MESSAGE FROM THE CHAIR

While we are sprinting to the finish line of another academic year, please join me in taking a moment with this issue of Highflight to be inspired by all of the many initiatives, talents, and cutting-edge research in the department. This is an especially poignant moment for me, as I have recently accepted the appointment of chair of the department. I am very grateful for this new opportunity to serve our A&A community.

The past few months as interim chair have shown me that the department has a fantastic community and an exciting future. The recent hire of Justin Little along with the upcoming searches for lecturers and two new tenure track faculty will add energy and capability to the department. The Direct to College entrance for undergraduates will enable a more holistic approach to undergraduate education, and updates to the master's level programs will provide interdisciplinary and project-based learning. We will also be exploring options for short courses for professionals.

We have been especially energized by the enthusiasm of our alumni surrounding the centennial celebration of aeronautics at the UW, and we are responding to the call to strengthen the bonds between our students and alumni. With alumni participation, we have launched an on-going series of internship and career-focused events exclusively for A&A students in collaboration with the Career Center @ Engineering, and we will be kicking off an alumni mentoring program in the upcoming fall quarter. We look forward to updating you in the future about all of these efforts.

Kristi A. Morgansen, Professor and Chair

For now, dig into this issue of Highflight. As you will read, we are implementing very exciting upgrades to the Kirsten Wind Tunnel, furthering our commitment to a world-class facility. Our students are living the Husky Experience through clubs like SARP and Women in Aerospace that deliver real innovations and service to our community. Enjoy the coverage of our centennial, the landing of the Mars InSight, the awards of our students and young alumni, and our advances in plasma fusion, nonlinear complex networks, versatile origami structures, damage sensing composites, and supersonic retropropulsion.

Kristi A. Morgansen
Professor and Chair

On the cover: The current Kirsten Wind Tunnel (KWT) student crew who have been crucial in making a smooth transition to recent upgrades. See the KWT Feature Stories.

Cover photo by UW Photo.

HIGHFLIGHT 2019

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NEW FACULTY SPOTLIGHT

Justin Little

appointed assistant professor

A&A is pleased to announce the appointment of Justin Little to assistant professor. Little's research focuses on the intersection of electric propulsion and plasma physics.

Although electric propulsion systems have been flying in space since the early 1960s and have proven to be extremely reliable, Little notes that "We are entering a phase where new ideas are needed to push the bounds of what is possible."

These new ideas include working on technology applications that have transformative potential. For example, he is working on a magnetic nozzle to accelerate new forms of molecular propellant that can provide significant mission benefits. He is also pursuing the miniaturization of electric propulsion systems for small satellites, plasma-assisted aerocapture technologies, and methods to monitor electric thruster health in orbit.

Little is also pleased to be further developing the electric propulsion laboratory class he established three years ago as a research scientist. "I originally developed this class to introduce students to the concepts and laboratory techniques important to electric propulsion. The creativity and excitement that students bring to this course make it incredibly fun to teach."

Indeed, students are already seeing the benefits of that course. Graduate student Nadiah Jenkins credits it with preparing her for her electric propulsion internship at Aerojet Rocketdyne this past summer. Says Jenkins, "Professor Little's course was my first introduction to electric propulsion. We got to see the scale and integration of the equipment, which was new to me. He really demystified the field and helped me identify and reach out to the people building these new thrusters."

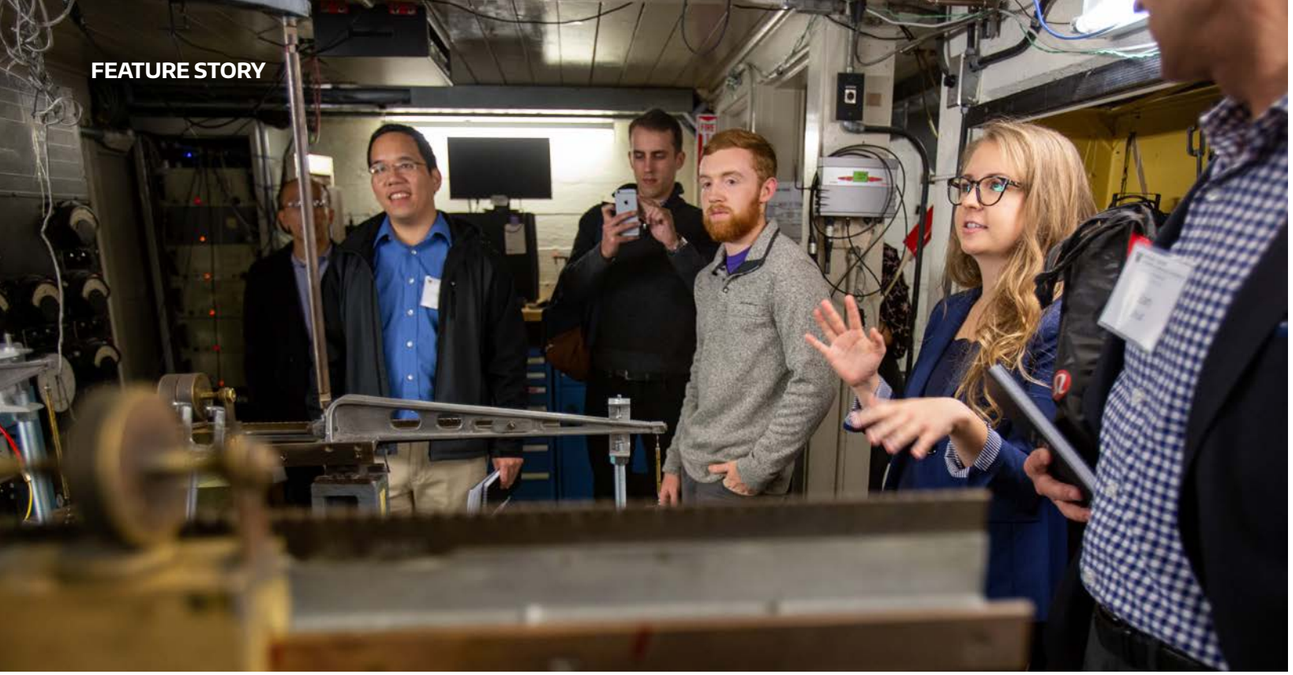
Building on the momentum of the reception of this course, Little is establishing the UW Space Propulsion and Advanced Concepts Engineering (SPACE) Lab to pursue new ideas in the science and technology of electric space propulsion.

