FOCUS

UAH Research Magazine // Fall 2016

ALABAMA ACCOLADE

National Academy of Sciences elects Dr. Gary Zank full member

page 4

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

KEY CONTACTS

VICE PRESIDENT FOR RESEARCH AND ECONOMIC DEVELOPMENT
Dr. Ray Vaughn
(256) 824-6100
Ray.Vaughn@uah.edu

ASSOCIATE VICE PRESIDENT FOR RESEARCH AND ECONOMIC DEVELOPMENT
Dr. Thomas Koshut
(256) 824-6100
Tom.Koshut@uah.edu

ASSOCIATE VICE PRESIDENT FOR RESEARCH AND ECONOMIC DEVELOPMENT
Dr. Robert Lindquist
(256) 824-6100
Robert.Lindquist@uah.edu

OFFICE OF RESEARCH SECURITY
Denise Spiller
Security Administrator
(256) 824-6444
Denise.Spiller@uah.edu

OFFICE OF SPONSORED PROGRAMS
Gloria Greene
Director
(256) 824.2657
Gloria.Greene@uah.edu

OFFICE OF TECHNOLOGY COMMERCIALIZATION
Kannan Grant
Director
(256) 824-6621
Kannan.Grant@uah.edu

OFFICE FOR PROPOSAL DEVELOPMENT
Dr. Virginia (Suzy) Young
Director
(256) 829-3448
Suzy.Young@uah.edu

CENTER FOR APPLIED OPTICS
Dr. Robert Lindquist
Director
(256) 824-6100
Robert.Lindquist@uah.edu

CENTER FOR CYBERSECURITY RESEARCH AND EDUCATION
Dr. Tommy Morris
Director
(256) 824-6576
Tommy.Morris@uah.edu

CENTER FOR SPACE PLASMA AND AERONOMIC RESEARCH
Dr. Gary Zank
Director
(256) 961-7401
Gary.Zank@uah.edu

EARTH SYSTEM SCIENCE CENTER
Dr. John Christy
Director
(256) 961-7763
John.Christy@nsstc.uah.edu

INFORMATION TECHNOLOGY AND SYSTEMS CENTER
Dr. Sara Graves
Director
(256) 824-6064
Sara.Graves@uah.edu

PROPULSION RESEARCH CENTER
Dr. Robert Frederick
Director
(256) 824-7200
Robert.Frederick@uah.edu

RESEARCH INSTITUTE
Dr. Steven Messervy
Director
(256) 824-6881
Steven.Messervy@uah.edu

ROTORCRAFT SYSTEMS ENGINEERING AND SIMULATION CENTER
Dave Arterburn
Director
(256) 824-6846
arterbd@uah.edu

SYSTEMS MANAGEMENT AND PRODUCTION CENTER
Dr. Gary Maddux
Director
(256) 824-0635
Gary.Maddux@us.army.mil

Dr. Ray Vaughn

Excitement at UAH

Welcome to this edition of FOCUS, UAH's research magazine. We are excited by UAH's growth and by its successes – many of which are highlighted in these pages. We are very pleased to see Dr. Gary Zank elected to the National Academy of Sciences (NAS) – the highest honor that a scientist can receive and recognition of his many accomplishments in space science. Dr. Zank is the director of UAH's Center for Space Plasma and Aeronomic Research as well as the chair of the Department of Space Science. His work with NASA, the National Science Foundation and other sponsors has led to advances in theoretical space physics and greater understanding of the heliosphere. Dr. Zank is the only current full NAS member in the State of Alabama and we are very proud to call him our own.

We also focus on Marshall Space Flight Center in this issue. Marshall has been a longtime partner of UAH, and in many ways was largely responsible for the founding of UAH through the efforts of Dr. Wernher von Braun. Our initial mission statement included "support to Marshall Space Flight Center" and we have executed that mission over the many ensuing years with a great deal of pride and competence. Working in partnership with MSFC scientists in Cramer Hall on the UAH campus has resulted in a strong alliance unlike that found on most university campuses. We feel a part of the Marshall family and the NASA mission.

Our alumni focus feature is on Jim Hudson, cofounder and chairman of the HudsonAlpha Institute for Biotechnology. The relationship between HudsonAlpha and UAH has been exceptionally productive and has provided teaching opportunities for world-class HudsonAlpha scientists at UAH and opportunities for UAH faculty to incubate businesses and work alongside HudsonAlpha on a daily basis. A world-class scientist and entrepreneur, Jim creates contagious enthusiasm for his work. We are proud to count him among our graduates.

UAH has a long history of propulsion research and is pleased to be celebrating the 25th anniversary of the UAH Propulsion Research Center. The achievements of this center are contained within this issue and the event itself will take place Oct. 13-14 at UAH. This center has not only produced many technical achievements, it has also been the classroom for a large number of propulsion students who have gone on to great careers in this area.

This issue also comes at the beginning of the 2016-2017 academic year, which will see the largest enrollment in UAH history and continued growth on our campus. That growth will include a new business incubator located adjacent to our College of Business Administration, a new dormitory to house our rapidly growing student population and new Greek housing. If you have not been on our campus recently, please come and take a look. You will be pleasantly surprised.

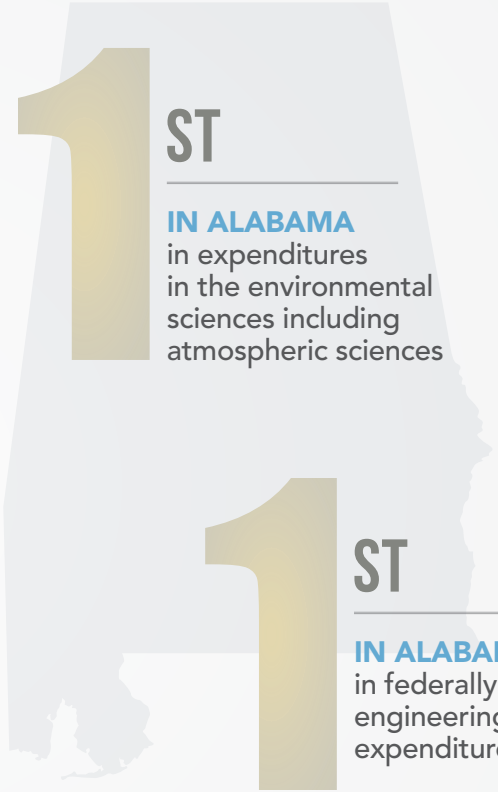
It is our hope that this magazine helps to maintain our connection with the Huntsville community and our many sponsors. We are so privileged to do the work that we do and at the same time, we are proud of the accomplishments that our faculty, staff, students and alumni have achieved. My office is available to provide information on the efforts featured in this magazine or any other research project ongoing at UAH. ■

TABLE OF **CONTENTS**

COVER: UAH's Dr. Gary Zank is Alabama's only current full member of the National Academy of Sciences (NAS).

UAH RANKS AMONG THE NATION'S BEST in research productivity, according to the National Science Foundation – **28TH** nationally in research expenditures per faculty and research staff.

IN ALABAMA



1ST

IN ALABAMA in expenditures in the environmental sciences including atmospheric sciences

1ST

IN ALABAMA in federally funded engineering research expenditures

NATIONALLY

- **5TH** Federally financed aeronautical/ astronautical engineering research
- **11TH** Federally financed atmospheric sciences research expenditures
- **12TH** Federally financed computer sciences research expenditures
- **13TH** NASA R&D expenditures
- **16TH** Federally financed business and management research
- **17TH** Federally financed astronomy research expenditures
- **19TH** Department of Defense R&D expenditures

RESEARCH

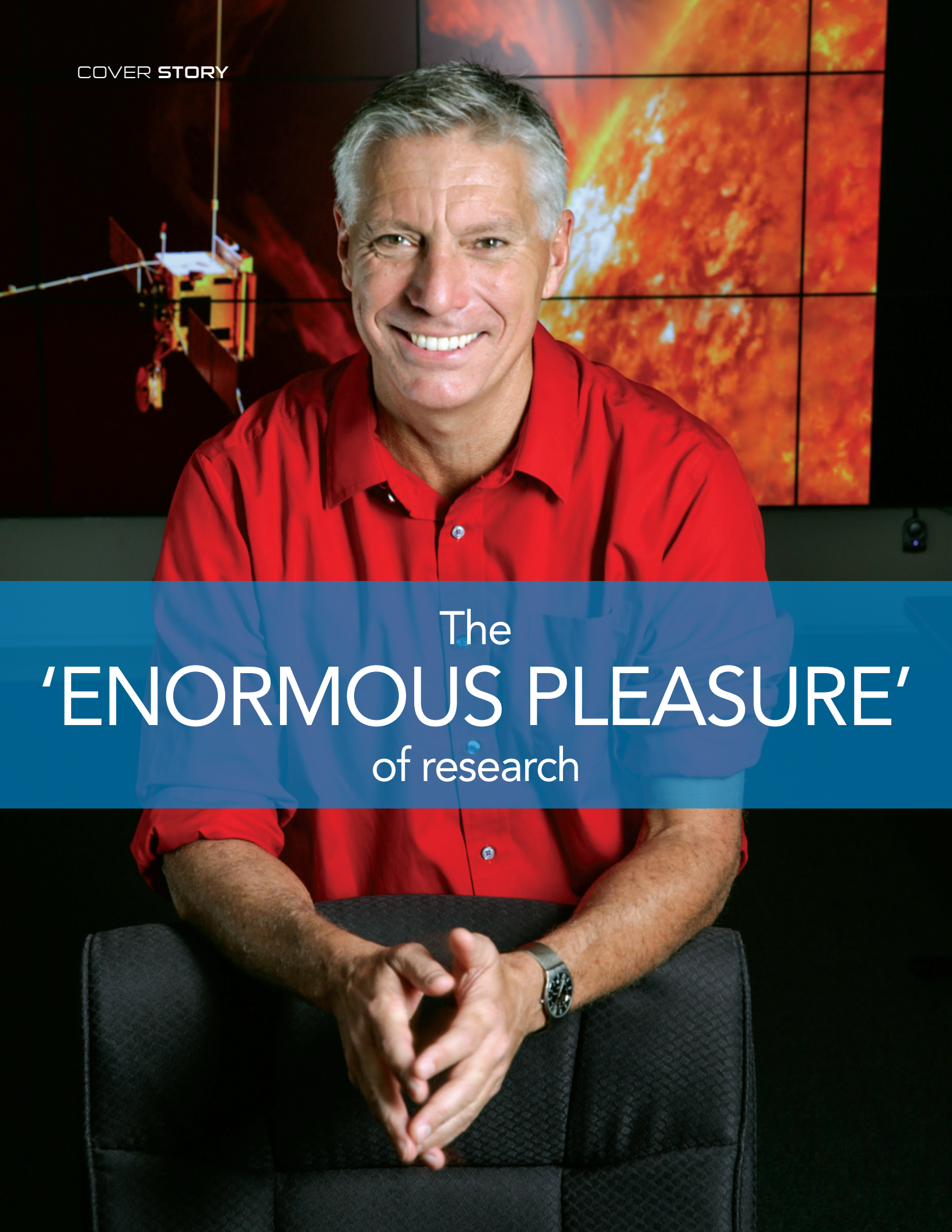
$437 million
Five-year contract and grant research total

