FOCUS

UAH Research Magazine // Fall 2019

HOT ROD ROCKETRY

UAH works with NASA to model a nuclear thermal propulsion spacecraft

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SHAKEN FURY

UAH helps DHS improve first responder communications

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THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

KEY CONTACTS

VICE PRESIDENT FOR CONTRACTS AND GRANTS
Dr. Robert Lindquist
(256) 824-2882
Robert.Lindquist@uah.edu

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

CONTRACTS AND GRANTS ACCOUNTING
Valarie King
Director
(256) 824-2231
Valarie.King@uah.edu

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

OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY
Kristy Olive
Director
(256) 824-6053
Kristy.Olive@uah.edu

OFFICE FOR PROPOSAL DEVELOPMENT
Dr. Virginia (Suzy) Young
Director
(256) 824-3448
Suzy.Young@uah.edu

CENTER FOR APPLIED OPTICS
Dr. Pat Reardon
Director
(256) 824-2530
Patrick.Reardon@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
David.R.Arterburn@uah.edu

SYSTEMS MANAGEMENT AND PRODUCTION CENTER
Dr. Gary Maddux
Director
(256) 824-2679
Gary.Maddux@us.army.mil

INVENTION TO INNOVATION CENTER
Rigved Joshi
Director
(256) 824-6058
Rigved.Joshi@uah.edu

Dr. Robert Lindquist
Interim VP for Research and Economic Development

Welcome to the Fall 2019 edition of *FOCUS: The UAH Research Magazine*.

As America celebrates the 50th Anniversary of the Apollo 11 moon landing, Huntsville reflects on its transformation over the past five decades and on its role in advancing space exploration, missile defense, and the aerospace industry. The University of Alabama in Huntsville (UAH) is literally a university launched from America's quest to conquer space, having its roots in Dr. Wernher von Braun's vision for a Huntsville-based research university.

Just as it has since the days of Apollo, UAH research is playing critical roles in Huntsville's amazing transformation. In the future, UAH's vital contribution will continue as new challenges emerge with the growth of Huntsville-based efforts in biotechnology, cybersecurity, hypersonics, lunar landers and counter terrorism.

Our cover story on nuclear thermal propulsion (NTP) on page 4 describes work being done by UAH under a NASA contract to model a spacecraft that can use NTP during a human mission to Mars. The effort is led by Dr. Dale Thomas, UAH's eminent scholar in systems engineering and director of the Alabama Space Grant Consortium.

Meanwhile on page 14, we learn that UAH was the only academic institution on hand during the U.S. Department of Homeland Security Science and Technology Directorate (DHS S&T) Next Generation First Responder – Birmingham Shaken Fury Operational Experiment. UAH's Rotorcraft Systems Engineering and Simulation Center evaluated Unmanned Aircraft Systems during the operational experiment to evaluate emerging communications technologies in disaster situations.

And on page 18, we find that UAH atmospheric scientists have published new research about tornado formation resulting from the multiyear Verification of the Origins of Rotation in Tornadoes Experiment Southeast (VORTEX-SE) program.

Behind the research are quality people like Dr. Emanuel Waddell, a UAH associate professor in the Department of Chemistry and the associate dean of the College of Science, who we find out on page 8 was recently selected by the National Science Foundation to serve as director of the Centers for Excellence in Science and Technology program and the Historically Black Colleges and Universities Undergraduate program.

In support of a statewide effort, Robert Lightfoot, vice president of strategy and business development at Lockheed Martin Space and former acting NASA administrator, has been named chair of a newly formed Alabama Space Grant Consortium Industrial Advisory Board, says a story on page 13. UAH is home to the ASGC, which besides UAH counts as its members Alabama A&M University, Auburn University, Tuskegee University, The University of Alabama, The University of Alabama at Birmingham and the University of South Alabama.

And student members of the Space Hardware Club at UAH are launching weather balloons into thunderstorms to try to directly observe the terrestrial gamma ray flashes (TGFs) storms generate, we learn on page 9. The High Energy Lightning Emission Network hoists aloft a network of sensor devices to measure intense bursts of gamma rays produced in the atmosphere.

As the region and the nation celebrate Apollo 11's achievement, UAH's M. Louis Salmon Library continues to be a resource that lets researchers literally relive the development of technologies that made the Apollo moon landing and first walk on the moon possible. On page 20, we find out about its extensive collections of NASA materials produced during the development of the Saturn V rocket and materials from the Apollo era space programs, all available to the general public.

We are proud of the accomplishments of our faculty, staff, students and alumni. We are excited about the future and welcome collaborative partnerships. Please contact the Office of Research and Economic Development to be provided more information on the efforts featured in this magazine or any other research project at UAH. ■

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

A **"RESEARCH INTENSIVE"** national university that is located within the second–largest research park in the United States, UAH is considered one of the nation's premier research universities.

IN ALABAMA

1ST IN ALABAMA

- Environmental sciences including Atmospheric sciences
- Math & Computer sciences
- Physical sciences

2ND IN ALABAMA

- Federally funded research expenditures

NATIONALLY

- **5TH** Federally financed Aeronautical/ Astronautical engineering research
- **9TH** Federally financed Economics research
- **10TH** Federally financed Computer sciences research expenditures
- **11TH** NASA R&D expenditures
- **12TH** Federally financed Atmospheric sciences research expenditures
- **21ST** Federally financed Astronomy research expenditures
- **28TH** Department of Defense R&D expenditures

SOURCE: National Science Foundation

RESEARCH

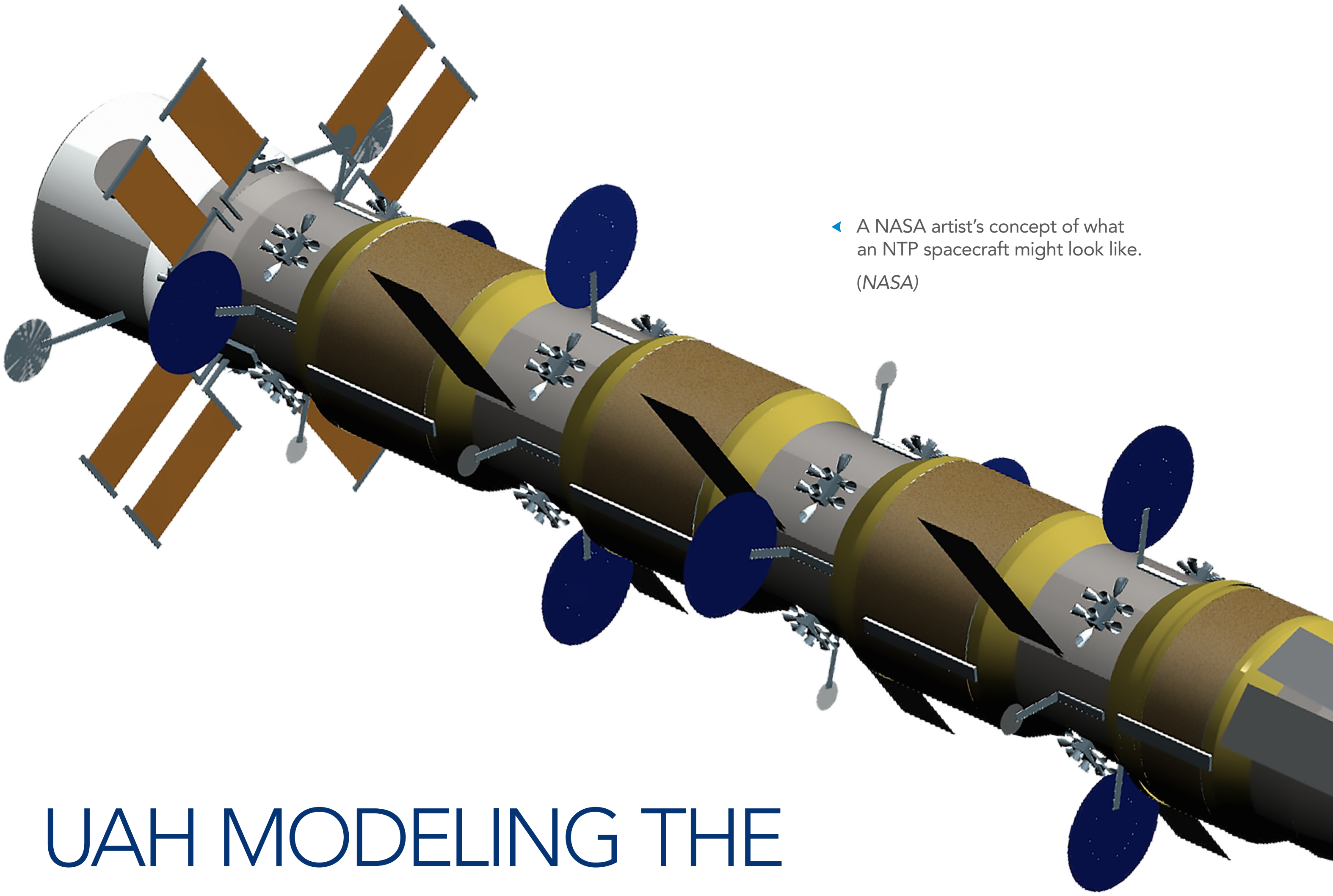
$463 million
Five-year contract and grant research total

