



THE UNIVERSITY OF
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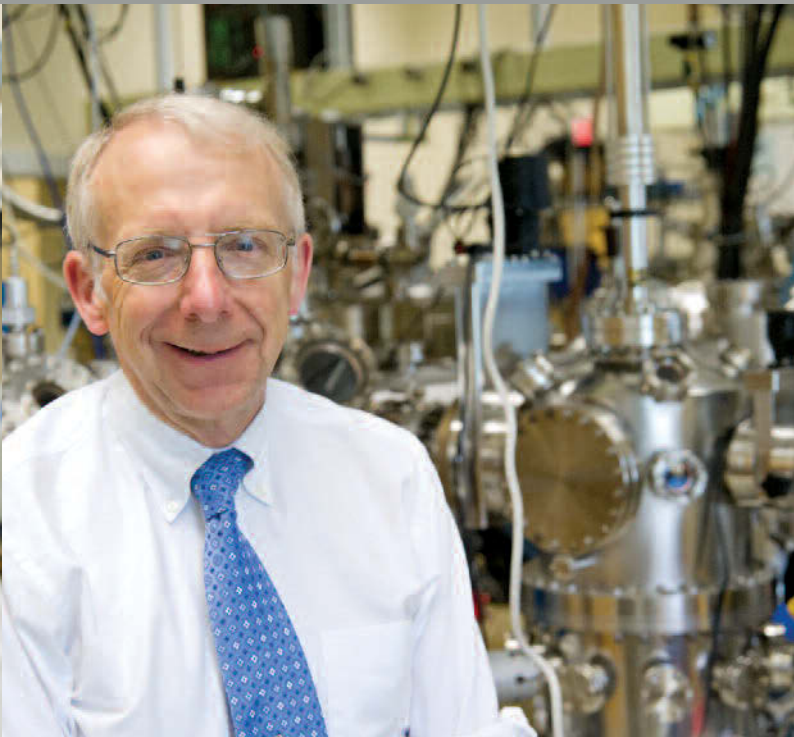
2014

Engineering



Active learning

Engineering's intense
capstone experiences
bring students to the
crossroads of theory
and practice



2 Active learning

Student-structured learning is a key component of capstone projects — the culmination of the UMaine undergraduate experience that students across all engineering disciplines have described as challenging, intense and innovative.

8 Three decades

Before public service was an expectation in education, UMaine mechanical engineering technology students were working to benefit the community.

12 Remediating wetlands

In his research, Aria Amirbahman is focusing on ways to remove methylmercury from the wetland environment before it begins to move up the food chain.

15 Designed to detect

Nanoparticles are integral to the cancer detection research of Michael Mason and his students.

18 Learning research

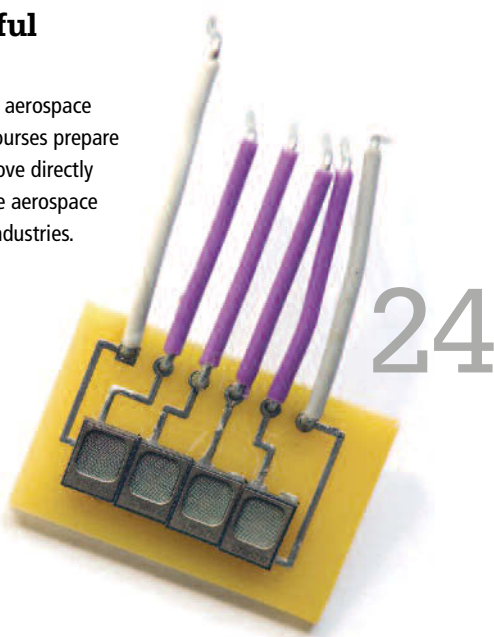
A coalition of UMaine faculty, students and regional elementary, middle and high school teachers are collaborating to improve K–12 STEM learning and teaching.

22 Successful launch

UMaine’s new aerospace engineering courses prepare students to move directly into jobs in the aerospace and defense industries.

24 Safety in space

Ali Abedi is working with other UMaine researchers to develop a wireless sensor system to monitor NASA’s inflatable lunar habitat, checking for impacts and leaks, and pinpointing their location.



Student Focus 21, 27

Alumni Focus 6, 10

Spotlight 28



ON THE COVER: The Lombard steam log hauler restored by capstone teams of mechanical engineering technology students was built between 1901 and 1917 in Waterville, Maine. It is now part of the Maine Forest and Logging Museum in Bradley, Maine. Videos of the log hauler project are linked off the MET website (umaine.edu/met/capstone-projects).

WELCOME TO THE annual College of Engineering magazine, where we get a chance to highlight some of the many outstanding individuals who make up the College of Engineering. In this issue, we bring you stories and reports from our faculty and students who are creating solutions to local and world challenges, and working to grow Maine’s economy.

You’ll read about capstone projects that allow students to experience real-world engineering projects and build team skills while benefiting both the community and their future careers. Hear from current students and alumni who share senior projects from across engineering disciplines. In particular, you will read about the three decades of mechanical engineering technology (MET) capstone projects, headed by Herb Crosby, an emeritus professor in the MET program who, with Joel Anderson, teaches the capstone course.

Our research is making a difference in the human body and in deep space, including research in cancer detection using nanoparticles, removing toxins from wetlands, and developing sensors to monitor NASA’s lunar habitat for impacts and leaks. We also explore UMaine’s new online programs, such as the aerospace curriculum and Professional Science Master’s in Engineering and Business.

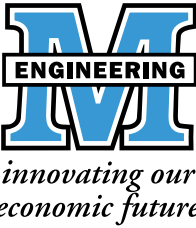
Maine needs more engineers and the College of Engineering is working hard to meet this need with growing enrollment. Currently, our fall 2014 enrollment is 1,823, which sets another record. From fall 2001 to fall 2013, UMaine’s engineering and engineering technology enrollment grew by 58 percent, compared to 47 percent growth for the U.S. Even with this growth, the College of Engineering is struggling to graduate enough engineers to maintain Maine’s current engineering workforce.

An engineering career is full of opportunity for our graduates. As of this year, the average annual starting pay for a graduate with an engineering degree is \$55,000. An estimated 99 percent of our new graduates are either employed or in graduate school within six months following graduation. Moreover, 80 percent of engineering students have a co-op or internship experience with industry, or conduct research with faculty prior to graduation.

UMaine’s engineers are the key to growing our economy and creating solutions to improve our lives, communities and our world.

Dana N. Humphrey

Dana N. Humphrey
Dean, College of Engineering



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Active learning

Engineering's intense capstone experiences bring students to the crossroads of theory and practice

ON A SUNNY Saturday morning in April, 40 University of Maine mechanical engineering technology students fire up a 1910 Lombard steam log hauler — the first time it has run in 80 years. The following week, the students conclude the 30-year restoration project on one of the legendary machines that paved the way for modern construction, military and recreational tracked vehicles.

For their senior capstone project, students in the class taught by Herb Crosby and Joel Anderson completed a total restoration of the vehicle, built in Waterville, Maine, and used to travel on ice-coated roads at 4 mph — replacing the work of 50 horses.

Through their project, the students preserved a piece of Maine history.

“To me it’s an incredible thing — a pride to the state of Maine,” says Matt MacCaughey of Winchester, Massachusetts, a member of the boiler steam systems team, one of six groups taking part in the project.

With the completion of the restoration on Maine Day 2014, the log hauler is now on display at the Maine Forest and Logging Museum in Bradley, Maine.

Student-structured learning is a key component of the capstone project — the culmination of UMaine undergraduate experience that students across all engineering disciplines have described as challenging, intense and innovative.

The UMaine senior capstone project is a chance for students to display what they’ve learned throughout their academic career, as well as take steps into the communities and engineering worlds they intend to work in upon graduation.

A requirement for seniors of every major at UMaine, projects can range from Honors theses to art exhibitions to restoring a Lombard steam log hauler.

Although each project is different, a core tenant is the benefit to the local community and beyond. This past year, some engineering students took their capstones to the next

level with work that could influence people in the nation and the world.

Civil and environmental engineering students worked to improve the Bangor Waterfront concert venue by proposing a safer access road, new parking lot, venue roof and sound barrier. The project, according to civil engineering major Kara Zadakis of Bryant, Maine, would help expand the pavilion for the client and improve the experience for patrons.

Eric Landis, a professor of civil and environmental engineering and adviser to Zadakis and her team, has watched students, as well as the entire capstone process, transform. About 10 years ago, the capstone model switched from all groups working on the same problem to projects designed by students, giving each team a different design problem. According to Landis, this transition made the projects more interesting and diverse.

“Each group has to rely on itself,” he says. “There’s no looking over at other groups to see what they’re doing.”

Landis says the quality of work has improved because students get ideas from studying previous projects. He also cites collaboration with the English Department to incorporate technical writing and communication into projects.

“The result is that the students are doing real engineering. The groups are almost always very proud of their work, as they should be, and they have lots to talk about when they are interviewing for jobs,” Landis says.

Electrical engineering students Matt Merritt of Damariscotta, Maine, and Matt Herbert of Hampden, Maine, used the Maine Department of Transportation to help illuminate roads in remote locations in northern Maine to reduce vehicle-moose collisions. The project aims to use solar power to charge batteries that can be used to drive high-efficiency lights when needed. The lights will turn on and off using radar that detects oncoming traffic.

Creating connections with community partners is a step many engineering students say is necessary to prepare themselves for post-graduation work.

