THE UNIVERSITY OF ALABAMA® | Alabama Water Institute

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UA RESEARCHERS DEVELOPING DRONE-BASED UNDERWATER LASER MAPPING TECHNOLOGY

Undergraduate students and researchers at The University of Alabama are making it possible to scan and image the bottom of waterways using light detection and ranging, or LiDAR, mounted on drones fitted with green lasers.

By Brock Parker

Dr. Seongsin Margaret Kim and her students are developing a system to make it faster and more affordable to measure and map the beds and floors of coastal areas, rivers and streams. LiDAR-equipped drones will allow researchers to quickly gather data of those underwater environments to calculate how flow rates and paths are changing.

"Our system we're developing was started as a student senior design project where they successfully demonstrated water-penetrating LiDAR," said Kim, UA professor of electrical and computer engineering.

There are several airborne systems on the market for bathymetry – the measurement of submarine topography – using traditional LiDAR technology. Those systems can cost more than $1 million and are designed to be used on airplanes that are unable to fly just above the water's surface unlike drones. Kim's LiDAR system reduces the size and power consumption needed so they can be used on the smaller drones at a fraction of the price.

"You can deploy them any time because if you have larger airborne systems, you have flight limitations and regulations to follow," said Kim. "Those are going to be nearly minimized with the drones."

Kim's group uses green lasers because the light's wavelength can penetrate deeper into the water with lower absorption and provide high-resolution scans. By placing visual lasers on drones instead of airplanes, they can also safely operate at shorter distances from the surface.

"With some lasers you don't actually see the light, but to make the water-penetrating LiDAR, you have to have use visual lasers," said Kim. "Visual lasers sometimes need more regulations to the fly in the field outside because you can hit something or hurt someone."

Bathymetry is the measurement of the depths and shapes of underwater terrain such as sea floors and riverbeds. According to Kim, the bathymetry of larger areas is usually measured by SONAR placed on boats and smaller locations by physical means with measuring sticks or other devices.

Multiple drones in a group, referred to as a constellation or swarm, can be quickly deployed on-demand to cover these areas instead and result in reduced manpower, time and cost. "You can quickly see what's happening, say, at the bottom of a river in terms of flow speed and location, and that data can then help with predictive water models," said

The students are currently testing their equipment in a small tank and swimming pool where they were able to collect point cloud data on them. Point clouds are generated by LiDAR where each point represents a single laser scan measurement and are then stitched together creating a complete image of a scene.

The U.S. Geological Survey has experience mapping riverbeds, and Kim hopes this new technology can increase their partnerships with it and other federal agencies. Kim, Dr. Patrick Kung and Dr. Sevgi Gurbuz, both also from UA's electrical and computer engineering program, were recently awarded a grant from the U.S. Navy to develop polarimetry LiDAR, which utilizes the polarization properties of light for better performance in underwater imaging.

"It all started as a student project, but now we are much ahead in competing to achieve a new innovation" said Kim.

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DRONE-BASED LASER TECHNOLOGY

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With the Alabama Water Institute, National Oceanic and Atmospheric Administration and USGS all located on UA's campus, Kim sees more opportunities for collaborations and for her students to get hands-on work for the project.

"My intention was to create a project that students actually can learn about the new things that we don't teach in the classroom," she said. "This is a really great chance for them to get experience with career developments and help them to enter the workforce."

HOW TO GET AFFILIATED WITH THE ALABAMA WATER INSTITUTE

If you have expertise that could contribute to addressing complex water issues, please register yourself on our website. All registered members are considered affiliated with AWI and have access to all AWI resources.

To register, visit the AWI website: http://awi.ua.edu

Eligibility Criteria:

- A faculty/staff/student appointment at UA.
- Research expertise in a water-related field.
- Completion of registration form.

For questions contact Stefanie O'Neill at: soneill2@ua.edu or 205-348-9128

AWI AWARDS $144,450 IN RESEARCH SUPPORT TO UA FACULTY

By Brock Parker

Equipment, proposals and publications are critical tools for ensuring successful research at The University of Alabama. The Alabama Water Institute recently awarded $144,451.50 in multiple grants to AWI-affiliated faculty members to support their water-related research efforts.

