UMaine Engineering

2019/2020

ENGINEERS AS ENTREPRENEURS

University of Maine innovation solves problems and shapes the future

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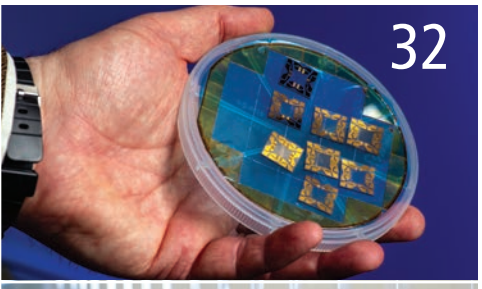


These are exciting times for the College of Engineering. In September, we revealed that E. James (MEE'64) and Eileen P. Ferland are the primary naming donors for the Engineering Education and Design Center. Their $10 million gift is critical to the construction of this new building that will be named in their honor. In October, we announced that Pratt & Whitney pledged $1 million to name the Tool Lab Suite in the Ferland EEDC.

This project is truly a team effort with more than 435 individuals and corporations having made contributions. The fundraising for this $77 million to $78 million project totaled more than $67.6 million as of early November. With continued help from our alumni and friends, I am confident we will raise the remaining funds. Groundbreaking is planned for spring 2020, with completion two years later. The building will be open for classes in fall 2022 and will transform how we teach engineering.

In October, the Advanced Structures and Composites Center unveiled the world's largest 3D printer. It can print thermoplastic structures up to 60 feet long by 22 feet wide by 10 feet tall. The machine printed a 5,000-pound, 25-foot-long powerboat in 72 hours. This is the world's largest 3D printed boat and has become a worldwide internet sensation.

Our excitement goes even further. Our online B.S. in surveying engineering technology, the only accredited program of its kind, has attracted over 100 students from across the country. This two-year-old initiative is nationally ranked for online B.S. programs in engineering.

These developments and more will allow the College of Engineering to fulfill its mission to provide the graduates and new technologies that are critical to moving our economy forward.

Dana K. Humphrey

Dr. Dana Humphrey
Dean, College of Engineering
Saunders Professor of
Engineering Leadership and Management

On the cover The University of Maine's 25-foot, 5,000-pound 3D-printed boat, named 3Dirigo, is the world's largest solid 3D-printed object and largest 3D-printed boat, printed by the largest prototype polymer 3D printer on the planet, according to Guinness World Records. Its debut in October made international headlines. Biobased additive manufacturing research and development by the Advanced Structures and Composites Center has the potential to generate economic development opportunities in Maine and beyond.

On the **horizon**

The E. James and Eileen P. Ferland Engineering Education and Design Center will break ground in spring 2020

Skowhegan natives E. James "Jim" Ferland and Eileen P. Ferland are the formerly anonymous donors whose $10 million investment will help construct the Engineering Education and Design Center at the University of Maine. The new facility will be named in honor of the couple.

The announcement was made by University of Maine Foundation president and CEO Jeffery Mills at the UMaine Alumni Association 2019 Reunion dinner in September on campus, where Jim Ferland was celebrating his 55th class reunion.

A month later as part of Homecoming Weekend, the foundation announced a $1 million pledge from Pratt & Whitney, which will name the center's Machine Tool Suite, featuring more functional, updated space for mechanical engineering technology students to develop production and manufacturing skills. The suite will have open workspace, computer-controlled milling machines and lathes, tool crib, applied research lab, and a computer-aided drafting/computer-aided manufacturing classroom.

"This gift will allow our mechanical engineering technology students to gain the hands-on experience that they need to be effective from day one in their careers. It is so appropriate that Pratt & Whitney named this space since they hire so many of our engineering graduates. I am deeply grateful for the strong and long-standing relationship between UMaine engineering and Pratt & Whitney," says Dana Humphrey, dean of the College of Engineering.

Pratt & Whitney's previous support for UMaine engineering includes a $100,000 gift in 2015, which provided scholarships and equipment for UMaine's MET program.

The $1 million pledge brings the total amount raised in support of the new facility to over $67 million, which includes over 400 gifts from alumni, friends, foundations, corporations and UMaine employees, $50 million invested by the state of Maine, and principal gifts from the Ferlands, $1.5 million from the Gustavus and Louise Pfeiffer Research Foundation, $1 million from the Abbagadassett Foundation and $1 million from the Packaging Corporation of America.

The expected cost is $77 million to $78 million. Groundbreaking for the center is planned in spring 2020, with anticipated completion in 2022.

The E. James and Eileen P. Ferland Engineering Education and Design Center (EEDC) will house the Biomedical

E. James "Jim" Ferland and Eileen P. Ferland Photo by Adam Küykendall

> "The Ferland Engineering Education and Design Center will **transform engineering education at UMaine and for the state**, fostering an even more collaborative community of learners, teachers and partners."
>
> Joan Ferrini-Mundy

Engineering Program and Department of Mechanical Engineering, as well as teaching laboratories for mechanical engineering technology, and provide space for all UMaine engineering majors to complete their senior capstone projects.

According to Mills, the Ferlands' investment gave the EEDC fundraising campaign momentum, inspiring others to believe that "together, this project will be accomplished." Ferland EEDC is the highest capital priority for UMaine's $200 million Vision for Tomorrow Campaign, which has raised over $182 million, led by the University of Maine Foundation.

"We are pleased to make a contribution toward improving the infrastructure at UMaine, and hope others will be encouraged to join in bringing this important project to the finish line," said Jim Ferland.

Jim Ferland and his wife, Eileen, have previously endowed a $1 million Engineering Excellence scholarship at the University of Maine Foundation to encourage students from Skowhegan consider UMaine engineering.

Jim Ferland received a bachelor's degree in mechanical engineering at UMaine in 1964 and began his career as an engineer with the Hartford Electric Light Company, a subsidiary of Northeast Utilities in Connecticut. In his career, he served as president of Northeast Utilities, and chairman, president and CEO of Public Service Enterprise Group.

UMaine President Joan Ferrini-Mundy thanked the Ferlands, Pratt & Whitney, and other UMaine alumni for their contributions, and also recognized the Maine Legislature's critical $50 million investment in this important facility that will benefit Maine and its future workforce.

"The Ferland Engineering Education and Design Center will transform engineering education at UMaine and for the state, fostering an even more collaborative community of learners, teachers and partners," said Ferrini-Mundy. "This new facility will help fulfill a critical need by educating engineers for Maine and beyond, and it aligns with the University of Maine System plan for research and development."

Currently, UMaine engineering graduates have a 99% placement rate in careers or graduate school. ◆

In3D

Composites Center breaks world records, makes global headlines

IN OCTOBER, more than 250 federal and state officials, business executives, University of Maine System leaders and community members were on hand to witness the UMaine Advanced Structures and Composites Center receive three Guinness World Records for the world's largest prototype polymer 3D printer, largest solid 3D-printed object, and largest 3D-printed boat.

The world's largest 3D-printed boat, a 25-foot, 5,000-pound vessel named 3Dirigo, was unveiled and tested in the Alfond W^2 Ocean Engineering Laboratory, an offshore model testing facility with a high-performance wind machine over a wave basin. James Anderson, senior R&D program manager and 3Dirigo project lead, developed the innovative, patent-pending process to print the boat. The boat, printed in 72 hours, was monitored 24/7 by Anderson and Rich Fredericks, a recent grad from the UMaine School of Forest Resources.

The new 3D printer can print objects as long as 60 feet by 22 feet wide by 10 feet high, up to 500 pounds per hour. The one-of-a-kind printer will support several ambitious initiatives.

A $20 million research collaboration with Oak Ridge National Laboratory, the U.S. Department of Energy's largest science and energy laboratory, will advance efforts to produce new biobased, recyclable materials conducive to 3D printing large, structurally demanding systems. "This groundbreaking effort builds on more than 20 years of biofilled thermoplastic materials research by professor Douglas Gardner, structural composites work by professor Roberto Lopez-Anido, and cellulose production by professor Hemant Pendse and his colleagues in Chemical and Biological Engineering," says Habib Dagher, project principal investigator.

The U.S. Army Combat Capabilities Development Command Soldier Center is partnering with UMaine to accelerate shelter prototyping and production to support Army Futures Command objectives. An S-280 vehicle-mounted shelter was printed in 48 hours, the first 3D printed full-scale shelter.

Working with the U.S. Army Corps of Engineers, the 3D printer will further advance UMaine's groundbreaking innovations in rapidly deployable, low-logistics infrastructure systems. That includes a 5,000-pound, 21-foot-long 3D-printed mold for a new composites bridge girder. The large 3D printer will support rapid construction of transportation infrastructure and potentially speed up response and recovery to natural disasters.

The UMaine Composites Center received $500,000 from the Maine Technology Institute to bring together the expertise of UMaine researchers and Maine's innovative boatbuilders to develop a local supply chain and commercialize 3D printing. By 3D printing plastics with 50% wood, boat molds can be produced faster and more economically than traditional methods. ◆

3D printer technology is an outgrowth of research that the Advanced Structures and Composites Center has been doing for 15 years in combining cellulosic nano and micro fibers with thermoplastic materials. The goal is to print with 50% wood products at 500 pounds per hour, and achieve properties similar to aluminum.
Photo by Adam Küykendall

Engineering **entrepreneurs**

UMaine students and alums innovate to problem solve

Engineers are trained to solve problems and to remain optimistic that there is, indeed, a way forward. An engineer rarely has all the facts needed to solve a problem. Thus, they become comfortable designing creative solutions, even with uncertainties. These skills also are shared by entrepreneurs, so it is no surprise that engineers make great entrepreneurs.

Engineers and entrepreneurs share many of the same skills that create success. The clear communication of ideas, goals and processes is essential for both engineers and entrepreneurs. Both need to have the fortitude to turn early failures into future successes. The ability to execute a concept into a viable solution is a critical skill for not only engineers, but also entrepreneurs.

There are many entrepreneurs among the ranks of UMaine engineering graduates. Chuck Peddle (EPS '59), the founder of the personal computer industry, is a shining example. He literally saw the future and made it happen. So many of our alumni, as well as our students and faculty, are engineers who are also great entrepreneurs.

Five of their stories follow.

With two high school friends, mechanical engineering major Maxwell Burtis of Brunswick, Maine started Ferda Farms on the New Meadows River. The sophomore leads technology and innovation for the oyster farm, which most recently involved designing an oyster tumbler to advance culling productivity.
Photos by Holland Haverkamp

UNIVERSITY OF MAINE mechanical engineering student Maxwell Burtis from Brunswick, Maine says designing and building machines is the best way he can help the world. And he's doing just that through his business, Ferda Farms, a small oyster farm on the New Meadows River, co-founded with two friends — UMaine marketing major Sam Dorval, and University of Rhode Island aquaculture and business double major Max Friedman.

All three are in their second years at their universities.

Burtis, Dorval and Friedman, all Brunswick High School seniors when they founded the business, dig clams in the summer. Clams can only be harvested at low tide, so the trio began thinking about what they could do to improve productivity during high tide.

They decided on oyster farming, began holding weekly business meetings and ordered 100,000 oyster seed. With help from Burtis' father, Chris Burtis, the group had the business running by spring 2018. Burtis and Dorval started classes at UMaine that fall.

Dorval chose UMaine because of "the vast resources the state has to offer," because it's close to home, and because of "the impact we can achieve through both the farm and school."

Burtis decided to attend UMaine so he could be close enough to work on the Brunswick farm, while taking advantage of resources like the Foster Center for Student Innovation and programs in the College of Engineering.

