HIGH**FLIGHT**

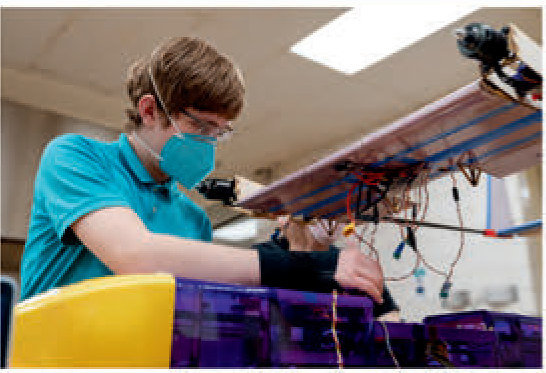
WILLIAM E. BOEING DEPARTMENT OF AERONAUTICS & ASTRONAUTICS

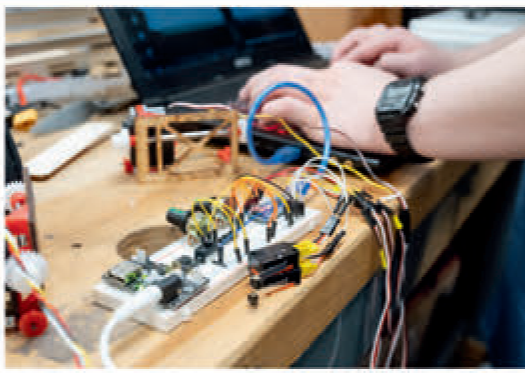
2022 – 2023 IN THIS ISSUE

Design Build Fly Charts a New Course

Nanofoams Are Full of Surprises

Fusion Energy is Finally Getting its Moment





MESSAGE FROM THE CHAIR

Dear A&A Alumni and Friends,

I am always very excited to see the latest issue of *Highflight* take shape. But now, seeing all of the stories of our work and research inspires me even more. With the upheaval of the last three years, we know not to take anything for granted and to celebrate all we can. While our teaching and research never stopped, we find ourselves so grateful to return a bit to how things were "before." This academic year we are continuing with in-person instruction, our student clubs are planning for their annual competitions, our Machine Shop is back to full operations, and we have new faculty bringing in fresh perspectives, all producing a dynamic academic year!

In this issue, you will meet our new faculty, celebrate our award-winners and read about so many of the innovative ways A&A is shaping our future. From improved wildfire responses stemming from an understanding of turbulence, to a sustainable energy future through fusion and advanced materials made possible by bubbles, we are creating a more safe, secure, equitable and efficient future.

Kristi Morgansen
Professor and Boeing Egtvedt Chair

Kristi A. Morgansen

HIGHFLIGHT 2022–2023

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

Mike Taniguchi ('71)
is the 2022 A&A Distinguished Alum


Catherine and Mike Taniguchi

For Mike Taniguchi, the thrill of working on liquid rocket propulsion systems for over forty years has always been the controlled "fire and smoke" needed for successful maneuvering and booster stages. His expertise is in transient modeling and analysis, a technical discipline that combines design constraints and dynamic performance measures from across the comprehensive engineering components (the turbopumps, valves, feed-lines, controller and combustion chambers) of the propulsion system. The design limits and performance characteristics are integrated in a whole systems model to define a start, throttle and shutdown valve sequence that safeguards each mission.

Taniguchi worked continuously to advance transient modeling and analysis as an engineer and a first-line manager of a multi-disciplined engineering staff focused on liquid rocket engines from 1976 to his retirement in 2020. His efforts spanned four different corporate cultures which took over Rocketdyne as an aerospace division (Rockwell International, Boeing, United Technologies and General Corp). He is currently working remotely as a consultant/contractor for Blue Origin.

Taniguchi had some interesting luck with timing before he started at Rocketdyne. Born and raised in Seattle and a graduate of Rainier Beach High School, he enrolled at the University of Washington to graduate from A&A in 1971, just as the aerospace industry fell into a deep slump. A professor in one of his last classes asked who had a job lined up, and no one raised a hand.

He had bigger worries than the poor job market, however. The US Selective Service lottery picked his birthday to be included in the Vietnam War draft. He explains, "I didn't have to bother trying to look for a job because Uncle Sam already told me where I was going to go if I did not enlist."

With his enlistment he spent his time in the Army, first in basic training at Fort Knox, then in Germany. Three years later, he returned to Seattle and took advantage of the GI Bill to work toward a second bachelor's degree at the UW, this time in numerical analysis. When he graduated in 1976, he faced a job slump in mathematics. When a math professor asked one of his large classes who had a job lined up, only two hands went up.

After graduation, he headed to Japan with a friend for a trip to climb Mt. Fuji. An approaching typhoon threatened their hike departure, but they left anyway, hoping the storm would miss them. It didn't. The weather ultimately forced them to shelter in a stone hut for a night. When they finally arrived at the summit of Mt. Fuji, it was July 4, 1976, and to this day, Taniguchi loves showing off the hiking stick he got on that trip carved on the summit with that bicentennial date to mark his feat.

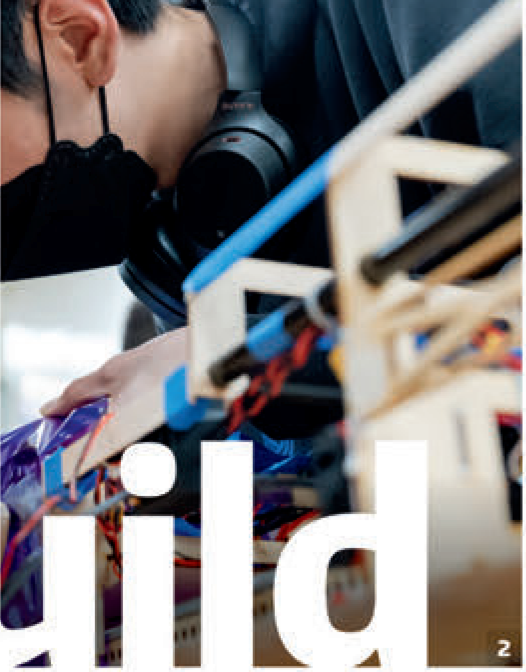
When he returned from his trip while he was recovering from an acute case of jet lag, he received a call offering him a job at Rocketdyne. He wasn't even sure exactly what he said, but apparently it was good enough that they did not revoke his offer. Taniguchi's troubles with timing finally worked out, as he stayed with Rocketdyne through all of its various iterations until his retirement in 2020.

Taniguchi has been a dedicated mentor over the years, helping give career advice to many young engineers. Many of his efforts in mentoring and expanding diversity caught the attention of the several rotating parent companies of Rocketdyne. He is currently participating in the A&A mentoring program. He has been invited to share his career in an A&A class and took the opportunity to hire an A&A student as a summer intern and then hired him as a full-time staff member. In recent years, he has supported the A&A capstone design projects as a jurist. Throughout his career, he built extensive experience as both an engineer and manager. He knows the advantages and challenges of each. He encourages students and early-career colleagues to be honest about how they want to be spending time as they navigate their paths.

We are proud to name Mike Taniguchi as the 2022 A&A Distinguished Alumnus!

Design Bu

1. *Angelina dos Remedios (left) and Caleigh Stagnone (right) assemble the rudders and vertical stabilizers of the second 2021–22 prototype aircraft. In the background Shawn Ni works preps a 3D-printed adapter that connects the stabilizers to the plane.*
2. *Shawn Ni (left) and Jake Li (right) apply covering film to the prototype fuselage just days before a test flight in February.*
3. *The 2022 Albatross in flight.*
4. *Team members trace a wing stencil onto an XPS foam block prior to cutting wing.*
5. *Ethan Uehara observes as Daniel Moore secures batteries in the 2020-21 prototype aircraft prior to first flight in January 2021.*
6. *The DBF team in Wichita, KS, awaiting results after they completed all flights for the 2022 AIAA DBF Competition.*
7. *Pilot Ryan Check (left) and Aaron Greison carry the Albatross out to the flight line on a breezy day at competition in Wichita, KS.*



CHARTS A NEW COURSE

A vastly expanded membership base and a reimagined organizational structure delivered a very successful airplane and groundwork for more

While Design Build Fly (DBF) has long been one of A&A's most popular student organizations, the AIAA-sponsored competition team is transforming itself from a smaller, less-structured group to one that is not only focused on this year's plane, but building the team capacity to build winning planes in the years to come.