$99 million
Fiscal 2018 research expenditure total

$5 million
Five-year license and royalty revenue total

[ISSUED PATENT TOTAL – 75]

Cover: Dr. Dale Thomas holds an inert nuclear thermal propulsion fuel sample at the NTREES test facility at Marshall Space Flight Center.



A NASA artist's concept of what an NTP spacecraft might look like. (*NASA*)

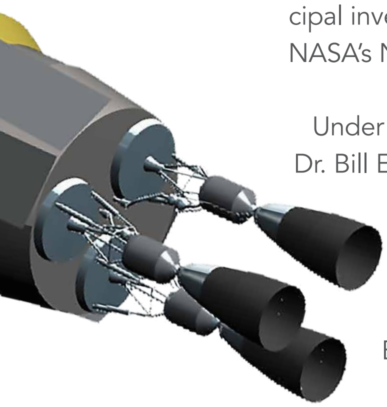
UAH MODELING THE SPACECRAFT FOR NASA'S INTRIGUING ENGINE SWAP IDEA

Successful human spaceflight to Mars and back is bound by basic rules of physics that any home garage hot rodder knows: mass, power and fuel consumption. To complete the mission, there must be enough thrust to propel a spacecraft's weight to the target destination and enough fuel economy to ensure there is adequate propellant.

Nuclear thermal propulsion (NTP) can help achieve the goals of low weight, high power and good economy. An NTP engine uses low enriched uranium (LEU) to heat a lightweight propellant such as liquefied hydrogen to 2,800 degrees Kelvin through channels in the core. The expanding gas exits the nozzle, providing thrust. If something goes awry and the craft crashes to Earth, the engine design and use of LEU reduce the chance of a catastrophic nuclear incident to near zero, as well as making flight safer for the crew.

NASA studied nuclear propulsion early on with the roughly two-decade long Nuclear Engine for Rocket Vehicle Application (NERVA) program that ended in 1972. Current NTP research can be viewed as a modern-day progeny of NERVA.

"The heartbeat of the program at this time is demonstrating that the reactor elements can be manufactured such that they will function in and survive the intense environment internal to the engine," says Dr. Dale Thomas, UAH's eminent scholar in systems engineering, who is the principal investigator for a UAH research grant with NASA's NTP Program Office.



Under the management of NASA researcher Dr. Bill Emrich, who teaches nuclear propulsion as an adjunct UAH faculty member, that testing is underway at NASA's Marshall Space Flight Center (MSFC) in the Nuclear Thermal Rocket Element Environmental Simulator (NTREES) facility.

As all hot rodders know, swapping engines can pose technical challenges. That's why NASA has a research grant with UAH to model how a spacecraft might be engineered to work with NTP, en route to an eventual test flight. NASA is currently focused on determining the feasibility and affordability of an LEU-based NTP engine with solid cost and schedule confidence. The space agency has started looking into a potential flight demonstration as a follow-on project in the mid-2020s.

UAH's Propulsion Research Center (PRC) manages the university's role in the project. The university's Complex Systems Integration Laboratory in its Rotorcraft Systems Engineering and Simulation Center (RSESC) is working closely with MSFC and private contractors to solve the challenges and exploit the opportunities created by a nuclear reactor at the heart of a rocket engine.

"We're trying to figure out – assuming you can make the engine – can we fit it to the vehicle and make it work," says Dr. Thomas, who incidentally is swapping engines to hot rod a classic pickup truck at home.

UAH's research focus is not on the reactor design, but rather on modeling the spacecraft during a human mission to Mars.

"How does the utilization of NTP affect the mission architecture and the spacecraft design and operation within that mission architecture?" Dr. Thomas asks. "What all do we have to change in what we're used to doing in designing a human crewed spacecraft?"

NTP is such a radical departure from liquid fuel rockets that even the NASA phrase "We have ignition" becomes obsolete because the propellant isn't burning. The crew will be shielded from the LEU in the reactors and will "get more radiation from deep space than from this engine," Dr. Thomas says. Yet the reactor poses other design challenges.

One of the first problems that NASA asked UAH to research is the heating effect that the NTP engine's gamma ray and neutron emissions will have on the hydrogen stored in the propellant tanks.

"Hydrogen, which must be in its liquid state to be used as NTP propellant, must be chilled to near absolute zero," Dr. Thomas says. "And it turns out that hydrogen is a great absorber of neutrons, and a good absorber of gamma rays."

As the hydrogen absorbs the particles, heat is generated.

▲ Dr. Bill Emrich in the Nuclear Thermal Rocket Element Environmental Simulator (NTREES) facility at NASA's Marshall Space Flight Center (MSFC).

A team led by Dr. Jason Cassibry, associate professor of mechanical and aerospace engineering, is modeling the behavior of the hydrogen in the system with the goal of keeping it liquid until the precise time it is to be expended.

"Storing hydrogen on a mission for months at a time is difficult, and every little thing that heats up the hydrogen is a problem," says Dr. Cassibry.

His computer modeling explores the impacts of variables such as the craft's trajectory and the design of the hydrogen tanks.

"Downstream of the reactor, we're modeling the flows of hydrogen and using those to validate the data against the results from the NERVA rocket development in the '60s and '70s," Dr. Cassibry says. "We're looking at the fuel economy and the thrust that comes out of the cone."

The initial modeling is being done at full power, but Dr. Cassibry expects that in a year or two, the team will begin to model the throttling process.

The stack of an NTP rocket begins with the nozzle, where liquefied hydrogen undergoes rapid expansion. Next up is the nuclear reactor, supplying heat to the nozzle. The reactor will only be powered up once conventional rockets have lofted parts of the craft into space so it can be assembled there. While on Earth, the reactor is in safe mode. Atop the reactor is the hydrogen storage, and atop that is the crew module.

Very cold and very light, liquid hydrogen is also a viscous fuel that can be hard to pump and utilize. UAH is investigating whether injection seeding the hydrogen with a noble gas such as argon would make it flow better. However, the argon seeding will affect engine performance.

