MECHANICAL
ENGINEERING
THE MAGAZINE OF ASME
No. 07
140
Technology that moves the world

Galaxy QUEST

Unmanned missions to explore new frontiers.

Image: Moley Robotics

THE ROBOTIC KITCHEN IS COOKING

POP CULTURE DEPICTIONS OF THE FUTURE HAVE ALWAYS INCLUDED FOOD produced instantly by a robotic chef or automated machinery. Just think of Jane Jetson pushing in a punch card for "Pizza" or "Fried Chicken" and having it pop out fully cooked seconds later, and you get the idea. The goal of Moley Robotics of London may not be that cartoonish, but they are aiming to produce a consumer version of a robotic kitchen that will allow you to order food on your mobile device and have it ready and waiting when you arrive home.

Image: Radik Shvarts, ASME.org

FLYING TO SPACE ON BUTTERFLY WINGS

The butterfly effect is well known: The flap of a butterfly's wings in Ecuador could result in a tornado in Kansas. Two mathematicians will use the phenomenon to explore something that seemingly has little to do with butterfly wings: cutting the cost of space travel. Those decreased costs could, in turn, open up the final frontier to greater exploration.

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

3-D PRINTING BETTER ROOT CANALS

BIOENGINEERS AT AN OREGON DENTAL SCHOOL are using 3-D bioprinting to take some of the bite out of root canal therapy. Their fabricated vasculature restores natural blood flow to a treated tooth, leaving it healthier and more resistant to damage and reinfection—two major reasons for repeated root canal treatments.

SUPER ALLOY RESCUES MEMS SENSORS

RESEARCHERS FROM THE JOHNS HOPKINS University mechanical engineering department have created an alloy that they believe can create better sensors. The new alloy can handle temperatures over 1,800 °F. That means sensors can now go where they've never gone before.

CREATIVE APPROACH TO ENGINEERING IMPROVES GRADES

Image: Radik Shvarts, ASME.org

DIANA BAIRAKTAROVA, professor of engineering education at Virginia Tech and director of the school's ACE(D) Lab, typically asks students to produce a creative piece about a subject covered in her thermodynamics class. And it apparently helps the students learn.

NEXT MONTH ON ASME.ORG

RIVER-ROAMING ROBOT

If there's one thing robots are good for, it's doing stuff humans don't want to do themselves. What better task for a robot, then, than picking trash from a river? Urban Rivers has created a river-roaming robot that can grab waterborne garbage in its beak. Who controls it? Anyone who wants to.

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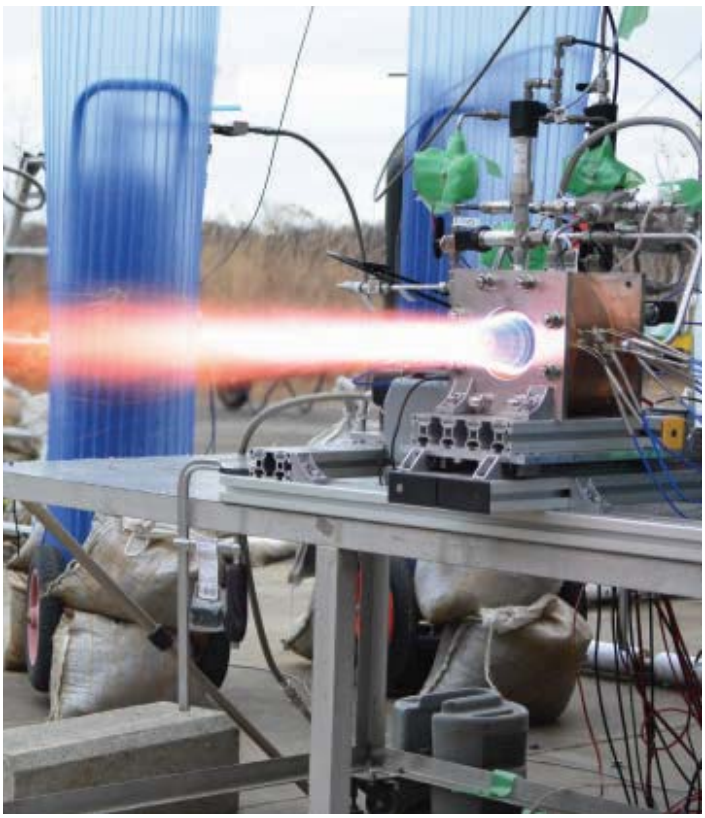

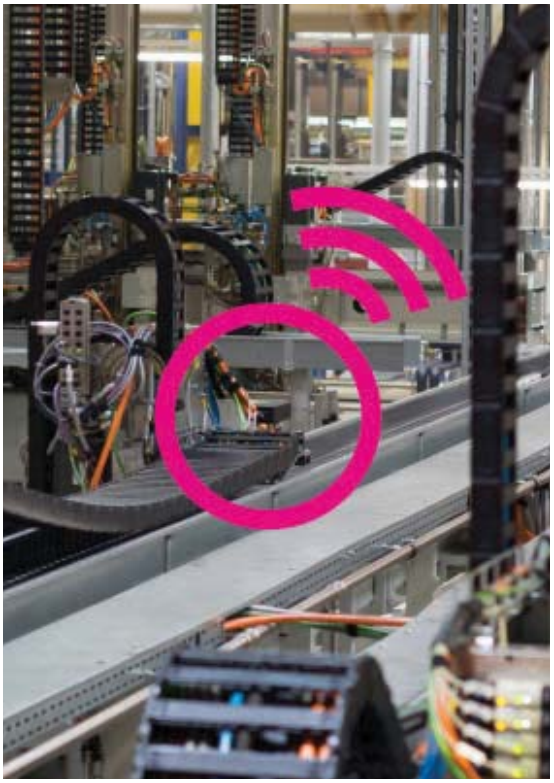

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Give me the place to stand, and I shall move the earth
—Archimedes

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John G. Falcioni
Editor-in-Chief

ASME'S NEW EXECUTIVE DIRECTOR

Beginning this month, we add a new name to the magazine's masthead on page four: Thomas Costabile. More importantly, the organization gets a new staff leader who, along with senior volunteers, will shepherd the growth of ASME into the future.

Costabile joined ASME in late May as the Society's new executive director, after an extensive search by a committee of the Board of Governors.

Costabile has a broad and impressive professional background as a corporate leader, giving him a foundation from which to draw upon as he helps implement the organization's ambitious strategy and growth plans.

"I am excited to be here and inspired by the hard work and enthusiasm which is palpable throughout the Society," Costabile said in June at ASME's annual business meeting in Vancouver, B.C.

According to Charla Wise, ASME's past president, the Board was impressed by Costabile's strong track record of delivering outstanding results for large, global organizations, and leading organizations through significant change.

It was under Wise's term as president that the search for a new executive director was initiated.

ASME's new executive director began his career as a mechanical engineer working on a joint venture between Gibbs & Hill and Ammann & Whitney, focused on the development of nuclear reactors. After several years, he joined CBS Records to oversee the development of the company's compact disc manufacturing and distribution operations.

During the next 20 years, Costabile earned leadership roles in the music distribution industry, including serving as senior vice president of operations for Sony music, where he had P&L responsibility for $400 million in revenues. He later became president of WEA Manufacturing-Warner Music Group, a $3-billion business with a staff of more than 4,000.

Most recently, Costabile served as a consultant at Carlan Advisors and as partner at 3essential, LLC, where he advised boards, senior executives, private equity sponsors, and investors. In these roles, he not only analyzed businesses and developed strategic initiatives to ensure profitability, but also implemented and monitored projects to profitability.

In addition to his business career, Costabile also served on the boards of several not-for-profit organizations, including as board chair of the Montgomery Academy and as board member emeritus of the University of Oregon Foundation.

He received his BSME with honors from Manhattan College and an MBA in finance with honors from Long Island University, both in New York.

"Tom is an outstanding, results-oriented leader," Wise said. "The Board and I are confident that he is the right person to lead us as we move forward together."

ASME's new president, Said Jahanmir, echoed those comments at last month's annual business meeting: "We are very fortunate to have someone like Tom as our new executive director. He is a smart leader and a very good man."

Costabile replaces Phil Hamilton, a long-time member of the ASME staff, who served as interim executive director for six months.

In an upcoming issue, I will talk with Costabile about the current state of ASME and his vision for the Society's future. All of us at *Mechanical Engineering* extend our heartiest congratulations and best of luck to ASME's new executive director. ME

FEEDBACK

What advice do you give to ASME's new Executive Director Thomas Costabile?

Email me
falcionij@asme.org


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LETTERS & COMMENTS

APRIL 2018

Reader Shilling recalls an earlier era of engineering via independent contract.

« One reader takes us to task for not identifying women researchers. Another questions whether engineering is a science.

NAMING NAMES

To the Editor: Does ASME have a gender bias? My wife pointed out some photos and captions in the April 2018 feature, "Cell Mechanics" by Jean Thilmany, that showed a discrepancy.

Both male and female researchers are depicted, but the captions only identify the males.

I am hoping this was not intentional and that you might let us know who those two female researchers are.

Mark Schanfein, *Eastsound, Wash.*

Editor's note: The vintage image of Jonathan Hartwell was from a stock agency that did not supply a name for the other researcher. Based on some additional sleuthing, we discovered that she was Sylvy Ruth Levy Kornberg, a biochemist who contributed to the discovery of the mechanisms of DNA and RNA synthesis, work which won the Nobel Prize for Medicine in 1959. The prize was awarded to her husband, Arthur Kornberg.

Her son, Roger David Kornberg, won the Nobel Prize in Chemistry in 2006.

The other researcher is Melis Hazar, whose name was not supplied with the photo. Hazar was a graduate student in Philip LeDuc's lab and is now a scientist at an international biotechnology company.

SCIENCE VS. ENGINEERING

To the Editor: I wholeheartedly concur with Adrian Bejan's conclusion that engineering has transformed our society for the better ("Without Engineering, Civilization Does Not Exist," May 2018). Unfortunately, Bejan's definition of engineering as a type of science was inaccurate, which contributes to the public's misunderstanding of our profession.

The article stated that "engineering is the science of what is useful" and "engineering is [a] body of science."

It concluded by repeating that engineering is "the science of useful things."

Although engineers need to learn science and some scientists do some engineering, engineering is not a type of science, for it has a different objective. Scientists study the world in order to understand it, but engineers design new products and systems. Scientists describe; engineers decide.

Henry Petroski discussed this distinction and provided more ways to view it in *An Engineer's Alphabet*.

Bejan was closer to the truth when he described engineers as those who "are developing new contrivances and improving old ones."

Jeffrey W. Herrmann, *College Park, Md.*

HOT GIG

To the Editor: The April 2018 feature, "Gig Engineering" by Kayt Sukel, reminded me of a job I got in the early 1960s. It was in what was then called a "job shop" to act as a middleman between individual engineers and customers—mostly in aerospace—who needed talent.

I had never heard of a "job shop," and as I settled into the job was surprised to find how much of the aerospace engineering in Southern California was done by contract engineers, who were called "job shoppers." Top engineers could make more money when they were hired as independents than they could as employees of the aerospace companies.

Sadly, my new career did not last very long. A major defense contract was cancelled, and the flood of unemployed engineers made the opportunities for contracting few and far between.

Regardless of what you call it, it's clear that the concept of "gig engineering" is nothing new.

Richard Shilling, *Shoreline, Wash.*

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.

Join us for this free webinar

MECHANICAL ENGINEERING WEBINAR SERIES

Thermally Induced Fatigue Modeling and Assessment

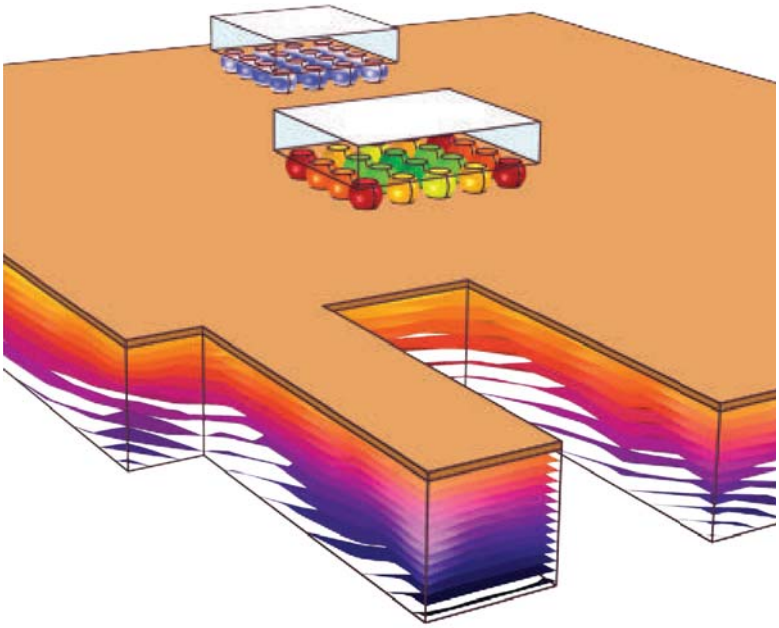
Date: Thurs., July 19th, 2018

Time: 2:00 pm EDT

Register today at: https://goo.gl/7mFWL3

Thermally induced fatigue can be extremely damaging to structures due to the large strain produced in structures experiencing variable or cyclic thermal and mechanical loads. Thermally induced fatigue is an inherently multiphysics phenomenon and, as such, its mathematical model should include the large thermal strains produced by heat sources and the conversion of thermal strains to mechanical strains in the presence of constraints. The model should also take into account the nature of the constraint, which could be purely mechanical, be due to different material properties, and have a non-uniform temperature distribution.

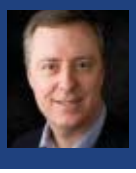
In this webinar, guest speaker Kyle Koppenhoefer from AltaSim Technologies will discuss thermally induced fatigue occurring for a low number of cycles (<10,000). Kyle will also talk about fatigue assessment in this regime, where plastic strain development during load cycles must be considered, often using a strain-life method, energy-based approach, or a combination. The webinar will feature a live demo of solving a thermally induced fatigue problem in the COMSOL Multiphysics® software and conclude with a Q&A session.



Visualization of temperature, cycles to failure and stress in the solder joints of two ball grid assemblies.

SPEAKERS:

KYLE KOPPENHOEFER
Principal
AltaSim Technologies



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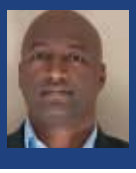

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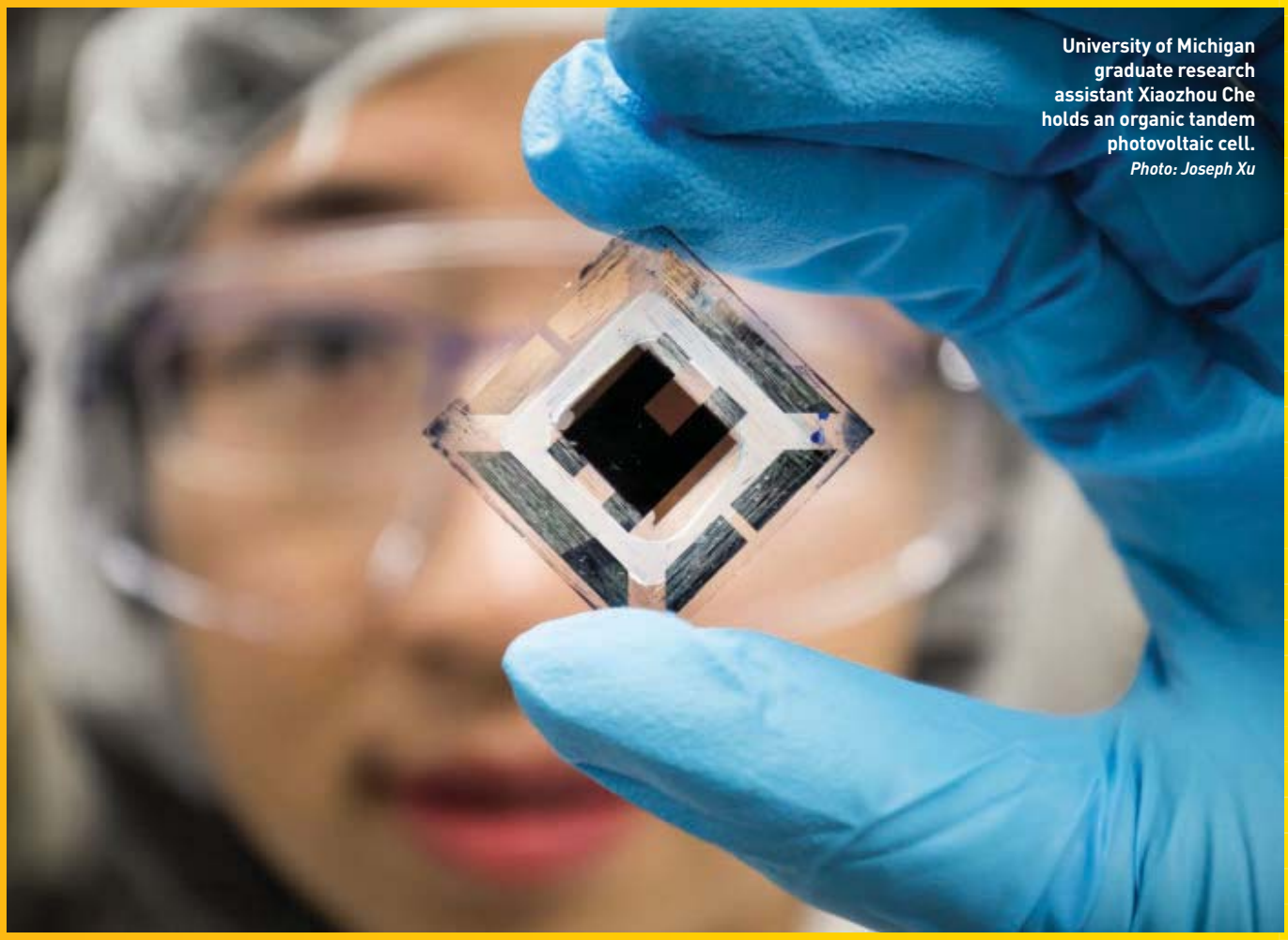
RECORD HIGHS ON

RESEARCHERS PUSH ORGANIC SOLAR CELL EFFICIENCY TO 15 PERCENT



University of Michigan graduate research assistant Xiaozhou Che holds an organic tandem photovoltaic cell.
Photo: Joseph Xu

Organic solar cells could be placed inconspicuously on a window or the roof of a car. But up to now, there has been little point: The efficiency of organic solar cells in converting sunlight to energy has been poor, especially compared to conventional silicon-based solar cells.

That fact isn't lost on researchers at the University of Michigan, Ann Arbor, who have worked to develop an organic solar cell based on carbon materials that pushes the needle ahead in terms of efficiency.

The multidimensional solar cells, made of simple, non-toxic materials, achieve an efficiency of 15 percent. That's higher than the 10 to 13 percent that have been achieved so far in organic solar cells.

"This is the first work to demonstrate 15 percent efficiency," said Xiaozhuo Che, a researcher at University of Michigan involved in the development of the organic solar cell. "All molecules we use are non-toxic. Some solar cells have lead and other materials that can be very toxic," she said.

These solar cells, which have a lifespan of 20 years, aren't meant to replace conventional utility-scale or rooftop solar cells, which have achieved efficiency rates of around 30 percent in recent years. Instead, Che said, the organic solar cells are intended to be a supplement.

A potential use is in smart windows, where the organic solar cells can be coated as transparent material. The material is flexible enough to be used on car roofs to generate power for car subsystems such as in-vehicle

SOLAR

entertainment systems. It may also be suitable for the exterior of everyday electronics and can be placed in paint, Che said.

The researchers developed a stacked organic solar cell with interconnecting structures to convert a wide spectrum of light into energy. They had to balance the material and thickness in order to raise efficiency.

The team also had to prove that both vacuum thermal evaporation and solution process could be used to make organic solar cells.

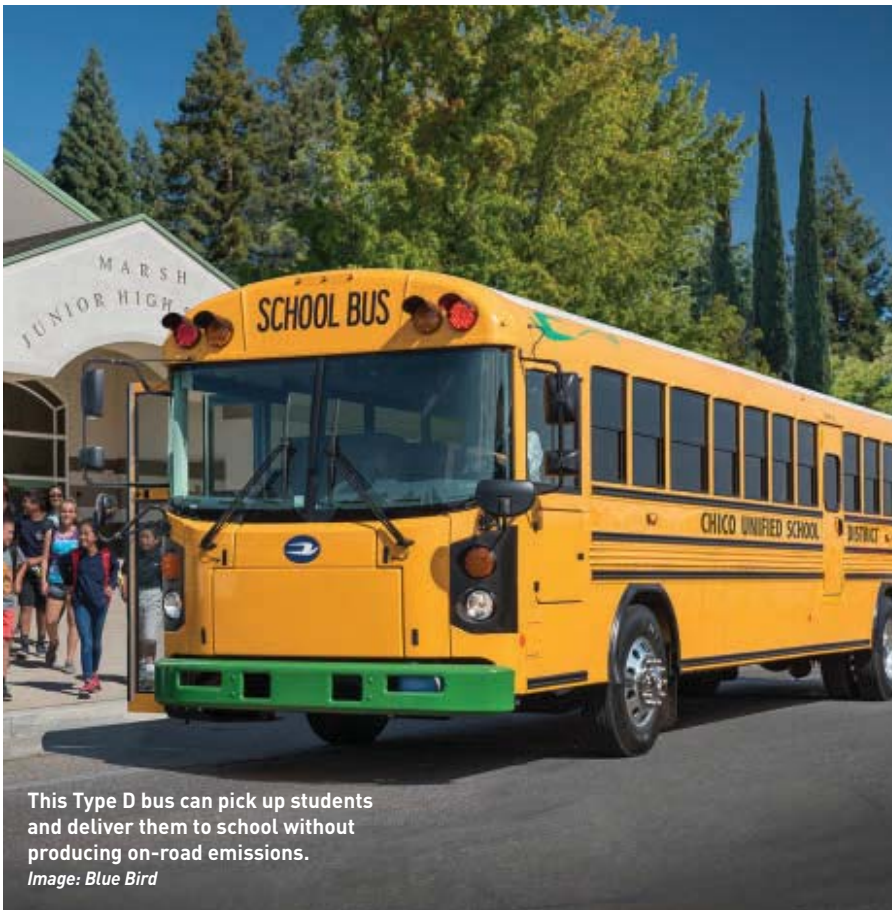
"There is no clear answer yet if one would be better than the other. In our work, we combine these two technologies in a tandem structure, which are two cells connected in series, that provides design flexibility for high-efficiency multijunction organic photovoltaics," Che said.

Innovations were also made in the process of bringing the multijunction solar cell together. The solar cell is also proof that the efficiency of organic solar cells isn't limited only to the materials, Che said.

The research team had aimed to develop a solar material that was cheap and easy to manufacture. The materials in the organic solar cell used are similar to those in OLED displays found in high-end smartphones, and can be made in those factories. OLED displays are primarily made by Samsung and LG Display, but smaller display makers are implementing the capabilities.

