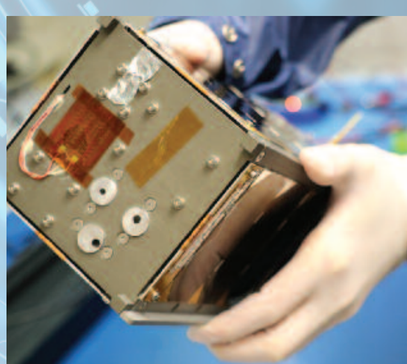
Aerospace Engineering/**2019**

UPDATE

Elevating ideas since 1944



AEROSPACE ENGINEERING 75 ELEVATING IDEAS SINCE 1944

ILLINOIS

Building for Future Aerospace Engineers

A three-story addition to the south face of Talbot Laboratory is under construction. When completed, this new instructional facility will provide AE students with transformative educational experience in composite manufacturing and nanosatellite technology.

About the composite manufacturing lab, Bliss Professor **Philippe Geubelle** said, "With the increasing importance of composite materials, it is critical that aerospace engineers be exposed to manufacturing techniques for this class of materials, including prepregging, filament winding, resin transfer molding, autoclave curing, etc. This is the primary objective of this new facility—no AE student will graduate without knowing the key techniques used to make complex, high-quality composite parts. But the lab will also serve anyone on campus who needs to make composite parts for a design project or for research."

The new lab, which will build on existing manufacturing facilities in Talbot, will also contain equipment for additive manufacturing and 3D printing.

"This will be truly transformative for the AE department and greatly improve the educational experience, not only for our students, but also for students across The Grainger College of Engineering. Any student who wishes to build something out of composites will be able to have access to this facility. So this new state-of-the-art lab will be the focal point of anything composite-related on campus."

Michael Lembeck, AE visiting associate professor and Director of the Laboratory for Advanced Space Systems at Illinois, commented on how the new nanosatellite facility will enhance the CubeSat program at Illinois.

"We'll have space to install equipment for vibration and thermal vacuum testing our satellites, in which we shake them to simulate what they'll experience during launch and then thermally cycle them like they'll see on orbit," Lembeck said. "We'll be able to test all of the systems with the ground stations as well. We can test like we fly, and fly like we test."

Lembeck said the facility will include a mission operation center, named for astronaut and alumnus **Steven R. Nagel** (BS '69), who died in 2014.

"The control center will allow the students to get actual mission operations experience sending commands and receiving telemetry from our satellites in low earth orbit," he said.

The Talbot Educational Laboratory Renovation and Expansion Project will cost $8.66 million and is expected to be completed in fall 2020.

Welcome

to the 2019 edition of the AE Newsletter.

The Department of AE has seen some extraordinary changes since the last issue of ***UPDATE***.

In January, the department gained five new assistant professors. That same month, after serving as department head for the past seven years, **Philippe Geubelle** became the Executive Associate Dean for The Grainger College of Engineering. At that time, I stepped in as interim department head to serve during the national search for a new department head.

Talbot Laboratory is currently sandwiched between the construction of two exciting new facilities. To the south is the Talbot Expansion Project described on the adjacent page. To the north, a new college instructional facility is being built. Both will greatly enhance AE students' education while at Illinois.

Throughout this academic year, we are also celebrating the department's 75th anniversary in a variety of ways. Please take a look at the special center section of this publication. The fold-out timeline shows how AE's first 75 years fit within the history of flight and space exploration.

Here's to the next 75!

Gregory Elliott
Professor and Interim Department Head

Stay connected by joining our networks

If you'd like to receive AE news throughout the year via email, please contact Debra Levey Larson (217-244-2880 or dlarson@illinois.edu).

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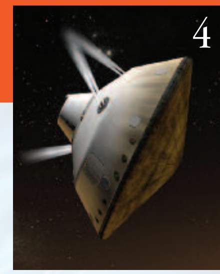

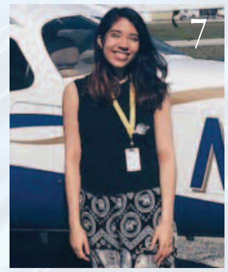

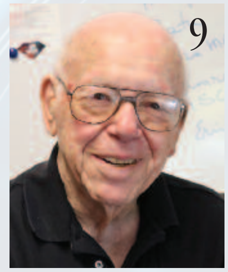

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Undergraduate Advising
Laura Gerhold
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Communications & Alumni Relations
Debra Levey Larson
Special Events Facilitator
Courtney McLearin
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Design
Pat Mayer
Content
Debra Levey Larson
Special thanks to Zana Essmyer for her work on the timeline.

People on the cover: Paul Tabaka, H.S. Stillwell, Martin O'Connor; Jo Ann Hoenninger Kamal Majied II, John Prussing; Jennifer Hommema, Jin Li, Scott White; Daniel Drucker, Stephen Hoffman, Eric Barnes, Harry Hilton; William Conway, George Carruthers; Mike Hopkins; Vanessa Awate, Phillip Ansell

