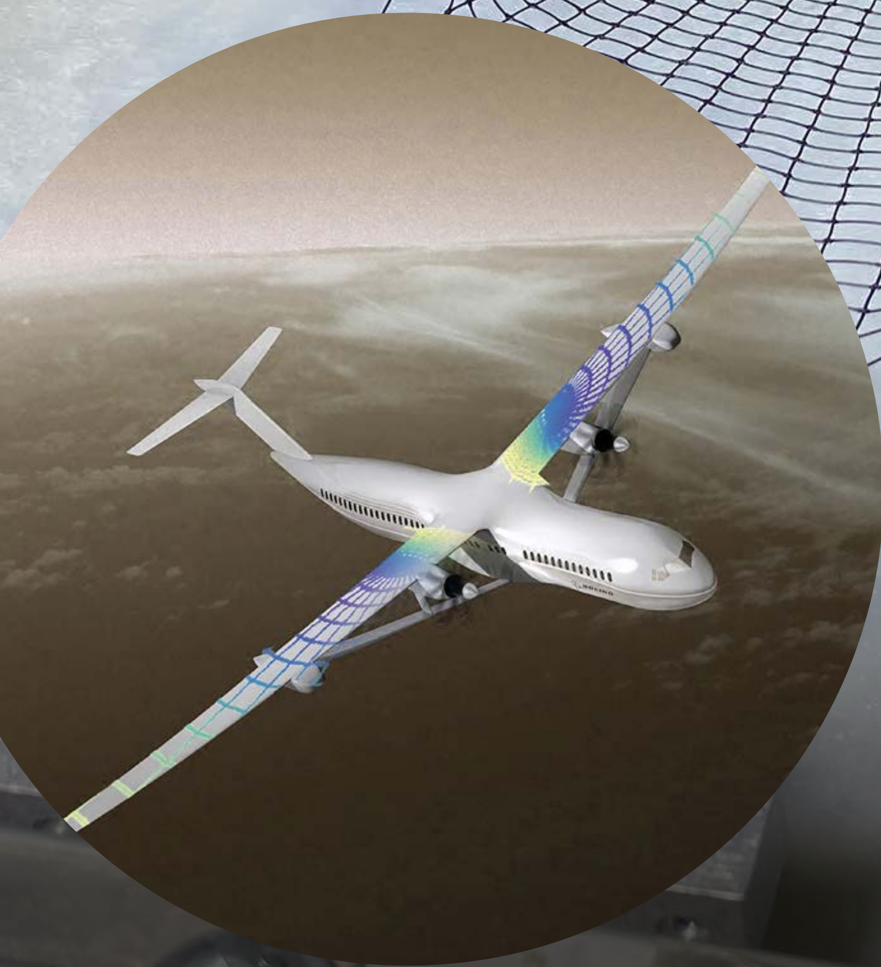
HIGHFLIGHT

WILLIAM E. BOEING DEPARTMENT OF AERONAUTICS & ASTRONAUTICS



2024 IN THIS ISSUE

Dear A&A Alumni and Friends,

As I reflect on the remarkable advancements taking place in the aerospace field, I am grateful for the incredible contributions that faculty, students, and alumni are making in shaping the future of air and space exploration.

Our department is at the forefront of cutting-edge research, and in this issue, we are showcasing some truly remarkable projects. From harnessing the power of solar winds on the Moon to developing microgrids for energy independence here on Earth, we continue to push the boundaries of innovation.

We are so proud to recognize our 2023 distinguished alumnus, Howard Hu, in this edition. Leading NASA's Orion Program, Howard and his team recently are setting the stage for future crewed lunar and Mars missions, starting with Artemis II. Their work not only expands our understanding of the universe but also holds the potential to transform life here on Earth. The lessons learned in space often lead to groundbreaking advancements, enabling us to tackle challenges and find solutions that benefit us all.

We are also well aware of and are embracing the hard technical challenges that lie ahead. Stabilizing propellants for long-distance space travel remains a daunting task, but one that we are advancing. Our exploration into catching up with satellites and learning from spiders to create sensing structures without discrete sensors demonstrates our dedication to pushing the boundaries of engineering and scientific discovery.

Let us remember that for us, the sky is not the limit. Our collective efforts have the power to propel us beyond boundaries, to reach new heights, and to redefine what is possible. I am excited to witness the progress in our field.

Thank you for being an integral part of our aerospace family. Together, we will continue to shape the future of aerospace and make a difference in the world.

Kristi Morgansen
Boeing Egtvedt Chair

HIGH**FLIGHT**

WILLIAM E. BOEING DEPARTMENT OF AERONAUTICS & ASTRONAUTICS | 2024

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Howard Hu ('91 and '94)

is the **2023 A&A Distinguished Alum**

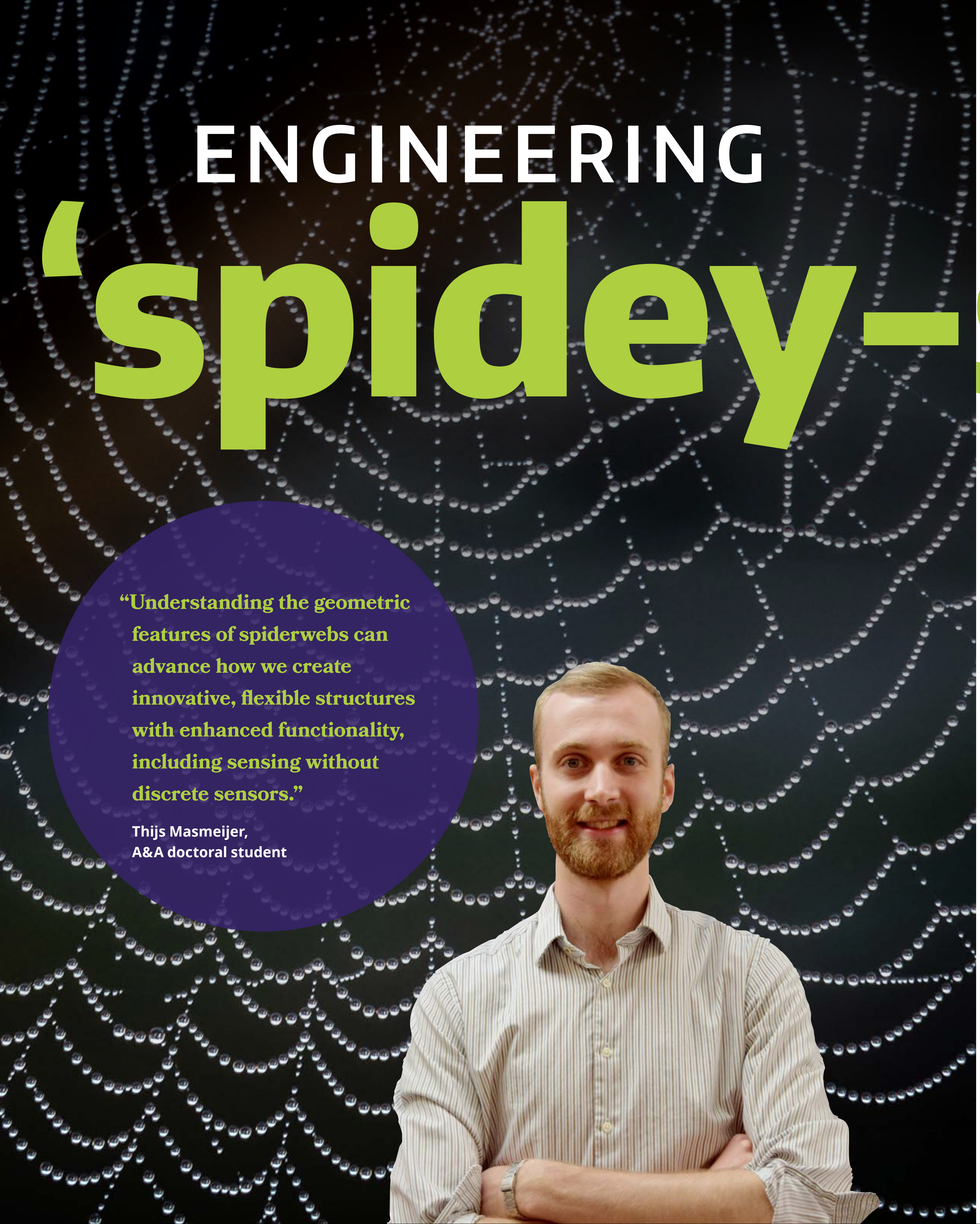
Howard Hu (BSAA '91 and MSAA '94) is the 2023 A&A Distinguished Alumnus. Hu has worked for NASA for more than thirty years and now leads the Orion Program.

The Orion Program is a part of NASA's deep exploration systems of the Artemis Mission. In December 2022 for the uncrewed Artemis I flight test, the Orion spacecraft performed two lunar flybys within eighty miles of the Moon, stayed in space longer without docking and traveled farther than any other spacecraft designed to carry humans. The successful flight and splashdown will lead into the crewed flights of Artemis II.

Previous to his current role, Hu served in a number of Orion leadership positions, including manager of avionics, power, and software, as well as deputy manager of the Vehicle Integration Office. Prior to joining the Orion Program, Hu held several technical and leadership positions in support of NASA human exploration initiatives, the International Space Station, and Space Shuttle Program.

