3...2...1...
Liftoff! Students, alumni, and faculty watched Oculus launch into space this summer while continuing work on two new nanosatellites.
This crucible is one of the tools from the campus foundry used to make and characterize forged materials including lightweight aluminum alloys for fuel-efficient vehicles.
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Golden Proving Ground: The Keweenaw Research Center installed a new course for military ground-vehicle testing. From steep hills to deep puddles, from rocky terrain to sand pits, the crew takes vehicles truly off road.

SubT Winner: Defense Advanced Research Projects Agency (DARPA) takes robots underground in the Subterranean Challenge (SubT). A team from the Michigan Tech Research Institute (MTRI) is competing in the virtual track and took second place the October 2019 round.

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### RESEARCH HIGHLIGHTS 2019

- Sponsored Awards Fiscal Year 2019
  - Federal | 71%
  - Industry | 14%
  - Gifts | 5%
  - Crowdfunding | 1%
  - Other | 4%
  - Foreign | 2%
  - State of Michigan | 4%

- Federal Awards Fiscal Year 2019
  - US Dept of Agriculture | 3%
  - US Dept of Health and Human Services | 6%
  - US Dept of Transportation | 6%
  - US Dept of Energy | 6%
  - US Dept of Education | 1%
  - Other Federal Agencies | 10%
  - National Aeronautics & Space Administration | 16%
  - National Science Foundation | 20%
  - Other | 4%

### 2018 Invention Disclosures Per $10 Million of Research Expenditures (Compared to Benchmark Universities)

- Michigan Tech | 3.3
- Penn State University | 1.8
- New Jersey Institute of Technology | 2.5
- University of North Carolina-Chapel Hill | 2.2
- Johns Hopkins University | 2.5

### 2018 Invention Disclosures Per $10 Million of Research Expenditures (Compared to Michigan Universities)

- Michigan Tech | 3.3
- Michigan State | 2.4
- University of Michigan | 3.1
- Wayne State University | 2.1

**Research Statistics**

- Total 2019 Research Expenditures: $80.4M
- Increase Over the Past Decade: $16.9M
- Research Institutes and Centers: 20
- Square Feet of Research Space: 279,365

Autonomous vehicles learn to drive rural roads in the Keweenaw.
HEARTFELT TISSUE ENGINEERING

2.5 billion. That’s approximately the number of times the human heart beats in 70 years. And sometimes during the course of its unrelenting contractions and relaxations, the heart muscle can no longer bear the strain.

There’s more than one way to fix a broken heart. For Michigan Tech engineers, the solutions they develop in the lab could help patients recover from heart attacks. It all comes down to engineering a tissue that works: from the tissue’s nutrient availability, to its growth environment, to its mechanical properties.

If heart muscle cells—cardiomyocytes—could be repaired by cells taken from one’s own body, the patient’s recovery improves. But heart muscle cells require an exacting environment, with the right mix of nutrients and oxygen, to proliferate and grow. “This is our basic building block; this is the two-by-two Lego. And you can build whatever you want from there.”

For Feng Zhao, associate professor of biomedical engineering, better engineering is inspired by the tissue’s network of tiny veins, capillaries, and nutrient-providing microvessels.

“The significance of microvessel organization in 3D scaffolds has largely been ignored,” Zhao explains. “Understanding the mechanisms behind microvessel alignment in biomaterials will help us and other biomedical engineers to create better, more refined implants and devices.”

Interdisciplinary work is inherent within health tech development and Smitha Rao, assistant professor of biomedical engineering, turns to materials science and biochemistry to also create better, more refined implants.

Her team developed an electrospun nanofiber substrate on the morphology of the cells, “On day one we start seeing the effect of the substrate on the morphology of the cells,” Abadi says, explaining the uses a process called photolithography to shape the mold to grow heart cells in. “I use microfluidization and nanofabrication techniques to tackle problems that are challenging for biologists or clinicians to address.”

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Interdisciplinary work is inherent within health tech development and Smitha Rao, assistant professor of biomedical engineering, turns to materials science and biochemistry to also improve ways to grow strong heart muscle cells. Her team developed an electrospun nanofiber using a specific polymer blend that creates ideal conditions for many kinds of cells.

“We’re trying to simplify the process to answer a highly complex question: How do cells proliferate and grow?” Rao says. “This is our basic building block; this is the two-by-two Lego. And you can build whatever you want from there.”

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Brzeski and her team found that isolation from mainland coyotes likely concentrated red wolf genetics within a canid group on Galveston Island. Isolation was the downfall, however, for the gray wolves on Isle Royale. The National Park Service worked with regional partners this past year to bring new wolves to the remote island, now up to 17 wolves. The annual Isle Royale Winter Study, now in its 52nd year and led by researchers John Vucetich, Sarah Hoy, and Rolf Peterson, will continue to document the island’s predator-prey dynamics.

“Tessa Ahlborn, professor of civil and environmental engineering, is Committee 318’s latest addition. Following the 1906 earthquake in San Francisco, buildings made of concrete reinforced with steel, known as rebar, spread across the nation and world because of how well they withstand the forces of nature. Today, concrete is the number one building material.

“We think of concrete almost as rock, but a big part of it is the steel,” Ahlborn says. “It’s a steel frame encased in concrete. And people the world over used to know, ‘How do I design with it?’ and ‘How does it behave?’ The code has had updates with over 100 years of research.”

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In the latest American Road and Transportation Builders Association report, more than 47,000 bridges in the US are structurally deficient and need repairs. Across Michigan, 73 percent of highway bridges are at least 40 years old. The Michigan Department of Transportation (MDOT) has partnered with research scientists at Michigan Tech Research Institute (MTRI) to develop technologies that can make bridge inspections safer, helping set aside records. There is no replacing people in the field, but technology can speed up and make bridge inspections safer, helping set aside more time and money to fix structurally deficient bridges.

3DOBS BRIDGE DECK ASSESSMENT

3DOBS is a cinema-quality camera attached to a pole braced on a vehicle trailer hitch that rises up nine feet above the ground. The RED 8K camera captures up to 60 frames per second and picks up details as small as millimeter-wide cracks in the pavement as the truck drives over the bridge deck. 3DOBS is one way to ensure timely bridge monitoring.

As team leader and MTRI research scientist Rick Dobson puts it, “On any vehicle with a standard trailer hitch, you can mount the camera and go.”

CONNECTED VEHICLES

“Connected vehicle technologies also have the potential to optimize traffic, reduce congested areas, and promote reduced fuel consumption,” says Aurenice Oliveira, associate professor of civil and environmental engineering at Michigan Tech. “Technologies used today in disaster management need to be taught to students so they can be ready for when a disaster hits a community this large.”

Oliveira was given a grant from the US Consulate General in Mumbai to travel there, along with Tim Frazier from Georgetown University and Himanshu Grover from the University of Washington, to meet with Indian officials. For two weeks in August 2019, they worked to identify gaps in the TISS curriculum, which they hope can then be replicated at universities across India to train more people to handle the disasters to come.

MICHIGAN TECH RESEARCH AROUND THE WORLD

The National Science Foundation’s International Research Experience for Students (IRES) divets into interdisciplinary research.

IRES Denmark and IRES Singapore

Led by Caryn Heldt, director of the Health Research Institute and the James and Lorna Mark Chair in Bioengineering, and Erin Smith, director of the Humanities Digital Media Zone.

