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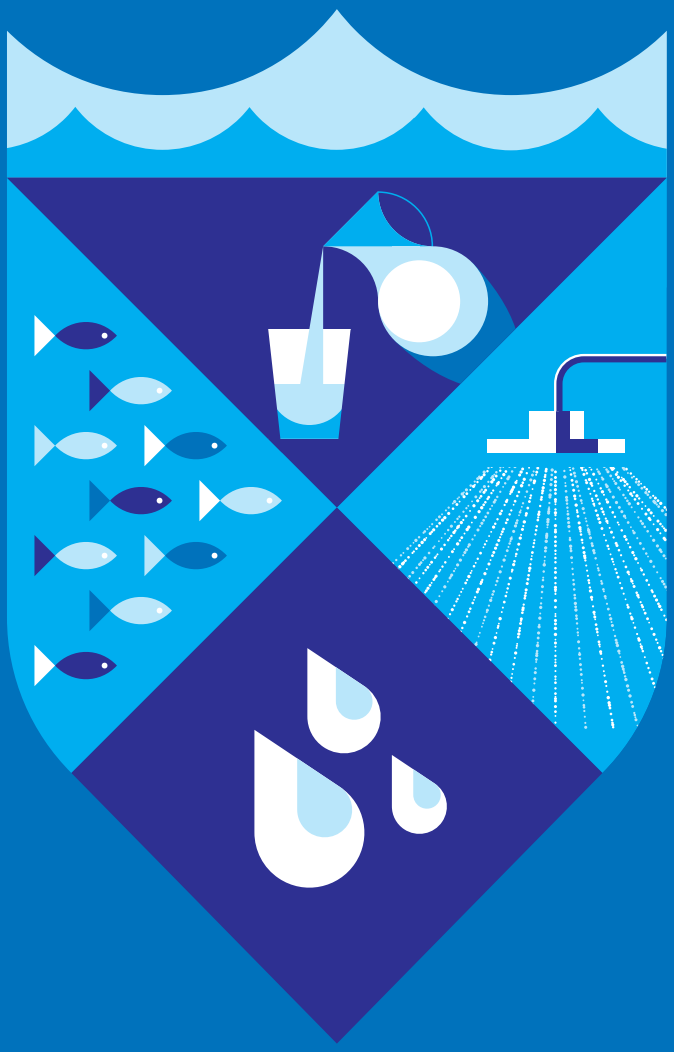
OPUS COLLEGE OF ENGINEERING MAGAZINE **2022**

DEFENDERS OF WATER

Marquette's largest-ever federal award for water research unites a multidisciplinary team in the protection of a vital natural resource.



Engineers have a hunger for solutions — it drives our creativity and technical achievement. But, just like our morning coffee, engineering practice can become routine. In the cycle of solve and repeat, an engineer may lose sight of the true problems, alternative approaches and even stakeholders. Hunger turns to habit, and true innovation fades.

In the Opus College of Engineering, we intentionally create moments to examine our work as educators and researchers. Have our solutions become routine? Where are we losing sight of emerging or evolving problems? How can we discover new opportunities to serve our students and the world? Through strategy retreats and frequent reflection, we are identifying areas for change, growth and, most recently, **collaboration**. We have a long history of seeking industry feedback and partnering with employers for our co-op and internship programs, and we are expanding our efforts to bridge gaps between industry practice and academic theory.

In the classroom, we are bringing our campus experience closer to the industry environment that most of our students enter after graduation. For example, we are eager to open a new, interdisciplinary learning laboratory in partnership with Omron Automation, an industry leader in industrial automation and supply chain (p. 6).

In our research, our teams are seeking out deeper partnerships with academia, government and industry to tackle novel, complex problems (p. 9). Through collaboration, our faculty are broadening the potential economic and environmental value of their work.

We also recognize that we can do more to develop the hearts and minds of practicing engineers beyond our traditional graduate programs. We are launching new initiatives to develop leaders and innovators outside of our typical student populations, including our programming to support Kohler's workforce (p.18).

I am grateful for our many partners and our faculty, staff and students leading new, innovative projects. Our work is not done, and our team is never fully formed — as Alexander Graham Bell said, "Great discoveries and improvements invariably involve the cooperation of many minds."

Dr. Kristina Ropella
Opus Dean
Opus College of Engineering

Follow the dean on Twitter @DeanRopellaMU.

IGNATIAN MOMENT

"Innovating with purpose … aligns well with the Jesuit philosophy, so that innovation is not just for yourself, but it is really like co-creating with God to make the world a better place."

—Rev. Nicholas Santos, S.J., Grad '06, '09, associate professor of marketing and management at Creighton University, from the Innovators on Tap *podcast episode "What the Jesuits Can Teach Us About Innovation," hosted by Chuck Swoboda, Eng '89. Visit innovatorsontap.com for more.*

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OPUS College of Engineering
MARQUETTE UNIVERSITY

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Environmental engineers collaborate with the city of Milwaukee to give new purpose to an urban brownfield site.

GREEN LIGHT

In 2016, the city of Milwaukee began an environmental cleanup of a 3-acre brownfield site near North 31st Street and West Capitol Drive. Today, the reimagined space — aptly called GreenTech Station — captures more than 100,000 gallons of stormwater every time it rains, thanks to a green infrastructure system of 440 trees, a 20,000-gallon underground cistern, bioswales, native prairies and wetlands, and more. A long list of partners including Marquette use the site for research, product demonstration and testing, and as an outdoor classroom.

Dr. Anthony Parolari, assistant professor of civil, construction and environmental engineering, and a team of graduate and undergraduate students have set up shop at GreenTech Station to study the success of often-used green infrastructure strategies, some of which are deployed at the site itself. Team members make regular visits to the site to collect data from two dozen barrels, treated with different combinations of soil amendments, irrigation strategies and vegetation management. The end game: to uncover the green infrastructure design and maintenance practices that together add up to the most effective pollutant-removal performance. Read more about Parolari's research on p. 24. —SARAH KOZIOL, ARTS '92

(l to r: Andrew Hiestand, Isabelle Horvath, Grad '20, Colin Wilson and Elaina Simms. Hiestand and Simms are civil engineering undergraduates; Horvath and Wilson are environmental engineering doctoral students.)

Radical Response

Graduate student's research grows into a startup that is poised to be a game changer for stormwater surges.

Eight hundred cities in the U.S. — Milwaukee included — have a sewage problem. These cities have a combined sewer system, which means that sanitary sewage and stormwater are sent through the same pipe. It also means that after a major rain event or snowmelt, the overburdened system can back up, leaving residents with sewage in their basements and discharging untreated water into local water bodies. It's detrimental for both public health and the environment, and the burden falls disproportionately on urban neighborhoods where population densities are higher.

This is the problem Opus College of Engineering doctoral student Paige Peters, Eng '11, Grad '19, wants to solve — and she's already well on her way. She's founder and chief technology officer of Rapid Radicals Technology, a startup developing and deploying water treatment technology that has the capacity to handle these stormwater surges. The tech combines solids removal and advanced oxidation (the "radicals" that remove all manner of pollutants) in low-footprint decentralized systems, which can be installed right at outfalls, where sewers empty into rivers.

Peters has been working with Dr. Daniel Zitomer, chair and professor of civil, construction and environmental engineering. In 2016, after the lab-scale systems Peters built achieved early proof-of-concept goals and thoroughly impressed industry partners, Zitomer suggested she start a company. "My goal had been to go to grad school for two years, to get my master's and maybe to do international development work," Peters says. "I had not thought of getting my Ph.D. and starting a company and getting millions of dollars in grants — that was the furthest from reality to me."

Since then, Peters has won multiple awards, including $50,000 from the Wisconsin Economic Development Corporation enterprise seed fund and an additional $500,000 collectively from the Milwaukee Metropolitan Sewerage District and the National Science Foundation to build the first pilot-scale system. Last November, Rapid Radicals Technology won a $1 million grant from NSF to continue scaling the technology to handle greater water volumes.

Rapid Radicals also won the People's Choice category of the 2021 Wisconsin Innovation Awards and the top prize at the 2022 Wisconsin Governor's Business Plan Contest. Peters received the 2021 Story Exchange Women in Science Incentive Prize, awarded to women in science working on climate change mitigation in the water sector.