Throughout his career, Hu has been recognized for his achievements, including two Johnson Director's Innovation Awards, the Orion EFT-1 Outstanding Leadership Award, the NASA Outstanding Leadership Medal, the Rotary National Award for Space Achievement Foundation's Stellar Team Award, and the Johnson Director's Commendation Award.

Hu received his award at the 2023 A&A Graduation where he delivered the keynote speech.



ENGINEERING ‘spidey-senses’

Spiders can inform how we engineer sensing structures without sensors.

> “Understanding the geometric features of spiderwebs can advance how we create innovative, flexible structures with enhanced functionality, including sensing without discrete sensors.”
>
> **Thijs Masmeijer, A&A doctoral student**

Spiderwebs are an engineering marvel with practical aerospace and robotics applications. A&A doctoral student Thijs Masmeijer, a researcher in A&A’s Illimited Lab, just returned from the University of Ljubljana’s Ladisk Lab in Slovenia with a Boeing Fellowship to advance the research of the structural properties of these silky creations.

He says, “Spiderwebs are not just a spider’s home. They are multifunctional structures. Not only do they capture prey, but they also relay to the spider what just got caught, how big it is and where exactly it is located in the web.” In engineering terms, we call this information transmission through vibrations signaling in a network. It’s this rapid signaling in the web that gives the spider the reputation of precognition known as “spidey-senses.”

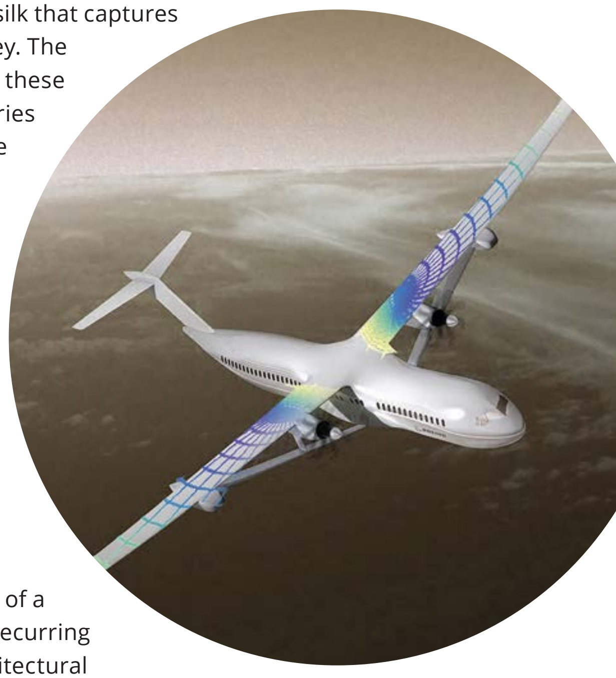
For Masmeijer, engineering these spidey-senses into structures could yield structural benefits for aerospace and robotics with applications for damage and impact sensing, noise reduction, energy steering and more, especially for flexible structures.

Functionalized geometries

The geometry of spiderwebs results from careful construction and strategic placement. They are intentionally not symmetrical. Spiders also use different types of silk to create various elements of their webs, each serving a specific purpose. The radial threads, also known as spokes, radiate outwards from the off-center hub of the web, forming a framework for support. These threads are typically stronger and stiffer than others.

Connected to these radial threads are spiral threads that form concentric circle-like shapes around the web. These spirals consist of sticky silk that captures unsuspecting prey. The spacing between these spiral threads varies depending on the spider species and its hunting strategy. Bridge lines strengthen the overall structure and provide stability against wind or disturbances.

Masmeijer has been working off of a hypothesis that recurring and distinct architectural choices found in spider webs provide “extended cognition” for sensing, localizing prey or damage, and applying structural maintenance when needed. Understanding these geometric features and how they contribute to sensing can advance creating innovative flexible structures with enhanced functionality.



Potential application is webbing on the flexible wing aircraft. Plane rendering courtesy of NASA, with webbing overlaid by the Illimited Lab designer M. J. Koo.

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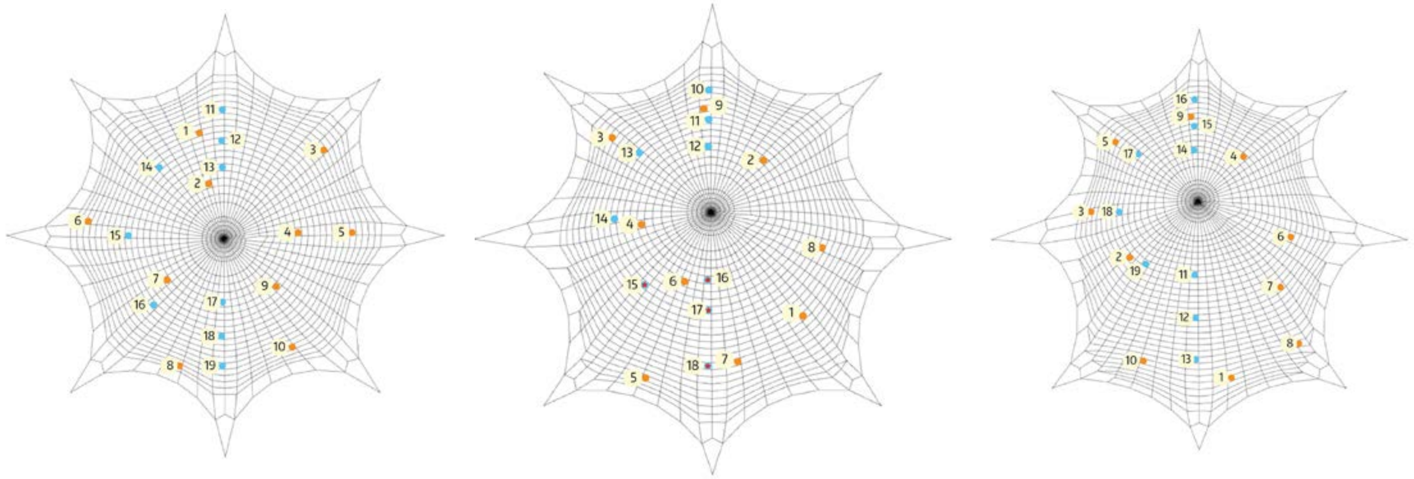
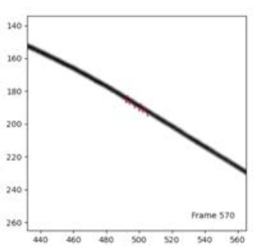


This research investigates the influence of varying asymmetries' in geometry on the vibration signals in spiderwebs. The left spiderweb is symmetrical with the hub in the center. The middle web has a slight eccentricity and the web on the right is highly eccentric.

3D spiderwebs and high-speed imaging

Testing the "precognition" of a spiderweb requires a creative approach. For this, Masmeijer turned to the University of Ljubljana's Ladisk Lab under Professor Janko Slavič. The lab, specializing in nonlinear mechanical vibrations, signal processing and digital image correlation developed imaging methodologies to detect very tiny movements.

The researchers created a frame within which they threaded a 3D-printed spiderweb. The Ladisk Lab specializes in the Lucas-Kanade method of optical flow estimation and a simplified Optical Flow method. The testing is set up that these methods will work well to capture the effects of small disturbances on the web. This method can detect displacement across a distance less than a pixel through measuring the change in light entering the camera lens across that pixel.



See a demonstration of the Simplified Optical Flow method on a section of a vibrating string. Usually this method is applied with vibration amplitudes of the sub-pixel level. As shown, the researchers are close to applying it to large amplitude vibrations.

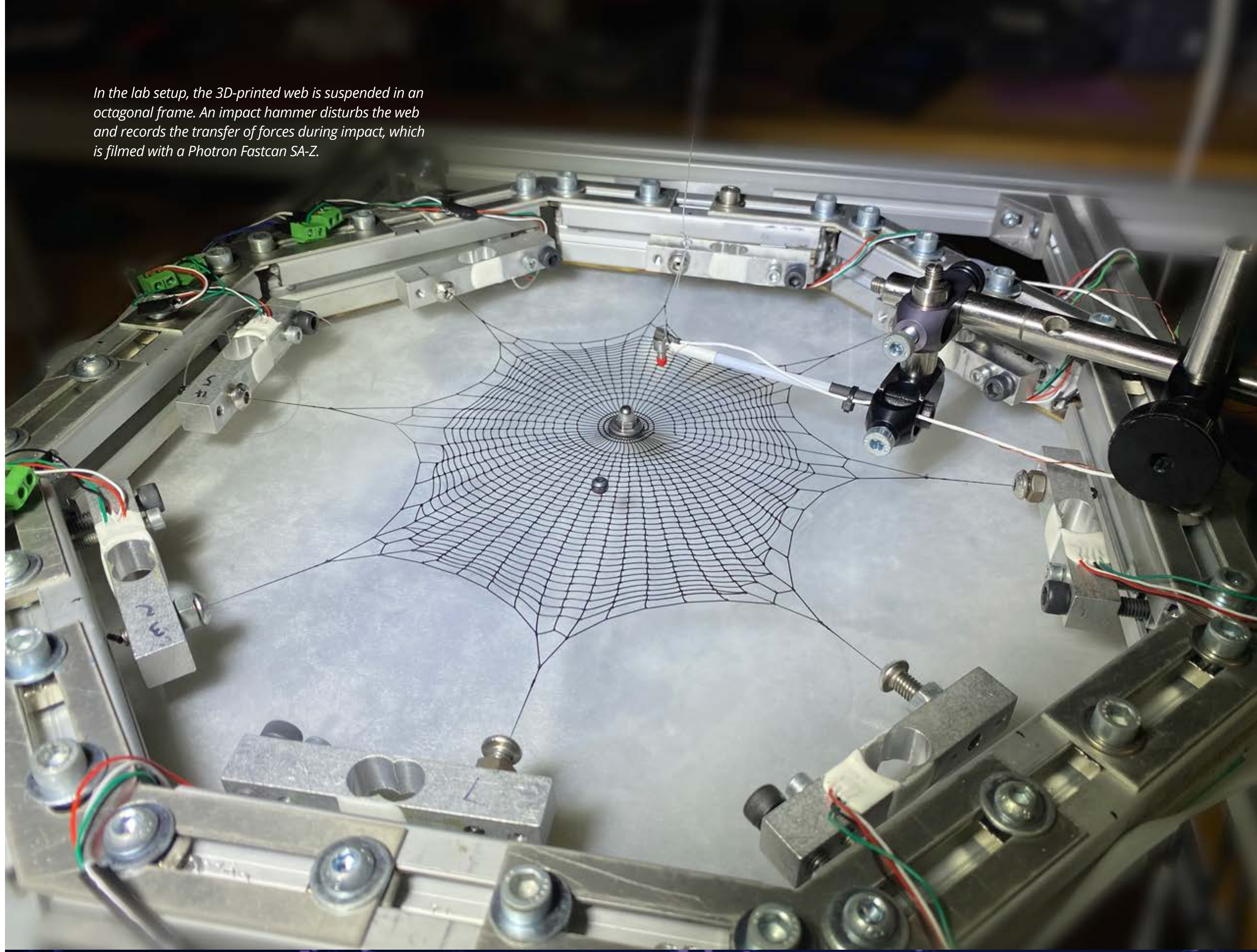
Where is this research heading?