And Little is excited to be at the UW. "It brings me great joy to join the faculty at the University of Washington. I grew up in the Pacific Northwest, so joining the UW had been a goal of mine for many years. Electric propulsion requires a strong understanding of plasma physics, a topic that has been a core strength within the A&A department for many years. Furthermore, A&A is home to elite faculty and researchers that are at the top of their fields from multiple disciplines. Interacting with these colleagues will undoubtedly inspire exciting new avenues of research. Finally, I look forward to building collaborations within Seattle's world-renowned aerospace industry to push the envelope of space technology."

Little received a Ph.D. in aerospace engineering from Princeton University in 2014. Prior to his appointment to assistant professor, he joined Redmond-based MSNW LLC as a propulsion research scientist and A&A as a research scientist and part-time lecturer.

"A&A is home to elite faculty and researchers that are at the top of their fields from multiple disciplines. Interacting with these colleagues will undoubtedly inspire exciting new avenues of research."

JUSTIN LITTLE



Through icing research, KWT installs structural upgrades

A&A student Hannah Stevens knows quite a bit about wind tunnel research. She has been a researcher with the UW Aircraft Icing & Aerodynamics Research Group (AIARG) for two years, working on printing 3D models of ice to attach to wing models for wind tunnel testing. She is also a senior crew member at the Kirsten Wind Tunnel (KWT). These two roles gives her a specialized perspective on both the advantages and challenges of using the KWT for research.

The work of AIARG, led by Engineering Dean Michael Bragg, includes a series of ice accretion studies funded by the Federal Aviation Administration (FAA), NASA, and other industry partners. These studies test how wings perform under icing conditions.

While these UW icing studies are built around wind tunnel testing, Stevens notes that much of this experimental research has been performed in other national and international wind tunnels due to KWT limitations.

A&A Professor Christopher Lum explains, "We haven't been able to test large wing models in our own wind tunnel, which has increased the cost of our research by sending us to other tunnels, in particular one in France. This limitation creates inefficiencies and expenses not only for us, but for commercial clients that we have in our backyard, like Boeing."

This limitation is about to be lifted. Now, with funding from Boeing and the Joint Center on Aerospace Technology and Innovation (JCATI) focused on these icing studies, A&A will be upgrading KWT capabilities by improving the main external balance and installing a new side wall balance that will be able to handle bigger models and bigger loads.

Continues Lum, "When KWT was built, it was state of the art, but now everyone wants bigger and faster performance, and we couldn't deliver for some customers or even for some of our own research. We're now making it possible for customers to test more technologies and different kinds of models."

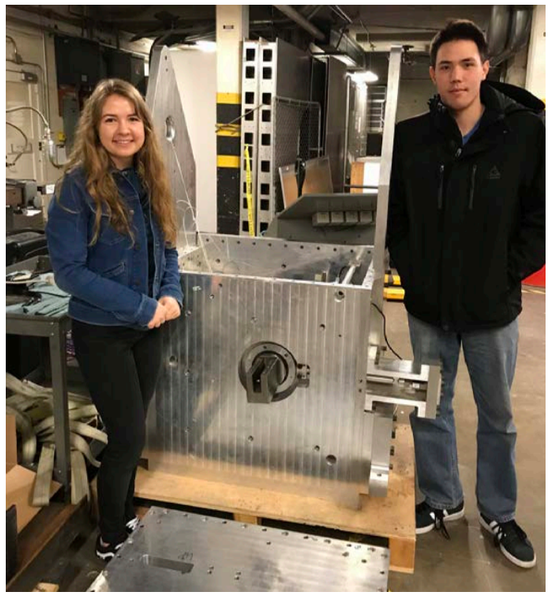
These upgrades, while funded to support the UW ice accretion research, will benefit all clients and studies requiring more robust balances for bigger models. Stevens notes that the KWT will now offer a responsive flexibility. She explains, "We are working on a heavy high-lift wing model for testing that will require tweaks to the balance that will have to return to an original configuration for other clients testing lighter models, such as unmanned aerial vehicles."

A&A recent grad Kevin Ho was hired as a research technologist to lead the design and manufacturing of the side wall balance. Explains Ho, "This balance, in particular, will allow for testing bigger 3D wing models at higher testing resolutions. We're thinking of the future of the models that will come here. We're not talking about just accommodating a few hundred pounds of model-generated aerodynamic loads, but a few thousand pounds."

The FAA's interest in funding the UW ice accretion research is to ultimately create a certified test for icing that can bypass the rarer and more expensive refrigerated tunnels, which is currently an important step in wing design. Advancing this UW research would open up the capabilities of most wind tunnels and reduce the time and cost needed to certify aircraft without compromising safety.

Says Stevens, "You have to keep updating to stay relevant, and these upgrades will keep us in the game. Over the last few years, we have tested lots of unmanned aerial vehicles. We can still work with them, but now we can attend to the high lift customers and the icing research. Plus it benefits the student crew because we get more exposure to another part of the industry."

Opposite page: Hannah Stevens gives a tour of the Kirsten Wind Tunnel. Below: Hannah Stevens and Kevin Ho with the side wall balance that will be tested, adjusted and installed in the wind tunnel.



The ice accretion testing involves printing 3D CAD models of ice that NASA has developed from their own refrigerated wind tunnels. These plastic printed models can simulate the ice in non-refrigerated tunnels like the KWT. Each printed model is about 45 inches long and will be attached to the leading edge of the wing and will be fitted with 70 taps to measure pressure.