As Peters works to scale up the technology, she'll also start collecting the data needed to prove all it can do — like remove PFAS, *Cryptosporidium* and *Giardia*, drug-resistant genes, pharmaceuticals and more. "We know that it can, based on the science," Peters says. "But now we're actually going to test it to prove it."

"I became an engineer because I wanted to effect change in water," Peters says. "The way water brings people together, and water itself as a public service, is something that's really important to me."

— ANNA FUNK

A Vision Sparked

New executive director appointed to develop Innovation Alley and its innovation initiatives for the university and industry.

Innovation Alley now has a dedicated leader to advance its evolving vision as John Knapp, former director of external relations for the College of Business Administration, was named its inaugural executive director this spring.

Originally conceived as a physical co-location space with industry, Innovation Alley has shifted its focus toward creative programming that will help develop innovation leaders across the university and within industry. The shift will enhance the innovation ecosystem across the Marquette community, Opus Dean Kris Ropella explains.

Fully donor-funded by alumni couple Chuck, Eng '89, and Karen (Kane), Eng '90, Swoboda and the Fotsch Family Foundation, Innovation Alley's vision is to develop leaders who use their talents in the service of and with others; to create a platform to share new ideas that push boundaries; to transform interactions between faculty, students and industry to promote novel solutions to real-world problems; and to change the face of innovation to look more like the world engineers serve.

Innovation programming is already underway, as Knapp, who joined Marquette in 2019, gets to work developing a five-year strategic plan to shape Innovation Alley into a centralized developer and convener of innovation leadership programs and other innovation-related activities.

"I had the opportunity to work closely with John on a new Innovation Alley program, and his ability to connect people and deliver real outcomes will be exciting to watch as we take this initiative from concept to reality," Ropella says.

—SARAH KOZIOL, ARTS '92

Real-world Engineering

Student organization delivers community-improving engineering efforts during pandemic.

Noah Meisner, Eng '21, graduate student

Despite pandemic restrictions that prevented the Marquette chapter of Engineers Without Borders from traveling from 2020 through 2021, the student organization managed to design three transformative community projects and remotely manage their construction with assistance from the EWB office in Guatemala.

One project was the construction of a new cable-suspended pedestrian bridge for the Guatemalan village of Guacamayas Hamaca (photo, right). The completed bridge allows more students to attend school and farmers to transport goods more easily to nearby markets by providing the community with safe passage across the Motagua River.

Another project involved Hogares Santa Maria de Guadalupe, an orphanage in Santa Apolonia that the Marquette chapter has worked with previously. This collaboration implemented cost-efficient water and electrical systems to reduce the monthly electricity and water bills for the orphanage, so more monetary resources can go directly toward the children's care.

The final project added a set of bathrooms and a handwashing station to a three-room schoolhouse the chapter constructed in 2019 in El Aguacate. This is the third project EWB-Marquette completed for this community.

More good news: The chapter's annual silent auction raised more than $16,000 for future sustainable infrastructure projects, and students were able to travel this past summer to work on their most recent project — a water treatment and distribution system to supply clean water to the community of El Tesoro. —SARAH KOZIOL, ARTS '92

NEARLY

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MARQUETTE STUDENTS PARTICIPATED IN EWB THROUGHOUT THE 2021–22 ACADEMIC YEAR.

Fostering Innovation

Hands-on lab will be designed to help both engineering and business students understand how to improve automation processes.

Dr. Phil Voglewede, associate professor of mechanical engineering, has enough lifetime experience as an engineer and an educator to know that from exploration and failure comes learning. He used this insight to pitch his vision for a new lab where students can experiment with all the actuation, sensor and controls essentials of industrial automation. His pitch hit the mark, and this summer the Opus College received more than $1 million from Omron Automation to establish the Omron Advanced Automation Lab, which will bring together engineering and business students by combining innovative industrial automation and robotics technology with supply chain platforms.

The Omron Advanced Automation Lab will educate both engineering and business students on fundamental and higher levels of how to implement Industry 4.0 into the design, manufacturing and delivery of products. Lab stations will be designed to teach students the foundational building blocks of industrial automation; a manufacturing area will teach how subsystems can be combined to produce a product; and a library of components will challenge students to identify what components are necessary to complete their tasks.

"We are grateful to partner with Omron on this lab where students will have the opportunity to learn best in an engaged environment that will foster experimentation, innovation and failure," says Voglewede. "This will not be a showroom of perfection. Students will be allowed to fail, and from failure comes understanding, learning and engagement. This lab has an intentional design that will teach students subsystem design and implementation from both business and engineering perspectives."

Omron Automation is an industrial automation partner that creates, sells and services fully integrated automation solutions that include sensing, control, safety, vision, motion, robotics and more. The corporation's gift also supports an endowed scholarship and the mechanical engineering graduate program. —SARAH KOZIOL, ARTS '92

New Certificate for Working Engineers

Graduate engineering program focuses on medical device design.

The Opus College has added to its reimagined graduate education opportunities with its new Clinical Immersion in Medical Device Design certificate program beginning this fall. The program is strengthened by the blending of faculty expertise within a clinical setting that is inherent in the Marquette University and Medical College of Wisconsin Joint Department of Biomedical Engineering.

Online course work is complemented by hands-on practical experiences in clinical simulation centers and in-person immersive clinical observation experiences, which provide engineers an opportunity to observe clinical procedures and how medical devices are meeting the needs of current users. The curriculum also provides potential to identify unmet needs and opportunities for new medical devices and technologies.

The certificate is designed for engineers at any stage in their career or experience level. For more information, contact Dr. Said Audi, Eng '88, Grad '90, '93, director of graduate studies and professor of biomedical engineering, at said.audi@marquette.edu.

Doubling Down on Building Leaders

E-Lead program experiences exponential growth that includes a new dedicated innovation space.

By the end of her freshman year, Erin Wells, Eng '20, decided to apply for the Opus College's Engineers in the Lead program. Her motivation? "It provides students the opportunity to develop leadership skills that are not traditionally included in undergraduate course work," she says. The college launched the first iteration of E-Lead, its innovation leadership development program for undergraduate engineering students, in 2014.

Wells, now a project engineer at Black & Veatch, says that regardless of the industry, professionals need to be able to communicate and work well on diverse team structures. "E-Lead allowed me to develop strong emotional intelligence, interpersonal communication skills and gave me the tools to bridge my technical education with leadership skills," she says. "That's incredibly valuable to any company."

The three-year, 12-credit E-Lead program develops a student's capacity to lead, with an emphasis on innovation. With original cohorts of 20 engineering students, the program expanded eligibility in 2020 to 40 participants from any discipline. It was rebranded to Excellence in Leadership and has been building momentum ever since.

Now, thanks to a $5 million gift from the Fotsch Family Foundation, it is gaining even more traction. "This gift will allow us to sustain the offering of the E-Lead program to 120 students per year for a very long time," says Kate Trevey, Bus Ad '04. It will also create an endowed directorship to be held by Trevey, who was named the first Nana Fotsch Director for the Fotsch Innovation and Engineering Leadership Development (FIELD) Center.

Trevey attributes the success of E-Lead to the ongoing need to develop a student's capacity to lead people and change. "Fundamentally that is what the program is about," she says. "It's about leading yourself, leading others and being able to lead innovation. There is a huge need to develop people to lead others through very complex situations. We are constantly hearing from our alumni how valuable what they learned here has been for their careers. This in turn is why there is so much interest from our corporate partners as well." —GUY FIORITA

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STUDENTS HAVE GRADUATED FROM E-LEAD SINCE ITS INCEPTION.

> "There is a huge need to develop people to lead others through very complex situations.
>
> —Kate Trevey, Nana Fotsch Director for the FIELD Center

Olympic Glory

Congratulations to long-track speedskater Emery Lehman (pictured second from right), Eng '20, who earned a bronze medal in the team pursuit at the Beijing Olympics this past February. Lehman was featured in *Marquette Engineer* in 2018 for his trip to the Pyeongchang Olympics, a pursuit he tackled while actively studying for his undergraduate degree in civil engineering.

On Board

Opus Dean Ropella expands her community engagement with new board position.