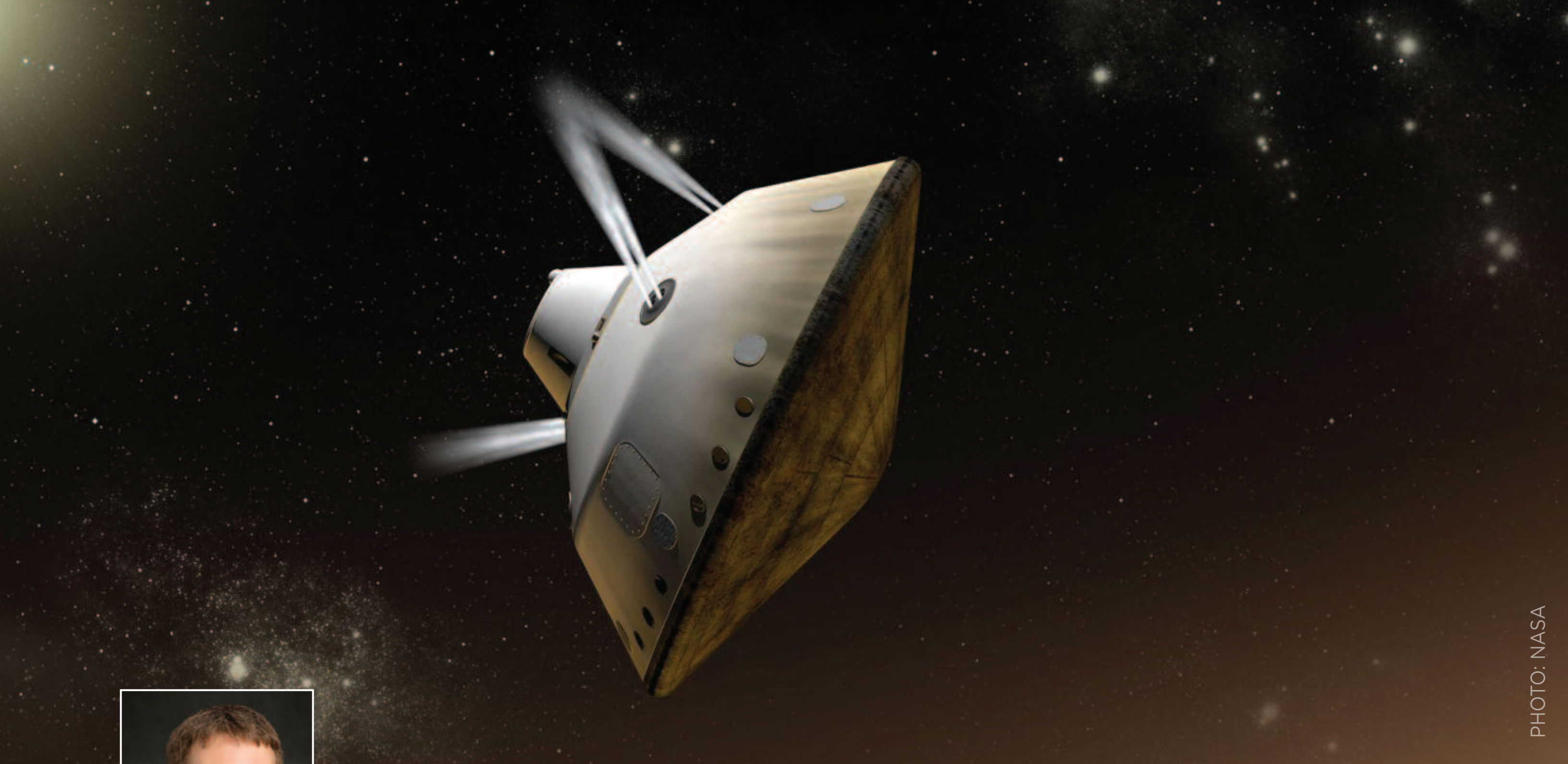


PHOTO: NASA

Zach Putnam

Landing Heavier Vehicles on Mars

Weighing in at 1 metric ton, about 2,200 pounds, NASA's Curiosity Rover is the heaviest vehicle to successfully land on Mars. Sending more ambitious robotic missions to the surface of Mars, and eventually humans, requires landed payload masses in the 5- to 20-ton range. To do that, we need to figure out how to land more mass.

"Unfortunately, parachute systems do not scale well with increasing vehicle mass," said AE Assistant Professor **Zach Putnam**. "The new idea is to eliminate the parachute and use large rocket engines for descent.

"When a vehicle is decelerating in the atmosphere, but still flying at hypersonic speeds, before the rocket engines are ignited, some lift is generated and we can use that lift for steering," Putnam said.

Putnam explained that the flow around the vehicle is different on the top and the bottom which creates a pressure differential. Because the lift is in one direction, it can be used to steer the vehicle as it decelerates through the atmosphere.

"We have a certain amount of control authority during entry, descent, and landing—that is, the ability to steer," Putnam said. "During gliding flight, the vehicle can use lift to steer. Once the descent engines are ignited, the engines have a certain amount of propellant. You can use engine thrust in such a way that you land very accurately, you can forget about accuracy and use all the propellant to land the largest spacecraft possible, or you can find a balance in between.

"The question is, if we know we're going to ignite the descent engines at, say, Mach 3, how should we steer the vehicle aerodynamically prior to that in the hypersonic regime so that we use the minimum amount of propellant and maximize the mass of the payload that we can land?

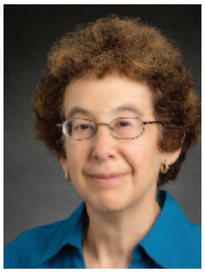
"To maximize the amount of mass we can land on the surface, the altitude at which you ignite your descent engines is important, but also the angle your velocity vector makes with the horizon—how steep you're coming in," Putnam said.

The study clarified how to make the best use of the lift vector, using optimal control techniques to identify control strategies that can be used hypersonically across different interplanetary delivery conditions, vehicle properties, and landed altitudes to maximize landed mass.

"It is propellant-optimal to enter the atmosphere with the lift vector pointed down so the vehicle is diving. At just the right moment based on time or velocity, switch to lift up, so the vehicle pulls up and flies along at low altitude," Putnam said. "This enables the vehicle to spend more time flying low where the atmospheric density is higher. This increases the drag, enabling the vehicle to dissipate more energy aerodynamically and reducing the amount of energy that must be removed by the descent engines."