What is DBF?

DBF chapters at several universities spend the academic year designing, building, and flying an unmanned electric-powered, radio controlled aircraft with a specific mission profile. The goal is to compete at the annual AIAA DBF Competition, now in its 28th year. Each year sees different challenges, and about 150 teams submit the initial design proposal for the annual DBF competition. Not every plane design is cleared for the build stage, but each team works toward a design that delivers excellent flight handling, affordable manufacturing and high performance.

Organized, explosive growth

A&A senior and DBF Project Manager Pranav Bhagavatula emphasizes that the UW chapter has been in a "building back" phase since before his freshman year. "We were trying to recruit new members and rethink our organizational structure," he says. Now with 140 people signing up at the beginning of last year and ultimately landing at about 70 active members, DBF is thriving under the growth.

"To give credit where it is due, Ethan Uehara (A&A '21) and Daniel Moore (A&A '22), worked to rebuild this team and structure the capacity to handle growth," says Pranav. Professor Dana Dabiri, DBF's faculty adviser last year, agrees. "Ethan's and Daniel's leadership transformed our DBF team into a highly organized and efficient group, and we have seen the result in superb performance and delivery in the last couple of years. This is most exciting, and we look forward to the team's continued success," he says.

The difference has been an organizational structure with subteams and excellent communications channels. Pranav continues, "This year we have subteams to look at every aspect of the plane versus in previous years when we'd be designing, say, our landing gear, and thinking, 'We're just going to wing it.' "

Educate and Compete

While some DBF chapters reuse and adapt the same airframe and manufacturing techniques from year to year, the UW team starts over again completely every year. Daniel says, "Starting with a clean-slate allows us to better educate our members and give them that extra experience. With our motto 'Educate and Compete,' we are trying to provide the opportunity and resources, not just to build a competitive aircraft, but to develop the member's design, academic, and professional skills."

Pranav adds that the educational opportunities that DBF offers are pretty amazing. "You don't need experience to join DBF. We're looking for an attitude and a mindset that's going to enable getting to that high level of competence. We need to build an aircraft and we're going to provide the resources to do it," he said.

The team has an impressive library of tutorials and lectures on their YouTube channel, including Ethan's playlist on Structures and Daniel's playlist on SolidWorks, and last year they resumed in-person seminars and manufacturing training. Some students enter the team as first years with introductory concepts of lift and drag.

CONTINUED NEXT PAGE

Materials & Manufacturing lead Alex Martin (left) watches as Kathryn Guttormsen conducts propulsion and airframe model tests in the 3x3 Wind Tunnel.

DBF Chief Engineer and A&A senior Caleigh Stagnone says, "We have a lot of underclassmen who are interested in getting lessons on aerodynamic analysis, finite element analysis or SolidWorks 3D design—things you wouldn't see until junior year in the curriculum."

While all of this training takes up a lot of the time of the experienced members, it is a strategy that will pay off for the sustainability of the program. With the extra membership, they have the capacity to both build this year's plane and lay the training groundwork for next year's plane.

The recent new strategy has also boosted efforts to engage local industry. These efforts have not only attracted sponsorships in excess of $15,000 last year, well beyond their previous fundraising efforts, but the team has engaged mentors from Boeing, Janicki, SpaceX and the Marymoor Radio Control Club, with many ex-Boeing and ex-Microsoft Engineers. Pranav notes, "They're taking us to the next level."

The philosophy is paying off for the more senior members. Caleigh says, "It's kind of cool that if you're in the team all four years, that at the end, you've built four complete airplanes that are all very different." She continues, "This experience is really valuable when you go into industry. Last summer I had an internship with Janicki Industries, an aerospace composite manufacturer. My position as DBF Materials Lead was directly applicable to my internship. This team provides experiences that you're not going to get inside of a classroom."

The Albatross

The Albatross, the team's official 2022 competition plane, was curiously named considering albatrosses are known for not sticking their landings because of their high-speed approaches. The plane lived up to its namesake bird in several of the test flights. Caleigh said with a laugh, "Well, it's true that one of the major design challenges this year was our nose landing gear."

The Albatross's design reflected a complicated mission for the spring competition. The plane was simulating a humanitarian vaccine delivery. The plane had to carry packages of syringes, fly three laps in under five minutes, deliver a package, and repeat the process as many times that time permitted.

It was working toward perfecting the reliability in the repetition that led to one of the most satisfying breakthroughs. Pranav explains, "It is actually quite a difficult challenge to land, deploy a package, take off and repeat the process six times. After three iterations and several 12-hour days in the shop, diagnosing and re-diagnosing, we finally got the reliability we were looking for. And it brought us to this place we have never been before – we're at a much more professional stage that we didn't see ourselves achieving, even just two years ago."

The 2022 DBF Competition in Wichita, Kansas

Three years ago at the 2019 DBF competition in Tucson, Arizona, our DBF team placed 93 out of 104 teams. While the 2020 and 2021 teams improved their standings, the team was looking for a big win in Wichita. In the 2022 competition, the Albatross flew well, with no crashes, finishing 9th out of ninety-seven teams, the highest standing by far the team has ever achieved.

Ethan and Daniel secure the wing of the 2019-20 prototype aircraft prior to first flight in February 2020.

Of this result, Daniel muses, "There are many highly competitive teams at competition, and after four years investing immeasurable time into the UW DBF team, it was a blessing to see the fruits of our labors, with our team competing on the same level with the very best of them." Looking ahead with this year's recruits, Caleigh is ready to go further, "Our team's goal this year is to win."

SEE DBF IN ACTION!

First test of the Albatross, the Director's Cut.

A&A welcomes Karen Leung, Alvar Saenz Otero and Amir Taghvaei to enhance our controls and capstone programs.

Karen Leung

Karen Leung comes to A&A as an assistant professor from NVIDIA Research where she was a research scientist working in the Autonomous Vehicle Research Group after earning her MS and PhD from Stanford in aeronautics and astronautics. Originally from Australia, she holds bachelor's degrees in aerospace engineering and mathematics from the University of Sydney.

What does your research include?

I focus on designing safe and trustworthy decision-making algorithms for robots that operate in safety-critical settings, whether that is in space, in the sky, or on the ground. A primary component of my research is in human-robot interactions—there's a lot of uncertainty in how humans behave so it is very challenging to design a robot that can safely interact with humans. For example, I have been studying how autonomous cars should safely interact with other road users.

My research will be a blend of theory and experiments. Since my goal is to design safe and trustworthy robots, not only do I need to design algorithms to tell robots how to act and prove that it will work well in theory, but I need to also demonstrate that it works well in practice.

Alvar Saenz Otero

Alvar Saenz Otero, originally from Mexico City, comes to A&A as an assistant teaching professor from MIT where he earned his bachelor's degrees in electrical engineering and computer science and also aeronautics and astronautics, a master's in electrical engineering and computer science, and ultimately a PhD in aerospace systems. He was the lead scientist of the SPHERES program at the MIT AeroAstro Space Systems Laboratory for twenty years, starting as a TA and continuing as a postdoctoral scholar and then a principal research scientist. He comes to A&A to work in our capstone program.

How do you approach teaching?

During my two decades at MIT's SPHERES, I led research on space systems, control systems, estimation, and autonomy, for missions that included formation flight, docking, modular space systems, and vision-based observation and navigation. My areas of expertise on space systems and real-time embedded systems allowed me to give students a good foundation of systems engineering so they could provide meaningful research beyond my familiarity. And now I look forward to guiding students in the many disciplines of our A&A capstone projects by introducing them to the systems engineering process.

