KEEPING THE PEACE
Making sure the nuclear option means energy
ROVE IN THE GROVE

Computer science undergrads Rishi Bhuta and Adithya Ramanathan try out the Eda U. Gerstacker Grove’s new sand volleyball courts—with a robot. Built to collect soil samples on other planets, the rover competed in the annual NASA Robotic Mining Competition in May of 2017. The volleyball court’s Mars-like terrain was the perfect place for a test run.

PHOTO: Joseph Xu
42 | BUILDING THE FUTURE, IN THE PAST
A retro photo spread, you dig?

THE MICHIGAN ENGINEER
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PUBLISHER
Alex D. Gallimore
Robert J. Vlasic Dean of Engineering
Richard F. and Eleanor A. Towner Professor
Arthur F. Thurnau Professor, Aerospace Engineering

SENIOR DIRECTOR
Jennifer Judge Hensel

EDITOR
Brad Whitehouse

SENIOR CREATIVE DESIGN LEAD
Mathias-Philippe Badin

ASSISTANT EDITOR
Gabe Cherry

RANDOM ACCESS EDITOR
Nicole Grace Moore

FEATURE EDITOR
Kate McAlpine

CONTENT CREATORS AND CONTRIBUTORS
Stephen Alvey, Charles Amyx, George Blichar, Alexander Cabadas, Ben Collins, Robert Corliss, Evan Doughtery, Esther Sigee, Carina Vanin, Sandra Hines, Emily Leglise, Ben Logan, Torrey Martin, Randy Milgrom, Steve Nagle, EJ Oliver, Kelly O’Sullivan, Marcin Sztajszor, December Therrien, John Walser, Allison Wells, Amy Whitehead, Joseph Xu

ADVISORY COUNCIL

MISSION STATEMENT
The Michigan Engineer is a magazine for the University of Michigan College of Engineering community, and especially alumni. Its main mission is to engage the College’s alumni through content that is thought-provoking, by covering the intersection of engineering, the world and their alma mater.

The Michigan Engineer magazine offices are located at:
Communications & Marketing
3214 SI North
1075 Beal Avenue
Ann Arbor, MI 48109-2112
Phone: 734-647-7085
Email: MichiganEngineer@umich.edu
Website: engin.umich.edu
Send address changes to the above address or email address.

The Regents of the University of Michigan
Cover illustration: Stephen Alvey

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Who’s making it happen? They are

Magazine cover: Stephen Alvey

42 | BUILDING THE FUTURE, IN THE PAST
A retro photo spread, you dig?
Thanks for chatting with us. To start, let’s talk about the current landscape. What do you think are the challenges facing higher education today? What do you believe is the role of higher education in society? How can they be more effective engines of social mobility?

Well, I believe we haven’t done enough to engage the public. Unfortunately, that’s led to a certain perception of higher education, and a lot of it is focused on the affordability and selectivity of admissions. I think many of us are beginning to see a hard look at our institutions and questions, “is it for me? Do I really belong there?” Making steps toward covering the cost of college at Michigan, such as the Go Blue Guarantee, that covers tuition for in-state students who fall under an annual income of $65,000, is a step in the right direction. But there is a lot more that needs to be done.

So what do you believe is the role of higher education in today’s society?

That’s a great question, and one with a multi-faceted answer. The role that is most obvious and that we’ve had the longest to education is the notion of educating people who are specialized in their trades and developing global citizens and workers who are integral to the job force. That is, and will always continue to be, a very important role that we play.

But Alec D. Gallimore, the Robert J. Vlasic Dean of Engineering, questions whether universities are fully embracing how the role of higher education has changed, particularly in the area of community engagement and earning the trust of the public. That is, he doesn’t believe it’s merely a communication problem. Instead, he thinks we may not be doing enough.

Gallimore believes we should be shifting the conversation, focusing not just on how we tell people what we’re doing, but also on how we talk about ourselves more accurately for actually affecting change in society. We followed up with Gallimore after the event to hear more about what he’s thinking, and what opportunities he sees for the College along this dimension.

But then there’s another responsibility that we have – one that is relatively new – in the area of public engagement and outreach. That’s where I think we could be doing more.

Tell us a little more about what that is. What does that entail?

The notion of civic engagement is something that universities are grappling with more and more. Quite honestly, it’s not something that many of us are specifically trained in, and it’s not an area that a typical incoming engineering faculty member would arrive here thinking about. But helping the general population view themselves as citizen learners, and increasing their interest in finding out about the world, is critical to our mission to serve the public good.

How do we encourage young people to stay in school and explain to them what universities have to offer? How do we engage high schoolers to research, or elementary school students to things like computer coding and sustainable energy production? And how do we help improve the quality of life? There are large groups of our citizens who have few prospects toward ever changing their quality of life. There are a lot of people suffering who feel they are being left behind, and with few allies. It would surprise me if many of those people view universities as allies. So I think we should look in the mirror and try to decide whether or not we want to do something about that.

That sounds like a lofty goal. Are there examples of that type of work happening now at the College?

Absolutely! Alex Haldeman in computer science and engineering is a great example. He’s working tirelessly in the area of democratizing the internet, and making people aware of the challenges and vulnerabilities in electronic voting. Jerome Lynch in civil and environmental engineering is collaborating with people in the School of Education to engage Detroit grade-school students in deploying experiments, giving them a chance to see first-hand how research applies to the world. John Foster is a top-notch plasma physicist in the nuclear engineering and radiological sciences department and a NASA rocket scientist. One of his projects focuses on how to use plasma to clean water, especially in resource-challenged environments.

The Center for Socially Engaged Design, co-founded by Mechanical Engineering Associate Professor Kathleen Stenkos, is a great example of what we’re talking about. They’re trying to develop a rigorous methodology of how to get faculty members and students to engage the community to find appropriate solutions. This kind of work provides both a research and educational experience – they’re learning by applying it – but it also impacts lives, because they’re engaging the community to make the decisions around which solutions are actually right for the world. They have engaged and more of our students and faculty members involved in that kind of education and community service.

It sounds like some great work is already happening here. So, what’s the problem?

The problem is that these are the outliers rather than the norm. These researchers are not unique in having the skill sets to apply the scientific method to these societal problems. They are certainly not the only ones who are or could be doing it. But they are among the relatively few choosing to use their expertise in this way. The question is, how can we make it one of our core mission directives as an institution that we should be doing that?

Good question. Do you have an answer?

(Laughs) Well, I think it is starting to happen more and more here at Michigan – we are seeing more individuals choosing to take on this work. But in order to truly push this, we first need to acknowledge that there is room for improvement. We need to be frank about the fact that we could – and should – do a better job. And if we do believe that it’s an important part of our mission, we need to think about what that actually means.

Universities are really good about being strategic. We employ massively complex strategies around research, initiatives and education. Why can’t we be more strategic about this area? For example, we’ve recently had a discussion about all the things we’re doing in Detroit – there are so many projects happening across the city in education and research! We have the established Michigan Engineering Zone and recently-launched Qualcomm ThinkLab, both of which are providing STEM pipelines to thousands of students in southeast Michigan. But how can we be more strategic about that and ensure we’re using our collective expertise to work toward a greater goal?

We could, but first universities have to own the fact that it’s a priority. At the College, our newly defined mission to provide scientific and technological leadership, improve the quality of life and serve the common good. So I think we need to take the first step to owning it, and now it’s our change to execute.

Honestly, I think our students are already there. In many respects, they are ahead of us. But more and more of our faculty and staff are stepping up and getting interested in this notion of community engagement. So I think it’s an area where we’re going to see exciting things happen in the coming years.

Gallimore is also an Arthur F. Thurnau Professor and the Richard F. and Eleanor A. Towner Professor of Engineering. Lynch is the Donald Malcolm Department Chair. Stenkos is an Arthur F. Thurnau Professor and Miller Faculty Scholar. Associate Professor.
Robotics facility

In response to our coverage of the construction of the Ford Motor Company Robotics Building that’s planned on North Campus.

This makes me want to go back to school just so I can play around.

Jacqueline Denoyer

Who is the design architect for this way cool building?

James A. Vargo

“The Ford Motor Company Robotics Building was designed by architectural firm Harvey Ellis DeMouza. The firm describes the building’s style as "Machine in the Garden."

The sails are exquisitely engineered composite material structures. They are permanently shaped, not flat when flaccid.

David Finkleman

Survey says

Responses to the survey included in the Spring 2017 issue.

Spring ’17 issue was fantastic! I read every article. It can’t get any better than that.

Kathleen D. Klinich (PhD ME ’06)

Algorithms can be more fair than humans

Response to H. V. Jagadish’s piece on Amazon’s same-day delivery service area algorithm.

Author H. V. Jagadish shows his anti-business prejudice when he characterizes perfectly logical business decisions from Amazon and Target as “unfair” and “discriminatory.” He implies that Amazon and Target are “biased” if they do not locate their delivery service and/or stores in poor and minority areas. This is just not so!

He goes on to refute his own implications when he says, “Stores attempt to have locations that are convenient for a large pool of potential customers with money to spend.” Isn’t this what businesses are in business to do?

He writes, “Designers likely don’t intend to discriminate, and may not even realize a problem has crept in…Amazon told Bloomberg it had no discriminatory intent, and there is every reason to believe that claim.” Shouldn’t we also believe them?

More, “Yet there has been no popular outcry against poor people in its store location decisions. This is because there is no real discrimination! Even more, “Someone who lives in a ZIP code without a Target store can still shop at Target -- and Target as “unfair” and “discriminatory.” He holds his anti-business prejudice, implying that Amazon and Target are “biased” and “unfair” and “discriminatory.” He believes them to have no real intention to discriminate, and may not even realize a problem has crept in…Amazon told Bloomberg it had no discriminatory intent, and there is every reason to believe that claim. Shouldn’t we also believe them?

Michael Sapienz

Brain Hacks

Responses to our trivia question about Michigan Engineers using this equipment in the 1800s to build an instrument for studying subatomic particles.

I remember building an underground nightclub detector was a big project for the physics Dept. @Doug Craig

It’s a mining machine, and high velocity particles are often recorded via deep sealed water tanks to detecting photon tracks from impacts. @Frederic Bartholomew

Have something to share? Email us at MichiganEngineer@umich.edu.

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Have something to share? Email us at MichiganEngineer@umich.edu.
SLICK AS A DUCK, TOUGH AS A RHINO

Amazingly waterproof and ridiculously durable. That’s how Materials Science and Engineering Associate Professor Anish Tuteja describes his new “superhydrophobic” coating. Made of a mix of fluorinated polyurethane foamur and a specialized water-repelling molecule called “F-POSS,” the new coating is hundreds of times more durable than its predecessors. Even better, it’s self-healing: if F-POSS molecules are scraped from the surface, new ones migrate from below to replace them.

Tuteja notes that the coating can bounce back even after being “abraded, scratched, burned, plasma-cleaned, flattened, sonicated and chemically attacked.” It’s currently being commercialized and could be available to consumers as soon as this year.

