EMBRY-RIDDLE AERONAUTICAL UNIVERSITY

RESEARCHER

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EXPLORING LIMITLESS HORIZONS

BUILDING A BETTER (HYBRID) JET

Electric propulsion is clean, quiet – and heavy. Embry-Riddle is helping to get commercially viable hybrid planes off the ground.

FEATURES

Embry-Riddle/David Massey

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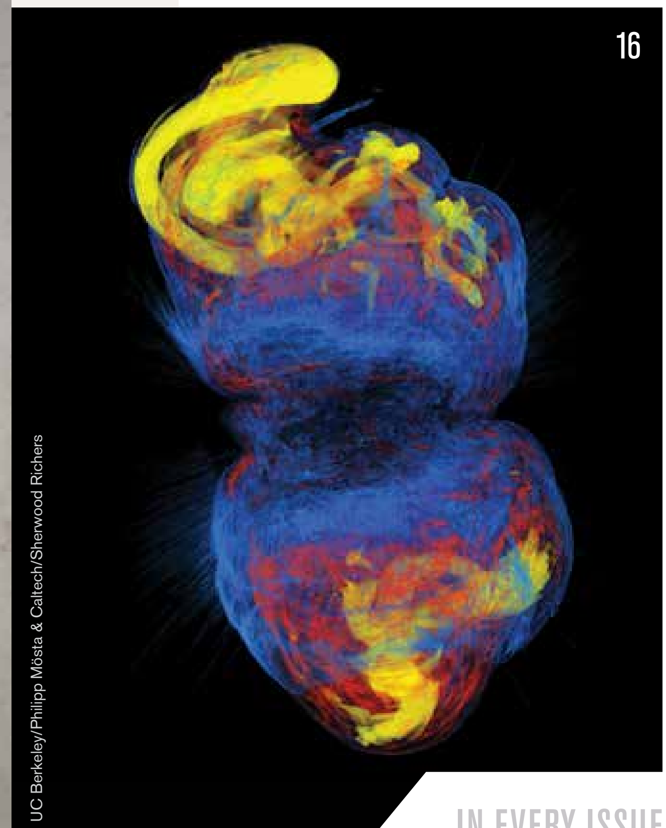
Clockwise, student Tony Zhao, Professor Pat Anderson and student Lenny Gartenberg examine the inner workings of the *eSpirit* electric aircraft under development at the Eagle Flight Research Center in Daytona Beach, Fla.



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UC Berkeley/Philipp Mösta & Caltech/Sherwood Richers

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IN EVERY ISSUE

Dear Friends and Alumni,

I am pleased to share this inaugural issue of *ResearchER* highlighting some of the exciting research happening at Embry-Riddle Aeronautical University. As the world's leader in aviation and aerospace education, Embry-Riddle is a unique institution. Over the past 90 years, we have evolved with the industry to break new ground and produce top-level graduates who serve the ever-changing needs of aviation and aerospace.

With two residential campuses – one in Daytona Beach, Fla., and the other in Prescott, Ariz. – and a Worldwide Campus operation with 135-plus domestic and international learning centers, Embry-Riddle has a reach that few other institutions of higher education enjoy. Around the world, we have built our reputation on outstanding undergraduate programs and a commitment to being a trusted pipeline of practicing professionals.

While we will always be one of the most reliable providers of talent to our industry, we have been positioning ourselves over the past decade to be a major player in research and innovation by investing in our faculty, building infrastructure and transforming our culture to embrace the discovery of new knowledge.

This is an ambitious goal, and as the featured research in this publication shows, we are making significant strides in achieving it. The technology revolution has narrowed the gap between innovation and discovery and has accelerated the research-to-product cycle. This has blurred the line between education and research and created more opportunity for universities striving to achieve excellence in both of these areas.

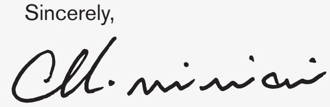
Our undergraduates are a major beneficiary of this growing opportunity. I invite you to read the article on our Prescott Campus team's contribution to the landmark LIGO discovery on Page 16. I had the good fortune of listening to presentations from two of our undergraduate students, Kiranjyot "Jasmine" Gill and Sophia Schwalbe, on this project last November. I could not be more optimistic and proud about the future of our institution.

Embry-Riddle is also uniquely positioned to take advantage of its close ties to industry – something we've been doing since our earliest days. The pioneering work we are conducting at the Eagle Flight Research Center to develop a hybrid turbine-electric propulsion system – which includes the full backing and participation of a consortium of industry partners including Rolls Royce, Pratt & Whitney, Airbus and Textron – is a perfect example of our commitment to help transform the industry through shared innovation. To learn more, turn to Page 8.

Everyone at Embry-Riddle is excited about the opening of the new John Mica Engineering and Aerospace Innovation Complex (the MicaPlex) this spring, which will usher in a new era for research, innovation and entrepreneurship for Embry-Riddle. This 50,000-square-foot facility will house a dozen interdisciplinary research labs, lease space for established industry or start-ups to occupy, incubator space and support offices for technology transfer. Adjacent to it, we are busy building a state-of-the-art subsonic wind tunnel, unique in its measurement capabilities to support research and industry. These facilities are the cornerstone of Embry-Riddle's future research park, which is currently under development.

It's an exciting time at Embry-Riddle, as we build up for a future of excellence in education, research and innovation. Please join us in our ongoing journey and transformation.

Sincerely,



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A Step Toward Disease-Free Flight

STUDY FINDS PRACTICAL SOLUTIONS TO REDUCING VIRAL TRANSMISSION DURING AIR TRAVEL

Embry-Riddle Aeronautical University Professor Sirish Namilae and Ph.D. student Pierrot Derjany are marrying the principles of molecular dynamics, pedestrian motion and epidemic modeling to develop a supercomputer program that may someday help mitigate the spread of infectious diseases during air travel. Their early findings suggest that altering airline practices during a viral outbreak could impact the rate of human infection, potentially saving lives and reducing economic losses.

The principal investigator for Embry-Riddle, Namilae is collaborating with researchers from Florida State University and Arizona State University in this multi-year study known as the Viral Infection Propagation through Air-Travel (VIPRA) project. Launched on the heels of the West African Ebola outbreak, which killed more than 11,000 people between March 2014 and January 2016, the project has received $240,000 to date in grant support from the National Science Foundation (NSF).

EARLY RESULTS

The research has already determined some practical steps to reduce infections during flight.

"We know how the size of an airplane affects disease transmission rates. Smaller airplanes (less than 50 seats) are better," Namilae says. Additionally, the study, *Self-Propelled Pedestrian Dynamics Model: Application to Passenger Movement and Infection Propagation in Airplanes,* which was published in 2016 and coauthored by Namilae, found that the number of contacts between pedestrian particles (read: germs) was lowest using random passenger boarding and column-wise deplaning processes. The column-wise process involves all aisle seats exiting first, followed by middle and then window seats.

Implementing specific boarding and deplaning practices could potentially decrease the rate of infection (e.g., the probability of generating 20 new travel-related cases a month during the peak of the Ebola epidemic would be reduced from 67 percent to 40 percent). Using smaller aircraft (50 seats or fewer) would reduce it even further, Namilae says.

MANAGING UNCERTAINTY

In addition to NSF funding, the project was awarded 500,000 hours of access to the Blue Waters supercomputer at the National Center for Supercomputing Applications at the University of Illinois, Urbana-Champaign. This access allows the group to analyze its data using 100,000 computer processors at a time. This is key to the project's future success, Namilae says, because it will permit researchers to quantify the effects of passengers' unpredictable behavior.

Mapping pedestrian movement and behaviors related to boarding, deplaning and traveling to and from boarding gates involves a lot of uncertainty and raises a variety of questions, such as: Does shopping at the airport raise the risk for transmission of disease? How many people does an air traveler encounter within a 2-meter radius (the average projection distance of a sneeze)?

These are the types of questions the Blue Waters supercomputer will help answer.

"The challenge is to study these uncertainties and try to find a protocol that can model all of them," says Derjany, who does the coding and mathematical modeling for the project.

Namilae's pedestrian-motion epidemic models will ultimately be combined with a collaborator's (Mathew Scotch, Arizona State University) phylogeographic model, which examines geographic and historic variations of viral genetic mutations, to evaluate the spread of disease across cities, and even continents.

Namilae's models can be applied to other scenarios, as well. "The math we developed could be applicable to disaster evacuations and for optimizing safety," he says.

The VIPRA project is years from completion but the ultimate goal is to create a tool to help policymakers and public health agencies make quick decisions in the case of a viral outbreak akin to the Ebola epidemic.

"Eventually, if our models can make small changes in airports and it leads to reduced infections, that's a great thing," Namilae says.

/SARA WITHROW

Savings at the Gate

JETWAY EXTENSION AND OPTIMIZED BOARDING STRATEGY PROMISE TO REDUCE BOARDING TIMES FOR AIRLINES

A unique two-door commercial aircraft boarding and deplaning proposal and a future jet bridge extension, designed and patented by Embry-Riddle Aeronautical University student Dynamite Obinna, are getting the attention of the airline industry.

The research supporting the proposal earned Best Presentation at the 56th annual symposium of the Airline Group of the International Federation of Operational Research Societies (AGIFORS) held in October 2016 in Santiago, Chile. The honor was voted on by industry members attending the symposium.

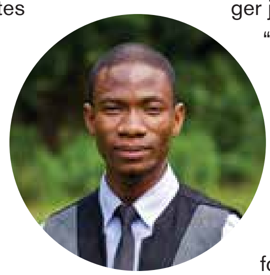
"They loved it, especially the United States' airline representatives," says Massoud Bazargan, professor and associate dean for research at Embry-Riddle's Daytona Beach Campus College of Business.

The U.S. hub-and-spoke air transportation system makes time spent boarding and deplaning crucial, particularly for passengers who have tight connections to other flights.

"On average, every minute of delay at an airport translates into $73. This is a cost to the airlines and ultimately a cost to passengers," he says. For low-cost carriers that rely on shorter turnaround times to maximize profitability, delays are even more critical.

A Simulation Approach to Aircraft Braiding Strategy – Part II, published by Bazargan, et al., in 2016, shows that narrow body aircraft could reduce their gate times by up to 12 minutes by combining Bazargan's optimized boarding strategy (the Efficient Model, first proposed in 2005) with Obinna's jetway extension, which would use both the forward and aft doors of an aircraft for boarding and deplaning.

AirTran adopted the Efficient Model for its boarding process in 2005, saving the airline an average of 4 minutes at the gate, Bazargan says. The aircraft boarding strategy stopped working when airlines started charging passengers for checked baggage. "People started bringing more bags on the airplane, which eliminated the time savings," Bazargan explains. However, with Obinna's two-door boarding plan, the Efficient Model is again viable.



"When you're operating five to seven flights a day, you need to have a maximum 25- to 30-minute turnaround time. With one door, that's almost impossible. With two doors, the research shows it's feasible," Bazargan says.

A BRIDGE TO SUCCESS

Obinna, who immigrated to the United States from Nigeria in 2010, designed the jetway extension, named the Dynaerobridge, after being frustrated with the slow deplaning process as a frequent flyer. "It was a problem I wanted to fix," he says.

To save space on the ramp, Obinna designed the Dynaerobridge to function as an attachment to the existing passenger jet bridges used at airports.

"This is one passenger boarding bridge that replaces the need of having two," he says.

The recipient of a National Science Foundation Innovation and Research (I-Corp) grant, Obinna recently formed his own company, SkyGenex Incorporated, and is exploring possible partnerships with a jetway manufacturer or airport.

"As long as the airlines can prove a cost savings, the benefits [of the Dynaerobridge] would outweigh the initial production costs," says Obinna, who plans to graduate in May with a B.S. in Aeronautics.