"It should be commercialized in five years," Che said, though she added that the lab would need a partner to take the technology to market. "What we are now trying to do is push the efficiency to new records." ME

AGAM SHAH



This Type D bus can pick up students and deliver them to school without producing on-road emissions.
Image: Blue Bird

ELECTRIFYING BUSES

The emission-free way to get to school.

School buses are prime candidates for electrification—they travel fixed routes and have plenty of downtime for a recharge. Bus manufacturer Blue Bird now offers emission-free Type C and Type D school buses, which have neither engines nor transmissions.

A 160-kWh lithium-ion battery provides a range of 120 miles. The chassis was developed in conjunction with California-based ADOMANI, Inc. and operates on an energy-efficient electric drivetrain supplied by Efficient Drivetrains, Inc.

Blue Bird has been advocating electric school buses for a long time, and school districts are finally buying as the buses are becoming more affordable, a company spokeswoman said. Manufacturing the buses has also become cheaper.

The benefits over conventional buses include reduced maintenance costs, and the buses bristle with high-tech telematics and other tracking features. Blue Bird recently took a prototype electric bus on a roadtrip across America to show off its capabilities.

Type C school buses have a traditional engine compartment jutting from the front, while Type D buses have a flat front, much like a city transit bus. ME

Manmeet Maggu and Rahul Udasi started Trexo Robotics to design, manufacture, and market their robot walker.
Image: Trexo

WEARABLE ROBOT HELPS CHILDREN WALK

Researchers from the University of Toronto have created a wearable robot that gives wheelchair-bound children the ability to walk. The Trexo, as they call it, looks like a sleek, custom-made walker, with a few robotic joints. Those joints help children, who would otherwise never take a stride on their own, put one foot in front of the other.

Founders Manmeet Maggu, Trexo Robotics' CEO, and Rahul Udasi, the company's CTO, came up with the idea as students and eventually started their own business to design, manufacture, and market their robot walker.

The two robotics engineers met while studying mechatronics at the University of Waterloo. In 2011, Maggu learned his four-month-old nephew had cerebral palsy and would likely never walk.

"That was a turning point," he said. "We started looking into it and realized that being in a wheelchair for your entire life can have some negative consequences." Those can include blood clots, muscle degeneration, and kidney failure. "We wanted to help my nephew get out of the wheelchair."

A robotic device to help kids do that had already been invented. The only problem was that there were only two in Canada, and they cost $500,000. "It's not really accessible to most families out there, including mine," Maggu said. So he set out to fix that.

The pair decided to go back to school to develop a prototype of the kind of walker they had in mind. They both matriculated at the University of Toronto, where Udasi went for a master's degree in the robotics department while Maggu pursued an MBA. With grants they were able to complete their first prototype. They took it straight to India so that Maggu's nephew, now eight, could give it a try.

They started him off with an "air gait" where he could practice moving his legs with the robot suspended above the ground. Over several sessions he learned enough to traverse the room. But there was much work to be done. The actuation system on the first prototype was fairly basic, among other issues.

First there was the issue of size. Would they have a different walker for different age groups? Would it be able to adjust over time? Could they get the necessary power in a compact design? Then there was the issue of software and control, which was also challenging because, as Maggu put it simply, "Different children have different difficulties."

More crucial than any of that was the issue of comfort.

"It cannot be stressed enough how important it is," said Maggu. "Using a device for 30 minutes—or an hour or two—the smallest discomfort can really amplify. You could build the most amazing technology, but if it isn't comfortable and usable, it will not work. "

One by one, the pair knocked out these problems. They created two sizes of the Trexo, one for three- to six-year-olds, and another for six- to twelve-year-olds. Both have telescoping legs and adjustable waist and arm supports so the walkers can grow with the children. They worked with an ergonomics expert to create removable padding shaped to meet the comfort needs of children of different sizes and with different challenges.

They powered the walker with a battery and further developed the software and control system to better detect a child's intent.

"WE WANTED TO HELP MY NEPHEW GET OUT OF THE WHEELCHAIR."

The result is a robot that looks like a walker for the elderly with two dangling legs between the handles. Those legs have actuators at the hips and knees. Straps and cushions abound.

Having made their walker a useable reality, they had to make it a commercial reality. The duo joined Techstars, one of many programs that help young entrepreneurs, which helped them define their business model and connected them with investors.

The Trexo has now been approved by Health Canada, and the company is getting ready to go commercial. But they need to fine-tune the software and run a few more tests before they hit the market. The two are also working with the Cincinnati Children's hospital to create a pilot study. They'll also be trying to get the walker approved by the U.S. Federal Drug Administration. ME

MICHAEL ABRAMS is an independent writer. For more articles on robotics visit www.asme.org.

"TODAY THE GLOBAL ROBOT POPULATION is probably around 57 million. That will grow quickly in the foreseeable future, and by 2048 robots will overtake humans. If we allow for likely market acceleration, that could happen as early as 2033."

Futurist Ian Pearson, *as quoted on April 23, 2018, in the English newspaper* The Sun.

TARGETING CHINA'S MOUNTAINS OF TOXIC SLUDGE

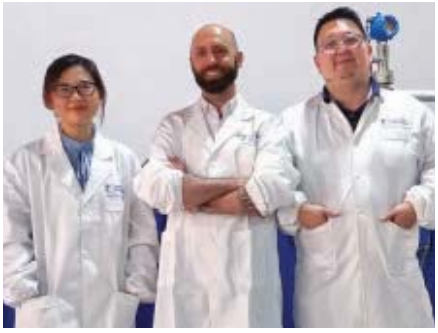
China has been burying itself under heaps of toxic sludge, but one startup may have a technological solution. Innov8tia has developed a microwave pyrolysis reactor that decontaminates industrial sludge, converting it into valuable gases and chemicals.

China's sewage and industrial sludge has contaminated water and soil with heavy metals, pesticides, and pathogens. Some of the waste goes to landfills that will accept it, but illegal dumping has been easy and cheap.

"To dispose of 500 tons of toxic sludge in the south China city of Guangzhou, all you need is a hired boat and a little money for petrol," Yang Dazheng and colleagues write in *Chinadialogue*.

There may be change on the horizon after a nationwide government crackdown on polluters in late 2017 that swept up 12,000 officials and fined 18,000 companies.

The Dafeng Pesticide Factory in Yancheng City, 250 km north of Shanghai, closed during a surprise inspection; the company then turned to Innov8tia for help processing its sludge.



Jessica He, Seth Knutson, and Kaiqi Shi (shown at left) created a microwave pyrolysis system (above) for turning toxic sludge into valuable chemical feedstock. *Photos: Innov8tia*

Test runs of two scaled down versions of Innov8tia's reactors found that they could convert 30 to 35 percent of a Dafeng sludge sample to char, and 65 to 70 percent into gas, most of which was hydrogen and carbon monoxide. Both gases are valuable. Hydrogen is used in the petroleum and chemical industries and as a coolant, and carbon monoxide, also called syngas, is used in chemical manufacturing, meat packing, medicine, and even lasers.

The process also yields other useful materials, including carbon nanotubes and more than 70 chemicals (levoglucosenone, furfural, phenolic compounds, 3-aminopiperidin-2-one, D-allose, cresols, vanillin, and others) that value at $1,200 to $250,000 per ton.

The process is more efficient than traditional pyrolysis at harvesting materials from sludge, and it generates more energy than it requires.

The three-person Innov8tia team graduated from the Vatican's Laudato Si Accelerator in December 2017 and returned home with a $100,000 grant. Now the team has moved into a 530 m^2 warehouse in the Ningbo National Hi-Tech Zone, a government-operated technology park. Their neighbors are 30 other startups, all better funded than they are, says Seth Knutson, one of the co-founders.

"Our current reactor system, capable of treating 20-40 kg of sludge per hour, is up and running in this facility,

although it's essentially an empty warehouse right now," Knutson says. "This is the largest, and we think only, microwave pyrolysis industrial sludge treatment system currently in operation in the world. Innov8tia should be the first company in the world to offer microwave pyrolysis systems for industrial sludge treatment."

Another co-founder, chemical engineer Kaiqi Shi, developed the microwave pyrolysis technology while studying at the University of Nottingham's China campus. Shi developed a self-cleaning nickel catalyst that converts more of the sludge into gases and less into char. Thus, the microwave process harvests more materials from sludge and requires less energy than traditional pyrolysis.

Innov8tia's first commercial system can treat 500 kg of sludge per day.

The technology has been independently certified by a group at the Chinese Academy of Sciences. The team's patent won an Innovation Award from the government of China, and the prototype was independently verified by a group of industry experts.

THE SYSTEM TURNED WASTE INTO ONE PART CHAR AND TWO PARTS GASES LIKE CARBON MONOXIDE.

One of Innov8tia's first jobs in its new headquarters is to test sludge samples sent from a leading international environmental services provider, a relationship forged in Rome during the accelerator. No agreements have been signed, yet, and the company will remain anonymous until a possible future public announcement.

In the meantime, a technology like Innov8tia's has a vast market in China. The Chinese government has pledged to clean up the country's polluting industries, and companies may be seeking legal means of treating their waste. ME

ROB GOODIER is managing editor at Engineering for Change. For more articles on global development visit www.engineeringforchange.org.

"ARIZONA HAS ALLOWED THIS TECHNOLOGY to test and flourish. We will continue to encourage innovation. But public safety comes first. It's always been our focus and it will remain our focus."

Arizona Gov. Doug Ducey, in a March 27, 2018, announcement on Twitter. The state of Arizona banned Uber from experimenting with self-driving cars after one of their test vehicles killed a pedestrian.

REIMAGINING ENGINEERING EDUCATION

The curriculum of today needs to be transformed for the **engineers of tomorrow.**

Educators and professionals owe it to our students to prepare them to become successful contributors to society. Today's students will be living and working in an era characterized by what has been termed the grand challenges—in energy, health, poverty reduction, and so on. What will today's engineering students do to address these issues?

Policy makers will make policy and scientists will investigate, but it falls on engineers to build the necessary "new machines and systems." We use the term "machines" generally to describe all of the constructs that engineers build: mechanical, informational, biological, energetic, molecular, and infrastructural.

With this in mind, the Massachusetts Institute of Technology, where I work, is reimagining its undergraduate engineering education through its New Engineering Education Transformation (NEET) program. The aim is to reimagine engineering education—what students learn and how students learn—in a fundamental way across the school. We began by identifying four student-focused principles that are aligned with student desires, industry and societal needs, faculty ideals, and university culture.

First, we should prepare our students to develop the new machines and systems that they will build in the middle of the 21st century. These new machines will integrate disciplines, be complex and networked, autonomous, and support a sustainable environment. Much educational practice currently focuses on the "old machines" that defined the products of engineering when engineering science was codified in the mid-20th century.

Second, we should prepare our students to be makers and discoverers. Some of them will be makers, creating synthetic artifacts, while others will be discoverers, unraveling the mysteries of our world. Our students don't know which path they will follow but want to be prepared for both.

Third, we should shape engineering education around the way our students best learn. They arrive at engineering school with a much richer set of project experiences than in the recent past, and are immersed in digital media. We must continually evolve our pedagogies to address these changes.

Last, we should prepare them in the NEET ways of thinking. In view of the exponential evolution of knowledge, the valuable long-lasting outcomes of university education are an ability to learn on your own, and to think more effectively. We have identified 11 ways of thinking that a student should acquire, including analytical, computational, creative, critical, and systems thinking.

We also gathered evidence on the state of play of engineering education by listening to thought leaders (on TED Talks), and surveying industry, alumni, students, and faculty. Particularly valuable was a benchmarking report full of insight called *The Global State of the Art in Engineering Education*, available at neet.mit.edu.

Based on evidence and principles, NEET developed two "inventions"—a project-centric curricular construct and the concept of threads. Historically, the organizing armature of the curriculum was a series of courses. We propose replacing that with progressive projects linked to the new machines. Students choose a sequence of interdepartmental projects, while fundamentals continue to be learned in classes. In the projects, students are coached in personal and interpersonal skills and are challenged to develop their ability to learn by themselves. These are supplemented by digital education, peer-to-peer learning, faculty mentoring, and self-study.

Threads are pathways for interdisciplinary engineering education that cut across disciplines and departments, and link the projects. Each student still has a home department, but they use the flexibility in their degree program to take complementary subjects in other departments or disciplines, defined by the threads. Students will get a degree from the department they are majoring in plus a NEET certificate in the cross-disciplinary thread they have opted for.

MIT launched two pilot threads in Fall 2017, Autonomous Machines and Living Machines. We have learned a great deal from these pilots—most importantly that our students highly value the community that is forming around NEET. ME

EDWARD F. CRAWLEY, Ford Professor of Engineering in the Department of Aeronautics and Astronautics at MIT, leads the NEET initiative with **ANETTE HOSOI** and **BABI MITRA**.

"I'm used to it, because I've been in college for so long. I've been taking community college since I was 7."

14-year-old Tanishq Abraham, who graduated from U.C. Davis with a degree in biomedical engineering, as quoted by KXTV on May 21, 2018. He will soon be starting on his doctorate.

BE A MAKER

Engineers who can also code are in demand, especially with a future where mechanical parts are controlled by software. Proficiency in C and C++ is considered a good start, MATLAB is valuable for engineering design, and Python is hot for machine learning.

For a good introduction to coding, Arduino—the hardware-and-software platform used to make moving robots and other electronics—is offering a new Arduino Engineering Kit. The kit is intended to teach students how to make moving objects and comes with a license to MathWorks' MATLAB and Simulink, which are widely used in engineering and design.

The engineering kit has mechanical and electronic parts to build a navigable mobile rover with a forklift, a self-balancing motorcycle, or a robot that can replicate a drawing on a whiteboard. The parts to build these things—including chassis and wheels—are included in the package.

This kit, priced at €199, will first ship in Europe.

Arduino isn't known for teaching students about security, which is becoming critical in machine design, but the engineering kit will provide exposure to IoT and wireless communications. Low-cost Arduino boards are being strung together in IoT projects and to prototype equipment. ME

The new Arduino Engineering Kit is intended to teach students how to make and control moving objects.
Photo: Alberto Morici

SAID JAHANMIR, ASME'S 137TH PRESIDENT, is a technology leader with extensive scientific, technical, and management experience. Jahanmir received his doctorate from MIT and worked as a Senior ASME Legislative Fellow in the office of Congressman Tim Ryan of Ohio. Today, he serves in the Advanced Manufacturing National Program Office at the National Institute of Standards and Technology and acts as the executive secretary on the Subcommittee on Advanced Manufacturing for the National Science and Technology Council.

Q&A SAID JAHANMIR

ME: What has been your proudest moment as a technologist?

S.J: You often have a difficult time explaining to laypeople what you do because some of it is so imperceptible. The work on the implantable artificial heart is something that is easy for people to understand. They can see the impact of the engineering—and of the team that is working on it.

ME: What is something you want people to know about you?

S.J: I'm an easygoing guy and I'm also a good judge of people. Professionally, I like to surround myself with those who share my values and my passion. I've always also enjoyed being with young engineers. I love the energy they bring and I enjoy being a mentor.

ME: Is there something else about yourself you don't often share?

S.J: This will surprise you: When I was in high school I was a member of the International Thespian Society—I was a star. The kids would ask me for autographs. Then, for fun, I took a theater class in college, and I realized that engineering called ... and also that I needed to make a living.

ME: Do you have advice for students and early career engineers?

S.J: Twenty years from now, I will not likely be standing here. The future is yours. You must start shaping it now. If you don't participate in defining the future, you will not have the future you will be proud of. It is your responsibility to get it right. Get involved. Help shape your society.

ME: Why have you advocated for engineers holding elected positions?

S.J: It is a fact that what moves our society forward is the way that the standard of living has improved. If it were not for the ability to create new products that shape our lives, we would be in the Dark Ages. I'm not convinced that politicians really understand this. ASME and other professional societies have programs on Capitol Hill. These are critical in helping lawmakers make informed decisions. Even better would be to have more engineers who become politicians.

I tried running for public office about 15 years ago as a member of the board of education. I didn't make it, but I really enjoyed being a candidate. I've thought about running for office again.

ME: With the recent appointment of a new executive director, ASME is in transition. What are your goals during your term as president?

S.J: I want to build volunteer and staff trust. I want to help make sure that ASME is in the best financial position to deliver the mission-driven products and services to all our constituents. Ensuring safety and improving quality of life is a great mission, and I believe in it wholeheartedly. ME

ME: What motivates you as an engineer?

S.J: Engineers help improve quality of life and have an impact on society and on humankind. Striving for those goals has been a motivating factor for me.

Research has also motivated me because by disseminating your work, you create the building blocks for other researchers to carry forward what you have done. Innovation leads to innovation.

ME: You are a recognized leader in bioengineering. What gave you the impetus to enter this area?

S.J: My work on implantable artificial hearts is very interesting to me because of its impact on improving quality of life, and it gives me the opportunity to work on multidisciplinary teams that include engineers, medical doctors, the FDA, and others. We all come together to help save lives. Ironically, I have spent 80 percent of my career in tribology and only 20 percent in the bio area.

JOHN G. FALCIONI

ROCKING IMAGES FOR COMPUTER VISION

The JPEG image file format was intended to look good to the human eye. Today, 25 years later, computer vision is central to the future of drones, robots, and self-driving cars. For them, JPEGs are not a good fit. The Joint Photographic Experts Group is now working on a modernized format, called JPEG XS, which promises to be a highly flexible means for encoding video and images for artificial intelligence, high-definition films, and lightweight mobile sharing.

At the core of the JPEG XS standard is the addition of profiles which can determine the user or device need, and tune images accordingly. The standard should be a better fit for drones looking to encode video at 120 frames per second, or self-driving cars looking to spit out hundreds of images per second for analysis. The updated compression rates will enable faster image and video transfers over wired and wireless networks.

The new image and video file standard is about a year away from being finalized as it goes through the paces of approval, said Ebrahimi Touradj, professor at Ecole Polytechnique Fédérale de Lausanne, who is a member of the working group driving the JPEG XS standard.

"Current image and video standards require some delay before transmission of pictures or video frames for analyses or to display them to the remote pilot. By decreasing the delay with JPEG XS, chances of accidents are decreased and either the AI module or the human operator can react faster," Touradj said.

Artificial intelligence and analysis of the content is not built directly into the file formats. That will make it compatible with multiple machine learning libraries like TensorFlow or Caffe, which are commonly used for image recognition in drones, robots, and autonomous cars.

The open-source JPEG XS standard is mostly focused on quicker delivery of pictures from the camera to the processor, which does the analysis.

"We make sure the content and the feed into the AI modules are of a quality that is distinguishable if not compressed. That is where we stop," Ebrahimi said.

The new file format could find a use in factories where image recognition is a key component in failure-rejection systems.

Ebrahimi said it will be easy to implement the new format into drones, robots, and self-driving cars, with no special hardware needed. The Fraunhofer Institute for Integrated Circuits IIS showed the JPEG XS implementation for 4K video production as a software plug-in for Adobe Premiere Pro CC. The software and hardware support will grow as the format is finalized, Ebrahimi said. ME

AGAM SHAH

BIG NUMBER

10.3 million

NUMBER OF JOBS IN THE RENEWABLE ENERGY INDUSTRY, WORLDWIDE

IN THE POPULAR IMAGINATION, ENERGY INDUSTRY JOBS are closely associated with fossil fuels: men climbing on drilling rigs or descending into coal mines. But that concept is increasingly out of date, as renewables become a bigger part of worldwide nameplate generating capacity. In 2017, there were some 10.3 million jobs worldwide in the renewable energy industry, according to the International Renewable Energy Agency. Solar photovoltaic power employs 3.4 million people—2.2 million of those jobs are in China—while liquid biofuels, hydroelectricity, and wind power all account for more than a million jobs each.

GETTING THE INTERNET

Net neutrality is a hot-button issue, pitting consumers and content providers against the telecommunications companies that deliver broadband data. While that conflict has driven the news coverage, there is another set of stakeholders who may benefit from prioritizing certain data streams: makers of Internet of Things devices and their customers.

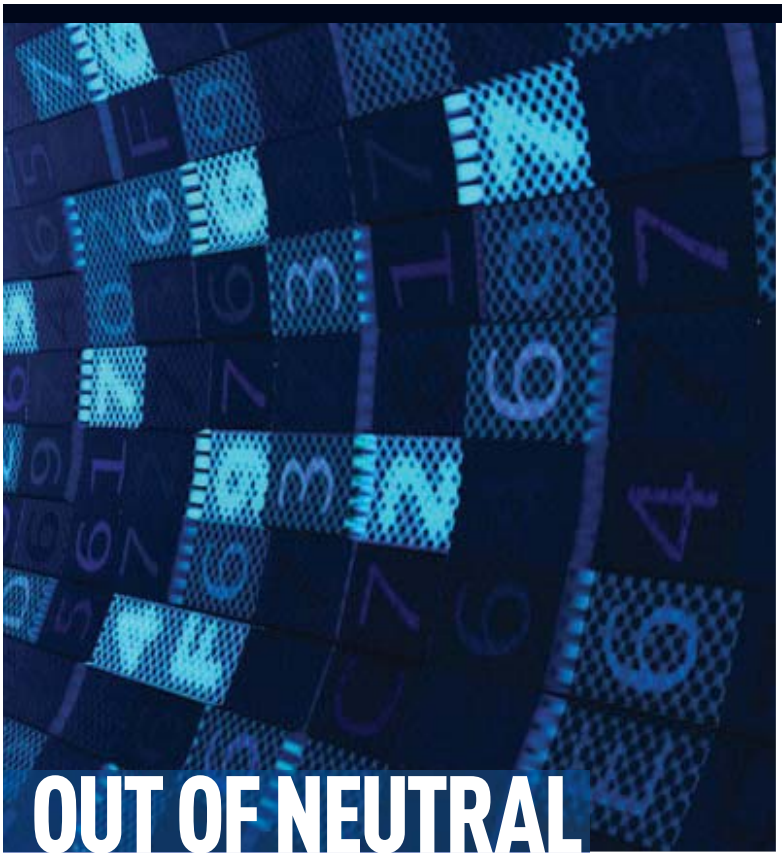
The net neutrality debate today is mostly around video, which dominates internet bandwidth. A broad set of rules established in 2015 discouraged internet service providers from blocking or slowing down internet speeds from selected content. The fear was that service providers would favor content providers with whom they have a financial interest or penalize those with whom they have a commercial or ideological conflict.

Those rules were recently repealed by the U.S. Federal Communications Commission. Opponents of net neutrality argue the internet should not be regulated as it will stall innovation and investment in next-generation technologies.

"Wearables, delivery drones, and driverless cars are among the 'killer apps' that require a lot of real-time data and would benefit from preferential treatment in areas with strained network capacity," the consulting firm PwC wrote in a research report.

Given the ability to prioritize data traffic, for instance, broadband providers could build services around security, artificial intelligence, or specialized IoT functions such as tracking services.