• Three cohorts: 2017-2019
• Collaborators: Aarhus University in Denmark and the National University of Singapore

IRES El Salvador

Led by John Gerike, chair of the Department of Geological and Mining Engineering and Sciences, with the Consortium of Universities for the Advancement of Hydrologic Sciences, Inc. (CUAHSI) and Lutheran World Relief (LWR)

• Three cohorts: 2020-2022
• Collaborators: Luke Bowman, geology; Karl Herskind, Peps-Honnef College; Angela Castro, social sciences; Frank Liu, forestry; David Watkins and Alex Mayer, civil and environmental engineering; researchers at the University of El Salvador FMP in San Vicente; CUAHSI and LWR professional staff

• The teams seek to understand the impacts of drought and extreme weather on water use in rural agriculture communities in the Central American Dry Corridor and explore adaptation strategies to improve water access.

NANOTECH IN DROUGHT AND DROUGHT AND EL SALVADOR, DENMARK, SINGAPORE

The teams examined biotechnological applications of nanotechnology for detecting and treating viral diseases.

All of this data creates the potential for connected cars to help transportation planners.

Kotlin Zhang, associate professor of civil and environmental engineering and affiliated associate professor of computer science, fills in the data gaps by reconstructing a vehicle’s missing location on photogram maps.

DRY CORRIDOR and LWR professional staff

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>>>Learn more: cuahsi.org/projects/ires

>>>Learn more: mtu.news/houghtontrafficsignals

>>>Read more: mtu.news/bridge-drone

>>>Read more: mtu.news/houghtontrafficsignals

>>>Read more: mtu.news/bridge-cv and

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A research forest—both organically beautiful and carefully measured—can be hard to capture in words. But there is a reason that nature has inspired haiku poems for hundreds of years. So, here are a few research-inspired haikus about some of the CFRES projects happening at the Ford Center and Research Forest.

**Climate Oaks**

*brought from as far South as deep West Virginia*

*acorns tell stories*

**Lead researcher:** Carsten Külheim  
**What:** Oaks from around the country could aid Upper Peninsula forest resiliency  
**Funding:** USDA McIntire-Stennis, MTU start-up, MTU Ecosystem Science Center

**Forest Road Surfaces**

*run off challenges*

*pumped and powered sprinklers mist geogrid forest*

**Lead researcher:** Matt Kelly  
**What:** Controlling the rain is no easy feat, but necessary to study runoff  
**Funding:** USDA-NRCS CIG, MTU start-up

**Small Mammal Traps**

*milk cartons hold mice like unbooked Airbnbs*

*weights and vitals, please*

**Lead researchers:** Kristin Brzeski and Jared Wolfe  
**What:** The smallest creatures reveal big impacts on forest ecosystems  
**Funding:** USDA McIntire-Stennis, MTU start-up, MTU Ecosystem Science Center

**Harvesting Forests**

*take only the top can logging be like growing broccoli at home?*

**Lead researchers:** Yvette Dickinson, Robert Fross, and Chris Webster  
**What:** Whole-tree logging and modern silviculture to protect trees  
**Funding:** NCASI, Weyerhaeuser Company, NHSEED, USDA McIntire-Stennis, USDA-NIFA, USFS, MTU start-up, MTU Ecosystem Science Center

**Bird Banding**

*nets like gossamer snare the subjects for banding released, again, wings*

**Lead researchers:** Jared Wolfe and Kristin Brzeski  
**What:** Bird banding station; small, metal bands help ecologists track bird populations  
**Funding:** USDA McIntire-Stennis, MTU start-up, MTU Ecosystem Science Center

**Enjoy a few poems inspired by research at the Ford Center and Research Forest.**

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“Given our changing world, we work to address the challenges in natural resource sustainability through education and training, research, innovation, and outreach.”  
—Andrew Storer  
Dean, CFRES

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One particular site, the Ford Center and Research Forest in Alberta, Michigan, is a hub for faculty research, student research, and, at 3,700 acres, Michigan Tech’s biggest classroom. It’s part of the reason the University’s forestry program ranks in the top five in the nation—it’s where students from the College of Forest Resources and Environmental Sciences (CFRES) come each year for the annual Fall Camp; it’s where they conduct senior design projects alongside faculty and industry partners. Overall, more than $2 million of federal and state funding has supported dozens of active research projects at the Ford Center.

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What is a research forest?
A space to observe the natural environment. A place to modify key variables. A laboratory that lives and breathes without walls around it.

At Michigan Tech, we have 5,866 acres of research forest within 50 miles of campus. That means our researchers have a spacious, all-natural lab close at hand to study invasive species, climate change, silviculture, and wildlife behavior.

“GIVEN OUR CHANGING WORLD, WE WORK TO ADDRESS THE CHALLENGES IN NATURAL RESOURCE SUSTAINABILITY THROUGH EDUCATION AND TRAINING, RESEARCH, INNOVATION, AND OUTREACH.”
—ANDREW STORER
DEAN, CFRES

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Lead researcher: Carsten Külheim
What: Oaks from around the country could aid Upper Peninsula forest resilience
Funding: Superior Ideas, USDA-NIFA, MTU start-up, MTU Ecosystem Science Center

**Bird Banding**
ets like gossamer
snares the subjects for banding
released, again, wings

Lead researchers: Jared Wolfe and Kristin Brzeski
What: Bird banding station; small, metal bands help ecologists track bird populations
Funding: USDA McIntire-Stennis, MTU start-up, MTU Ecosystem Science Center

**Harvesting Forests**
take only the top
can logging be like growing broccoli at home?

Lead researcher: Yvette Dickinson, Robert Froese, and Chris Webster
What: Whole-tree logging and modern silviculture to protect trees
Funding: NCASI, Weyerhaeuser Company, NHSEED, USDA McIntire-Stennis, USDA-NIFA, USFS, MTU start-up, MTU Ecosystem Science Center

**Small Mammal Traps**
milk cartons hold mice
like unbooked Airbnbs
weights and vitals, please

Lead researchers: Kristin Brzeski and Jared Wolfe
What: The smallest creatures reveal big impacts on forest ecosystems
Funding: USDA McIntire-Stennis, MTU start-up, MTU Ecosystem Science Center

**Forest Road Surfaces**
rain run off challenges
pumped and powered sprinklers mist geo grid forest

Lead researcher: Matt Kelly
What: Controlling the rain is no easy feat, but necessary to study runoff
Funding: USDA-NRCS CIG, MTU start-up

**Climate Oaks**
brought from as far South as deep West Virginia
acorns tell stories

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What: Oaks from around the country could aid Upper Peninsula forest resilience
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The mission kicked into high gear with winning the University Nanosat 6 competition in 2011. This netted the team the Air Force Office of Scientific Research (AFOSR) contract to launch Oculus under the guidance of the University Nanosatellite Program (UNP), for the Air Force Research Laboratory (AFRL). Graduate Jesse Olson ’17, who started building rockets when he was 12 years old and served as the chief engineer for Oculus as a student, now leads the UNP.

“I knew I was going to join the team before I even got to Michigan Tech because I knew I wanted to do aerospace. When I came into the process, the whole satellite was completely designed. A lot of the people who designed it had already graduated,” Olson says. “There was a learning curve to catch up. Debugging, fixing, trying to understand why designers made the choices they did.

“That’s one of the biggest challenges across all UNP and university projects,” he notes. “Teams working through multi-year projects have to come up with ways to combat that through documentation and training.”