The AWI has provided the following funds to five researchers through the institute's Equipment Support Program:

Dr. Gregory Starr, professor in UA's Department of Biological Sciences, was awarded $65,925 for a greenhouse gas analyzer. The analyzer will measure atmospheric concentrations of CO_2, H_2O and CH_4 at a site damaged earlier in the year due to a lightning strike. The analyzer will serve as replacement equipment.

Dr. Rachel Cajigas, assistant professor in UA's Department of Anthropology, has received $40,941.50 for a ground penetrating radar system, including survey accessories and slice processing software. The system will be used to detect and document acequias, or communal irrigation canals, in central New Mexico, aiding in outlining the evolution and configuration of acequias in this region throughout history. It will provide student training in the field of archaeology and federal funding opportunities.

Dr. Aijun Song, associate professor of electrical and computer engineering, was awarded $20,000 for side-scan sonar equipment that will provide acoustic imaging in aquatic environments. The high-definition side-scan sonar will first be used to image a prehistoric underwater cypress forest in the Gulf of Mexico. Subsequent uses will allow UA faculty members to inspect the health conditions of underwater structures.

Dr. Pamela Hart, assistant professor in UA's Department of Biological Sciences, has received $12,000 for a fluorescence stereo microscope and camera. It will primarily be used to image non-visual sensory systems in blind, cave-obligate Alabama-native cavefishes. It will use fluorescent dye to image cavefishes' smell, taste and water movement systems in conjunction with water condition experiments to understand the sensitivity of these unique and at-risk fishes to groundwater contamination. This equipment has the potential to open large avenues to uniquely study groundwater quality and subterranean water connectivity.

Dr. Mark Cheng, professor of electrical and computer engineering, has been awarded $5,585 for a 1100 degrees Celsius tube furnace with solid precursor sublimator for chemical vapor deposition growth. This equipment will allow for the capability to synthesize novel 2D materials to support research of filtration, PFAS and nanoplastics, which will be a new capability at UA.

For more information about how to apply for AWI support programs and for deadlines, contact Stefanie O'Neill at soneill2@ua.edu.

Affiliated Member Information:

awi.ua.edu/awi-affiliated-members/

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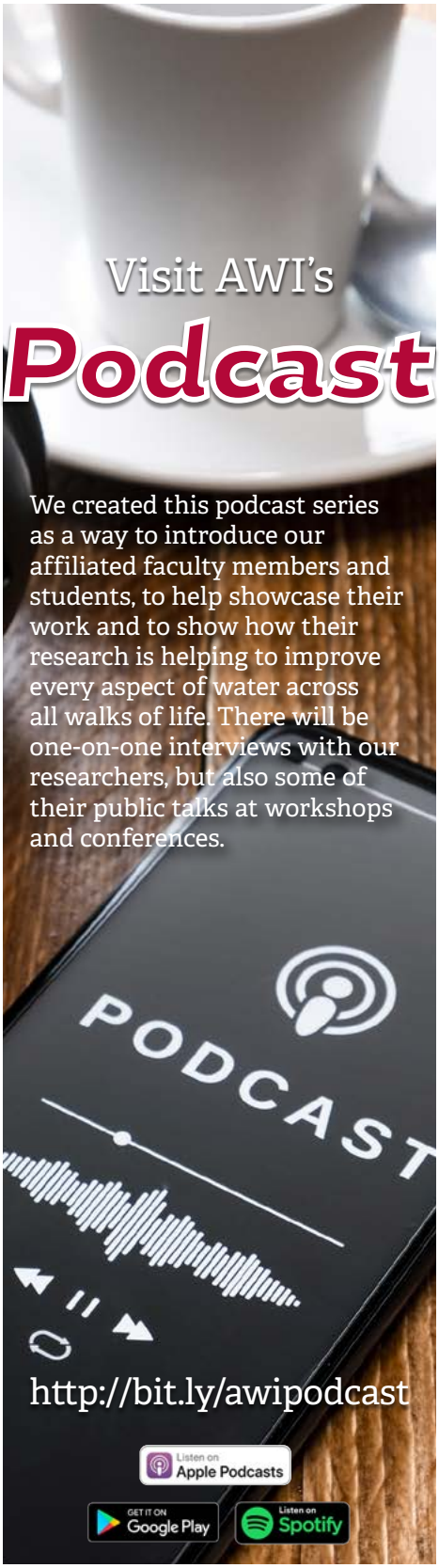