Engineers already use various sophisticated algorithms such as neural networks, system identification, and other methods to optimize the location of sensors to aid in damage sensing. But as professor Ed Habtour, Masmeijer's faculty adviser explains, the spider's approach to damage identification is much simpler and more elegant than these complex algorithms. He says, "The web's geometric patterns enable the structure to function as a sensor network without sensors. Just like a guitar string, each geometric feature on the web has its own unique vibration signal like a tone."

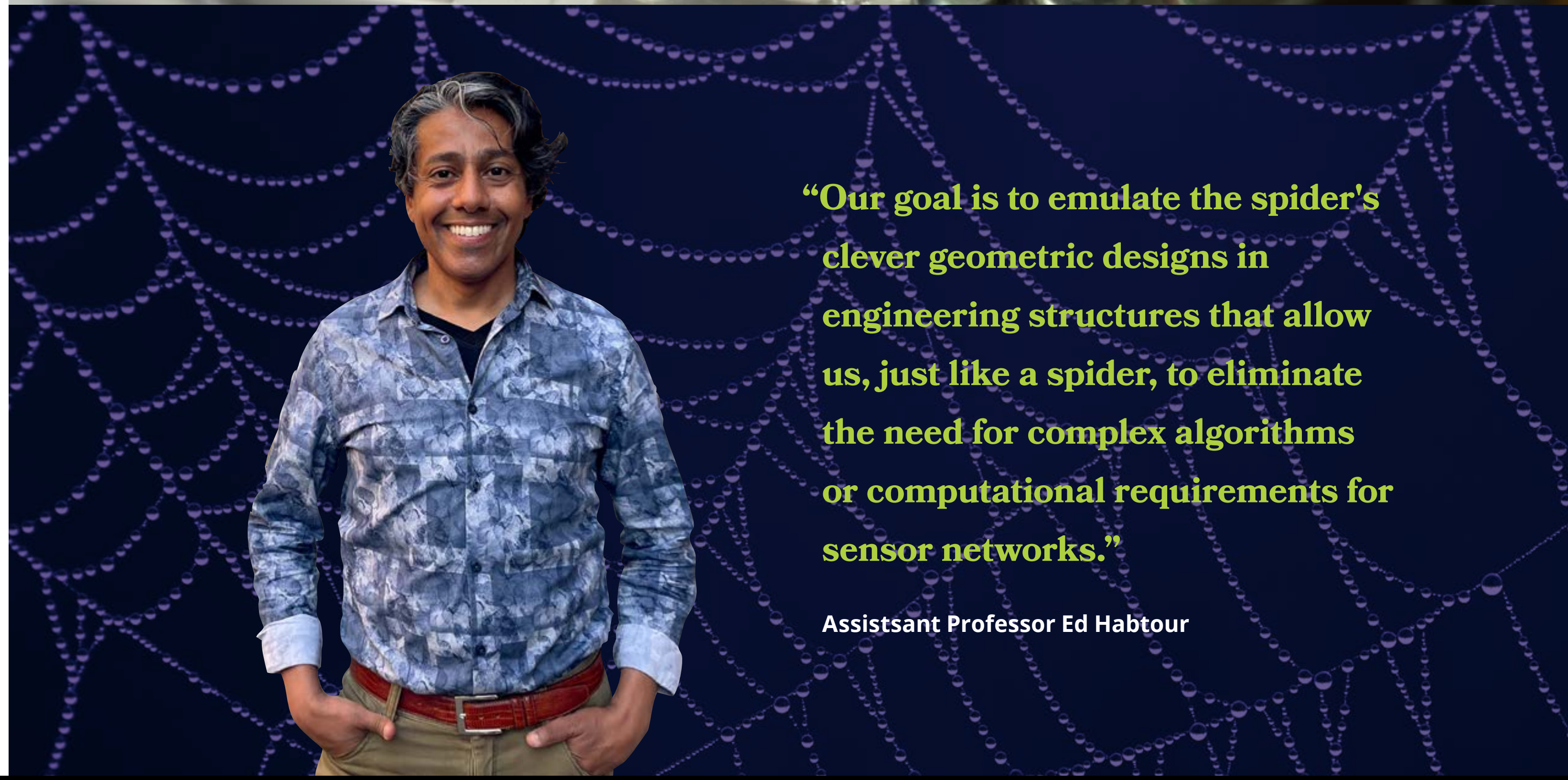
Habtour continues, "The hypothesis is that the web's asymmetric connectivity of its geometric features is key for translating the vibration signal, or data, into useful information. Our goal is to emulate the spider's clever geometric designs in engineering structures that allow us, just like a spider, to eliminate the need for complex algorithms or computational requirements for sensor networks. We want to know how these creatures build a sensor network without sensors."

For now, Masmeijer has a big task analyzing the data he collected in Slovenia. He says, "We will see what the data says regarding small asymmetric connectivity versus symmetric connectivity. We think some degree of asymmetry would make these algorithms perform better. Spiderwebs are a great proof of concept."

The web is suspended into an octagonal frame. Below the frame is a semi-transparent sheet. Lighting from the bottom ensures a white background, even at high frame rates. Lighting from the top ensures the web itself is sufficiently lighted at high frame rates.



In the lab setup, the 3D-printed web is suspended in an octagonal frame. An impact hammer disturbs the web and records the transfer of forces during impact, which is filmed with a Photron Fastcan SA-Z.



"Our goal is to emulate the spider's clever geometric designs in engineering structures that allow us, just like a spider, to eliminate the need for complex algorithms or computational requirements for sensor networks."

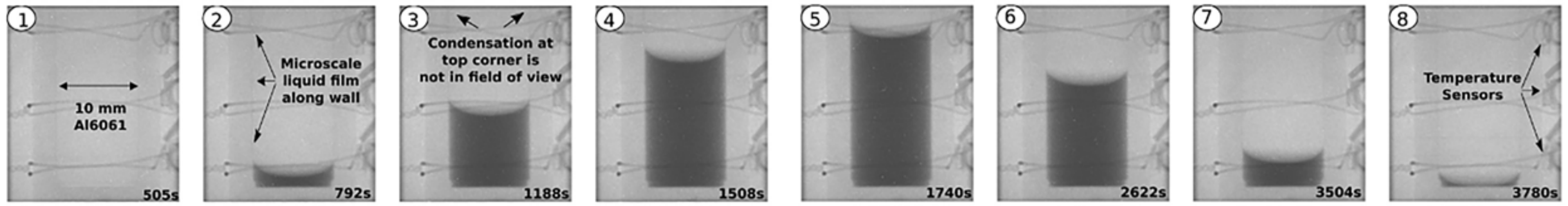
Assistsant Professor Ed Habtour

UNDERSTANDING

cryogenic propellants

FOR LONG-DURATION SPACE MISSIONS

Professor Hermanson's publication was selected as the Cryogenics Best Paper for advancement of propellant modeling.



As we are headed to more frequent long-range missions in space, we will need more reliable and efficient rocket fuels to go that distance. Liquid methane and liquid hydrogen are great candidates, but even with the very cold temperatures in space, these fuels can still boil-off at -258°F and -423°F, respectively. This makes them difficult to store reliably. and we don't yet fully understand their behaviors in space conditions.

A&A professor Jim Hermanson and his research colleagues from the University of Cincinnati, Michigan Technological University, and the National Institute of Standards and Technology (NIST), won the 2022 Cryogenics Best Paper award for advancing the understanding of cryogenic propellant evaporation and condensation, which will contribute to more efficient space missions in the future.

Hermanson explained, "Understanding the behavior of cryogenic propellants is critical for long-term space missions in that we will need to store these propellants on orbit where the boiling-off and vapor loss are major concerns."

