EMBRY-RIDDLE AERONAUTICAL UNIVERSITY

RESEARCHER

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MEET THE EXPLORERS

From space science missions to rare celestial events, Embry-Riddle researchers are pushing the boundaries of aeronautics

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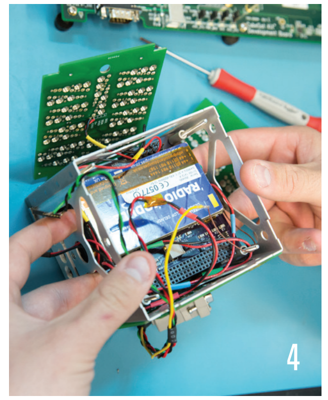

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David Massey

Clockwise from left: Denise Pomponio, David Massey and Daryl LaBello

FEATURES

IN EVERY ISSUE

Cover photo: Project PoSSUM

Dear Friends and Alumni,

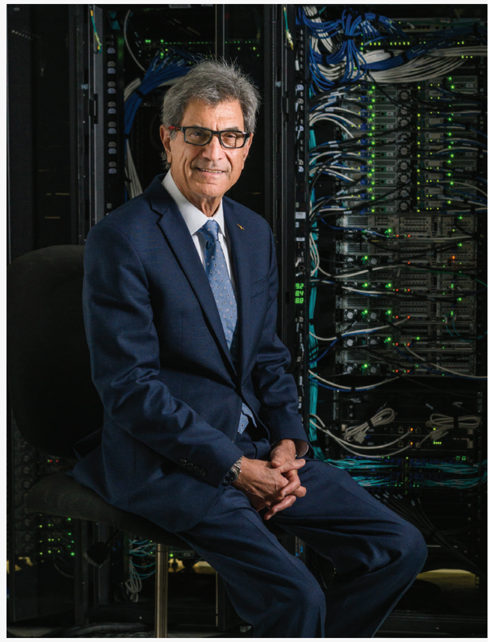
In a 1977 *Newsweek* profile of Carl Sagan, award-winning science journalist Sharon Begley, now a senior science writer for *STAT,* famously wrote that "somewhere, something incredible is waiting to be known."

Groundbreaking scientific research is also waiting to be communicated, which is why this edition of *ResearchER* explores Embry-Riddle Aeronautical University's effort to capture data from a rare celestial opportunity – the recent eclipse, or "occultation" of a star, by Triton, Neptune's largest moon (see Page 8). Also in this issue, you will learn about technology to protect astronauts working in inflatable space habitats (Page 12), a patented technology that keeps batteries at a constant temperature (Page 20) and an effort to help infants with severe hip dysplasia avoid surgery (Page 16).

Finally, I invite you to meet J. Gordon Leishman, one of our Distinguished Professors, who led an effort to design one of the most unique and capable university-level wind tunnels in the United States – the subsonic tunnel coming soon to Embry-Riddle's Research Park (Page 24).

Over the next few years, our goal is to emerge as a leader in research while maintaining our long-standing leadership in aeronautical and aviation education. We are excited about the new vision articulated by our sixth president – Dr. P. Barry Butler, former executive vice president and provost at the University of Iowa – and we are forging ahead to double our research enterprise within the next few years.

Our investments toward this goal have included superior facilities, such as the John Mica Engineering and Aerospace Innovation Complex, or MicaPlex; a new STEM Education Center and the Jim and Linda Lee Planetarium on our Prescott Campus in Arizona; and a Cray® CS™ cluster supercomputer.



Under Dr. Butler's direction, the university also continues to provide significant internal funding to jump-start promising research.

From simulations of rip currents (Page 28), to record-setting drone deliveries (Page 7) and plans for future high-speed mass transit (Page 5), Embry-Riddle researchers are busy expanding the boundaries of knowledge. I hope you find something remarkable on these pages to spark your curiosity. Your continuing support for our efforts remains critical to our success. I welcome your ideas for how we can achieve our most ambitious goals for both scientific advancement and communication.

Sincerely,

Dr. Maj Mirmirani

INTERIM SENIOR VICE PRESIDENT FOR ACADEMIC AFFAIRS AND RESEARCH AND DEAN OF THE COLLEGE OF ENGINEERING, DAYTONA BEACH CAMPUS

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The Eagle Flight Research Center at Embry-Riddle is serving as a testing ground for experimental unleaded fuels.

A Revolution in Aviation Fuel

EMBRY-RIDDLE RESEARCHERS ARE HELPING THE AVIATION INDUSTRY MAKE THE SWITCH TO UNLEADED

It's an ambitious goal — one that's been seriously talked about for the last 13 years and could affect more than 150,000 aircraft in the United States. The goal? To remove lead from aviation gasoline (avgas). Two flight engineers at the Embry-Riddle Aeronautical University's Eagle Flight Research Center (EFRC) in Daytona Beach, Florida, will help make that ambitious idea a reality, thanks to a $993,000 award from the Federal Aviation Administration (FAA).

In 2016, the FAA began its second and final phase of testing two 100-octane unleaded fuel formulations – one from Shell Oil Co. and one from Swift Fuels – as part of the Piston Aviation Fuel Initiative (PAFI) program. The initial two-year, phase one ground testing began with 17 different formulations from six fuel producers and was completed in 2015.

The change to unleaded fuel would be the most substantial change in avgas since the 1940s, when the mixtures being used today were developed for airline and military radial engines with high levels of supercharging.

There are more than 167,000 piston-engine general aviation aircraft in the United States (more than 230,000 worldwide) using avgas. It is the only remaining lead-containing transportation fuel in the country, and avgas emissions have become the largest contributor to lead emissions in the United States, according to the FAA and the Environmental Protection Agency.

FAA Administrator Michael Huerta has said, "We're on track to have unleaded aviation gasoline fully evaluated and ready to be authorized for use by the general aviation fleet in 2018."

NEW FUELS PUT TO THE TEST

Testing the experimental fuels at the EFRC is the responsibility of Borja Martos, an accomplished flight engineer and research pilot, and Scott Martin, a senior scientist and EFRC flight test pilot. Both researchers are excited to be working on this project to help create an aviation fuel with less environmental impact.

MORE THAN **230,000** PISTON-ENGINE GENERAL AVIATION AIRCRAFT AROUND THE WORLD USE LEADED GASOLINE.

The two engineers have been asked by the FAA to evaluate many aspects of how the new fuels interact with the aircraft fuel systems and engines, such as: How is the vapor pressure affected by altitude? Is the freezing point compatible with the current fuel? How do the new fuels' different chemical components affect seals or gaskets in the engine, hoses and pumps?

The work is confidential, but Martos can acknowledge that he and Martin are using multiple aircraft in evaluating different performance categories during flight: cold and hot fuel performance, anti-detonation performance, fuel systems compatibility, engine power and performance, and engine start ability.

Will the new formulations work for most of the general aviation aircraft with little or no additional hardware? Martos and Martin's research over the next year will be an important part of the answer. / JAMES RODDEY

EAGLESAT-1 LAUNCHES INTO ORBIT

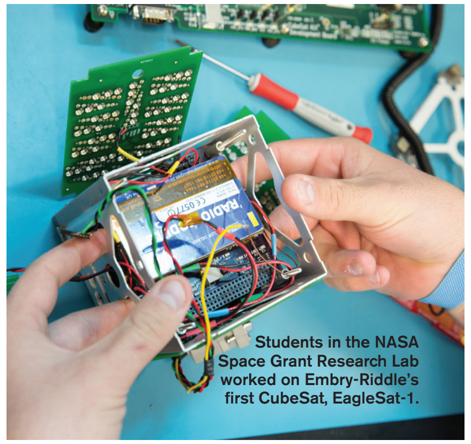
After two launch attempts were scrubbed earlier in the week, the third time was the charm: On Nov. 18, 2017, at 1:47 a.m. PST, a Delta II rocket lifted off from Vandenberg Air Force Base bearing NASA's Joint Polar Satellite System-1 and an Embry-Riddle Aeronautical University cube satellite (CubeSat) called EagleSat-1.

EagleSat-1 was launched with a dual mission.

MISSION #1: It was designed to analyze orbit decay, which is critical for tracking the fate of space debris in low Earth orbit. By tracking its movements, the Embry-Riddle research team can learn more about how small objects stay in orbit and how their orbits change over time.

MISSION #2: Secondly, EagleSat-1 was built to test whether supercapacitors might replace rechargeable batteries in supplying power for satellites. Supercapacitors are electrical storage devices that can deliver a faster charge and withstand more charge and discharge cycles than batteries, making them useful for decadeslong space missions.

EagleSat-1 is part of NASA's CubeSat Launch Initiative, deployed for educational and research purposes. About 35 students contributed to the project over a five-year period. At press time, researchers were attempting to communicate with EagleSat-1. If successful, Project Manager Deborah Jackson and her team on Embry-Riddle's Prescott Campus in Arizona will share their findings with NASA. / BECKY HAM



Students in the NASA Space Grant Research Lab worked on Embry-Riddle's first CubeSat, EagleSat-1.