The study was co-written by Christopher G. Lorenz and Zachary R. Putnam and is published in the *Journal of Spacecraft and Rockets*. It was funded by the NASA Jet Propulsion Laboratory.

Simulating hypersonic flow transitions from smooth to turbulent



Deborah Levin

Ozgur Tumuklu

To break out of Earth's lower orbit, hypersonic vehicles must reach speeds greater than Mach 5. At these hypersonic speeds, the air particles and gases that flow around the vehicle and interact with the surfaces generate heat and create shock waves that disturb the flow's equilibrium.

"At hypersonic speeds, the flow is moving at high Mach numbers, but there are also wings or flaps on the vehicle. At each of those junctures, you can have very strong recirculation, which leads to unsteadiness. It's difficult to predict how bad the unsteadiness can become before the flow is no longer smooth, and becomes turbulent," said AE Professor **Deborah Levin**.

Levin and **Ozgur Tumuklu** (PhD '18), along with Professor Vassilis Theofilis from the University of Liverpool, conducted research that brings a revolutionary understanding to the field of hypersonic flow.

Levin said she studies flow at a very fundamental level to understand the flow, the forces that the flow can create, and the length of time the flow remains stable in terms of microseconds to milliseconds—faster than the blink of an eye.

"From the very fundamental aspects of the flow, when the speed is so high, the gases around the surfaces become very hot and cause chemical reactions, or non-equilibrium effects. It's a phenomenon that occurs as the air gets thinner as you move faster," Levin said. "Coupling all of that—the non-equilibrium and the stability—that's what's really novel about this research and hasn't been done before. The outcome of this research is a model and the ability to now use this technique in the future to design shapes and induce chemical reactions that will or will not induce stability or quench it."

Levin said some of the original work in this field began with experiments by, then AE Professor Joanna Austin. A major part of her work at Illinois was designing a new facility that could measure some of the features of flow.

"She has a hypervelocity expansion tube—a class of measurement techniques that can be used to induce a flow over a double-wedge model about the size of my hand," Levin said. "Dr. Austin creates a hypersonic flow over the entire model. It used a tremendous amount of energy to accomplish but it can be used for low density (thinner air) cases."

Levin said they artificially reduced the conditions in the hypervelocity expansion tube by a factor of about an eighth. When they did that, "We still saw a lot of the features like the shocks, and recirculation, but the flow calmed down and we were able to simulate a steady state."

The research provided new understanding about the points of transition in flow from smooth to turbulent, which can ultimately inform safer vehicle design.

The study appears in the journal, *Physics of Fluids.* It was supported by the Air Force Office of Scientific Research.

Scholarship recipient Ashley Stahulak: Glad she chose Illinois

If you've ever been to Chicago and visited the Museum of Science and Industry on more than one occasion, you likely have a favorite exhibit. Your trip isn't complete without seeing the chicks hatch, touring the submarine, or walking through the giant, simulated, lub-dubbing heart.

For **Ashley Stahulak** (BS '19), her must-see was the United Boeing 727 that hangs in the museum's Transportation Gallery. Growing up in a family with an annual membership to the museum, gave her many opportunities to admire that 727 and spark an early interest in airplanes.

Now she's designing them.

She works for Boeing Commercial Airplanes as a systems design engineer on Boeing's avionics team.

"It's my dream job," she said in an interview just before she graduated. "I'll be designing for communications, navigation, and the radio systems in the cockpit of the aircraft."

And, although fresh out of college, this isn't her first gig at Boeing. She had a paid internship there the previous summer—which was actually her third internship as an undergrad. Stahulak recognizes that landing three internships as an undergrad is unusual.

"I think I was a bit of an anomaly. Not a lot of students get an internship after their freshman year," she said. But she didn't get them without taking the initiative. After only being on campus about a month, she applied to attend a conference in October with General Electric and was accepted.

"It was a women leadership diversity summit. They flew me to Cincinnati and then at the end of the conference, they held interviews for internships, so that's how I got the first one. G.E. invited me to New York the following summer. Then my junior year, I interviewed with Boeing at a career fair on campus for the internship last summer. From that, I got offered this job."

Stahulak is grateful for the experience she gained through the internships, although one she described as difficult.

"I had trouble meeting the deadlines that were set for me," she said. "Sometimes I felt like they were unrealistic, but at the end of the day, it was my responsibility. I had to meet them. I utilized as many resources as I could—other interns and engineers who knew more than I did."

In the spirit of full disclosure, Stahulak said, “Illinois wasn’t my first choice.” Ultimately, she chose Illinois for two reasons: Illinois' academic reputation and financial aid.

“When I first came to Illinois, I received two renewable scholarships from the college, as long as I kept my grades at a certain level and one scholarship from Boeing. That helped my decision to come.”

In her senior year, Stahulak also received an Engineering Visionary Scholarship from the college. Funding for these scholarships come from The Grainger Foundation and will match gifts for student scholarships up to $25 million until Dec. 31, 2019.

“I have four younger sisters. The oldest is just 11, so it was great to be able to take the financial load off of my parents. Coming to Illinois took away the stress of having to worry about the finances.”

Reflecting on what is a pivotal decision and causes a lot of stress for high school seniors, Stahulak said she believes she made the right choice.

“A friend came to visit me recently and we talked about whether we would have done the same thing if we had the chance to do it all again,” Stahulak said. “I don’t know if I would have had the same opportunities at another school. And I don’t know if I’d be in this same place if I had gone somewhere else—with a job at Boeing waiting for me after graduation like that. I’m very thankful.”

Two Funds Honor **Scott White**

Throughout his career at the University of Illinois, Professor Scott R. White influenced people on many levels, but particularly the students he advised and fellow faculty members with whom he worked and conducted research. In keeping with those two spheres of influence, two funds are being created to honor his life.

