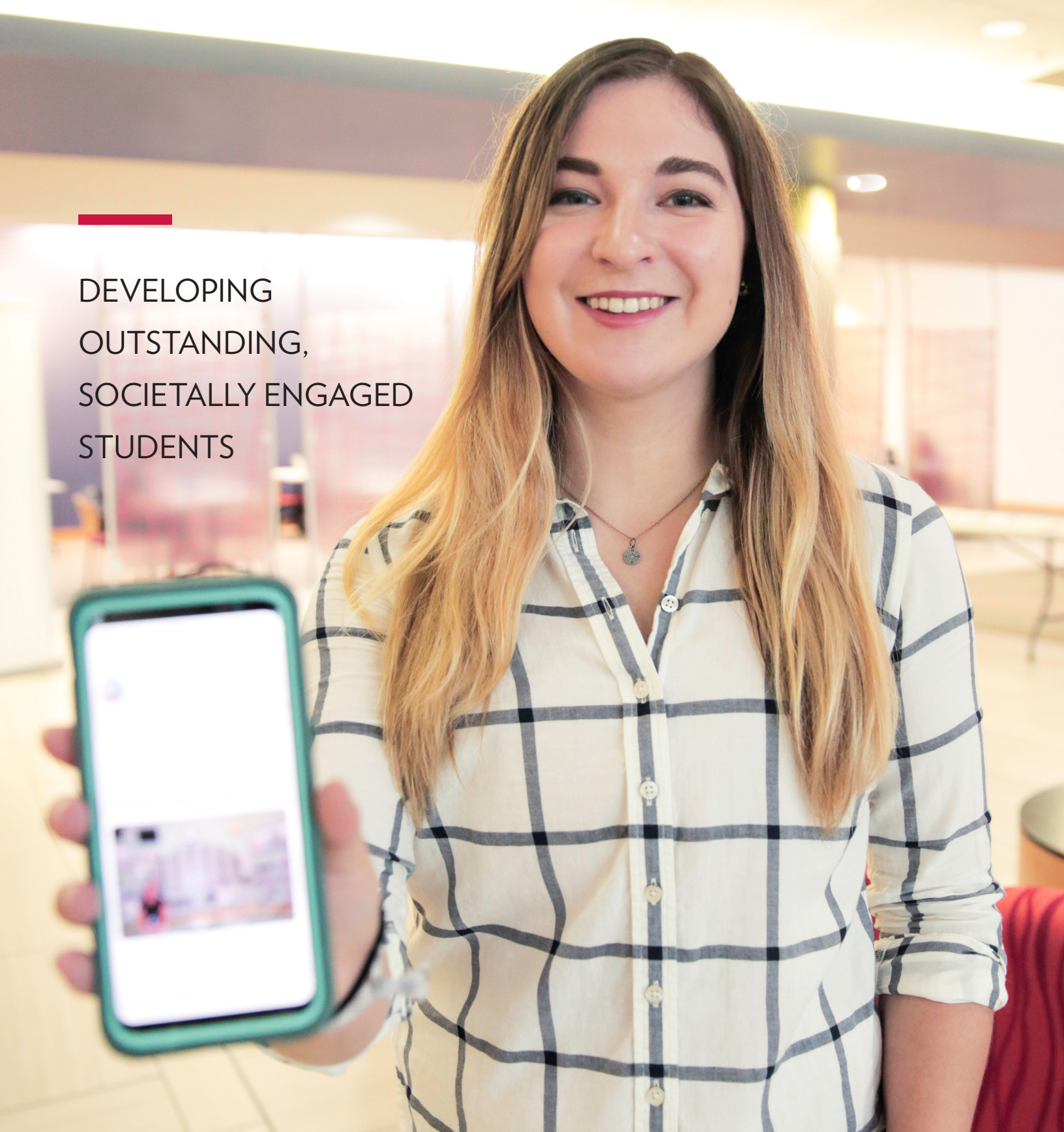
FALL 2018

ENGINEERING PHYSICS

UNIVERSITY OF WISCONSIN-MADISON



DEVELOPING OUTSTANDING, SOCIETALLY ENGAGED STUDENTS

CHAIR'S MESSAGE

Greetings!

We already are in the middle of our new academic year and it promises to be an exciting one for our department.