At UMaine, he learned the computer program SolidWorks and has used it to design an oyster tumbling machine. Running the company, in turn, has helped Burtis develop business and management skills to supplement his engineering coursework.

UMaine also has opened the door to research opportunities. Ferda Farms is partnering with the School of Marine Sciences on an individual oyster growth study to form a better understanding of the best conditions for growing oysters. This is one step in the direction of engaging in research to support the company's goals.

"Our mission is to make the aquaculture industry more sustainable and efficient while supporting the industry through research and the involvement of students," says Burtis.

And the company will benefit the aquaculture industry through innovation, including "improving the efficiency of the current industry standard oyster tumbling machine, developing a robotic oyster cage flipper, and researching methods into diversifying our crop with hard-shell clams to provide income in case of an oyster disease outbreak," according to Burtis.

Since its founding, the business has already seen significant accomplishments.

Sam Dorval and Max Burtis

Ferda Farms was recognized at the UMaine Business Challenge's eighth annual pitch contest in April 2019, presented by Business Lending Solutions. Burtis received both the $5,000 first-place prize and the $10,000 Innovations Prize, which is awarded to a company presenting a new innovation or technology as part of its business model.

Burtis attributes the success to hard work and support from the Foster Center, Brunswick-based Mere Point Oyster Co., and Dana Morse, a member of the Maine Sea Grant Marine Extension Team.

OWEN MCCARTHY knew early on that he wanted to lead a business — not necessarily as a business owner, but in an organization where he could set direction and drive policy. And the biological engineering major honed his leadership skills at the University of Maine, where he learned the importance of teamwork as president of both Student Government and Sigma Phi Epsilon.

McCarthy's mentors and advisors also helped make his college years "a transformational experience." They included 2004 electrical engineering graduate Matt Rodrigue, who pushed McCarthy to attend Harvard Business School. Then there was 1947 alumnus Al McNeilly, a former Exxon executive, with whom McCarthy frequently discussed leadership, teamwork and UMaine pride.

"McNeilly would say, 'Keep pushing on the elephant. It's big, but eventually it will move in the direction you want because it will get annoyed,'" McCarthy says.

When he graduated in 2010, McCarthy's first position was with Ashland, now Solenis, which sold chemicals for the paper industry. Those first couple of years, he visited over 20 paper mills. Then, the company asked him to work in a new division with a larger territory. There were no guidelines or procedures; he was told to "go figure it out and see what works." This appealed to McCarthy.

"Give me a puzzle and I'll create a structure around it," McCarthy says.

Strategizing the new division became his first entrepreneurial experience, and McCarthy and his colleagues increased sales 50% to 100% year over year. That first year, he also drove over 60,000 miles from Baltimore to Nova Scotia.

At Harvard Business School, McCarthy learned more about becoming an entrepreneur. Working with a professor in the School of Engineering, he participated in developing a start-up called Voxel8.

"We raised a few million in venture capital and secured a

Owen McCarthy

million dollars in pre-sales at CES (Consumer Electronics Show) that year," McCarthy says. The company made a desktop 3D printer incorporating sensors into footwear. Today, they offer a multi-material manufacturing system for high-performance athletic footwear and more.

Meanwhile, a UMaine classmate and SigEp brother, 2011 psychology alumnus Brian Harris, was working as a neurological music therapist at Spaulding Rehabilitation Hospital Boston, where he focused on brain injury and stroke patients. Using music therapy, people were getting better faster, but the demand was far greater than he could serve.

In 2015, they launched MedRhythms Therapy, with McCarthy as president and Harris as CEO.

The concept behind MedRhythms is playing music with specific rhythms to which individuals respond by improving their gait, pace, balance, etc. The company analyzes a song to establish the right rhythmic structure, and then they can change or augment the structure as necessary. Rhythm is the key component; however, melody also is important because if clients enjoy the music, they are more likely to stick with the program.

The physical product incorporates sensors into shoes to monitor the rehabilitative progress.

The company shows so much promise that they have secured significant funding in just a few years. Today, MedRhythms employs 16 — researchers focused on deliverables and therapists working with patients in the manner that Harris began at Spaulding.

"My engineering background from Maine helps me ask the right questions and understand the concepts," says McCarthy, who serves on the UMaine Board of Visitors.

IN HIGH SCHOOL, Karen Morrison knew she wanted to go to the University of Maine. She grew up in Yarmouth, her brother went to UMaine, and she was well aware of the school's excellent engineering program.

Initially, she hoped to be an architect and was advised to study mechanical engineering. UMaine provided a strong science and math background for her that "served as a base to be able to learn anything else," she says.

Upon graduation in 1988, Morrison started her career at Bath Iron Works (BIW) as an ergonomics and system safety engineer, advising on design issues and ensuring compliance with military specifications.

Then an environmental engineering position opened in the Maine Department of Environmental Protection Bureau of Air Quality. Among her many duties, she assisted businesses with managing their air emissions programs. One of those businesses was her former employer, Bath Iron Works.

Karen Morrison

And when BIW identified the need for an environmental engineer, the company came looking for Morrison. She worked at BIW as its Air Quality Program manager for several years. She later worked as a project manager for GZA GeoEnvironmental, focusing on environmental engineering, testing and compliance needs.

Along the way, Morrison continued to pursue educational opportunities through the United States Environmental Protection Agency, as well as the Environmental and Occupational Health Sciences Institute at Rutgers University.

After Morrison started consulting, she founded Morrison Environmental Engineering (MEE) in North Yarmouth in 1999. She serves as president; her husband, Alan, an environmental professional, later joined the business and now serves as vice president. Today, their multidisciplinary environmental consulting firm offers a range of services, including regulatory compliance assistance, pollution control design and environmental training.

Currently, their clients include hospitals, universities and a wide range of industries, such as power plants, forest product and lumber manufacturers, and high-tech electronics and fiber optic companies.

MEE provides a variety of environmental training classes throughout the Northeast and Canada, including "Smoke School," officially known as Visible Emissions Certification Training, for over 300 environmental professionals each year.

Morrison says she never intended to be in business for herself. However, her career experience provided the springboard and has led her down a highly successful and fulfilling path.

"This has been a tremendous experience," she says. "We have great clients and fun challenges, and Alan and I get to work together in a field that we both are truly passionate about."

Entrepreneurs have to be willing to keep learning and always be open-minded, she says. While she did not start her career as an environmental engineer or a consultant, being a top performer and always being open to new opportunities ultimately led to establishing a very successful small business.

"When you work hard and stay open-minded, new opportunities will emerge," Morrison says. "Setting goals is important, but be open to change and new possibilities can develop, often in a direction you never anticipated."

NICHOLAS LAJOIE has a knack for electronics and innovation — and he's using that to give back to Aroostook County.

"Growing up on a (potato) farm allowed me to develop a natural love for everyday problem solving, so I have always been interested in being an engineer," says LaJoie, a Van Buren, Maine native who graduated from the University of Maine in 2018 with a bachelor's degree in computer engineering.

LaJoie now works for Fitch Company in Gray, Maine, an engineering consulting firm that specializes in electrical and control system services for industrial spaces like paper mills and power plants.

As a student, LaJoie was making strides in engineering innovation, developing the company IoTato, based on an idea he had in high school.

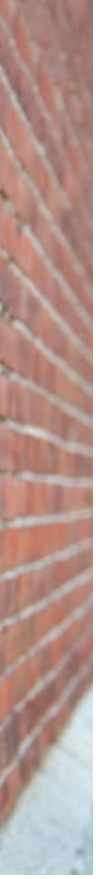
"My dad, a potato farmer, has multiple storage facilities that keep the crop at optimal temperatures during the winter months. To ensure these facilities are operating properly, (he) spends at least an hour of each day driving to each facility to manually check the temperatures. I used to ride around with him and wonder what I could do to save him the time and hassle," LaJoie says.

"By my senior year at UMaine, I had the technical depth to conceive of a device that my friends and I could design and build that would provide a low-cost, rural-friendly solution for farmers throughout the state of Maine."

LaJoie pitched the idea for IoTato at the UMaine Business Challenge in March 2018 and received the $10,000 innovation prize.

The company's name combines "IoT," the acronym for "Internet of Things" — referring to interconnection through computing devices embedded in everyday objects — and "potato," a blend of technology and its down-to-earth application.

"There are several existing products out there that are costly, not user friendly, and/or hard to implement in rural areas. Many stor-



Nicholas LaJoie

age facilities are not intended to ever need internet access, and are often in locations where using cellular data is either expensive or not yet possible," says LaJoie. "IoTato is focused on using different communication technologies to give small- and medium-sized farms an opportunity to add convenience and peace of mind to their operations at a low cost and with an easy-to-use interface."

The summer following graduation, LaJoie worked with other 2018 computer engineering graduates Kent Seneres and Max Geffken to build a prototype of IoTato. By January, they were in testing stages, and since then have worked on improvements and redesign, with plans to begin constructing an improved IoTato device. Isiah Brown, a civil engineering graduate who also just received his MBA from UMaine, helped the team develop a business plan.

"We are hopeful that our next iteration will be much closer to a final product, and are very eager to tackle this problem," says LaJoie. "While we work on this particular project, we fully expect to come across other ways that our technology may be applied to farming, and perhaps other Maine industries."

Vaughan Woodruff

GROWING UP in Pittsfield, Maine, Vaughan Woodruff attended Maine Central Institute, excelled in mathematics, and had the opportunity to go on to a private college or the University of Maine.

He chose UMaine, where he discovered an "amazing cohort of instructors" in civil engineering, including now-Dean Dana Humphrey and now-Advanced Structures and Composite Center executive director Habib Dagher. Woodruff also was an assistant to UMaine alum John Poulin to build a testing frame facility on campus that he still fondly describes as "an architectural marvel."

"I never could have received the education anywhere else that I got at UMaine," Woodruff says. "I have said before that UMaine assimilated my brain by instilling the skills of logic and practicality, and in many other ways that have been highly beneficial throughout my life."

Woodruff has pursued several interests throughout his career. He started at Gagnon Engineering in Gorham, Maine, then went into teaching, working in schools in Maine, California and Colorado, and earning a master's degree in education. In Montana, he built high-efficiency straw bale homes.

While in Bozeman, Montana, he joined Liquid Solar Systems. The owner, who was from New Hampshire, expressed interest in Woodruff's Maine roots and background in engineering. Woodruff explained that he hadn't been an engineer for a long time.

The owner's response? "Once an engineer, always an engineer."

In 2008, Woodruff launched his own company in energy efficiency and solar water heating, subcontracting work from Liquid Solar. In 2009, he returned home to Maine with his family and business and shortly thereafter served as lead instructor for a United States Department of Energy training program, helping technical high schools, community colleges, and universities throughout the Northeast integrate solar into their curricula.

In 2012, the company rebranded as Insource Renewables, providing renewable energy consulting, technical writing and contracting. Woodruff explains the small business, now with 15 employees, has worked for him because of his multidisciplinary background.

"Those experiences I have enjoyed have been teaching moments for an entrepreneur, such as the conflict resolution in challenging environments, the high-structure thought process, the discipline. I first learned about being an entrepreneur at a very young age."