/SARA WITHROW

Dynamite Obinna (pictured above) designed the Dynaerobridge (rendering shown here) after being frustrated with the slow deplaning process inherent to commercial air travel.

Alumnus Jamie Glover, who works in the Embry-Riddle UAS Simulation Lab, tests a small UAS.

Embry-Riddle/David Massey

Unmanned Guidance

EMBRY-RIDDLE RELEASES FREE sUAS GUIDE

Do you want to learn how to fly a small unmanned aircraft? A research team at Embry-Riddle Aeronautical University has created the first-ever comprehensive consumer guide to small unmanned aircraft systems (sUAS), commonly known as drones, for novice users – those interested in purchasing their first small remote-controlled or autonomous multi-rotor flying aircraft.

The Embry-Riddle sUAS Consumer Guide, published online in June 2016, is the result of months of study and assessment. Embry-Riddle Worldwide Campus professors, who are also UAS experts, collaborated with undergraduate teams from the Worldwide and Daytona Beach campuses to conduct dozens of separate quantitative and qualitative measurements on 12 readily available sUAS platforms. All aircraft tested cost under $3,500, had electric motors with removable batteries, could carry or had built-in HD cameras, and weighed less than 7.5 pounds with payload.

"Our hope is that novices and experienced operators alike will use this free resource to examine critical features and capabilities inherent to the safe and responsible use of sUAS technology," says Brent Terwilliger, a dual Embry-Riddle alumnus, co-author of the guide and Worldwide Campus program chair of the Master of Science in Unmanned Systems.

/ JAMES RODDEY

542,500

The Federal Aviation Administration forecasts a total fleet of 542,500 sUAS operating in the national airspace by 2020. Roughly 90 percent of these will be lower-end units with an average per unit value of $2,500.

GET THE GUIDE

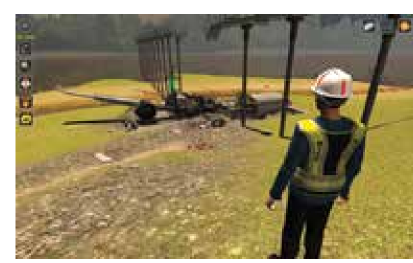
To view an interactive version of the sUAS guide, visit **uasguide.erau.edu.**

VIRTUAL TECHNOLOGY CREATES BRIDGE FOR DISTANCE LEARNING

Embry-Riddle Aeronautical University's Worldwide Campus is empowering students to experiment, test, develop, analyze and reconfigure crash sites and unmanned aircraft systems (UAS) using virtual reality technology.

The Embry-Riddle Virtual Crash and Virtual Aerial Robotics labs marry products developed by Michael Durant, a Worldwide Campus alumnus and the founder of Pinnacle Solutions, an engineering and training services company, with the university's award-winning distance-learning platform.

The Virtual Crash Lab places students in real-life crash investigations. As virtual National Transportation Safety Board investigators, students can direct their avatars to zoom in on details, collect and analyze data, and apply theory to determine possible scenarios and failures that led to an aircraft disaster.



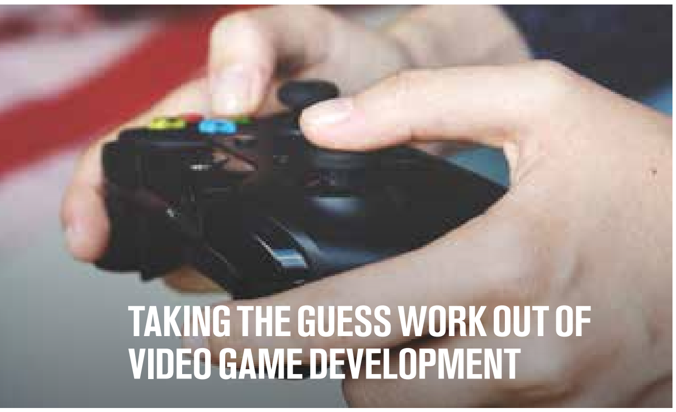
SEE FOR YOURSELF

To experience the Virtual Crash Lab, visit **goo.gl/reSOA6.**

The Virtual Aerial Robotics Lab allows students to design and build their own UAS in a virtual environment where they can test flight capability and analyze the results from anywhere in the world.

Aeronautics Professor Scott Burgess says virtual labs are the future of learning. "We want to lead with cutting-edge technology for students," he says. "What we want to do is bring Star Wars-like capabilities to life and position students to expand their learning in an enhanced environment. The virtual aspect is one way to do that."

/ MOLLY JUSTICE AND LACEY MCLAUGHLIN



TAKING THE GUESS WORK OUT OF VIDEO GAME DEVELOPMENT

What makes a video game better than another in the minds (and hands) of its players? Embry-Riddle Aeronautical University's Human Factors Professor Joseph Keebler and colleagues, Mikki H. Phan and Barbara S. Chaparro at Wichita State University, have developed a tool that answers this question.

The Game User Experience Satisfaction Scale, or GUESS, is a scientifically validated means of gauging a video game user's satisfaction based on playability, narratives, creative freedom, social connectivity and visual aesthetics, among others. A paper explaining the GUESS tool and the data used to produce it was published in *Human Factors: The Journal of the Human Factors and Ergonomics Society* in September 2016. GUESS is also available on a Creative Commons license, allowing for its free use and distribution.

"Measuring reactions to games has been a complicated endeavor for scientists and video game developers," Keebler says. "We now have a validated scale that's relatively short (55 items), which allows developers and researchers a quick and valid way to understand how good a particular game is in the eyes of its users."

Based on human factors psychology – the study and practice of designing products, systems and processes around how humans actually interact with them – GUESS was derived from a study of more than 450 video games across multiple genres.

Embry-Riddle students were some of its first beneficiaries. The Human Factors & Systems department in the College of Arts & Sciences at the Daytona Beach Campus is home to the Game-Based Education and Advanced Research Studies (GEARS) Lab, where research focuses on exploring how games and simulation can enhance education and training. Students are now conducting studies to understand how personality correlates with GUESS, as well as the effects of various virtual reality systems on GUESS responses.

/ JAMES RODDEY

Redefining the Metrics System

RESEARCH ESTABLISHES FOUNDATION FOR DYNAMIC, SELF-ORGANIZING CYBER THREAT RESPONSE MODEL

With the number and severity of cybersecurity breaches skyrocketing, researchers at Embry-Riddle Aeronautical University's College of Security and Intelligence at the Prescott Campus are creating a framework that may ultimately allow computer networks to autonomously detect intrusions and protect themselves accordingly.

Assistant Professor Gregory Vert, former Embry-Riddle graduate student Bryce Barrette and Bilal Gonen, assistant professor at the University of West Florida, are coauthors of *Towards a Mathematical Model for Autonomously Organizing Security Metric Ontologies.* Peer reviewed and published at the 2016 International Conference on Security and Management, their research identifies operational cyber system security metrics, and then organizes these into larger classes of metrics, or ontologies, based on their similarities.

"Research groups have attempted to develop security metrics over the years; however, the issue with current security metric systems is their static nature. They often only account for a single indicator," Vert says. Grouping metrics into classes based on how they apply to threat events within a system makes them more meaningful for decision-making regarding threat response, he explains.

Using computational math, researchers can assess potential threat events, looking at how closely those events occur together in time and space – the theory being that the closer they are together, the more likely the threat. If a threat is

indicated, the model may react by dynamically self-reorganizing or recombining into larger classes of metrics that can deal with the threat as it moves across the network. Vert and his team define this dynamic model as the Adaptive Security Metric Method. "By determining which ontologies fit best with one another, frameworks can be determined for a best security model," Vert says.

Vert adds that the work is conceptual at this point and that more empirical testing and validation are necessary. However, the model lays the mathematical groundwork for a future cybersecurity system that could dynamically and autonomously combat a cyber intrusion (i.e., spyware) or attack.

The research is being developed further for journal publication with undergraduates at Embry-Riddle's Prescott Campus.

/ SARA WITHROW

Embry-Riddle Ph.D. student Justin Yapp (pictured below) has plans to develop a cloud-based service that would allow business owners to rent UAVs for short-term use.

Eyes in the Sky

CYBERSECURITY STUDENT, PROFESSORS WIN NATO AWARD FOR UAV RESEARCH

As satellite and unmanned aerial vehicle (UAV) technology becomes increasingly important for capturing real-time data, doors of opportunity are opening for entrepreneurs. Justin Yapp, an electrical engineering and computer science Ph.D. student at Embry-Riddle Aeronautical University, is one such entrepreneur taking advantage of this developing industry. He plans to create a cloud-based service for commercial industries to store and share information gathered by UAVs.

Yapp's research, *UAV as a Service: A Network Simulation Environment to Identify Performance and Security Issues for Commercial UAV in a Coordinated, Cooperative Environment*, won the Best Paper award at the Modelling and Simulation for Autonomous Systems Workshop hosted by NATO in June 2016. The paper was coauthored by Embry-Riddle professors Remzi Seker and Radu Babiceanu.

Creating a cloud-based system would allow UAV operators and clients more accessibility to UAV-collected data and images, Seker says. For example, a farmer trying to determine the condition of his crops could access clusters of available commercial UAVs through the cloud infrastructure, he explains. Essentially, this would enable business owners and individuals to rent UAVs for short-term use rather than buy them and navigate Federal Aviation Administration guidelines on their own.

"This is analogous to Hertz or Avis renting cars," Seker says. "It's more complicated than that but the concept is similar."

To further develop the research, Yapp hopes to obtain funding for a test-bed site, where he could operate UAVs and the cloud-based communications system in real-time.

CENTER OF ACADEMIC EXCELLENCE

Seker credits the NATO award in part to Embry-Riddle's research-intensive computer systems engineering and cybersecurity environment. In May 2016, the Daytona Beach Campus was named a National Center of Academic Excellence (CAE) in cyber defense education by the National Security Agency and the Department of Homeland Security. The designation includes a focus area of secure software development.

"The CAE designation in cyber defense education is a major accomplishment for our Cybersecurity and Assured Systems Engineering Center (CyBASE)," says Seker, who directs the CyBASE research center at Embry-Riddle. "As one of only five schools in the country with a secure software development specialization, our students and research teams should see immediate benefits in access to prospective research grant awards, scholarships and job opportunities."

/ LACEY MCLAUGHLIN AND JAMES RODDEY

Yapp: Embry-Riddle/David Massey

EAGLE FLIGHT GOES ELECTRIC

1, 2, 4 and 5: David Massey; 3: Daryl LaBello

Clockwise from top: 1 Embry-Riddle goes green with its latest electric flight project. 2 Battery temperature control is a challenge for electric flight. This prototype battery is designed with phase-change materials that act as a heat sink, removing heat from the batteries quickly, and then releasing it slowly into the environment as the demand for power is reduced. 3 Erik Lindbergh, CEO of Powering Imagination and grandson of aviation legend Charles Lindbergh, is working with Embry-Riddle to reduce aircraft noise using electric and hybrid propulsion. 4 Axial-flux electric motor test configuration features power cables and a plug used to connect the motor to a ground-based battery pack. Once an ideal battery configuration is determined, battery packs will be installed behind the motor controller and in the rear of the aircraft. 5 Students Lenny Gartenberg, left, and Tony Zhao at work on the *eSpirit of St. Louis*.

BY ALAN MARCOS PINTO CESAR

EMBRY-RIDDLE'S EAGLE FLIGHT RESEARCH CENTER TEAM IS GOING FULLY ELECTRIC TO PAVE THE WAY FOR THE COMMERCIAL HYBRID AIRCRAFT OF THE FUTURE

Researchers at Embry-Riddle Aeronautical University's Eagle Flight Research Center (EFRC) are working with a consortium of aerospace companies to develop a hybrid gasoline-electric propulsion system that will reduce the noise, emissions and operating costs associated with commercial aviation.

