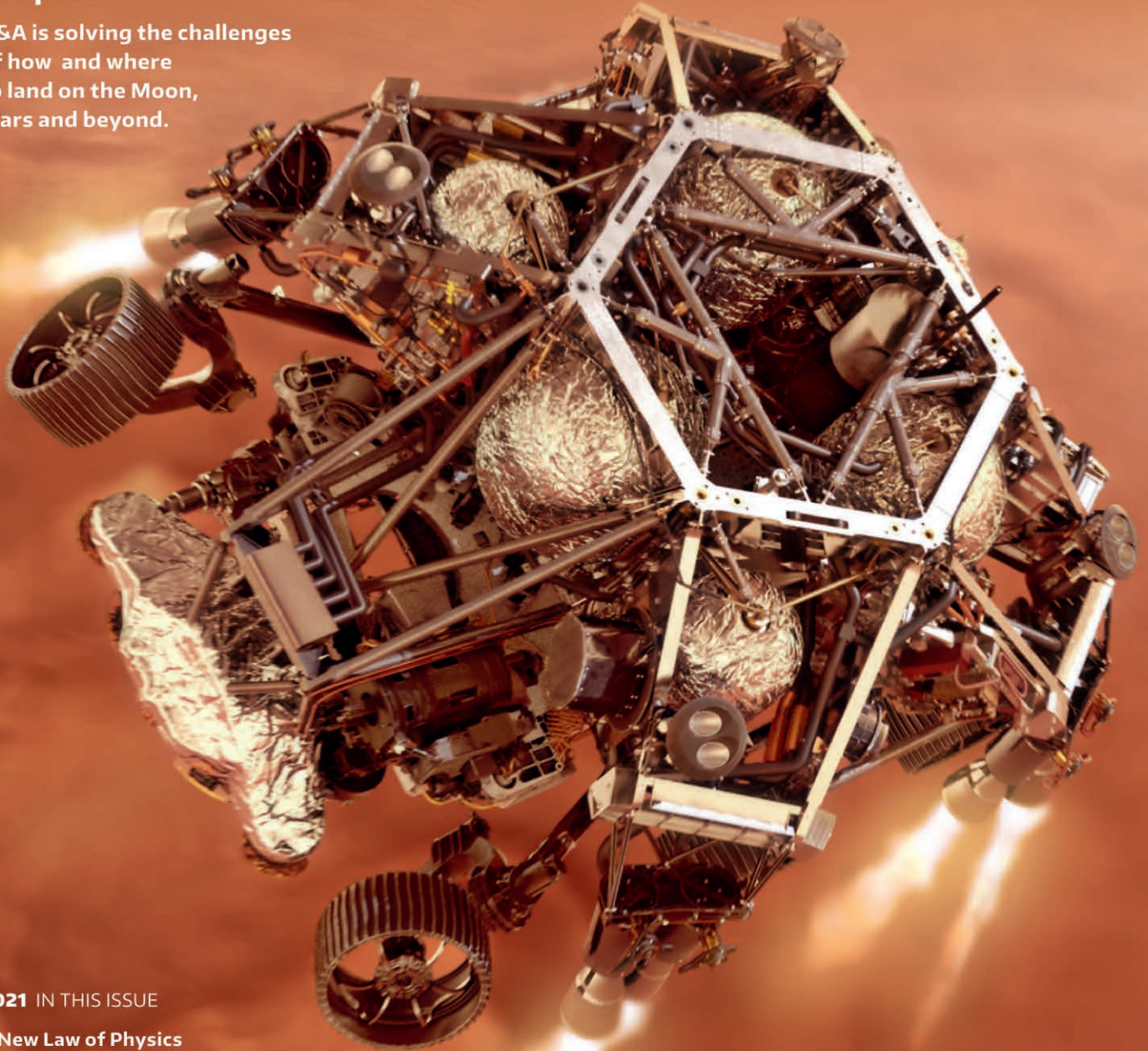


HIGHFLIGHT

WILLIAM E. BOEING DEPARTMENT OF AERONAUTICS & ASTRONAUTICS

Nailing the Landings in Space

A&A is solving the challenges
of how and where
to land on the Moon,
Mars and beyond.



2021 IN THIS ISSUE

A New Law of Physics

A&A Research Testing in Boeing's
ecoDemonstrator

Monitoring Snowpacks by Drone

Award-Winning Coral Research

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MESSAGE FROM THE CHAIR

Dear A&A Alumni and Friends,

This journey we've been on with the pandemic has led us to reflect on what kind of normal we would like to create going forward. As engineers, we have a spirit of imagination and invention that we can engage to craft a better future.

The College of Engineering released its newest strategic plan, "Engineering Excellence for the Public Good" which is a solid foundation on which to base our own departmental Strategic Plan to guide us through 2026. The A&A faculty, in collaboration with department staff and students, are contributing to evaluate what is meaningful to us in terms of delivering a holistic aerospace education, establishing a thriving research culture and identity, and nurturing a supportive community for faculty, staff and students.

Our commitment to Diversity, Equity and Inclusion is intrinsic in all these three pillars. As a department, we are deepening our understanding of DEI issues and expanding our outreach to potential students and faculty. We also welcomed the Washington NASA Space Grant Consortium into our department this year, as you will read later in these pages. Through this renowned NASA program, we are supporting underrepresented students in space-related STEM fields.

We hope you enjoy this edition of *Highflight*. I am so proud to represent this department pushing the boundaries of discovery and working toward a more just world. From a new law of physics and solving the challenges of landing in space to measuring glacial snowpacks and creating better research environments for coral recovery, A&A is applying aerospace engineering for a more expansive, brighter future.

Kristi A. Morgansen

Professor and Chair



Kristi A. Morgansen, Professor and Chair

HIGHLIGHT 2021

CREDITS:

Kristi Morgansen, *Professor & Chair*

Content by Amy Sprague, *Communications Manager*

Contributions by Drew Deguchi and Taylor Odom.

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aafrontdesk@uw.edu

TEL: 206.543.1950

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An electronic copy of Highflight will be posted on our website.

Anita Gale

is the 2021 A&A Distinguished Alumna

Gale, inspiring the next generation of space pioneers, is our latest recipient of the department's highest award.

By Amy Sprague



Gale at the UW centennial celebration of aeronautics instruction in 2018.

I knew 30 seconds into my Zoom interview of 2021 A&A Distinguished Alumna Anita Gale, that I was about to have a very interesting conversation. She started out describing the thrill of teaching someone sailboat racing in a J24 boat, a passion she and her late husband Dick Edwards developed together. She says, "That boat is the perfect size for newcomers. At 24-feet-long, with three people who know how to operate the boat well, you can invite two more who can follow instructions to join the team. That means you can have absolute novices racing a sailboat on their first day out!"

Scott Crossfield, an inspiration to Anita Gale and the 1986 recipient of the A&A Distinguished Alumnus award (BSAA 1946, MSA 1947), was the first pilot to fly twice the speed of sound in 1953. He was also a consultant to the House Committee on Science and Technology. He joined NACA after graduation. At North American Aviation, he was involved in all phases of the X-15 project, flew the checkout flights, and reached Mach 3. He was later a technical director at North American, and he served as division vice president at eastern Airlines. Crossfield's many honors include presentation of the Harmon and Collier Trophies by President Kennedy, and induction into the National Aviation Hall of Fame.

Photo right: Albert Scott Crossfield standing in front of the X-15, Los Angeles, California, October 1958 (Photo by Allan Grant/The LIFE Picture Collection via Getty Images).



Anita Gale in 1986 during her work for the Space Shuttle program.

Her alacrity for giving people new and amazing life experiences does not escape other people. "Anita Gale has such an amazing spirit, and she is eager to create unique experiences for high school students, college students, and life-long learners," says A&A Chair Kristi Morgansen. "Our A&A community would not only like to recognize her career accomplishments, but her generosity of spirit and her enthusiasm. And as a woman in aerospace," she continued, "I have long looked to Anita, who was a pioneer in the US space program and an inspiration to the women in the field after her."

A clear and early interest in space

Anita entered UW Engineering in the fall of 1969, right after Apollo 11. But her interest in space emerged well before then. Sputnik fascinated her in 1957 and the Mercury missions after that. In the third grade, she was reading Jules Verne's *From the Earth to the Moon* and the Buck Rogers comics.

"I was following it all," she reports. "My family subscribed to *Look* magazine which had exclusive stories on the Apollo astronauts. I followed Alan Shepard and Gus Grissom. Then there was Valentina Tereshkova, the first woman in space in 1963! I followed the feats of Chuck Yeager and Scott Crossfield. I followed it all!"

CONTINUED PG 24





NAILING THE landings in space

**A&A IS SOLVING THE CHALLENGES OF
HOW AND WHERE TO LAND ON THE MOON,
MARS AND BEYOND**

Space landings are evolving from the Apollo era as we plan to land in areas we can't see or predict with crafts that are autonomous, and soon larger and harder to slow down on entry. A&A is providing algorithms, structures and insights to make sure we stick those landings.



The app to find a good parking spot on the Moon

NASA's SPLICE is the landing app Apollo didn't have

When the Apollo missions headed to the Moon, astronauts knew basically where they were going to land before they even left. Then they used their eyes to do the rest. But as we ramp up to the next era of space exploration, we will want to land our spacecraft safely in areas that we don't have mapped out well, often without the benefit of human vision on-board, and we want to get there efficiently.

A&A developed guidance algorithms that determine efficient trajectories to arrive at that great parking spot. These guidance algorithms work together with additional algorithms that pull in streams of sensor, lidar and camera data to calculate the velocity and position of a landing spacecraft, and to detect previously unknown hazards on the surface. This suite of algorithms and technologies have now flown on two Blue Origin New Shepard missions. Spacecraft will use these algorithms, or variants of them, to find an optimized and precise landing location and determine the most efficient trajectory to get there. Future landers will be able to land safely and more precisely in ways they could not before.