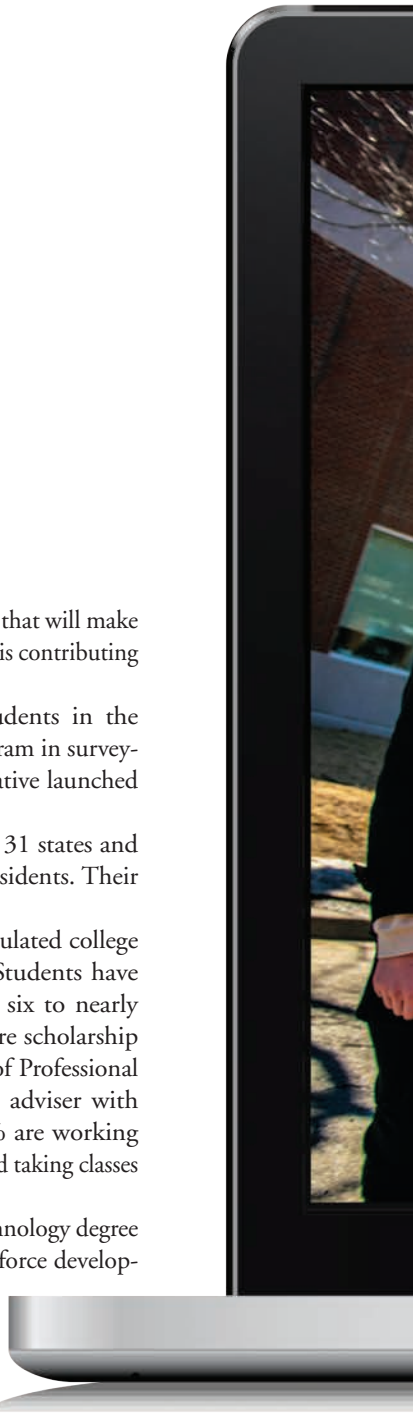
Woodruff's definition of entrepreneurial success is not about creating the perfect business plan, but "how well you learn from the mistakes you make."

Insource was the 10th solar company in North America to be accredited through the North American Board of Certified Energy Practitioners. This past February, Woodruff sold the company to his employees as a worker cooperative. It recently became the seventh Maine company to become a Certified B Corporation.

"Our communities need more entrepreneurs," he says, "and Maine has many, from farmers and fishermen to retailers and other small business owners. In building entrepreneurship across this state, we will rediscover the power of optimism and possibilities." ◆

Putting UMaine **on the map**

Surveying Engineering Technology program triples undergrad enrollment with new online degree program



Timothy Lydon, an engineering technician for the Town of Bourne, Massachusetts, has nearly a decade of experience in land surveying, GIS and engineering.

What he didn't have was a bachelor's degree in surveying engineering technology to enhance his ability to become a licensed land surveyor.

"I am looking to become licensed and save the town of Bourne money by doing most of our data collection in-house," says Lydon of his decision to pursue a degree in surveying engineering technology at the University of Maine. He already holds an associate degree in liberal studies from Cape Cod Community College.

"The synergies of a land surveying background are becoming more paramount at the local government level," he says. "A bachelor's degree will validate my experience and not only give me confidence, but promote confidence in my department."

For licensure in Massachusetts, Lydon needed 18 credit hours in surveying engineering technology classes. The closest certificate program was offered in Boston, a good hour's drive one way that Lydon would have to do weeknights after working his full-time job and juggling work-related night meetings. He also has a wife and a 1-year-old, with another baby on the way.

Then a notice in the Massachusetts Association of Land Surveyors and Civil Engineers newsletter caught his attention. The University of Maine offered a fully online bachelor's degree program in surveying engineering technology.

Lydon enrolled.

"This has been a truly great experience for me," says Lydon, who is taking classes part time. "Online coursework is available at all hours of the day and I am able to work on my time.

"Having an ABET-certified program available online will change the surveying community's ability to pursue licensure," he says. "It will be the best thing to happen to the New England surveying community since deeds became available online and cell phones became affordable. It is the modernization and free flow of knowledge and communication that will make the world a better place to live. UMaine is contributing to that with this online program."

Lydon is one of nearly 100 students in the UMaineOnline bachelor's degree program in surveying engineering technology. The initiative launched in fall 2018 with 30 students.

Today, those students come from 31 states and Guam, and 8% of them are Maine residents. Their average age is 37.

Many of the students have accumulated college credit before applying to UMaine. Students have entered the program with as few as six to nearly 100 transfer credits. Some students are scholarship recipients from the National Society of Professional Surveyors, says Tiffany Peterson, an adviser with UMaineOnline. Approximately 95% are working professionals in the field of surveying and taking classes on a part-time basis.

Offering surveying engineering technology degree programs online is an important workforce development initiative whose time has come, says Ray Hintz, UMaine professor of surveying engineering technology.

"There's been a change in surveying over a long period of years, from the nondegree process to requiring a degree for licensure," Hintz says. "The same thing happened in 99% of engineering disciplines in the past."

Many states now require a degree for licensure, Hintz says, but their in-state educational options range from four-year degree programs to none. UMaine's first surveying engineering technology students graduated from the four-year program in 1978.

"For a lot of people, surveying is not their initial

The online degree uses Zoom technology to allow students to interact live during the class. Photos by Adam Küykendall

profession or job choice," Hintz says. "They're working in surveying with no path toward licensure without the requisite education. They're really stuck, because they have families and are working, and have no way to get a degree unless it's online."

UMaine's online surveying engineering technology educational programs are providing opportunities "for a huge population that are not licensed," Hintz says. "They have a degree in geography or another discipline, and they're doing surveying as a job choice. Their skills lent themselves to the profession, but (without a license) they can't sign and seal survey products."

The online degree uses the technology of Blackboard to house course materials, Kaltura for viewing mp4 files and Zoom to interact live in the classroom and in faculty office hours.

To complete needed field work as part of survey labs, the online

The UMaineOnline bachelor's degree program in surveying engineering technology is the only one in the nation that is ABET accredited.

student partners with a local surveyor who provides the equipment and mentoring.

"The hands-on part of surveying engineering technology in the field is relatively straightforward because of automation," says Hintz. "If they're learning to use GPS equipment in a half hour, they can be an excellent button pusher until something doesn't work. They have no idea what to do with the data. (We teach them) how to create the product needed and how it fits under a licensed profession. They take an educational rather than applied exam in the path toward licensure."

UMaine has long been at the forefront of online coursework in surveying engineering. Longtime School of Engineering Technology professor Knud Hermansen gained national attention in the early 1990s when he introduced the first online UMaine course in surveying engineering.

"Knud was always a pioneer," Hintz says, "but no one was ready for it then. The computer hardware for online education was not there yet. The internet speed was not in place.

"The computer and internet today run light-years faster and can handle this data."

The College of Engineering online Professional Science Master's (PSM) in Engineering and Business, with a concentration in surveying engineering, launched in 2012. The online Surveying Engineering Graduate Certificate began in 2018.

Among the leaders in the field who now hold PSM degrees from UMaine: Ambrose Gmeiner, president of the New Jersey Society of Professional Land Surveyors; Mark Powell, surveying engineering instructor at Ferris University; and Steven Hyde, chair of the Florida Board of Professional Surveyors and Mappers.

For the visionary collaboration between the College of Engineering and UMaineOnline that made the online degree programs possible, UMaine was awarded the Surveying Education Grand Prize by the National Council of Examiners for Engineering and Surveying (NCEES) for four consecutive years. The annual award recognizes surveying programs that "best reflect the organization's mission to advance licensure for surveyors in order to safeguard the health, safety and welfare of the public," according to the NCEES website.

UMaine's successful online graduate programs helped guarantee the potential of the online Bachelor of Science in Surveying Engineering Technology Program. As a result, overall enrollment in the ABET-accredited surveying engineering technology undergraduate program has tripled to more than 120 students, with most of the majors pursuing the online degree option.

Today, it remains only one of two fully online bachelor's programs in surveying engineering technology in the United States, and the only one that is ABET accredited, Hintz says.

Keys to the program's success, Hintz says, are the accessibility to an accredited program in surveying engineering technology from anywhere, coupled with the e-tuition rate of $300 per credit hour for in-state students and $375 per credit hour for out-of-state students (on-campus in-state and out-of-state students pay $300 and $977, respectively).

"They're all my students," Hintz says of his on-campus and online undergraduate and graduate students. "I don't feel there's a difference. The curriculum is the same; how they receive their education doesn't matter."

For an increasing number of college and university graduates, no matter their major, online coursework is part of their degree completion, Hintz notes.

In the coming year, UMaine will add an undergraduate certificate in surveying to address the needs of students who could achieve licensure with 15 credit hours rather than a full bachelor's degree. This is especially helpful to those with an existing undergraduate degree in another field.

It is another step in innovating for the future, says Hintz.

"UMaine needs to focus on uniqueness," he says. "There are similar programs in surveying engineering technology that do not have our unique characteristics. We need to be proud of our reputation and concentrate on what we're good at — and that is what makes UMaine great." ◆

Caleb Bailey and Ben Leary
Photo by Adam Küykendall

Advanced learning

College of Engineering, Thornton Academy early college program provides an academic fast track

TWO UNIVERSITY OF MAINE STUDENTS are earning bachelor's degrees in three years with the help of the early college partnership between the College of Engineering and Thornton Academy, a private school in Saco for grades six–12.

"It's one of the best decisions I've made," says chemical engineering major Ben Leary of the early college program, citing the head start on coursework and reduced college expenses.

Caleb Bailey also is a Thornton Academy graduate who came to UMaine as a first-year sophomore, starting in the engineering physics program. He soon discovered he loved physics so much that he switched his major to physics. He's also working toward a mathematics minor.

Leary learned about the program his first year at Thornton, and organized his schedule for the next three years to accommodate as many advanced placement (AP) classes as possible — calculus, chemistry, computer science, physics, English, foreign languages, history/social science, humanities and an Honors Introduction of Engineering course, the equivalence of 30 college credits.

This allowed him to effectively complete a full year of college coursework before earning his high school diploma, saving time and thousands of dollars in tuition, room and board, and other costs.

Leary chose to study chemical engineering out of a love for chemistry. He also decided to take animal veterinary sciences courses at UMaine.

He works part time at Networkmaine on campus during the school year, and as an assistant at two veterinary clinics in the summer. Leary's ultimate goal is to be a surgeon in an emergency veterinary clinic. He says he also would consider working as an engineer in the oil or gas industries.

Like Leary, Bailey worked with his guidance counselor to create a schedule that would accommodate all the AP classes to cover the first year of college, including an English class at Southern Maine Community College.

He took his first physics class his sophomore year of high school and something clicked.

"I like the mathematical application and the theoretical application, and how it reflected reality in an odd, convoluted way," he says.

That course used a flipped classroom model in which students learned material at home and came to school prepared to discuss it, much like in college. Bailey says the experience sparked his interest in physics, and prepared him to study and learn off campus.

By his senior year of high school, he was taking calculus-based physics and was fascinated by the in-depth approach to the subject and the focus on abstract applications of theories.

After he graduates next spring, Bailey plans to pursue graduate school.

"I want to keep learning and diving deep into whatever field of physics I choose," Bailey says. ◆

Sugar kelp (*Saccharina latissima*) is the main cultivated kelp species in Maine, with a season that typically runs from October to May, according to Maine Sea Grant.
Photos by Holland Haverkamp

Sticky situation

Improving drying methods for sugar kelp is key to scaling up the state's growing industry

Sugar kelp (*Sachharina latissima*) is a nutrient-rich sea vegetable with flavorful ingredients that has been in the diets of generations of residents, primarily in Southeast Asia, and is now increasingly popular with today's health-conscious consumers worldwide. The wild and cultivated marine macroalgae has been discovered by the cosmetics industry and has been explored for its potential as a source of biofuel.