KWT gets a data acquisition upgrade

In the summer of 2017, during Professor Carl Knowlen's first week on the job leading operations at the Kirsten Wind Tunnel, Seattle had a soaking rain. The roof leaked, resulting in water dripping onto some of the data acquisition system (DAQ) components that read all of the data for the wind tunnel.

The DAQ started having some performance issues, giving the student crew more experience in troubleshooting and fixing on the fly. While it worked well enough, customers wanted a new DAQ that could accommodate their needs more precisely with new technologies they were including in their models. This old DAQ, which was installed in 2000, could not interface with the latest testing components and criteria.

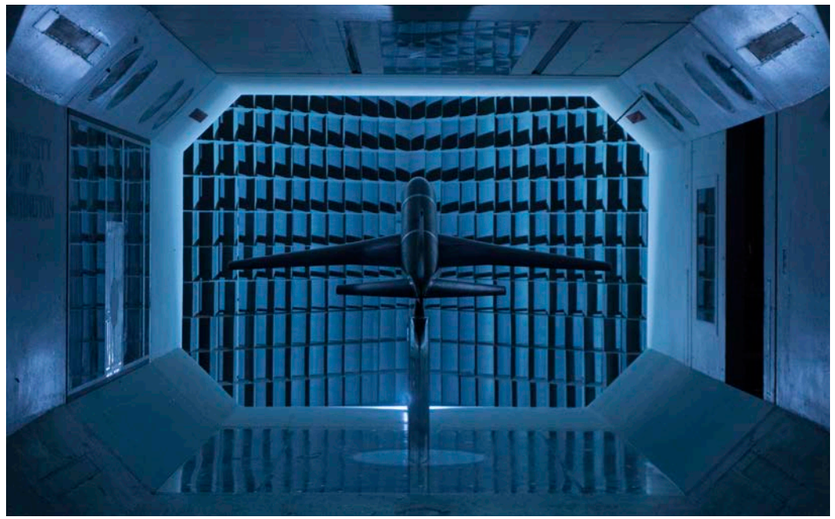
Customers don't have to wait any longer. With funding solely from testing revenues, the KWT is now integrating and validating a new DAQ that will accommodate wind tunnel testing needs for the next decade.

KWT Test Engineer Matt Hudgins explains, "This new DAQ is providing changes that customers wanted to see. The customers are incorporating more sensors, configurations, and data channels, higher sampling frequencies, and styles of testing that we couldn't accommodate before. They are now able to set up more easily in our wind tunnel because our system can now interface with their test models more fully."

The hiring of Hudgins himself was a recent improvement to the KWT. Knowlen explains, "KWT is unique in that its primary operations are executed by undergraduate student employees from different departments. While the crew is experienced and adept, having a professional engineer on staff is useful for their deeper development and mentorship, and this is what Matt is providing."

Top: Matt Hudgins and Carl Knowlen performing a balance calibration to ensure the most accurate data for customers.

Above: KWT crew chief Jess Grant makes some balance adjustments.



A recent KWT test model.

Keeping the KWT updated is important. Not only is it the only commercial wind tunnel in the Northwest, but it is only one of four university wind tunnels in the United States, and the only one operated almost exclusively by undergraduate students.

As Knowlen points out the importance for the UW: "We're a legacy asset. We've been in operation since 1939. At one point, every Boeing aircraft was tested in this wind tunnel. That ended in the 1990s as the aerospace industry shifted, but we now work with many subsidiary providers to Boeing. With this DAQ upgrade, we will be seeing more direct Boeing activity, which gives students a wider range of projects and a closer connection to local industry."

The transition to the new DAQ takes some time. The old and new systems will run in parallel for about six months to make sure all six computers tied into the DAQ are synchronized, using a new GPS timing device. "We have to make sure the DAQ software has access to all necessary drivers and subroutines on different platforms and that the PCs are talking to each other correctly over a wide range of test configurations," comments Knowlen.

Knowlen gives a nod to the student crew for making the time leading up to the transition as smooth as it was. "To their credit, the students, especially the three seniors who graduated last year and the eight seniors currently employed, kept wind tunnel operations on track and stepped up to learn how to do test engineering tasks that were above and beyond their job descriptions."

Jess Grant, A&A senior and KWT crew chief, acknowledged the rigorous problem solving aspect of the job, especially with the new DAQ installation. "The KWT student crew is known for our ability to solve problems quickly. This transition to the new DAQ definitely gave us more problems to solve, but we're smoothing it all out and have gained even more valuable engineering experience in troubleshooting, problem-solving, and bonding over the challenges."

UWAL / KWT alumni:

SUBMIT YOUR STORIES!

We would like to hear some of your favorite memories from your time on the UWAL/KWT student crew. Please visit https://www.aa.washington.edu/kwtalum to access alumni memories and submit your own.

UW CELEBRATES

CENTENNIAL OF AERONAUTICS INSTRUCTION

"The event was a clear demonstration of the amazing base of alumni and partners that we have developed over the hundred years of our department. We will definitely be engaging that enthusiasm for even more success as we continue into our next hundred years."

KRISTI MORGANSEN A&A CHAIR

UW President Ana Mari Cauce opened the event.

The centennial gathered many A&A alumni.

A&A, with the College of Engineering, celebrated 100 years of aeronautics instruction in November, bringing together for a day-long event Boeing executives, UW leaders, current and former faculty, partners and alumni. UW President Ana Mari Cauce kicked off the event, praising A&A for being an innovator in interdisciplinary initiatives.

The history of the UW-Boeing connection

Aeronautics instruction began at the UW with William E. Boeing's gift of the original wind tunnel in 1918. Founder of a budding company, which UW Engineering Dean Mike Bragg dubbed "one of the original aerospace startup companies," Boeing realized he would need skilled aeronautics engineers and a testing tunnel for designs. The gift of the wind tunnel would achieve both as the UW would use it to train aeronautics engineers as well as provide wind tunnel services to the Boeing Company.