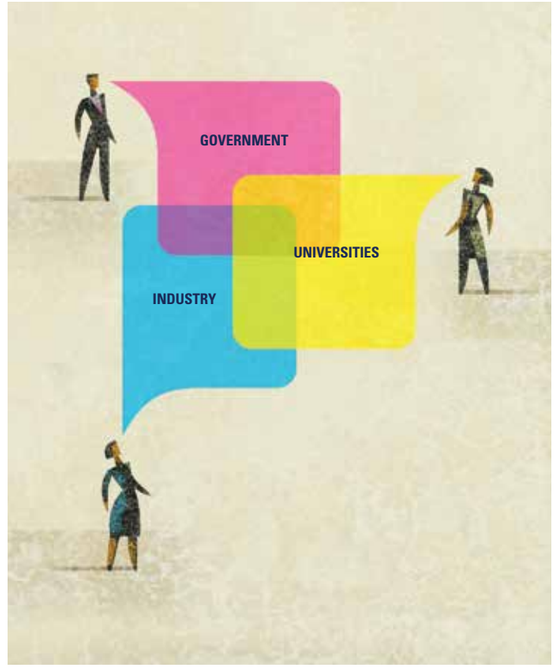
Opus Dean Kris Ropella has joined the board of directors for the Hispanic Professionals of Greater Milwaukee, an organization whose vision is to showcase Hispanic talent in the Milwaukee area and provide professionals with the support they need to reach increasing levels of success in their careers.

A tireless advocate for diversifying the engineering profession to better represent the world it serves, Ropella supports HPGM's vision to be a resource for professional development for Hispanics in Wisconsin. "A wide range of industries are represented on the board, including innovation and engineering fields. To keep innovating and moving forward, in any area, we need to have people from diverse experiences contributing," she says.

In a statement announcing her board membership, HPGM called Ropella "a trailblazer and innovator in her field." She assumed the permanent role of Opus Dean in 2015, after joining the biomedical engineering faculty in 1990 and serving as the chair of the Department of Biomedical Engineering from 2004 to 2013.

Pooling Resources for Better Solutions

Engineering researchers team up with collaborators beyond the university to tackle global concerns.



In a complex world where global challenges such as pollution and climate change threaten human health, academic research has never been more important. But the more difficult the problem, the more demanding the solution.

That's where multi-institutional collaborations come in. Working across diverse disciplines, cultures, methods and expertise, researchers in the Opus College of Engineering are pooling their resources into larger collaborations that strengthen the university in more ways than one and drive discovery that can improve people's lives.

"These partnerships benefit from having our outstanding faculty on the teams and, at the same time, provide new opportunities for our faculty and students," says Dr. Jeanne Hossenlopp, Marquette's vice president for research and innovation.

For many engineering researchers, teaming up with a colleague is common practice. "Collaboration has been one of the hallmarks of my career," says Dr. Brooke Mayer, associate professor of civil, construction and environmental engineering, who has worked with investigators across town at the University of Wisconsin–Milwaukee as well as across the Atlantic at the Universitat Autònoma de Barcelona.

Last October, Mayer received a $627,000 grant as part of a $25 million National Science Foundation Science and Technology Center initiative that involves seven other research institutions, with North Carolina State University leading the team. Called Science and Technologies for Phosphorus Sustainability, or STEPS, the initiative will address the overabundance of phosphorus in one area and its shortage in another.

These partnerships "increase Marquette's reputation in research" and lay "the foundation for further collaborations in the future," says Dr. Ayman EL-Refaie, Thomas H. and Suzanne M. Werner Endowed Chair in Secure and Renewable Energy Systems. EL-Refaie received two $5 million grants from the Department of Energy to lead multi-institutional teams — one brings together Virginia Tech, General Motors, Niron Magnetics and the National Renewable Energy Lab (NREL) to develop the next generation of drivetrains for electric vehicles; the second unites Florida State University, Raytheon and NREL to work on state-of-the-art electric drivetrains for hybrid and electric planes.

Receiving funds from a large federal agency like the DOE can put Marquette on the map, says Dr. Adam Dempsey, assistant professor of mechanical engineering. "Building that reputation is important as an up-and-coming research institution," he says. Dempsey and his co-investigator, Dr. Casey Allen, associate professor of mechanical engineering, were recently awarded more than $2.5 million from the DOE for a project that includes UW–Madison; Mahle, a German automotive parts manufacturer; John Deere, a farm equipment manufacturer; and ClearFlame Engine Technologies, a diesel-free industrial engine developer. In June, Dempsey earned another $3.9 million DOE grant to collaborate with UW–Madison, Mahle and Czero Inc. on reducing methane slip in lean-burn engines. (Read more about this project on p. 25.)

Being a part of such diverse teams brings Marquette's voice to the table, says Mayer. This is important not just for the individual researcher but for the university and its mission of operating from a Catholic, Jesuit perspective. Engendering *cura personalis*, or care for the whole person, is part of that mission and plays an important role in solving problems around sustainability, which involves social and generational equity, she says.

"Our most pressing global challenges can't be solved by a single gadget, person or discipline; these compelling problems require new ways of thinking to develop integrated solutions," Mayer says. —TRACY STAEDTER

Celebrating Our Distinguished Alumni

Distinguished Alumnus of the Year Award

Brian Truskowski, Eng '81

Brian Truskowski's passion for computers and engineering led to a rewarding career that saw him travel the world, serve as IBM's chief information officer and be appointed to the U.S. President's National Security Telecommunications Advisory Committee. Truskowski recently retired from IBM as vice president of enterprise and technology security. He has mentored students, has served as an E-Lead Shadow Host and is a past member of the college's National Advisory Council. "Marquette exposed me to mind-opening diversity, a focus on service to others, a true sense of community, and the importance of our Catholic faith in our everyday lives," he says.

Professional Achievement Award

Dr. Michael Yang, Grad '91, '03

Dr. Michael Yang has been developing novel medical device solutions that improve patient outcomes for the last 30 years. From interventional cardiology, pacemaker and ICD electrode designs, catheter design and manufacturing to orthopedic implants and neurosurgical products, Yang's influence in the medical field is far-reaching. Having held leadership positions at Integra LifeSciences, Cardiovascular Systems Inc., Johnson & Johnson and Abbott Labs, Yang is currently senior vice president of research and development with PDI Healthcare. "My long-term career goals always center around identifying unmet medical needs and creating solutions to improve patients' quality of life and well-being," he says.

Entrepreneurial Award

Victor Szczerba, Eng '89

As CEO and co-founder of Yeti Data, a startup that allows companies dealing with complex data to understand what is driving marketing results, Victor Szczerba is leaving his mark on Silicon Valley. Szczerba launched Yeti Data in 2013, after holding senior positions with Microsoft, SAP and Sun Microsystems. He is also involved with the Human Longevity Institute, which uses advanced analytics to create personalized care plans to increase lifespans. "The short-term goal is to add five to 10 years of healthy life by intervening early with cancer, cerebral and cardiovascular diseases. Eventually, we hope we can democratize the technology and make the impact available to everyone," he says.

Young Alumna of the Year Award

Gretchen Noth Borden, Eng '03, Grad '07

Now in her 20th year at Harley-Davidson Motor Co., where she has spent her entire professional career, Gretchen Borden has quickly moved up the ranks to chief engineer. Borden is driven by seeing designs come to life through product development. "I'm able to help people fulfill their dreams of personal freedom," she says. Her impressive corporate climb is matched only by her strong and active relationship with her alma mater. Borden serves on the Industry Advisory Board for Mechanical Engineering and advises students through the Marquette Mentors program, the business college's Mentoring Program and Society of Women Engineers Marquette collegiate chapter.

Engineered Cakes Top Off E-Week

Student council plans celebratory week that's all about engineers.

Frosting, sprinkles and engineering? It was clear from the start, this was no ordinary bake-off. The most-anticipated event of Engineers Week, Engineering Cake Wars, put eight teams to the challenge of decorating cakes in one hour using only 3D-printed, laser cut or handmade tools crafted before the competition began. On the line — a first-place brewery tour and, most importantly, bragging rights.