We have a new member of our faculty this fall who will be instrumental in our future vision and direction. Assistant Professor Jennifer Franck comes to us from Brown University with a background in computational fluid dynamics. Her expertise is in the area of modeling high Reynolds number flows, particularly unsteady fluid flow phenomena and fluid-structure interaction. She will apply her computational tools to applications in aeronautics, wind/tidal energy, and flow control techniques that can mitigate flow-induced vibrations and fatigue. She is excited about the opportunity to build connections to industry and to apply her computational tools to the development of emerging technologies.

The U.S. Department of Energy awarded nearly $4.7 million in Nuclear Energy University Program grants to numerous researchers in our department. Of the 39 U.S. universities, UW-Madison garnered the largest funding total from direct awards in 2018, not including sub-awards from other sources. Kumar Sridharan, Adrien Couet, Raluca Scarlat, Todd Allen and James Blanchard are among the faculty who will be able to expand their research areas with this increase in funding. The DOE also recently awarded funding to Professor Ray Fonck's group to completely reimagine the Pegasus lab. This award will bring our department and UW-Madison to the forefront of research in the fusion area nationally.

I again thank you for your support of our department. Your gifts are essential in our ability to recruit and hire outstanding faculty members who allow us to continue to provide an exceptional education to our students, conduct world-class research, and enhance our national reputation. You can make a gift online at **allwaysforward.org/giveto/ep** or reach out to our development director, Valerie Chesnik, at Valerie.Chesnik@supportuw.org. She can work with you to ensure that your gift will have the greatest impact on the department.

ON, WISCONSIN!

Douglass Henderson
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Dean Ian Robertson, Chancellor Becky Blank and Foxconn leadership, including founder and CEO Terry Gou, on the engineering campus in August 2018. *Photo: Bryce Richter*

$100 million Foxconn gift launches major new partnership

Foxconn Technology Group and its chairman and founder, Terry Gou, announced plans to invest $100 million in engineering and innovation research at UW-Madison, while also creating the framework for a science and technology institute that will collaborate closely with the company's facilities in southeast Wisconsin.

The Foxconn investment will include funding to help establish a new interdisciplinary research facility for the College of Engineering on the UW-Madison campus.

Gou and other senior Foxconn executives visited campus on Aug. 27, 2018, and with university officials signed several agreements designed to formalize and streamline their future working relationship.

The agreements formalize Foxconn's commitment to activities such as research, recruiting, creating opportunities for internships and hands-on work in campus labs. In addition, the planned new engineering building will enhance the college's capabilities.

Areas of potential study could include advanced technology on panel, biochips, semiconductors, application-specific integrated circuits, smart building, smart infrastructure and smart city development, high-performance computing, high-speed communications networks, cloud server storage, sensors, robotics and IT systems.

There will also be a focus on advancing research on human health in areas such as genomics, immune cell research, clinical data integrity and processing, and medical imaging in cancer and related diseases. Foxconn and UW-Madison will work together to identify and develop initiatives to promote technological advancement, education and scientific outreach.

Read more: www.engr.wisc.edu/100-million-foxconn-gift-launches-major-new-partnership-uw-madison/

FOCUS ON NEW FACULTY

JENNIFER FRANCK IS MODELING COMPLICATED FLOWS TO IMPROVE ENERGY SYSTEMS

Picture a fish swimming in water. As its fins move, they're constantly creating new flows and swirls in the fluid and producing vortices in the fish's wake.

Such turbulent flows are highly complex and ever-changing. And for researchers who study fluid flow, it's challenging to uncover the fundamental fluid mechanics that govern the flow. In fact, it's even difficult for a supercomputer to do it in a way that's practical for an engineering application.

"This area has a big challenge in that the computational resources needed to resolve one of these really complicated flows is insurmountable," says Jennifer Franck. "So instead you have to create models and make informed guesses about what the flow will do."

Franck, who joined the department as an assistant professor in fall 2018, works in the area of computational fluid dynamics. In her research, she focuses on developing new computational tools to investigate the physics of unsteady fluid flows.

"By gaining a better understanding of the flow physics, my goal is to harness these fundamental principles to help improve the performance of existing engineering systems and also to push new technologies forward," Franck says. "I tend to take new computational methods and apply them to real engineering challenges."

Franck is especially interested in applying her computational tools to renewable energy applications such as wind energy. For example, by modeling the interaction between the wind and turbine blades, she aims to enable better blades. These larger blades could produce more energy while also being less susceptible to vibration and mechanical failure as they're buffeted by the wind.