Project PoSSUM Executive Director Jason Reimuller works with student Rachel Weeks as she takes suborbital cloud samples in the space-flight simulator.

Research Beyond the Wild Blue Yonder

CITIZEN SCIENTIST-ASTRONAUT CANDIDATES PREPARE FOR SPACE SCIENCE MISSIONS

In the near future, when suborbital spacecraft begin traveling to low Earth orbit, a group of citizen scientist-astronaut candidates who have trained at Embry-Riddle Aeronautical University — people from around the world who have dreamed of going into space — will be on board for some of the first flights.

The nascent space travelers will journey up to and through a layer of clouds — 50 miles above the Earth's surface — formed of ice crystals seeded by fine debris from disintegrating meteors. The travelers' mission: to gather high-resolution 3-D imagery of noctilucent clouds in the mesosphere.

This hard-to-study cloud layer, seen seasonally over both poles, is so high it glows at night from sunlight on the opposite side of the Earth. Imagery of these elusive "night-shining" atmospheric phenomena will be used to develop high-fidelity dynamical models that will help scientists better understand our changing global climate.

David Massey

Left: Project PoSSUM; Right: Ken Fagan/Arizona State University

Before graduating from Embry-Riddle, Gavin James helped test a prototype spacesuit in zero gravity, as part of his Project PoSSUM experience.

Four Embry-Riddle students are a step closer to making the suborbital journey to space thanks to Project PoSSUM (Polar Suborbital Science in the Upper Mesosphere) – a suborbital research, training and education program based in Boulder, Colorado, that evolved from a NASA-supported flight opportunity.

Students Heidi Hammerstein, Amy Ramos, Karen Brun and Casey Stedman are all graduates of the PoSSUM spaceflight training program. They were chosen to join a recent PoSSUM mission that observed noctilucent clouds using a small, unpressurized aircraft flying high over the remote wilderness of northern Canada. The team also tested custom-built camera systems.

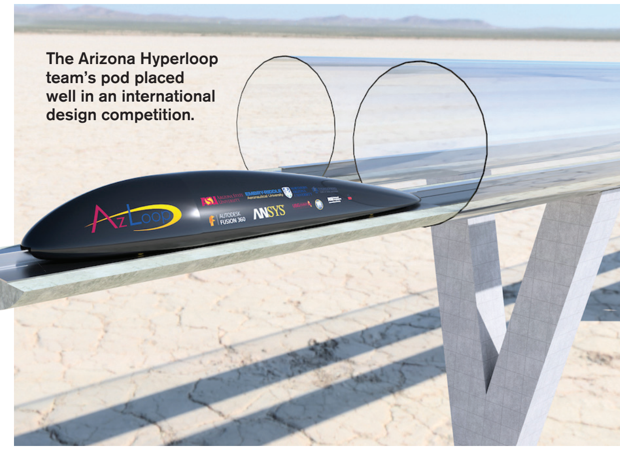
The only research program of its kind, Project PoSSUM has collaborated with Embry-Riddle since 2015 to offer a spaceflight training program designed by former NASA instructors and university spaceflight operations faculty. PoSSUM astronaut candidates complete three weeks of online instruction and then an intense week-long program at the Daytona Beach Campus in Florida. After graduation, they conduct upper-atmospheric research, test prototype spacesuits and instrumentation, and serve as educators supporting PoSSUM Academy programs designed for younger students.

Classroom instruction covers atmospheric science, remote sensing and spaceflight physiology. Students learn to work in high-altitude environments and how to use a next-generation spacesuit while operating PoSSUM instrumentation in the College of Aviation's suborbital spaceflight simulator. They also study physiological adaptation to spaceflight with world-champion aerobatic pilot Patty Wagstaff.

Back to the near future – a select group of citizen-scientists who have trained through Project PoSSUM will actually have a chance to travel beyond the wild blue yonder on a scientific mission to gather imagery of noctilucent cloud formations in a commercial, reusable manned suborbital spacecraft. And four Embry-Riddle students are hoping they are along for the ride. / JAMES RODDEY

LEARN MORE

To get more information about this program, visit **projectpossum.org**.



The Arizona Hyperloop team's pod placed well in an international design competition.

ARIZONA HYPERLOOP TEAM AT TOP SPEED

What's about 15 feet long, weighs 1,000 pounds and might someday zip you from Phoenix to Los Angeles faster than a plane? It's the "pod" designed by the Arizona Hyperloop team, and last summer it made an impressive showing in an international design competition hosted by rocket design company SpaceX.

Embry-Riddle Aeronautical University students Meaghan Moeller and Maciek Czyz recently described the challenges of designing this prototype transit vehicle during an event at the Jim and Linda Lee Planetarium on the Prescott Campus in Arizona. Czyz, Moeller and more than 100 other students designed, built and raced the pod.

The Hyperloop may someday carry people and cargo between regional cities in a near-frictionless tube track, propelled by compressed air and magnetic accelerators, at speeds nearing Mach 1. The Arizona pod design placed fifth among 23 teams (chosen from more than 1,300 entries) competing in a test-track competition. The AZLoop pod was the highest-ranked design among first-time competitors.

The team optimized the design of the air tanks, batteries and controls within their prototype in order to accelerate as fast as possible for the competition. When the Hyperloop actually debuts, Czyz says, passengers won't endure such a bone-jarring start. "There's going to be a lot of room to build up speed, move at high speed for a long time, and then slow down gradually." / BECKY HAM

Bringing Clean Water to Haiti

NEW ENGINEERING PLAN, REDESIGNED OVERNIGHT, KEEPS OUT CONTAMINANTS

With schematics and parts for a water-purification system in suitcases, a team from Embry-Riddle Aeronautical University's Daytona Beach Campus in Florida took off for an eighth year of helping a Haitian community gain access to clean water.

But when the team arrived in Drouin — which has no electricity, plumbing or sanitation — the drinking water was worse than expected. Instead of water flowing from an underground aquifer into a well, it was coming from the Artibonite River, which was contaminated with raw sewage containing the bacteria *Vibrio cholerae*, as well as *E. coli* and other water-borne pathogens.

The group of 11 students and two professors had to redesign the system overnight since their plans and previous installations had been designed for use with well water. Luckily, they were able to take parts from an older Embry-Riddle system, located about an hour away.

"There was a lot of scrambling around. It was really engineering in action," says mechanical engineering student Rachel Hunt.

The team was already planning to use a reverse-osmosis filter, which has a semipermeable membrane to remove ions, molecules and particles larger than 0.0001 micron. The Helix disc filters, which are able to remove sediment and some bacteria, came from a sponsor, Miller-Leaman of Daytona Beach.

> "THERE WAS A LOT OF SCRAMBLING AROUND. IT WAS REALLY ENGINEERING IN ACTION."

Because the water was so contaminated, however, the students also took another filter from the older system to remove even more particles before filtering the water through the reverse-osmosis membrane. Three months later, the team returned and installed yet another prefilter after the system clogged.

Joe Noto, an aerospace engineering master's student and president of Project Haiti 2017, says the team underestimated the river-water challenge. Despite the group's high-tech plans, time and gravity proved the best approach through the use of a sedimentation tank. By running the system once weekly, they found that sedimentation fell to the bottom of the tank, preventing it from going into the system.

The Project Haiti 2017 team redesigned a water filtration system overnight to help give one Haitian community access to clean water.

In addition to the purifier, the team installed a 3.5-kilowatt solar panel and backup battery system to power the well and purifier. The well pumps water from the river into a 500-gallon storage tank. The water then moves through the Helix filters and through a carbon filter to remove odor and bad tastes. The reverse-osmosis purifier pushes the clean water into another 500-gallon tank while the pathogens are routed back into the river. Special color gauges signify when the filters need cleaning.

The 2017 project team also included Marc Compere, associate professor of mechanical engineering; Geoffrey Kain, professor and director of Embry-Riddle's Honors Program; and students Calli Brown, Felina Chotoo, Noah Driggers, Audrey Hallam, Zahra Khan, Fevens Louis-Jean, Dynamite Obinna, Jon Prine and Daniel Tellez.

/ DEBORAH CIRCELLI

Marc Compere

WHAT'S THE MOST EFFICIENT AIRPORT IN THE WORLD?

In 2017, the Air Transport Research Society (ATRS) recognized Hartsfield-Jackson Atlanta International Airport as the world's most efficient airport.

That conclusion was based on an assessment of 206 airports and 24 airport groups spanning North America, Europe and the Asia-Pacific directed by Chunyan Yu, professor of air transport management with Embry-Riddle Aeronautical University's College of Business in Daytona Beach, Florida. Yu presented the results of the *2017 Global Airport Performance Benchmarking Task Force Report* during the ATRS World Conference in Antwerp, Belgium.

Chunyan Yu

The report compares productivity, efficiency, unit costs, cost competitiveness, financial results and airport charges at each airport. College of Business students compiled and analyzed the data, supervised by a 16-member task force, including Yu who has been a member since the task force began at The University of British Columbia in 2000. The project moved to Embry-Riddle in 2014, following a competitive bidding process.