NEW CENTER TO STRETCH AIRPLANE WINGSPANs

Big wingspans have a lot to offer in terms of efficiency for long-haul flights, resulting in lower emissions and operating costs. But the benefits will be countered by the additional weight if those wings are built to be as stiff as conventional ones.

So, what will it mean to fly with flexible wings? That’s the question to be answered by a new $8.25 million joint Airbus-Michigan center to be located at U-M. Together, Michigan aerospace engineering researchers and Airbus flight physicists will develop methods to study how the wings will move during turbulence and maneuvers — and also explore techniques to mitigate the bendiness.

“We will be addressing very fundamental research questions while exploring this new uncharted territory in commercial transport aircraft configurations,” said Carlos Comik, a professor of aerospace engineering at U-M and the director of the new center.

A Michigan Engineer now leads the National Science Foundation’s Directorate for Engineering. Dawn Tilbury, professor of mechanical engineering and former associate dean for research, assumed the role in June. The office she heads awards about 32 percent of the federal funding for fundamental engineering research at academic institutions across the U.S. each year, and is charged with fostering innovations to benefit society. Tilbury retains her U-M appointment and plans to return to the faculty when her term is completed within four years.
Each of the 21 billion neurons in the human cerebral cortex is believed to be connected to roughly 10,000 other neurons, through tendrils that can stretch for several centimeters or more. Explains why we haven’t mapped any brains yet.

But a new $7.75 million National Science Foundation project that brings together electrical engineers, biomedical engineers and neuroscientists, led by professor Eunus Youn, is going to put a suite of tools into the hands of neuroscientists that could enable individual circuits within rodent brains to be mapped and connected to behaviors. Observing neural circuits could lead to better understanding of disease in the brain as well as more effective treatments.

“A tiny synthetic pore may help researchers study misshapen proteins in the muscle tissue of a rodent’s heart,” said Youn. “This would be possible because researchers could control the opening of the pore, and each opening could be read by the computer.”

The research team, “fingerprinting,” the technique uses a nanopore so small that only one protein molecule can pass through at a time. The protein fingerprinting technique can then be used to map and understand disease in the brain as well as more effective treatments.

**PROBING THE SUN**

Justin Kaspar, a climate and space sciences and engineering associate professor who designs sensors for spacecraft that explore extreme environments, is joining four other researchers leading teams in flying instruments aboard the Parker Solar Probe in late 2018. Kaspar’s Solar Wind Plasma Alphas and Protons (SWEPAP) investigation, will examine the most abundant particles in the solar wind: electrons and ions of helium and hydrogen.

The craft will:
- Come as close as 2.5 million miles to the sun – more than seven times closer than any spacecraft before
- Plunge through the sun’s corona, called the corona
- Do 5 flybys in the 7 years mission, ending in 2025
- Have a 4.5-inch-thick carbon composite shield to protect it from the sun’s heat

**SPACE FOR ROBOTS, DRONES AND NUCLEAR RESEARCH**

Four major new and renovated spaces are taking shape, adding to the College’s capabilities for cutting-edge engineering research. Once complete, Michigan will be the only engineering school in the country with access to test facilities for air, sea and land.

**CENTRAL CAMPUS**

**AARON FREISMAN MARINE HYDRODYNAMICS LAB**

**NORTH CAMPUS**

**Ford Motor Company Robotics Building**

Robotic technologies for air, sea and roads, for factories, hospitals and homes will move into new laboratories at the new facility, and a smaller establishment will be added to provide more space to Ford researchers.

**MAR**

Situated right next to the new robotics building, this outdoor fly lab will allow for testing of autonomous aerial vehicles, putting the edge in “sky.”

**NANOPOROT FoIGHT ALZHEIMER’S**

A tiny synthetic pore may help researchers study misshapen proteins believed to play a role in Alzheimer’s and Parkinson’s. Called “3D protein fingerprinting,” the technique uses a nanopore so small that only one protein molecule at a time can fit through. The pore is filled with saline solution and charged with an electrical current. The research team, including Biomedical Engineering Professor David Sept, measures the tiny fluctuations in that current as each protein molecule tumbles through to get a snapshot of its makeup. In the future, such measurements could provide valuable insight into a variety of deadly diseases.

**$65,000**

The income threshold for the University’s new “Go Blue Guarantee,” which will provide free tuition for Michigan residents who apply and are admitted. The guarantee covers the full cost of in-state tuition for four years of undergraduate study on the Ann Arbor campus – a $60,000 value.
NEW CHAIRS AT THE HELM

Where is your field headed in the next five to ten years, and how is your department at the forefront?

Sharon C. Glotzer, Donald Mal Isaacson Chair of Chemical Engineering, Dean of the College of Engineering, and Professor of Chemistry, Bioengineering, Chemical Engineering, and Materials Science & Engineering

"Despite being one of the youngest engineering disciplines, computer science is transforming nearly every area of our lives. Michigan's unique strengths – depth across breadth, a deeply collaborative nature, and a willingness to experiment in established fields – provide us with an opportunity to shape how this transformation unfolds. To do so, we must provide an inclusive environment to ensure the broadest possible collection of talent is focused on equitably solving the world's problems. At the same time, our field is facing several inflection points, including the end of Moore's Law, the promise of data science, and the need to build systems that are trustworthy and provably correct. These trends ensure that our field will face interesting community resilience.

Jerome P. Lynch, Department Chair of Computer Science & Engineering

"Coming out of World War II, the country entered a long period of expansion, building the impressive infrastructure systems we depend on today. Generations of engineers were trained to design and build infrastructure. Today, there is a profound shift occurring with our role broadening – we are now also renewing and maintaining our infrastructure with an emphasis on ensuring our built environment is in better harmony with the natural environment. Our department is boldly leading the development of high-tech tools and cutting-edge analyses to ensure our communities are resilient to natural hazards, climate change and pollution. For example, we're leading in autonomics and intelligent systems – smart mobility, smart waterbodies, smart construction, and smart structures – that are key to delivering community resilience.

Jing Sun, Department Chair of Architectural Engineering & Marine Engineering

"The marine engineering fields are broadening and diversifying, at a dizzying speed. Their impacts on society, the environment, and the economy are growing and far reaching. We are adapting to maintain our educational and research leadership on both the national and international stages. We are focusing on scientific discoveries that transform our world, ensuring that when you're standing in front of a giant, scary machine for the first time, I didn't know what to do. I apparently wasn't allowed to ask for help. But I couldn't just sit there and let all the men and women, and hope to magically become enlightened either. So I left.

I thought it was my fault, that I wasn't good enough to be an engineer. I had never felt so stupid in my whole life. I sat on a bench outside the EECS building and called my dad, crying progressively harder the further I walked away.

That man didn't know was I had actually watched every single instruction video three times. I was monumentalized, but that moment when you realize you're standing in front of a giant, scary machine for the first time. I didn't know what to do. I apparently wasn't allowed to ask for help. But I couldn't just sit there and let all the men and women, and hope to magically become enlightened either. So I left.

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ELEGANT MECHANICS FOR STREAMLINED SURGERY

Fundamental engineering principles give this all-mechanical surgical instrument the dexterity of a robot at a fraction of the cost.

This spring, U-M startup FlexDex Surgical released a paradigm-shifting needle driver for stitching inside the body in minimally invasive surgical procedures. More intuitive and ergonomic than any similar device on the market, it operates like an extension of the surgeon's own hand. At less than $1,000 apiece, the device could rival multi-million-dollar robotic technologies to make minimally invasive surgeries much more widely available.

Here's the problem it solves

Minimally invasive, or laparoscopic, surgery has several benefits for the patient, such as reduced pain and blood-loss and shorter hospital stays. However, in conventional hand-held instruments for laparoscopic procedures, the instrument tip that goes inside the patient's body lacks wrist-like articulation and moves in the opposite direction as the surgeon's hand. Using these counter-intuitive instruments can be a physical and mental strain, and as a result not all surgeons are able to perform laparoscopy. Today, surgeons have to choose between these awkward hand-held "straight sticks" or expensive robotic systems that require considerable training and are not readily accessible in all hospitals in the U.S. and around the world. FlexDex disrupts that binary.

"HAVING WORKED IN INDUSTRY, THE VAST DIFFERENCE BETWEEN A PROOF-OF-CONCEPT PROTOTYPE AND A PRODUCT WAS CLEAR TO ME. A TRUE SOLUTION TO A SOCIETAL NEED IS ONE THAT HAS BEEN PUT TO PRACTICE, WE FORGED A UNIQUE PARTNERSHIP BETWEEN ENGINEERING AND MEDICINE TO TRANSLATE THESE INNOVATIONS TO A COMMERCIAL TECHNOLOGY THAT IS CLINICALLY RELEVANT, AND POTENTIALLY GAME-CHANGING."

Shorya Awtar
Associate professor of mechanical engineering and co-inventor of FlexDex with Jim Geiger, the Daniel H. Teitelbaum M.D. Collegiate Professor at the U-M Medical School. Awtar is CTO of FlexDex Surgical and Geiger is CEO.

Parallel kinematic virtual center mechanism: Parallel kinematic flexure strips enable a unique “virtual center” mechanism.

Forearm cuff: Rather than simply holding the instrument in hand, the surgeon mounts it to the forearm via a unique three-axis gimbal cuff.

Virtual center of rotation: FlexDex’s most important innovation situates the instrument handle’s input joint at the same point in space as the user’s wrist. In other hand-held instruments, these joints are separated, leading to the disparate and counterintuitive motions of the user and the instrument. FlexDex inventors leveraged basic research in parallel kinematics (a field of mechanical design) from Prof. Awtar’s lab to create a unique input joint comprising two polypropylene flexure strips. This path-breaking design not only projects the virtual center of rotation at the user’s wrist but also mechanically separates the pitch and yaw rotations at the instrument input so that these can be effectively transmitted to the instrument tip via simple cable routing. Each flexure strip is stiff in one rotation and compliant in the other. This allows, for example, the transmission of only the pitch component of the handle rotation to the pitch transmission pulley, filtering out the yaw component, and vice versa. FlexDex’s handle almost floats, only connected to the instrument frame via these two flexure strips that also help attenuate hand tremors.

Frame: To make the instrument shaft an analog of the forearm, FlexDex designers connected the shaft to the forearm cuff via a bridge that goes over the hand and wrist. This decouples the surgeon’s forearm motion from wrist motion so that each can be separately transmitted to the instrument. The user’s forearm guides the tool shaft’s three degrees of freedom – translations along the x-, y-, and z-axes. And the user’s wrist guides the additional degrees of freedom that the tip requires – pitch and yaw rotations. Finally, a continuous roll rotation of the instrument shaft and tip is provided by a twisting action of the surgeon’s fingers and thumb.
The now-closed Ulrich's bookstore on South University. Ulrich's is moving, along with the other businesses on the north side of South U between East U and Church Street. The buildings will be demolished and replaced with a 10-story high-rise that will house retail businesses on the first two floors and 40 student apartments above.

PHOTO: Joseph Xu
OUT OF THE COLD WAR’S SHADOW
The new technology of nuclear nonproliferation

STORY BY: Kate McAlpine
PHOTOS BY: Joseph Xu
“MY GOD, WHAT HAVE WE DONE?”

