THE MICHIGAN

ENGINEER

UNIVERSITY OF MICHIGAN | COLLEGE OF ENGINEERING | FALL 2017

KEEPING THE PEACE

Making sure the nuclear option means energy

UNIVERSITY OF MICHIGAN

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

FALL 2017 **VOLUME XXXIV, NUMBER 2**

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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.

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MICHIGAN ENGINEERING
UNIVERSITY OF MICHIGAN

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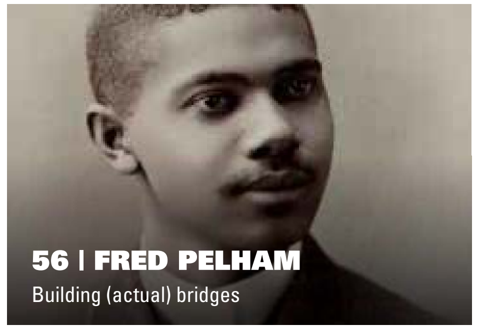

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Cover illustration: Stephen Alvey

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WE MUST DO MORE

Are research universities having a positive impact on society? How can they be more effective engines of social mobility?

This was a question posed at a recent Bicentennial Presidential Colloquium in June, where the presidents of some of the world's leading universities gathered to explore the public perception of the value of higher education, and how we can better communicate our contributions to society. The discussion covered concerns about media portrayals emphasizing the rising costs of higher education, and the need to communicate how the research enterprise produces knowledge that eventually leads to discoveries, cures and jobs.

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 to hold ourselves more accountable for actually effecting 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.

Q: Thanks for chatting with us. To start, let's talk about the current landscape. What do you think are the challenges with public perception of higher education?

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 are beginning to take a hard look at our institutions and question, "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.

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

That's a great question, and one with a multifaceted answer. The role that is most obvious and that we've had the longest is education – 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 always will continue to be, a very important role that we play.

Universities are also a place for artistic expression and creativity, and I view research as a technical form of that. At the College, research is at the core of what we do, and although the public certainly knows we do research, I don't think they fully understand the extent to which it has an impact on them. There has been a shift in our economy, where more and more often research is no longer happening in industry. Companies are being more judicious in their efforts to focus on core competencies, and are using universities and startup companies to augment their internal capabilities. We've seen this play out heavily in the area of autonomous and connected vehicle research, with major companies like Ford and Toyota partnering with our researchers and with startups. And the majority of startups are also being generated out of universities with graduate students and faculty members turning the fruits of their work into products. Intellectual property generated in universities is also being purchased by startup companies.

In fact, I recently had a company reach out about one of my patents for an application I never would have dreamed of.

But there's also 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.

Q: Tell us a little more about that. What does that entail?

The notion of citizen 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 more 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 expose 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. I think we should look in the mirror and try to decide whether or not we want to do something about that.

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

Absolutely! Alex Halderman 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 Sienko, is a great example of what we're talking about. They're trying to develop a rigorous methodology of how to prepare 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 engineering 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 them. We need to have more and more of our students and faculty members involved in that kind of education and community service.

Q: 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 missional directives as an institution that we should be doing that?

Q: Good question. Do you have an answer?

(Laughs.) Well, honestly, 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 to really 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 Thinkabit Lab, 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 is to provide scientific and technological leadership, improve the quality of life and serve the common good. So I think we have taken the first step to owning it, and now it's our charge 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 year.

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

Top to bottom: J. Alex Halderman, Jerome P. Lynch, John E. Foster, Kathleen H. Sienko

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 Harley Ellis Deveraux. The firm describes the building's style as "Machine in the Garden." –Editor

Brain Hacks

Responses to our trivia question about Michigan Engineers using this equipment in the 1980s to build an instrument for studying subatomic particles.

I remember building an underground neutrino(?) 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 & detecting photon tracks from impacts.
@Frederic Barthelemy

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

Racing for Control

On our coverage of Michigan Engineering alumni's role on the ORACLE TEAM USA sailing team.

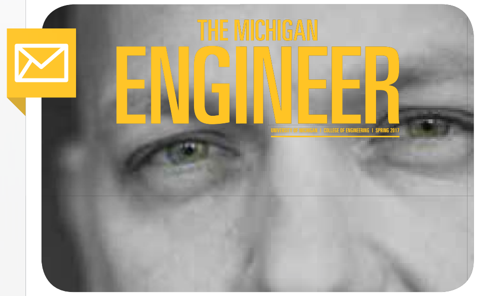
They obviously have several identical boats. They must have really good configuration control. My company touched on America's Cup sails for the outer covering of airships. The sails are exquisitely engineered composite material structures. They are precisely permanently shaped, not flat when flaccid.
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.

Where are the women? Compare photos of women to photos of men in the magazine.



Thumbs Up

My compliments on the Spring issue. It was informative, very interesting, and easy reading. I look forward to the next issue.
Jeff Skorupski (BSAE '69)

Diversity

As we end the first academic year where U-M launched their effort to improve Diversity, Equity, and Inclusion (DEI), the spring issue of the Michigan Engineer was disappointing. I have had the pleasure of hearing Dean Gallimore speak on the college's efforts to improve DEI and Michigan Engineering is ahead of peer institutions in many respects. Not that you would be able to tell from the spring issue of the magazine. I see pictures of about 15 women and over 100 men in this issue. The college's numbers are better than that – surely you can do a better job of sharing stories in a more representative manner.
Kathleen D. Klinich (PhD ME '06)

COMMENTS, TWEETS & LETTERS

Camp Davis

On our Bicentennial story about the U-M field station in Wyoming.

OMG; no GPS, laser, or cell phones!
Michael Sapienz

Visit **bicentennial.engin.umich.edu** for more Michigan Engineering history stories.

Revved up

On our Bicentennial story about the Automotive Research Laboratory that once stood on the Diag.

Hate to say it, but I might be on the law students' side on this one
Jeffrey Arthur Marsh

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 alleging that Target unfairly discriminates 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 – though it may take longer to get there." Anyone is welcome to shop at Target wherever a store is located. Again, no real discrimination!

I believe this author is looking to find prejudice where none exists, and should apologize to Engineer readers!
Charles F. Morton (BSE IE '57, MBA '58, DDS '69)

In response to Charles F. Morton

Discrimination and unfairness come in many forms, and each of us draws a line separating fair from unfair based on our own value system. If a business were to put up a "Whites only" sign, most of us would find that wrong. But reasonable people can disagree about more subtle forms of (potential) discrimination.

My point is not to argue about where we should draw a line as a society, or even to say that Amazon's decision was unfair and discriminatory. Rather, my point is to say that it is appropriate to hold electronic businesses to a higher standard than traditional brick and mortar businesses because of dominance and rigidity, and it is also possible for these businesses to meet the higher standard because data analysis is easier.

I take no position on what this standard should be. The specific example of Amazon Prime same-day service was in the news because many politicians and many journalists thought it was an issue. Amazon itself took immediate steps to remedy what could have become a public relations disaster for them. I just ran with this example in the news, since many in society would find Amazon's actions troubling, but not Target's. A different example may better illustrate my point to a reader who is not troubled by Amazon's original choice.
H V Jagadish
Bernard A. Galler Collegiate Professor of Electrical Engineering and Computer Science

PHOTO: Kevin Golovin

RANDOM ACCESS

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 elastomer 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.

ILLUSTRATION: courtesy of Airbus

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.

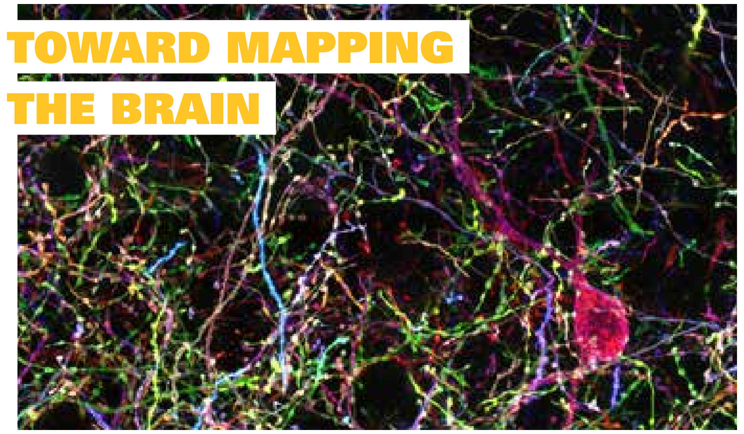
"We will be addressing very fundamental research questions while exploring this new uncharted territory in commercial transport aircraft configurations," said Carlos Cesnik, a professor of aerospace engineering at U-M and the director of the new center.

PHOTO: Joseph Xu

MICHIGAN AT THE NSF

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.

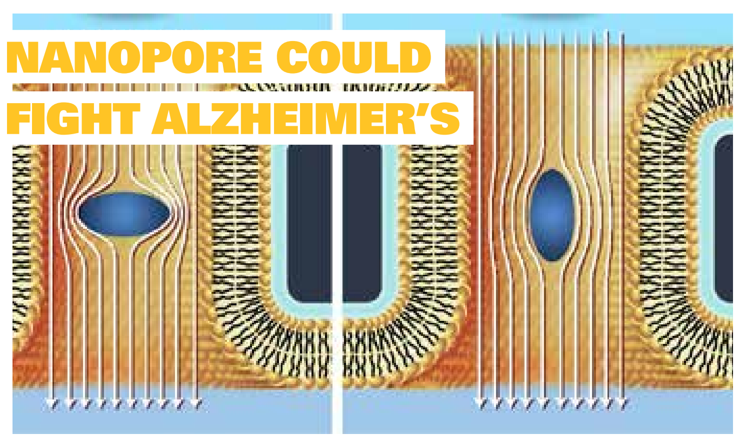
TOWARD MAPPING THE BRAIN



Each of the 21 billion neurons in the human cerebral cortex is believed to be connected to roughly 1000 other neurons, through tentacles 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 Euisik Yoon, 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.

NANOPORE COULD FIGHT ALZHEIMER'S



A tiny synthetic pore may help researchers study misshapen proteins believed to play a role in Alzheimer's and Parkinson's. Called "5D 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.

"IT'S LIKE THE OPERA SINGER WHO HITS THE NOTE TO BREAK A WINE GLASS, ONLY IN OUR CASE, WE CAN SPELL OUT WORDS AND ENTER COMMANDS. YOU CAN THINK OF IT AS A MUSICAL VIRUS."

Kevin Fu, associate professor of computer science and engineering, in the New York Times. Fu and his colleagues showed that sound waves could be used to hack into critical sensors in a broad array of technologies including smartphones. Read the full article by going to http://umicheng.in/kevinfu.

PROBING THE SUN

Justin Kasper, 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. Kasper's Solar Wind Electrons Alphas and Protons (SWEAP) 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 3.9 million miles to the sun – more than seven times closer than any spacecraft before
- Plunge through the sun's atmosphere, called the corona
- Do 7 flybys in the 7-year mission, ending in 2025
- Have a 4.5-inch-thick carbon composite shield to protect it from the sun's heat

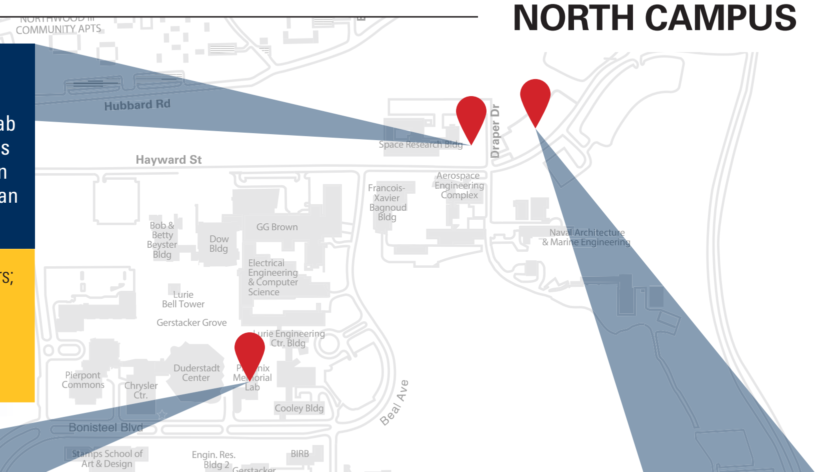
$65,000

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.