The first commercial kelp farm in the nation started in Maine and today, the state is an industry leader. With increasing interest in cultivating the sea vegetable in Maine and New England, University of Maine scientists in aquaculture, marine sciences, engineering and food science have focused their research on advancing production, processing and consumption.

A lynchpin in enabling the economic development efforts: improving sugar kelp drying methods. And that's where UMaine researchers Peter van Walsum, Balunkeswar Nayak and John Belding come in.

Most recently, as part of a more than $908,000 NOAA grant, van Walsum, an associate professor of chemical and biomedical engineering, Nayak, associate professor of food processing and cooperating faculty of chemical and biomedical engineering, and Belding, director of UMaine's Advanced Manufacturing Center (AMC), have moved an invention for drying sugar kelp from lab model to commercial-scale prototype.

The NOAA grant supporting research into sustainable post-harvest processing of aquacultured seaweed and development of value-added products is led by Nayak. He and other faculty in the School of Food and Agriculture — Jennifer Perry,

Denise Skonberg and Mary Ellen Camire — are conducting research focused on helping the Maine aquaculture industry develop new markets for the value-added products using sugar kelp.

Working with industry partners in New England, Nayak and the team also are focused on systems for post-harvest processing of seaweed, such as drying, blanching and freezing.

The goal is to increase technical capacity of Maine seaweed producers and processors to compete in the food marketplace.

"Drying is one of the biggest bottlenecks in scaling up sugar kelp farming," van Walsum says. "People are trying different things, but there's not a ready-made solution to the problem."

Freshly harvested sugar kelp with its high moisture content is very perishable, which is why preservation efforts are so important. Drying freshly harvested kelp in the sun or by heated air to remove excess moisture extends its shelf life. But the quality and nutritional attributes of dried sugar kelp are highly dependent on the drying technique.

In addition, sun drying is labor-intensive and weather-dependent, as is open-air shed drying. Hot air drying can be inefficient and costly. All three methods are less than ideal with harvests averaging 1 ton per day. Sugar kelp blades become extremely sticky as they start to dry, making the design of a dryer particularly challenging.

Van Walsum, Nayak and Belding were among the UMaine researchers involved in the statewide, multi-institutional Sustainable Ecological Aquaculture Network (SEANET) program, funded by a five-year, $20 million National Science Foundation EPSCoR award in 2014. They built a model drying container to conduct temperature and humidity control research.

Most recently, they designed a 9-foot by 8-foot by 40-foot portable drying facility featuring an overhead oval track conveyor and circulating air in an epoxy-coated chamber, and a control room operating furnaces and blowers on 220-volt power. It's like an oversized clothes dryer, able to dry up to 800 pounds of sugar kelp a day.

"We needed to scale up the system so we could test the effectiveness of drying on a commercially relevant scale," says van Walsum, whose research has included the exploration of biofuel production from seaweed processing residuals. "That also introduced the health and safety requirements of apparatus, choices in the materials used in construction, protocols for how to handle the equipment."

Another critical factor in the design: mobility.

"It needed to be portable and available to multiple harvesters," van Walsum says. "A small farming operation would only need the dryer for a few days or weeks over a three-month harvest season. Hence, it would make sense for a group of small farms to share the use of a portable dryer. From a business point of view, it could be in a co-op model — a shared dryer in a community of similar farmers."

Mechanical engineering major Amber Delaney is a member of the team developing the portable drying facility that includes an overhead oval track conveyor.

Chemical and biomedical engineering graduate student Tuqa Al-Asadi is modeling energy expenditures based on average coastal temperature and humidity that could help farmers determine when to harvest based on ability to dry fresh sea vegetables.

And as with all inventions, there are other questions to be answered — from the best custom-designed clips for holding the fronds on the conveyor and the maximum density for best drying to the potential for incorporating robotics to more fully automate the drying process.

"This is expected to be a learning project," van Walsum says. "We won't be able to predict all the key performance measures until we actually use it. We will test the prototype. Anything we can learn and do before next season — March to the end of May — is critical.

"As an engineer, designing something and having it work is very satisfying," van Walsum says. "We'll be most proud if we can get a high volume through it so farmers can get excited to dry that much seaweed in a day with relatively reduced labor costs associated with it." ◆

Building **bridges**

UMaine's Advanced Structures and Composites Center has new solutions

AIT Bridges in Brewer, Maine is a spinoff company of UMaine's Advanced Structures and Composites Center, and a licensee of the university's arch system and composite girders. Photos by Adam Küykendall

Throughout the United States and territories in 2018, there were 616,096 bridges, more than 7% of them considered to be in poor condition, according to the Bureau of Transportation Statistics. In Maine, 13% of the 2,437 bridges are in poor condition.

The potential to address the need by building less-expensive, longer-lasting, quality bridges using composite materials rather than steel or concrete is the focus of a major research initiative in the University of Maine Advanced Structures and Composites Center (ASCC).

"Composite materials provide advantages, including high-strength, corrosion resistance, reduced weight, and ability to create innovative shapes and forms. Our research is focused on augmenting the properties of traditional steel and concrete by combining their use with composite materials. For example, our new composite CT (composite tub) girder design supports a concrete deck, taking advantage of both a very lightweight composite girder and a conventional concrete wearing surface," says ASCC executive director Habib Dagher, who recently received a 2019 Transportation Champion Award from the Maine Better Transportation Association.

ASCC's pioneering work in this area includes the Composite Arch Bridge System, where fiber-reinforced polymer tubes are the formwork for cast-in-place concrete. Initially known as

The Advanced Structures and Composites Center developed the patent-pending composite girder technology that could provide a solution for up to 70% of the nation's bridges that need repair or replacement, ASCC experts estimate.

Bridge-in-a-Backpack, the components are easily transportable, exceed construction standards and extend bridge life to 100 years.

To date, nearly 30 have been constructed across the U.S. and beyond by Advanced Infrastructure Technologies (now AIT Bridges) in Brewer, Maine, a licensee of the UMaine arch system and an ASCC spinoff company.

However, according to ASCC experts, only 10% of the nation's bridges require arches. Another 60% to 70% can be standard girder bridges.

Now, ASCC has developed the composite girder bridge, with the first installation scheduled for 2020 on a 75-foot span on Route 1A in Hampden, Maine. Commercialization of the product also will be led by AIT Bridges.

The new patent-pending composite girder technology, like the composite arch bridge, was funded by the U.S. Army through the Engineering Resource and Development Center in Vicksburg, Mississippi, because of its interest in understanding how those composite materials work for its own projects, says Bill Davids, the John C. Bridge Professor in Civil Engineering, department chair and UMaine alumnus.

Research and development of such innovative technology is in keeping with ASCC's leadership in this area. In 2018, UMaine was awarded a $14.2 million grant from the U.S. Department of Transportation to lead the creation of a University Transportation Center (UTC) called the Transportation Infrastructure Durability Center (TIDC). Partners include the University of Rhode Island, University of Connecticut, University of Massachusetts Lowell, University of Vermont and Western New England University, plus New England departments of transportation and the American Society of Civil Engineers.

TIDC is focused on improving the life of transportation assets — roads, bridges and rails — and save taxpayer dollars. At the TIDC opening ceremonies, the strength of the new tub girder design was demonstrated with a load test. The girder

“ASCC is always researching methods and materials to find improved solutions, and we can take their findings and commercialize them. We also learn from doing, and what we found with the composite arch bridge is that **we were not just delivering a product, but could develop all the parts and pieces to create an entire system.”**

Tim Kenerson

withstood the load applied up to 370,000 pounds. (By way of comparison: the Statue of Liberty weighs 390,000 pounds.)

Maine Department of Transportation saw the value in this new technology and plans were developed to make Hampden the first real-life installation of a tub girder bridge.

“A lot of engineering design, a lot of sophisticated analysis has gone into this bridge,” Davids says. “With all the laboratory testing that we have done, the development of the connectors, the validation of the design tools, and the software we wrote, this bridge is ready to be built.

“The other important point is that this composite bridge will be installed just like any other girder bridge,” says Davids. “The construction crew will not see any differences in the manner in which it is constructed, albeit with lighter materials that will be easier to handle than steel or concrete.”

Proving his point, the precast concrete deck panels on the test bridge were placed and grouted without any difficulty by several students supervised by two graduate students.

AIT Bridges designed the bridge and will oversee construction. The company also is making the girders.

“We have a mutually beneficial relationship with the university,” says Tim Kenerson, AIT Bridges senior engineer and UMaine alumnus. “Our success is their success.

“ASCC is always researching methods and materials to find improved solutions, and we can take their findings and commercialize them,” Kenerson says. “We also learn from doing, and what we found with the composite arch bridge is that we were not just delivering a product, but could develop all the parts and pieces to create an entire system.

“AIT Bridges is excited about the tub girder system and our first installation next year in Hampden. It is personally exciting to me because this was the first time I used my PE (professional engineer) stamp since receiving it,” says Kenerson. “We have been conservative in the design, underestimating the capacity and overestimating the load, but will learn from the sensors after installation about what improvements we’ll be able to make in the future.”

With funding from UTC, UMaine graduate student Andrew Schanck will monitor the bridge during construction, and also will do live load testing, Davids says.

“We always learn new lessons as the bridge goes in,” says Davids. “With our TIDC partners at other universities, sensors will be installed to perform structural health monitoring, gathering real-time data over a long period and allowing us to further enhance the structural design.”

Dagher says they took time to find the best approach.

“Our bridge design projects are the result of 25 years of learning. In fact, before we finalized our work on our design, one graduate student, Anthony Diba, was asked to find every composite bridge in existence in the U.S.,” Dagher says. “He took two and a half years, writing at least a page on each bridge he found.

“There have been a few major failures on certain composite bridges in past years and people have lost their jobs. Not wishing to lose our jobs, and because we wanted it to be right the very first time, we considered all the angles.

“Typically, engineers design a bridge with one factor in mind, like making the lightest structure,” Dagher says. “They don’t think about how to fabricate it, how to transport it to the jobsite, how difficult it might be to assemble, how long will it last, or what do I do with it at its end of life.”

UMaine’s bridge designs take all of those factors into consideration, Dagher says. A 40-foot bridge of 15 girders weighs just 1,323 pounds and easily fits on one flatbed. Even an entire 70-foot bridge system can be loaded on one stretch flatbed.

These CT girders can be unloaded using a smaller rental crane and placed on the bridge span on the first day, the precast deck segments could be added and grouted the second day, and the paving would take place on day three.

The CT Girder Bridge System has a life expectancy of over 100 years, can be easily repaired and by the next generation will be recyclable. The molds that are made to print the girders will be 3D-printed using biobased materials and are fully recyclable today.

Moving forward, ASCC’s strategic vision is to operate a green energy and materials plant.

“LEED bridges, like LEED buildings, is where we are headed,” Dagher says. ◆

Maintaining **motion**

Robotics research a key to next generation assistive devices

In the University of Maine Biorobotics and Biomechanics Lab, wearable robots — a robotic glove, a shoulder assistive robot and a smart shoe — have the potential to improve people's capacity for movement.

That includes restoring motion lost due to a medical condition, or enhancing existing function.

Babak Hejrati, an assistant professor of mechanical engineering, heads the lab that is dedicated to research in assistive robotics, rehabilitation robotics and biomechanics. He and a team of student researchers generate knowledge that informs designs that could be used by people.

His research also focuses on "pure" biomechanics, the study of human motion to inform better designs for wearable robots. This encompasses collecting data on range of motion, oxygen consumption and other elements to increase the body of knowledge in the field and provide a foundation for designs.