Their ultimate goal is to have a nine-passenger hybrid turboprop aircraft in production by 2025, and a large hybrid-electric jet, akin to a Boeing 737, by 2035.

It's an ambitious vision, but the EFRC is already well on its way with several patents and an established record of successful hands-on hybrid and electric aircraft projects that provide the basis for two paper studies into the feasibility of hybrid aircraft.

For their current project, the EFRC is outfitting a Diamond HK-36, donated by Lockheed Martin Skunkworks, with a fully electric propulsion system. Christened the *eSpirit of St. Louis*, the pioneering aircraft will help the team develop a better understanding of the electric side of the hybrid propulsion equation – a key challenge in developing a viable hybrid propulsion system for aviation.

EXPERIMENTS AND TESTING OF THIS FULLY ELECTRIC AIRCRAFT WILL PROVIDE MUCH-NEEDED DATA TO DESIGN AND OPTIMIZE HYBRID PROPULSION SYSTEMS.

HEAVY LIFTING

Electric propulsion is attractive as an alternative to gas for a number of reasons: It's cleaner and typically more cost effective. It's also quieter, which, surprisingly, is what makes it so appealing to the industry.

Erik Lindbergh, CEO of Powering Imagination and grandson of aviation legend Charles Lindbergh, is closely involved in Embry-Riddle's electric and hybrid aircraft efforts. Lindbergh joined with the EFRC to create the Quiet Flight Initiative, and says low-noise flight is the biggest factor for the industry players involved.

"We thought their reasons would be reducing emissions and operating costs, but we found out that noise is seen as the biggest threat to the industry," Lindbergh says.

Electric propulsion may help provide an answer for reducing noise, but it still has one major problem: It's much heavier than its gas counterpart.

Storing electrical energy on something that flies is not simple. The electric motor in the *eSpirit* is a pizza-sized, puck-shaped axial-flux machine that's much lighter than the piston engine it replaces, but the batteries that power it are another story. Presently, three thick, orange power cables connect the motor to a ground-based battery pack weighing 800 pounds.

The weight and volume of the ground test battery is the biggest barrier to electric flight. "You can choose two of three things when it comes to batteries: cheap, small or light. Automotive batteries are cheap and small," says Richard "Pat" Anderson, professor of aerospace engineering and EFRC lab director. "We are 100 percent focused on weight, but there's no one trying to make batteries lighter." The *eSpirit* team is currently charged with designing and testing a battery pack to meet the airplane's requirements for takeoff and sustained flight.

While a viable battery could propel the *eSpirit*, the prospect for fully electric commercial aviation is dimmer. The amount of energy stored in each pound of batteries is very low compared to liquid fuel – and will be for the foreseeable future, Anderson says. This places a practical barrier to fully electric aviation at about 200 knots – slower than nearly all commercial flight. Because of this, Anderson believes all bigger airplanes of the future will have to be hybrids to reach and sustain commercial aviation speeds while taking advantage of the efficiency gains from electric propulsion.

"There are no large or fast electric airplanes because it's not really possible right now," Anderson says. "Gas turbine engines will always be the answer for maximum range until the specific energy of batteries exceeds liquid fuel. A lot of people don't think that will ever happen."

THE ELECTRIC EXPERIMENT

While all-out electric propulsion is a lofty goal, developing a functional hybrid turboprop won't be easy either. There's a lot of work left to do on the electric side of the gas-electric hybrid system, which is why the EFRC

AIRBUS   Pratt & Whitney A United Technologies Company   GAMA

The Eagle Flight Research Center team is building a fully electric aircraft, christened the *eSpirit of St. Louis*, which draws its power from a ground-based 800-pound battery pack. Pictured (left to right, diagonally) are students Sergio Bacca, Kyle Petesch, Juan Rosales, Lenny Gartenberg, Brandon Antosh and Tony Zhao; and (directly behind the prop) faculty researchers D. Steven Daniel and Pat Anderson.

is building the *eSpirit of St. Louis* as a fully electric aircraft. Its experiments and test flights will provide much-needed data to design and optimize the hybrid system, says Lenny Gartenberg, a master's student at Embry-Riddle.

Gartenberg is the project manager for the Hybrid Conceptual Design Tool (HCDT) being developed at the EFRC. When complete, the tool will be able to weigh factors such as efficiency, noise, range, emissions and cost to come up with the ideal batteries-to-fuel ratio and an optimized hybrid setup – whether that's a parallel hybrid, a series hybrid or some combination of the two (see sidebar).

"We're trying to develop the necessary models, retrieve the data required for these models and incorporate them into the HCDT. The data is widely available only for gas airplanes, so I am using data from our new electric airplane. We need to be able to model the electric end and then combine this with the gas to create one seamless process for how the two energy sources interact with each other," Gartenberg says.

Most of these models have the potential to reduce carbon dioxide emissions, operating costs and noise when compared to their gas-only counterparts, in at least some scenarios, Anderson says. That makes hybrid aviation a viable technology for a sustainable future.

"Reduced fossil fuel usage is good for everybody on earth," Anderson says. "The operating cost reduction means it's probably a durable technology, meaning people won't have to pay more money to do it. If we can get over the research hump, the other side is less expensive." ER

EFRC Team: Embry-Riddle/David Massey; Motor: Alan Marcos Pinto Cesar

FINDING THE HYBRID SWEET SPOT

There are many different ways to build a hybrid system, though they mostly stem from combinations of and variations on two basic types: serial and parallel systems. Each has its benefits and drawbacks.

In a serial (or series) hybrid system, a gas generator produces power for the electric motor, which in turn drives the propeller. This solution is optimal for reducing noise, but it can be less efficient than a direct-powered gas system, particularly when charging the batteries in flight.

In a typical parallel system, both a gas engine and an electric motor can directly drive the propeller. A parallel hybrid airplane could take off using the gas engine and cruise on electricity, making for quiet aerial flight. Or, when designed differently, it could take off on electric power, making for quieter takeoffs, and maximize range by switching to the gas engine when the batteries are exhausted. While potentially noisier than a serial system, a parallel system is more efficient than 100 percent gas-fueled systems in almost all cases.

There is still a lot of research ahead before Embry-Riddle's Eagle Flight Research Center team can determine the ideal hybrid configuration to meet their goals, but its director, Richard "Pat" Anderson, believes all large commercial aircraft in the future will use hybrid propulsion to reduce noise, operating costs and fossil fuel consumption.

"We've been using an incremental method for the last 70-some odd years with [improving the efficiency of] jet engines. We can probably continue to economize at a 10th of a percent for years. But we have solutions with our hybrid systems that are in the 9 percent realm right now, and if we keep searching the design space, we can hopefully find better than 9 percent."

EFRC PARTNERS INCLUDE:

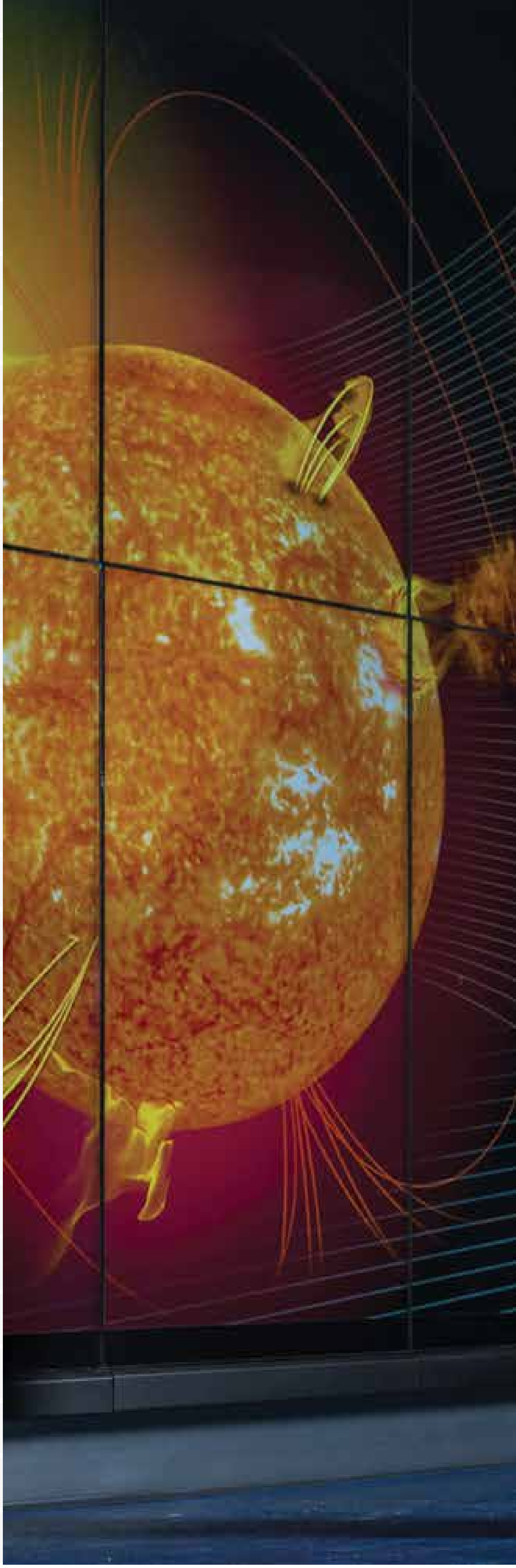
GE Aviation · Hartzell · UTC Aerospace Systems · Argonne National Laboratory · Rolls-Royce · Textron Aviation

heat wave

by
Alan Marcos
Pinto Cesar

Embry-Riddle researchers' discovery of how solar wind heats up ions across Earth's magnetic boundary points to bigger questions about the nature of the sun and could advance research into clean nuclear power

Photo: Embry-Riddle/Daryl LaBello; Background illustration: NASA



Katariina Nykyri, a physics professor and researcher at Embry-Riddle's Center for Space and Atmospheric Research, is hoping her work on space plasma could help answer an enduring question: What heats the solar corona?

a discovery made by Embry-Riddle Aeronautical University researchers about space plasma might help answer one of the burning questions in solar physics: How is the sun's corona heated? It could also someday reveal a pathway to making clean nuclear fusion power a reality.

Katariina Nykyri, a physics professor, and Tommy Moore, a doctoral student — both researchers at Embry-Riddle's Center for Space and Atmospheric Research (CSAR) — published their findings on how solar wind transfers energy across Earth's magnetic field barrier in the September 2016 issue of *Nature Physics*. Together with Andy Dimmock from Aalto University in Espoo, Finland, they dug deep into sensor data from the European Space Agency's Cluster satellites to discover how solar wind interacting with Earth's magnetic field is responsible for heating particles in Earth's magnetosphere.

PLASMA POWER

Solar wind – a continuous flow of plasma comprised of mostly electrons and protons – streams away from the sun at speeds up to 1 million miles per hour, hurtling its way toward Earth and other objects in the solar system. Embedded in that solar wind are elements of the sun's magnetic field that interact with Earth's magnetosphere, a boundary layer created by the magnetic field around the Earth that is impenetrable to solar wind.

"The Earth's magnetic field acts as a shield from these particles. Without our magnetic field, they would strip off our atmosphere," Moore says. "The sun is a source of energy, but particles can't cross straight over. We're looking to see how this energy is transported into the inner parts of the Earth's magnetosphere."

A key to answering that question lies within a common phenomenon known as the Kelvin-Helmholtz (KH) instability. As the sun's plasma flows alongside the Earth's relatively stationary plasma, the magnetic field boundary begins to ripple, forming waves measuring approximately 36,000 km from peak to peak.

These enormous waves made up of the Earth's plasma and solar plasma then curl and spill over each other – similar to the way ocean waves act as wind moves over them – creating a turbulent mix of charged particles in a predictable KH instability pattern. The pattern can be seen anytime two different fluids flow past one another at different speeds – certain cloud formations, for example, and even in daily office life.

