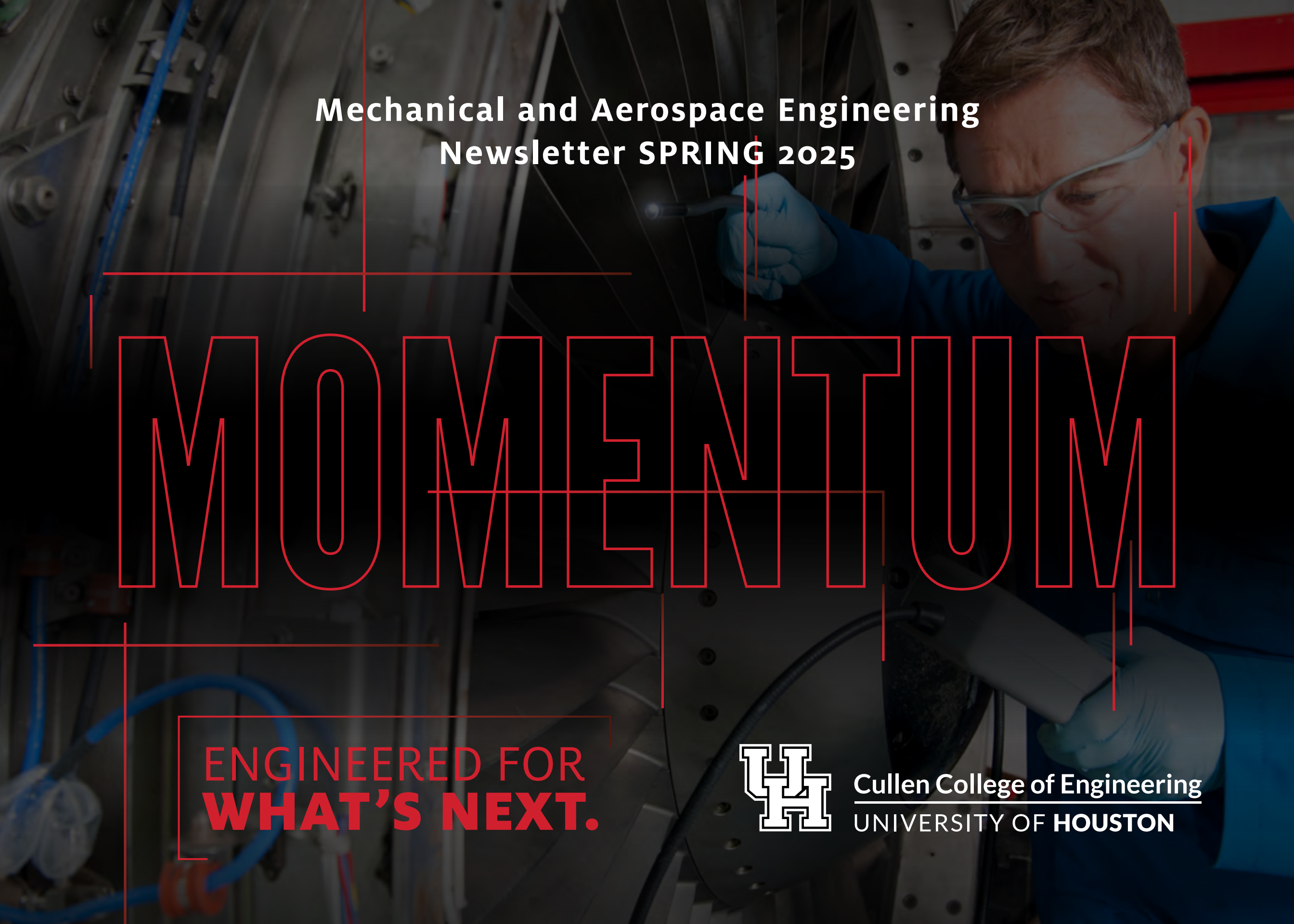

Mechanical and Aerospace Engineering
Newsletter SPRING 2025

MOMENTUM

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WHAT'S NEXT.