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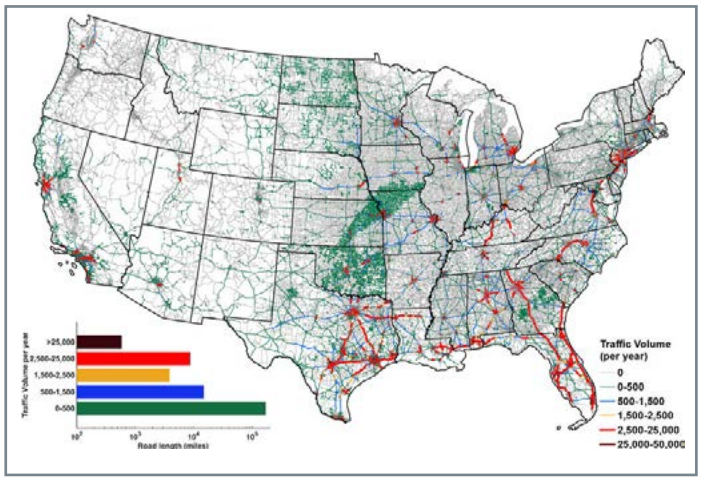
UA RESEARCHERS FIND HYDROPLANING RISKS GREATER IN SOUTHERN US

Research from The University of Alabama reveals the southern United States is a primary hotspot for hydroplaning due to extreme rainfall, a phenomenon that is known to elevate the risks of road accidents.

By Brock Parker



A study recently published by Kaustubh Anil Salvi, a postdoctoral researcher with the Alabama Transportation Institute, and Dr. Mukesh Kumar, associate professor of civil, construction and environmental engineering, is the first to map the spatiotemporal distribution of rain-induced hydroplaning on a national scale and detect regions with relatively high risks.

Weather is often a substantial factor in automobile accidents, particularly during rainfall when visibility decreases and ponded water creates reduced friction between the pavement and the tires of a moving vehicle. Other influences include the condition of the pavement and tires, the speed of the vehicles and human factors.

Between 1980 and 2017, approximately 24%, or 200,444 miles, of road within the continental U.S. were at risk of hydroplaning events. Of these, more than 840 miles of the roads experienced five or more of these events per year. Approximately 87% miles of such sections are in southern states, which receive frequent and intense rainstorms. In fact, six of the top 10 states at risk for these hydroplaning events reside in the South – Florida, Texas, Alabama, Oklahoma, Mississippi and Georgia.

Salvi and Kumar found that when coupled with rain, hydroplaning risks increase with wider and larger numbers of highway lanes, and higher speed limits. These conditions are more prevalent in the South than, for example, in the Pacific Northwest where rain is also significant, but roads are slightly narrower and speed limits are slower on average. Narrower roads keep the runoff depth in check.

As climate change continues, the frequency of larger precipitation events is expected to become more intense. That poses a bigger problem for drivers everywhere but especially for those in areas already prone to hydroplaning.

"If the temporal trends of the past 38 years continue into the future, our results show that road sections with large traffic volumes will be disproportionally affected," said Kumar.

"While locations with frequent risks of hydroplaning will likely catch the attention of planners, road sections experiencing lower risks but with high traffic volumes should also be prioritized for risk mitigation," added Salvi.

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HYDROPLANING RISKS GREATER IN SOUTHERN US

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Current designs and engineering of pavement, tires, traffic signs and rules often help reduce the likelihood of hydroplaning and ensure road safety. However, it still occurs when intense rainfall results in the development of thick water film on the pavement. By using the results of this study, Salvi and Kumar believe the data gathered can help decision-makers facilitate targeted and precise mitigation plans to alleviate future risks.

AWI RESEARCHER DEVELOPS NEW SNOW MODEL MACHINE LEARNING TUTORIAL

The creation of a new machine learning tutorial based on a national snow model from researchers at The University of Alabama and the University of Utah has been funded by a grant from the Earth Science Information Partners.