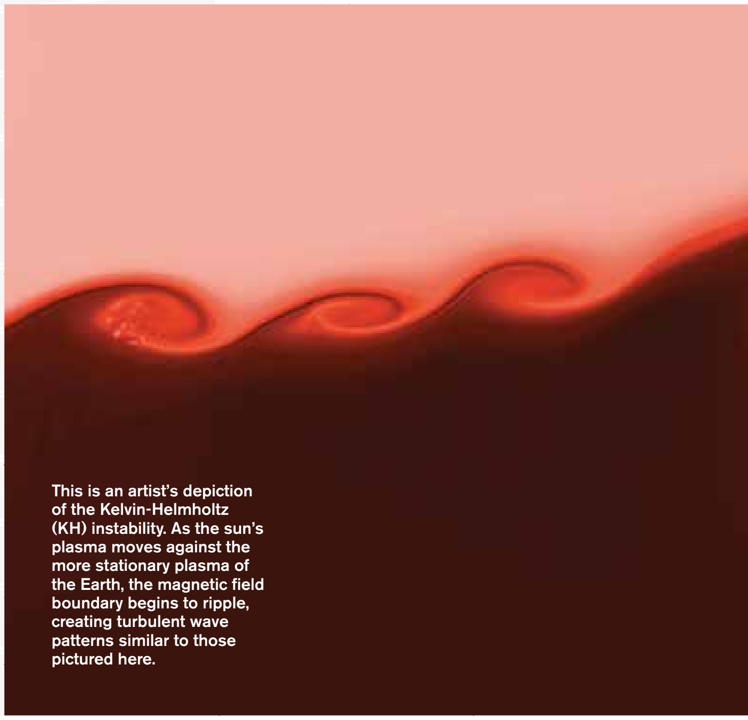
"It's like pouring cream into a cup of coffee," Moore explains. "The cream is thicker and moving faster than the coffee. The boundary between the two is unstable, and that's where a swirl starts to form. In this case, coffee is Earth's hot plasma and the creamer is solar wind plasma."

The presence of these huge waves has been correlated with increased temperatures of the plasma ions in Earth's magnetosphere. What was not understood prior to this discovery is how the energy from these huge waves is able to directly heat the plasma at the boundary layer.

THE HOT DISCOVERY

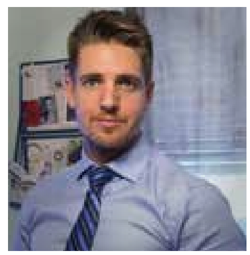
This seemingly straightforward question has a surprisingly complex answer, because plasmas don't interact with each other in the same way as other states of matter. It's not obvious that plasma interactions would generate heat because they don't crash together in the traditional sense.

"When a truck collides with a small car, it creates heat as both vehicles absorb energy from the impact. Space plasma is actually collision-less. You don't have particle-to-particle collisions like you see in classical mechanics. Here we have this huge velocity shear and all this kinetic energy, but how does this kinetic energy become heat?" Nykyri says. "These particles aren't colliding directly with one another; they're interacting with electromagnetic waves."



This is an artist's depiction of the Kelvin-Helmholtz (KH) instability. As the sun's plasma moves against the more stationary plasma of the Earth, the magnetic field boundary begins to ripple, creating turbulent wave patterns similar to those pictured here.

It turns out that these KH waves, which are too big to directly heat plasma particles, generate smaller waves of their own, with wavelengths on the scale of plasma ions (200 to 2,000 km). These waves, which Embry-Riddle researchers discovered radiating from the low pressure center of the KH instability, speed up the plasma particles in the Earth's magnetosphere by synching up with their orbits and pushing them over and over again as they circle their magnetic field lines. In the world of particle physics, a faster moving ion is a hotter ion. "The ions can get in resonance with the right kind of waves, and these waves then can heat them up," Nykyri says.



That transfer of energy from the large KH waves to the much smaller, ion-scale waves inside the low-pressure center of the KH vortex is the crux of the discovery, because it explains to an important degree how the ions in the Earth's magnetosphere are heated.

"What we showed is that we found ion-scale waves in the center of a KH wave vortex that had sufficient energy to heat the cold ion population," Moore says. These ion-scale waves are created by an unstable distribution of ions, and the specific mechanism for how these distributions are created is currently under investigation by Nykyri and her collaborators.

UNLOCKING THE MYSTERIES OF THE SUN

The discovery by Moore, Nykyri and Dimmock has potential impacts for developing nuclear fusion reactors, a cleaner alternative to nuclear fission. Nuclear fusion creates energy the same way the sun does: by smashing small hydrogen atoms together. The only exhaust is helium.

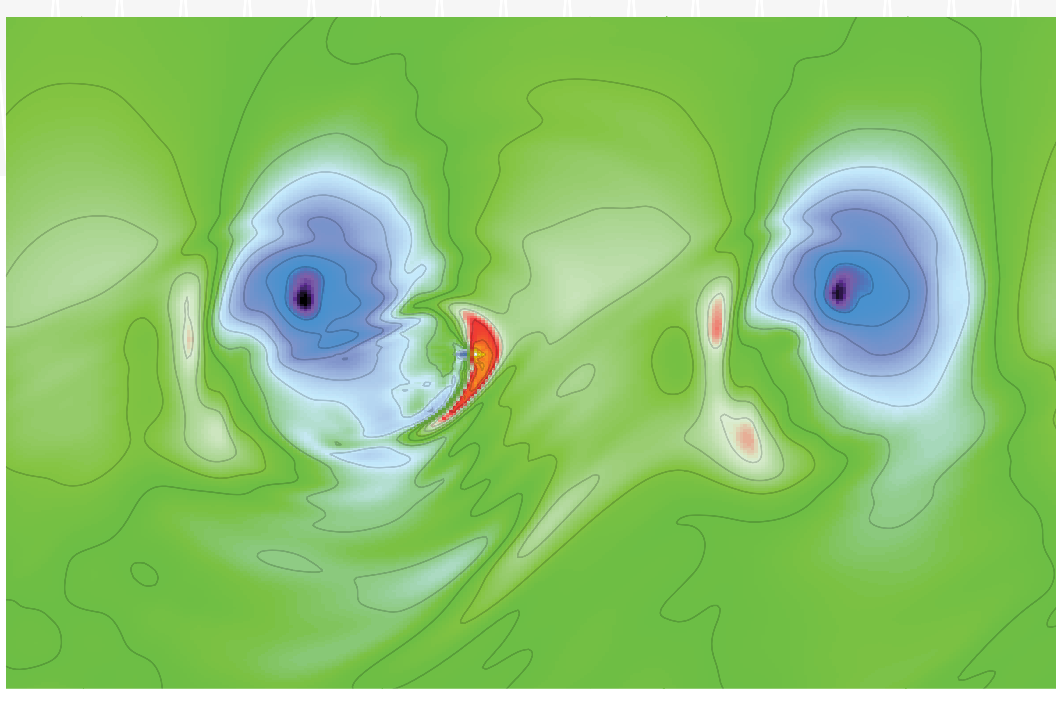
But fusion reactions are challenging to contain. Prototype reactors currently use magnetic fields around the superheated plasma, Nykyri says, but they use more energy than they generate. A lot of energy is lost because plasma particles stray away from the area being heated.

"Fusion systems can't reach critical temperatures because of this transport problem. But if we are able to put an appropriate boundary layer there with the right density gradient, we can make it so the energy transport always occurs toward the center. This mechanism not only prevents plasma from transporting away, it could also provide additional heat to the center."

> "It's like pouring cream into a cup of coffee. The cream is thicker and moving faster than the coffee. The boundary between the two is unstable, and that's where a swirl starts to form. In this case, coffee is Earth's hot plasma and the creamer is solar wind plasma."
>
> TOMMY MOORE, RESEARCHER AT EMBRY-RIDDLE'S CENTER FOR SPACE AND ATMOSPHERIC RESEARCH

These findings could also propel continued research on one of the biggest mysteries in space: "The holy grail of all of space physics is, 'What heats the solar corona?'" Nykyri says.

At the sun's core, the temperature is millions of kelvins, but cools as you move from the center to about 6,000 kelvins at the surface. "When you come to the corona, boom! It heats up again to several million kelvin. This is not understood," Nykyri says. "But what we know about the sun is that you have shear flows. It's possible the same mechanism heating ions in Earth's magnetosphere is occurring in the solar corona." ER



This graphic indicates the total pressure of the plasma at the magnetopause boundary when the KH vortices are well-formed. The magnetosonic wave discovered by researchers was located at a 'pressure minimum' in the center of a KH vortex, indicated here by dark purple and black.

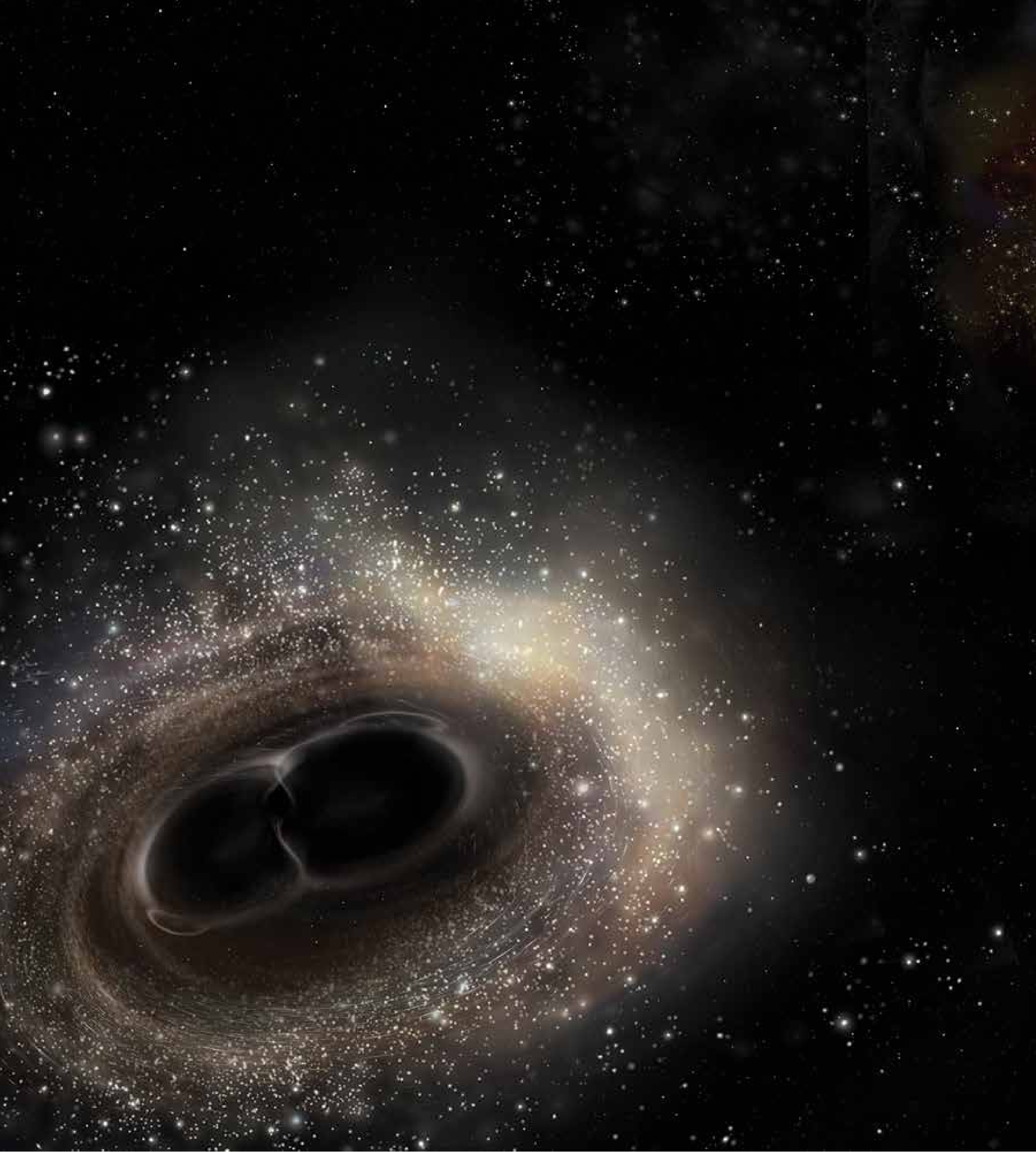


Illustration: LIGO/A. Simonnet

THE SOUNDS OF SPACE

EMBRY-RIDDLE PRESCOTT CAMPUS FACULTY AND STUDENTS HELP PROVE EINSTEIN'S THEORY IS CORRECT

On Sept. 14, 2015, Embry-Riddle Aeronautical University astrophysics faculty and students at the Prescott Campus in Arizona joined colleagues around the world in listening to the very first notes of what they hope will one day be a symphony of sound coming from the universe.