This research involves exploring how placing actuators on the surface of a turbine blade could modify airflow to produce desired results. The actuators might pulse and, in turn, generate flows that would reduce the wind load on a section of the turbine blade. The concept also has aeronautics applications. For example, actuators on an airplane wing could alter the flow around the wing to more efficiently produce lift or reduce drag. By collaborating with engineers who are experimenting with new kinds of actuators, Franck hopes her models will help advance this emerging technology.

Franck is trained as an aerospace engineer, and she also has a passion for coding and computation. "So this research blends my two interests very nicely," she says. "I get to do a lot of coding, and I also get to help people build things and design new engineering systems, which is very satisfying."

After earning her master's degree in aeronautics and PhD in mechanical engineering from the California Institute of Technology, she completed a postdoctoral fellowship at Brown University. She was on the faculty at Brown for seven years before joining UW-Madison.

During her time at Brown, Franck was part of a team that developed a prototype tidal energy harvesting system. The system uses underwater devices shaped like flat plates, which are connected to a generator. As the water flows through the system, it moves the devices and generates electricity.

Using Franck's models, the team found that oscillation is the best way for the devices to move, and that stacking them close to each other in arrays would generate more energy.

"But stacking them is complicated, because each device leaves behind wakes of swirling fluid, so you have to optimize the placement to take advantage of these 'vortex wakes,'" she says. "By modeling the unsteady fluid mechanics, I'm trying to come up with optimal stacking configurations."

Franck also draws inspiration from phenomena like geese flocking and fish swimming in schools. "I'm getting some ideas from the patterns these animals are arranged in, and looking at it from an energy-harvesting angle," she says.

In addition to her research, Franck is passionate about teaching and working with students. She is excited to be teaching aerodynamics in fall 2018. "I think it's really cool," she says. "It's a course that I love to teach."

"My goal is to harness fundamental principles to help improve the performance of existing engineering systems and also to push new technologies forward."

LIFT OFF, WISCONSIN! STUDENT TEAM SHOOTS FOR THE STARS IN ROCKET CONTEST

Wisconsin's state motto may be "Forward," but a team of engineering students from UW-Madison is looking upward at the stars.

The students are setting their sights sky-high, aiming to design, build and launch a liquid-propelled rocket capable of breaching the boundary of outer space.

If they are the first team to achieve this lofty goal by Dec. 30, 2021, the students stand to win a $1 million prize in a first-of-its-kind contest called The Base 11 Space Challenge, sponsored by the companies Base 11, Dassault Systems and Spaceport America.

Designed to encourage more students, especially those from minority backgrounds, to join the next-generation aerospace workforce, the challenge pits university teams from around the world against each other in a modern-day space-race.

More important than the prize money, though, the students are helping humanity blaze beyond the final frontier.

"I'm passionate about a future where we are exploring the cosmos," says Brandon Wilson, a senior majoring in engineering mechanics and astronautics who is the team's co-founder and technical lead. "In the long term, I hope to work toward exploring other stars."

That passion motivates all 21 of the students on the UW-Madison team, who will also gain real-world experience constructing a rocket.

The students are shooting to achieve an altitude of 100 kilometers—the so-called Kármán line that marks the threshold of where Earth's atmosphere ends and outer space begins.

In order to achieve such great heights, the students plan to build a liquid-propelled rocket more than 20 feet in length and weighing more than 1,000 pounds.

UW-Madison has performed well in other aerospace contests, with the Badger chapter of the American Institute of Aeronautics and Astronautics posting solid top-10 finishes in solid-fuel rocket competitions.

But the Base 11 Space Challenge will push the students like never before.

"We've never done liquid rocket engines on campus, so we have to start from the ground up," says Wilson.

But starting from square one isn't necessarily a disadvantage. In fact, freedom to innovate gives the student team a metaphorical leg up over private industry.

"We're starting fresh, we have no constraints, we can explore new technology without the development costs that companies might have," says Wilson.

Preliminary designs are due by March 2019, and the students aim to build a small-scale prototype within the same timeline. During the competition's first year, the students are beginning to fund-raise, seek out corporate sponsorships, and establish a local space-race infrastructure, including rocket testing grounds.

They're aiming to test-fire their first prototypes by spring 2019.

Win or lose, the competition will serve as a launchpad for the students' careers in the aerospace industry. Perhaps more importantly, though, the contest represents a chance for the students to embody the Wisconsin Idea all the way beyond the classroom and into the stars.