My teaching background and interests have always been in laboratory classes, specifically in the capstone classes taught the last year of the undergraduate degree at MIT AeroAstro and teaching and mentoring avionics. I absolutely value the need for theoretical classes, and all my teaching of capstone classes depends on robust understanding of the theory behind the sub-systems of a spacecraft. My academic objective has always been to teach students how to use that theory when designing and building a spacecraft and to understand the complexity of making all that theory from different areas come together into one system.

Amir Taghvaei

Amir Taghvaei comes to A&A as an assistant professor from the University of California, Irvine, where he was a postdoctoral scholar in Tryphon Georgoiu's lab during the COVID era working on the timely subject of epidemic modeling. He holds an MS in mathematics and a PhD in mechanical engineering from the University of Illinois at Urbana-Champaign where he worked on the intersection of machine learning and control theory. He grew up on the south coast of the Caspian Sea in Iran and earned bachelor degrees there in mechanical engineering and physics at the Sharif University of Technology.

What does your research include?

Control is about processing the sensory data and producing control actions. This feedback structure is the basic principle of control theory and implemented in almost every aerospace system. A major challenge is the uncertainties that are involved (for example, incorrect modeling, noise in measurements, etc). Dealing with uncertainty is gaining more significance as we are incorporating data-driven machine learning modules that are inherently stochastic. The main part of my research is to develop algorithms that can take these uncertainties into consideration in order to achieve an efficient and reliable control performance.

An A&A-developed experiment is going to the International Space Station

A&A researchers are developing a film evaporation experiment for the ISS under a new grant from CASIS and the National Science Foundation.

A&A fluids doctoral student Andrew Jansen picked the right dissertation topic at the right time. He is researching film evaporation under faculty advisers Dana Dabiri and Jim Hermanson using 3D Particle Tracking Velocimetry (PTV). Andrew will be using that experience to set up film evaporation experiments and observations on the International Space Station and parallel research down on earth with schlieren visualization, ultrasonic gauging, and PTV under a grant from the Center for the Advancement of Science in Space (CASIS) and the National Science Foundation.

Andrew became fascinated with heat transfer research in his undergraduate studies and the related study of film evaporation when he arrived at A&A for his master's. "You get these weird things happening on a microscopic level with the varying density creating repeated complex patterns breaking down into other repeated patterns as the liquid evaporates. It's quite amazing, and we don't quite understand it."

Now, for this project funded by CASIS and the National Science Foundation, Andrew will be developing a pair of connected test chambers to study film evaporation in the microgravity environment of the ISS.

Why study film evaporation?

Liquid films have many practical uses including adhesives, coatings and cooling applications, specifically in semiconductor manufacturing. Knowing exactly how a film evaporates and the resulting patternation and heat transfer is crucial to improving these, and many other, practical applications.

Principal Investigator Professor Hermanson explains why studying film evaporation in the microgravity of the International Space Station is important. "Conducting experiments in microgravity essentially turns off the forces due to gravity so we can study other effects. In the case of evaporating films, testing in microgravity removes buoyancy due to heating the film, allowing the study of other important phenomena, such as the effects of surface tension and mass loss, not easily studied on earth."

He continues, "We're trying to discern the convective structures in the evaporating film that develop in normal- versus microgravity. We use ultrasound to measure the film thickness with time, which gives the rate of evaporation and the heat transfer. We are also working on visualizing the flow structure in detail."

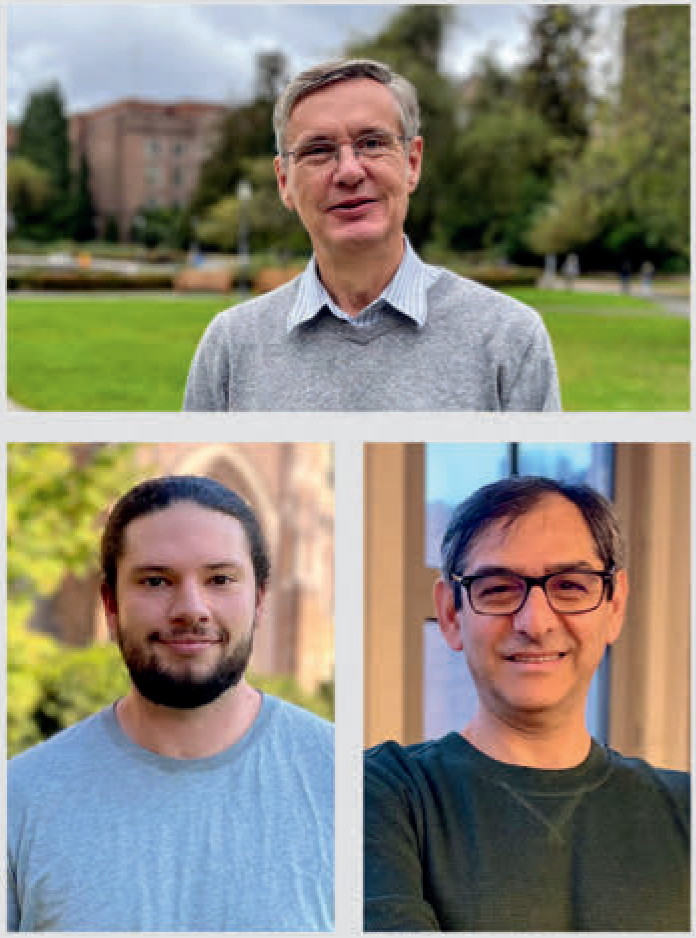
Above: Schlieren flow visualization detects the deflection of light to determine density gradients. The deflected light is imaged by a camera. The visualization is a pattern representing the expansions (lower density) and compressions (higher density) of the regions of the flow. Source: Jeremy Kimball, 2010 PhD Dissertation "Instability, Convective Structure, and Heat Transfer in Liquid Films Undergoing Phase Change."

Microgravity, gravity and modeling for both

While A&A will be prototyping the experiment for the ISS, the company Space Tango will be advancing the prototype into the actual hardware to fly to the ISS, and the Multi-Scale Technologies Institute at Michigan Tech University will be developing detailed numerical modeling of the expected film evaporation behavior under both normal- and microgravity conditions.

The numerical modeling will use the results of the experiments to reveal additional important physical information not easily measured, such as the temperature variation at the surface. And while Space Tango's hardware will be relaying data from the microgravity of the ISS, A&A's prototype will be performing similar experiments down on earth. The three partners together are creating a system to isolate gravity as a factor in film evaporation.

Station



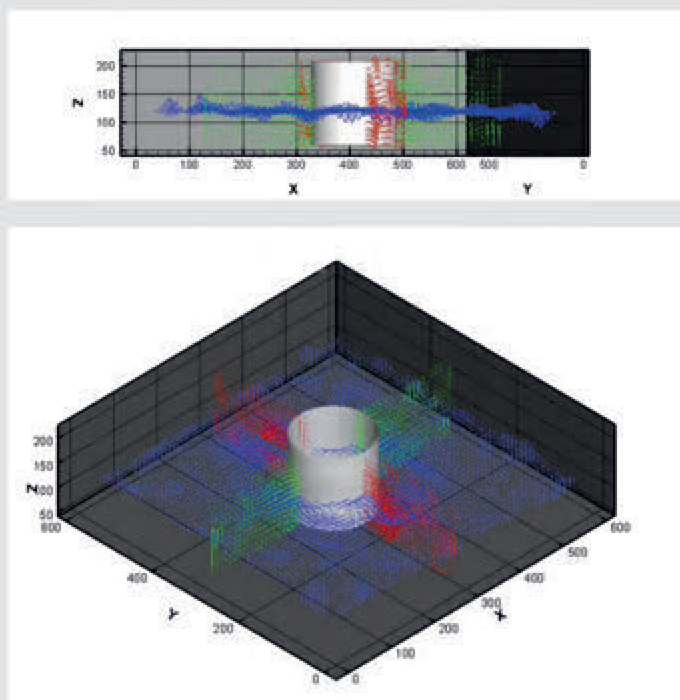
Jim Hermanson (top), Andrew Jansen (left), Dana Dabiri (right)

The payoff

When asked what the most exciting aspect of this project was, Andrew doesn't hesitate. "Sending something to the ISS is not that common, and it's definitely a challenge because you have much stricter design guidelines — things you have to consider — and you have to be very diligent and careful. It's a fun challenge."