Olson now guides a new generation of Aerospace Enterprise students through the very program that resulted in the successful Oculus launch. In its 25-year history, UNP has worked with 38 universities and has 15 satellites and seven launches under its belt. Olson is currently working with 12 universities on 14 missions.

Working on the Oculus project as an undergrad showed Olson the inherent Greenwood of the effective mentoring techniques he uses today.

“I’m always getting advice from other people. This is not a one-man show,” Olson says. “And while I don’t see him as often as I used to, I still regard Dr. Brad King as a mentor.”
At 2:30 a.m. on June 25, 2019, Michigan Tech’s student-built Oculus-ASR nanosatellite rode the SpaceX Falcon Heavy from Cape Canaveral Pad 39A into orbit. It’s a University first, but by no means the last.

MISSION(S) ACCOMPLISHED

The new space race is driven by commercialization, tech miniaturization, and cost optimization. Space is easier and cheaper to reach than ever before. However, there’s still nothing simple about building a satellite.

At Michigan’s current members with more than 100 alumni, one satellite in orbit, and two more missions in the works, Michigan Tech’s Aerospace Enterprise team has worked through the challenges and experienced the triumphs. It’s one of the largest and most successful teams in Michigan Tech’s 20-year Enterprise Program. Started at the request of students roughly 18 years ago, it’s also one of the oldest. Nearly two decades of training in small-satellite development, from concept to launch-ready, has positioned students among the next generation of aerospace leaders. Here’s how they get their first nanosatellite, Oculus-ASR, into space last summer and their plans for two new missions, Auris and Stratus.

“We have an established presence in the field,” says current team program manager Marcello Guadagno. “You’re working on something that until very recently was in the domain of large corporations and governments. You get to see your work in space; people don’t get to see that too often.”

NOT YOUR PARENT’S SPUTNIK

In the systems concept and critical design review phase, research is paramount. The initial step, deciding what you want your satellite to do and how that aligns with a funding agency’s mission, can take months, as can diving deep into what has worked and what hasn’t. Be it with a military branch, National Aeronautics and Space Agency (NASA), or private entity, the team is tasked with creating a compliant proposal that meets all criteria. In the assembly, integration, and test phase, the spacecraft comes together, employing both off-the-shelf and custom components created in-house. In the environmental test phase, the satellite is shipped for bake out, thermal cycling and vacuum, and vibration testing—a violent process commonly referred to as shake-and-bake that simulates the rigors of launch and orbit in the space environment. These steps all lead to the costed launch and missions operations phase.

Read more about the nuts and bolts of spacecraft or the University research blog Unscripted: mtnu.nasa/aerospace

MISSION: OCULUS-ASR

Oculus-ASR is fittingly named for its role to help the US Department of Defense (DOD) improve its vision when monitoring satellites; the ASR stands for attitude and shape recognition. Its mission is one of the first dedicated to providing a cooperative target for ground observatories as a means to help compensate for the ever-shifting changing shape and performing complex maneuvers to present an ever-shifting target for ground telescopes.

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King, the Henes Endowed Professor in Space Systems, has been the Aerospace Enterprise team advisor since the group formed. Over the years students have made their mark in the industry—and also left their mark in laboratory work spaces. King shows a scribbled piece of paper that reads, “Oculus means family—and that means nobody goes home.”

“That perfectly captures the perseverance of the team,” King says. There were many moments when the end-goal seemed doubtful. “The number of near-failures are too numerous to list. I can’t count how many times we were on the brink of missing a key deadline, or we were out of funds with no clear path forward, or we damaged an irreplaceable component during testing. Somehow they always found a way to make it work.”

The hardest decisions involved descoping critical components or functions to reduce budget or meet a government deadline. “These decisions involved abandoning something that part of the team spent years developing, in order to ensure success of the core mission,” says King. “In the end, all of the decisions proved to be justified and correct.”

LAUNCH: OCULUS-ASR

In spring 2019, SpaceX announced a June 24 launch window beginning at 11:30 p.m. for the DoD Space Test Program-2 mission, managed by the US Air Force Space and Missile Systems Center. The mission would deliver 24 satellites to space with Oculus first off the pad. Nearly 40 alumni and their advisor headed to Cape Canaveral.

The five-year wait was over. Almost.

“Ten, nine, eight, seven, six,” alumni counted down together, “five, four, three, two, one, zero … Wooooo!”

“Some energy and anticipation, and now we had to cool our heels for a few hours,” says King, who watched with his son from a balcony at the Operations Support Building. “So much energy and anticipation, and now we had to cool our heels for a few hours,” says King, who watched with his son from a balcony at the Operations Support Building II located next to the Space Center’s iconic Vehicle Assembly Building. Roughly five miles away, about 40 Aerospace alumni played the waiting game. It was so much fun!” says 2018 graduate Sarah Wade, an electrical engineer with Space Dynamics Laboratory in Utah. The launch wasn’t her first Oculus-induced adrenaline rush.

Several years earlier, Wade, a double major in electrical and computer engineering, was among the small group that worked tirelessly to get the nanosatellite shipshape to transporting spacecraft, was more nerve-wracking than day—then returning to darkness as the flash of the rocket flare was swallowed in the lower horizon of following stream mirroring from the launch pad.

Falcon Heavy blasted into the sky. The lagoon illuminated, briefly illuminated brighter than day then returning to darkness as the flash of the rocket flares were swallowed in the lower horizon of following stream mirroring from the launch pad.

Their eyes were on Oculus.

“It’s difficult to describe,” says Guadagno. His phone video captures the elation of the moment—bright voices in the dark—as the rocket carrying a milestone accomplishment for so many steadily ascends toward the stratosphere, encouraged every step of the way. “Here we go!” “Yes!” “Go, baby, go, baby!” There was spotters as the boosters separated and fell to Earth accompanied by sonic booms.

Back at the Space Center, King watched the video livestream. Oculus was scheduled for release 13 minutes into the mission. Seconds before deployment the video stream cut out as the rocket passed beyond line-of-sight from ground control. Another antenna picked up the feed a few minutes later.

“When the video stream came back, Oculus was gone!” King says. “While it was frustrating to miss seeing her release, it was striking to notice the empty spot where she used to be located.”

The celebration, including a group photo and high-fives, continued at Banana Creek.

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In spring 2019, SpaceX announced a June 24 launch window, beginning at 11:10 p.m., for the DoD Space Test Program-2 mission, managed by the US Air Force Space and Missile Systems Center. The mission would deliver 24 satellites to space with Oculus first off the rocket. Nearly 40 alumni and their advisor headed to Cape Canaveral.

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Delayed by a ground hydraulics system issue, launch took place three hours into the four-hour launch window.

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“When the launch date finally came, current and former students traveled across the country to be together again and watch their satellite head off to do its job.”
—BRAD KING

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Several years earlier, Wade, a double major in electrical and computer engineering, was among the small group that worked tirelessly to get the nanosatellite shipshape when the call for environmental testing at Kirtland Air Force Base came unexpectedly in summer 2017. After six years of development and hundreds of undergraduate R&D hours, it was go time.

The deadline: four weeks to reassemble, test, and ship the nanosatellite. Olson, who would go out to Kirtland himself not long after, remembers the pressure as well as the satisfaction of accomplishing the goal. The team was short on members—most had already left campus for the summer—but powered through in one intense week.