Cullen College of Engineering
UNIVERSITY OF **HOUSTON**

MAE'S XU RECEIVES CAREER AWARD TO INVESTIGATE LASER-INDUCED BUBBLE DYNAMICS IN HYDROGELS

Assistant Professor of Mechanical & Aerospace Engineering **Ben Xu** has received a National Science Foundation CAREER award for $598,991 for his research to understand bubble dynamics in hydrogels.

His project, "Multiscale Understanding of Laser-Induced Bubble Dynamics and the Mechanism of Resultant Jet Flow in Thin-Shearing Hydrogels," seeks to advance the understanding of bubble dynamics in hydrogels — which are widely used in biomedical and energy applications — and their interactions with lasers, focusing on how these interactions drive material behavior and jet flow formation.

This year marked Xu's third submission for the award, and indeed, the third time was the charm.

"I've been working on this topic since 2018, so that's six years of effort," he said. "I've kept working on this topic, improving it, refining the hypothesis, and fortunately everything went well this time. When I got the award email… It was a relief."

While significant research has been conducted on interactions of lasers with water and other Newtonian fluids, growing use of laser-assisted bioprinting (LAB) has highlighted our need to better understand the behavior of complex materials like hydrogels.

Laser-assisted bioprinting (LAB) uses lasers to precisely deposit materials, such as hydrogels embedded with cells, onto a surface substrate. In this process, hydrogels serve as a carrier, or "bioink," encapsulating bioactive cells to enable controlled placement and create functional biological structures.

The laser-induced bubble dynamics and subsequent hydrogel jet flow play a critical role in determining the precision and quality of the printing process. Understanding these dynamics is essential for optimizing printing processes and ensuring reliable fabrication of functional biological structures.

Unlike Newtonian fluids, which maintain a constant viscosity regardless of applied strain, non-Newtonian fluids — such as hydrogels — exhibit viscosity that changes with variations in shear rate. This means the behavior of non-Newtonian fluids depends on the forces acting upon them, adding a layer of complexity to the study of laser-material interactions in these systems.

Ben Xu
Assistant Professor

CHEN SOFTENS THE HARD SCIENCES WITH NEW RESEARCH ON KNITTING

Two papers recently co-authored by Kamel Salama Endowed Assistant Professor of Mechanical & Aerospace Engineering **Tian "Tim" Chen**, Ph.D., represent a new technological and engineering-focused foray into one of humanity's oldest fields: fiber works. Specifically, knitting.

"Knitting is actually really intriguing because it arranges yarns or threads into interconnected loops, which combine to make much of the clothing that we wear every day without any adhesives or glue; the only thing that's holding these fibers together is their mechanical interactions," said Chen. "We want to understand why, so in my lab, we focus on geometry and mechanics. We want to understand how the intricate geometries of different materials give rise to their mechanical behavior."

"[Knitting] is not traditionally seen as engineering research, but in the past decades, the definition of mechanical engineering has broadened greatly," he continued. "It's because of the great engineers of the past who solved really hard problems that we started to venturing into this whole new dimension of research that focuses on soft and flexible systems with much more complicated geometries."

The word textile derives from the Latin verb texere, meaning "to weave"; texere, in turn, shares the same Indo-European root teks, also "to weave", with the Latin techne, meaning "skill" or "craft." While weaving and knitting are two distinct methods of creation, this etymological genealogy highlights the deeply interconnected relationship between textiles and technology – the skilled and practical application of knowledge.

"We wanted to investigate these mechanical systems that are very intimately connected to human systems," he explained. "We already have a pretty good idea about how stiff things like steel and concrete work, but we don't have a very good idea about how soft things work. Our theories were all developed for things like building a bridge or an airplane; we don't have a lot of theoretical background for things that are very soft and interconnected."

Tian "Tim" Chen
Kamel Salama Endowed Assistant Professor

YASHASHREE KULKARNI WINS **2024 ASME MATERIALS DIVISION CENTENNIAL MID-CAREER AWARD**

Yashashree Kulkarni, the Bill D. Cook Professor of Mechanical & Aerospace Engineering at the University of Houston's Cullen College of Engineering, has received the 2024 American Society of Mechanical Engineers (ASME) Materials Division Centennial Mid-Career Award. She is being recognized for her "pioneering work in applying statistical mechanics methods to problems at the interface of mechanics and materials science."