$5 million
Five-year license and royalty total

$88 million
Fiscal 2015 research total

PATENT TOTAL – 59

SOURCE: NSF Herd Survey



The ‘ENORMOUS PLEASURE’ of research

National Academy of Sciences elects Dr. Gary Zank as member

When the National Academy of Sciences (NAS) elected him as Alabama's only current full member of that august body, UAH's Dr. Gary Zank says the experience was "surreal."

The well-traveled, world-renowned space physicist, an eminent scholar and distinguished professor who directs UAH's Center for Space Plasma and Aeronomic Research (CSPAR) and chairs its Department of Space Science, says his early May notification was a pleasant start to his day.

"I received a phone call in the morning from a close colleague who is a member of the NAS to tell me that I had been elected, and then another call from another close colleague at the NAS annual meeting, who then passed the phone around to many of those present," he says. "It's difficult to both express one's feelings about being elected – it's not something that one works to or aspires to, it simply happens – while wanting to thank everyone for supporting my candidacy."

He was welcomed into a select group. Established under a congressional charter signed by President Abraham Lincoln in 1863, the private, nonprofit NAS recognizes achievement in science by election to membership, and – with the National Academy of Engineering and National Academy of Medicine – provides science, technology and health policy advice to the federal government and other organizations. This year, the NAS elected 84 new members and 21 foreign associates from 14 countries in recognition of their distinguished and continuing achievements in original research. Those elected bring the total number of active members to 2,291 and the total number of foreign associates to 465. Foreign associates are nonvoting members of the academy, with citizenship outside the United States.

"It was a powerful moment, perhaps more because I recognize that this truly represents an honor that is shared by all the people I have been fortunate to work with, the people who have been with me in my life – especially Adele Corona – who have encouraged and supported my work and ideas and ambitions," says Dr. Zank. "It is not and never can be simply a reflection on me, but it reflects the wonderful people I have been fortunate enough to share my life and career with.

"So in many respects, yes, it's a powerful moment, but more especially a humbling moment because this is not a journey that I took by myself. I have no idea how to express my profound thanks to everyone who has been part of my life and career but, somehow, I would like to reach across and recognize them all and thank them all."

Dr. Zank's NAS membership followed his June 2015 receipt of the Axford Medal, the highest honor given by the Asia Oceania Geosciences Society (AOGS), an organization similar to the American Geophysical Union (AGU), at the society's annual general assembly. The medal acknowledges an individual for outstanding achievements in geosciences, including planetary and solar system science,

as well as unselfish cooperation and leadership in Asia and Oceania. Oceania refers to the broader Pacific Ocean region excluding the Asian region.

A driving force behind the creation of the university's Department of Space Science, the South Africa-born Dr. Zank's research at UAH has included study of the heliosphere, the area of space influenced by the solar wind, and solar weather and plasmas. He has also applied his computational modeling expertise to biologically invasive species and homeland security inquiries.

His scientific and computational interests have encompassed design of space architectures and the missions needed to provide the raw data for such research, as well, including UAH's role in NASA's Solar Probe Plus mission, slated for launch in 2018.

Currently, Dr. Zank and UAH post-doctoral student Xiaocan Li are developing a theoretical computational model to investigate the results of NASA experiments on a new kind of long-distance solar space propulsion system called the Heliopause Electrostatic Rapid Transit System Electric Sail (HERTS E-Sail). The models will extend that laboratory simulation to conditions appropriate to the solar wind and be developed into an engineering tool that will aid in cost-effective mission design.

Gifted with both mathematical ability and eloquence in describing physics research

▲ **Dr. Gary Zank** is a driving force behind the creation of UAH's Department of Space Science.

"There is an enormous pleasure to be derived from understanding something about nature that has not been understood, and it stems as much from an inner creativity as an ability to formulate problems mathematically and solve them."

– Dr. Gary Zank

visually to the lay person, Dr. Zank says he keeps at the research because it's a pleasure to him rather than work.

"I would almost always rather go home and work on my research than watch TV or movies. So my typical routine is to do the research after work, generally five nights or more a week and typically until 1 a.m. or later. I get far too little time to spend on research at work since I have basically two administrative jobs during the day," he says. "While important, especially from the perspective of building up CSPAR and building a brand new Space Science academic program, both these jobs are time consuming and correspond to 'work.' By contrast, research is something that I do for pleasure and so an evening working on an interesting problem is as pleasurable as just about anything else that I can think of.

"There is an enormous pleasure to be derived from understanding something about nature that has not been understood, and it stems as much from an inner creativity as an ability to formulate problems mathematically and solve them," says Dr. Zank. "Many of my colleagues feel much the same. So the drive to do research is something that is deeply innate, and it never feels like work, and the drive to do it comes from the pleasure of understanding. Perhaps there is also a sense of contributing to the creation of knowledge and the broadening of culture that somehow renders one's purpose on Earth meaningful. I cannot see myself ever slowing down and I would like to find more time to fit in more research."

Joining UAH and CSPAR in 2008 was "a wonderful further catalyst" for the NAS membership, Dr. Zank says.

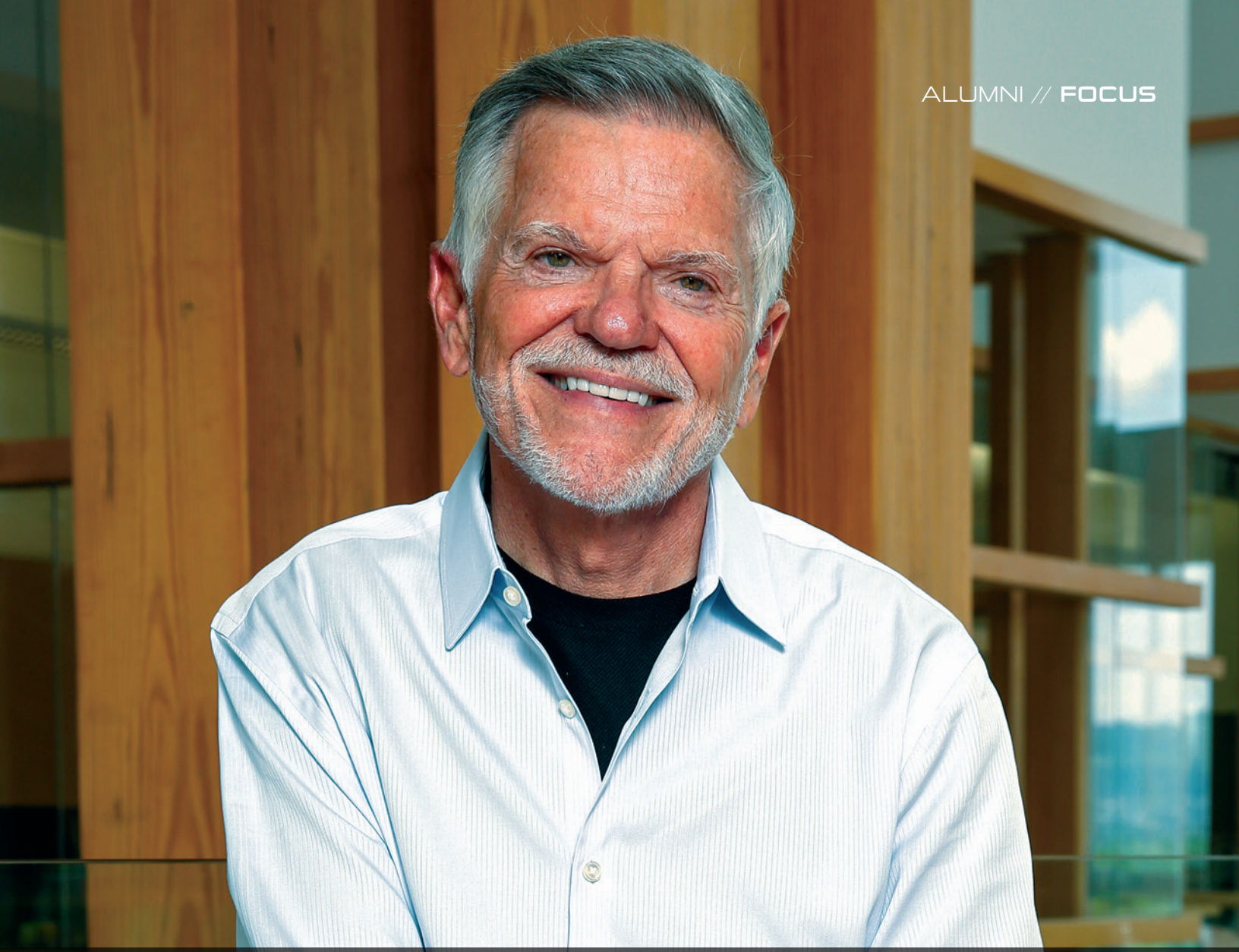
"I have been blessed to work with outstanding vice presidents of research at UAH, and Dr. Ray Vaughn has been one of CSPAR's and my greatest supporters. The guidance and encouragement from Dr. Vaughn and his predecessors has truly allowed CPSAR to flourish and for me to work in an environment that contributed to my being elected to the NAS," he says.