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.

NORTH CAMPUS

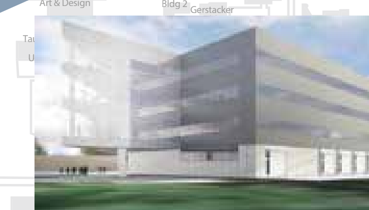


M-AIR
Situated right next to the new robotics building, this outdoor fly lab will allow for testing of autonomous aerial vehicles, pushing the edge in a safe way where the worst that can happen is they fall from the sky.

TIMELINE: Winter 2017
COST: $800,000
SIZE: 50' high, 80'-by-120' footprint
COOL FEATURES: Pavilion for up to 25 users; four-story-high netted fly area; adjustable lighting for evening use.

NUCLEAR ENGINEERING LABS
Housed in the old Ford Nuclear Reactor Building, researchers in the nation's top-ranked nuclear engineering program will advance nuclear security, nonproliferation, safety and energy.

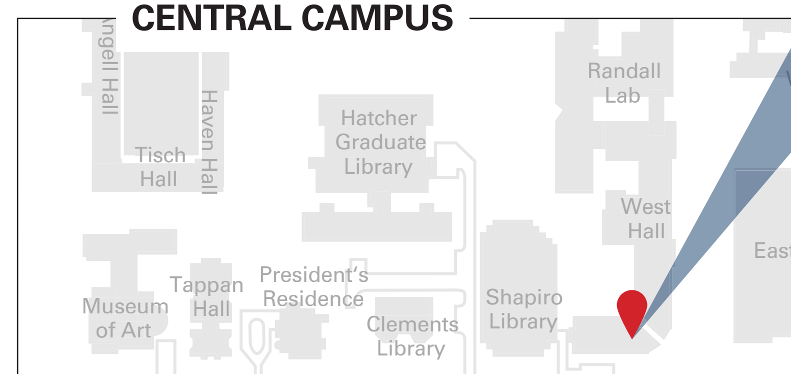
TIMELINE: Spring 2017
COST: $12.4 million
SIZE: 4 stories, 13,200 sq. feet
COOL FEATURES: High-resolution system for imaging coolant flow in reactors; accelerator to develop faster, more accurate ways to identify nuclear materials.



FORD MOTOR COMPANY ROBOTICS BUILDING
Robotic technologies for air, sea and roads, for factories, hospitals and homes will have tailored lab space in the new facility, and a unique collaboration will lease dedicated space to Ford researchers.

TIMELINE: Winter 2019
COST: $75 million
SIZE: 4 stories, 140,000 sq. feet
COOL FEATURES: Three-story-fly zone for autonomous aerial vehicles; outdoor obstacle course for walking robots; high-bay garage space for self-driving cars.

CENTRAL CAMPUS



AARON FRIEDMAN MARINE HYDRODYNAMICS LAB
Built in 1904, the "tow tank" was the first university-affiliated facility of its kind in the U.S. It will get a new name and a fresh face, with renovations focused on making workspaces more open, flexible and collaborative, and the building more engaging for the campus around it.

TIMELINE: Early 2018
COST: $2.2 million
SIZE: 5,077 sq. feet being renovated
COOL FEATURES: Existing 360-foot-long indoor body of water viewable by windows that preserve the integrity of the 1900s architecture; upgraded and relocated computer lab; displays that tell the story of U-M's unique naval architecture heritage.

NEW CHAIRS AT THE HELM

They are leaders in their fields. Now they lead their departments. We asked the four new department chairs what the future holds.

Q. ***Where is your field headed in the next five to 10 years, and how is your department at the forefront?***

Sharon C. Glotzer
CHEMICAL ENGINEERING

"Most science and engineering disciplines haven't yet incorporated data science into their curriculum, and this is true for chemical engineering. But companies I speak to are desperate to hire chemical engineers who know data science. This is a natural opportunity for us because Michigan is a leader in this space, with a campus-wide institute for data sciences that partners with our faculty and students on research ranging from food, water and energy solutions for the developing world to bio-nanotechnology for health. We will develop what our students and their employers are asking for – a curriculum in data science for chemical engineers that will propel our students to the forefront of solving important engineering problems with modern tools."

Anthony C. Lembke Department Chair of Chemical Engineering,
Stuart W. Churchill Collegiate Professor of Chemical Engineering,
John W. Cahn Distinguished University Professor of Engineering

Brian Noble
COMPUTER 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 analytics and deep learning, and the need to build systems that are trustworthy and provably correct. These trends ensure that our field will face interesting challenges, and our faculty, staff and students are ready to meet them."

Chair, Computer Science and Engineering

Jerome P. Lynch
CIVIL & ENVIRONMENTAL 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 leaders in autonomous and intelligent systems – smart mobility, smart watersheds, smart construction, and smart structures – that are key to delivering community resiliency."

Donald Malloure Department Chair of Civil and Environmental Engineering

Jing Sun
NAVAL ARCHITECTURE & MARINE ENGINEERING

"The marine engineering fields are broadening and diversifying, at a dazzling 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 and technological innovations, as we continue to strengthen in traditional hydrodynamics and structure areas while expanding to new domains in the ocean space, such as autonomous systems, electrification, and digitization of marine platforms. The combination of the depth and breadth of our faculty research expertise, together with our unique infrastructure and collaboration opportunities within the college and university, will continue to be our advantages moving forward."

Department Chair of Naval Architecture and Marine Engineering,
Michael G. Parsons Collegiate Professor

REDEFINING "MICHIGAN ENGINEER"

Laura Murphy graduated in the spring with a bachelor's degree in mechanical engineering, and is co-founder of Adapt Design. In her last semester as a student, she wrote this opinion piece, published in the Michigan Daily. It has been edited for print publication.

For the past three and a half years, I've fought fiercely against being titled a "Michigan Engineer." I rejected this title because it seemed like it represented so many of my negative experiences: having to prove to my male teammates that I'm just as capable as them, students and faculty not understanding how our decisions as engineers affect real people, and fighting against the administration to accept my work in disability design and design research.

I remember so vividly the day sophomore year that I walked into the machine shop for the first time. I was sweating and my hands were shaky. I tracked down one of the guys in flannel shirts who looked like he might be in charge and told him why I was there. He walked me over to a big scary lathe and told me the project was easy – don't worry. I asked him how I should start. He shot his wide eyes at me and said: "Didn't you watch the instructional videos? You really should come here prepared." Then he walked away.

What that man didn't know was I had actually watched every single video about three times. I memorized everything, but it's different 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 stand there, look at all the knobs and levers, 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 got into recounting my story.

This memory and the way I felt that day will forever be burned into my mind. Unfortunately, it's not the only negative experience I had in engineering. To me at that time, identifying as a Michigan Engineer meant being close-minded, condescending, exclusionary of women and minorities, unwilling to ask for or give help, and too proud to admit mistakes.

So why did I stay in this program? It's a question almost everyone asks me and one that I've asked myself every day for the past three years. I realized recently that it's because of those whose energy and action contradict the negative stereotype of a Michigan Engineer. Despite my experience in the machine shop, my design team that semester was incredibly supportive, and we were able to bring out one another's strengths in ways I never imagined.

That same year, I began a disability design company with Sidney Krandall (BFE' 16, art and design), and individual faculty sat down with

PHOTO: Laura Murphy

Laura Murphy (left) works with Adapt Design co-founder Sidney Krandall.

us and gave feedback on cardboard-and-duct-tape prototypes. I discovered people whose offices I could stop by and pose big questions to about carving my own path. Shanna Daly, an assistant professor of mechanical engineering, became one of my closest mentors in this way. Amy Hortop, a coordinator of mechanical engineering capstone projects, became my partner in creating an Interdisciplinary Design Conference, which introduced me to an entire group of engineers, architects and designers who care just as much as I do about doing impactful work. And finally, my capstone design project team has been a source of unending creative energy as we navigate an intense case study in disability design.

A couple of months ago, I realized I'm graduating this spring with a degree from the University of Michigan College of Engineering. So by definition, I am a Michigan Engineer. What does that mean?

I am a designer. I'm passionate about designing with and learning from people who have disabilities. I'm insistent that every single person has the opportunity to create a positive impact in the world. I care about being reflective and constantly question whether or not I'm a good person.

Some days, when the answer is no, it's up to me to figure out why and put the right work in.

I think now is our opportunity to define that the Michigan Engineer doesn't just take one form. Each one of us has carved our own paths and every day my fellow students define what it means to be a Michigan Engineer. The weight is on our shoulders to create our own definition and to ensure that our legacy is one we can be proud of. Our shared background as Michigan Engineers is the platform from which we take our big jump with eyes wide open into creating the world in which we want to live.

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.

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

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

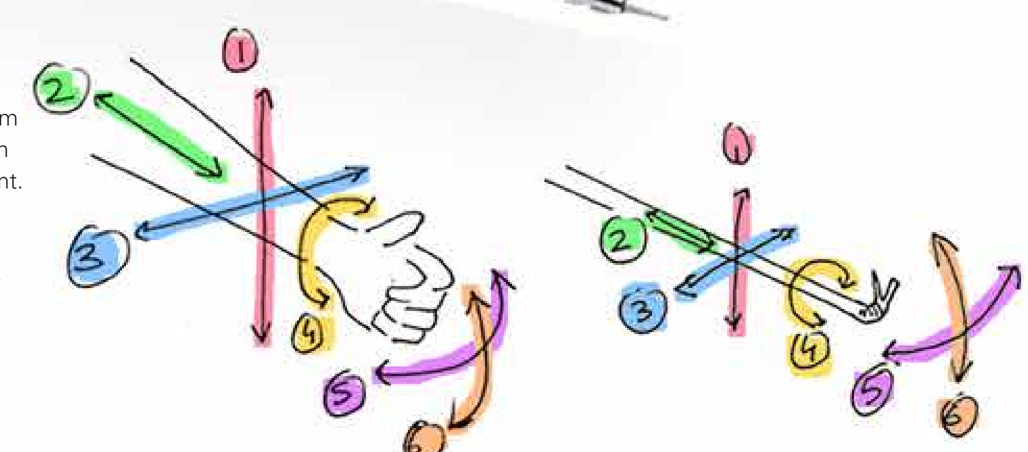
INFOGRAPHIC: Stephen Alvey

"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.

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 counter-intuitive 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 twirling action of the surgeon's fingers and thumb.



SKETCH: Shorya Awtar

MISSING U
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 swallow 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 around 200,000. 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 in Hiroshima and Nagasaki," said Paul Richards, a special research scientist at Columbia University. "And pointing at us from the Russian Federation, there are about 1,800 large nuclear weapons deployed now, ready to be delivered, and also nearly 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 fuels.

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 at U-M.

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 nearly 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 around 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 the material they claim to have – it hasn't passed to nuclear weapon 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 facilities misused (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,

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

they are slow to register neutrons, which muddies 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-reaction fission events 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 nuclear test among thousands of earthquakes.