The ASME Materials Division Centennial Mid-Career Award was established in 2020 to celebrate the 100th anniversary of the Materials Division. The award honors mid-career researchers who have made impactful contributions at the interface of materials and mechanics.

"It is an honor to receive this prestigious award, and I am really humbled by it. I am grateful to all my wonderful students, mentors, and colleagues for their support through these years." said Kulkarni.

Kulkarni is a recognized leader in mechanics and computational materials science. Specifically, her research focuses on elucidating the mechanical behavior of materials from fundamental scales using statistical mechanics, continuum mechanics, atomistic simulations and multi-scale modeling approaches with potential applications spanning the aerospace and energy industry to biotechnology and healthcare industry. Her work continues to push the boundaries of our understanding of the role of mechanics in materials science and biology.

Yashashree Kulkarni
Bill D. Cook Professor of Mechanical & Aerospace Engineering
Director of Research Computing

AGRAWAL EXPLORING NEW GEOMETRIC DESIGN WITH VARIED ENGINEERING APPLICATIONS

Associate professor of mechanical and aerospace engineering **Ashutosh Agrawal**, Ph.D., is putting a newly-awarded $334,569 grant from the National Science Foundation toward the study of "Mechanics of Optimal Biomimetic Torene Plates and Shells with Ultra-High Genus".

Torenes are unique structures that resemble the nuclear envelope of a eukaryotic cell and have the potential to scale up into "lightweight shell structures for extreme mechanical environments."

Ordinary shell structures – rounded structural components with few to no joins – are an elegant solution to support large loads with relatively thin, lightweight construction in almost any size. Common man-made examples include bicycle helmets, airplane fuselages, and the Sydney Opera House.

Agrawal, however, believes that the torene shell structure may be an innovative solution for redesigning or reinforcing the shell structures we currently know and rely on.

So dubbed by Agrawal because they comprise "concentric shell layers fused via torus-shaped holes", torenes are a "novel geometric strategy" that exhibit one to two orders of magnitude greater flexural stiffness than corresponding solid cylinders and solid domes. These torene shell structures "could provide novel ways to design lightweight structures across length scales for countering extreme mechanical loads."

"Our findings are length-scale and material-properties independent, and therefore suggest that the torene architecture could be used to design lightweight shell structures for extreme environments in diverse set-ups," Agrawal explained.

"In civil and mechanical engineering, structures called I-beams are routinely used in high-rise structures and bridges as they offer high flexural rigidity. We realized that Nature is using a 2D analog of this concept in the architecture of the nucleus to safeguard the genome. Subsequently, we thought of using this geometry in man-made plate and shell materials."

Ashutosh Agrawal
Associate Professor

SPACE ARCHITECTURE AT UH: WHAT MAKES A HOUSE (OR A LUNAR BASE CAMP) A HOME?

The Cullen College of Engineering's Sasakawa International Center for Space Architecture (SICSA) and its space architecture degree program might be the University of Houston's unintentionally-best-kept secret.

"Houston is definitely the right place for this program."

Though last year marked 20 years of the accreditation of the Master of Science in Space Architecture program by the Texas Higher Education Coordinating Board, program director **Olga Bannova**, Ph.D., still regularly encounters people who aren't familiar with space architecture as a field of study and research.

That's perhaps understandable, given that SICSA houses the only Master of Science in Space Architecture program in the world United States — there is a Space Architecture and Extreme Environments Design master's program located at Arizona State University, though it doesn't confer a STEM degree — but with NASA's Artemis campaign intending to return humans to further explore the Moon, and eventually Mars, fully underway, it's an area you'll probably be hearing a lot more about in the near future and the coming years.

"[Space architecture entails] a lot of systems engineering with significant human factors embedded in it," she said. "It's about human spaceflight, of course, but it goes way beyond the design of, say, interiors of space habitats. We really want to teach our students to define a potential problem in design, and that includes from not only a systems engineering point of view, but also thinking about the humans.