Manufacturers are increasingly connected to the internet, and a robust telecom infrastructure is a must to keep factories up to date, said Robyn Boerstling, vice president of infrastructure, innovation, and human resources policy of National Association of Manufacturers. Instead of growing, the broadband providers' capital expenditure declined to $76 billion in 2016 from the



OUT OF NEUTRAL

decade-high $78.4 billion in 2014, according to industry consortium USTelecom.

"Continued investment in networks, led by the private sector, allow for improvements and upgrades that keep economic growth moving in a positive direction and give the U.S. a competitive advantage," Boerstling said. "A regulatory regime that holds back the development and deployment of the latest manufacturing technology would be a step in the wrong direction."

On the other hand, a number of U.S. cities are taking steps to preserve net neutrality in their jurisdictions, saying moving control of the internet to broadband providers would affect smart city projects. Broadband providers that act as gatekeepers to the internet could make it costlier and more difficult for municipalities to deploy IoT technologies related to services like safety and smart street lighting, said officials of 62 U.S. cities in a filing with FCC.

Local governments worldwide will spend almost $41 trillion on IoT technologies over the next 20 years, according to the filing.

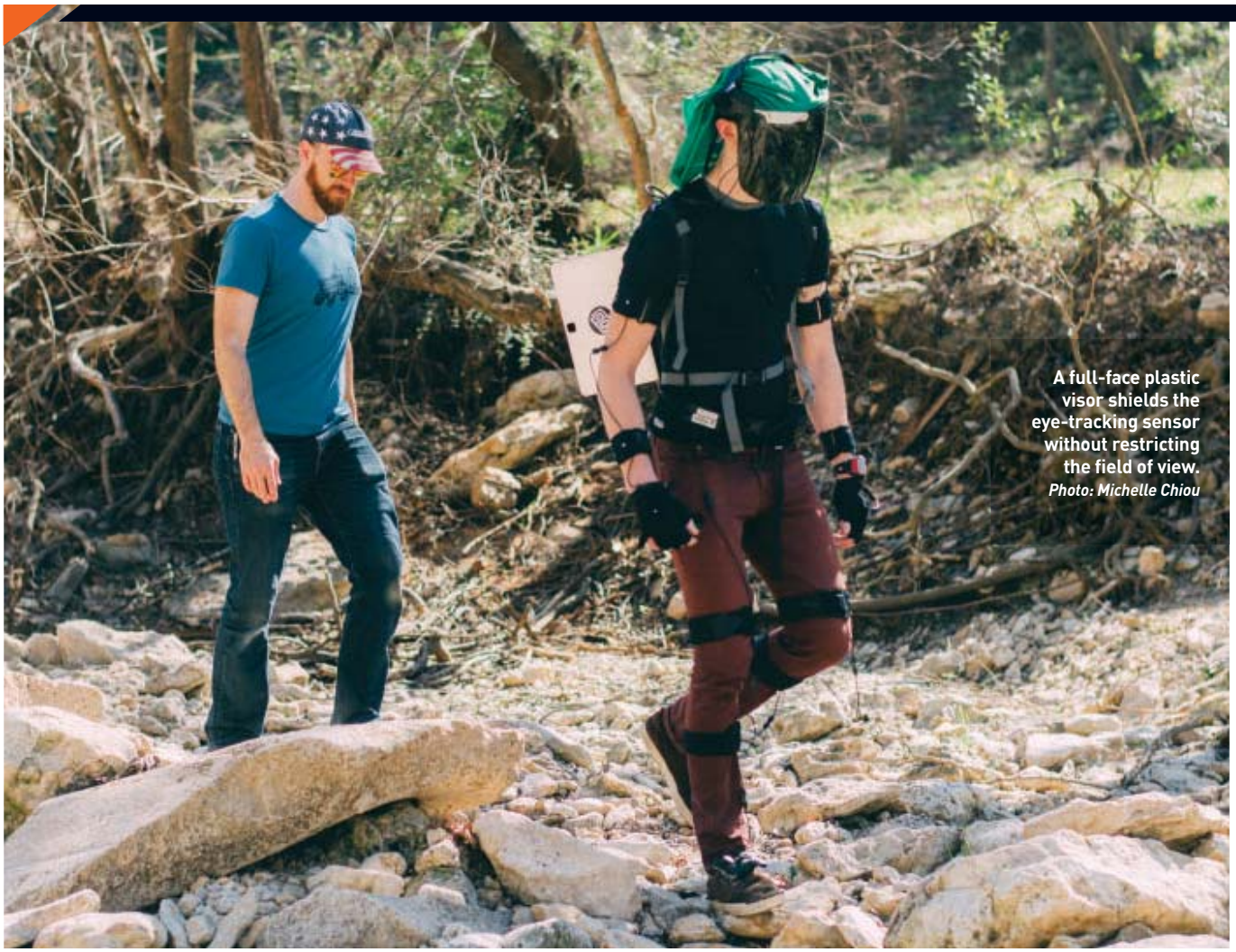
Startups with no purchasing leverage also will not be able to afford tolls for higher priority lanes or premiums for next-generation internet services imposed by broadband providers, wrote FCC commissioner Mignon Clyburn in a dissent on the repeal of net neutrality rules.

"Maybe several providers will quietly roll out paid prioritization packages that enable deep-pocketed players to cut the queue. Maybe a vertically integrated broadband provider decides that it will favor its own apps and services. Or some high-value internet-of-things traffic will be subject to an additional fee," Clyburn wrote. ME

AGAM SHAH

FLOATING NUCLEAR PLANT READY FOR FUEL

In May, a barge arrived in the port of Murmansk, Russia, to be loaded with nuclear fuel. The barge, the Floating Power Unit *Akademik Lomonosov*, is the world's first floating nuclear power plant and holds two KLT-40C reactors, each with a capacity of 35 MW. Once fueled, the 144 m barge is slated to be towed to Siberia, where it will power the town of Pevek.



A full-face plastic visor shields the eye-tracking sensor without restricting the field of view. *Photo: Michelle Chiou*

INSIGHT FROM HUMAN SIGHT

MACHINES STRUGGLE WHEN FACED WITH unpredictable conditions. Improving their image processing capabilities could help them navigate complex environments. Two groups are leveraging human vision to sharpen machine sensing: one mimics how the human eye and brain process images, while the other seeks to understand how eyes collect data to guide motion.

WATCHING HOW VISION GUIDES MOTION

THE LAB Vision, Cognition, and Action Virtual Reality Lab, University of Texas, Austin. Mary Hayhoe and Dana Ballard, co-directors. Jonathan Matthis, postdoctoral scholar.

OBJECTIVE Understanding how humans use vision to guide motion.

DEVELOPMENT A system tracking eye movement and full-body motion simultaneously, in outdoor terrain.

When hiking a rocky trail, humans maintain a sight line ahead of each step. Machines don't have those instincts. To improve robotic trajectories, a team at University of Texas is studying how humans use vision to traverse rough terrain, using a full-body suit that deploys eye trackers and 17 motion capture sensors.

"If we could understand how humans move with the kind of precision and grace that we do through natural environments, that would help us design artificial systems that can approximate that type of control," said postdoctoral scholar Jonathan Matthis, who developed the system.

Before working on this project, Matthis studied locomotion by using multiple cameras to track reflective dots on the bodies of volunteers. When mobile technology brought a wave of smaller, cheaper sensors, Matthis saw an opportunity to do experiments in a natural outdoor environment.

To measure full-body kinematics and eye motion, Matthis wove together off-the-shelf sensors. The motion capture sen-

sors combine an accelerometer, gyroscope, and magnetometer to collect three-axis data on the suit-wearer's movement. An infrared-illuminated eye-tracking device uses two cameras to follow pupil motion.

It took some engineering to get the system to work. Eye trackers typically use infrared light to follow pupil motion because they work with both dark and light eyes. While they are fine indoors, outdoors the Sun's infrared rays overwhelm them.

To let in visible light but keep out IR wavelengths, Matthis settled on a welding screen, a full-face green plastic visor that shields the eye-tracking sensor without restricting a subject's field of view.

Calibrating 2-D eye-tracking information in a 3-D experiment was a challenge that took Matthis into uncharted territory. To do it, Matthis leveraged a human reflex, called the vestibulo-ocular reflex. This works like Newton's third law: If a person moves his or her head while focusing on a given object, their eyes will move in the opposite direction, compensating to keep the same object in view.

By having a volunteer focus on a fixed point while moving his or her head, Matthis could map from 2-D eye movements to the 3-D environment using eye-tracking and head-motion data.

Among his findings: Humans look two strides ahead on medium terrain, and look at the ground more than 90 percent of the time on rugged paths. In both cases they consistently look 1.5 seconds ahead of their current position.

Next, Matthis plans to study how visual deficits affect motion. He hopes to work with new computer algorithms to elicit more granular vision data, watching exactly what cues subjects use to decide where to step next. ME

Humans use an important trick to process complex images in milliseconds: prioritizing dynamic data over static information. Prophesee, a French startup, channels that approach in an imaging sensor and processing algorithms that samples and analyzes only what changes in a scene.

"These are really like high-speed eyes for machines," said Christoph Posch, co-founder and chief technology officer of Prophesee.

The problem with conventional vision systems, Posch explained, is that they sample each pixel equally. This imposes a large computing burden and limits processing speed. While their algorithms are plugging away, these systems often miss data between video frames.

Neuromorphic sensing, a term coined by neural computing pioneer Carver Mead, promises to address this problem. It seeks to mimic the brain by focusing only on the parts of the image that change.

Receiving and processing information on an event-by-event basis, creates faster, and more adaptive vision systems that use less computing power, Posch said.

At 10,000 frames per second, Prophesee's Onboard event-based vision chip captures motion like a high-speed camera. It consists of a silicon CMOS image sensor and circuits that send signals only when they detect changes in the light hitting a pixel. By filtering out static information from each frame, it produces lean data that specialized algorithms analyze while using only milliwatts of power.

Prophesee's event-based vision chip captures motion like a high-speed camera.
Photo: Prophesee

HUMAN-MIMICKING MACHINE VISION

THE LAB Prophesee, Paris. Christoph Posch, co-founder and chief technology officer.

OBJECTIVE Develop biologically-based sensors and algorithms to make machine vision faster and more efficient.

DEVELOPMENT The Onboard vision system, a combination of sensor plus processing algorithms modeled after the human eye and brain.

Prophesee also developed brain-inspired algorithms to process this asynchronous data, enabling fast tracking and object recognition for multiple shapes.

The challenge, Posch said, has been to cram more complex processing circuitry into each of the sensor's pixels. Current chips accommodate a 15 μm pixel pitch, but Posch says better resolution is in the works. As their pixels shrink, Posch and his team envision their systems improving monitoring in factories, surveillance, and driverless vehicles.

Posch originally started out developing event-based particle detectors for CERN, the European Organization for Nuclear Research. They were instrumental in identifying the Higgs Boson particle in 2012.

As Posch shifted to vision-focused work, he took on projects with both machine and medical applications. He is also scientific advisor to a company called Pixium Vision that makes medical devices to restore partial vision in certain cases of blindness. The company currently has two bionic vision systems in clinical trials.

He also thinks it might be possible to apply event-based principles to LIDAR, a radar-like laser sensor used in some autonomous cars, or other types of sensors. Low-power, low-bandwidth sensing, he said, should make it easy to work with many of these devices at once. ME

ALAN S. BROWN

AI IN DESIGN

Artificial intelligence is being used by engineers at the micro-levels of design and engineering, and for small-scale simulations. Now computing resources are becoming available to deploy AI on large-scale development and maintenance projects.

MathWorks—the maker of popular Simulink and MATLAB—is folding more AI tools into its portfolio for more efficient engineering design and simulation. AI will offload a good part of the design process to the computer, with algorithms helping deduce the next steps to take, much like an autonomous car deciding the next step after it recognizes a person crossing a road. As a result, engineers have more time to think up effective designs.

Another area of application for AI is predictive maintenance, which came under the microscope recently after a fatal engine explosion during a Southwest Airlines flight. AI tools could take advantage of data collected by components like sensors to create a more reliable maintenance model to prevent such accidents. The maintenance will improve as more data is collected and fed into the learning model.

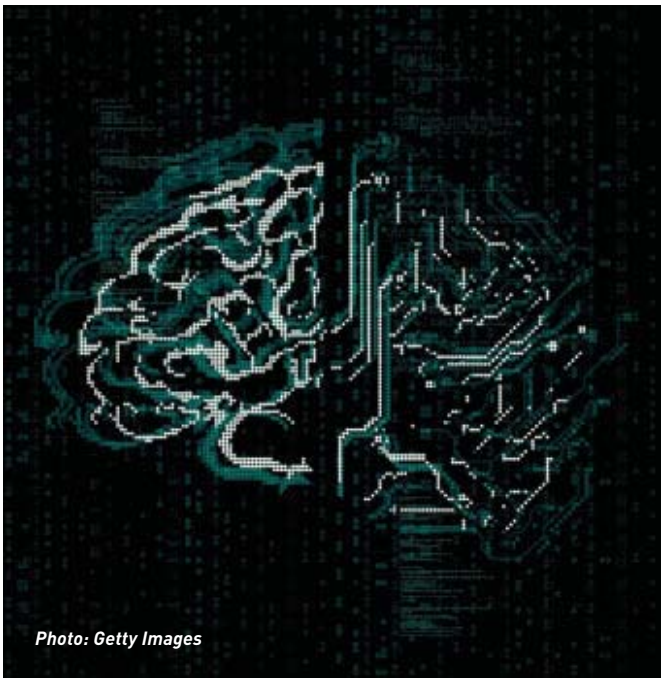


Photo: Getty Images

New engineering projects will benefit from artificial intelligence, but what about things that are already built? AI could still provide a boost. For example, to keep aging wind turbines from failing catastrophically, models and simulations can be used to figure out when the turbines need to be serviced. The idea is to collect and harvest data for predictive actions, said Andy Thé, partner manager for AI and deep learning at MathWorks.

Many are looking into AI implementation in engineering projects, but deployments have been uncommon, more in single digit percentage points, Thé said.

MathWorks is adding to MATLAB—a programming language for technical computing—the AI framework tuned for use on GPUs from Nvidia, which are the backbone of speech recognition tools like Amazon's Alexa, or image recognition via Facebook or Google. Students and engineers can develop AI and deep-learning models in MATLAB for faster development and more effective engineering design, simulation, and validation.

"It's a platform for scientists exploring an engineering project. It enables ideas," said Amnon Gai, manager for partner marketing and development. Engineers can hook MATLAB to Simulink, which is popular for graphical design and simulation. Combined, the two can be used for full-scale prototyping.

AI in the form of machine and deep learning isn't new to MathWorks. The company has possessed the hooks in the form of neural network toolboxes, and the industry-specific algorithms have been around, Gai said. But GPUs have emerged to enable supercomputer-like number crunching, and the availability of prebuilt functions and libraries makes the integration of AI into engineering projects simpler. ME

AGAM SHAH

"I don't like using the words 'trade war,' but I can't see how this isn't part of warlike behavior."

European Commission president Jean-Claude Juncker on steel and aluminum tariffs proposed by the U.S. government, quoted in the Financial Times *on March 2, 2018.*

THREATS OF 3-D PRINTING

Additive manufacturing has its charms, but expect perils too. RAND, the research organization, investigated the impact of 3-D printing, and the groups said by 2040, improvements in additive manufacturing could bring significant security risks.

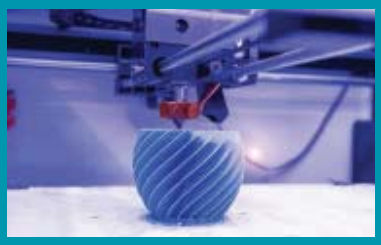
For instance, the U.S. Army has 3-D printed a grenade launcher called RAMBO (Rapid Additively Manufactured Ballistics Ordnance), and it's expected non-state actors will have that capability soon if they gain access to the digital file.

As a proof of concept, guns have already been printed.

Industrial-scale 3-D printers could also blunt the coercive power of trade sanctions. "Economic sanctions and trade embargoes would become far less effective if rogue states could simply print what they need," the RAND study said.

There's also the fear of additive manufacturing and robots taking away jobs, but it could impact globalization with more products locally sourced. Countries such as China—which rely heavily on manufacturing exports—could be one of the first countries to be affected by shortened supply chains.

The benefits of 3-D printing outweigh the threats, RAND wrote, but countries would be wise to build additive manufacturing strategies revolving around access to materials, hardware, software, and intellectual property to prepare for its disruptive effects. ME



Additive manufacturing can produce munitions as well as knickknacks.
Photo: Rand

LOOKING BACK

The intersection of engineering and management was in full swing when this article was first published in July 1928.

THE MAKING OF BUSINESS EXECUTIVES

EUGENE G. GRACE, NEW YORK, N.Y.

The president of Bethlehem Steel Company examined the character traits that help great engineers become outstanding leaders of industry.

We have briefly reviewed certain qualities of engineers who have become successful business executives. Is it possible for us to say that the material success of all of these men was due to any one characteristic common to each one of them? Indeed, I venture to assert that there is one quality which, in the last analysis, is determining as to whether any man shall realize material success in this world of ours. That quality is sound judgment.

I have known many businessmen seemingly slow in their mental processes, possessed apparently of little imagination and of none of the flair which gives fascination to so many characters, and yet who, when crises come—be they big or be they little—are able to so steer their business courses that they move in the right direction instead of into shallow waters or upon the rocks of trouble.

What is the basis for sound judgment and what makes a man able to judge wisely? Is this ability capable of development and training?

It seems to me we generally find that the man who judges wisely is usually the man who has observed accurately in the first place. He has seen and analyzed correctly that which has passed before him. He has reasoned out in his own mind the relationships of the things which he has seen; he has noticed the effects which have followed from causes which have come under his own observation—and he has seen these things straight. And that is the most difficult thing in the world to do!

If I were to prescribe one process in the training of men fundamental to success in any direction, it would be thoroughgoing training in the habit of accurate observation. It is a habit which every one of us should be seeking ever more to perfect.

Will you think I am venturing upon a field which has no relationship to the subject before me if I make a suggestion which might well be considered by the educational authorities of our country? And that is this: From the moment children begin their studies in the grammar schools, even in the lowest grades, give them daily some training in accurate observation. Even in our colleges I think it would be wise if the students were called upon to devote a certain amount of their time regularly to a definite exercise in the practice of observation. ME

GRAF ZEPPELIN

The month that Grace's essay was published, the 776-foot-long LZ-127 *Graf Zeppelin* was christened. The rigid-framed airship was the first aircraft designed for transatlantic passenger service, and a few months later it took off from its home base in Friedrichshafen, Germany, for Lakehurst, N.J., making the 6,200 mile crossing in 111 hours. After a series of notable excursions, including a trip around the world, the 20-passenger airship settled into regular commercial service between Germany and Brazil. A number of factors, including improvements in the performance of heavier-than-air craft and the fallout of the *Hindenburg* disaster, doomed passenger airship service and by 1940 a wartime materials crunch led to the scrapping of *Graf Zeppelin*.

LZ-127 *Graf Zeppelin* landing at its home base in Friedrichshafen, Germany.

PLASTIC FOR POTHOLES

Ghanaian entrepreneur recycles plastic waste into inexpensive paving blocks.

The West African nation of Ghana has problems with both deteriorating roads and plastic waste. Nelson Boateng, an engineer from a town outside the capital, Accra, has formulated an ingenious way to take care of both issues.

Boateng's company, Nelplast, is turning recycled plastic into blocks that can be used to pave streets. It's a response to the piles of plastic littering streets and landfills.

Ghana is undergoing a spurt of economic development, and the road infrastructure isn't keeping up with the increasing number of cars. The result is potholes—and traffic jams caused by slowed vehicle speed. Fixes can't come fast enough, and Boateng believes his recycled plastic blocks could replace the more expensive concrete paving blocks.

The blocks were created by washing recycled plastic and mixing in sand. "The mix is fed into a special extruder designed by us," Boateng said. "What comes out is then put in a mold and pressed under a hydraulic press machine."

The sand adds texture to the plastic, ensuring that the blocks are nor slippery. Each block costs under $1 to make, and that compares favorably to concrete, which Boateng estimated cost $1.60 to make. One of the main challenges of plastic waste—it degrades slowly—is an advantage for use as paving material.

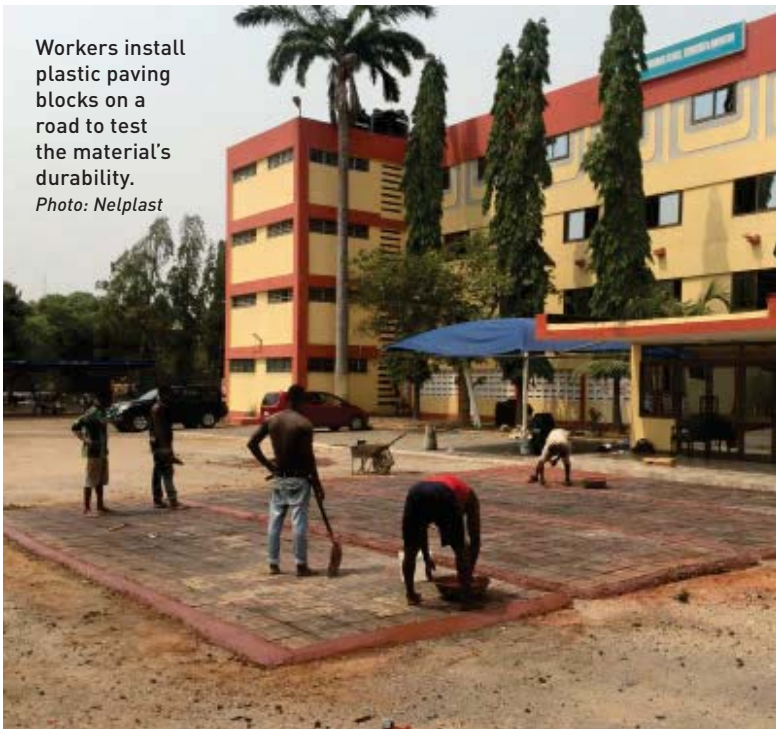
Previously a network engineer, Boateng quit his job and founded his company after seeing how poorly plastic waste recycling was managed. About 2 percent of Ghana's plastic waste is being recycled, but Boateng said a complete plastic ban isn't the answer. Plastics are also important in Ghana because many people are employed in the industry.

Boateng recycles all kinds of plastic except PVC. He deploys 500 plastic collectors, paying each about $30 a day. That's good pay in a country where the poverty rate stood at 21.4 percent in 2012, according to the World Bank.