To mark this centennial of the close collaboration between the UW and Boeing, Boeing CTO Greg Hyslop reported that Boeing currently employs over 9000 UW alumni, including 6000 from the College of Engineering. The UW alumni hires began in 1916 with mechanical engineering graduates Clairmont Egtvedt and Philip Johnson, both of whom eventually served as Boeing presidents.

Boeing Commercial Airplanes Engineering Historian Sarah Musi teamed up with A&A Former Chair and Professor Emeritus Adam Bruckner to tell the extended history of the UW - Boeing connections and the effect of World War I on the state of aeronautics in 1918.

Bruckner revealed that the original UW plans for the wind tunnel labeled the still-standing building as a "temporary testing shed." In addition, Guggenheim Hall was funded through a $290,000 grant from the Guggenheim Fund for the Promotion of Aeronautics in 1928 and housed not only the aeronautics department, but also electrical and civil engineering, the Engineering Library and the Dean's Office.

A&A Interim Chair Kristi Morgansen highlighted the A&A programs through today, including many dynamic research efforts and centers: the Space Policy and Research Center (SPARC), the Boeing Advanced Research Center (BARC), the A&A Capstone Projects, the Society for Advance Rocket Propulsion (SARP) and the upcoming Advanced Composites Center.

The future of aeronautics

In a panel moderated by Engineering Dean Mike Bragg, Hyslop was joined by his colleague former Boeing CEO Phil Condit and A&A Professor Eli Livne to discuss their take on the current challenges leading us to the future of aeronautics.

As Hyslop sees it, the worldwide trend of increasing urbanization presents barriers to mobility: "People don't like wasting time in traffic. Infrastructure is not keeping up with growth, so we're going to have to put things up on the z-axis."

As for Boeing's role in this future, he says, "Boeing needs to be a leader in this effort. We're a 102-year-old company, but we have to go fast like a two-year-old startup."

Condit emphasized the need to bring the cost of manufacturing down. He said, "Aerospace is unique in that it is high technology with a long product lifestyle. The 747 flew in 1969 and is still in production. Having said that, the challenge is that these devices are extraordinarily expensive. How do we think of the design of manufacturing to reduce the cost of the product?" He continued that the new technologies, such as 3D printing with metals and other materials will be a piece of the solution.

Livne spoke of those features of aeronautics that, in his view, will continue to drive the field: The optimal integration of form and function, the complexity of the multidisciplinary interactions involved, the bypassing of transportation obstacles on the ground, and the "bird's eye view" it provides. He also talked about the "awe factor" of flight vehicles and the importance of sustained investment in aeronautical engineering education and in the development of commercial supersonic flight.

The future of space

A&A Professor Behcet Acikmese moderated a lively all-alumni panel on the Future of Space with CEO of Spaceflight Industries Jason Andrews, CEO of Tethers Unlimited Rob Hoyt, and Rob Grover from the Jet Propulsion Lab. All of the panelists spoke of the shrinking of space technologies in that we are developing smaller, higher-functioning satellites closer to earth made of parts at a lower cost.

For the future, CubeSats will be a big part of planetary exploration, and the challenge that we are starting to overcome is reaching an economy of scale to launch more, smaller space systems at a lower production cost.

When asked about whether it is necessary to launch humans into space for space exploration because, as Bruckner amusingly pointed out, "Humans are messy and they're difficult to keep alive," all of the panelists voiced an imperative for human exploration. While Andrews noted that while it depends on what your mission is because "exploring a moon of Saturn would not require a human present," he continued, "Space tourism or colonization is by definition a human endeavor."

Centennial photos: Matt Hagen Photography

A&A Interim Chair Kristi Morgansen, Boeing Commercial Airplanes Engineering Historian Sarah Musi, and A&A Professor Emeritus Adam Bruckner related the history of aeronautics at the UW and the close connection with Boeing.

Attending alumnae gathered for a photo.

Director of Product Development for Boeing Commercial Airplanes and A&A Boeing Focal (and A&A alumnus) Kourosh Hadi welcomed the crowd and moderated the lively Alumni Panel during the event.

CEO of Spaceflight Industries Jason Andrews during the Future of Space Panel.

Alumni recollections

The centennial event was, above all, a celebration of A&A's influence in the world personified through its alumni. We heard from alumni from each decade since the 1950s talk about the state of technology when they were in school and their favorite memories. Alumnus Kourosh Hadi, Director of Product Development for Boeing Commercial Airplanes and the Boeing Focal for the A&A Department, fondly remembered putting in many hours working at the wind tunnel and his first class with Bruckner requiring several all-nighters.

Says Morgansen, "The event was a clear demonstration of the amazing base of alumni and partners that we have developed over the hundred years of our department. We will definitely be engaging that enthusiasm for even more success as we continue into our next hundred years."

The Alumni Panel gathered graduates from the 1951 through 2002 classes. L-R: Kourosh Hadi, Luella Armstrong, Dana Andrews, Anita Gale, Suzanna Darcy-Hennemann, Emilio Beltran, Kyu Hwang.

The Future of Aeronautics Panel from L-R: A&A Professor Eli Livne, Boeing CTO Greg Hyslop, Former Boeing CEO Phil Condit, and UW Engineering Dean Michael Bragg.

A&A Professor Behcet Acikmese, JPL's Rob Grover, and CEO of Tethers Unlimited Rob Hoyt after their Future of Space Panel.

Laura McGill 2018

During the centennial celebration, A&A recognized Laura McGill from the graduating class of 1983 as the 2018 Distinguished Alumna. McGill, VP of Engineering for Raytheon Missile Systems, fondly remembered her time as an A&A undergraduate.

She noted that smoking was still allowed and when "things got difficult, labs got smokier." She also remembered that she and her classmates were very tied to current events. They followed the testing of the space shuttle on the 747 and watched the launch of Columbia. After the May 1979 crash of the DC10 in Chicago, they did wind tunnel testing of Boeing airplanes under similar stresses.