"I was fortunate, too, in that the foresight of both the previous and current presidents led to the creation of an environment that allowed for the development and flourishing of a great research group in space physics. President David Williams had the foresight to make a bold move in offering me both a position and six faculty lines to continue the development of space science at UAH. President Robert Altenkirch took this further in his equally bold move in creating the new Department of Space Science.

"Both these steps and the support of the VPRs, and their willingness to tie CSPAR and the academic Department of Space Science together closely, have contributed enormously to creating what is becoming one of the top – if not the top – group in the world in terms of theoretical space physics," he says. "So I applaud both presidents and all the VPRs for their meaningful, far-sighted and positive goals in creating a world-class group of scientists. All of these actions have contributed greatly to my being elected to the NAS." ■

PROBING THE GENETICS OF BEHAVIOR

How much impact do genes have on behavioral changes? In his current research, UAH assistant professor of biological science Dr. Luciano Matzkin wants to find out. "We are looking at the genetic basis of behavior and how the environment shapes genomes over generations," he says. "That will help us to understand in general the evolution of behaviors in other species." His efforts to better understand the genetic underpinnings of ecologically relevant behaviors have been awarded $612,000 by the National Science Foundation (NSF). That's just one of the fundamental biological questions being probed in Dr. Matzkin's Shelby Center for Science and Technology lab. Others include how the ecology of a species shapes patterns of variation from genes to genomes, how populations adapt to environmental shifts and the implication of ecological adaptation in the process of speciation. The lab primarily studies a group of cactophilic *Drosophila* fruit flies that inhabit the deserts of North America. Past research has shown the benefit of a maternal larvae protein diet versus sugar in subsequent generations of the small flies, which have many human similarities. The lab focuses on the study of the genetic basis of adaptation; analysis of genome evolution via sequencing and assembly; examining the role of gene expression changes in evolution; the effects of ecological adaptation in behavioral evolution and its effects on reproductive isolation; speciation genetics/genomics; the relationship between molecular, expression and life history variation and evolution; and using new genome editing techniques CRISPR-Cas9 to assess the functional consequence of variants in an ecological context. Dr. Matzkin is also an adjunct faculty investigator at Huntsville's HudsonAlpha Institute for Biotechnology. ■



ENVISIONING PRESSING HEALTH ISSUE SOLUTIONS

When HudsonAlpha opened its doors in 2008, founders Jim Hudson and Lonnie McMillian envisioned a place where scientists, entrepreneurs and educators would come together to solve some of the world's most pressing health issues. Today, HudsonAlpha has over 30 associate companies, 16 faculty investigators and is one of the top sequencing centers in the nation.

Hudson received a master's degree in biology from UAH. As a scientist and businessman, Hudson's investments have made profound impacts in the advancement of biotechnology, not only in Alabama but also throughout the world.

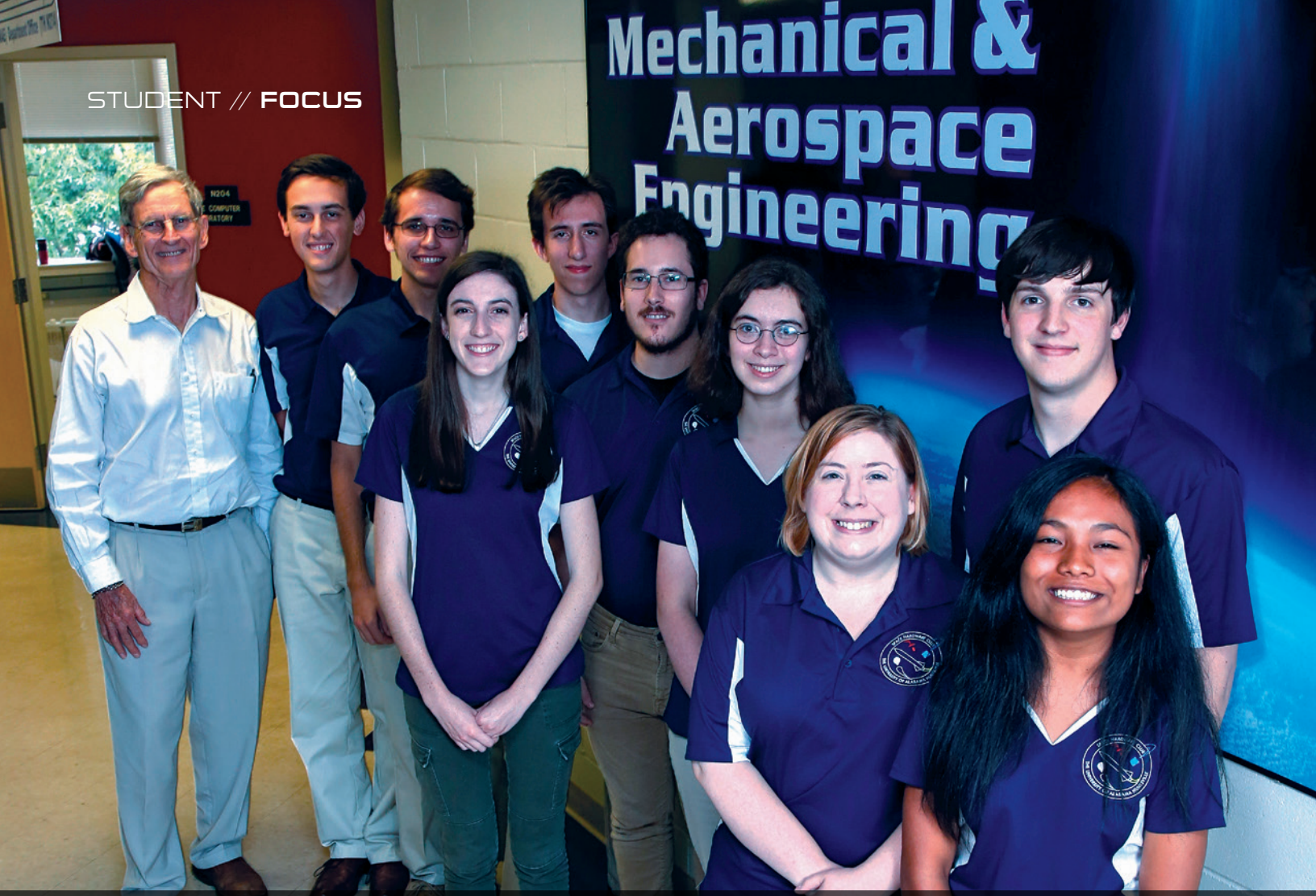
"I'm a scientist by nature, but I have a desire to take my education and use it in business. I continue to believe that biotechnology is second only to electronics in its potential to improve life for all of us."

In 1987, Hudson founded Research Genetics, which later became a biotech business icon. Research Genetics was a chief partner in the Human Genome Project. The capital from Research Genetics opened doors that helped biotech gain a foothold in Huntsville, leading to the creation of the HudsonAlpha Institute for Biotechnology.

"The HudsonAlpha model is based on bringing academic researchers, commercial companies and educational outreach together all under one roof."

What started as an idea has blossomed into a leading genomics research institute where scientists, educators and entrepreneurs work together to spark scientific discoveries, bring genomic medicine into clinical care, foster life sciences entrepreneurship and create a genomics-literate workforce and society.

"Lonnie and I seized a special moment in history at the completion of the first human genome sequence. It wasn't that long ago that we had this dream but it has grown and grown – beyond our expectations. It's wonderful." ■



CLEARER VISION FOR TELESCOPES

UAH's Space Hardware Club is fully funded by NASA's Undergraduate Student Instrument Project for a $49,800 project to protect X-ray telescopes from stray X-rays that can spoil their view.

With more energy at higher frequency than visible light, stray X-rays can penetrate metal and other materials and interfere with optics. The SHC's solution is an active anti-coincidence shielding X-ray detection sensor system that the club will design and build, as well as performing its initial testing.

"When we know a background X-ray penetrated the body of the telescope and hit the optical sensor, this is a coincidence of the X-ray particle," says Adam Bower, SHC president and the project's student principal investigator and program manager. "In order to know when X-rays came from the intended celestial object being studied, we look for the anti-coincidences. This gives us a way to solely measure X-rays from the intended celestial object."

Dr. Francis Wessling, a professor of mechanical and aerospace engineering and the project's faculty principal investigator, advises the SHC. Over 18-months, the SHC will design shield geometry, electronics for the X-ray data system, the power system, data storage, mechanical structure, flight software and environmental control systems. The SHC will manufacture the shielding and mechanical enclosure at UAH and assemble the system.

Dr. Jessica Gaskin from the National Space Science Technology Center, Dr. Albert Shih and Dr. Steven Christe from Goddard Space Flight Center are the project's NASA mentors. Eighteen SHC members are involved. Besides Bower, Jared Fuchs is systems engineer, Chloe McFadden is budget analyst and environmental control systems lead, Matt Haskell is mechanical lead, Elena Pradhan is electrical lead, Samantha Johnson is sensor lead, Chris Helmerich is flight software lead and Kyle Renfroe is manufacturing lead. Subsystems team members are Daniel Corey, Dashiell Hajian, Bradley Henderson, William Hill, Nicholas Jordan, Brent Kennamer, Jarod Matlock, Elizabeth Payne, Devon Sanders and Akifumi Takeyama.