With cakes and frosting provided, teams focused on engineering and decorating their cakes, which would be judged for overall appearance, innovative tools used, decoration, teamwork and theme by Opus Dean Kris Ropella; Dr. Mark Federle, associate dean for academic affairs; and Ben Correia-Harker, associate director of engineering and innovative leadership development. Team Shop Squire Squad — seniors Jordan Towe and Zach Thompson, Kat Meza, Eng '22, and Gabby Lukanus, Eng '22 — took first place for their toolbox cake honoring their boss Tom Silman, Eng '01, Grad '07, operations engineer for Engineering Hall.

The competition was the icing on the cake of several activities planned by the Engineering Student Council to recognize the profession of engineering and the positive contributions engineers make through their work. The national celebration of E-Week was launched in 1951 by the National Society of Professional Engineers.

View more E-Week photos on the Marquette University Opus College of Engineering's social media.

—SARAH KOZIOL, ARTS '92

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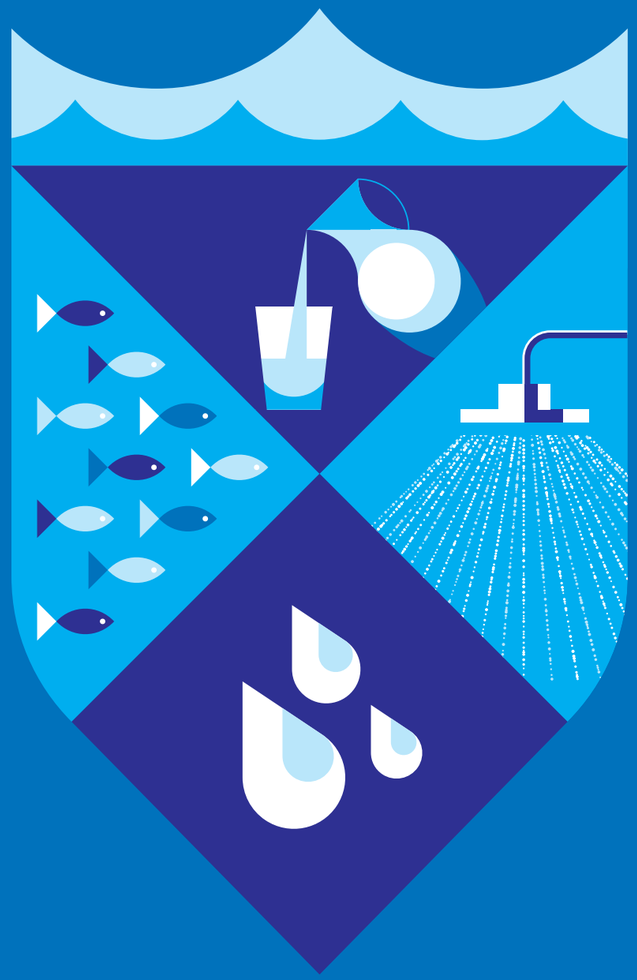
STUDENTS PARTICIPATED IN ENGINEERING STUDENT COUNCIL IN THE 2021–22 ACADEMIC YEAR.

DEFENDERS OF WATER



BY STEPHEN FILMANOWICZ

Supported by Marquette's largest-ever federal award for water research, a new multidisciplinary collaboration addresses water quality challenges and promotes healthier environments for troops and civilians.

About five years ago, Marquette faculty members specializing in water research began meeting monthly during the academic year as part of the university's participation in Milwaukee's Global Water Center. As colleagues briefed one another on projects underway in their labs, their scientific approaches and research aspirations, they quickly revealed areas of shared interest and potential collaboration. The participants, mainly from environmental engineering and biological sciences in the early days, began inviting colleagues from other disciplines — hydrologists, chemists, social scientists, and law policy and education scholars — and saw the circle of complementary expertise and eager collaborators expand again and again.

Out of this collaboration, teams have formed, courses have been developed, and grants have been sought and obtained. And recently, this approach generated its biggest dividends yet when Marquette received its largest federal award to date for water-related research — $3.8 million from the U.S. Army Corps of Engineers — to fund an ambitious program, Novel Technologies to Mitigate Water Contamination for Resilient Infrastructure, which the researchers have given a more memorable name, In Defense of Water.

Working with colleagues from the Army Corps' Engineer Research and Development Center (ERDC), four multidisciplinary research teams from Marquette are pursuing solutions to high-priority water quality issues such as field-based wastewater recycling, antibiotic- and antiseptic-resistant pathogens, and more. The projects will help the Army promote sustainability, resilience and health on and around military sites — and yield important public health benefits as well.

"This award demonstrates the breadth and depth of water group expertise at Marquette," says Dr. Jeanne Hossenlopp, vice president for research and innovation. "It serves as a reminder that our faculty does significant environmental-related research on a major scale." The award also provides research experience for eight undergraduates, seven graduate students and up to three law students. "It recognizes that

we're a community of scholars, which includes our students. We're training the next generation of scientists and engineers," Hossenlopp says.

This collaboration with ERDC "expands the water technology development we at Marquette have been doing for decades to help provide clean drinking water and protect the environment," says Dr. Daniel Zitomer, principal investigator of In Defense of Water and chair and professor of the Department of Civil, Construction and Environmental Engineering. "Marquette researchers will now work closely with Army researchers on processes to treat wastewater, improve control of pathogenic microbes, reduce soil and water contamination, and develop technologies to help mitigate forever chemicals such as PFAS in the water."

Dr. Martin Page, who leads a water treatment and reuse technology research team at ERDC in Champaign, Illinois, comments: "This academic research effort at Marquette University will complement Army efforts to increase water resiliency while furthering the scientific understanding of the associated technologies and frameworks in a manner that benefits the military as well as the public. ERDC researchers at the Construction Engineering Research Laboratory in Champaign, Illinois, and the Environmental Laboratory in Vicksburg, Mississippi, will collaborate with the Marquette team in a manner that leverages knowledge and skills across institutions to address important technical questions relating to water resiliency."

In Defense of Water is now poised to have a major impact as four research projects get underway, with Opus College faculty leading two of them and co-investigating on the other two led by Klingler College of Arts and Sciences colleagues.

Removing contaminants in mobile wastewater recovery systems

Led by Dr. Brooke Mayer, associate professor of civil, construction and environmental engineering, this project advances research and development of a mobile wastewater recovery system consisting of solids removal, disinfection with ozone, nutrient recovery and membrane processes. "We believe that water reuse will play an increasingly critical role in resilient and sustainable infrastructure in the future," Mayer says, envisioning this technology playing a key role in recycling water and reducing water waste in deserts and other water-scarce or remote locales where clean water and/or sewerage resources are insufficient for habitation, requiring water to be transported in and out.

To return wastewater to drinkable standards, the multidisciplinary team will target advances in the ability of mobile systems to mitigate viruses, antibiotic-resistant bacteria and chemicals. And in keeping with the waste-to-resource paradigm that is a hallmark of Mayer's research, the project will focus on generating clean water and more. "If we can not only recover high quality water but also co-recover value-added products such as nutrients, the treatment system offers greater resource recovery benefits," she says. Mayer's co-investigators include Zitomer; Dr. Patrick McNamara, Eng '06, associate professor of civil, construction and environmental engineering; and Dr. Chris Marshall, assistant professor of biological sciences in the Klingler College.

Harnessing data to improve water infrastructure

In the past few decades, there has been an explosion of environmental data made possible by new sensor technology and expanded environmental monitoring systems, such as earth-observing satellites. "There is a lot of work still needed to utilize these datasets and uncover their value for improved design and management of water infrastructure," says Dr. Anthony Parolari, assistant professor of civil, construction and environmental engineering and lead investigator of this project. "So-called 'big' environmental data offers a sandbox of sorts to develop and test out new algorithms to solve some of the most pressing problems facing society."

To that end, this project strives to harness massive water-related datasets and uncover their value for improved design and management of water infrastructure, engaging colleagues from engineering and water policy to develop a data- and policy-driven approach to improve water quality. The team plans to use data to optimize green stormwater infrastructure performance, including pollutant capture. Data and systems modeling will improve understanding of how data and management uncertainty impact risk of water quality impairment. Legal, policy and governance strategies that affect pollutant transport will be compared and policy roadblocks will be identified.