As for being a woman in engineering, she said, "There was less diversity when I started than there is today. For much of my career, I was the only woman in the room, but I never doubted my ability to do the work." Regarding the root of this confidence, she says, "Through all of my A&A classes and projects, I learned how to be a hands-on engineer. It served me well in managing all of my projects, including the Tomahawk cruise missile."

McGill continued, "Aerospace still has a way to go in diversity, but this university is making strides in doing that."

Rao Varanasi 2019

Dr. Rao Varanasi (A&A Ph.D. 1968) has been named the 2019 A&A Distinguished Alumnus. He will accept the award at the departmental graduation ceremony in June, where he will also serve as the keynote speaker.

Having worked over 45 years at The Boeing Company, Varanasi held various positions in the fields of research and development in structural engineering, computational mechanics, analytical modeling of engineering systems, and management of military and commercial airplanes. Most recently, Varanasi served as Chief Engineer for Structures and Aging Fleet in Boeing Commercial Airplanes and served as a technical leader and engineering liaison for aircraft structures for the Federal Aviation Agency and the European Aviation Safety Agency before retiring.

Varanasi has been a great contributor to A&A over the years as well. He is an affiliate professor in the A&A Department as well as a member of the A&A Visiting Committee, which reviews undergraduate and graduate programs and curricula, and faculty requirements to make recommendations for a broad set of strategic goals for future growth including increasing the department's academic ranking in five years. He also serves as Chair of the Diamond Awards Committee for the College of Engineering.

WOMEN IN AEROSPACE:

Making women engineers accessible to girls

A&A Ph.D. student Ellie Forbes is frustrated with the reasons she hears why more women are not in the aerospace field. She says of her own experience, "Plasma is a field with 7 percent women nationally. In the American Physical Society Division of Plasma Physicists, only 4 percent of the membership are women. I keep hearing explanations that we need to offer more childcare and maternity leave to attract more women to the field, but that's not what's keeping college women from pursuing plasma studies."

Forbes continues, "Girls don't pursue these engineering fields because they're told that they can't and they don't see any women in these fields. So one of the ways we can change this whole dynamic is by telling them they can be engineers, showing them women engineers, and reaching them at a young age."

This is the grounding reason she founded the Women in Aerospace club. "We need to show girls that it is really fun and cool to be interested in science and math."

As one of the newest engineering clubs at the UW, founded in 2017, Women in Aerospace has been getting traction engaging girls in elementary and middle schools. With approximately 20 members, they have been reaching out to organizations in the Seattle area for opportunities and potential partnerships. And they have been met with enthusiasm.

For the club, the Girl Scouts are a timely and receptive audience. With the appointment of former Jet Propulsion Labs rocket scientist Sylvia Acevedo as CEO of the Girl Scouts in 2017, the organization has a greater urgency to emphasize science and technology. New badges have been released over the past year in engineering, computer science, space science, robotics, and mechanical engineering.

Women in Aerospace specializes in a range of sharing sessions and activities to groups like the Girl Scouts. Over the summer, they visited Camp River Ranch outside of Seattle for a weekend workshop. A few Women in Aerospace members who had participated in SARP, the rocketry club at the UW, taught the girls about propulsion and facilitated making stomp rockets. The girls built their own rockets, learned about how to make the nose cone and fins more effective, and put a lot of thought into naming their creations.

Club member Nadiah Jenkins explains why she see this outreach effort as so important: "Often, people try to explain away the gender disparity in engineering by saying girls aren't interested in how things

"Girls don't pursue these engineering fields because they're told that they can't and they don't see any women in these fields. So one of the ways we can change this whole dynamic is by telling them they can be engineers, showing them women engineers, and reaching them at a young age."

ELLIE FORBES

work, or they can't focus on the 'scientific process.' While working with the Girl Scouts, I saw girls methodically testing and iterating through their designs, asking us how to make their rockets fly further and higher, and taking pride in what they were discovering. This is the research experience in a nutshell. We want to encourage girls and young women to continue engaging in that process."

Anna Sheppard, the club's treasurer, attended Seattle Girl Scout Troop 44407's meeting as they started the aMUSE Journey badge series, focusing on all of the different roles women play and the accessibility and perception of those roles. Sheppard shared her experience of her ROTC training in college, being an officer in the Air Force, testing fighter plane engines, and joining A&A as a Ph.D. student. She also shared some of the gender dynamics she has noticed along the way.

The troop of fifth grade girls explored many of her different roles, including problem solver, advocate for women and engineer. Linnea, age 10, said, "That is so great that Anna spent her evening coming to talk to us. The meeting flew by and everyone was so engaged. I learned a lot about designing airplanes."

For her part, Sheppard says, "Growing up, I had no role models in engineering, and I think it's important to emphasize that the problems engineers face are ubiquitous. Engineering relies on many disparate fields that interest girls. There's math and science, sure, but engineering also requires design, coding, logic, creativity, construction, and trial and error. At the end of the day, engineering is fun, and that shouldn't be limited to just boys."

As for the club's outreach strategy, they are looking to engage more groups like the Girl Scouts and to build on their efforts at the Museum of Flight.

Says Forbes, "There is a cultural issue with math in general. Math is hard, but it's hard to understand why it's cool to be bad at math. That's something we're going to have to change."

Clockwise from top right: Nadiah Jenkins, Anna Sheppard with Girl Scout Troop 44407, Ellie Forbes.

SARP: IGNITING A PASSION

BY CHELSEA YATES

PHOTOS BY SILAS CHU AND SARP

It's 109 degrees in the New Mexican desert at Spaceport America, where more than 110 college teams from across the globe have convened and are ready to compete. In addition to sunblock, tools and plenty of water, they have brought the high-powered rockets they've built over the last year. Ranging from eight to 20 feet in length, the rockets are designed to reach heights of 10,000 to 30,000 feet.

The challenge — Spaceport America Cup — is an incredible, if not unusual, opportunity. Designed around the Intercollegiate Rocket Engineering Competition, the challenge hosts student-built rockets of all chemical propulsion types— solid, liquid and hybrid. To win, the teams' rockets must launch successfully, achieve maximum altitude and be recovered after landing, hopefully in one piece.