"In rocket terms, you talk about specific impulse. How much energy can you get out of a fuel?" Dr. Thomas says. "When an engine is running hydrogen, it has one thrust level. If you seed it with argon, it generates more thrust, but at less efficiency."

The researchers are investigating whether seeding improves thrust enough to make up for the loss of efficiency, while at the same time conferring the benefit of better fuel flow.

NTP engines generate high thrust at over twice the specific impulse of the best chemical combustion engines. They also provide engineers with new opportunities for innovation.

"That's why NASA brought us onboard, to explore opportunities and to kind of look off into the distance to see what might be accomplished," says Dr. Thomas.

One possibility that would appeal to a hot rodder: add a conventional combustion component to the nuclear engine. Adding an oxygen tank to create an afterburner that ignites the hydrogen coming out of the nozzle could significantly boost thrust when needed.

Another intriguing opportunity lies in the reactor's waste heat.

"When you look at it, a Mars spacecraft is going to require a big solar array to get its power, and that creates design challenges of its own in weight and strength," Dr. Thomas says. "Plus, the farther away you get from the sun, the less efficient those arrays are going to be."

Because it's difficult to turn the reactor off and on due to the thermal effect on its materials, it has to idle when not in use. While idling, the reactor continues to generate heat. Perhaps hydrogen can be directed through the core to carry that heat to radiators coated with a thermoelectric compound that would generate electricity, Dr. Thomas suggests. Or the heat could be used to run a mechanical generator.

"If we tap the power off the reactor, we may be able to do away with the array," he says.

Exploring these kinds of design challenges and opportunities attracts graduate students to UAH from universities across the country, according to Dr. Thomas.

"It's amazing, the team we have been able to build," he says.

Besides Dr. Thomas and Dr. Cassibry, the NASA grant currently supports four graduate research assistants (GRAs). They are doctoral candidates Alex Aueron and Samantha Rawlins, and master's student Dennis Nikitaev. The team added another GRA position this fall and Dr. Thomas anticipates UAH's role will expand in the future.

"My attraction to NTP research stems from the understanding that, from a technical standpoint, nuclear thermal propulsion is hands-down the best way to get humans to Mars in my lifetime," Rawlins says. Because of their orbits, the energy required to travel from Earth to Mars reaches minimum expenditure every 16 years. The next opportunity is in 2033.

"We got to the moon in 8 years, so this is definitely possible, but it'll require making sure we play our cards right," Rawlins says.

"That's what's so exciting about working with Dr. Thomas on my research within the Complex Systems Integration Laboratory," she says. "We're using systems engineering to look ahead, question our current process and identify potential solutions or alternatives before they even become an issue."

It's the UAH team's job to smooth the path for NASA to help it get to Mars, Rawlins says.

"With this research, it feels great to contribute to the next 'giant leap for mankind,' sending humans to Mars," says Nikitaev. "The most challenging task is figuring out how to make all the components work together in a high-fidelity NTP engine simulation."

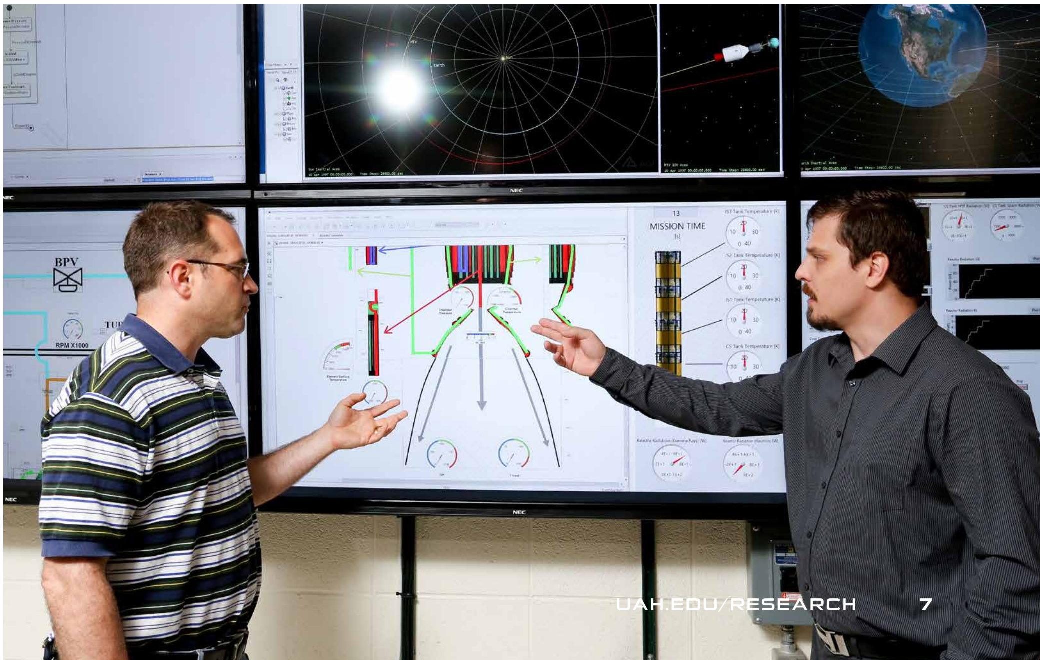
Being able to intellectually dream about possibilities "is one of the very best things I like about being at UAH," says Dr. Thomas, who joined the university in 2015 after being associate center director (technical) at MSFC.

"What we're doing here has wider implications for other areas," he says. "NTP moves the ball on Dr. Cassibry's work on PuFF (the Pulsed Fission-Fusion engine). It could even lead to a single-stage-to-orbit engine."

A hybrid NTP single-stage-to-orbit engine could lead to resurrection of a program similar to Lockheed Martin's X-33, a NASA Reusable Launch Vehicle (RLV) test bed that was scheduled to fly 15 suborbital test hops before it was cancelled in 2001.

"There's potential to come up with an air-breathing engine in the thick atmosphere," Dr. Thomas says, "and then use nuclear power once we get out of the atmosphere." ■

▼ Dr. Jason Cassibry, left, and Dennis Nikitaev discuss the NTP engine in the Complex Systems Integration Laboratory at UAH.



LEADING THE WAY

NSF TAPS DR. EMMANUEL WADDELL FOR DIRECTORSHIP

Dr. Emanuel Waddell, an associate professor in the Department of Chemistry and the associate dean of the College of Science at The University of Alabama in Huntsville (UAH), has been selected by the National Science Foundation (NSF) to serve as director of the Centers for Excellence in Science and Technology (CREST) program and the Historically Black Colleges and Universities Undergraduate program (HBCU-UP).

"A mentor, Dr. Louis Dale, informed me about the position opening during a conversation and it sounded like an excellent professional development opportunity," says Dr. Waddell, who has also served as president of the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers, president and chemistry chair for the Alabama Academy of Science, and UAH campus director of the Louis Stokes Alliance for Minority Participation (LSAMP) program.

The one-year assignment is part of the Intergovernmental Personnel Act (IPA) program, which allows for the temporary assignment of non-governmental subject matter experts to federal agencies for the purpose of furthering the goals and objectives of both the agency and the participant's organization. Dr. Waddell was selected for the director position by Dr. Jermelina Tupas, division director, Division of Human Resource Development, Directorate for Education and Human Resources at the NSF.

"It presents an opportunity for me to learn about the process from the point of view of the NSF," says Dr. Waddell. "I hope to be able to share information about the grant process with colleagues at UAH, especially when it comes to collaborative proposals and those that fall under the Human Resources Division of the NSF."