Olga Bannova
Research Professor | Director of the Space Architecture Graduate Program

LOVE ELECTED UH FACULTY SENATE PRESIDENT

As the 2024-25 Faculty Senate President at the University of Houston, **Holley Love** brings a wealth of experience and leadership to the role. A lifelong Houston Cougar, Love's connection to UH runs as deep as her commitment to its continued growth and success.

Love is passionate about advancing faculty interests and fostering collaboration across the University. In addition to her role as Faculty Senate President, she serves as an instructional associate professor in the Cullen College of Engineering Department of Mechanical and Aerospace Engineering.

Love recently sat down with us to share insights on her goals, her academic journey, hobbies and her vision for the future of the Faculty Senate.

Can you tell us a little about yourself and your background?

HL: I was born in Houston to parents who are also native Houstonians. Since I was little, I loved nature and science — I did a lot of home science experiments and nature explorations with my mom and a lot of work fixing things around the house with my dad. Or at least I tried to help! I ended up focusing my studies on the intersection of biomedical and mechanical engineering.

How long have you been with UH?

HL: I was a student from August 2003 to May 2013. [Love earned a B.S. in Biomedical Engineering, M.S. in Mechanical Engineering, and Ph.D. in Mechanical Engineering from UH.] I returned as an instructional faculty member in Fall 2016, and I've been here ever since.

What inspired you to pursue a career in academia?

HL: Reflecting back, it's difficult to pinpoint a single event. When I was graduating with my bachelor's degree, I didn't feel "ready" to leave school and go to work. I stayed on just to do a master's degree … but I ended up really enjoying my work and wanted to keep going. The girls on my floor at Moody Towers started to call me "Dr. Love"— even though I was only starting my graduate studies … but, honestly, it felt pretty good! When the teaching position at UH in the mechanical department opened, I was nervous about applying. I had gotten some exposure to teaching in my graduate studies and supervising interns in my post-doc. I am so glad that my family encouraged me to apply — my time teaching and advising are very rewarding.

Holley Love
Instructional Associate Professor

IMPROVING EYE TRACKING TO ASSESS BRAIN DISORDERS NEW EYE SENSORS USE SPECIAL MATERIAL THAT GENERATES ELECTRICITY WHEN IT BENDS