"For students interested in rocket science and aerospace engineering, it's the best," says A&A senior Jess Grant. He's the chief engineer for the UW's student-run rocketry organization, the Society for Advanced Rocket Propulsion (SARP).

Grant joined SARP as soon as he stepped on campus his freshman year. "The team is one of the main reasons I decided to attend the UW," he says. He's eager to spend his final year leading SARP to success at next June's Spaceport America Cup.

Above: SARP team members prepare their rocket for launch at the 2018 Spaceport America Cup.

It's not rocket science (wait, yes it is...)

Nearly 200 students are involved with SARP; most are A&A majors but some come from other areas, such as mechanical engineering (ME) and computer science and engineering (CSE). The team focuses a full-year's efforts on designing and building a single rocket for competition.

"We start each year with a new rocket," says Grant. "But we are continually iterating on previous years, so you could say that this has been a multi-year process, extending back to the team's inception in 2009."

SARP primarily builds hybrid rockets — rockets that use a combination of solid and liquid fuel. These types tend to be safer than their solid or liquid counterparts but are more complicated to design and construct.

Opposite top: Team members spend the academic year designing and constructing their rocket. Here Cody Olson and Aakash Kurse prepare aluminum stock to be lathed into the payload coupler.

Opposite bottom: Cat Hannahs adjusts a mill during fin manufacturing. The team fabricates rocket components in A&A's Bossart Machine Shop and the ME Machine Shop.

"There's so much involved in building rockets," says CSE senior and SARP's Avionics lead Sabrina Tong. She joined the team a few years ago; SARP needed students with programming and circuitry skills, and she was excited for the opportunity to apply hers to an aerospace-related project.

"In addition to technical skills such as programming, system design and analysis, we learn project management and leadership skills," she says.

At competition, each team usually launches just one rocket, so they hone their efforts into precision design and construction. Successful rockets must launch a payload — the equipment being transported by the rocket — and be recovered after flight.

SARP designs its rockets to reach 30,000 feet at a speed of Mach 1.3. Last year, the team's rocket measured about 14 feet from the tip of the nose cone to the bottom of the fin can.

Building a successful — and safe — rocket is no easy feat. To get the job done, the team divides into several subteams. The Avionics team focuses on remote fill and launch sequence control, in-flight data and tracking. Structures is concerned with the airframe and other structural components. The Propulsion team develops the motor. Payload designs and creates the item that will be transported inside the rocket (last year's was an autonomous rover and this year's is a plasma actuator). The Recovery team determines how to safely recover the rocket, and the Business team is responsible for administration, publicity and sponsorship.

SARP's rocket is single-use, and competition marks the first — and only —time it will fly, so everything has to run smoothly.

"We test components, subsystems and small-scale versions on campus and at remote sites in Oregon and Washington, but usually the only time we get to see the whole rocket fly is at competition," says Tong.

"As you might imagine, we all get a little anxious on Launch Day," Grant adds.

Three, two, one...lift off!

Launch Day is a thrilling mix of emotions. Competing teams cheer each other on, as all know what it's taken to get there.

"Even though we're competing, we all have similar anticipation at the moment of lift off," says Grant.

The teams spend three days in the desert preparing for launch. On day one, they set up their base camps, launch pads and guide rails. They also start assembling their rockets, installing payloads and testing subsystems. On day two, they set up remote control stations. Judges review and assess the rockets; those that pass inspection are moved to their respective launch sites.

On the third day, the rockets are ignited, and teams and judges watch from a safe distance as each soars into the air. Environmental elements — rising temperatures, wind and dust — can make a launch even more challenging, and sometimes dangerous.

Last June, SARP's was one of 94 rockets that took off during the competition's launch window.

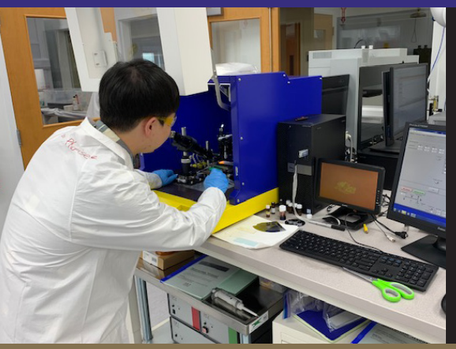
"We were so nervous; our rocket flew straight for about three seconds but then experienced some instability on its ascent to 30,000 feet," Grant remembers. "On the descent there was a glitch with parachute deployment. Fortunately we were able to recover the rocket mostly in one piece."

Teams are assessed on everything from written technical reports to design implementation to overall flight performance, recovery and successful payload functionality and landing.

Despite the abnormal flight, SARP's rocket met its altitude goals, and its construction and engineering impressed the judges. The team took first place in their division.

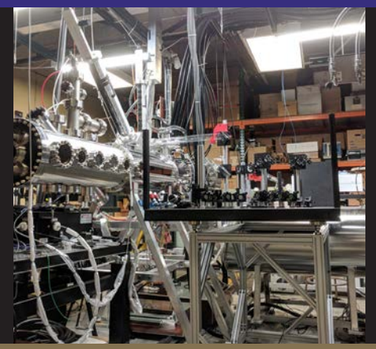
Team members are now focused on refining last year's rocket design for next June's competition.

"The lessons we learn in our engineering classes are super important, but they're only part of engineering education," says Grant. "Getting to build a rocket from scratch with other students who share a passion for rocketry is such a cool project to apply our skills to. It's amazing to have this opportunity at the UW."