These words echoed in the mind of Enola Gay pilot Robert Lewis after watching a radioactive ball of fire swirl over Hiroshima on August 6, 1945 in the first attack of the Atomic Age. Tens of thousands of people were killed instantaneously. Burns, radiation sickness and other injuries brought the death toll to about 180,000. It was the world’s first look at a terrifying weapon that is still both coveted and abhorred.

The attacks on Hiroshima and Nagasaki set off a worldwide race to produce nuclear bombs. The mushroom cloud of a successful test sent a message to other countries: you mess with us, we’ll annihilate you. The international community tried to put on the brakes, but the past 70 years have seen more countries gradually arming themselves. In the heat of the Cold War, nuclear warheads piled up to a global peak close to 60,000.

WE'RE STILL LEFT WITH ABOUT 15,000 NUCLEAR WEAPONS TODAY. IT DOESN'T MAKE SENSE BY ANY MEANINGFUL STANDARD.

"Right now, the United States has 1,700 nuclear weapons ready to be delivered and another 2,700 in storage. Some are literally thousands of times more powerful than what was delivered at Hiroshima and Nagasaki," said Paul Richards, a special research scientist at Columbia University. "And pointing at us from the Russian Federation, there are about 18,000 large nuclear weapons deployed now, ready to be delivered, and almost 3,000 on reserve."

Still, the effort to prevent another Hiroshima -- or worse -- has been an unparalleled unifying force on the international stage. The great challenge is that outlawing nuclear technology is no solution; nuclear power has far too much to offer in emissions-free electricity, especially relevant in this moment when we are reckoning with the climate effects of conventional fuch.

The challenge instead is to prevent nuclear energy countries from becoming nuclear weapon states, along with efforts toward nuclear disarmament and the banning of nuclear tests. No country wants to take it on faith that the others are following the rules, so engineers need to design monitoring solutions that all sides can trust.

To bring treaty verification into the 21st century, the National Nuclear Security Administration offered $25 million to a team of engineers, scientists and policy experts at 12 universities and nine government laboratories. Their Consortium for Verification Technology (CVT) is headed by Sara Pozzi, a professor of nuclear engineering and radiological sciences and director of the Consortium for Verification Technology (CVT) at the University of Michigan.

Pozzi has over 20 years of experience in nonproliferation, security and the monitoring of nuclear facilities. She spent several years at Oak Ridge National Laboratory, where she was part of a team working with Russia on new methods for disarmament verification.

"It’s really important to be able to verify a treaty to give confidence to the states that are part of the treaty, as well as to other states around the world, that the treaty can be implemented and enforced," said Pozzi.

The work of the CVT touches on every aspect of nuclear nonproliferation, including the development of methods to better ensure that nuclear energy countries aren’t diverting materials for weapons, that any significant nuclear test under the world can be detected, and that countries engaging in disarmament are meeting their obligations.

As methods for monitoring nuclear activity become ever more precise, concerns about whether we can reliably catch treaty violations should fade, leaving the one big question: is the world ready to dismantle these weapons?

CHANNELING ATOMIC POWER

The dawn of the atomic age, before the world had ever heard of a meltdown, was a time of great optimism with the promise of virtually limitless energy. Nuclear nations like the U.S. wanted to share their expertise, on one condition: countries receiving nuclear power technology agreed never to obtain nuclear weapons.

Nuclear power has spread across the globe under the watchful eye of the International Atomic Energy Agency, founded in 1957. The IAEA’s role was formalized in the Nuclear Non-Proliferation Treaty in 1970.

There are maybe 140 countries that have nuclear materials, and the IAEA is responsible for verifying that the countries have not used them to obtain unauthorized material they claim to have – it hasn’t paused to nuclear weapons or secret programs,” said Zhong He, a professor of nuclear engineering and radiological sciences at U-M. He leads the CVT research group tasked with solutions for inspections and non-covert monitoring.

There are many points along the fuel cycle where nuclear material could be diverted or lost from civilian control (see infographic: "How Peaceful Atoms Go Bad"). Likewise, the IAEA has many tools for identifying bad behavior. Still, the agency’s funding doesn’t extend to research and development, so it is left to the universities and national labs to push detection ahead.

The IAEA depends heavily on the use of helium-3 detectors to spot the neutrons that are critical to recognizing radioactive uranium and plutonium. These detectors have two big downsides. For one, they are slow to register neutrons, which muddles the timing of their neutron detections and makes them less precise at determining the concentrations of fissile materials that power reactors and bombs.

Also, the helium-3 supply has tightened significantly since the end of the arms race: it is a byproduct of nuclear weapon production. As it becomes scarce, new detection materials are needed. "In the CVT, we’re pioneering the use of these fast neutron detectors based on scintillators," said Pozzi. "It’s really changing the way we’re doing detection for things like nuclear fuel.

BETTER DETECTORS

Scintillators react to radiation in forms like gamma rays and neutrons, producing light where the radiation passes through. Their big advantage, in addition to cost, is that they can sense neutrons quickly, picking apart fleeting chain-reacton fissions in uranium and plutonium materials. The problem is that they light up not only when neutrons come through, but also in response to gamma rays, a form of electromagnetic radiation that is a step up from x-rays in energy. At first blush, the many gammas are indistinguishable from the much rarer neutrons, and this has always excluded plastic scintillators from the neutron detection game. But Pozzi and her colleagues are trying to turn this deal-breaking disadvantage into an advantage.

Her group has developed algorithms that can tell the difference between neutrons and gammas, and these are being further refined with help from Alfred Hero, a professor of computer science and engineering at U-M. His algorithms are good at picking out rare, important events in a sea of similar but unimportant events: the neutron among ten thousand gamma rays, or the neutron test among thousands of earthquakes.

While the neutron data is prized, Pozzi’s group goes beyond merely filtering out the gamma radiation – they’re trying to make it useful. By looking at neutrons and gamma rays together, they can tell the difference between forms of plutonium, whether it’s a compound destined for fuel rods or a metal that could be shaped into a weapon.

Going beyond basic detection, convenient radiation imaging could change the game in nuclear inspections. An IAEA agent could use a camera to determine whether there is radiation coming from unexpected locations – for instance, a corner of a room that might have been overlooked with a simple detector because all of the radiation was assumed to come from the fuel assembly offered for inspection. Now, researchers are developing new handheld detectors that not only identify radiation but pinpoint its source.

Zhong He is best known for his gamma cameras. Those that his company, HSD, makes are priced by nuclear safety professionals for their ability to identify tiny amounts of radioactive material – “radioactive dust,” as one user said. The IAEA has already bought two. He’s group is taking these cameras further by beginning to harness the neutron-detecting ability of the crystal at the heart of the camera.

Likewise, Pozzi’s combination radiation detectors are moving into imaging. CVT assistant director and U-M associate research scientist Shaun Clarke described their image prototype: an array of centimeterscale scintillating crystal pillars inside a handheld box. While He’s cameras superimpose the radiation image over the image of the room on

Sara Pozzi, U-M professor of nuclear engineering and radiological sciences and director of the Consortium for Verification Technology (CVT) near a newly installed linear accelerator in the U-M Nuclear Engineering Laboratory. The accelerator will be used to test new types of radiation detectors.
HOW PEACEFUL ATOMS GO BAD

ISOTOPE BASICS

One element can contain different numbers of neutrons; these versions are known as isotopes.

Pu-239: Plutonium-239 is a key to nuclear weapons. If the centrifuges are enriching uranium to higher, weapons-grade concentrations of U-235, it will be visible in the form of greater radiation levels under a treaty agreement. Non-design data, on the other hand, are just lying around and not collected for a nonproliferation purpose.”

“The number of birds perched on the line. When more power is coming in, the magnetic field and noise rise while the heat deters the birds. “We want to go beyond formal intelligence-gathering with cheap, pervasive technologies that can ensure — through the use of machine learning, image analysis and big data processing — a more effective way of detecting diversions and anomalies,” said Hero. Among these anomolies are secret nuclear weapon tests.

“The IAEA’s toolkit also includes long-term monitoring technology such as video and radiation surveillance and satellite imaging. In the CVT, Hero and other researchers are looking at ways to use advanced data science to take surveillance to the next level, merging data from different sources to identify anomalies that might indicate foul play. Hero leads the data analysis arm of the CVT, which is investigating how to leverage the data that is available.

“Design data are, for example, specifically targeted campaigns to measure radionuclide levels under a treaty agreement: Non-design data, on the other hand, are just lying around and not collected for a nonproliferation purpose.”

One CVT project, led by Lawrence Carin, a professor of electrical engineering at Duke University, is trying to take advantage of non-design data with a method for spotting secret shipments out of known facilities. Because the IAEA obtains reports of all nuclear material comings and goings, it essentially has a transport network as design data. While some shipments are tracked with GPS, the routes and stopover times for others can be inferred — for instance, by comparing the time that a truck left one facility and arrived at another.

“The odds of catching a facility in the middle of an illicit transfer of materials are low. That’s why the IAEA’s toolkit also includes long-term monitoring technology such as video and radiation surveillance and satellite imaging. In the CVT, Hero and other researchers are looking at ways to use advanced data science to take surveillance to the next level, merging data from different sources to identify anomalies that might indicate foul play. Hero leads the data analysis arm of the CVT, which is investigating how to leverage the data that is available.

“The number of birds perched on the line. When more power is coming in, the magnetic field and noise rise while the heat deters the birds. “We want to go beyond formal intelligence-gathering with cheap, pervasive technologies that can ensure — through the use of machine learning, image analysis and big data processing — a more effective way of detecting diversions and anomalies,” said Hero. Among these anomolies are secret nuclear weapon tests.

PARTICIPATING IN THE CVT

Universities
University of Michigan
Massachusetts Institute of Technology
Princeton University
Columbia University
North Carolina State University
University of Arizona
Oak Ridge
University of Wisconsin
University of Florida
Argonne National Laboratory
Yale University
University of Illinois at Urbana-Champaign

National Labs
Brookhaven National Laboratory
Los Alamos National Laboratory
Lawrence Livermore National Laboratory
Sandia National Laboratory
Oak Ridge National Laboratory
Oak Ridge National Laboratory
Pacific Northwest National Laboratory
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory

Companies
Microsoft
Pacific Northwest National Laboratory

Other Non-Profit Organizations
Defense Threat Reduction Agency
Lawrence Berkeley National Laboratory
Pacific Northwest National Laboratory

These routes can then be confirmed by satellite images, the non-design data. But it’s not just about confirming that shipments occurred as reported; by looking at slight variations in the shipping network, the researchers believe that they could turn up the times and places where undercover shipments may have occurred.

Another potential strategy is to observe power consumption at uranium enrichment plants. If the centrifuges are enriching uranium to higher, weapons-grade concentrations of U-235, it will be visible in the form of greater electricity use. Hero pointed out that the reported electricity bills could be compared to indirect measurements of the power line running into the facility — monitoring the magnetic field around it, the noise it makes or even the number of birds perched on the line. When more power is coming in, the magnetic field and noise rise while the heat deters the birds.