“There were six of us. It was like six 16-hour days in a row. We made it—got it on the truck in time!” Olson says. Shipping, in a truck with a driver likely not accustomed to transporting spacecraft, was more nerve-wracking than shake-and-bake.

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There was suspense as the boosters separated and fell to Earth accompanied by four sonic booms.

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“Oculus-ASR was first off the SpaceX payload at approximately 315 kilometers altitude.”

Falcon Heavy waits on iconic launch pad 39A, where the Apollo missions lifted off.
“Even though we do beat the satellites up [at AFRL], there are very controlled environments, conducted with the proper equipment and trained personnel,” says Olson, adding that the hurry-up-and-build syndrome continues with securing a launch vehicle. “We were launch-ready for several months. Oculus was isolated from the world, first in a clean room, then in a shipping container under a nitrogen purge.”

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Olsen is among those who have been keeping an eye on Oculus since the launch. “We had successful sphere deployment, and the ground telescopes collected some light curves as Oculus flew overhead,” he says. Data coming in continues to indicate that Oculus is doing its job. “So far everything seems to be functioning as expected.”

MISSION: STRATUS

Stratus, named for its cloud-imaging mission, is funded through NASA’s Undergraduate Student Instrument Program and the CubeSat Launch Initiative. Sietsema says there are no specifics on a timeline yet, but that Stratus will be launched from the International Space Station. The 10-by-10-by-30-centimeter and 4.4-kilogram spacecraft could be deployed to gather hyper-local weather data.

The CubeSat underwent and passed its critical design review in December. Additional reviews are scheduled remotely in the eight-to-10-hour series of team presentations.

“A satellite has value for the research and science it can do, it needs to be compliant [with the requirements for its mission]. The feedback from formal design reviews helps guide students,” Olson says.

The CubeSat’s team chief engineer Matthew Sietsema, a double major in electrical and computer engineering, says the group was looking forward to demonstrating the maturity of the project and the progress made since the last review. A prototype of Stratus, named for its cloud-imaging mission, is pictured. An A prototype of Stratus, named for its cloud-imaging mission, is pictured.
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The 10-by-10-by-30-centimeter and 4.4-kilogram CubeSat (named for its cube-like configuration) is a three-axis-stabilized thermal infrared telescope designed to provide a low-cost solution to imaging atmospheric clouds. Cloud fraction, top wind, and top height data are used to reconcile climate models. If all goes as planned, more Stratus spacecraft could be deployed to gather hyper-local weather data.

A prototype of Stratus, the CubeSat destined for launch from the International Space Station

A CAD model of microsatellite Auris, which underwent preliminary design review in December

“ASR, which has been compared to a mini-fridge. A peer-evaluation system provides feedback and promotes advancement within the team, and King says the Enterprise operates as a real business.

“During the early years, I played an active role in creating our design processes, management structure, and overall culture,” says longtime team advisor King. “Working together with students, and also mentors from AFRL and NASA, we created a systems engineering infrastructure that’s become a de facto all of our design projects.”

The system defines and tracks requirements. It gives team leaders templates to manage the schedule and budget of a large team. It includes a self-sustaining leadership and management hierarchy.

“With this system in place, the Aerospace Enterprise is now run entirely by the students,” says King Current leaders mentor their successors, providing year-over-year continuity.

“We get to say your code is in space. Not every undergrad can say that.”

As the Aerospace Enterprise’s software team leader Dante Paglia puts it: “All of us joined not knowing how to write software for a satellite. It’s not taught in classes. You get to say your code is in space. Not every undergrad can say that.”

With too much spacecraft in process and ever-expanding opportunities on the horizon, the Aerospace Enterprise team continues to design, build, and launch both satellites and careers. The thrill of the first success remains and Olson says the coolest part of his job so far was watching Oculus launch. “That was incredible. The Falcon Heavy is currently the most powerful operational rocket in the world. Seeing it launch, feeling it, was all around an amazing experience.”

LAUNCH: ENTERPRISE FOR STUDENT SUCCESS

There are many moving parts to business ventures as well as satellites. Like all Enterprise teams, Aerospace Enterprise operates as a real business.

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The currents of the Straits of Mackinac are known for their volatility; they have for millennia pushed the birch bark canoes of Native Americans and voyageurs alike off course and forced lake freighters aground.

The currents are also part of the complex lake system that links Lake Michigan to Lake Huron. Monitoring currents and waves in the Straits—and throughout the Great Lakes—is of great interest to scientists, municipal managers, the shipping industry, environmentalists, and government agencies.

In late May 2019, the waters of the Straits were calm, ruffled only by wind and boat wakes, on a brilliantly sunny day. Aboard the S/V Osprey, one of Michigan Tech’s survey vessels, testing was underway to measure a radar pattern across the water from temporarily installed high-frequency radar antennae.

During the visit to the Straits of Mackinac, Lorelle Meadows, dean of the Pavlis Honors College and an oceanographer by training, and Guy Meadows, founding director of the Great Lakes Research Center (GLRC) and the Robbins Professor of Sustainable Marine Engineering, conducted the first test of an onshore high-frequency radar system specifically tuned to map complex current patterns in the Great Lakes.

GREAT LAKES GEOMETRY

High-frequency radar is a shore-based remote sensing system used to measure currents offshore by sending a low-power electromagnetic pulse over the water.

Developed on ocean shorelines, the electromagnetic wave interacts with marine surface waves, which scatter the radar signal. By measuring the return pulse bounces from marine waves back to the radar antenna, researchers are able to map the speed and direction of the underlying currents.

High-frequency radar has not been implemented as a routine tool for measuring currents in the Great Lakes because, in comparison with salt water, the electromagnetic pulses travel shorter distances. High-frequency radar works in freshwater between six to eight kilometers (about four to five miles). Where the distance between coastlines narrows, the geometry makes high-frequency radar more effective and there are many such locations in the Great Lakes.

The Straits of Mackinac, where Lake Michigan and Lake Huron meet underneath the towers of the five-mile-long bridge, are known for their unpredictable currents and winds. The bottleneck of the Straits is kept busy by freighter traffic and the ferries that take tourists to and from the famed Mackinac Island. Not only do the Great Lakes provide shipping lanes, but more than 30 million Americans rely on the lakes for drinking water.

“A lot of the infrastructure in the Great Lakes that gives us drinkable water is within a few miles of the coastline,” Lorelle Meadows says. “A system like this could be valuable in different strategic locations. I could imagine it in southern Lake Huron near Port Huron and Sarnia, at the Detroit River, or the Chicago waterfront—any place you want to have insight into the way the currents are moving.”

In May 2019, with funding from the Great Lakes Observing System (GLOS), Lorelle Meadows and a team of scientists temporarily installed two 14-foot CODARN SeaSonde high-frequency radar antennae, one on each side of the Straits just west of the Mackinac Bridge. Because of its sheer size, there was the potential the bridge would interfere with the radar signal; field testing showed the bridge did not directly interfere, a big step in moving the radar project’s viability forward.
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Drifting along the shadow of the bridge, Travis White, research engineer at the GLRC, sat at the Osprey’s helm, ensuring the vessel kept a precise trajectory along waypoints to test the radar signal. Mike García, systems engineer with CODAR Ocean Sensors, spoke on a two-way radio with Lorelle Meadows about the strength of the radar signal.

Unlike buoys, which provide single-point measurements, high-frequency radar antennae use broad beams that intersect over the water surface to create maps of an entire area.