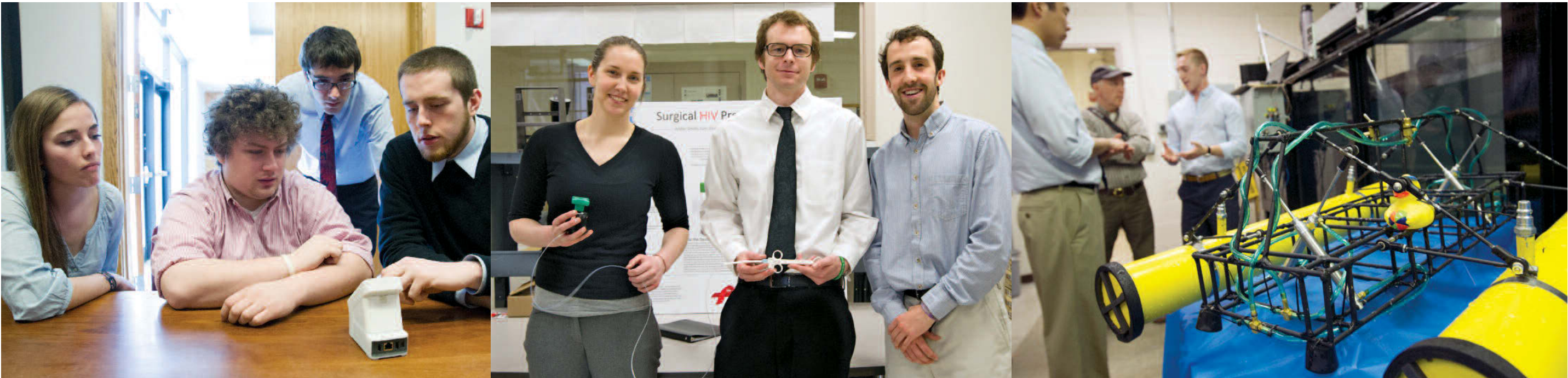
“Any opportunity to get out and interact with new people is exciting,” says Jeff Servetas, a bioengineering senior from Hancock, Maine. “As an engineer, getting ‘out’ to work on projects I’ve never even thought of, and to hear from people whose perspectives are vastly different from my own, really helps to broaden my horizons. It makes me a better engineer, and a better person in general.”

Bioengineering students have the opportunity to work

Although each project is different, a core tenant is the benefit to the local community and beyond. This past year, some engineering students took their capstones to the next level with work that could influence people in the nation and the world. In photos, left to right, are capstone teams in mechanical engineering technology, civil engineering, and chemical and biological engineering.



In photos, left to right, are capstone teams in chemical and biological engineering, and mechanical engineering.



on three projects throughout their capstone semester. Servetas and his group’s first project grew from a connection with IDEXX Laboratories, a leader in pet health care innovation, serving veterinarians worldwide with diagnostic and information technology-based products and services. The UMaine students created a prototype design for an instrument that diagnoses ear mites in dogs.

For group member Wilson Adams of Barrington, Rhode Island, his relationship with IDEXX Laboratories extends beyond his classwork to a co-op he did with the company’s research and development department.

“I know that something I have done will eventually lead to a product that will help vets take care of pets for families that love them dearly,” he says. “It really assured me that I am ready to tackle a job in industry. Even if I

am thrown into a situation I know little about, I can use what I know and learn what’s needed to complete a project.”

Capstones at UMaine are not confined to the state or nation. Mechanical engineering student Amber Smith of Ipswich, Massachusetts, and her capstone team are working to patent a device they created that has the potential to stop the spread of HIV in sub-Saharan Africa.

According to the Centers for Disease Control, as of 2011, the HIV/AIDS epidemic has killed more than 33 million people worldwide. Through their capstone work, Smith’s team is attempting to reduce the spread of the disease by creating a single-use circumcision clamp.

Although students are serving others through their work, the communities are providing for them, as well. Experience with industry and stakeholders prepares students for jobs and graduate work. David Neivandt, a bioengineering professor and capstone adviser, says students learn independence and responsibility.

“The students are solving problems for external clients. As such, they are representing themselves, the bioengineering program, the College of Engineering and the University of Maine,” he says.

In April, bioengineering students gathered with residents of Dirigo Pines, an assisted living community in Orono, to discuss problems that could be addressed through engineering, such as making laundry less laborious and improving stovetop safety. The students then presented their designs to a group of involved residents.

When students move on from UMaine engineering, they leave with a degree in the field they desire, and experience in problem solving.

Smith’s interest in biomedical engineering was sparked by her capstone and two co-ops with medical technology company Stryker. She began working for the company as an associate project engineer after graduation.

“I think the UMaine Mechanical Engineering Department does a good job teaching students the skills they need to know to excel in the workplace, but they also teach the students how to find the information they need to know,” she says.

Haylea Ledoux, another student who worked with Dirigo Pines residents, is now studying at Harvard University’s Wyss Institute for Biologically Inspired Engineering.

Adams, who worked with IDEXX, is considering earning a master’s degree in business administration and will

pursue a career in industry. He says he feels prepared for whatever comes his way.

“If there’s one thing I have learned in industry, it is that you are always going to be thrown into situations where you have no idea what you are doing. Engineering has taught me that there is a way to approach these tasks and that no mountain is too big to climb,” he says.

Back at the restoration site in Bradley, Maine, Emmett Hodder stands in the cab of the 1910 Lombard steam log hauler and watches the piping get connected and the project come together.

“The capstone project has been a valuable experience in team dynamics and project management,” says group leader Hodder. “It will be immensely gratifying to return to the museum in the future and see the Lombard log hauler being operated.”

With all its challenges, unexpected turns and the complications of working with new regulations on an antique machine, Hodder can think of one word to encapsulate his whole experience — rewarding.

“It really speaks to Maine,” said MacCaughey, of the log hauler restoration project. “We can accomplish great things.” ■

Capstones for life

Alumni reflect on the lessons that endure

FOR MANY UNIVERSITY OF MAINE students, the capstone experience stays with them long after their days as an undergraduate. In response to a College of Engineering query, several engineering alumni reflected on their capstones and other research projects completed during their senior year, and how the experience continues to influence them today.

Matthew Maberry

Maberry graduated in 2013 with a bachelor's degree in mechanical engineering and works as an aircraft structural engineer at TASS Inc., in Everett, Washington. His capstone was the SAE Aero Design project, a competition offered by the Society of Automotive Engineers (SAE) that provides engineering students with a real-life engineering challenge.

The goal of the SAE Aero Design project is to produce a remote-controlled aircraft that can carry as much payload as possible while complying with size and power limits. The plane Maberry worked on was 4 feet 6 inches long with a wingspan of 10 feet 9 inches.

"Much of the work I did in my capstone project is related to the work I am doing now," Maberry says, adding he did a lot of aerodynamics-related design for the project and supported a good portion of the aircraft's structural design, including the process of taking it from concept to final product.

Maberry says the student team he worked on finished the plane on time and met the goal of completing a flight. The students didn't have the funds to attend the national competition, but the aircraft met competition specifications and performed well overall, he says.

"This is a project I was very passionate about because I am an aviation enthusiast," Maberry says. "The project was a lot of fun and a great exercise of many engineering principles. Everyone on the team was new to aircraft construction, but we worked well together. It was great to see the plane fly at the end of the year after starting months earlier from scratch."

Maberry says the group left the plane in Boardman Hall, along with a nitromethane engine, six-channel radio and receiver, fuel and balsa wood, for any student who wanted to continue the project.

Eben Estell

Estell, who was a student in UMaine's Honors College, graduated in 2012 with a bachelor's degree in bioengineering. He is pursuing a Ph.D. in biomedical engineering at Columbia University.

In place of a capstone, Estell did an Honors thesis on engineering strategies for controlling neuronal growth. His research focused on the material neurons are grown on and the proteins to which the cells attach. The goal of his thesis was to develop a method for creating patterned materials on which neurons could grow.

"These materials can serve as a

platform for better understanding the factors controlling neuronal growth, which would inform future attempts at engineering nervous tissue for clinical repair," Estell says.

Estell is now developing tissue engineering strategies for articular cartilage repair.

"The same idea of applying a basic science understanding of cells in engineering methods to develop medical solutions has persisted from my undergraduate to graduate research," he says.

Estell says the thesis experience reaffirmed his decision to pursue a graduate degree in biomedical engineering and further his academic research. The skills he learned while working on his thesis — from analyzing and presenting data to managing a thesis committee of busy professors — are skills he depends on daily at Columbia.

Joseph Scott

Scott graduated from UMaine in 1976 with a bachelor's degree in mechanical engineering. His capstone project in energy efficiency focused on development of a woodstove as the backup system for solar heat in a house designed by mechanical engineering professor Dick Hill.

The experience involved working with Hill and living in the "Hill house," which had hot water baseboard heat supplied by a heat pump driven by solar collectors.

"Needless to say, it was either get the systems to work or freeze," Scott says.

Scott was in charge of designing

the combustion air system. He had to develop a system that produced the cleanest possible exhaust gases by eliminating creosote deposits that cause corrosion and can be a fire hazard.

To eliminate the deposits, the burned exhaust was recycled back into the combustion area. That made the temperature hundreds of degrees hotter than in an average woodstove or fireplace, which created a few challenges, Scott says. When a wet piece of wood was placed in the stove, the water would expand quickly, causing the wood to blow apart and destroy the firebox.

"After we blew up the stove a few times, we finally got it to work very well," he says, explaining the problem was solved by adding a rack on top of the stove that allowed the wood to dry.

The stove was later installed as the backup system for the hot air solar heating in the Maine Audubon Society's headquarters in Falmouth, Scott says.

After graduating, Scott worked in the energy recovery field designing equipment for the paper industry that aimed to recover heat and manage environmental issues of mills. He has used skills acquired during his capstone to design many fluid-handling and combustion systems, and is often reminded of an even greater lesson.

"The major lesson learned from the senior project was how to learn from failing," he says. "Each time we wrecked the stove, there were valuable lessons learned that finally produced a safe working stove. Today, we use

simulation tools and hazard studies to avoid actually breaking things, but the principles are the same."

Richard Ludwig

Ludwig, a 1952 graduate with a bachelor's degree in pulp and paper technology, recalls working on a senior research project designed to demonstrate the practicality of recycling magazines into a fiber source for manufacturing printed papers.

The now-retired vice president of engineering and logistics at International Paper Co., conducted the research in the basement of Aubert Hall with fellow student Alfred Wynne.

The students used *Saturday Evening Post* magazines as their raw material and tested two methods of recycling the cellulose fibers.

Wynne's process was based on using organic solvents to extract ink from the magazine after pulping the pages into a slush form, Ludwig says. Ludwig used more conventional paper industry practices, such as mixing the slushed magazine stock with caustic soda, using extractive water displacement washing and bleaching with calcium hypochlorite.

Paper sheets were made using both processes and were tested for properties such as strength, brightness, opacity and dirt count. Ludwig doesn't recall which method was optimal, but believes he and Wynne were both heading in the right direction.