Professor Hermanson echoes Andrew's enthusiasm: "Flying an experiment on the ISS is a big deal and takes years of detailed design, testing of components, and meeting stringent safety and operational requirements." Because of all of the rigor to get the experiments, modeling and test beds set up correctly, we can expect to see our A&A hardware on the ISS in four years.

And with an eye toward replicating this process in the future, Professor Dabiri says, "Our goal is to be able to set up the foundations for implementing these experiments on the ISS, and it is most exciting to be able to use one of the most novel measurement methods in fluid mechanics, 3D-PTV, to help reveal flow physics associated with film evaporation under various conditions."



In fluid mechanics, particle tracking velocimetry (PTV) is a technique to seed particles into a fluid to observe their movement to measure velocities and trajectories in the flow.

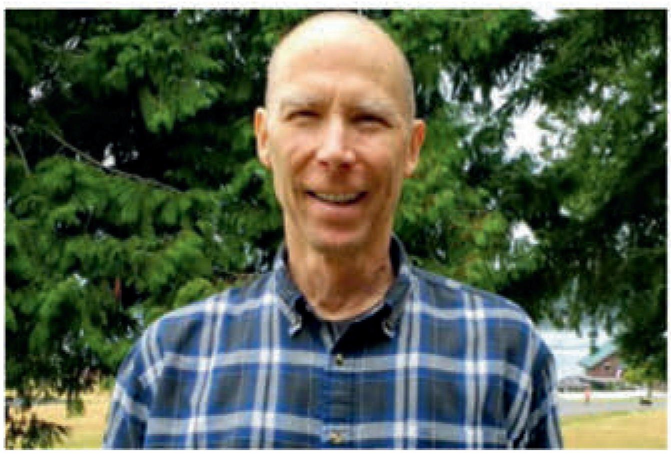
At right, two frames from videos employing particle tracking velocimetry (PTV) show a 3D velocity field of oscillating flow around a cylinder.

Adding Turbulence to Wild

A conversation with A&A's Professor Robert Breidenthal

A&A Professor Robert Breidenthal is a contributor to a new study on wildfire behavior that highlights the obstacles for fire science and provides guidance for investing in future research, which must include building diverse partnerships and collaboration across disciplines.

A&A's Jessica May interviewed Professor Breidenthal on this research.



Robert Breidenthal

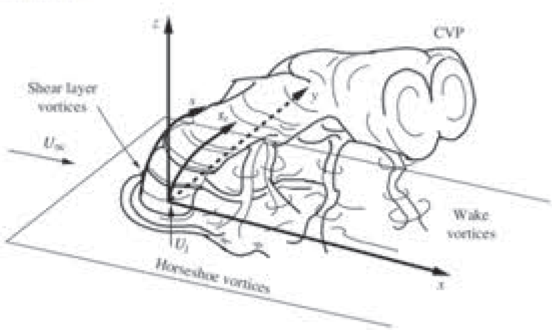


Illustration of a transverse jet from Fric & Roshko. The fundamental structure consists of a pair of counter-rotating vortices and vertical wake vortices. The transverse plume would look more-or-less the same, except the flow is generated by a buoyancy source rather than a momentum source from a jet nozzle.

How does aerospace engineering fit into this study?

It's about turbulence. Naturally, aerospace departments research turbulence, since it is a critical phenomenon for flying machines. Turbulence is all around us, including in wildfires. The fundamentals are the same.

Have you applied your research to fire or environmental analysis previously?

Yes. A number of visiting summer students joined our research group to investigate a model for a compact wildfire in a wind. We were looking at the behavior of a transverse plume using a chemical reaction in our big water tunnel. I had earlier done some work with UW geophysics Professor Marcia Baker on entrainment and mixing in turbulent clouds. Clouds are the largest uncertainty in our climate.

What is entrainment and mixing in clouds?

At the edge of a cloud, cloudy air is adjacent to clear, sometimes drier air. Turbulence inside the cloud draws clear air into the cloud. When the clear air mixes with the cloudy air, water droplets may evaporate. This process competes with the growth of droplets as the cloud rises, thereby controlling the evolution of the droplets: they might evaporate away completely, or grow and eventually precipitate as rain or snow.

fire Research:

How did you become involved in this research?

Half a century ago, I was at Caltech studying the fundamentals of turbulence with Anatol Roshko. Later as a postdoc there, my officemate Gene Broadwell and I studied the transverse jet, which is closely related to the transverse plume. Both the transverse jet and the transverse plume are fundamental flows, with of course many applications in engineering, geophysics, and biology. For example, mosquitos may be hard-wired to reach their targets by exploiting the x to the two-thirds trajectory of the transverse plume.

What was this research on a transverse jet trying to solve?

The transverse jet is a fundamental flow element in many engineering devices, such as high-performance mixers in chemical lasers and combustors. We were studying the basic behavior of the flow. At the time, Gene was working with TRW Inc. on the world's largest continuous-wave chemical laser.

What is particularly significant or surprising about the findings in this paper?

Two major things stand out. First, there is a critical wind speed that corresponds to the most rapid mixing. Second, tornado-like vortices form in the wake of a fire plume, which may affect the ability of a firebreak to stop a wildfire.

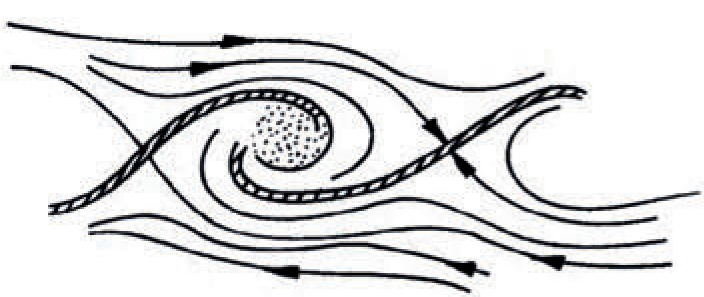
The mixing in a fire is most intense at a particular wind speed that depends in a certain way on the integrated buoyancy flux of the plume. Hot, buoyant gas from the fire may include unburned hydrocarbons and cool, oxygen-rich air. If the combustion is mixing-limited, then this wind speed would correspond to the most intense fire.

First discovered by Fric and Roshko in the transverse jet, the tornado-like wake vortices presumably play a role in the downstream transport of burning embers in wildfires. Their propagation can defeat firebreaks built by firefighters.

What is the biggest impact you expect to come out of this paper?

We want to focus attention on and attract research funding to the scientific questions about wildfires. For a century, we humans have artificially suppressed natural wildfires. So now we are confronted with the consequences of all that excess fuel. Another factor is a changing climate. Firefighters have a tough and dangerous job. We hope this research will be a step to improving techniques for greater firefighting effectiveness and to keep firefighters safer.

To access this research directly, please see, "Reimagine Fire Science for the Anthropocene" in Proceedings of the National Academy of Sciences (PNAS) Nexus.



Sketch of mean streamlines and molecular mixing zones in shear layer from Broadwell and Breidenthal.

NSF supports our research into why

nanofoams are full of surprises

NSF SUPPORTS A COLLABORATIVE INVESTIGATION OF A NOVEL NEW MATERIAL

Reimagining the disposable coffee cup

Mechanical engineering professor Vipin Kumar developed and manufactured a curious material in the early 2000s. He injected gas into a polymer, much like making carbonated water. When this polymer was heated up, tiny bubbles expanded, making a thin "nanofoam" which, it turned out, had remarkably low thermal conductivity. Conventional foams that provide such insulation have bubbles too large for a thin material, so this new material was noteworthy.

He teamed up with a couple of his former students to start a company to commercialize the technology, and their first application was a well-insulated disposable cup. Kumar remembers, "Our sales people were trying to get customer feedback, so they gave free cups to bars and restaurants, and the customers said, 'You know, this cup does not crack.'"

Kumar explained further, "We hadn't focused on the toughness of this material before. We liked it because it was both thin and insulating. People were saying it doesn't crack, so we pressed the cup, smashed it and jumped on it. It would bend, but we would just bend it back, and it remained completely intact."