The current understanding of cryogenic phase change and boil-off is limited, in part, because we still don't fully understand the fluid physics, and the available experimental data show a wide range of uncertainty.

The researchers used a helium-cooled cryostat to cool down hydrogen and methane to cryogenic temperatures at the BT-2 Neutron Imaging Facility at NIST. They induced phase change through precise control of pressure and temperature and used neutron-beam imaging to visualize the cryogenic liquids, providing new, detailed information on phase-change behavior.

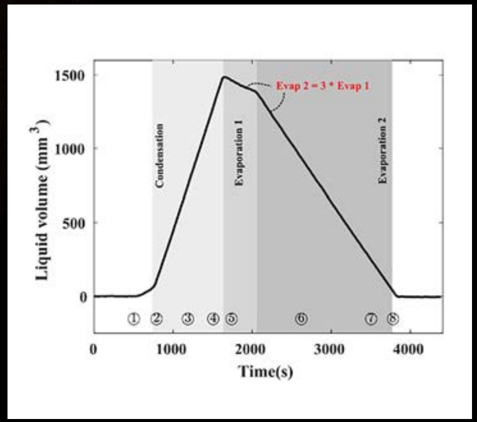
At the UW, Professor Hermanson and his research group in A&A's Aerospace Thermal Lab provided a detailed numerical simulation of the heat-transfer behavior associated with the phase change. He said, "The challenge was that there were only temperature measurements at a few points, so we needed numerical modeling to take into account changes in thermal properties of the test cell material to accurately determine the actual heat flux into and out of the liquid."

This research provided the first known images of the evaporation behavior of these cryogenic rocket fuels and showed how the rates of this phase change depend on the wall materials and geometry, major sources of uncertainty in previous experiments. This new information is vital to the accurate prediction of the boil-off and vapor loss of these propellants.

Go to the source:

Results from neutron imaging phase change experiments with LH2 and LCH4: Kishan Bellur, Ezequiel F. Médici, Daniel S. Hussey, David L. Jacobson, Jacob LaManna, Juscelino B. Leão, Julia Scherschligt, James C. Hermanson, Chang Kyoung Choi, Jeffrey S. Allen. Cryogenics, Volume 125, July 2022, 103517.

> **"Understanding the behavior of cryogenic propellants is critical for long-term space missions in that we will need to store these propellants on orbit where the boiling-off and vapor loss are major concerns."**
>
> *A&A Professor Jim Hermanson*



Opposite page: One set of results from an evaporation/condensation experiment with liquid hydrogen. Images 1–4 show condensation while 5–8 depict evaporation. The volume of the liquid is calculated through image processing and shows two distinct evaporation zones where the observed rate from zone 2 is 3 times that of zone 1.

This page: The volume of the liquid is calculated through image processing and shows two distinct evaporation zones where the observed rate from zone 2 is 3 times that of zone 1; right: Professor Jim Hermanson

SUPPORTING TRIBAL-LED

salmon monitoring

USING COMPUTER VISION

UW researchers are developing a drone-based salmon survey method that the Sauk-Suiattle can use to manage resources.

Climate change is not only negatively affecting Chinook salmon populations, but it's also making it harder to monitor those affects. UW assistant professors Andrew Berdahl and Karen Leung are working on a solution, with an EarthLab Innovation Grant, that will not only make monitoring more easy and accurate, but will also give the Sauk-Suiattle Indian Tribe more power to manage their salmon stock.

Surveying Chinook salmon just got even harder

The Sauk-Suiattle harvest Chinook salmon in the Skagit River system for commercial, subsistence, and ceremonial benefits through treaty-protected fisheries. Management of the fishery, with the State of Washington, includes setting harvest guidelines and recovery planning. But a successful management system depends on an accurate survey of Chinook numbers in the ecosystem.

The Tribe has partnered with the Washington Department of Fish and Wildlife to conduct helicopter surveys of the gravel nests that female Chinook salmon build to lay their eggs, or redds, to estimate population numbers. Not only are helicopter surveys expensive, but they are becoming less feasible with the effects of climate change on the river systems.

The increased temperatures are altering river runoff, creating more silt in the water and obscuring the view of the Chinook redds. While there are times when the water is clearer, it is hard to predict, and helicopters need to be booked months in advance. Researchers need a more responsive, cost-efficient and nimble method to conduct these surveys,

An interdisciplinary UW effort will deliver advantages

Berdahl from the School of Aquatic and Fishery Sciences (SAFS) and Leung from the aeronautics and astronautics (A&A) department, with A&A staff engineer Helen Kuni, and SAFS postdoc Benjamin Kroger (now faculty at the University of Wyoming), are partnering with the Sauk-Suiattle's Fish Program Manager Grant Kirby through a UW EarthLab Innovation Grant to develop a safe, cost-effective, and accurate system based on drones and AI-based computer vision to monitor numbers of spawning Chinook salmon in the Skagit River and its tributaries.

There are advantages to using drones and computer vision techniques to collect the data on salmon and their nests. Getting this system right will increase accuracy while delivering tremendous savings.

Leung explains, "Researchers won't be booking an expensive helicopter in advance for what turns out to be a low-visibility day. We can fly drones opportunistically based on daily river conditions. Also, because of the lower cost and convenience, we can survey more frequently throughout the season for higher precision monitoring."

Background photo bottom left: A female Chinook salmon stands guard on her redd at McAllister Springs in Lacey, Washington. © to USFWS – Pacific Region (credit to Roger Tabor), used under Attribution-NonCommercial 2.0 Generic.

Using drones has the added benefit of giving the Sauk-Suiattle the ability to collect their own data to best co-manage their salmon fishery. "Additionally," Berdahl says, "beyond giving just raw counts, as the helicopter surveys do, the drone surveys give the location of each redd. These data will allow us to quantify how the Chinook make fine-scale habitat-use decisions about where to spawn as river conditions change across years."

The challenges of setting up a drone-based Chinook survey

The research team has several steps with logistics, protocols, and training a neural network model to identify Chinook salmon and their redds. First, they need to establish the flight operations which need to be safe, efficient, and repeatable while capturing usable images and covering the entire target region. This will include interpreting conditions such as the position of the sun and general brightness and positioning the drone for reduced glare.

A&A researchers from Leung's Control and Trustworthy Robotics Lab (CTRL) will be developing ways to automate a lot of the processes and investigate ways where autonomy could be used to streamline the operations. Flying a drone taking imagery along a winding river with varying landscapes is challenging. The drone must remain in line of sight of its pilot, so the pilot needs to travel along the river in a boat. A&A research can improve the drone piloting process.

Researchers will also develop computer vision techniques to identify the salmon and redd. Working with Tribal biologists, they will manually review sets of drone images to identify salmon and redds to develop and train a neural network model to automatically highlight likely redds in all survey images. Biologists will then verify flagged images.

This human-in-the-loop process allows managers to generate efficient and reliable redd counts into the future. And the system will get more efficient over time. Many ever-changing daily and seasonal conditions are outside of the training set, but with continued training of the neural network, the system will account for these conditions.

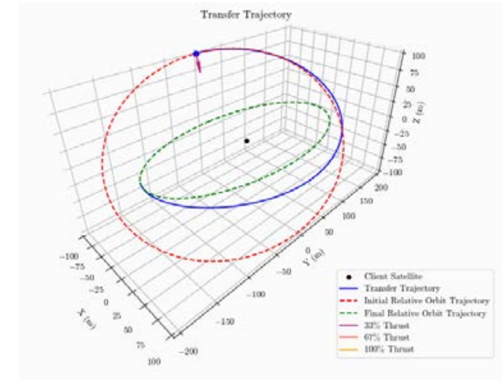
This approach, part of an emerging field, does not try to replace human expertise, but instead trains models to more efficiently leverage human expertise across a wider range of images so that humans only have to solve the hardest out of domain examples which can then be used to further improve the model further.

UW EarthLab awarded this project $75,000 as a viable project to develop actionable research at the intersection of climate change and social justice, making a positive impact on people's lives and livelihoods.

View video footage of salmon in the Snoqualmie River during a CTRL practice drone flight. Credit to CTRL's Helen Kuni and Evelyn Madewell.

Inset headshots left: A&A assistant professor Karen Leung and SAFS assistant professor Andrew Berdahl

Tugs in space



A&A's Autonomous Controls Lab is working toward trajectory planning for precise space maneuvers with electric propulsion for Starfish Space.

Countering the high costs of satellite obsolescence

A&A's Avi Mittal is building his expertise to tackle one of the most increasingly pressing challenges in space. There are around 6,000 active satellites orbiting earth, with some estimates putting 100,000 in orbit by 2030. And most satellites aren't built to last. Of the 5,465 satellites tallied in the latest update of the Union of Concerned Scientists' Satellite Database, about two-thirds have a recorded expected operational lifetime, the average being just under six years.

Mittal says, "When one satellite goes out of commission and runs out of maneuvering fuel in low earth orbit, its orbit may start to decay, which could happen anywhere from a couple of weeks to several hundred years. So you are contributing to the orbital debris problem. And, to regain your satellite capabilities, you have to launch a new satellite, which is expensive."

He continues, "What would be less expensive would be to send up another satellite to attach to the first to push it back into orbit like a tugboat in space, permanently attach to it to supply power, or do some servicing and repairs and then move on to the next satellite for repair. Or if repair is not a viable option, connecting with the satellite to remove it from orbit like a tow truck would enhance safety."