"Given that the U.S. paper industry currently employs (the) recycling of old papers as the source for more than 60 percent of its fiber raw materials, Al Wynne and I were well ahead of the curve in looking at waste paper as a possible future fiber source," Ludwig says. ■

Three decades

The legacy of MET capstone projects



1987

SINCE THE 1980s, students in the Mechanical Engineering Technology program have used their capstone projects to solve real problems in unique ways. And before public service was an expectation in education, these students worked on issues that benefited the community, whether it was through large, visible projects that would be seen by many people, or by tackling individual issues that had benefited one person.

“We’ve always had projects here,” says Herb Crosby, an

emeritus professor in the MET department who, with Joel Anderson, teaches the capstone course. “We thought it would be nice to get some projects involved where students work in teams and solve a real problem.”

The projects often come from the community, although students can develop their own initiatives. For more than 30 years, the projects have met a wide variety of community needs.

For instance, one project was to design a magic Christmas tree for the Robinson Ballet annual performance of

The Nutcracker — an evergreen that grows to 20 feet tall in the course of the show.

Capstone students also created kinetic sculptures for the Maine Discovery Museum in Bangor. They enjoyed the project so much, they then created more sculptures for area schools. And when ZF Lemforder Corp., an auto parts manufacturer with a plant in Brewer, needed a mechanism for unloading stabilizer bars after they were painted, it turned to the MET capstone program for a solution.

Sometimes project ideas have come from individuals or organizations working abroad. One local resident worked with an organization in Mozambique that assisted people who have lost a leg due to land mines. Capstone students designed a hand-operated bicycle that included cargo space, and they built it for less than \$200.

For a group working in Haiti, mechanical engineering technology students designed and built a portable water purifier that could be operated and transported by bicycle.

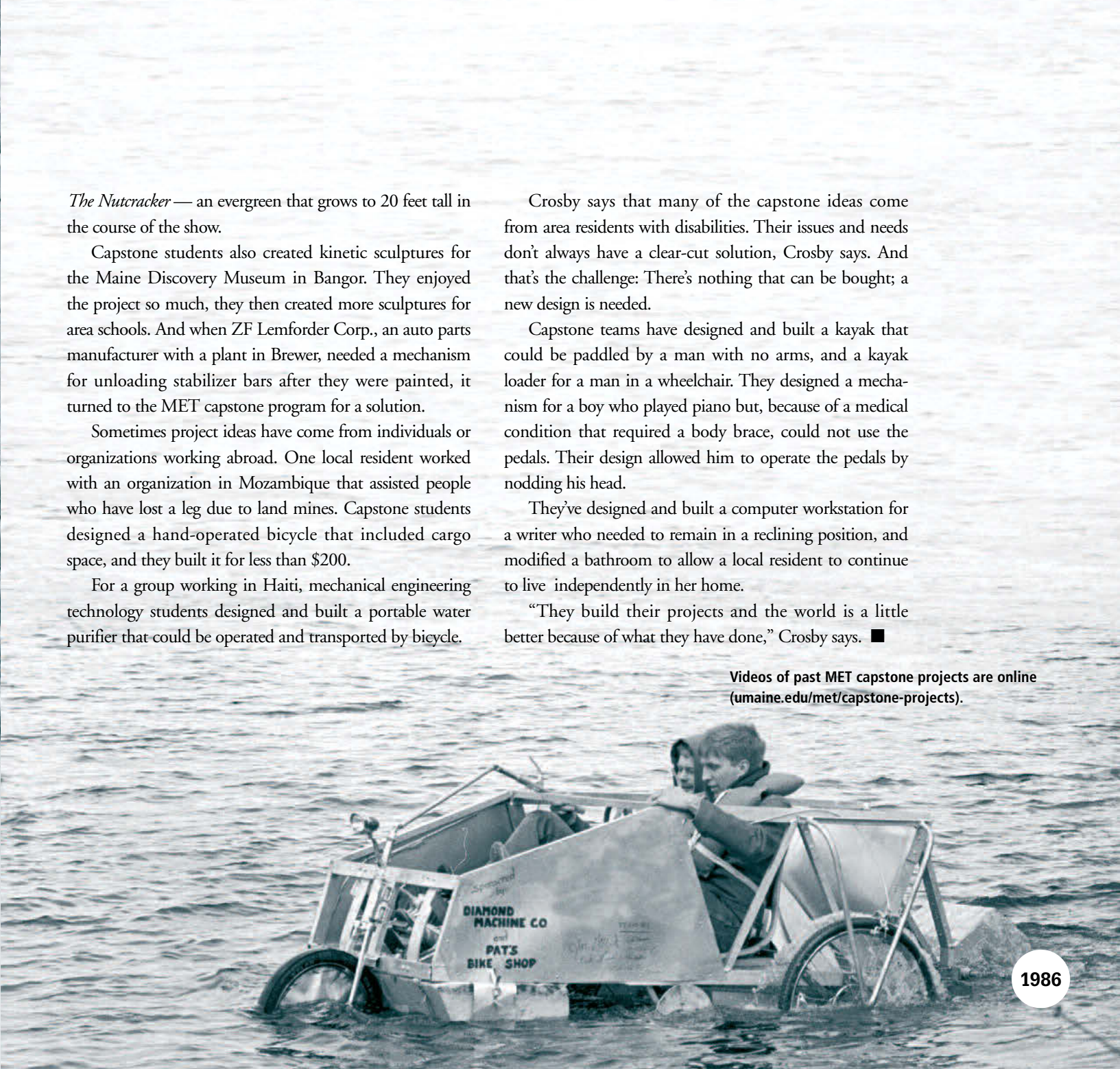
Crosby says that many of the capstone ideas come from area residents with disabilities. Their issues and needs don’t always have a clear-cut solution, Crosby says. And that’s the challenge: There’s nothing that can be bought; a new design is needed.

Capstone teams have designed and built a kayak that could be paddled by a man with no arms, and a kayak loader for a man in a wheelchair. They designed a mechanism for a boy who played piano but, because of a medical condition that required a body brace, could not use the pedals. Their design allowed him to operate the pedals by nodding his head.

They’ve designed and built a computer workstation for a writer who needed to remain in a reclining position, and modified a bathroom to allow a local resident to continue to live independently in her home.

“They build their projects and the world is a little better because of what they have done,” Crosby says. ■

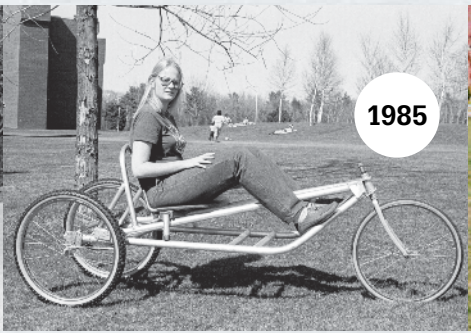
Videos of past MET capstone projects are online (umaine.edu/met/capstone-projects).



1986



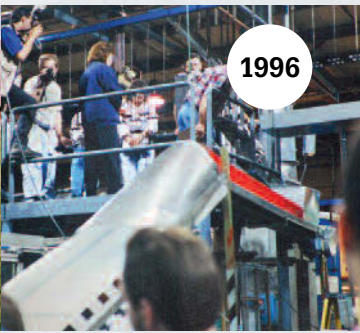
1984



1985



1994



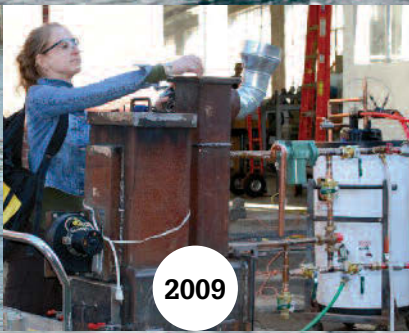
1996



2002



2005



2009



2013

Engineering business

Alumna is at the helm of a multidiscipline engineering team at Bath Iron Works

HILARY HENRY graduated from the University of Maine with a bachelor's degree in computer engineering in 1994. In 2013, she became the first UMaine student to earn a Professional Science Master's Degree in Engineering and Business. Henry currently oversees 36 engineers in her role as manager of engineering at General Dynamics Bath Iron Works for the Life Cycle Services Department.

Describe your job and responsibilities.
I manage a team of 36 multidiscipline engineers who develop the design products needed for installing system upgrades for the 65 Aegis-class destroyers in the U.S. Navy fleet. The team supports hundreds of technologies and systems on the ships. Everything from icemakers to secure networks, from ballistic missile defense to solid state lighting, and more. The focus of my work is providing leadership and direction to the team and managing budget, workflow, product quality, lean initiatives and staffing.

Why engineering?
I started college 10 years out of high school. I was a single mom at the time and my daughter was 2 years old. I originally planned to pursue a teaching degree so I could teach high school math; math was always my favorite subject. I decided I could better support my daughter with a company job and like many college students changed my major.
I moved from the Machias campus to the Orono campus and started working on a degree in computer science. One of my classes that first semester was a computer engineering class taught by Eric Beenfeldt, which I enjoyed so much I decided to go over to the Electrical and Computer Engineering Department to find



Hilary Henry

out more information about the program. I made my inquiry to Janice Gomm in the office and within seconds the department chair, John Field, emerged from his office and welcomed me to the department. John spent two hours showing me the building, all the labs, and introducing me to students and professors.
Needless to say, I was sold and changed my major to computer engineering. It was the best decision I have ever made. It allowed me to follow in the footsteps of my father, an electrical engineer and also a UMaine graduate.

Why did you decide to pursue a professional science master's degree?
I started pursuing my master's in electrical engineering about 10 years ago and had to stop due to being busy with work and family. I was torn as whether to continue with the engineering master's or switch to an MBA, since my career path was going in the direction of management.

Dean Dana Humphrey came to Bath Iron Works several years ago to discuss online engineering degree opportunities and talked about the Professional Science Master's Program. This was the perfect solution for me, as it had the best of both worlds with study in engineering and business in an online program.
Right away, I started working with Dean Humphrey taking courses in spring 2011. The approval for the PSM degree was finalized in 2012 and I graduated in December 2013.

What are some of the biggest challenges in your field?
The Zumwalt DDG 1000 is a ship with half a million electrical conductors, 23,000 pieces of electrical equipment, and power and controls technology so advanced that much of it has never been deployed on any other platform.
Managing the electrical engineering team to enable successful production and activation would be challenging even if the resources

were unlimited. Budgets for Zumwalt called for a team of 35 engineers to handle this huge scope of electrical work.
Fortunately, my team embraced innovation and developed many integrated data-driven tools to help them manage the information and prioritize their work. As the manager, I fostered and supported these efforts by the team. Their innovation greatly contributed to the ongoing activation of this amazing ship.