By Emily Fischer

Dr. Ryan Johnson, an artificial intelligence research scientist at the Alabama Water Institute, and his collaborator, Dane Liljestrand, a Ph.D. student from the University of Utah's Department of Civil and Environmental Engineering, were awarded a $7,500 ESIP grant to create a tutorial using the GeoWeaver software package. It will demonstrate data pre-processing, model training, data ingestion, model prediction and a graphical interface for the end user to interact with model results. The six-month project will last through January 2023 and is also supported by the Cooperative Institute for Research to Operations in Hydrology, or CIROH, and the National Oceanic and Atmospheric Administration.

"Data-driven modeling is often referred to as a 'black box' with little to no communication of model processes," Johnson said. "The ESIP grant emphasizing the GeoWeaver software package provides a key funding opportunity to increase the interpretability of the National Snow Model, which will support curriculum development and tools to transition the research into an operational water resources management environment."

Melting snowpack is an essential source of water for many regions. Accurate understanding and portrayal of available water supply is crucial for water management efforts. The tutorial will utilize cutting edge machine learning techniques, public data sources and open-source software packages to advance snow-related products and streamflow prediction by allowing near-real-time snow-water-equivalent, or SWE, modeling inference. Such developments will improve water resources planning and management decision-making for a broad range of stakeholders.

The water supply from melting snow can be measured in the form of SWE, a common measurement used by hydrologists to gauge the amount of liquid water contained within a snowpack. Though classical, physically based models can predict snow depth and SWE values well in homogeneous landscapes, they are limited when it comes to spatial resolution, landscape heterogeneity and quality of input data.

This project aims to address the need for a high-resolution machine learning SWE prediction model that can adapt to non-homogenous settings. Machine learning is a branch of artificial intelligence and computer science that uses data and algorithms to imitate intelligent human behavior and gradually improve model prediction accuracy. Such systems can draw inferences from patterns in data and learn to adapt without being explicitly programmed to do so. Deep learning is a subset of machine learning that uses a complex structure of algorithms modeled after the human brain. Deep learning algorithms use a series of artificial neural networks which mimic the way biological neurons fire signals to each other in the human brain.

This project's model employs a multi-model technique which utilizes gradient-boosted decision trees and a deep learning multilayer perceptron neural network model. Gradient boosted decision trees are a machine learning technique for optimizing the predictive value of a model through subsequent steps in the learning process. Each new piece of the decision tree works to minimize loss function, or the difference between the predicted value and target value.

"While we are continuously improving the internal model engine and looking at adding new input features from satellite remote sensing products, the current project is working towards transitioning the model into an operational setting that includes the production of mapping products to support water resources management planning guidance and ultimately, integrate into NOAA's Next Generation National Water Model to support informed season-to-season water supply estimates in the drought-prone western U.S.," Johnson said.

AWI EDITORIAL

PINE HILLS AND HICKORY SMOKE: ICHUAWAY'S LIVING LABORATORY AT THE JONES CENTER

By Michael Fedoroff

Sometimes being a water researcher has unexpected opportunities and provides for unique travel experiences — such as dining with the ambassador from Spain or visiting an ancestral kiva in the Southwest. The invitation for me and my University of Alabama and Alabama Water Institute colleague Dr. Kate Brauman to visit the Jones Research Center in Baker County, Georgia, was one such opportunity. As the director for the AWI Cultural and Water Resource Preservation Program, I was eager to pursue a partnership with the center in support of our mutual program goals of ecosystem conservation and watershed research. The Jones Center is known nationally and internationally as a first-class research facility for longleaf pine ecosystem management. Located in the Flint River watershed, the Jones Center is nestled within the historic Ichuaway Plantation created by the former Coca-Cola president and Georgia business magnate, Robert Winship Woodruff, in 1920. Our invitation to visit was received from Dr. Steven Brantley, and as part of the site tour, we were taking part in a traditional quail hunt, landscape ecology tour and laboratory visit.