“We want to go beyond formal intelligence-gathering with cheap, pervasive technologies that can ensure — through the use of machine learning, image analysis and big data processing — a more effective way of detecting diversions and anomalies,” said Hero. Among these anomolies are secret nuclear weapon tests.

VERIFYING TEST BAN TREATIES

In the mid-1990s, many people believed the world was ready for a total ban on nuclear tests, so in 1996, the United Nations adopted the Comprehensive Test Ban Treaty, expecting it to sail through. It didn’t. Several nations didn’t sign, and several more — including the U.S. — agreed but didn’t ratify. Still, the 183 signatories (of the 193 states in the UN) have housed it and contributed to the funding of the International Monitoring System (IMS), a global network of 321 monitoring stations and 16 labs that can detect major nuclear tests anywhere in the world. The IMS was just getting
WE ENVISION A WORLD IN WHICH A NUCLEAR INSPECTOR WEARING A HOLDENS COULD WALK INTO A ROOM AND BE ABLE TO SEE THE RADIATION SOURCE.

started when India and Pakistan conducted their tests in 1998, but by the time North Korea began testing nuclear explosives in 2006, it was already too late.

The international monitoring stations come in four flavors: seismic, measuring seismic waves through the earth’s crust; hydroacoustic, measuring sound waves in the ocean; infrasound, picking up inaudible low sound waves in the atmosphere; and radionuclides, identifying radioactive particles found in the atmosphere.

The IMS was built-up very quickly once the U.N. adopted the treaty, leaving little time to hone the monitoring techniques. Now, members of the CVT are trying to improve all aspects of the measurements.

Paul Richards of Columbus University, an expert in seismology, studies the blips from nuclear tests and earthquakes, developing techniques to tell them apart even for relatively small nuclear explosions.

There are several different types of seismic waves, and whether you have an earthquake source or a nuclear source, that generates a different mix of seismic waves,” said Richards.

Right now, the IMS can pick up an underground blast anywhere in the world that exceeds 1,000 tons TNT equivalent. For context, the Tomsk-75 missiles launched at Syria in April of 2017 bore 500-ton chemical warheads. In a thoroughly monitored region like North Korea, Richards said explosions of just a few tons — well below military significance — can be detected. For other regions, he is working closely with Hero to apply advanced statistical analysis to the problem, reducing the threshold to detect a nuclear explosion. This will give treaty signatories more confidence that violators can be caught and stopped.

In addition to improving the analysis of seismic data, CVT researchers are exploring improvements in other means of detection. For example, Milton Garca’s, director of the Infrasound Laboratory at the University of Hawaii, is exploring how armies of smartphones can augment the existing arrays of infrasound sensors.

His group developed an app called RedVox that harnesses the infrasound portion of sound registered by the iPhone’s built-in microphone and sends it off to his servers, where it can be analyzed. And because infrasound waves are so much longer than those produced by human voices, they can be gathered with a lower sampling rate, requiring less data and preventing the capture of conversations.

The smoking gun, so to speak, of a weapons test is the presence of radioactive gases in the atmosphere. John Lee, a professor of nuclear engineering and radiological sciences at U-M, develops tools to predict where the wind will take their invisible fumes so that they can be captured and analyzed. By understanding and reducing the uncertainties in the models, his team improves the odds that inspectors can identify the type and location of a suspected nuclear test.

While the IMS was designed to detect nuclear tests, Garcia pointed out these are usually advertised as a form of saber rattling. The most important benefit of better monitoring may be in de-escalating tensions, he said. “For example, mortars could be incorrectly identified as being an attack. This has happened to us various times — when something just came out of the sky and blew up. And the first few hours to days can be tenuous,” he said. “If you can identify the signature quickly, you can de-escalate from a military to a natural hazard response. And that is really key to stability in the world.”

TOWARD DISARMAMENT

When the non-nuclear-armed countries agreed never to pursue nuclear weapons in the Nuclear Non-Proliferation Treaty, the nuclear-armed countries promised to disarm. This commitment was largely ignored during the Cold War, and even today, progress is slow. This is partly because warheads are hard to monitor, explained Alexander Glaser, an associate professor of nuclear engineering, and mechanical and aerospace engineering, at Princeton University. Delivery vehicles, such as intercontinental ballistic missiles, are held in rather obvious silos, making them easy to spot as though it was destroying more warheads than it really was. But these fakes could be spotted with a mismatch in the detector signals, and the differences would give away details of the warhead’s design.

The weakness of the strategy is that it relies on a warhead that the inspectors believe is real. Still, Glaser points out that it would be risky and illogical to present inspectors with an entire arsenal of missiles fired with decoys and a set of identical fake warheads to “disarm.” Zero-knowledge methods could go a long way toward enabling more aggressive disarmament targets.

“Better verification technologies are necessary to significantly reduce the number of nuclear weapons,” said Clarke. “If the U.S. and Russia each have five nuclear weapons, the ability to verify one is much more important.”

NUCLEAR-ARMS-FREE WORLD?

Five nuclear weapons each seems fulfills from where we are now.

“We’re still left with about 15,000 nuclear weapons today,” said Glaser. “It doesn’t make sense to have that many.”

Some CVT researchers can envision a world with just a handful of nuclear weapons — or even zero. In such a world, treaty verification is critical. Violators must be detected early and stopped before weapons are produced.

Judging by past progress, Glaser anticipates that it will take a long time just to get nuclear warheads into the low hundreds, but once we’re there, the international community may have changed so much that zero doesn’t seem like such a difficult leap.

Prior to a variety of zero-knowledge approaches, Glaser had some ideas. “How can we verify zero weapons, especially in large states such as the U.S. or Russia?” she asked. “Many would argue that keeping nuclear weapons to modest levels in the hundreds for the U.S. and Russia provides a more stable situation.”

In the meantime, nuclear-weapons-free countries are tired of waiting around for weapons countries to disarm. They are taking action with a new treaty, adopted by 122 U.N. countries in July 2017, to ban nuclear arms. It opened for signatures in September.

It may not be long until, at least on the international stage, nuclear weapons are no longer a mark of power, but the mark of a pariah.
Access to clean water and sanitation is a human right. How a U-M professor is working with communities from Flint to Addis Ababa to stand up for it.
Nancy Love is driving north from her Ann Arbor office to Flint, Michigan, the notorious city where tens of thousands were exposed to lead-laced drinking water beginning in 2014. She’s on her way to meet collaborators and the team of Flint residents collecting water samples around the city. Together, they’re investigating whether an outbreak of a severe type of pneumonia called Legionnaire’s disease can also be linked to the drinking water.

It’s an hour-long drive that she makes about once a week, and it exemplifies the “outside-the-box/school” approach that defines her long career.

As the highways intersect in the city proper, she passes the urban gospel format radio station where she was a guest in May with both Flint Mayor Karen Weaver and the leader of the Flint Area Community Health and Environment Partnership (FACHEP). Wayne State University professor Shawn McKlnmurray. On the air, they discussed steps that vulnerable residents can take to limit their risk to any waterborne diseases.

Today, her destination is the FACHEP headquarters. She’ll be meeting with McKlnmurray and the local people who are gathering samples.

“We’re not from this community,” Love said. “The greater trust is going to come from people who are. And the more we can push grant money to employ Flint residents and train them on how to sample and monitor their own water, rather than have our students do it for them, the better. To me, that’s a philosophy that we have to maintain in the future.”

A bridge over troubled water

The planet’s urban and natural water systems—and in turn, the humans who rely on them—will face unprecedented stresses in the coming decades. Developed countries must contend with aging pipes and treatment plants, while developing nations will need to figure out how to provide access to safe drinking water and manage the sewage and industrial wastewater of growing cities. All this while the climate changes, shifting the patterns of precipitation that we’ve long depended on to replenish supplies.

In her own state, and on the other side of the world, Love is working closely with community collaborators not only to prove how dire the problems are, but also to put solutions in place. Both her approach and her end goal represent the type of public engagement that public institutions like the University of Michigan arguably owe to society.

“The developing world has different water complexities. Just 14 percent of Ethiopia’s population has access to clean drinking water and manage the sewage and industrial wastewater of growing cities. All this while the climate changes, shifting the patterns of precipitation that we’ve long depended on to replenish supplies.”

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The ideal engineer

“In my mind, the ideal engineer is a bridge,” said Glen Daigger, a professor of engineering practice in the U-M Department of Civil and Environmental Engineering and a member of the National Academy of Engineering. “Science tells you what is possible. We can’t do anything the natural world won’t allow us to do. Engineering provides the mechanisms to translate that into something useful.”

“Nancy is a role model in that she understands this. It’s one thing to have a solution. It’s quite another thing to get people to implement it.”

In Ethiopia, a world of different water worries

Flint is a testament to how precarious water systems can be in a developed country with centralized water treatment: flushing toilets and running taps at the ends of intricate networks of pipes and treatment complexes. In the financially strapped city, residents were exposed to lead in their drinking water when a water source switch didn’t meet with an appropriate water treatment switch. High levels of lead, a neurotoxin, were found in children’s blood. The city is still reeling.

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The developing world has different water complexities. Just 14 percent of Africa, for example, is connected to a sewer system. Though centralized water treatment may not be the answer, the United Nations has called for solutions. Poor water quality is causing health problems, especially for children who are particularly vulnerable to dying from preventable waterborne diseases.

Love has seen some of the repercussions firsthand. In 2011, she and her husband, Brian Love, who is a professor of mathematics and engineering at U-M, adopted one of their children from Ethiopia. Through visits to the country, Love has come to understand its childhood stunting problem.

Stunted children don’t reach their full height potential because of poor nutrition and frequent diarrhea episodes that leave their bodies unable to absorb enough nutrients from food. Beyond being short, a child can suffer cognitive delays and chronic health conditions if the condition isn’t caught before he or she turns 5. Government programs are improving the situation, but studies estimate that more than 35 percent of Ethiopian children are stunted.

To assess the role that waterborne pathogens play in childhood stunting, Love is working with two faculty members in U-M’s School of Public Health—Joe Eisenberg, chair and professor of epidemiology, and Andrew Jones, assistant professor of nutritional sciences. They visited Addis Ababa in July 2016 to get started. As in Flint, the project will employ local residents to gather samples and involve a close collaboration with Ethiopian researchers from Addis Ababa University (AAU). The team is aiming to obtain data from 700 children between the ends of intricate networks of pipes and treatment complexes. In the financially strapped city, residents were exposed to lead in their drinking water when a water source switch didn’t meet with an appropriate water treatment switch. High levels of lead, a neurotoxin, were found in children’s blood. The city is still reeling.

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“We should not assume that what was true about bacteria in pipes 20 years ago is true today.”

…”
Adey Desta is an assistant professor at the Institute of Biotechnology at AAU. On Twitter, she calls herself “janitor of the Earth’s aquatic system.”

“The textbooks cover the half of the world that relies on centralized systems. A large part of Ethiopia is in the other half.”

Broader scale solutions will need to come from Ethiopians themselves, the next generation of engineers should be technically capable of working with decentralized systems. This is going to be one of the sustainable ways to manage the waste coming out of our cities. And sustainability in this context is measured by how you can deal with the waste without expending more energy.’’