The leadership for the UW-Madison team in the Base 11 Space Challenge. From left: William Gorecki, Travis Sheperd, Brandon Wilson, Mary Claire Mancl, Max Goldberg, Vincent Bensch.

Investigating new materials for advanced reactors

The U.S. Department of Energy Nuclear Science User Facilities (NSUF) awarded grants to three UW-Madison researchers for their rapid turnaround experiment projects in 2018.

All of the research proposals submitted by UW-Madison researchers were awarded funding out of a total of 33 selected projects. The recipients, all members of Assistant Professor Adrien Couet's research group, include PhD students Michael Moorehead and Zefeng Yu and assistant scientist Mohamed Elbakhshwan.

First established at Idaho National Laboratory, NSUF is the nation's only user facility overseen by the Office of Nuclear Energy. NSUF provides research teams with access to reactor, post-irradiation examination, high-performance computing, and beamline capabilities at a diverse mix of affiliated partner facilities in university, national laboratory and industry institutions across the country at no cost to the user.

Couet's research focuses on accelerating the development of alloys that can sustain the harsh environments of a nuclear reactor core. His research integrates high-throughput experiments with fundamental understanding and modeling of irradiation and corrosion mechanisms.

The next generations of nuclear reactors require materials that are resistant to radiation damage and corrosion in harsh environments (liquid metal, gas or molten salts, depending on the reactor design) at relatively high temperatures for extended periods of time. High entropy alloys (HEAs) are a new class of alloy systems, and some HEAs possess many attractive properties such as high strength, thermally stable microstructure, low inter-diffusion and high oxidation resistance. Therefore, Couet says HEAs are a natural choice for developing new materials that would ultimately enable advanced nuclear reactors.

Read more: **www.engr.wisc.edu/uw-madison-researchers-highly-successful-garnering-doe-nuclear-science-user-facilities-awards/**

After hurricanes, Puerto Rican grad student finds second research home at UW-Madison

In September 2017, Hurricane Maria slammed Puerto Rico just days after Hurricane Irma blew through. The public utility was still in the midst of repairing its already tenuous electric grid—and the back-to-back storms dealt the fragile network a death blow with prolonged ramifications.

The U.S. territory's woes since Hurricane Maria have received widespread attention. Power outages have been measured not in hours since Maria, but in weeks and months. The initial storm damage and the lingering outages combined have made conducting scientific research at UPRM and other universities in Puerto Rico extremely difficult, if not impossible—not to mention the storms' toll on food production, tourism and the rest of the island's economy.

Power outages are less frequent today, but still occur occasionally, and there's an ever-present anxiety that power interruptions could trigger additional setbacks in ongoing research projects.

These problems pose a particularly acute dilemma for researchers whose work is funded by time-limited grants and for students trying to complete their degrees. How can they maintain momentum in their careers while some of the power infrastructures remain unsettled in Puerto Rico?

That question has been answered by a call to action within the UW-Madison College of Engineering, as the dean's office asked faculty to consider supporting Puerto Rican scholars. In response, Professor and Chair Douglass Henderson reached out to faculty at UPRM who work with nuclear engineering students and was put in touch with a graduate student who was facing the prospect of a significantly delayed master's degree.

Normarieli Passalacqua began her master's program at UPRM in 2016. She studies carbon nanotubes and their use in reinforcing polymers, and her research requires the use of a scanning electron microscope, which helps her characterize the materials she's studying, and a dynamic mechanical analyzer, which allows her to conduct tension and compression tests and other mechanical tests on those same materials. Following the hurricanes and power outages, heat and humidity damaged the specialized instruments. Technicians with the specialized skills to repair the instruments are few and far between, and with the scale of the disaster in Puerto Rico, there was no timetable for making repairs, Passalacqua says.

"In Puerto Rico, we already don't have too much research equipment, and after Hurricane Maria, we had almost no equipment," says Passalacqua. "You need a lot of money to fix these instruments, and some universities in Puerto Rico don't have the funds for that. It's a really bad situation."

Still, Passalacqua was lucky enough to have samples that do not require refrigeration or advanced climate control. She says that many of her colleagues lost all of their materials, sometimes representing years of work. Without the invitation from Henderson and UW-Madison, Passalacqua says her research—and degree—would also be delayed by at least a year.

Passalacqua arrived in Madison in March 2018 and was given access to office and lab space for more than two months so she could characterize her samples and complete her degree on time. In Madison, she worked with Distinguished Research Professor Kumar Sridharan.