"The report provides an unbiased, comprehensive assessment of airports," explains Yu, co-author of two books on airline efficiency. "The goal is to help airports improve their overall performance and operate as efficiently as possible."

In Antwerp, College of Business Dean Michael Williams presented the Efficiency Excellence Award to Balram Bheodari, deputy general manager of the Atlanta airport.

/ GINGER PINHOLSTER

Left: David Massey; Right: Latitude Engineering LLC

Setting Records

EMBRY-RIDDLE SUPPORTS THE LONGEST UAV URBAN PACKAGE DELIVERY IN THE UNITED STATES

Embry-Riddle Worldwide faculty, staff, students and graduates recently took part in a world record-breaking unmanned aerial package delivery destined to make future drone delivery a reality.

The new world record was completed on May 5, 2017 in Austin, Texas, by a Nevada unmanned aerial systems (UAS) consortium called Team Roadrunner, which flew the HQ-40 — a fixed-wing unmanned aerial vehicle (UAV). Using cellular connectivity, the 143-minute, 54-second flight traversed exactly 97.592 miles.

Launched from the central Texas location, the UAV flew a preplanned route through the National Airspace System (NAS) using mobile command and control combined with visual observers along the flight path, who relied on enhanced radios and cellphone communications.

> **97.592 MILES**
>
> Distance covered by Team Roadrunner's record-breaking unmanned aerial package delivery.

"Embry-Riddle has always been at the forefront of revolutionizing the aviation industry," says Kandi Windham, Embry-Riddle Worldwide's Houston-based campus director. "Participating in unmanned research and testing is an exciting, unique experience."

Team Roadrunner consisted of the FAA-designated Nevada UAS Test Site (Nevada Institute for Autonomous Systems), Volans-i UAS, Latitude UAS, AUV Flight Services and an Embry-Riddle Worldwide contingency.

The Embry-Riddle group, led by Associate Professor Scott Burgess, included Windham and Adjunct Assistant Professor Chris Walach, who also serves as director of the FAA-designated Nevada UAS Test Site, plus more than a dozen students and alumni.

"Projects such as this not only allow hands-on experience, but they also align with our university's commitment to being the leader in aviation innovation," Burgess says. / MELANIE HANNS

CHASING TRITON'S SHADOW

ASTRONOMERS RACE TO WITNESS NEPTUNE'S MOON AS IT HIDES A BACKGROUND STAR

BY GINGER PINHOLSTER

WEDNESDAY, OCT. 4, 2017
AFTERNOON IN CENTRAL FLORIDA

If the skies cleared, Bert Kallio, an Embry-Riddle Aeronautical University graduate student, knew he would have no more than two minutes to witness a rare celestial event.

It was a long shot, given the rain that had lashed Florida all day, but Kallio, with Embry-Riddle research assistant Cody Shaw and Tim Brothers of the Massachusetts Institute of Technology (MIT), drove a portable telescope west from Daytona Beach, Florida. By late afternoon, they had reached the Rosemary Hill Observatory near the University of Florida at Gainesville.

Like astronomers worldwide, they were racing to capture images of Triton, Neptune's largest moon, as it blocked the light from a background star, tossing a shadow like an enormous, dark curtain across much

Terry Oswalt

Opposite page: Pilot Dean Neeley, an Embry-Riddle Worldwide graduate, reviews the flight plan. This page: A highly modified 747 "Special Performance" aircraft, SOFIA can fly at a maximum altitude of 45,000 feet and above 99 percent of the Earth's atmospheric water vapor — a benefit since the water vapor blocks infrared light from astronomical objects, making them difficult to detect using ground-based telescopes.

of the Earth's Northern Hemisphere. Embry-Riddle researchers and their colleagues at MIT, Williams College and Lowell Observatory were at the forefront of a global effort to document Triton's eclipse, or "occultation," of a star called UCAC4 410-143659.

Kallio, Shaw and Brothers scrambled to set up their instruments before sunset. "We were ready in time and it was clear," Kallio recalls. But then came heartbreak: One last cloud rolled through. "We were hoping it would pass, but it didn't."

EMBRY-RIDDLE STAYS IN THE GAME

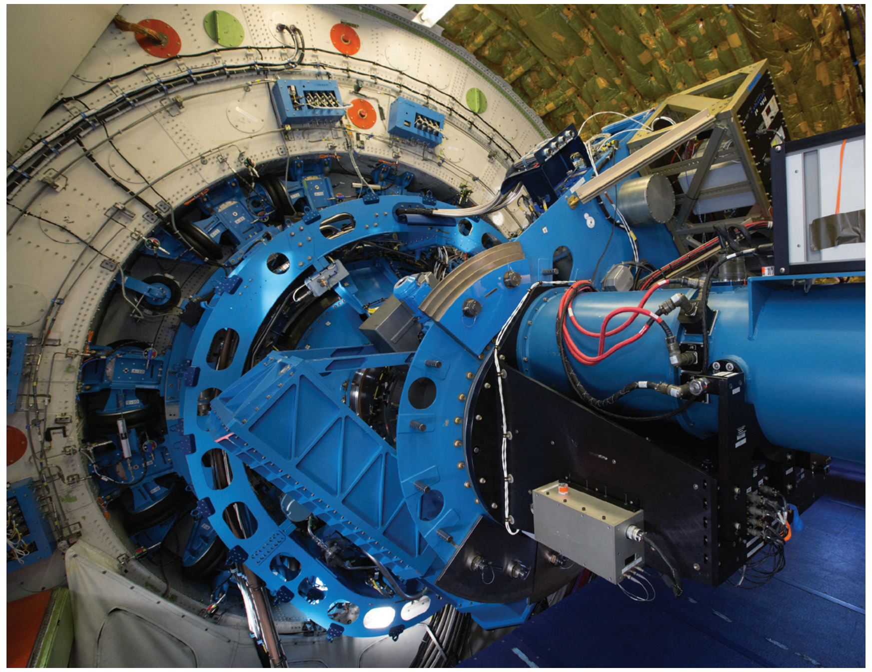
Fortunately, Embry-Riddle researchers were still in the occultation race, thanks to faculty member Terry Oswalt's founding role in a scientific consortium called SARA – the Southeastern Association for Research in Astronomy. Oswalt, chair of the physical sciences department and a professor of engineering physics, called on key research partners within the SARA network to point another ground-based telescope at Triton – in particular, one located in the Canary Islands, off the northwestern coast of Africa.

At the same time, following a historic stop at Embry-Riddle and the Daytona Beach International Airport, NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) – a modified 747SP equipped with a 2.5-meter, 17-ton infrared telescope – zoomed toward the centerline of Triton's shadow, as part of the aircraft's first scientific mission to be flown over the Atlantic Ocean.

Aboard SOFIA was Embry-Riddle collaborator Michael J. Person, a research scientist at MIT and director of the Wallace Astrophysical Observatory.

WEDNESDAY, OCT. 4, 2017
AFTER SUNSET, DAYTONA BEACH

Inside Embry-Riddle's observatory, graduate student Margaret Gallant was operating the university's research-grade, 1-meter telescope. To precisely align it with Triton, she took cues from Associate Professor of Physics and Astronomy Ted von Hippel, as well as from Jay Pasachoff, the Field Memorial Professor of Astronomy at Williams College, and his team (student Christian Lockwood and former student Allen Davis).



Left: Student Margaret Gallant and Ted von Hippel, associate professor of physics and astronomy, operate Embry-Riddle's research-grade telescope. Top: SOFIA is equipped with a 2.5-meter infrared telescope.

Top: David Massey; Bottom: Daryl LaBello

Von Hippel had opened the observatory's lower shutter, leaving the upper hatch closed to keep the telescope dry. Gallant aimed the instrument at the horizon.

"It was drizzling," she says. "They were telling me, 'Go north – more north.' So despite the rain, I pointed the telescope until enough GPS satellites were in sight to get timing and location data."

Pasachoff had equipped Embry-Riddle's telescope with an ultra-high-speed camera called a Portable Occultation, Eclipse and Transit System (POETS), which captures an image every three seconds. Linked with GPS data, it could provide details about Triton's tenuous nitrogen atmosphere as well as clues to its mysteriously wrinkled surface. A moon larger than Pluto, Triton appears to be covered in a mix of nitrogen, water and carbon dioxide ices, sculpted by wind and cryogeysers spewing liquid nitrogen.

"During an occultation," Oswalt explains, "the way the background star dims is a sensitive probe of the density and composition of the foreground object's atmosphere. It can also give us very sensitive measurements of Triton's size and shape." Researchers also wanted to know how Triton's climate had changed since its last documented occultation in 2001.

But the clouds wouldn't budge. "There was a moment when we realized it was over," Gallant says.

TRITON OCCULTATION DATA SHOULD PROVIDE DETAILS ABOUT TRITON'S TENUOUS NITROGEN ATMOSPHERE AS WELL AS CLUES TO ITS MYSTERIOUSLY WRINKLED SURFACE.

"That was disappointing, but it was a great experience overall. I operated a meter-class telescope, and I worked with an amazing team of researchers from other schools."