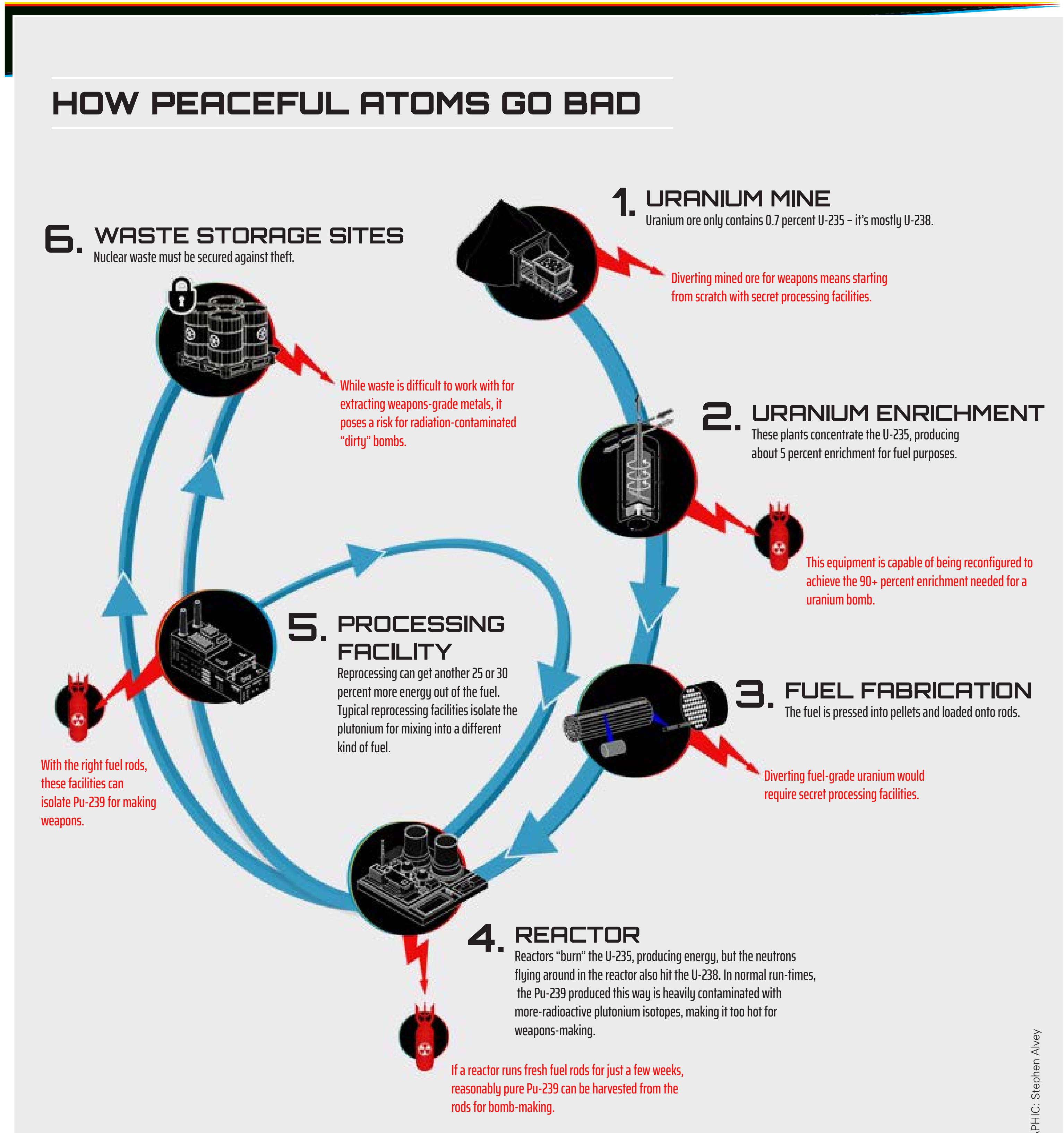
While the neutron data is prized, Pozzi's group goes beyond merely filtering out the gamma radiation – they're trying to make it useful. By looking at neutrons and gamma rays together, they can tell the difference between forms of plutonium, whether it's a compound destined for fuel rods or a metal that 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, H3D, makes are prized 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 imager prototype: an array of centimeter-scale scintillating crystal pillars inside a handheld box. While He's cameras superimpose the radiation image over the image of the room on

HOW PEACEFUL ATOMS GO BAD



INFOGRAPHIC: Stephen Alvey

ISOTOPE BASICS

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

Pu-239: Plutonium 239 is an isotope of plutonium that can be used for making nuclear weapons.

U-238: Uranium 238 is the most common isotope of natural uranium. It is not fissile.

U-235: With three fewer neutrons than U-238, this isotope of uranium is fissile. It can be used as reactor fuel or in nuclear weapons.

PARTICIPATING IN THE CVT

Universities

University of Michigan
Massachusetts Institute of Technology
Princeton University
Columbia University
North Carolina State University
University of Hawaii
Duke University
University of Wisconsin
University of Florida
Oregon State University
Yale University
University of Illinois at Urbana-Champaign

National Labs

Brookhaven National Laboratory
Los Alamos National Laboratory
Lawrence Livermore National Laboratory
Sandia National Laboratory
Idaho National Laboratory
Oak Ridge National Laboratory
Pacific Northwest National Laboratory
Lawrence Berkeley National Laboratory
Princeton Plasma Physics Laboratory

PhD candidate Michael Hamel tests a Microsoft Hololens headset, using augmented reality to detect radiation sources in the Nuclear Radiation Laboratory. To see a video of hololens technology in action, visit umicheng.in/CVT_Headset

a tablet computer screen, Pozzi's group is experimenting with a Microsoft Hololens virtual reality headset.

"We envision a world in which a nuclear inspector wearing a Hololens could walk inside a room with a detector in his or her hand and be able to see the radiation source," said Pozzi.

THE POWER OF DATA

While inspections are indispensible, they aren't a complete monitoring solution. 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.

"There is this notion of design data and non-design data," said Hero. "Design data are, for example, specifically targeted campaigns to measure radiation 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.

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 those anomalies 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. – signed but didn't ratify.

Still, the 183 signatories (of the 193 states in the UN) have honored 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

Sara Pozzi adjusts a scintillator-based detector, which detects the neutrons and gamma rays given off by radioactive uranium and plutonium.

> "WE ENVISION A WORLD IN WHICH A NUCLEAR INSPECTOR WEARING A HOLOLENS 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 ready.

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 inaudibly low sound waves in the atmosphere; and radionuclide, 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 Columbia University, an expert in seismology, studies the blasts from nuclear tests and earthquakes, developing techniques to tell them apart even for relatively small nuclear explosions.

"There are several different types of seismic wave, and whether you have an earthquake source or an explosion 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 Tomahawk missiles launched at Syria in April of 2017 bore 500-ton chemical warheads. Once a nuclear weapon is no more powerful than a conventional bomb or warhead, it's no longer considered a special threat from a military perspective.

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 Garcés, director of the Infrasound Laboratory at the University of Hawaii, is exploring how armies of iPhones can augment the existing arrays of infrasound sensors.

His group developed an app called RedVox that harvests 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 gasses 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 these 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 investigators can identify the type and location of a suspected nuclear test.

While the IMS was designed to detect nuclear tests, Garcés 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, meteors 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 tense," 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 public and international affairs, and mechanical and aerospace engineering, at Princeton University. Delivery vehicles, such as intercontinental ballistic missiles, are held in rather obvious silos, but warheads can be stored in innocuous-looking warehouses and move around during maintenance activities.

The U.S. and U.S.S.R. worked around this problem with their early arms reduction efforts; in 1972, they began limiting not the warheads themselves but the delivery vehicles. But the U.S. -Russia Strategic Arms Reduction Treaty (START) of 1994 and its successor New START limited actual warheads for the first time, putting a cap on how many warheads could be mounted on those missiles or loaded into bombers. The deployed warhead limit to be met by February 2018 is 1,550.

To make real progress with disarmament, the treaty verification community will need new techniques for monitoring the number of warheads each country has and verifying that warheads earmarked for dismantlement are rendered unusable. The CVT is looking for these new methods.

Nuclear warheads are especially difficult to count because countries want to protect classified information. "If this were simply a measurement problem, it would already be solved," said Clarke.

He added that knowledge of the quantity of nuclear material plus its shape is enough to give away the explosive power of the nuclear weapon. Even the mass of the nuclear material alone is more than nations want to reveal.

Yet all an inspector really wants is a yes or no: this device contains a plausible amount of weapons-grade nuclear material, or it does not. So, many researchers are working to produce detectors that can give that simple answer without recording any classified information in a form that might be stored or intercepted. If these techniques existed, they could make a new kind of disarmament treaty feasible.

Some researchers, including David Wehe, a professor of nuclear engineering at U-M and science advisor to the CVT, are developing technologies that blur the detailed signals from the detectors very early on, before they can be diverted and recorded.

Glaser leads one of the projects that have taken this a step further, trying to stop classified information from even making it into the detectors. He calls it "zero knowledge" verification, inspired by cryptography. Through the CVT, his group worked with a team at Yale University to demonstrate that it was possible to confirm that two warheads are identical without ever recording design details.

Using non-electronic detectors that respond to neutrons by forming bubbles in a gel, Glaser's team showed that they could confirm that two sets of metal blocks, which represented warheads, were identical in chemical composition, size and arrangement. They did this by preloading the detectors with the complement of the signature expected by measuring the blocks, like a photo negative. Then, when two identical sets of blocks were scanned with the neutron beam, two detector sets showed the same number of bubbles.

In an inspection, Glaser explained that a warhead could be removed directly from a missile and taken to a set of warheads with the same design that had been earmarked for dismantlement.

The preloading would be done by the country under investigation, and that complement would be wiped out during the scan. The inspectors would never see it, and it would never be recorded electronically. The investigator would choose which set of detectors would be used with which warhead.

If the country was trying to fake out its inspectors, it might try to sneak in some warheads without uranium or plutonium, making it look 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 investigators believe is real. Still, Glaser points out that it would be risky and elaborate to present inspectors with an entire arsenal of missiles fitted 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 fanciful from where we are now.

"We're still left with about 15,000 nuclear weapons today," said Glaser. "It doesn't make sense by any meaningful standard."

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 weapon numbers 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.

Pozzi is more cautious about the security of an arms-free utopia. "How can we verify zero weapons, especially in large states such as U.S. or Russia?" she asked. "Many would argue that keeping nuclear weapons to numbers in the hundreds for the U.S. and Russia provides a more stable solution."

In the meantime, nuclear-weapon-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.

LOVE IN ACTION

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.

STORY BY: Nicole Casal Moore
PHOTOS BY: Marcin Szczepanski

Construction crews replace lead service lines that connect Flint, Michigan homes to the water main on a street not far from the Broome Center, where Nancy Love and her colleagues work in Flint.

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-ivory-tower"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 McElmurry. 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 McElmurry 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, I don't see any other way."

That's not a common perspective.

Love is the Borchardt and Glysson Collegiate Professor in the University of Michigan Department of Civil and Environmental Engineering. She's a former department chair, a licensed professional engineer and a well-known water system scholar whose work on detecting and remediating biological and chemical pollutants has improved water treatment processes in the U.S. and abroad.

While she navigates U.S. 23, she talks about how she got to this pivotal place, and the communities along the way that have opened doors, guided her through them and continue to work side-by-side with her. Her journey passed through a neurosurgery ward, international orphanages and a campus shooting – all of which inform the difficult and crucial work she and her colleagues are doing today on two continents.

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 U-M arguably owe to society.

Across academia, distinguished researchers – from up-and-coming junior faculty members to big-shot tenured professors – focus their careers on solving the grand challenges of our time. They identify key research questions. They find eye-opening answers. They publish them in peer-reviewed journals with high-impact factors and present them at conferences. They teach students how to do the same. And that's where they see their role ending. It makes sense. It's the cycle of academia.

And then there are faculty members like Love. She takes the engineering profession's creed to heart, acting as a link between science and society. Love is by no means the only professor at Michigan Engineering who operates like this. And it's true that not all fields or problems are suited to this approach. But many consider her a leader.

"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.

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

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

for solutions. Poor water quality is causing health problems, especially for children who are particularly vunerable to dying from preventable waterborne diseases. Love has seen some of the repercussions first-hand. In 2011, she and her husband, Brian Love, who is a professor of materials science 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

(From left to right) Georges Manard, a Flint resident working with Love and colleagues to sample water, calibrates a testing instrument. Love and Shawn McElmurry, associate professor at Wayne State University and Flint Area Community Health and Environment Partnership project (FACHEP) leader, go over plans. FACHEP staff member Kwesi Reynolds drafts a work plan (foreground) while Nasienka Francis discusses the day's plans with Love and McElmurry.

ages of 6 and 24 months. They'll take fecal samples from a subset of the children, interview family members and observe how they handle water in their households. They will test their samples for waterborne pathogens, as well as three inflammation markers that the literature suggests are present in stunted children.