“The hope is to produce vector maps every half hour,” García said. “The Straits West buoy reports conditions at a single point every 10 minutes. This system has the capability to create a new vector map of currents every 30 minutes, every day.”

A LIFE’S WORK

For Lorelle Meadows, the high-frequency radar pilot test was the culmination of 20 years of research. Her graduate research focused on the application of radar in freshwater systems and, while she was certain high-frequency radar had important uses in the Great Lakes, funding agencies saw only the limitations of freshwater without until to conduct the electromagnetic pulses farther out over the water. As a result, freshwater high-frequency radar research in the Great Lakes was shelved.

“An individual antenna only provides the radial component of the current. But by combining the two stations together, we achieve the full-surface current vector,” García says. “The Straits West buoy reports every half hour,” Guy Meadows says. “One station individuals can only tell you the speed at which a current is traveling toward or away from it.” Lorelle Meadows says. “An individual antenna only provides the radial component of the current. But by combining the two stations together, we achieve the full-surface current vector.”

Not meant to replace the buoy’s current measurements, the radar antennae provide more data to gain better understanding of complex lake systems.

The pilot testing of the temporary radar antennae also took the Osprey to the bottom part of a mile from the Mackinac Bridge to the west alongside one of Michigan Tech’s buoys, 45175 Straits West. Tethered to the lighthouses during Michigan’s spring, summer, and autumn, the buoy tracks wind speed, direction, and gusts as well as wave height and direction, water current, and water temperature, wind chill, and dew point. As the Osprey hobbled beside the buoy, it was readily apparent how vast the Straits are. Just as the Mackinac Bridge is more impressive from a boat floating beneath it than from a car driving across it, the Straits seem to stretch on, despite being a narrow point in the Great Lakes. The vividly yellow buoy provides crucial information, but from just one point. Radar coverage could be more comprehensive.

“High-frequency radar data is new to the Great Lakes,” says Kelli Paige, GLOS chief executive officer. “By funding the permanent installation in the Straits, we hope to see long-term benefits for those living near the bridge and beyond in lakes Huron and Michigan.” Specifically, the technology helps by providing information that can be used for safe boating, spill response and cleanup, and research.

“Our ocean coasts are instrumented with these towers,” Lorelle Meadows says. “This is our opportunity for the Great Lakes coastline to be.”

But as concerns about environmental contaminants in the Great Lakes grew, so did interest in deploying the system. If it could mean reducing risk and better understanding the lake systems themselves, what was there to lose? GLOS approached Lorelle Meadows with a request to fund a pilot system.

“For a long time, we’ve been asking people to listen to the story that this technology is valuable in this space,” she says. “The fact that we were finally heard and we can make an operational capability for the Great Lakes is huge for freshwater science.”

NEXT STEPS

Beyond their use to scientists, vector maps can be used by many different interests: providing warnings to ships about currents that might force them aground or off course, giving vital information to search and rescue operators, tracking a hazard spilled into the water, tracking ice floes, or monitoring harmful algal blooms to protect municipal water intakes.

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NEXT STEPS

Beyond its use to scientists, vector maps can be used by many different interests: providing information that benefits the public, for instance, or for search and rescue operations, helping them recover victims from a passing lake freighter. The scene belies the side of the towers of the Mackinac Bridge, the reflection mining like watercolors, smeared by the wake of a passing lake freighter. The scene belies which might appear calm above, hiding turbulence below. During the pilot test in late May, steady drifting clouds in the sky shimmered and dipped in the cold water of the Straits. The Osprey darted to the side of the towers of the Mackinac Bridge, the reflection mining like watercolors, smeared by the wake of a passing lake freighter. The scene belies how differently wind and current might behave on a given day.

Back at the GLRC, the researchers are processing data and have applied for permanent GLOS and Michigan Tech’s systems and, while she was certain high-frequency radar had important uses in the Great Lakes, funding agencies saw only the limitations of freshwater without admit to conduct the electromagnetic pulses further out over the water. As a result, freshwater high-frequency radar research in the Great Lakes was shelved.

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GLOS is following up on their $300,000 grant in 2019 to purchase, site, and test the high-frequency radar system. In project year 2019-20, GLOS granted Michigan Tech an additional $150,000 to install and operate the system.
MATH SINGS ITS OWN ARIA

STEM: science, technology, engineering, and of course, mathematics. It’s time for math to take centerstage.

When most people talk STEM, they’re likely focused on S-T-E. If math is at all mentioned, it’s a polite—perhaps intimidated—nod to the orchestra pit. Because math, as the popular attitude goes, should be left to the nightmares of seventh-grade algebra. Not surprising given that the National Institutes of Health report 93 percent of adults in the US experience some level of math anxiety.

There are those who enjoy a bit of numerical play. We expect them to become engineers (because, of course, engineers have to like math). But straight-up mathematicians? They’re a rare and different breed.

And to see research problems through their eyes is to know truth and beauty. Math is as much an art as it is a major influence on other STEM fields. Particularly with applied math, where models and algorithms provide foundational support in scientific and technological endeavors, the M of STEM joins the chorus or keeps behind the curtains to work the grand sets of modern research. The show could not go on without mathematics.

So in these pages, applied math sings its own aria.

OVERTURE UPON DETONATION

A surprising problem in the field of partial differential equations is that of instantaneous detonation.

Take a two-meter-long tube, for example. If an explosion sets off in one end, how quickly does it travel through the rest of the tube? In true Hollywood style, the blast would be nearly instantaneous—and with just enough time, the main character jumps away. But the problem is that if we zoom in on the explosion, slowed the scene way down, and tried to measure the fiery movement tick-tick-tick down the tube, we wouldn’t be able to come up with a precise mathematical model that perfectly replicates what we observe in real life.

This bothers mathematicians.

“Math always tells you the truth,” says Yang Yang, an associate professor of applied mathematics, explaining one solution to the instantaneous detonation problem is to add more ticks in the measurement, which creates its own challenge. “With more variables, you need more equations.”

Enter one of the most common misconceptions about mathematics: Math is entirely about numbers. That’s like saying singing is about the notes. So, throwing in more numbers or more variables to a mathematical model is not always ideal, although greater computing power with facilities like the Michigan Tech high-performance computing facility Superior and advances in math theory have certainly expanded research horizons with more data and complexity. However, what applied mathematicians like Yang are truly interested in is how to streamline and verify models.

“Engineers use mathematical models to solve concrete problems—math is a tool,” Yang says, clarifying that in his world, math is a mindset. “Applied mathematicians need to understand those engineering problems and ensure the math is consistent. The solution you find should follow common sense.”

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Another misconception about math: Show your work; a single right answer means a single methodology. Models may be right or wrong—but there’s no silver bullet. Many mathematicians tackle similar problems with many different approaches.

Cécile Piret, associate professor of applied math, contributes to research in physics and geology. It is a tension in the difference between what is observed in experiments and what a model predicts that drives the field, she says. “Why does the simulation not represent what happens in nature?” Either the mathematical representation of the phenomenon is wrong, or it is correct, in which case the computational method used is inaccurate. Part of my job is to ensure that the method used is as accurate as possible.”

Accuracy is not the only demand; efficient and computationally inexpensive methods are also prized. Geologists, physicists, and other scientists are not mathematicians, and some of their analytical tools do not meet the rigorous standards of applied math, which presents opportunities that applied mathematicians happily delve into. When given enough time, these collaborations drive innovation and foster new techniques.

