UMaine Today

CREATIVITY AND ACHIEVEMENT AT THE UNIVERSITY OF MAINE

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Engineering

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2020 vision for UMaine engineering

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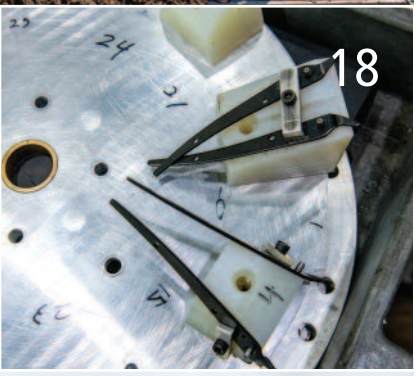


THE COLLEGE of Engineering is forging ahead with design for the new 105,000-square-foot Engineering Education and Design Center (EEDC). This $75 million to $77 million project will be located on the site currently occupied by the Machine Tool Lab.

EEDC will feature a project design suite where students from all engineering majors will come to build their projects. It will have shops for 3D printing, electronics, composites, vehicles, metal and wood. When completed, it will be the best space of its kind in the Northeast.

Classrooms will be set up for active learning, and there will be many collaboration spaces for students and faculty.

EEDC will become the home for mechanical engineering and biomedical engineering, as well as teaching labs for mechanical engineering technology. We plan on breaking ground in spring 2020, with a ribbon cutting in spring 2022.

The center is essential to growing the number of engineering graduates who are critical to powering Maine's economy. This fall, the college's incoming class was up 8 percent, bringing our total student population to just under 2,000.

To date, we have commitments for more than $62 million for EEDC — over 80 percent of the total needed. With your help, the class that starts in fall 2019 will be building their senior capstone projects in the EEDC! Please consider joining the over 250 donors who have already contributed to the center.

Dana L. Humphrey

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

On the cover: An architect's conceptual rendering of the Engineering Education and Design Center, as seen from Cloke Plaza.

Building mindset

CET students empowered to be engaged for the greater good

This past year, 22 construction engineering technology majors, including Alex Porter, pictured in photo at left, volunteered 1,000 hours in a Habitat for Humanity service project to make a house a home for a family of four in Old Town, Maine.

THE UNIVERSITY of Maine's Construction Engineering Technology (CET) program is designed to give students the "skills, experience and knowledge to construct buildings and infrastructure nationwide." And close to home.

In diverse service learning projects as part of their coursework and capstone projects, students apply the civil engineering technology and construction business management skills they learned in the classroom. It's in these projects that they also learn firsthand the importance and value of community engagement for the greater good, and the difference it can make in people's lives.

This past year, the CET projects included a Habitat for Humanity of Greater Bangor initiative — a repossessed house in Old Town, Maine. With the help of a 22-member CET team, that house became a home for a family of four within a year. It was the second Habitat for Humanity home CET seniors have undertaken in recent years in their capstone community service projects.

"I thought we could put the service project aspects of actually building something for a community partner with learning opportunities for management of construction," says Will Manion, CET coordinator and associate professor of construction engineering technology.

Overall, students volunteered about 1,000 hours.

The students began the planning phase of the project in the late spring and early fall 2017 semesters, designing and evaluating several new floor plans, estimating material quantities and developing a schedule. Then they moved into the construction phase, reframing the interior walls and roof to eliminate the second floor. They also installed insulation, siding, windows and doors.

It was a good project for learning teamwork and problem solving, says CET student Alex Porter of Bangor, Maine.

"If a plan didn't work necessarily perfectly, we were able to adapt and find better solutions," he says.

During the winter months, several more volunteers, subcontractors and Habitat employees finished the interior

drywall and trim work, refinished the floors, installed kitchen cabinets, painted and finished the siding, and installed new electrical, heating and plumbing systems.

"Working with Will Manion and the UMaine CET program has transformed our organization. Their involvement has enabled us to renovate two homes that we otherwise would not have had the capacity to renovate," says Lynn Hempen, executive director of Habitat for Humanity of Greater Bangor. "This partnership is a win-win: Their students gain real-world experience and we can provide more families with the opportunity to own a decent, affordable home."

To Manion, service learning projects like this are a natural fit for CET.

"We've been very fortunate to have a number of developing, nice partnerships with some area organizations. They come up with ideas and we try to implement them," says Manion, who is joined in teaching and mentoring the seniors by CET professor Philip Dunn.

"It's like a family kind of community, and all the classes are taught by people who've been professionals in the field, and have a lot to contribute to our success and future," says Porter of the CET program.

In addition to Habitat for Humanity, two of the other ongoing collaborators include Hirundo Wildlife Refuge in Old Town and Leonard's Mills at the Maine Forest and Logging Museum in Bradley. The students learn to work with experts in other fields, including biologists and naturalists.

The students need to "learn how to speak their language, too," says Manion. "It's the whole package, which is what it's like to manage construction."

The CET program also benefits from connections with local construction businesses, particularly Sargent Corp.,

Photos left to right: Old Town-based Sargent Corp., partners with the UMaine CET program to provide students hands-on learning opportunities with heavy equipment. In Hirundo Wildlife Refuge in Old Town, students constructed a viewing deck as part of an ADA-compliant "Trail of Senses."

in Old Town and Central Equipment Co., in Stillwater.

"They'll essentially loan us rental equipment when it's not out on 'real' rental," Manion says. "Sargent Corp., also provides support to the CET program by training the students on proper equipment usage."

THE CET program typically has multiple concurrent service projects — initiatives all requiring management and attention to detail. The students are highly invested and have a tendency to want to fix any problem they see.

On the Habitat for Humanity house, the students split up into five teams to take turns leading the work. Each student team acts as the foreman for a specific part of the project. By taking turns managing, students gain leadership experience that they can transfer to their careers, says Manion. And the different aspects of the project provide a well-rounded experience.

"It's obviously a real project with real problems and real (logistics), including scheduling other folks to come in and do pieces of work," says Manion. That included the collaboration with Eastern Maine Community College students, who did the electrical and plumbing work on the Habitat for Humanity house.

"Construction is really evolving into a much more people-centered industry," says Manion. "It's really becoming more team-oriented. Our graduates are being asked more and more to lead project teams — from planning and design (to) all the way through the construction process.

"I'd also like to think that the students are gaining a little bit of civic satisfaction or pride," he says. "A lot of construction folks have a real strong sense of pride, that we're building the infrastructure, the buildings, the power generation — all the stuff that makes our society go. It's something we're very proud of."

CET student Austyn Shea of Concord, New Hampshire, knows that sense of pride.

"We put a lot of work into this, and it means something to you once you've done that," he says of renovating the Habitat for Humanity house. "It was fun to work with everyone (and) it was fun to help someone out while you're doing it.

"When you're doing something that someone's actually going to benefit from, it adds a whole new purpose and gives you a little more drive during the process."

CET ASSISTANT professor Amber Killip teaches an introductory estimating and planning course similar to the capstone, but on a smaller scale. It is geared to first- and second-year students. The course and the capstone "are kind of like bookends," Killip says, framing the students' experiences in the CET program.

"Each semester we pick a different nonprofit organization, and the nonprofit supplies us with materials, and then our students plan the work and build it," says Killip.

In the project portion of the course, students demonstrate what they have learned and apply their knowledge to translate the 2D plans into a 3D finished product. The idea for one recent project came from Lucy Quimby, president of Bangor Land Trust. The students built kestrel nesting boxes that the Land Trust is installing in Penjajawoc Marsh to aid the falcon species whose numbers are declining.

This and other projects in the course are developed in partnership with local community organizations that have a need for extra hands to help with a project. The students gain skills ranging from interpersonal communication and group dynamics to problem solving in the moment, on a job site, even at the introductory level, Killip says.

They're also motived by the meaningful projects that have a community outreach component.

> "A lot of construction folks have a **real strong sense of pride,** that we're building the infrastructure, the buildings, the power generation — **all the stuff that makes our society go.** It's something we're very proud of." Will Manion

Killip says the students spend most of the semester working on the plans, and learn about safety and quality control before completing the projects themselves. The project build lasts two hours, taking the place of a final exam.

Typically, seven or eight groups of three to four students work on an identical part of the same project. In executing their plans, the students learn what works well and what needs tweaking, adapting to solve unanticipated problems as they arise.

"Doing this project, we're learning a little bit about the planning process that goes into building something — and teamwork," says Bryan King, a CET student from Stillwater, Maine who worked on the kestrel boxes. "It's really about just being detail-oriented, and just looking at it from all angles.

"We learn a bunch of problem-solving skills," he says. "When we make our plans, we basically talk about any steps that might have some minor alterations. It's just about adapting to your environment."

For Emerald Boisselle-Byers of Orono, Maine, who also worked on the kestrel box project, the leadership experience he gained was important.

"The best part of the lead job is actually being on-site and building, having the authority to say which screw goes where, and where you want your materials — how you really want to design it. It's been a blast," says Boisselle-Byers.

King also appreciates the opportunities that UMaine offers for students to get involved in the community on projects that "actually benefit more than just ourselves and the college."

"The outreach is really nice and I'm glad to be a part of it," he says.

IN THE fall 2016 semester, the CET program partnered with the Maine Audubon Society to make bird boxes for

One of the introductory course projects focused on building kestrel nesting boxes for the Bangor Land Trust to install in Penjajawoc Marsh. Professor Amber Killip, second from the left, leads the course, which last year included students, left to right, Kyle Tobin, Emerald Boisselle-Byers, and Chris Perkins.

the organization's Fields Pond center in Holden. The next two semesters, students built ADA-compliant benches for the Hirundo Wildlife Refuge in Old Town, and parrot boxes for DEW Haven, a wildlife sanctuary in Mt. Vernon, Maine.

Other recent service projects include replacing cedar shingle roofs on the covered bridge and sawmill building at the Maine Forest and Logging Museum, and installing a metal roof on the museum; constructing a storage shed for Old Town Parks and Recreation; wall removal and repair for the Good Samaritan Agency in Bangor; sign repair and solar lighting enhancement for the Knights of Columbus in Old Town; and ADA-compliant trail construction for the "Trail of Senses" at Hirundo.

"We try to do a lot of service learning, and it's amazing how much the students actually get more invested in what they're doing when they realize that this work is actually going to get used," says Killip.

"And it's fun to see their faces light up when they realize that, 'I'm doing something and it's for my coursework, but it also is making a difference,'" she says.

"The intent is also to help teach them early on that it's important to be citizens, and active in your community, and give back," says Killip.

"I think the best thing about students doing these projects is that it's real. That we're working for a real client, with real needs and real constraints," says Manion.

"It's powerful, it's like we helped a family in the community. It's cool that we were able to come together and do something like this of this magnitude," says Porter. ■

Vests and pests

Biomedical engineering students tackle health-related issues in capstone research projects

SENIOR BIOMEDICAL engineering majors at the University of Maine spent the last year of their undergraduate careers putting their know-how to the test on health-related research projects. The challenging projects are designed to prepare graduates to have a positive impact on society.

"Capstone projects allow our students to take all that they've learned over their undergraduate years and put that knowledge to use addressing a problem of real importance to the community," says Caitlin Howell, a UMaine assistant professor of biomedical engineering. "The students see that after all their years of hard work and studying, they have developed the skills to be able to contribute in a tangible, meaningful way."

This past year's projects included development of a vest with realistic heart and lung sounds that can be used in medical training scenarios, and a filtration system aimed at killing disease-carrying mosquitoes.

"My whole life I wanted to be a doctor," says Jennie Daley, of Sullivan, Maine. "I realized doctors help one person at a time, whereas if you're a biomedical engineer and you're advancing medical equipment, you can help millions and can continue helping people even after your death."

The four students who developed the vest sought to create an affordable and wearable training system for medical personnel in an effort to increase health care quality and decrease costs for rural Maine communities.