"The whole purpose of this robotic glove is to provide further assistance to people with fragile grasp to do their activities of daily living," says Hejrati.

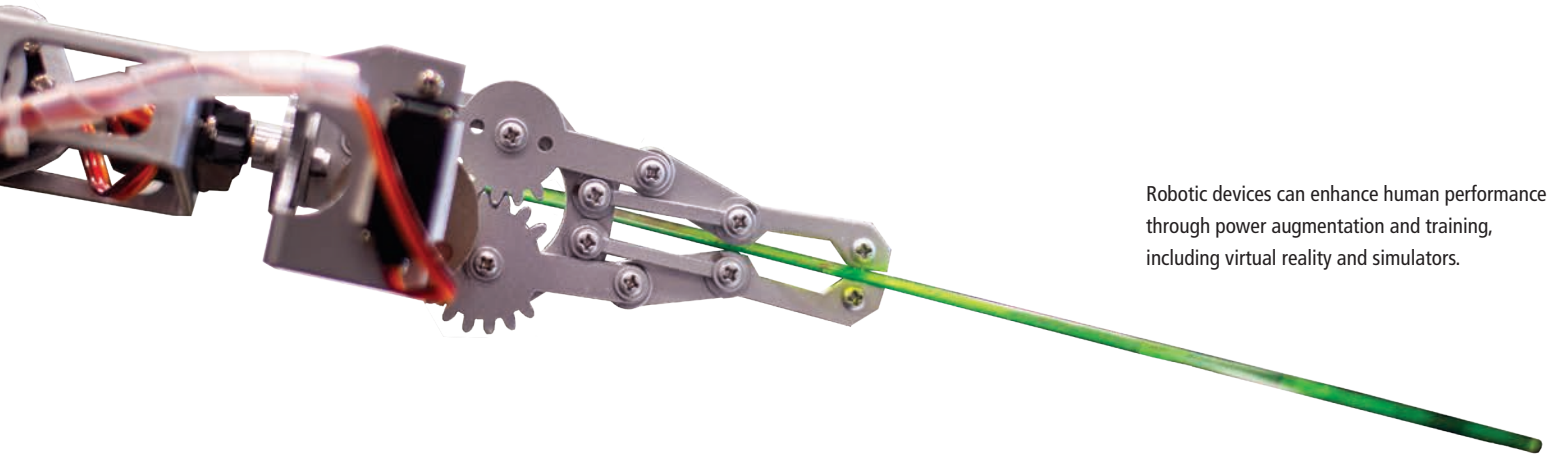
The glove combines principles of biomechanics through the forces a hand needs to generate to accomplish ordinary activities, with principles of robotics through a system of sensors and mechanisms designed to help the user generate enough grasping force.

The shoulder assistive exoskeleton, or shoulder assistive wearable robot, is designed to help move the user's arm by assisting the shoulder joint.

"We know what kind of motions a human arm can perform, and what kind of motions are important for certain tasks" by drawing on biomechanics knowledge, Hejrati says. "For example, we know this is an important motion — forward and backward motion

In the lab, undergraduate and graduate students use robotic technology and human motion analysis to learn how to design devices for assisting individuals with impairments.

Photos by Holland Haverkamp



Robotic devices can enhance human performance through power augmentation and training, including virtual reality and simulators.

called flexion-extension. This is the important motion that should be assisted."

Other types of arm motion should ideally be left to move through all the degrees of freedom unhindered by the shoulder robot, a balance made possible by the intersection of biomechanics with the technology.

The third project, a "smart shoe," measures all three components of the force of the user's foot while walking, allowing for the capture of comprehensive data that facilitates full analysis of the motion.

In addition to these major projects, Hejrati also creates small, light, wearable wireless sensors to measure motion, and inform ongoing and future design projects. Ideally, he says, these sensors could capture a person's motion anywhere, not just in a lab setting.

And Hejrati has several graduate students in his lab who play a core role in the research and development of the major projects. He also emphasizes giving motivated, hardworking undergraduate students the opportunity to engage in research that differs from what they might typically expect in terms of applications for mechanical engineering, broadening their perspectives on what's possible. And sometimes the experience is a springboard leading those students to do research at the graduate level.

National Science Foundation funding has supported Babek Hejrati's robotics research related to gait rehabilitation and enhanced walking recovery in people with spinal cord injuries.

"I always encourage those who like it to just continue to just do research, because it's a very unique experience," says Hejrati. "And hopefully that can be a good mechanism for them" to expand their study at a higher level.

Hejrati says there are still many questions to be addressed, from the best ways to design modifications, to how a person with unique challenges would respond to technology based off models created in a lab.

"When you have a system laid on a table, everything looks perfect, but as soon as it's used by humans, things are totally out of control sometimes," says Hejrati. "Working with humans, designing for human users, is always very challenging, it's very unpredictable. We have to make a lot of adjustments. But that's part of discovery."

Hejrati partners with the UMaine Center on Aging to recruit and work with older adults, an initiative he hopes to expand to further refine the technology and make it more compatible with individuals and their unique needs.

In many engineering fields, it can be difficult to see the end user who will benefit from something designed by the engineer, according to Hejrati. But UMaine has given him an opportunity to bridge that gap.

"One unique aspect of (this field) is that you get to see the difference if things are successful. You get to see the difference in some people's lives with what you've designed or what you've proposed or what you've discovered," Hejrati says.

"There's a shorter path to your end user. And you will see a significant, tangible difference in their lives. It's not just about designing some cool stuff. It's that the person with Parkinson's disease or a stroke can recover at least part of their functions. And that's the most rewarding part." ◆

Irja Hepler
Photo by Adam Küykendall

Number **cruncher**

Internship introduces Maine School of Science and Mathematics student to engineering research

IRJA HEPLER started working at the University of Maine Advanced Structures and Composites Center (ASCC) before college, when she landed an internship as a sophomore in high school.

"I really like math and I especially like applying it to the real world, which is exactly what engineers do," says the now UMaine senior. "I chose civil (engineering) because I want to build structures and I already had connections to the department."

Those connections arose from her internship during January Term (J-Term) her sophomore year at the Maine School of Science and Mathematics (MSSM), a public residential magnet high school in Limestone, Maine.

J-Term is "an innovative 10-day program that provides students with the opportunity to dedicate themselves to a particular course or project," according to MSSM's website. Hepler says her internship was a significant factor in deciding to come to UMaine. And she was able to receive college credit for some of her MSSM classes through a dual enrollment program at the school.

Hepler's internship led to a summer job that she held for the rest of high school and now continues year-round as a UMaine student.

As a student research assistant, she works about eight hours a week during the semester and nearly full time during breaks. Hepler's work encompasses data processing, file management, project finance and other tasks.

"I do a lot with digital image correlation (DIC), which basically is a way to convert pairs of images of a test into engineering data. It's a really powerful software," she says. "My favorite tool is MatLab, which is a coding language.

"There really isn't anything I've found that it can't do, from processing and plotting data, to running the cameras for the DIC."

At ASCC, she's also worked on a project for NASA, understanding of the behavior of a hypersonic inflatable aerodynamic decelerator, a cone-shaped structure made of inflatable rings called tori that can be used to slow down a spacecraft as it lands.

"Working on it was really cool, especially since I'd been interested in space travel for as long as I could remember and now I was helping with some of the newest research to get us there," she says.

And she's involved in designing and testing composite bridge girders. Her role focuses on data processing.

After she graduates next year, Hepler plans to pursue graduate school at UMaine and do research at ASCC. ◆

Chuck Peddle
Photos by Adam Küykendall

He changed the **world**

Alumnus Chuck Peddle is considered the 'founder of the personal computer industry'

There are certain alumni whose names are widely recognized by Black Bears of all generations. Stephen and Tabitha King. Bernard Lown. Cindy Blodgett. Raymond Fogler. Olympia Snowe.

Chuck Peddle's name may not be among the most recognizable of UMaine alumni. But it deserves to be.

Before you could stream movies or access your bank account on your phone, before Google or Amazon or i-everything, even before Bill Gates or Apple's two Steves (Jobs and Wozniak) there was Chuck Peddle, a 1959 University of Maine graduate whose innovation and leadership made those activities, companies and careers possible.

Peddle led the development of a revolutionary microprocessor known within the technology industry as "the 6502." For a computer, a microprocessor is its electronic brain. The development of the 6502 made consumer-affordable personal computers possible — and changed the world.

"More than any other person, Chuck Peddle deserves to be called the founder of the personal computer industry," wrote veteran technology journalist Phil Lemmons in the November 1982 issue of *BYTE* magazine. Lemmons, who went on to become editorial director of PC World Communications, Inc., said, "Peddle made the personal computer possible."

"Chuck Peddle's contribution to the world goes much further than the start of personal computers, to countless embedded processor applications," Apple co-founder Steve Wozniak told *MAINE Alumni Magazine* after learning that Peddle had been selected for UMaine's 2019 Alumni Career Achievement Award. "Chuck's name is totally famous among techies who go back to the start of our modern tech life."

"Throughout his career, Chuck has been consistently ahead of the curve," says Dana Humphrey, dean of UMaine's College of Engineering. "Chuck may be known for his engineering prowess, but he is also an industry visionary."

Humphrey cites a handful of examples: Peddle's role as "the driving force" behind the implementation of hard drives within personal computers. The now-ubiquitous gas pump credit card reader. And perhaps most notably, the development of "the 6502," the microchip that made possible the world's first personal computer, the Commodore PET, intentionally named to comfort tech-shy purchasers.

It's a wonder at all that Chuck Peddle became an engineer, much less the father of personal computing. Growing up in a working-class family in Augusta, he says he never intended to go to college.

"I never planned on doing anything; we were just trying to survive because we were so broke," he says.

The Monday following his high school graduation from Cony High School in 1955, his mother provided the first spark of motivation: She told young Charles to get out of bed and get a job. The employment office set him up with a road gang, swinging pickaxes and slinging shovels. He was no stranger to hard work; he had worked in mills, like his friends and others in his family. But there was a man on the crew who had worked his whole life laying down asphalt, who said the thing he most looked forward to in the world was when his landlady bought a quart of beer for him on Saturday so he could drink it on Sunday.

"This is bullshit," he thought. "I want to do something with my life!"

So Peddle enrolled at UMaine, with a little help from then-President Arthur Hauck, who was aware of Peddle's potential and arranged for him to receive a modest scholarship. Peddle studied engineering and made good grades. Still, as he entered his junior year, he says he still didn't have a clue about what to do with his education.

An engineer had joined the UMaine faculty from Massachusetts Institute of Technology, where he had worked with Claude Shannon, the legendary mathematician who introduced information theory to the world. Among many other breakthroughs, Shannon had demonstrated that Boolean algebra — the use of 1s and 0s — could translate into language. Peddle signed up for the new faculty member's class on computer systems engineering.