On that day, the Laser Interferometer Gravitational Wave Observatory, or LIGO, recorded the first evidence of gravitational waves – ripples in space time first predicted by Albert Einstein a century ago. The "chirp" detected was the signature sound of two massive black holes merging together 1.3 billion light years from Earth, and it was music to the ears of Prescott physics faculty Michele Zanolin, Brennan Hughey and Andri Gretarsson, and their students.

BY JOSEPH M. KAYS

"We've been saying for years that we wanted to listen to the universe, to add ears to the eyes, but it didn't become real until we actually had a detection," says Gretarsson, an associate professor who first began working on LIGO as a student in 1996.

"With sound you can listen to the heart of a baby or you can listen to a symphony orchestra," adds Zanolin, associate professor and Embry-Riddle's principal investigator on a LIGO project that has brought about $1 million in National Science Foundation funding to the university. "Hopefully in the future we can listen to different songs from different sources."

It's that opportunity to listen to different songs that excites Hughey, an assistant professor of physics. "Supernovae are going to look and sound different, and a cosmic string will sound and look different again, so in another 20 years we'd like to be able to listen to this whole symphony of gravitational waves."

The headphones for all this celestial music are the pair of 4-kilometer-long, L-shaped laser rangefinders – one in Livingston, La., and another in Hanford, Wash. – that comprise LIGO. A gravitational wave reaching the Earth will stretch one arm of the L and squeeze the other by a mere ten-thousandth the width of a proton. But in a machine this sensitive, even such an infinitesimally small disruption of the laser beams inside can be detected.

Embry-Riddle is part of the LIGO Scientific Collaboration (LSC), which comprises more than 1,000 scientists from hundreds of universities and research institutes around the world. Zanolin, Hughey and Gretarsson have been part of the LSC for years, helping to build and test the devices and to create the software needed to catch a gravitational wave as it passed through the detectors.

Hailing from some of the leading physics labs in the world – Zanolin and Hughey from MIT and Gretarsson from Caltech – the researchers have built a robust gravitational wave astrophysics program in Prescott, particularly in the area of supernovae.

FIRST DETECTION

Zanolin, Hughey and Gretarsson say they greeted news of a detection from LIGO with a certain amount of skepticism, born of a deliberate effort by the project's leaders to build in safeguards that would ensure it couldn't be anything else before they went public.

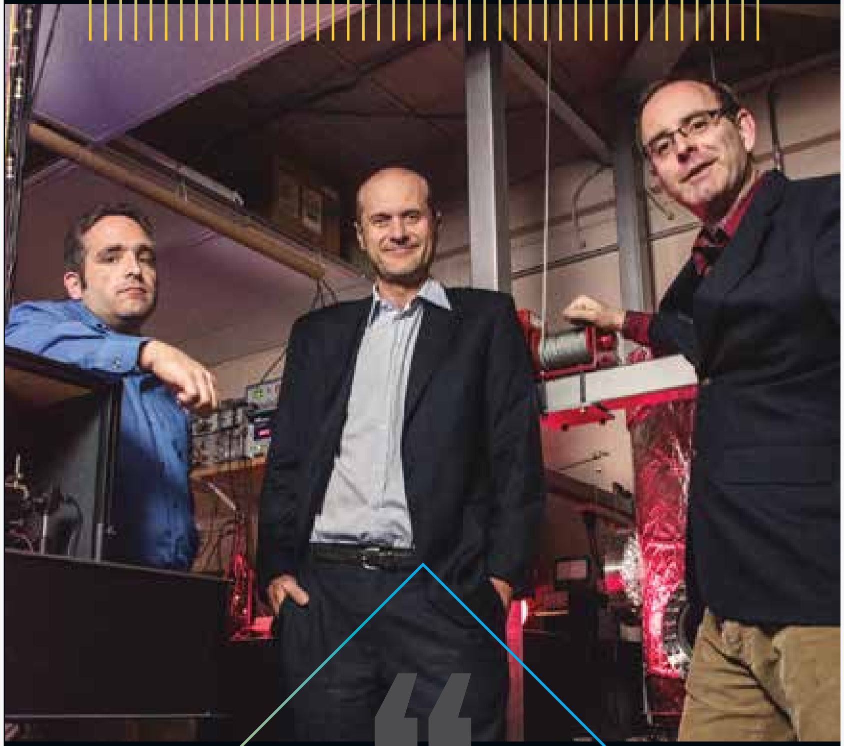
"The signal that we saw was such a slam dunk that it gave us a lot of confidence that it was a real signal," Hughey says. "You couldn't ask for a more beautiful signal than the one we had."

Zanolin says it took a week before the now-historic detection sunk in. "By then I felt like I had won an enormous lottery. It's like one day you discover you have a new sense. I felt like a Jedi."

But perhaps his favorite part of the discovery? The confirmation of gravitational waves only begged many new questions. "Sometimes you have a discovery that's like finding a remote little island that no one has ever seen before, and you map it and you're done," Zanolin says. "This was like discovering a new continent, and we still don't know where it ends. There are an enormous number of physics questions we can now explore."

LOOKING TO THE FUTURE

Moving forward, Zanolin is focused on supernovae, exploding stars that produce the most powerful explosions in the



From left to right, Brennan Hughey, Michele Zanolin and Andri Gretarsson lead the LIGO group at Embry-Riddle's Prescott Campus.

A Storybook Moment Photography/Matt Wilson

> "THIS WAS LIKE DISCOVERING A NEW CONTINENT, AND WE STILL DON'T KNOW WHERE IT ENDS."
>
> MICHELE ZANOLIN, ASSOCIATE PROFESSOR AND PRINCIPAL INVESTIGATOR OF EMBRY-RIDDLE'S LIGO PROJECT

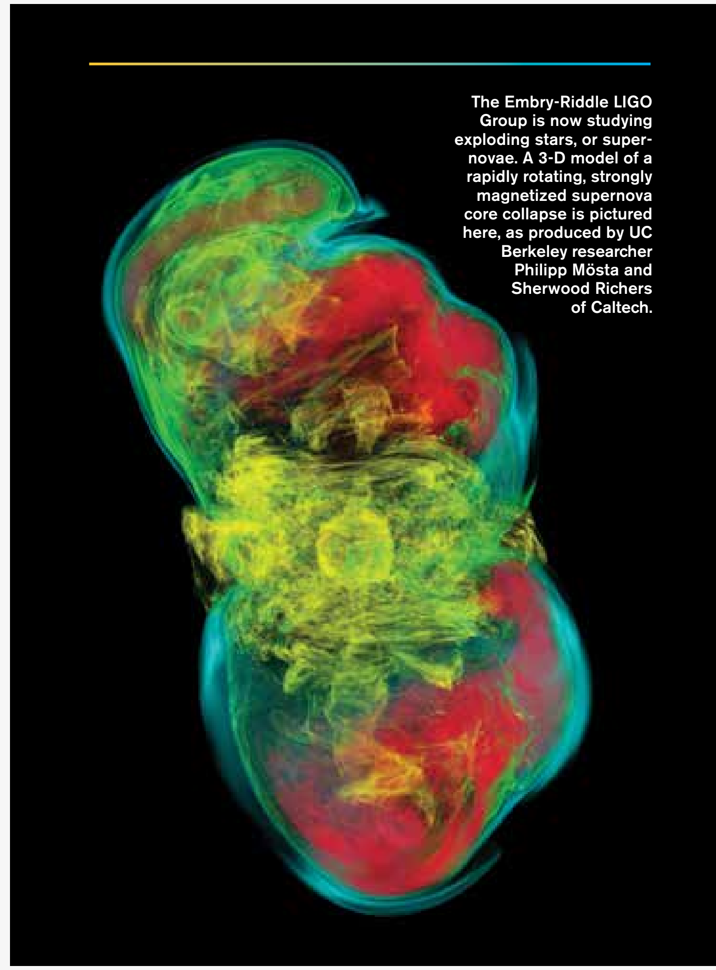
universe. But he says sometimes, instead of vaporizing, the supernova fails and collapses into a black hole.

"It turns out that black holes are the output of failed supernovae," Zanolin says, "so the cool thing is that the black holes we are detecting will establish how many failed supernovae are out there. If we continue to detect binary black hole systems, we'll be able to study the physics of supernovae through the population of those systems."

Zanolin says he would like to see the next LIGO instrument have arms 40 km long, because "longer wavelengths make the interferometer more sensitive."

Gretarsson, who specializes in the optical coatings on LIGO's incredibly sensitive mirrors, says he is now focused on future upgrades to LIGO that would detect gravitational waves at a rate 100 times higher than the current instrument.

"Right now we're looking through something like Galileo's telescope. We'd like to ultimately get to the gravitational wave equivalent of the Hubble Telescope," Gretarsson says. "It's still pretty insensitive given all the sources that are out there. We've just gotten to the point where we can hear things, and that required 40 years of effort."



The Embry-Riddle LIGO Group is now studying exploding stars, or supernovae. A 3-D model of a rapidly rotating, strongly magnetized supernova core collapse is pictured here, as produced by UC Berkeley researcher Philipp Mösta and Sherwood Richers of Caltech.

THE NEXT GENERATION

As excited as the researchers are about the new opportunities to pursue their research, they are equally excited about sharing the discovery with their students. All of them say they were attracted to Embry-Riddle because it offered an ideal mix of research and teaching.

"It's a pretty exciting place to be," says Hughey, who was a post-doctoral researcher at MIT with Zanolin. "My goal with research is to give students a hands-on experience in dealing with data and to participate as collaborators on real, active physics experiments. They are real researchers and are officially part of the collaboration."

In fact, Embry-Riddle undergraduate Kiranjyot "Jasmine" Gill is the youngest of the 1,004 authors on the paper announcing the detection and discovery of the merging black holes in the prestigious journal *Physical Review Letters*.

Kiranjyot 'Jasmine' Gill, the youngest author on the paper announcing the detection of merging back holes using gravitational waves, is now researching how often supernovae collapse in the local universe.