THURSDAY, OCT. 5, 2017
AFTER DARK, LA PALMA, CANARY ISLANDS

West of Morocco, atop a volcanic mountain on the island of La Palma, the sky was vivid with stars: a perfect, clear night, says researcher Javier Licandro of the Instituto de Astrofísica de Canarias, a member of the SARA network.

But a missing adapter meant collaborator Stephen Levine, an astronomer and Discovery Channel telescope scientist with the Lowell Observatory, couldn't get his high-speed camera properly attached to the La Palma telescope. He engineered a last-minute solution and hoped for the best.

After that, all Licandro and Levine could do was sit and watch. As Triton appeared to merge with the background star, it became increasingly faint, and after about two minutes, it brightened again. "Yes, yes, yes!" Licandro recalls saying.

SUCCESS ABOARD SOFIA

Levine and Licandro didn't see the "central flash" – a burst of light at the shadow's centerline when the foreground object's atmosphere bends and magnifies the background starlight in an observer's direction.

From left to right, pilots Dean Neeley and Emmanuel E. "Manny" Antimisiaris joined flight engineer Matt Pitsch in SOFIA's cockpit for a test flight prior to the Triton occultation event.

But high above the Earth's water vapor, SOFIA recorded a strong central flash in four wavelengths, says MIT's Person. He was roaming among three instrument teams: a Lowell Observatory group operating dual high-speed cameras called the High-Speed Imaging Photometer for Occultations (HIPO); researchers with the German Aerospace Center, which had a focal plane imaging (FPI+) camera; and the First Light Infrared TEst CAMera (FLITECAM) team from the University of California, Los Angeles.

"When the background star's light started to fade," Person says, "there was a big cheer, and then when the light came up again, there was excitement and chatter, followed by more cheering when we had the central flash."

What happens next? "It was three minutes of data-gathering," Levine says. "Now we're looking at three to six months of analysis." ER

CONFIRMING "EINSTEIN RINGS"

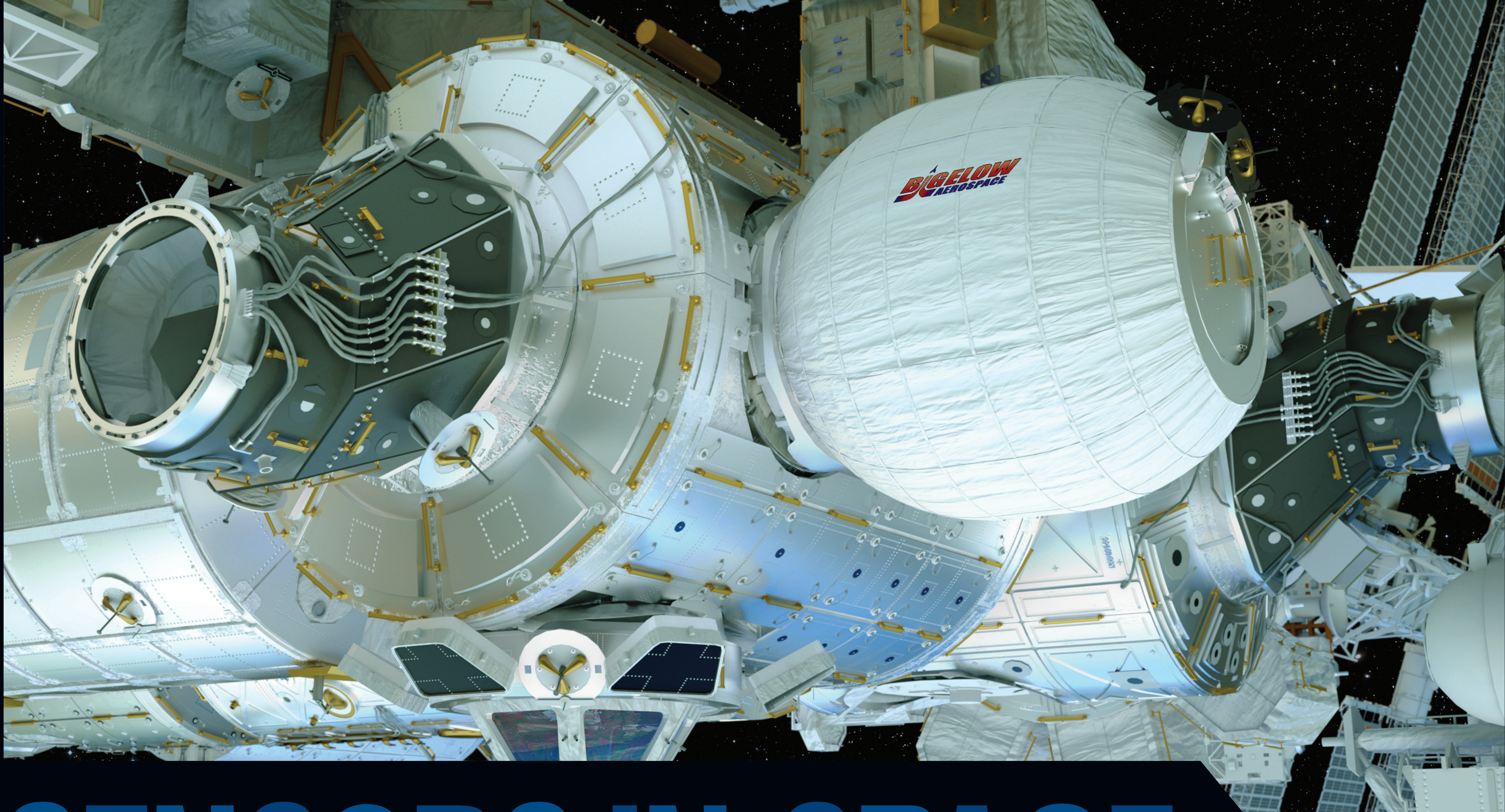
Top: Terry Oswalt; Bottom: David Massey

In other astronomy news that generated global headlines, Embry-Riddle's Terry Oswalt provided an invited review to the journal *Science* on research that confirmed a phenomenon called "gravitational microlensing."

Whenever light from a distant star passes a foreground object, Albert Einstein predicted, gravity should bend and brighten the starlight, similar to the way a lens focuses light. In his June 9, 2017, *Science* article, Oswalt wrote that Kailash C. Sahu's research "provides a new tool for determining the masses of objects" that are otherwise difficult to measure.

Gravitational microlensing by a star forms a perfectly circular ring of light – a so-called "Einstein ring."

Sahu's group observed a more common scenario: two objects that were slightly out of alignment, forming an asymmetrical version of an Einstein ring. "The ring and its brightening were too small to be measured, but its asymmetry caused the distant star to appear off-center from its true position," Oswalt explains. "Sahu's team was the first to observe this 'astrometric lensing' in a star other than the sun."



SENSORS IN SPACE:

KEEPING ASTRONAUTS SAFE IN INFLATABLE HABITATS

BY JAMES RODDEY

RESEARCHERS ARE DEVELOPING TECHNOLOGIES TO HELP ASTRONAUTS SAFELY COEXIST WITH SOME DANGEROUS NEIGHBORS – MICROMETEOROIDS AND ORBITAL DEBRIS

AT FIRST,

inflatable habitats in orbit around Earth may sound like a dangerous idea, given that the vacuum of space is littered with, as NASA says, "millions of pieces of human-made debris or space junk consisting mainly of fragmented rocket bodies and spacecraft parts created by 50 years of exploration."

Most space debris is tiny – almost microscopic – but there are also millions of naturally occurring objects in orbit called micrometeoroids. NASA must often move the International Space Station (ISS) away from larger pieces of space debris – the half-million objects in Earth's orbit that are larger than a marble.

Imagine the consequences of a micrometeoroid or a piece of space junk half that size, moving at 22,000 miles per hour as it strikes an inflatable space habitat.

THE RISKS OF MMOD

Micrometeoroids and orbital debris (MMOD) may seem innocuous because of their small size, but at speeds averaging 10 kilometers per second, they can become killers. In fact, they are the top hazard facing spacecraft, satellites and astronauts, NASA says.

As NASA describes it: "A 1-centimeter paint fleck is capable of inflicting the same damage as a 550-pound object traveling 60 miles per hour on Earth. A 10-centimeter projectile would be comparable to 7 kilograms of TNT."

Despite such hazards, NASA has been designing inflatable space habitats since the 1960s.

Today, there are at least three inflatable structures orbiting Earth. One was launched in 2006. Another has been docked to the ISS since April 2016. It's hoped that soft-sided, expandable, interconnected modules may provide a cost-efficient, safe way to keep people in orbit around the Earth, in a colony on the moon or in an inter-solar spacecraft as it carries explorers to Mars.

Previous spread: Docked at the International Space Station, an expandable habitat developed by Bigelow Aerospace uses layers of tough, flexible materials that offer protection from micrometeoroids and orbital debris, as well as from radiation.