What are some of your greatest professional achievements?
When I took on the role of manager of electrical engineering, I was the first woman to be on the BIW director of engineering's staff, and that was pretty exciting.
I find in my role as engineering manager, my greatest achievements are seeing the engineers that work with me grow and achieve their own professional goals.

"As an undergrad, I recognized the education and experience I received at UMaine was extraordinary. In engineering, the class sizes were small, the curriculum was challenging, and there were many experiential opportunities."

Why UMaine?
I attended UMaine as an undergraduate student primarily because I lived in Maine, and UMaine offered the programs I wanted to study. As an undergrad, I recognized the education and experience I received at UMaine was extraordinary. In engineering, the class sizes were small, the curriculum was challenging, and there were many experiential opportunities.
What I found most extraordinary about my education at UMaine was the engagement, dedication and accessibility of the professors. At UMaine, the undergrad students are just as important as the graduate students, which is not the case in many large universities that cater to graduate students.
I chose UMaine for my graduate studies because of the positive experience as an undergrad and because of the online PSM degree offering. This was exactly what I was looking for to further my education.

What kind of research were you involved in as a UMaine student?
In the graduate program, I completed the wireless communications concentration working with Ali Abedi. One of my projects had to do with polarization of antennas used for cellular communication. I had never worked with antennas before, so this was a great learning experience for me. I developed computer models of various circular and linear polarized antennas, and compared the gain of each in several communication channels.

Describe your internships as a student.
For the PSM degree, I completed an internship with BIW while I was working my regular job there. The radio frequency identification project was for the materials department and I worked in engineering.
When I was an undergraduate, I interned three summers with Digital Equipment Corp. in Augusta. They manufactured electronic products, and it was that internship that paved the way for my first job in a cell phone factory with Motorola.

How does UMaine still influence you?
As an engineering manager, I frequently hire UMaine graduates, as I know they are well-educated and are up for the challenges we face at BIW every day. I participate in the Electrical

and Computer Engineering Visiting Committee, which keeps me engaged with UMaine. This interaction with the students, professors and other engineering professionals is very important to ensure UMaine students are being trained in the technologies needed by General Dynamics Bath Iron Works.

What difference has UMaine made in your life?
The education I received from UMaine was everything in helping me reach my goals. I would not be where I am today without it.

What was your favorite place on campus?
As an undergrad, my favorite place was the Bear's Den. It was a great place to get a meal and meet friends. I also love the library; what an amazing wealth of information. Being in the stacks in the basement with all the old texts and engineering books was like traveling back in time. Today, the extensive digital databases available online puts the world at your fingertips. I miss not having that access now that I am no longer taking classes.

What's your most memorable UMaine moment?
I'm sure I could write a book. I won't talk about taking a physics final with the stomach flu, although that was memorable.
As an undergraduate, I worked in the controls lab with Eric Beenfeldt and Andy Sheaff, coding the controller for a robot. I loved working in the lab, which confirms that I am a true geek. It was a great day when we set the robot down in the hallway of Barrows and directed it remotely to meander about and return on command.

If you weren't an engineer what would you be?
I've never really imagined being anything other than an engineer, but thinking about it, I would like to be a marine biologist. My oldest daughter, also a UMaine graduate, initially wanted to be a marine biologist and I thought that would be very exciting, and the UMaine program was excellent. Alas, my daughter decided to change her major to art history, which she absolutely loved and now happily lives and works in the U.K on the Norwich Arts Council. ■

Remediating wetlands

Study focuses on techniques for removing mercury from sediment

Aria Amirbahman says one of his long-term goals in research is to help policymakers in Maine refine their consumption advisories and to identify which water bodies have fish that are safe to eat.

ACADIA NATIONAL PARK has hot spots for the transformation of mercury from the atmosphere into a toxic form known as methylmercury. The wetlands surrounding the many small ponds in the park are ideal habitats for that transformation, and fish in some of the park's ponds have some of the highest levels of methylmercury in the Northeast.

That's one of the reasons why University of Maine researcher Aria Amirbahman was looking for a way to interrupt the process, to remove methylmercury from the wetland environment before it begins to move up the food chain. And he did. In a limited study, Amirbahman and graduate student Ariel Lewis, with collaborators at the U.S. Geological Survey, were able to remove about half of the methylmercury from the study area in the field and under laboratory conditions.

Much of the mercury deposited in Maine and New England is the result of the burning of coal, which releases volatile elements such as mercury into the atmosphere, according to Amirbahman, a professor of civil and environmental engineering. But the mercury from the atmosphere is transformed naturally as some microbes take up the atmospheric mercury and secrete it as methylmercury.

That transformed methylmercury gathers in fat and muscle tissues of small organisms; it remains there and easily moves up the food chain as smaller organisms are eaten by larger ones — zooplankton, fish, birds and mammals, including humans. The higher up the food chain, the higher the concentrations of

methylmercury. Even if the world stopped burning coal tomorrow, legacy mercury already in sediment will, under the right conditions, continue to become toxic and work its way into the food chain for decades to come, Amirbahman says.

Methylmercury is toxic and has been shown to cause neurological damage in infants, young children and developing fetuses. Every state in the country has issued consumption advisories warning that pregnant women and young children should not eat fish from inland lakes and rivers. Maine is one of two states to issue blanket advisories, warning people not to eat fish from any Maine lake or river if they are in a high-risk category. Other states have refined their advisories, pinpointing the water bodies containing fish that are safe to eat.

Amirbahman says one of his long-term research goals is to help policymakers in Maine refine their consumption advisories and identify which water bodies have fish that are safe to eat.

Part of that effort involves the kind of remediation techniques he used in Hodgdon Pond in Acadia National Park. Amirbahman and his collaborators initially looked for methylmercury in the sediment in the pond, assuming that was the site of the transformation process. But their samples showed the sediment was not generating any significant methylmercury.

"Then we looked at the data from an earlier study, the 150 Lakes Project, and what dawned on me was that the smaller the lakes are, on average, the larger the methylmercury concentration in fish," he says. "All of the high methylmercury fish lakes were small lakes. All had major contributions from wetlands. That's

"Then we looked at the data from an earlier study, the 150 Lakes Project, and what dawned on me was that the smaller the lakes are, on average, the larger the methylmercury concentration in fish." Aria Amirbahman

Remediating wetlands

when we realized the reaction was taking place in the wetlands. And the methylmercury generated in the wetlands goes up the food chain and ends up in the fish in these lakes.”

That’s when the focus of the study shifted to the wetlands surrounding Hodgdon Pond, which cover nearly the same area as the pond. The study used two substances, granular active carbon (GAC) or ground-up charcoal, and zero valent iron (ZVI), which is basically iron shavings from a metal shop. Both are highly reactive and have been used successfully to remove contaminants by means of sorption.

Their methods were simple. For the first phase, they took a 2.5-foot diameter segment of PVC pipe that was about 2 feet long and pushed it into the wetland, creating a mesocosm by sequestering that small area of the wetland. They did that 12

times in the park. Four of the mesocosms were left untreated as controls; four were treated with carbon and four with iron.

The second half of the study was done in the lab. They collected clumps of the wetland sediment, including plants, and set up 12 aquaria. The sediment was treated the same way as the 12 mesocosms. In the lab study, they also added 10 snails to each aquarium.

The results were promising. In the 28-day tests, the carbon and iron media were effective in removing methylmercury from the sediment, both in the field test and in the lab, Amirbahman says.

“Carbon and iron had lowered the level of methylmercury compared to the control statistically significantly,” Amirbahman says. “We lowered the methylmercury in these samples by an average of 50 percent.

That’s a lot. If we can have half as much methylmercury pumped from the root zones in the wetlands into the water, I think that is very good news for the park.”

The lab tests also showed that the snails in the control aquaria picked up significantly higher amounts of methylmercury than the snails in the treated fishbowls.

While the method shows promise, Amirbahman stresses this was a limited study, really just a “proof of concept” showing that at some level, the method works. Years of study are needed before the method could be used on a wide scale, he says. They would need to study the longevity of the additives, how long they last and how they react in a dynamic environment. They also need more information about the effects of those additives on the environment, and on organisms that live in that environment.

“In our 28-day test, we did not see any adverse effects of the additives on the snails,” he says, “but, long-term exposure can be a different story. And we only tested one type of snail.”

The next step would be to broaden the study, both in the field and in the laboratory, over multiple years, measuring the methylmercury concentrations in sediment and water, and in the habitat’s organisms.

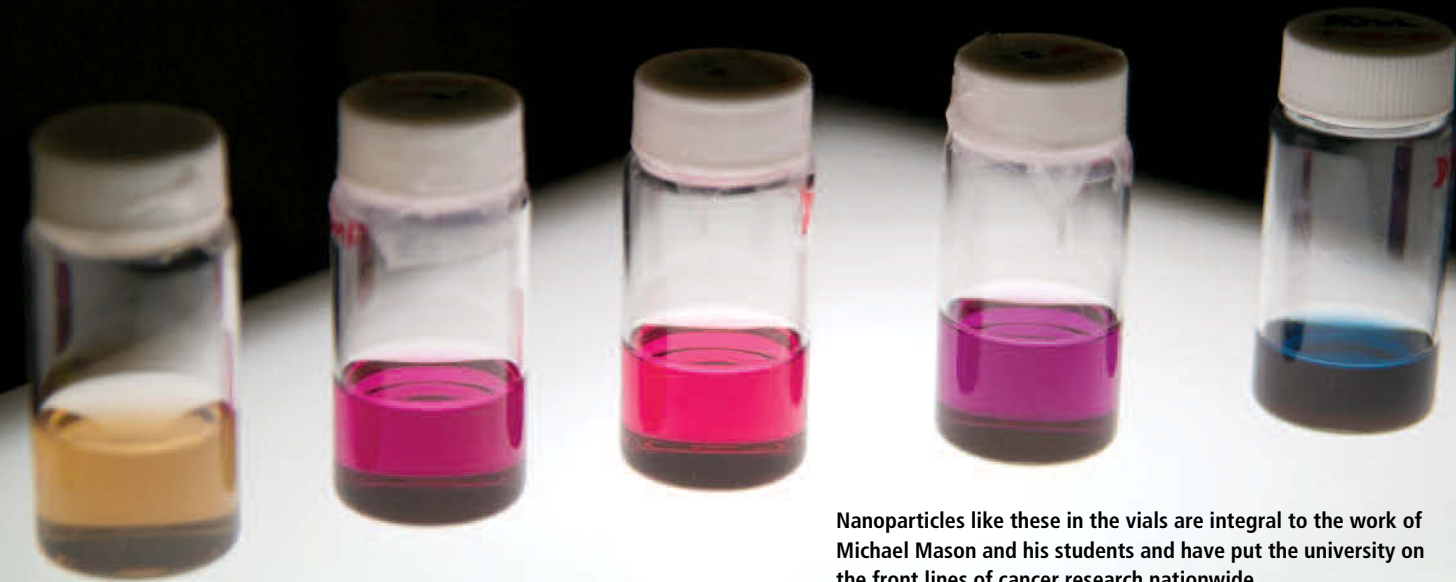
“There is definitely promise in these schemes,” he says. “The cost is relatively low and, if the adverse environmental effects are not significant, then absolutely, this is something that can be implemented in the field.” ■

Aria Amirbahman, center, works in the lab with graduate student Heather Doolittle, left, and Paige Brown, a Bangor High School junior.