Gill: Embry-Riddle/Connor Mcshane; Supernova collapse: UC Berkeley/Philipp Mösta & Caltech/Sherwood Richers

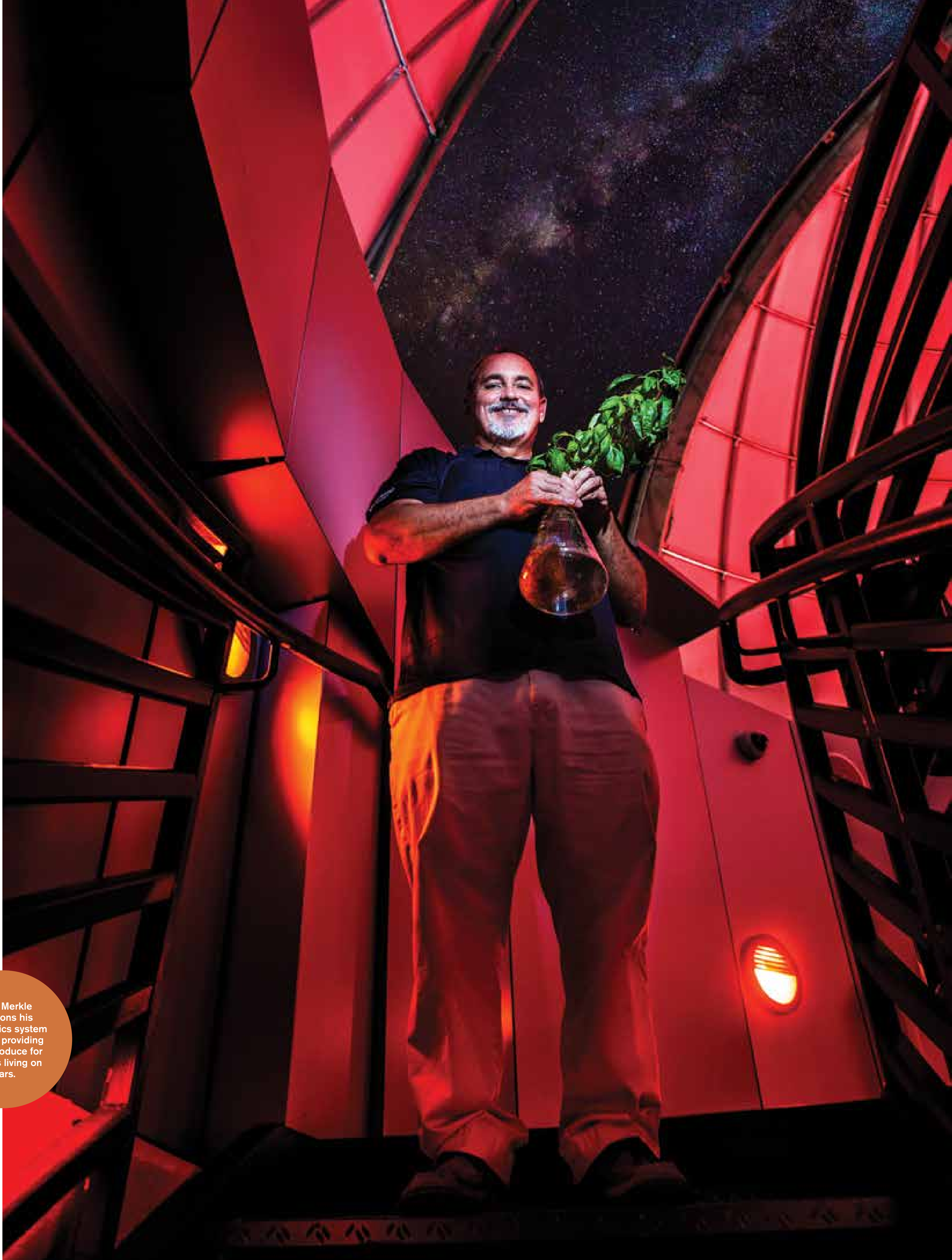
Gill, who aspires to be an astronaut, is presently working to improve how scientists identify gravitational waves that occur when a supernova collapses. Collaborating with Zanolin and Ph.D. student Marek Jan Szczepańczyk, she is researching how often these massive star explosions happen in the local universe, a region of approximately 1 billion light years in radius, to aid in future LIGO detections.

Szczepańczyk, who presented his work at the International Conference on General Relativity and Gravitation in New York last year, came to Embry-Riddle after finishing a master's degree in Poland. Now, he chairs the LIGO supernova research group.

"At a recent meeting, Ray Weiss and Kip Thorne, the founding fathers of LIGO, were talking quite a bit about supernovae, and here we are leading the world in supernova science. That's a good feeling," Szczepańczyk says.

It's students like these who inspire Zanolin.

"When someone is 20, they believe that everything is possible," he says. "When I'm working with them, I think the same way. Everything is possible." E-R



Peter Merkle envisions his aquaponics system one day providing fresh produce for humans living on Mars.

GROWING RESEARCH

BY MELANIE STAWICKI AZAM

AQUAPONICS LAB EXPLORES FOOD PRODUCTION FOR EARTH AND POSSIBLY MARS

Professor Peter Merkle can envision his research, which involves networks of eco-tubes full of plants, fish and fish waste, one day helping feed humans living on Mars.

"My idea is essentially to have a swamp on Mars," he says. "We have to learn how to maintain an ecosystem off the planet Earth."

But for now, the research being done in the Aquaponics Lab at Embry-Riddle Aeronautical University's Daytona Beach Campus is focused on creating a more sustainable food supply here on Earth.

Aquaponics combines fish farming, known as aquaculture, with hydroponics, which involves growing plants without soil, into one integrated, mutually beneficial system.

Here's how it works: The fish waste provides an organic, nutrient-rich fertilizer for the growing plants, and the plants act as a natural filter for the water in which the fish live. Beneficial bacteria in the aquaponics system convert the ammonia from the fish waste into nitrite and then nitrate, which fertilizes the plants. Water is cycled through the system to collect the fish waste, pump it to the plant beds, and then return it to the fish tank (see illustration on Page 23).

Aquaponics consumes minimal space and uses waste water to produce fresh, healthy food close to where people live. Indoor or enclosed aquaponics systems are inherently pesticide- and herbicide-free, and the fish waste is a natural alternative to chemical fertilizers.

"I think about the triple bottom line – environmentally sustainable, socially beneficial and economically viable," Merkle says. "Whatever you're doing with engineering, you've got to think about the triple bottom line."

TAKING AQUAPONICS INTO THE CLASSROOM

After 17 years of conducting research at Sandia National Laboratories in New Mexico, Merkle decided to make a career change. Hired as an associate professor of civil engineering at Embry-Riddle's Daytona Beach Campus in 2012, he built the Aquaponics Lab in 2013 with the help of his students.

"I'm interested in environmental systems, and I was struck by aquaponics as a way for students to understand an enclosed system," says Merkle, who created one of the first aquaponics courses in the country.

The lab is also a hands-on way to help students learn about environmental processes and sustainability. In the lab, fish, such as tilapia or koi, are kept in tanks, and plants are cultivated without soil in a rigid foam raft, called a grow raft, that floats in a pool of nutrient-rich water fertilized by the fish waste. One of the plants cultivated in the lab is a species of tree, *Moringa oleifera*, whose leaves are highly nutritious. Merkle is exploring the plant as a possible food source for space colonists.

"I think we were the first place to grow *Moringa* in aquaponics back in 2013," Merkle says.

Aquaponics systems are versatile and efficient food-growing systems. They can be built anywhere, including indoors or on top of a building. They can also be used with a variety of plants, and the fish can be harvested as a protein food source.

Opposite: Embry-Riddle/David Massey. This page: NASA/JPL/USGS.

AQUAPONICS SYSTEMS ARE VERSATILE AND EFFICIENT FOOD-GROWING SYSTEMS. THEY CAN BE BUILT ANYWHERE, INCLUDING INDOORS OR ON TOP OF A BUILDING.

***Above:* Mohammed Qahwaji, pictured in the Aquaponics Lab at the Daytona Beach Campus, is now a graduate of Embry-Riddle and has started his own aquaponics business in Saudi Arabia. *Inset:* Peter Merkle and two students install an aquaponics system at the Mars Society's Mars Desert Research Station.**

"Food production is very inefficient, and moving the production of food to a more accessible method is important," Merkle says. "Indoor agriculture and agriculture on the rooftops of buildings bring the food production closer to people."

FOOD FOR MARS

Merkle and his students are also researching the possibility of using aquaponics to produce food for future Earth colonists on Mars. "Whether we are on the moon or on Mars, the cost of bringing food would be extremely prohibitive," Merkle says.

However, one issue with operating an aquaponics system on Mars is electricity. "The challenge is to develop a system that consumes less energy and is more sustainable," Merkle says.

Bjorg Olafs, who graduated from Embry-Riddle in 2014, has made progress on that front. Through research she discovered a way to reduce energy consumption in an aquaponics system by 75 percent with no significant negative effect on crop or fish growth. Such a dramatic reduction in electricity demand would enable an aquaponics system to operate more economically and efficiently using solar power, a distinct advantage on Earth and a necessity on Mars, Merkle says.

"Aquaponics can be placed virtually anywhere since it does not require soil," explains Olafs, who designed a commercial-scale aquaponics unit for a geothermally heated greenhouse during an internship in Iceland. "The possibilities are endless, even in space colonization."

In 2015, Merkle and students Matthew Maccarrone and Connie Cuneo designed and constructed an aquaponics system at the Mars Society's Mars Desert Research Station in Utah, an outpost where teams hold mock missions simulating the

Embry-Riddle/David Massey

conditions on Mars. Merkle is involved in the station as a principal investigator for the GreenHab facility.

"With the increasing population, there is a higher demand for food but less and less space to grow it," Maccarrone says. "With controlled environments like an aquaponics system, the space could be used most efficiently. This is especially true for Mars colonization."

GROWING COMMERCIAL SUCCESS

Merkle's aquaponics course is growing more than plants; it's helping sprout new ventures in unexpected places. Civil engineering student Mohammed Qahwaji didn't plan to study aquaponics, but he was hooked after taking Merkle's course. He sees aquaponics as a solution to increasing food production in his home country of Saudi Arabia.

"Aquaponics is so important to Saudi Arabia, due to its lack of rivers, rain and suitable agriculture land in many areas," he says.

In 2015, Qahwaji created a business proposal as an assignment in Merkle's class to start an aquaponics business in Saudi Arabia. He then entered it in the U.S. National Saudi Student Entrepreneur competition. With a minor in business administration, he placed fourth out of 200 and was promised $1.5 million in startup funding from the Saudi government.