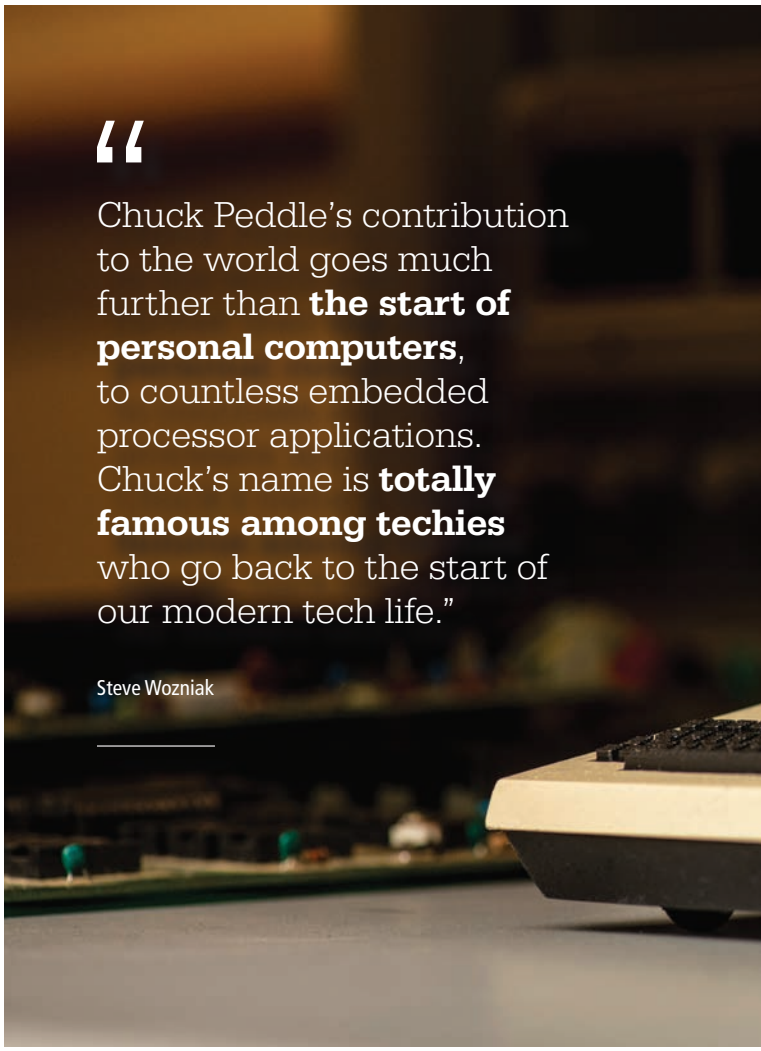
"We studied the eye for four weeks, then we studied the ear for two weeks," Peddle says. "He told us, 'You can't communicate with a human being until you know how they communicate.'"

Then, Peddle says, "He wrote down Boolean arithmetic. It was the first time I'd seen it. I was totally impressed. Then we started fooling with it, and I realized that what he was teaching me (was computer language).

"I was convinced computers were the future. I knew I wanted to do computers for the rest of my life."

After a stint in the Marine Corps, Peddle went to work with General Electric, earning recognition as a world-class engineer during his 11 years with the company. He then joined Motorola and led the design of an early microprocessor, Motorola's 6800. The technology was sound, but his potential customers — other tech companies — felt its $250 price tag was not cost effective.

Peddle relayed the feedback to Motorola with a plan to make a more affordable version of the 6800. The timing coincided with bits of information he had picked up from clients about a project being worked on by Intel: development of a new generation of semiconductors, a necessary component of microprocessors that Peddle thought could revolutionize computing and make microprocessors less expensive to produce and cheaper for customers.



But his bosses at Motorola weren't interested in making a cheaper device. Deeply discouraged, Peddle and a team of engineers went to work for another company in the microprocessor business, MOS Technologies. Within six months, they had created the 6502 with a consumer price of $25 — one-tenth the cost of the Motorola 6800. Soon after that, MOS Technologies — and, importantly, its Peddle-led engineering team — was purchased by Commodore Business Machines, a move that would soon make the company the global leader in personal computing.

In the early 1970s, two very different markets for computers existed — one for corporations that squeezed the expansive

At MOS Technologies, Chuck Peddle and a team of engineers created the 6502 microprocessor. The business was purchased by Commodore Business Machines, which went on to be a global leader in personal computing.

machines into specially air-conditioned rooms; and another for hobbyists, the do-it-yourselfers who hooked up circuit boards in their basement or garage to see what they could make happen.

Peddle was one of the few techies who understood that with the right features, price point and marketing, personal computers would become a high-demand consumer product.

"Nobody believed us. Everybody thought we were crazy," Peddle said recently from his home in Santa Cruz, California. "We took an idea and created an industry — a big industry."

Realizing Peddle's vision for consumer-oriented personal computers required something that did not exist: an affordable, scalable microprocessor whose integrated circuitry could accomplish very complex activity. By 1975, Peddle and Commodore had come up with an answer: the 6502. Over the summer, they peppered trade publications with ads: In September, computer makers could buy their own 6502 for $25 at WesCon, an electronics show and convention in San Francisco.

The opportunity to buy Peddle's cutting-edge processor attracted the attention of Apple co-founders Wozniak and Steve Jobs, as well as many other members of the now-legendary Homebrew Computer Club, a group of techies who were instrumental in the eventual creation of the Silicon Valley technology complex in northern California.

"The Intel chip cost close to $400 (then) in single quantities," Apple co-founder Wozniak told *MAINE Alumni Magazine*. "Chuck's marketing plan for the 6501/6502 processors was to offer them directly for $20 and $25 at WesCon in San Francisco. This was unheard-of marketing, but those of us who were ready to start a revolution wouldn't miss this chance."

For Peddle, there was a last-minute glitch. Event organizers wouldn't allow companies to sell items on the floor of the show. Ever the engineer, Peddle quickly created a work-around. He rented a suite at the nearby St. Francis Hotel and directed customers there.

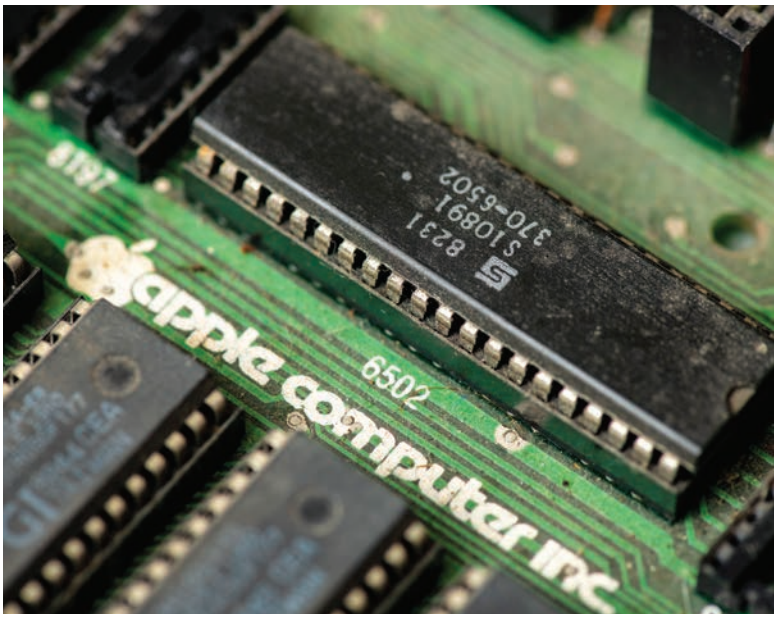
"I went to WesCon and I remember paying $20 in cash for the 6501 processor, not knowing what its architecture and features were," Wozniak recalled. "I also paid $25 for a 6502, which was the same to me, but with one great simplification. I also paid $5 for a manual.

"I paid this (in) cash directly to Chuck and his wife," Wozniak added. "Many of us in the Homebrew Computer Club bought our first microprocessor chips from Chuck."

Al Alcorn, the man who invented Pong, the very first video game, remembers seeing Peddle in San Francisco. "Steve Jobs was there, we were there, MOS was there with a barrel full of 6502 processors. It became obvious how important that processor was going to be to launch the personal computer industry. It turned semiconductors into an electronics industry."

All — yes, all — of the first successful home computing and gaming systems depended on the 6502. Peddle's microprocessor also drove the most successful personal computers of the 1970s and early 1980s: the Commodore PET, which debuted in 1977; the Commodore VIC, launched in 1980;

> “Throughout his career, **Chuck has been consistently ahead of the curve.** Chuck may be known for his engineering prowess, but he is also an **industry visionary.”**
>
> Dana Humphrey



The 6502 microprocessor developed by Peddle and his team was the key to launching affordable personal computers for what would become a high-demand consumer market.

and the Commodore 64, which hit the market in 1982 and remains the best-selling computer of all time.

“The PET is big news,” *Personal Computing* magazine reported in 1977. It described Peddle’s PET as “a clean break from commercial and hobbyist computer systems … into a consumer market.”

In that article, Peddle presented his vision for how personal computers would affect lives. He posited that personal computers would one day connect with and access information from other personal computers. (Keep in mind: He said this 13 years before the World Wide Web would become a thing.) He spoke about home-based education and self-help resources that could be accessed through computer applications; using computer games to teach computing skills at an early age; and the inevitability of computer-assisted remote shopping, bill-paying, and banking.

Even the way people watch TV programs would change as personal computers became commonplace, Peddle told the interviewer in 1977.

The *Personal Computing* article assessed Peddle’s prognostications and the Commodore PET’s appeal with cautious admiration. “This is an experiment on a grand scale,” the story declared. “It remains to be seen if the market (Peddle) predicted really exists or is imaginary.” (Spoiler alert: Those market predictions proved real.)

Peddle later designed the VIC 20 and then the Commodore 64. The company was selling 22 million computers a year, far outpacing its competitors, and Peddle’s team won “computer of the year” for the PET and the C-64. What made all of that possible, Peddle says, was simply the supply-and-demand principles of economics. Making computers affordable was perhaps the single most significant success that ushered in personal computing.

Eventually, his success at Commodore came at odds with Jack Tramiel, the company’s hard-charging founder and president. Peddle was the young engineer getting all the attention, which, he suspects, rubbed the image-sensitive Tramiel the wrong way. The parting was not amicable, and Peddle later lost his Commodore stock in legal proceedings.

At 82, Peddle hasn’t stopped. Along with his longtime partner Kathleen Schaeffer, he shuttles between homes in northern California and Sri Lanka. He’s currently working on a new computer built around Flash memory that, he says, he can build 25% cheaper than competitors.

“This time I’m going to make money,” Peddle jokes.

The future for engineers, Peddle says, is combining robotics with the biomedical industry. He advises other tech innovators to follow the approach that helped him succeed: Look for ways to drive an industry by repurposing available technology. But even more important than technical skills, he says, is the same thing that set him apart from other engineers — having big ideas and the determination to pursue them.

“You take a dream, and you build a dream, and you keep building on it and you don’t let anybody stop you.” ◆

By Clinton Colmenares, reprinted with permission from the *MAINE Alumni Magazine.*

Programming **solutions**

Like his grandfather, Bradley Denholm jump-starts his engineering career at UMaine

A FAMILY CONNECTION brought Bradley Denholm to the University of Maine from Johannesburg, South Africa. The opportunity to contribute daily to projects that benefit Maine businesses kept him here.

That connection was Denholm's grandfather, William "Bill" Bacigalupo, who graduated from UMaine in 1966 with a degree in mechanical engineering.

Nearly 50 years later, an award from the Class of 1966 Scholarship Fund confirmed Denholm's choice, and he began classes in fall 2014.

The now fifth-year student in electrical engineering and computer engineering spends his days at UMaine's Advanced Manufacturing Center (AMC) devising programming solutions for the center's business clients, bridging academics and real-world experience.

One of Denholm's latest achievements was designing a streamlined production method for PackGen, an Auburn, Maine-based company that manufactures industrial shipping containers. He was tasked with designing the control system for a machine, and researching and selecting components.

"It was a lot of responsibility, as a student. It was an incredible experience. As an undergrad working on an industry project that's going to be used on manufacturing every single day, by real operators, there's a lot of real-world experience that it gave me that you just don't get in a classroom," Denholm says.