The **Scott R. White Aerospace Engineering Visionary Scholarship** has been established by a former student of White to support undergraduate students. What is unique about the EVS is that through the end of 2019, all gifts made to the Engineering Visionary Scholarship Initiative will be matched dollar-for-dollar, up to $25 million by The Grainger Foundation. This very generous match includes matching funds provided by employers.

The **Scott R. White Aerospace Engineering Professorship**, which received a seed gift of $250,000 from White’s wife, **Nancy Sottos**, is being created to provide faculty support for an individual who has expertise, academic abilities, and research within the field of polymers, polymer matrix composites, or multifunctional polymeric materials. The funds provided by Sottos are matching funds and will encourage additional gifts to move the professorship to its full endowment level of $500,000.

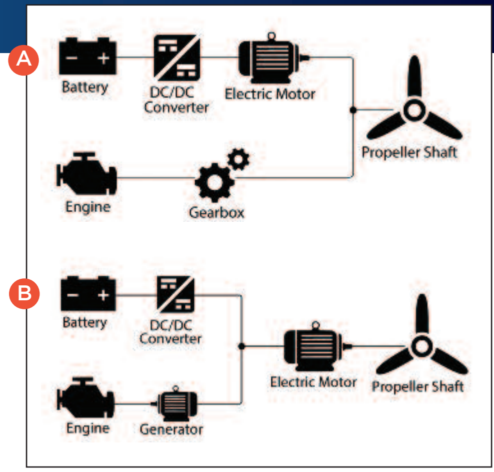
Because White was globally recognized as an expert in autonomous materials—materials that can adapt or respond on their own—this professorship will help advance the body of knowledge and research in his field.

White’s research group at the Beckman Institute for Advanced Science and Technology at the U of I developed self-healing plastics, electronics, batteries, and coatings; coatings and materials that indicate when they are damaged or strained; self-destructing devices to reduce electronic waste; and many other innovations to make materials safer and more reliable on both the micro and macro scale. This important work will continue in Scott White’s name and honor.

White passed away in May 2018 at the age of 55. A celebration of his life at the Beckman Institute the following month was attended by a large number of current and former students and members of the Autonomous Materials Systems group that he led for two decades. A memorial can be found on the Dept. of Aerospace Engineering website.

For information about ways you can support the department*, including growing these two Scott R. White funds and the Engineering Visionary Scholarship Initiative which ends Dec. 31, 2019, contact Tim Cochrane at tcochran@illinois.edu or 217-333-1149.*

Putting **Hybrid-Electric Aircraft Performance** to the Test



This figure shows the a) parallel and b) series drivetrain models.

Although hybrid-electric cars have become commonplace, similar technology applied to airplanes comes with significantly different challenges, one of which is the technological development of sustainable alternatives to fossil fuels to power airplanes.

Phillip Ansell, AE assistant professor, along with former aerospace undergraduate student **Tyler Dean** (BS '18) and and doctoral student **Gabrielle Wroblewski** (BS '14; MS '16) conducted research which was published in the *Journal of Aircraft.* They created a flight-performance simulator to represent the flight performance of a Tecnam P2006T, including take off, climb, cruise, descent, and landing, with sufficient reserves to meet FAA regulations. Transition segments were incorporated into the simulation during climb and descent where the throttle setting, flap deployment, propeller rotation rate, and all other flight control variables were either set to mimic input from a typical pilot or prescribed in accordance with the aircraft flight manual.

After configuring the simulator to collect baseline performance data, a parallel hybrid drivetrain was integrated into the simulation. The researchers compared the sensitivity of range and fuel economy to the level of electrification, battery-specific energy density, and electric motor power density. The same sensitivities were studied with a series hybrid-electric drivetrain.

Ansell said, overall, a hybrid-electric drivetrain can lead to substantial improvements in fuel efficiency of a given aircraft configuration, though these gains depend strongly on the coupled variations in the degree of drivetrain electrification and the required mission range.

The fuel efficiency improvements were shown to particularly shine for short-range missions, which is a good thing because range limitations serve as one of the key bottlenecks in hybrid aircraft feasibility. Though, through this study the changes in the range capabilities of the aircraft were also able to be forecast with advancements in hybrid component technologies. "For example," Ansell said, "the propulsion system today could be configured to have 25 percent of its propulsive power come from an electric motor. However, it would only be able to fly about 80 nautical miles. Fast forward to projections for lighter battery technologies for roughly the year 2030 and the same aircraft could fly two and a half to three times as far. The range increase is nonlinear, so the largest improvements can be seen for the most immediate improvements with battery-specific energy density, with gradually diminishing returns for that same proportional increase in specific energy."

This study was supported by NASA. "Using our data, they will be able to have at least a ballpark idea about how the hybrid system can be expected to perform on their X-57 demonstrator aircraft, without the other distributed propulsion modifications."

Phillip Ansell is leading the new **Center for High-Efficiency Electrical Technologies for Aircraft**. This research proposes a fundamental shift away from jet fuel toward more sustainable energy sources for aviation, and the introduction of new electrically driven propulsion systems for commercial aircraft. NASA will provide $6 million over the course of three years.