"The system we are building is going to be tested as a secondary payload on a zero-pressure balloon in New Mexico that is being provided by NASA to ensure the design functions as intended," Bower says. "Our big test will be to validate our system on a balloon gondola separate from the telescope." ■

LAUNCHING NEW DISCOVERIES

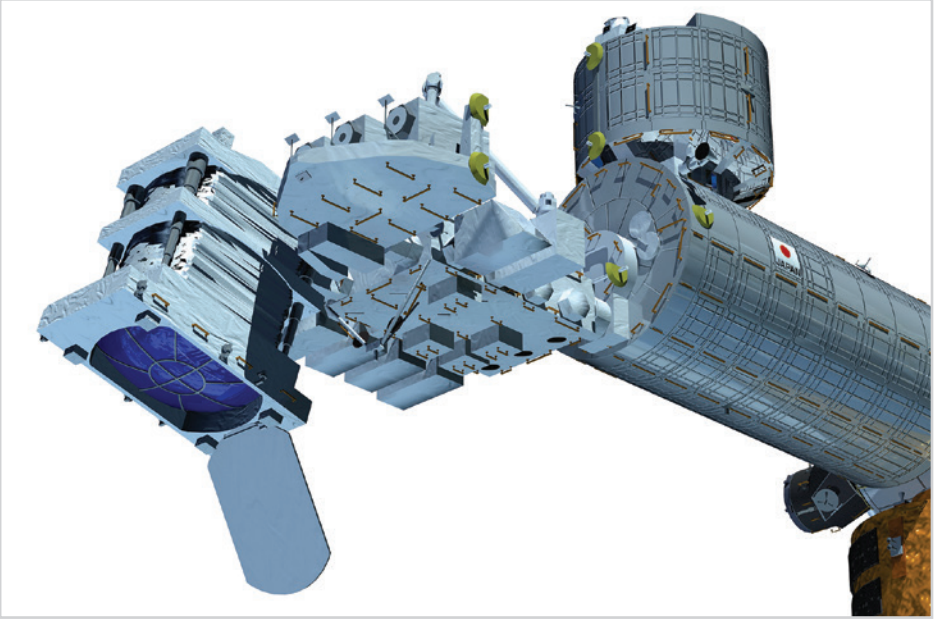
UAH collaboration with NASA brings benefits to both

If it weren't for the unique and decades-long collaboration between NASA's Marshall Space Flight Center (MSFC) and The University of Alabama in Huntsville (UAH), Dr. Michael Brigg's research might not ever have gotten off the ground.

Instead, bolstered by close cooperation among the NASA and university scientists working in UAH's Cramer Hall, Dr. Briggs and his fellow researchers have made groundbreaking discoveries about gamma-ray bursts originating from outer space and from our own planet – including detection of the largest gamma ray burst ever observed.

"Our research is based on being a part of the research team that conducted a joint effort on the Burst and Transient Source Experiment (BATSE) with the Compton Gamma Ray Observatory, and on the Gamma-ray Burst Monitor (GBM) on the Fermi Large Space Telescope," says Dr. Briggs, who is the assistant director of UAH's Center for Space Plasma and Aeronomic Research (CSPAR).

More discoveries may be on the way. Dr. Briggs is currently using the GBM – designed and tested by UAH, NASA/MSFC and the Max Planck Institute for Extraterrestrial Physics in Germany – to probe whether the merger of two neutron stars that creates the gravitational waves recently detected by the LIGO group also is the source of short gamma ray bursts in space. The GBM detects about 850 gamma ray bursts a year.



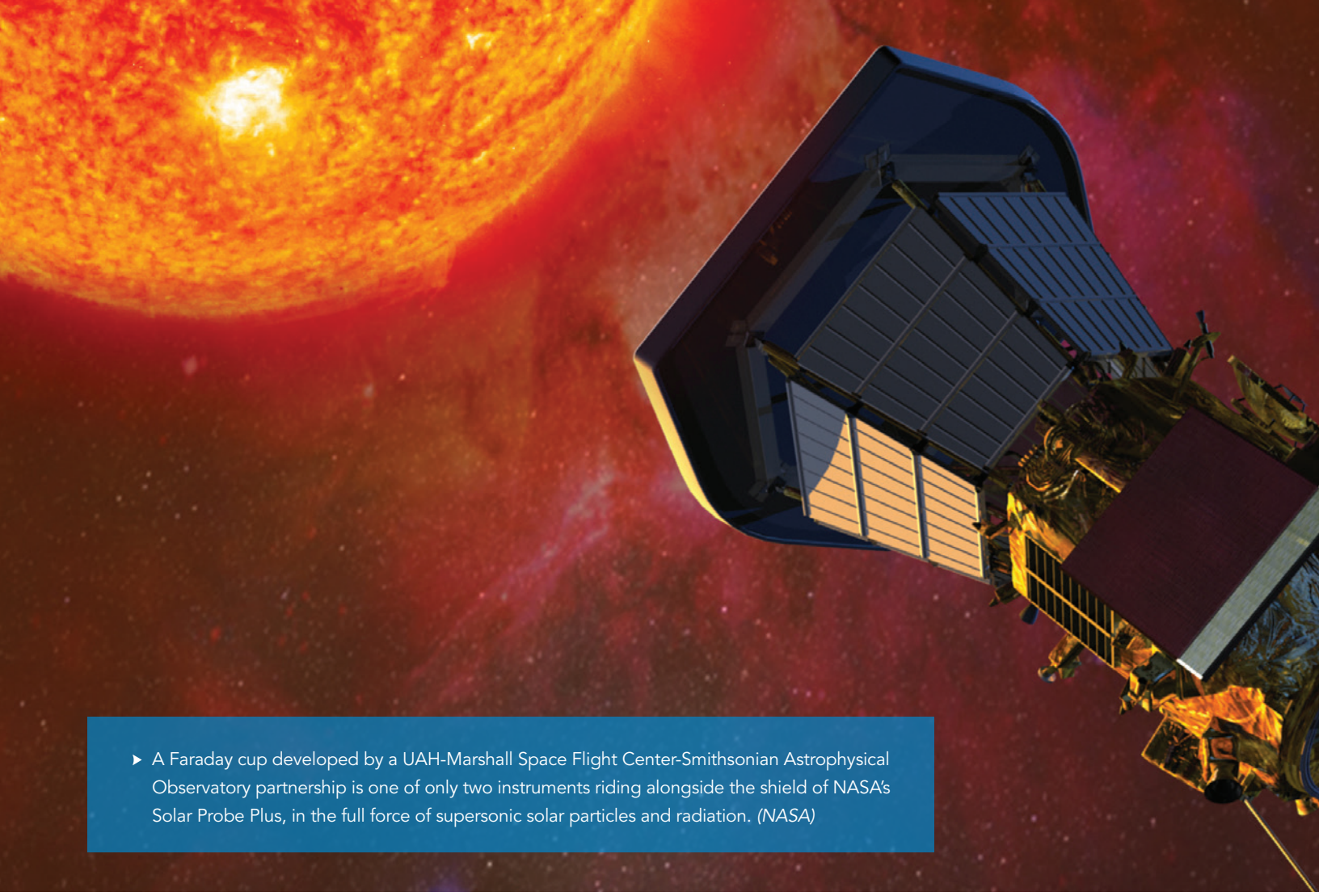
▲ The JEM-EUSO instrument is designed to investigate the highest energy cosmic rays, single sub-atomic particles, each with as much kinetic energy as a major league pitcher's fastball. *(NASA)*

And in 2018, the launch of the Terrestrial RaYs Analysis and Detection (TRYAD) mission will put a gamma ray detector now being designed by three UAH undergraduate students into space to study terrestrial gamma ray flashes (TGFs) that originate from thunderstorms.

One UAH building in particular, Cramer Hall, is home to the National Space Science and Technology Center (NSSTC) and a crucible of collaboration that creates intellectual alloy from the everyday blending of NASA personnel, UAH faculty and staff, and the university's students. Dr. Briggs says the arrangement is advantageous.

"We are co-located and we work seamlessly together," he says.

The NSSTC is truly a one of a kind research center, says Cindy Upton, MSFC Science and Technology Office operations lead and NSSTC facility manager. "Because we are allowed to work in a predominately academic environment every single day, we benefit by being exposed



▸ A Faraday cup developed by a UAH-Marshall Space Flight Center-Smithsonian Astrophysical Observatory partnership is one of only two instruments riding alongside the shield of NASA's Solar Probe Plus, in the full force of supersonic solar particles and radiation. *(NASA)*

to new ideas and new energy."

The combined research teams have literally "changed the textbooks" with their research, says Upton, whose NASA roles include managing the UAH-MSFC cooperative agreement, federal and state regulations compliance and managing the workings of the partnership.

"We truly have a unique partnership among the residents of the NSSTC. UAH and Universities Space Research Association (USRA) colleagues work together with NASA to accomplish amazing research outcomes that are beneficial worldwide," Upton says.

"We often work alongside UAH professors and their students, and that interaction means that we have the wonderful opportunity to keep reaching for the next big idea and push our research into the next realm," she says.

"We stay on top of our game better when we are challenged by an out of the box approach or a question on the status quo. We have the ability to partner with professors who have worldwide respect in their fields," says Upton. "We are able to work with people from all over the world and our scientists can benefit from the combined experience base as the research goes forward. We see outcomes all the time as our colleagues travel the world to discuss their work as a unified team."

MSFC's space scientists share the same physical space on an equal footing with UAH Department of Space Science (SPA) and CSPAR scientists, "unlike almost every other NASA-university relationship," says Dr. Gary Zank, chair of SPA and director of CSPAR.

"Here, we are completely mixed together and talk to one another in a departmental/center/MSFC setting, making it a seamless and highly engaged relationship," says Dr. Zank, who was a catalyst for CSPAR to move to NSSTC when he came to UAH in 2008. "This makes it very easy to build science partnerships, bring new ideas to each other, talk over coffee or around the water fountain or on the way to the car."