Researchers in A&A's Autonomous Control Lab and the RAIN Lab developed the guidance algorithms under NASA's "Safe and Precise Landing - Integrated Capabilities Evolution" or "SPLICE" program, which is developing a suite of lunar landing sensors, computers and algorithms working together for landing.

Cameras and other instruments on a spacecraft will capture altitude and terrain characteristics. The A&A algorithms will then kick in to process the information, guide the vehicle to a desired

location on a trajectory that keeps the cameras pointed at the landing site, thus helping the onboard vision algorithms make more informed decisions on a safe landing spot.

Taylor Reynolds (A&A '20), the project lead, says that this work will modernize precision landing, which will be valuable for missions to the Moon and Mars, as well as asteroids.

Another application for UW-defined "state-triggered constraints"

Reynolds credits colleague Miki Szmuk (A&A '19) for laying the groundwork for these algorithms. Szmuk had the "a-ha" moment on a new method to solve for trajectories with challenges like these, which he dubbed "state-triggered constraints."

Szmuk explains, "These are constraints that become active only when you meet some sort of condition, and what's tricky about it is that there is a circularity to the conditions. The solution to what trajectory you are going to take depends on when conditions are met, but conditions you meet depend upon the trajectory." As Reynolds sees it, "Miki developed a way to handle these constraints directly and without an 'engineering hack.'"

The resulting algorithms provide new ways to embed discrete decision making into continuous trajectory design. For example, if a camera sensor only needs to point at the ground above a certain altitude, when should the vehicle cross that altitude threshold? Or, if a speeding lander can only maneuver laterally at low speeds, what is the best time to fire the rockets and slow down? State-triggered constraints allow us to find trajectories that answer these types of questions using an efficient series of computations.

Similar discrete decisions appear in other problems autonomous applications as well, notably self-driving cars, spacecraft rendezvous and docking.

Photo above: Experimenting with two telescopes, three sighting scopes, and a sighting camera that connect to the doppler lidar laser source for navigation. Credit: NASA

CONTINUED PG 25

A successful Mars rover landing ends with a crash

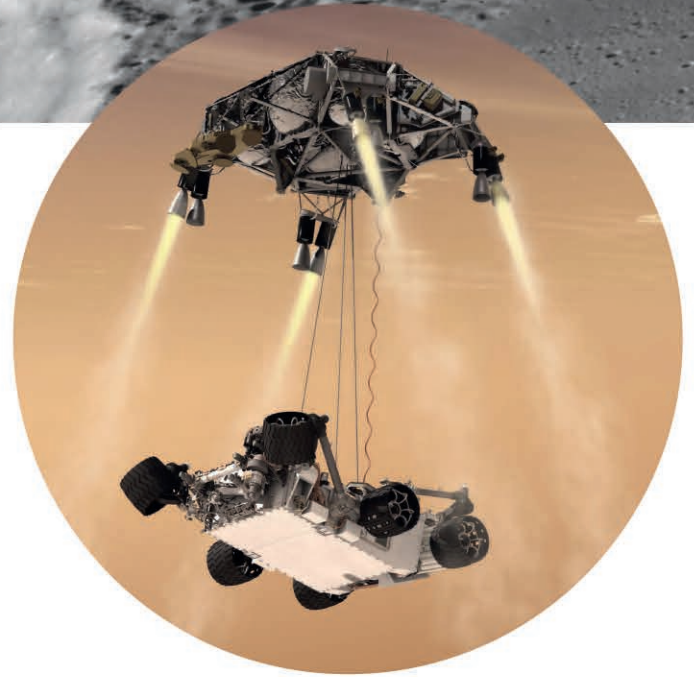
The suggestion was even surprising to NASA administrators. Engineers proposed that the very last stage of landing for a Mars rover would be the hurling of the hovering sky crane to crash at a safe distance. And for the landings of Curiosity (2011) and Perseverance (2020), that's exactly what NASA did.

The famous "seven minutes of terror" of a spacecraft's Entry, Descent and Landing on Mars slows the rover's spacecraft from about 12,500 mph as it enters the Martian atmosphere to a delivery on the Martian surface. In a series of stages as the craft gets closer to landing, it deploys a supersonic parachute, loses its heat shield and then starts the "powered descent" phase at about 6900 feet of altitude. At this point, engines fire up to counter the descent and slow the vehicle down to a mere 1.7 mph. For the last twelve seconds, the sky crane mode gently lowers the rover to a soft landing with a winch-like cable system.

And this is the precise moment when A&A's Behcet Açıkmüşe's research deploys into action to remove the sky crane from any possible position to damage the rover. The sky crane, once its job is done with the rover safely deposited, poses a threat as a large, hovering piece of equipment. Engineers deemed that the safest maneuver would be hurling the machinery as far from

Above right: This artist's concept shows the sky crane maneuver during the descent of NASA's Curiosity rover to the Martian surface. For the last twelve seconds of descent and landing, the sky crane gently lowers the rover to a soft landing with a winch-like cable system. Credits: NASA

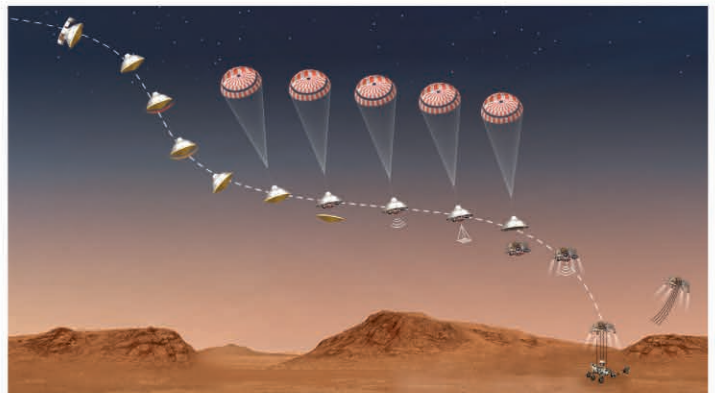
Below left: An artist's concept of an aerial view of the sky crane. Credits: NASA. Center: Professor Behcet Açıkmüşe. Right: Perseverance Rover's Entry, Descent and Landing Profile: This illustration shows the events that occur in the final minutes of the nearly seven-month journey that NASA's Perseverance rover takes to Mars. Credit: NASA/JPL-Caltech.



the rover as possible. For the Curiosity landing in 2011, Açıkmüşe jokes that his algorithms served up the first human-made crater on Mars.

Açıkmüşe, who has a joint appointment with NASA, helped develop these hurling algorithms for Curiosity which NASA used again for the 2020 Perseverance landing. He notes two unique engineering challenges for space landings: "First, we have no recovery. We have one shot at landing these rovers and the only outcomes are total success or total failure. Second, the first time these landing systems are fully tested is when we are executing the mission. There is no way to test in closely simulated conditions."

A primary challenge in the "fly away" mode of the sky crane was to stabilize it before steering it away. If the sky crane is not stabilized, the thrust plumes could affect the rover's sensors. Açıkmüşe notes that the window to violently dispose of the sky crane is only a few seconds after the rover is delivered. He says, "Then the programming slices the cable, and we have to immediately turn the vehicle and launch to fly away as far as possible." For Curiosity, the sky crane successfully crashed 650 meters from the rover's landing location and earned NASA's final ruling of a successful landing.





SOC-i: Training for SPLICE capabilities



A&A's "SOC-i" CubeSat (pronounced "sockeye" after the iconic PNW salmon), which has secured a launch spot in an upcoming NASA mission, served as an incubator for some of the concepts of UW's contribution to NASA's SPLICE project. Specifically, SOC-i orients itself and aims its camera depending upon that orientation using algorithms that are similar to those developed for the SPLICE project. While SPLICE is solving for a more complex trajectory generation problem, SOC-i is providing good practice on the orientation and imaging functions to process information.

SOC-i laid some important groundwork to A&A's contribution for SPLICE. Researchers thought through how to integrate these algorithms within a traditional Guidance, Navigation and Control (GNC) system and practiced implementing such algorithms for a "real" system. Also, the SOC-i release will be the first time that an on-orbit spacecraft will use an algorithm like this to plan its trajectories without prior knowledge of what they will be. For GNC systems, this is a paradigm shift that for now is inherently more risky. SOC-i will be able to provide a working example of optimization-based trajectory planning to give credence to the method.



Above right: A CubeSat is deployed from the International Space Station's JEM Small Satellite Orbital Deployer. CubeSats are cheaper and lighter, therefore getting them into orbit is easier and less risky. Credits: NASA

Above Left: Three CubeSats released from the International Space Station. Credits: NASA



See the full story including our origami-inspired landings and supersonic retropropulsion with videos, links and more.



A&A sensing research gets a ride on Boeing's

ecoDemonstrator

A&A research will get the rare opportunity to fly in real flight conditions on the 2021 Boeing ecoDemonstrator, the ultimate step in sensing research from theory to small-scale testing in our 3X3 Low-Speed Wind Tunnel to more complex testing in the larger Kirsten Wind Tunnel.

A&A doctoral student John Berg is well-versed in testing flight sensing models. As part of A&A's Nonlinear Dynamics and Control Lab (NDCL), he is the go-to for hardware integration for actual testing of the lab's theoretical models, bringing these models closer from theory to practice.

Berg has positioned a multitude of sensors, based on the lab's advanced research informed by the agile and responsive wonder of natural sensing, the hawkmoth, into small wing models for the 3X3 wind tunnel and then for a large highly-flexible wing for the Kirsten Wind Tunnel. Now, his research team has the extraordinary opportunity to test its sensor data collection models in real flight conditions.

This NDCL research is one of about twenty new technologies chosen to fly on this year's ecoDemonstrator, a Boeing 737-9 operated in partnership with Alaska Airlines. Boeing's ecoDemonstrator program, which first flew in 2012, has tested close to 200 new technologies that enhance the safety and sustainability of flight.

Above: A rendering of this year's ecoDemonstrator plane, a Boeing 737-9 operated by Alaska Airlines.