Surprising strength in what should be a compromised material

Kumar recently told his colleagues, mechanical engineering assistant professor Lucas Meza and aeronautics and astronautics associate professor Marco Salviato, about the unbreakable cup and the specifics of the nanofoams he had developed since then.

In the first iteration of the cup, Kumar was injecting bubbles approximately one-tenth the size of a human hair. Now, with further advances, the bubble "pore size" has been reduced so much that 5,000 could fit in the width of a human hair. But even more extraordinary than the size of these bubbles is that the new nanofoams are 27 times tougher than the original polymer.

Salviato said, "When Vipin showed us the preliminary data, Lucas and I were completely blown away because we had never seen anything like that."

Meza continued, "Introducing bubbles into a material naturally creates defects. If you think of a piece of paper, if you have a tear, the paper breaks apart easily. Introducing bubbles into a material naturally makes a defect. But what we're seeing with these nanofoams is the opposite — an increase in toughness . . . Which is unexpected."

Teaming up to solve the riddle

Kumar, Meza and Salviato realized they had complementary skills to research why Kumar's nanofoam was so tough. Meza said, "We want to understand the system holistically. We know we see these nanofoams toughening, and we are going to figure out at a fundamental level why."

To get there, Kumar excels in manufacturing and can scale the production of the material. Meza specializes in multiscale experimentation. And Salviato adds expertise in computational modeling. Says Salviato, "It's detective work. You have some evidence which you collect and then use a computer to guide you to look at exactly what is going on. It's like CSI and you're finding the DNA match."

The National Science Foundation found their team compelling and is awarding them over $850,000 to advance their research. The researchers are aiming to advance improved commercial thermoplastics and new nanocomposite blends.

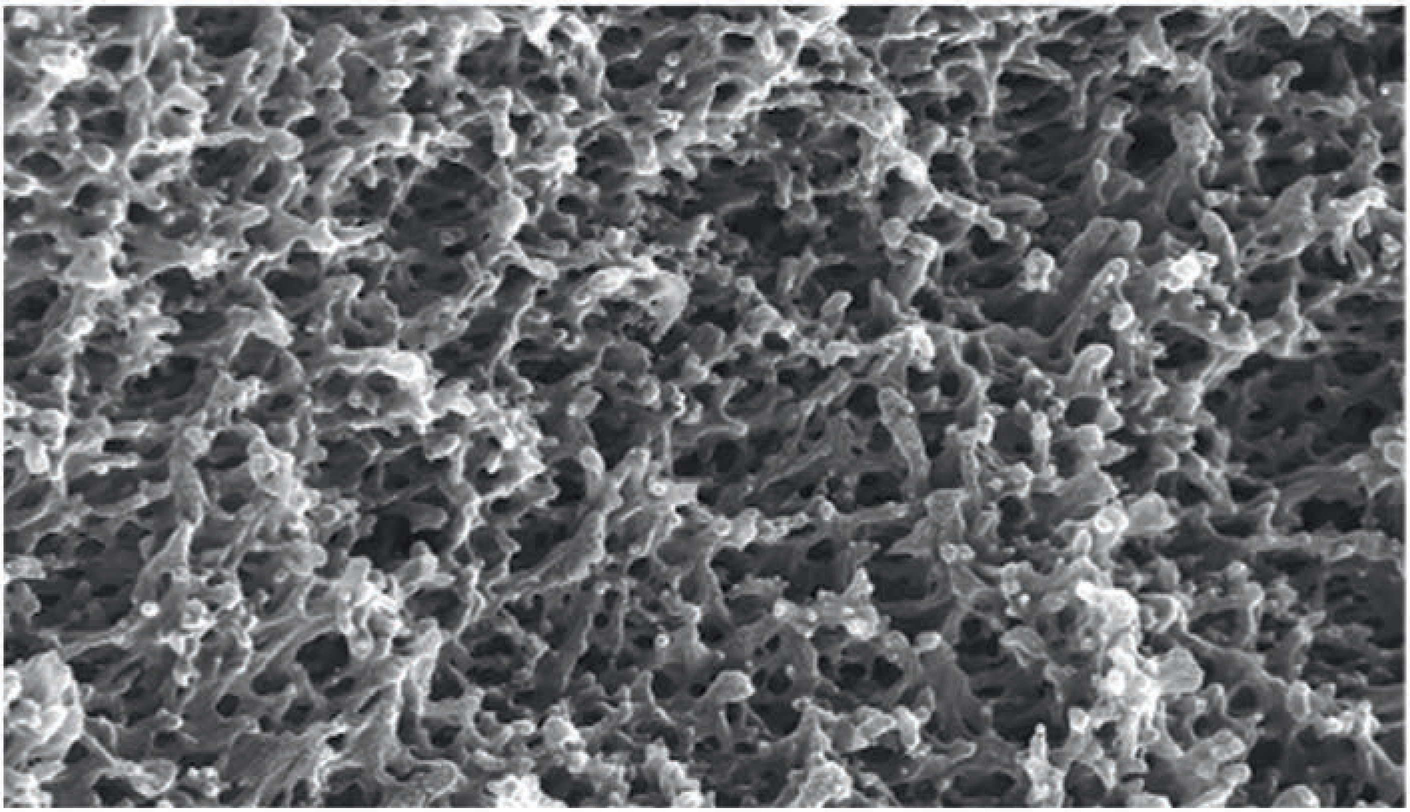
Nanofoams can be porous or non-porous, so their research has far-reaching applications. Porous nanofoams can be used for advanced filtration systems that need to allow nutrients, air and water to flow through, such as medical meshes that are placed in a body, agricultural weed barriers, or protective clothing and gear. Non-porous applications include lighter, tougher glass and other materials. From an aerospace perspective, the goal is to generate materials that are light and reliable. A lot of plastics currently in use could be swapped out with nanofoams.

Salviato sums it up, "There are so many ways this can go. For me, I think aerospace is another order of magnitude for these applications. We could also add other elements, like carbon fibers, to the nanofoam system to get the strength of carbon fibers and the toughness of nanofoams. It's in the future, but it is a very exciting prospect."

Marco Salviato

Vipin Kumar

Lucas Meza



fusion energy

IS FINALLY GETTING ITS MOMENT

Investment in fusion energy, including in A&A's research and spinoffs, is taking off with advances in computing and modeling techniques.

In the last few years, investment in a fusion energy future has taken off. Everett-based Helion recently announced a $500 million round of investment with the potential for $1.7 billion more. Our own A&A spinoff Zap Energy landed close to $200 million, and our A&A fusion labs have received over $5 million of funding over the past two years.

And while fusion energy has been decades in development, the current moment is offering vast advancements in computing power, which is finally robust enough to run the modeling needed to figure out the last sticky issues with sustaining a fusion reaction long enough for meaningful power production. And A&A is providing key research to make this sustainable energy future come as quickly as possible.

A&A is pursuing two different approaches to compact, cost-effective fusion energy. As plasmas need to be formed in specific shapes to stably undergo sustained fusion, each lab's strategy involves a different shape and device for the magnetic fields and confined plasma. The HIT-SI Lab, led by Senior Research Scientist Chris Hansen, takes advantage of the natural property of plasmas to self-organize and uses Imposed-Dynamo Current Drive to keep it going in a spheromak. In contrast, the Flow Z-Pinch Lab, led by Professor Uri Shumlak, forms and compresses plasma in a 50-cm long column, the Z-pinch, with plasma flowing along its length, which, in turn, stabilizes it.

Though A&A's approaches through a spheromak and a Z-pinch can lead to cost-competitive commercialization, further advances are needed. Fusion energy, the power source of the sun, is, to say the least, difficult to achieve. Plasmas need to reach temperatures over 100 million degrees Celsius, which makes confining and stabilizing them extremely challenging. Plasmas cool down quickly unless continuously heated and must be extremely well insulated to maintain fusion conditions. Both strategies use magnets to confine and insulate the plasmas and keep them from touching the walls of the reactor.

Now, with funding close to $1 million from the National Science Foundation (NSF), A&A will advance more effective plasma modeling techniques.