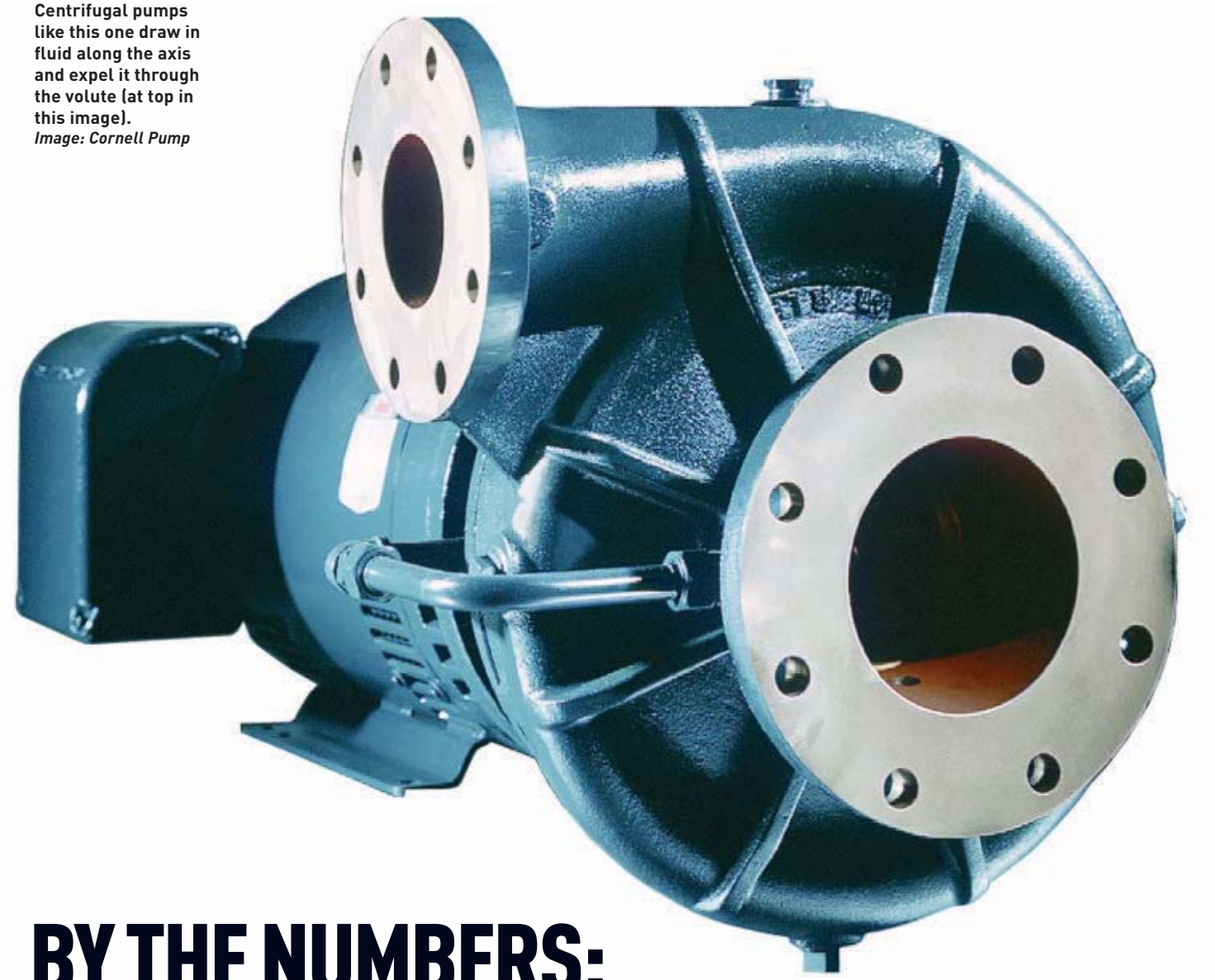
Boateng said solving problems like plastic waste can't be implemented immediately at a global level, so he's starting small. "For $2 million, I can clean up my district. We plan to do it," he said.

There is worldwide interest in the plastic blocks, Boateng said. But first he has to prove that plastic blocks are viable to handle the rigors of street traffic. His startup laid down about 500 feet of recycled plastic blocks on a heavily trafficked street in Ashaiman, a town 10 miles from Accra. If that pilot project performs well, expect to see more roads paved with recycled plastic. ME

AGAM SHAH



Workers install plastic paving blocks on a road to test the material's durability. *Photo: Nelplast*



Centrifugal pumps like this one draw in fluid along the axis and expel it through the volute (at top in this image).
Image: Cornell Pump

BY THE NUMBERS: PUMPS KEEP PUSHING AHEAD

A new report suggests demand from the water and wastewater, chemical, and power generation industries will sustain long-term market growth.

Centrifugal pumps are a mature technology, but one that is crucial for a variety of applications, from wastewater treatment and papermaking to petroleum production and pipelines. Even with the relative lack of innovation, there are changes afoot in the North American market, according to a recent report from Frost & Sullivan, an international research firm.

The near-term outlook is not terribly promising. Low oil and gas prices over the past few years have depressed capital expenditure in the petroleum industry, which accounts for more than 20 percent of the centrifugal pump market. Indeed, after seeing a revenue decline of more than 10 percent from 2015 to 2017, petroleum has lost its spot as the largest market for pumps. That role is now taken by water and wastewater, which this year is forecast to have $932 million in revenue, versus $915 million for petroleum, thanks to investment in municipal water delivery to cut waste and increase energy efficiency, according to Frost & Sullivan.

The total revenue for the North American centrifugal pump market is forecast to be $4,323 million this year. Frost & Sullivan sees slow but steady growth to 2024 (after having stayed basically flat for several years before 2018), reaching $5,288 million.

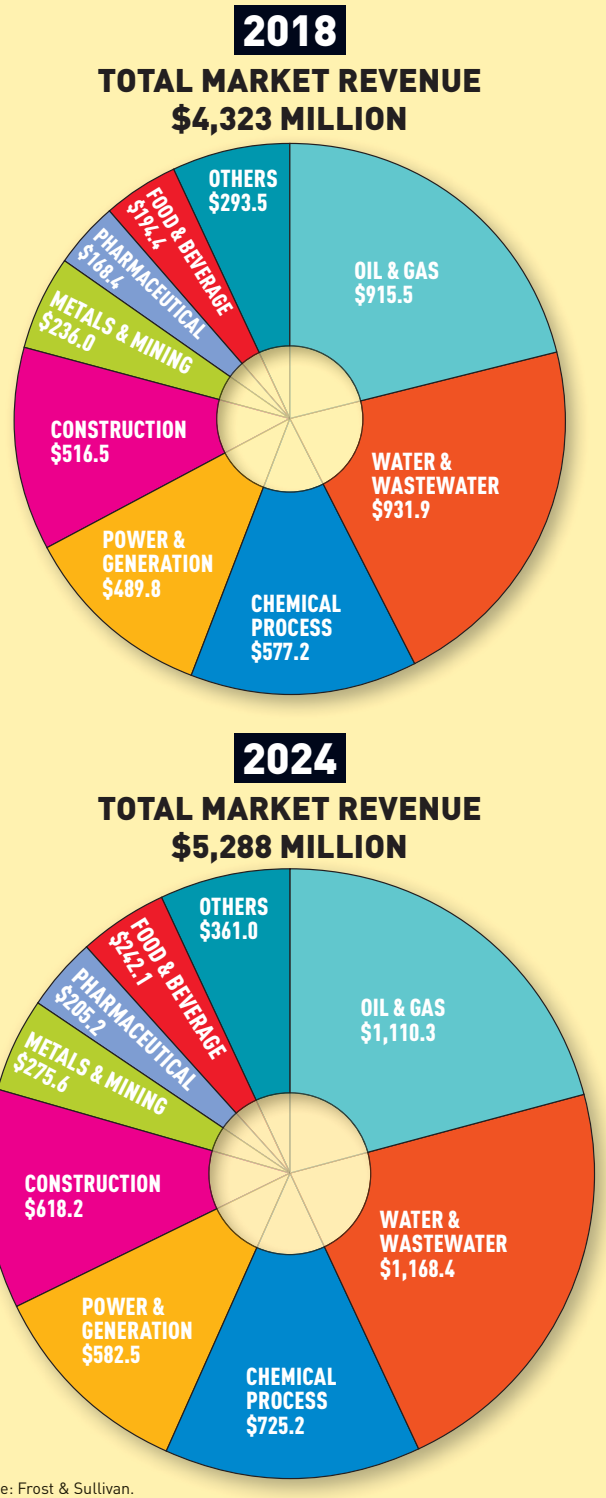
In spite of this seemingly sclerotic market, Frost & Sullivan sees challenges ahead. "As prices of commodities, such as oil and gas, metals, and minerals, stay low, end-users need to reduce the cost of operation to increase profitability," the company wrote in its report, "North American Centrifugal Pumps Market, Forecast to 2024." The report continued, "As a result, companies are focused on improving product efficiencies, thereby driving the demand for energy-efficient products."

Opportunities for efficiencies come from a variety of directions. For instance, adding capability through the sensors and data-processing platforms, collectively known as the Industrial Internet of Things, could create value through the more efficient operation of pumps and the selling of data services in addition to the mechanical device. That more holistic view of selling pumping services rather than pumps as discrete machines is going to be critical, the report suggests, since imported pumps will likely be able to outcompete on price and therefore overall quality and functionality will be an important selling point for pump makers in the North American market.

The report also suggests that manufacturers should look for niche applications to increase their customer base, rather than trying to wring more from existing customers. Ultimately, however, the health of the pump market is going to be tied to the fortunes of the many industries that rely on pumps. ME

JEFFREY WINTERS

CENTRIFUGAL PUMP MARKETS SHARE OF TOTAL, 2018 AND 2024



Source: Frost & Sullivan.

ROBOT EXPLORERS

ARE ASTRONAUTS OBSOLETE?

Robotic space probes have proven themselves to be capable explorers, roaming the solar system, observing the galaxy, and pushing back the boundaries of the final frontier.

Human spaceflight does have great sentimental appeal. Former U.S. astronaut and MIT professor Jeffrey Hoffman misses the old days. "When I was flying in the space," he laments, "we were putting 40 astronauts a year, now we are putting four." Those few astronauts are dispatched to the International Space Station for scientific research and in-flight maintenance.

Those looking for a return to the glory days of human space exploration will need patience. NASA is aiming for a human landing on Mars in the 2030s, though cynics might contend that a Mars mission has been "just over the horizon" for a generation. Private-sector efforts in the near term are limited to suborbital tourism.

For now, we will have to be content with robot missions. Fortunately, NASA, the European Space Agency, and groups from other countries are readying a variety of missions that should answer some of astronomy's biggest questions, all while keeping human feet firmly on the ground.

TESS

The April 2018 launch of the Transiting Exoplanet Survey Satellite was a milestone for astronomers, who expect TESS to find as many as 20,000 planets orbiting nearby stars. This so-called planet hunter will detect its quarry by monitoring the brightness of 200,000 target stars; whenever a planet passes in front of the star, it will dim the star ever so slightly. It's the same kind of observation performed until recently by the Kepler satellite, which discovered 2,343 exoplanets including 30 that were Earth-sized planets within their star's habitable zone.

"TESS will also identify promising candidates for detailed follow-up by other powerful telescopes like Hubble and the upcoming James Webb Space Telescope to better understand these planets' atmospheres," said Natalia Guerrero, a TESS researcher at MIT.

Image: NASA/KSC

Over the coming decade, unmanned missions will be taking the next giant leap into space.

BY AGAM SHAH


Image: NASA /JSC

James Webb Space Telescope

The Hubble Space Telescope revolutionized astronomy in the 1990s, and astronomers have even higher hopes for its successor, scheduled to launch in 2020. As an infrared telescope with more than seven times the light-gathering ability as the Hubble, JWST will see more distant galaxies with greater detail, and its spectrograph will provide insight on the chemical makeup of far-off objects. The telescope will also feature coronagraphs that can block the direct light from a star so that the instruments can focus on the light reflected from adjacent objects such as extrasolar planets. Astronomers think JWST can answer a lot of their questions, but if the half-billion dollar instrument needs a repair, they'll be out of luck: it will orbit around a gravitational node some 1.5 million km from Earth, far beyond the reach of any astronaut.


Image: NASA/KSC

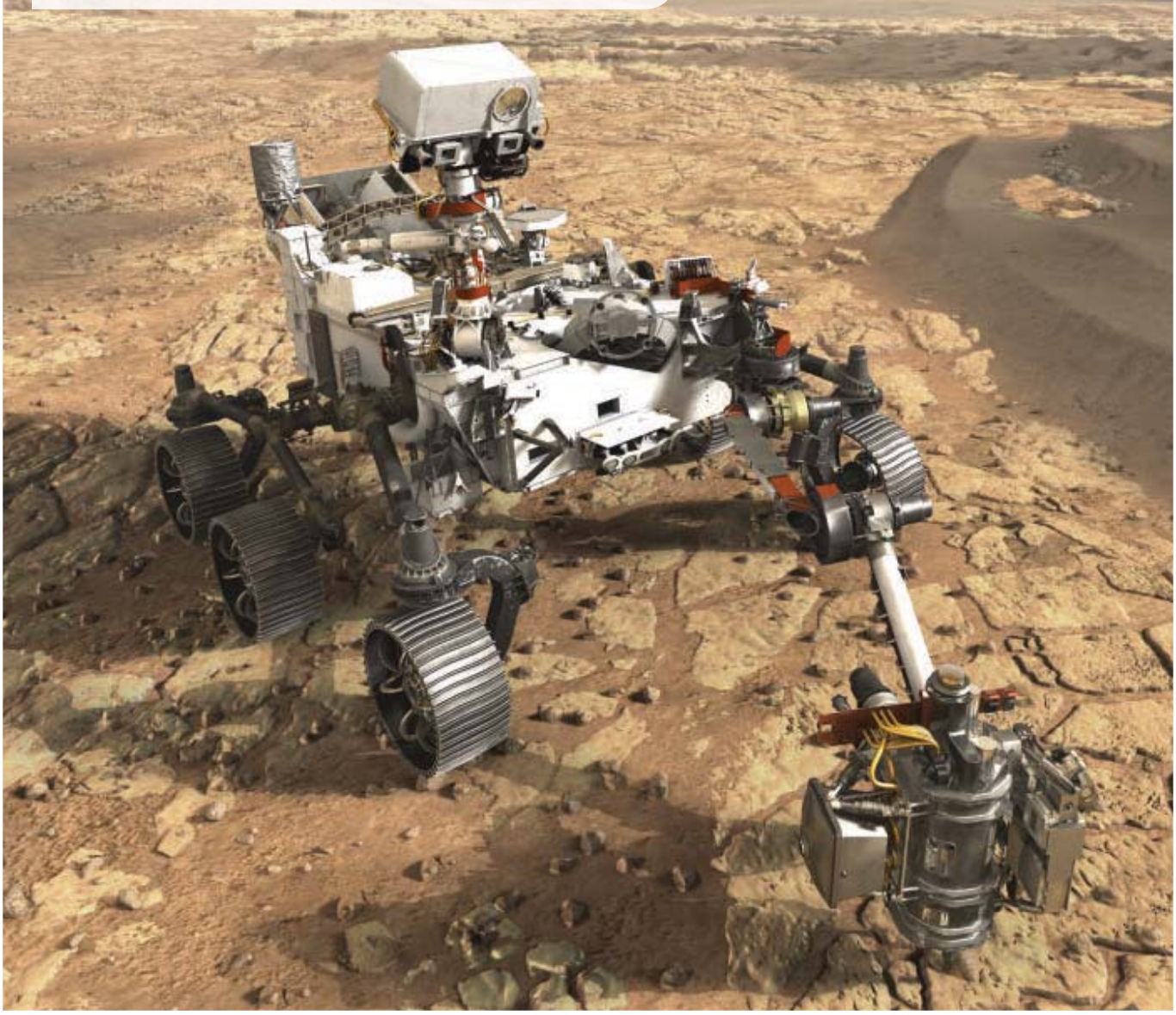
OSIRIS-REx

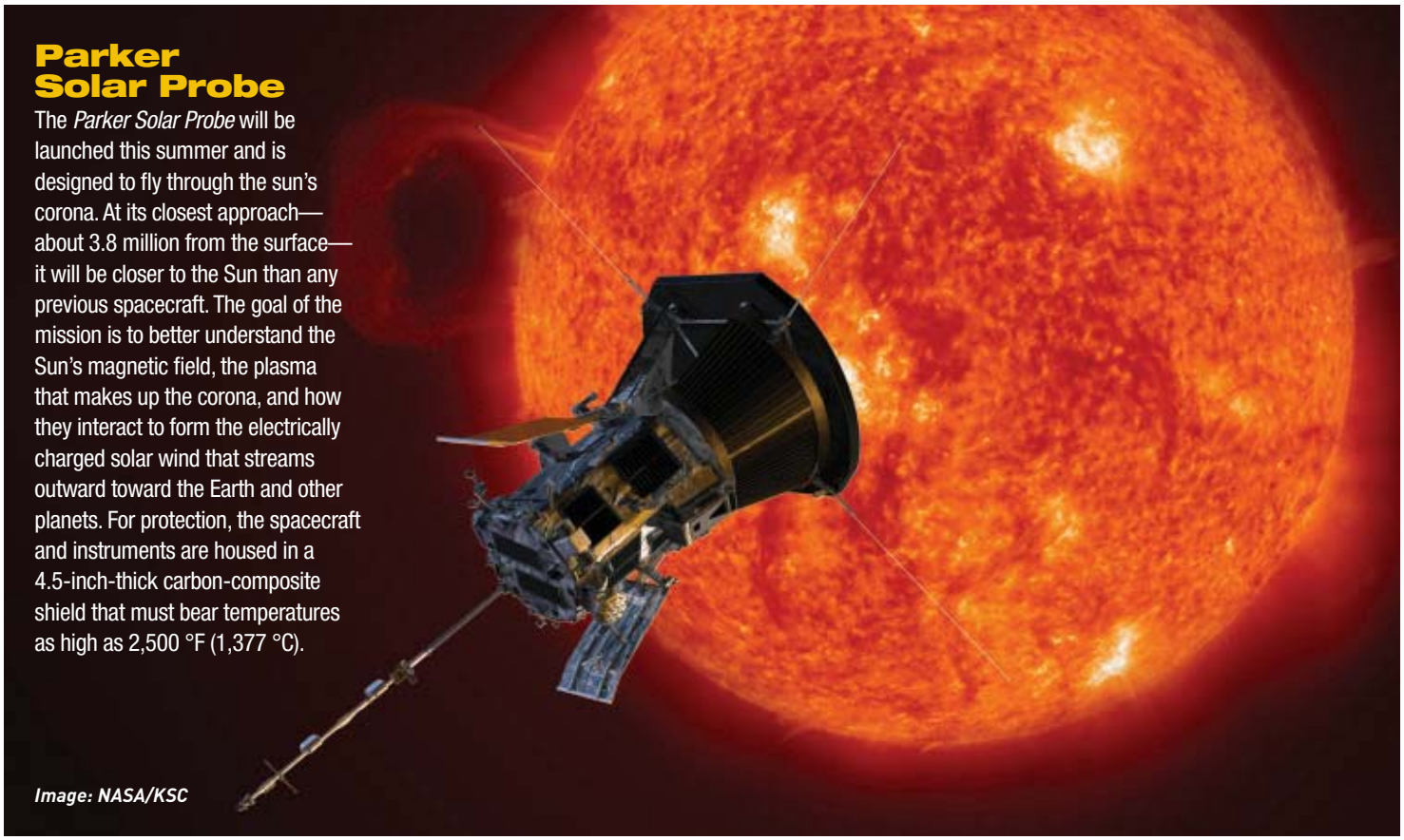
The OSIRIS-REx mission is already underway (it was launched in 2016) but next month it will reach its target, the asteroid Bennu. The spacecraft will spend more than a year mapping the asteroid—not so hard, since it's about 0.3 miles across—and then make a close enough pass to scoop up some soil with a robotic arm. If that daring maneuver works, the probe is scheduled to return to Earth in 2023. "For the first time we'll bring back a sample of an asteroid," said astronaut Jeffrey Hoffman. Private companies are also planning to visit asteroids, and even start mining them.

Images: NASA/JPL

Mars 2020

Humans have been sending robotic explorers to Mars since 1964, when Mariner 4 sent back the first close-up images of the Red Planet. The next visitor, scheduled for launch in 2020, will investigate Mars not from orbit, but over land and through the air. The one-ton rover, powered via a radioisotope thermoelectric generator rather than solar panels, has 23 cameras and sensors measuring the composition of the rocks and soil. One experiment will see whether it is possible to extract oxygen from the carbon dioxide in the Martian air, while a ground-penetrating radar will look for buried rocks and meteorites, and can detect underground water ice and salty brine at depths of up to 30 ft. "Mars is intricate and complex, and it doesn't have just one surface," said Eric Ford, a professor of astrophysics at Penn State. "It's worthwhile studying Mars." The 4 lb. helicopter will act as a scout for the rover and is designed to cover 2,000 ft. per day.





Parker Solar Probe

The *Parker Solar Probe* will be launched this summer and is designed to fly through the sun's corona. At its closest approach—about 3.8 million from the surface—it will be closer to the Sun than any previous spacecraft. The goal of the mission is to better understand the Sun's magnetic field, the plasma that makes up the corona, and how they interact to form the electrically charged solar wind that streams outward toward the Earth and other planets. For protection, the spacecraft and instruments are housed in a 4.5-inch-thick carbon-composite shield that must bear temperatures as high as 2,500 °F (1,377 °C).

Image: NASA/KSC

Europa Clipper

Data from earlier robotic explorers suggest Jupiter's moon Europa has oceans of liquid water under its icy crust. To verify those results and find out if anything might be swimming there, NASA is developing the *Europa Clipper*. The mission, with a tentative launch set for the mid-2020s, is slated to carry instruments to measure the moon's chemical, thermal, and magnetic anomalies from orbit. A lander (below) has been proposed to directly sample the surface and look for life-supporting molecules.

Image: NASA/HC

ARIEL

Astronomers first detected extrasolar planets in 1995, and since then, all we have measured is their masses and orbits. With the European Space Agency's Atmospheric Remote-sensing Infrared Exoplanet Large-survey, or ARIEL, astrophysicists will get spectrographic data on at least 1,000 exoplanets. That will provide answers about the composition of those planets' atmospheres and how they interact with their home stars. Those answers will have to wait, though, since ESA doesn't plan to launch ARIEL until 2028.

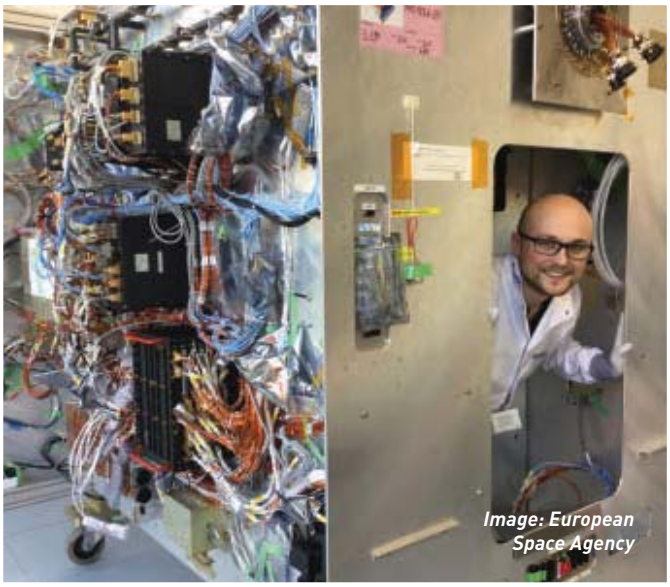


Image: European Space Agency

BepiColombo

Mercury is the closest planet to the Sun and also one of the least explored. Robotic flybys have produced images of the planet's surface, but questions about its chemical composition, core, and thin atmosphere remain unresolved. BepiColombo, a double-probe joint mission of the European Space Agency and the Japan Aerospace Exploration Agency, aims to delve into Mercury's mysteries, such as its internal composition and the source of its magnetic field. Scientists will also look to answer critical questions of how it fares so close to the Sun.