Daley, Samantha Brown, Dakota Sudbeck and Jordan Tremont created a high-fidelity simulation vest that can be worn by patients, or actors, in medical training scenarios.

In the UMaine School of Nursing, the students observed use of medical manikins in the simulation training lab. They learned from Valerie Herbert, an assistant professor of nursing, that actors instead of manikins are preferred for training purposes. But creating realistic abnormalities on a person is a lot more difficult, which is where the vest came in, says Tremont, of Lunenburg, Massachusetts.

Using state-of-the art approaches, such as flat, embroidered speakers, the students developed a vest that can emit realistic abnormal heart and lung sounds that mimic health conditions, including pneumonia and heart valve abnormalities. Medical trainees can hear the sounds with a standard stethoscope while also communicating with the patient.

"It's about trying to mix the best of those two realms," says Sudbeck, of Hampden, Maine, noting that the prototype would be worn in training scenarios to not only improve diagnostic

skills, but to work on interpersonal communication.

Currently, there is no vest on the market that a standardized patient can wear that has discreet speakers for heart and lung sounds, according to the students. Medical training manikins have speakers, but they can't easily be used in the field. There's also a stethoscope that creates heart and lung sounds, but using that means medical personnel can't practice with their own instruments. Both tools can cost thousands of dollars, according to the students, who estimate their vest could cost under $1,000.

Having a low-cost device available for medical simulation training in rural areas is important because every patient deserves the same quality of care, according to Brown, of Hampden, Maine.

"You don't want someone to miss out on being diagnosed with something because their nurse didn't have the adequate training," she says.

The project was funded by the Department of Chemical and Biomedical Engineering, and NASA's Maine Space Grant Consortium.

ANOTHER GROUP of biomedical engineering students was tasked with creating a filtration system that can detect overwintering mosquitoes underground and eliminate them without use of pesticides.

Colin Benson of Auburn, Maine; Rachael Bergeron of Waterville, Maine; David Scidmore of Escondido, California; and Brad Trenteseaux of Seekonk, Massachusetts consulted with researchers at the Maine Medical Center Research Institute in Scarborough to develop a safe, effective method of controlling the spread of mosquitoes.

In recent years, eastern equine enceph-alitis (EEE) virus outbreaks have been on the rise in Maine. Approximately one third of those who develop EEE die, and many who survive have mild to severe permanent neurologic damage, according to the Centers for Disease Control and Prevention.

The vector-borne disease is trans-

Students working on the vest project are, left to right, Jennie Daley, Samantha Brown, Dakota Sudbeck and Jordan Tremont.

Students, left to right, Brad Trenteseaux, Colin Benson, David Scidmore and Rachael Bergeron (not pictured) developed a selective filtration method — a pump and a series of meshes and filters — to eliminate 90 percent of mosquito larvae in crypts.

mitted from birds to mammals, such as horses and humans, through the black-tailed mosquito *Culiseta melanura*.

Current methods for reducing incidence of the disease involve careful observation of the insect's overwintering habitats, along with use of pesticides. This is problematic for many coastal communities, where the runoff from toxic chemicals severely affects the surrounding ecosystem, say the students.

To reduce the use of harmful chemicals, the students developed a selective filtration method to eliminate 90 percent of mosquito larvae found in crypts, or the underground root systems filled with stagnant water, where they live during the winter.

The prototype features a pump and a series of meshes and filters. The initial filter prevents the device from removing anything too large; the next two filters remove only mosquito larvae and allow any smaller life-forms to easily pass through.

The use of the filters eliminates the need for chemicals and preserves other life within the crypt, the students say.

"Pesticides pose a huge threat to aquatic life in coastal Maine," says Benson. "The lobstering and fishing industries of Maine are huge, and we're reducing threats to those industries."

To ensure the full volume of a crypt has been treated, the team employed a series of ultrasonic, capacitance and flow sensors, along with a Raspberry Pi computer to perform area measurements and calculations.

The group's project, funded by the Department of Chemical and Biomedical Engineering, is important because of the threat posted by vector-borne diseases, including Zika, Trenteseaux says.

"It's an issue where there is one traditional way of tackling, which is very impactful and harmful on the environment," he says. "It's important to think outside the box. How can we solve a large problem without causing any more harm?"

According to Benson, biomedical engineering is biological problem solving using engineering principles, which, Trenteseaux adds, usually involves creative thinking.

"Innovation is important because not always is there a direct translation between an idea you have and the solution that ultimately comes out of it. This might not be the perfect solution, but it's a start," he says, adding that future biomedical engineering students can continue the work to improve the prototype.

Howell served as the primary adviser for the vest team and secondary adviser to three other groups, including the mosquito team. She oversaw the work of 12 biomedical engineering majors, together with her colleague Karissa Tilbury, also an assistant professor of biomedical engineering.

Howell further consulted on the capstone project of four mechanical engineering technology students, supervised by assistant professor of mechanical engineering technology Brett Ellis, as well as two electrical engineering majors, supervised by associate professor of electrical engineering Nuri Emanetoglu and lecturer Andrew Sheaff. ■

Student innovation has the potential to improve search and rescue efforts

AS UNIVERSITY of Maine biomedical engineering major Dakota Sudbeck approached his senior year, he sought an independent research project that would prepare him for medical school.

He consulted with Robert Bowie, a newly appointed professor of practice in the Department of Chemical and Biomedical Engineering. Bowie has 20 years of experience as an emergency physician. He also serves as the medical director for the Orono-based search and rescue group, Down East Emergency Medicine Institute (DEEMI).

After meeting with Bowie, Sudbeck was intrigued by the possibility of improving search and rescue techniques for the local organization and others. That includes improving the collection of biometric information from persons in need of rescue, especially when a first responder can't reach them for hours.

"Earlier assessment allows you to send interventions medically to the patient," Bowie says. "In the long run, you could decrease morbidity because doctors in the whole chain of survival at the hospital are preparing to receive the rescued patient."

The more information emergency doctors have, the better prepared they can be for a patient, according to Bowie.

Sudbeck initially was interested in preventing hypothermia and wanted to research the collection of body temperature and respiration rate using an uninhabited aerial vehicle (UAV), or drone, equipped with an infrared imaging camera.

In summer 2017, Sudbeck was awarded an undergraduate fellowship for the project by UMaine's Center for Undergraduate Research and the Maine Space Grant Consortium.

After initial research, Sudbeck and Karissa Tilbury, an assistant professor of biomedical engineering, determined it would be difficult to detect respiration rate using a flying drone, which can't get close enough to a patient. That's when they turned their focus to something they believed they could establish — body weight.

The information would be critical to search and rescue crews.

"We use weight when we have to medevac someone out," Bowie says. "We need to know how much they weigh, especially at high altitude, to help estimate the amount of medication you might give a person. If you can get within 10–20 percent of their actual weight, you're in a good range."

Additional funding from the University of Maine System Research Reinvestment Fund allowed Sudbeck to continue work. The funding also allowed Dan Schlabig, a junior in UMaine's Electrical and Computer Engineering Department, to join the project in fall 2017.

Schlabig found his experience in signal processing helpful for the project. He wrote code before the pair switched to investigating existing software and techniques.

They focused on taking multiple images from different angles to create a 3D model of a person.

Using the collected 120 high-resolution photos and a laptop, the students calculated a person's weight within 15 pounds in about an hour.

"Dr. Bowie was hoping for 20 percent; the percent error on that one was about 9 percent," Sudbeck says. "But it's not fast enough yet."

Going forward, the students say they will focus on making the process quicker and more accurate.

"It takes DEEMI about 30 minutes to gather the medevac equipment and medication, figure out an extraction point for a patient in a remote area, and fly there, so that's about the window," Sudbeck says. "If we can get these images and a final weight value within 30 minutes, then it's a success." ■

In testing, UMaine alumnus Vinal Applebee, left, an FAA-licensed DEEMI remote drone pilot, flew a DJI Inspire 1 UAV, equipped with a thermal camera, 360 degrees around Dakota Sudbeck, center while taking about 120 images. Sudbeck and Dan Schlabig then uploaded the images to VisualSFM, a computer-based application that uses a structure from motion algorithm for 3D reconstruction.

Quality monitoring

Citizen scientists, researchers collaborate to build lake vulnerability index for Maine

CLOUDS HANG low over Phillips Lake in Dedham, Maine as an engineering research team from the University of Maine, anxious to avoid the inevitable rain, methodically takes water readings while trolling across the deepest part of the lake.

Trailing their boat is a pontoon carrying a handful of lake residents, some of whom are members of the Lake Stewards of Maine (LSM), a statewide organization working with the university research team. Also aboard is Stephen Norton, UMaine professor emeritus of Earth and climate sciences, who is providing an update on the types of measurements the research team is taking as part of his informal seminar on lake chemistry and morphology.

In turn, the lake residents share their local knowledge of the lake, pointing to past and present trouble spots, as well as areas of recent development. Their information sparks questions, and the answers spur more questions.

This mid-lake discussion is a key component of the UMaine lake research project.

Civil and environmental engineering graduate student Nick Messina, left, and senior Bailey Simmons-Brown take water samples on Hurd Pond, another waterway in Dedham, Maine.

The study, led by Aria Amirbahman, a UMaine professor of civil and environmental engineering, combines both the physical and social sciences. The goal is to develop a lake vulnerability index that will utilize a variety of physical and chemical indicators to predict which lakes are more susceptible to water quality deterioration.

In addition, working with a social scientist from the University of Southern Maine, the project will use surveys and interviews to help identify the factors that encourage people to be involved in lake stewardship, and to develop activities that will encourage more stewardship involvement.

Funded initially through a grant from the Senator George J. Mitchell Center for Sustainability Solutions, and the Maine Outdoor Heritage Fund, the project last year received a $100,000 grant from the National Science Foundation, which will keep the study going into 2019. Collaborating with the researchers is the Maine Department of Environmental Protection (DEP) and LSM.

The project grew out of Amirbahman's research during his 20-year tenure at UMaine. Much of his focus has been on lake chemistry — the microprocesses that occur at different levels in the lake water and sediment.

This project has a larger scale.

"(We're) looking at the lakes in a region as a whole rather than getting into the nitty-gritty of what is happening in a specific lake," he says. "Maine has several thousand lakes. Any agency in charge of understanding water quality would like to have a model, a rubric that they can use — a relatively easy metric to say something about the future of those lakes."

IN ADDITION to professors Amirbahman and Norton, the UMaine research team consists of three students at varying stages in their academic careers. Jeremy Deeds, a biologist with

Jeremy Deeds, left, is a biologist with the Maine Department of Environmental Protection and a Ph.D. student. His doctoral research focuses on how activity on land by humans and animals, especially along the shoreline, affects lake water quality. Among his faculty collaborators is professor emeritus Stephen Norton, right.

the Maine DEP, is a UMaine Ph.D. student; Nick Messina is a master's student from Derry, New Hampshire, and Bailey Simmons-Brown is a senior environmental science major from Chicago, Illinois. Under Norton's direction, the students do most of the readings, and also analyze the data in UMaine labs.

Deeds' doctoral research focuses on how activity on land by humans and animals, especially along shorelines, affects what happens in the rest of the lake. When he is not collecting readings, Messina is writing code in an effort to create a model to predict how extreme weather events will affect a lake. Simmons-Brown is using the experience to design his capstone.

The UMaine researchers work closely with citizen scientists like the group on Phillips Lake. Although they are observers that day, the citizen scientists are regularly out monitoring the lake more frequently than is feasible for the researchers.

"We could not have done a study like this without them," Amirbahman says.

Those citizen scientists are organized by LSM, formerly the Maine Lake Volunteer Monitoring Program, the oldest and largest citizen scientist lake monitoring group in the country. LSM has an intensive training and certification program for its volunteers, and provides calibrated equipment for them to use.