Toward a More Perfect **Flying Vehicle**

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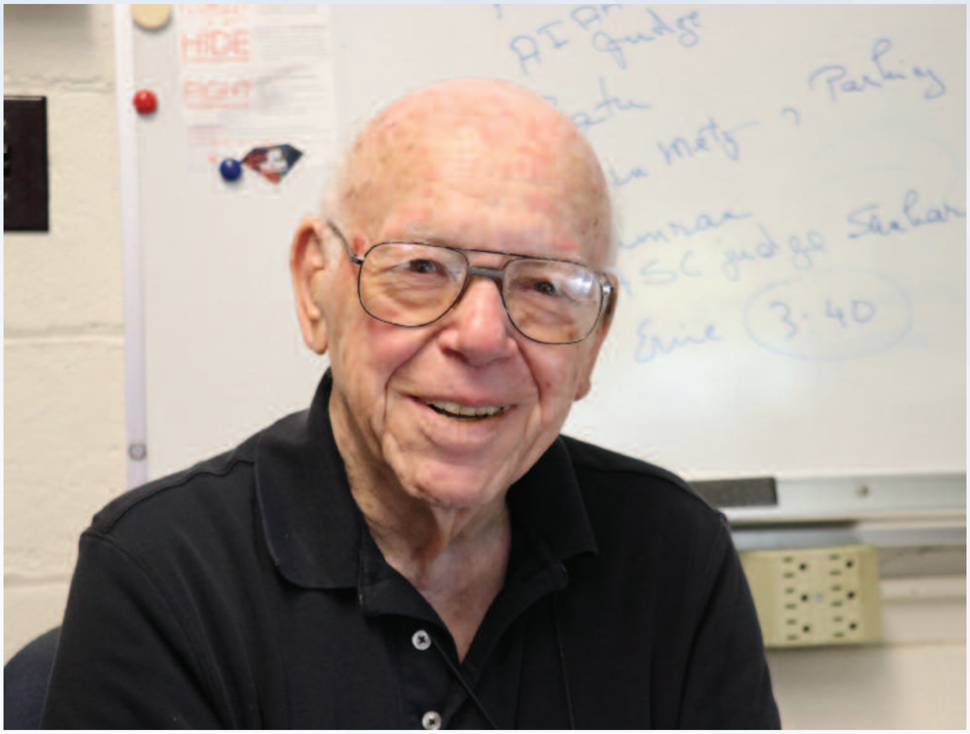


Harry H. Hilton

In recent research, AE Professor Emeritus **Harry Hilton** brought together several mathematical and physical models to help look at problems in more unified ways and solve physical engineering problems.

“If you don’t use the right model, the rest becomes an exercise in futility. It may be a model that’s self-consistent but has no reality,” Hilton said. “Of course, the only way you can validate a model is to run experiments and even then, you’re introducing another reality into the picture which is the experiment and not the real airplane. So each one of these is an idealization.”

Hilton began by analyzing the da Vinci-Euler-Bernoulli theory of elastic bending. “It’s deterministic, that is, determined that it is true with a probability of 1, based on a set of equations that give a set of answers,” he said.

Added to that is the Timoshenko theory that takes load and other realistic properties such as wind shear into consideration. Hilton merged those theories with properties of viscoelastic materials—which includes time-dependent material behavior and is of particular importance in modern composite materials and metals at elevated temperatures.

“We may assume that the loads and material properties are certain, but they’re not. Think about wind gusts. They can be sudden and unpredictable in strength and direction,” he said. “It’s the difference between deterministic, which means the probability is 1 and events are going to happen, as opposed to a probability between zero and 1 where zero is never and 1 is always.

“Probability happens in the real world. What’s the probability of you getting hit by a car when you cross Green Street? Pretty high. When you cross Wright Street, maybe not as likely,” he said.

Hilton’s analysis provides a new model that takes into consideration as many, but still not all, known phenomena. These analyses, although more inclusive, form a linear beginning as a stepping stone to the real nonlinear random world.

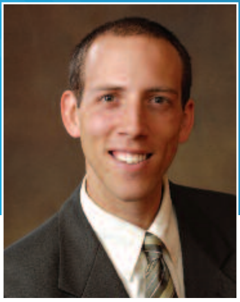
“We use both math and physics in engineering, but within limitations. In physics, we don’t always understand what’s going on,” he said. “That’s the case here as well. There are pieces of principles that haven’t been resolved. The mathematics are very exact but we tend to shade the equations in terms of what we can solve, rather than what it should be.

“The probabilistic analyses really pay off when designing a missile because you have just one flight to get it right. Either it hits the target or it doesn’t. But it never comes back and is reused.”

About his merging of models and its potential impact, Hilton quoted Winston Churchill from a speech he gave in 1942 concerning the Second Battle of El Alamein.

“Churchill said, ‘It’s not the beginning of the end but the end of the beginning.’ You could look at it that way. We’re so far from the total knowledge that any one of these types of fundamental analytical papers is an end of the beginning.”

The paper is published in the journal of *Mathematics in Engineering, Science, and Aerospace.*



Timothy Bretl

Enhancing Robot Vision

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Robots are good at making identical repetitive movements, such as a simple task on an assembly line. (Pick up a cup. Turn it over. Put it down.) But they lack the ability to perceive objects as they move through an environment. (A human picks up a cup, puts it down in a random location, and the robot must retrieve it.) A recent study was conducted by researchers at the University of Illinois, NVIDIA, the University of Washington, and Stanford University, on 6D object pose estimation to develop a filter to give robots greater spatial perception so they can manipulate objects and navigate through space more accurately.

While 3D pose provides location information on X, Y, and Z axes—relative location of the object with respect to the camera—6D pose gives a more complete picture.

"Much like describing an airplane in flight, the robot also needs to know the three dimensions of the object's orientation—its yaw, pitch, and roll," said **Xinke Deng** (MS '15).

And in real-life environments, all six of those dimensions are constantly changing.

"We want a robot to keep tracking an object as it moves from one location to another," Deng said.

Deng explained that the work was done to improve computer vision. He and his colleagues developed a filter to help robots analyze spatial data. The filter looks at each particle, or piece of image information collected by cameras aimed at an object to help reduce judgement errors.