MAMS Lab advances damage sensing through composites

A&A's Multiscale Analysis of Materials and Structures (MAMS) Lab, under Professor Marco Salviato, has developed an innovation to detect structural compromises to composite materials. This advance is of particular interest to UW Hyperloop, SpaceX, automotive manufacturers and others for early troubleshooting of structural integrity of earth and space vehicles. While composites are usually made of fibers placed in straight lines, the MAMS Lab is using additive manufacturing to lay conductive curvilinear paths on composite material. Because the paths are conductive, any structural compromise can be immediately sensed by measuring a change in electric resistivity as these paths are broken or distorted. The Lab is currently testing, validating and refining the math and methods behind this technique. The technology will then be installed on the UW Hyperloop prototype and the findings reported to SpaceX for possible incorporation into the Dragon projects. [Pictured above: Sean Phenisee is 3D printing a metal curvilinear path to optimize the conductivity of the circuit.]



Plasma flows may lead to a cheaper, more compact route to nuclear fusion

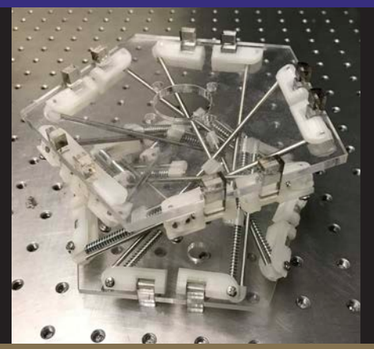
Nuclear fusion powers the stars and offers the promise of unlimited, clean energy on Earth. But controlled thermonuclear fusion in the lab usually requires large and expensive magnetic field coils to stably confine burning plasma, ionized nuclei that collide to initiate nuclear fusion. A&A's FuZE (Fusion Z-Pinch Experiment) Lab, together with the Lawrence Livermore National Laboratory, has developed a smaller, cheaper method. Research, under the direction of Professor Uri Shumlak, has measured sustained nuclear fusion for the first time from a 50-cm long plasma column called a Z-pinch. While the Z-pinch is not a new plasma confinement concept, it was largely abandoned as a path for fusion energy because the plasma was not stable, which limited how long it could be confined. To get around this issue, researchers exploited the fact that flows can stabilize plasma, and the flowing plasma was maintained 5000 times longer than a static plasma. Because this approach provides a path to nuclear fusion without coils, it could be used in the future for long-duration fusion burns in a compact and low-cost device.

Fine-tuning supersonic retropropulsion

While supersonic parachutes worked to slow NASA's Mars Insight and Curiosity Rover for landing, this Viking-era technology has reached its limits. New landing technologies are needed that are simple, scalable, and made from conventional space hardware. Research under Professor Owen Williams is advancing supersonic retropropulsion (SRP), identified by NASA as a key entry, descent and landing technology for future Mars missions and for the reuse of rocket boosters back here on Earth. With this landing method, the vehicle slows down from supersonic speeds by firing its engines into the oncoming high-speed, supersonic flow. Depending on flow conditions and vehicle layout, the bow shockwave and surrounding flow may become unstable. Current research includes investigating the influence of jet pressure and vehicle geometry on this unsteadiness to determine the sources of shockwave unsteadiness in SRP flow and ways it can be mitigated. [Pictured above: Xiuqi "Charlie" Yang is adjusting nozzle alignment in preparation for more testing.]

The RAIN Lab's science of sync

A&A's RAIN Lab, led by Professor Mehran Mesbahi, conducts research on how the structure of networks affects the dynamics of systems that evolve over them. One area of research examines how symmetric the structure of networks are. If two parts of the network can be rearranged without changing the qualitative features of their interdependence, the network has an inherent symmetry. The RAIN Lab's recent research, published in *Science*, examined a simple system of eight nanoelectromechanical oscillators interconnected over a ring. Similar oscillators are found, for example, in cell phones. A chip that uses an oscillator detects the orientation of the phone as it is rotated. Results showed how each simple rearrangement of this ring of oscillators — each network symmetry -- corresponds to an oscillation pattern. The technique proposed in this work has a number of consequences for understanding complex dynamics exhibited by large-scale nonlinear networks, such as power grid and neuronal networks. [Pictured above: Afshin Mesbahi, Siavash Alemzadeh, Professor Mehran Mesbahi, and Mathias Hudoba de Badyn from A&A's RAIN Lab.]



Origami for designing novel materials and structures

Origami is an ancient art of paper folding, but recently, it has attracted a significant amount of attention from the scientific community due to its wide-ranging applications. Professor Jinkyu Yang's research team in the Laboratory for Engineered Materials and Structures (LEMS Lab) is working on designing and fabricating origami-inspired aerospace structures, such as jumping and grasping robots, space landing structures, and foldable rocket motors. The key challenge is how to make a lightweight, deployable, yet highly stiff and strong structure in all of these applications. Typically, lightweight and deployable structures tend to lack an appropriate mechanical stiffness and strength, while stiff and strong structures are not easily foldable. To tackle this challenge, Yang's team has developed a technique to fabricate versatile structures that are simultaneously rugged and reconfigurable. They have successfully shown prototypes in laboratory, and currently are working on expanding the concept to various applications.

U.S. Department of Energy awards advance fusion research at the UW

A&A was awarded two grants from the U.S. Department of Energy's (DOE) Office of Fusion Energy Sciences. The UW has been a leader in fusion research with the plasma confinement system called a tokamak, and these grants will improve the process and current inefficiencies in heating plasma in a tokamak and making the process more economical for smaller-scale models. A major challenge with a tokamak is that some of the heated plasma comes in contact with its chamber wall, melting the wall and then cooling the rest of the plasma. The funding will cover experiments with a liquid metal wall that acts like double-sided tape to protect the chamber wall and prevent the cooled plasma from cooling the rest of the fuel. The funding also will advance Transient Coaxial Helicity Injection. This method is a step in simplifying a tokamak's vessel and magnetic coil configurations to make fusion more economical, and therefore, scalable, for widespread use in power plants. [Pictured above: Brian Nelson, Professor Tom Jarboe, and John Rogers in A&A's HIT-SI Lab.]