Once they have a handle on what pathogens may be infecting the children, they can move to figuring out how to slow their spread or eradicate them in communities. The plan will take shape based on what they find.

"Chlorine treatment won't kill cryptosporidium, for example," Love said. "You'd have to boil the water to get rid of it. And we see certain protozoa come through water filters, so water filters wouldn't offer complete protection as a single form of treatment. Different waterborne agents will call for different strategies."

Broader scale solutions will need to come from Ethiopians themselves, and Love is working with others to lay the groundwork there as well.

What's missing from textbooks

"When it comes to water treatment, more than half the world relies on technologies that we do not teach in our classes, and that we do not research in our labs," Love said.

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

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." She and Love have been collaborating for several years.

"What is in the textbooks is very beautiful, but we cannot achieve that," Desta said. "Centralized systems require a lot of electricity. You have to supply oxygen for the waste to be clarified and supplying oxygen requires electricity. We don't get enough electricity at the household level, let alone for the wastewater."

The city of Addis Ababa has two centralized plants that supply drinking water to some parts of the city. But the taps are sometimes turned off for system maintenance and it is not uncommon for water flow to stop due to power outages. And as the city grows – which it's doing fast – it will need to rely more on decentralized approaches. Those include treatment systems at the community level. An apartment complex, for example, could have its own on-site setup.

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 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 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 can get 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'll go through hundreds of options sometimes.

"I've 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 behaviors 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 their solutions."

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."


"It's one thing to have a solution. It's quite another thing to get people to implement it."

(Left to right) The growing skyline of Addis Ababa, Ethiopia behind an urban slum. Cities in the developing world need different drinking water and sanitation solutions than their Western counterparts. Love talks with colleagues at the Ethiopia-Michigan Platform for Advancing Collaborative Engagement meeting in Addis Ababa in 2015.

When she received her named professorship in 2016, the Borchardt 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 from breathing in aerosolized bacteria in the shower. Healthy people aren't all that susceptible, but the elderly and those with compromised immune systems are vulnerable.

The study is a complicated task, involving not only researchers from different disciplines at multiple institutions, but also a list of city, county, state and federal agencies. And, of course, the Flint residents who take the water samples.

"This type of broad collaboration was intentional," said McElmurry, who is also a licensed professional engineer. "We wanted to engage with residents 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 Broome 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' weren't tested for this strain. Many questions remain and the team is further assessing the situation. While Love was involved in this work, it was led by Michele Swanson, a professor of microbiology and immunology at the U-M Medical School. Love leads another track that's looking into whether water filters that were distributed to help alleviate the crisis actually compounded it.

Understanding Flint's faucet-mounted water filters

Since October 2015, more than 100,000 faucet-mounted, point-of-use water filters have been distributed to Flint residents. These activated carbon block filters, which are available at hardware stores, do an excellent job eliminating heavy metals like lead. But from the start, Love and her colleagues worried that they could encourage the growth of potentially harmful bacteria. (They're not necessarily concerned about Legionella 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 are 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: 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 travel 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 rely upon what are called "indicator bacteria" that don't tell the complete story about microbial risk to public health.

An ongoing effort

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 to the professor for personal reasons.

"It's what I'm supposed to be doing," Love said. "I'm working with collaborators 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 those difficulties when working with committed colleagues, and when I know the work outcomes are centered on the greater good."

She is trusting her intuition.

"I try to 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 GPS interrupted: "Arriving at your destination." 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 en route.

BUILDING A STRONGER HAITI WITH CHOCOLATE

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.

Story by: Gabe Cherry
Photos by: Marcin Szczepanski

"I didn't want to wake up at 60 having never tried to do anything for Haiti."

"OK, adventure!"

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 32-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 ticking 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

Opposing page: A view of the flooding out the back of Askanya's truck. **Top:** Cacao farmer Deceus Jean Gilles climbs a tree to harvest cacao pods for sale to Askanya. The vast majority of the world's cacao is grown by small farmers. **Bottom:** Corinne Joachim Sanon questions the quality of the pods she is buying from a farmer who is holding the machete he uses to open them.

Left: Corinne Joachim Sanon displays a freshly-opened cacao pod. **Center:** Askanya production head James Dobson Bélizaire stirs cacao on a drying table to help it dry more evenly. **Right:** Corinne Joachim Sanon naps after the harvested cacao is brought safely to Askanya's fermenting and drying facility.

> "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, a few miles away. They'll need a safe place to stay. And they'll need to get their cacao to the fermentation facility near Ouanaminthe by 8:00 a.m., a few hours from now. She pulls out her cell phone and starts making calls.

THE HARVEST

The start of the day couldn't have been more different. Sun streamed through the leaves of banana trees overhead as the pickup crawled into the jungle on a cratered 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 the farmers nearest to Askanya and travel further out as the season progresses, journeying to the isolated villages where small farmers grow cacao. Usually, they work with about 50 farmers, turning 5,000 cacao pods into 1,600 pounds of raw beans.

Small farmers have been walking these dirt roads for centuries. They make up 60 percent of Haiti's population and an even larger part of its identity. After independence, they were allowed access only to the sloping land near the base of Haiti's foothills – above its flat plains, but below the lucrative coffee-growing zones in the mountains. They've been growing crops like plantain, breadfruit, cacao and mango ever since, enough to eat and a little to sell.

University of Guelph PhD candidate Jenn Vansteenkiste has been working with Haitian farmers for years. She says Haiti's government has long ignored small rural villages, leaving a deteriorating infrastructure that makes it difficult for farmers to earn a living.

"The state has always been very extractive of the peasantry," she said. "There are few schools, few health services, roads are poor. There needs to be investment, and that hasn't happened."

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 revenue to farmers. 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 fist-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 800 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 twists 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 glistening 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, she plans 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 to 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 that Sanon credits with helping her start Askanya. Cohn says this combination of engineering theory and on-the-ground know-how is what sets industrial and operations engineers apart.

"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. Thurnau 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 has decided 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.

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 chocolate bars. That's important because Sanon needs to squeeze maximum value from every bean to fund the labor-intensive harvesting and transportation process and pay the farmers a good price. So, working with a chocolate consultant from Seattle, she designed a system of self-contained fermenting and drying modules.

First the cacao ferments, sandwiched between layers of burlap and banana leaves, for a week. The beans are then transferred to wooden 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

Left: Jocelyne Diometre uses a laye to separate cacao shells from the nib inside.
Right: Workers wrap finished bars at the Askanya factory in Ouanaminthe.

process that varies with the weather, so Sanon has incorporated six drying tables for each of the 10 fermentation boxes. 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, the center 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 children attend school. Bélizaire's parents saw that he was bright and made sure he was one of them.

In the 1990s, things got more difficult: president Jean-Bertrand Aristide began giving guns to Cité Soleil's street children in an attempt to tighten his grip on power. The family had to flee to northern Haiti to escape the violence.

"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 4,900 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 people – inside Haiti and elsewhere – what Haitians are capable of.

"Before Askanya, all our chocolate came from the USA. Now that has changed. I'm helping the people who plant cacao get more money, I'm helping the other workers get money and I'm promoting Haiti. We can transform Haiti by growing and processing more food here, and I plan to be a part of it."

THE FACTORY

Askanya's factory is easy to spot, a bright pop of yellow and turquoise that stands out among the battered buildings on Ouanaminthe's noisy main street. This is the final destination for the cacao beans, where they're roasted, ground and turned into one of three different flavors of high-end chocolate bars.

What stands out most about the factory is its small size. It occupies the first floor of a modest two-story house with bright yellow concrete walls and well-worn tile floors. There are no assembly lines, no conveyors, no gleaming stainless steel tanks.

Instead, 32 year-old Jocelyne Diometre sits in the front room surrounded by 80-pound sacks of cacao beans. She's sorting them by size, an essential step because small beans roast faster than large ones. One bean at a time plinks into the steel bowls in front of her. Once a bowl is full, she pours it onto a metal baking sheet and slides it into an electric oven about the size of a countertop microwave. 30 minutes later, she takes it out and dumps the beans on a metal screen to cool.

Diometre has worked in Askanya's factory for about a year – some days she sorts beans, other days she handles the pouring or the wrapping of the bars. She makes about $100 per month, enough to send her three children to a Catholic school, one of the best in Ouanaminthe. Like Askanya's other employees, the company pays the taxes on her earnings and also provides meals, English lessons, disability insurance, paid holidays and a year-end bonus.

Before starting on at Askanya, Diometre was a live-in housekeeper in the Dominican Republic. She was away from home six days a week, with risky trips back and forth across the border to work. Once, she was accused of stealing and had to stay in jail until it was discovered that her employer's relative was the real culprit. Here, she's learning about the chocolate business, and she has begun thinking about what her children, ages 10, 9 and 5, might do with the education they're getting.

"I'd like my two boys to be agronomists," she says, "And my daughter? A doctor."

Askanya employs five other factory operators, all women. Sanon works to create a culture at Askanya that's much different than most Haitian employers.

"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 laye.

Sitting in front of a fan, a worker scoops beans out of the laye and holds the scoop high, slowly shaking the beans out. The fan blows the lighter shells away while the heavier nibs fall into the laye.

The nibs are then pulverized in a process called conching. This requires the factory's most specialized equipment – three squat, knee-high machines. Their steel urns turn slowly as heavy granite wheels inside crush the nibs into silky 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 restarted 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 drones 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 a small tabletop machine for tempering, a series of precise heating and cooling cycles that nudge the cacao molecules toward a particular crystal structure. This produces the glossy sheen that chocolate buyers expect. It's then ladled by hand into molds and cooled for about 30 minutes in a refrigerator. Finally, the cooled bars are trimmed by hand and wrapped by two workers, who carefully crease two layers of wrapping over each and every finished bar.

Askanya's labor-intensive operation is a matter of necessity in Haiti. Economies 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 IOE 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 its added value funds the entire Askanya supply chain. Vansteenkiste, who has started several Haitian 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 design 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."

To Sanon, Askanya 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." ■

"I try to make sure that everyone is treated equally, whether you're a girl or a boy, Catholic or Protestant or Vodouisant."