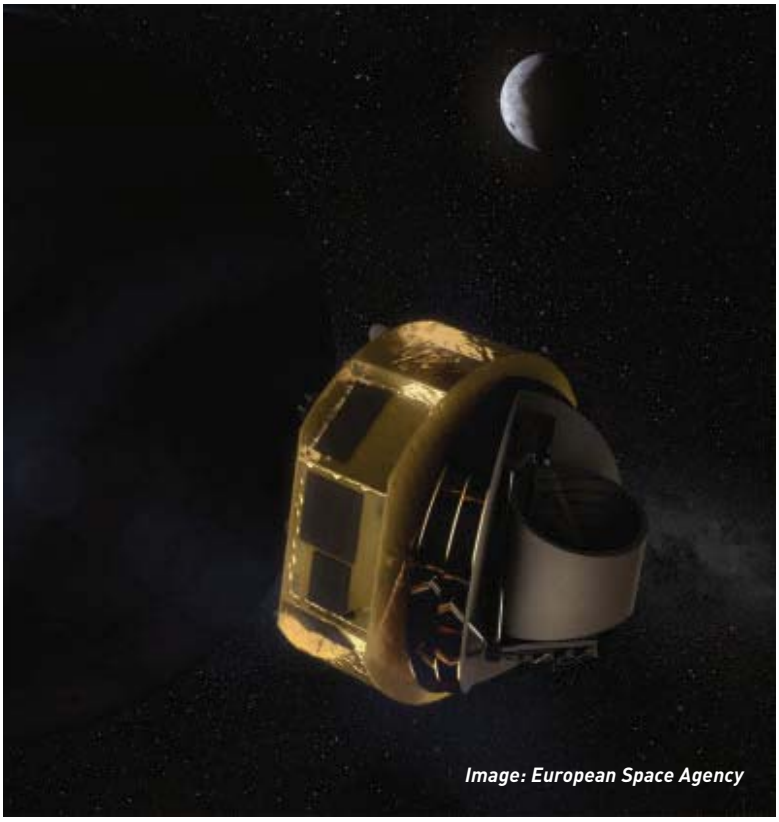


Image: European Space Agency

Image: Indian Space Research Organisation

Chandrayaan-2

India, trying to make its name as a spacefaring nation, hopes to launch its first lunar lander by the end of 2018. The Indian Space Research Organisation said Chandrayaan-2's coordinated orbiter, lander, and 40-lb. rover will collect information on the "lunar topography, mineralogy, elemental abundance, lunar exosphere and signatures of hydroxyl and water-ice." The moon will soon be crawling with robots: China's Chang'e 4 rover is also scheduled to land this year, and about a dozen surface missions—including several private ventures—are planned for the next five years. When humans finally return to the moon, it might almost seem crowded. ME

AGAM SHAH is an associate editor at *Mechanical Engineering* magazine.

THERE'S A *NEW*

The rotating detonation combustor promises a simple and efficient engine to transform heat directly into work.

BY CRAIG A. NORDEEN AND LEE S. LANGSTON

New technologies appear to come out of nowhere. The long gestation period is often hidden.

Franz Stolze first filed a patent application for the turbojet engine in 1873. It was rejected. It wasn't until the 1930s that Hans von Ohain and Frank Whittle designed operational jet engines. It took another 20 years after that before gas turbines beat piston engines in thermal efficiency to become the primary propulsion method of modern aviation.

Similarly, Herman Oberth's writing on electric propulsion waited 60 years for the launch of the first ion engine aboard Deep Space I in 1998.

If there is a half-century wait for technologies to develop, then it is time for the rotating detonation engine (RDE). The RDE was first conceived in the 1950s and the first experimental devices were run at the Lavrentyev Institute in Novosibirsk, Russia, and at the University of Michigan. Such an engine would differ from a conventional turbojet by combusting fuel via detonation rather than deflagration.

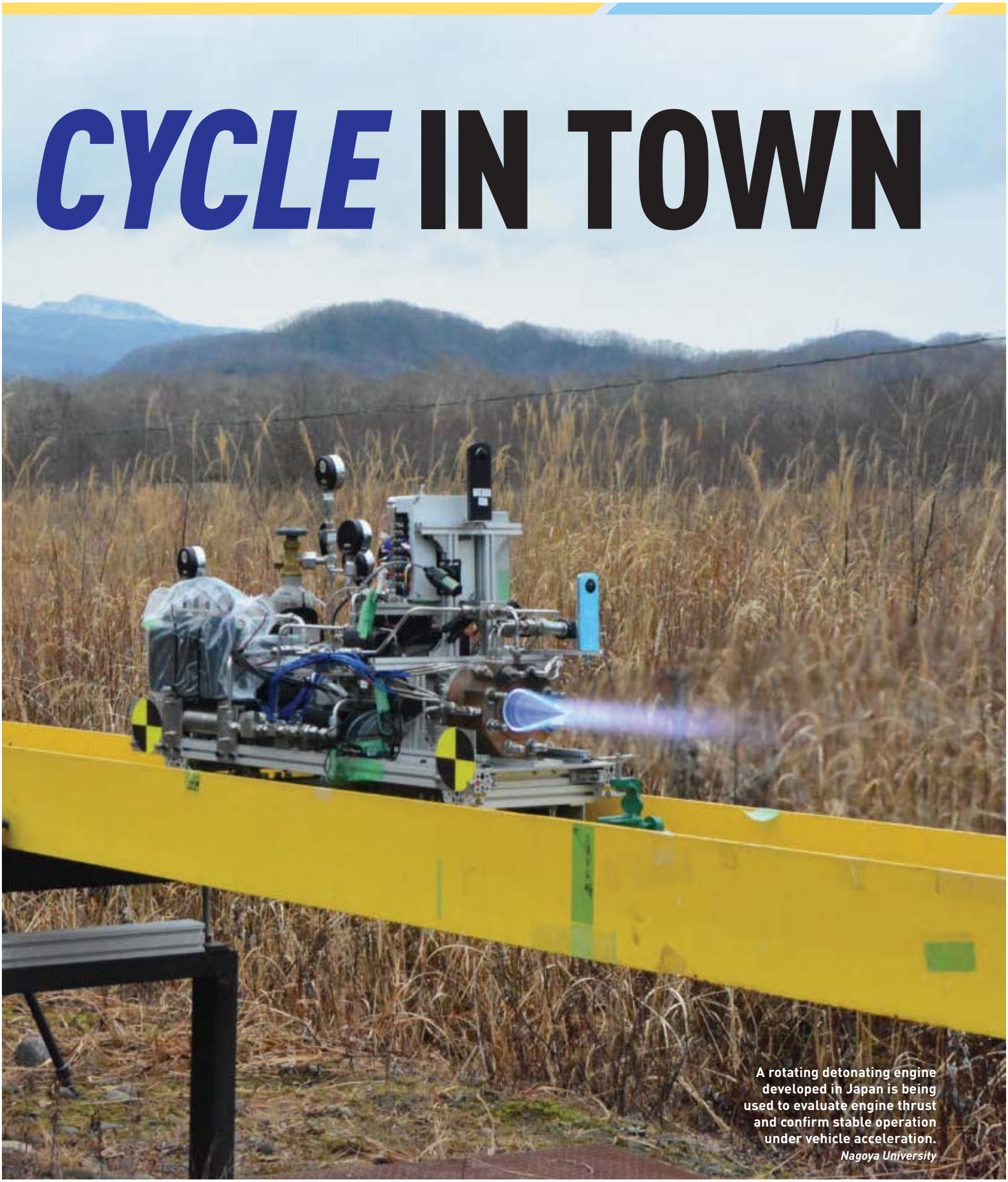
Deflagration and detonation waves differ by structure and characteristic velocity. Deflagration—whether the controlled burn inside a gas turbine or the rapid burning of gunpowder—features a subsonic flame front that advances by diffusion of heat and species. In contrast, detonation is a layered structure of a leading shockwave, subsonic combustion, and thermal choke followed by a supersonic expansion. The entire sandwich is driven through the reactants at supersonic or even hypersonic speeds.

In popular imagination, detonations are short, sharp shocks, but a rotating detonation engine will run as long as reactants are supplied, producing a roar worthy of any NASA rocket.

An engine that uses detonation rather than deflagration could have some key advantages. If harnessed in a gas turbine or rocket, detonation could reduce the need for some expensive hardware, lighten engine weight and increase power output and efficiency.

Today, variants of the RDE as a combustor for gas turbines, rockets, and scramjets are being explored at the Air Force Research Laboratory (AFRL), Naval Research Laboratory, Naval Postgraduate School, and the Department of Energy. Similar work is being conducted in Russia, France, Poland, Japan, China, Germany, and several other countries.

CYCLE IN TOWN



A rotating detonating engine developed in Japan is being used to evaluate engine thrust and confirm stable operation under vehicle acceleration.
Nagoya University

The pace of development has been accelerating in the past decade, with the first experimental RDEs running in the U.S. since the 1960s. An RDE powered turbine at the AFRL has accumulated more than 20 minutes of operation since 2016.

In August 2017, a team of Japanese researchers from Nagoya and Keio Universities, JAXA, and the Muroran Institute of Technology conducted a test of an ethylene-burning RDE that produced 895 Newtons of thrust. Their aim is to develop a sounding rocket powered by an RDE.

The promises of increased efficiency, simplicity, and high power density are driving the current research focus on RDEs. A quiet unannounced race is ongoing between nations and institutions to figure out how best to utilize the cycle.

The Detonation Cycle

A gas turbine powered by detonation would have a detonation wave rotating continuously at thousands of cycles per second around the inside of an annular combustion chamber, pressurizing the products of combustion and producing thrust. The wave is sustained by a continuous inlet flow of oxidizer and fuel at one end of the annulus. As the wave passes over the injectors, the high pressure shuts down the reactant flow. Injection flow is restarted after the wave passes, creating the triangular-shaped fill region of unburned gasses that feed the detonation. No moving parts are required. The only rotating feature is the wave structure.

The supersonic shock wave within an RDE acts as a compressor. Combustion starts at a much higher pressure and temperature than what is found in an equivalent constant pressure process at the same initial conditions. As a result, the ideal detonation cycle produces a higher performance than the Brayton cycle.

But this means that an RDE uses a different thermodynamic cycle than the ones familiar to engineers—the Otto and Diesel cycles found in automobile engines, the Rankine cycle in steam turbines, and the Brayton cycle that is the heart of the gas turbine. Understanding the detonation cycle is crucial to predicting the amount of useful energy available for thrust or turbine work extraction.

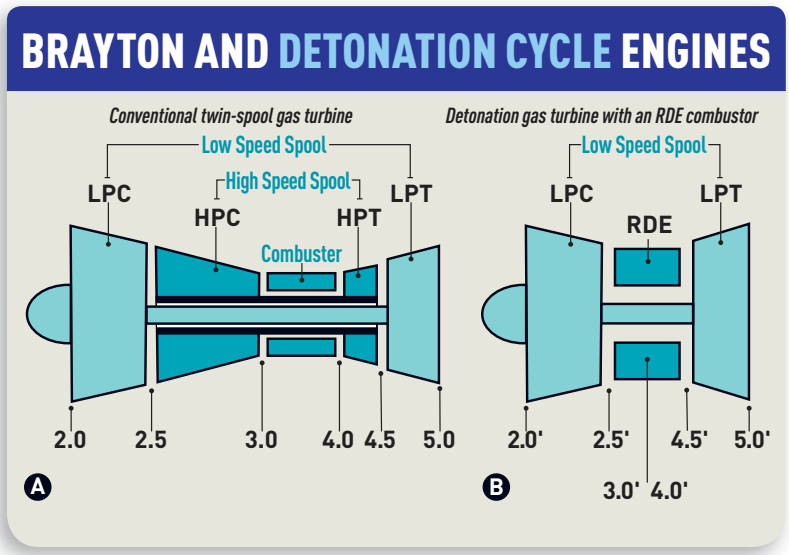
Detonation belongs to a class of cycles called pressure gain combustion, where a rise in pressure is produced by the action of combustion instead of mechanical compression. Tracing the cycle across the familiar thermodynamic cycle diagram helps explain why detonation cycles have sustained such interest.

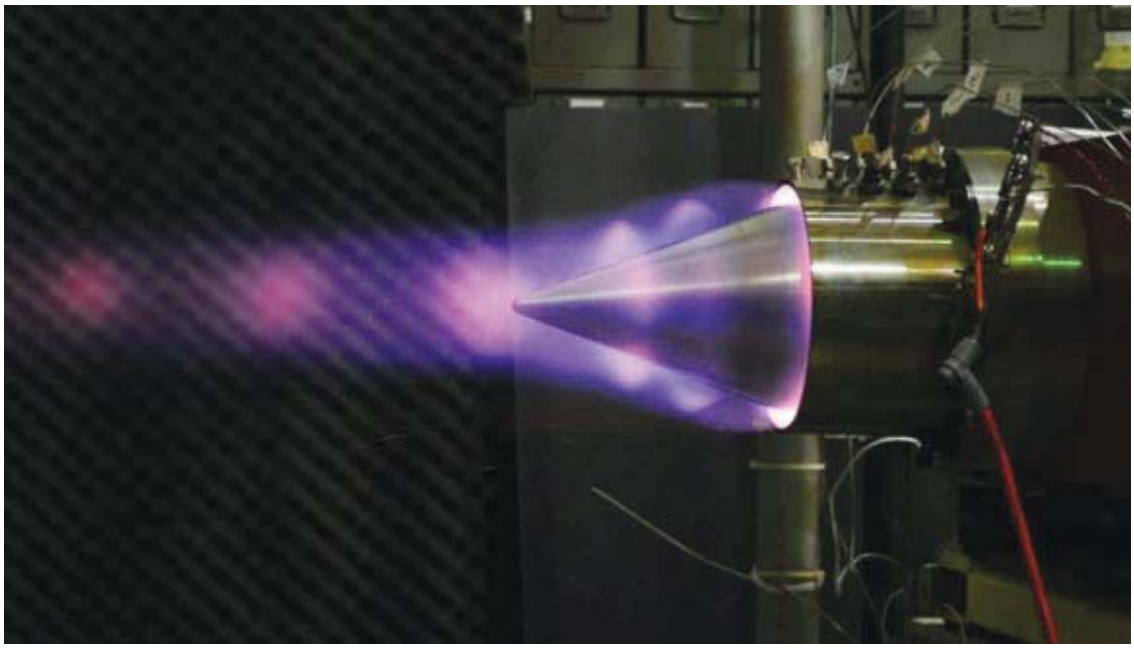
The detonation cycle will work without pre-compression, although an RDE is usually paired with a pressurized tank or compressor to boost efficiency as the first leg of a five-part ideal cycle. After pre-compression, the detonation proper starts with shock compression. The rising temperature and pressure of the shock compression creates free radicals that initiate auto-ignition. Heat release further increases temperature until combustion ends with the thermal choke.

The fourth process of expansion has two parts. The first expansion produces unrecoverable energy that is required to power the forward motion of the leading shock. The second expansion creates useful work that may be used for thrust or turbine work extraction. The fifth leg returns the gas flow to ambient conditions.

Mapped against the Brayton cycle, one sees that entropy generated by the detonation is less and the useful work is greater than the Brayton cycle. For this reason, the detonation cycle has captured the interest of a world trying to squeeze every useful joule out of available fuels.

A close examination of the h-s diagram (opposite) might lead to protests that the peak enthalpy exceeds that of the heat addition. The discrepancy is partly due to the fact that a plot of static enthalpy ignores the inherent kinetic and rotational energies in the wave. Only then can the sum of energies be matched against the





RDE combustor and nozzle test, showing shock diamonds in the supersonic flow. *Photo: AFRL WPAFB*

heat addition. Unfortunately, the explanation is lengthy and we must refer the reader to the academic RDE literature.

Short of Ideal

Ideal cycles tell only half the story.

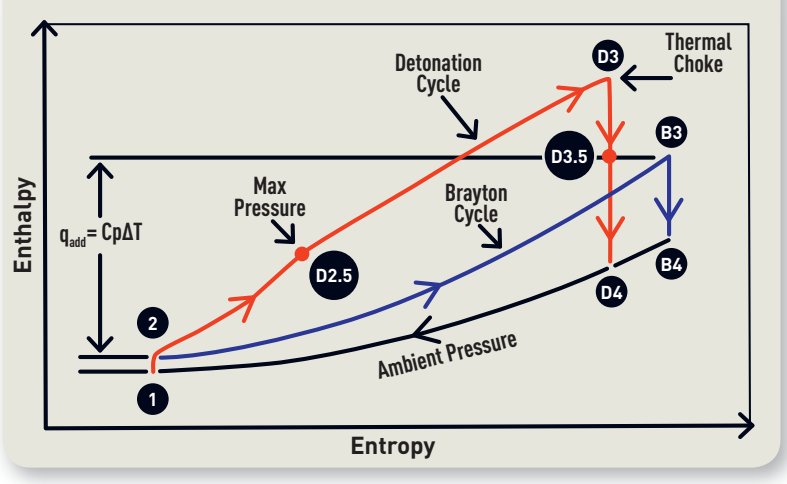
All ideal cycles become more efficient as the pre-compression increases and asymptotically approaches 100 percent. The ideal Brayton cycle has zero efficiency with no pre-compression. With no pre-compression, the ideal detonation cycle has a significant thermal efficiency, about 35 percent because of the leading shock. The difference between the two cycles narrows with increasing pre-compression. The ideal detonation cycle is always more efficient.

The story changes dramatically when realistic component losses are introduced. Academic studies often assume compressors and turbines to be 90 percent efficient to demonstrate impact and trends. Realistic values might differ considerably, but the effect of component efficiencies on the total system is clear. Instead of continually rising and approaching 100 percent, a maximum system thermal efficiency is reached at some optimal point and then drops with an increasing pre-compression.

The net effect is that perhaps half of the useful work of an ideal heat engine is lost. The narrowing gap between detonation and Brayton cycles is not immune to this effect. Indeed, there are conflicting conclusions on the utility of a detonation cycle. Some studies have determined that the Brayton cycles can actually be better at high pre-compression and the investment in a new cycle is not justified. Others have concluded that the detonation cycle will always be more efficient than the Brayton cycle even with component efficiencies less than unity. For engines with high pre-compression, even a 0.1 percent increase in efficiency can have a big effect on fuel consumption over time.

For that reason, the promise of RDEs is significant. Many real internal combustion engines are less than 25 percent efficient. The best aeroderiv-

IDEAL DETONATION AND BRAYTON CYCLES



ative gas turbines, such as the H series turbines used for electric power generation, might break 40 percent. It is a major challenge for a single-cycle heat engine of any type to achieve 50 percent. Gas turbine and steam combined cycles can approach 60 percent.

With enough pre-compression and efficient components, however, an RDE gas turbine by itself might top 50 percent. A combined-cycle RDE plant could possibly reach 70 percent efficiency, a goal of current DOE research.

Whether an RDE could ever reach that goal is an open question. The truth of the matter is buried in the details of any given engine design. The real component efficiencies of a RDE gas turbine will never be the same as a conventional gas turbine.

Simple comparisons based on some equivalency of component efficiency will only show general trends. Such a method is not reliable if the difference between the two systems is small and very sensitive to modeling assumptions.

Crack and Roar

The current state of research has passed from a proof of concept to the establishment of a working theory of operation and the exploration of a range of operating characteristics. The next step must be actual demonstrations for energy production or experimental flight.

An allied technology, the pulse detonation engine, has been demonstrated, with the first manned flight of a PDE-powered aircraft occurring in 2008. These engines, which produce a repeating sharp crack as the shock wave exits the tube at perhaps 100 times per second, have a smaller power density than an RDE, which emits a steady 5 kHz roar.

But experimental demonstrations of the thermal efficiency and overall performance of an RDE are generally lacking. The published results to date come from rigs that are designed for general study and not specifically for efficiency. (It is true, however, that not all results have been published, since some of the RDE research and development is subject to various levels of restriction or classification.)

In addition to providing efficiency and performance data, the engine must also be operated for an extended period to demonstrate that it can be protected from the heat and pressure it generates.

To provide cooling for a constantly running

Brayton gas turbine, the compressor-discharge air is routed around the combustor, driven by the pressure drop from the compressor to the turbine. The cooling air is ported to orifices in the turbine blades to create a film of air to protect the blades from damage. A pressure gain combustor does not provide this useful drop in pressure, so other means must be used to protect the turbine. Researchers at the Air Force Research Laboratory at Wright Patterson Air Force Base are investigating the use of air injectors to provide the necessary cooling, with encouraging results.

Engineers must also perform the exacting work of system integration. No engine cycle exists without a complex web of factors that tie it to a larger whole. For aircraft and rockets, a heavy efficient engine may be useless, since weight also

A Long E-Z aircraft was adapted to operate with power from a pulsed detonation engine. The airplane flew once over Mohave, Calif., (inset) and is now on display at the National Museum of the U.S. Air Force on Wright-Patterson Air Force Base, Ohio.

Photos: Museum of the U.S. Air Force and US Airforce (inset).

drives the flight range or the deliverable payload.

The opposite is also true; a lightweight engine of mediocre efficiency may bring leverage to reducing structure and other system requirements throughout the vehicle.

The larger system also includes the time and cost limits of development. For instance, RDEs may find a possible use in heavy lift rocket turbopumps, which represent as much as half of all rocket development costs. Since the RDE brings its own shock compression, the turbo pump size—and the development cost—may be reduced. Given the high cost of lifting payloads into Earth orbit, such an effort may be worthwhile, even if there is no overall performance gain.

The detonation cycle has great promise for improving performance and reducing the size of turbomachinery. Until the rotating detonation engine hits its important development milestones, some skepticism is warranted.

Skeptics should recall the lag between a technological concept's inception and its realization. The pace of such development can indeed be measured in generations.

We may soon see the day when the RDE transforms from a long-gestating idea to an overnight success. **ME**

CRAIG A. NORDEEN is a postdoctoral fellow in the mechanical engineering department at the University of Connecticut in Storrs. **LEE S. LANGSTON** is a professor emeritus there.

IOT PUTS A NEW SPIN

How one of the oldest mechanical devices became a poster child for the Internet of Things.

BY ALAN S. BROWN

As anyone who ever had a bearing fail knows, durability counts. So, imagine the reaction of bearing engineers and tribologists at a recent Bearing World conference when a keynote speaker from one of the world's largest bearing makers announced that predictability is more important than longer bearing life.