Piret works with a relatively new mathematical tool called radial basis functions method, or the stochastic RBF. The method can describe complex geometries with extremely high accuracy, but with the curse of a rock formation, the placement of an aquifer, the slipperiness of a muddy hill about to give way. Instead of relying on meshes and grids, the RBF method just requires a set of points that naturally follows the complexities of the domain.

Another way to look at changes over time is to sketch it out first. Benjamin Ong, assistant professor of computational mathematics, tackles mathematical problems in computing. Sketching data is a method that Ong and his students study by looking at the underlying structures in a dataset that could help speed up computation. For example, if you know the data is linear, then it’s easier to predict the slope and direction of the line rather than wasting time determining that it’s not a logarithmic regression or parabola. In another project, Ong works on a family of methods called parallel-in-time; the idea, relatively new in the US, is to generate a solution quickly to ensure that the simulation is on track. Using the parallel-in-time method, the model makes a prediction then simultaneously assesses it while making another. In parallel steps, the model predicts and assesses, constantly improving its outputs as it goes.

“It’s a problem agnostic,” Ong says. “Applied mathematics is about versatility.”

UNDERGROUND AND SEE-THROUGH, A FINALE

Versatility takes applied mathematics into unexpected spaces—like deep in a submarine labyrinth with a fleet of divers or through walls. How can you tell the difference? What are the reflection patterns?

Sun and his team were able to develop pattern recognition for ultrasound-and radar tech using an algorithm called a fast Fourier transform. As Sun puts it, all it comes down to wave equations and those equations are treated all the same in math, so finding differences in the equations means pulling in enough data to separate the signal from the noise. “Big Data does not simply mean lots of data,” he says. “It’s about extracting useful information.”

In the case of pulling a fast Fourier on through-wall detection, the solution came down to predictable periodic movement—a perfect cosine. Inching and exhilarating created enough air in the wave equations to reveal a person on the other side of the wall.

“Math does not belong to science, technology, and engineering. It is a different perspective, a precise way to understand, explain, and view the world.”

---JIUGINS SUN

In essence, this is what all research is about: Starting with a question and following a clear logic to seek an answer. This deceptively simple idea is one of the reasons math is so ubiquitous in the other STEM fields. And in practice the math and the applications only get more complex.

“You learn to abstract away the complexity to get to the core of a difficult problem,” says Sarah Kitchen, a research assistant with the Michigan Tech Research Institute (MTRI), who leads a project called Bayesian Adaptive Robot Control System (or BARCS, a good Husky name). BARCS placed second in the virtual track during the latest round of Defense Advanced Research Projects Agency’s (DARPA) Subterranean Challenge last October. The demanding environment, a partially collapsed mine with many obstacles being explored by a fleet of divers, looks like a video game. Successfully navigating it draws on Kitchen’s background in representation theory, and while she doesn’t use this form of pure math directly, it drives her thinking on challenging systems problems. Working with robotics engineers and software developers now, Kitchen takes tools from different math fields and fine-tunes applications, using a mathematical eye to cut through complex string of equations and algorithms to get to the heart of the system’s components and how they relate.

Kitchen’s MTRI colleagues, including Susan Janinowski, Mark Stoff, Ismael Xique, Joseph Lindgren, Jiguang Sun, and John Kitchen’s MTRI colleagues, including Susan Janinowski, Mark Stoff, Ismael Xique, Joseph Lindgren, Meryl Spence, Sean Kelly, and Erek Vega, also draw on their math backgrounds to solve difficult engineering and ecological problems. Janinowski loves the challenge of figuring out how to apply mathematical frameworks to real-world constraints.

“When people think of graphs, it’s visual,” Janinowski says. “But it’s really about the mathematics behind the scenes. Math is not static. Math is not just about the numbers, solving for the right answer; or how it plots on a graph. Math is more versatile and dynamic than any non-mathematician could imagine, which is why we all keep coming back to them with our STEM challenges. But rather than seeking them out for more numbers-crunching, we can take a moment with the final note hanging in the air to appreciate the artistry that is the mindset and practice of applied mathematics.

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developing models for the shift of stars, or the movement of oil in a rock formation, or composable flow in gas dynamics, he
wants to preserve the observable physical properties of variables
while upholding the truths of mathematics relationships.

There is no “close enough” in this perspective. When a
blast goes off in one end of a tube and we try to predict the
movement, the model is either right or wrong. Since it’s still
wrong, there are seemingly infinitely important opportunities to improve
and plenty of job security in applied mathematics.

THE BALLET IN PARALLEL

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Versatility takes applied mathematics into
unexpected spaces—like deep in a submarine
labyrinth with a fleet of drones or through walls.

“If someone is standing on the other side of a wall,
how do you know?” asks Jiguang Sun, professor of
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>>>Go backstage and see the research
behind the science: mtu.edu/mtri
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Mathematician Benjamin Ong
Mathematicians Cécile Piret and Jiguang Sun
Cloudy with a chance of snow. Though some may regard this sort of forecast negatively, weather like this makes the Keweenaw the perfect location to test solar photovoltaics (PV) in less-than-ideal conditions. The interdisciplinary work encompasses all levels of solar development: improving panel materials, demonstrating how solar works in a home setting, helping a town go solar, and tackling the red tape of renewable energy policies.

**SOLAR’S ELEMENTAL COMPONENTS**

Silicon, which makes up a lot of Earth’s sand, is the second-most abundant mineral in the Earth’s crust. It’s a cheap material to use as an absorber for solar cell fabrication; however, cells made with one absorber have a maximum efficiency of just 33 percent. Finding the next material to raise the efficiency is something of a holy grail quest. The obstacles? Compatibility, durability, cost.

Chito Kendrick, managing director of Michigan Tech’s Microfabrication Shared Facility and adjunct assistant professor in electrical and computer engineering, works with students to create test silicon solar cells.

“We help them become aware of the fabrication steps that are used to make both solar cells and electric devices that need microscale features,” Kendrick says. “These test solar cells can be used as a base structure for the incorporation of a second absorber. The question is then which absorber to use?”

Potential candidates: 2D transition metal dichalcogenides (TMDs), made from highly abundant sulfur and selenium.Stacking TMDs on top of silicon creates a solar cell that absorbs two different parts of the visible spectrum, which overcomes what’s known as the Shockley-Queisser limit—how efficiently a solar cell can convert sunlight to electricity.

“If you stack two different absorbers on top of one another, with the right band gaps—the amount of energy that needs to be overcome to produce electrons, the free carriers that produce power—you can increase the efficiency limit to 45 percent,” Kendrick says.

Still, 45 percent isn’t 100, but it’s an improvement, which will also encourage more widespread solar adoption.

>>>Explore the Microfabrication Shared Facility: mtu.news/microfab

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**SOLAR RISING**

At home, in the lab, and in the community: Michigan Tech researchers and students turn sunlight into energy.

The Village of L’Anse, Michigan, installed a community solar array.

**SAVING MONEY AND ENERGY**

Jay Melnum was skeptical. He knew solar power works where there’s abundant sunshine year-round, but the snowy, often cloudy Upper Peninsula is a far cry from the Sunshine State. He installed a solar panel behind the Keweenaw Research Center (KRC) to prove solar PV couldn’t pay off here.
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SOLAR RISING

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“Energy prices are so high that I tried to find some way to save money for the KRC,” says Meldrum, KRC director and also the executive director of campus sustainability and faculty advisor to the Alternative Energy Enterprise (AEE) team. “Surprisingly, solar worked.”