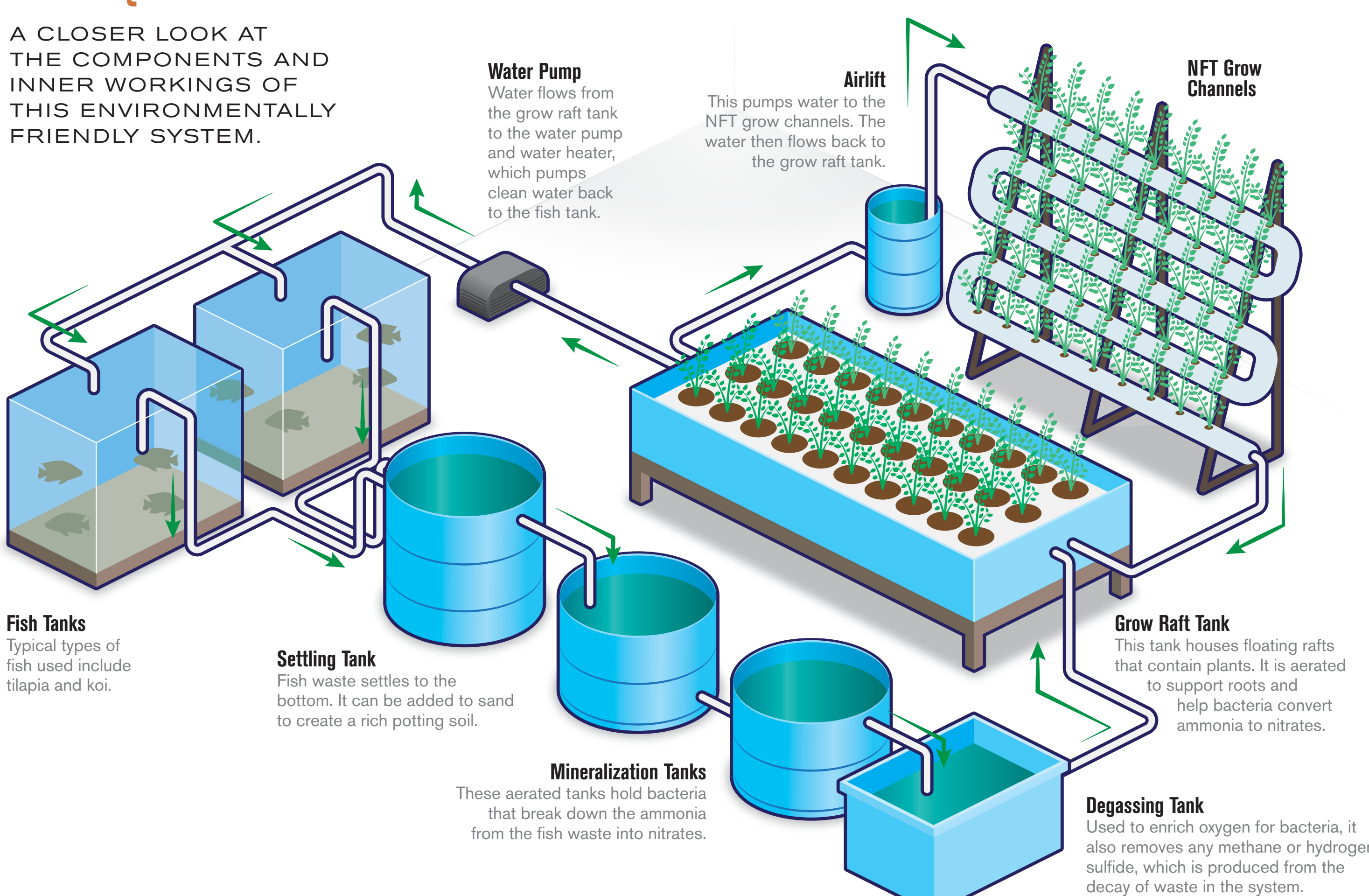
After graduation, Qahwaji enrolled in a hands-on aquaponics course at Morningstar Fisherman in Florida, and then interned at Olomana Gardens Farms in Hawaii. In Hawaii, he visited more than 60 different aquaponics facilities, ranging from backyard setups to commercial systems, and completed a course on water chemistry in aquaponics systems at the University of Hawaii.

Wanting to start his business off small, he declined the Saudi government loan, and in 2016, he self-funded his company, which offers design, installation, maintenance, operation and consultation for home and commercial aquaponics systems.

"My life has now become dedicated to aquaponics," Qahwaji says. "All of this started with Dr. Merkle and Embry-Riddle. All my success is credited to them." ER

HOW AQUAPONICS WORKS

A CLOSER LOOK AT THE COMPONENTS AND INNER WORKINGS OF THIS ENVIRONMENTALLY FRIENDLY SYSTEM.



SPACE CRAFT

Meet an Embry-Riddle professor whose research is helping write the space policies and laws of the future

BY MELANIE STAWICKI AZAM

Growing up in Florida during the Cuban Missile Crisis, Diane Howard recalls hiding under her desk at school for bomb drills.

But she also remembers her excitement watching space launches from Cape Canaveral. The contrast between those two experiences made a lasting impact on her.

"You would go outside and look up at the sky," says the assistant professor of commercial space operations at Embry-Riddle Aeronautical University's Daytona Beach Campus, "and the launches just seemed so much more positive to me and so full of promise."

Those experiences fueled Howard's desire to help craft space policies and laws encouraging global cooperation and innovation. Her research focuses on sustainability of space activities, the dynamics of interagency interaction and issues pertaining to all aspects of space traffic management and coordination.

Embry-Riddle/David Massey

MAKING SPACE A SAFER PLACE

Much of Howard's work is directed at making space activities safer, including getting space vehicles into and out of controlled airspace without disrupting general and commercial flight operations. To that end, Howard is currently principal investigator on a set of projects for the Federal Aviation Administration (FAA) that deals with integrating commercial space activities into the National Airspace System (NAS).

"I think the work that we have been doing with the FAA is pretty groundbreaking," Howard says, "because the United States has the most developed body of space regulations, and the FAA is the largest aviation navigation space provider globally. Aligning the regulations relevant to all stakeholders is complex."

Her research aims to provide technical expertise to FAA officials as they plan for an increase in space vehicle operations. Howard's work includes performing research and analysis of FAA Air Traffic Organization regulations, policies, procedures and orders pertinent to space vehicle operations, as well as international coordination issues for integration of space activities into NAS operations.

She is also working with the FAA to get safety approval for a space flight simulator at the university. Embry-Riddle has the only spaceflight simulator connected to an undergraduate university program, Howard says, and this student-focused, student-driven research offers a unique opportunity for undergraduates to interface with the FAA's Office of Commercial Space Transportation on a real application in real time.

TEAMING UP FOR THE GREATER GOOD

Howard serves as executive secretary of the International Institute of Space Law, and in October 2016, she was a member of the Project PoSSUM (Polar Suborbital Science in the Upper Mesosphere) program, which is training citizen scientist-astronauts to conduct research on commercial space vehicles. She also chairs the annual Space Traffic Management conference at Embry-Riddle's Daytona Beach Campus and is a private sector adviser/subject matter expert who has worked with the U.S. State Department.

"The original space treaties were written based upon a tenet of international cooperation for the good of all of us," she says. "There was an understanding that this could be a game changer – and it has been and will continue to be."

The field of space law and policy is a growing and evolving field, and a lot of questions remain to be answered, she says. Issues like which agency should oversee space activities, such as resource extraction and traffic management; the need for and extent of safety standards; the coordination of activities in orbit; and dealing with debris.

"Trying to manage the overlap between different jurisdictions is far more proactive than allowing conflict to escalate," Howard says. "It's counterproductive to allow fear and paranoia to curtail some of the amazing things our technology can make possible."

> "Space always provided this paradigm of hope, positivity and opportunity for like-minded and higher-minded individuals to work together towards a common objective."
>
> DIANE HOWARD, ASSISTANT PROFESSOR OF COMMERCIAL SPACE OPERATIONS AT EMBRY-RIDDLE

Opposite: Diane Howard shows off Embry-Riddle's space flight simulator, which is used to train citizen-astronauts for the Polar Suborbital Science in the Upper Mesosphere program.

A CIRCUITOUS CAREER TRAJECTORY

Despite a lifelong interest in space, Diane Howard's pursuit of a career in space law came later in life. She was in her early 40s when she left a successful career in the fashion industry to attend law school.

After working as a staff attorney in the Florida appellate courts for several years, Howard decided to specialize in space law and attended McGill University's Institute of Air and Space Law in Montreal, Canada, where she earned a Master of Laws degree and a Ph.D. Her master's thesis centered on private space law issues, while her doctoral work focused on effective spaceport regulation.

Initially, she had planned to teach space law at a law school, but that changed after she met Professor Lance Erickson at a conference. Erickson, who spearheaded the commercial space operations program at Embry-Riddle before his recent retirement, encouraged her to join his team.

Howard says she didn't want to limit herself to simply writing and presenting papers to the legal academic community. Teaching in Embry-Riddle's interdisciplinary commercial space operations program allows her to make a broader impact and help develop a pipeline of space sector workers who understand responsible behavior in space.

"When students get the big picture, there is nothing better for me than knowing that they get it," she says. "It's exciting seeing our students go out into the world and do good things."

A MODEL FOR GOOD BEHAVIOR

Linda M. Pittenger identifies key behaviors that set superior aviation and aerospace leaders apart

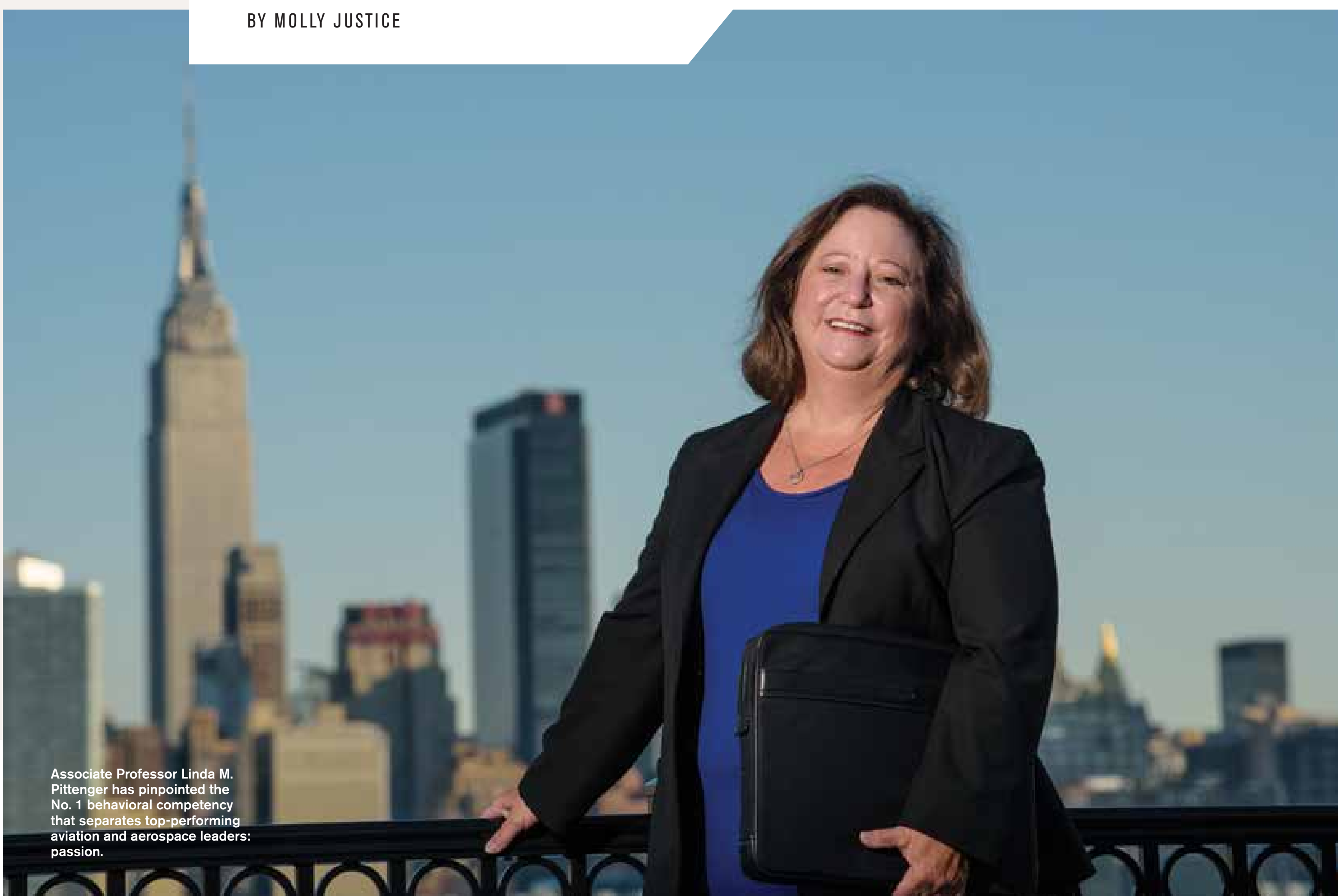
BY MOLLY JUSTICE

Is there a silver bullet for aviation and aerospace organizations in search of superior performing leaders? Maybe not, but one Embry-Riddle researcher is helping narrow the field by identifying the behaviors that distinguish top performers.

Linda M. Pittenger, associate professor at the College of Business at Embry-Riddle Aeronautical University's Worldwide Campus, has identified several "behavioral competencies" that distinguish superior performers in aviation and aerospace leadership roles.