On face value, a historic quail plantation might seem like a bit of a stretch for water research, however, water is central to the longleaf pine habitat and supporting ecosystems. Both fire and water are central to the management of longleaf, and the research produced at the Jones Center's 29,000-acre living laboratory is at the forefront of illustrating the benefits of good land management for improved water quality, water availability and building resilient watersheds. The diverse ecology and habitat found at Ichauway represent the ecosystem challenges often found in the greater lower coastal plain of the Southeast. This makes the Jones Center a hub of research activity helpful to water resource conservation scientists. The center has a research program with full-time core research staff, state-of-the-art labs, graduate student researchers, dormitories for visiting scholars and generous support from the Woodruff Foundation to promote excellence in natural resource management across the Southeast.

After driving many hours, we reached the famous research center and met Dr. Brantley. Wasting no time, we loaded up and followed him to our guest accommodations. The fog was thick as it filtered through the Spanish moss hanging from the giant live oak trees that lined the driveway. A faint outline of a house could be seen from the carefully maintained dirt road, and the occasional glimpse of electric light assured us that we had not inadvertently stepped back to some earlier time in Georgia. Dr. Brauman and I had arrived at the famed Woodruff House built in 1931. As we exited our vehicle, dogs began to howl a mixed sound of excitement and longing. We both immediately paused and identified the nearby kennels as Dr. Brantley smiled, almost apologetically, and said, "For the hunt, tomorrow."

After meeting the land manager and covering some safety basics, we settled in for the evening and prepared for the tour/hunt the following day. After a delicious breakfast, we loaded up on horse and wagon and began the slow ride across the property. As we lumbered along in the wagon, I got the opportunity to discuss the latest research interests of Dr. Brantley and (later Dr. Jeff Cannon) and share the AWI vision for our own research program. It was valuable to not only see firsthand the living laboratory that the Jones Center had worked hard to preserve, but also witness the linkages between water research outcomes and land management operations in action.

As we talked of water research and ecology, the men on horseback managed the dogs roaming the grasses in search of birds. The dogs were amazing to watch as they systematically ran full-sprint covering every available inch of ground in search of their quarry. Upon finding the scent of quail, the dogs would freeze and point with every muscle twitching with excitement. When a covey of quail was located by the dog, the master of the hunt would halt the group and signal our dismount from the horses and wagons. We would slowly ease past the dogs waiting for the tell-tale explosive sound of quail breaking for the sky. To say such small birds sound like cannons would not be an understatement for those who have heard them.

When the hunt concluded, we returned to the house for the evening meal. The food was so well prepared that I felt guilty eating it, however the conversation soon turned to the lab tour scheduled for the next morning, so we turned in early. My room smelled faintly of hickory smoke, and I slept soundly dreaming about old growth pine trees. After breakfast, we headed to the labs for a tour, and on our way, we passed an old dog cemetery. I had seen a few of these types of cemeteries before, yet not one as well maintained as this one. Mr. Woodruff certainly loved his dogs.

The labs and conference center build-

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AWI EDITORIAL

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ings at the Jones Center are near each other allowing easy walking of the campus. The central analytic facility within the lab houses wet labs and conservation equipment while lab and field technicians have space to stage field monitoring and operations. This 18,000-square foot area boasts nine research scientist labs with specialties that compliment a holistic ecosystems science approach to natural resource management such as aquatic ecology, forest ecology, ecohydrology, etc. After the tour, we discussed potential research partnerships and agreed that many opportunities for future collaborations exist especially for hosting student field research.

As I sit here now in my university office, I can still smell the hickory smoke of the Woodruff house and feel the pine breeze on my face. Living laboratories of this size and capability in the Southeast are rare, and through the partnership of UA, AWI, CWRP and the Jones Research Center of Ichauway, hopefully UA students and researchers will get to experience the wonders of the longleaf pine savannah ecosystem like I did.

UA HOSTS SYMPOSIUM TO ADDRESS FOOD AND WATER CHALLENGES

By Emily Fischer

The University of Alabama recently hosted "Multiple Inequalities in Every Meal: Theorizing Intersectional Foodways, Past and Present." This interdisciplinary workshop assembled an international panel of food scholars from archaeology, cultural anthropology, American studies, women's studies and African American studies to engage in discourse about the ways inequality was manufactured and maintained in the past and its lasting effect on the present.