Once the assignment begins on July 8, he will relocate temporarily to Alexandria, Va., where his responsibilities will include coordinating review panels, learning about the grant process, educating stakeholders about the grant process, and participating in the decision-making process for awarding grants. He may also be involved with the NSF's Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science program and LSAMP during his tenure with the IPA program. "I am really excited about this professional development opportunity," says Dr. Waddell. "However, I will miss some of my daily interactions with my colleagues and students across the UAH campus." ■

Members of the Space Hardware Club with HELEN hardware are, from left, Elena Pradhan, Fred Snopl, Jennifer Miller, Everett Cavanaugh, Christopher Helmerich and Kayla Capitan.

SPACE HARDWARE CLUB HUNTS FOR TERRESTRIAL GAMMA RAYS IN THUNDERSTORMS

Student members of the Space Hardware Club (SHC) at UAH are launching weather balloons into thunderstorms to try to directly observe the terrestrial gamma ray flashes (TGFs) storms generate.

The High Energy Lightning Emission Network (HELEN) project uses the balloons to hoist aloft a network of sensor devices to measure intense bursts of gamma rays produced in the atmosphere.

Scientists think intra-cloud and positive cloud-to-ground lightning are correlated with the rays. Leading theories suggest strong electric fields inside of thunderstorms can become momentarily destabilized by a stroke of lightning, which causes the acceleration of electrons in the opposite direction of the electric field. The origin of the electric field, TGF propagation characteristics, and TGF source location, however, are still unknown.

"HELEN's goal is to directly observe terrestrial gamma-ray flashes in order to verify scientific models of TGF formation and to determine the neutron fluence of TGFs," says team lead Christopher Helmerich, a physics graduate student. "This has been a very challenging project, and to see it all come together successfully has been very rewarding. I am very proud of the team and all the work they have put in."

The HELEN team is aiming for eight to 10 thunderstorm flights over the course of the next year.

"That would give us a very good chance of detecting something interesting," Helmerich says. "We are aware of one or two groups at other universities investigating this method of TGF research, and we would be very excited if our team of mostly undergraduates was to make a valuable contribution to the field."

The complex endeavor means the team has had to drill to prepare for it.

"We have to launch four weather balloons simultaneously near a thunderstorm. We have planned out the events and timeline leading up to the launches very carefully and have had multiple training flights with our flight crew, so that they are familiar with the launch process," he says.

The crew will identify potential

Besides Helmerich, the HELEN team is:

- Elena Pradhan, systems engineer; senior, aerospace engineering;
- Everett Cavanaugh, science; senior, physics;
- Cory Wolfe, electronics; senior, aerospace engineering;
- Sean Widmier, FPGA programming; senior, computer engineering;
- Kayla Capitan, flight operations; junior, aerospace engineering;
- Frederick Snopl, mechanical design; senior, mechanical engineering;
- Jered Hunn, embedded programming; senior, computer engineering;
- Sarah Dangelo, prototype development; senior, mechanical engineering;
- Jennifer Miller, mechanical assembly; junior, physics.

launch opportunities a couple of days in advance and the time of launch will be refined as the launch window gets closer. A briefing to review weather forecasts, determine exact meeting times, and prepare will be held 12 to 24 hours before launch.

"For flights during the semester, we will have a 12-hour window from noon to midnight in which we will consider launching so that we reduce interference with students' life schedules," Helmerich says.

HELEN is funded through SHC, which includes in its sponsors the Alabama Space Grant Consortium (ASGC), the UAH College of Engineering, the UAH Department of Physics and Astronomy, the UAH College of Science, and the UAH Office of the Vice President for Research and Economic Development.

"We have had a total budget of $16,000 over two years," says Helmerich.

The HELEN team's UAH advisors are Dr. James Miller, chair of the Department of Physics and Astronomy; Dr. Don Gregory, distinguished professor of optics; and Dr. Richard Tantaris, Department of Mechanical & Aerospace Engineering lecturer.

NASA advisors to the HELEN team from the National Space Science and Technology Center (NSSTC) at UAH are Dr. Michael Briggs, assistant director of the UAH Center for Space Plasma and Aeronomic Research (CSPAR) and deputy principal investigator of the Fermi Gamma-Ray Burst Monitor, and Dr. Oliver Roberts, a member of the NASA Gamma-Ray Astrophysics team at NSSTC and the Universities Space Research Association.

To detect electric fields, the team designed and assembled electric field meters (EFMs).

"EFMs consist of two metal spheres that are spun around a rod by a motor. In a strong electric field, these spheres gather charge that can be measured by components on a printed circuit board (PCB) inside one of the spheres." Helmerich says. "The PCB also has an inertial measurement unit on it that records which direction the EFM spheres are pointing. From the data across all our EFMs, we can determine, over the course of the flight, the structure of the electric field around the thunderstorm."

HELEN's sensor units will detect radiation using a scintillation material called LYSO, which is composed of lutetium, yttrium, cerium, silicon and oxygen.

"We then use a photomultiplier tube to capture the light from the scintillator and turn it into an electrical signal," Helmerich says. "That signal is processed by our custom data acquisition system, which includes a high-speed 150 million samples per second analog-to-digital converter (ADC), a field programmable gate array and a processor running Linux. The data is then stored on an onboard SD card."

Using this setup, the HELEN team will be able to determine the energy and type of each radiation event in the detector.

"Unlike most radiation data acquisition systems, ours is able to process and store raw ADC data from each radiation event," he says. "This is important during the detection of a TGF, since we will need to capture many events in a very short amount of time."

Developing the data acquisition system was challenging because none of the team members had in-depth experience in developing such a system, he says, adding that getting all the different components of the data acquisition system talking to one another required a great deal of work over many months.

"Team members did have some prior experience with radiation detector assembly and PCB creation from previous SHC projects, but HELEN helped develop and refine many of those skills," Helmerich says. "In addition to the technical challenges, the organization of flight operations for launching four balloons simultaneously took a lot of careful thought and planning."

Helmerich says he's learned a few things as the project lead.

"I have learned that the most important task for any leader is to enable the members of the team to do amazing work. A leader needs to be able to acquire necessary resources, build team fellowship, bring the best out in each member and help build team members' skill sets," he says. "A leader should also be more invested in the well-being of individual members than in the member's commitment to the project, especially in a university environment." ■

David McNeill credits his Dad with inspiring his affinity for engineering.

MDA CHIEF ENGINEER'S PATH HAS BEEN DOING THE WORK HE LOVES

For David McNeill (B.S., Mechanical Engineering, 1986), doing the work he loves has been the pathway to greater responsibility.

McNeill is the chief engineer at the Missile Defense Agency (MDA) located on Redstone Arsenal and he says his Dad had a lot to do with inspiring his affinity for engineering.

"There is a Dilbert video called 'The Knack,' easily found on YouTube. Bottom line is, the doctor diagnoses Dilbert as an engineer," McNeill says. "I think I have always enjoyed engineering, maybe because I spent a lot of my time with my Dad fixing things around the house and working on our car. I also wanted to follow in my Dad's footsteps, though he is an electrical engineer."

His career took him from the U.S. Army Aviation and Missile Research Development and Engineering Center (AMRDEC) to the Army's Space and Missile Defense Command (SMDC) and to the Department Of Defense's Ballistic Missile Defense Organization (BMDO), now known as MDA.

As the chief engineer, McNeil is responsible to the director for engineering to provide:

- Sound and integrated engineering and manufacturing processes and products;

- Thorough element engineering controls, and management and verification through audit;
- Independent test, analysis and assessment of failed and high risk events and engineering efforts;
- Industrial and manufacturing readiness;
- Integrated, reliable and sustainable ballistic missile defense elements;
- A competent next generation of project engineer leaders.

McNeill's objective is to bring the Ballistic Missile Defense System (BMDS) into being by providing authoritative and technically sound direction over a broad spectrum of technical and programmatic issues.