Designed to detect

UMaine research shows the potential of gold nanoparticles to not only identify, but also monitor and treat cancer



Nanoparticles like these in the vials are integral to the work of Michael Mason and his students and have put the university on the front lines of cancer research nationwide.

IN A CHEMISTRY lab in Jenness Hall, small glass vials sit in a semicircle on a light box, each containing a different colored liquid: gold, yellow, deep shades of red, purple, blue and green. The colors are a result of incredibly small nanoparticles of gold, their size and shape designed and created in the lab.

The nanoparticles are integral to the work by Michael Mason and his students that has put the university on the front lines of cancer research nationwide. Mason, an associate professor in the Department of Chemical and Biological Engineering, has been using gold nanoparticle technology to develop new imaging methods that can detect cancer cells early in their development, monitor them as they grow and potentially deliver medication to cancer cells, all using minimally invasive nontoxic methods.

Mason’s lab concentrates on developing and employing new highly sensitive techniques that make it possible to look at things on the single-molecule or single-nanoparticle

level, where individual characteristics of these nanoscale objects, not apparent on a larger bulk scale, can be observed.

“Nanoscience is designed to focus on the oddities and often those oddities have properties that are exceptional,” he says.

Using imaging technologies developed in the past few decades, researchers are able to observe and study these individual qualities and learn how to use their special characteristics. By changing the size, shape and combinations in these nanoparticles, Masons says it is possible to design and engineer them to become effective tools with different applications.

“We can take this technology and develop it into tools and instruments, and we can use the technology to tell us things about systems that we did not know before,” he says. “We look at all the design criteria we want to engineer into something and we develop a list of the design requirements. Then we go in to the lab and decide how to make it.”

Designed to detect

The nanoparticles that Mason describes are a few billionths of a meter wide — so small that about 500 of them could fit on the end of a human hair. The design process often starts with a cartoon, a simple drawing of what they think a nanoparticle should look like in order to exhibit the desired properties. The designs vary from the fantastic to the mundane: a starburst or a dog bone, each

interacting with light in a different way, depending on the design requirements. In the lab, the researchers grow and chemically modify nanoparticles, changing their size, shape and surface. They often link them with other targeting molecules, depending on what they want it to accomplish.

Each new project has its own challenges, but each different application helps develop a general approach and technique, improving results.

“We’re getting better and better in our ability to go from design to reality,” Mason says.

A focus for Mason has been the potential to use gold nanoparticles in cancer research. Funded by grants from Maine Cancer Foundation and Memorial Sloan Kettering Cancer Center in New York, Mason has frequently collaborated with Dr. Peter Allen at Sloan Kettering to develop better techniques to look at cancer cells.

Mason has been able to attach bioactive agents onto specially designed gold nanoparticles in a way that has been effective in detecting cancer cells early during their development and providing better images of those cells. The bioactive molecules can seek out and attach to the cancer cells, while the gold generates strong X-ray image contrast that provides an image of the cancer that is more readily visible to doctors and technicians.

Currently, a team of graduate and undergraduate students is working on creating a gold nanoparticle with an iron oxide core that could simultaneously be used in CT scans, MRIs and spectral imaging.

“We can take this technology and develop it into tools and instruments, and we can use the technology to tell us things about systems that we did not know before.” Michael Mason

According to Mason, this method provides clearer and longer-lasting images than the currently used iodine-based contrasting agents, which can result in a negative reaction in patients.

Mason’s collaboration with Dr. Allen at Sloan Kettering has been crucial in matching clinical and surgical needs with emerging laboratory technology.

“We speak different languages and often we don’t understand each other,” he says. “But we have had the opportunity to sit in on surgical consultations, and we hear about what they need, even if it is just anecdotal information.”

Those sessions have led Mason to develop new cancer detection and staging techniques. For example, cancer specialists noticed the fluid viscosity in precancerous lesions appeared to change over time as the lesions develop from benign cysts to more malignant tumors. Armed with that information, Mason designed a low-cost portable tool that allows researchers to monitor the changes in cancer cyst fluid viscosity over time and to correlate those changes with different stages of the cancer.

“This could help surgeons determine what stage the cancer is in and determine a course of treatment — and to do it early on,” Mason says.

Likewise, an earlier study developed a technique to use nanoparticles to clearly image the boundary of pancreatic cancer tumors, providing surgeons with a fast, accurate and noninvasive way of determining whether they have removed all of the cancer from a patient. Current methods require a lengthy analysis of tissue samples while the patient remains on the operating table.

Currently, a team of graduate and undergraduate students is working on creating a gold nanoparticle with an iron-oxide core that simultaneously could be used in CT scans, MRIs and spectral imaging. And the department’s most recent grant from the Maine Cancer Foundation will fund a three-part study to use nanoparticles designed for

CT and MRI imaging to monitor cancer progression over time. With Jackson Laboratory in Bar Harbor, Mason is directing the study designed to develop nanoparticles attracted to a specific cancer cell. They will study those cells in a laboratory setting, then implant a cluster of the cells into a mouse. A nanoparticle solution injected into the mouse will enable the researchers to monitor the cancer cluster as it grows.

“We’ll be able to watch the disease progression and correlate this with spectroscopic genetic information,” Mason says. “We’ll be able to monitor the tumor as it develops over time.”

Although the work has the potential to greatly benefit patients, these systems, and other nanotechnologies, are slow to make it to the clinic. Part of the difficulty, Mason says, is that in many cases, nanoparticles have unknown and unexpected properties, making it difficult to obtain approval by the U.S. Food and Drug Administration for use in humans. So far, the FDA has agreed to review a handful of nanotechnologies for human use. One challenge Mason faces is to create nanoparticles that are engineered to be biocompatible, using materials the FDA has already approved for use in humans.

There are other, bigger challenges for scientists before they can bring the nanoparticle technology from the testing stage to a viable tool for cancer research. But Mason says, the potential is also great and offers both a means to detect and monitor cancer cells, and a way to treat cancer patients. The same techniques used to create a nanoparticle that can seek out and attach to a cancer cell can also be used to design a nanoparticle that could deliver medication to a specific cancer in the body, he says.

While the medical uses of nanoparticles have been the focus of his research, Mason says there is an economic component to the field of nanoparticle research and development. The state is well-suited for this type of industry, says Mason. It does not require a large facility or factory, and much of the required equipment is already here.

“I think we are very well equipped in Maine to do this in the state,” Mason says. “I think it could provide commercial and industrial growth opportunities for Maine.” ■

STEM outreach

EVEN BEFORE THERE was a nationwide emphasis on teaching in science, technology, engineering and mathematics, University of Maine Department of Chemical and Biological Engineering faculty and students were focused on community outreach to support STEM education in local schools. Their work encourages students in all grade levels to learn more about those subjects while introducing them to UMaine bioengineering research.

“This is a significant piece of our program and it has real value,” says professor Michael Mason.

For a number of years, the department regularly brought in nearly two-dozen high school sophomores and juniors, and gave them experience working with graduate students and faculty members in a variety of lab activities, many of them based on the ongoing nanoparticle research at the lab.

More recently, that program has included middle school students in hopes of getting them interested in science. In addition, through the Consider Engineering Program, offered in conjunction with the Pulp and Paper Foundation, high school juniors are in the lab for three or four separate sessions during the year in an effort to

expose them to 21st-century science. Through his work as a school board member in Orrington, Mason realized that the youngest students in the schools were not getting a significant amount of science exposure. He worked to obtain a National Science Foundation grant to develop activity kits that his graduate students use in K-4 classrooms at the Center Drive School in Orrington. The UMaine students have visited each of those classes multiple times, delivering hands-on science activities to about 400 children.

Mason also is involved in the university’s Elementary Science Partnership, which works to build the infrastructure — including materials, curriculum and professional development for Maine science teachers — in the early grades. All these efforts, he says, are an important part of STEM education at UMaine and statewide. They help create public awareness of the work being done at the university and provide an opportunity for UMaine students to interact with the community. They also serve as a potential long-term recruitment tool. More important, those efforts are generating an interest and excitement about science.

“Their faces light up when they know it’s science time,” Mason says. ■



Learning research

RiSE Center best practices prepare teachers and students to get the most out of STEM education

THE MAINE CENTER for Research in STEM Education (RiSE) already had a decade of experience researching ways to improve science teaching and learning when, in 2010, it received a \$12.3 million National Science Foundation grant that broadened the scope and the impact of those efforts.

With the funding, the center developed a coalition of UMaine faculty, students and regional elementary, middle and high school teachers. They work together to better understand how K–12 students learn science concepts, implement new instructional resources and techniques to present those concepts, and assess their effectiveness in classroom settings. The initial Maine Physical Science Partnership spawned several offshoot projects that have generated more enthusiasm for science among young students and more excitement among teachers at all levels. And, in early assessments, the projects have improved student understanding of science topics.

Meanwhile, what happens in the K–12 classrooms doesn't stay there. The teaching strategies and instructional resources, and the educational foundations behind them, are making their way back into UMaine classrooms, informing the education of a new generation of science teachers and offering opportunities for university professors to improve their teaching.