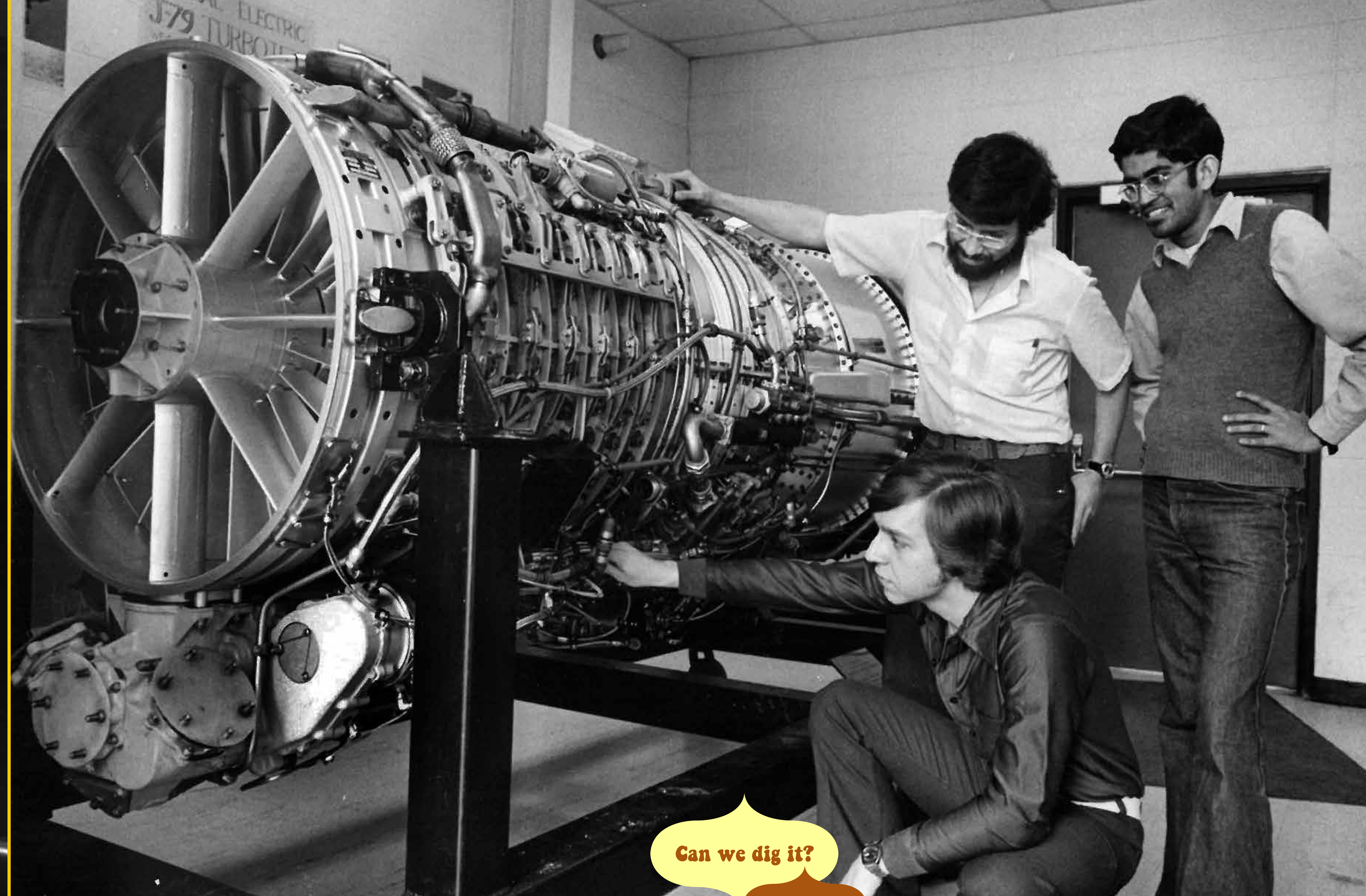

Corinne Joachim Sanon at the entrance of the Askanya factory.

SOMETHING GROOVY THIS WAY GOES

BEFORE "GEEK" WAS "COOL," MICHIGAN ENGINEERS STILL FOUND TIME FOR FACT-FINDING, FASHION – AND FUN.

BY: RANDY MILGROM

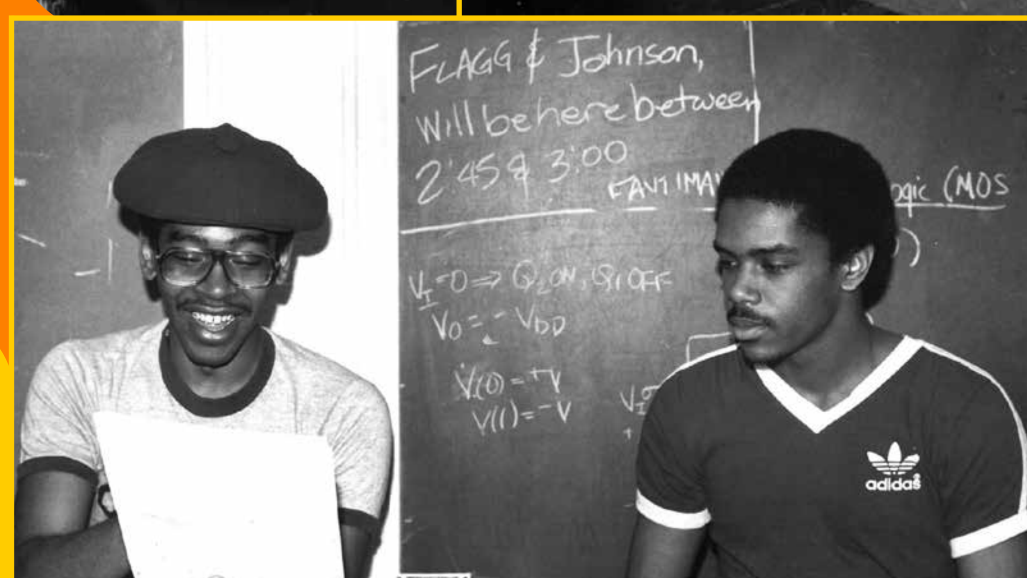
All photos courtesy Bentley Historical Library



Can we dig it?

Bummer

Keep on Truckin'



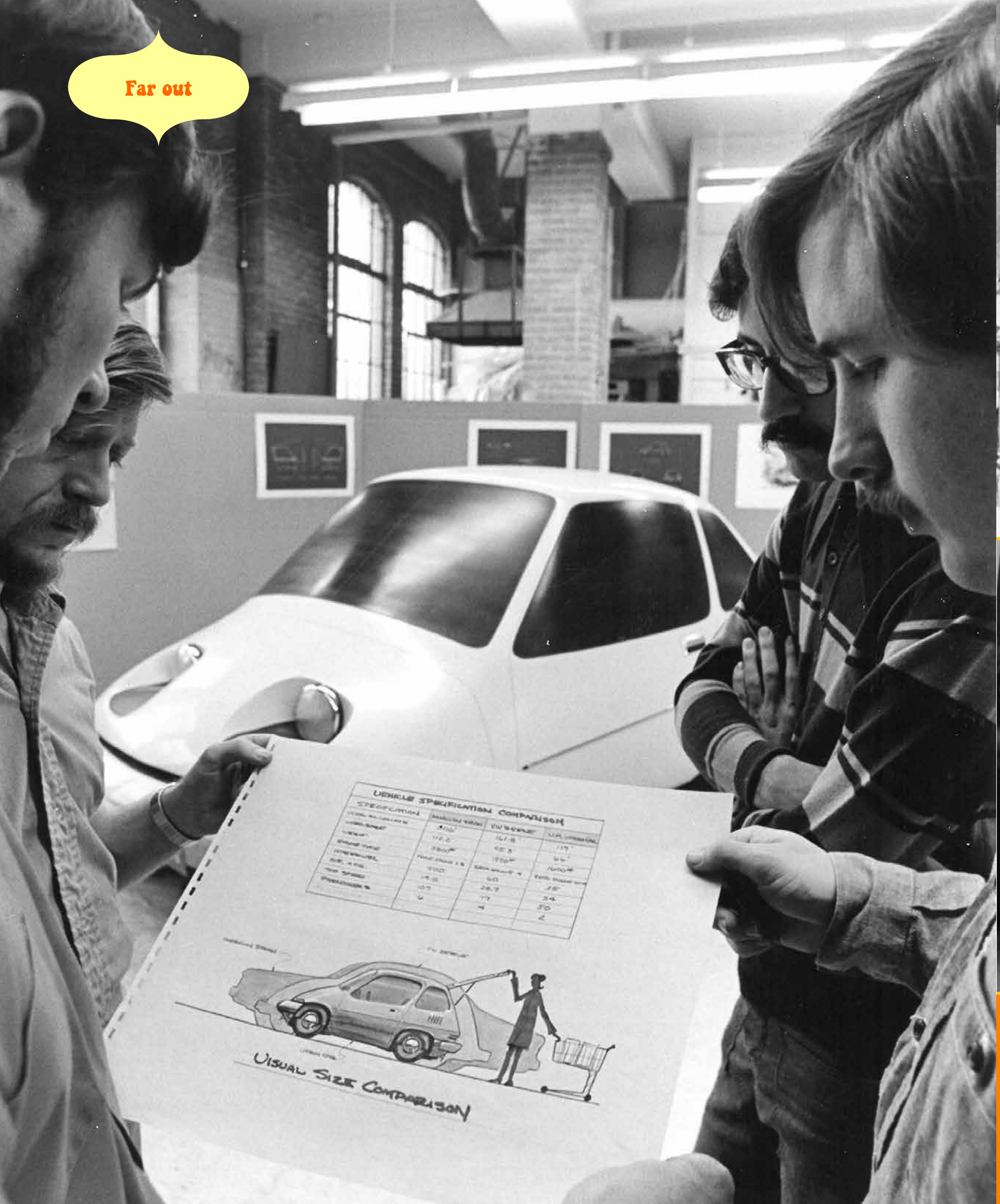
PRIOR PAGES:
They're not just proud of their checked pants and striped shirts. That Wankel (or rotary combustion) engine on the right was developed as the powerplant for Michigan's entry in the 1972 Urban Vehicle Design Competition.

LEFT:
Not yet a paperless world, and well before pocket computers, students had to check social media – painstakingly slowly – at the Computing Center.

ABOVE:
Making adjustments before a wind-tunnel experiment.

ABOVE LEFT:
An intent lab student labors alone.

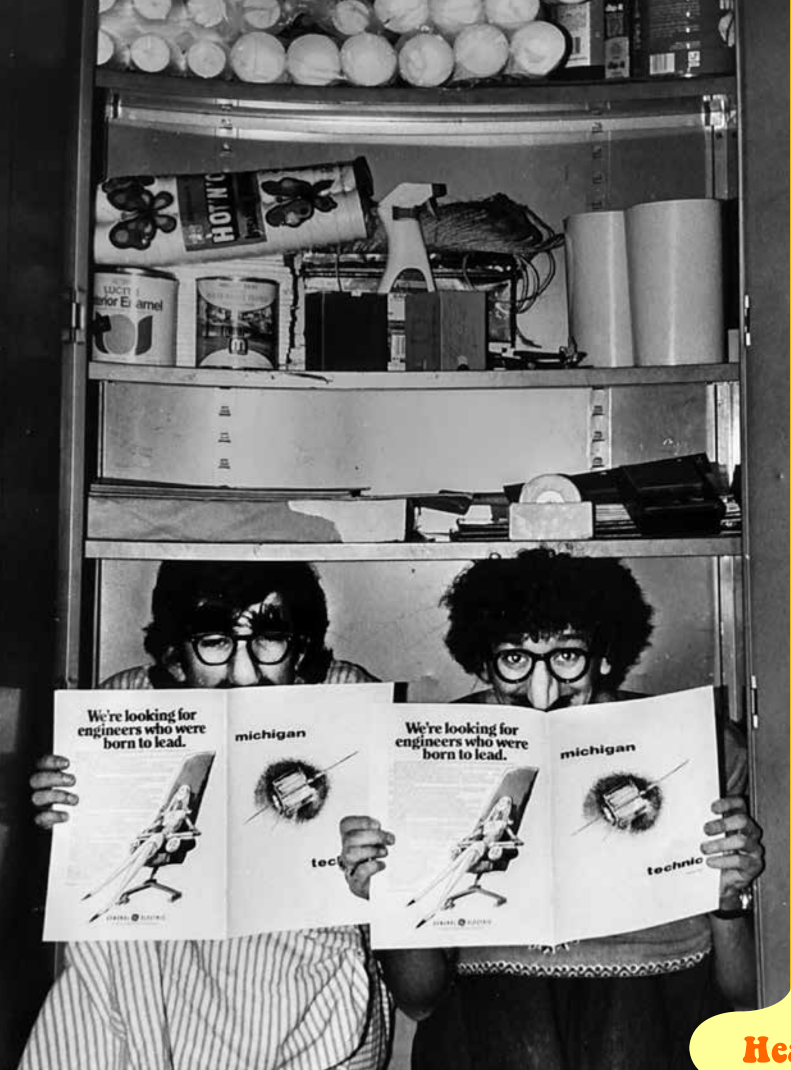
FAR LEFT:
Students reviewing their notes.