"My entire career has provided numerous memories that have built on each other," he says.

"Working in research and development provided the experience on how new technology makes it to weapon systems. Working in Terminal High Altitude Aerial Defense (THAAD) provided experience on how weapons systems are developed and tested to support fielding decisions. Working in targets provided the experience on how weapon systems are tested against threat-representative targets, proving the BMDS could defeat the threat."

The one thing that pulled it all together was when he was in Israel and witnessed the Iron Dome system take down a real threat, McNeill says.

"That provided the confirmation that the mission was real."

While attending UAH, McNeil says most of his fellow students were working students, balancing jobs with schoolwork.

"I was able to apply what I was learning in school to the job," he says. "I think this provided me with the understanding of what my discipline required and also with something I wanted to spend my career pursuing."

A key lesson that McNeill says he has used numerous times in his career came from Dr. Donald Wallace at UAH.

"He gave us a problem where, when you calculated the answer, it didn't make sense. When we told him that something was wrong with the assignment because the answer wasn't logical, he told us we were correct," McNeill says. "In other works, we correctly calculated the answer with the information provided but we also had to be critical thinkers and determine if it made sense. Don't accept it just because that's what the numbers tell us."

The need for students to study math and the sciences is critical for our nation, McNeill says.

"The work is hard – or at least for some of us – and it's not for everyone. Those who choose to endure, and to push themselves when quitting would be easier, will be the ones who will help change and shape the future," he says. "Everything we enjoy today is because of engineering. In the defense industry, we are using words like 'game changing' technology. We must develop new technologies, and it's possible that today's engineers will be part of creating technology that doesn't even exist now. "

Students should learn in the workforce like they do at school, McNeill thinks.

"When you enter the workforce, don't look down at working the lower level jobs. It takes time to develop into an engineer using the tools provided in your discipline," he says. "I've seen some college graduates who come into the work force with little to no experience yet wanting the higher profile jobs. Be a person of integrity. Don't be afraid to fail. " ■

Robert Lightfoot is chair of the Alabama Space Grant Consortium Industrial Advisory Board.

LIGHTFOOT CHAIRS NEWLY FORMED ASGC INDUSTRIAL ADVISORY BOARD

Robert Lightfoot, vice president of strategy and business development at Lockheed Martin Space, has been named chair of the newly formed Alabama Space Grant Consortium Industrial Advisory Board (IAB).

"I look forward to chairing the Industrial Advisory Board of the ASGC. It will be the IAB's goal to advise and guide the ASGC in preparing the next generation space workforce to meet the rapidly expanding opportunities existing in the space economy," Lightfoot says.

"As the acting NASA administrator, I found providing the hands-on experience to a diverse workforce and driving collaboration across multiple organizations to be keys to success, and will challenge the ASGC to do the same across these great universities."

The IAB is comprised of 11 members in addition to the chair, with each ASGC campus nominating a member and the chair nominating five members. ASGC member universities are Alabama A&M University, Auburn University, Tuskegee University, The University of Alabama, The University of Alabama at Birmingham, The University of Alabama in Huntsville and the University of South Alabama.

IAB members will be geographically dispersed across Alabama. Initially, of the 12 members, six will serve two-year terms so that terms will be staggered in the future. IAB board members will serve for four years following the initial startup period. A board member can continue to serve upon re-nomination by his or her campus or the IAB chair and approval by the ASGC management committee.

The inaugural board meeting was June 28 in Huntsville. Besides Lightfoot, board members are:

- Mark Becnel, president, RadioBro Corp.;
- Miranda Bouldin, president and chief executive officer, LogiCore Corp.;
- Steve Cash, vice president, Advanced Space Systems Division, QuantiTech);
- Kim Doering, vice president of Space Systems, Dynetics;
- Todd May, senior vice president, Space and Mission Solutions, KBR, Inc.;
- Kenneth Sartor, associate professor, School of Technology, Engineering and Physical Sciences, Alabama A&M University;
- Charles Scales, director of business development, Sierra Lobo, Inc.;
- Daniel Schumacher, AMCOM Express deputy and senior manager, Torch Technologies;
- Joey Shelton, senior vice president of defense systems, TriVector Services, Inc.;
- Raymond Thompson, chief executive officer, Vista Engineering;
- David Trent, site director, Mobile Engineering Center, Airbus Americas Inc. ■

UAH CENTER PART OF EFFORT TO EVALUATE TECHNOLOGIES FOR FIRST RESPONDERS

The Birmingham Shaken Fury Operational Experiment is based on a New Madrid Fault earthquake scenario, says Casey Calamaio, an RSESC research engineer.

The University of Alabama in Huntsville (UAH) was the only academic institution selected to be a contractor in an experiment designed to improve first responder communications and on-site information during a major disaster.

UAH's Rotorcraft Systems Engineering and Simulation Center (RSESC) contracted to evaluate Unmanned Aircraft Systems (UAS) on Aug. 19-23 during the Next Generation First Responder – Birmingham Shaken Fury Operational Experiment.

Commonly referred to as Shaken Fury, the effort is a U.S. Dept. of Homeland Security Science and Technology Directorate (DHS S&T) operational experiment to evaluate emerging communications technologies in disaster situations.

Further, the Federal Emergency Management Agency (FEMA) and Federal Aviation Administration (FAA) Southeast Regional Office asked Jerry Hendrix, RSESC director of Unmanned Aircraft Systems Programs responsible for UAS research, to serve as the air boss for the exercise.

Hendrix has prior experience as the Air Wing 1 Commander for Texas and worked in recovery operations at Hurricane Harvey and at the FEMA earthquake exercise at the Muscatatuck Urban Training Complex, Indiana.

"I operated as the air boss for DHS S&T responsible for safe operations and mission success for UAS platforms," Hendrix says. "The air boss approves and coordinates all operations, working directly with the incident commander (IC). The air boss orchestrates all operations via clear and concise communication with the IC and to each UAS 'strike force' or squad."

Operational platforms included free-flying UAS and tethered UAS operating in and around Legion Field from industry and first responders like the Jefferson County Emergency Management Agency.

"Our operational protocols followed the FEMA and FAA protocols for UAS operations in and around a disaster," Hendrix says. "The FAA and FEMA were thoroughly briefed on the air boss duties and concurred with these duties."

Hendrix provided DHS S&T with an after-action review report along with UAH's operational notebook on the UAS operations.

Birmingham was the last of a five-year series of Federal Emergency Management Agency (FEMA) Shaken Fury experiments.

"Alabama Emergency Management Agency Director Brian Hastings helped to initiate this exercise in Birmingham," Hendrix says.

The experiment evaluated selected DHS-developed and commercial technologies to see how they integrated with existing public safety systems using open standards, and how those integrated capabilities enhance operational communications, increase operational coordination, improve responder safety and augment situational awareness.

Shaken Fury simulated the after-effects of a large earthquake at the University of Alabama at Birmingham (UAB) Legion Field. DHS partnered with public safety agencies in Jefferson County and the City of Birmingham in the experiment.

The experiment brought together private technology industries and first responders to gather information needed to develop the communications systems of the future. The experiment's integration demonstration was intended to help local emergency responders augment public safety capabilities before Birmingham hosts the World Games in July 2021.

Shaken Fury simulations included a partial structural collapse and a hazardous material release at Legion Field. In real life, those events would require significant public safety coordination for search and rescue, stadium evacuation, decontamination and mass medical care.

RSESC's role involved integrating Unmanned Aircraft Systems (UAS) into disaster response and recovery operations by using open-source Internet of Things (IoT) software.

Jerry Hendrix, RSESC director of Unmanned Aircraft Systems Programs responsible for UAS research, served as the exercise's air boss.