More accurate sensing in flight creates more responsive control for a smoother ride and increased fuel efficiency. Sensors placed in strategic locations on aircraft capture gust information which is combined with various other factors including speed and airplane orientation relative to the airflow.

Location, location, location

The precise positioning of sensors is important. Graduate student Burak Boyacıoğlu, who leads A&A's research on hawkmoth sensing, has worked extensively on getting the sensor locations right. He says, "We need to be precise about where we place these sensors to get the best data. The answer is not adding more sensors because the costs add up. You will have too much data flowing in to process cheaply and quickly, and the hard-wiring involved for each sensor creates complexities in both manufacture and the added weight added to the plane."

Building upon research of colleague Ena Hodzic and informed by the theoretical research based on hawkmoth sensing, Boyacıoğlu says, "The key is sampling the data systematically and placing the sensors in the optimal places on the aircraft to get the best information." He indicates to Berg and the team where to place sensors on the wings and tests the data coming back to analyze and adjust the locations.

Tamping down the noise

Sensing can be messy. Doctoral student and Boeing guidance, navigation and control engineer Kimber Hinson aims to make sensing more accurate by accounting for the “noise” the sensors pick up and incorporating them into a dynamic model of the vehicle. Noise can include air pressure, friction, electromagnetic interference, or temperature (heated wires behave differently), all of which skew sensor readings.

To account for these discrepancies, she explains, “You have to use several methods to measure the same thing. And if you understand the noise that’s in each measurement and the system as a whole, then you can more accurately estimate how to control for it and develop more accurate algorithms.”

She explains how Boyacıoğlu’s measurements and her modeling fit together. “While Burak is looking at measuring actual values, I am looking at model estimations. Can we establish a dynamic model from test data to estimate the forces and responses? Burak can measure, and I can estimate based on a model, and we can compare those values,” she explains. “The accuracy of these estimations will tell us if we need to adjust the model to account for additional forces, or noise that we cannot measure.”

Extraordinary opportunity to advance flight

Kristi Morgansen, A&A chair and principal investigator of this research, notes that we are uniquely positioned to test this research from theory to practice. “This project is extremely exciting because we are combining the theory of sensor placement that Burak and Ena are developing and the noise covariance that Kimber is advancing with a progression of wind tunnel testing, which is a huge advantage here at the UW. And to have earned a spot on the ecoDemonstrator to test our algorithms under actual flight conditions is invaluable to help us adjust our modeling.”

“This is really exciting for us, as UW students, to partner with Boeing and Alaska Airlines. It is a great opportunity to start a long-term partnership for our students to see their research fly in the air,” says Hinson.



Photos of the researchers: Kristi Morgansen, John Berg, Burak Boyacıoğlu, Kimber Hinson, Ena Hodzic

Paul McElroy, Boeing’s focal for ecoDemonstrator communications, says, “We are thrilled to have this UW research on this year’s airplane. Our goal with this program is to accelerate innovation by working with partners and trying new technologies to create more sustainable aviation.”

This sensing research is supported by the Joint Center for Aerospace Technology Innovation (JCATI), the Office of Naval Research and the Air Force Office of Scientific Research.



John Berg observes data on a flexible wing model installed vertically in the test section. The “3X3” serves as a good stepping stone test environment to gain initial data before moving forward in complexity and expense to the larger Kirsten Wind Tunnel. Photo by Eddie Ting.

Hawkmoth:

Lessons in agile flight from a small creature

A&A research of the biological sensing mechanisms of the hawkmoth informs the advancement of aerospace systems.



A&A graduate student Burak Boyacıoğlu knows well that living systems inform engineering design. In aerospace systems, achieving agile flight through sensing, processing and computation is one of the ultimate aspirations. That is, how do factors change in an environment, how is that message relayed, and how does the system respond.

The hawkmoth, or *Manduca sexta*, is a favorite subject for this research because it delivers just that combination. Boyacıoğlu, in collaboration with the UW Department of Biology and in partnership with the Air Force, is researching exactly how the insect senses its surroundings in order to inform the creation of engineered systems that can also sense with such precision.

Bing Brunton, UW biology professor and head of the research collaborative, explains why the hawkmoth is worthy of study. "There are many other flying animals that have been studied in the context of agile flight, including smaller flying insects such as fruit flies and larger flying vertebrates such as birds and bats. However, the hawkmoth occupies a sweet spot because of the accessibility of its invertebrate nervous system and its relatively large size. It is particularly favorable because of the observability of its biomechanics and neural circuitry, having long served as a model system for both aerodynamics and sensing."

Boyacıoğlu simply says, "Hawkmoths are amazing. They're extremely good at agile maneuvers and we're trying to understand how such a small insect can be that clever."

Part of the answer lies in the neural sensors on their wings. They can sense slight strain, such as small changes in the air, and adjust quickly.

Boyacıoğlu goes further, "It's interesting to note that while their eyes also sense their environment, their wing sensors, mechanosensors called campaniform sensilla, deliver a signal at 40 milliseconds, more than twice as fast as an optical signal. Their neural wing sensors are delivering messages with amazing speed."

This research into neural encoding includes sensing, how the animal perceives its environment, as well as control, how the animal reacts to its environment. Boyacıoğlu's research focuses on sensing and includes not just how the message gets through, but how the sensors might be placed for better sensing on an engineered craft or vehicle. He uses a mathematical tool called empirical observability Gramians to analyze the system, which is a main research focus of his adviser and A&A Professor and Chair Kristi Morgansen.

An **empirical observability Gramian** is a numerical method to determine the level of observability in a system. If researchers have specific pieces of information, they may be able to arrive at other pieces. For example, if an object moves, and we can measure its beginning and ending positions and the time elapsed, then we can determine the velocity. However, the opposite is not true; that is, if we know the velocity and the time elapsed, we can't precisely calculate the beginning and ending locations even though we may have witnessed it. Empirical Gramians help us figure out how observable the system precisely when the system can be quite complicated.

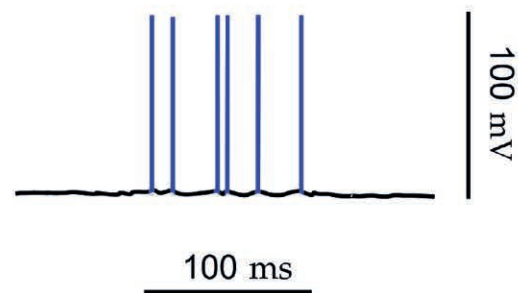
Neural encoding is the mechanism that filters out "noisy data" to an organism and converts an outside stimulus into a reaction, or what is known in biology as voltage spikes. In this research, observable voltage spikes are assigned a value between 0 or 1 to enter into the data collection to analyze how the hawkmoth is responding.



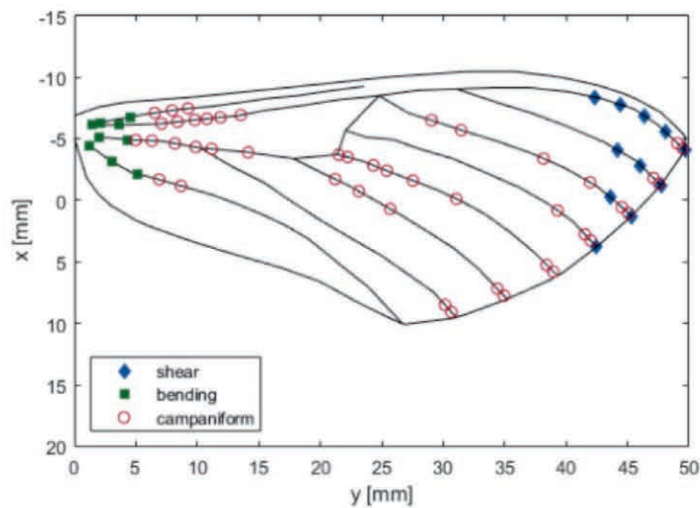
Burak Boyacıoğlu presented his research at the UW Leonardo da Vinci celebration in November 2019, highlighting nature-inspired innovations.

Morgansen explains, “The trick is to make sure that you’re getting the most and best information in the system so that you have the ability to quickly change in response. We need to know if we are interpreting the sensing system adequately to get the information we want. Burak’s work is to see if we can observe what the hawkmoth is experiencing and how it reacts to that.”

In trying to replicate the hawkmoth’s sensing, Boyacıoğlu is analyzing where to place sensors on engineered systems such as unmanned aerial vehicles (UAVs), aircraft and more. He says, “The hawkmoth’s sensor positions are informative, but tweaks need to be made for optimal sensing in our systems. This is a great iterative process from biology to engineering.”



The recording of high voltage spikes, shown in blue and measured in milliVolts and adapted from *Theoretical Neuroscience* by Laurence F. Abbott and Peter Dayan, that would be assigned a value of one and lower spikes that would be assigned a value closer to zero.



This image represents where the campanilla sensilla are located on a hawkmoth’s wing (red circles) versus the optimal placement to detect shear strain and bending strain as identified in the Boyacıoğlu and Morgansen’s research.

This research is funded by the Air Force Office of Scientific Research in collaboration with MIT and Carnegie Mellon through the Multidisciplinary University Research Initiative on Neural-Inspired Sparse Sensing and Control for Agile Flight. “Bioinspired Observability Analysis Tools for Deterministic Systems with Memory in Flight Applications” by Boyacıoğlu and Morgansen was presented at SciTech in January 2021.

Peering into

SNOW

THE AUTONOMOUS FLIGHT SYSTEMS LAB OUTFITS A DRONE TO MONITOR SNOWPACK

Rough terrain complicates research

Civil and environmental engineering and A&A adjunct assistant professor David Shean has pioneered new techniques to measure changes in glaciers. He combined old spy satellite images and modern satellites to create time-lapse 3D maps as one method to study what has happened over the past 50 years. In 2014, he saw the potential of using drones to collect detailed, overlapping photos of glacier surfaces to map changes with accuracy of better than 1-2 inches.