"They have done such an amazing job in training these folks and they have their own internal way of quality control," Amirbahman says. "The data are good. They take this very seriously."

The study has relied on this collaboration with volunteers to collect data on more than 100 Maine lakes. The on-site data is combined with other intel, including geological information, depth, climate forecasts, the amount of development and agriculture in the region and the number of miles of roads in each lake's watershed.

> "Any agency would like to have **a model, a rubric that they can use** — a relatively easy metric to say something about **the future of those lakes.**"
>
> Aria Amirbahman

Back in the lab, that information is analyzed to create a basic formula that is the lake vulnerability index.

"It's a statistical model," Amirbahman says. "You put in the predictor variables and it comes up with an estimate of how much nutrient you can expect in the top part of the lake. It's that nutrient, phosphorous, that leads to eutrophication and the loss of water quality."

Although the team has another year of research and analysis to complete, Amirbahman says a preliminary model already has been developed based on physical and chemical parameters, as well as climate and geology factors that affect lake water quality.

"We know that the percentage of agricultural land around a lake influences water quality. The more development, the more agriculture around a lake, the more deterioration of the water quality," he says. "Also, we know that a shallow lake is more susceptible to deterioration. That's important for the DEP to know. If you have a shallow lake, you need to limit land use activities around it."

FOR THE social science portion of the study, the researchers have surveyed lake stewardship volunteers, collecting a range of demographic information, such as education, age and income. In addition, the survey also tracks their wide-ranging reasons for involvement on the lake.

For Chuck Maclead, who has spent 35 volunteer years taking measurements on the lake, watchdogging it for potential dangers and working to correct those problems when they arose, the reason is simple: He's seen what can happen when a lake isn't cared for.

"A clean lake is better than a dirty one," he says.

John Wedin agrees. He has a degree in environmental science and currently is the watershed steward for Ellsworth, Maine. In that position, he regularly monitors the health of Branch Lake, the city's water supply — activities he translates to the lake near his home.

"I've worked with water and wastewater treatment in my professional life," he says. "I also do it now as a volunteer."

The information gathered is being reviewed in an effort to develop a

For the past two decades, professor Aria Amirbahman's research has focused on lake chemistry — the microprocesses that occur at different levels in the lake water and sediment. His current project looks at regional lake health.

checklist of sorts to guide future activities aimed at increasing and improving stewardship efforts.

"We want to come up with a blueprint of activities that can influence positively the stewardship behavior among the public," Amirbahman says. "We rely on them for collecting data. We learn from them and then come up with a rubric of activities that encourages these folks to become better stewards of their lakes."

Amirbahman stresses that the university and DEP simply don't have the resources to monitor the more than 100 lakes they've studied over the past three seasons. Not only do the volunteers provide the "boats in the water" resource that can regularly monitor the lakes, but, as in Maclead's case, they can provide years of data that further inform the current research.

Deeds notes that the data Maclead amassed during 35 years of lake monitoring in Phillips Lake are now part of the archive at UMaine.

"In some cases, volunteers have been collecting information on the lake for as long as 40 years," he says. "That gives us good baseline information and it gives us a clear picture of how the lake has changed over time."

The information flow is a two-way street, Amirbahman says. Norton's informal seminar out on Phillips Lake was just one example of how the university is transferring the information gained from the study back to those who helped conduct the research.

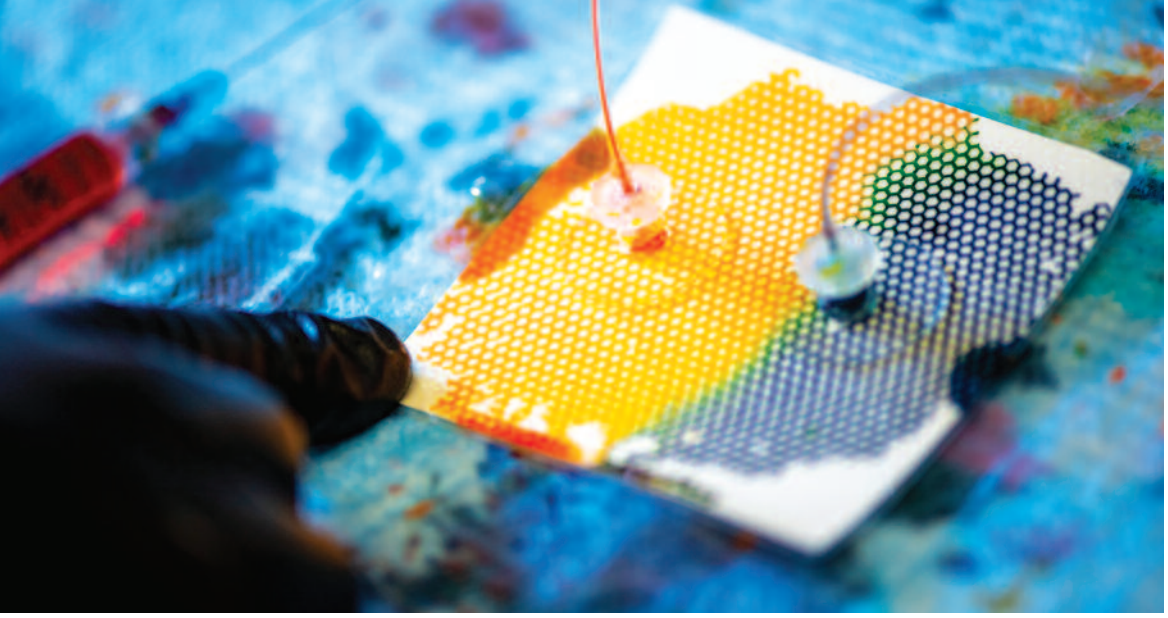
Providing highly technical, scientific information in an understandable manner is extremely important, he says.

"I think it makes a big, positive influence when people see that a public university actually cares about where they live, that locality, and sort of gets down and dirty with them to help them," Amirbahman says. "They realize how much influence they have.

"All in all, I think it has been a very positive experience for us and for the citizen scientists," he says.

Back on the shores of Phillips Lake, with the gray clouds growing darker and rain imminent, Wedin acknowledges the feedback, noting that the information not only tells them about their lake, but also helps guide what actions they take to preserve it.

"Knowledge is important," he says. "We all enjoy living on the lake, but we have to know if we're enjoying it too much." ■



The aha moment: Researchers from UMaine and Sappi North America discovered that an existing technology — patterned paper — can be used for an environmentally friendly diagnostic device.

Inventing solutions

A NEW University of Maine technology accelerator program provides resources and expertise to allow researchers to move their inventions out of the lab and into public and commercial use.

Earlier this year, five inventions created by UMaine faculty-led teams were the first to benefit from the Maine Innovation, Research and Technology Accelerator (MIRTA) program. MIRTA was made possible by the University of Maine System 2018 Research Reinvestment Fund, a pool of competitive internal grants allocated to advance research projects along the path from discovery to becoming commercial products with public benefit.

All projects are tied to Maine businesses or industries critical to the future of the state. This fall, MIRTA's second cohort includes teams researching projects ranging from digital visual aids for people with visual disabilities to replacing plastics with biodegradable materials.

MIRTA is part of UMaine's statewide focus on innovation, economic development and workforce development — a commitment to create meaningful employment and help improve the lives of people across Maine and beyond.

The first five MIRTA teams spent 20 hours a week for 16 weeks learning about the market and intellectual property analyses, and business model development needed to bring their invention to market. Most of the teams included undergraduate and graduate student researchers.

Guiding the research teams were business incubation staff from the university's Office of Innovation and Economic Development, and an advisory committee of industry and technology experts, many of whom are UMaine alumni, who provide feedback and advice.

At the end of their program, the teams had clear plans to move forward, from starting a company to licensing and collaborating with business partners. The three MIRTA teams led or co-led by College of Engineering inventors:

HEALTHY HIVES

To learn more about bee colony health and prevent collapses through early intervention, a radar-based, noninvasive beehive activity monitor was invented to record the insects' movements. Armed with the customer and market knowledge gained through MIRTA activities, Healthy Hives inventor Nuri Emanetoglu plans to launch a startup in late 2018, with companies in Ellsworth and Portland expected to collaborate on manufacturing.

POINT-OF-CARE DIAGNOSTICS, SIMPLIFIED

The need is ever-increasing for handheld point-of-care biomedical diagnostic testing devices, such as those used in blood and urine testing in the health care and pharmaceuticals arenas. These kinds of tests enable providers to detect diseases earlier and offer diagnostic testing to underserved populations. Despite the numerous benefits these devices bring to the health care community, they are costly to produce. In collaboration with Sappi North America in Westbrook, Maine, a UMaine research team is developing low-cost, paper-based devices that leverage the existing patented patterning technology and microfluidics engineering in disposable, biodegradable devices that could ultimately increase accessibility to health-related diagnostic testing worldwide. The team is led by inventors Caitlin Howell, Amber Boutiette and Matthew Talbot in collaboration with Amy Blakeley of Sappi.

MAKING PERIPHERAL NEUROPATHY RIGHT

Neuropathy, the death of peripheral nerves, is a health condition that can result in pain and loss of mobility and, in some cases, can lead to amputation. Causes range from diabetes and aging to certain viruses and exposure to some chemicals. A research team led by Kristy Townsend and Rosemary Smith has developed a microneedle medical device for early detection and diagnosis of small-fiber neuropathy. The device also has the ability to deliver noninvasive, pain-free treatment on and below the skin. The flexible microneedle array is capable of nerve conduction measurements and drug delivery, and has the potential to stimulate nerve regrowth. ■

Icing on the cake

Advanced Manufacturing Center innovation transforms industries' next great ideas into prototypes, products or proof of concept

THE ADVANCED Manufacturing Center at the University of Maine is an engineering support and service center dedicated to promoting economic development in the state and beyond.

As part of UMaine's College of Engineering, AMC aims to link UMaine's education and research with the university's active industrial support and economic development programs.

Since its inception in 2004, the center has worked with more than 350 Maine companies, helping with simple product prototyping to complex multiprocess automation equipment. And in all the projects, undergraduate and graduate students gain hands-on experience in innovation and real-world problem solving that advances industry.

"It is very rewarding when we can help small in-state manufacturers with a process that can really revolutionize the way they do business," says AMC director John Belding. "That is the power of having the AMC staff and students, and entire university behind you."

The center is committed to maintaining a first-class facility equipped with the latest manufacturing technologies. AMC's professional staff and students design and build prototype and development projects ranging from large-scale fabrications to machined parts with micromillimeter tolerances.

The center has the ability to expand its range of expertise by working with engineering faculty, other UMaine research centers and industry partners.

Four of the Maine companies partnering with AMC profiled the issues they brought to UMaine and the innovations that led to improvements in efficiency and effectiveness — and taking their companies to the next level.

These are their stories.

LABREE'S BAKERY

LaBree's Bakery in Old Town makes more than 400 items, including doughnuts, whoopie pies and jelly rolls. The company, which has been part of the community for 70 years, supplies its products to grocery stores nationwide, and a large part of its business comes from cakes.

The company came to AMC when it noticed small cosmetic imperfections in its decorated cakes — the result of an automated process that, when less than perfect, required additional labor to get the products up to the standards customers expect and the company demands, according to Damian LaBree, vice president of the bakery.

"All the product we make has to go through a mechanical process to apply the icings and decorations, and to move the product down the line," LaBree says. "We needed a solution to fix our current problem that would provide reliability, robustness and repeatability."

Progress Engineering of Manchester, Maine looked at the controls and electronics side of the cake decorating line, while AMC looked at the mechanical side, according to LaBree.