Fun fact: On average, there are 184 sunny days per year in Houghton; the US average is 205 days. But cloudy days don’t preclude solar. Meldrum discovered that even on cloudy days, the panel performance doubled to a whopping 2 percent. There’s less hassle and risk involved because residents can take advantage of a municipally maintained solar array rather than individually installing solar panels at their homes.

>>>Read more about L’Anse community solar: mtu.edu/news/solar/SOLAR FOR EVERYONE?

Research by Johnna Prave, Richard Wite Endowed Professor of Materials Science and Engineering and professor of electrical engineering, has been working on the economics of solar feasibility since 2011. Since then, the cost has plummeted—often, it’s the least expensive energy option. So why don’t we see solar panels on every roof in the neighborhood?

“The policies that impact its adoption are primarily those that limit the amount of solar on the grid for distributed generation,” Prave says. “For example, here in Michigan we were limited to only 1 percent distributed generation. Recently the Michigan cap doubled to a whopping 2 percent. There is no technical reason for this limit—in fact we can have over 15 percent of the grid he solar without any changes and over 25 percent with modest changes.” Additionally, federal subsidies to solar are significantly lower than subsidies to coal, oil, and gas. But solar costs are so low that subsidies are not necessary. In a study last year, Prave points out that only 70 ultrawealthy Americans could fund a complete US solar transition in our electric grid and make money while doing it.

“We need policies that simply allow solar to compete on a level playing field so people who want it can get it,” Prave says, also noting that many large corporations are transitioning to using solar power.

In November 2019, McDonald’s announced large-scale solar and wind power purchase agreements—enough to power 2,500 restaurants and aid in meeting its corporate goal to cut overall greenhouse gas emissions by 36 percent. “There are incredible environmental benefits to solar,” Prave says. “In the short term, replacing all road with solar would reduce premature deaths from air pollution by about 52,000 Americans per year. In the long run, a transition to PV will help slow climate change. At the same time, solar is good for the wealthy and those with modest incomes alike—if they are allowed to own it and interact with the grid, they will have more financial security.”

In a time of transitions and global discussions about how best to provision energy, Michigan Tech researchers are at the forefront of the conversation nationally and in communities, and are positioned to cast light on decisions made at national and global scales.

>>>Watch the video on solar research: mtu.edu/magazine/solar-rising

ENERGY TRANSITIONS

Kathy Hahen, associate vice president for research development and university professor of natural resource policy, is the principal investigator on a $3.7 million National Science Foundation Convergence Research grant titled “Foundations for a Convergent Discipline in Socio-Technological System Transitions through Research on Michigan Community and Anishinaabe Renewable Energy Sovereignty [MICARES]”. The five-year project, in partnership with the Sault Tribe of Chippewa Indians, Keweenaw Bay Indian Community, Michigan State University, and six non-Native American communities around the state, will examine renewable-energy transitions in the communities.

>>>Read more about MICARES: mtu.news/micares

Another campus trothed: the AEE team’s Sustainability Demonstration House, where six student tenants demonstrate energy-saving sustainable living practices.
“Energy prices are so high that I tried to find some way to save money for the KRC,” says Meldrum, KRC director and also the executive director of campus sustainability and faculty advisor to the Alternative Energy Enterprise (AEE) team. “Surprisingly, solar worked.”

Fun fact: On average, there are 184 sunny days per year in Houghton; the US average is 205 days. But cloudy days don’t preclude solar. Meldrum discovered that even on cloudy days, the panel produced about 30 percent of the output it produced on a sunny day. Since then, he has pieced together a 20-kilowatt (kW) system, saving the KRC about $5,000 it produced on a sunny day. Since then, the panel has produced about 30 percent of the output it produced on a sunny day. Since then, the panel has produced about 30 percent of the output it produced on a sunny day.

In addition to aquaponics, hydroponics, app-monitored energy flows, low-flow fixtures, high-efficiency appliances, and LED lightbulbs, students monitor the 0.64 kW solar array that powers the house at 100 percent in the summer and 50 percent in the winter. Future plans include upgrading battery storage to increase winter solar power supply to 75 percent.

“The students are modeling a living situation that’s moving closer to net zero,” Meldrum says. “Lifestyle changes need to be considered: use less. The easiest way to save on energy bills is to use less energy.”

>>>Learn more about the Sustainability Demo House:
mtu.edu/news/demohouse

POWER BY THE PEOPLE

Travel south to US-41 to the village of L’Anse and see how solar power has become a community way of life. In summer 2019, L’Anse installed a 300-panel, 110 kW solar array with room to grow. Village residents and businesses can buy one or more panels and earn credits back on their bills for the energy generated. The AEE team provided a conceptual design and feasibility study for a senior design project along with the municipal utility WPPI and the Western Upper Peninsula Planning and Development Region office. Richelle Winkler and Chelsea Schelly, social sciences associate professors, along with graduate and undergraduate students, worked with community members to gauge how open they were to the project and how the team could design a localized program that fits their needs.

“We learned that people were excited about the community aspect of it,” says Winkler, associate professor of demography and sociology. “They saw this as a chance for L’Anse to be a leader and as a way to demonstrate community pride. They recognized their community spirit and desire to come together to benefit the local community.”

L’Anse made panel purchases affordable across the financial spectrum through payment plans and programs to help low-income families participate. There’s less hassle and risk involved because residents can take advantage of a municipally maintained solar array rather than individually installing solar panels at their homes.

>>>Read more about L’Anse Community Solar:
mtu.edu/news/solar

SOLAR FOR EVERYONE?

Research by Joshua Pearce, Richard Witte Endowed Professor of Materials Science and Engineering and professor of electrical engineering, has been working on the economics of solar feasibility since 2011. Since then, the cost has plummeted—often, it’s the least expensive energy option. So why don’t we see solar panels on every roof in the neighborhood?

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Additionally, federal subsidies to solar are significantly lower than subsidies to coal, oil, and gas. But solar costs are so low that subsidies are not necessary. In a study last year, Pearce points out that only 79 ultrawealthy Americans could fund a complete US solar transition in their electric grid and make money while doing it.

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mtu.edu/magazine/solar-research

ENERGY TRANSITIONS

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>>>Read more about MICARES:
mtu.news/micares

2-ABSORBER (TANDEM) PV CELL

Most solar cells are made using just one semiconductor. But Erica Konopka, managing director of Michigan Tech’s Interdisciplinary Science and Technology Institute, is researching the possibilities of 2-absorber PV cells, which add an additional element to the solar cell to increase how efficiently the cell can convert sunlight to electricity.

BACK CONTACT

TOP CONTACT

GLASS

ABSORBER 2

ABSORBER 1

28 RESEARCH 2020
Awards

BHAKTA RATH RESEARCH AWARD
The Bhakta Rath Research Award recognizes a doctoral student and their Michigan Tech faculty advisor. The pair earns the award for research that dares to be cutting edge while remaining focused on the social contribution of the work. The award was established by Bhakta B. Rath and his wife, Sushama Rath, to promote and reward excellence in scientific and engineering research at Michigan Tech.

BRUCE LEE
associate professor of biomedical engineering

What we do: Engineer smart adhesives that stick and unstick based on a set of defined conditions.
Why we do it: To form temporary attachments that can be removed and reapplied without damage. No more ripping off that Band-Aid.
mtu.news/leenarkar

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NATIONAL SCIENCE FOUNDATION CAREER AWARD
The National Science Foundation’s faculty early career development (CAREER) award program supports big research ideas for new faculty.