The researchers in the audience had spent years modeling the interaction of moving parts, loads, and wear to model bearing lifespans, keynoter Victoria van Camp, SKF Group's president for innovation and business development, recalled.

"So, what if we could combine those models with real-time data on bearing performance?" she asked. "It would be difficult, but then we could say, 'I know for a fact that this bearing will fail next week, rather than say, '10 percent of these bearings will fail within a certain timeframe.'"

While some researchers argued that this was impossible, van Camp was adamant: "This has to become the norm, because no one should accept a failed bearing shutting down a factory."

Her vision goes far beyond condition monitoring done in many factories today. By harnessing the Internet of Things (IoT) and other Industry 4.0 technologies—low-cost sensors, Big Data analytics, and machine learning—SKF and its competitors want to catapult one of the world's oldest mechanical devices into the digital future.

In fact, bearings are emerging as a poster child for Industry 4.0. Yet this heady mixture of digital technology and physical products is also disrupting how companies monitor, operate, and service rotating equipment; the way they sell and service products; and who they partner with and compete against.

Bearings are everywhere in factories, from robotic arms and conveyor belts to pumps, fans, and milling tools.
Photo: NTT

ON BEARINGS

SKF has embraced this disruption. In the past, the company sold bearings, lubricating systems, and related products. It also provided services that range from rebuilding worn and damaged bearings to monitoring the condition of "several million" bearings around the world.

Today, SKF is using that crucial data—and its research into bearing failure—to sell "reliable rotation" as a service.

"The most expensive event in a factory is when a bearing fails in a critical machine and shuts everything down," van Camp explained.

By turning unexpected failures into planned maintenance, van Camp promises to lower costs and boost factory output. But she wants a share of those additional profits.

"If we sell bearings as pieces of steel, it's hard to get a fair share of their value," she said. "Instead, we want to pick the right bearing and lubrication system for each application, monitor them, and take the right remedy action when there is a problem. We want to negotiate key performance indicators with our customers and get paid for meeting them. This is the business model that our company is betting on," van Camp said.

SKF is not the only company seeking to sell mechanical products as services. Rolls Royce and its aircraft engine competitor, General Electric, get paid on operating time. So, do companies in other industries, such as Boeing, Valmet, and Caterpillar.

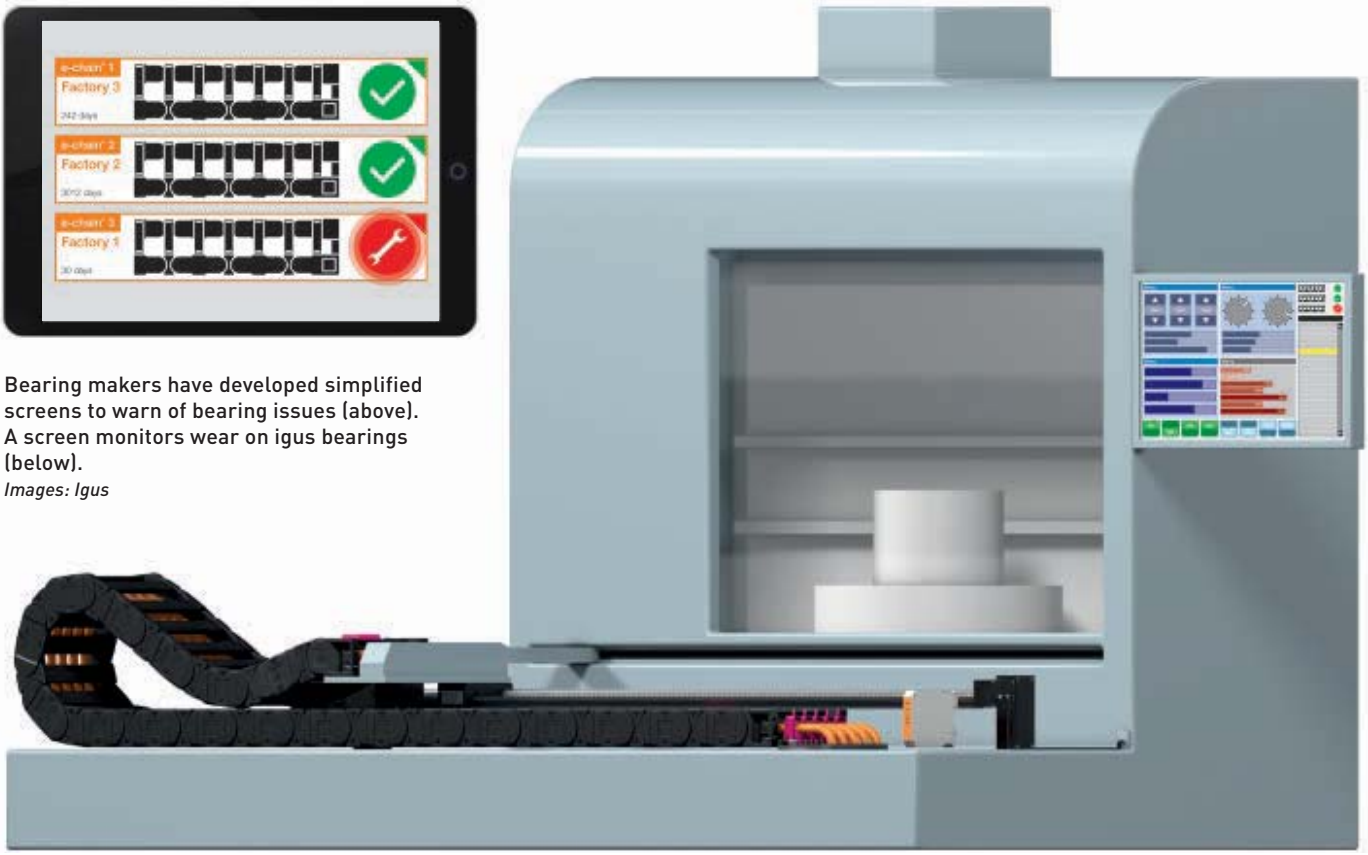
Yet digital disruption slices both ways. It enables SKF to bind itself more tightly to customers but exposes it to more—and sometimes very different—partners and competitors.

PREDICTIVE MAINTENANCE

How did bearings become the spear tip of the IoT revolution?

They are, after all, among the oldest mechanical devices. Bearings were used in hand drills in ancient Egypt and revolving tables in the Roman Empire. Today, they go into everything from pumps, fans, engines, and milling machines to wind turbines, ore crushers, and paper manufacturing machines.

They get their name from "bearing" the load of a rotating shaft. In a simple bearing, the inner ring spins with the shaft and transmits its load through rotating balls or cylinders to an anchored outer ring that takes the shaft's weight and torque.



Bearing makers have developed simplified screens to warn of bearing issues (above). A screen monitors wear on igus bearings (below).
Images: Igus

Companies often monitor bearings in remote applications, like the top of wind turbines (left). An SKF ball bearing (below).
Images: SKF

Industrial bearings are custom designed for each application. They consist of hard, finely machined metals that roll easily and resist wear, elastomeric seals to prevent contamination, and lubricants to reduce friction.

They fail in many ways. Sometimes, they are damaged (often with a hammer) or misaligned during installation. Seals get punctured or eaten away by chemicals. Operators run machines too fast or cut an alloy or crush ore with different hardnesses or chemical compositions. Even lubricant can be an enemy if operators use too little, too much, or the wrong type.

Before they fail, bearings emit cries for help. Each mode of failure has a distinct sound. By listening to those sounds with a vibration monitor—while monitoring heat, torque, and rotating speed—researchers can estimate how long a bearing has left.

This is called condition monitoring. First, engineers calculate the frequencies to watch from the bearing's geometry. Then they try to isolate those frequencies while suppressing the noise made by other bearings and moving parts inside a machine.

A large paper mill, for example, might have hundreds of rotating parts. It takes a combination of sensors and algorithms to get it right.

SKF got into the business when it purchased a pioneer in the field, Palomar Technology, in 1989. As van Camp noted, it now monitors millions of bearings. Yet condition monitoring has its limits.

"You could look at vibration and draw conclusions about whether to stop now or continue to operate, but you couldn't really say how much longer," she said.

"To do that, we need more data about the process. For example, if it is an ore crusher, we needed to know what type of rocks they were crushing, the sizes going in and out, and the loads. For a paper plant, we needed the wood content and its flatness, which means different things depending on the process.

"With all that process data, we can start making accurate predictions. We can tell a miner how long the crusher will operate or to crush smaller rocks to run longer. We can tell how long a cutting machine can run before it ruins a part," she added.

The Industrial Internet of Things makes it possible for large—and increasingly, small—factories to monitor machine condition by integrating bearing software with machine and factory software. *Images: NTT*

"And when a bearing needs replacement or maintenance, we can tell what kind of maintenance it will need and connect back to our supply chain to have those parts ready. If we see a recurring problem, we can redesign the bearing to fix it," van Camp said.

As the number of sensors it monitors has grown larger, SKF has turned to machine learning to find hidden patterns. According to van Camp, the data are too great for humans to discern those patterns. Machine learning does that well and comes without the prejudices of engineers who look for problems only where they expect to see them.

SKF provides customers with software, including apps that help install and analyze bearings. It also makes portable vibration testers, which technicians use like a stethoscope to take the pulse of individual machines during walk-by inspections.

In larger factories, embedded sensors eavesdrop on bearings in critical machinery. This data may go to an SKF monitoring center or to a factory's control system.

"We've publicly announced a partnership with Honeywell, but we work with several other main control system players," van Camp said.

The same is true with machine makers, who also want to offer condition monitoring services.

"Where we fit in is as a service or knowledge partner with rotating equipment," she said. "If you're producing gear boxes, you don't have to be a bearing expert. Leave it to us. We work to build our intelligence into their software, so users don't have 10 different screens to look at."

"In exchange, we provide the bearings and the maintenance on them, and they do the services they're good at, like winding motors or building machines," van Camp said. "We cannot give this away because we do not want to become the Red Cross for bearings."

A NEW LANDSCAPE

SKF is not the only company trying to shake up the industry. Schaeffler Group, Germany's largest bearing maker, recently signed a deal with IBM to use Watson technology and the cloud to monitor and analyze its bearings under operating conditions and opened a Silicon Valley research center to tap the region's disruptive energy.

It also became the second company, after SKF, to embed sensors within a bearing. This is an impressive achievement, since the chip-based sensors must retain power and function flawlessly for years inside a dirty and aggressive environment. The payoff is greater accuracy and better predictions.

Other large producers of industrial bearings are following the same path. Surprisingly, so is Germany's igus, a producer of self-lubricating plastic bearings used in applications with lower loads.

"You don't need to have a complicated system of electronics to monitor our bearings," said Richard Habering, who heads the company's new smart plastics division.

One way is to measure the thickness of a bearing wall. Another is to embed a wire in a bearing; when enough of the bearing wears away, the wire closes a circuit that sends a warning.

"In most of our bearings, the gliding part is changeable," Habering said. "If you wait too long, you can destroy the shaft and the bearing. But do it too early and you lose money by replacing a bearing that could run longer."

In addition to traditional competitors, SKF's digital journey has put in competition with traditional control system companies, such as Emerson Electric. Like SKF, Emerson also bought a condition monitoring company, Computer Systems Inc., in 1995. The two competitors, however, have very different value propositions.

In smaller factories, technicans typically monitor bearings by using portable viibration monitors.
Images: Emerson

"Instead of the bearing level, we're looking at the facility level," said Jacob Swafford, Emerson's senior manager of sales development. "Our focus is much broader."

SKF has strong analytics, he explained. But it can also pull a bearing out of a machine, determine the root cause of failure, recommend improvements, and repair or replace the bearing.

"I could argue that our technology is just as deep or deeper, but we chose to go the other way," he said. "We look at things more holistically."

Emerson's goal is to aggregate data from bearings—and other machines and components—run high-level analytics on it, and help customers use that information to make "step changes" in plant operations and productivity.

Honeywell has both large and small customers. While many large facilities take condition monitoring seriously, many smaller facilities often seek help only after a machine failure hurts their business.

Digital technology, and especially the mad scramble to plug into the IoT, also brings out some unexpected partners and competitors. One is NTT Data Services, a $22 billion subsidiary of the Japanese telecommunications giant Nippon Telegraph & Telephone (NTT).

So, how much does NTT know about running a factory?

"Data centers are an amazing example of monitoring and controlling physical assets," said Siddharth Sharma, vice president of industry solutions for NTT's manufacturing team.

In addition to stand-alone data centers, the company operates factory IT systems around the world, and is on 70 percent of the shop floors in Japan. Branching into the industrial IoT is a logical extension of that business.

Sharma makes a strong case. His team consists of experienced factory IT engineers who understand how to collaborate with customers on instrumenting bearings and machinery. NTT develops its own machine learning algorithms and builds several types of factory sensors.

Like Emerson, it understands how to aggregate data to provide its own monitoring and predictive maintenance. In fact, Sharma said the company is considering building command centers just for John Deere. And it has vast experience integrating factory data into control systems and corporate enterprise software, such as SAP.

Yet, even as digital technologies are turning the factory floor into a free-for-all of competing technologies, bearing manufacturers—and companies like them—have a key advantage. They have built them, pulled them apart, and analyzed how and why they fail. Software that embeds that knowledge and makes it easy for companies to access gives them an edge.

As van Camp noted, "Data analysis and visualization and the ability to draw conclusions and to take the right remedy action is where SKF is unique and provide real value to customers." **ME**

ALAN S. BROWN is a senior editor at *Mechanical Engineering* magazine.

FEATURED

PRIMER ON ENGINEERING STANDARDS: EXPANDED TEXTBOOK EDITION

OWEN R. GREULICH AND MAAN H. JAWAD

ASME Press Books, 2 Park Avenue, New York, NY 10016. 2018.

The successful design, fabrication, and operation of any product relies on foundational understanding of pertinent standards. Some will contend that standards and guidelines form a central pillar of the engineering profession. This textbook and quick reference, co-published by Wiley and ASME Press, goes beyond a list of rules to help students and practitioners gain a better understanding of the creation, import, and use of standards. Greulich and Jawad discuss the impact and value of different types of standards, and the process of standards creation is emphasized in terms of essential characteristics and common pitfalls to avoid, with detailed guidance on how, where, and with whom one may get involved in official development.

168 PAGES. $49; ASME MEMBERS, $39. ISBN: 978-1-119-46617-8

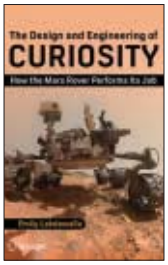
THE PERFECTIONISTS: HOW PRECISION ENGINEERS CREATED THE MODERN WORLD

Simon Winchester

HarperCollins, 195 Broadway, New York, NY 10007. 2018.

We live in a world that reveres precision—a concept more powerful than mere accuracy, according to Winchester, the bestselling author of science and technology books. We certainly are surrounded with precision-built gadgets and track time with atomic clocks. But while Winchester holds up the Antikthera mechanism as the earliest artifact of precision and the gravity observatory known as LIGO as its most recent apotheosis, he contends that 18th century mechanical engineers should be credited for creating precision. "It was brought into being for severely practical reasons," he writes, "related to the potentially awesome power of that high-temperature form of water ... known as and defined by the word steam."

432 PAGES. $29.99. ISBN: 978-0-0626-5255-3



THE DESIGN AND ENGINEERING OF CURIOSITY: HOW THE MARS ROVER PERFORMS ITS JOB

Emily Lakdawalla

Springer Praxis Books, 233 Spring Street, New York, NY 10013-1578. 2018.

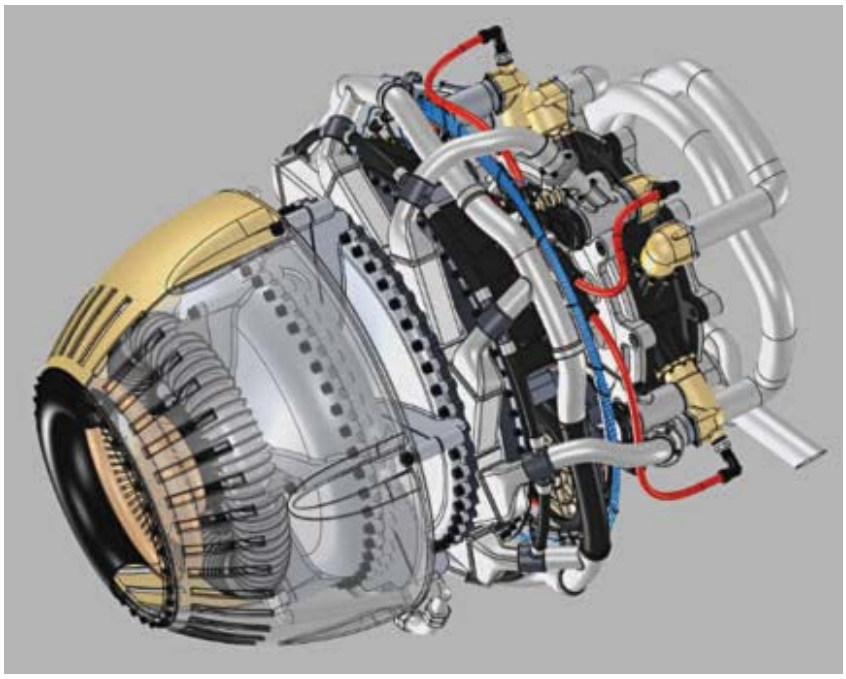
The Curiosity rover is a mobile laboratory, bristling with cameras, spectrometers, a meteorological station—even an oven, useful for baking soil samples to free up their volatile components. Lakdawalla describes how this one-ton robot was designed and put together, and how the various instruments functioned. She even discusses the malfunctions and the methods mission scientists and engineers developed to cope with them. Given the unforgiving conditions and the self-sufficiency with which Curiosity must work, it's little short of miraculous that the rover has not only exceeded its two-year mission but also continues to return data today, nearly six years after it landed on Mars.

394 PAGES. $39.99. ISBN: 978-3-3196-8144-3

CAD DRAWING TOOL

IRONCAD, ATLANTA, GA.

IRONCAD IS KNOWN MORE FOR ITS 3-D CAD capabilities, has added some new 2-D tools, which are still considered important in linear designs. The new software has the ability to change 3-D designs to 2-D, and do so in bulk with the Bulk Drawing Creation tool. That helps save time from the repetition involved in converting individual files. The software also features better security and productivity tools, with an improved workflow and collaboration feature. A new user interface helps create larger 3-D assemblies, and also allows for a web-based view of designs. The application is used by metal fabricators and custom machine makers. The overall goal of the application is to expedite design creation and encourage collaboration among multiple team members.



MATERIAL SIMULATION

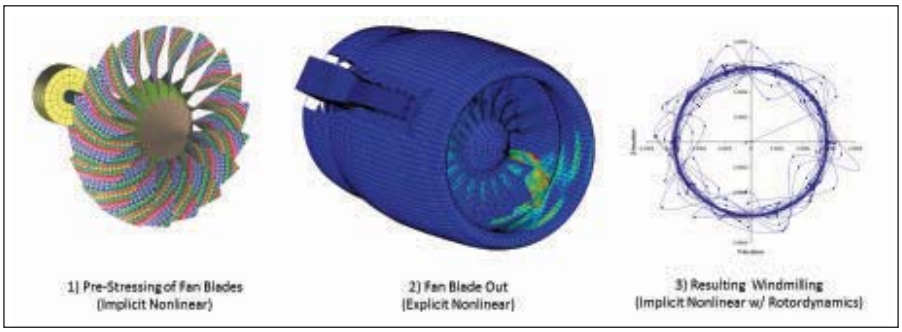
MSC SOFTWARE, NEWPORT BEACH, CALIF.

Multiple engineering disciplines are coming closer together, and effective design involves breaking silos and mixing all elements. The MSC Nastran 2018.0 software aims to merge all disciplines effectively when creating assemblies and simulating products in the aerospace, automotive, defense, energy, manufacturing, and other high-tech industries. The software takes advantage of high-performance computing techniques to boost simulation. During simulations, the software can capture the true behavior of materials for more accurate analysis, design and noise abatement. Engineers are getting creative on designs, and using lightweight and high strength materials including carbon fibers that could have similar characteristics.

PROCESS VISUALIZATION

SEEQ, SEATTLE, WASH.

Seeq's visualization tools for process manufacturing has now been integrated into business intelligence software offered by Tableau, a well-known BI vendor. That means users will be able to get faster insights into data, and thus take faster action. The Seek Workbench is designed to visualize input data to improve manufacturing processes, and Tableau provides the analytics tools. Seeq's software is used by manufacturing and food and beverage and other process industries. Tableau software is already being used by many Fortune 500 companies, and also offers other plug-ins to source data which is then analyzed using its software.



UPDATED CAD DATABASE

VOSS FLUID, WIPPERFURTH, GERMANY

VOSS FLUID, which makes hydraulic coupling and vehicle engineering systems, has updated its online CAD database for design engineers. The database now includes more 3-D models of hose fittings, and those are easily accessible through search. The files are available in more than 70 3-D and 2-D formats, and can be loaded with various software including AutoCAD 2018. The goal is to make it easier for engineers to design products using VOSS FLUID parts, and also find matching components. Users can buy the 2-D

SUBMISSIONS

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

or 3-D models from VOSS FLUID's partner site, and can request quotes before purchasing. Beyond hose fittings, VOSS Fluid also offers couplings, valves, flanges, cutting rings and other products.

DESIGN FOR PRINTING

IMSI DESIGN, NOVATO, CALIF.

The popular DesignCAD 3D Max software, which is used for 3-D and 2-D modeling and drafting, has many upgrades. It is friendlier with 3-D printers, and can check if 3-D designs are watertight before printing. There are also enhancements in rendering, allowing more realistic graphics in 3-D and 2-D mode so users get better visuals of designs. An interesting feature is "Icon Scaling" so users can scale the size of icons up to 64 pixels, giving a better preview of designs. There are also better shaping tools, dynamic scaling of text and support for the OpenGL graphics driver. There are also improvements in the user interface, and support for export and import of files from AutoCAD 2018.

SMART MANUFACTURING

DP TECHNOLOGY, CAMARILLO, CALIF.

DP Technology's Esprit CAM software is designed for digitization of additive manufacturing, or what the company calls "Industry 4.0 smart manufacturing." The software helps design and simulate tools and create digital twins critical to the automation of factory tasks. The virtual machining results will be a duplicate of what's deployed on the factory floor, the company promises. ESPRIT integrates into existing workflows and data can passed on easily into other management and analytics tools already being used on factory floors. A piece of accompanying software, called ESPRIT Additive Suite, is for digitization of additive manufacturing, and focuses on direct metal deposition, 3-D powder bed, and subtractive manufacturing.