MONITORING HEALTH, DETECTING IMPACTS

A team of Embry-Riddle Aeronautical University faculty and graduate student researchers, led by Aerospace Engineering Professors Daewon Kim and Sirish Namilae, are helping NASA answer questions about the feasibility of humans living in these balloon-like structures beyond the Earth's grasp.

Kim's research has focused on developing and refining smart material sensors that are used to detect stress or damage in critical structures, such as automobile motors or the wings of aircraft. Namilae, working in the fields of solid mechanics and materials science, has worked for years with an exceptional material called carbon nanotubes.

These microscopic hollow tube-like structures of graphene (think: pencil lead) have countless uses – everything from lightweight body armor to growing biological tissue to making the next generation of TV screens.

Now, Kim and Namilae are creating a new generation of sensors using a type of carbon nanotubes called buckypaper that is sensitive enough to detect the impact of even the smallest MMOD.

Carbon nanotubes, which are the main component of buckypaper, are 50,000 times thinner than a human hair and 500 times stronger than steel. With buckypaper, layers of nanotubes are loosely bonded to form a paper-like thin sheet. Buckypaper owes its name to Buckminsterfullerene, a molecule composed of 60 carbon atoms shaped like the geodesic domes championed by architect and futurist Buckminster Fuller.

What if, Kim and Namilae wondered, thousands of these tiny sensors could be used to coat a large flexible membrane on, say, an inflatable habitat in space? They might more accurately monitor strain to the structure and pinpoint impacts from nearly invisible micrometeoroids.

The Embry-Riddle team is now building highly sensitive strain sensors which offer unique electromechanical, or "piezoresistive," properties when subjected to mechanical deformations.

"It was Sirish's idea to use buckypaper," Kim says. "And when we experimented with adding micrometer-sized graphite platelets to our original carbon nanotube/epoxy mix, it boosted the sensitivity of the sensors."

Kim and Namilae – with colleagues at LUNA Innovations, a leading fiber optics sensing company – were awarded a $125,000 Phase I grant in 2016 to begin work on two different sensor prototypes to enable structural "health monitoring" as well as impact detection for inflatable space habitats.

Previous page: © Bigelow Aerospace

Daryl LaBello

From left to right: Sirish Namilae, Sandeep Chava, Audrey Gbaguidi, Daewon Kim and Muhammad Anees work on nanocomposite sensors used to detect micrometeor strikes in inflatable space habitats.

KEEPING SPACE HABITATS INFLATED

The expandable structure currently docked at the ISS, built by Bigelow Aerospace, is made of several sheets of flexible Kevlar-like materials with closed-cell vinyl polymer foam between the layers. In a configuration like this, the structural shell is expected to provide excellent MMOD impact and radiation protection, superior to existing metal structures in space.

LUNA began modifying its patented high-definition fiber optic strain sensors to be embedded into one of the multiple interior walls of a space module.

The Embry-Riddle researchers began work on their carbon nanotube sensors to cover multiple outer layers. NASA requested sensors that could detect and pinpoint the impact of MMOD up to 3 millimeters in diameter traveling up to 6 miles per second. Graduate students Jiukun Li and Sandeep Chava helped design, build and test the impact sensors. Two other grad students, Muhammad Anees and Audrey Gbaguidi, worked on space applications of the sensors.

In static tests, the team successfully demonstrated dynamic impact detection with the sensors. LUNA and the Embry-Riddle research team have now begun Phase II testing, having received an additional $750,000. Their goal this time is to increase the capabilities of the sensing technologies.

"Our biggest current challenge is embedding these smart sensors into a flexible and compliant material that can expand as the modules are inflated in space," Kim says.

Namilae is also developing a computational modeling algorithm to gather data from the sensors when an MMOD impact occurs, including its severity and the exact location on the sensing layer.

Soon, a crucial test will take place at the University of Dayton Research Institute's Hypervelocity Impact Facility: 3 mm projectiles will be fired at hypersonic speeds (3 to 5 miles per second) at the sensor array, which will be embedded in multiple impact-resistant layers separated by vinyl polymer foam – materials similar to what's being used for the ISS module.

"We also have to show that our sensor materials are space-worthy and figure out how much power the sensor array will use," Namilae says.

The ultimate goal is a possible Phase III grant to commercialize the sensor technology with NASA and NASA affiliates, but the research also offers more down-to-Earth benefits.

"We hope that our work will lead to applications of our sensors in space, but the thing I value most in this process is our students having an opportunity to learn and grow as scientists and create new knowledge," Namilae says. ER

Eduardo Divo and student Kristin Sverrisdottir

MAKING STRIDES IN HIP DYSPLASIA RESEARCH

EMBRY-RIDDLE RESEARCHERS ENGINEER NEW WAYS TO FIGHT A CRIPPLING CONDITION

BY MELANIE STAWICKI AZAM

Victor Huayamave

David Massey

WHEN Tori Parr was born, the nurse heard the newborn's left hip click. A sonogram done when the infant was just 1 day old revealed she had hip dysplasia.

"Tori is our firstborn, female and was breech, which are all high risk factors for hip dysplasia," says her mother, Lauren Parr, an Orlando, Florida, attorney.

Tori went home from the hospital in a Pavlik harness, which she wore nonstop for a month to correct the condition. Now she is nearly a year old and taking her first steps.

"We just had her one-year appointment, and her hips are still in place," Lauren says. "We were very lucky. She didn't have to have surgery."

Not all babies born with hip dysplasia are so fortunate. Many infants, especially those with more severe cases or cases diagnosed late, do not see their condition corrected with the Pavlik harness, which is a much less invasive and costly alternative to surgery.

That is why Eduardo Divo and Victor Huayamave, who are researchers in Embry-Riddle Aeronautical University's growing biomedical systems field, are investigating new ways to improve hip dysplasia treatment in infants. The research received funding from the International Hip Dysplasia Institute (IHDI) and the Paul B. Hunter and Constance D. Hunter Charitable Foundation.

"Severe developmental dysplasia of the hip is a condition for which we want to find a solution that is effective, inexpensive and does not involve surgery," says Divo, Ph.D. program chair and interim department chair for mechanical engineering.

Working in collaboration with IHDI and University of Central Florida (UCF) faculty, Divo and Huayamave are using 3-D computer modeling to simulate hip dysplasia reduction dynamics with the Pavlik harness and also to look for different engineering solutions. The biomechanical research studies seek a better understanding of how various hip dysplasia treatments and positions affect the hips and also focus on improvements in nonsurgical treatments.

"The research being conducted at Embry-Riddle has a strong possibility of improving the mechanical function of modern braces," says Charles Price, M.D., a pediatric orthopedic surgeon and IHDI director. "It has real potential to extend nonsurgical treatment to older children, in addition to improving success rates for newborn infants."

"WE WANT TO FIND A SOLUTION THAT IS EFFECTIVE AND INEXPENSIVE AND DOES NOT INVOLVE SURGERY."

EDUARDO DIVO, EMBRY-RIDDLE PH.D. PROGRAM CHAIR AND INTERIM DEPARTMENT CHAIR FOR MECHANICAL ENGINEERING

Lauren Parr and her daughter, Tori.

Denise Pomponio

COLLABORATING TO MEET A GLOBAL NEED

Hip dysplasia is a condition where the hip socket is shallow or the wrong shape, resulting in the joint wearing out faster. Approximately two to three children per 1,000 need treatment for hip dysplasia, according to the IHDI.

Common in infants, hip dysplasia can range from mild instability that resolves spontaneously to complete dislocation that may require surgery. The Pavlik harness is very effective for babies younger than 6 months of age, when the hips are most malleable, Price says.

But many babies go undiagnosed. At 8 months, infants often need surgery, Price says, and after 18 months, every child needs surgery because bone deformity develops.

"The real sweet spot is to find a harness we can apply for children between 6 to 18 months of age," Price says. "If we can improve nonsurgical treatment for those up to 18 months, then we'd make a huge difference and help the developing world. In the developing world, most children are not diagnosed until they are walking and have a limp."

Divo and Huayamave are working with UCF Engineering Professors Alain Kassab and Faissal Moslehy on computer modeling aimed at improving the Pavlik harness to help more children with severe hip dysplasia. Exchanging files for a common database, the two teams are investigating multiple aspects of the condition.

"This project required a new way of looking at a medical problem," Price says. "The engineers at Embry-Riddle are very innovative in this type of cross-disciplinary collaboration."

SEARCHING FOR SUCCESS FOR THE MOST SEVERE CASES

Additionally, Divo and Huayamave are the first to conduct a biomechanical analysis of bracing techniques, Price says. They are studying how babies are carried and the devices worn to carry them. They are then examining how the different mechanics impact baby hip development and hip dysplasia.

In research published by the *Journal of Biomechanics*, Divo, Huayamave and their colleagues computationally validated the usefulness of a nonsurgical approach for reducing dysplasia. The technique – hyperflexion combined with external leg rotation – involves simply manipulating a baby's leg and hip in a particular manner.