Desta, Love and other faculty at AAU’s engineering school have been working together to develop curriculum around decentralized systems. “It’s very essential,” Desta said. “The next generation of engineers needs to be trained the future engineers and public health officials in order to better understand the culture and the systems work in cultures, and if you don’t understand the culture, you don’t understand the system. You have to go in and listen. And you don’t understand the system, you have to go in and understand. If you don’t understand the context, you can’t deal with the waste without expending more energy.”

Desta is often struck by Love’s resilience. She smiles warmly as she describes her colleague’s combination of patience and tenacity. “It’s very tricky for someone who has everything on hand and who gets anything they want at any time to come to a place where there is absolutely nothing you can get whenever you want – including power, sometimes,” Desta said. “But I have never seen her be frustrated. She always has Plan B and Plan C on hand: If we can’t do this, can we do that? If we can’t get this, can we get that? She’s go through hundreds of options sometimes.

“She’s learned a lot from her.”

And Love has learned a lot from Desta and other colleagues who live or work in Ethiopia.

“I think sometimes we start with good intentions but possibly not knowing how colonialist our behavior are,” Love said, remembering the first draft of the first grant she wrote with international colleagues. “Systems work in cultures, and if you don’t understand the culture, you don’t understand the system. You have to go in and listen. And through the academic capacity building we’re doing, the hope is that they can train the future engineers and public health officials in order to better equip them to make these engineering and public health decisions for their country. So the solutions will be theirs.”

For the next generation

Love has always seen her graduate students – the next generation of water engineers – as the product of her work. As time has passed, her priorities have broadened. ‘It’s been a long road affected by personal struggles and life circumstances.

Before she came to U-M, Love spent 13 years at Virginia Tech, where she won awards for her teaching, research and mentorship. Midway through her time there, she was diagnosed with a brain arteriovenous malformation, or AVM.

A tangle of veins had developed deep in her brain, causing problems with her vision and balance. She’d need to get rid of it, but she had to decide whether to take a chance on a series of surgeries that could leave her partially blind, or undergo radiation therapy. For months she couldn’t choose. She mulled over the literature and eventually decided on surgery. But over and over again, as the day approached, she’d get sick.

“I finally realized that my intuition was screaming at me: Don’t do the surgery. Do the radiation. I was following my intellect and wasn’t listening to my intuition. Then I finally listened, canceled the surgery and did the radiation,” Love said, “and three years later, it was gone and I was fully functional.’’

A few months after radiation treatment had ended, she met someone at a conference who’d had a good friend with the same brain malformation. ‘The friend had opted for surgery and died on the table. “Once I heard that story I let everything go at that moment,” Love said. “I knew I had done the right thing.”

And that was to trust her gut. It would be a few more years before Love, and her husband Brian, who was also at Virginia Tech, made the move to Michigan.

They were close to accepting offers here when Virginia Tech became the site of the deadliest campus shooting in U.S. history. In April 2007, a gunman murdered 32 people and injured 25. Many were people the Loves knew personally – students, a friend, a collaborator.

“You don’t go through something like that and not be changed,” Love said.

They almost didn’t follow through with their plans to leave. Ultimately, they did. That December, they flew to Guatemala City, where they adopted their first son. Brian went back to Blacksburg to drive their car and cats through the Midwest and Nancy flew to Detroit with a baby.

They settled into their new life, she as the first female department chair in Michigan Engineering’s history, and he as a professor in his current department. Both of them as parents. Eventually they adopted their second son from Ethiopia.

Love’s children have given her work more meaning, and in some ways, they’ve directed it. ‘I’ve taken something from these countries,’ she said, “and so I feel compelled to give something back.”
When she received her named professorship in 2016, the Borcardt and Glysson Collegiate Professor, she vowed to use her endowment on projects at the interface of water quality and childhood health. Her work in both Ethiopia and Flint are steps in that direction.

Beyond lead in Flint, a rise in bacterial counts
Lead is not the only waterborne concern in Flint. Changes to the water’s chemistry and the use of certain filters can increase its bacteria levels. Through FACHEP, Love has been working with McElmurry at Wayne State, colleagues at U-M and other institutions, as well as Flint residents, to quantify and reduce these risks.

This summer, FACHEP focused on a Legionnaires’ disease study — a $3 million, state-funded effort to determine whether there is a link between Flint’s water and the Legionnaires’ outbreak that killed 12 people during the height of the crisis.

You don’t get the respiratory ailment from drinking water. You catch it when you’re washing your hands or brushing your teeth...only thing we do with the water is wash clothes, take a shower and flush the toilet,” Hodges said. “We don’t brush our teeth with it. None of that happens.

FACHEP’s headquarters is in a shuttered school known as the Brownie Center. Inside it, coordinators make phone calls and plan their routes, and sample gatherers pass through in waves. Shayne Hodges is one of the sample gatherers. He and his family bought a house in Flint in 2014. Right away he noticed something off with the water. As the water crisis unfolded, he became an activist.

"Only thing we do with the water is wash clothes, take a shower and flush the toilet," Hodges said. “We don’t brush our teeth with it. None of that. We drink bottled water.”

He and a teammate might visit 12 homes in a day, administering a half-hour survey about health and behaviors, and getting samples from the hot water heater, the kitchen faucet, a point-of-use faucet filter if the household has one, and the showerhead. Researchers then analyze these samples for various water quality indicators and the presence of bacteria like Legionella.

"I love this job," said Hodges. "I’d do it for free. And when I see the results in the news reports, I know they’re correct. ‘Cause I took them.”

As she said this, she pulled into the Broome Center in Flint and the professor for personal reasons.

Whether they’re shrinking or expanding, 21st century urban centers are bringing water issues to the forefront on a global scale. Though Love’s work in Flint and Ethiopia are a world apart in some ways, they also feel similar...a public research institution, and she is grateful to the colleagues and community-centered research work isn’t easy and one is going to be vulnerable to criticism, but it is easier to move through the difficulties when working with committed colleagues, and when I know the work outcomes are centered on the greater good.”

So this could be something that they were part of and they were doing for their community, rather than have it be something being done to them...Beyond that, there was more going on than one discipline could handle.”

Soon after he launched FACHEP McElmurry invited Love to join because of her strong reputation in water systems – both the drinking side and wastewater – and her focus on pollutants.

FACHEP’s headquarters is in a shuttered school known as the Brownie Center. Inside it, coordinators make phone calls and plan their routes, and sample gatherers pass through in waves.

Shayne Hodges is one of the sample gatherers. He and his family bought a house in Flint in 2014. Right away he noticed something off with the water. As the water crisis unfolded, he became an activist.

“Only thing we do with the water is wash clothes, take a shower and flush the toilet,” Hodges said. “We don’t brush our teeth with it. None of that. We drink bottled water.”

He and a teammate might visit 12 homes in a day, administering a half-hour survey about health and behaviors, and getting samples from the hot water heater, the kitchen faucet, a point-of-use faucet filter if the household has one, and the showerhead. Researchers then analyze these samples for various water quality indicators and the presence of bacteria like Legionella.

“I love this job,” said Hodges. “I’d do it for free. And when I see the results in the news reports, I know they’re correct. ‘Cause I took them.”

At this point, the FACHEP team has identified a strain of Legionella in Flint water that can cause disease but is not detected by routine clinical tests; the people who died of Legionnaires’ on these particular filters, which are connected to kitchen taps and not showerheads. So Love set out to determine strategies to guide Flint residents on how to maintain their point-of-use filters and improve their water quality.

In August, she and her colleagues published a study based on Ann Arbor water that showed bacterial counts increased 100-fold across activated carbon block filters. She has not connected that to any diseases at this point, and it’s probable that she never will. All water contains bacteria, and a majority of people aren’t susceptible to them. Those who might be very vulnerable populations like the elderly people with compromised immune systems and young children. Even if direct connections aren’t made, Love says it’s important to identify risks.

She and her colleagues are currently examining the microbiological quality of water coming through point-of-use filters in Flint. They’re looking to see if there’s an association between microorganisms in Flint water and disease. When they compared Flint and Ann Arbor water, they noticed some differences in the type and numbers of microorganisms present.

They’re still finalizing the Flint study. In the meantime, they are getting an important message out to residents...”It’s one thing to have a solution. It’s quite another thing to get people to implement it.”

Running water for several minutes in the morning, and then for 15 seconds through filters before using it, can dramatically cut bacterial counts.

“Flushing as we recommend can reduce the bacteria levels in water by 10 or 100 times,” Love said in a news release this summer, underscoring the message she had delivered on the radio in May.

“We want to tell people what they can do to reduce their exposure.”

Love said: “We are concerned that using a sole filtering device with water that we found to be microbiologically unstable in some regions of Flint can put vulnerable populations at risk.”

Flint illuminates a national issue that’s most pronounced in the post-industrial upper Midwest and Northeast where urban populations have dwindled. Fewer residents mean less demand and longer treated time for water in the pipes. And if utilities don’t maintain the system, the pipes corrode. These factors combine to make it harder to maintain enough disinfectant to keep the water as safe as it should be. Bacteria can flourish in niches.

“While bacteria in appropriately disinfected water are generally harmless, we should not assume that what was true about bacteria in pipes 20 years ago is true today as the types and virulence of pathogens have evolved,” Love said.

Utilities aren’t required by law to monitor what bacteria are in the water, Love points out. They only spot them as are called “indicator bacteria” that don’t tell the complete story about microbial risk to public health.

An ongoing effort

It’s what I’m supposed to be doing,” Love said. “I’m working with colleagues who have similar values and, together, we’re addressing very important and tangible issues. Community-centered research work isn’t easy and one is going to be vulnerable to criticism, but it is easier to move through the difficulties when working with committed colleagues, and when I know the work outcomes are centered on the greater good.”

She is trusting the intuition. “I say no focus on what’s important,” Love said, hearkening back to her brain malformation recovery. “Sometimes I’ll catch myself forgetting and I’ll think, you know, I was supposed to learn this lesson.”

As she said this, she pulled into the Broome Center in Flint and the professor for personal reasons.

“The electronic voice spoke a truth beyond the geographic. At this point in Love’s career, her work aligns with her vision of what it means to be an environmental engineer at a public research institution, and she is grateful to the colleagues and communities that have helped her get there. But this work isn’t done. Collaborating with disparate groups takes time, and it can be circuitous. In a bigger sense, she’s still in route.”
Meet the Michigan Engineer who walked away from a six-figure career to help farmers and create jobs, building Haiti’s first bean-to-bar chocolate operation in her hometown.

BUILDING A STRONGER HAITI WITH CHOCOLATE

Story by: Gabe Cherry
Photos by: Marcin Szczepanski
The weary crew looks up as Corinne Joachim Sanon announces herself, her face emerging from the rainy night. Squeezed into the bed of a covered pickup, her crew has spent all day harvesting cacao in an isolated Haitian farming village. Sanon budgeted three hours for the 70-mile trip back to town. That was seven hours ago.