"This operational experiment is actually based on a scenario where a 7.2 or 7.3 magnitude New Madrid Fault earthquake sets things off," says Casey Calamaio, an RSESC research engineer.

"Unmanned aircraft systems are increasingly used in disaster response and recovery because they are easily deployed, operate in a range of environments and collect data from a perspective that is extremely valuable in dangerous situations," Calamaio says.

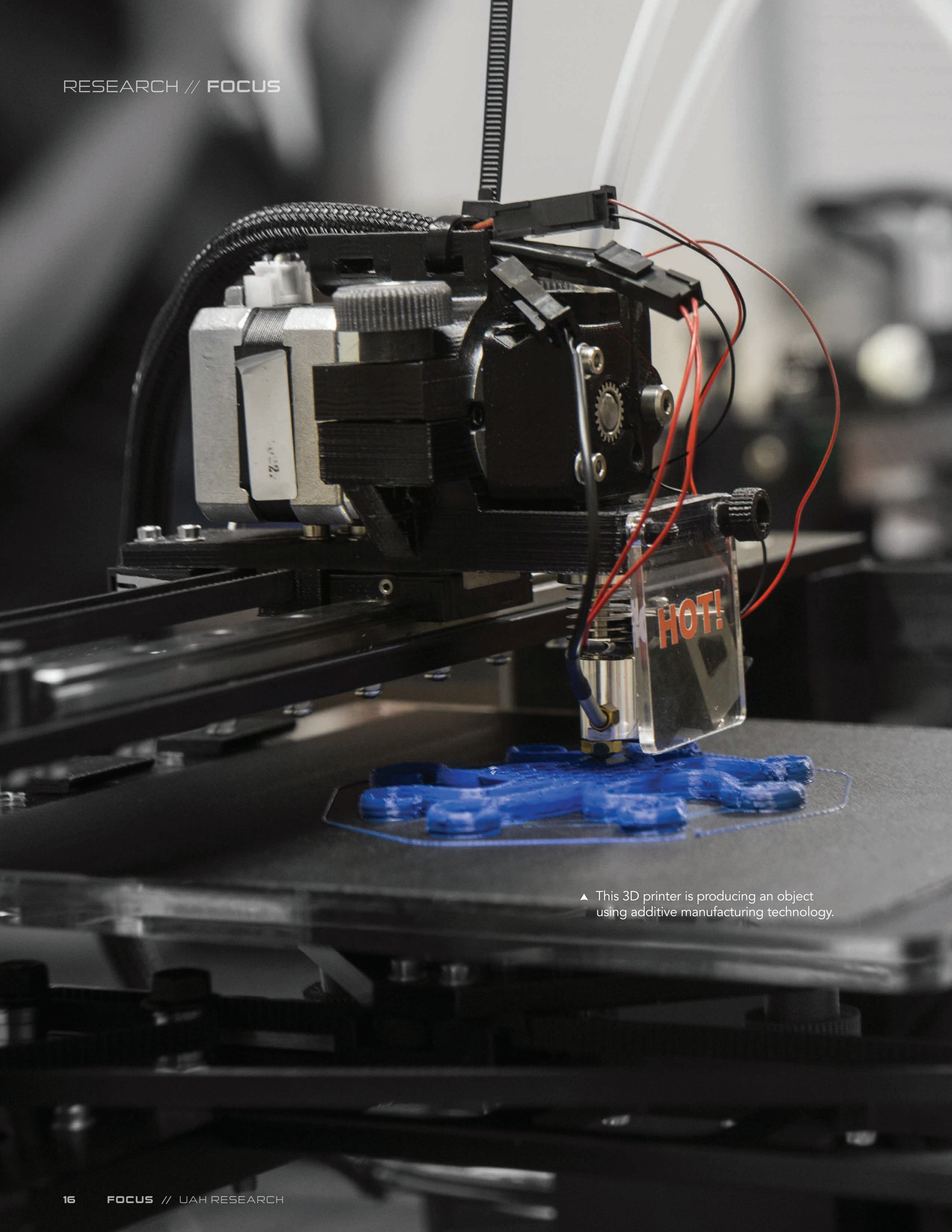
As the only academic institution involved, UAH worked on three fronts: technological development, integration testing and operational deployment, Calamaio says. The university's role included "testing a variety of emerging technologies for plug-and-play solutions," he says.

"Some of the key capability gaps that DHS has identified are tools for resource tracking, image and video analysis, and common operating pictures for situational awareness platforms."

RSESC also gathered drone imagery of the experimental site beforehand, so that comparative imagery for damage assessment could become a part of the testing, Calamaio says.

Involvement in the experiment is a first step toward a greater disaster preparedness research and development role for RSESC's UAS research, Hendrix says.

"This lays the foundation and framework for what we are going to do as we evolve." ■



▲ This 3D printer is producing an object using additive manufacturing technology.

UAH HELPS THE ARMY ADOPT ADDITIVE MANUFACTURING

The University of Alabama in Huntsville (UAH) Office for Operational Excellence (OOE) has a role in a recently funded program to integrate additive manufacturing into the United States Army and pilot an additive manufacturing-based supply chain.

Additive manufacturing is the process of making a three-dimensional solid object from a digital model.

As a collaborator with the Pennsylvania-based National Center for Defense Manufacturing and Machining (NCDMM), UAH received a portion of the $3.7 million in funding used to launch NCDMM's Additive Manufacturing NOW (AMNOW) program. The OOE is an office of the university's Research Institute.

▲ Joe Paxton, OOE director

"AMNOW is designed to help the Army reap the benefits of additive manufacturing," says Joe Paxton, OOE director. He says additive manufacturing's benefits include shorter project lead times, lighter weight parts, nearly limitless design capabilities and the potential for lower costs.

Structured as a potentially multi-phase, multi-year contract, AMNOW is funded by the U.S. Army Combat Capabilities Development Command (CDCC) – Aviation & Missile Center, through the U.S. Army Manufacturing Science and Technology (MS&T) Division, under the newly formed U.S. Army Futures Command. NCDMM is in partnership for the contract with Catalyst Connection, a Pittsburgh, Pa., privately held nonprofit organization.

"AMNOW is working to evaluate the ability of the additive manufacturing industrial base to support the Army and to ultimately put any missing pieces in place to pilot a robust and secure additive manufacturing supply chain for the Army," Paxton says.

"Some areas of focus are evaluating the readiness of additive manufacturing suppliers to support the Army, evaluating the ability of processes within the Army to source additive manufacturing parts and putting in any missing pieces for a pilot."