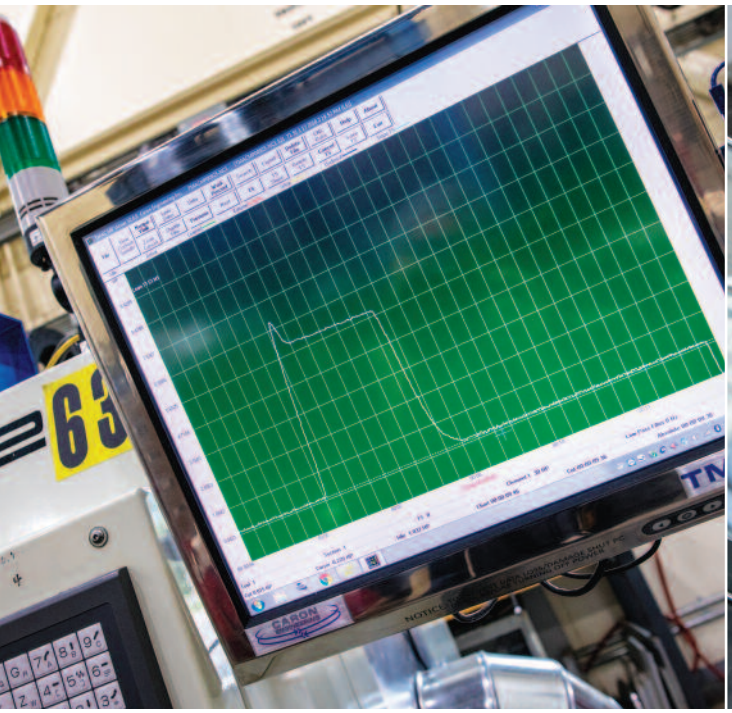
Indeed, the AMC staff was able to analyze the entire process.

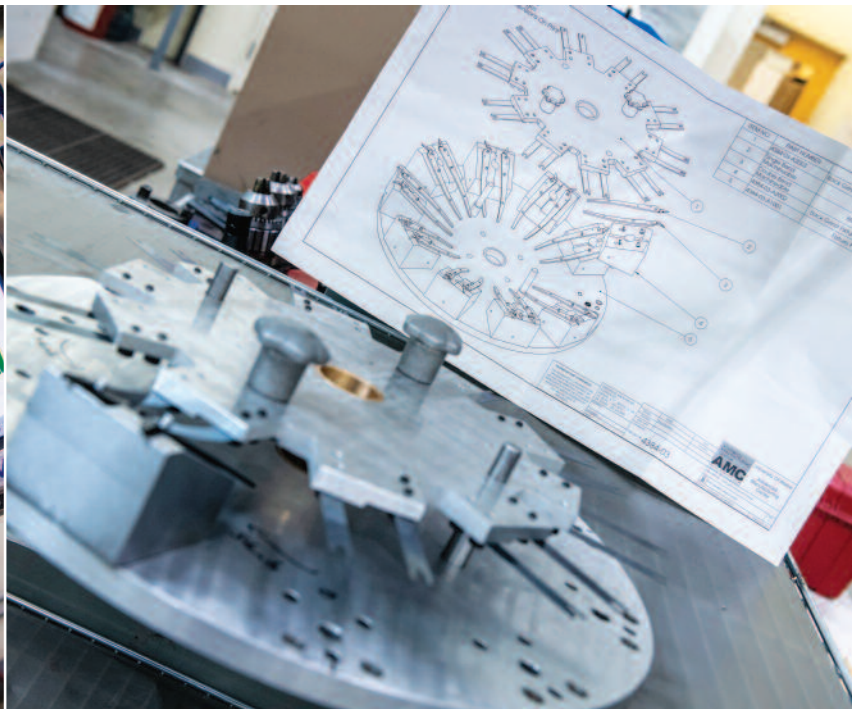
"They didn't just come in and say, 'Let's fix X, Y and Z,'" LaBree says. "They looked at it and said, 'This is the process, but how do we do this process better? Is there something we can incorporate to not only fix the problem, but also improve upon it so it works better, not just for now but also for the long term?'"

In the six months of the project, AMC met all of the bakery's criteria in making a reliable piece of food industry equipment that performed well, LaBree says.

When LaBree's Bakery in Old Town, Maine needed to increase the efficiency of its automated cake decorating equipment, the company collaborated with the Advanced Manufacturing Center for mechanical upgrading assistance.

Icing on the cake





CARON ENGINEERING

Rob Caron founded Wells-based Caron Engineering more than 30 years ago to develop advanced technology for the computer numerical control (CNC) machining industry to improve performance, productivity and profitability.

To better determine when tools are worn, the company pursued a data analytics project with help from AMC.

"The university helped us lay out and determine a consistent experimental process where we could find the largest factors at play and then try to control them," says Tyler Romano, a data scientist at Caron Engineering.

"The university provided a controlled environment so we could then get a theoretical model to base our future analysis on."

Romano says AMC helped develop the company's analytical strategy foundation.

"The university was great at providing a launchpad to expedite the early stages of our data analytics project," Romano says, citing advantages such as access to a controlled environment and expert analysis from the staff.

AMC provided data collection and testing on the company's Tool Monitoring Adaptive Control (TMAC) System, which protects CNC machines by effectively measuring tool wear in real time.

Caron said working with AMC allowed the company to bring the product to market quicker. "AMC helped us get further along in the process," he says. "They did a great design of experiments that gave us some really good information, good data and a very detailed analysis looking at tool wear."

Caron says he hopes to continue the relationship with future projects and prospective employees.

"Caron Engineering is a growing company, and we're always going to be looking for more engineering talent," Caron says.

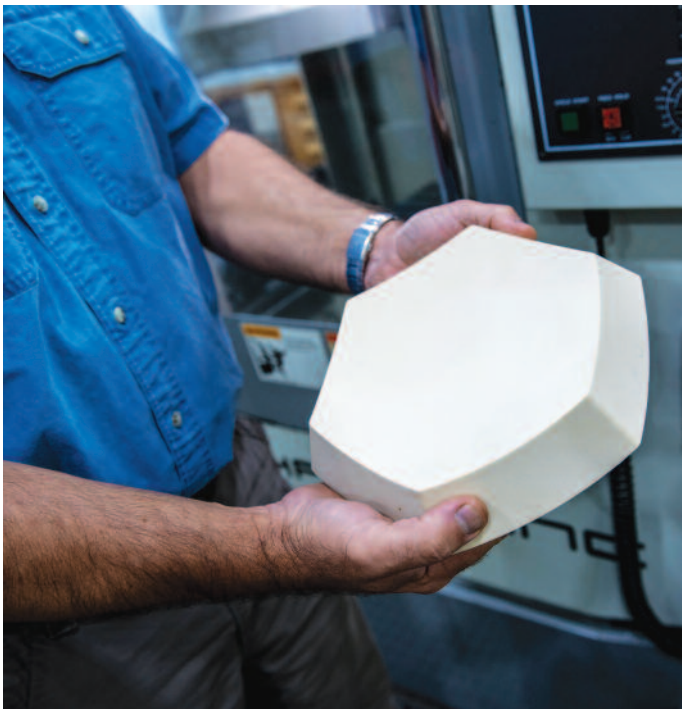
FIBER MATERIALS INC.

Steven Violette, an application engineer at Fiber Materials Inc. (FMI) in Biddeford, approached AMC three years ago while working on a project for NASA's Ames Research Center in California.

FMI, which manufactures high-temperature composites for space and missile applications, was tasked with making a unique thermal protection material for NASA called HEEET — heat shield for extreme entry environment technology.

The program required accurate measurements throughout different stages of the manufacturing process, which led FMI to AMC's laser scanning services.

"From that point, the project became larger in scope



Photos left to right: Advanced Manufacturing Center engineers and students worked with Caron Engineering on a data analytics project, focused on data collection and testing on the company's Tool Monitoring Adaptive Control System, which protects CNC machines by effectively measuring tool wear in real time. For Xuron Corp., AMC created new fixtures to be used with the grinding machines to speed up production and increase accuracy of tool production. Fiber Materials Inc. used AMC's laser scanning and manufacturing capabilities, including fixturing and machining, in its production of a unique thermal protection material for NASA called HEEET — heat shield for extreme entry environment technology.

and we ended up using the AMC for a number of manufacturing capabilities, including fixturing and machining of the HEEET project," Violette says. "They were able to provide very accurate fixtures for machining of parts."

Violette says working with AMC has been most helpful when FMI doesn't have a particular manufacturing capability in house.

"They've worked with us to install the capability or to show us the manufacturing they do, and then helped us learn to do the same things on-site at FMI," Violette says.

The majority of the projects between FMI and AMC have involved students.

"That's very helpful for us. Not only are we getting the capabilities in hand and receiving the services, but some of the students have gone on to work for our company, as well," Violette says.

XURON CORP.

Xuron Corp. of Saco manufactures a variety of hand tools, such as wire cutters and pliers. Its products are sold worldwide to markets that include industrial electronics, aerospace, jewelry making and plastics molding.

After experiencing problems producing one of its top-selling models on an older machine, Xuron contacted AMC.

"Having worked with the AMC in the past, we decided (the staff) might have a good solution and be able to think out of the box," says Bob Warner, one of Xuron's three owners. "We're kind of entrenched in the way we do things, like a lot of companies are."

Xuron approached AMC to create new fixtures to be used with their grinding machines to speed up the production process and increase accuracy, Warner says.

One of the problems the company faced: It could only manufacture one side of a blade at a time.

"Part of the solution was to be able to grind a complete pair so we can test them as we're working on them," Warner says. "Right now we go through 5,000 of one side before we start the other side. If we've caused a problem, we might not realize it."

Warner says the company will now be able to produce 10 pairs instead of seven in the same amount of time.

"We should be able to get more through and be more accurate in that we can test them as we're taking them off," he says. "That's huge."

Warner says he already has another project in mind in collaboration with AMC and looks forward to meeting new students.

"It's a whole pool of ideas that I can't have just by myself, or me and a few colleagues. It makes a big difference," he says of working with AMC staff and students. ■




Going with the *flow*

Research focused on the mechanics of fluid dynamics has multifaceted implications

HUMANS' ABILITY to speak is made possible by an intricate combination of muscles, cartilage, ligaments, membranes, tissues and bones. Understanding how each of those facets functions in speech production or phonation — and what happens when one or more of them doesn't work as they should — is the focus of mechanical engineering research by University of Maine professors Qian Xue and Xudong Zheng.

The research is an example of the breadth and depth of mechanical engineering, which, in essence, focuses on "almost everything that moves in the universe, including fluids, solids, thermal systems, robotics, the human body, automotive parts, energy, materials and aerospace technology."

In 2017, Zheng received a more than $500,000 grant through the National Science Foundation to continue his work in computer modeling to better understand the mechanisms involved in speech production. Xue's research, funded earlier this year with a nearly $407,000 grant from the National Institute on Deafness and Other Communication Disorders, a division of the National Institutes of Health (NIH), will advance computer models that provide accurate, real-time simulation of irregular voice conditions.

In the past decade, Xue and Zheng have worked on simulating speech production, research that has long-term implications for the way physicians diagnose and treat speech disorders. But their immediate focus is on improving the computer models they've developed that can replicate the human mechanics that produce speech and can be manipulated to recreate various speech disorders. The research and models are based on the principles of fluid dynamics.

"Both of us work in the general field of computational fluid dynamics that uses computer simulations to simulate flow-related phenomenon and to try to understand the underlying physics," Xue says. "One of the applications we do is on human voice production and we're looking at the biomechanics of this process."

> **It's all fluid mechanics.** We are looking at fluids inside the body, we are looking at how fish swim, how insects fly, how seal whiskers (work), and **how we can use their strategies that have evolved over years and apply them** to manmade devices." Qian Xue

XUE AND Zheng are interested in flow structure interaction in human voice production. They study the mechanics of the vocal folds — the twin mucosal membranes in the larynx that vibrate during phonation or speech — and the interaction between air flow and the vocal fold, and the effect that interaction has on vocal quality.