"The Pavlik harness is mainly built to treat and correct mild dislocations, but for severe cases, it just doesn't work mechanically," says Huayamave, assistant professor of mechanical engineering. "We're trying to use a combination of the harness, plus other methods, to help doctors successfully treat children with severe cases of hip dysplasia. One approach is hyperflexion of the hip."

Researchers from Embry-Riddle and the University of Central Florida are working together to find engineering solutions for hip dysplasia.

David Massey

For the research, a 3-D model of a 10-week-old girl was created, based on CT scans and MRIs, and researchers looked at five key adductor muscles, which pull body parts inward toward the midline. Their model indicated it is possible to achieve reduction of severe hip dysplasia by hyperflexion and resultant external rotation. This is significant, since the Pavlik harness effectively reduces lower-grade hip dysplasia about 92 percent of the time, but has just a 2 percent reduction rate in patients with severe hip dysplasia.

FURTHER RESEARCH OPPORTUNITIES

Embry-Riddle researchers are also looking at different aspects of femoral anteversion (an inward twisting of the thigh bone) as related to the reduction of dysplasia, Huayamave says.

Embry-Riddle students are involved in the research as well, including graduate students Anthony Khoury and Jansyn Johnston.

"The human body doesn't respond to the same engineering principles that materials do," Khoury says. "It's very complex and really keeps you on your toes."

Johnston, president of the university's Biomedical Engineering Society, says she likes that biomedical engineering has a direct impact on society.

"And there is a lot of variety," she says. "It's a large and broad field."

Divo and Huayamave want to involve more students in their research. In May, they applied for the National Science Foundation's (NSF) Research Experiences for Undergraduates program, which would provide about $300,000 for paid summer undergraduate research positions for 12 students. The research had previously received $340,000 in NSF funding, part of which Divo brought with him to Embry-Riddle in 2013.

Eventually, Embry-Riddle's research could not only help infants, but adults, too. Nine out of 10 cases of hip dysplasia are diagnosed during adolescence or adulthood, Price says. This silent form of hip dysplasia is the most common cause of hip arthritis in women younger than 50, and the reason for up to 10 percent of all total hip replacements in the U.S.

"Embry-Riddle's modeling is very adaptable to the adult deficient hip," Price says. "Hip dysplasia is definitely a crippling disorder, and I can't think of a single disorder that is so amenable to a mechanical cure. As a true mechanical disorder, this is it." ER

LIGHTWEIGHT TECHNOLOGY KEEPS BATTERIES COOL, SUPPORTING ECO-VEHICLES

SHAPE SHIFTERS

BY ALAN CESAR

High-density polyethylene pellets could help make phase-change material 3-D printable.

David Massey

WHEN RUN AT THEIR LIMITS, BATTERIES GET HOT. It's a reality that all hybrid and electric cars must overcome. Typically, they do so with complex cooling systems. The work of faculty and student researchers at Embry-Riddle Aeronautical University aims to eliminate the need for these complicated systems, making electric cars lighter and cheaper to manufacture.

Sandra Boetcher, associate professor of mechanical engineering, and her mechanical engineering students are conducting research into phase-change materials – compounds that can absorb large amounts of energy while maintaining a constant temperature. With implementation input from Associate Professor Patrick Currier's EcoCAR team, Boetcher's group – working in the newly built Thermal Laboratory at the John Mica Engineering and Aerospace Innovation Complex (MicaPlex) – hopes to create something that's light, cost-effective and easy to manufacture for many applications.

THIS COLD PLATE IS LIGHTER AND SIMPLER THAN A WATER-COOLED SYSTEM: "UNLESS IT LEAKS, IT CAN'T FAIL."

BATTERY CHALLENGES

All batteries produce some heat when they're in use, Currier says. The heat produced increases exponentially with the amount of power drawn from them, and the batteries can become not only inefficient, but also dangerously hot without proper cooling.

"When you buy a lithium-ion battery, the manufacturer directs all the heat to one side and you have to put your own cooling device on it," Boetcher says. "Typically people use an aluminum cold plate with liquid cooling – usually water mixed with ethylene glycol – basically antifreeze."

An active water-cooling system like most carmakers use requires a fluid pump, heat exchangers, cooling fans, hoses and more, Currier says. Its complexity means many failure points. Boetcher wanted to innovate something lighter and simpler for the EcoCAR program, which led to a patent that bears her name along with other Embry-Riddle faculty.

THE SELF-CONTAINED HEAT SINK

Instead of using a system of heat exchangers and pumps to extract energy, Boetcher suggested a phase-change material (PCM) to absorb all the heat.

The PCM she's using is an oil that is a waxy solid at room temperature, but has a low melting point in a precise range and a high specific heat capacity – the amount of energy required for a material to change from a solid to a liquid.

When any compound reaches its melting point, it remains at that temperature until all the material has turned to a liquid. When using a PCM, it's the changeover from solid to liquid that has the power to control temperature. "As long as you haven't gotten past the melting point, you haven't really degraded the material's capacity. It's the latent heat of fusion that's magic," Currier says.

PCM isn't new, but it's proved challenging to use to cool batteries because it turns liquid under use. For EcoCAR 3, the team purchased large battery modules and began looking for a method to extract the heat from them.

They melted a batch of PCM pellets and poured it into a tray cut from a solid block of aluminum. By combining different grades of off-the-shelf PCM, they made a custom batch that melts at the perfect temperature for the car's needs – in this case, 45 degrees Celsius (113 degrees Fahrenheit). It's topped with a rubber seal and another aluminum plate, completely containing the PCM inside.

This cold plate is lighter and simpler than a water-cooled system. "It doesn't take any energy to run," Currier says. "We're not wasting power cooling things. This is a totally passive system, so unless it leaks, it can't fail."

The cold plate is sized to absorb the heat released by the batteries in nearly all scenarios. That heat radiates into the air, and a small, traditional water-cooling system acts as a fail-safe. The design was successfully tested in the EcoCAR 3 competition in desert temperatures in Yuma, Arizona. Boetcher and her collaborators have received a U.S. patent for their PCM cold plate.

The phase-change material team includes, from left to right, David Spitzer, Sandra Boetcher, Tami Green, Thomas Freeman and Patrick Currier. Their research takes place in the new Thermal Laboratory in Embry-Riddle's MicaPlex facility.

David Massey

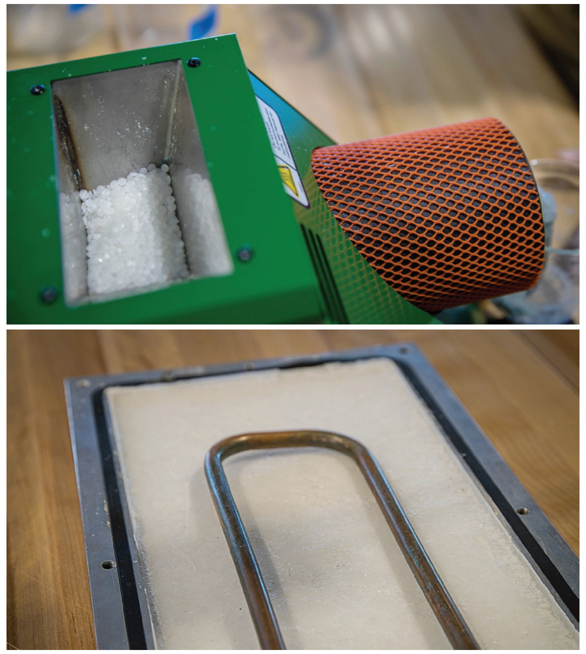
GOOD ENOUGH IS NEVER ENOUGH

Boetcher and her students – Thomas Freeman, a master's student in mechanical engineering, along with Tami Green and Sam Yaney, undergrads studying mechanical engineering – are looking to take PCM research a step further and make it 3-D printable. This is where the space and equipment in the Thermal Laboratory comes fully into play.

"What we're trying to do with the new research is actually mix the PCM with HDPE [high-density polyethylene], which is the stuff they make milk jugs out of. It's a plastic," Currier says. "That way, when you heat it, it doesn't turn into a liquid and go everywhere. It holds its shape."

They dye the PCM blue so they can tell if the mixture is homogenous, but combining the materials has proved more difficult than melting them together, Green says. "We can't just separately heat these two elements and hand-mix them. They have very different melting points, so we were trying to depress the viscous HDPE with a very, very liquid PCM. It just goes into suspension."

By putting the plastic and the PCM into a filament extruder, the team has been able to create a string that's a combination of the two materials. They're using a differential scanning calorimeter to measure the new material's melting point and specific heat capacity. Once they find the right combination of the two materials, that string will be fed into a 3-D printer.



Top: A Filabot is used to heat high-density polyethylene pellets. Below: This cold plate filled with phase-change material is part of a battery cooling system patented by Embry-Riddle researchers.

"Because we can make it into a filament like that," Currier says. "We want to 3-D print it. The idea, in essence, is to 3-D print a heat sink out of the plastic." When it gets hot, he explains, it would absorb the heat, yet it "won't melt and run all over the place."