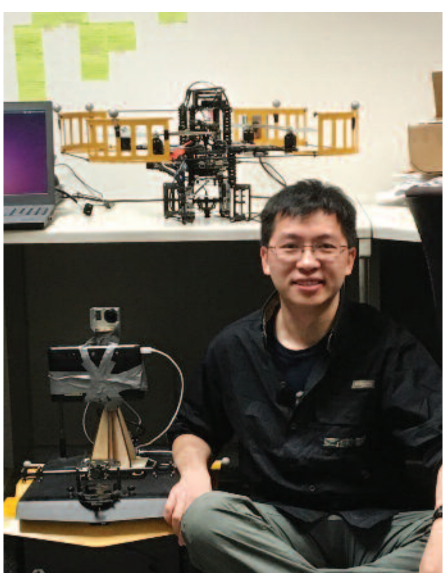
"In an image-based 6D pose estimation framework, a particle filter uses a lot of samples to estimate the 6D pose," Deng said. "Every particle is like a hypothesis, a guess about the 6D poses that we want to estimate. The particle filter uses observation to compute the value of importance of the information from the other particles. The filter eliminates the incorrect estimations.

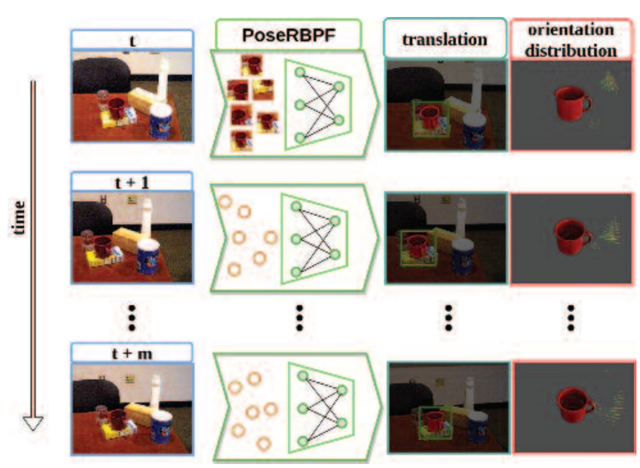
"Our program can estimate not just a single pose but also the uncertainty distribution of the orientation of an object," Deng said. "Previously, there hasn't been a system to estimate the full distribution of the orientation of the object. This gives important uncertainty information for robot manipulation."

The study uses 6D object pose tracking in the Rao-Blackwellized particle filtering framework, where the 3D rotation and the 3D translation of an object are separated. This allows the researchers' approach, called PoseRBPF, to efficiently estimate the 3D translation of an object along with the full distribution over the 3D rotation. As a result, PoseRBPF can track objects with arbitrary symmetries while still maintaining adequate posterior distributions.

"Our approach achieves state-of-the-art results on two 6D pose estimation benchmarks," Deng said.

Deng conducted the research as a part of an internship with NVIDIA. He is currently a doctoral candidate in the Dept. of Electrical and Computer Engineering with AE Associate Professor **Timothy Bretl** as his adviser. In addition to Deng and Bretl, the study was co-written by Arsala Mousavian, Yu Xiang, Fei Xia, and Dieter Fox.





Left is Xinke Deng in the laboratory. The graphic shows an overview of the the PoseRBPF framework for 6D object pose tracking. The method leverages a Rao-Blackwellized particle filter and an auto-encoder network to estimate the 3D translation and a full distribution of the 3D rotation of a target object from a video sequence.

CubeSat: Mission Accomplished

In the AE clean room left to right: Ravi Patel, Adam Newhouse, Dillon Hammond, and Nick Zuiker in the white lab coat.

Michael Lembeck

A successful launch might be described as: the rocket launched on time, the satellite deployed as scheduled, it de-tumbled, and began transmitting data as planned.

Although all of these are wonderful ways to describe success, for AE Visiting Associate Professor **Michael Lembeck** the measure of success is how much students learned.

One example. In December 2018, CubeSail, a small CubeSat satellite designed and built by CU Aerospace and AE engineering students, launched from New Zealand's Māhia Peninsula. It hitched a ride on a Rocket Lab Electron vehicle, as a part of the Educational Launch of Nanosatellites mission for NASA. CubeSail was designed to separate and unfurl a thin ribbon about the length of a football field. The solar sail would demonstrate a technique for steering a novel population system.

That was 10 years from when NASA first funded the project, and during which many students participated in its design, fabrication, acceptance testing, delivery, and launch.

"Because mission success rates are only 45 percent," Lembeck said. "for academic institutions, student education is the primary measure of success, regardless of the ultimate outcome of the flight. And funding through NASA's educational program encourages students to pursue careers in science, technology, engineering, and mathematics."

In April 2019, a second student satellite counted down. SASSI2 was bolted to the second stage of a Northrop Grumman Antares rocket that launched from NASA's Wallops Flight Facility on the Eastern Shore of Virginia.

SASSI2, stands for Student Aerothermal Spectrometer Satellite of Illinois and Indiana. It was pushed out into space with a very different mission—to collect data as it orbits the Earth to help scientists understand more about what happens to the flow of atmospheric gases around vehicles traveling at very high altitudes at hypersonic speeds.

According to Assistant Professor **Zach Putnam**, the launch went well, but the team was never able to communicate with it. "Still, SASSI2's mission was educational at its core and has involved over 50 undergraduate students actively over the past three-plus years at U of I and Purdue. And that's remarkable."

Student team leader **Nick Zuiker** (BS '18), began on the project as the payload lead when he was a sophomore and is now in year two of a master's program.

"More than half of my time at U of I so far has been spent working on SASSI2 in some capacity," Zuiker said. "Over the summer, I worked on it for six to 10 hours a day, seven days a week."

Zuiker said he learned from a variety of communications-related issues. He said although the team verbally communicated well on a daily basis, they didn't document enough about decisions that were made. This forced them to retrace their thinking and even redo some tests.