Parolari and colleagues foresee progress addressing gaps in managing how and where pollutants are transported during rain events. "The opportunity to track these pollutants at high temporal and spatial resolution and control in real time where they move on the landscape — all enabled by data and models — can help us better manage infrastructure that is critical to our everyday lives, from the navigability of our ports and rivers, to making our rivers and lakes safe for fishing, swimming and boating," Parolari says. "What is new in this project is the integration of these monitoring and modeling strategies with the human side of the equation — decision-making, policy and regulation."

Parolari is joined by co-investigators Dr. Walter McDonald, assistant professor of civil, construction and environmental engineering; and David Strifling, Eng '00, Law '04, director of the Water Law and Policy Initiative and adjunct professor of law at Marquette Law School.

Additional projects focus on disinfection's impact, removal of PFAS

Another team, under the direction of Dr. Krassimira Hristova, associate professor of biological sciences in the Klingler College, is investigating the microbial ecology of biofilms that form on everything water touches in buildings including pipes, sinks and shower curtains. In addition to learning more about what is killed by typical disinfectants and what comes back after their use, the team will study UV treatment and novel disinfection materials that efficiently control growth of bacteria and viruses on surfaces and in biofilms. Hristova's co-investigators include Mayer and Marshall.

The fourth team, led by Marshall, is advancing research and development of an innovative two-step system involving electrochemical removal of PFAS (per- and polyfluoroalkyl substances) and subsequent bioelectrochemical degradation and destruction. Widely used in food packaging, firefighting foam and other products, PFAS chemicals are toxic and accumulate in the environment, with inadequate remediation strategies available to address the threat they pose to human health. The system could be used in a range of applications, including drinking water treatment, wastewater treatment and in-place treatment of soils and sediments.

While engineering teammates Mayer and McNamara work to improve existing technologies such as electrooxidation and electrocoagulation for the easier separation of PFAS, Marshall is leveraging research progress he's made using microbes to degrade halogenated compounds such as PCBs. There are signs the same or related strains of bacteria may help degrade PFAS chemicals. Hristova is also a co-investigator of this project.

Foundation existed to position Marquette as a valued research partner

In assessing how Marquette positioned itself to provide research leadership on a project of this scope and impact, program participants cite several factors that developed over the last few decades. First was the creation in 1993 of the Water Quality Center in the Opus College and its recruitment, through Zitomer's leadership as director and department chair, of faculty members with outstanding water research expertise. The emergence of a similar, if smaller, cluster in biological sciences in the Klingler College extended this expertise.

Next was the establishment in 2010 of the Water Equipment and Policy Center, a joint venture through which industry members, such as Badger Meter, A.O. Smith, Pentair and the Milwaukee Metropolitan Sewerage District, and researchers from Marquette and the University of Wisconsin–Milwaukee develop new technologies to clean contaminated water. The center, managed at Marquette by Zitomer and under the auspices of the National Science Foundation's Industry/University Cooperative Research Center program, has resulted in multiple patents and licensing agreements.

And Marquette's membership in the Global Water Center helped to give researchers and partners from many departments a collective identity and a critical forum for collaboration.

"The R&D projects we're now engaged in complement the world-class results Marquette water quality researchers have been obtaining for many years and put us on track to invent the next generation of sustainable water management technologies," Zitomer says. "It's an exciting time for students and faculty to be Marquette water team members."

Opus College alumnus Ryan Serfas, S.J. (left), Eng '19, took his First Vows on Aug. 14, 2021, at St. Thomas More. He was joined by friend and fellow Opus alum Justin Prom, S.J., Eng '18, who took his First Vows a year earlier in the same church.

Living their calling

Two alumni started at Marquette as engineering students. Now they are on a faith-inspired journey as Jesuits.

BY CLAIRE NOWAK, COMM '16

Opus College of Engineering alumni Justin Prom, S.J., and Ryan Serfas, S.J., don't have traditional engineering jobs. As Jesuits in the stage of formation known as First Studies, their schedules include daily Mass, silent prayer, philosophy readings and community service projects. Both are studying for master's degrees in philosophy — Serfas, Eng '19, at Fordham University and Prom, Eng '18, at Loyola University Chicago. Yet, every day, they put their engineering educations to good use.

"We were, of course, learning skills specific to engineering," Prom says of his undergraduate education. "But a huge focus of the program was training in a way of problem solving — of systematically looking at a problem, identifying its most basic components, and then with that knowledge, coming up with the solution."

Much of the men's current work relies on understanding people and situations at their most basic level. It influences Prom's approach to giving spiritual guidance to people struggling with their faith, and it helps Serfas better understand philosophy assignments. Their more technical skills also come in handy. Serfas, for instance, teaches math to middle school students at St. Ignatius School in the Bronx and helps run their STEM club.

"One of the things that's so cool and beautiful about the Jesuits is that they make use of the gifts and experience that guys bring," he says.

Granted, they didn't intend to use their gifts this way. As freshmen, Prom planned to pursue a career in biomedical engineering, and Serfas one in mechanical engineering. Both became heavily involved in Campus Ministry, which helped spark their friendship — and their separate but nearly simultaneous desires for the priesthood. By Prom's last year at Marquette, he was set on joining the Jesuits, and Serfas was experiencing the "unmistakable" call to do the same. Both entered the Society of Jesus only a few months after graduating.

A defining characteristic of the Jesuit order is to "Go where the need is greatest." For Serfas, that means spending First Studies, which lasts about three years, living and working in impoverished Bronx neighborhoods. All his students at St. Ignatius School live below the poverty line. The placement initially made him a bit uncomfortable: "As a white man, I kind of stick out."

What changed his perspective was a phrase that stuck with him from his time in the E-Lead program: "Come in right." It essentially means to approach new situations with the right attitude through active listening and observation rather than immediately pointing out what may be "wrong." With that in mind, he and his Jesuit roommates decided to simply get to know the locals.

"We started building relationships and hearing stories," he says. "I'm grateful to get to know our neighbors … and not judge the way they're carrying their crosses."

Prom takes a similar attitude as chaplain to Loyola's women's track team (perhaps inspired by his E-Lead participation). He organizes service projects for the student-athletes in the style of Labre Ministry, which emphasizes starting conversations and relationships with people experiencing homelessness while providing them food. The women often get as much out of it as those they serve. "To see them have this heart-opening, world-opening experience, saying things like, 'I didn't realize that the poor could inspire me in such a way,'" Prom says. "It's so exciting."

That these men are on the same journey from Marquette engineers to the priesthood is still surreal to them, and they don't take it for granted. Frequent phone calls with each other let them share the highs and lows of formation and let loose after long days. As much as they know they are using their gifts the way God intended, these Jesuits also find comfort in pursuing their vocation with a friend.

COLLECTIVE DISCOVERY

Fitting innovative solutions to tomorrow's problems starts with collaborative industry relationships.

BY ERIN O'DONNELL

Well steeped in the Opus College of Engineering's storied history is its strong connection to industry. After all, more than 240 companies in 25 states regularly offer Marquette engineering students valuable co-ops and internships through programs more than a century old. Never resting on its laurels, the Opus College is currently forging deep, next-generation partnerships with companies such as Kohler Co. and Omron Automation, creating new ways for students, faculty members and companies to collaborate, learn from one another and face the challenges of a rapidly changing world together.

"In this environment, if you don't keep thinking differently, you're going to be left behind,"

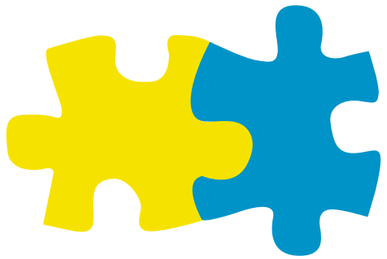
says Dr. Kris Ropella, Opus Dean of the Opus College of Engineering. "Today there are a lot of unknowns. We're going places we've never had road maps for, politically, economically and education-wise. We all see the need to innovate and think differently than we have in the past."

All of this means pursuing new university-corporate relationship models — especially those that foster innovation and synergistic collaborations.