The collective benefits of having 70 or so scientists with similar interests all in one building are enormous, he says.

"MSFC has a strong focus on experimental programs that as a university UAH cannot easily afford in the areas of solar physics, astrophysics – gamma ray and X-ray especially – and dust. UAH adds to those our expertise in theory and computation in space physics," says Dr. Zank. "So MSFC brings access to slightly different but related disciplines and uses different techniques. So students, staff, faculty at UAH benefit immensely from having access to different disciplines while enjoying the academic programs at CSPAR/SPA."

UAH contributes complementary research expertise and energetic students to MSFC programs. SPA/CSPAR and MSFC scientists teach classes that reflect subjects in which they want the students to be trained and knowledgeable so the bond helps MSFC employ post-doctoral researchers and scientists, Dr. Zank says.

Other fruits of collaboration are the Solar

Probe Plus SWEAP project and CSPAR principal research scientist Dr. Jim Adams' project to develop the Extreme Universe Space Observatory onboard the Japanese Experiment Module (JEM-EUSO), a new type of observatory that will utilize very large volumes of the Earth's atmosphere as a detector of the most energetic particles in the universe. Equally important are multiple smaller projects that range from NASA's Heliopause Electrostatic Rapid Transit System Electric Sail (HERTS E-Sail) to writing joint scientific papers with CSPAR/SPA and MSFC authors on many different topics.

While benefiting from MSFC through involvement in fields and disciplines in which SPA faculty do not engage and in experimental programs including solar physics, students bring to MSFC a smart, motivated and young cadre to work on projects.

"They are inexpensive, have more time and bring fresh ideas as well," Dr. Zank says. "They are happy to work at all hours. They often have fresh skills, especially in information technology. So it's enormously beneficial to MSFC, and the cost-benefit ratio is very favorable."

Meanwhile, in UAH's Optics Building, the physics department faculty also has close research ties with NASA.

Dr. Ming Sun, a UAH assistant professor of physics, and his students rely heavily on the MSFC-managed Chandra X-Ray Observatory to make research discoveries such as their recent use of observations of galaxy clusters to empirically measure the rate at which the universe expands, or their observation of the second-strongest merger shock in clusters of galaxies ever seen.

"Both research projects used the Chandra data, and the Chandra data account for over 95 percent of the results," Dr. Sun says. "Of course, these projects are impossible without Chandra. We discussed with MSFC researchers the Chandra calibration and analysis. Their expertise on Chandra is a great resource for us."

UAH supplies MSFC with diverse new research ideas and projects, as well as providing an education and public outreach channel, Dr. Sun says. The X-ray group in MSFC provides astronomical projects for physics master's degree and doctoral students, and also X-ray optics projects for those students, he says.

"Collaborations between the UAH optics researchers with the X-ray group in MSFC are supported by external grants," Dr. Sun says. "We bring our important, different expertise together to form new research ideas and projects, and together we educate and develop future scientists."

At graduation, the student alloy from the crucible is forged into a new workforce.

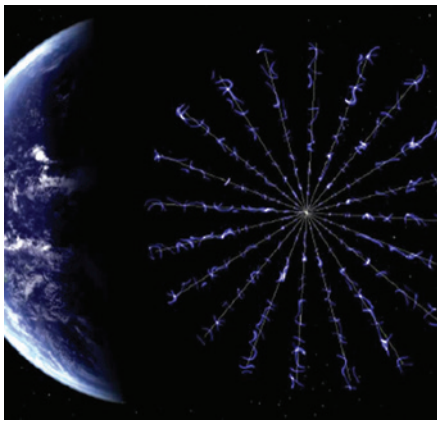
"And a lot of our students end up getting hired by NASA," says Dr. Thomas Koshut, UAH associate vice president for research and economic development. "After all, it's a great fit, since NASA got to shape them all along in their academic endeavors."

These partnerships are important because knowledge discovery is different than most of the other work that NASA does, says Upton, the NASA partnership manager.

"When we build hardware or need something specific done, it's relatively easy to define requirements and deliverables and go through whatever process is needed to have that met," she says. "In the case of scientific research, we can't simply write down what specific skills we need and ask someone to find those people."

Instead, she says, scientific research is based more on the collaborative relationship with individuals whose expertise is needed to complement or supplement what NASA has already.

"UAH does a wonderful job of working alongside us, and the best part is that we are all equally excited when great things happen and we want to continue on the journey together," Upton says. "That's the sign that we are successful as a team." ■

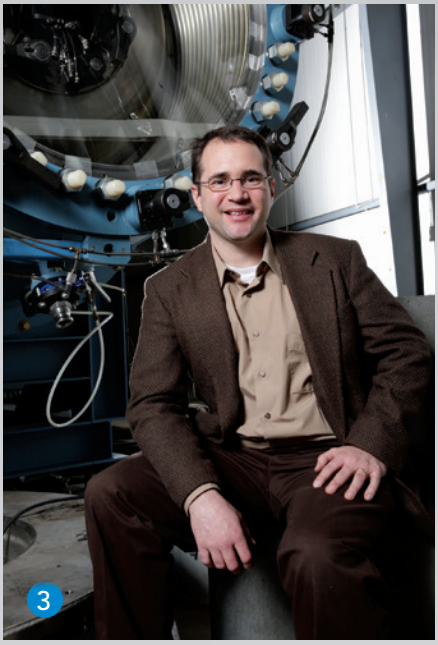


▲ UAH and Marshall Space Flight Center are collaborating on testing and computer modeling for NASA's Heliopause Electrostatic Rapid Transit System Electric Sail (HERTS E-Sail). *(NASA)*

Coming in the spring edition of FOCUS: How UAH and NASA advance atmospheric science through collaboration.

The latest on the PRC's 25th anniversary is at:

#UAHPRC
prc.uah.edu



celebrating **25 years** of achievement

1 **Dr. Hugh Coleman**, **Dr. Clark Hawk** and **Dr. Robert Frederick** in 1991.

2 PRC Von Braun Propulsion Scholar **Dr. John Bennewitz** speaks in 2013 to SpaceX employees in Hawthorne, Calif., about his doctoral research using white noise to combat combustion instability. Dr. Bennewitz, who currently is employed as a researcher at UCLA, will return to speak at the PRC symposium.

3 **Dr. Jason Cassibry** with Charger-1, the PRC's repurposed nuclear weapons effects simulator that will be used to study pulsed fusion propulsion for long-distance missions.

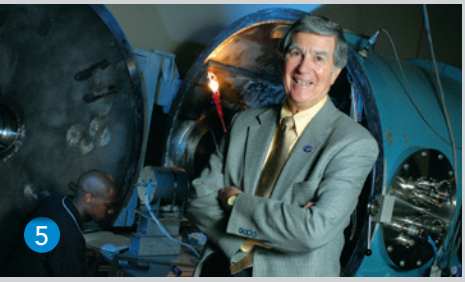
4 **Dr. Matthew Hitt** readies to test a hybrid engine that burns both solid and liquid fuels at the same time in the Johnson Research Center during his 2015 doctoral research. In October, Dr. Hitt will be employed by the U.S. Army Space and Missile Defense Command.

5 **Dr. Clark Hawk**, founding director of the Propulsion Research Center.

6 Johnson Research Center is the home base for many of the Propulsion Research Center's experiments and also home of the PRC's new wind tunnel.

7 **Dr. Phillip Ligrani**, the PRC's eminent scholar in propulsion, is the principal investigator for its SuperSonic/TranSonic/WindTunnel.


4


5

6


7

PROPULSION RESEARCH CENTER

UAH's Propulsion Research Center (PRC) is commemorating 25 years of achievement in propulsion research and student education with a symposium and celebration Oct. 13-14.

The symposium will highlight the achievements of PRC students, alumni and staff, says Dr. Robert Frederick, PRC director.

"The 25th year reminds us to look back on all the achievements members of our PRC family have attained during that time," says Dr. Frederick, who became director in 2013. "It's important to recognize the achievements of all the people who have contributed to the PRC's success over the years. We also want to find out more about what they have achieved as they have gone on from the PRC, as graduates or in other roles, and recognize that."

On Oct. 13, a "Leading the Way in Propulsion" banquet at 5:30 p.m. in the Student Services Center will celebrate founding PRC contributors.

"We'll recognize the people who did important first things that have helped us to grow and to evolve into the organization we have become today," says Dr. Frederick.

On Oct. 14, a student and alumni symposium in the Charger Union Theater will feature invited alumni talks and student research. Later, the PRC will conduct tours of its Johnson Research Center laboratories and of the UAH campus.

Over 25 years, the PRC has performed $35 million in research. Annual research presently is in the $1 million to $3 million range. The U.S. Missile Defense Agency is one of the PRC's biggest current customers.

The PRC began as an effort to consolidate UAH's propulsion research.

"The university decided that it wanted a more focused approach to propulsion in the late 1980s," says Dr. Frederick. "It wanted something to bring together its research efforts and focus these efforts in that area."

The center's official beginning came in February 1991 when Dr. Clark Hawk accepted the position as director, bringing with him Dr. Frederick.

"He liked to do things that hadn't been done before, so really it was perfect for him," Dr. Frederick says.

At the same time, UAH funded an eminent scholar in propulsion, a move that was supported by industry, Redstone Arsenal, Marshall Space Flight Center and the missile community. Currently held by Dr. Phillip Ligrani, the position was first filled in August 1991 when Dr. Hugh Coleman was appointed and added to the faculty as a professor of mechanical engineering in the College of Engineering.

"At that time, the industry was downsizing, which seems to be a recurring theme, and so that would seem to not be a real good time to be starting a research organization," Dr. Frederick says. "But because of that environment, industry began to use us as a resource to train people so that they could quickly integrate them into their operations and have them become a valuable resource in a very short period of time."