These are exactly the missions of Seattle-based Starfish Space, working on developing two commercial missions that allow the extension of satellite life or the removal of space debris. Starfish Co-Founder Trevor Bennett explains some of the difficulty in reaching this goal, "When you're moving through an orbit, there are all of these dynamic effects trying to pull you away from where you're trying to go. The earth's tugging you, as are the sun and the Moon. There's atmospheric drag. So we need an autonomous system capable of adjusting for all of these things."

To advance Starfish's capability in this, Bennett contacted A&A's Autonomous Controls Lab, led by Professor Behçet Açikmeşe, and is working with Mittal and PhD researchers Kazuya Echigo and Chris Hayner in a project funded by the Joint Center for Aerospace Technology Innovation (JCATI).

It's hard to catch a satellite

Rendezvous and docking with a satellite is not easy. Satellites travel at about seven kilometers per second, or about 16,000 miles per hour in slightly changing orbits. Not only do the two satellites have to meet at this high speed, but, if they are docking, they need to meet gently from their different orbits.

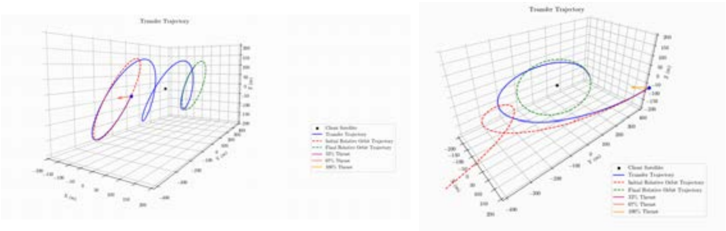
Typically for a rendezvous, a spacecraft will use chemical thrusters to guide it through point maneuvers. These are a set of predetermined points in space used as reference points to ensure correct positioning for the two spacecraft to approach each other. Mittal explains, "You'll have these different orbits that you can stitch together and find the intersections."

Starfish Space, however, plans to use electric propulsion instead of chemical propulsion because of its tremendous advantage in efficiency and cost savings. But using electric propulsion creates an additional challenge of catching the satellite. Mittal goes further, "With electric propulsion, the satellite accelerates relatively slowly with long continuous burns instead of the usual point burns with chemical thrusters. Now we don't have these predetermined orbits that we can just stitch together. It's much more difficult to solve."

Another challenge to sort out is thrust. Chemical thrusters are usually either on or off. Pulsing them produces the effect of variable throttle. Electric thrusters are capable of continuous throttle, but manufacturers don't generally plan for this, so Starfish Space plans to use a few preset levels of thrust to bridge this gap. This means that the solution must account for these various quantized levels.

Left: A rendering of Starfish Space's "Otter Pup," the company's flagship satellite that will rendezvous with other satellites, courtesy of Starfish Space. Top of page: Computer-simulated trajectories for one of the three different maneuvers at varying electric propulsion thrust levels — drift cancel, plane change and non-planar shift.

> **"With the increased complexity of using electric propulsion and the accumulation of orbital perturbations during thrust arcs, clever optimization techniques are all the more important."**
>
> *- Starfish Co-Founder Trevor Bennett*



Above: Computer-simulated trajectories for three different maneuvers at varying electric propulsion thrust levels — drift cancel, plane change and non-planar shift.

Below: A closer view of the Otter Pup.

Simplifying the equation with the Autonomous Controls Lab

Bennett knew the advantage of being able to collaborate with the ACL. He says, "With the increased complexity of using electric propulsion and the accumulation of orbital perturbations during thrust arcs, clever optimization techniques are all the more important." The Autonomous Controls Lab is one of the premier groups working on a type of optimization called convexification."

He continues, "Basically, ACL has shown you take a really complicated problem that has too many inputs and variables, you simplify it to something that is close, and you solve that problem and use it as a best guess to solve the harder problem. If you use these best guesses enough times in a row, you'll actually get very close to what it would take to solve the full problem with a lot less effort on the computer."

Now Mittal, along with fellow ACL researchers Echigo and Hayner, are working on adapting their algorithms to account for the various constraints of electric propulsion.

Echigo translates the problem into mathematical theory. He explains how the real equation to solve is non-convex and, therefore, extremely difficult to solve. To find the solution, he went back to fundamental theory and developed a specific convex cost function while using convex equations of the constraints: orbital dynamics, control input (thruster levels), the state (position and velocity), and boundary conditions. Because these are solvable, they serve as a proxy for the more complex problem.

He says, "The results are the same, which is 'theoretically guaranteed' under some conditions. Thanks to the cost function, which promotes the results to satisfy non-convexities, we can get a solution by just solving convex optimization. This is the advantage of convexification."

Mittal and Hayner then get to work on simulating Echigo's solution. Mittal details the process, "One: We have to turn Kazuya's math into something the computer can handle. Two: We simulate it. And three: We characterize where the system breaks down."

They go to work setting up as many simulations as possible. Their program may run through 200,000 simulations overnight to verify that the control works for various conditions. Right now, over 99 percent signal a successful rendezvous.

Where will these advances take us?

Bennett says that while Starfish is focusing now on satellite servicing and debris removal, the advances that will enable doing this successfully will serve to enable a whole new future and operation in space.

He reports, "What Avi, Kazuya, and Chris have delivered is a new control law based on where we are, where we are trying to go, with a limited amount of thrust available."

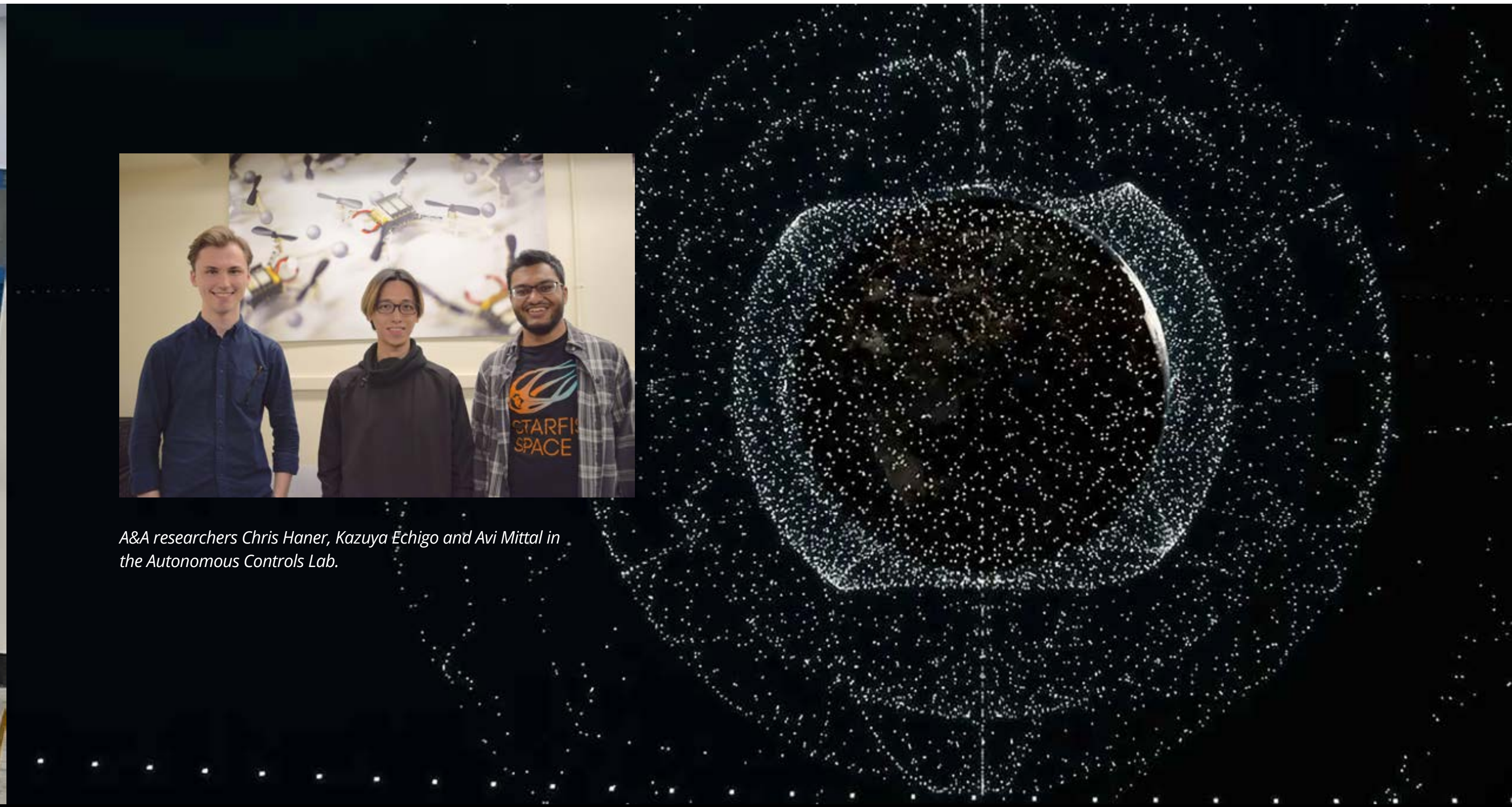
While Starfish is building their business on these first two missions, which are crucially important, they are building their expertise in spacecraft autonomy and technology like capture systems that will provide the foundation to grow into on-orbit manufacturing, assembly, recycling and more. Bennett says, "We need the spacecraft to have the ability to make onboard decisions to establish this future."