A steadfast partnership eyes the future

Marquette's relationship with Kohler began in 1919 and was formalized last fall with a global agreement that streamlines the process for students and faculty members to work with Kohler teams across the company. Marquette is home to the Kohler Center for Entrepreneurship, which offers programming to help students, faculty and staff with their entrepreneurial aspirations through mentoring, workshops, speaker series and funding. Dozens more students and faculty members across the university are currently engaged with Kohler through research projects, internships, scholarships and professional education. "This is the most comprehensive engagement we have at Marquette," explains Dr. Carmel Ruffolo, Marquette's associate vice president for corporate engagement.

The Opus College recently added a new element to its relationship with Kohler by launching the Kohler Engineering Leadership Development program, in which Kohler engineers receive leadership development from Marquette faculty and staff with a focus on elevating innovation. The first cohort of Kohler engineers in the program, from the company's global power and kitchen and bath groups spanning the U.S. and EMEA, began the program in March. They met regularly through a combination of virtual and in-person sessions and completed the curriculum in August. A new cohort of Kohler associates will begin the program soon.



The curriculum is customized to Kohler's needs but built around the Opus College's multidisciplinary programs. "The first module is really about unleashing your creative genius, helping people with the self-awareness of who they are, their strengths, their personal mindsets and relationships to risk and failure," explains Kate Trevey, Bus Ad '04, Nana Fotsch Director for the Fotsch Innovation and Engineering Leadership Development Center at Marquette, who began her career as an analyst at Kohler. "You can't ask that of a team if you've not explored that for yourself." The program also explores a process of harnessing called "collective genius."[1] This involves recognizing and appreciating the talents and perspectives that each employee brings to the team and establishing an environment in which staff members feel safe proposing new ideas.

Ropella is also passionate about preparing young engineers to advocate for their ideas. "Some early career people are afraid to bring new ideas to their supervisors," she says. "They don't necessarily have skills and tools to have tough conversations or disrupt ideas. We teach them how to do that in a professional, effective way."

Philip Malliet, Eng '84, Grad '94, CEO of Hayes Performance Systems, approached Ropella about offering leadership training to early career engineers and technology staff at his company. Ropella and Trevey led the training, which became a pilot program for future Marquette-industry leadership courses. Trevey gathered data about what worked and didn't work, which gave them information to improve the curriculum for other companies, including Kohler.

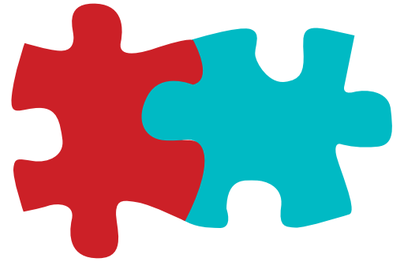
New collaboration with Omron Automation flourishes

The Opus College has also been collaborating internally with the College of Business Administration to help engineering students develop greater business acumen. Companies are eager for engineers who also have business expertise. Omron Automation, which has American headquarters outside Chicago, began working with Marquette's engineering and business faculty to develop new talent pipelines for its engineering, technical sales and supply chain management workforce needs.

Ropella says that Omron is a fitting partner for Marquette. "When I walked into their headquarters and read their mission statement on the wall, it sounded like the Marquette mission statement," she notes. The relationship began to deepen, with the Opus College looking for ways that Omron Automation could help inform the engineering curriculum and "engage with faculty over research challenges," Ropella explains.

This led the company to make a more than $1 million gift to Marquette to establish the Omron Advanced Automation Lab in Engineering Hall, which will be used by engineering students as well as business students studying supply chain management, allowing them to explore issues related to automation, robotics and manufacturing. (Read related story on p. 6.) The Omron gift is also supporting the development of a graduate-level certificate in automation.

Omron Automation also sponsors technical sales pitch competitions on campus. Students from a variety of disciplines make sales pitches for Omron technologies and products to Omron executives acting as prospective manufacturing clients. "Students get firsthand experience doing a sales pitch in a safe environment, but it's relevant because you're doing it with a real company," Ruffolo says. She adds that programs like these make companies aware of promising student talent, as well.



Opportunities expand for faculty

Another extension of the college's innovative industry relationship-building is the growing number of faculty members who are completing externships or sabbaticals with industry partners. These stints away from the academy can help professors forge relationships that can lead to shared research projects and shape the way faculty members teach their courses. For example, Dr. Jay Goldberg, professor of practice in biomedical engineering, served a five-week externship at GE Healthcare, investigating technologies that enhance the patient and user experience during MRI scans. Before coming to Marquette, Goldberg spent 14 years in new product development for the medical device industry. "I left industry 23 years ago, so I wanted to go back for a short time to learn about new trends and tools in product development, product management, design and innovation," Goldberg says. "My goal was to confirm that what I am teaching is relevant and up-to-date and helps prepare my students for careers in industry."

Dr. Patrick McNamara, Eng '06, associate professor of civil, construction and environmental engineering, took a sabbatical during the 2021–2022 academic year and spent it working full time for engineering firm Black & Veatch, where he focused on wastewater process engineering. "I looked at large datasets including chemistry, microbiology and mass flows, and tried to determine why a certain wastewater treatment process failed and how to improve it," he explains.

He says this experience makes him better able to incorporate current, real-world challenges and engineering problems into homework, lectures and exams. "Bigger picture, I can be a better career mentor to students about what work life is like and how to prepare for it," he adds. McNamara also sees ways that this experience could influence future research projects. "Research is a blend of working on problems now and predicting problems of the future," he says. "I have a better sense for what problems in the field are and what future problems will be."

These faculty opportunities in addition to the partnerships with Kohler Co. and Omron equip Marquette to prepare students for a rapidly changing world. Ropella says that given this environment, it's essential "to think differently about our educational programs, our research programs, how we translate some of the discovery that we do in our research labs into real solutions and real products and real businesses. Industry tends to do that well, so we need to partner better."

[1] From *Collective Genius: The Art and Practice of Leading Innovation* by Dr. Linda Hill, professor, Harvard Business School

OPUS COLLEGE
RESEARCH & INNOVATION

The Opus College of Engineering is transforming engineering education by preparing today's engineers to be creative problem solvers. We invite you to read how our professors and programs are seeking **SOLUTIONS TO OUR WORLD'S GREATEST CHALLENGES,** all the while leading the way for the next generation of Marquette engineers.

HEALTH & HUMAN PERFORMANCE

52%

The estimated percentage of neurons in the cerebral cortex that respond exclusively to visual stimulation is 52 percent. **Dr. Adam Greenberg**, assistant professor of biomedical engineering, is studying how the brain interprets complex visual scenes in which our eyes see a patchwork of overlapping surfaces and our brain performs a series of computations to group these various surface patches into unified objects — a poorly understood process that happens effortlessly every day. Greenberg's research, funded by the National Science Foundation, will develop novel neuroimaging analysis tools to help uncover which brain regions are specifically involved in the process of visual perceptual grouping and the different constituent computations performed by them to this end.

"A more complete understanding of the brain mechanisms underlying perceptual grouping will lead to optimized designs for environmental visual displays, including street signs, occupational safety warnings and medical equipment instructions, as well as better artificial intelligence and robotic visual scene analysis, crucial for new technologies such as driverless cars," Greenberg says.

370,000+

More than 370,000 Americans each year undergo heart bypass surgeries, many of which use vessels harvested from the patient to improve blood flow to the heart. While lifesaving, vessel harvesting is expensive, painful and risky, and not all patients have suitable vessels available.

Dr. Brandon Tefft, assistant professor of biomedical engineering, earned a $1.9 million grant from the National Institutes of Health to establish an autologous endothelium (a single layer of tissue cells originating from the patient) on small-diameter bypass grafts. Because synthetic grafts and vessel harvesting are often poor options for many patients, Tefft's research aims to combine synthetic grafts with living cells as a superior approach. His research team will accomplish this by "identifying novel molecular signaling targets for molecular modulation strategies to promote cellular adhesion strength," he says. "We hope to enhance the health of all patients with coronary heart disease, so that they can live longer and more productive lives."

DR. ROBERT SCHEIDT
BIOMEDICAL ENGINEERING

IMPROVING HOW ROBOTICS-BASED THERAPIES RESPOND

"Intelligent machines will need to model and predict how people naturally respond to dynamic changing events as they unfold in time. Accurate models do not yet exist."