Initially, the PRC relied on NASA and Thiokol Corp. labs, and those were where Dr. Frederick went to work on hybrid propulsion research as a NASA summer faculty member. By summer of 1996, the PRC had expanded into the 15,000 square-foot Johnson Research Center on the south side of the UAH campus, a facility originally built in the 1975 for energy research and then repurposed to propulsion research. There, the PRC has six primary facilities: the Hot Fire Test Cell, the High Pressure Spray Facility, the Plasma Combustion Laboratory, the Water Tunnel Flow Facility, a Large Scale Vacuum Chamber and the SuperSonic/TranSonic/WindTunnel (SS/TS/WT).

"We began to develop more and more laboratories to provide our students with hands-on experience and expertise in the various aspects of propulsion because


Dr. Robert Frederick

that's what industry wanted," says Dr. Frederick. "And then we expanded that, and the idea was to work with all the local agencies and their laboratories, as well. These kinds of relationships continue to this day."

Currently, UAH and Marshall Space Flight Center are working together at Redstone Arsenal with industry partners to probe a futuristic propulsion system that could send explorers to Mars and beyond at the university's Charger-1 Pulsed Power Generator.

Led by UAH's Dr. Jason Cassibry and Dr. Bill Feidler, scientists are repurposing machinery originally built for nuclear weapons research into a test facility for a spacecraft propulsion system based on nuclear fusion. The facility will produce an extremely brief pulse of plasma created by an equally brief nuclear fusion reaction. An engine producing these pulses could propel a spacecraft over inter¬planetary distances at great speeds.

"We've gone from no labs to 10 labs on campus," Dr. Frederick says. "Some were built by the university and others were constructed with federal or state government support, or some mixture of the three. These have allowed us to become one of the main universities in propulsion research areas."

The vision of founding director Dr. Hawk, who died in 2008, was to create a positive and supportive community where students were at the center of research activities. The first seven master's degrees with PRC involvement were earned in 1993. The first four doctoral degrees registered in 1997.

"We are approaching 250 graduate students who have worked with the PRC on completing their degrees," says Dr. Frederick. "The PRC is a different organization in that we don't actually provide the degrees. Those come from their respective colleges and departments. What we do is help form the research groups that allow the students to do that research."

In addition to the Department of Mechanical and Aerospace Engineering, the PRC collaborates with other academic units on the campus, including Chemical Engineering, Electrical and Computer Engineering, Industrial and Systems Engineering, Civil Engineering, Physics, Chemistry, Mathematics and Music.

The PRC is also involved with teams or consortiums of universities on projects, as well. Universities such as Alabama, Auburn, the Georgia Institute of Technology, Maryland, the Massachusetts Institute of Technology, Penn State, Purdue, Stanford, the University of Illinois Urbana-Champaign and others have been collaborators on proposals or funded research.

Twenty-five years of achievement in propulsion research and collaboration has brought growth.

"We started from three people, each of us with a used desk, and now we touch about 60 faculty, staff and students a year who are supported by our research efforts," says Dr. Frederick. "As we've matured, we've had to become more of an organization to provide the kind of cooperative environment where our faculty, students and staff can thrive in our areas of interest in propulsion and energy.

"We have also evolved to work closely with small industry in these fields, where we are able to provide them with the kind of close working relationships and attention they need to succeed." ■

EXPLORING LIFE

UAH and HudsonAlpha collaborate to study nature's genetic bounty

When GeneCapture bore fruit as the $100,000 winner of Alabama Launchpad's inaugural LEAP Alumni Startup Competition, the roots of that achievement grew in the special collaborative relationship The University of Alabama in Huntsville (UAH) has with Huntsville's HudsonAlpha Institute for Biotechnology.

GeneCapture, founded by UAH professor and interim chair of the Department of Chemical & Materials Engineering Dr. Krishnan Chittur with two others, has its offices at HudsonAlpha. The company's team of chemical engineers, molecular biologists, physicists and entrepreneurs is developing a portable instrument to screen for dozens of pathogens within an hour, for less than $20.

"GeneCapture's mission is to change the current paradigm in infection detection, and so the technologies we are developing include elements from molecular biology, biochemistry, bioinformatics and biological sensing," Dr Chittur says.

GeneCapture's collaboration with HudsonAlpha and UAH has been critical, he says.

"We are so fortunate to have at HudsonAlpha a collection of incredible researchers and for-profit companies and scientists. There is almost no problem for which we cannot find someone to find a solution at HudsonAlpha. At UAH, our Office of Technology Commercialization has been very helpful and encouraging – helping us transition from an idea into a company and a product that will have a direct impact on the Alabama economy.

"It is indeed difficult to imagine how we would fare as a company without the support of UAH and access to the amazing intellectual capital that HudsonAlpha has assembled."

Working within the collaborative experience has helped him to become a better educator, as well, Dr. Chittur says.

"I am honored that I can wear the hat of an academic and professor, and also an entrepreneur, all made possible by UAH and HudsonAlpha," he says. "While I cannot prove it, I can sense that I have become a better classroom instructor and mentor to graduate students because of the ease with which I have been able to live in the world of education and the 'real world,' as it were. The key in this has been the people, both at UAH and HudsonAlpha."

HudsonAlpha co-founder Jim Hudson says this kind of "revolving door of collaboration between us" is exactly the kind of relationship he and HudsonAlpha co-founder Lonnie McMillian had in mind.

"HudsonAlpha works to train the biotech workforce and attract serial entrepreneurs, and collaborating with UAH allows us to do so," Hudson says. "UAH equips students with the skills and knowledge needed for a career in biotechnology, and because of the connection to HudsonAlpha, they get hands-on laboratory experience and sometimes end up working for the Institute.

"We have over 30 associate companies on campus, some of which were founded by UAH faculty members like Dr. Chittur and Dr. Joseph Ng," he says. "Professors like Dr. Eric Mendenhall, Dr. Luciano Matzkin and Dr. Leland Cseke hold adjunct faculty positions at the Institute and are able to collaborate with HudsonAlpha scientists and use high quality sequencing technology for various research projects."

> "I am honored that I can wear the hat of an academic and professor, and also an entrepreneur, all made possible by UAH and HudsonAlpha."
>
> – Dr. Krishnan Chittur

Dr. Ng owns HudsonAlpha associate company iXpress Genes, which in 2014 flew a Protein Crystals for Neutron Crystallography (PC4NC) experiment developed with Oak Ridge National Laboratory on the International Space Station to study the roles enzymes play in biological processes.

Dr. Cseke, who in the past has worked on United States Dept. of Agriculture genetic identification of invasive plant species with HudsonAlpha's Dr. Jian Han, developer of the iCubate modular gene sequencing system, says the collaborative relationship continues to support his current work on the interaction of plants and soil microbes.

"My interactions with companies and researchers at HudsonAlpha have definitely been beneficial," Dr. Cseke says. "I have worked extensively with the HudsonAlpha Genomic Services Laboratory (GSL), which allows access to some of the most cutting edge DNA and RNA sequencing platforms at a good price."

Dr. Cseke's lab, with the help of experts at GSL, has elucidated the metabolome of interacting plant and soil microbes.

"I continue to work with the GSL and HudsonAlpha on my current project, designed to identify what soil microbes interact with and enhance the plant immune system, allowing for increased productivity of crop plants," Dr. Cseke says.

"I have been making use of a compost tea facility that I designed and established at the south end of campus as part of the UAH Community Garden. The facility runs off of rain water and solar power alone, and it produces beneficial soil microbes that are then used to treat field plots on the UAH campus as well as on some property owned by one of the board of trustees at HudsonAlpha. We will be doing genomic sequencing as well as metagenomic sequencing of the soil and plants at these field plots."

Dr. Matzkin says that being an adjunct faculty investigator at HudsonAlpha has facilitated the expansion and growth of his research program at the Institute and at UAH. He primarily studies the role of genetic adaptation and expression in the evolution of a group of cactophilic *Drosophila* fruit flies that inhabit the deserts of North America.

"All the genomic work that we do in my lab has been done at HudsonAlpha, and being part of the Institute is very beneficial, since I have the opportunity to discuss my experiments with outstanding faculty investigators," says Dr. Matzkin. "HudsonAlpha is the model for what an internationally renowned research institute should be, focusing not only on innovative and trail-blazing genomic research, but as well focusing on community outreach and education."

One of the genetic tools Dr. Matzkin uses was developed in the Institute's Richard M. Myers Lab by a team that

included UAH genetic scientist and HudsonAlpha adjunct faculty member Dr. Eric Mendenhall.

"Dr. Mendenhall and the Myers Lab worked together to develop the CETCh-seq method, which is a faster, more efficient method for finding specific points on DNA that control when a gene is turned on or off," says Dr. Myers, who is president and science director of the Institute. "In doing so, we combined an established technique for locating the switches – ChIP-seq – with a common method for manipulating DNA sequences for research – CRISPR/Cas9."

The new technique is already looking like it's making a big difference, he says.

"HudsonAlpha has had such a strong relationship with UAH since the beginning and because of that relationship, we're able to not only work directly with their students, but also their faculty," Dr. Myers says.

"The HudsonAlpha Institute, led by President Richard Myers, is especially prolific in their research, and future collaborations seem like they would be easy to establish and mutually beneficial," Dr. Mendenhall says. Then with a laugh, he says, "Dr. Myers really helped recruit me to come to UAH with promises of future collaborations!"

In education, UAH has partnered with HudsonAlpha in the UAH-HudsonAlpha Outreach Partnership (UHOP) to ensure a quality supply of trained biology and biotechnology employees will be readily available.

Funded by a $638,000 National Science Foundation grant, UHOP is designed to identify high school students who are both academically talented in the STEM fields and interested in pursuing an academic and professional career in biotechnology, then mentoring them while they earn their degrees. Women and minority students are a particular focus.

Students in UHOP start early with hands-on biotechnology research at HudsonAlpha, including sequencing and analyzing DNA. Co-principal investigators for the program are Biological Sciences Chair Dr. Debra Moriarity and HudsonAlpha Vice President for Educational Outreach Dr. Neil Lamb.