TABLET-BASED CAD

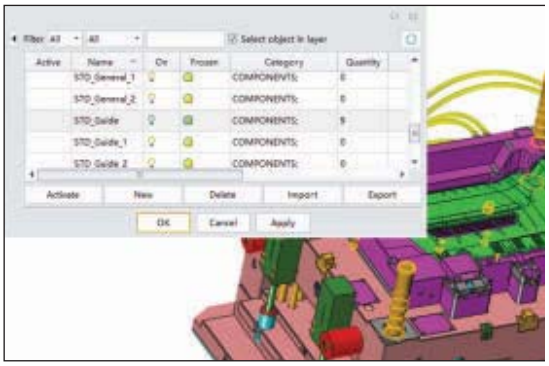
SHAPR3D, BUDAPEST

Shapr3D is a popular 3-D CAD tool for Apple's iPad. This software brings the desktop CAD engines used in SolidWorks, Siemens NX and SolidEdge to a device like the iPad Pro, which has pen capabilities for modeling and design. The software is designed to be easy to use and has more 2-D and 3-D modeling features. Models in the XT, STEP, IGES, SHAPR formats can be loaded and manipulated. The software is also designed to fit more effectively into workflows. It has all the major tools of manipulating designs, including revolving, lofting and sweeping. And this all can be done while sitting in a park or traveling on a plane. The software is available for download at Apple's App Store.

COMMAND BY VOICE

PROTOTECH SOLUTIONS, PUNE, INDIA

Voice commands in Autodesk's BIM 360 cloud platform are now possible with Voice 360, a new app released by ProtoTech Solutions. The app brings voice command interaction, similar to Apple's Siri, Microsoft's Cortana and Amazon's Alexa. The interaction is targeted specifically at the Forge Viewer API, which allows the integration of 2-D and 3-D viewing and access of 3-D models into browsers, without the need for CAD software. Mouse and pen remain critical to design and simulation, but the app's goal is to bring voice into the mix. The Forge Viewer was scripted with WebGL, an API used for cloud-based services.

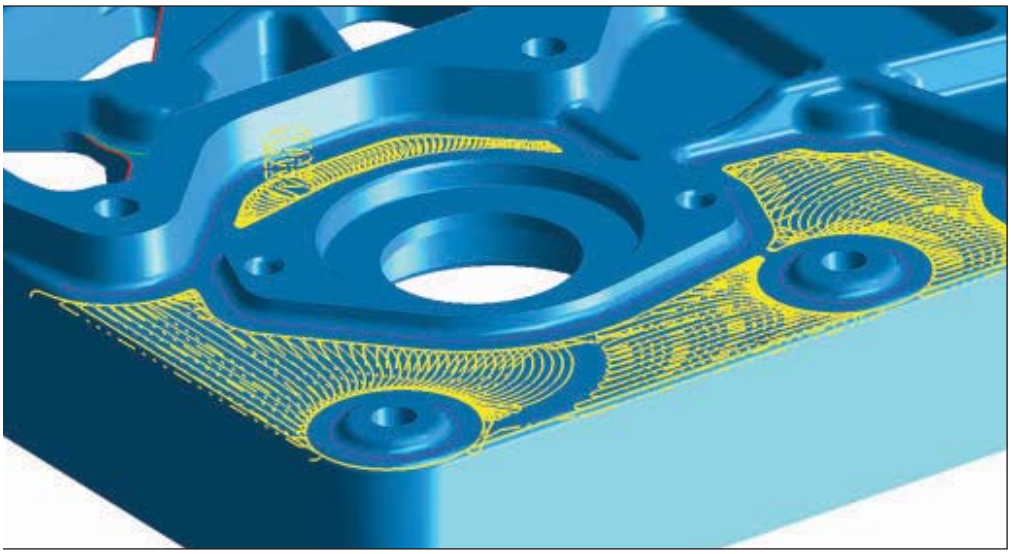


FASTER CAD/CAM

ZWSOFT, GUANGZHOU, CHINA

Every year, CAD/CAM software makers release updated software with new features. ZWSoft recently released ZW3D 2018, an updated CAD/CAM application aimed at product and manufacturing design. ZW3D 2018 offers improved flexibility for creating different layers in the design process, which helps keep tabs on components and shapes. It also has a new Category attribute to group layers. The application also features annotation and design enhancements, and it also integrates the MISUMI 3-D CAD library, which has more than 10,000 types of part models. Relevant models can be found by search. The application also integrates five-axis strategies capability that makes it easier to create complex machine designs in fewer steps.

SOFTWARE



FACTORY AUTOMATION

SMARTCAMCNC, SPRINGFIELD, ORE.

SmartCAM v2018 is the latest version of the application for CNC milling, turning, fabrication and wire EDM. The software accounts for some advanced technologies, such as adaptive milling, involved in the automation of tasks in industries. It also has new verification modules, and improved feed rate controls. The SmartCAM adaptive roughing toolpath increases the lifespan of tools, reduces production time and reduces shock among other features, providing consistent cutting conditions and adapting feed-rates.

BUSINESS INTELLIGENCE

VIEWPOINT, PORTLAND, ORE.

The Spectrum Business Intelligence application in marketed to the construction industry. It can collect and analyze construction data, making it easier for builders to plan projects. It provides measurements, creates and visualizes reports, and has a dashboard from which to manage data and projects. The application helps in scheduling and projecting the cost, which helps builders plan out projects. For larger builders, the software will provide an overview of multiple projects over different regions to show how each one is performing. The analytics and reporting tools help save time and increase the efficiency of construction projects. The other features include providing consistent cutting conditions and some level of user control in certain toolpaths.

SENSOR ANALYTICS

FOGHORN SYSTEMS, MOUNTAIN VIEW, CALIF.

FogHorn Systems can provide analytics, monitoring and diagnostic services for sensors, PLCs and other devices inside factories with its application, which can be hosted remotely or on-premise. Essentially an IoT platform, the software monitors data exchange, and provides access to live data feeds that helps keep factories or other infrastructure in top condition. If a machine goes down or isn't operating properly, the FogHorn platform will report it immediately. The service gives IoT devices access to a wealth of data, and all of that information can be united and analyzed for smoother business operations. Processing all that information happens on the "edge"—or on remote computers in data centers—as IoT devices typically don't have a lot of computing power. The FogHorn software can support a wide variety of IoT devices and computers, and is targeted at the manufacturing, oil and gas, mining, transportation, healthcare, and other industries.

CAD FILE SHARING

TECH SOFT 3D, BEND, ORE.

HOOPS Exchange 2018 is a tool that makes it easier to reuse, import or export 3-D CAD files between applications. It is relevant to the auto, machining and other industries. CAD files typically blend in proprietary features unique to the software's capabilities that could make them difficult to use with other applications. But the HOOPS Exchange 2018 tries to make it easier to read multiple file formats in different software without degrading the quality of a 2-D or 3-D model. The SDK supports SolidWorks 2018, SolidEdge ST10 and AutoCAD DWG, among other software and file formats. The SDK can be applied in mobile, cloud or desktop environments, and it supports mobile app development in Apple mobile devices with support for IGES, STEP and Siemens' Parasolid. The software development kit can integrate in multiple software environments.

PDF PUBLISHER

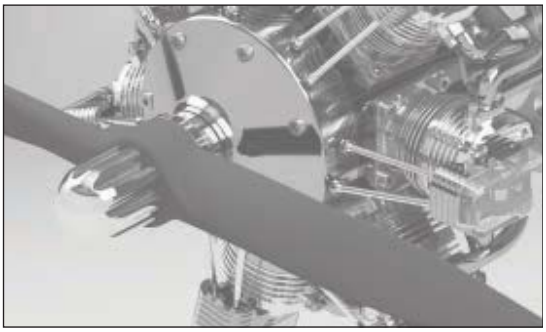
THEOREM, TAMWORTH, U.K.

The JT-3D PDF Publisher v20.2 allows the creation of 3-D PDF files and templates using its publishing tools. PDF is an essential document format since those files are viewable on PCs and mobile devices. JT-3D PDF Publisher v20.2 has enhanced tools and supports a number of file formats including JT, an open file format from Siemens that is widely used in the aerospace industry. The application can export JT data to 3-D PDF and can also expand the use of JT data to the popular HTML5 standard. File transformation can be done in batches. The software is intended to make engineering data easy to read, understand, and manipulate for projects.

COGNITIVE CAD

PARAMATTERS, IRVINE, CALIF.

Paramatters is a design-to-manufacturing CAD software that is different compared to conventional CAD/CAM software. Its CogniCAD 2018 software runs in the cloud, and relies on an algorithm-based engine to help in design and simulation in the aerospace,



automotive and other industries. First, CAD files need to be uploaded and then design criteria needs to be specified. Using machine learning tools, the software can generate designs within minutes. The products can be made using additive manufacturing tools like 3-D printing. The latest CogniCAD engine is much faster than previous versions, cutting design times from hours to minutes, and raises the quality of design. Automation of design is also key to the CogniCAD engine—the goal is to save time and increase productivity.

ELECTROMAGNETIC SIMULATION

SIMULIA, DARMSTADT, GERMANY

CST Studio Suite 2018 is a full-featured electromagnetic simulation software that provides insight into EM behavior on circuit boards, antennas and other equipment. The new software has new 3-D environment to simulate complex models, and new workflow tools for system assembly and modeling. The application also supports photonic and terahertz applications, used commonly in communications, and a new user interface can be set up to conduct simulations based on wavelength rather than frequency. The software supports the latest hardware and also has tools for bio-EM and medical device EM simulation.

3-D MAPPING

INDOOR REALITY, BERKELEY, CALIF.

A proprietary cloud service from Indoor Reality can now map out large areas such as floor plans by stitching together images taken from multiple devices. These images could be taken simultaneously, or by one device in a given order. Mapping out large areas has been a problem, and this service makes the job easier. The images could be taken with Indoor Reality's IR-500 handheld mapping device. Creating 3-D models becomes significantly faster, and those files can be exported to different CAD software. The cloud service also provides web-based visualization of large spaces. The service is targeted at building managers, real estate professionals, contractors and those involved in the construction industry.

CURVE GENERATOR

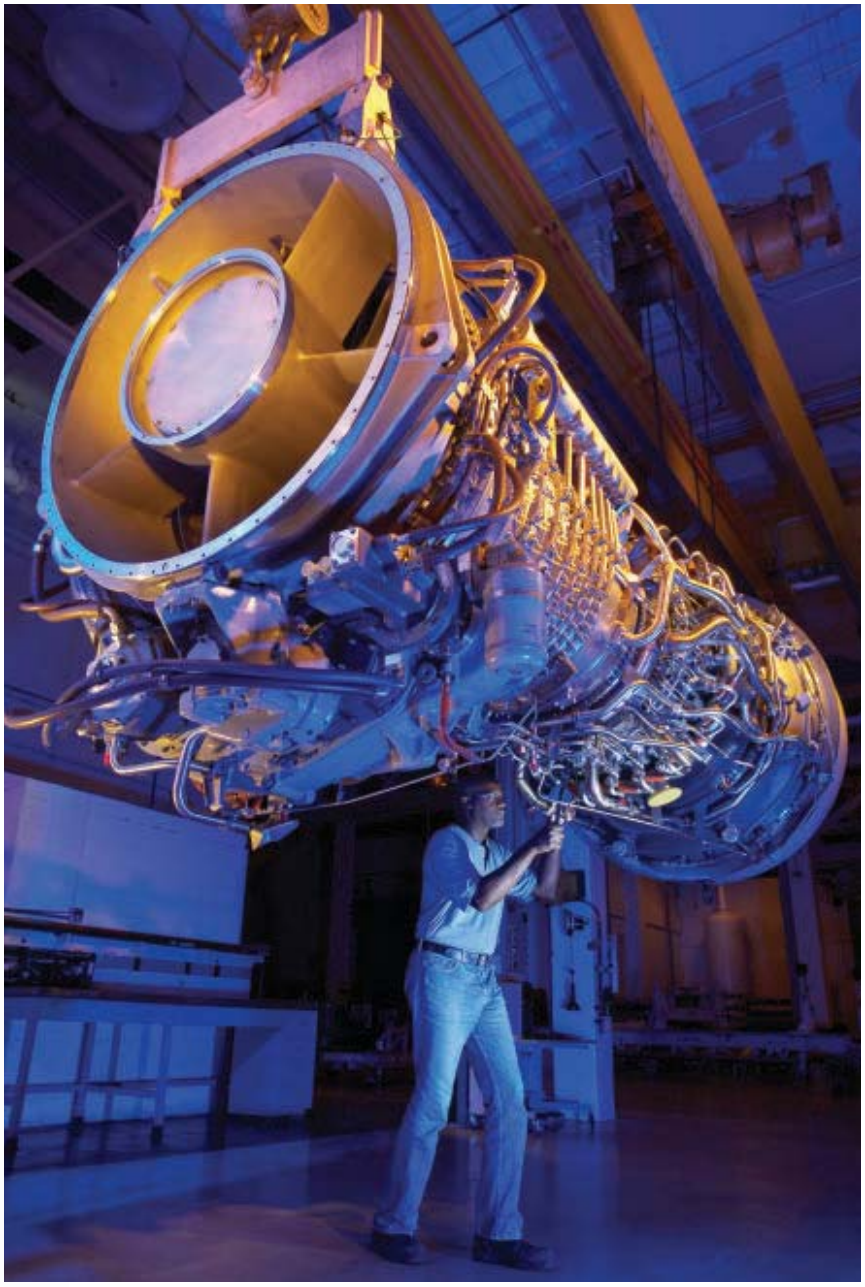
XNURBS, XUZHOU, CHINA

XNURBS claims software to generate shapes and curves is easy to use, thanks to an optimization algorithm that helps generate surfaces on the fly. It is a NURBS (non-uniform rational basis spline) software, which refers to a mathematical model to generate curves and shapes. The application can generate a surface from 12 curve constraints, and can be used to generate CAD surfaces and applied to CAD models. XNURBS takes advantage of the latest hardware and has a simple user interface and is designed for use with SolidWorks.

MARINE TURBINE

GE, BOSTON, MASS.

GE Marine Solutions unit's LM2500+G4 marine gas turbine propulsion system is now being used on French Navy's Auvergne FREMM frigate. By year 2022, ten frigates will be equipped with the system. LM2500+G4 is a combined diesel, electric, or gas turbine—popularly known as CODLOG—propulsion system that produces 25 MW. The GE LM2500 gas turbine family also includes the LM2500+ (30 MW) and LM2500+G4 (35 MW), and can be designed to meet multiple frigate designs with various propulsion configurations. The gas turbines are also being used by the Egyptian and Moroccan naval organizations. GE recently said it made deliveries of 750 gas turbines to the U.S. Navy, and supplies its marine solutions to 34 governmental naval organizations worldwide.



SOLUBLE SALT TESTER

POSITECTOR, OGDENSBURG, N.Y.

The PosiTector SST Soluble Salt Tester is a device that measures the levels of salt in metal surfaces. The portable unit—which operates on a battery—essentially tries to detect salt contamination in devices. The tests are conducted in metal surfaces with the ISO 8502-6, 8502-9 standards. The device is durable, weatherproof, and resistant to oil, water, solvent, and acid. It comes in a protective rubber case that protects it from damage and helps absorb shock. It can also store results so comparisons can be made over multiple tests. The unit shows results, temperature, conductivity and surface density.

SUBMISSIONS

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

TENSION MEASUREMENT

STRAIGHTPOINT, HAVANT, U.K.

The Clamp On Line Tensionmeter (COLT) measures tension on static lines and transmits the results back to mobile devices with the help of Bluetooth. It can measure tension on wire rope up to 11,000 pounds of force. The instruments hook up to wire ropes directly, reducing the need for additional instruments or clamping tools. It takes only a few seconds to measure the tension, and the Bluetooth component helps send results wirelessly to an Android or iOS mobile device. The COLT can deal with different wire types and parameters, and the app has a library of different rope types for the calculations. It is targeted at cables and wires used in towers, bridges, elevators transit, aircraft and utilities. The COLT has an aluminum construction and high precision components and arms, and is also water-resistant.

STEEL-MAKING PLANT

TENOVA AND SMS CONCAST, CASTELLANZA, ITALY

A new steel plant has been built by Tenova and SMS Concast in Ardakan, which is in the Yazd province of central Iran. The plant has the ultimate goal to produce different grades of steel with various properties with the intention for internal use and export. It has a 170-ton Electric Arc Furnace (EAF) and Ladle Furnace (LF) provided by Tenova and a six-strand continuous caster provided by SMS Concast. There is room for a Vacuum Degasser that will allow production of special steel grades. The electric arc furnace is designed to produce 1.2 million tons per year of billet from cold direct-reduced iron (DRI), and was also designed to process scrap. The plant has a hot DRI which adds to the steel plant's efficiency and productivity gains. The order for the factory was placed by Engineering and Commercial Services GmbH (CPG), which partnered with Parsland Mines & Industries Development Company.

HARDWARE

VISCOMIXER

PAUL N. GARDNER CO. INC., POMPANO BEACH, FLA.

The Paintlab+ viscomixer measures the change in viscosity after a solvent or thinner is added, which is to ensure the product quality is consistent. The device can be used to check the viscosity of coatings, for example, as any undesirable effect can affect the overall product quality. This high-precision instrument is an important component in quality control during manufacturing. The viscomixer has high levels of accuracy, can measure temperature, is automated, and can be used in a wide variety of settings, though add-on rotor kits would need to be purchased. There are three models of viscomixers available in the Paintlab+ lineup that offer different measuring ranges. A sample from a production batch can be measured in 250 ml tins, after which the thinning ratio can be determined, and production then scaled. The instrument operates at a fixed speed of 562 rpm.

FAST USB STRAIN MODULE

MANTRACOURT ELECTRONICS, EXETER, U.K.

The FSU-SSB fast strain module is a precision and test measurement device in the areas of telemetry, impact, drop, vibration, materials and non-rotational torque testing. The USB module connects to a PC, and can take 4,800 samples per second, with a fraction of a temperature drift. The FSU-SSB comes with a software toolkit that provides real-time data-analysis, calibration and captures up to 30 minutes of data at 4,800 samples per second. The software can also chuck unwanted data, while showing information that is relevant. The company is targeting the markets of load cell signal conditioners, wireless telemetry and high performance analog to digital converters with USB strain. It connects and is powered by a micro-USB socket.

RACE CAR COMPONENT

VACUUMSCHULZE, HANAU, GERMANY

VACSTACK is a special production technology to produce core stacks for electric powertrains in cars. The process uses thin strip material (down to 50 µm) in lamination stacks, and individual sheets are bonded to the height of the finished core. The final shape is produced using wire-cutting technology. The metal sheet is thin, but achieves packing densities of 98 percent and high levels of insulation between the lamination layers. VACSTACK is used in the ERS (Energy Recovery System) to recover energy kinetically and via the exhaust gas stream using a generator. The VACSTACK is associated with use in racing cars in Formula 1, Formula E and World Endurance Championship, which can test the endurance of race cars to extremes.

FIREFIGHTING AIR TANKER

BAE SYSTEMS, FARNBOROUGH, U.K.

BAE Systems' BAe 146/Avro RJ Airtankers are built for aerial firefighting. These planes drop retardants to douse forest fires, and are purchased by operators in the business. Like with many of the old Boeing 747s now operating as firefighting planes, these airtankers are repurposed from jets originally released as civil jetliners but then retired. The planes have played a significant role at combating wildfires, which have been a big issue in recent years. These planes are designed to run thousands of missions to drop millions of gallons of retardant, and are also designed to last many years. The target market are companies dedicated to fighting wildfires from the air, and BAE Systems said it is growing its focus on the market as wildfires become a critical issue.

RECYCLABLE PACKAGING

KHS AND NMP SYSTEMS, GERMANY

The Nature MultiPack from KHS and NMP Systems has been granted approval by the European PET Bottle Platform, a non-profit consortium that provides design guidelines on recyclable bottles. The Nature MultiPack is intended to be used for sodas and water, and will be tested in the European market starting in June 2019. Based on tests, permanent approval could be granted. The Nature MultiPack PET bottle packaging is an improvement over other types of PET bottles as it does not require any visible secondary film packaging. It's a sustainable design, and also cuts the cost associated with packaging. A special adhesive in the bottle makes the bottle friendlier for recycling.

MILLING MACHINES

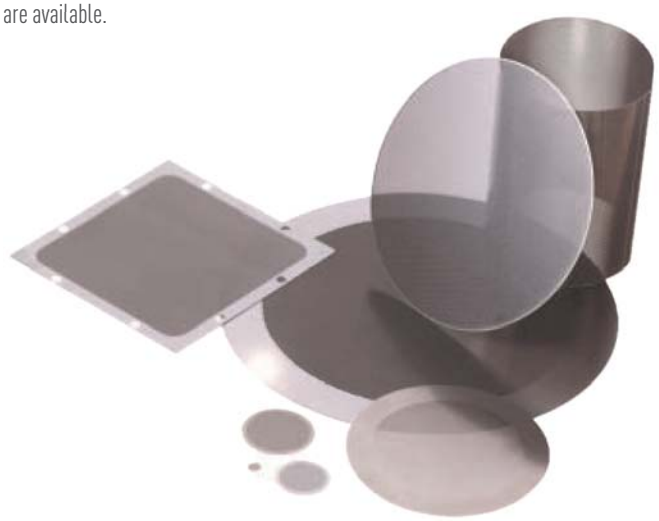
HURON, ESCHAU, FRANCE

Huron's new series of MU milling machines will "throw conventional wisdom out of the windows," the company said. The new generation of five-axis machines provide higher levels of accuracy in making airline components, medical devices, prostheses, and other precision instruments. The machines work to more accurate calculations, and provide rigidity in frames made using various kinds of metal including titanium. Huron, a 130-year old company, is bringing higher levels of technical expertise with its two machines, and promises that the new design and technologies will be appreciated by engineers. The machines will fit into a wide range of assembly lines and meet a range of needs.

FINE SCREENS

TECH-ETCH, PLYMOUTH, MASS.

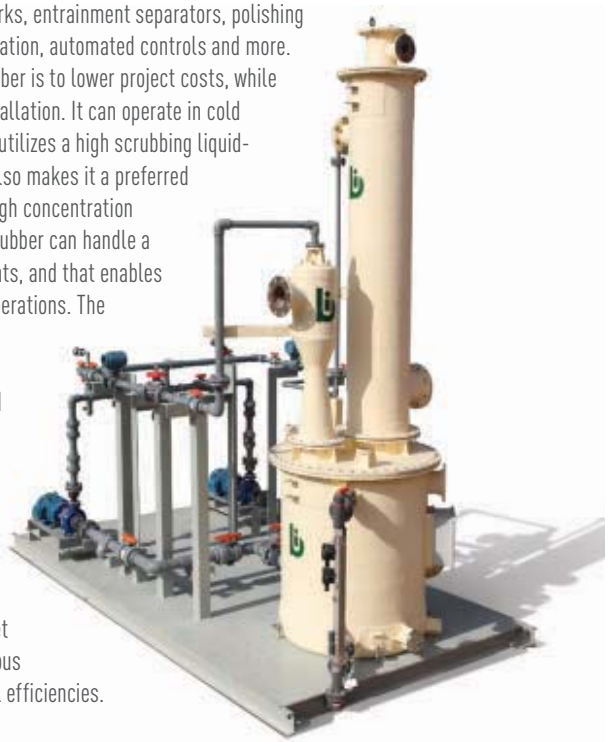
Stainless steel MicroEtch screens are made using photo etching technology, which enable hole sizes from 0.003 inch and up. Photo etching allows designers to specify a straight hole or a tapered hole, which helps facilitate liquid filtration and back flow cleaning. Unlike stamping, photo etching yields a burr-free product resulting in cleaner, more efficient screens with greater material integrity. MicroEtch screens feature a tighter tolerance on hole sizes and greater dimensional stability than woven wire mesh, making them ideal in applications requiring frequent cleaning or in devices where there is mechanical contact. Typical applications of MicroEtch screens are particle separation and sizing, hydraulic valve screens, fuel filters, laser light filters, extruding screens, as well as filters used in the medical market. These tight tolerance screens are primarily produced from stainless steel, but other materials are available.