Robotics-based therapies have been used in stroke recovery since the late 1990s. But with all the advancements rehabilitation robotics and human-machine interaction offer these patients, researchers recognize that artificial intelligence is limited in effectively estimating human intent. This is a critical disadvantage — people are not interested in assistive devices that resist their movements should they decide to change course.

"If the coming wave of intelligent physical assistants is to be widely accepted, they will need to respond appropriately to changes in the user's intended actions during physical interaction with people and things that often move unpredictably," says **Dr. Robert Scheidt**, Eng '89, professor of biomedical engineering. Scheidt and his research team, composed of biomedical engineering and Klingler College of Arts and Sciences faculty, are working on a National Institutes of Health grant to advance a fundamental understanding of how a healthy brain integrates information from vision and other sensory input to correct movement errors that often occur when a person reaches toward moving targets.

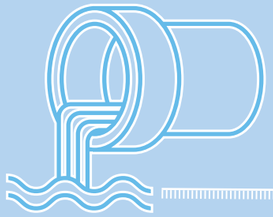
"Intelligent machines will need to model and predict how people naturally respond to dynamic changing events as they unfold in time. Accurate models do not yet exist," Scheidt adds. Their research will focus on neurologically intact subjects, as an understanding of how healthy brains integrate sensory, motor and cognitive functioning to control movement is key to advancing therapeutic interventions needed to improve motor function after neuromotor injury.

Scheidt's long-term goal of this research is "to leverage low-cost wearable technologies to address the impact of each patient's neural injury on their ability to perform everyday activities, and to help them respond appropriately when movements do not proceed as planned."

SIGNAL BOOST

Although famous cosmologist Stephen Hawking brought much attention to the progressive neurodegenerative disease amyotrophic lateral sclerosis, or ALS, not much is known about why people get it or how to track its debilitating progression in nerve cells. **Dr. Brian Schmit**, Eng '88, Hammes Family Endowed Chair and Professor of Biomedical Engineering, is part of a team that includes researchers from the Medical College of Wisconsin who've been awarded $486,000 from the National Institutes of Health to develop a technique for monitoring motoneuron degeneration. Researchers will use external electrodes to measure signals from the nerves of people with and without ALS as they perform different levels of effort. Schmit and Dr. Xiaoyan Li, principal investigator from MCW, will then employ artificial intelligence programs to analyze these signals and find patterns that can be used later, for instance, in a medical device that can test how much a patient's motor neuron function is declining. Ultimately, the information can help clinicians develop better treatment plans for patients with ALS to improve care. — **Tracy Staedter**

WATER



850,000,000,000

In 2004, the Environmental Protection Agency estimated that all communities with combined sewers released 850 billion gallons of untreated wastewater a year into rivers and lakes, affecting both human and environmental health. To address this challenge, water level and velocity data are collected from system pipes to help make infrastructure and operations decisions. Existing technologies, however, often produce inaccurate data and cannot detect critical sewer events.

Dr. Walter McDonald, assistant professor of civil, construction and environmental engineering, has partnered on a startup called Water Intelligence LLC, which provides real-time, reliable flow data to avoid sewerage overflows and basement backups. The company developed a patent-pending non-contact sensor that collects video of sanitary sewer system flows by using optical flow algorithms to measure water level, velocity and flow rate, which can detect blockages and illicit discharges. McDonald's startup team is seeking additional research funding to work through some technical hurdles that are crucial to commercializing the innovative technology.

DR. ANTHONY PAROLARI
CIVIL, CONSTRUCTION AND ENVIRONMENTAL ENGINEERING

ANALYZING GREEN INFRASTRUCTURE RESULTS

Restoration of urban green spaces has gained footing nationally as a strategy to offset ecological effects of urban development. But despite this momentum, green infrastructure performance is highly variable and uncertain, according to **Dr. Anthony Parolari**, assistant professor of civil, construction and environmental engineering.

Building on previous research in which he monitored the effects of soil types and hydrology on nutrient cycles in green infrastructure, Parolari has built a pilot-scale field experiment at Green Tech Station in Milwaukee to test and compare eight bioretention design and maintenance strategies. (Read related story on p. 2.) He is testing whether soil design, vegetation management and irrigation strategies can be used together to achieve desired water-quality outcomes. He will analyze the data collected from the experiments to test hypotheses related to green infrastructure performance, which he hopes will lead to guidelines on best practices for design and maintenance.

"Stormwater pollution causes billions of dollars per year in lost recreational use, reduced property values, and increased costs of endangered species recovery and drinking water treatment," Parolari says. "Our research focuses on understanding the pollutant removal performance of these green infrastructure systems and will test the effect of combining commonly used design strategies — soil amendments, water management and vegetation management."

200+

Quaternary ammonium compounds, or QACs, are active ingredients in more than 200 disinfectants recommended for destroying the virus that causes COVID-19. QACs inevitably make their way into wastewater treatment plants, and some will subsequently end up in lakes, rivers and streams. The impact these disinfection chemicals have in treatment plants and receiving waters is largely unknown, but the concern is that they are harmful to aquatic life and may contribute to the spread of antibiotic-resistant microorganisms.

Dr. Patrick McNamara, Eng '06, associate professor of civil, construction and environmental engineering, has National Science Foundation funding to address these major gaps in understanding. His research team will assess the compounds in wastewater treatment plants and determine what happens to them in different plant processes and receiving waters. His research strives to assess the risk of QACs to protect public health while minimizing environmental persistence and effects. "This research is transformative given the expectation of increased QACs due to the COVID-19 pandemic and long-term changes in purchasing of products containing them," McNamara says.

ENERGY EFFICIENCY & INFRASTRUCTURE

$20 BILLION

Estimated losses from the 1994 Northridge (California) earthquake, the last major urban earthquake in the U.S., totaled more than $20 billion. **Dr. Andrew Sen**, assistant professor of civil, construction and environmental engineering, received a National Science Foundation grant to investigate a novel segmented brace design for steel-braced frames used in structures designed to remain safe during large earthquakes. Diagonal braces in these buildings are designed to sustain damage as they dissipate seismic energy, which may leave them permanently deformed or fractured. When this damage needs swift repair post-quake, however, these braces can be difficult and expensive to replace. Sen's segmented bracing scheme is theorized to mitigate the impact of seismic damage in these common systems, as well as enhance seismic resiliency by enabling relatively fast, low-cost replacement of the brace's midspan segment while safely retaining most of the other system components.

DR. ADAM DEMPSEY
MECHANICAL ENGINEERING

PREVENTING METHANE LEAKS IN ENGINES

Diesel-powered machines were a familiar part of **Dr. Adam Dempsey's** childhood in rural Illinois, where he spent summers working for his father's concrete business and on his uncle's farm. He says he fell in love with the internal combustion engine at a young age. Now an assistant professor of mechanical engineering, Dempsey is investigating combustion engine developments to reduce their emissions that are harmful to human health and the environment.

In his latest project, funded with a $3.9 million grant from the U.S. Department of Energy, Dempsey and his colleagues are developing technology to eliminate methane leaks, or slips, from large natural-gas-powered engines, called lean-burn engines, used in the gas pipeline industry. Methane is the second most abundant greenhouse gas in the atmosphere next to carbon dioxide, but its potential to trap atmospheric heat is 25 to 80 times more potent than that of CO_2.

Methane slip happens when gas premixed with air becomes trapped in crevices inside a lean-burn engine. When the spark plug located at the top of the engine's combustion chamber ignites the gas-air mixture inside, the trapped gas doesn't burn. When burned, methane becomes CO_2, which is still a greenhouse gas but one that causes less damage.

Dempsey's team proposes replacing the spark plug with a fuel injector that directly injects natural gas into the combustion chamber. It's ignited before it has a chance to sneak into crevices.

"We are proposing that we can reduce the methane slip from these engines by about 90 percent," Dempsey says.