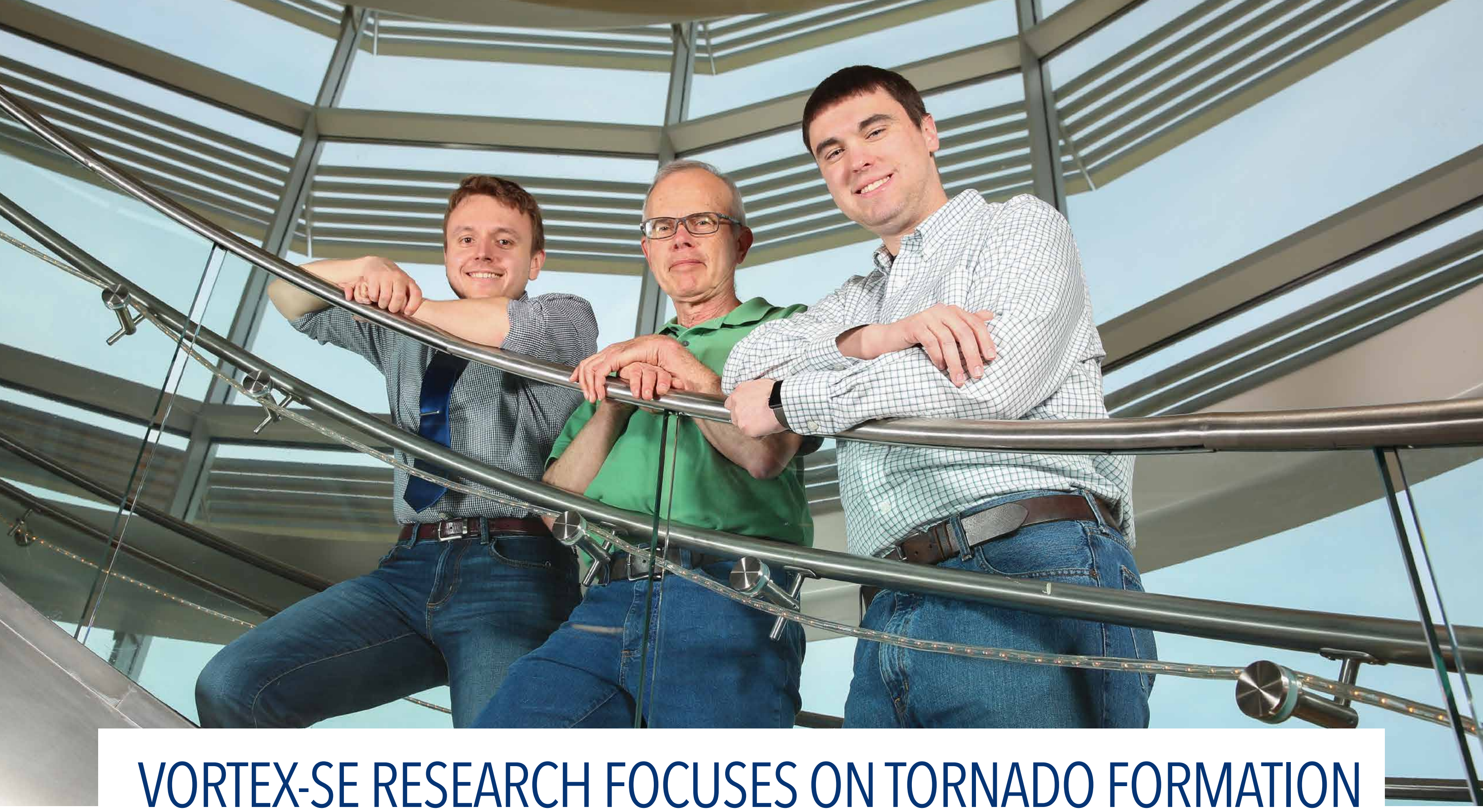
Challenges include the need to securely and digitally transmit and process Dept. of Defense design data, obtaining complete design data to use to source parts, ensuring the ability to validate that the final part matches the exact design that was provided and standardization of material properties within the additive manufacturing sector.

"While some of these challenges have been addressed with traditional manufacturing, the landscape of manufacturing is different with additive and the challenges are more complex, appear differently, or simply have not been faced before," Paxton says.

UAH and The Barnes Group Advisors LLC have partnered with NCDMM. UAH will focus on assessing additive manufacturing suppliers and evaluating the Army's sourcing processes for additive manufacturing, as well as supporting initiatives led by the other partners. Paxton is the lead for the work, supported by OOE research scientist Brian Tucker and undergraduate students.

Paxton says the OOE brings to AMNOW its supply chain mapping and supplier assessments experience with the Army, its experience with additive manufacturing, its experience with cybersecurity and an unbiased perspective. The work will contribute to the Army's adoption of broad-based additive manufacturing practices.

"There are some real challenges that are difficult to describe and some that have complicated histories," Paxton says. "We are looking at opportunities to expand our role now and in future phases." ■



VORTEX-SE RESEARCH FOCUSES ON TORNADO FORMATION

Scientists at The University of Alabama in Huntsville (UAH) are publishing research about tornado formation resulting from the multiyear Verification of the Origins of Rotation in Tornadoes Experiment Southeast (VORTEX-SE) program.

Begun in 2016 and centered at UAH's Severe Weather Institute – Radar and Lightning Laboratories (SWIRLL), VORTEX-SE brings together multiple universities and other scientific entities annually during springtime to study storm formation and the storm components that spawn tornadoes. It has been well supported nationally by Alabama legislators who recognize the tornado forecast challenges and the importance of research needed to improve forecasts and warnings.

"Rep. Robert Aderholt has supported VORTEX-SE on the House side, while U.S. Sen. Richard Shelby has supported it on the Senate side," says Dr. Kevin Knupp, professor of atmospheric science at UAH. Much of Sand Mountain and the VORTEX-SE operational area are within Rep. Aderholt's 4th Congressional District.

As many as 11 universities have concentrated their observational, data gathering and research capabilities on storms during Intense Observation Period (IOP) operations, Dr. Knupp says. Also involved are National Oceanic and Atmospheric Administration (NOAA) laboratories, including the National Severe Storms Laboratory at Norman, Okla.

Other VORTEX-SE supported entities conducted social science research, such as the University of Alabama, Mississippi State University and the National Center for Atmospheric Research.

A VORTEX-SE IOP tracked the long-track EF4 tornado blamed for killing at least 23 in Lee County, Ala., on March 3, 2019.

Two published UAH research studies from VORTEX-SE probe tornado formation factors.

SAND MOUNTAIN EXPLORATION

The first study examined the geographic features in the Sand Mountain area, a sandstone formation in northeastern Alabama that to a lesser degree extends into southwestern Tennessee and northwestern Georgia.

The Alabama portion of Sand Mountain sees the formation of an above average number of tornadoes, and the new research explores the possibility that topography has an influence on tornado formation in the Sand Mountain region. Researchers don't know yet exactly how the environmental changes impact the storms, but they have gained insights into the environments surrounding tornadic storms in northeast Alabama.

"The first paper that we published

Atmospheric scientists involved in the VORTEX-SE research are, from left, Anthony Lyza, Dr. Kevin Knupp and Dustin Conrad.

(*Michael Mercier / UAH*)

on the subject shows a statistically significant 'hot spot' of tornado formation centered on the Sand Mountain plateau when analyzed against a region within 250 kilometers of either Sand or Lookout Mountains," says author Anthony Lyza, who started the research as a UAH master's student and continues it as a doctoral candidate. Much of the work in the paper he completed as a doctoral student.

Prior to 2016, the only consistent long-term weather observations available for that area are from surface stations at Albertville, Scottsboro and Ft. Payne.

"When comparing surface observations prior to tornado events on Sand and Lookout Mountains, we found that cloud base heights tend to be lower at Albertville, atop Sand Mountain, than at Scottsboro in the adjacent Tennessee Valley, and that surface winds tend to be stronger and more backed, or counter-clockwise oriented, over the plateau," Lyza says. "Lower cloud base heights and more backed flow both tend to be generally more supportive of tornadoes."

Surface observations are limited in telling the extent of atmospheric wind, temperature and moisture changes over the plateaus vs. the surrounding lowlands.

"Thus, our goal in the fall 2016-spring 2017 VORTEX-SE experiment period was to gather information about deeper layers of the atmosphere over northeastern Alabama to address a fuller extent of how the atmosphere evolves in the terrain and how that may potentially affect the possibility of tornado formation in northeast Alabama," he says.

"The initial analysis of data gathered in northeast Alabama since 2016 indicates that the atmospheric changes associated with lowered cloud base heights are typically present atop Sand Mountain," Lyza says. "These observations also show that the vertical wind shear changes that were hypothesized based off the long-term surface observations can occur, but are not consistent under all environmental conditions."