At 11 p.m., they’re stranded at a gas station near the city of Cap Haitien. Torrential rain has turned the road ahead into a river. To make matters worse, the driver of one of the two hired pickup trucks has given up and turned back. The 10-member crew is now shoehorned into a single vehicle along with 14 buckets of raw cacao beans. The cacao is snugly sealed against the rain blowing in. The crew, not so much. Soaked to the skin, they sit on benches, buckets and each other.

To stay fresh, the beans need to get to the fermentation and drying center near the town of Ouanaminthe within 24 hours of harvest – that’s 8 a.m. It’s not going to be easy.

Outside, the gas station’s lights lend a glow to pounding raindrops. The station is closed but they’ve left the lights on for security, drawing a swarm of stranded buses and motorcycles. The heavy air smells of charcoal smoke and sodden travelers. Creole rap music plays from a radio.

In many places, a night like this would qualify as a catastrophe. In Haiti, it’s a hurdle – discouraging but not entirely unexpected. There’s nothing to do but handle it. And, dressed in a pink tank top, khakis and cornrows that point to a bun, that’s precisely what Sanon is doing.

The 22-year-old Michigan Engineering and Wharton School grad, industrial engineer and Haitian entrepreneur has found dinner for the crew. She passes out a stack of Styrofoam containers filled with fried chicken and cold spaghetti. She also brings news: the flood is worse than it looks. They may be stuck here until morning. She grins wryly behind her red-framed glasses. “We promised you adventure,” she says, and produces a stack of paper napkins, unaccountably dry.

For Sanon, the flood is just another variable in a decision tree that has been tickling through her mind since she founded Les Chocolateries Askanya two years ago. She left a six-figure consulting job in New York to be here, returning to her native Haiti to start the country’s first bean-to-bar chocolate operation. Located in Ouanaminthe, a border city in northeastern Haiti, Askanya harvests raw cacao beans and turns them into finished, wrapped bars.

Bean-to-bar had been done in a few other developing countries, like Grenada and Ecuador. But not in Haiti. Haiti has few good roads, little electricity and a government that’s often in flux. Nothing is easy when tomorrow could bring anything from a stolen wallet to a flood or a coup, and running a factory is a particularly tall order.

But Sanon has designed Askanya to do more than make chocolate. At its core, it’s a machine that churns out better futures for Haitians. Having grown up in Haiti, Sanon knew the hurdles to running a business here. Being an engineer, she knew she could overcome them.

“I was one of the lucky ones, far luckier than the majority of Haitians,” she said. “I went to a good school and a great university and have a great life. But I didn’t want to wake up at 60 having never tried to do anything for Haiti.”

So, Sanon divides her time between Askanya’s distribution center in Brooklyn and its factory in Ouanaminthe. She makes a fraction of her old salary, heading an operation that runs on hired pickups, hard labor and endless patience: It isn’t glamorous or high-tech, especially on nights like this.

“Most of the time, my family thinks I’m crazy,” she says. “They’d rather see me in a safer, more traditional career path. But they understand that this is what I choose, and they’ve grown more proud and supportive as they’ve seen the business growing.”

Askanya coaxes 6,000 artfully wrapped, organic, single-origin chocolate bars each month from one of the most unforgiving places
“In Haiti, having a plan B isn’t enough...you have to have backup plans all the way through to Z.”

on Earth, selling them to Haitian hotels, online buyers and high-end chocolate retailers. It employs dozens of workers and buys cacao from thousands of small farmers. After a huddle with her team, Sanon decides to give up on reaching Ouanaminthe tonight. If the road clears, they’ll spend the night in Cap Haitien. Slogging through knee-deep floodwaters and a crush of stranded vehicles, it takes them nearly two hours to travel two miles to the hotel Sanon has secured. They arrive at 2 a.m. and are back on the road by 6 to get their cacao to the fermentation and drying center in time. Built from scratch by Sanon and her team, the center sits at the end of a narrow dirt path that winds across fields and farmland. Lugging a bucket in each hand, the crew carries the cacao over a muddy creek past cows, chickens and pigs toward the plastic-covered drying tunnels ahead. As they approach, the smell of fermenting cacao gets stronger: a decidedly un-chocolatey odor somewhere between spoiled fruit and vinegar. At long last, they dump the cacao into a coffin-sized wooden box. Careful fermenting and drying bring out the cacao’s distinctive fruit and floral notes, helping Askanya claim top dollar for their finished bars.

As a result, Haiti’s agriculture sector, which easily fed the country as recently as the 1970s, has withered in the decades since. The cacao trade is no exception. Haiti is home to some of the best beans in the world, but production has fallen from 20,000 tons per year in the 1960s to less than 4,000 tons in 2014. Most is exported raw and unfermented, which brings less money to farmers and invites mold and spoilage.

In Askanya, Sanon has designed a workaround: a self-contained harvest and processing system that turns raw cacao into finished bars, bringing maximum value to farmers’ efforts. It’s low-tech, adaptable and nearly indestructible.

First, an agronomist scouts locations ahead of time, using GPS and on-the-ground assessment to make sure there’s enough ripe cacao to make the difficult journey worthwhile.

Next, a nine-member crew heads to the harvest site. This generally includes two three-member harvest teams, a driver and two helpers who stay with the driver—they can push a stranded truck out of the mud or unload it before a difficult river crossing. Sanon has built relationships with a network of for-hire trucks and drivers to get harvest teams in and cacao out.

In old rice sacks, metal pans and on the backs of donkeys, farmers bring their cacao to an improvised harvest site—usually just a clean tarp spread near a crossroads. The manager of the harvest team carefully notes what time each farmer arrives and counts the finest-sized yellow pods. The farmers get seven Haitian gourdes (about ten U.S. cents) per pod, about one-third more than they’d get from a larger company. At this rate, 100 cacao trees can earn a family 400 U.S. dollars a year, a solid middle-class income in Haiti.

After the pods are counted, the other two members of the harvest team begin extracting the beans. One holds a pod in an outstretched hand and hacks through its thick husk with a machete. After a few hacks, he deftly twirls the machete blade, prying open the pod with a crunch like a bitten apple.

Inside sits the payoff: a lemon-shaped mass of cacao beans surrounded by gloating white pulp, which gives off a tart, earthy smell. A worker scoops the beans into a white plastic bucket and tosses the husk into a pile. When they’re full, the buckets are sealed and loaded into a pickup for the journey to Askanya’s fermenting and drying facility.

Sanon buys half her cacao this way, in the future, she plans to expand these direct buys to as many as 3,000 farmers. She also buys pre-processed beans from a federation of Haitian farmer cooperatives. Soon, the plan to further diversify her supply by starting a 15-hectare farm on land the company already owns.

“In Haiti, having a plan B isn’t enough,” Sanon said. “You have to have backup plans all the way through to Z. A diverse cacao supply will give us that, helping us grow our capacity and continue to help farmers.”

Sanon says demand for cacao is growing, from 4,000 tons per year when Askanya started around 6,000 tons today. That means higher prices for farmers and more cacao trees in the ground, helping to stabilize Haiti’s badly deforested hillsides.

U-M assistant professor Amy Cohn teaches the methods class to help farmers.”

“Engineers like Corinne have to understand this whole world outside the core equations. And there’s something exciting about that,” said Cohn, an Arthur F. Thomas Associate Professor of Industrial & Operations Engineering. “Whatever you care about, you can take this set of industrial operations engineering tools and use it to make a difference. So it’s not surprising to me that this is something that an industrial engineer would choose to do. Plus, there’s chocolate.”

Fermenting and Drying

Back at the gas station, the crew decides to push through the flood to reach Cap Haitien. Slogging through knee-deep floodwaters and a crush of stranded vehicles, it takes them nearly two hours to travel two miles to the hotel Sanon has secured. They arrive at 2 a.m. and are back on the road by 6 to get their cacao to the fermentation and drying center in time.

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First the cacao ferments, unchambered between layers of burlap and banana leaves, for a week. The beans are then transferred to wood-drying racks where they dry for two to three weeks, taking on a brown color that begins to look like chocolate. Drying is an unpredictable

"In Haiti, having a plan B isn’t enough...you have to have backup plans all the way through to Z.”

THE HARVEST

The start of the day couldn’t be more different. Sun streamed through the leaves of banana trees overhead as the pickup crawled into the jungle on a cracked dirt path. Harvest trips like these happen two or three times each week during the two cacao seasons, from March through May and September through November. They start with a network of for-hire trucks and drivers to get harvest teams in and cacao out.

In old rice sacks, metal pans and on the backs of donkeys, farmers bring their cacao to an improvised harvest site—usually just a clean tarp spread near a crossroads. The manager of the harvest team carefully notes what time each farmer arrives and counts the finest-sized yellow pods. The farmers get seven Haitian gourdes (about ten U.S. cents) per pod, about one-third more than they’d get from a larger company. At this rate, 100 cacao trees can earn a family 400 U.S. dollars a year, a solid middle-class income in Haiti.

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process that varies with the weather, so Sanon has incorporated six drying tables for each of the 10 fermentation rooms. The boxes must be filled at least 90 percent full to ferment properly, so they need to be carefully sized to hold one day’s cacao harvest. Ultimately, she will grow to 80 tons of capacity, enough to accommodate larger buys from small farmers and process the cacao from the planned on-site farm. For the harvesting crew, this trip has been even more grueling than most. But James Dobson Bélizaire, Askanya’s head of production, takes it in stride. Like the beans themselves, he has travelled a long and difficult road to get here. Bélizaire grew up in Cité Soleil, one of the most dangerous and destitute slums in Port au Prince. His family was poor — some nights, dinner was a stalk of sugarcane. Only about half of Cité Soleil’s children attend school. Bélizaire’s parents saw that he was bright and made sure he stayed away from the guns. But the other kids all had them, and it was too dangerous to stay. “I was lucky,” he explains. “I had a good family and they made sure I stayed away from the guns. But the other kids all had them, and it was too dangerous to stay.” Still, he continued his education. In 2007, he was one of 4,000 students who applied for admission to Université d’Etat d’Haiti’s business school. Of those, 300 passed the exam. Bélizaire was among them. Now 28, he makes about $450 per month, an impressive salary in a country where per-capita GDP is $863. Bélizaire sees the job as a way to help Haiti reclaim its agricultural heritage and make a product that shows the world what Haitians are capable of. “Haiti is a very patriarchal society,” Sanon explains. “I want people to see that women can be great employees and leaders. I try to make sure that everyone is treated equally, whether you’re a girl or a boy, Catholic or Protestant or Vodouisant.” After roasting, the cacao goes through a process called cracking, separating the outer shell from the meat inside, called the nib. First, a worker cracks the beans open with an old peanut butter grinder. Next, the ground beans are spread onto a flat, shallow Haitian basket called a laie. Sifting in front of a fan, a worker scoops beans out of the laie and holds the scoop high, slowly shaking the beans out. The fan blows the lighter shells away while the heaviest nibs fall into the laie. The nibs are then pulverized in a process called conching. This requires the factory’s most specialized equipment — three squat, kines-high machines. Their steel tuns turn slowly as heavy granite wheels inside crush the nibs into alley brown liquid chocolate. It’s at this stage that other ingredients — milk, cacao butter or other flavorings, depending on the recipe — are added. Conching takes 72 hours and sometimes has to be stopped and started as the electricity comes and goes. And electricity does come and go. Ouanaminthe’s electrical grid, when it’s working, provides power from about 6 p.m. until midnight. The rest of the time, the only electricity comes from the diesel generator that drives out back. Fuel is a big expense, as is bringing in maintenance technicians from the larger city of Cap Haitien. But it’s the only way. From here, the liquid chocolate goes into a sealed cold room — the only room at Askanya with air conditioning. It’s poured into small tabletop machines for tempering, a series of precise heating and cooling cycles that nudge the chocolate molecules toward a particular crystal structure. This process gives the glossy sheen that chocolate buyers expect. It’s then ladled by hand into molds and cooled for about 30 minutes to a reftarstage. Finally, the cooled bars are trimmed by hand and wrapped by two workers, who carefully create two layers of wrapping over each and every finished bar.