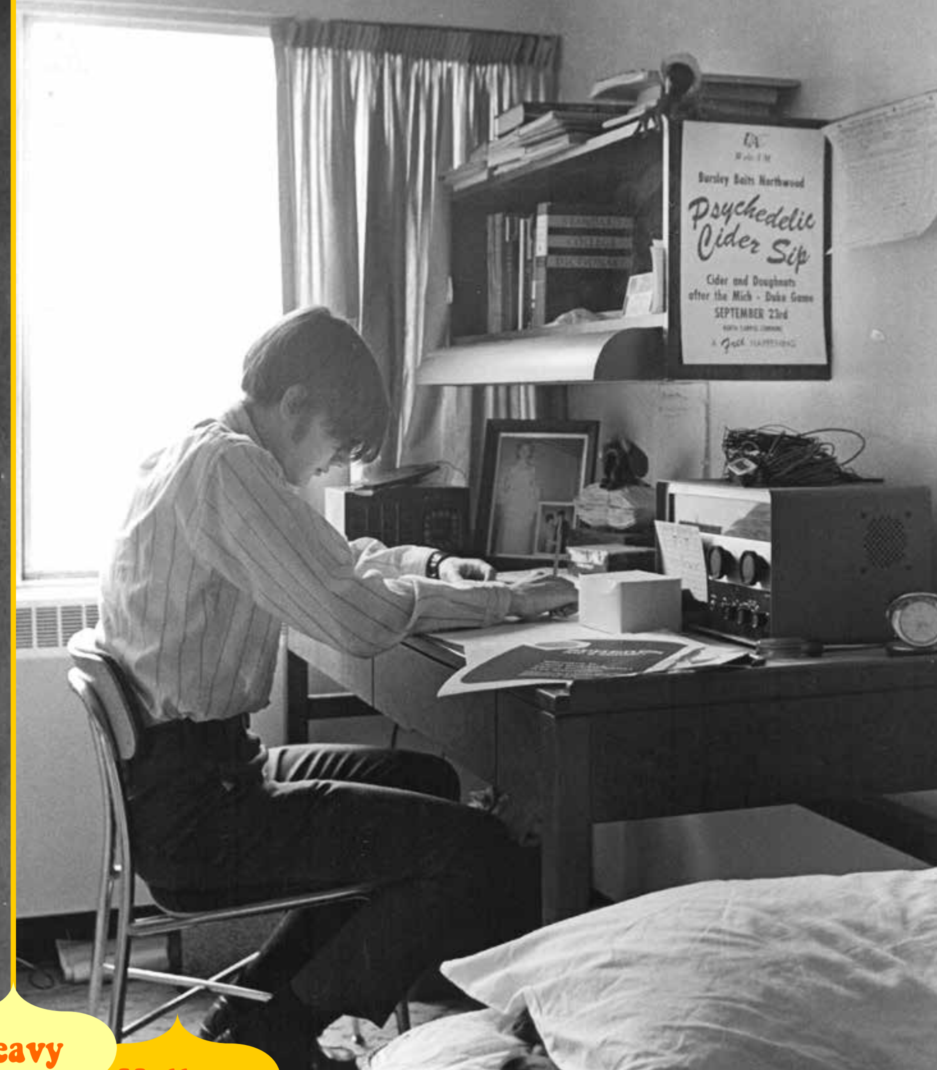


TOP:
Loads of bushy mustaches, hair and sideburns in the chemical engineering lab – but no goggles? Maybe those broad-rimmed specs did the job.

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.

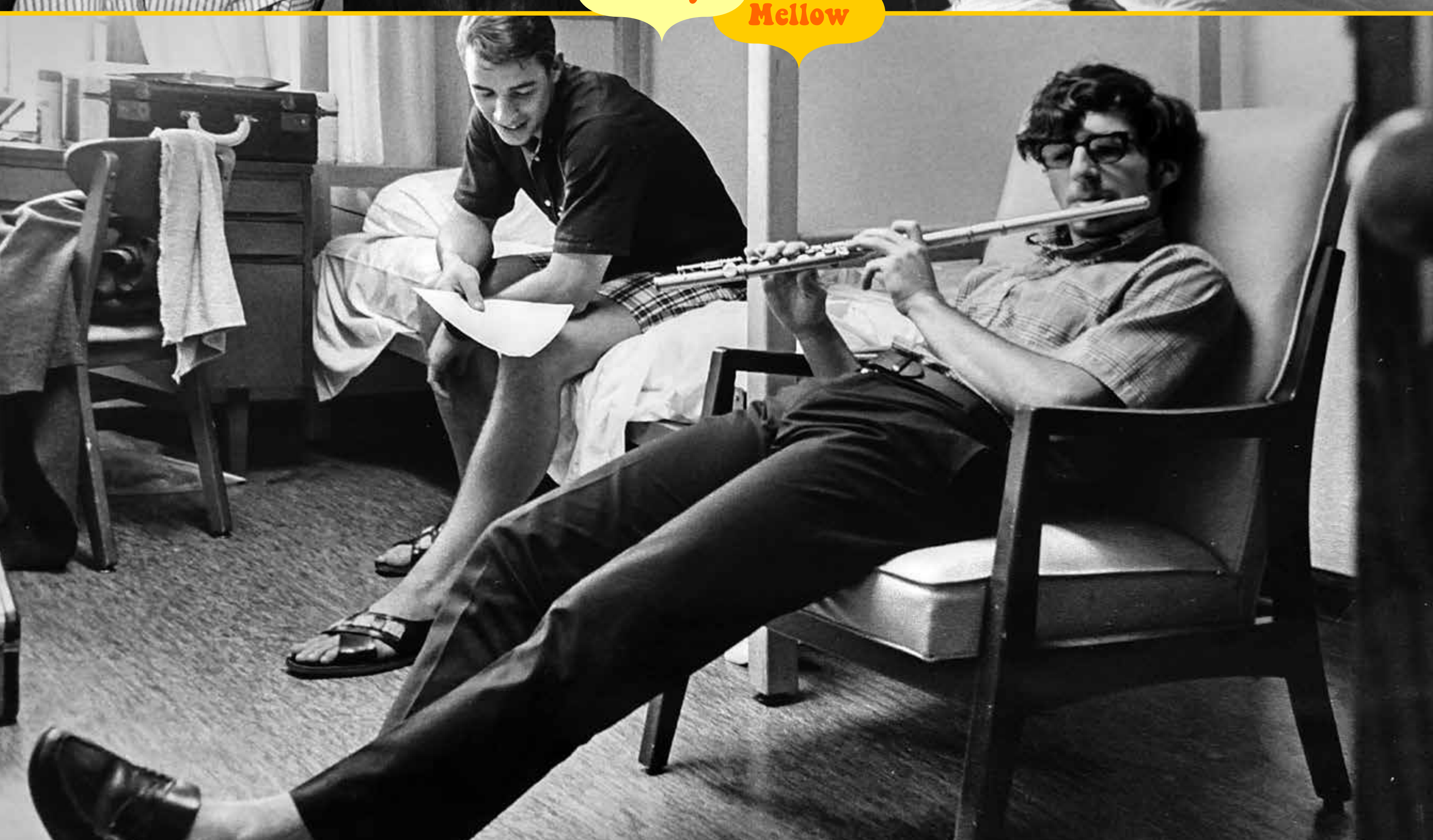
LEFT:
In 1972, mechanical and electrical engineering students built an automobile "particularly suited to an urban environment." Though its report conceded that it had not forged any "earth-shaking technological breakthroughs," the team did focus on curbing emissions, enhancing safety, decreasing size and cost, and improving drivability, handling, and styling.





Heavy

Mellow



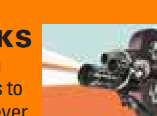
Out of sight

UPPER LEFT:
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.

UPPER MID AND LEFT:
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.

ABOVE:
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. Unexpectedly large crowds gathered to witness the splatter.

FAR-OUT FLICKS



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 a ride on the Diag, get a glimpse of an Ann Arbor that's gone forever.
umicheng.in/NAME_reels

VICTORS STEP UP

MICHIGAN ENGINEERS ARE STEPPING FORWARD TO TRANSFORM THE COLLEGE – AND THE WORLD – IN OUR $1 BILLION RESOURCE-GENERATION EFFORT

SHIP SHAPE

An artist's rendering of the new exhibit space in the Aaron Friedman Marine Hydrodynamics Lab.

The outside of 112-year-old West Hall, which houses the Marine Hydrodynamics Laboratory, looks much the same as it did when Michigan Engineer **Aaron Friedman** studied there in the 1940s. But inside, the lab is getting a 21st century makeover, thanks in part to a gift from Friedman's family.

The changes will include a new interior vestibule that showcases the testing basin, renovations to offices and research spaces and an upgraded and relocated computer lab with a retractable glass wall that will enable students to observe the testing being conducted in the basin.

Overall, the renovation will focus on creating a space that's worthy of the tow tank's heritage – it was the first university-affiliated facility of its kind in the United States when it was built, and is still the largest. Renovations are now in progress and re-opening is scheduled for January 2018.

The facility will also get a new name: The Aaron Friedman Marine Hydrodynamics Lab. Friedman was a 1943 naval architecture and marine engineering alumnus who earned an undergraduate degree in naval architecture and marine engineering and a master's degree in mechanical engineering from U-M. He served in the U.S. Naval Reserve during World War II and had a lifelong love of boats and the water.

"The knowledge that my father gained at U-M is something that stayed with him every day of his life," said **Barbara Friedman-Kohler**, Aaron Friedman's daughter and a 1973 alumna of what was then the U-M College of Architecture and Design. "I hope this gift will help make the lab a place that draws in and inspires today's students, that helps them see that with a great education, the sky is the limit."

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 at U-M.

Their experiences motivated Kania (BSE NE '77, MSE '79, PhD '81; BS '77, MS '80 (LSA)) and DuBois (AB '78 (LSA), MSW '80) to help students who don't otherwise have the resources or family support to pursue advanced degrees. For that reason, they have created the Don R. Kania and Renee L. DuBois Fellowship Fund to help graduate students stay the course despite the challenges.

The new fellowship fund, which is matched by the University's Diversity, Equity & Inclusion Initiative, will help the Department of Nuclear Engineering and Radiological Sciences support students who are the first generation in their families to attend college or graduate school, who have overcome substantial educational or economic obstacles, or who come from an educational, cultural or geographic background that is underrepresented in engineering graduate study. If NERS has no such candidate, the fellowship can instead help a student in a different engineering discipline at U-M.

"Our Michigan experience set the stage for us to be successful, and we'd just like to help others have the same opportunity," said DuBois.

FACULTY GIFTS

Faculty invest a lot in Michigan Engineering through a career of research and teaching and public service. As these funds illustrate, they sometimes choose to invest in other ways as well.

FOR DOCTORAL STUDENTS

PhD students in Materials Science and Engineering have gained a valuable resource. **Robert D.** (BSE MetE '55) and **Julie A. Pehlke** have provided a gift to endow a fund to provide them with fellowship support. Pehlke, a professor emeritus who joined the faculty in 1960, has also endowed a lectureship in materials processing to bring speakers to campus.

FOR THE MOST CITED

Publishing papers that are cited could earn an award, thanks to the gift of another professor emeritus. The Mechanical Engineering faculty member who has the year's largest number of citations in Scopus, the database of academic journal articles, will receive the E. & M. Ulsoy Citation Leader Award. The fund for the award was created by **A. Galip Ulsoy**, C.D. Mote Jr. Distinguished University Professor Emeritus and William Clay Ford Professor of Manufacturing Emeritus, and **Susan Glowski**. Ulsoy joined the faculty in 1980.

FOR UNDERGRADS IN NEED

Four professors emeriti – **George I. Haddad**, **Don B. Chaffin**, **David J. Anderson** and **Thomas B. A. Senior** – have joined to endow the Engineering Emeritus Faculty Scholarship Fund. It will provide need-based scholarship support to Michigan Engineering undergraduate students.

Haddad (BSE EE '56, MSE '58, PhD '63) joined the faculty in 1961, retiring in 2005 as the Robert J. Hiller Professor of Electrical Engineering and Computer Science. Chaffin (PhD '67), the Richard G. Snyder Distinguished University Professor Emeritus, joined the Industrial and Operations Engineering department in 1969, was named the G. Lawton and Louise G. Johnson Professor of Engineering in 1993, and retired in 2007.

