can coat, cool, treat, and paint a variety of products using compressed air and liquids with a viscosity of up to 300 centipoise.

AC MOTORS

AUTOMATION DIRECT, CUMMING, GA.

Industrial automation products distributor AutomationDirect's IronHorse line of general-purpose, three-phase motors includes the MTRP-series 56HC-frame premium efficiency motors available from 1 to 3 hp. The rolled steel motors come in 1,800 and 3,600 rpm models and feature 4:1 constant torque and 10:1 variable torque speed ranges, TEFC frames, cast aluminum end bells, and removable mounting bases. MTRP-series motors meet RoHS and low-voltage directives, and are CSA- and EU-approved; available accessories include bases, junction boxes, fans, and fan shrouds.

VERTICAL SCISSOR LIFTS

PRESTO ECOA, NORTON, MASS.

These extended vertical travel lifts use multiple scissor mechanisms to achieve maximum lifting heights with minimum footprint. Double, triple, and quad scissor configurations are available in capacities from 2,000 to 6,000 lb. with lifting heights of 70 in. up to 356 in. Standard platform sizes range from 30 x 48 in. up to 84 x 144 in. All models are built with heavy-duty structural tube scissor legs and torque tubes for maximum stability and minimum deflection. They also feature UL- and/or CSA-approved controller components, hydraulic limiter valves at the base of each cylinder, mechanical upper travel stops, and safety-restraint maintenance bars. High lifts come with a variety of options including beveled edges, handrails, safety chains, bridge plates, accordion skirting, roller shades, and custom finishes.

SUBMISSIONS

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MOTORIZED LIFT STAGE

OES, LOS ANGELES, CALIF.

The AT20-100 motorized vertical lift stage is a stable, high-precision, high-load vertical lift stage that can be easily integrated into almost any application. The large 120 mm x 180 mm (4.72 in. x 7.08 in.) drilled and tapped platform has a vertical travel range of 100 mm (3.93 in.) and features 3.315 μm (non-Micro-Step) resolution, 5 μm repeatability, and 15 μm positional accuracy. The precision ground lead screw, precision linear bearings, and the rigid box construction of the moving component of the elevator stage assures smooth, flat (parallel to mounting surface) vertical motion. Applications include testing, inspection, assembly, sampling, laser drilling, and machining in a broad range of industrial, medical, semiconductor, and research facilities.

MULTIPURPOSE VISE

SCHUNK, MORRISVILLE, N.C.

Schunk designed the KONTEC KSC vise to be used in a variety of applications. The centric clamping multifaceted vise has optimal jaw support for I.D. and O.D. clamping with long base jaw guidance. It can be easily adapted for conventional clamping, short clamping depths for 5-sided machining, mold parts, plates, or saw cuts. A pre-tensioned and backlash-free center bearing and an extra fitted slide guarantee a repeat accuracy of ±0.01 mm and enable the precise processing of the first and second side in a clamping system. An integrated chip drain and a protected spindle assure maximum process reliability. The vise comes with jaw width of 80, 125, and 160 mm and two base body lengths from 130 to 480 mm.

LINEAR SLIDES

LM76, EAST LONGMEADOW, MASS.

These FDA/USDA/3A-Dairy-compliant water dog sliders feature durable Corro-Slick-coated 300 series stainless steel rails and contoured WDX polymer blocks that can be washed down with aggressive chemicals and caustic foaming agents. With an operating temperature range of -400 °F to +180 °F, they're usable dry, submerged in liquids, and in refrigerated and frozen environments. The Corro-Slick coating is not subject to cracking or micro-fractures with deflection of the rails. Designed for side loads up to 179 lb. and vertical compression loads of 89 lb., the sliders are available in two sizes: WD1 rail and block assemblies measure just 1.02 in. x 1.00 in. high. Standard off-the-shelf rail lengths are 12, 24, 36, and 48 in., and standard stock lengths of 157 in. are available.