The program does several things for students interested in biotechnology at UAH, according to Dr. Moriarity. It provides freshman with finances to cover tuition and at least part of their room and board on campus so they don't have to work outside while starting their college career, allowing them to focus on their schoolwork.

It provides information about research in biotechnology through a course at UAH, Introduction to Biological Research, and a course at HudsonAlpha, Sample to Sequence. At HudsonAlpha, students also participate in a workshop on being a biotech professional.

UHOP provides students with faculty and peer mentoring and an opportunity to be involved in research in a laboratory. Also, they find out about graduate school and the UAH JUMP program, in order to help them further their education in biotechnology.

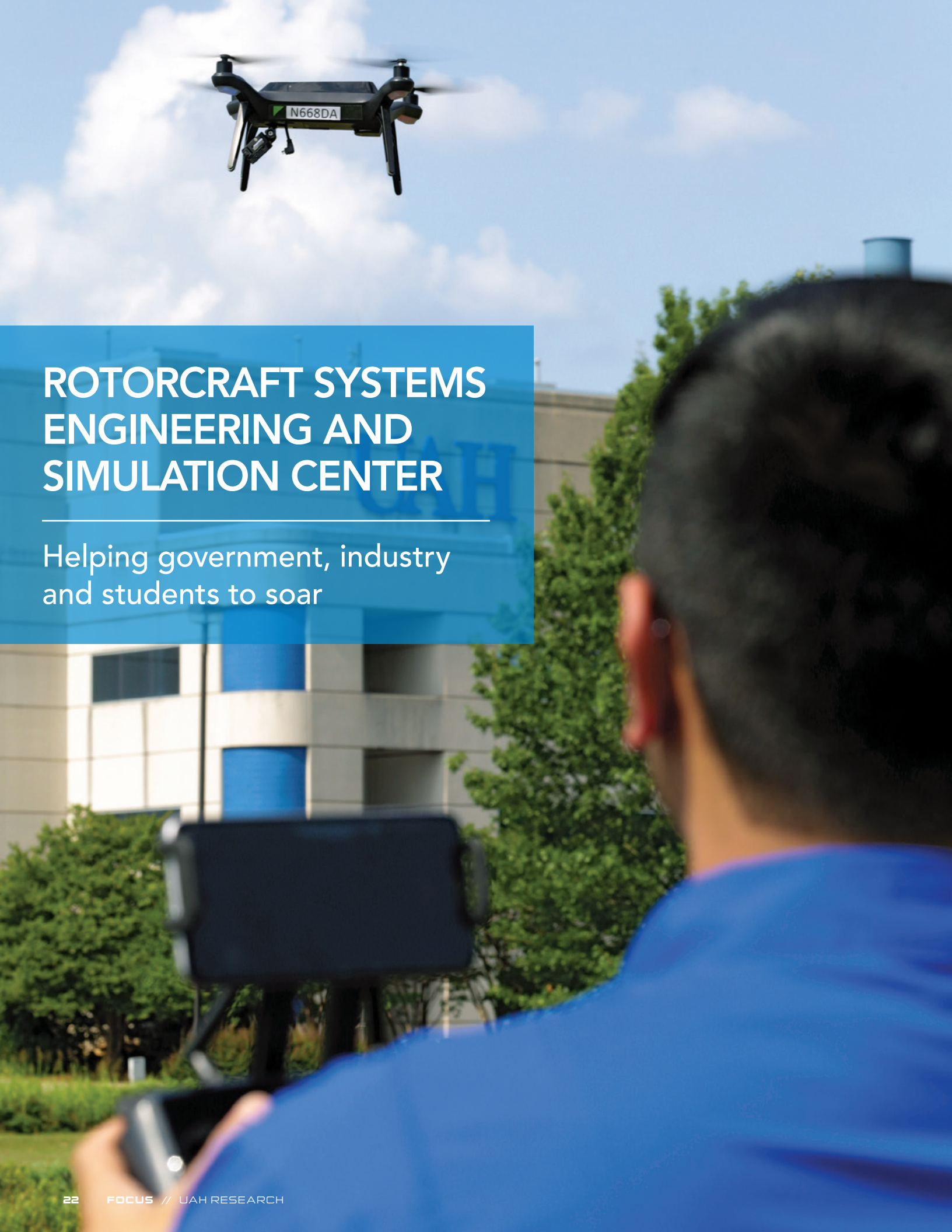
"All of this is intended to help them be successful and graduate from UAH ready to enter the biotechnology field in whatever way they choose," says Dr. Moriarity.

Entrepreneurially, UAH and HudsonAlpha are partners in the HudsonAlpha-University of Alabama in Huntsville Entrepreneurship Collaboration, which aims to strengthen the business skills of life science sector startups at Hudson Alpha and enhance the educational experience for students in UAH's College of Business.

The Entrepreneurship Collaboration is jointly led by Dr. Jason Greene, dean of UAH's College of Business Administration, and Carter Wells, HudsonAlpha's vice president for economic development. It includes speaker exchanges from HudsonAlpha, the associate companies, and UAH; internships and assistantships for HudsonAlpha and the associate companies; and workforce development initiatives and specific programs for the associate companies and students in the UAH College of Business Administration.

The university and HudsonAlpha continually communicate on ways to bolster the regional biotechnology community, combining their strengths to address key manpower and research needs. ■

▲ **Dr. Krishnan Chittur** is cofounder of HudsonAlpha company GeneCapture.



ROTORCRAFT SYSTEMS ENGINEERING AND SIMULATION CENTER

Helping government, industry and students to soar

▲ **Atchima Klomkaew** solders a circuit board.

Talk with David Arterburn on a short walk through the halls of the Rotorcraft Systems Engineering and Simulation Center (RSESC), in UAH's Wernher von Braun Research Hall, and you'll quickly realize the center is about much more than helicopters.

Rotary wing platforms remain the foundation of their work, says Arterburn, director of the center since October 2013. But the "systems" in the center's name could refer to a space payload, such as the Lightning Imaging Sensor they helped build that will soon be mounted on the International Space Station to gather data for lightning scientists. Or it might refer to designing, building and flight-testing an unmanned aircraft system (UAS) for the U.S. Army.

The RSESC was formed at UAH in 2003 as an initiative with the Army's Program Executive Office – Aviation (PEO-AVN) and the Aviation and Missile Research and Development and Engineering Center (AMRDEC), based on the technical needs of nearby Redstone Arsenal. The center has grown to about 26 full-time employees who, along with students, continue to not only meet the real-world needs of Army aviation, but to anticipate them.

There are vertical lift research centers of excellence elsewhere that work with the hard science of blade dynamics and the physics of flight, Arterburn says. The RSESC is more involved in rotorcraft design, with a focus on model-based systems engineering and simulation and an eye toward the Army's acquisition programs.

It's a world he knows well. Arterburn is a retired Master Army Aviator with more than 28 years of experience in the cockpits and program offices for UH-60 Black Hawks, OH-58 Kiowa Warriors and other helicopters. He also served as an experimental test pilot and as an assistant professor at the U.S. Military Academy at West Point.

"We're always trying to evolve their capabilities," he says of the center's important partnership with the Army. "We're also training their future workforce. Our students will eventually go to work in many of those offices or the offices of their industry partners."

Arterburn was asked to conduct a study with the Aviation Development Directorate at Redstone Arsenal to examine the airworthiness and development of complex systems such as today's technologically advanced helicopters. It was determined there was a growing need for model-based systems engineering methodology and tools and, over the last year, UAH has invested in an RSESC Complex Systems Integration Laboratory (CSIL). He said the center is already seeing interest in the lab from the Army's Future Vertical Lift Office, NASA and others.

The CSIL is an ideal complement to the center's other resources, including labs for prototyping, for materials and non-destructive testing and experimentation, and for electrical, mechanical design and manufacturing, with a fully equipped machine shop. Arterburn points out that RSESC's origins involved UAH materials science centers and that structural and prototype development have always been part of the center's pedigree.

A few of the hands-on projects underway include redesigning Army Aviation Ground Power Units for aircraft and developing, prototyping and flight-testing an Army Unit Maintenance Aerial Recovery Kit (UMARK).

"We've been a design, build and fabricate organization for quite some time, building science and space payloads to support other researchers here at UAH, at NASA's Marshall Space Flight Center on the arsenal and elsewhere," Arterburn says.

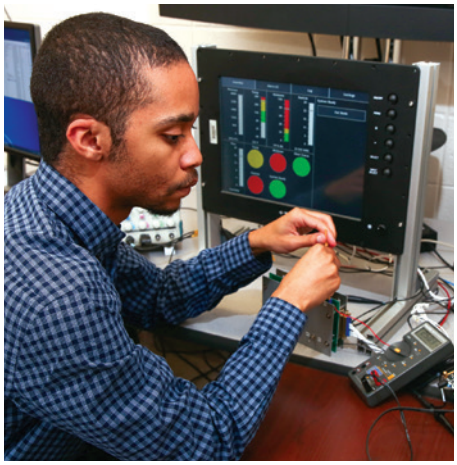
In 2014 the center began its involvement in UAS programs, and that continues to grow. The RSESC is part of a team with the Center of Excellence for Unmanned Aerial Systems led by Mississippi State University working on issues related to integrating UAS flights into the national airspace system. UAH is one of 14 core universities in the Alliance for System Safety of UAS through Research Excellence (ASSURE) team that executes research for the Federal Aviation Administration (FAA) Center of Excellence for UAS. Currently, the center is studying UAS ground collision severity under a contract with the FAA. That's work that Arterburn says could expand into a number of different areas and leads the efforts to improve the safety of UAS, as well as providing research that will eventually open new airspace to many UAS platforms.

"We're also looking for new, innovative vehicles," he says. "We are using our design heritage to find ways of creating new unmanned aircraft, especially in the small UAS category."