David J. Anderson joined the department of Electrical Engineering and Computer Science in 1970, Otorhinolaryngology in 1971, and Biomedical Engineering in 1997. He retired in 2005. And Thomas B. A. Senior joined the department of Electrical Engineering's Radiation Laboratory in 1957. An Arthur F. Thurnau Professor, Senior retired in 1998 as associate chair for academic affairs.

FOR SPECIAL PROJECTS

Student projects for Computer Science and Engineering will get a boost from a CSE professor and his company. Lattice Data, Inc., which was co-founded by assistant professor **Michael Cafarella**, has made a donation to the Computer Science and Engineering Special Projects Fund, an endowment that supports student projects, special instructional needs, seminars and special visitors to the division and other activities related to the mission of the division.

Lattice Data is a data intelligence company that transforms "dark data," such as unstructured text and images, into high quality structured data for use by traditional data analysis tools.

EXPANDING ROBOTICS FOR DETROIT STUDENTS

Students work at the MEZ, which is outfitted with computer labs, a machine shop, a robot testing area, and collaborative workshops.

More Detroit-area high school students will have access to expanded hands-on science and engineering after-school programs, thanks to a $250,000 Google grant to a U-M makerspace in Midtown.

The Michigan Engineering Zone, or MEZ, provides space, mentorship and tools for hundreds of students from across the metro area who compete in the national FIRST Robotics program each year.

FIRST students design, build and test robots that perform different tasks every year. The MEZ is a collaboration among the University of Michigan College of Engineering, Detroit Public Schools and FIRST to encourage young people to pursue careers in science and technology fields.

This spring, the MEZ finished its eighth season with 18 teams and more than 275 students. Its leaders have recently added summer camps that reach 100 more students, and in-depth coding workshops for students who want to learn more. The grant from Google will allow the program to build the infrastructure to expand by 33 percent to reach a total of 500 students per year.

"Participating in robotics is what cultivated my passion for engineering," said Wayne Lester, a 2017 U-M aerospace engineering graduate who first came to the MEZ as a high school student. "I loved every moment I spent at the MEZ, whether build season, ACT practice, or other academic-focused workshops, it was all so helpful for me.

"Being around many of the U-M student mentors, I had the opportunity to ask all the questions I wanted about college."

During the 2016 MEZ season, 38 of the 40 high school seniors at the MEZ were accepted to two- or four-year colleges or universities. Of these, 80 percent planned to pursue an education and career in science or technology.

ANN ARBOR: A HUB FOR AUTONOMOUS VEHICLES

PHOTOS: Joseph Xu

Autonomous vehicle research is flourishing in southeast Michigan. This vehicle at the Mcity Test Facility at U-M is an open connected and automated vehicle research platform, or open CAV.

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 risk-taking – is the reason that it's happening here.

HOTBED OF 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. Its 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. McCarthy 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 research, testing and on-road deployments at one site – Mcity – and graduate to another – ACM – for later stage product development testing and standards validation," said Volker Sick. Sick, 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," Sick 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.

One of the world's largest deployments of connected vehicles and infrastructure has been underway for three years, with around 1,500 vehicles traveling the streets of Ann Arbor.

In addition, the area is home to a growing startup culture, including May Mobility, co-founded in Ann Arbor by faculty member Edwin Olson. And students now team up with startups through Techlab at Mcity, a U-M Center for Entrepreneurship course 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 part of the Michigan Engineering DNA to aspire to bring revolutionary, life-saving, environmentally-conscious technologies like driverless vehicles into existence. At essence, the College is engineers who serve the common good.

This requires 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

UNIVERSITY OF MICHIGAN BICENTENNIAL 1817 2017

ALWAYS INNOVATING. FOREVER VALIANT.

ALWAYS INNOVATING. FOREVER VALIANT.

The University of Michigan Bicentennial celebration continues throughout 2017 with four multi-day festivals, culminating on October 26-27 with a Campus of the Future Colloquium, faculty "Feast of Ideas" talks, a time capsule ceremony and the Third Century Expo – a participatory, future-oriented, fair-like exposition of Michigan's cutting-edge research and scholarship. Michigan Engineering will continue to add to its Bicentennial Project collection at **bicentennial.engin.edu**, featuring stories that both draw meaning from our illustrious past and prepare us for an even more productive future.

The titanium-beaded end of an Instacone implantable knee is shown here; the cone-shaped clusters stimulate the growth of natural bone, which bonds tightly to the implant. U-M biomedical engineer Steve Goldstein and orthopedic surgeon Larry Matthews devised the idea on the back of a napkin while flying to a conference in 1983.

PHOTO: Michigan Engineering

BIOMEDICAL ENGINEERING / 1960s

THE RISE OF BIOMEDICAL ENGINEERING

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 Cedomir Sliepcevich and his graduate student, Phil Bocquet, 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 coalesced in 1962, when Michigan Engineering dean Stephen Attwood 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.

LIFTOFF

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 prosthetics – with chemical engineering, industrial and operations engineering, nuclear engineering, nuclear medicine and other engineering and medical disciplines also providing support.

The National Institutes of Health was keen to support the use of engineering in biomedical research, and Edmonson was able to secure a National Institutes of Health training grant in 1969 that grew the program from 38 students (26 doctoral) in 1969 to 53 (31 doctoral) by the end of Edmonson's time as chairman in 1972.

BUILDING MOMENTUM

The program racked up numerous achievements in the two decades that followed, including the development of an artificial "spherocentric" knee, creation of a system for heart-lung bypass support, breakthroughs in ergonomics and occupational biomechanics, leading work in radiation measurement and detection for nuclear imaging and the "Michigan Probe" – a multi-channel neural probe that remains a foundational tool for brain research.

A FULL-FLEDGED DEPARTMENT

By 2005, Michigan was among nine universities chosen to receive the Wallace H. Coulter Foundation's $5 million Translational Research Partnership Award in Biomedical Engineering. In 2011, it received a Coulter Foundation $10 million award that was matched by both Michigan Engineering and the Medical School – a clear sign of growing cooperation.

Biomedical Engineering transitioned to a joint department between the College of Engineering and U-M Medical School in September 2012. When the formal announcement was made, no fewer than 35 Medical School faculty members held shared appointments in the department.

Today, William and Valerie Hall Department Chair of Biomedical Engineering Lonnie Shea shepherds that continuing work, with Biomedical Engineering playing an expanding role in areas such as immunomodulation, 3D culture, single-cell analysis and in internal medicine in general.

"Biomedical engineering has evolved so dramatically that many people don't realize the role we can play," Shea says. "As engineers, we need to understand the challenges faced by physicians in the clinic and researchers at the bench, and to apply our engineer's perspective and novel tools to both advance the research and clinical practice."

The department recently hosted a multi-day "50-20-5" bicentennial celebration – 50 years as a bioengineering program, 20 years as a department and five years as a joint department with the Medical School. It would have made Glenn Edmonson proud.

CIVIL & ENVIRONMENTAL ENGINEERING / 1880s

FRED PELHAM: BRIDGE BUILDER

Frederick B. Pelham's Michigan Engineering graduation photo.

PHOTO: Bentley Historical Library

Frederick 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 this 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've 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 passes over Dexter-Pinckney Road at the northwest 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).

With a mere 11 feet, 10 inch clearance, the Dexter-Pinckney bridge was originally designed to accommodate pedestrians and horse-drawn buggies passing under a one-lane opening. But with the advent of the automobile, and increased traffic, local officials were forced to post signage to warn motorists of its low and narrow dangers.

Before constructing the arch, laborers installed a temporary wooden frame under the rail bed and the soil they dug out was used to raise the banks along Mill Creek as protection for the bridge. Masons fit the stones by hand, and for many years Michigan Engineering students made field trips to study the bridge's elegant structure.

A Michigan Central plaque near the bridge contains several names, but not Pelham's – either because only higher officials were generally so honored, it has been speculated, or because of Pelham's race.

NUCLEAR ENERGY & RADIOLOGICAL SCIENCES / 1950s

1954: ATOMS FOR PEACE

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 curse into a benefit for humankind," and the prevailing "culture of secrecy" into "a culture of openness."

Though it took some effort to plan – mostly due to this shift from secrecy to openness – the University of Michigan responded in June 1954 by holding 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, hatred and lack of understanding swirling around them.

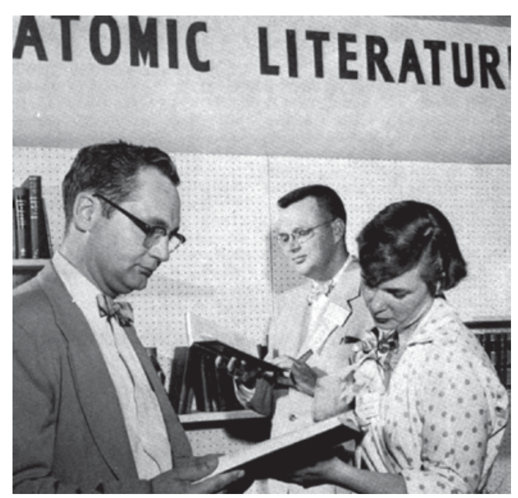


PHOTO: Bentley Historical Library

R.R. White and C.M Sliepovich of Chemical Engineering and Jane Boswell, East Engineering librarian, browsing a display of atomic literature at the Atoms for Peace conference.

CLIMATE & SPACE SCIENCES & ENGINEERING / 1990s

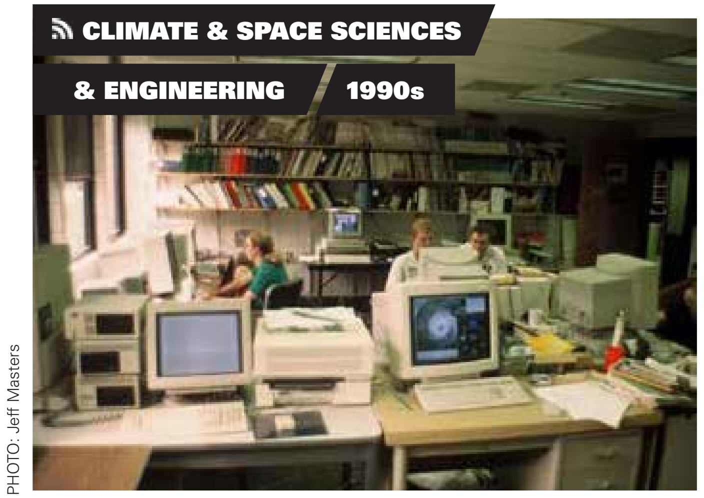


PHOTO: Jeff Masters

The Michigan Atmospheric Deposition Laboratory (MADLAB) in the Space Research Building hosted the original telnet service.

WUNDERGROUND: DEMOCRATIZING WEATHER

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 where the NSF called and asked me to write a proposal," Samson says – Samson was able to hire computer science students Alan Steremberg (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 – 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.

bicentennial.engin.umich.edu

An online multimedia story collection, the Michigan Engineering Bicentennial Website Project brings past achievements, incidents, and other noteworthy events back to vivid life for the examination, education and entertainment of the Michigna Engineering community.

Michigan Engineering has been adding at least one new piece of content to its Bicentennial Project Website every week throughout 2017, so please visit often – and sign up to receive the e-newsletter at **bicentennial.engin.umich.edu.**

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WANDERING WAYS

PHOTOS: Courtesy Scott Haber

After landing in Indonesia in August of 2016, **Scott Haber** (BS LSA, MSE BME '16) spent a year wandering the world. His aim, funded by a $20,000 Bonderman Fellowship, was to experience and observe life in non-Westernized countries.

Journeying through Indonesia, Malaysia, Singapore, Thailand, Cambodia, Nepal, India, Peru, Bolivia and Ecuador, Haber picked up new languages; connected with people of all walks of life; redefined his needs and expectations regarding sanitation, shelter, transportation and possessions; practiced yoga and meditation; spent time with nature and gained a new understanding of his privilege as a white American and his role in a global society.

In particular, Haber was struck by the poverty – the lack of adequate housing, sanitation and access to clean water and healthcare. Equally, he was impressed by the kindness and generosity of the people who gave him a ride or a place to wait out a rainstorm, shared a meal or taught him something.