SIS TRANSMITTER

MOORE INDUSTRIES, NORTH HILLS, CALIF.

The SFY functional safety frequency-to-DC transmitter with display provides reliable and accurate monitoring of frequency or pulse signals in safety instrumented systems (SIS) that can give overspeed protection by sending signals that warn the logic solver to alarm or shut down the monitored device for plant, process, and personnel safety. The SFY is designed and approved for use in a wide variety of processes and factory automation SIS including turbine flowmeters, magnetic pickups, dry contact closures, variable frequency drives, turbine tachometer generators, rotating equipment, motor and conveyor speed, as well as pulse and frequency output transducers.

RESOURCEFILE

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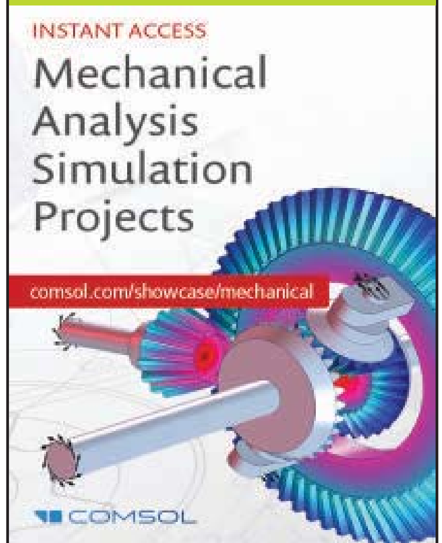
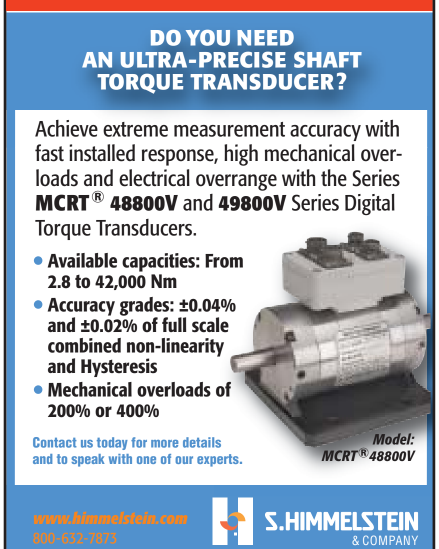
A bimonthly listing of the industry's latest technical literature and product information available FREE to *Mechanical Engineering* readers.



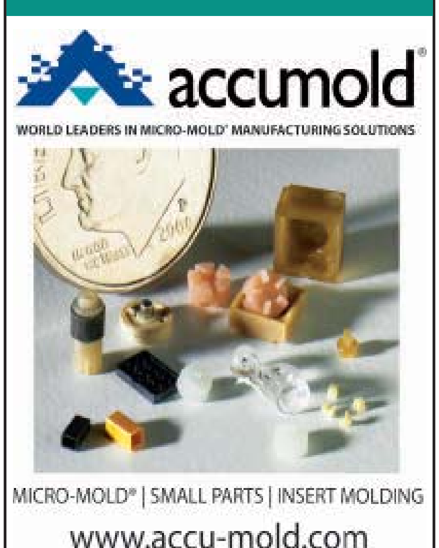
COMSOL



S. HIMMELSTEIN & CO.

MASTERBOND

PAVE TECHNOLOGY CO.