No. 1 on the list? Passion.

"Superior performing leaders exhibited passion for their work, enthusiasm for their peers and subordinates, and excitement for the aviation and aerospace industry, while average performing leaders did not," Pittenger says. "Superior performing leaders shared a deep commitment to their work and an obsession-like love for the aviation and/or aerospace industry."



Associate Professor Linda M. Pittenger has pinpointed the No. 1 behavioral competency that separates top-performing aviation and aerospace leaders: passion.

In her qualitative research study, *Leadership Metamorphosis: Behavioral Competencies that Distinguish Superior Performing Leaders in Aviation and Aerospace*, Pittenger also uncovered that superior performing leaders take the time to build relationships at all levels of the organization and also with key external influencers.

"For example, superior performing leaders relate well to their followers and are often seen as 'one of them,'" she says. "They form close bonds with peers and those senior to them who can provide them with resources and opportunities. They develop and nurture a network of industry relationships who expose them to emerging trends and/or can provide solutions to technical or organizational issues."

Pittenger's findings are the result of a rigorous and systematic analysis of data collected from 112 one-hour, semi-structured interviews with average and superior performing leaders at Southwest Airlines, United Airlines, JetBlue, Northrop Grumman, Rolls-Royce/American Airlines (formerly Texas Aero Engine Services), Bell Helicopter, FedEx and the U.S. Federal Aviation Administration.

The study's findings supported the prevailing conceptual model guiding the research, which recognized that job performance may be affected by a specific set or combination of behavioral competencies influenced by job demands, interpersonal relationships and organizational climate.

FROM C-SUITE TO ACADEMIA

Pittenger first became interested in behavioral competencies when she was chief information officer at AT&T.

"I wanted to know which behaviors differentiated the most effective leaders. If I knew the unique behaviors, I could hire, develop and promote for those behaviors. After developing and implementing a behavioral competency model in my organization, I witnessed improved employee satisfaction and increased engagement and performance," she says. "This inspired me to dig deeper. I was hooked on behavioral competencies."

After leaving AT&T to start her own business, Pittenger used behavioral competencies as the foundation for all hiring decisions and talent management. The company was profitable in nine months, and she sold it four years later to a Fortune 100 company.

Pittenger's career path has taken her from Wall Street to academia, where she now blends her professional experiences with her academic skills to define her research initiatives. Citing reports that identify lack of leadership talent as a No. 1 concern for executives, she is expanding her research focus to understand what behavioral competencies drive successful leaders in digital business and the business of innovation.

Pittenger finds that executives often don't achieve the improvements they seek because they settle for "off-the-shelf" consultant advice, rather than invest in initiatives, such as research-based solutions that support their culture and align with the organization's mission, vision and strategic plan.

"Behaviors are more predictive of performance than IQ, and there is so much that can be and should be done in organizations to increase leadership effectiveness, especially the performance of those in key roles," she says. "The C-Suite should prioritize building a strategic people plan. They need to pay attention to and gain an understanding of which behaviors differentiate superior performers in critical roles such as leadership, project management and technology. Doing so will most certainly result in improved performance."

CRACKING THE CODE OF TOP PERFORMANCE: THE METHODOLOGY

How exactly do you pinpoint behaviors that translate to leadership? First, Linda M. Pittenger, associate professor at the College of Business at Embry-Riddle's Worldwide Campus, identified superior performers on the basis of having achieved the highest possible performance appraisal/review rating, while average performers were selected on the basis of appraisals documenting average or fully met objectives. The performance status of each participant, however, was not revealed to the researcher until the analysis stage of the research.

Next, a strict interview protocol was developed and used. All interviews were recorded, and respondents were asked to recall and narrate recent specific events reflecting perceptions of effectiveness. The transcribed interviews were rigorously coded to identify fragments of text with potential significance. A codebook was then developed to convert open-ended responses and behaviors into a set of quantified variables, forming the findings.

Passion and relationship-building emerged as two of the behavioral competencies of superior performing aviation and aerospace leaders. Additional findings will be included in research articles that are pending publication in academic and industry journals.

"Superior performing leaders relate well to their followers and are often seen as 'one of them.' They form close bonds with peers and those senior to them who can provide them with resources and opportunities."

LINDA M. PITTENGER, ASSOCIATE PROFESSOR AT THE COLLEGE OF BUSINESS AT EMBRY-RIDDLE'S WORLDWIDE CAMPUS

Richard Stansbury

SAFE AND ASSURE

Embry-Riddle researchers are shaping the future of UAS integration

Richard Stansbury knows a thing or two about unmanned aircraft systems (UAS). He's Embry-Riddle Aeronautical University's principal investigator for the Alliance of System Safety for UAS through Research Excellence, or ASSURE, the Federal Aviation Administration's (FAA) Center of Excellence for UAS. When ASSURE launched in 2015, Embry-Riddle was named the technical lead for research involving air traffic integration, and co-lead in pilot and crew training. We recently spoke with Stansbury to learn more about this groundbreaking research center.

Q: What is the ASSURE team's current research focus?

A: As of today, we have two projects nearly complete and two ongoing. These include a ground collision study that's determining the level of human injury and damage to property that might occur should a UAS crash over a populated area. In this study, we're modeling human injury based off of a UAS strike. In a second project, we're determining maintenance repair and modification requirements for UAS and necessary training for maintainers. This project includes using simulated scenarios to study maintenance-induced failures and the impact of those failures – the levels of risk associated with systems failures that could be mitigated by maintenance. We are also using simulation to validate minimum performance standards for detect-and-avoid technology. Additionally, we're developing pilot and crew processes and operational requirements based on a mockup control station created by ASSURE partner Drexel University. The idea is to establish a minimum set of control station requirements and procedures to assure safe and reliable operations.

Q: Are there any findings to report from the ASSURE center to date?

A: The FAA is not allowing us to share any end results or conclusions yet, but I can tell you that our work will definitively assist in creating UAS policy and regulations. UAS are no longer just a concept, a novelty. They are becoming a disruptive technology within our world. It's vitally important that we make sure their integration is as safe as possible.

Q: What is the most critical issue for ASSURE to address?

A: It's widely agreed in the industry that a secure communication frequency and available spectrum is most important because the system needs solid, reliable datalinks between operators and aircraft, as well as a communications system that allows UAS to be handled separately, to include detect-and-avoid technology and air traffic management. Traditional file-and-fly UAS operations similar to manned aviation is the goal for UAS operations. The plan is to get UAS to a point where they are taking off and landing at an airport or airfield (towered and non-towered).

Q: Does the announcement of Part 107 small UAS regulations impact your research?

A: Part 107 rules are the first addition to FAA regulations that specifically address UAS. The regulations only pertain to small UAS – just a subset of UAS that are operating – and they are fairly limited. For example, the regulations state that maintenance is required to ensure airworthiness of an aircraft, but there is no definition of what that entails. Our research will inform future policy that will ultimately provide these necessary details for Part 107 and other regulations that develop.

Q: Are there other FAA regulations on the horizon for UAS operations?

A: In March 2016, the FAA convened a rulemaking committee focused on micro UAS. Presently, micro UAS fall under Part 107 rules. Regulations specific to micro UAS could allow for broader operations over people and property. My guess is that the FAA will continue with its crawl-walk-run approach to passing regulations. There are so many types of UAS that they have to be cautious with how they allow their entry. They are bringing different elements into the law as they determine safety.

/SARA WITHROW

GET THE LATEST UAS UPDATES

To find out more about ASSURE's cutting-edge research, visit **assureuas.erau.edu.**

Embry-Riddle/David Massey

CENTERED ON INNOVATION

Embry-Riddle's AERIS center will focus on technical training for aviation industry professionals

Embry-Riddle Aeronautical University is growing and developing its research capabilities through several centers, many of which are nationally and internationally recognized.

The newest research center to join the university is the Air Transportation Center of Excellence for Technical Training and Human Performance, nicknamed AERIS, which is Greek for air. The Federal Aviation Administration (FAA) is expected to invest $5 million over the next five years in this public-private partnership, which includes a team of top-tier academic research institutions and more than 20 industry partners.

"We are honored that the FAA chose an Embry-Riddle-led team to conduct research needed to transform training for its 22,000-employee air traffic organization workforce," says Karen Holbrook, interim university president. Embry-Riddle will lead research and development on technical training for air traffic controllers, aviation safety inspectors, engineers, pilots and technicians, with a focus on human performance. Other research centers at Embry-Riddle include:

$5 MILLION

The amount of money the FAA is expected to invest in AERIS over the next five years.

Embry-Riddle/David Massey

Eagle Flight Research Center (EFRC)

The university's aerospace/aviation research and development facility, EFRC conducts experimental flight testing, aircraft modifications for FAA certification, and design and testing of aircraft and unmanned aerial systems.

→ *Read about a current EFRC project on Page 8.*

Robertson Aviation Safety Center (RASC)

As a professional development, outreach and consulting organization, RASC offers opportunities for advanced professional training, consulting on safety projects with corporate partners and applied research activities.

Center For Space and Atmospheric Research (CSAR)

This center explores the fundamental physics of planetary atmospheres and space environments.

→ *Turn to Page 12 to read about an exciting CSAR discovery.*

Cybersecurity and Assured Systems Engineering Center (CyBASE)

CyBASE is composed of Embry-Riddle faculty members who conduct research in cybersecurity associated with critical infrastructures and assured systems, such as aviation and aerospace systems. It's also involved in projects that include embedded systems security, aviation and aerospace cybersecurity, digital forensics and cloud computing security.

→ *To learn more about CyBASE, see Page 7.*

Center for Wildlife and Aviation

By combining Embry-Riddle's resources with those of other institutions, including the FAA, the U.S. Department of Agriculture (Wildlife Services), the Department of Defense (Air Force and Navy) and the Bird Strike International Committee, the center seeks to collect, maintain and disseminate relevant bird strike data and bird strike research; to promote wildlife mitigation training, policies and plans; and to bridge the gap between the scientific community and stakeholders.

Alliance for System Safety of UAS Through Research Excellence (ASSURE)

Embry-Riddle is a founding member of the 21-member coalition of research universities dedicated to unmanned aerial systems safety, known as ASSURE.

→ *See opposite page to learn more about ASSURE.*

Next Generation Air Transportation System (NEXTGEN) Facility

NextGen is an FAA initiative in which government, industry and academia work together to transform and modernize the nation's air traffic control system, shifting from ground-based radar to satellite-based technology. The FAA has contracted Embry-Riddle to operate its Florida NextGen Test Bed facility, located in Daytona Beach, Fla.

Southeast Association for Research In Astronomy (SARA)

This 12-university consortium led by Embry-Riddle operates 1-meter class telescopes for astronomical research and education at Kitt Peak National Observatory in Arizona, Cerro Tololo Inter-American Observatory in Chile and the Canary Islands off the African coast. SARA telescopes are accessible over the internet in real time.

EMBRY-RIDDLE
Aeronautical University

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EMBRY-RIDDLE IS 'GO' FOR RESEARCH

Here at the world's largest aerospace and engineering-oriented university, our focus on applied research is unique.

Known as the world's leader in aviation and aerospace education, Embry-Riddle is equipped for and experienced in research, specifically associated with its seven areas of focus: Applied Science, Aviation, Business, Computers and Technology, Engineering, Safety, Security and Space.

Opening for business in 2017, the John Mica Engineering and Aerospace Innovation Complex (MicaPlex) is the cornerstone building of the Embry-Riddle Research Park. This unique 50,000-square-foot, cutting edge innovation hub is designed to support partner companies and organizations with research in aviation, space, engineering, unmanned systems and the environment.

MICAPLEX
THE JOHN MICA ENGINEERING & AEROSPACE INNOVATION COMPLEX
at the EMBRY-RIDDLE Research Park

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