Askanya’s labor-intensive operation is a matter of necessity in Haiti. Economics of scale don’t work and neither does just-in-time delivery. There isn’t enough electricity to run big machines, and if they break, there are no parts to fix them. But for Sanon, engineering isn’t about machines or technology. It’s about designing the best system and making it work, day in and day out. “I’m a U-M OR engineer — that’s how we are, right?” she explains. “We’re tough, we try hard. We try different ways until it works.” The approach has enabled Askanya to succeed where few others have. The factory may be small, but it adds value funds the entire Askanya supply chain. Vansteenkiste, who has started several Haitian businesses, ventures herself, says it’s a game changer. “Value-added processing is where money can be made. Haiti does very little of it because processed imports are cheap to buy and too competitive, but community based organizations do niche projects,” Vansteenkiste explains. “The beauty is that they invest back into the people; they don’t take the money and put it in a shareholder’s pocket.” At Askanya, engineering is also an example that shows would-be Haitian entrepreneurs, the government and others what small business can do. As more cacao becomes available and Askanya’s farm comes online, she hopes to quadruple capacity, expanding to 10 to 12 flavors over the next five years. Ultimately, she believes this could go far beyond chocolate. “I think the future of Haiti is going to be a mix of agricultural and light manufacturing,” she says. “What we’re doing with chocolate could be done with water bottling, trash removal, juice making. It’s not rocket science. It’s all possible. And it could change a lot of lives.”
BEFORE “GEEK” WAS “COOL,” MICHIGAN ENGINEERS STILL FOUND TIME FOR FACT-FINDING, FASHION – AND FUN.
Not yet a paperless world, and well before pocket computers, students had to check social media – painstakingly slowly – at the Computing Center.

Making adjustments before a wind-tunnel experiment.

An intent lab student labors alone.

Students reviewing their notes.

PRIOR PAGE:
They’re not just proud of their checked pants and striped shirts. That Wankel (or rotary combustion) engine on the right was developed as the powerplant for Michigan’s entry in the 1972 Urban Vehicle Design Competition.
TOP: Loads of bushy mustaches, hair and sideburns in the chemical engineering lab – but no goggles? Maybe those broad-rimmed specs did the job.

BOTTOM: Dean Dave Ragone probes students’ minds. In the early 1970s it was thought that sitting on, rather than behind, desks made for more informal discussions – and turned conversationalists into better listeners.

LEFT: In 1972, mechanical and electrical engineering students built an automobile “particularly suited to an urban environment.” Though its report conceded that it had not forged any “earth-shaking technological breakthroughs,” the team did focus on curbing emissions, enhancing safety, decreasing size and cost, and improving drivability, handling, and styling.
The Michigan Technic — established in 1888 — proclaimed itself the oldest student-run publication of its kind. Under financial strife for much of the last century, it staved off a 1960s administrative push to merge it out of existence. These early 1970s staffers may have joked through their troubles, but before the decade was out the Technic was gone.

Some things never change: In tiny dorm rooms, some students studied — despite the allure of a free “psychedelic cider sip” — while others hung out (and hung laundry over furniture) and played.

The honorary mechanical engineering society Pi Tau Sigma sponsored the first Egg Drop Competition. Students constructed containers, placed eggs in them and dropped the whole kit and caboodle from West Engineering’s fourth floor. Unusually large crowds gathered to witness the splatter.

Are you picking up what we’re laying down? Then stay in the groove with our secret stash of 1960s home movies. From a brand-new North Campus to hitching rides on the Diag, get a glimpse of an Ann Arbor that’s gone forever.

umicheng.in/NAME_reels
Supporting First-Gen Students

"Why can't you just be a regular doctor?" Don Kania’s mother asked as he applied to Michigan’s PhD program in nuclear engineering.

She wanted to be supportive. Kania knew, but as he and his brother were the family’s first college grads, she didn’t have a context for graduate school and the opportunities in a technical field.

Don’s wife, Renee DuBois, was in the same boat. She was the first in her family to go to college, going on to earn a master’s degree in social work.

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Don’s wife, Renee DuBois, was in the same boat. She was the first in her family to go to college, going on to earn a master’s degree in social work.
Early one morning while you were drinking your coffee, a driverless Kia Soul cruised around a bend at the Mcity Test Facility and abruptly slowed down and stopped—avoiding a crash with a Honda Accord that neither a human driver, nor the automated vehicle sensors on the Kia, would have been able to see. It is one of many experiments occurring on a continuous basis at the facility. Nearby, on public roads across Ann Arbor, some 1,500 cars send signals to each other about their speed and direction at a rate of 10 times a second, in one of the world’s largest operational, real-world deployments of connected vehicles and infrastructure. It has been underway and collecting data for three years, relying on the same secure, wireless communication between vehicles that allowed the Kia to avoid the Honda inside the Mcity Test Facility. Just a few miles away in Ypsilanti Township, work continues on a different test track. The American Center for Mobility, a nonprofit testing and product development facility located on 335 acres, will soon allow later-stage testing to enable safe validation of connected and automated vehicle technology.

And plans are underway for the Ford Motor Company Robotics Building on North Campus, a facility that will bring together and attract leading autonomy researchers. It’s a region that is buzzing with research projects into how autonomous and connected vehicles will change the world, a nexus that prompted the New York Times to call Ann Arbor the new Motor City in July. And in many ways, Michigan Engineering— and its commitment to values such as collegiality, collaboration and stake-taking—is the reason that it’s happening here.

NOTED FOR ACTIVITY
One of the major players in the area is Mcity. Originally called the Mobility Transportation Center, the public-private partnership is overseen by U-M’s Office of Research, which cultivates interdisciplinary research across U-M’s three campuses. Mcity is perhaps best known for the Mcity Test Facility, a one-of-a-kind simulated urban and suburban environment where the Kia was driving. In 16 acres of roads and infrastructure is replete with intersections, traffic signs and signals, and construction obstacles. Researchers recently began using augmented reality to incorporate virtual vehicles into testing scenarios at the site for more robust testing. The facility is highly sought by industry and academic researchers because it allows them to repeat tests on new technologies in a safe, controlled setting before trying them in public.

The test facility is only one aspect of Mcity. In partnership with the U-M Transportation Research Institute, Mcity participates in the deployment of 1,500 connected vehicles on the roads of Ann Arbor and southeast Michigan and plans to increase that number in the near future. Mcity also funds research, with about $16 million in projects underway.

“Mcity is the only advanced mobility R&D center that combines these three components,” said Huei Peng, director of Mcity and the Roger L. McCreary Professor of Mechanical Engineering, at a demo day at Mcity this summer. Perhaps the most impressive—and challenging—aspect of Mcity is that it is a partnership between industry, government and academia. It currently has more than 65 industry members, collaborates with the Michigan Department of Transportation and other government agencies, and works with approximately 50 U-M professors involved in Mcity-funded research.

Fifteen miles away from Mcity is the American Center for Mobility (ACM). The nonprofit is a joint initiative with the State of Michigan and was founded in partnership with the University of Michigan and several other entities.

“Nowhere else in the country do facilities exist literally within miles of each other that together offer the capability to begin early stage testing, testing and on-road deployments at one site—Mcity—and graduate to another—ACM—for later stage product development testing and standards validation,” said Volkert Sicc, associate vice president for natural sciences and engineering in the U-M Office of Research and Arthur F. Thurnau Professor of Mechanical Engineering, oversees Mcity on behalf of the Office of Research.

“Together, Mcity and ACM help establish Michigan as the global center of advanced mobility research and development,” Sicc said.

Michigan will become even more important as robotics ramps up at Michigan Engineering. A $75 million robotics building is slated for completion in 2019 and will house top roboticists under one roof, including many working on problems related to mobility and autonomous vehicles. In addition, Ford Motor Company will locate teams of engineers on the building’s fourth floor, expanding the limits of collaboration. The building will be named for Ford in recognition of a $15 million gift from the company to the College of Engineering.

Ford is one of many companies conducting research in southeast Michigan. The Toyota Research Institute committed $22 million to U-M for research focused on artificial intelligence, robotics and autonomous driving in 2016. And Toyota, General Motors, Fiat Chrysler, and Waymo (formerly the Google self-driving car project) are all pursuing their own projects and investments.

In addition, the area is home to a growing startup culture, including May Mobility, co-founded in Ann Arbor by faculty member Edwin Ochoa. And students now team up with startups through Techlab at Mcity, a U-M Center for Entrepreneurship that is one of a growing number of educational offerings designed in response to the increase in autonomous vehicle activity.

Meanwhile, the state continues to show signs of support for research, including enacting new laws in December 2016 allowing autonomous vehicle testing on public roads. This makes Michigan an excellent place to conduct research.

VALUES IN ACTION
With faculty members leading Mcity and Michigan Robotics, and having major involvement in the American Center for Mobility, Michigan Engineering plays a major role in Ann Arbor’s development as a national hub of autonomous and connected vehicle research. These programs are all examples of Michigan Engineering collaborating in new ways with industry and the state on research that will improve the way people around the world get from A to B.

It is a part of the Michigan Engineering DNA to aspire to bring revolutionary, life-saving, and connected transportation technologies like driverless vehicles into existence. At essence, the College is engineers who serve the common good.

“Takes creativity and daring. It requires leadership. And it requires finding new ways to solve big problems together.”

“From the streets of Ann Arbor to the roads and computers of the Mcity Test Facility,” Peng said, “U-M is leading a transition to connected and automated vehicles that will transform how people and goods move around the world.”

—Brad Whitehouse
The 1960s was a time of major upheaval and innovation in healthcare. Engineers and scientists had regular access to computers for the first time, and they were looking for ways to apply their new power to improve the healthcare system. At the same time, the advent of Medicaid and Medicare meant that new innovations would be accessible to larger numbers of patients.

At U-M, researchers had been working to integrate medicine and engineering for decades. In 1948, chemical engineering professor Codemir Sliepcevich and his graduate student, Phil Boag, initiated Michigan’s first biomedically-oriented chemical engineering research project. Several years after that, chemical engineering professor Lloyd Kempe would pioneer the nation’s first program in biochemical engineering and applied microbiology, as multidisciplinary collaborative research proliferated across the University.