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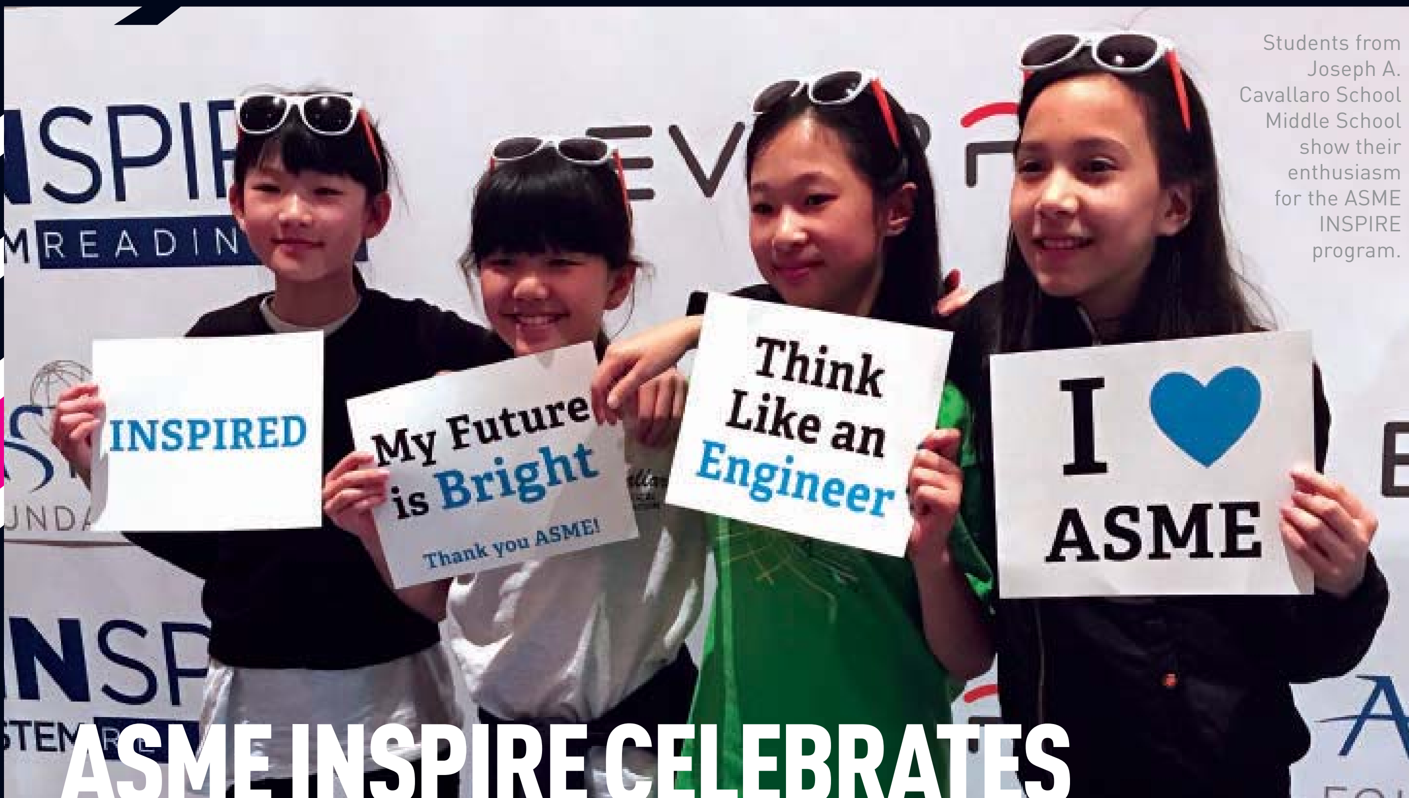

Students from Joseph A. Cavallaro School Middle School show their enthusiasm for the ASME INSPIRE program.

ASME INSPIRE CELEBRATES STUDENT CHAMPIONS

The third year is indeed the charm for ASME INSPIRE, as the program finishes the 2017 academic year in more than 1,000 middle and high schools—1,034, to be exact—across 47 states and the District of Columbia. In terms of classroom reach, more than 1,000 teachers and nearly 48,000 middle- and high-school students are engaged on the INSPIRE platform.