That could be a major victory — half of the methane produced by human activity comes from the natural gas pipeline industry. — **Tracy Staedter**

50 YEARS

More than half of the nation's pipelines are at least 50 years old. While fuel-carrying pipelines are generally regarded as safe, critics blame aging pipes and insufficient oversight for hundreds of annual accidents. **Dr. Qindan Huang**, associate professor of civil, construction and environmental engineering, is developing artificial intelligence-enabled tools to improve the accuracy of probabilistic performance modeling, a methodology the pipeline industry uses to inform inspections and repairs. Huang says better processing of pipeline inspection data can minimize data errors and improve risk assessment and decision-making. "Developing AI-based solutions that can identify connections between pipeline safety datasets through data analytics; developing data-driven probabilistic failure models of pipeline corrosion; and optimizing decision-making of pipeline inspection and repair timing will save costs," she says.

TECHNOLOGY & SYSTEMS

DR. CHUNG HOON LEE
ELECTRICAL AND COMPUTER ENGINEERING

SENSOR PROTOTYPE SPARKS RARE DEAL

For **Dr. Chung Hoon Lee**, associate professor of electrical and computer engineering, involvement in Milwaukee's Water Equipment and Policy Center has been a boon. With feedback from industry partners, Lee developed a waterborne lead sensor that continuously monitors water for heavy metal contaminants without ever contacting it, thereby limiting corrosion and the sensor failures that result from it. The technology was so appealing to the water industry that it sparked a rare licensing agreement that Marquette's Office of Economic Engagement negotiated with five WEP-member companies: A.O. Smith, Badger Meter, Pentair, Watts Water Technologies and GE Appliances, a Haier Co.

Lee's sensor is called a block loop-gap resonator, which tests for the presence of lead and other heavy metal contaminants in water. Feedback from industry partners identified specifications for the prototype early on, such as the need for continuous detection; a cost of $1 per sensor; and the ability to easily integrate it into existing water systems.

After some trial and error and feedback from the partners, Lee made a device that looks like a small metal box pierced with a quarter-inch diameter glass tube. A water sample goes inside the tube, preventing it from contacting metal components and corroding them. Inside the box, an alternating electrical current emits microwaves that permeate the glass tube and reflect off charged metal ions in the water. Those that bounce off lead ions produce a slightly different microwave signal than those that bounce off other ions. The reflected microwave amplitudes are analyzed using a machine-learning algorithm to evaluate the concentration of lead in water.

Lee's current prototype can be tuned to work well with water from specific municipalities but needs more technological tweaking before it's universal. Nonetheless, industry partners recognized the potential for incorporating the technology into their products without stepping competitively on one another's toes. —Tracy Staedter

45+ PATENTS

held by **Dr. Ayman EL-Refaie**, the Thomas H. and Suzanne M. Werner Endowed Chair in Secure and Renewable Energy Systems, inform his groundbreaking research around electrifying transportation and renewable energy solutions. Considered a lead educator and influencer of engineering communities across the globe, EL-Refaie was named the 2021 Engineer of the Year by STEM Forward, metro Milwaukee's leading STEM education and outreach provider. The award follows previous achievements, including multiple multimillion-dollar grants and being named an IEEE Fellow, one of the highest grades of recognition for the field. Some of his latest work, supported by the Department of Energy, includes development of electric drivetrains free of rare-earth metals for hybrid/electric-powered vehicles and aircraft.
— Tracy Staedter

"Just like snowflakes, there are no two soot particles that are perfectly alike."
—Dr. Somesh Roy

DR. SOMESH ROY
MECHANICAL ENGINEERING

SECRETS OF SOOT

Turn up a thermostat, preheat a gas stove, start a car, and carbon atoms caught up in the resulting combustion clump together as soot. These particles are linked to cancer and heart and lung diseases and are a pollutant that ranks with methane among the most significant contributors to climate change.

Reducing soot is important, but so too is mitigating its presence. With support from a five-year, $550,000 National Science Foundation CAREER Grant, **Dr. Somesh Roy**, assistant professor of mechanical engineering, is working toward cultivating a deeper understanding of how soot forms, grows and spreads in the environment.

Soot particles come in a wide variety of sizes and shapes with a range of properties. "Just like snowflakes, there are no two soot particles that are perfectly alike," Roy says. Differences in surface area, volume, shape and other properties alter the way soot particles affect human health and how they absorb, scatter and reradiate heat energy from the sun.

With help from Raj, Marquette's high-performance computing cluster, Roy will create computer simulations of combustion at the molecular level. Roy says when he and his team have many, many simulations of sooty "snowflake" evolution, they will use machine learning, an artificial intelligence technique, to predict how molecular interactions of soot influence the world at large. The knowledge gained "can help guide policy to limit particular sources and mitigate the effects of soot."

On the way to new, fundamental understandings of soot formation, Roy will partner with Marquette's Haggerty Museum of Art to create outreach programs and exhibitions to help the public better understand the role the pollutant plays in society.
— Chris Barncard

In 2021, biomass provided about 5 percent of the total primary energy used in the United States, according to the U.S. Energy Information Administration. Biomass — renewable organic material such as herbaceous and wood waste and agricultural crops — can be used as an alternative energy source.

Biomass gasification — the process of turning biomass into fuel — represents a sustainable and potentially carbon-neutral technology to generate electricity and produce liquid fuels and chemicals. **Dr. Simcha Singer,** assistant professor of mechanical engineering, is using a National Science Foundation award to understand the complex geometry of the small, porous biomass char particles formed during gasification, which has a strong effect on biomass conversion and process efficiency. By using high-resolution 3D imaging and simulations of the gasification of biomass char particles from several feedstocks, Singer expects his project will generate fundamental knowledge and modeling capabilities for the impact of real particle geometries, which will help design more reliable and efficient gasifiers.

"This work will help advance clean bioenergy technologies that reduce pollution, mitigate environmental damage and increase efficiency," Singer says.

AT HOME

The Engineering Living Learning Community offers academic support and social connection for first-year students.

BY MATT CURRAN

Tim Winger, Eng '22, arrived at Marquette from California to a campus full of strangers. Though enrolled as an engineer, he considered himself undecided and worried engineering might not be the right fit.

"I truly believe that without living in the Engineering Living Learning Community, I would not be an engineer today," Winger says.

The Engineering Living Learning Community, or LLC, is co-led by the Opus College of Engineering and Office of Residence Life to help more than 70 first-year engineers transition into life at Marquette. From study sessions and student success workshops to beach days and bonfires, engineers in the LLC receive academic and social support to help find their footing on campus.

Clare Murphy, Eng '22, still remembers making valentines with her floormates during that first cold February at Marquette. The LLC gave her more than happy memories though; it helped Murphy find her voice. "The LLC increased my confidence to put myself out there and introduce myself," she says, explaining that this continues to empower her to expand her professional network and land engineering jobs.

Grateful for his freshman year in the LLC, Winger returned as a peer mentor for his next three years at Marquette. "I knew that I wanted to help this program flourish and help other freshmen, like myself, thrive in engineering," he says. Winger credits the mentor role for broadening his worldview as he met more students seeking his help. Plus, he now has a long list of friends to rely on — at least one partner from the LLC was in almost every one of his engineering group projects.

Organized by Jenna Lassila, Grad '15, the Opus College's assistant director of academic advising, and Tracy Gerth-Antoniewicz, assistant director of residence life education, the community continues to adapt to maximize engineers' early success. The team has found that engineers participating in the LLC are about 10 percent more likely to be retained from first to second year than their non-LLC counterparts.

Marquette University, P.O. Box 1881, Milwaukee, Wisconsin 53201-1881 USA

REIMAGINING INNOVATION.

At the Opus College of Engineering, we believe innovation starts with people. We're driving innovation by shaping those who will lead it. From designing skills-based programs in partnership with corporations to offering career-forward graduate education programs to building a centralized hub for innovation leadership, we're creating opportunities for students, faculty and alumni to not only be innovative, but to lead innovation. Opportunities such as:

Excellence in Leadership (E-Lead)
A leadership development program for undergraduates that develops a student's capacity to lead, with an emphasis on innovation.

Bridge to Business
A non-credit program that gives early career engineers the business fundamentals they need to be successful in their organizations.

Innovation Alley
A Marquette innovation ecosystem that facilitates interactions between faculty, students and industry to promote novel solutions to real-world problems.

Find your opportunity at **marquette.edu/engineering**.

MARQUETTE UNIVERSITY

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