But to really find out what is going on beneath the surface of a glacier and to precisely measure the total water content of seasonal snowpack, researchers like Shean use a technique known as Ground Penetrating Radar (GPR). GPR works like sonar - an antenna sends a radar "chirp" into the snowpack. Another antenna precisely measures how long it takes for the chirp to travel through the snow and bounce off of the underlying ground (or ice). The total travel time can then be converted to depth.

Shean describes the current challenges of field work in the mountains with GPR, "We collect data by dragging the GPR instrument around on skis. It's obviously not an ideal situation as we're near crevasses, beneath avalanche hazards, and going up and down steep slopes."

WHY SNOWPACK MATTERS, ACCORDING TO DAVID SHEAN

"Glaciers work like a bank account - winter snow is the annual deposit, and summer melt is the annual withdrawal. If the two add up, the account is balanced, but if there is less snow or more melt, then you have a deficit, and the glacier retreats. We need to measure snow to understand how glaciers are changing today. We're glacier accountants."

He notes that the U.S. Geological Survey uses the same instrument to collect data over glaciers in Alaska, but they mount it on the skids of a manned helicopter and ask the pilots to fly as low as possible over rugged mountain terrain for hours. With GPR, the closer you are to the ground, the deeper down into the subsurface you can collect data.

In Antarctica, GPR devices have been attached to autonomous ground vehicles (“rovers”), eliminating the need for a helicopter pilot and bringing it close to the ground, but this is not without risks. As Sean notes, “If you roll into that crevasse, then that’s it, your expensive equipment and precious data are gone.”

Partnering on a drone-based solution

The idea of mounting the GPR equipment on a drone was naturally appealing after success with the camera surveys over glaciers. And a drone would be able to keep the scientists and their equipment safe while also flying lower than a helicopter to see deeper into the snow and ice. Sean contacted professor Christopher Lum who was then head of A&A’s Autonomous Flight Systems Lab (AFSL), and they hatched a partnership to outfit a drone with GPR.

The work started with designing a system to attach the unwieldy GPR equipment to “Argo,” a large student-built octocopter drone that had been sitting idle in the lab for a few years.

A&A’s Chris Hayner was eager for the challenge. He says, “It’s more than just attaching the GPR to a drone. We have to reconfigure compasses, antennas and sensors, reprogram software with the new configurations, rewire the drone to accommodate the new parts, design appropriate bracing systems and keep an eye on the weight of the entire system. And then there’s all of the troubleshooting with such an intricate system.”

He also built on previous work by former A&A master’s student Brian Katona designing brackets that would stabilize the system and buffer it properly in case of a hard landing.

The team tested Argo in A&A’s Bowman facility right before the COVID-19 pandemic shut down access to the facility in March 2020. Argo crash-landed several times, leading the team to reexamine wiring configurations, sensors and soldering connections.



The Argo endured several crashes during test flights. See one dramatic drop caused by a strong current flow that melted a soldering connection.

After pandemic delays, a long-awaited test flight over snow

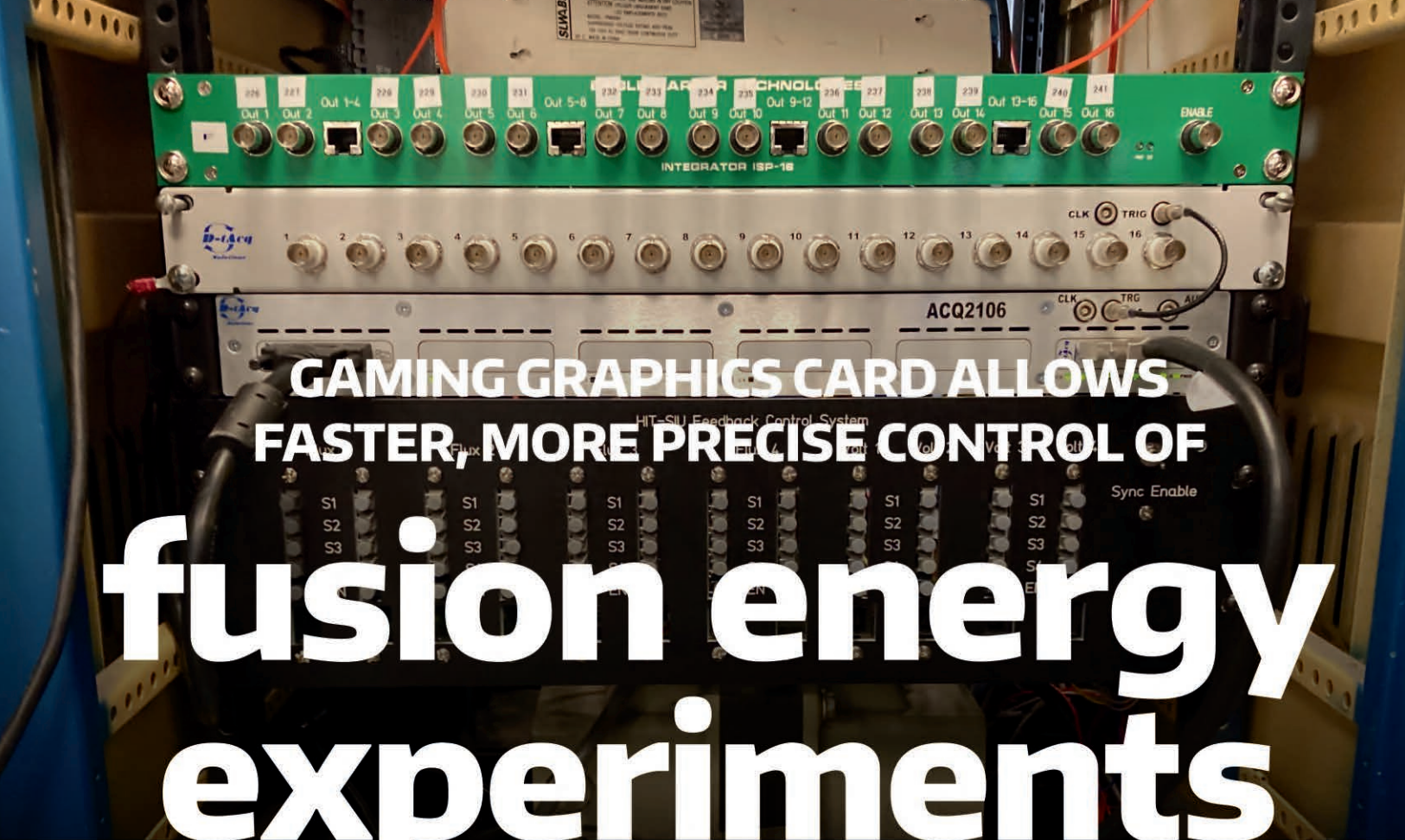
Ideally, an April expedition would capture the deepest snowpack on the local glaciers. But with the governor’s stay-at-home order that spring, the opportunities to test Argo with a decent snowpack were dwindling. After performing a final round of test flights and receiving permission from the UW to carry out time-sensitive in-person research, Sean and Hayner were finally able to test the newly-outfitted Argo in late May 2020 on Mount Baker.

All of the test flights paid off as Argo flew smoothly out on the mountain. The system successfully collected GPR data that clearly measured the total snow depth and showed detailed layers in the snowpack. They also tested different flight configurations, and discovered that operating the drone in short hops versus a long continuous flight would preserve battery power.

Next steps will be to integrate the system with drone models offering improved battery life and tuning the system for longer, autonomous mapping missions over hazardous terrain. In the meantime, Sean looks forward to collecting more data using drones for his research measuring seasonal snow and understanding ongoing glacier change.



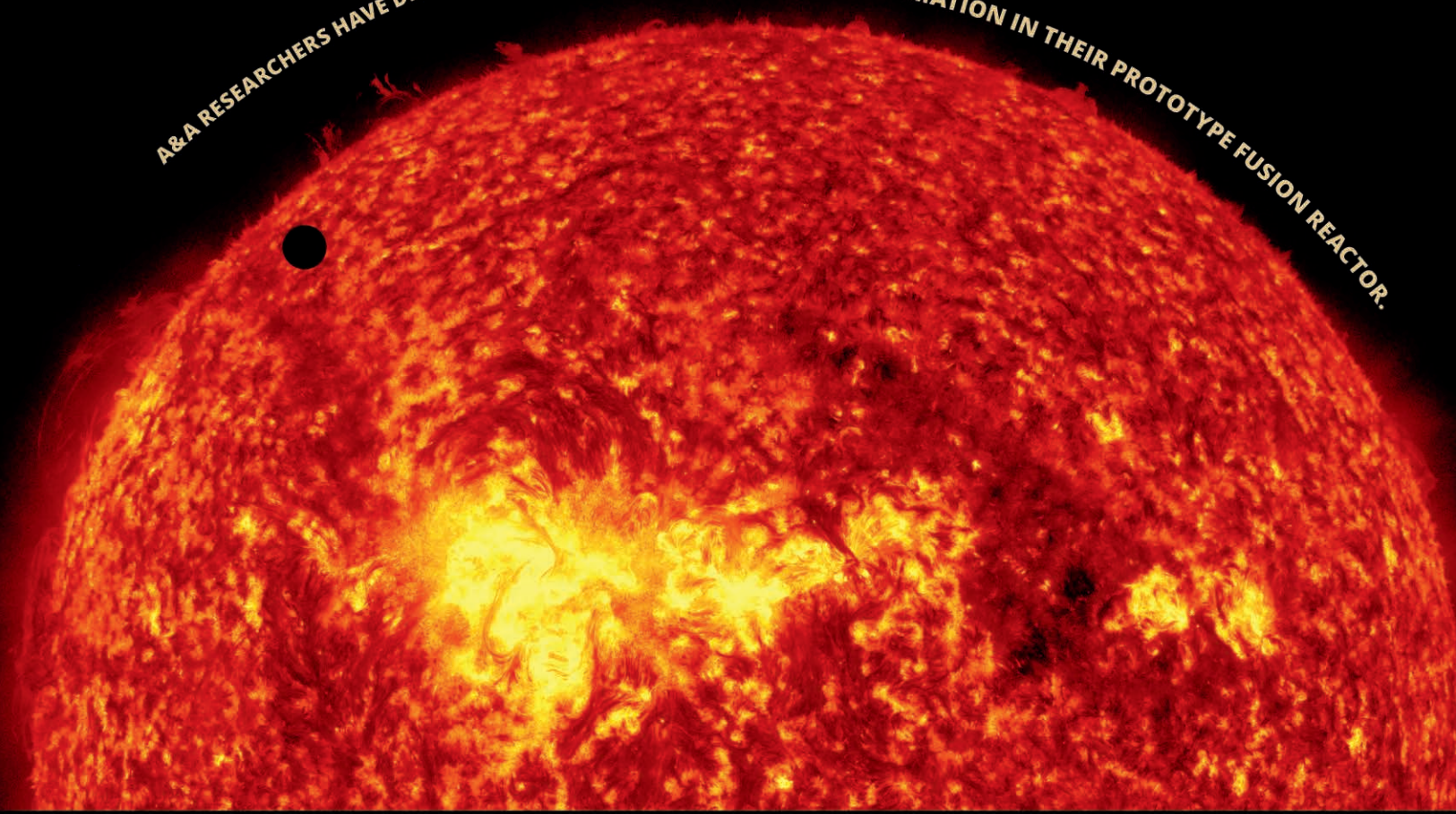
Photo above and left: Chris Hayner at the “command center” getting ready for the next test flight.