KUILIN ZHANG
associate professor of civil and environmental engineering, affiliated associate professor of computer science

What I do: Improve automated driving decisions using real-time, predictive feedback.
Why I do it: Autonomous vehicle advances can’t stop at a single car. Cars must communicate and anticipate traffic like human drivers.
mtu.news/zhang

ZHANPING YOU
professor of transportation engineering

What I do: Research roads and how best to make them with what materials for climate, sustainability, and use.
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MICHIGAN TECH RESEARCH AWARD

The Michigan Tech Research Award recognizes outstanding scholarly achievement by a faculty member. It is based on the impact of the person’s research, particularly sustained research or a noteworthy breakthrough. The Michigan Tech Research Award is symbolic of the University’s high standard for research endeavors.

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Beyond the Lab

$100 ANSWER TO A $100,000 PROBLEM

More than two years ago, Blue Marble Security, born out of Tech’s Enterprise program, was given a daunting, albeit straightforward challenge—make something old new again. Ford Motor Company had a problem: An important piece of analytical equipment, an older-model JEOL 6300 scanning electron microscope (SEM), used with cathode ray tubes (CRT), essentially old-school TV tubes. CRTs are expensive, becoming hard to find, and environmentally hazardous to dispose. Because JEOL was running out of spare monitors for its 6300, Ford’s 6300 SEM would become useless without new displays. A problem that would cost the company more than $100,000 to remedy.

Blue Marble took up the challenge, finding a way to replace the CRT monitors with off-the-shelf LED displays, similar to what you would find in most office computers. Success didn’t come easy or easily.

The group’s first efforts involved examining the CRT’s video signals. This was ruled unsafe because of the high voltage involved. Using printed schematics and manuals from a similar SEM at Michigan Tech, Blue Marble found what they were looking for—a low voltage signal in an early video display protocol pioneered by IBM called monochrome display adapter.

“In the end, the video signal was available and adaptable to modern display protocols with a low-cost, commercial, off-the-shelf adaptor,” says Glen Archer, Blue Marble’s faculty advisor and interim chair of the Department of Electrical and Computer Engineering. After taking their final exams in April, members of Blue Marble drove to Ford lab in Dearborn, Michigan, and in about two hours had installed their new system on the JEOL 6300. The total system cost less than $100.

The team members on this project were Dayton Antiekum, Alex Newman, Zarek Polaska, Phillip Munter, John Hughes, and Jonathan Boik.

Blue Marble Security is a student Enterprise, a University entrepreneurship program now in its 20th year.

Student Research

UNDERGRADUATE STUDENT

Tessa Steenwinkel is Michigan Tech’s 15th recipient of the prestigious Barry M. Goldwater Scholarship. This national scholarship is awarded to college sophomores and juniors based on academic excellence, research experience, and an intent to pursue a STEM career. Besides this, she also became the Departmental Scholar in Biological Sciences and won the Provost’s Award for Scholarship, a Summer Undergraduate Research Fellowship (SURF), and a Songer Research Award—all in 2019.

Steenwinkel met her advisor Thomas Werner while on a tour of his lab during the University’s annual Preview Day. She immediately knew that she wanted to come to Michigan Tech and work in his lab. In her first two years on campus, she became lead researcher of her own independent project. She uses tiny fruit flies in her research because they share about 70 percent of disease-causing genes with humans. “My current research looks at how different qualities and quantities of food affect fertility, fecundity, and longevity,” she says.

Steenwinkel is already co-author on a book and two research articles, and more of her papers are expected to be published before she graduates. Her time at Michigan Tech is, perhaps, best summed up by Werner: “I’m very, very proud of Tessa, and a bit sad because I’m pretty sure I will never get a student like her again. She is the best student I have ever witnessed in my entire career.”

GRADUATE STUDENT

“There’s no place like home” could be Rose Turner’s motto. Turner graduated from Michigan Tech in December 2018, when she was the student commencement speaker.

After exploring options in the renewable energy industry and making the difficult decision to turn down a scholarship opportunity at the esteemed Iceland School of Energy at Reykjavik University, the environmental engineering alums returned to Michigan Tech. This time she’s back as the recipient of a National Science Foundation Graduate Research Fellowship (NSF-GRFP).

Turner is back in the lab with her undergraduate advisor Daisuke Minakata, associate professor of civil and environmental engineering. She even has her old address back—the Sustainability Demonstration House, where she serves as project manager.

She says other opportunities were intriguing but Tech had its advantages. “You can’t guarantee anywhere else the resources or would support my research interests like Tech does,” she says. There was another resource she couldn’t find elsewhere—Minakata. “At another school, I would have to work with a new advisor. It is really an advantage to continue my research with Dr. Minakata.”

Her research involves perfluorooalkyl and polyfluorooalkyl substances, commonly known as PFAS, more than 4,000 classes and categories of durable chemicals used in virtually every aspect of life that have found their way into the world’s water supply.

Turner says conventional water treatment doesn’t degrade PFAS. “The carbon-fluorine bond is very strong. It’s up to researchers to find a way to degrade these compounds.”
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When researchers have the next big idea, we want to make sure they have every opportunity to carry out their project. So, we created a pretty big idea: crossfunding research, using a University-operated platform. Since October 2012, we bring together donors and researchers, ideas and innovation.

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$347,060 raised

78,562 unique users to the site

122 funded projects

>> Check out more projects at superiorideas.org
I worked on a vaccine for Zika because I want to do research with real impact. The disease is carried by tropical mosquitoes, so refrigeration and cost matter to affected communities. That’s why we want to make affordable, thermostable vaccines.”

Brenna Rosso
undergraduate researcher
biological sciences

Studying how to develop candidate vaccines against infectious viral disease requires attention to detail. Knowing the smallest details of virus proteins and their location help biologists make a big difference in many people’s lives. Rosso, working in Ebenezer Tumban’s lab, uses bacteriophage virus-like particles as a platform to display proteins from human viruses and to elicit immune responses.
Shared Facilities

Advanced Power Systems Research Center (APSRC)
Jeremy Worm, jworm@mtu.edu

Applied Chemical and Morphological Analysis Laboratory
Owen Mills, opmills@mtu.edu

Geospatial Research Facility
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Microfabrication Facility
Paul Bergstrom, pabergtr@mtu.edu

Marine Research Assets Facility
Andrew Barnard, abarnar@mtu.edu

Microanalytical Facility
Andrew Burton, ajburton@mtu.edu

High Performance Computing Facility
Gowtham, g@mtu.edu

Research Centers and Institutes

Advanced Power Systems Research Center (APSRC)
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Center for Technology & Training (CTT)
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Ecosystem Science Center (ESC)
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Great Lakes Research Center (GLRC)
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Michigan Tech Research Institute (MTRI)
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Research and Innovation in STEM Education Institute (RISE)
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David Shannon, dshannon@mtu.edu

The Elizabeth and Richard Henes Center for Quantum Phenomena (CQP)
Jack Barzykewicz, jbarzykewicz@mtu.edu

Ravindra Pandey, rpandey@mtu.edu

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“Tomorrow needs biologists. Tomorrow needs Michigan Tech.”

mtu.edu/tomorrow-needs
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Tomorrow needs gamers. Tomorrow needs Michigan Tech.

mtu.edu/stories