Vocalization in humans and other mammals, as well as other species such as birds, begins with air flowing through the larynx and over the vocal chords, generating mucosal waves in those folds. That movement of the mucous membrane, Zheng says, is the flow-induced elastic wave that radiates in the superficial layer of the vocal fold and controls glottal air pulses that form the primary sound source of the voice.

The way the vocal folds open and close, and vibrate during vocalization, as well as the different pressures, vacuums and vortices that process generates, creates interesting mechanical problems that are the basis of their research. The goal is to better understand the internal structure of the vocal fold and how that affects the voice quality.

The computer model the researchers use recreates each element used in voice production: the air

passage, larynx and vocal folds, as well as the tongue, teeth and lips. That model uses each of those simulated parts to produce speech: so far, a single word — Ohio.

The beauty of the model is that each simulated piece of the phonation mechanism can be altered, and those alterations can produce variations in the voice. That gives Xue and Zheng the ability to observe the effect each of those changes has on voice quality and production.

It is that capability that has interested NIH and other agencies, Xue says, because currently, physicians are limited in the ways they study voice disorders.

Existing techniques offer only partial observation of the voice mechanisms and there is no effective computer simulation that can help doctors look into the mechanics of the vocal folds, she says. Their computer model offers some key advantages.

"The computer simulation can be easily manipulated," Xue says. "You can change the parameters and have parallel simulations."

The software is adaptable and can be used in a variety of situations. Utilizing the computational flow dynamic software, researchers are working on a variety of problems that all relate to the principles of fluid dynamics.

"One exciting thing is that the obtained knowledge is not just used for voice production," she says. "It can have broad applications. It is very fundamental, but it can be translated into other fields."

WHILE UMAINE doctoral candidates Weili Jiang and Biao Geng continue to work on refining the computer models, other researchers are looking at different applications.

Geng Liu, a postdoctoral researcher, is using high-speed video and the flow structure interaction modeling to study the distinct shape generated in a rainbow trout's caudal fin during propulsion and analyze the biomechanical advantages of that shape.

That research, he says, is of interest to developers, including the U.S. Navy, working on underwater vehicles or "robot fish" that might use those characteristics in their design.

He also is studying how the shape of harbor seals' whiskers helps them locate fish in low-light environments. The shape, which has a wavy surface, can detect the flows disturbed by fish.

Using computer models, Liu has determined that a harbor seal's unique whisker design is the most efficient in generating low drag and low vibrations, enabling the animal to better locate and identify fish.

The flow dynamics software also may have applications in reducing noise due to blade-vortex interactions in wind turbines.

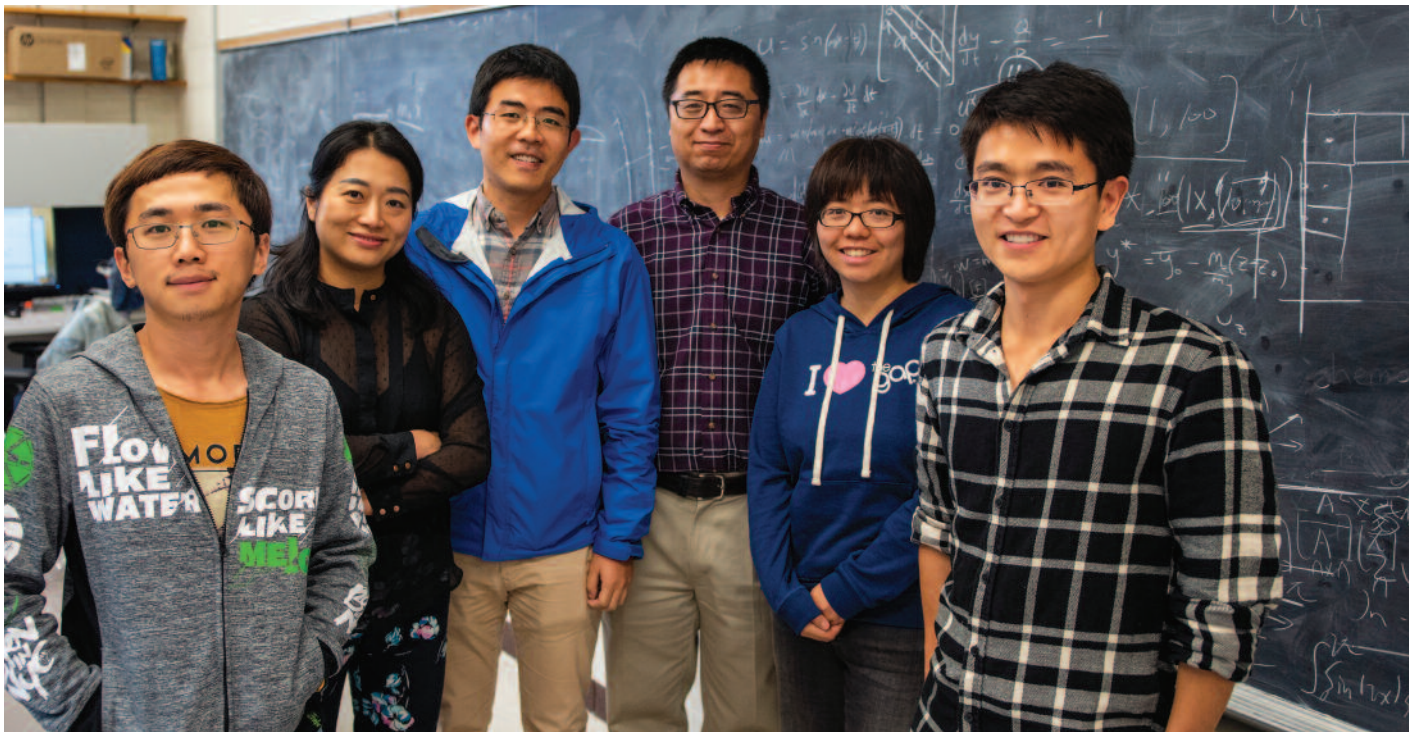
"It's all fluid mechanics," Xue says. "We are looking at fluids inside the body, we are looking at how fish swim, how insects fly, how seal whiskers (work), and how we can use their strategies that have evolved over years and apply them to manmade devices.

"We're using the same techniques, we're just working on different problems."

Zheng sees opportunities to move the simulations into other departments in the university. In the not too distant future, he says, he would like to see the simulations introduced into the classroom to help students studying communication better understand voice production and what sounds are related to individual pathological changes.

But their ultimate goal is to see the work they're doing on the human voice move into the practical

Qian Xue and Xudong Zheng have worked for the **past decade on simulating speech production,** research that has **long-term implications for the way physicians diagnose and treat speech disorders.**



Members of the Complex Flow Modeling and Simulation Lab are, left to right, student Biao Geng, professor Qian Xue, student Yang Zhang, professor Xudong Zheng, and students Weili Jiang and Xiaojian Wang.

realm of the doctor's office or the hospital. They are working with medical researchers nationwide and have run simulations on blood flow in coronary arteries to measure the decrease in blood flow resulting from stenosis.

This, Zheng says, could offer a noninvasive method to determine whether the decreased blood flow requires a stent or surgery.

Likewise, Zheng says, they hope to be able to use patients' MRI images in the computer simulation to help physicians diagnose and treat vocal disorders.

With a CTI or MRI image, simulations reproduce the patient's sound production to help determine the voice problem, Zheng says. Then the simulator is used by the surgeon to design different surgical procedures to see what will be optimal to restore a patient's voice.

That technology already exists, Xue says. But it is expensive — and needs to be quicker.

"A physician wants to see results in two minutes or 10 minutes. We are looking at how we can improve the model," Xue says. "Now it is high-fidelity so you can see the three-dimensional flow field and vocal fold geometry. We want to keep that high fidelity and shorten the computational time by developing a new flow model."

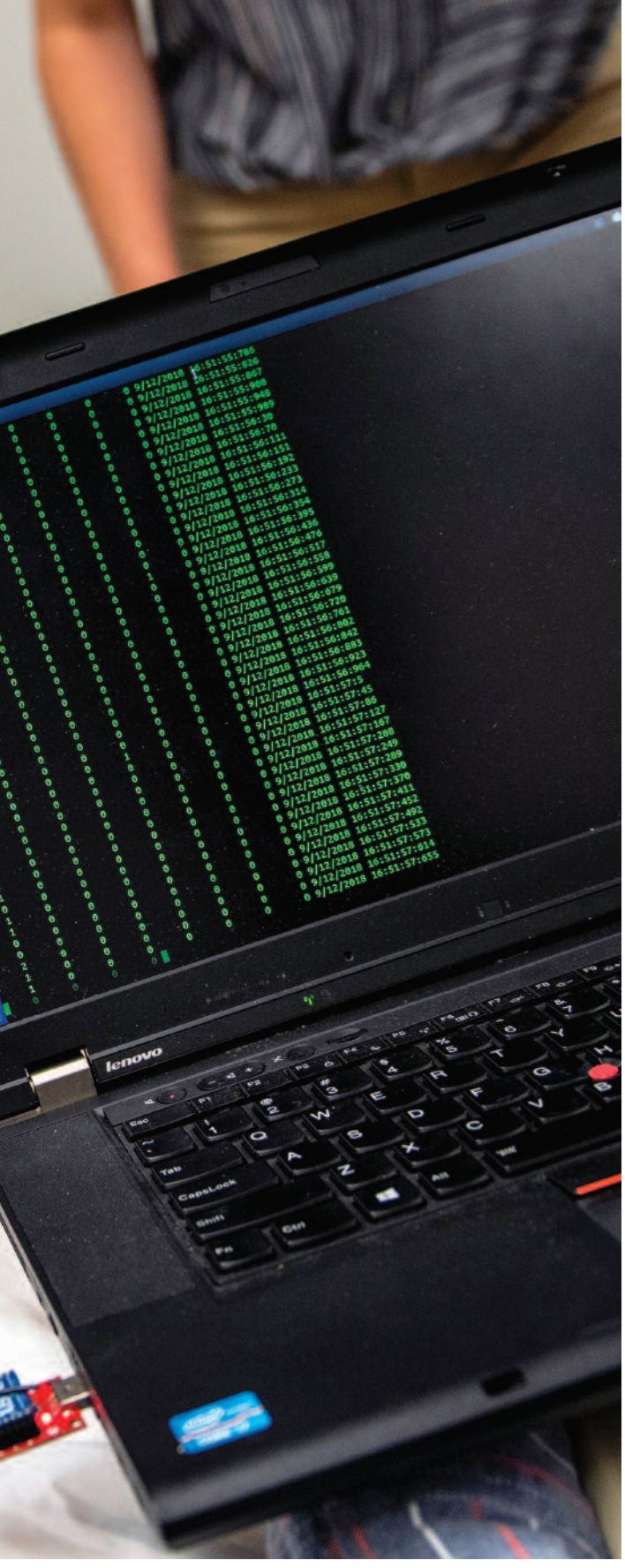
In the next two years, refining the computer models, increasing speed and improving the speech replication will be the focus of their work. In addition, their research will continue to focus on understanding why pathological problems create voice problems, and how human beings compensate for those problems.

The prospect of making this technology available to physicians drives them.

"The most exciting thing for me is to see it used in the hospital," Xue says. "One day, you go into the hospital and you have this voice problem. You take the image and the doctor will see immediately where the problem is and in two minutes can identify the problem, and then design the surgical procedure on the computer." ■

When **engineers** and **psychologists** meet

Sleep monitoring invention that could help detect early symptoms of Alzheimer's receives $1 million NIH award



Interdisciplinary research led to the founding of a spinoff company, Activas Diagnostics LLC, by UMaine professors Marie Hayes and Ali Abedi.