"One area we excelled in was documenting what was currently wrong with the satellite," Zuiker said. "We had a tight and organized issue tracking system which allowed us to continually understand what areas of the satellite needed work, what reasons they currently didn't work, and potential fixes to try."

In other words, mission accomplished.

2019 Alumni Award Recipients

Samantha McCue

Karl Klingebiel

Mark Maughmer

Jason Ditman

Susan Althoff Gorton

Adi Boulos

Larry Howell

Samantha McCue, BS ’13 from Illinois; MS ’19 from Texas A&M University
At 5D Systems, Samantha McCue is the Integration and Test IPT Lead and Flight Test Director for a newly designed full-scale unmanned aerial vehicle. She has been a part of the clean-sheet aircraft design through integrated system testing. McCue led the program team through test range integration and first flight in 2019. She also owns and manages two Omnibarre boutique fitness studios in Austin and Houston.

Karl Klingebiel, BS ’04 from Illinois; MS ’06 from Penn State
At AeroVironment, Karl Klingebiel is a senior staff Robotics/GNC engineer. He was the lead engineer on the DARPA Nano Air Vehicle Program—the robotic hummingbird. His contributions included design, machining, and testing of wing flapping and control mechanisms, circuit board design, and embedded flight control software. He has also taken the lead in guidance, navigation, and control for the Snipe Nano Air Vehicle on which he was responsible for embedded flight control software and was a technical lead for the DARPA Fast Lightweight Autonomy program.

Mark Maughmer, BS ’72, PhD ’83 from Illinois; MS ’75 from Princeton University
For more than 40 years on the faculty at Penn State, Mark Maughmer’s research centered on the aerodynamic design and performance of flight vehicles, both fixed wing and rotorcraft. Maughmer developed airfoil design tools and airfoil designs, which have been employed on a number of low-speed aircraft and sailplanes. His winglet designs are on hundreds of production sailplanes. In the rotorcraft area, he was the first to introduce Gurney flaps near the trailing edge of rotor blades to improve overall rotorcraft performance. Maughmer is also an AIAA Fellow.

Jason Ditman, BS ’91; MS ’92
Jason Ditman’s career began as a Transmission Noise and Vibration Development Engineer at General Motors in 1998. Today, he is the Chief Engineer of Electrification Propulsion at GM. He leads the engineering and execution of electric propulsion systems in the Chevrolet Spark EV, Chevrolet Bolt EV and ARĪV eBikes, as well as future products.

Susan Althoff Gorton, BS ’84 from Illinois; MS ’87 from George Washington University
As project manager for NASA’s Revolutionary Vertical Lift Technology Project, Susan Gorton’s desk is at the Langley Research Center in Hampton, Virginia, but she is responsible for the work done at Langley, Glenn Research Center, Ames Research Center at Moffett Field, and Armstrong Flight Research Center—a staff of about 150 people. Gorton is an AIAA Associate Fellow since 2009 and in 2018, was named Honorary Fellow in The Vertical Flight Society.

Where are they now?

Adi Boulos, BS ’08
Shortly after graduating, Adi Boulos began his career as a NASA contractor in the International Space Station’s Mission Control at United Space Alliance in Houston, Texas. Boulos earned a certification as a flight controller for the ISS Communication and Command and Data Handling systems where he has logged over 3,000 hours in the ISS Flight Control Room. This past year, Boulos was selected to be a part of the newest NASA flight director class.

Larry Howell, BS ’66, MS ’68, PhD ‘71
At General Dynamics Corporation, Larry Howell began his career as a senior dynamics engineer. He was a principal investigator on NASA contracts focused on the structural dynamics of the Space Shuttle. Later, at General Motors, Howell was head of the engineering mechanics department in research and development. He was responsible for research in vehicle structures and materials, vehicle noise and vibration, vehicle aerodynamics, and vehicle safety including vehicle crashworthiness and occupant protection. Howell was a member of GM’s safety sub-committee and eventually became Executive Director, Science, of General Motor’s R & D Center.

McCue, Klingebiel, and Boulos named Outstanding Recent Alumni by the department; Maughmer, Ditman, and Gorton named Distinguished Alumni by the department; Howell received The Grainger College of Engineering Alumni Award for Distinguished Service.

Read the full stories about these alumni at aerospace.illinois.edu.

Elias Waddington, BS ’17
At Impossible Aerospace I design, test, and fly the world’s longest-flying production electric quadrotor. This past year I got an unexpected call from the Chief of Police that led to my drone and me helping them with a complicated hostage situation.

Gabe Rogers, BS ’96, MS ‘97
Since joining the Johns Hopkins University Applied Physics Laboratory in 1997, I have worked on more than 10 different spacecraft missions for NASA, most recently supporting the integration and launch of the Parker Solar Probe mission to the Sun and the New Horizons flyby of 2014 MU69.

Grant Kramer, BS ‘16
I work in Washington, D.C. for the Rolls-Royce Americas Customer Service Center. I am a service engineer in charge of resolving technical issues and root cause investigations for the RB211-535 engine used on the Boeing 757. Last year, I fulfilled a lifelong dream of mine to become a pilot.

Catherine Kuersten, BS ’09
Pennsylvania Law School, JD ‘14
After graduating in 2009, I spent two years at Rolls-Royce as a controls software engineer on engines for Airbus and the US Army. I then attended law school. Currently, I’m an attorney at a global law firm in Washington, D.C. where I advise domestic and international corporations on technology-related legal issues. My work includes public policy advocacy, litigation, overseeing mergers and acquisitions of technology companies, assisting satellite and submarine cable companies with launches and landings, responding to government investigations into data security/privacy breaches, and advising companies in relation to national security and cybersecurity issues. I also maintain a pro bono practice, offering free legal representation sponsored by my firm which focuses on obtaining asylum for refugees.