**GAMING GRAPHICS CARD ALLOWS
FASTER, MORE PRECISE CONTROL OF**

fusion energy experiments

**A&A RESEARCHERS HAVE DEVELOPED A METHOD THAT USES A GAMING GRAPHICS CARD
TO CONTROL PLASMA FORMATION IN THEIR PROTOTYPE FUSION REACTOR.**



By Sarah McQuate, UW News

Nuclear fusion offers the potential for a safe, clean and abundant energy source. This process, which also occurs in the sun, involves plasmas, fluids composed of charged particles, being heated to extremely high temperatures so that the atoms fuse together, releasing abundant energy.

One challenge to performing this reaction on Earth is the dynamic nature of plasmas, which must be controlled to reach the required temperatures that allow fusion to happen. Now A&A researchers have developed a method that harnesses advances in the computer gaming industry: It uses a gaming graphics card, or GPU, to run the control system for their prototype fusion reactor.

"You need this level of speed and precision with plasmas because they have such complex dynamics that evolve at very high speeds. If you cannot keep up with them, or if you miscalculate how plasmas will react, they have a nasty habit of going in the totally wrong direction very quickly," said A&A senior research scientist Chris Hansen.

"Most applications try to operate in an area where the system is pretty static. At most all you have to do is 'nudge' things back in place," Hansen said. "In our lab, we are working to develop methods to actively keep the plasma where we want it in more dynamic systems."

A&A's experimental reactor self-generates magnetic fields entirely within the plasma, making it potentially smaller and cheaper than other reactors that use external magnetic fields.

"By adding magnetic fields to plasmas, you can move and control them without having to 'touch' the plasma," Hansen said. "For example, the northern lights occur when plasma traveling from the sun runs into the Earth's magnetic field, which captures it and causes it to stream down toward the poles. As it hits the atmosphere, the charged particles emit light."

A&A's prototype reactor heats plasma to about 1 million degrees Celsius (1.8 million degrees Fahrenheit). This is far short of the 150 million degrees Celsius necessary for fusion, but hot enough to study the concept.

Here, the plasma forms in three injectors on the device and then these combine and naturally organize into a doughnut-shaped object, like a smoke ring. These plasmas last only a few thousandths of a second, which is why the team needed to have a high-speed method for controlling what's happening.

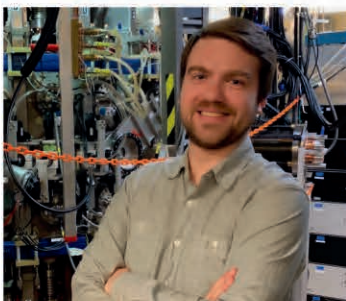
Previously, researchers have used slower or less user-friendly technology to program their control systems. So the team turned to an NVIDIA Tesla GPU, which is designed for machine learning applications.

"The GPU gives us access to a huge amount of computing power," said A&A's Kyle Morgan. "This level of performance was driven by the computer gaming industry and, more recently, machine learning, but this graphics card provides a really great platform for controlling plasmas as well."

Using the graphics card, the team could fine-tune how plasmas entered the reactor, giving the researchers a more precise view of what's happening as the plasmas form — and eventually potentially allowing the team to create longer-living plasmas that operate closer to the conditions required for controlled fusion power.

"The biggest difference is for the future," Hansen said. "This new system lets us try newer, more advanced algorithms that could enable significantly better control, which can open a world of new applications for plasma and fusion technology."

For more information, see "High-speed feedback control of an oscillating magnetic helicity injector using a graphics processing unit" by Kyle Morgan, Aaron Hossack, Chris Hansen, Brian Nelson and Derek Sutherland.



Left to right: Chris Hansen, Aaron Hossack, Kyle Morgan.



WA Space Grant moves to A&A

The renowned NASA program's relocation to A&A will help strengthen hands-on student learning.

A&A welcomes WA Space Grant, the renowned NASA program supporting undergraduates and graduate students in Washington state, to the department. Its mission is to increase access to and participation in STEM for underrepresented communities.

Mary Denmon, one of the Deputy Directors of WA Space Grant, details the many assets of the programs they manage, "We support so many opportunities for undergraduates including programs around rocketry, high-altitude ballooning, lava tube exploration, as well as the Husky Satellite Lab. And we fund close to 100 undergraduate summer research positions and scholarships from across majors at the UW as well as internships at NASA and fellowships for graduate students."

A&A Chair Kristi Morgansen who is taking over as Principal Investigator of the program says, "WA Space Grant enhances our extracurricular and research offerings here in A&A. And we are especially interested in the expanded pathways into STEM. Aerospace, in particular, is currently one of the least diverse of the engineering disciplines. We are extremely happy to join forces."

Sadly, this transition comes after the sudden passing of Director Robert Winglee, a professor and former chair in Earth & Space Sciences and a champion of getting students of all ages excited about space and science. Morgansen says, "We were terribly saddened by Robert's passing. We will do our best to carry on his enthusiastic stewardship of this very influential program."

She continues, "We are also looking forward to deepening A&A's collaborations across other units at the UW through this program, particularly Astrobiology, Astronomy, Atmospheric Sciences, Physics, and the other engineering departments. The aerospace field was built across disciplines and its benefits reach across disciplines, so these meaningful opportunities to collaborate are crucial."

The new partnership will strengthen many hands-on programs for students across the University, including the Husky Satellite Lab and Artemis Student Challenges.

HUSKY SATELLITE LAB BOLSTERS A&A'S HIGH ALTITUDE ASSETS

CubeSats

One of WA Space Grant's most recognized supported programs at the UW is the Husky Satellite Lab, which specializes in CubeSats and high altitude ballooning to test space capabilities. The Lab famously built HuskySat-1, Washington state's first student-built CubeSat that launched into space in November 2019 in NASA's Cygnus cargo spacecraft from the Wallops Flight Facility in Virginia. Lab members are currently developing HuskySat-2.

Husky Satellite Lab is moving to A&A to create a UW CubeSat cluster and share research and workshop space with the A&A CubeSat Team, which has itself secured a coveted ride on a NASA mission in late 2021 or 2022 for its Soc-I CubeSat.

Below: HuskySat-1 that launched into space in November 2019. Photo by Dennis Wise



High altitude ballooning

The Husky Satellite Lab also specializes in using high altitude balloons as an affordable testing environment to bring CubeSats up to about 90,000 feet for further refinement before release in space. The Lab developed PHAT-1 (Platform for High Altitude Testing) during the 2018-2019 academic year to prepare for the launch of HuskySat-1 into space.

The components launching in PHAT-1 included a power source, data logging and controls, GPS, magnetometer and altimeter. The payload section held a camera, pulsed plasma thruster (PPT) and deployable langmuir probe.

Although PHAT-1 was lost after deployment, the mission provided critical insights for the eventual successful launch of HuskySat-1.

Above: The PHAT-1 mission, like this one pictured, consisted of two parts: a system bus, containing mission hardware, and a payload section, both of which hung below a high altitude balloon. The balloon was then launched to ~90,000 feet. Components on the bus included main power, data logging, and controls, as well as a GPS, magnetometer, and altimeter. The payload section consisted of a camera, pulsed plasma thruster (PPT) and deployable langmuir probe.

WA Space Grant

moves to A&A

ARTEMIS STUDENT CHALLENGES

WA Space Grant is one of many state Space Grant consortium members selected to host one of the NASA Artemis Student Challenges, a series of team competitions to inspire the next generation of students working for a return to the Moon – the Artemis Generation.

Lava tube exploration

A prolonged presence on the Moon will call for using more of the Moon's resources. Like the Earth, the Moon has a series of lava tubes that we could use for mining resources such as sulfur, iron or oxygen or for storage or habitation.

The Lava Tube Exploration Challenge calls on student teams to develop a rover prototype that must fulfill a list of requirements to tackle the hazardous conditions round in a lava tube, such as rocky and steep terrain, extreme darkness and limited communications.

Teams had to develop a rover that could drop independently into the course without human contact, avoid obstacles, navigate tough terrain of sand- and rock-covered paths and slopes, and capture images of rock samples. WA Space Grant constructed a closed obstacle course for all of the participating rovers' final test.

First Nations Launch

With support from WA Space Grant, a team of four UW undergraduates entered the The First Nations Launch (FNL), organized by the Wisconsin Space Grant. Cayenne Matt (physics and astronomy), Charlie George (mechanical engineering), Oswaldo Aldaz (aeronautics & astronautics) and Chyson Acoba (chemical engineering) with adviser Scott Pinkham and mentor Mike Harrell, launched a rocket to win second place overall and a first in altitude.