As for his take on JCATI, which is supporting this research, Bennett says, "Washington state is quite unique in its aerospace support. Generally, you have the early research levels and then advanced technologies that companies can profit from, but generally there's no support to get the early research across the so-called Valley of Death of TRL levels. But JCATI helps bridge that gap, and we got access to these amazing researchers. There is a great mutual benefit in our success."

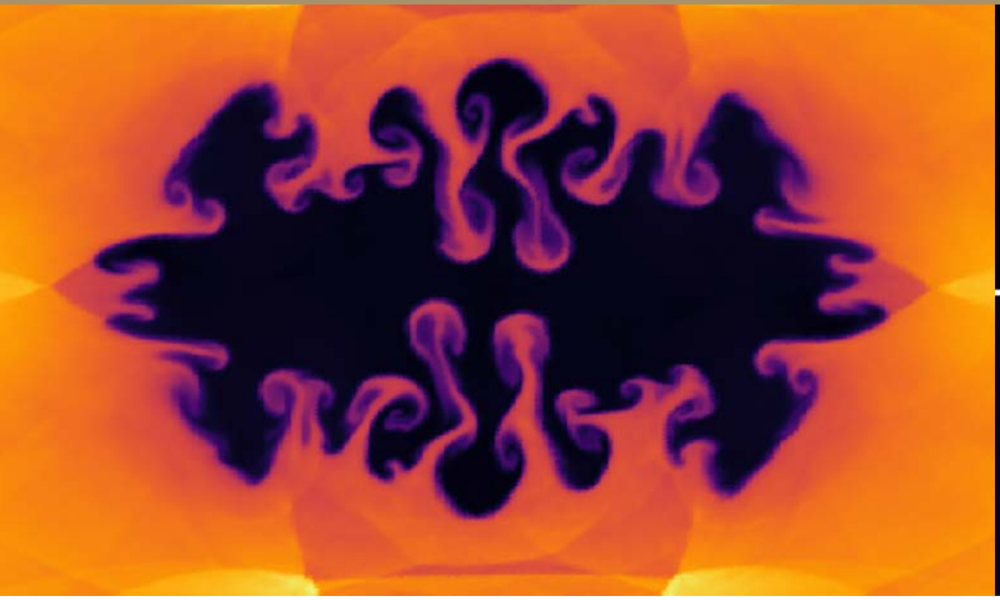
This research is funded by the Joint Center for Aerospace Technology Innovation (JCATI).

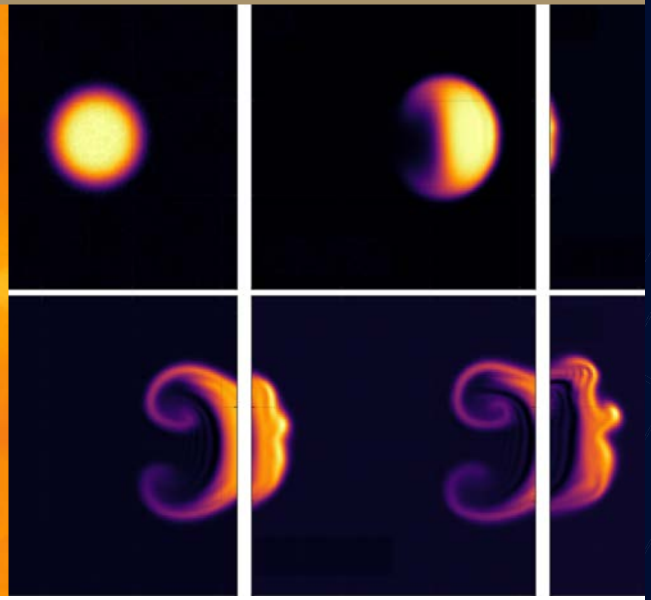
Go the source:

Convex Trajectory Planning for Proximity Operations using Electric Propulsion with Quantized Thrust, by Kazuya Echigo, Christopher R. Hayner, Avi Mittal, Behcet Acikmese, Selahattin Burak Sarsilmaz and Matthew Harris, presented at AIAA SciTech 2023.



A&A researchers Chris Haner, Kazuya Echigo and Avi Mittal in the Autonomous Controls Lab.





A&A welcomes associate professor Bhuvana Srinivasan

Associate Professor Bhuvana Srinivasan, an A&A alum (M.S. ‘06 and Ph.D. ’10), joins us from Virginia Tech's Kevin T. Crofton Department of Aerospace and Ocean Engineering, where she served as the director of the Plasma Dynamics Computational Laboratory.

During her time at Virginia Tech, Professor Srinivasan held the prestigious Endowed Crofton Faculty Fellowship in Engineering from 2021 until the end of her tenure. Prior to that, she gained experience as a postdoctoral researcher and scientist at the Los Alamos National Laboratory. In her doctoral studies at A&A, she focused on computational plasma physics, specifically in the context of nuclear fusion, utilizing the discontinuous Galerkin method to develop high-fidelity multi-fluid models.

Her research is centered around advancing fusion energy concepts, developing plasma-based propulsion systems, and enhancing our understanding of fundamental plasma physics as it pertains to both space and astrophysical plasmas. Some specific areas of focus include investigating plasma-material interactions in fusion devices and thrusters, analyzing instabilities in high-energy-density fusion and astrophysical plasmas, studying ionospheric plasma instabilities, and developing numerical algorithms for fluid and kinetic models.

Her groundbreaking research has garnered support from organizations such as the National Science Foundation (NSF), the U.S. Department of Energy (DOE) Advanced Research Projects Agency-Energy, DOE Office of Science, DOE National Nuclear Security Administration, the Air Force Office of Scientific Research, and multiple DOE national laboratories.

Professor Srinivasan is now the director of A&A’s PLASMAWISE (PLAsma Simulation for MAterial interactions, Waves, Instabilities, Shocks, Everything else plasma) Laboratory, which investigates various plasma physics phenomena in the context of nuclear fusion, space exploration, and other fundamental plasma science applications.

The pursuit of controlled fusion remains one of the most significant challenges of the twenty-first century. Professor Srinivasan's work involves developing highly accurate physics models to study fundamental plasma science in the realms of plasma-based space propulsion, inertial confinement, magneto-inertial fusion, magnetic confinement fusion, and space science, among other areas of focus.

The potential of nuclear fusion to meet our long-term energy needs and power high-thrust, long-duration human spaceflight is immense and challenging. Professor Srinivasan's research plays a crucial role in advancing our understanding of plasma physics and bringing us closer to achieving these transformative goals.

Visit the PLASMAWISE Lab.

A&A alum Stephanie Bostwick wins College of Engineering Diamond Award

Solar microgrids are localized electric grids that can operate independently from main power grids, unlocking opportunities for energy self-sufficiency while improving sustainability and combating climate change. Stephanie Bostwick is harnessing the potential of solar microgrids — bridging renewable energy practices, government relations and Indigenous knowledge — in her mission to create engineering educational programs and initiatives that uplift Indigenous communities. For this work, she received a 2024 Diamond Award, an honor given by the College of Engineering to recognize outstanding alumni and friends who have made significant contributions to the field of engineering. Bostwick’s award is in the category of “creating a healthier and more just world.”

After graduating from A&A (BSAA ‘05 and MSAA ‘07), Bostwick worked for Raytheon and other aerospace companies before redirecting her focus to engineering education for Native students. As a member of the Blackfeet tribe, she wanted to empower students to bring change into their communities. She became a professor at Northwest Indian College (NWIC) and created their first A.S. engineering program. Through her partnerships with educational, Tribal and government groups, she highlights the potential of microgrid technology and energy independence using hands-on solar kits, rooftop solar training programs, and developing vocational and 4-year degree programs for her students. Her innovative curriculum directly supports the Lummi Nation, on whose land NWIC is located, in their goals for energy self-sufficiency and combating climate change.

Beyond NWIC, Bostwick is also a program manager at the National Renewable Energy Laboratory and the Tribal Colleges and Universities Coordinator at the Department of Energy’s Office of Indian Energy. In this role, she is working to ensure all TCUs have access to clean energy workforce training as well as infrastructure funding for their campuses. Her leadership across sectors has made her a trusted advisor for government-Tribal programs aimed at future renewable energy projects. Her thoughtful approach to collaboration and her dedication to equity have provided a blueprint for how institutions and agencies can intentionally and respectfully partner with tribal communities in their endeavors. By merging principles of sustainability with cutting-edge technology, she equips generations of engineers with the tools to sustainably power their communities. From academic programming to industry collaborations, Stephanie Bostwick has enhanced human health and well-being through clean energy deployment.