Cat Hannahs wins Brooke Owens Scholarship

A&A sophomore Cat Hannahs won a Brooke Owens Fellowship to work as a vehicle engineering intern at SpaceX this summer. At the UW, Hannahs has been an active member of the Society for Advanced Rocket Propulsion (SARP). She currently leads SARP's oxidizer tank project and oversees design, analysis, manufacturing, and testing of the pressure vessel. In addition, Hannahs has been a researcher in the Autonomous Insect Robotics (AIR) Lab in the mechanical engineering department since June 2018. At the AIR Lab, Hannahs works on micromachined insect-inspired hopping robots designed to explore and gather data as extraterrestrial rovers. As a member of the Washington NASA Space Grant Consortium, she has volunteered in Washington and Idaho to expose elementary students to opportunities in STEM. She is also a presenter at the UW Planetarium where she gives shows to the public and grade school groups.

Alexis Harroun selected into 20 Twenties

A&A congratulates 2017 alumna Alexis Harroun for being selected into Aviation Week's prestigious 20 Twenties list for 2019. Harroun is currently working towards her master's degree at Purdue University. Her research is on nozzle design for rocket application rotating detonation engines (RDEs). RDEs are a promising rocket engine technology that in the future may allow rockets launched from earth to carry heavier payloads. While at the UW, Harroun was president of the AIAA student chapter and also a member of SARP, the UW rocketry club, rising to become the propulsion lead her senior year. Of her time in A&A and SARP, she says, "I have a passion for propulsion and wanted to work on the next great propulsion technology. Not many students get hands-on experience in exactly what they want to do after school – at least not in rocket engines. SARP was an incredible experience."

Charlie Kelly wins NASA Fellowship

A&A Ph.D. student Charlie Kelly won a prestigious NASA Space Technology Research Fellowship for research on "Revolutionizing Orbit Insertion with Magnetoshell Aerocapture." Magnetoshell aerocapture is an aeroassist maneuver enabling satellites to achieve stable orbits around space bodies with significant atmospheres with the use of a "plasma parachute." This fellowship is awarded to students who are working on the development of technologies that will bolster NASA's science mission goals. This fellowship is specifically for technology development, which will enable Kelly to turn the magnetoshell aerocapture concept into a technology NASA engineers can use in mission designs. Kelly, who just submitted his thesis to earn his MSAA last June, is excited for this transition into his doctoral work. While the generous tuition and stipend award, $300,000 in total, will be a tremendous help in his academic career, he is most grateful about the opportunity to spend ten weeks per year over the next four years working at a different NASA location as a "Visiting Technologist."

Gustavo Fujiwara wins SAE Engineering Scholarship and Phi Kappa Phi Fellowship

A&A Ph.D. student Gustavo Fujiwara won one of only two 2018 SAE Doctoral Engineering Scholarships. This scholarship recognizes and provides financial support to students pursuing doctoral degrees in engineering who demonstrate strong academic achievement and leadership skills. The total of 36 graduate and undergraduate scholarships were awarded from a pool of over 2,500 applicants. He is also one of only ten Ph.D. students to win a dissertation fellowship from Phi Kappa Phi, the nation's oldest and most selective collegiate honor society for all disciplines. Fujiwara currently works with Professor and College of Engineering Dean Michael Bragg and Professor Eli Livne in the field of Multidisciplinary Design Analysis and Optimization (MDAO) applied to aircraft design. Their research targets ways to improve the design of future-generation aircraft by developing a more integrated optimization framework to ultimately increase aircraft fuel efficiency.

Finn van Donkelaar's innovative space launch proposal wins AIAA first place

A&A graduate student Finn van Donkelaar is working to change the current course of how large, acceleration-insensitive payloads will be launched into space. He caught the attention of AIAA, winning first place in the graduate division at the 2018 Regional AIAA Region VI Student Conference. His winning paper, "Velocity Measurements of Projectiles Propelled by Underexpanded Supersonic Jets" advanced to be presented at the 2019 AIAA SciTech Forum. The paper outlines a novel approach to launching large supplies payloads into space, as well as experimental validation of the concept. With human exploration of space poised to increase dramatically in the near future, vast amounts of supplies will be needed in space. Van Donkelaar's proposed system uses a powerful electrical arc to heat inert propellant before exhausting it through a rocket nozzle. The resulting jet of high-speed gas pushes the payload to orbital velocity, which would eliminate the need to carry huge amounts of fuel to reach space.

AIAA first in team for rotating detonation engine lab setup

A&A undergrads Andrew Jacob, Chinmay Upadhye, Andrew Milligan, and Kevin Chau won first place in the team category at the 2019 AIAA Region VI conference for their research on configuring a facility to enhance the testing of rotating detonation engines (RDEs). This work makes possible rapid swapping out of test conditions such as instrumentation, configuration, boundary conditions, sensors and parts for continuous RDE testing. The team reports that the most important element in RDE research is the ability to control as many variables as possible. The laboratory setup they proposed and implemented led to a rapid installation of A&A's new RDE, with the ability to change different variables with little downtime. This gives A&A's RDE Lab an edge in testing and interpreting results. [Pictured above: Andrew Jacob and Andrew Milligan are part of the team that won first in the AIAA team category for RDE facility research and application.]

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Rob Grover before the Mars InSight landing with a traditional jar of peanuts passed around JPL's control room for luck before landings.

A&A's Rob Grover on the InSight probe landing

A&A alumnus and current doctoral student Rob Grover led the landing of NASA's InSight probe on Mars on November 26, 2018, as the NASA Jet Propulsion Lab (JPL) Head of Entry, Descent & Landing (EDL). Grover notes that "The process of entry, descent, and landing is known as seven minutes of terror because it's a very challenging and exciting event with probably the highest risk of the whole mission. The entire process has to happen autonomously. You can't manage it remotely because of the time it would take for a signal to get there."

Grover, who has also worked on three previous Mars landings, noted his A&A preparation for his career. "I had a strong interest in Mars exploration even before I came to the department for my masters, so I was happy to find Professor Adam Bruckner, and I got a great introduction in his space system design class."

Grover's current doctoral research involves EDL design margins, building on much of his InSight mission work. His research will complement JPL's InSight EDL reconstruction, taking all of the data of the landing to understand better exactly what happened.