"This was for a Maine-based company, to help the state's economy and not just something theoretical."

Denholm began working at AMC in May 2015, and has since been involved in numerous projects for other companies. Primarily, he manages the center's IT systems and takes on any programming projects. He says he came into the job with little experience, but quickly learned and grew into the role. Now he's training another student in the same position.

"As a high-level system integrator programmer, it makes me a better low-level designer because I know what the end user is going to need out of the product," says Denholm. "And then vice versa." ◆

Bradley Denholm Photo by Adam Küykendall

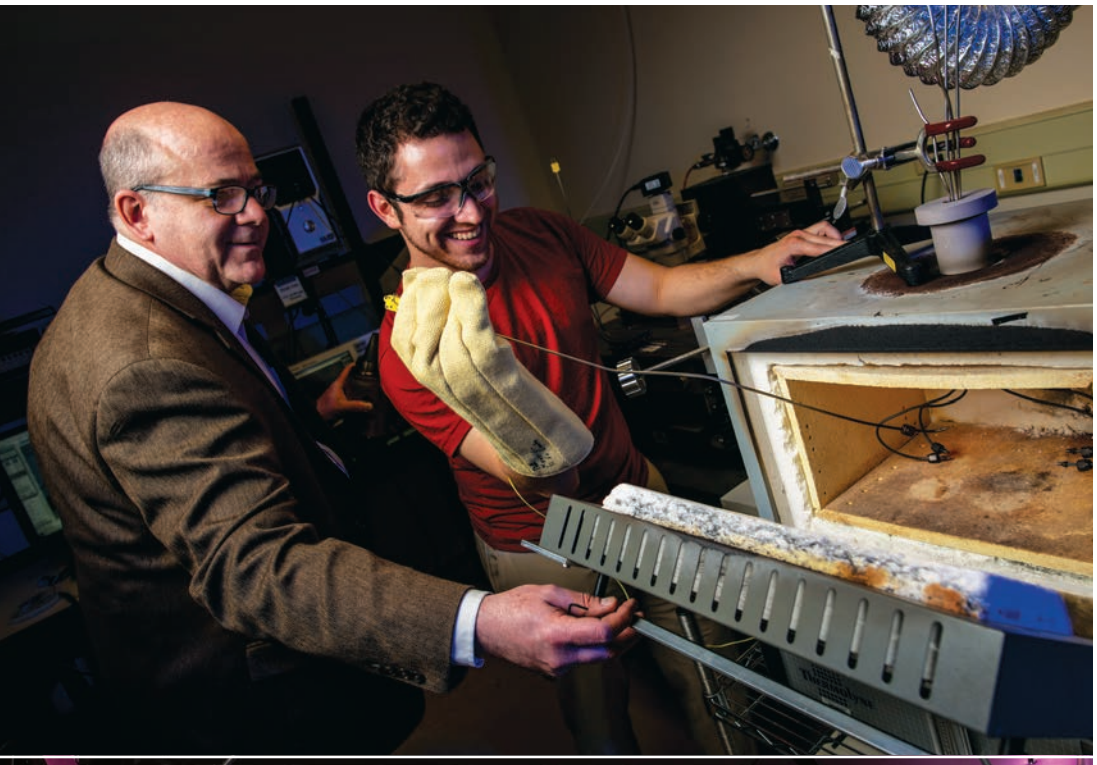
Taking the heat

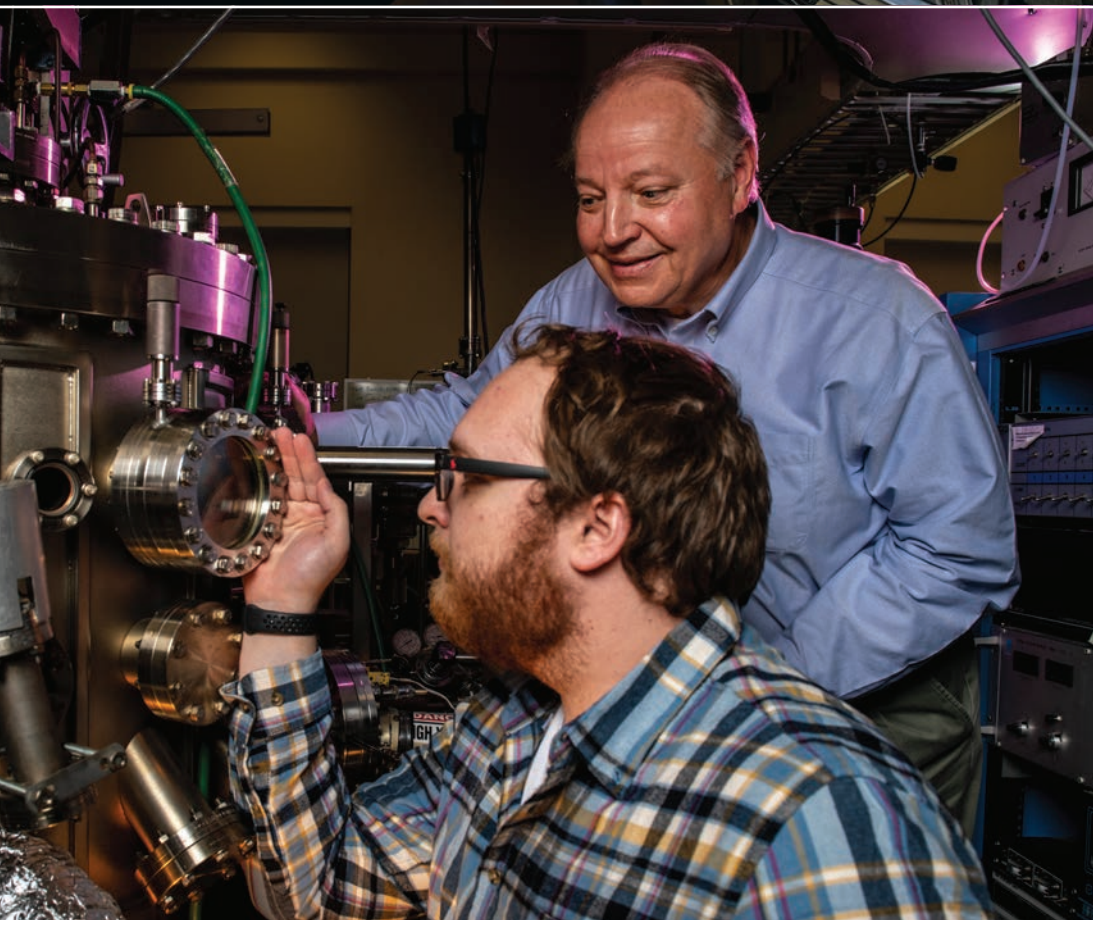
Wireless sensor research focuses on high-temperature, harsh-environment applications

Wireless sensors that can operate at temperatures up to 2700 degrees F in harsh reactive gaseous environments are critically needed in large-scale industrial processes. The sensors are required to provide real-time data for temperature, strain, pressure, corrosion, gas concentration and more.
Photos by Adam Küykendall

Development of novel materials and sensors for wireless sensing applications in high-temperature, harsh environments, such as those found in energy generation, advanced manufacturing and other industrial sectors, is the focus of a $750,000, two-year award from the U.S. Department of Energy (DOE) to a University of Maine research team.

The UMaine-led research project is one of nine funded by DOE under the federal Established Program to Stimulate Competitive Research (EPSCoR). EPSCoR is designed to build capacities in underserved regions of the country that will enable them to compete more successfully for other federal research and development funding.





An integrated team of faculty, staff and students, led by Mauricio Pereira da Cunha, UMaine professor of electrical and computer engineering, and Robert Lad, UMaine professor of physics, is focusing their research efforts on applications of materials, packaging techniques and new sensor mechanisms for the development of sensors capable of operating in high-temperature harsh environments. The project aims at advancing the functionality and reliability of wireless sensor devices that yield critical sensing data in field applications, such as those found in power plants and turbine engines. The collaborative research ranges from integration of materials into prototype sensor devices to testing harsh environment materials and sensors in industrial environments.

Wireless sensors that can operate at temperatures between 400-1200 degrees C (750-2700 degrees F) in harsh reactive gaseous environments are critically needed in large-scale industrial processes. They provide economic benefits through better control of harsh-environment industrial equipment and structure operational conditions, thus lowering equipment maintenance costs, improving safety, attaining more efficient processes leading to reduced emissions of polluting gases, and achieving overall better quality control and higher manufacturing product yields. The sensors are required to provide real-time data for parameters, such as temperature, strain, pressure, corrosion and/or gas concentration.

However, there are significant material and sensor challenges in devising better sensor materials and sensing techniques that remain stable in high-temperature harsh-environment operating conditions. The materials must retain conducting or insulating functions and properties under such demanding conditions, and not react and degrade at interfaces with other materials. The sensors must retain

TOP: Working in UMaine's Frontier Institute for Research in Sensor Technologies are electrical and computer engineering professor Mauricio Pereira da Cunha and graduate student Armando Ayes, and, **BOTTOM:** professor of physics Robert Lad and graduate student Morton Greenslit.

The research builds on more than **two decades of UMaine advancements** in thin film materials and tiny, wireless battery-free microwave acoustic sensors designed to be long-lasting, lightweight, and able to **withstand severe vibration and high temperatures.**

long-term stability and be able to operate wirelessly and battery free under a wide range of harsh conditions.

The main tasks in the EPSCoR project investigate thermal-expansion limitations for layered materials used as sensor protective layers and packaging, and new sensor mechanisms and integrated electronics for operation in high-temperature conditions. These topics represent key areas where material constraints and the lack of more accurate sensing mechanisms currently limit the implementation, and ultimate reliability and robustness of wireless harsh-environment sensor operation.

Research activities are benefiting from established capabilities within UMaine's interdisciplinary Frontier Institute for Research in Sensor Technologies (FIRST), previously known as the Laboratory for Surface Science and Technology (LASST). They include thin film deposition, clean room microfabrication, nanoscale materials analysis using microscopies, spectroscopies and diffraction; high-temperature thermal processing; and testing of prototype sensor component materials and sensor devices. Faculty, staff and students participating on the research team have expertise in electrical and computer engineering, mechanical engineering, chemistry and physics.

This is the second major DOE award Pereira da Cunha and Lad have received in the past 15 months. In spring 2018, the researchers received a $2.5 million, three-year grant from the National Energy Technology Laboratory through the Department of Energy's Office of Fossil Energy for a project focused on improving sensor technologies in coal-based power plants. Prototype wireless surface acoustic wave sensor systems developed by the UMaine team already have been installed and tested in UMaine's Steam Plant, the Penobscot Energy Recovery Center in Orrington, Maine, and Longview Power Plant in Maidsville, West Virginia.

The research builds on more than two decades of UMaine advancements in thin film materials and tiny, wireless battery-free microwave acoustic sensors designed to be long lasting, lightweight, and able to withstand severe vibration and high temperatures. Previous funding has come from the National Science Foundation, U.S. Army, NASA, Petroleum Research Funds, U.S. Air Force and DOE.

Environetix Technologies Corp., a spinoff company launched in 2009, located in the Upstart Center for Entrepreneurship in Orono, has advanced the technology applications through U.S. Air Force and Army SBIR Phase I and Phase II projects, as well as through contracts with several commercial customers.

There is a critical need to further the technology, and train the workforce in its development and use, say Pereira da Cunha and Lad. Foundational materials science research of the sensor material components and applications-oriented research of the sensor devices and wireless communication techniques are needed to improve all building-block aspects of the smart wireless sensor technology.