CHILLING THE WORLD

Though EcoCAR has implemented PCM solely for battery cooling, Boetcher is pursuing many other uses for it. A weather station built by students involved with another project, the Solar Decathlon, will be placed on the roof of the MicaPlex to test the benefits of using the material in solar panels. "We built a prototype box to put PCM in and attached it to the back of solar panels," Yaney says.

"These are all different projects, but whether it's the Solar Decathlon or it's EcoCAR, from my side of it, it's the same thing: the fundamental application of phase-change materials," Boetcher says. "In solar panels, for example, not only can you use the PCM to keep them at optimum temperature, but you can use a heat exchanger to extract that waste heat for things like domestic hot water use."

The power of PCM even drew Freeman toward an entirely different emphasis. He was taking one of Boetcher's heat transfer classes, and she encouraged him to come to the lab to work with this material. "I took a wide turn from studying vehicle aerodynamics to doing this. PCM has huge heat storage capacity. That was new to me at the time, how it can be used for anything," Freeman says. "Anything that needs temperature regulation, this could be used for." ER

Daryl LaBello

GALE FORCE SUCCESS

J. Gordon Leishman helps bring a world-class subsonic wind tunnel to Embry-Riddle

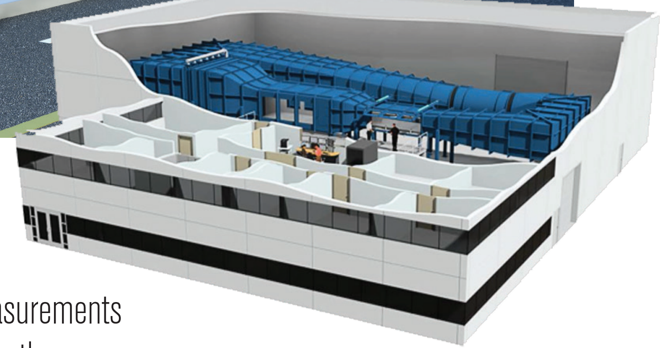
BY KELLY PRATT

Thirty-five years ago, J. Gordon Leishman had to clean, paint and upgrade the instrumentation on an old wind tunnel at the University of Glasgow in Scotland before he could commence his doctoral research. Today, as an internationally recognized specialist in experimental aerodynamics, Leishman has led the effort to design one of the most unique and capable university-level wind tunnels in the United States.

Set to open by the summer of 2018, a newly constructed 16,000-square-foot building will house a large, advanced subsonic wind tunnel at Embry-Riddle Aeronautical University's Research Park in Daytona Beach, Florida. The system, designed and manufactured by ASE/AeroSystems and FluiDyne, will be capable of delivering flow speeds of up to 230 mph, with a test section measuring 6 feet wide, 4 feet high and 12 feet long.

Considered more capable and more flexible than most established wind tunnels, it will offer almost unimpeded visual access to the test section through a series of large optical-grade glass windows to leverage a technique known as particle image velocimetry, or PIV. The PIV method makes it possible to measure the intricate details of the air flow velocities by using tiny smoke particles, powerful high-speed lasers and sophisticated cameras. Leishman says it will also feature the biggest and most accurate custom-built force and moment balance that AeroLab has manufactured in its 60-year history, which will be mounted below the tunnel test section on a seismically isolated 18,000-pound concrete slab.

Thanks to J. Gordon Leishman's specifications, Embry-Riddle's new wind tunnel will be a world-class facility capable of delivering flow speeds of up to 230 mph.



PGAL

CREATING A LASTING LEGACY

Dictating the specifications for the new wind tunnel and how the building and its infrastructure will wrap around the facility has been the culminating experience of Leishman's career, especially because most tunnels historically tend to require retrofitting into an existing building, which may involve many compromises.

"Who gets an opportunity like that? Very few people," says Leishman, who was a chaired professor at the University of Maryland for 28 years before joining Embry-Riddle in 2014 as a distinguished professor of aerospace engineering. "This is the most exciting opportunity I've had in my career – to be involved in the design and construction of a world-class wind tunnel-testing facility."

It also has more far-reaching potential. Leishman's specifications provide enough flexibility for retrofits to support acoustic testing or testing at higher wind speeds because the tunnel can be reconfigured as new technologies and financial resources become available. "Generations to come can adapt the facility as they think about new problems that need to be studied," he says. "Designing it with this in mind will help ensure it will be here 100 years from now in some form."

> The measurements made in the new wind tunnel could someday help ensure safer helicopter landings on the decks of ships.

Created primarily for faculty and student research, the wind tunnel will also become available to external customers such as government agencies, private companies and other research organizations.

"This is a very unique project in the world of wind tunnels, certainly for a university, in that it has a very broad range of testing capabilities. We're not just testing wings and airplanes anymore," Leishman says. "In today's environment, we need to be flexible to accommodate a very diverse range of objects that need to be tested aerodynamically."

In fact, one of the first experiments will leverage the tunnel's PIV technology on a 5-foot model of a U.S. Navy frigate ship. Embry-Riddle faculty and graduate students will study how air-wake flow physics adversely affects helicopter landings on the decks of ships. Measurements from these tests will contribute to a greater body of research on computational fluid dynamics of ship air-wakes, a larger project managed by Penn State University's Vertical Lift Center of Excellence on behalf of the United States.

FROM THE BEDSIDE TO THE BENCH

Mindful of a key faculty mentor's pivotal guidance, Kathy Lustyk pays it forward to her own students

BY GINGER PINHOLSTER

Kathy Lustyk's groundbreaking regulatory behavior research has shown the benefits of behavioral interventions in treating physical conditions, such as irritable bowel syndrome, and addiction.

Connor McShane

Carol Browne / Seattle Pacific University

As a pre-med student at the University of Washington in the mid-1980s, Mary Kathleen Lustyk was working the graveyard shift in an emergency room, handling triage when she had a sudden, terrifying realization: She didn't want to be a surgeon, after all. Frustrated by people clogging the ER with complaints of sniffles and hangnails, Lustyk had to admit she wasn't cut out for daily interactions with patients.

"I'm much better suited for research and teaching and mentoring students in a lab," says Lustyk, now dean of the College of Arts and Sciences at Embry-Riddle Aeronautical University's Prescott Campus in Arizona. "I wanted to work at the bench instead of the bedside."

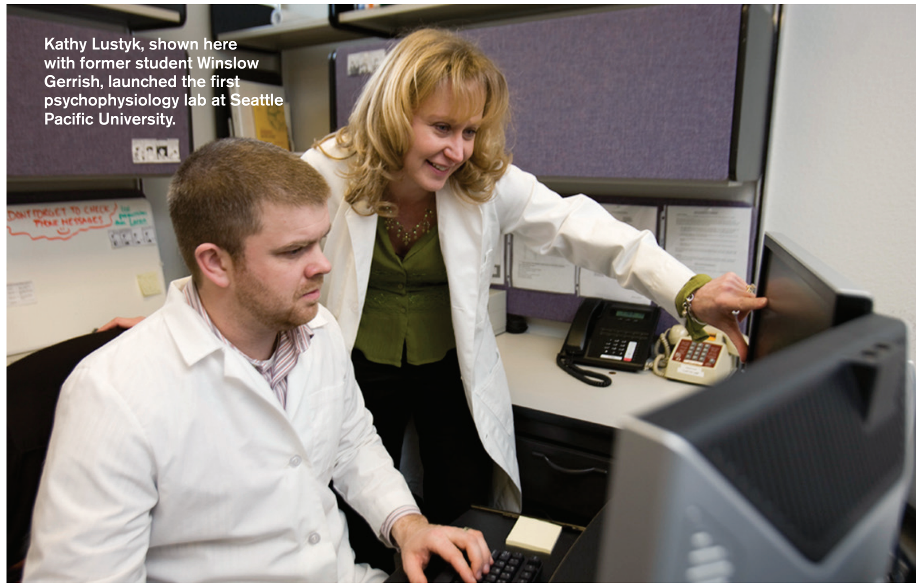
Lustyk met with University of Washington faculty member Nancy J. Kenney, now director of undergraduate studies. "She gave me entry to her laboratory," Lustyk recalls. "She was a pivotal person and an excellent mentor to me."

RESEARCH THAT CHANGED COMMON ASSUMPTIONS

After earning a Ph.D. in physiological psychology with a minor in endocrinology, Lustyk landed an assistant professorship at Seattle Pacific University (SPU), and she established the first psychophysiology lab on that campus. Since then, her investigations of human and animal regulatory behavior have changed thinking about the value of behavioral interventions in treating physical conditions.

Lustyk's groundbreaking research article in *Gastroenterology*, for example, showed that a physically active lifestyle can be beneficial to women with irritable bowel syndrome. That paper, which received an Outstanding Research Article Award from the Society of Gastroenterology Nurses and Associates in 2002, inspired a wave of researchers to assess the effects of behavioral interventions on various gastrointestinal problems. As director of the Lustyk Women's Health Lab at SPU, her research expanded to encompass the complicated interrelationships between stress, impulsivity and mindfulness – a technique for paying attention to the present moment in a nonjudgmental way – in women across all phases of their menstrual cycles.