Boosting computing power with more efficient methods to model plasma

Plasma modeling is vital to help us unlock the potential of plasma to help us ensure the safe operation of satellites and spacecraft and realize the potential of plasmas for fusion energy, propulsion and other engineering applications. Unfortunately, this task is extremely challenging due to the complex physics involved and the need to capture wide ranges of both time and space.

Current methods require tradeoffs between speed, computing power, and fidelity. With this NSF investment, our two A&A fusion labs will develop optimized methods that can mitigate these tradeoffs — using fidelity selectively with advanced computing technology.

Professor Shumlak, who is also a co-founder of Zap Energy, is pushing the frontier of what is possible to model with limited computing power by assembling a hierarchy of models and using the simplest possible model that still captures important physics in each region of study.

Researchers will target higher resolution and higher fidelity models only where the local conditions require it, which will accelerate simulations and facilitate studying plasma systems in greater detail over a wide range of time and space.

Says Shumlak, "Not only will we be able to do plasma simulations faster, but now simulations that we previously couldn't do will become possible on devices from a laptop to a supercomputer. It opens up new possibilities of deeper understanding and development of plasma science and technologies."

Machine learning will speed up plasma behavior predictions

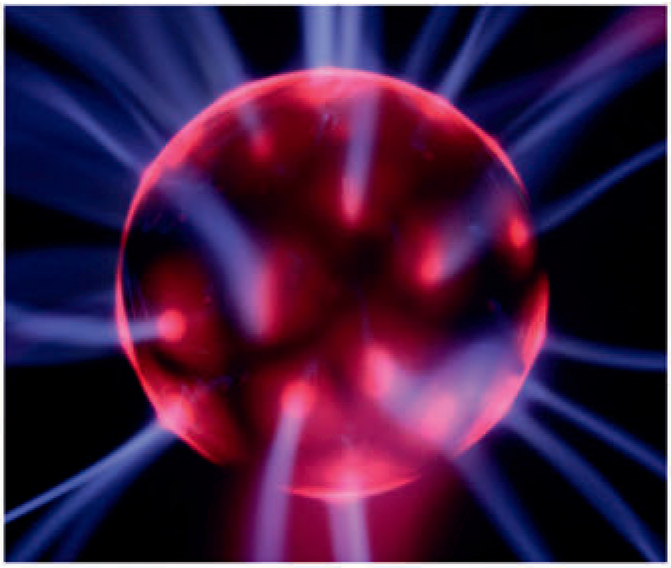
Meanwhile, Hansen in the HIT-SI Lab is teaming up with UW mechanical engineering professor Steve Brunton to leverage data-driven (machine learning) approaches to improve our ability to rapidly predict the behavior of magnetized plasmas by "discovering" simplified models for these systems directly from data and known physical laws, such as the conservation of energy.

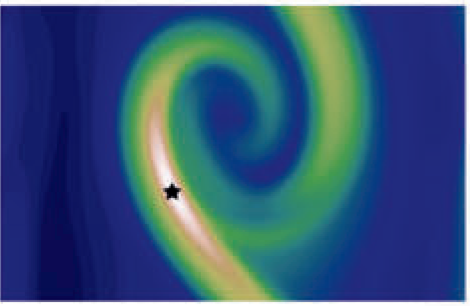
Such simplified models may require only a few parameters to describe the important aspects of the system, compared to the many millions or billions required to resolve the entire system with conventional simulations.

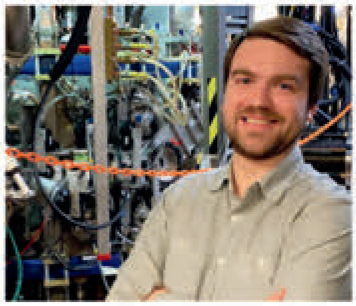
Hansen explains, "One of the primary challenges to understanding and predicting plasmas is the huge range of scales involved. For example the evolution of a solar flare 60,000 miles across can depend on plasma dynamics on the scale of a few feet, about 10 million times smaller than the primary structure."

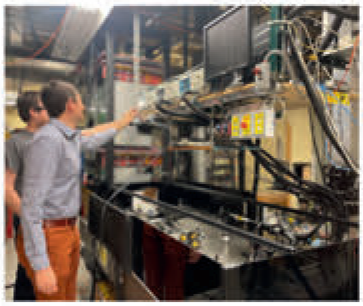
Resolving this huge range of scales can often be out of reach with present technology and even approximations can require complex computer models run on massive supercomputers. He continues, "These new methods allow us to bypass a lot of extra information in the system and focus on what's really important for a given problem."

See the full story on our fusion work.









Left to right: An image of a plasma flow with the black star indicating a region where a higher fidelity model is needed in comparison with the blue and yellow/green regions; Chris Hansen with the HBT-EP Tokamak; A&A Professor Uri Shumlak; A&A Research Scientists Aaron Hossack and Kyle Morgan demonstrate the laser system which directs infrared and visible beams through the chamber of the HIT-SIU plasma physics experiment so our researchers can measure the density of the plasma inside.

Summer undergraduate research takes the stage

By Jessica May

A&A undergrads deliver summer research through Space Grant's SURP program, spanning from vaccines to space travel.

Four A&A students presented the results of their research at the Washington NASA Space Grant Consortium's Summer Undergraduate Research Program (SURP) Symposium. SURP offers students the opportunity to work in a STEM research position under the guidance of a faculty member, postdoctoral scholar or research scientist at the University of Washington. Topics tackle a wide range of issues in the physical and natural sciences and engineering. The following are snapshots of their work.

Mechanical and Thermal Modeling of a High Pulse Rate Pulsed Inductive Thruster

Jacob Sawyer, SPACE Lab

Jacob Sawyer's research comes out of A&A's SPACE Lab, which studies how plasmas behave under the influence of electromagnetic fields in order to create the next generation of Electric Propulsion (EP) systems for satellites and spacecraft. EP is the use of electrical energy to accelerate a propellant, often in the form of plasma. Electromagnetic propulsion is currently used to keep satellites in stable orbits over long periods of time, and in long distance robotic exploration missions.

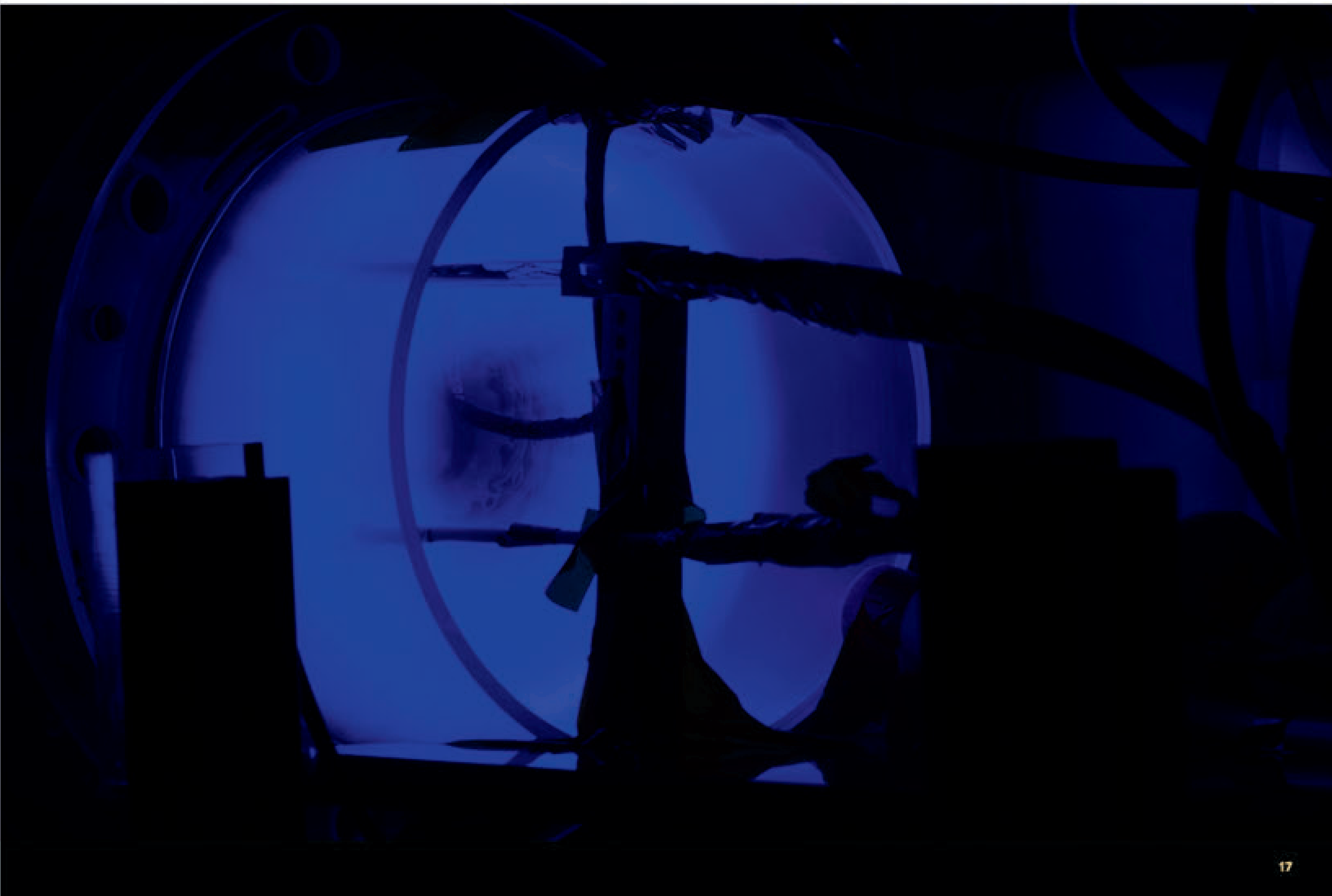
Jacob presented the results of thermal and mechanical modeling of Pulse Inductive Thrusters (PITs). A thruster is a type of rocket used for space propulsion, typically in a system that provides highly controlled amounts of thrust, usually over long durations.