The center, now in its 14th year, was founded for the advancement of research and practice in teaching and learning in science and mathematics. The goal was to foster a more focused, interdisciplinary approach to researching science and mathematics teaching and learning at the university, and to use that research to improve teaching of science topics and to make science more satisfying and

interesting, especially to younger learners. An initial \$1.2 million grant from the U.S. Department of Education allowed the fledgling center to hire new faculty and to establish the Master of Science in Teaching (MST) program, which offers secondary certification in life sciences, physical sciences and mathematics, as well as graduate opportunities for certified teachers in these disciplines.

"That was a big step," says Susan McKay, the founding director of the RiSE Center and a UMaine professor of physics. "It brought us all together around the research projects of the students."

In the ensuing years, the center developed a research team of faculty, postdoctoral research associates and undergraduate and graduate students focused on a broad spectrum of research areas related to teaching and learning science and mathematics at the K–12 level, as well as higher education. The NSF grant allowed the center to develop the Maine Physical Science Partnership (MainePSP) that now includes 25 Maine school districts, 46 individual schools and more than 80 teachers. The goal of the partnership was to focus on grades 6–9, a time when many students lose interest in science.

The center brought together grade-level teachers and RiSE researchers to review possible instructional resources, supported by current science education research. Participating teachers began using a common set of instructional



"We're always looking for evidence on how we are doing and ways to make it better." Susan McKay

Learning research

resources recommended by the task force, which helped the university work with those teachers to design professional development programs to meet their needs. The partnership has provided materials to accompany the science units, enabling teachers to do more hands-on science. UMaine students paired with teachers to provide in-class assistance with challenging lessons.

Among the initiatives: Eighth-graders are doing design work that introduces engineering principles and practices, and elementary school students are working in teams to role play and solve problems in different engineering fields.

The approach has been collaborative rather than top down. Although much of the research is conducted by UMaine faculty and graduate students, the middle school and high school teachers are an integral part of that process. Rather than being research subjects, they are true research partners. They gather data and interact with RiSE faculty regarding what data mean. The process creates a loop: the research initiates changes in the classroom which, in turn, drive new research.

The process had a clear challenge last summer as the team assessed a physics unit on force and motion. While students enjoy the activity — building and testing a model car — they still were not understanding some of the fundamental concepts.

This past summer, university faculty with experience in researching and teaching these concepts, MST students with a background in physics and the grade-level teachers met to examine the materials and the ways they were teaching these ideas. They redesigned the lessons to be used by the partnering teachers. A small group of teachers piloted the new materials early this fall and made changes, if needed. The rest of the MainePSP community will use what they’ve developed in the remainder of the school year.

“That’s just one example of how the research interplays with the instruction,” McKay says. “You use research to take your best shot at learning in the classroom, then you look at how that works, modify what you’re doing based on what you’ve found, and then

you try that again and again. We’re always looking for evidence on how we are doing and ways to make it better.”

Although MainePSP materials have only been in the classrooms for three years, and it is too early for a definitive assessment of the partnership’s effectiveness, McKay says there are some early indications it has had a positive effect on teaching and learning.

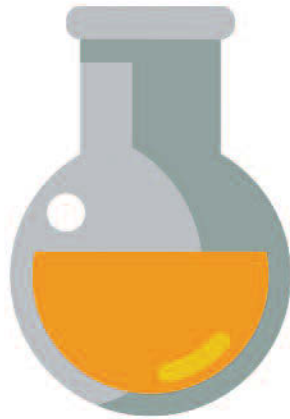
To date (2012–14), MainePSP eighth-graders meeting or exceeding standards on standardized state tests in science have gone from 74 percent to 80 percent. Students in nonparticipatory schools statewide improved from 72 percent to 73 percent. The percentage of MainePSP students who don’t meet the standards has decreased each year of the program. As important, McKay says, is evidence that the partnership seems to be changing student attitudes about science.

In an online survey, 46 percent of students responding said their science class in the past year made them more interested in jobs related to science. Surveys also indicated that those in the program are more likely to view themselves as good or very good science students. Participating grade-level teachers indicate they have strengthened their knowledge of science; particularly in the areas of physics, chemistry and Earth science, and 85 percent said they considered themselves better science teachers for having been a part of the partnership.

And, based on demand from elementary school teachers seeking additional support for younger students, the center used a Maine Department of Education grant to expand the MainePSP and create the Maine Elementary Science Partnership (MaineESP). Still in its early

stages, MaineESP includes about 80 elementary school teachers working as Science Resource Partners with more than 960 teachers in their individual districts throughout the state.

“Part of our philosophy is that we really want to invest in and support teachers. They are there year after year and have such an impact on students. And it’s a tough job. We want to continue to work together — to better understand and improve teaching and learning in science, engineering and math.” ■



In an online survey, 46 percent of the students responding said that their science class in the past year made them more interested in jobs related to science.

At the nano scale

EVELYN FAIRMAN of Bangor, Maine, graduated from the University of Maine in May with a bachelor’s degree in chemical engineering, and minors in renewable energy engineering and mathematics. This fall, she began graduate work in energy science, technology and policy, with a disciplinary concentration in chemical engineering at Carnegie Mellon University. Upon graduation in May 2015, she plans to work with alternative liquid fuels in an industrial setting.

For two years while at UMaine, Fairman was involved in nanocellulose research. Her work, which applied cetyltrimethylammonium bromide (CTAB) to dry and rehydrate nanocellulose for easier transport, was recognized with a 2013 UMaine Center for Undergraduate Research Fellowship. This spring, her work was featured in the Maine Journal, and Fairman was recognized by UMaine with the Edith M. Patch Award. Most recently, the poster from her Honors thesis, “Avoiding Aggregation During the Drying and Rehydration Phases of Nanocellulose Production,” was a finalist in the Society of Women Engineers Collegiate Technical Poster Competition.

Earlier this year, Fairman presented her research findings at the 2014 National Collegiate Research Conference at Harvard University. This summer, she spoke at the 2014 TAPPI International Conference on Nanotechnology for Renewable Materials in Vancouver, B.C.

In her research, Fairman was mentored by engineering faculty members David Neivandt, James Beaupre and Karen Horton; Honors College Dean Francois Amar, and forest operations professor Douglas Gardner.

Why did you decide to major in chemical engineering?

I chose to major in chemical engineering because I wanted to change the way energy is manufactured and distributed. I felt obligated as an educated citizen to reverse the effects of climate change by reducing our nation’s dependence on fossil fuels. As a junior in high school, I hoped to one day design an alternative liquid fuel for the transportation sector. I was especially interested in the potential of fuel cells. I knew I wanted to major in engineering, but it was the University of Maine’s Consider Engineering summer program that convinced me to choose chemical.



How did you get involved in undergraduate research?

I contacted David Neivandt after I graduated high school. I had met him at the Consider Engineering program the previous summer, so I felt comfortable reaching out to him via email. He knew I was an incoming first-year chemical engineering major, and he was more than happy to assign me a student research assistantship under the guidance of one of his Ph.D. students, James Beaupre. The three of us continued to work on various research projects throughout my undergraduate career at the University of Maine.

What difference did the research make in your overall academic experience?

My classroom experience was richer because I was able to reinforce academic topics with hands-on experimental testing. I always loved math and science in high school, but I chose

For two years while at UMaine, Fairman was involved in nanocellulose research. She has presented her research at national and international conferences, and she was a finalist in the Society of Women Engineers Collegiate Technical Poster Competition.

engineering because it was an applied field. It’s not often that an undergraduate has the opportunity to collect and analyze data for an independent research project, while getting paid. I was extremely lucky to have Dave and James as mentors. The research experience gave me the confidence to speak up in class, to ask questions if I didn’t understand the material, to present my results in weekly meetings, and to never hesitate to use upperclass and graduate students as resources. Indeed, my research experience convinced me by the end of the summer before my freshman year at UMaine that chemical engineering was the right field for me.

How do you describe your research?

That is a very good question. It is very important for scientists to be able to translate their research to laymen’s terms, not just to fuel curiosity in those who work outside the field, but also for funding purposes. Here is what I usually say: Maine has a strong pulp and paper industry. I am sure you know that we use trees to make paper. Trees — and all plant matter — are composed of cellulose. Cellulose is a useful material, but if you break it down into smaller pieces until it reaches nanoscale dimensions, we call that nanocellulose. Nanocellulose has very unique properties that allow it to be applied in a wide variety of fields. There is, however, a problem with the way nanocellulose is being produced industrially. Currently, nanocellulose is produced in an aqueous slurry. The water in this slurry eventually needs to be removed. However, when we remove the water, the nanocellulose clumps together and loses its nanoscale dimensions. Thus, its desirable properties are lost and it is no longer nanocellulose. My research project has a patented solution to this problem: We use the chemical additive CTAB to effectively dry and rehydrate nanocellulose.

Which faculty mentor did you work with most and what did you learn from him or her?

I worked most closely with James Beaupre. James encouraged me to think outside the box and to consider all possibilities before drawing a conclusion. His guidance taught me to pay close attention to detail, both during experiments and during data analysis. Outside the laboratory, his positive attitude reminded me not to forget the big picture. ■

Successful launch

UMaine's online aerospace engineering program focuses on design and simulation

WHEN DAVID RUBENSTEIN gave a quote to a Portland paper about Maine's aerospace industry six years ago, he had no idea it would lead to the creation of the University of Maine's fledgling aerospace engineering program or that he would be teaching in that program.

But since 2009, Rubenstein, now an associate research professor of aerospace engineering, has been the instructor for UMaine's undergraduate and graduate aerospace engineering courses. And the university is marketing the program nationwide.

Rubenstein, who holds a master's and Ph.D. in aerospace engineering from Pennsylvania State University, has more than 20 years of experience in the aerospace industry. He's worked in navigation and control system design and dynamic modeling, and simulation development at aerospace and defense contractors, including Martin Marietta, Raytheon Systems Design Laboratory and Draper Laboratory. During that time, he worked on systems for NASA space shuttle missions, defense satellites, unmanned aerial vehicles, unmanned underwater vehicles and even a flying saucer, as well as government projects.