FNL offers students at Tribal Colleges and Universities and in American Indian Science and Engineering Society (AISES) chapters the opportunity to demonstrate engineering and design skills through high-powered rocketry. Teams of undergraduate students design, fabricate and compete with high-powered rockets.

The UW team included a warning sensor system (flight recorder) inside the rocket to record the separation event and an air frame anomaly during their flight going to an apogee of close to 4,000 feet.

Photo top right: The UW FNL team in Pasco, Washington, after the successful launch and recovery of the rocket. From left to right: Scott Pinkham, Charlie George, Aaron Ashley (Wisconsin Space Grant), Oswaldo Aldaz, Cayenne Matt, Mike Harrell, and Chyson Acoba.

Photo bottom right: A look inside the Husky rocket at the warning sensor system.





PERSPECTIVE: John Correy

In the summer of 2016, A&A's then-undergraduate John Correy joined Professor Winglee's Advanced Propulsion Lab as a recipient of a WA Space Grant's Student Undergraduate Research Project (SURP). He soon also joined the Husky Sat Lab and worked on preparing the CubeSat HuskySat-1 for launch in 2019 and release in 2020. He is still in A&A, transitioning from finishing his masters program to starting a doctorate this fall. As a long-timer involved in these WA Space Grant activities, we asked John about this move to A&A.

"I'm excited personally because I will be able to spend more time in the aero department. I've been a student here, but all of my activities have been in Earth and Space Sciences. There are currently several other A&A students in the Husky Sat Lab, and I feel like we're all coming home. And as we move to engineering, we can strengthen our ties to BioEngineering, Computer Science, and more of the space-critical engineering disciplines."

He continued, "Change is hard, obviously, but we are seeing a lot of support from A&A. Not only is Professor Morgansen joining as the new director, but we are also getting additional faculty support with two new deputy directors, A&A Professor Jim Hermanson and Professor Sarah Tuttle from Astronomy. While we all are mourning the passing of Professor Winglee, we are encouraged that A&A is building the program's infrastructure to support the WA Space Grant staff, students and programs, and I'm looking forward to seeing this transition in action."

Robert Winglee: Excerpts from Earth and Space Sciences' "UW community mourns passing of Professor Robert Winglee (1958-2020)"

Robert Winglee became director of the Washington NASA Space Grant Consortium in 2007. In 2016 he established the NASA-sponsored Northwest Earth and Space Sciences Pipeline, which he also directed to bring STEM outreach to underserved communities. He made STEM more approachable to students by emphasizing that anyone can be a scientist.

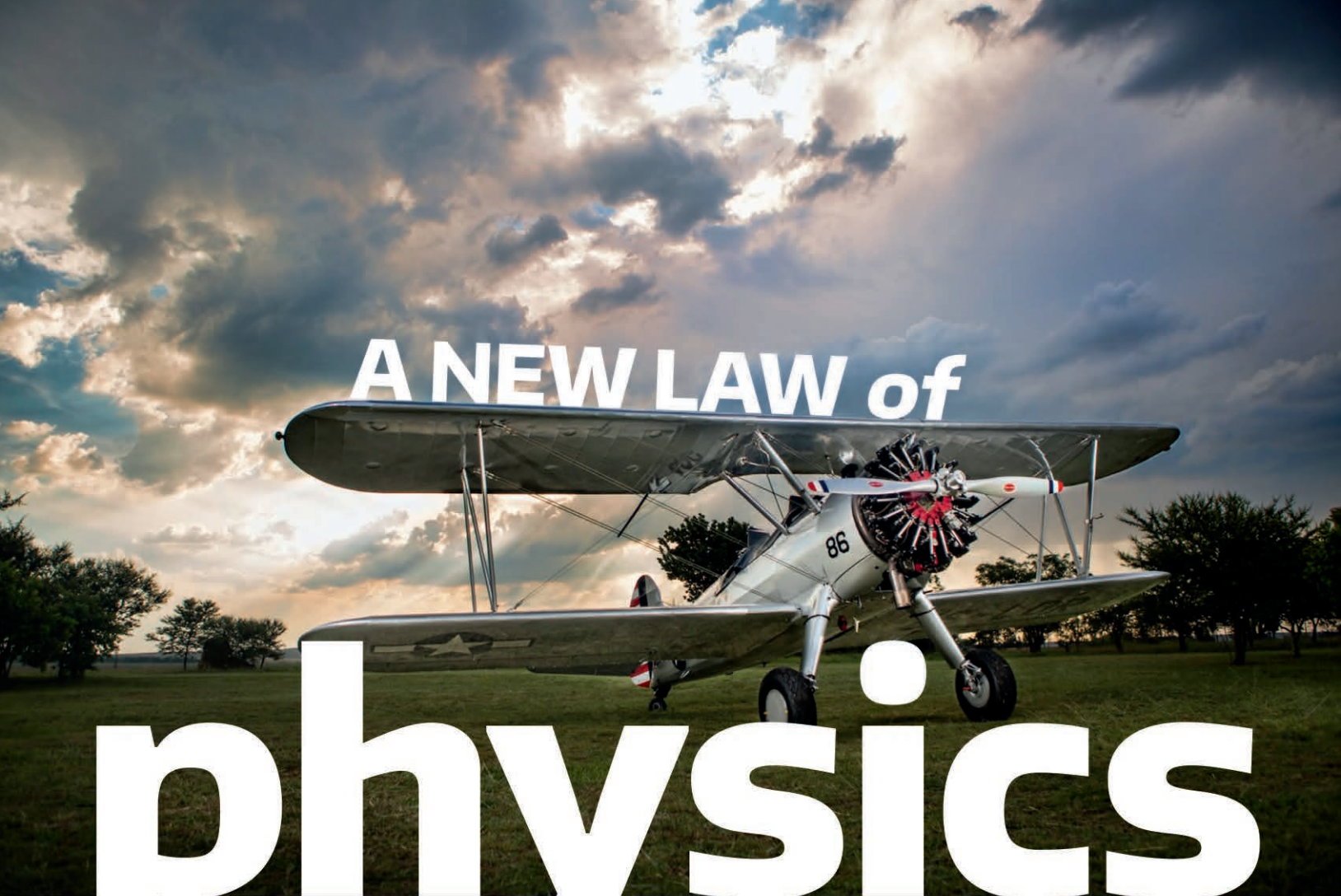
The outreach efforts included balloon and rocket launches, microscope observations, observations of the surroundings and maintaining logbooks. For example, during the solar eclipse in August 2017, Winglee facilitated a balloon launch with the Confederated Tribes of Warm Springs in Oregon to obtain a high-altitude perspective on the eclipse.

In 2019, for the 50th anniversary of the Apollo 11 moon landing, he developed a moon-themed robotics challenge for hundreds of middle and high school students from across the country, with a grand prize trip to NASA Johnson Space Flight Center. He continued to design student competitions with the ROADS on Mars challenge in 2020, which he adapted from in-person to online during the pandemic.

"Robert worked tirelessly to inspire students and educators across the country in his work towards inclusive STEM education," said Denmon who remembers the ambitious and original ideas Winglee proposed. "It is difficult to measure the impact Robert has had. Honoring the energy and passion he had is a high bar, but we'll certainly give it a try."

Robert Winglee speaking in July 2019 at a student challenge held on the 50th anniversary of the Apollo 11 moon landing. Credit: Mark Stone/University of Washington

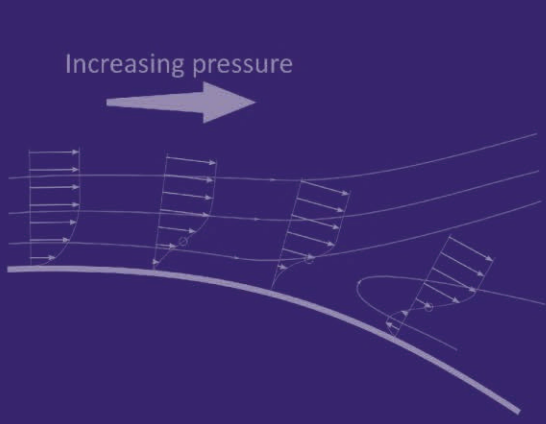




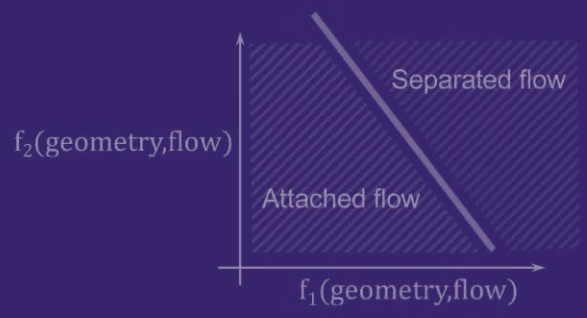
A NEW LAW of

physics

THE A&A DISCOVERY FINDS A SWEET SPOT FOR AIRCRAFT EFFICIENCY



Flow separation



Law of incipient separation

Researchers in A&A's Computational Fluid Mechanics Lab discovered a new law of fluid mechanics, a branch of physics, that will aid the future of aircraft design. The "Law of Incipient Separation" defines the maximum slope of an aircraft fuselage to avoid the separation of airflow that increases pressure-drag. Drag is the aerodynamic force that opposes forward motion.

Getting the slope of the fuselage right will reduce the drag and create a more efficient aircraft to reduce fuel consumption. A new paper written by Associate Professor Antonino Ferrante, Dawei Lu (M.S. 2019) and doctoral student Abhiram Aithal defines the parameters of this newly-discovered law.

Aithal explains that getting as close as possible to flow separation is ideal. He says, "When the flow gets close to separation, the drag actually goes down, so the best scenario is to be as close to separation as possible without crossing the line because peak performance in control and efficiency is right before separation."

Patterns uncovered

Says Ferrante, "I had an intuition that the law existed – nature follows laws that are just waiting to be discovered. Dawei and Abhiram worked out the simulations and data-analysis to prove it. We were able to discover a law that predicts the maximum slope a curved surface like the fuselage of an aircraft can have to avoid airflow separation based on the flow variables and few geometrical parameters."