That includes examining the design protocols used for larger aircraft to see what might be adapted, and exploring technologies like additive manufacturing or 3-D printing of different materials. Arterburn hopes to tie RSESC's design work with model-based systems engineering to additive manufacturing technology. He is currently working on a proposal to merge these two fundamental capabilities for rotorcraft, rockets and space applications.

▲ UAV on the UAH grounds.

▼ Student **Marc Byrd** tests components.



"There's interest all over in additive manufacturing, but the development of metal parts for rotorcraft is a challenge and must address airworthiness issues like fatigue," he says. "How do you determine airworthiness of those craft? That's what we're interested in, establishing standards and looking at design methodologies, looking at the airworthiness of those parts."

He emphasizes that the RSESC isn't trying to take the place of the roles of industry or the government, but to provide added value and synergy amongst the team. The center is also a place where industry and government can come together before there are the constraints of a contract, to talk about expectations and models.

"We can help them collaborate, and we can involve the men and women who will make up their future workforce," Arterburn says. "We don't bid research projects without students being a part of it."

The premiere example of the RSESC's commitment to students is its unique partnership with the Boeing Huntsville Design Center. Today, the program is responsible for more than 100 students – primarily from UAH but also from other universities working through the RSESC – to gain practical experience in a real-world engineering environment as employees, not interns. Arterburn says UAH is exploring similar partnerships with other area companies because of the successes of this program.

He is proud of the RSESC's relationships with a local community of industry and government partners, including a surveying company, training organizations and airports, as they work to identify and create opportunities for students, unmanned aircraft systems and developing technologies for space and rotorcraft.

"We build systems. We don't build parts. I've enjoyed the interaction with other UAH centers to bring various groups together to solve interesting problems for agencies on the arsenal, industry, and the larger aviation and aerospace community," Arterburn says.

"I enjoy that aspect of it. Every day is something different," he says. "Every week is a challenge in some area: To push someone's research farther, to move a company's capability forward, to discover something interesting." ■

INFORMATION TECHNOLOGY AND SYSTEMS CENTER

▲ **Todd Berendes**, **Ryan Tucker**, **Jason Toone** and **Dr. Sara Graves** work with ITSC infrastructure.

Managing data to benefit science and society

Data analytics. Deep learning. Artificial intelligence. Data processing. Cybersecurity. Big data. Data mining.

It takes all these terms and many more to describe what UAH's Information Technology and Systems Center (ITSC) does, but there's an easier way to look at it, says the center's director, Dr. Sara Graves.

"All of this is centered on trying to help others – scientists, engineers, policy makers, business people – use the huge amounts of data they have," she says. "We help them with analysis, and that's really key. Today, a researcher can have mountains of data, petabytes or millions of gigabytes available. But what do you do with all of it? How do you work with it to find the answers to the questions you have?"

Dr. Graves has been director of ITSC since its founding 20 years ago, and is also a UAH computer science professor and University of Alabama System professor. She and the ITSC team work with government, industry, academia and other researchers around the world to collect, organize, move, share, analyze and secure their rapidly growing amounts of data – facilitating the high-tech alchemy that turns bits and bytes into knowledge.

"There is a very collaborative spirit among our group, who have the information technology expertise and skills, and the end users, whether they are scientists, government leaders, executives or the general public," she says.

On any given day, ITSC researchers can be found working with lightning, hurricane and hazardous weather data in the Global

Hydrology Resource Center, a NASA Earth Science Distributed Active Archive Center managed by the Earth Science Office at NASA's Marshall Space Flight Center and the ITSC. Or in the Data Mining Laboratory where, among other advances, they created ADaM – the Algorithm Development and Mining system now helping scientists around the world sift through large amounts of data.

The ITSC assists defense agencies with creating high-fidelity gaming, models and simulations; is pioneering new tools and uses of geospatial data with government and commercial interests; runs a High Performance Computing Laboratory to support scientists with large volumes of any kind of data; and the Collaborative Technologies Laboratory, where researchers develop new tools to manipulate, mine, manage and share information – tools like Spyglass, which can quickly search and index libraries of text documents.

Among other research, the ITSC is involved in developing event-based technologies that can automatically deliver defined types of data from multiple sources about an event to the people who need it. During an earthquake or tornado, emergency management agencies could get a more complete and quick picture of where to allocate resources using integrated information from satellites, publicly available data, amateur radio operators and even social media. That requires analytics, and the ability to integrate the information from one source with other forms of data.

"We are a very interdisciplinary research center, and we're creating technologies that can be used in a lot of different applications," Dr. Graves says.

The ITSC has about 45 full-time employees and 25 students, ranging from undergraduates through PhDs, working in facilities at Olin B. King Technology Hall and the National Space Science and Technology Center (NSSTC) in Cramer Hall. Dr. Graves is proud that many of the full-time employees are former students, and some have been with the center since its beginnings.

▲ From left, **Evans Criswell**, **Casey Calamaio** and **Gretchen Pangle** discuss cybersecurity.

She points out that many of the scientists at ITSC, who are helping others manage and mine the data essential to moving their research forward, are also top researchers themselves.

"So when somebody comes to UAH and says they are very interested in developing a pipeline to our students, I say sure, but don't forget our expertise in research scientists," Dr. Graves says. "That's really unique at UAH. A lot of our researchers here at ITSC also teach, and not just in computer science, but in Earth science, mechanical engineering and other fields."

The broad scope of activities brings a broad scope of ever-evolving challenges before the ITSC researchers. And they wouldn't have it any other way.

"Working with students and sharp people, constantly trying to help someone do something? It's very tough work, but it's so much fun," Dr. Graves says with a smile. "We never have any dull conversations." ■

UAH weaves cybersecurity into engineering classes

Engineers who graduate from The University of Alabama in Huntsville (UAH) will have broad exposure to industrial control systems cybersecurity within their fields of study under a new initiative.

Funded by a three-year, $500,000 grant from the National Science Foundation (NSF), the effort's goal is to expose engineering students to cybersecurity beginning in their first-year common courses.

In the first phase, undergraduates will construct virtual models of industrial control systems in different engineering disciplines, says Dr. Tommy Morris, an associate professor of electrical and computer engineering and director of UAH's Center for Cybersecurity Research and Education (CCRE).

Dr. Morris is the principal investigator (PI) for the grant, along with co-PIs Dr. Krishnan Chittur, interim chair of the Dept. of Chemical and Materials Engineering; Dr. Farbod Fahimi, associate professor in the Dept. of Mechanical and Aerospace Engineering; Dr. Rhonda Gaede, associate professor in the Dept. of Electrical and Computer Engineering; and Dr. Hongyu Zhou, assistant professor in the Dept. of Civil and Environmental Engineering.

Undergraduate senior design teams advised by the professors in the four disciplines will build four virtual industrial control systems. The systems will then be used by doctoral students in the CCRE for cybersecurity research. They will serve as test beds to research the impact of cyber attacks against industrial control systems, develop cyber defenses to detect and defeat the attacks, and to gather data and evaluate solutions.

"The undergraduate students will build a distillation tower used in chemical refineries for the Dept. of Chemical and Materials Engineering, a robotic arm used on a factory floor for the Dept. of Mechanical and Aerospace Engineering, a mass damper for the Dept. of Civil and Environmental Engineering and an electric generator for the Dept. of Electrical and Computer Engineering," says Dr. Morris.

Dr. Morris and his doctoral students will develop cybersecurity classroom lectures and lab exercises and teach them in junior-level classes in each affected discipline, exposing engineers from the other engineering disciplines to the cybersecurity problem.

"How can you add cybersecurity to an engineering department and, by doing so, take away content more relevant to the degree itself? You can't," says Dr. Morris. "Our innovation is to teach cybersecurity relevant to systems they are already learning, so we get two lessons for the price of one."

Part of Dr. Gaede's involvement will be to help evaluate the curriculum and its effectiveness.

"I will be working with the various faculty from the College of Engineering that teach the common first year classes, FYE 101 ENG – 'First Year Experience for Engineering Students' and ENG 101 – 'Introduction to Computing for Engineers,' to introduce cybersecurity principles into those classes," Dr. Gaede says. "I will also be providing support for the evaluation of this project in the two areas of student understanding and in dissemination of the products of this project."

Dr. Gaede will gather assessment data and will be responsible for outreach efforts.

"We have identified some metrics for assessing the broader impact of this project," Dr. Gaede says. "One example is distributing virtual industrial control systems (ICS) to 30 schools by year three of the program."

Students in Dr. Gaede's Dept. of Electrical and Computer Engineering will gain deeper understanding of the industrial control systems for which they may be tasked to provide software, she said.


Dr. Tommy Morris

"This project is very timely as indicated by the commercials we see from GE talking about being both industrial and digital," says Dr. Gaede. "That's what we're trying to achieve here."

The project advances some of UAH's larger educational goals, as well, Dr. Gaede says.

"I think this project folds nicely into the university's Quality Enhancement Plan of Collaborative Learning and epitomizes the interdisciplinary type of education that our accrediting body, the Accreditation Board for Engineering and Technology Inc. (ABET), is seeking."

Dr. Fahimi says the Dept. of Mechanical and Aerospace Engineering knows robotic cybersecurity is vital to industry, where the number of industrial robotic manipulators in use is rising.

"During operation of the robots, the desktop computer commands the series of programmed motion commands to the motion control hardware of the robot, which is connected to the desktop computer via a serial or Ethernet connection," Dr. Fahimi says. "If the desktop computer is hacked, malicious software can redefine motion commands for the robot, causing it to misbehave. That can lead to property damage, personal injuries, or loss of lives." ■

THE UNIVERSITY OF
ALABAMA IN HUNTSVILLE

VICE PRESIDENT FOR RESEARCH
AND ECONOMIC DEVELOPMENT
301 Sparkman Drive
Huntsville, Alabama 35899

Nonprofit Org.
U.S. Postage
PAID
Huntsville, AL
35899
Permit No. 283

UAH.EDU/RESEARCH