Jacob's adviser, Assistant Professor Justin Little says, "The most important outcome of Jacob's research is that we have found that PITs can be operated at a much higher temperature than other types of thrusters. What this means is that we can radiate more heat away from the propulsion system, enabling less heat to get back to the spacecraft. Heat transfer problems such as this can be very important when it comes to integrating an electric propulsion system with a satellite."

Sawyer's research brings clarity to the full capabilities of PITs, and provides direction on future ways to optimize the system.

For more information, access Jacob's research poster.

Vacuum chamber shot of HiPeR-PIT testbed, SPACE Lab



Guns...that Save Lives!? Fluid Dynamics of Vaccine Gene Guns

Treyson Gleich, Williams Turbulence Lab

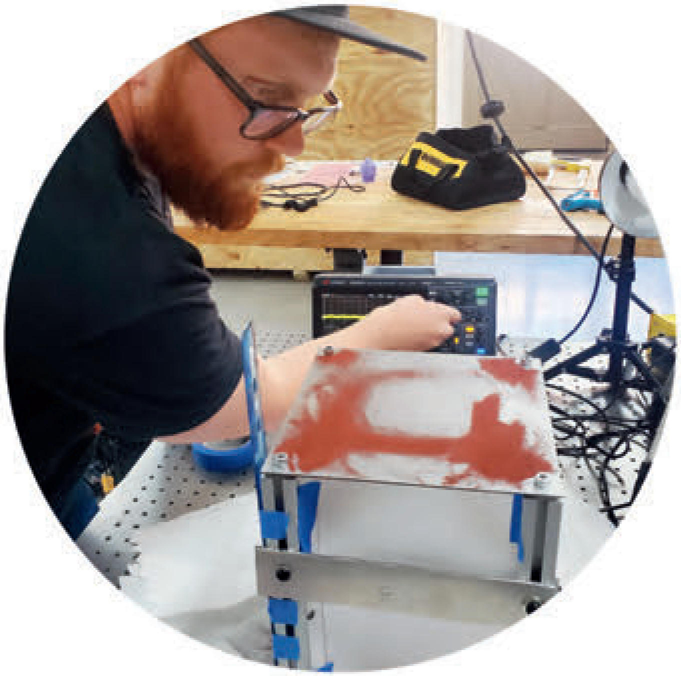
Treyson Gleich, a researcher in A&A's Williams Turbulence Lab, is working on a better way to inject vaccines. This research is related to retropropulsion, one of the lab's specialties, in terms of compressibility, shockwaves and acceleration of the vaccine.

As an alternative to injections, this gun uses a concentrated blast of gas to launch DNA-coated beads into the skin, which are then absorbed into the body. Treyson spent his summer working on improving the gas dynamic properties of gene guns. He tested using air instead of helium, as well as how different nozzle designs could improve the gun's ability to tailor the flow's speed to deliver vaccines more effectively.

A vaccine gun has several advantages over needle injections, including a less painful delivery, fewer disposable parts, and the ability to deliver multiple vaccines or drugs at once without reducing efficacy. Currently, the only gene gun on the market is a disposable type that uses helium. Assistant Research Professor Owen Williams explains, "If we can switch these guns to air, we can pave the way for wide use and cheap deployment, increasing vaccination rates around the world. This includes potential vaccines for malaria."

For more information, access Treyson's research poster.

Treyson Gleich adjusting the testing chamber he built to keep researchers safe while testing firing with prototype nozzles on the supersonic wind tunnel.



Fighting Vibrations with Vibrations: Towards Self Optimized Aerospace Structures

Roger Colglazier, The Illimited Lab

Roger Colglazier from A&A's Illimited Lab presented research into creating composite structures with a fiber orientation based on vibrations to give them resistance to vibration damage. These composites would be useful to aircraft, which face vibration-based loading conditions.

Colglazier described his methods, "Via a system of a vibrating plate and scattered particles, patterns coalesce at the nodes of the standing waves induced in the plate. This approach is advantageous since the nodes are areas of high stress concentration. Therefore, the particles gravitate towards the areas where structural reinforcement is actually needed."

For more information, access Roger's research poster.

Above: Roger Colglazier prepares the final set up for his vibrating plate with a MODAL shaker hooked up to an oscilloscope.

Measuring the Electron Density of Z-Pinch Plasmas on the ZaP-HD Experiment

Harry Furey-Soper, Z-Pinch Lab

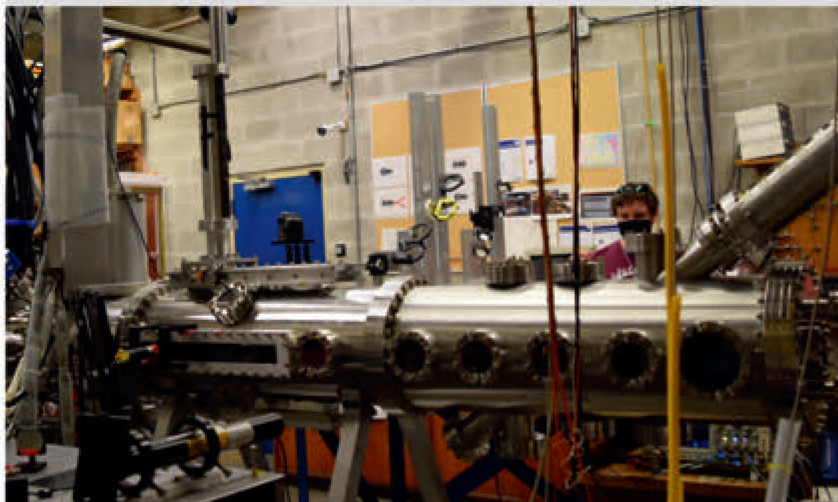
Harry Furey-Soper, a researcher in A&A's Z-Pinch Lab, studied electron density in the plasma in the Z-Pinch. The lab is pioneering the "sheared-flow-stabilized Z-pinch" which confines and compresses plasmas to high densities and high temperatures (the necessary ingredients to achieve thermonuclear fusion reactions). Fusion, the same process that powers the sun, combines the nuclei of atoms like hydrogen, which releases energy. A&A researchers are working on some of the remaining challenges to fusion energy.