Those efforts culminated in 1962, when Michigan Engineering dean Stephen Arwood established a multi-disciplinary degree-granting program in the new field of biomedical engineering. To lead the new program, he tapped Glenn Edmonson, then associate dean of the College. Though he couldn’t know it at the time, Edmonson was one of the first pioneers on a 50-year journey that would see biomedical engineering rise from a relatively unknown offshoot to an integral part of Michigan Engineering.

**Without faculty of his own, Edmonson drew on expertise throughout the University. Students were similarly diverse, including working engineers seeking specialty training, medical and would-be medical students and some who enrolled following military stints. All took a leap of faith, committing to an untested field that still puzzled industry.**

Medical School faculty soon began working with Michigan Engineering, collaborating on projects such as signal processing in neurons, nuclear imaging and prosthesis – with chemical engineering, industrial and operations engineering, nuclear engineering, nuclear medicine and other engineering and medical disciplines also providing support.

**LIFTOFF**

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**THE RISE OF BIOMEDICAL ENGINEERING**

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Fredrick Blackburn Pelham was the first African-American, in 1887, to receive an engineering degree from the University of Michigan. As a civil engineer, Pelham forged a reputation for designing bridges built to last — though he was less true of Pelham himself, who died an untimely death in 1895, reportedly of acute pneumonia, at the tender age of 30.

In his brief but prolific career, Pelham — whose position with the Michigan Central Railroad was secured by a recommendation from Michigan Professor Ezra Greene — was credited with designing and building approximately 20 bridges known for their form and strength. They’re held up for well over a century, spanning roads and rivers along the Michigan Central Line between Detroit and Chicago and providing safe passage for hundreds of thousands of trains — including the Amtrak passenger cars that continue to pass through Ann Arbor at least twice daily.

Perhaps the most famous and unusual of Pelham’s creations is the “skew arch” bridge — a design used when a span is not perpendicular to the crossing — that spans over Dexter-Pinckney Road at the northeast edge of the town of Dexter, Michigan (though there’s an even more impressive Pelham-designed bridge, also within the Dexter city limits, whose much higher arch spans Mill Creek).

In his December 8, 1953, Atoms for Peace speech at the United Nations, President Eisenhower — determined to solve “the fearful atomic dilemma” — sought to turn nuclear power “from a cause into a benefit for humankind,” and the prevailing “culture of secrecy” into “a culture of openness.”

Thought it took some effort to plan — mostly due to this shift from secrecy to openness — the University of Michigan participated in the first-ever international conference on nuclear energy. Hosted by Donald L. Katz, Chemical and Metallurgy Department chair and chemical engineering professor, and sponsored by the Atomic Energy Commission, the hope was that the conference would help to advance the cause of nuclear medicine and power — especially given that the Ford Nuclear Reactor was being built on North Campus at that time.

Scientists and engineers from Great Britain, Italy, France, Norway, India, Canada, Spain, Belgium and elsewhere responded with cautious optimism. More than 100 papers were delivered on topics as concrete as “Thorium Metallurgy” and as abstract as “The Impact of Nuclear Energy on Religious Thought.” But this was not just a technical conference. Journalists participated, as did lawyers and physicians, and sometimes sparks flew. One question underpinning the rest: how to balance secrecy and openness about atomic energy when it came to matters of national security.

This conference, ahead of its time, was both provocative and useful. And perhaps no more so than for its role in exposing the possibility that the products of atomic energy might well be less destructive than the fears, harmful and lacking of understanding swirling around them.

The first real-time internet weather service was built in Ann Arbor in 1991—and it all started with an adventurous graduate student and his more than willing faculty advisor.

After earning a BS (1982) and MS (1983) in meteorology at Michigan Engineering, Jeff Masters embarked on an occasionally terrifying stint with the Hurricane Hunters at the National Oceanic and Atmospheric Administration. By 1991, Masters returned to the safety of academia and the University of Michigan to study air pollution meteorology — and to pursue his curiosity about this new thing called “the internet.”

Masters was in the right place at the right time. Michigan’s North Campus was at that time the backbone hub of the nascent internet, and home to many brilliant network engineers. And Michigan boasted a uniquely deep and rich history in the study of weather, climate, atmosphere and space. The Space Research Building even had a satellite dish that received data directly from the National Weather Service. None of this escaped Masters’ attention.

“I have all of the world’s weather data here, and a way to get it to everybody,” Masters remembers thinking at the time. “We’ve got to connect these up. Nobody has done this yet.”

Perry Samson — now an Arthur Thurnau Professor of Climate and Space Sciences and Engineering at Michigan, and at that time Masters’ faculty advisor — gave Masters that opportunity. Armed with a National Science Foundation grant — “one of the few times the NSF called and asked me to write a proposal,” Samson says — Samson was able to hire computer science students Alan Sternberg (BSE ’94) and Chris Schwerzler (BSE ’96), as well as staff member Jeff Ferguson, and the project took flight.

No wonder the first real-time internet weather service was built in Ann Arbor in 1991—and progressed from UM-WEATHER to Weather Underground to its multi-million dollar sale to The Weather Channel in 2012. Go to bicentennial.engin.umich.edu to learn more about what’s likely to come next.
**NAME ALUM GETS PULITZER NOD**

As a Long Island sixth grader in 1968, Larrie Ferreiro (BSE NAME ’80) thrilled to the Jacques Cousteau television specials. It wasn’t the marine life that fascinated him; young Larrie fell in love with the ships. And just like that, he knew he wanted to design them.

Ferreiro always thought he’d attend nearby Webb Institute, which specializes in naval architecture and marine engineering, but later he yearned for a more well-rounded education. Grants and scholarships enabled him to come to Ann Arbor, where he also studied poetry and history — and where he learned to write, under the “gentle lash” of legendary NAME professor Harry Benford.

That experience paid enormous dividends in 2017, when Ferreiro’s book, Brothers at Arms: American Independence and the Men of France and Spain Who Saved It, was designated a Pulitzer Prize finalist in History.

A U.S. Navy ship designer, Ferreiro also has a keen interest in history, having earned a PhD in History of Engineering, Science and Technology Studies from Imperial College London. During his research, he made the surprising discovery that France and Spain had formed a joint navy in the 1770s to ward off mutual enemy Britain.

“It’s the opposite story from what almost all of us learned,” Ferreiro says. “It’s a key part of what we do at the FDA. I can put a huge technical understanding of scientific approaches to issues that can affect people everywhere. ‘These issues that are happening in the United States are not just happening here. They also have global impact,’ she points out.

“Between the two of them, they’ve had a major influence on the FDA’s research itself and the way the organization handles its projects and communications. After graduating from U-M in 2012, Aftin performed research at The Karlsruhe Institute of Technology in Germany as a Whitaker Research Fellow to her post-doctorate, developing hydrogels for cell cultures and learning how to leverage those techniques for healthcare purposes.

She joined the FDA in 2013 as a Commissioner’s Fellow in emergency operations involving medical device availability and delivery. Now as a Staff Fellow, she continues to provide engineering expertise for a preparedness program that makes sure patients have access to medical devices during emergencies like disease outbreaks or radiological events. She is also working to establish a policy for making sure patients have access to medical devices during emergencies like disease outbreaks or radiological events.

What’s better than one Michigan Engineer making critical innovations at the Food and Drug Administration? How about two?

In the fall of 2007, after earning their bachelor’s degrees in mechanical engineering at the University of Maryland, identical twins Aftin and Astrin Ross joined U-M’s biomedical engineering master’s program. They were eager to apply their longstanding interests in science to improve the quality of people’s lives.

“Flash forward 10 years later: They are both using their PhDs to advance public health in the FDA’s Center for Devices and Radiological Health. And although Aftin and Astrin didn’t initially plan to come to the same center, their divergent paths following their Michigan doctorates in the past few years have brought them back together once again. Between the two of them, they’ve had a major influence on the FDA’s research itself and the way the organization handles its projects and communications.”

Their graduate studies, coupled with their activities outside of class, have given them a boost in collaborating, organizing, leading and networking in their current roles. “Having worked with people with different personalities, and various nationalities and cultural perspectives as Michigan has been extremely valuable,” Astrin says. “It doesn’t hurt that Aftin and Astrin have been surrounded by Michigan alums at their organizations post-graduation — the shared experience has been a jumping off point for countless new conversations and collaborations.”

For more information about Scott Haber, contact Laura Rudich at lrudich@umich.edu. To learn more about Alumni Notes, visit AlumniNotes@umich.edu.
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CASSIE BLUE
Meet Cassie, the latest two-legged robot to arrive at Michigan. Built to handle falls, and with two extra motors in each leg, the new robot will help U-M roboticists take independent robotic walking to a whole new level. It’s in the News Center right now.

BRAIN HACKS

WORLDWIDE GEEKOUT: The Rubik’s Cube takes the 1980s by storm

“The [Rubik’s] Cube is much more than just a puzzle. It is an ingenious mechanical invention, a pastime, a learning tool, a source of metaphors, an inspiration,” gushed physicist and former U-M professor Douglas R. Hofstadter in the March, 1981 issue of Scientific American.

Engineers and math lovers around the world were transfixed by the new puzzle. How did Hungarian inventor Erno Rubik get the individual cubes (called “cubies”) to hold together, yet rotate in so many different ways?

The cube is held together a simple yet ingenious mechanism of axles and interlocking feet that enable the individual cubies to be arranged in an incredible number of combinations. The original ads for the cube billed it as having “over three billion combinations.” In fact, that’s not even close.

Can you calculate the actual number of solvable combinations using the information below?

The Rubik’s cube is made up of 26 individual cubies, including 8 corner cubies, 12 edge cubies and 6 center cubies.

Hint: Solvable combinations are those that can be achieved by rotating the cube’s movable parts as intended. Other combinations are possible, but can only be achieved by taking the cubies apart and reassembling them.

Answer: 43,252,003,274,489,856,000

REINVENTING THE CUBE

A team of U-M mechanical engineering students recently built the world’s largest solvable, freestanding Rubik’s cube. Measuring over six feet tall, it’s too large to use the same system as the original cube. Instead, the team designed a system of rollers and transfer bearings that enables it to move smoothly. It’s currently on display in the lobby of the G.G. Brown building.
IN MEMORIAM

1940s

1950s

1960s

1970s

1980s

1990s

2010s

Faculty

Stanley J. Jacobs 1/26/17

Robert L. Hess 5/19/17

IN MEMORIAM 63
Makin’ Robots
Cass Technical High School students Yousef Obeid (right) and Nyja Johnson assemble the frame of a robot for the Cass tech team to use in the FIRST Robotics Competition at the Michigan Engineering Zone (MEZ) facility in Detroit. Made possible by Michigan Engineering, the MEZ helps Detroit high school students gain access to the knowledge and tools they need to prepare for careers in the STEM fields.

PHOTO: Joseph Xu
DIVING INTO FLINT AND OTHER COMMUNITIES TO SOLVE THE PROBLEMS OTHERS AREN’T.

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