TWICE A week in laboratories in Little and Barrows halls, University of Maine graduate student researchers meet to pore over algorithms and clinical data. They talk about the brain, sensors and signals, software and signature biomarkers, all in an effort to push for the next technological breakthroughs in monitoring and understanding the dynamics of sleep loss and neurological health in people — newborns to elders.

The psychology students have backgrounds in clinical neuroscience and quantitative analysis, engineering students have backgrounds in communications and signal processing, and all work under the direction of professors Marie Hayes and Ali Abedi. The students' work is part of research that has been ongoing for the past decade and has contributed to development of a home-based sleep monitoring invention, now one step closer to commercialization.

Working on the project has been a valuable experience, says Ahmed Almaghasilah, a master's degree student in electrical engineering who has been on the team for the past two years, developing algorithms from signal processing to identify such aspects as wake/sleep periods.

"I've enjoyed every moment, working side-by-side (with) psychology and engineering (students)," Almaghasilah says.

Undergraduate Ryan Dufour, who is pursuing dual degrees in electrical and computer engineering, describes the interdisciplinary research as "incredibly enlightening."

"Working with the psychologists helped provide context for my education," says the Glenburn, Maine student, who joined the team earlier this year. "It let me see how the problem-solving skill set I have been taught fits when approaching real-world challenges."

According to Abedi, a professor of electrical and computer engineering, and UMaine assistant vice president for research, "this is engineering informed by science. What makes this collaboration successful and long-lasting is we are continually informing each other — two-way dialogue to improve design and testing."

Marie Hayes' research has shown that **sleep-related movement arousals are deficient** in individuals with underlying sleep debt from sleep disorders, **a common prodrome in neurological disease.**

UMaine professor of psychology Marie Hayes, second from the left, in one of the weekly lab sessions with graduate student team members, left to right, Chris Gilbert, Jessica Aronis and Ahmed Almaghasilah (seated in foreground), Ryan Dufour and Ariel Bouchard.

Leading research assessing the impact of sleep and cognitive decline in aging individuals, which ultimately resulted in high-level innovative funding. is a unique and exciting opportunity, says Katrina Daigle, who was the student team leader on the project before heading to Suffolk University for a Ph.D. in clinical psychology. "Being part of a research team that developed the first sleep monitoring system of its kind and being the first to identify a specific set of sleep parameters associated with cognitive decline in Alzheimer's disease was incredible.

"This type of cutting-edge research could not be conducted without an interdisciplinary team of talented individuals from neuroscience and engineering," she says.

It's an amazing team, tuned in to each other, says Hayes, professor of psychology and member of UMaine's Graduate School of Biomedical Science and Engineering. "They get excited. I really like my work when this happens."

In June, the home-based sleep monitoring invention that has the potential to detect early symptoms of mild cognitive impairment and Alzheimer's disease in elders received a $1 million Small Business Innovation Research Award from the National Institute of Health's Institute on Aging.

The two-year NIH Phase II award to Activas Diagnostics LLC, founded by Hayes and Abedi, focuses on bringing the spinoff company's patented SleepMove product — a fitted mattress undersheet instrumented with 16 hybrid wireless sensors — to market as a new approach to diagnostics and monitoring in early stage neurological disease, including Alzheimer's disease.

ACTIVAS DIAGNOSTICS' SleepMove technology allows for home-based, nonintrusive recording of small movements. It integrates wireless sensing technology, signal processing and statistical inference software to identify two novel biomarkers of sleep disorder that complement standard actigraphy, and provide a new level of accuracy for outpatient sleep recording.

The funding project will focus on proof of concept —

Professor Ali Abedi's wireless communications research ranges from coding and information theory to wireless sensor networks. In the past decade, he has collaborated with Marie Hayes. Their spinoff company, Activas Diagnostics LLC, created the patened SleepMove technology that has the potential to be a tool in detecting early symptoms of Alzheimer's disease.

through clinical testing and device development to validate the SleepMove device's predictive power — and an early-stage commercialization plan. The goal is to move the technology into clinical trials and establish approval from the U.S. Food and Drug Administration to allow insurance coverage as a medical screening for hospital and home use.

The biotechnology innovation provides an assessment of respiratory signals and small sleep movements, including arousals, to evaluate mild cognitive impairment (MCI). Older people with MCI are at greater risk for developing Alzheimer's, according to the National Institute on Aging. To date, biomarkers to help determine the severity of MCI, a recognized prodrome to dementias, remain elusive.

Hayes' research program has shown that sleep-related movement arousals are deficient in individuals with underlying sleep debt from sleep disorders, a common prodrome in neurological disease. During sleep loss, sleep movements decline in vigor and there is no periodic increase in respiration, which may promote hypoxemia and apnea during sleep. Many persons with sleep loss from restriction, aging or brain injury can show this pattern, which is associated with memory loss.

Early detection of cognitive deterioration can help with prevention and treatment. The SleepMove technology has the potential to detect mild brain trauma and early onset of brain disease, as opposed to finding out with an MRI when it is too late. With earlier detection, treatment could start earlier to extend quality of life.

ACTIVAS DIAGNOSTICS, established in 2009 and based in the UpStart Center for Entrepreneurship in Orono, develops noninvasive wireless sensor system and software products for diagnostics of traumatic brain injury or neurological diseases, such as MCI. Before the company started, NIH funding supported basic clinical studies on spontaneous movements during sleep and relation to brain injury.

The company started with funding from the Department of Defense, which is interested in the potential of the Sleep-

Move technology to aid individuals with traumatic brain injury. Through the years, other funding sources have included NASA, Maine Economic Improvement Fund, the Maine Technology Institute and currently NIH SBIR Phase II funding from the National Institute on Aging.

Hayes and Abedi have been collaborating on the technology for almost 10 years.

Hayes' longitudinal sleep research funded by NIH examined the role of high-frequency sleep movements in patients affected by neurological injury. It began with sleep studies in high-risk newborns affected by prematurity, pharmacological treatment for apnea, and opioid and alcohol exposures prenatally and consequences, such as neonatal abstinence syndrome.

Abedi's wireless communications research ranges from coding and information theory to wireless sensor networks. In the NASA inflatable lunar habitat module on campus, Abedi and his team are developing wireless sensors for leak detection. In 2016, a prototype of the wireless leak detector technology was sent to the International Space Station, where astronauts installed it to send data to Abedi's team for analysis.

> **"This is engineering informed by science.** What makes this collaboration successful and long-lasting is we are continually informing each other — **two-way dialogue to improve design and testing."**
>
> Ali Abedi

THROUGH THE years of their collaborative research, Hayes and Abedi brought together UMaine undergraduate and graduate psychology, and electrical and computer engineering students, two postdoctoral researchers — Abouzar Ghavami and, now, Somayeh Khosroazad — and health care collaborators from the community. Among the overarching questions in their collaboration since 2010: How does the evolving innovation compare in performance to other single-point technology, and is it capable of detecting the difference between the signals from healthy and diseased brains?

Those students included engineering alumnus Timothy Falkner, whose preliminary findings from his master's thesis research in 2010 demonstrated that the technology was capable of monitoring signals not easily detected in adults with mild traumatic brain injuries and PTSD.

The patent for a "system and method for early detection of mild traumatic brain injury" was issued in 2015, and the company is in the licensing agreement process.

The research that led to this technology has been presented at Wireless Sensor Systems Conference, June 2012 in the United Kingdom, the Society for Research on Biological Rhythms, June 2014, and Traumatic Brain Injury Conference, April 2015 in Washington, D.C.

Most recently, the researchers were invited to present their research at the annual international meeting for sleep medicine, hosted by the Associated Professional Sleep Societies, this past June in Baltimore, and the Sleep and Circadian Rhythms Symposium of the International Psychogeriatric Association this past September.

"It's extremely exciting to do space research, send a payload to the space station and find things in other galaxies," Abedi says.

"This technology will help people on Earth, including those who went to fight for us. If we can use this technology to do something to help them get back (to normal/some quality of life), that's the value." ■

Transportation Infrastructure Durability Center
AT THE UNIVERSITY OF MAINE

Advanced Structures and Composites Center receives $14.2M DOT award

THE U.S. Department of Transportation (DOT) has selected the University of Maine to lead the creation of a highly competitive University Transportation Center called the Transportation Infrastructure Durability Center (TIDC).

TIDC aims to save taxpayer dollars by extending the life of transportation assets, including bridges, roads and rail.

The DOT will provide as much as $14.2 million over five years for the UMaine-led coalition that includes the University of Rhode Island, University of Connecticut, University of Massachusetts Lowell, University of Vermont and Western New England University.

Additional partners include the Vermont Agency of Transportation and the Departments of Transportation (DOTs) in Maine, Massachusetts, Connecticut and Rhode Island.

This is the first time UMaine was selected from a highly competitive group of other colleges and universities to lead U.S. DOT transportation research in New England, says Habib Dagher, founding executive director of the UMaine Advanced Structures and Composites Center, and director of the new TIDC. Ten technical experts from across the country reviewed and ranked competing proposals, which led to UMaine's selection.

"Along with our partners from all New England states, we look forward to leading research to extend the life of existing bridges, construct longer-lasting assets, and reduce costs for the DOT and the public. Our New England DOT partners will help guide our research efforts to focus on real DOT needs that will make a real difference to the public," Dagher says.

Working with state DOTs, the new TIDC seeks to identify new materials and technologies that maximize the impact of transportation infrastructure investments. The center will work along four pathways:

- develop improved road and bridge monitoring and assessment tools
- develop better ways to strengthen existing bridges to extend their life
- use new materials and systems to build longer-lasting bridges and accelerate construction
- use new connectivity tools to enhance asset and performance management while promoting workforce development

TIDC will harness the experience of 28 faculty researchers and train 280 student researchers from all New England states. It will focus on real infrastructure needs identified by DOT partners, and prioritize extending the life of existing transportation assets to ensure cost-effectiveness.

Since 1987, the University Transportation Center (UTC) program has advanced transportation research and technology at colleges and universities across the country. Every five years, academic institutions nationwide compete to form their region's UTC.

UMaine and the other member universities of the new Transportation Infrastructure Durability Center have an extensive record of accomplishments in transportation infrastructure research, education and technology transfer. ■

Student Justin Puckett's research in the Hess lab focused on high-altitude operation.

Taking drones to great heights

Research focuses on improving UAV technology for high-altitude use on this planet — and others

FOR THE PAST four years, the research of University of Maine physics professors C. Thomas (C.T.) Hess and Samuel Hess has brought the University of Maine into the age of uninhabited aerial vehicles (UAVs), resulting in unique opportunities for students, and spectacular footage of the Orono campus and surrounding areas that can only come from drone technology.

The focus of the researchers, who are father and son, is development of a production pipeline to design, model, build and test rotors for a variety of UAVs for this world and beyond.

The long-term goal is to develop drones capable of flight at high altitude on Earth — and on other planets.

Their research has been supported by grants from the Maine Space Grant Consortium, a NASA-funded nonprofit focused on improving research infrastructure in areas of mutual interest to the national space administration and the state, and encouraging more students to consider careers in fields of science, technology, engineering and mathematics (STEM).

Though the relatively small profile of the drones they work with — ranging in size from 5 centimeters to a little more than a meter — may seem far removed from the large Saturn rockets and International Space Station, aviation here on Earth has long been a staple of NASA's mission, says C.T.

"It's National Aeronautics and Space Administration," he says. "Aeronautics first; they've been doing propellers and planes and things that fly for a long time. They didn't always do rockets. We're doing the aeronautics thing. That's very NASA. It's kind of cool because what we wanted to do was something that was the beginning of NASA."

Sam, a longtime pilot who now holds a UAV pilot certificate, got hooked after seeing an article in the *New York Times* highlighting the increasing interest in commercial drones. Although he hadn't done any work in UAVs, it seemed to him like a good way to stay connected with aviation, and, he adds, it was clear that students might also be interested in that kind of work.