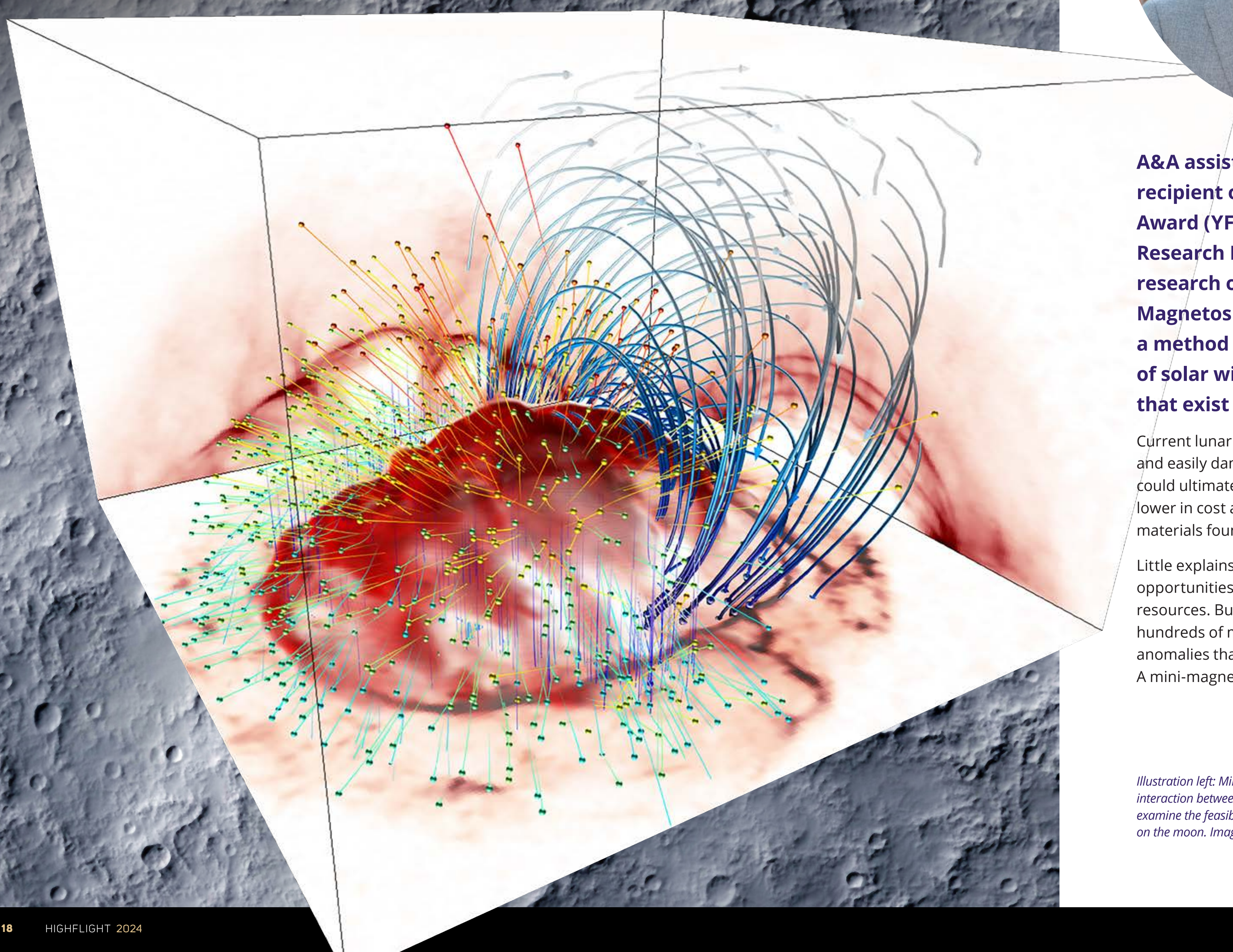
Watch “Toward Energy Independence”, an episode of the “Deeply Rooted” series featuring Stephanie Bostwick’s microgrid work, produced by Crosscut, Cascade Public Media.

Assistant professor Justin Little receives

DARPA Young Faculty Award

Little's award is for research on extracting power from solar winds on the lunar surface.

By Clarice Mauer



A&A assistant professor Justin Little is a 2023 recipient of the prestigious Young Faculty Award (YFA) from the U.S. Defense Advanced Research Projects Agency (DARPA). Little's research on "Power Extraction from Mini-Magnetosphere Polarization Fields" proposes a method of extracting power from the action of solar winds against magnetic anomalies that exist on the lunar surface.

Current lunar power sources can be complex, expensive, and easily damaged by the harsh environment. This research could ultimately lead to power sources that are more robust, lower in cost and mass, and can be constructed primarily from materials found on the moon.

Little explains, "Our Moon, unlike Earth, has very few opportunities for generating renewable power from natural resources. But it turns out that the solar wind deposits hundreds of megawatts of power into regions called magnetic anomalies that were formed long ago on the lunar surface. A mini-magnetosphere that results from this interaction acts like a battery, storing energy from the solar wind. Our research hopes to answer the question: can we tap into the energy contained in a mini-magnetosphere plasma to achieve net positive power production?"

Little's successful YFA proposal will have him working with DARPA Program Manager Michael Nayak, who is also the program manager of two recently announced lunar initiatives from DARPA – the 10-year Lunar Architecture (LunA-10) capability study and the Lunar Operating Guidelines for Infrastructure Consortium (LOGIC). Both LunA-10 and LOGIC are examining lunar power, among other topics.

Little adds, "Funding from this award will enable my lab team to examine the concept using both numerical simulations and experimental testing. The ultimate goal is to understand the physics of the problem well enough to be able to say whether or not a system like this is feasible, and to provide an estimate of how the size, mass, and cost of the system scale with power. I am honored to have been chosen for this award and am very excited about the research that it enables."

About the DARPA Young Faculty Award

This award highlights rising stars in junior research positions who receive funding, mentoring, and industry and Department of Defense contacts to further develop their research in the context of national security needs.

Illustration left: Mini-magnetospheres near the lunar surface form by the interaction between the solar wind and magnetic anomalies. This research will examine the feasibility of using these magnetospheres for generating power on the moon. Image credit: epp.golp, CC BY-SA 4.0, via Wikimedia Commons.

A&A FLUIDS PROFESSOR

Mitsuru Kurosaka retires

Excerpts from an interview with Kurosaka, who joined the A&A Department in 1987, as he reflected on his research and inspirations over his career.

Your research contributed to the fundamental understanding of vortices, which is crucial in the design and operation of gas turbines. Can you distill your findings for us?

With my former student Brenda Haven, we predicted and demonstrated the effectiveness of vortical cooling. Brenda is now teaching at Embry Riddle University. Vortical cooling is a technique that intentionally induces vortices to transfer heat from a blade surface to the surrounding fluid. The advantage of this technique is that it does not rely on higher airflows. The efficacy comes by manipulating flow patterns. Our results have led to improvements in the design of various gas turbines. As a side note, it is gratifying to add that recently Brenda co-authored a well-known textbook on gas turbine design concept.

With my former students C. B. Cain and Jeremy Wimer, both later rising to the rank of colonel in the Air Force, and with contributions from others, we provided a definitive explanation for the formation of vortex breakdown, a sudden enlargement of flow in delta wings. Understanding vortex breakdown is also crucial for optimizing the design and performance of gas turbine combustors, which rely on swirling flows.

You are also well-known for your long-time research on detonation engines. Where do you see that technology taking us?

The detonation engine has been quite interesting because, despite its apparent simplicity, it has a complex interplay of gas dynamics and chemistry. I had made several predictions which former students Jake Boening and James Koch confirmed.

Although the technology may not be used for launching large payloads, it's lightweight and compact, which makes it ideally suited for deep space propulsion and spacecraft attitude control.

What has been your greatest inspiration?

Before I started my academic career, I was an engineer at the General Electric R&D Center in Schenectady, New York, now called GE Research. Instead of being pigeon-holed in one particular area, I was exposed to different research topics related to a wide variety of GE products such as jet engines, nuclear reactors, power generating steam turbines, torpedoes and more. My mission there was to solve industrial problems, but I was reminded again and again of the importance of the fundamental perspective I had internalized as a student at CalTech.

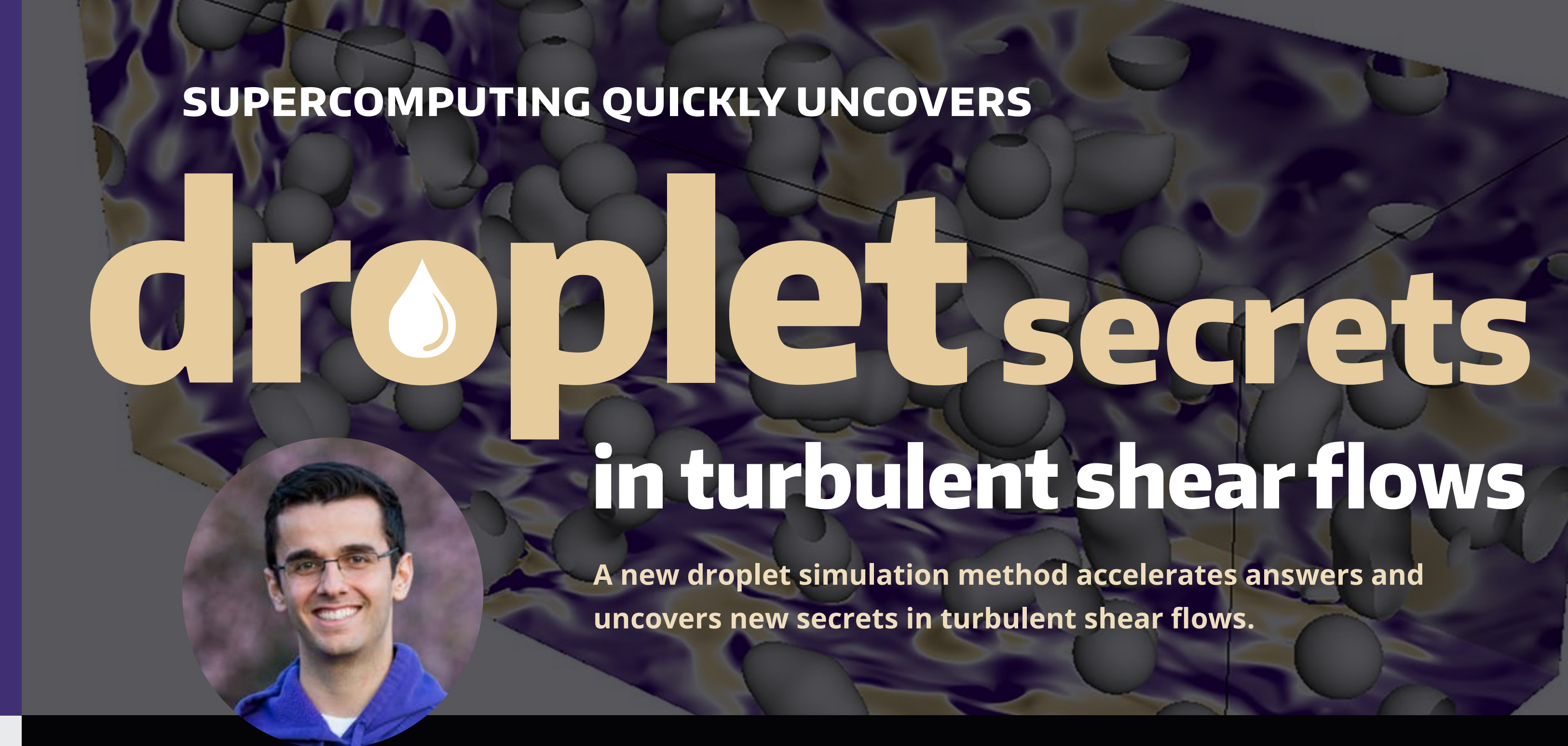
What sticks with you the most of your years at the UW?