Supported through the generosity of ASME Foundation donors and in collaboration with EverFi, ASME INSPIRE was introduced to U.S. classrooms in the fall of 2014 as an online, in-class experience, designed to use gaming technology that leans on coding and algebra-based skill sets to complete a series of missions that celebrate the “E” in STEM. Rounding out the student experience are a series of career cards that highlight unique and compelling fields in engineering.

Over the course of three years, ASME INSPIRE has reached more than 100,000 students across the country.

Beyond the impressive numbers, measuring the impact of a program like INSPIRE in real time can be daunting, but the program’s experience at Joseph A. Cavallaro School Middle School in Brooklyn, N.Y., offers insight and validation.

On May 17, the school marked the program’s third year as part of its curriculum with a celebration where 63 of its sixth-grade students were recognized for successfully completing all 16 missions of the INSPIRE online program. During the event, students shared their career aspirations—math teacher, web designer, engineer, game developer, neurosurgeon—along with an appreciation for how INSPIRE brings a more dynamic and fun STEM element into their classroom experience. ME

ASME ONLINE VOTING PROCEDURES: SOCIETY OFFICER BALLOT

This September, ASME members can once again expect to receive an e-mail that includes information on how to log into the ballot page, to be hosted on ASME.org, and vote for the Society’s new president and members of the Board of Governors. ASME members who do not have an e-mail address, as well as members whose e-mails get bounced back, will be sent a hard copy ballot along with online voting instructions.

Members are advised to check their ASME records to ensure that their e-mail address is up-to-date or to add an e-mail address if one is currently not on file.

To check on your current e-mail address or update it, please go to your Membership and Benefits page on asme.org, or contact ASME Customer Care at (973) 882-1170 or (800) 843-2763. Questions about the online voting procedure should be submitted to RuthAnn Bigley, ASME Governance, by e-mail at bigleyr@asme.org. ME

ASME RECOGNIZES ENGINE COLLECTION IN ITALY FOR ITS HISTORICAL IMPORTANCE

A collection of more than 100 artifacts at the University of Palermo in Italy—including a variety of steam, automotive, and aircraft engines—was recently recognized by ASME for its historical significance. The engine collection, which is housed at the university's Museum of Engines and Mechanisms, was designated as an ASME Historic Mechanical Engineering Heritage Collection during a ceremony held on May 31 at the museum.

Approximately 125 people attended the designation ceremony, which was the first ASME landmark recognition program held in Italy. Attendees included members of ASME leadership and the ASME History and Heritage Committee, as well as students, government officials, members of the military, and employees and friends of the museum.

The collection of engines at the University of Palermo consists of both stationary and transportation power units, with an emphasis on automotive and aircraft engines, and features both reciprocating and turbine designs, many of which are now rare. Some of the more notable items in the collection include the Neville stationary steam engine and the Ljungström counter-rotating steam turbine, the FIAT 8V and FIAT-Ferrari Dino automobile engines, and the Siemens-Halske Sh.IIIa counter-rotary aircraft engine and the General Electric J47 turbojet engine.

During her presentation of the Historic Mechanical Engineering Heritage Collection plaque, ASME Past President Madiha El Mehelmy Kotb noted several reasons the museum's collection was significant, including that the collection was novel because the engines are displayed in the museum without their coverings and because the types of engines were varied, ranging from everyday engines used in factories to automobile and airplane engines. The collection displays the evolution of engine technology from the late 19th through late 20th centuries, and shows the many fields that are touched by mechanical engineering. ME

Roy Allela (second from left), the creator of a sign-language translation glove, accepts a trophy during ISHOW Kenya.

THREE WINNERS NAMED AT THE ASME ISHOW IN KENYA

The creators of three new social innovations—a device for detecting malaria, a portable science lab, and a glove that translates sign-language—were named the grand-prize winners at the recent ASME Innovation Showcase (ISHOW) in Nairobi, Kenya, which was the second of three regional ISHOWs the Society is holding this spring.