HIGH-PERFORMANCE SCRUBBERS

BIONOMIC INDUSTRIES, MAHWAH, N.J.

The Series 6500 Jet Scrubber is a tool for gaseous or particulate contaminant removal. The skid-mounted package integrates recirculation pumps, piping networks, entrainment separators, polishing scrubber, instrumentation, automated controls and more. The goal of the scrubber is to lower project costs, while enabling quicker installation. It can operate in cold weather climates. It utilizes a high scrubbing liquid-to-gas ratio, which also makes it a preferred choice for treating high concentration gas streams. The scrubber can handle a high level of pollutants, and that enables effective flow and operations. The scrubber is designed for different types of tasks, and single and multiple stages, or can be used with a Series 5000 Packed Bed polishing scrubber with additional transfer units to meet extremely high gaseous contaminant removal efficiencies.



NEXT-GEN ADDITIVE MACHINE

GE ADDITIVE, FRANKFURT, GERMANY

The first BETA machine was unveiled as part of GE Additive's Project Atlas program, which is targeted at making large metal parts in the aviation, automotive, space and oil and gas industries. The scalable machine is a breakthrough in the metal powder additive manufacturing sector, bringing advanced laser technology into manufacturing of complex parts. It is designed to address different geometries, and can build parts at a fast rate, providing it with high levels of scalability when production needs to be ramped up. It also has a 3-D scanner, and multiple lasers can be incorporated. As with many manufacturing technologies, it can also be customized. Software helps monitor the health of the machine. The BETA machine is the first of its kind and was developed in nine months, and is currently is being beta tested by select customers, but delivery is expected to come soon.

PICKING LIFT

SOUTHWORTH PRODUCTS, PORTLAND, ME.

The PalletPal Order Picker Load Leveler picking lift is designed to make order picking or stock replenishing faster, safer and easier. As boxes are added or removed, the load picker uses a calibrated spring mechanism to adjust the height of a pallet load. Safety and convenience are also key benefits, as the top layer of the load has a convenient working height for easy loading or offloading. Operators can spin the load with an integrated turntable. It has a universal design to work with all brands of order pickers and attaches easily without the requirement of extra tools, according to the company. It can work with loads from 400 to 2,200 pounds.

CAMPBELL UNIVERSITY

School of Engineering

Campbell University, Associate, Assistant Or Full Professors, School Of Engineering

The School of Engineering at Campbell University (http://www.campbell.edu/engineering/) seeks two Engineering Faculty for full-time, tenure-track positions at the rank of Assistant, Associate or Full Professor. One position in Mechanical Engineering begins Fall 2018 and is focused on teaching the thermal, energy and fluid sciences. One position in Mechanical Engineering, focused on teaching a common senior design sequence, begins in January 2019. Campbell's BS in Engineering program (with concentrations in mechanical engineering, chemical engineering and electrical engineering) welcomed its inaugural first-year class in fall 2016. These positions present faculty with a unique opportunity to provide leadership in building an innovative engineering program and the prominence of the new School and University.

Responsibilities: Duties will include: develop, implement and teach project-based engineering curricula; actively participate in the scholarship of teaching and learning; engage in student advising, student organizations, assessment, accreditation activities, and committee responsibilities. Applicants should be interested in contributing leadership toward the development of the engineering program. Candidates must be committed to innovative engineering undergraduate education; dedicated to excellence in undergraduate teaching, mentoring students, and scholarship; and committed to the University's mission.

Qualifications: Candidates are required to have a PhD in Mechanical Engineering or a closely related engineering discipline from an accredited institution of higher education; experience developing and teaching project-based engineering curricula; and knowledge of the current practices and research pertaining to innovative undergraduate engineering curricula.

Applications: Interested applicants should apply online at **http://www.campbell.edu/about/employment/** and include a cover letter of introduction, a curriculum vitae, and contact information for five professional references. Questions may be directed to Dr. Jenna Carpenter, Dean, School of Engineering [**carpenter@campbell.edu**].

Campbell University maintains a continuing policy of nondiscrimination in employment. It is our policy to provide equal opportunity in all phases of the employment process and in compliance with applicable federal, state, and local laws and regulations. Accordingly, the University is committed to administering all educational and employment activities without discrimination as to race, color, sex, sexual orientation, gender identity, age, ethnicity or national origin, religion, disability, genetic information, protected veteran status and any other characteristic protected by law, except where appropriate and authorized by law.

EEO/AA/Minorities/Females/Disabled/Protected Veterans

1848

Assistant Professor of Design and Manufacturing

The University of Mississippi is proud to offer a comprehensive salary and generous benefits package. Benefits include employer-paid portions of medical, dental, vision, and tuition waiver programs for employees and dependents. In addition, the UM retirement program includes an employer contribution. UM offers generous paid holiday time off, personal (vacation) and medical leave for most employees – staff members accrue personal and medical leave based on their years of service. UM was named the state's healthiest workplace among all Mississippi colleges and universities and offers wellness programs. For eight consecutive years, UM has been recognized as one of the best colleges in the nation to work for by The Chronicle of Higher Education.
For information about our employee benefits package, visit: Employee Benefits Overview **(http://hr.olemiss.edu/benefits/)**.

Thank you for your interest in this position. Your information will be sent to the department. If the search committee would like to schedule an interview, then a committee member will contact you. You can check your status at any time by logging on to your employment service account. Members of the Human Resources team do not have any additional information about the status of the search. It is recommended that applicants do not call regarding the status of the employment application or search. We are unable to provide any information.

Thank you for your interest in this position. Based on the answers and information you provided, you do not meet the minimum qualifications for this position. If you believe this is an error, please contact our Employment Office at **rebeljobs@olemiss.edu** or **(662) 915-1518**.

NEXT MONTH IN MECHANICAL ENGINEERING

SPECIAL REPORT: INSPECTION BY UAV

Many utilities are looking to send robots and UAVs to check the safety of their infrastructure, saving workers from the time-consuming and dangerous task. Find out what needs to be done to ensure the robots are doing as good a job as human inspectors.

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WINNERS ANNOUNCED AT ASME ISHOW IN INDIA

Paul Scott (left), director of ASME's Engineering for Global Development, presents the trophy to Sanskriti Dawle and Saif Shaikh of Team Annie.
Image: ASME

The inventors of a device for learning Braille, a medical screening monitor for diabetes patients, and a wearable device that records and relays infant diagnostic information were selected as the grand-prize winning entries at the 2018 ASME Innovation Showcase (ISHOW) in India. Eight teams of socially conscious inventors and entrepreneurs participated in the event, which took place April 5 at Le Méridien Hotel in Bangalore.

The three winning teams at ISHOW India will share $500,000 in cash and in-kind prizes with the winners of ISHOW Kenya and ISHOW USA, held in May and June, respectively.

The winners were chosen by a panel of experts from the social engineering space based on criteria that included knowledge of the customer or user; hardware validation and development; manufacturing optimization; and the team's strategy for implementation.

Sanskriti Dawle and Saif Shaikh of Thinkerbell Labs were recognized as one of the event's winning teams for creating Annie, a low-cost, audio-tactile device that enables the visually impaired to teach themselves Braille. Vinayak Nandalike and Ram Mohan of Yostra Labs were also honored with the competition's grand prize for their entry, Sparsh, a portable and inexpensive hand-held medical tool that enables medical care providers in developing communities to examine diabetic patients for symptoms of peripheral neuropathy—permanent nerve damage to the foot that is often caused by the disease.

The third winning team at ISHOW India, Balaji Teegala and Manisha Laroia of Brün Health, were recognized for developing an affordable wearable device that aims to diminish the high neonatal mortality rate in India. The team's prototype, Brün CG, collects and records fetal medical data and transmits that information to physicians, thereby allowing for more timely treatment for patients. ME

ASME SELECTS THOMAS COSTABILE AS NEW EXECUTIVE DIRECTOR

The Board of Governors has selected Thomas Costabile as ASME's next Executive Director. Costabile is an accomplished executive, with a strong track record of delivering outstanding results for large, global organizations, and leading organizations through significant change. Costabile began his career as a mechanical engineer working on a joint venture between Gibbs & Hill and Ammann & Whitney, focused on the development of nuclear reactors. After several years, he joined CBS Records to oversee the development of their compact disc manufacturing and distribution operations. Over the subsequent 20 years, he earned leadership roles in the music distribution industry, including serving as SVP, Operations for Sony music and then as President, WEA Manufacturing-Warner Music Group.

Most recently, Costabile served as a Consultant at Carlan Advisors and as Partner at 3essential, LLC, where he advised boards, senior executives, private equity sponsors, and investors. He received his BSME (with honors) from Manhattan College and an MBA in Finance (with honors) from Long Island University. ME

CLAYTON DANIEL MOTE, JR., PRESENTS THE ASME ROY V. WRIGHT LECTURE

ASME recently honored Clayton Daniel Mote, Jr., president of the National Academy of Engineering (NAE) during a dinner held in the Mansfield Room of the U.S. Capitol in Washington, D.C., on April 23.

Mote was the recipient of the ASME Roy V. Wright Lecture and Award. The lecture, established in 1949 to honor Wright, ASME's 50th president, is bestowed upon a leading engineer for his contributions as a citizen to the nation and to his community.

The event was hosted by Lester Su, chair of the ASME Committee on Government Relations.

Mote was the keynote speaker for the dinner. Mote's lecture, "The National Academy of Engineering's Grand Challenges for Engineering and the Scholars Program," presented an aspirational vision of what engineering needs to deliver to all people on the planet in the 21st century.

Mote shared how the NAE's Grand Challenges report, which was published in 2008, spawned a biannual series of Global Grand Challenges Summits hosted by the NAE, the Chinese Academy of Engineering, and the U.K. Royal Academy of Engineering. The NAE Grand Challenges Scholars Program was first launched at a U.S. national summit on the Grand Challenges in 2009.

The vision for the NAE Grand Challenges for Engineering and their solutions are global, so a principal goal of the NAE Grand Challenges Scholars Program is to engage young engineers to work on global challenges.

A second, broader goal is to prepare students for the multicultural, multidisciplinary, socially conscious global engagement needed for 21st century engineering, through an educational supplement that is adaptable to any university engineering education.

In closing, Mote stated that as the Grand Challenges Scholars Program continues to expand nationally and globally. The bridges for solutions to Grand Challenges for particular locales, he said, will be built by the young engineers who participate in the program, which is why this program is the key to fulfilling the vision of the Grand Challenges for Engineering in this century. ME

ASME Past President Charla Wise with Clayton Daniel Mote, Jr., at the Roy V. Wright Lecture in Washington, D.C. *Image: Daniel Delgado for ASME*

ECLIPSE INTERNS CONTINUE THE 'PUT-A-SMILE' EFFORT IN PUERTO RICO

Earlier this year, the 2017-2018 class of ASME Early Career Leadership Intern Program to Serve Engineering (ECLIPSE) interns attempted to lift the spirits of school children in Puerto Rico, which is still slowly recovering from the devastation wrought by Hurricane Maria last fall.

Spearheaded by ASME members and ECLIPSE interns Jonathan Jennings, Kushi Sellahennedige, and Joseph Radisek, theirs was the second activity in the "Put-A-Smile" endeavor. Several ASME members of the Orange County, Santa Clara Valley, and Los Angeles Sections in California launched the program last fall when they sent gift bags to elementary school students in Dickinson, Tex., a community that was hit especially hard last summer by Hurricane Harvey.

After hearing about the "Put-A-Smile" activity in California, Jennings coordinated the effort, while Sellahennedige took on fundraising responsibilities, collecting a total of more than $300 from an office fundraiser. Jennings, his daughter, and some of her neighborhood friends packed the gift bags, which were filled with an assortment of candy and toy airplane gliders for the kids and accompanied with supplies for a STEM-based activity.

Eduardo Morales Rivera, who was president of the ASME student chapter at the University of Puerto Rico Mayaguez Campus at the time, distributed the packages at the Aurora Mendez Charneco Elementary School during a special STEM presentation led by two of the chapter's student members, Andrea Nemesszeghy and William Rios. ME

LATTE LAYERS PLUMBED

Researchers take a deep dive into the fluid dynamics of coffee.

Latte lovers know that the pleasures the drink has to offer aren't for oral and nasal nerve endings alone. The eyes are also delighted—first by the sight of fractal swirls of entangling milk and coffee, and then, as the drink settles, by the emergence of separate layers. Though usually disturbed by the consumer eager to consume, untouched, these comely bands of tan can last for hours.

Princeton researcher Nan Xue wanted to know why.

Xue, who doesn't actually drink the stuff, and his colleagues initially thought that there might be some kind of oil and water thing going on. "In the milk there are a lot of oil particles," says Xue. "We thought they were playing a role. Actually, they're not."

To get to the deeper truth he needed to take a few good snaps of the layer formation in action. Making a good latte, however, is a tad labor intensive—especially for a non-coffee drinker—and relatively expensive compared to water. So in place of coffee, Xue used dyed water, and in place of milk he used salt water, to approximate the density of milk.

It turns out that the layers have nothing to do with any of the characteristics of coffee and milk beyond their relative density. To achieve latte-like striations, all you need, in addition to the different densities, is a drink temperature that is higher than that of the air outside the glass.

Needless to say, as a fluid becomes hot it becomes less dense and moves upward, and when cooled it becomes denser and sinks. "This kind of gradient is trying to make the fluid stable," says Xue. "Temperature and concentration are competing with each other." Conceivably one kind of stability would be an evenly mixed, monotone milky coffee. But the rising fluid never rises all the way to the top and the sinking fluid never makes it to the bottom. Where the density of the fluids is nearly the same, a kind of natural barrier appears and sinking and rising stop. Convection still occurs, but horizontally, within the layers. Given a gentle stir, the two fluids will mix momentarily and then return to their striation.

The phenomenon is so strong that if the coffee was somehow settled atop the milk without the turbulence of pouring or mixing it would likely just sit there. "I think there would be circulation, but only inside the milk, and only inside the coffee," says Xue.

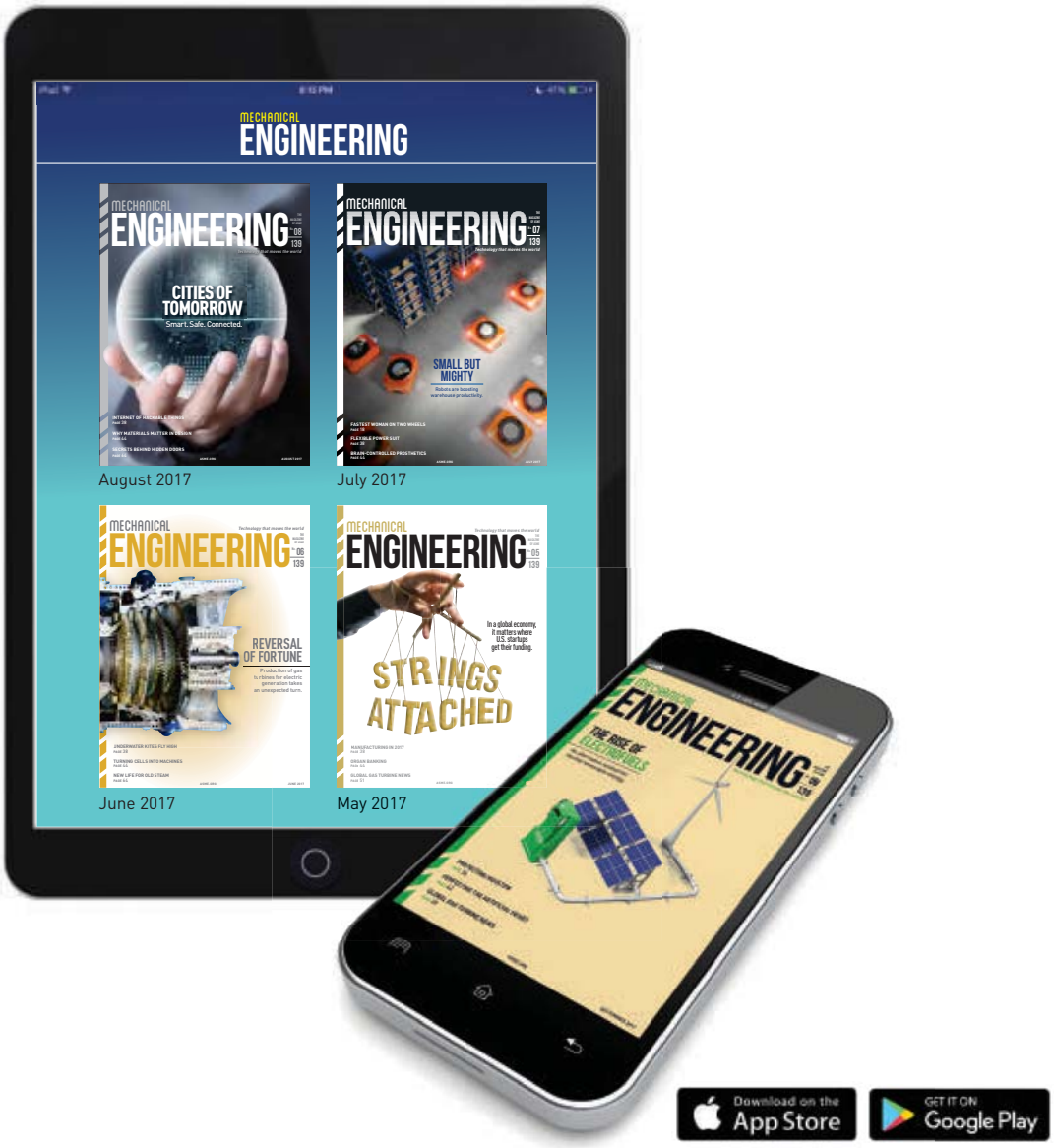
Any temperature differential between the two liquids is immaterial. It's the cooler air of the room that drives the convection. In fact, if the coffee and the milk are at room temperature there will be no convection, and thus, no layers.

The researchers say it's a form of double-diffusive convection. The phenomenon can be found in laces and oceans, where pockets of warm and cool water can stay separate from each other. Xue's research could have applications in tissue engineering and industrial fluid mixing. But there's more work to be done.

"We only understand this experimentally," says Xue. "But we don't have a very satisfying argument on the mathematics of the mechanics." ME

MICHAEL ABRAMS

GO DIGITAL



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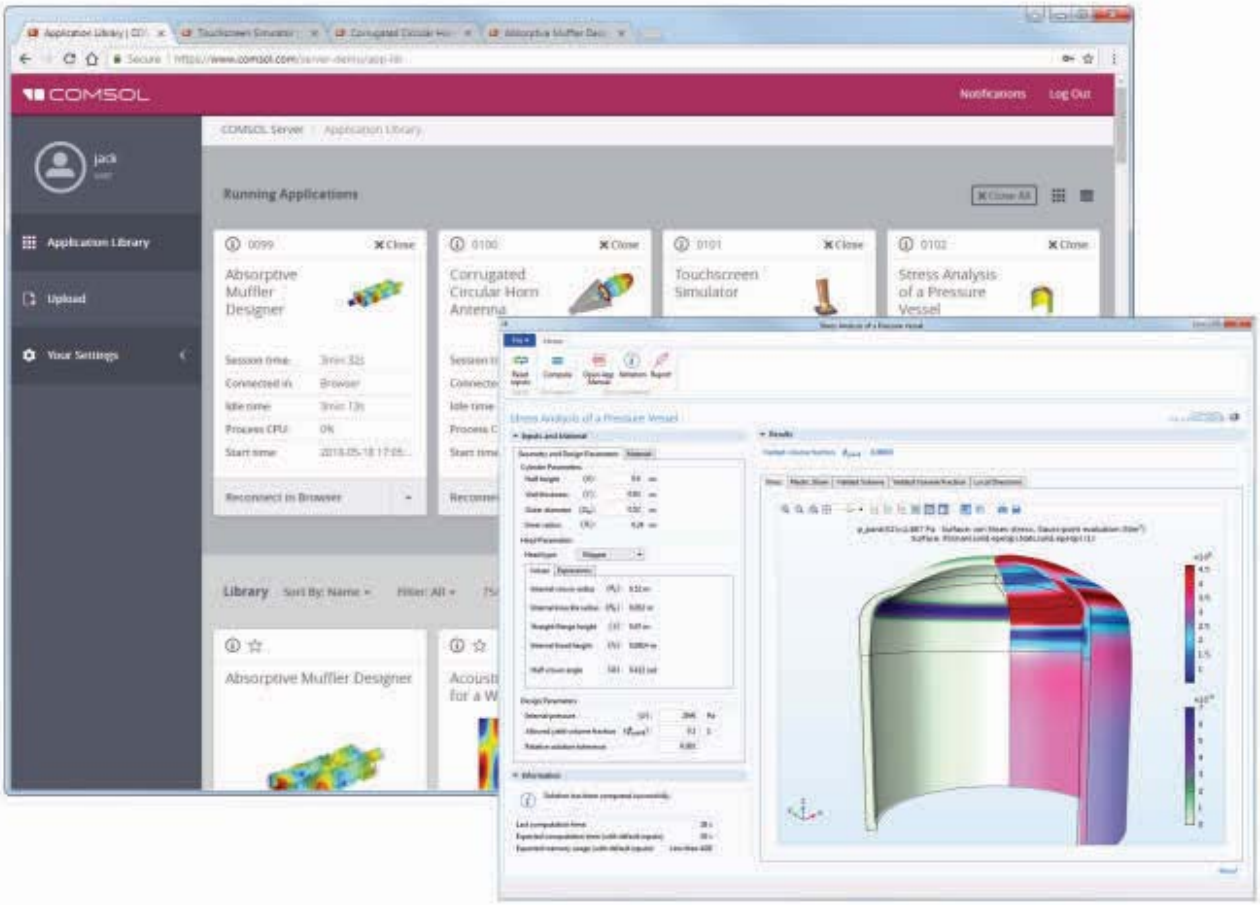

An example of a simulation app in the COMSOL Server™ app library. App users can find an optimal design without having any knowledge of the underlying mathematical model.

Pressure vessels come in different shapes and dimensions. Height, wall thickness, head type, material... There are a lot of design configurations to test before moving into production. Stress analyses are critical at the design stage, but you need simulation experts to run them. Custom apps extend the power of simulation beyond numerical modeling experts. By using simulation apps, pressure vessel designers can easily analyze different configurations for various operating conditions in order to ultimately pick the best design.

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