When he moved to Maine in 2002, Rubenstein started his own consulting company, which has kept him involved in aerospace, and related research and design projects. He also joined a local steering committee to promote the aerospace industry in Maine. It was in connection with that steering committee that he was interviewed in 2008 for a story in the Portland Press Herald. Almost as an aside, he told a reporter that he was not aware of a successful aerospace industry and R&D presence in a state that did not have an aerospace curriculum. The day after the story appeared, Rubenstein received a phone call from Dana Humphrey, dean of the college of engineering, who asked, "What can I do about that?"



"These courses are available to students in any of the 50 states."

David Rubenstein

While some of the students who enter the UMaine program have pilot training and even a pilot's license, Rubenstein says the curriculum is not designed to train pilots. The program offers two undergraduate courses in aeronautics and astronautics, focusing on the basics of the design and physics of aircraft and spacecraft. Two graduate courses expand upon the undergraduate courses, focusing on the flight dynamics, modeling, and control of aircraft and space vehicles.

Undergraduate students can obtain a concentration in aerospace engineering, while graduate students can receive graduate certification.

Rubenstein says he approaches the courses as an engineer, making each element relevant to real-life engineering situations. To that end, every student in each of the four courses is required to develop a design for a computer simulation of a particular aerospace system. The students use Matlab software — one of the most important pieces of design equipment in the aerospace industry, according to Rubenstein — to create mathematical models necessary to study the effects of various control applications on the

aircraft or spacecraft. Those simulations, he says, are an important part of the program, and key in the research and development sector of the industry.

"In the aerospace industry, it is very expensive to build a prototype. Before they ever run tests on the hardware, they run numerous trials with simulations," he says. "There is a tremendous need for engineers who have strong simulation capabilities on aerospace systems."

By bringing current industry standards into the program, he says UMaine is preparing students to move directly into jobs in the aerospace industry when they graduate. That background will make them attractive to companies in the aerospace and defense industries.

Although Maine's aerospace sector is a small part of the overall aerospace industry, Rubenstein says it may be possible for those UMaine graduates to become a driving force to grow the industry in Maine. Since he has lived in Maine, Rubenstein says he's observed a fair number of small firms in the state that have been started by UMaine graduates, particularly in civil engineering. Part of the idea behind UMaine's aerospace program is to develop mechan-



David Rubenstein teaches all of his courses online from Falmouth, Maine, where he lives and works.

ical engineers with aerospace training who will stay in Maine and become part of a growth industry here.

Rubenstein not only teaches science and technology, he uses communications technology to present that information to students. Rubenstein teaches his courses online from Falmouth, Maine, where he lives and works. Rubenstein presents all his lectures live. Students ask questions in real time via microphone or chat window; Rubenstein uses a whiteboard and digital tablet to add visual and written information to the lectures. Many prepared graphics, videos, links and other presentation elements are integrated into the presentations.

More important, Rubenstein says, all of the lectures are recorded, giving students flexibility in how they approach the course. They can "attend" the lecture live and they can watch the recording. The recorded lectures also are available to nontraditional students, many of whom are working engineers.

The first student to complete the program took the online courses while working as an engineer at Bath Iron Works.

Rubenstein says there has been some discussion about expanding the aerospace course offerings, and he has ideas for specific courses that could be added. For the first time this year, UMaine is marketing the aerospace engineering courses across the country.

"These courses are available to students in any of the 50 states," he says. ■



Safety in space

Wireless sensor research provides leak-detection technology for NASA

SPACE MAY BE the final frontier, but the work to put men and women into space and keep them safe while they're there has always been done on Earth. Increasingly, some of that work is being done at the Wireless Sensor Network (WiSe-Net) Lab at the University of Maine.

For several years, UMaine researcher Ali Abedi, an associate professor of electrical and computer engineering, has been working with other researchers at the university to develop a wireless sensor system to monitor NASA's inflatable lunar habitat, checking for impacts and leaks, and pinpointing their locations. Recently, Abedi and the WiSe-Net Lab received NASA funding to adapt that leak detection system for use on the International Space Station.

While the space research has brought some notoriety to UMaine and the lab, Abedi stresses that all of the NASA work, as well as other research being done at the lab, has applications on this planet.

Abedi created the WiSe-Net Lab, now a 3,600-square-foot lab on campus, to foster the kinds of collaborations with other researchers that would match the long-standing sensor work.

"They build chemical sensors, biological sensors and physical sensors. I thought 'wouldn't it be wonderful to attach wireless radios to those sensors and put them in the field rather than trying to hook them up with wires in the lab?'" Abedi says. "That's where I thought it would be a very good match for me to collaborate with the sensor

people here. They knew how to build sensors; I knew how to communicate with those sensors, so we put out heads together and figured out a way to make a wireless sensor."

Abedi's team approached their design not by creating a radio and a sensor and putting them together as everyone else had, but by designing the radio and sensor as a single platform. Their initial effort was a single radio-sensor, designed so that the radio's frequency would change based on temperature fluctuations. This system had the added advantage of being powered remotely using radio waves and did not require a battery.

That basic design, Abedi says, enabled a large area of applications that were previously not possible. From there, the WiSe-Net team, which included graduate students as well as collaborators from other UMaine departments, worked to expand and refine the system, using different materials and developing different hardware and software to eliminate interference and to distinguish responses from multiple sensors talking to each other.

The scope of that research has resulted in the development of diverse applications in areas that have surprised Abedi. For instance, the U.S. Army is using a device — a fitted bed sheet embedded with an array of sensors — developed in conjunction with colleagues in the UMaine Psychology Department that can detect mild traumatic

brain injuries in soldiers. As a person sleeps, the sensors collect data about large sleep movements, and heart and respiratory rates. They also detect high-frequency vibrations in the spinal cord that can determine if a person has been exposed to any traumatic brain injury.

"That's one aspect of this research that I didn't anticipate," he says.

Although the sensor array was initially developed for use in monitoring substance-exposed newborns going through withdrawal, Abedi says they recognized that the sensor system could be used with soldiers. With a grant from the U.S. Army, Abedi's team developed a product used to diagnose mild traumatic brain injuries. Early detection and treatment of these types of injuries can help prevent significant post-traumatic sleep disorders, he says.

A company in Boston has approached Abedi about taking the technology to the National Football League. He is currently working with a senior adviser to the NFL to write a proposal for a clinical trial to test if the device can be modified for football players to help determine if and when it is safe to for them to resume play after a concussion.

It might seem like a giant step from the football field to the International Space Station, but that same type of wireless sensing technology has linked the WiSe-Net Lab to NASA's ongoing efforts in space exploration. The lab's initial foray into space involved development of a leak detection system for NASA's inflatable lunar habitat.

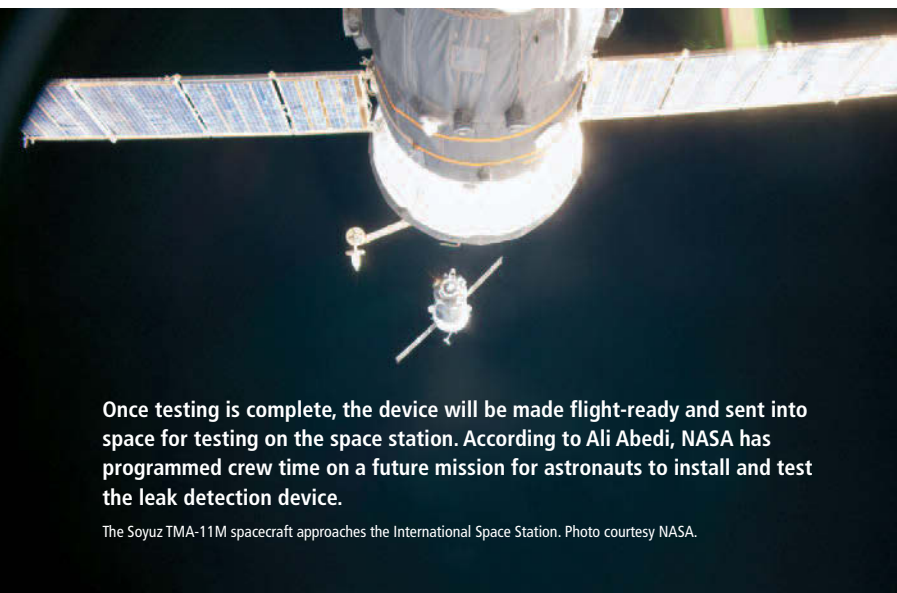
The first-of-its-kind inflatable lunar habitat is a 42-foot-long inflatable donut 10 feet tall, erected at the WiSe-Net Lab in 2009. Abedi, graduate student Joel Castro and postdoctoral fellow Hossein Roufarshebaf, as well as colleagues in the Mechanical Engineering Department and at NASA, developed a sensor array that could monitor the structure for leaks as it was being inflated, detect impacts from space debris and autonomously monitor for leaks for as long as the habitat remained in use.

That required them to develop sensors that communicate with each other to detect the ultrasonic sounds



The wireless sensor research of professor Ali Abedi and his students on NASA's inflatable lunar habitat on campus, pictured far left, also has applications for human health and safety on Earth. Initiatives are exploring their use in monitoring head trauma and sleep disorders.

Safety in space



Once testing is complete, the device will be made flight-ready and sent into space for testing on the space station. According to Ali Abedi, NASA has programmed crew time on a future mission for astronauts to install and test the leak detection device.

The Soyuz TMA-11M spacecraft approaches the International Space Station. Photo courtesy NASA.

produced by a leak, as well as a way to quickly and reliably process all the data gathered by those sensors.

In 2013, NASA began looking for research projects for the International Space Station and Abedi submitted a proposal to develop a similar leak detection system. Earlier this year, that project was one of five in the nation to be funded through NASA's Experimental Program to Stimulate Competitive Research (EPSCoR).

The three-year, \$100,000 grant will allow researchers to adapt the technology from the inflatable lunar habitat leak detection system to the space station. Although the function is the same, Abedi says the research team will have to redesign the hardware and software for use in the space station, making it more durable and adapting it to a micro-gravity environment.

"It's a very different system, both in the hardware and the software," he says. "It follows a similar concept, but we have to redesign it for a whole different structure."

The design will focus on detecting and localizing leaks in one module of the space station. If it proves reliable, the system can be expanded for use throughout the International Space Station. Abedi notes that other researchers are working on the possibility of attaching inflatable modules to the space station, where the WiSe-Net technology also could be used for leak detection.