An ongoing analysis aims to identify the conditions under which vertical wind shear may be favorably enhanced atop Sand Mountain. While there are some encouraging signs being noted in the data, Lyza says, the results are too preliminary to discuss at this time.

"All of these results are currently being compiled and prepared for a journal article that will likely be submitted for peer review in the next couple of months," he says.

SHIFTING WINDS

Another UAH research paper explores the influence of wind speed, horizontal shear instability (HSI) and wind angle on tornado formation in storms.

"For this case, we are primarily concerned with the wind shear in the horizontal direction, or how the wind speed and direction changes over a horizontal distance, says author Dustin Conrad, a master's student who did the research for his thesis.

"The wind shift angle is the wind direction change in respect to a plane. In this case, the plane is perpendicular to the leading edge of the storm."

HSI is an instability that results from rapid turning of the winds over a very short distance.

"It is this instability that we believe may lead to tornadoes in some of the quasi-linear convective systems (QLCSs) that occur in North Alabama," Conrad says. "For an example of HSI releasing, place a pen between your hands and then move them in opposite directions to cause the pen to rotate."

Because of data limitations, the certainty of a relationship between tornadoes and HIS could not be confirmed, but the research found that in some QLCSs, especially those that occur in the cold season, HSI is a potential mechanism for the formation of mesovortices. Every tornado has a mesovortex in it, but not all mesovortices produce tornadoes.

"With more observations and modeling studies, these results could help our understanding of which storms are more or less likely to produce severe weather during the cold season," Conrad says.

"Both studies have improved our understanding of the physical processes occurring within storms," says Dr. Knupp. "These processes often have signatures that can be used by forecasters to issue tornado warnings with greater confidence and accuracy, and longer lead time." ■

UAH'S APOLLO ERA ARCHIVES VITAL TO RESEARCHERS

The July 20 anniversary of the Apollo moon landing highlighted a resource at The University of Alabama in Huntsville (UAH) that lets researchers literally relive the development of technologies that made the Apollo moon landing and first walk on the moon possible.

Extensive collections of NASA materials produced during the development of the Saturn V rocket and materials from the Apollo era space programs reside in the archives on the ground floor of the M. Louis Salmon Library and are available to the general public from 9 a.m. to 4 p.m. Monday through Friday.

"This documentation was actually going on during the Apollo launch process," says Reagan Grimsley, the library's head of special collections and archives. "It's the technical documentation that allows us to know about the Saturn program."

The 40 linear feet of archived materials range from the early 1960s to the early 1970s and provide a ringside seat to the development processes NASA underwent to build, test and transport the necessary machinery to put man on the moon. Included are personal papers, oral histories and diaries from many scientists who were instrumental in the race to space.

"The space program was not just about technological development. It was about people, and we've tried to represent that aspect well in our collection," Grimsley says.

The library moved the archives to their current location in 2001, and an enclosed reading room was built where anyone who wants to peruse the collections can do so simply by asking.

"You can go back and look at the updates and see the Saturn V project as it moves along," say Grimsley while leafing through a vintage NASA document in archive storage.

Want a quicker view? Many of the space program archives are digital and available online.

Working under a Shooting for the Moon grant, staff are digitizing the oral histories in the collection so that they can be made available online, a process that has involved restoring the sound from hundreds of hours of magnetic tape recordings.

People involved in the space program, their relatives and space aficionados are constantly adding more materials to the expanding archives, Grimsley says, which is something that makes him happy.

"We have a pretty good pipeline," he says.

Gathering materials is one part detective work, one part donor enthusiasm and one part sheer luck, but the process serves some very specific goals.

"First of all, we want to document Alabama's role in the space race, but our collection is international in scope," Grimsley says. "Our overall goal is that we want to be one of the

the pre-eminent institutions involved in space history research."

Apollo materials also include documentation of the development of the Lunar Rover, including the papers of Saverio "Sonny" Morea, designer and project lead for the rover, who also was the NASA manager for the F-1 and J-2 engines.

"We have probably the most complete documentation of the Lunar Rover anywhere," Grimsley said.

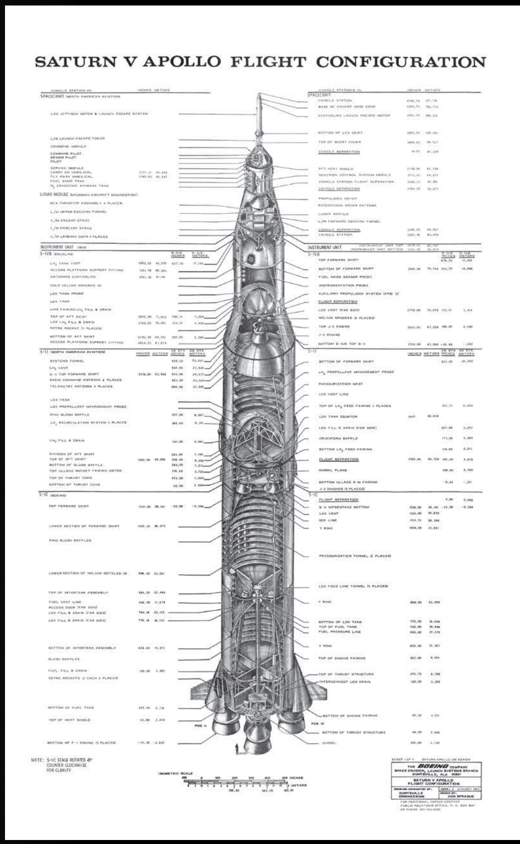
Copies of a publication called "Space Journal" that was produced in Huntsville for about two years beginning in 1957, with the direct involvement of Dr. Wernher von Braun, are being digitized.

"We worked with the Von Braun Astronomical Society to digitize as many copies of the 'Space Journal' as we could get a hold of, and put them in our collection," Grimsley says.

In collaboration with NASA's Marshall Space Flight Center (MSFC), Salmon Library began to gather space agency materials when a 1967 NASA grant proposal written by Dr. Rudolph Hermann, the first director of the UAH Research Institute, was funded. Dr. Hermann's papers are also in the archives.

Found in the NASA archives are major collections donated by:

- Konrad Dannenberg, also brought to the U.S. from Germany, who was deputy manager of the Saturn program;
- David Christiansen, who worked on liquid rocket propulsion systems for the Redstone, Jupiter and Saturn rockets and was project engineer for the Saturn H-1 rocket engine;
- Ernst Stuhlinger, who was brought to the U.S. from Germany after WW II as part of Operation Paperclip and developed guidance systems;
- Charles Lundquist, former director of the Space Sciences Laboratory at MSFC, who spent 40 years in high-level positions with the U.S. Army, the Army Ballistic Missile Agency and NASA.
- U.S. Rep. Bob Jones, who represented Alabama's Fifth District from 1973-1977 and had in the collection that he donated many papers that pertained to the development of the Apollo program from a legislative point of view.



▲ Among the archives stored at UAH are the original Saturn V Apollo Flight Configuration illustrations completed in 1968.

The Saturn V and Apollo materials are part of a wider space-oriented collection that includes original film shot by Skylab during its 1973-1974 mission. Also part of the wider collection is an extensive cache of science fiction books, many of which could have been formative in the young minds of future space race leaders.

"We want to document space history," Grimsley says, adding that the library is always interested in hearing from people who are interested in donating material that furthers that goal.

"When you think of the legacies of UAH regarding the space program, one of the legacies is in this collection," Grimsley says. "The other UAH legacy is in the people we trained who became part of the space program." ■

THE UNIVERSITY OF
ALABAMA IN HUNTSVILLE

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

UAH.EDU/RESEARCH