And the next generation of scientists, including graduate and undergraduate students, working with industrial partners, is key to expanding and sustaining the technology. ◆

Research scientist Syeda Fizzah Jilani is a member of the team working on harsh-environment surface acoustic wave sensors as part of the U.S. Department of Energy project.


RELIANCE ELECTRIC
IRT

Welcome to Nanocellulose Valley

Process Development Center has leadership role in cellulose nanofibers production

California has Silicon Valley. Maine has Nanocellulose Valley, according to University of Maine Process Development Center (PDC) director Colleen Walker.

PDC's nanofiber pilot plant is an internationally recognized leader in cellulose nanofibers (CNF) production. Since 2013, it has shipped over 4 tons of nanocellulose samples in one-pound samples to 49 countries, reaching 305 companies, 276 universities, and 49 government and other entities. It supports nano research worldwide, with significant advancements occurring in Japan, Finland, Sweden and Canada.

PDC produces the material; researchers, including those at UMaine, find the applications — from biodegradable food packaging to chemical-free fiberboard. Many products now on the market already incorporate cellulose nanomaterials (CNM), including personal care products such as lotions, bandages and other biomedical supplies, coatings, inks, food additives and composites, including foam reinforcement in athletic footwear.

CNM is an emerging industry whose products can be used in a wide range of materials and goods. In the past three years, PDC has produced more than 25 tons of CNF in over 100 production runs, some of which supplied 11 commercial-scale paper machine trials and three high-speed pilot trials.

Currently, PDC is the only facility in the United States that can commercially supply CNF at a rate of 1 ton per day — a material with an estimated market potential of 6.4 million metric tons in the U.S. annually, and 35 million metric tons globally.

The University of Maine Process Development Center (PDC) in Jenness Hall includes a full-scale pilot facility. PDC is a world leader in the production of cellulose nanofiber, some of which supplied commercial-scale paper machine trials and three high-speed pilot trials in the past three years. Photo by Adam Küykendall

PDC works with a variety of raw materials, from **wood and bark to herbaceous crops and agricultural residuals.** Processes available for clients range from extraction to paper production finishing along with extensive paper testing. Recent Maine-based product innovations include **a nontoxic grease-proof coating additive, a unique cellulose insulation product, a flame-resistant fiberboard used in commercial roofing, and a biodegradable landfill cover to control odors.** CNM technology is patented by the University of Maine.

A goal is to explore the potential of the numerous paper mills, open and closed, across the state of Maine with the refining capacity for CNF to go into large-scale production as demand increases, says Walker, who joined UMaine in 2018 after a decade at the Technical Association of the Pulp and Paper Industry (TAPPI), most recently as technical director.

Earlier this year, PDC was awarded a $1 million grant from the Northern Border Regional Commission covering Maine, New Hampshire, Vermont and New York. A first goal is to design and upgrade to a continuous process production facility (the current process is batch) as demand increases, which might also reduce energy costs. The second goal is far-reaching — and exciting.

PDC will study, state by state, the feasibility of revitalizing the pulp and paper manufacturing industry by considering the capabilities of both open and closed mills across the northeastern United States.

"We have the inventory, we know how to grow, harvest, (regrow), transport, and process that inventory to make pulp and paper," Walker says. "There are refineries in all of these mills that could be used to manufacture CNM. We should take advantage of these resources to grow the capacity for CNM-based applications."

PDC is a fee-for-service research facility that has been serving clients in the pulp and paper industry since 1987. With its state-of-the-art facilities and dedicated staff, the center supports all stages of development, evaluating new materials and product innovations, and assisting with commercialization of new technologies. The eight staff members work on eight to 10 projects per month, ranging from testing to pilot trials, helping clients move from bench to commercial scale.

The facility works with a variety of raw materials, from wood and bark to herbaceous crops and agricultural residuals. Processes available for clients range from extraction to paper production finishing, along with extensive paper testing.

Recent Maine-based product innovations include a nontoxic grease-proof coating additive, a unique cellulose insulation product, a flame-resistant fiberboard used in commercial roofing, and a biodegradable landfill cover to control odors.

The center's CNM technology, patented by UMaine, features both a 3% slurry and an 18% pressed cake product. UMaine and PDC partner with Valmet, which has licensed the technology to research, develop and produce solutions using nanocellulose.

The breakthrough has been due in large part to the technological developments at UMaine, allowing for low-cost, high-volume production that has increased the access by researchers at universities and companies worldwide. Valmet has three installations around the globe, with two more underway for launch by the end of 2019.

Colleen Walker joined UMaine in 2018 after a decade at TAPPI. As director of the Process Development Center, she heads a team of eight focused on projects ranging from testing to pilot trials, helping clients move from bench to commercial scale. Photo by Holland Haverkamp

At the Cellulose Nanomaterials Researchers Forum held at UMaine in August, Robert Moon, a materials research engineer with the U.S. Forest Service, noted that there continue to be challenges in developing applications for these promising materials, including development costs, scaling issues and more, but CNM strength benefits, plus reduced materials cost and improved performance when combined with other materials, make the efforts worthwhile.

UMaine alumnus Alper Kiziltas, now a research scientist at Ford Motor Co., talked about the variety of materials, from forest and agricultural waste to recycled and emerging micro and nanocellulose that are considered for, or implemented in, some of the 40,000 motor vehicle parts.

When he was a UMaine graduate student, 2007–14, Kiziltas did award-winning research in UMaine's Advanced Structures and Composites Center. In collaboration with professor Douglas Gardner, they explored the use of natural fillers, such as microcrystalline cellulose, wood flour, hemp, flax and kenaf fibers, as opposed to conventional reinforcing fillers, such as glass fiber, carbon fiber, nanoclay and silica. He explored new heat-resistant automotive plastics from natural materials that can stand the stress of high temperatures and are low-cost, low-density, strong, renewable, recyclable and biodegradable.

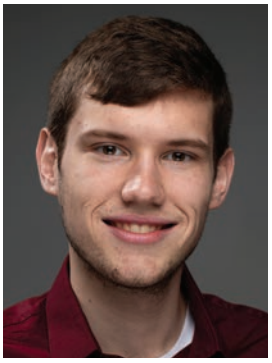
He was part of a growing network of UMaine researchers working with cellulose nanomaterials. This network includes researchers from chemical, biomedical, civil and environmental engineering, chemistry, forest resources, and food and agriculture. Research also extends to UMaine centers, specifically the Forest Bioproducts Research Institute, Advanced Structures and Composites Center, Frontier Institute for Research in Sensor Technologies and Process Development Center.

At the Cellulose Nanomaterials Researchers Forum, Michael Goergen, vice president and director of P3 Nano, spoke of the need to develop markets so that the forests can be sustained.

Development of cellulose nanomaterials can solve problems, he says. Goergen cited one application of the many in development: concrete with just a small amount of CNC (two buckets in an 8-yard truck), which is being considered for California highways to cut costs and reduce greenhouse gas emissions.

"I am so excited about the work here and working with all of you," Goergen said. "We have three active projects with P3 Nano here and we really believe in what's happening here at the University of Maine, and will continue to." ◆

Two of UMaine's top 2019 graduates



Eben Lenfest

Outstanding Graduating Student in Engineering

Bachelor's in Mechanical Engineering

Shayla Kleisinger

Outstanding Graduating International Student in Engineering

Bachelor's in Biomedical Engineering

EBEN LENFEST of Smithfield, Maine, majored in mechanical engineering, with minors in robotics, and ocean and marine engineering.

As a student research assistant at the Advanced Structures and Composites Center, Lenfest worked on a project to test the feasibility and effectiveness of applying a new NASA-developed structural damping technology to the VolturnUS floating offshore wind turbine platform. He also interned at NASA's Marshall Space Flight Center, and worked with a doctoral student to test a scale model wind turbine with active pitch control.

As a UMaine graduate student in mechanical engineering, he continues his work in active pitch controls and spends his summers at the U.S. Department of Energy National Wind Technology Center in Colorado.

SHAYLA KLEISINGER of Winnipeg, Canada, majored in biomedical engineering, with a minor in nanotechnology.

As a member of the swimming and diving team, her primary events were freestyle and individual medley. In 2016–17, she was named to the America East All-Academic Team.

She was involved in research in the Howell Biointerface and Biomimetics Laboratory, and in interdisciplinary project through the Senator George J. Mitchell Center for Sustainability Solutions.

Kleisinger's capstone research project focused on microsatellite technology used in NASA's CubeSat initiative that would be capable of sustaining the growth of microgreen plants in space. She is pursuing a job in biomedical technology and plans to attend graduate school.

Welcome new faculty

Bashir Khoda

Assistant Professor of Mechanical Engineering

Ph.D., Industrial and Systems Engineering, University at Buffalo

WHY UMAINE? Balancing my professional growth with very supportive community while maintaining a quality family life.

Richard Kimball

Professor of Mechanical Engineering; Presidential Chair of Ocean Engineering and Energy

Ph.D., Ocean Engineering, Massachusetts Institute of Technology

WHY UMAINE? I came here to be part of UMaine's world-class research in offshore wind energy research, to contribute to solutions for climate change mitigation.

Curtis Marston

Lecturer in Construction Engineering Technology

B.S., Construction Management Technology, University of Maine

WHY UMAINE? I have seen the need for well-educated graduates during my time in the construction industry, and I have come to UMaine to help educate the next generation of construction professionals.

Ali Shirazi

Assistant Professor of Civil and Environmental Engineering

Ph.D., Civil Engineering, Texas A&M University

WHY UMAINE? A welcoming and collaborative environment.

A. Richard Vannozzi

Assistant Professor of Surveying Engineering Technology

M.S., Forestry, University of Maine

WHY UMAINE? UMaine has given me so much academically, professionally and personally, this is the ultimate opportunity to give back.

“When I was a civil engineering student in 1969, little did I know that I would meet my future wife at East Annex. **Engineering is the seed that has enriched our lives in so many ways.** We are honored to be able to give back by supporting this great project, UMaine, the state and, especially, its future students.”

Gerald “Jerry” Parmenter ’69, ’71G and Judy King Parmenter, General Engineering Department ’64–’71

JERRY AND JUDY PARMENTER of Oregon recognize the importance of the Ferland Engineering Education and Design Center. They have named the North Grand Staircase and have brought the Vision for Tomorrow comprehensive campaign total one step closer to completing the fundraising goal for this important priority.

To discuss ways to support the Ferland Engineering Education and Design Center, contact Pat Cummings ’89, ’44H or Diane Woodworth at the University of Maine Foundation.

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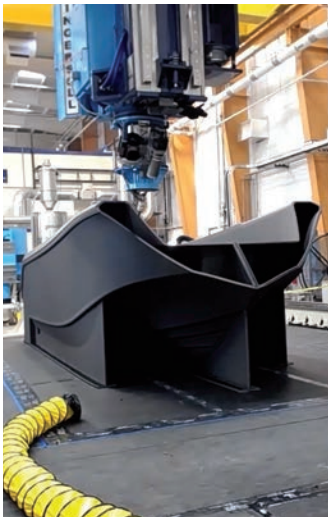

A TIME-LAPSE VIDEO of the creation of the world's largest 3D-printed object and the largest 3D-printed boat at the University of Maine went viral in October. The Advanced Structures and Composites Center video of 3Dirigo had more than 6.3 million views on various websites and on social media, and news of the installation of the world's largest prototype polymer 3D printer made headlines around the world. See that video online: youtu.be/34F71XqvOjg. See the story on page 5.