One of the challenges of this project will be to shrink the prototype system from the inflatable habitat so it fits in a small box that can be transported to the space station. Once the system is built, it will be tested at the lab in Orono and later move to the Johnson Space Center in Houston, Texas, where there is a module of the International Space Station

Once that testing is complete, the device will be sent into space for testing on the space station. According to Abedi, NASA has programmed crew time into a future mission for astronauts to install and test the leak detection device.

The International Space Station project is expected to last three years, but Abedi says there is a bright future ahead for wireless sensor technology, both in space and on the ground.

Currently, all of the space station systems are wired and NASA is interested in technology that could eliminate the need to transport the weight of that wiring. There also is an annual International Conference on Wireless for Space and Extreme Environments, which Abedi helped establish, that gathers experts from space agencies around the world to discuss issues surrounding the use of wireless technologies in space, as well as future applications.

On the ground, the technology has a multitude of applications — from monitoring aging bridges for structural weaknesses to helping older people remain safely in their homes.

Wireless technology can also be used to make homes more energy efficient, and to help make the nation's power grid smarter and more efficient. With "smart home" wireless technology, Abedi says, appliances at home can "talk" to each other: the dishwasher will know if the washing machine is running and won't turn on until that cycle is done, he says.

Expanded to the nation's power grid, he says, the technology can allow the grid to monitor use in different areas, and determine if and when a power generating station needs to run.

"In my mind, we are working toward an energy crisis," Abedi says. "If we can use technology to make us more efficient, that is good for us and for the next generation." ■

Engineering success

JONATHAN TORSCH of Old Town, Maine, struggled in high school while coping with his mother's cancer diagnosis and grandfather's death. Falling behind in school cost him acceptance into college, so he focused on work. When he was laid off from his retail job five years later, he decided to go back to school and enrolled at Eastern Maine Community College (EMCC), where he earned an associate degree in electrical and automation technology, graduated with a 4.0 grade point average and was named 2013 EMCC Student of the Year. To continue to challenge himself, Torsch transferred to the University of Maine to pursue a bachelor's degree in electrical engineering technology, which he expects to earn in the spring of 2015 — again with a 4.0. He also is OSHA certified, a licensed Journeyman-in-Training Electrician and is studying to earn his Maine Engineer-in-Training License.

Why study engineering?

I was unsure of exactly where I would excel, but I enrolled in the electrical and automation technology program at EMCC, with the intention of learning a trade that I would have at my disposal the rest of my life; providing job security and higher earnings for my family. It worked out perfectly, as the program at EMCC is far more geared toward engineering than electrician work, as I had initially thought it to be. I absolutely fell in love with engineering, and could not see myself doing anything else now. Problem solving, logic, organization, teamwork and strong math skills are exactly what engineering can instill, and with those, I

have found success not only academically but in many other areas in life. Upon graduating from EMCC, I knew that I had to continue to push forward and challenge myself in the electrical engineering technology program at UMaine.

Tell us about your internship with TRC Companies, Inc.

I have been working as an intern/designer with TRC Companies, Inc. in Augusta, Maine, since summer 2012. TRC is one of the foremost engineering firms with a presence in Maine, and while there I have learned an incredible amount. I have worked specifically with the automation and communications group. With them, I have done drafting in AutoCAD, designed communication profiles, programmed substation relays and devices, and was the lead on building a piece of software from the ground up that is now used daily to automate internal processes, saving the group large chunks of meticulously spent time.

Have you worked closely with a professor or mentor who has made your academic experience better?

At EMCC, Rick Reardon was an incredible influence on me. I owe an incredible amount of where my future is headed to him. He was my adviser, professor, and the head of the electrical and automation technology program, and his commitment to every student really helped me grow academically, professionally and personally. He stands out as someone I admire and aspire to be like because of his consistently

positive attitude, his excitement for education and the material both in and out of the classroom, and his investment to the betterment of others. At UMaine, I was fortunate to have Jude Pearse as my adviser, professor and supervisor for my teaching assistant and lab technician work. Her commitment to the students is something that followed nicely with Rick's style, and it made my transfer smooth and welcoming. She stands out as someone I admire and aspire to be like because of her commitment to being a human first — recognizing that whether student or professor, younger or older, employee or employer, we're all just people with the same main goals in life, and we can approach professional goals together while maintaining a fun and engaging social environment.

What are your plans after graduation?

First and foremost — work. I hope to obtain a career in my field after graduation. I'd love to work in the automation and/or power engineering fields, as those are the areas of study that have most intrigued me, as well as the ones in which I have had the most success. Meanwhile, I plan to attend Worcester Polytechnic Institute for a master's degree in power systems engineering, and eventually work toward earning my professional engineering license in Maine. ■

The time I spent at EMCC was the most fulfilled and the most challenged I had ever felt. I was absolutely addicted to engineering and academia. I wanted to attend UMaine to pursue a higher degree to learn as much as I could about all of the aspects of the electrical, power and automation engineering world.



2014 Outstanding Graduates



FINN BONDESON
Civil and Environmental Engineering

FINN BONDESON of Woodland, Maine, was the Outstanding Graduating Student in the College of Engineering. His many honors include membership in Phi Kappa Phi, the Marcus Urann Scholarship and the University of Maine Presidential Distinguished Scholar Award.

Bondeson had two summer internships — with Civil Engineering Services in Brewer, Maine, in 2011, and with Stantec Consulting in Limestone, Maine, in 2012 and 2013. More recently, he's been involved in potato breeding research led by Gregory Porter, professor of plant, soil and environmental sciences, as well as professor of agronomy. The goal of the research is to introduce disease-resistant traits into commercial potato varieties.

Bondeson's numerous campus leadership activities included serving as vice president of programming in Sigma Phi Epsilon, vice president of the Senior Skull Society, trip leader with Alternative Breaks and president of the Nordic Ski Club. He also has been a member of Tau Beta Pi, Chi Epsilon, the UMaine chapter of the American Society of Civil Engineers, the National Society of Collegiate Scholars and Black Bear Men's Chorus.



CHI TRUONG
Chemical Engineering

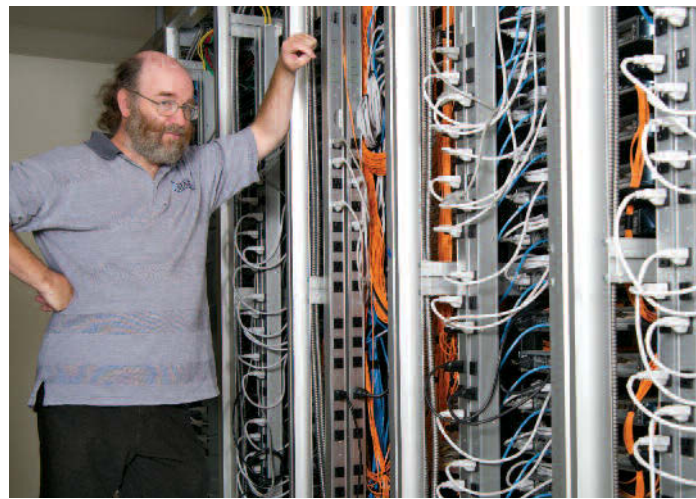
CHI TRUONG of Quang Ngai, Vietnam, was the Outstanding Graduating International Student in the College of Engineering. Truong had pre-med and chemistry minors. She was a Tau Beta Pi Engineering Honor Society National Scholar and received a 2013 Center for Undergraduate Research (CUGR) Fellowship. This past spring, Truong received a second-place poster award at the CUGR Academic and Research Showcase.

Working in the laboratory of professor of chemical engineering Joseph Genco, Truong helped conduct research on the feasibility of generating acetic acid from Maine hardwood extract using electrodialysis. She also was a student research assistant and teaching assistant in the Department of Chemical and Biological Engineering. Truong did two co-op terms at Lincoln Paper and Tissue.

Her campus leadership activities included serving as treasurer of All Maine Women, Sophomore Eagles and Tau Beta Pi, and vice president of the Asian Student Association and the International Student Association. Her extensive volunteer activities included participation in Alternative Breaks and Partners for World Health.

2014 UMaine Presidential Public Service Achievement Award

BRUCE SEGEE has been actively engaged in public service for more than two decades, assisting entrepreneurs and businesses large and small with cutting-edge instrumentation and automation systems. Since 2007, his work has focused on improving the cyberinfrastructure in Maine and the Northeast that is critical to the success of the University of Maine and the region. His interdisciplinary work ranges from development of production-ready infrastructure to the creation of new technologies for visualization, education and communication. His research and outreach efforts have improved the usefulness of laptops in K–12 education, supercomputing and cloud computing, networking and videoconferencing, and resource sharing. Segee helped spearhead the state's Three Ring Binder project, which brought \$25 million in funding, matched by \$6 million in private investment, to form the Maine Fiber Company, providing unprecedented rural connectivity and job creation with the installation of more than 1,100 miles of fiber-optic cable. Three Ring Binder, completed in 2012, was followed the next year by Gigabit Mainstreet, a public-private partnership between UMaine and Great Works Internet to bring gigabit-speed connectivity to the Orono and Old Town communities. It resulted in UMaine being cited as one of the top 10 universities for connectivity nationwide. Gigabit Mainstreet is part of a nationwide program named Gig.U, and Segee had a leadership role in bringing Gig.U to Maine. He has served as the director of the UMaine supercomputer, providing cost-effective, cutting-edge computational power for many significant research projects, classes and simulations for K–12 education. In addition, he directs the UMaine Cyberinfrastructure Investment for Development, Economic Growth and Research, and has been involved in the annual Maine Learning Technology Initiative of the state Department of Education. Segee holds the Henry R. and Grace V. Butler Professorship of Electrical and Computer Engineering. He received the College of Engineering's 2008 Ashley S. Campbell Award, as well as Dean's Awards of Excellence in 2004 and 2008, Outstanding Young Faculty Research Award in 1995 and Outstanding Young Faculty Teaching award in 1994. Segee received a bachelor's and master's degree in electrical engineering from the University of Maine in 1985 and 1989, respectively, and was awarded the College of Engineering Outstanding Graduate Student Award in 1988. In 1992, he received a Ph.D. in engineering from the University of New Hampshire and joined the UMaine engineering faculty. His publishing has included co-writing a textbook.



Bruce Segee

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IN OCTOBER, the University of Maine dedicated Cloke Plaza. Paul Cloke was dean of the College of Engineering, serving from 1925–50.