"I feel very moved, very called and, in a sense, very obligated to work with the communities I've been a part of to help foster change," he said.

Each year, the Bonderman Fellowship offers four seniors in the College of Literature, Science and the Arts $20,000 to travel the world alone, exploring at least six countries in two regions over eight months.

NAME ALUM GETS PULITZER NOD

PHOTO: Aaron Spicer

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, he says, 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. "When we declared independence, we did so without an army, without a navy, without even gunpowder…. The only way we were going to win is if we enlisted the help of France and Spain."

The discovery would later form the basis of Brothers at Arms – which asserts that America gained its independence not by itself but at the center of an international coalition it coaxed into existence.

Ferreiro now teaches largely self-styled courses combining lessons in naval architecture and history at George Mason University, Georgetown University and Stevens Institute of Technology, where he asks his students to examine past problems to help shape current projects.

TWIN SISTER SCIENTISTS

PHOTO: Laura Rudich

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 **Astin Ross** joined U-M's biomedical engineering master's program. They were eager to apply their longstanding interest 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 Astin 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.

After graduating from U-M in 2012, Aftin performed research at The Karlsruhe Institute of Technology in Germany as a Whitaker Research Fellow for 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 issues in cybersecurity.

"We want to make our decisions based on science — that's a key part of what we do at the FDA. I can put a huge technical background into the work I do, and I'm then able to use that to make broader, more immediate impacts. I have helped enhance or even saved people's lives through my projects."

Aftin's work in Germany also gave her a cross-cultural 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.

Astin joined the FDA a bit later; after graduating from U-M in early 2014, she spent close to two years editing papers for scientific journals at Cactus Communications. She also did research on drug delivery methods at the National Institutes of Health for a year and a half, before getting a call from the FDA asking her to join as a Staff Fellow.

Now, she manages two main projects at the FDA. She is developing a human-centered approach to the process of researching and reviewing by changing communications from written to more collaborative. She has also launched a program that serves as a one-stop shop for various groups within the FDA, so people can understand which experts are already working in a given area and where they might start a new initiative themselves.

"What really attracted me to come here was that I enjoy my research, but it took a long time to see the application of my work. Coming into a position like this, I can see the application and visibility of my impact. To manage and improve the way people work effectively at the FDA, which in itself improves public health, is really powerful."

During graduate school, Aftin and Astin had been involved in many of the same extracurriculars, including the Society of Minority Engineers and Scientists – Graduate Component and the Movement of Underrepresented Sisters in Engineering and the Sciences.

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 at Michigan has been extremely valuable," Astin says.

It doesn't hurt that Aftin and Astin 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.

Have a story you'd like us to consider for the next issue's Alumni Notes? Let us know by sending an email to MichiganEngineer@umich.edu with "Alumni Notes" in the subject line.

PHOTO: Joseph Xu

MICHIGAN ENGINEERS NEVER STOP MOVING. MOVE WITH THEM.

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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.

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

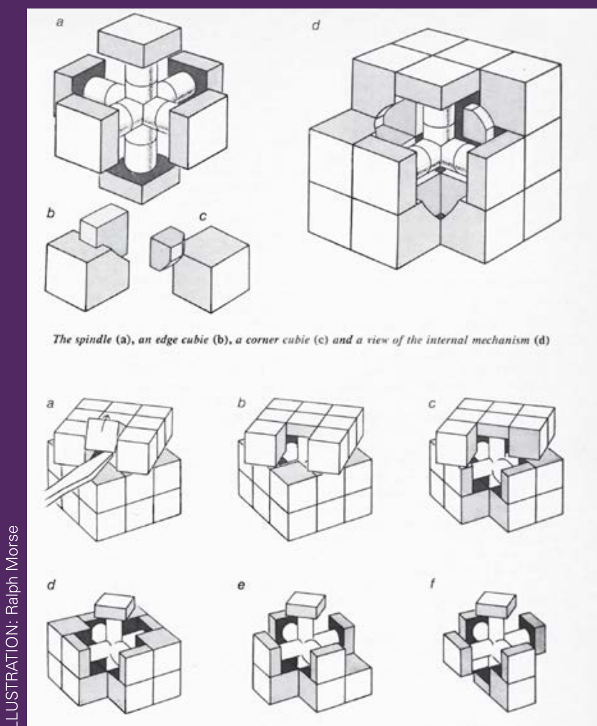
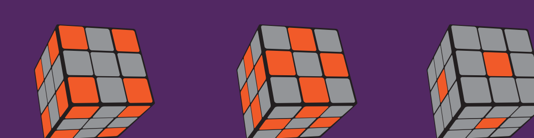


ILLUSTRATION: Ralph Morse



8 corner cubies 12 edge cubies 6 center cubies

"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 Ermo 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 eight corner cubies, 12 edge cubies and six center cubies.

Each corner cubie can occupy any of the eight corner positions, and each edge cubie can occupy any of the 12 edge positions. The six center cubies are stationary and do not move.

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.

PHOTO: Joseph Xu

IN MEMORIAM

1940s

'41 Ward W. Thiel 4/9/17
'41 John P. Lord 5/11/17
'42 Charles J. Daniels 2/23/17
'42 Alfred E. Falk 4/1/17
'42 P. Kenneth Pierpont 5/3/17
'44 E. Peter Schellens 5/9/17
'45 Carl Eggebeen 1/26/17
'45 Robert L. Hess 5/19/17
'46 John J. Fleischmann 5/31/17
'46 John S. Burtt 6/21/17
'47 Albert E. Maass 3/3/17
'47 William O. Schoedinger 3/25/17
'47 John G. German 4/23/17
'47 Stephen S. Squillace 4/24/17
'47 Herbert E. Chinworth 5/3/17
'48 Douglas W. Anderson 1/28/17
'48 Donald P. Schiesswohl 1/31/17
'48 John J. Lambe 2/12/17
'48 Richard A. Schmidtke 3/27/17
'48 Charles A. Gallup 4/23/17
'48 Harold J. Jobse 4/29/17
'48 Justin H. Smalley 7/1/17
'49 Jack C. Stone 2/2/17
'49 Warner C. Jennings 2/9/17
'49 Duane F. Taylor 4/7/17
'49 Thomas S. Heines 4/21/17
'49 Leonard G. Allen 5/6/17
'49 Harold M. McCaskey 6/8/17
'49 Robert G. Caughey 6/14/17

1950s

'50 Addison H. Kermath 2/1/17
'50 Robert L. Du Mond 2/13/17
'50 Charles R. Fuller 2/20/17
'50 Gerald P. Jolette 3/10/17
'50 Anton Longhini 3/28/17
'50 Kek C. Tan 3/31/17
'50 Ronald S. Greenslade 4/7/17
'50 John M. Keir 4/9/17
'50 Billy D. Monk 5/8/17
'50 Harold L. Aurand 6/14/17
'51 Robert P. Carr 1/21/17
'51 Lawrence J. Lareau 2/10/17
'51 Walter R. Tuuri 2/12/17
'51 William E. Hole 2/18/17
'51 Arthur W. Gottschalk 3/8/17
'51 Wayne H. Fenton 3/22/17
'51 Dale R. Weill 3/25/17
'51 James R. Wey 4/23/17
'51 LeRoy F. Hinspeter 5/10/17
'51 Lynn H. Barber 5/22/17
'51 Eugene C. Blankenship 5/28/17
'51 Charles R. King 6/8/17
'52 Kizhanatham Raman 1/31/17
'52 Charles H. Van Deusen 2/15/17
'52 William S. Hayes 2/17/17
'52 Norman F. Goeckel 5/20/17
'52 Stacy L. Elliott 5/31/17
'52 Jesse D. Crell 6/6/17
'52 James C. Streicher 6/20/17
'53 John G. Albert 2/3/17
'53 Richard F. Wilson 3/6/17
'53 Louis J. Krzych 3/20/17
'53 Franklin W. Vogenitz 3/21/17
'53 Albert A. Jadach 3/22/17
'53 Joseph G. Hipfel 4/9/17
'53 James E. Cline 6/12/17
'53 F. Leroy Higgins 6/14/17
'54 David W. Pletcher 1/31/17
'54 Louis Galan 4/14/17
'54 Lester K. Arquette 5/20/17
'54 George A. Davidson 6/1/17
'54 Philip A. Hogan 6/2/17
'55 John J. Buckley 4/1/17
'55 Wallace O. Enderle 5/16/17
'56 Edward R. Godfrey 1/27/17
'56 William W. Gay 3/6/17
'56 Howard R. Voorhees 5/25/17
'57 Arthur H. Boylan 1/25/17
'57 Richard A. Reinlein 3/20/17
'57 Bruce W. Brunson 4/10/17
'57 Fredrick W. Osborn 5/16/17
'57 Frederick J. Peters 5/23/17
'57 Charles G. Richards 6/5/17
'58 Bernard W. Hanna 3/15/17
'58 William K. Huggett 5/25/17
'58 Nalinkumar H. Udani 5/27/17
'58 William L. Wainwright 12/8/17
'59 Harold G. Collins 3/11/17
'59 William L. Kilmer 3/16/17
'59 Daniel N. Chappelear 6/1/17
'59 Andrew Zakala 6/27/17

1960s

'60 William C. Gilbert 2/28/17
'60 Eugene A. Horsman 3/6/17
'60 Richard R. Darr 3/24/17
'60 David R. Jarrett 4/30/17
'61 William R. Heitzig 1/21/17
'61 Kendall E. Born 1/26/17
'61 John Stencel 2/20/17
'61 Dennis C. Zeiss 2/26/17
'61 Herbert T. Louv 4/14/17
'62 George W. Ritsema 5/13/17
'62 Peter T. Kirschner 5/22/17
'63 Edward J. Fronczak 2/8/17
'63 John M. Burke 3/9/17
'63 Harold W. Trenouth 5/23/17
'64 Carl A. Hansen 3/7/17
'64 Thomas E. Carlson 3/11/17
'64 Christopher Hayden 3/14/17
'65 Fredric C. Dall 2/19/17
'65 Louis J. Banciu 5/28/17
'65 Joseph A. Sutorik 6/23/17
'66 John G. Moyer 5/15/17
'67 Fontain M. Johnson 2/4/17
'67 Richard T. Eger 5/8/17
'68 Jack L. Gray 3/29/17
'68 Michael E. Kane 4/15/17
'68 Joseph H. Stocks 5/6/17
'69 Chaman N. Kashkari 3/23/17
'69 Stephen G. Kemp 6/11/17

1970s

'70 Randy L. Hammond 4/26/17
'70 John J. Dellas 5/26/17
'72 Eugene S. Horwitz 3/16/17
'72 Jonathan B. Schoch 4/17/17
'72 Lawrence K. Hui 6/19/17
'73 James A. Phillips 3/18/17
'73 Edward A. Strait 3/29/17
'74 David G. Ryser 1/27/17
'74 Michael W. Hyer 2/15/17
'76 Howard D. Franklin 2/1/17
'77 Jack L. Sheneberger 2/22/17
'77 Kurt T. Knorpp 4/30/17
'79 Thomas R. Nesbitt 5/27/17

1980s

'80 Bryan K. Pourcho 5/11/17
'80 Gregory J. Schneider 5/17/17
'80 John J. Moskwa 6/3/17
'81 Aogu A. Tsukamoto 3/11/17
'82 Wayne P. Klug 1/25/17
'85 Rickey O'Donald 2/17/17

1990s

'92 Thomas R. Plenefisch 6/5/17
'95 Bruce O. Nordquist 2/1/17
'95 David K. McConnell 3/15/17
'95 Christopher J. Norman 3/26/17

2010s

'16 Allen S. Zhao 4/4/17

Faculty

Stanley J. Jacobs 1/26/17
Robert L. Hess 5/19/17

MAKIN' ROBOTS

Cass Technical High School students Yousif 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 get access to the knowledge and tools they need to prepare for careers in the STEM fields.

PHOTO: Joseph Xu

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