"This has been so good," Passalacqua says. "I feel welcomed in Madison. People are always willing to help me."

ADVOCATING FOR NUCLEAR ENERGY WITH SOCIAL MEDIA SAVVY

In an age increasingly defined and connected by online discourse, nuclear engineering PhD student Katie Mummah is taking full advantage of the digital tools at her disposal—all in the name of science.

Mummah is known as "Nuclear Katie" (@nuclearkatie on Twitter) online, where she's leveraged her passion for nuclear science into a social media presence that is at once brimming with enthusiasm for science and nuclear energy and teeming with factual information.

Mummah's goal? To inject the online debate surrounding nuclear technology with some fact-based optimism. Her approach? Frequent info-laden posts supplemented by a healthy dose of the internet's lingua franca: memes, GIFs and retweets. Her online charisma has to-date netted Mummah more than 3,000 followers on Twitter. And while she enjoys engaging in the social media banter, what Mummah really wants is to open minds.

"As a nuclear scientist, I see myself as an advocate for nuclear energy," Mummah explains.

That can be a tricky prospect online, where advocacy can easily be drowned out or even backfire. So Mummah has learned to pick her battles and to shun emotional pleas in favor of sober analysis. "There's a pretty healthy anti-nuclear community on Twitter," Mummah says. "But the only time I choose to engage with that community directly is if I think that my half of a discussion will provide insight for other people reading the thread."

"I'm sharing my enthusiasm for nuclear energy with facts, and in a way that I think is interesting and provides a lot of context."

Implicit in that strategy is the understanding that Mummah and her like-minded peers likely aren't going to change the minds of people who already solidly oppose nuclear energy. Instead, Mummah wagers that she can wield facts to provide a credible counterpoint to naysayers. And she counts on her personality and her respectful, positive tone to starve the trolls, who tend to feed on emotional pleas and negativity.

Mummah has spent the last two summers conducting research at the Los Alamos National Laboratory in New Mexico.

"My approach to social media is all about balance," Mummah says. "There are nuclear scientists who only present facts and are very dry. Then there are really emotional people. I try to sit in between, where I'm sharing my enthusiasm for nuclear energy with facts, and in a way that I think is interesting and provides a lot of context. I like to answer questions and to be respectful when I'm making a point."

The final ingredient in Mummah's social media success is the sheer profusion of her enthusiasm for nuclear science in the form of nonstop activity. Her prolificity is a constant whether she's preparing for qualifying exams or working on her research, in which she models the nuclear fuel cycle from mine to repository. Mummah hopes the computer models she's developing will make it more efficient for the International Atomic Energy Agency (IAEA) to keep track of nuclear materials in the future. That's a must if nuclear energy is to become more widely available worldwide, which Mummah contends is itself a must if the world is serious about moving away from fossil fuel-derived energy.

"At the end of the day, we're going to need a diversity of energy sources going forward," Mummah says. "Wind, solar and nuclear fit different needs, and nuclear will be necessary for a baseload source. At the same time, we'll need the wall between nuclear energy and nuclear weapons to be as strong as possible if we want nuclear energy to expand."

Mummah believes her high-power computational models, which draw on complex physics models and systems models, will help the international community keep nuclear materials safe throughout their lifecycle.

The federal government's national laboratory system also sees promise in Mummah's efforts. In 2018, Mummah spent her second summer conducting research at Los Alamos National Laboratory in New Mexico, where she was funded by a Glenn T. Seaborg Institute summer fellowship to continue developing her models. The fellowship was funded through the Los Alamos and Lawrence Livermore National Labs as a part of the National Security Education Center.

"Basically, this summer I wanted to see if the models I've been working on at Wisconsin could be integrated with tools that'll go to the IAEA," she says. "I wanted to know: Can these models be of benefit? Is this something that'll be useful. The verdict is 'yes.'"

2018 ENGINEERS' DAY AWARD RECIPIENT

W. Kent Lorenz: Distinguished Achievement Award

Chairman and CEO (retired), Acieta LLC
BSEM '84, UW-Madison

Each year, the College of Engineering recognizes outstanding alumni during Engineers' Day—a celebration of engineers, held on Homecoming weekend. EP alumnus Kent Lorenz is among the engineers we honored in 2018.

For the better part of his career, Lorenz has worked in industrial robotics. His interest in applying emerging technologies enabled him to make significant contributions in advanced automated machining solutions. Starting as a sales engineer for Ellison Technologies in 1985, he ultimately became chairman and CEO of its spinoff, Acieta LLC, retiring in 2017. He now is the managing partner for a commercial real estate company and serves on numerous boards of public and private companies.