A sheared-flow-stabilized Z-pinch could lead to a viable fusion energy source that would provide essentially limitless energy and enable rapid deep space transit. These capabilities could open new possibilities for human exploration of deep space, even beyond our solar system.

Regarding the importance of Harry's research, his adviser Professor Uri Shumlak says, "Harry's research measures and analyzes electron density within the plasma to inform our understanding of the size of the plasma, its stability, and expected fusion performance."

For more information, access Harry's research poster.

Harry Furey-Soper at work in A&A's Z-Pinch Lab.



Nathan Precup

By Drew Deguchi

A&A is saddened to learn of the death of Nathan Precup (BSAA '11 and MSAA '18) during the test flight for Raisbeck Engineering that crashed in Snohomish County on November 18, 2022. Nathan, also a former student crew member and Operations Manager of the Kirsten Wind Tunnel (KWT) spanning from 2008-2017, had just finished replacing the KWT's Test Control and Acquisition Module (TCAM) software in October through his work at QuickSilver Aerospace, where he was an instrumentation engineer.

In 2018, Nathan graduated from A&A and moved on to become a Senior Researcher at the University of Minnesota. Here, he worked on the BICEP (Background Imaging of Cosmic Extragalactic Polarization) Array microwave telescope.

In November 2019, Nathan deployed to the South Pole to install the BICEP Array, which scans for gravitational waves in hopes of providing insight into how the universe began. Nathan lived in the up to minus-100 degree weather for over a year, with a small community of around 40 people. His job was to monitor and operate the telescope, trekking a kilometer from the station everyday.

When asked what lured him to the dark Antarctic winter, Nathan answered, "I wanted to explore my comfort zone and see if I could step away from all the things that I'm used to having — green landscapes, places to hike, the ocean — and still be content and happy." In his free time at the South Pole, Nathan took photos, enjoyed the starry sky, read, and spent time with his fellow "winterovers."

Nathan enjoyed adventuring; his hobbies ranged from hiking, climbing, scuba diving, sailing, and photography.

KWT's business manager Cara Winter said, "Through his work at KWT, Nathan influenced the lives and careers of many A&A students over the years. He was patient and thoughtful in both his technical work and his role as a mentor to the KWT crew. He will be missed beyond measure."

If you have memories of Nathan that you would like to share with his family, please send them to NathanPrecupMemories@gmail.com.

Nathan (purple shirt, center) with his KWT staff cohort, circa 2011.

Dana Andrews
Our 2014 A&A Distinguished Alumnus (A&A '66), board member and affiliate professor passed away in January. Read more of his story on the back cover.

George Marklin
Retired Research Scientist George Marklin, an educator, mentor, and expert in numerical methods and tools to model plasma, died in August 2022.

Leland Nicolai
The 2016 A&A Distinguished Alumnus (A&A '57) leaves behind a legacy as an aircraft designer, developer, and educator. He died in May 2022.

Reid Parmerter
The A&A professor in composites, who taught from 1963 through 1999 and was known for his mentorship, died in November 2021.

Jan Roskam
Roskam (A&A PhD '65), an accomplished Boeing and Cessna engineer, Kansas University professor and mentor, died in September 2022 in Lawrence, KS.

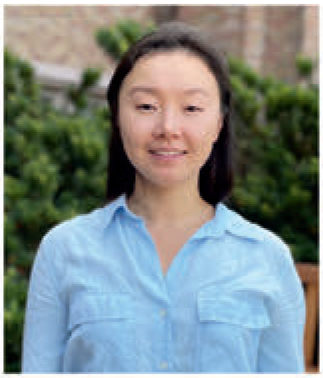
Robert Sandusky
Sandusky (A&A MS '71), the Chief Engineer of the Northrop-McDonnell Douglas "Black Widow II" advanced tactical fighter, died in January

Student Awards

Best Student Paper Award at IEEE

Danny Crews

Condit Dissertation Fellow



Sarah Li

UW + Amazon Science Hub Doctoral Fellow

Niyousha Rahimi

Varanasi Scholar

Isabella Rieco

A&A Student Excellence Awards

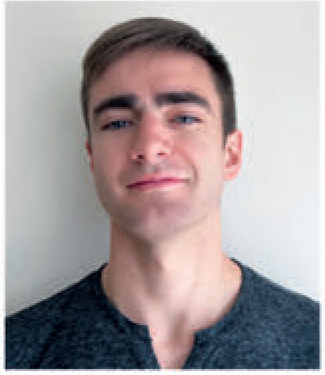
Excellence in Doctoral Research

Abhiram Aithal

Excellence in Masters Research

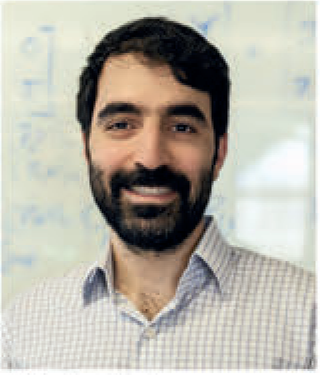
Jeremy Brockmann

Excellence in Undergraduate Research



Alexander Scott Javor

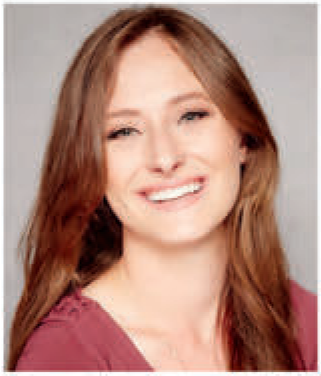
Excellence in Teaching



Shahriar Talebi

A&A Graduate Research Showcase

First Place



Skye Mceowen

Second Place

Elliot Jennis

Third Place

Spencer Kraisler

People's Choice

Sean Phenisee

NSF Research Fellowship

Carter Vu

Excellence in Service

Michael Gabalis

People's Choice

Antonio Deleo

Faculty Awards

IEEE and AIAA Fellow
Behcet Acikmese

Boeing Egtvedt Chairship
Kristi Morgansen

UW + Amazon Science Hub Faculty Research Award
Karen Leung

IEEE Fellow
Uri Shumlak

Enoch Thulin ICAS Innovation in Aeronautics Award
Eli Livne

HIGHFLIGHT

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A&A remembers Dana Andrews (BSAA '66)

By Clarice Mauer

A&A mourns the passing of Dana Andrews, our 2014 A&A distinguished alumnus, board member and affiliate professor. A&A Chair Kristi Morgansen says, "Dana Andrews not only leaves a legacy as a pioneering aerospace engineer, but his concern about the ripple effects of human decisions gave us much to think about. He also cared about the potential of our students and dedicated his time as a thoughtful mentor and capstone adviser over the years. His passing is a huge loss for our community — both A&A and the wider aerospace community."

Andrews received his Bachelor of Science from A&A in 1966 before pursuing a Master's from the California Institute of Technology and a Ph.D. from Stanford University, both in aeronautics and astronautics. He worked for 34 years with Boeing, known for his contributions to the X-33/RLV program, the Boeing habitation module for the International Space Station and the aero-assisted orbital transfer vehicle. He left Boeing to work with his son Jason Andrews (A&A '94) for ten years as the Chief Technology Officer at Andrews Space, Inc.

Andrews dedicated a great deal of time to A&A over the years as well. He participated in the Undergraduate Seminar Series and was one of our longest-serving current External Advisory Board members, having joined the Board in 2008.

In 2012, Andrews was a Capstone faculty adviser to 23 A&A seniors who won the annual NASA-sponsored RASC-AL student space design competition which that year solicited ways to support a 30-person habitat on the Moon. Our A&A team went beyond this mission in developing a lunar mining strategy to mine for rare metals and elements available on the Moon and in high demand on earth.

In 2020, Dr. Andrews published the non-fiction book "Chasing the Dream" which details several programs of the U.S. space program over the past 50 years, and the costs of many political decisions. Up until last year, he maintained his "The Rocket Doc" blog on current events, ranging from the invasion of Ukraine to global warming.

We will miss this great conversationalist, teacher, mentor, and inventor.