Lu described the process of proving the law's existence, saying that they first searched for an aircraft fuselage geometry from NASA in fluid mechanics literature. This geometry is an analytical model used to run computer simulations of aerodynamics. They first ran simulations with varied heights using this single geometry to find the slope value where flow gets close to separation. Next they ran hundreds of simulations for different geometries and flow parameters and filed a patent on these new geometries which will aid further research (U.S. Patent Application 63/027,041).

"We had difficulty seeing the correlations of the data points at first," Lu said, "but after adjusting our methodology, the scattered data collapsed closer to one line on the plot - the maximum slope of flow separation."

"What surprised us most," Lu continued, "was that the maximum slope of the aircraft body and not the maximum curvature or the shape of the curved surface dominates this phenomenon."

Further work

The team is working on calculating the law's more accurate coefficients by using more advanced numerical simulations. Ferrante says, "What is exciting is that we will be able to tell airplane designers that given the height and length of the aircraft and the general flight conditions you are expecting

with this aircraft, that there is a defined maximum slope for the aircraft body that they should not exceed to keep the flow attached." Thus far, the law has been determined for an incompressible flow, which covers flow aircraft such as small prop planes that travel much slower than the speed of sound. The team is working on including expanding the dataset to faster commercial airplanes.

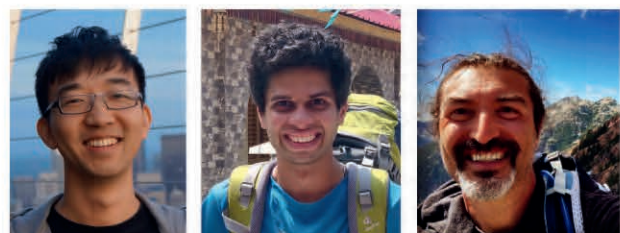
Reducing global emissions

While the design of aircraft bodies may not seem to have changed much in the last several decades to outsiders, small changes bring large rewards. Slightly adjusting designs, such as the fuselage shape of an aircraft to get as close to flow separation as possible while keeping the flow attached could mean large savings in fuel and lower emissions for the aviation industry which contributes about 2.4 percent of global emissions.

Ferrante says, "Climate change is a huge motivator for me. If we can decrease airline fuel consumption by a few percent simply by adjusting aircraft design through the discovery of this new law, the statistic may seem small but on a global scale, that is a great accomplishment in reduction of fuel consumption and fossil fuel emissions."



For access to the paper, "Law of Incipient Separation over Curved Ramps as Inferred by Reynolds-Averaged Navier-Stokes,"



Left to right: Dawei Lu, Abhiram Aithal, Antonino Ferrante.



AWARD-WINNING

coral research

A SUMMER PROGRAM IN OCEANOGRAPHY PAVED THE WAY FOR ISAIAH CUADRAS TO APPLY HIS INTEREST IN FLUID DYNAMICS TO OCEAN ECOSYSTEMS.

A&A student and McNair Scholar Isaiah Cuadras won best undergraduate mechanical engineering presentation for his research at the 2020 SACNAS: The National Diversity in STEM Virtual Conference. Cuadras presented his fluids research in A&A's Laboratory for Engineered Materials and Structures that is contributing to coral conservation work through a grant with the National Science Foundation. Specifically, he simulated ways to advance coral research in the laboratory by improving the water flow around them, which can create unintended negative impacts on the corals, interfering with accurate research findings.

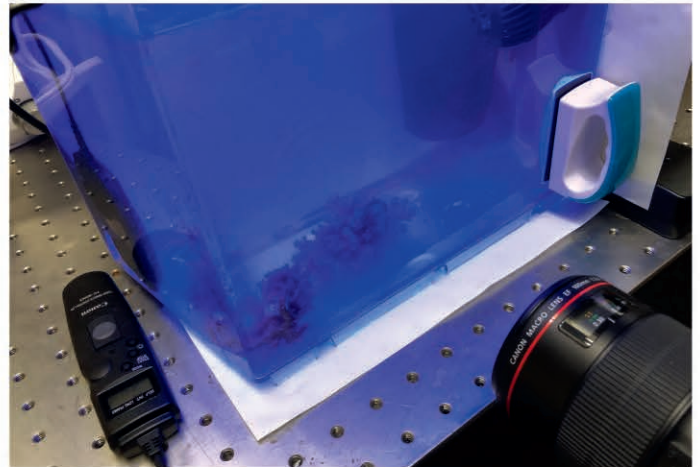
Cuadras explains, "In coral research, chemists and biologists try to identify the corals' response to chemical stressors to correlate the changes in the chemical composition of the ocean and the effects of climate change on corals going forward. However, the test environments may subject the coral to water flows that are too fast and unfortunately harm the coral, so it is difficult to figure out what is causing stress and damage."

The solution Cuadras is working on is to optimize a "coral-on-a-chip," a millifluidic device which channels water past the corals and tempers the flow and reduces stress on the corals. Cuadras notes the technical term for this is "reduces dynamic shear stresses." Cuadras performs simulations through computer programs which can then be translated into building a better millifluidic device in the future.

Associate Professor Jinkyu "JK" Yang puts Cuadras' research in context, "Marine biologists started using a coral-on-a-chip technology, which is useful in studying corals but still has substantial challenges, particularly in its optimal design. Isaiah's computational fluid dynamics simulations on a new coral-on-a-chip device we are developing in collaboration with Professor Natassja Lewinski's group at Virginia Commonwealth University saved us a tremendous amount of time and effort in the design stage."



Cuadras (right) working on the autonomous underwater vehicle “Ecomapper” as part of the LSAMP summer oceanography program in Australia. The Ecomapper records salinity, pH, and more. Here, Cuadras is attaching a camera to record footage for the Ecomapper’s upcoming project to investigate seagrass beds.



Currently the corals under observation in the LEMS Lab are in a tank. Isaiah Cuadras’ research opens an avenue for observation of very small fragments of corals in the coral-on-a-chip millifluidic device. Water from this tank will filter into the device.

A&A graduate student Shuaifeng (Scott) Li mentored Cuadras through this research and said, “I am very impressed by his effort and work. Especially given that Isaiah is only an undergraduate student, he learned finite element analysis and fluid mechanics in a very short time. His research makes it possible for us to directly observe the microscopic live coral polyps, and his adaptations will benefit labs working on coral around the world.”

This research is sponsored by the National Science Foundation’s Office of Cyber Infrastructure for “Harnessing the Data Revolution Big Idea” (Award #1939249) in partnership with Professor Natassja Lewinski in the

Department of Chemical and Life Science Engineering at Virginia Commonwealth University. This research combines aerospace engineering, computer science, materials science, data science and biology to capture data on the coral’s manufacture of calcium carbonate structures (similar to 3D printing), how they heal damage to these structures, and how they create environments and co-exist in symbiosis with scores of other organisms. This research will produce large amounts of data that will be analyzed to determine key molecules involved in coral processes and predict and manipulate coral behaviors to aid recovery.

Coral-on-a-chip

Coral-on-a-chip refers to a very small microfluidic device running saltwater which can integrate several complex laboratory functions and allow for observation of micro-scale interactions between corals and their environment in the lab. – A&A graduate student Shuaifeng (Scott) Li from the Laboratory for Engineered Materials and Structures

Inspiration

Isaiah Cuadras was long interested in aerospace when he participated in a study abroad program focusing on oceanography, sponsored by LSAMP and the College of Engineering, which introduced him to ocean conservation strategies. The previous year, Professor Jinkyu Yang led the Australia LSAMP summer program with an emphasis

on aerospace structures inspired by origami, and through the program, Cuadras learned about Yang’s work in the Laboratory for Engineered Materials & Structures.

With this introduction, Cuadras contacted Professor Yang, who was leading the UW effort under a new grant by the National Science Foundation for coral research. Cuadras’ interests in both aerospace systems and ocean conservation came together with this interdisciplinary opportunity.

Says Cuadras, “This was the first time I saw research involving both fluid dynamics and biological systems.” The McNair Scholar, who thanks that program for helping him prepare to present his research at the SACNAS conference, plans to pursue a doctorate in oceanography, applying his fluid dynamics background to examine how ocean currents affect biological systems and the global climate.

Then, in the ninth grade at Tillicum High School in Bellevue, WA, Gale took an aptitude test “probably out of the University of Washington” as she remembers. “The results came back, and that was the first time I saw the words ‘aeronautical’ and ‘engineer’ put together,” she says.

Seeing that the UW offered aeronautics and astronautics, she laid out her path to the department. She kept her grades up and her plans quiet from her high school counselors so they would not discourage her and steer her into more “traditional” paths for women. By the time she entered the College of Engineering as a freshmen, she was one of a handful and when she entered the A&A department, she was the only woman in her cohort.

Her space shuttle career

Gale graduated in 1973, but stayed to get her masters due to the bottoming out of the aerospace industry. By 1974 and armed with a masters degree, the market was up again, and she entered the Space Shuttle Program with Rockwell International. Though she switched organizations a few times, she spent most of her career working on the Space Shuttle program, working on payload and cargo integration. She co-owns three US patents on launch vehicle payload interface standardization and cargo containerization. She left Rockwell in 1978 for Aerojet Electro-Systems. Then in 1980 she moved back to Rockwell and ultimately she became a Boeing employee with its acquisition of Rockwell in 1996.

Gale is pretty clear about “the times” of her career. She was often the “first woman, only woman, most vintage woman” in her divisions. She trained herself to ignore a lot from bosses and coworkers. And she excelled in not only doing difficult jobs, but made it a point to do them better than anyone else would. She remembered a time at Rockwell when they were transferring locations from California to Houston. She worked tirelessly on the tedious process of documenting processes for the transition and wound up setting up a system that was well beyond ISO compliant.