We honored Lorenz for his dedication as a leader whose efforts to advance industrial robotic automation have led to new and improved manufacturing processes. These advancements have helped to improve quality, lower costs and increase safety for North American manufacturers. His passion in industrial robotics has also inspired future generations of engineers through his work with Project Lead the Way and the Schools to Skills programs.

We chatted with him about everything from his memories as a student at UW-Madison to his career and hobbies. Here are his responses to some of our questions.

Is there a professional accomplishment of which you are most proud?

I was part of the Ellison Technologies senior management team consisting of three regional presidents and a CEO. We grew the company from $60 million to $650 million in revenue and expanded the workforce from 100 employees to almost 700 employees. We were a machine tool and industrial robotics engineering and integration company, providing CNC milling, turning and grinding solutions to North American manufacturers and their worldwide subsidiaries. There is no doubt that my engineering education provided me with the ability to meet with customers and apply complex technologies to provide solutions to their manufacturing challenges.

Why did you choose engineering?

In middle school, my family moved from Madison to Waukesha, Wisconsin. I went to Waukesha North High School and found that I really liked math. I took all of the electives that I could in math and physics. I distinctly remember sitting down with my high school physics teacher, Mr. Mitchell, during my junior year. He said, "Have you ever considered a degree in engineering?" I said, "No, not really. Tell me about it." He said, "Well, you're really good at math and physics, and that's what engineers do. So, I think you should look at UW-Madison's engineering program."

The other driver in selecting UW-Madison was that, due to my being a gymnast in high school, I was being recruited by the gymnastics coach at Madison. So, for my first three years, I was on the varsity gymnastics team, traveling and competing throughout the Big 10 for UW-Madison.

What is your fondest memory of your time at UW-Madison?

In the fall of 1983, Marching Band Director Michael Leckrone contacted the gymnastics coach and said, "We're going to do a three-ring circus act for the halftime show. Could we get some gymnasts to come out on the field and be circus performers doing some tumbling, flips and handstands as part of our show?" I volunteered along with several other teammates. We performed on the field with the band at halftime, but the best part was the Fifth Quarter. When the band started playing after the game, one other gymnast and I ran back onto the field and to the north end zone and shimmied up the goalpost. As the Bud song began to play, we both simultaneously did handstands on the crossmember of the goalpost, while clapping our feet in rhythm to the song. The student section went wild!

Who has played the greatest role in your achievements?

There's a lot of people that have had a hand in my career and my development. But certainly my father is number one. My dad and I are very close, and I have always used him as a sounding board for business and personal advice. I would also have to say Jim Ellison, who was the son of the founder of Ellison Technologies. Jim's invitation to me to become an owner in the company in 1993 turned out to be life changing for my family and me personally.

What do you enjoy in your free time?

My wife, Abby, and I are pretty physically active. We snowshoe, cross-country and downhill ski, and snowmobile in the winter. In the summer, we're involved in competitive water skiing. We also hike quite a bit, and we love to kayak. We basically try to do a fun, physical activity several days a week together. We are also both involved in a number of nonprofits, educational groups and charitable organizations. We feel it's important to give back to your community in multiple ways to have a positive impact on others' lives.

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STUDENT MAKES A DIFFERENCE WITH SUMMER INTERNSHIP IN URUGUAY

Sophomore Alex Plum, from Whitefish Bay, Wisconsin, sought a summer internship that would enable him to take what he was learning in the classroom and apply it to improving people's lives. He also wanted to hone his Spanish and work in an interdisciplinary research environment.

He found all that and more in Maldonado, Uruguay, where he interned with Centro Universitario de la Región Este.

Through his work in a lab, he helped ensure the sustainability of a reservoir near the city of Minas that many residents depend on for high-quality water. The reservoir recently had come under threat due to increasing afforestation and agriculture within its watershed.

"Our job was to study all aspects of the reservoir and come up with recommendations for regulators and for those who manage the dam on the reservoir," Plum says.

He collected samples and measurements from the reservoir during day-long sessions of field work. He helped develop a hydrodynamic model of the reservoir, and he designed a land-change forecasting model to determine how the water quality in the reservoir would be affected by various hypothetical changes to its watershed.

Plum says he also enjoyed getting to cheer on Uruguay's victories in the 2018 FIFA World Cup with locals.