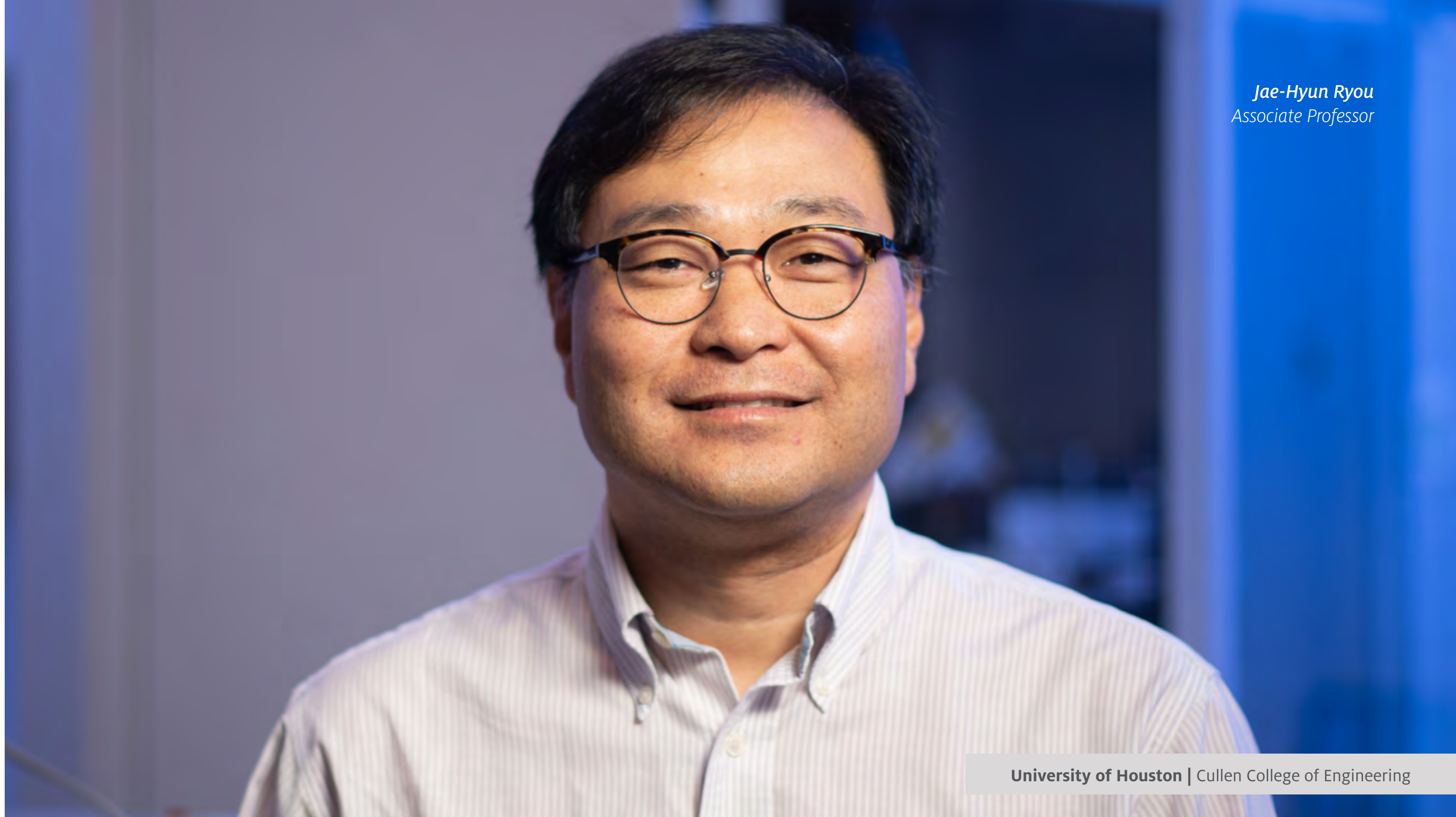
A University of Houston engineering team has developed wearable sensors to examine eye movement to assess brain disorders or damage to the brain. Many brain diseases and problems show up as eye symptoms, often before other symptoms appear.

You see, eyes are not merely a window into the soul, as poets would have it. These incredibly precious organs are also an extension of the brain and can provide early warning signs of brain-related disorders and information on what causes them. Examining the eyes can also help track the progression and symptoms of physical and mental shocks to the brain.

Researchers say current eye-tracking systems have flaws and deliver insufficient amounts of data. Plus, they're bulky, with multiple electrodes on the face and neck, expensive and have weak outputs.

And in the blink of an eye... improvement.

The new method, developed in the UH lab of **Jae-Hyun Ryou**, associate professor of mechanical engineering, with assistance from Nam-In Kim, post-doctoral researcher, is non-invasive, comfortably wearable, and safe, enabling easy and continuous measurements and monitoring of eyeball movements when combined with a hand-held display and computing device.



Jae-Hyun Ryou
Associate Professor

2024–25 OUTSTANDING SENIOR TARI ROCKETS TOWARD SUCCESS

Parsa Tari, graduating with his Bachelor of Science in Mechanical Engineering this spring, has been selected to receive the 2024–25 Outstanding Senior award from the Cullen College of Engineering.

Having developed an early interest in aerospace engineering thanks to a NASA-employed neighbor when he was a child, Tari said that it was an "obvious choice" to attend the University of Houston due to its physical proximity to aerospace industry opportunities.

His decision has paid off in more ways than one.

"At the end of my junior year, I found a job opportunity at a company called Leidos. I've learned a lot, and I think my learning in that position has been really important. That was a very big deal for me, and it's something I'm definitely proud of and happy about," he said.

Though getting involved with campus life and social opportunities was a bit trickier as a commuting student, Tari is particularly thankful for the friendships he made in his junior year and through Space City Rocketry, for which he also served as a lead on two different sub-teams last year.

Tari initially joined Space City Rocketry to get more hands-on aerospace-related skills and experience, learning to make things from solid rocket propellant to fiberglass tubes.

"You're working with a lot of other people, and I really enjoy getting to interact with people and learn more about different types of engineering, like electrical and chemical engineering. It broadens your horizons," he said.