Initially, most of their research focused on payload design and sensor application, and there almost was no limit to what they came up with, as long as it was light enough for a drone to carry.

"This was earlier in development of commercial drones, so almost anything you could think of was new," Sam says. "We thought physicists might be interested in measuring radiation, magnetic fields, atmospheric parameters like temperature, pressure, gas concentration, humidity, infrared temperature. We put in a whole lot of possibilities that we would consider doing. We looked to see what was interesting to students."

The latest round of NASA funding will allow the team to work on **three projects with the tantalizing long-range goal of developing UAVs that can fly in the thin atmosphere on Mars.**

Students were interested. One built a drone-mounted radiation sensor using a Geiger counter and a tape recorder. Another worked on ways to reduce the sound generated by the drone engine, and another mounted an infrared camera on a drone that could scan the entire campus in seconds, imaging heat signatures in various locations: leaking windows, recently parked cars that were still warm; footprints where people had recently walked; a break in underground steam pipes; and heat leaking from a campus building.

"The amount of data you can get from that up-high perspective (is) immense," Sam says.

In a few short years, their research expanded and now includes the theoretical, experimental, practical and virtual elements of UAVs.

Three NASA-funded projects now in the Hess lab focus on developing UAVs that can operate in the thin atmosphere of space. The research includes proximity detection and obstacle avoidance, especially when GPS navigation is degraded or absent, high-altitude performance of UAVs, and detection and visualization of geological structures.

"We've done a lot of work on computers, but we've also done some hands-on, experimental work as well," Sam says. "The first installment of the grant was much more using what you could get your hands on and building payloads. Now, I'd say we've gotten a feel for what's available and we're looking into ways to make the actual aircraft better."

THE LATEST round of NASA funding will allow the team to work on three projects with the tantalizing long-range goal of developing UAVs that can fly in the thin atmosphere on Mars. The research projects include proximity detection and obstacle avoidance, especially when GPS navigation is degraded or absent; high-altitude performance of UAVs; and detection and visualization of geological structures.

A fourth element of the grant is to utilize the research projects to attract and retain students, and increase diversity in STEM fields in general and in the Physics and Astronomy Department, in particular.

Moving toward high-altitude flight has been the main emphasis of the early part of the project as they work to develop and test various designs in high-elevation/low-pressure settings. The idea, according to C.T., is to test the rotors in conditions that are similar to altitudes above 100,000 feet on Earth.

"If you can do that — go up high to 100,000 feet, which is where balloons go — it becomes possible to use that same drone on Mars," he says. "All you have to do is figure how to make a propeller just right."

This is not the stuff of science fiction. Shortly after they began developing the idea of high-altitude flight for the grant proposal, C.T. says, NASA announced that on its next Rover mission to Mars, the payload will include a drone.

The UMaine research is now focused on developing a streamlined, effective process for making and testing rotors — a pipeline that can allow rapid prototyping.

"You test, design and 3D print the propeller, put it onto a motor and a set of sensors, spin it up and see how much lift it's making, see if it fails — see if it does what it's supposed to do," Sam says. "Then you take that data and go back and change the design a bit, and 3D print anew. Being able to iterate that process is, I think, the big medium-term goal."

Developing that pipeline was the task last summer for a team of three students: Michael DeMaria, an undergraduate electrical engineering technology student from Bangor, Maine; Ben Hebert, a graduate student in engineering physics from South Berwick, Maine; and James Stevens, a senior in mechanical engineering from Oakland, Maine. Together, they focus on the design, computations, 3D printing and electronics needed to test the rotors.

They worked with Stephen Abbadessa, the Crosby Laboratory manager, for some of the initial rotor tests until they could set up a design and production system on a small scale, including a small test chamber they created where they trial each rotor they build.

They also plan to work with Rick Eason, an associate professor of electrical and computer engineering, to launch a drone and payload on one of his high-altitude balloons.

The next challenge, DeMaria says, is to refine the production process, reducing the printing time. Working with off-the-rack 3D printers, they face some limitations and have had to make some adaptations to the equipment. Some of what they're doing, they acknowledge, is trial and error.

"We have to work with what's commercially available," he says, "and we're working with a material that not everyone uses, so there's a steep learning curve."

ONE OF the things they've learned: Humidity has a tremendous effect on the overall quality of the rotors they can print. As a result, they have developed systems to control humidity and monitor temperatures during printing to obtain the surface texture and profile they need to get the desired lift. They're now able to 3D print a propeller in about 12 hours and hope to reduce that time so they can run through the entire process — design, modeling, printing and testing — in about two days.

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>
> C.T. Hess

Once they hone the process, they can develop the other elements of the current grant project, all of which have applications on Earth and Mars. The high-altitude, low-atmosphere capabilities needed for Mars also can allow drones to deliver internet capabilities to sparsely inhabited terrain or provide measurements as a function of height, Sam says. It can enable a drone to go where a conventional aircraft can't, including mountain rescue missions, like the drone recently used to locate a lost hiker on K2 in the Himalayas.

Likewise, obstacle avoidance, a critical capability for drones when they are almost 34 million miles from Earth, is essential for Earth-bound activities, such as the popular notion of package delivery.

"The lift and the flight characteristics are compatible with that," Sam says, "but the object avoidance is the big question. If you want to send something and have it be autonomous — (operating) out of sight and out of human hands, you've got a much higher bar to meet. You can't just veer out of the way if something comes unexpectedly into the path. The drone has to know what's happening and what's going to happen, and stop anything dangerous from occurring."

The third research area will involve aerial photography and infrared imaging equipment mounted on drones to locate and identify glacial features remaining from the most recent glaciation in Maine, and geological features left over from the state's far distant volcanic past, such as underground chambers and lava tubes. That last feature may be crucial for future martian habitation, C.T. says.

The drone project also has the potential to attract interest in the university and in the Physics and Astronomy Department, which is the fourth arm of the current effort. Studies have shown that involving students in research early in their undergraduate careers helps increase retention. The Hesses

Professors C.T. Hess and Sam Hess, from left, talk drone wind blade technology with mechanical engineering student James Stevens, who collaborates on drone research in the Hess lab.

hope to use drones and drone research to attract and retain more students, particularly underrepresented groups such as women and minorities. Moreover, they want to involve nonscience students.

The professors already have begun to include aerospace-related material in many of the standard physics courses in the curriculum, and drone research has become an option for capstone projects for engineering seniors.

Drones and aerospace in general are a part of the UMaine Physics Roadshow, a popular outreach program of the Department of Physics and Astronomy that brings the science into elementary and middle schools statewide.

They've also done demonstrations for local groups such as the Orono Bog Walk and Hirundo Wildlife Refuge. Both groups have UMaine drone video on their websites.

And Sam has provided video for the university's Division of Marketing and Communications, which has used it in student recruitment efforts.

Flying the drones on campus becomes an event that also attracts students and potential students from a variety of disciplines. That, along with their research, has increased interest in drones.

Student involvement, DeMaria says, has the potential to change their perspective as it did his.

"Having all this exposure to (drones) has kind of changed my perspective of what direction I want to go in when I go back to my work career," he says.

"I think that will happen with other students — students who have hands-on exposure right on campus, see the program working; touch, feel, play. It's going to spark an interest in them and maybe they'll choose to go into the drone development field." ■

Graham Van Goffrier
Valedictorian
Bachelor's in Physics
Master's in Electrical Engineering

Brianna DeGone
Salutatorian
Outstanding Graduating Student in Engineering
Bachelor's in Bioengineering

Yousuf Ali
Outstanding Graduating International Student in Engineering
Bachelor's in Chemical Engineering

UMaine's top 2018 graduates

THREE OF the University of Maine's top graduates in 2018 came from the College of Engineering.

GRAHAM VAN GOFFRIER of Norwell, Massachusetts majored in physics, with minors in electrical engineering, mathematics and nanotechnology.

In addition to other honors, he was one of 240 outstanding sophomores and juniors nationwide to receive a 2017 Goldwater Scholarship.

In his four years at UMaine, he spent summers involved in UMaine research in the Maine Software Agents and Artificial Intelligence Laboratory, Biophysics Research Group, and Laboratory for Surface Science and Technology. His research ranged from a MATLAB simulation of surface-acoustic-wave sensor devices to optical modeling efforts and the visualization of string theory. Van Goffrier credits UMaine and its physics and electrical engineering professors with offering so many research opportunities to students — experiences that make a difference in helping determine career path options, he says.

In summer 2017, he participated in the University of Michigan's Research Experience for Undergraduates Program at the European Organization for Nuclear Research (CERN), the particle accelerator facility in Switzerland, where he worked with an analysis team on the ATLAS experiment.

Van Goffrier's capstone project in physics, supervised by professor Neil Comins, investigated correlation between minimal surfaces and relativistic string solutions.

This fall, Van Goffrier entered the MASt program in applied mathematics at Cambridge University, which includes one year of self-driven coursework designed to encourage independent study skills in preparation for further research. He plans to pursue a Ph.D. program in theoretical physics the following year.

BRIANNA DEGONE of Turner, Maine is a first-generation college student who majored in bioengineering, with a minor in business administration.

As a member of the UMaine women's track and field team, DeGone's personal-best throw of 36.99 meters in the javelin ranks seventh best in program history. She has been recognized as a scholar-athlete for three consecutive years.

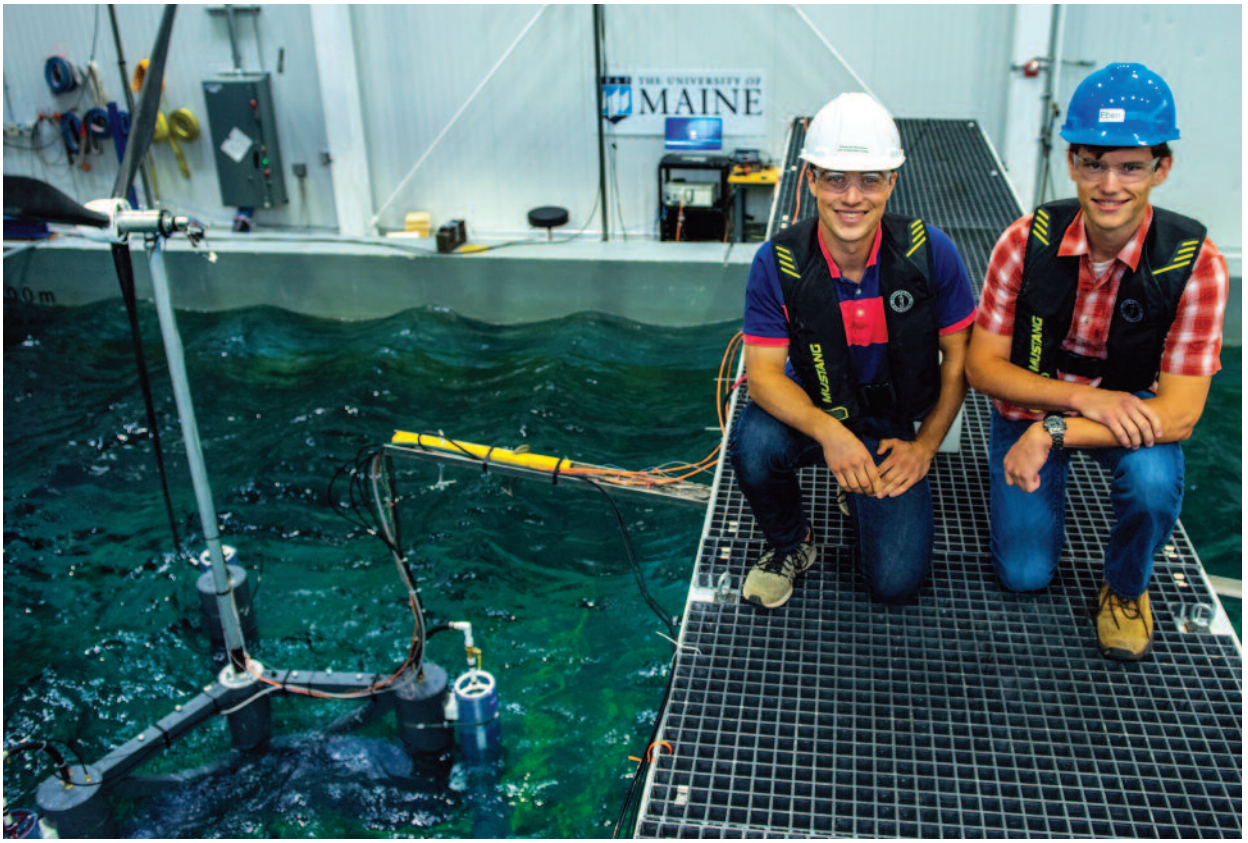
DeGone was one of 127 sophomores nationwide to be selected as a 2016 Ernest F. Hollings Undergraduate Scholar. As a Hollings Scholar, she conducted water quality research on the Kennebunk River Watershed for NOAA. Based at Wells National Estuarine Research Reserve in southern Maine, she also participated in studies focusing on York River fisheries, green crabs and lobsters.