"The Alabama Water Institute is honored to participate in this invitation-only panel to help scope and solve some of our toughest challenges related to food and water," said Mike Fedoroff, AWI's director of cultural and water resources preservation.

The workshop took place Oct. 28-30 at Hewson Hall and featured four discussion topics.

The first topic, "Setting the Table: Understanding the Complexities of Intersectionality," examined the current state of intersectionality theory from both within and outside anthropology to explore how anthropological and archaeological theory can intervene. One of the major questions discussed included distinguishing societal hierarchies in intersectional frameworks.

The second, "Building an Intersectional Framework for the Archaeology of Food," discussed how best to articulate an inclusive, yet operational, intersectional agenda that could bring to light marginalized narratives of history.

The third topic, "Intersectional Commensality, Premodern and Modern," examined how intersectionality originated and whether the "premodern" and "modern" divide had empirical salience. Among this discussion was the question, how does the materiality of food itself, for example, sweetness, reinforce or break down intersectional social hierarchies?

Topic four, "Methodological Considerations in the Intersectional Archaeology of Food" intended to identify appropriate methodologies and lines of evidence that could potentially uncover intersectional dynamics in past social relations.

AWI SPOTLIGHT: EMILY FISCHER & CODY TAYLOR

The Alabama Water Institute recently welcomed Emily Fischer as a science communications student intern.

Fischer is a sophomore at The University of Alabama, majoring in biology with a minor in English. As a science communications intern, Fischer writes press releases and feature articles highlighting cutting-edge hydrological research and projects being conducted at UA and by the institute's partners.

"I've always been interested in both science and writing, so I've really enjoyed the opportunity to combine the two through the pieces I write for the institute," Fischer said.

Fischer has been fascinated by the multitude of ways that the AWI applies its science.

"Water isn't just relevant to science, it's often a major topic of discussion for policymakers, too," she said. "Water directly affects public health, food security, climate change and economic growth. The more people are aware of these issues, the more minds we have engineering solutions to these problems."

Fischer hopes that the institute will continue to educate the public on water issues and looks forward to assisting in this cause.

"Water is a fundamental element of life. Yet, before working at the AWI, I rarely thought about water-related issues," Fischer said. "I feel very passionately about environmental justice and social justice topics, and water has such a close tie to each of these. I look forward to deepening my understanding of these issues through the institute."

Fischer works to effectively communicate research efforts to a wide audience of scientists, policymakers, faculty, staff, students and the public alike. Additionally, she assists in creating content for the AWI's social media channels. Fischer is mentored and overseen by AWI Director for Research to Operations Communications Zach Krauss and Brock Parker, AWI's senior writer and editor.

"It's one thing to explain science to scientists, but it's a whole separate thing to be able to communicate important information in an understandable way from which everyone can benefit," Fischer said.

The Alabama Water Institute recently welcomed student intern Cody Taylor as an undergraduate research assistant.

Taylor, a sophomore at The University of Alabama, joined AWI in August 2022. He is on the STEM path to an MBA, majoring in math with a minor in the Randall Research Scholars program. He is an assistant to Amy Hammett, AWI's director of regional and national collaborations. Taylor works to conduct background research and critical analysis for current and future energy projects.

Taylor has always been interested in waterways and energy, as well as the application of water intelligence to power. Prior to college, Taylor volunteered for SOLVE, a nonprofit organization that promotes environmental stewardship in the state of Oregon. He also attended an engineering camp where he was able to observe the inner workings of the Rocky Reach Dam, a hydroelectric dam located in Washington.

Taylor became involved in AWI after reading a research project description posted by Hammett. Through his research for AWI, he has found that there is a substantial overlap between water and energy, and the connection to agriculture, health, power and infrastructure.

"It's been really enlightening to explore how water intelligence seeps its way into every sector," Taylor said.

Taylor anticipates continuing research efforts throughout his career and hopes to continue working for AWI on future projects.

"I'm excited to find my next project," he said. "The last semester has given me a great tool belt to tackle future work."

Taylor is proud of the growth he has witnessed within AWI.

"I look forward to new minds bringing new perspectives to current projects," Taylor said. "Not only is it helpful for finishing projects faster, but it's great for scoping out new projects that will be important to the United States in the future."

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