Some of those same friends are now members of Tari's capstone team, which he credits with bolstering his development as an engineer.

"They've helped me get through hard patches and have taught me so much," he added. "If I need cheering up, they're always there for me."

Tari also expressed his gratitude for the support of Kamel Salama Endowed Professor of Mechanical & Aerospace Engineering **Haleh Ardebili**, who helped connect him with her research group.

Parsa Tari
Graduating with his Bachelor of Science

JOZWIAK NAMED 2025 TEXAS SPACE GRANT CONSORTIUM FELLOW

Cullen graduate student **Amber Jozwiak**, who is currently pursuing dual master's degrees in aerospace engineering and space architecture, has been selected as a NASA/Texas Space Grant Consortium (TSGC) Fellow for the 2025 academic year. The fellowship includes a $5,000 stipend and is open to students from any field with an interest in STEM and space-based research; Jozwiak fits the bill perfectly.

With education and experience in mechanical and aerospace engineering plus space architecture, including internships with Boeing and NASA, she's eager to find practical, hands-on applications for her knowledge and research.

Jozwiak chose to pursue her bachelor's degree in mechanical engineering at UH instead of going straight into an aerospace education so as not to commit to a niche too early, but she quickly "fell in love" with controls. "Aerospace is all controls," she said. "So now here I am!"

Jozwiak also noted that AIAA — the UH student chapter of the American Institute of Aeronautics and Astronautics — helped further develop her "love for aerospace". AIAA comprises four sub-teams: competitive international rocketry and aerodynamics teams as well as hobby rocketry and radio club teams. Students can compete in design-and-build competitions on the first two teams or obtain rocketry (levels one and two) and HAM radio certification on the second two.

Amber Jozwiak
Graduate student | Pursuing dual master's degrees in aerospace engineering and space architecture

CAPSTONE GROUP DESIGNING ADAPTER FOR NASA

For their capstone project, a group of students in the Mechanical and Aerospace Engineering Department at the University of Houston's Cullen College of Engineering is designing, fabricating and testing a dynamic adapter that attaches to a device being developed by NASA's Marshall Space Flight Center (MSFC).

According to the group, H.O.R.I.Z.O.N.S. aims to deliver a dynamic connection between NASA's experimental Domed-Shaped Device (DSD) and an UR-series robotic arm that will allow the DSD to dynamically tilt 30 degrees circumferentially to account for irregular terrain.

The team consists of **David Whaley, Cory Crow, Ashton West** and **Charity Golleher**. All four are MAE students at Cullen. Their advisors for the project are **Karolos Grigoriadis**, Hugh Roy and Lillie Cranz Cullen Endowed Professor & Department Chair, and the Director of the Aerospace Engineering Graduate Program; **Farah Hammami**, Instructional Assistant Professor in Mechanical Engineering; and Brandon Phillips, the team lead for the NASA MSFC Electrostatic Levitation Lab.

As part of the Capstone Experience, students are tasked with identifying problems and designing a viable solution. Funding isn't provided, so students are heavily encouraged to network with external groups and companies to secure support for their projects.

H.O.R.I.Z.O.N.S. was able to pursue this opportunity by leveraging the connections that Whaley made with his previous NASA internships. Thanks to the support of Grigoriadis and Phillips, the team was able to receive sponsorship for this capstone project and the opportunity to test it at MSFC's Lunar Terrain Field.

The objective of the capstone project is to develop an adapting mechanism between the UR-Series arm and DSD to deliver circumferential actuation by utilizing Shape Memory Alloys (SMAs). This technology was chosen in collaboration with our advisors.

Pictured: H.O.R.I.Z.O.N.S. team with the NASA MSFC Electrostatic Levitation Lab

The University of Houston
Cullen College of Engineering

The University of Houston Cullen College of Engineering addresses key challenges in energy, healthcare, infrastructure, and the environment by conducting cutting-edge research and graduating hundreds of world class engineers each year. With research expenditures topping $40 million and increasing each year, we continue to follow our tradition of excellence in spearheading research that has a real, direct impact in the Houston region and beyond.

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