Lustyk's continuing research confirmed that women may tend to experience more stress and may be more emotionally reactive during their monthly luteal phase, following ovulation but before menstruation. "That got me thinking about what people do when they're stressed," she says. "They self-medicate with pills, alcohol and other substances."



Kathy Lustyk, shown here with former student Winslow Gerrish, launched the first psychophysiology lab at Seattle Pacific University.

Working with G. Alan Marlatt, a leader in the field of addiction science who died in 2011, Lustyk explored whether mindfulness can reduce stress and craving – two factors that contribute to the 80 percent relapse rate among people with addictions. Her research showed that a "Mindfulness-Based Relapse Prevention" method was beneficial for addressing both factors. Lustyk's work has also focused on how mindfulness can help balance the body's automatic "fight-or-flight" sympathetic nervous system reactions with "rest-and-digest" parasympathetic responses mediated by the vagus cranial nerve.

Securing grants and conference invitations proved easier after Lustyk moved into addiction research. "It's a shame, but even today, some people cringe if you talk about menstruation," she says. "I had to learn how to communicate effectively with different audiences."

> "I've been able to shepherd others and guide them, just as [my mentor] did for me. I've found that increasingly rewarding."
>
> KATHY LUSTYK, DEAN OF THE COLLEGE OF ARTS AND SCIENCES AT EMBRY-RIDDLE'S PRESCOTT CAMPUS

PLAYING A SUPPORTING ROLE

Named a Professor of the Year by SPU for two consecutive years, Lustyk was a department chair when she felt called to focus more on mentoring. "I've been able to shepherd others and guide them, just as Nancy Kenney did for me," she says, "and I've found that increasingly rewarding."

Her work with students is paying off. "Kathy changed my life," says former student Haley Carroll, a clinical fellow in psychology at Harvard's Massachusetts General Hospital. "She saw things in me that I didn't necessarily see in myself."

Under Lustyk's direction, Carroll co-authored three scholarly articles and won a highly competitive clinical internship. "I wouldn't be where I am without Kathy," Carroll says. "She's amazing."

Andrei Ludu, professor of mathematics, works with Embry-Riddle student Moriah Calfin on research using the nonlinear wave tank.

David Massey

CALMING THE WATERS

The effects of climate change take shape in the Department of Mathematics Wave Laboratory in Daytona Beach, Florida

BY GINGER PINHOLSTER

A fully functional 32-by-4-by-4 foot wave tank – equipped with high-speed cameras, multiple wave-makers, and control systems capable of moving water at a rate of 3 feet per second – allows researchers to study the local influence of climate change. Rising seas affect the shape and behavior of shore waves and rip currents, explains Embry-Riddle Aeronautical University Mathematics Professor Andrei Ludu.

Q: How do you study local climate change effects?
Near Embry-Riddle's Daytona Beach Campus in Florida, Indian River Lagoon is one of the most diverse lagoon systems in the Northern Hemisphere. The changing climate causes higher tides. It can also contribute to extreme weather events such as big storms. We want to understand the effect of different types of waves and storm surges on the lagoon, as well as on our local beaches, at different tide levels.

In the wave tank, we simulate various types of sea-floor topography, and we use a unique numerical model to predict outcomes. We can control the intensity and frequency of waves to see if our predictions were correct. We can also apply wind and see what happens.

Q: How might this research help keep people safer?
As an example, if you precisely understand rip currents at different tide levels, you can add sand to the sea floor to change the flow dynamics. You have to know exactly where to put the underwater dune, and how high and wide it should be.

Q: How does Wave Lab research relate to tornadoes?
Right now, we're studying how to inhibit water waves by leveraging a phenomenon called Landau damping. In the future, we want to study the same mechanism in the air to see if it might be useful for damping the destructive energy of tornadoes, too.

Q: What is Landau damping?
We know, based on work by the late physicist Lev Landau, that an instability, such as a big wave, can be reduced or damped through an energy exchange between the waves and surface particles. If the particles are moving with or faster than the wave, they get pushed along like surfers. If the particles are moving opposite to the wave, they're stopped and they lose energy. That oscillation damps resonance, reducing the wave's action.

In a plasma, electromagnetic energy can promote this resonance-damping effect. Charged particles moving in the same direction as a wave are accelerated by it. Those moving in the opposite direction slow down. While I was working with students to demonstrate this on a large scale, we realized it could be used to damp rogue waves or tsunamis.

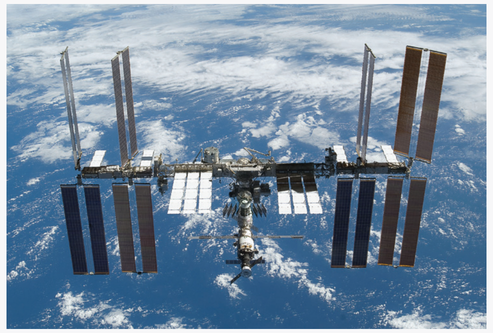
Q: How do you visualize this phenomenon?
We string 6-inch pieces of PVC pipe between pingpong balls and very strong magnets. The magnets sink in water, but the pingpong balls stay vertical. When we generate a wave, the magnets repel each other, pretty much like free electrons in a plasma. At first, all of the magnets are pushed in one direction, but soon, some are moving in the opposite direction and energy resonance occurs. We essentially steal energy from the wave so that we are damping its action. [This work was presented in May 2017 at the 4th International Conference on Recent Advances in Pure and Applied Mathematics.]

We hope to try this in air, too. That's where tornadoes come into it. Researchers have thrown different types of things into the air to try to damp the energy of tornadoes. To my knowledge, no one has tried to harness energy resonance for that purpose.

Q: What other projects take place in the Wave Lab?
Our many different projects include studying 'macro algae' drifts. We're doing this in collaboration with the Indian River Lagoon Council – part of the National Estuary Program.

EXPLORING ABOVE & BEYOND

The Center for Space and Atmospheric Research pursues fundamental insights



NASA

How does space weather impact satellites? Can underwater detonations be detected within the Earth's ionosphere? How do atmospheric waves affect the path of the International Space Station?

Such fundamental physics questions are being explored by Embry-Riddle Aeronautical University researchers within the Center for Space and Atmospheric Research (CSAR).

Here, investigators study planetary atmospheres and near-space environments to better understand the neutral and ionized atmosphere, as well as the space plasma environment and space weather. The research leverages both modeling and advanced instrumentation such as a high-resolution sodium LIDAR.

→ *Visit csar.erau.edu*

ADDITIONAL EMBRY-RIDDLE RESEARCH CENTERS AND INSTITUTES INCLUDE:

Alliance for Systems Safety of UAS through Research Excellence (ASSURE)
Embry-Riddle is a founding member of the multi-university ASSURE coalition, which comprises 21 research universities. ASSURE was designated as the FAA's Center of Excellence for Unmanned Aircraft Systems in May 2015.
→ *Visit assureuas.erau.edu*

Eagle Flight Research Center (EFRC)
Established in 1998, the EFRC is helping to shape the future of human mobility, including clean, quiet flight, through research focused on propulsion, unmanned autonomous vehicles (UAVs), manned flight control and the certification of new technologies.
→ *Read about a current EFRC project on Page 3.*

FAA Center of Excellence for Technical Training and Human Performance (SOAR)
This consortium of 25 universities and nearly 40 industry partners is helping the FAA revolutionize technical training practices and human performance for its workforce. It is led by Embry-Riddle and The University of Oklahoma.
→ *Visit coetthp.org*

Center for Entrepreneurship
Marrying technological knowledge in aeronautics, aerospace, engineering and computer science with business acumen, the Center for Entrepreneurship educates and connects entrepreneurs seeking to establish and expand high value, high-growth companies.

Center for Wildlife and Aviation
This center collects, maintains and disseminates relevant bird strike data and bird strike research; promotes wildlife mitigation training, policies and plans; and bridges the gap between the scientific community and stakeholders.
→ *Visit wildlifecenter.pr.erau.edu*

Cybersecurity and Assured Systems Engineering (CyBASE) Center
CyBASE leverages academic, industry and government expertise to provide cybersecurity solutions for aerospace, aviation and other enterprises. It investigates high-assurance systems in aviation and aerospace, with an emphasis on cybersecurity.

Next Generation Air Transportation System (NextGen) Facility
NextGen is an FAA initiative in which government, industry and academia work to modernize the nation's national airspace, shifting from ground-based radar to satellite-based technology. The FAA has contracted Embry-Riddle to conduct national and international airspace research and operate its Florida NextGen Test Bed facility.
→ *Visit nextgen.erau.edu*

Robertson Safety Institute
As a professional development, outreach and consulting organization, the Robertson Safety Institute offers opportunities for advanced professional training, consultations on safety projects with corporate partners, and applied research activities.
→ *Visit prescott.erau.edu/robertson-safety-institute*

Southeastern Association for Research in Astronomy (SARA)
Led by Embry-Riddle, this 14-university consortium operates 1-meter class telescopes for astronomical research and education in Arizona, Chile and the Canary Islands.
→ *Learn about a recent research project on Page 8.*

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