In fall 2016, DeGone interned with IDEXX Laboratories in Westbrook, Maine, working in research and development on veterinary diagnostic devices.

She was a member of a capstone research team developing a wearable biosensing device to aid first responders assisting missing persons.

DeGone is now working in the biomedical field.

YOUSUF ALI of Dubai, United Arab Emirates majored in chemical engineering, with a minor in mathematics. His honors included a scholarship from Abu Dhabi National Oil Co. He plans to pursue a master's degree in chemical/processing engineering. ■



William Ramsay and Eben Lenfest

Deep-space, deep-sea technology

WILLIAM RAMSAY and Eben Lenfest interned with NASA in Alabama this past summer to help advance wind technology in Maine.

The mechanical engineering majors from Maine explored vibration mitigation technology — think of a shock absorber to prevent structural damage — at NASA's Marshall Space Flight Center in Huntsville.

They are applying the NASA-developed technology to the VolturnUS offshore floating wind turbine platform at the University of Maine Advanced Structures and Composites Center.

The UMaine-developed, patented VolturnUS floating concrete hull technology can support wind turbines in water depths of 45 meters or more, and has the potential to significantly reduce the cost of offshore wind.

Ramsay says the highlights included learning from NASA engineers, doing design and prototyping work, touring facilities where rocket components are tested and exploring Huntsville.

"It was a challenging and exciting process, and it's where I learned the most about real-world engineering and problem-solving," says the third-year student from South Berwick.

The experience also connected theory with a real, purposeful project for Lenfest.

"While this technology had already been discovered by others and work had been done to better understand it, Will (Ramsay) and I were on the front lines of learning more about its limitations and determining how best to design a vibration absorber to target low frequencies," he says.

Both Ramsay and Lenfest say they enjoy outdoor recreation and note that it's gratifying being involved in a project that could bolster green energy.

"I'm really passionate about the outdoors, so when I have the ability to help the planet with renewable energy engineering, it gives my education at UMaine meaning," says Ramsay, who continues to intern with NASA, working on vibration mitigation for the Space Launch System during the fall 2018 semester.

Lenfest, who minors in ocean and marine engineering, and robotics, is working on scale model turbines at the Composites Center.

"I grew up in the Belgrade Lakes region and enjoy developing machines to work in an aquatic environment," says the senior from Smithfield. "Boy Scouts got me interested in conservation and clean energy."

Both Lenfest and Ramsay say they appreciate the opportunities they've been afforded at UMaine. And both plan to earn graduate degrees in engineering. ■

COMPOSITE CROSSINGS

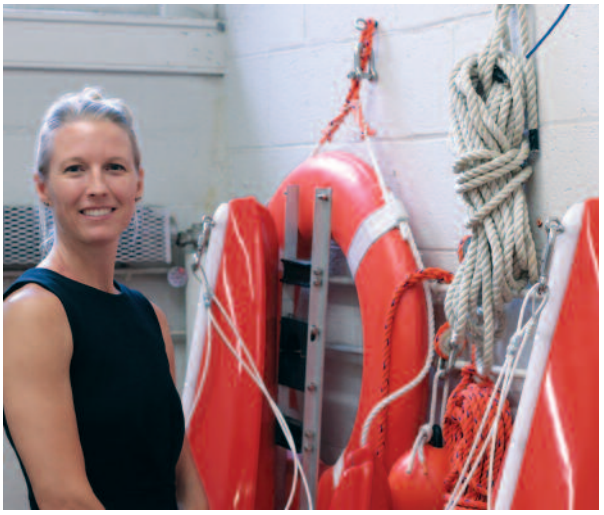
THIS PAST summer, the University of Maine Advanced Structures and Composites Center unveiled an innovative, rapidly deployable bridge system featuring composite material girders and precast concrete deck panels.

The patent-pending system is designed to be constructed in 72 hours, reducing the time and logistics of highway bridge building. The new bridge girders are built to last 100 years, and the precast concrete deck is designed to be easily removed and replaced.

The bridge system can be used for highways, pedestrian byways and military applications. The design is targeted for short- to medium-span bridge applications, up to 80-foot unsupported spans.

An August strength test of the composite girder confirmed the design modeling predictions, and demonstrated the bridge system can withstand the truck load specified in the American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Specifications. The composite bridge withstood forces up to 376,000 pounds and 7.5 times the HL 93 design load specified by AASHTO.

The project, funded by the U.S. Army Corps of Engineers, is led by professor Habib Dagher, PI. Collaborators include professor William Davids, co-PI; James Anderson, co-PI; Josh Clapp, project manager; and Cody Sheltra, project engineer. Graduate students include Anthony Diba and Dante Guzzi.



TIDAL TURBINES IN 3D

A UNIQUE computer model developed by University of Maine researcher Lauren Ross can aid energy producers and decision-makers implementing tidal turbine farms in estuaries.

The model simulates the impact and benefits of the geographic location of tidal turbine farms and the most efficient way to arrange them, saving energy-producers testing and planning costs.

Ross, an assistant professor of civil and environmental engineering, gained knowledge of tidal turbines in estuary systems along the southwest coast of France. The model offers valuable data showing the effects of placing power-generating turbines in waterways that experience tides. It has positive implications for local and national companies moving to expand the market for clean energy.

GRAD DEGREE IN WATER, ENVIRONMENT

THE DEPARTMENT of Civil and Environmental Engineering has designed an innovative Master of Engineering (ME) degree in Water and Environment. The ME is a fast-track graduate program designed to equip students with advanced knowledge in the areas of water and environment.

Courses are designed to cover modeling, analysis, and design aspects of engineering and scientific problem solving. Students gain skills critical to success in their future career, and also earn credit toward professional engineering licensure.

Students complete a core graduate curriculum in civil and environmental engineering, and gain broader knowledge through coursework in related disciplines. Departmental faculty bring fresh perspectives from their research programs on issues ranging from water sustainability, declining water quality in lakes and rivers, innovative approaches to waste management, viability analyses for marine renewable energy systems, assessing flow around aquaculture farms, and new models for water infrastructure design in a changing climate.

Welcome new faculty

Robert Bowie

Professor of Practice

M.D., Medical College of Virginia

SPECIALTY: emergency medicine

WHY UMAINE? Collaboration on improving medevac, and search and rescue technology with biomedical engineering.

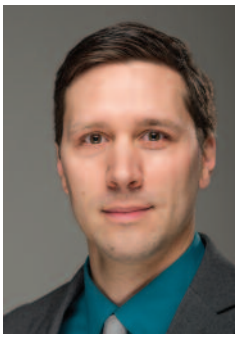
Aaron Joy

Visiting Assistant Professor of Mechanical Engineering

Ph.D. in mechanical engineering, University of Kansas

SPECIALTY: continuum mechanics and computational mathematics

WHY UMAINE? The university and the area are a perfect fit for me and my family; the climate, the rural area, the programs offered by the school, and the scholarship of my own department made the decision to come here easy.



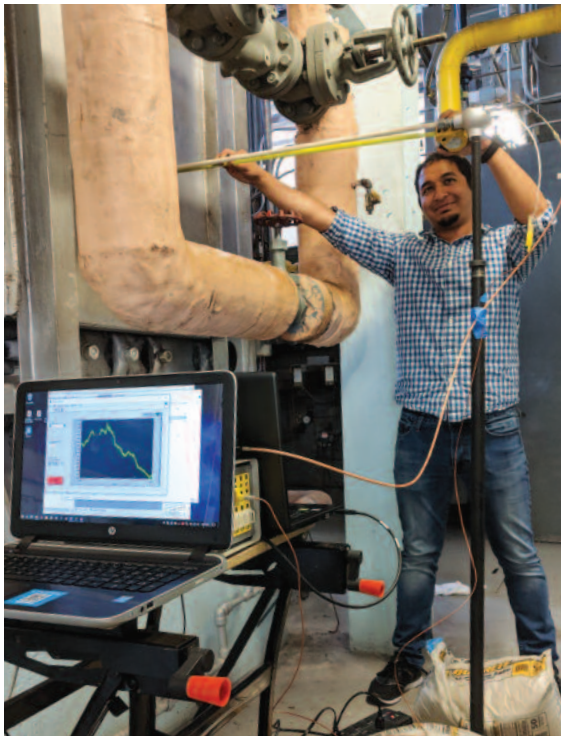
Justin Lapp

Assistant Professor of Design

Ph.D. in mechanical engineering, University of Minnesota

SPECIALTY: heat transfer in solar thermal energy

WHY UMAINE? I am excited about the opportunity to add a new topic on renewable energy to a campus, which is incredibly cooperative and which already puts a focus on researching and solving issues related to climate change.



ADVANCED COMBUSTION

IMPROVING WIRELESS sensor technologies in coal-based power plants is the focus of a $2.5 million grant from the National Energy Technology Laboratory (NETL) through the Department of Energy's Office of Fossil Energy to the University of Maine.

The UMaine project, led by Mauricio Pereira da Cunha, professor of electrical and computer engineering, and Robert Lad, professor of physics, is one of nine projects funded by NETL as part of the Advanced Combustion Systems Program.

The goal of the program is to develop new advanced sensor instrumentation that can provide improved condition-based maintenance in existing coal power plants, reliably decreasing costs of operation and maintenance, increasing efficiency and safety, and significantly reducing pollutant emissions, according to DOE.

UMaine's research, led by faculty, staff and students in the Laboratory for Surface Science and Technology (LASST), is based on wireless, battery-free surface acoustic wave sensor devices that allow measurements of temperature, as well as stress and strain, on equipment operating under harsh environments, including very high temperatures.

The technology aims to monitor temperature and equipment degradation at both the fire and steam sides of boilers and other critical components. The DOE project will focus on technology transfer and development of new materials and packaging for wireless harsh-environment sensor applications in coal-fired power plants.

This project is good for the future of UMaine and the state of Maine. We are grateful that UMaine provided us an opportunity to have successful careers and the resources to **give back to support future students and Bear Pairs."**

James Weaver '69, '71G and Virginia Farwell Weaver '69

Bear Pairs give back

JAMES "JIM" Weaver '69, '71G and Virginia "Ginny" Farwell Weaver '69 are a Bear Pair couple. They met as students at UMaine.

Jim majored in civil engineering and Ginny majored in education. They went on to establish their careers and are now giving back in appreciation of the education they received.

Their support for a faculty office space in the Engineering Education and Design Center brings the Vision for Tomorrow comprehensive campaign total one step closer in completing the fundraising goal for this important priority.

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

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