It is definitely teaching. I have received many kind comments from the alumni working in industry and the military, which is so rewarding. Many have communicated that their exposure to airbreathing propulsion in my lectures was valuable to their careers. It was indeed a privilege to be given an opportunity to mold so many young minds. This was in no way one-sided. Students with their fresh and unfettered perspectives asked many out-of-box questions, which helped me to deepen my own understanding — a very fulfilling and lasting experience indeed.

Do you have any last words for A&A?

I would like to leave you with a phrase from the poem "To ----" by 18th century British poet Percy Bysshe Shelly which refers to the burning desire of the tiny moth to reach a higher ground: "The desire of the moth for the star."

Onward and upward!



SUPERCOMPUTING QUICKLY UNCOVERS

droplet secrets in turbulent shear flows

A new droplet simulation method accelerates answers and uncovers new secrets in turbulent shear flows.

Tiny droplets have a big impact on aerospace applications. A&A Ph.D. student Pablo Trefftz Posada and Professor Antonino Ferrante have made a significant breakthrough in developing a highly accelerated method for simulating and comprehending the behavior of droplets in turbulent shear flows and have uncovered previously unknown mechanisms with the process.

Turbulent shear flows, characterized by significant velocity variations across the flow, result in chaotic and irregular movement of fluid particles. In these flows, the mixing and exchange of momentum among fluid particles create eddies and vortices, influencing mass, momentum, and energy within the flow.

Ferrante explains the importance of understanding these flows, "Understanding the complex dynamics of turbulent flows is crucial for designing efficient propulsion systems and optimizing aerodynamic performance of aircraft."

Simulations reduced from months to two days

Trefftz Posada and Ferrante have reduced the processing time remarkably by leveraging supercomputing capabilities to run highly accurate simulations of droplets in these flows. Trefftz Posada says, "For our new method, we ran eight simulations with different droplet properties by using 300 computing cores on the Stampede2 supercomputer. Each of these simulations took about two days to complete. Before our method was developed, each of these simulations used to take up to 75 days on such a supercomputer, and 62 years on a conventional personal computer!"

These simulations are highly accurate, but don't include any complex geometries. Engineers and scientists can use the results to improve their lower-accuracy models based on the accurate physics they have discovered.

Pictured above: A&A Ph.D. student Pablo Trefftz Posada

The simulations uncover two previously-unknown mechanisms

From the simulations, Trefftz Posada discovered two previously-unknown mechanisms to explain the physics of droplets in turbulent shear flows. Ferrante explains, "Pablo has unraveled the 'catching-up' and 'shearing' mechanisms that occur in the interaction of droplets with shear turbulence."

The "catching-up" mechanism describes the phenomenon where droplets moving at different speeds due to the mean velocity eventually combine, leading to an increase in kinetic energy throughout the fluid when the surface tension is large enough to return the combined droplets to a more spherical shape. On the other hand, the "shearing" mechanism refers to the deformation of individual droplets due to the mean velocity, ultimately converting surface energy into turbulence kinetic energy.

Trefftz Posada sums up the significance of the findings, "The two mechanisms we have discovered allow us to explain the pathways of turbulence kinetic energy in multiphase turbulent shear flows. Understanding these pathways helps engineers to perform more accurate simulations of the highly complex phenomena occurring inside jet engines. As the aviation industry pushes for sustainable aviation fuel, accurate simulations will play a crucial role in designing engines that are as safe and efficient as possible."

Go to the source:

On the interaction of Taylor length-scale size droplets and homogeneous shear turbulence: Pablo Trefftz-Posada and Antonino Ferrante. Journal of Fluid Mechanics. 2023; 972:A9.

A&A Awards

2023 A&A Undergraduate Showcase Winners


1st Place
John Michael Racy


1st Place
Ojasvi Kamboj


2nd Place
Isaac Remy


3rd Place
Senna Keesing

2023 A&A Graduate Research Showcase Winners


1st Place
Chris Hayner


1st Place
Samuel Buckner


2nd Place
Collins Davis


1st Place
Troy Nakagawa


People's Choice
Ari Athair


People's Choice
Peter Thoreau

2023 A&A Excellence Awards


Service (Undergraduate)
Caleigh Stagnone


Service (Graduate)
Danny Broyles


Teaching
Arvindh Sharma


Doctoral Research
Chris Hayner


Graduate Research
Collins Davis


Undergraduate Research
Yusuf Rasyid

Varanasi Endowed Fellowship


Isabella Rieco

Condit Dissertation Fellowship


James O'Neil

Other Graduate Awards

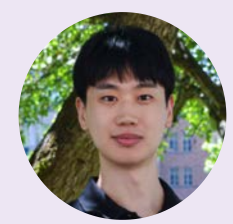

Boren Fellowship
Thomas Key


AIAA Abe M. Zarem Graduate Award
Quentin Roberts


Graduate School Boeing International Fellowship
Thijs Masmeijer


NASA NSTGRO Fellowship
Chris Hayner

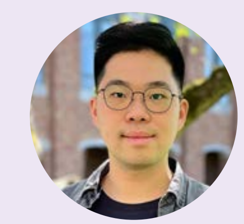

Fulbright Fellowship
Nick Andrews


Amazon Fellowship
Taewan Kim


Herbold Fellowship
Kevin Manohar


Aerospace Career Enhancement Fellowship
Nithin Adidela


Aerospace Career Enhancement Fellowship
Jared Smythe


Aerospace Career Enhancement Fellowship
Eddie Ting

Other Undergraduate Awards


Brooke Owens Fellows
Caleigh Stagnone
2023


Brooke Owens Fellows
Senna Keesing
2024


Husky 100
Salma Hassanain


Levinson Emerging Scholars Award
Jasper Geldenbott


Mary Gates Research Scholarship
Marc Alwan


Grand Prize: Alaska Airlines Environmental Innovation Challenge
Morgan Golden

Faculty Awards


AIAA Fellow
Behçet Açıkmeşe


Vagners-Christianson Endowed Faculty Fellow
Karen Leung


DARPA Young Faculty Award
Justin Little


AIAA Fellow
Mehran Mesbahi

HIGHFLIGHT
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Generating dynamically feasible trajectories wins IEEE Control Systems Magazine Outstanding Paper Award

By Clarice Mauer

A&A professor Behçet Açıkmeşe and A&A Ph.D. graduates Danylo Malyuta, Taylor Reynolds, and Michael Szmuk, together with colleagues from Stanford University, received the 2023 IEEE Control Systems Magazine Outstanding Paper Award for “Convex Optimization for Trajectory Generation: A Tutorial on Generating Dynamically Feasible Trajectories Reliably and Efficiently.”

Açıkmeşe describes the overall importance and significance of the research, “It presents a mathematically sound and computationally robust approach to solving trajectory optimization problems that are routinely encountered in dynamical systems, which include aerospace vehicles as well as ground and marine vehicles and robotic manipulators.”

He continues, “Since the proposed methods rely on efficient computational methods of convex optimization, they can be embedded on mobile computing platforms and executed autonomously in real time, making them highly applicable to many current and emerging autonomous vehicle applications. These techniques have already been utilized by many in aerospace industry for autonomous reusable rockets and spacecraft, as well as in autonomous ground vehicles.”

While there are many benefits to autonomous aerial vehicles delivering goods and medical supplies and space vehicles landing on planets, these applications present challenges with their stringent requirements on performance, safety and trustworthiness. This research introduces reliable and efficient convex optimization based trajectory generation methods and algorithms to meet given requirements while optimizing mission objectives, by using lossless convexification (LCvx), successive convex programming (SCvx), and guaranteed sequential trajectory optimization (GuSTO).

Go to the source:

Convex Optimization for Trajectory Generation: A Tutorial on Generating Dynamically Feasible Trajectories Reliably and Efficiently, in IEEE Control Systems Magazine, vol. 42, no. 5, Oct. 2022.