A total of 10 teams presented their inventions at ISHOW Kenya, which was held May 25 in Nairobi at the Golden Tulip Westlands Nairobi Hotel. The first competition of the 2017 ISHOW season, ISHOW India, was held in Bengaluru in April. A third event, ISHOW USA, took place in the month of June in Washington, D.C.

The 10 ISHOW Kenya finalists presented prototypes of their hardware-led innovations to a panel of judges and advisors that included entrepreneurs, academics and founders of venture-funded startup companies. The three grand-prize winners—who hail from Uganda, Ghana, and Kenya—will share in more than $500,000 in cash prizes and in-kind technical support, including an extensive design and engineering review of their products.

Judges and advisors at ISHOW Kenya included Heather Fleming, chief executive officer of Catapult Design; Kamau Gachigi, executive director of Gearbox; June Madete from Kenyatta University; Robert Karanja, CEO of Villgro Kenya; and Thomas G. Loughlin, executive director of ASME. ME

The secret passageways are cleverly integrated in bookshelves, dressers, mirrors, and walls.

HIDDEN DOORS EXPOSED

When opportunity knocks, most people find the door and answer it. Steve Humble had to take the opposite approach. He created an opportunity because he couldn't find the door.

Back in 2003, the mechanical engineer was designing surgical lasers for a medical device company and living in Salt Lake City in a rented house with a few vacant rooms. Fascinated by the camouflaged doors that hid villain's lairs in the movies, Humble thought a secret space would add a cool touch to the bachelor pad.

"It was a way for me to live out a fantasy in real life," he said. But he was thrown back to reality after he failed to find a company that could build the passageway.

Humble never did get a secret door for the house. Instead, he founded Creative Home Engineering, a Gilbert, Arizona-based company that custom-designs and builds secret motorized passageways.

The engineering behind the doors is hidden.

His company is now on a growth trajectory. When people realize they can have a secret door that hides almost any kind of room, they call Humble.

"The jobs have been getting more complex because our abilities have increased; we're getting better and better at what we do," said Humble. "We're asked to stretch our limitations, and that builds new skills into the organization."

The secret passageways are cleverly integrated in bookshelves, stone brick and wood walls, dressers, mirrors, and staircases. Their automated doors swing, slide, or lift to reveal anything from a child's playroom to a wine grotto to a high-tech fallout shelter.

Prices average $17,000. They range from about $5,000 for a custom door disguised as a dressing mirror to $200,000 for a suspended door that closes like the aperture of a camera to conceal a spiral staircase.

Security-conscious clients looking to hide valuables or protect their families during an emergency make up about 75 percent of Humble's customer base. They include the person who hired Humble for the job he's most proud of: A motorized, exterior wall that hid a 20,000-square-foot nuclear-proof fallout shelter.

"All of the contractors working on the house agreed it was one of the coolest things they had ever seen," he said.

Like the doors themselves, the amount of engineering behind each one is also hidden. And that's what makes them so cool.

Each custom passageway takes an average of a few months to build. Humble and his team of 10 spend hours designing on SolidWorks, calculating density and load calculations, learning new machining procedures and broaching techniques for crafting different shapes and parts, choosing actuators, building pneumatic and hydraulic systems, and testing the quality and accuracy of each finished product on a jig.

Of course, the team also designs what most clients consider the passageway's coolest component: the activation system.

People can open their doors by turning a non-descript object in the room, like a small statue or vase, pushing a button that's concealed in the spine of a book or integrated in the room's paneling, or scanning their fingerprint on a concealed screen. Humble always keeps a few Shakespeare busts in stock for fans of the old *Batman* TV show. ME

JEFF O'HEIR is a technology writer based in Hutington, N.Y.

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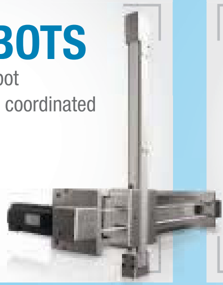

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