Seizing opportunities

Gale has dedicated herself to service at many points in her career and recommends it for several benefits. She ran the Society of Women Engineers Convention in 1981 and gained a lot of management experience from that. She managed over 100 volunteers and managed \$250,000 coming through the convention budget. She says, “While these conferences are now centrally run, there is a lot of value in throwing yourself into the technical societies and gaining experience that does not have the same stakes of trying out management in a major company.”

“And you never know where these things will take you,” Gale says. A small project with her husband and a colleague to set up a competition for Explorer Scouts in 1984 has led to a major effort, the annual Space Settlement Design Competition, that Gale now runs that annually reaches over 1000 high school students around the world approaching the challenges we face with establishing human habitation in space.

She has embraced being open to where these things have led her. “You need to be open. If something is pulling you to do something philanthropic, embrace the opportunity. Part of being human is to enrich the experiences in the lives of others.”

Gale retired from the Boeing Commercial Crew program in 2016. She was completing her work on schedule, then the schedule slipped and she found she would have nothing to do for a year and a half. That just means she puts more time into volunteer pursuits. Space Settlement Design Competitions are expanding to reach more students, she was recently elected CEO of the National Space Society, and now she goes on a Grand Canyon raft trip every year.

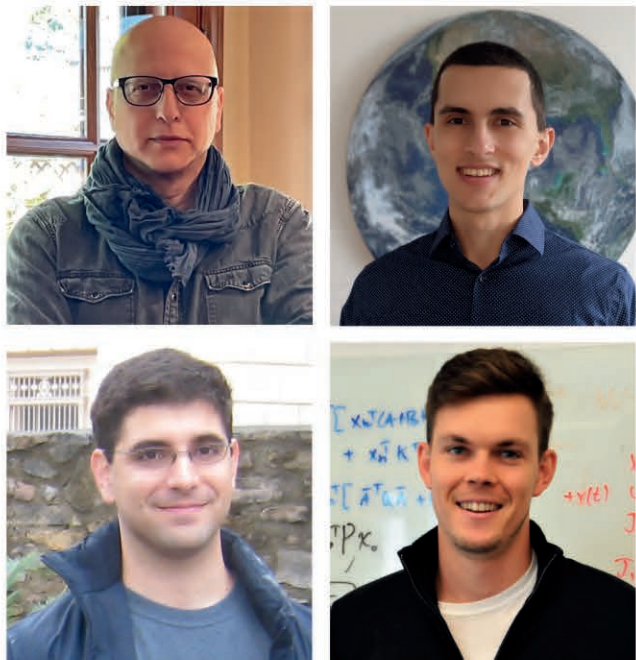
So for her career accomplishments and the great works she has done for students, we congratulate Anita Gale on her selection as the 2021 A&A Distinguished Alum.

The UW advantage

Szmuk says, "We were very fortunate to have the opportunity to work on these algorithms as part of our graduate school research. It is very rare that a professional engineer, much less a PhD student, gets to have one of their algorithms fly in space. It's a testament to the work that Taylor, Danylo, and the rest of the team did to make this happen, and that our faculty have been able to provide us with these kinds of opportunities."

Professor Mehran Mesbani continues, "At A&A, we are in a unique position to make major contributions to various aspects of next generation space systems. Our contributions to the SPLICE program not only is a testimony to our close collaborations with colleagues at NASA and Blue Origin built over many years, but also reflect our commitment to take high caliber research developed in academia to NASA and the space industry. Our vision and research efforts, and most notably, the excellence of our students, underscore this overarching commitment."

A&A developed these algorithms under NASA's SPLICE technology development program, in collaboration with NASA Johnson Space Center (JSC), Blue Origin, and Draper Laboratory. A&A researchers include Professor Mehran Mesbahi, Professor Behcet Açıkmeye, Taylor Reynolds, Danylo Malyuta, Michael (Miki) Szmuk, Daniel Dueri and Unsik Lee.



Clockwise: Mesbahi, Malyuta, Reynolds, Szmuk.

IN MEMORIAM

Eleanor Dickson

Alumna Eleanor Dickson (A&A 1949) forged extraordinary paths in aeronautics, often being the only woman in her cohorts. From an unusual-for-the-time early interest in building model airplanes starting at ten years old, she was the only woman student in the A&A department when she graduated. She then started her career working at Boeing as a junior engineer, moving up to become a wind tunnel testing engineer, or "aerodynamicist." One of her many projects included design and testing in our Kirsten Wind Tunnel of "winglets" for large airplanes. We remember and honor Eleanor's passion, courage and strength as an aeronautics pioneer. Eleanor Dickson passed away on February 23, 2021.



Joan Oates

We are deeply saddened by the passing of one of our great champions, Joan Oates. Joan came to know A&A through her husband, Professor Gordon Oates who joined the Department in 1967, specializing in propulsion and winning many awards including a Distinguished Teaching Award from the University in 1982. He suddenly passed away at only 54 years old shortly after being named the associate dean for academic affairs in the College of Engineering in 1986. In his honor, Joan, with her family, established an endowed fellowship for an annual award to an A&A graduate student of outstanding academic merit. Joan eagerly met each recipient of this award every year for many years and continued to be a great supporter and friend of our department. Joan Oates passed away on February 6, 2021.



Student Awards

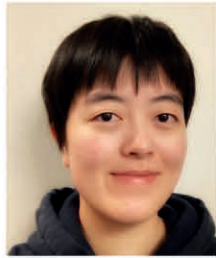
AIAA Region VI Student Conference Awards:

First in undergraduate category for the potential application of a Z-pinch for space travel



Michelle Graebner

Second in undergraduate category for origami mechanical wave isolation



Gloria Yin

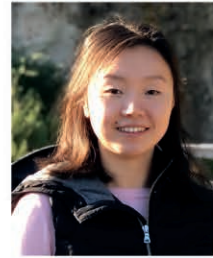
2020 SACNAS:

Best undergraduate mechanical engineering paper on improving laboratory coral research



Isaiah Cuadras

Amelia Earhart Scholar



Sarah Li

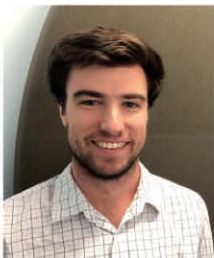
ARCS Scholar



Samuel Buckner

A&A Student Excellence Awards

Excellence in Doctoral Research



Charlie Kelly

Excellence in Masters Research



Ryan Howe

Excellence in Undergraduate Research



Michelle Graebner

Excellence in Teaching - Undergraduate Level



Daniel Crews

Excellence in Service



Isaiah Cuadras

UW WISE Outstanding Female



Helen Kuni



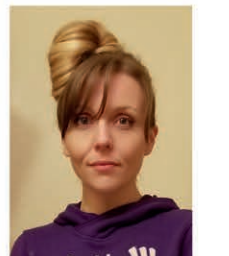
Jackie Marquette



Cat Hannahs



Kristina Dong



Taylour Mills

Astronaut Scholar



Carter Vu

Isakowitz Fellow



Khalil Jones

Husky 100



Cat Hannahs

AIAA Associate Fellow



Antonino Ferrante

Excellence in Teaching - Graduate Level



Mengyuan Wang

Condit Distinguished Dissertation Fellowship



Abhiram Aithal

Washington State Academy of Sciences & AIAA Fellow



Kristi Morgansen

COE Dean's Fellowship



Carey Whitehair

PNAAScholarship



Danny Beeson

McNair Scholarship



Isaiah Cuadras

J. Ray Bowen Endowed Professor in Engineering Education



Mehran Mesbahi



WILLIAM E. BOEING
DEPARTMENT OF AERONAUTICS & ASTRONAUTICS

UNIVERSITY of WASHINGTON

211 Guggenheim Hall, Box 352400, Seattle, WA 98195-2400

Graebner wins AIAA first place for Z pinch research

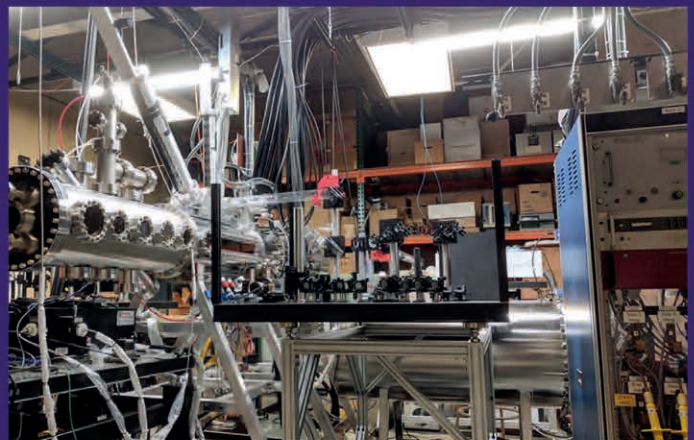


A&A's Michelle Graebner won first place at the AIAA Region VI student conference in the undergraduate category for her paper "Measuring Electron Temperature and Density of a Sheared-Flow Z-Pinch Plasma Exhaust Plume." The sheared-flow-stabilized Z pinch could unlock fusion energy and enable rapid travel to deep

space. Graebner's research, performed out of A&A's Flow Z-Pinch Lab, specifically advances the potential application of a Z pinch for space travel. She is investigating the conversion of the energetic plasma (over 107 Kelvin) into a directed kinetic energy rocket plume.

She explains that, as we all have seen, chemical rockets have an obvious exhaust plume that indicates thrust. The same is true of a sheared-flow Z pinch which produces plasma exhaust. Her research examined the density and temperature of this plume. Her results show that the hotter gases move outward when the gas expands outside of the Z-pinch chamber, signaling acceleration and producing more thrust, which is a good indicator for successful space travel applications.

Professor Uri Shumlak noted, "Michelle's careful measurements and analyses are topics in our advanced graduate courses, but Michelle was able to learn the material and provide insight into the inherent collimation of the exhaust plasma, which would greatly simplify a fusion rocket design".



The UW Z-pinch machine is compact and easily fits in the Flow Z-Pinch Lab, an advantage over other designs.