Read more Where are they now? stories at aerospace.illinois.edu.

Faculty Highlights

Phillip J. Ansell (Assistant Professor / PhD, University of Illinois, 2013) is leading a $6 million NASA University Leadership Initiative program for the formation of the Center for Cryogenic High-Efficiency Electrical Technologies for Aircraft (CHEETA). He also received the 2019 Dean's Award for Excellence (Assistant Professor) in Research from The Grainger College of Engineering.

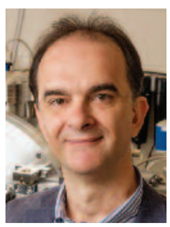
Lawrence A. Bergman (Research Professor, Professor Emeritus / PhD, Case Western Reserve University, 1980) was an invited speaker at the 7th International Conference on Nonlinear Vibrations, Localization, and Energy Transfer in Marseille, France.

Daniel J. Bodony (Blue Waters Associate Professor / PhD, Stanford University, 2005) initiated several new research efforts to support commercial and military aviation needs, including reducing the noise from twin-engined Navy tactical fighters (Office of Naval Research), reducing the noise from commercial jet engines (NASA/Ohio Aerospace Institute), modeling the interaction of shockwaves and flexible control surfaces of hypersonic vehicles (Air Force of Scientific Research), and modeling aeroelasticity-induced resonances in UAS power plants (Army Research Laboratory).

Michael B. Bragg (Research Professor and Professor Emeritus / PhD, The Ohio State University, 1981)

Timothy W. Bretl (Associate Professor / PhD, Stanford University, 2005) gave invited talks at the University of Toronto Institute for Aerospace Studies, at Johns Hopkins University, and at the Robotics Institute of Carnegie Mellon University. He has a NASA grant to study distributed inertial navigation systems and is co-PI on a second NASA grant to study control of aircraft with distributed electric propulsion.

Rodney L. Burton (Professor Emeritus / PhD, Princeton University, 1966)



Ioannis Chasiotis (Professor and University Scholar / PhD, California Institute of Technology, 2002) continues as the Editor in Chief of *Experimental Mechanics.* In 2019 was elected a Corresponding Member of the International Academy of Engineering.

Huck Beng Chew (Associate Professor / PhD, National University of Singapore, 2007) received two grants from NSF and AFOSR and gave an invited talk at the Century Fracture Mechanics Conference, Singapore.

Christian M. Chilan (Research Assistant Professor / PhD, University of Illinois, 2009) presented the paper "Optimal Nonlinear Feedback with Feedforward Control of High Speed Aerospace Vehicles Using a Spatial Statistical Approach" at the 2018 AAS/AIAA Astrodynamics Specialist Conference in Snowbird, Utah. The research was carried out under a contract with the Air Force Research Laboratory.

Bruce A. Conway (Professor Emeritus / PhD, Stanford University, 1981) was appointed the editor in chief of the *Journal of Optimization Theory & Applications*, which is published by Springer. As a prestigious journal in the field, it receives about 900 submissions a year, publishing approximately 175 in 12 issues per year.

J. Craig Dutton (Professor / PhD, University of Illinois, 1979) received the department's 2019 AIAA Teacher of the Year Award and presented an invited talk on compressible mixing layer experiments for CFD validation at the 2019 AIAA Aviation Conference.

Gregory S. Elliott (Professor / PhD, The Ohio State University, 1993) became AE's interim department head in January and received the campus award for Excellence in Undergraduate Teaching. He is part of a new center funded by AFRL on the interaction of deforming surfaces in unsteady aerothermal environments relevant to hypersonic flows.

Jonathan B. Freund (Donald Biggar Willett Professor of Engineering / PhD, Stanford University, 1998) completed his service as Secretary/Treasurer of the APS Division of Fluid Dynamics. He continues to serve on the editorial board of *Annual Review of Fluid Mechanics*, and directed the Center for Exascale Simulation of Plasma-Coupled Combustion.

Philippe H. Geubelle (Abel Bliss Professor of Engineering / PhD, California Institute of Technology, 1993) stepped down as the AE department head and became the Executive Associate Dean of The Grainger College of Engineering at Illinois.

Andres J. Goza (Assistant Professor/ PhD, California Institute of Technology, 2018) presented his group's work at the Computational Science and Engineering Conference hosted by the Society for Industrial and Applied Mathematics and at the Division of Fluid Dynamics conference hosted by the American Physical Society. He also served as a review panelist for the NSF Fluid Dynamics Program.

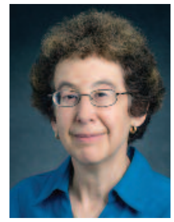
Harry H. Hilton (Professor Emeritus / PhD, University of Illinois, 1951) continued analytical studies of displacement and thermal wave propagations in linear and nonlinear elastic and viscoelastic media. His research was published in *MESA*, the journal of *Mathematics in Engineering, Science, and Aerospace.*

Kai James (Assistant Professor / PhD, University of Toronto, 2012) is the principal investigator on a new grant through the NSF-sponsored POETS Center to study 3D packaging and routing design algorithms. He is also co-investigator on a $6 million NASA grant to study the design of electric transport aircraft.

John Lambros (Professor and Donald Biggar Willett Professor of Engineering / PhD, California Institute of Technology, 1994) became officially invested as a Donald Biggar Willett Professor of Engineering of The Grainger College of Engineering and is the President of the Society for Experimental Mechanics for 2019-2020.

Cedric Langbort (Associate Professor / PhD, Cornell University, 2005)

Michael F. Lembeck (Visiting Associate Professor / PhD, University of Illinois, 1991) As the Director of the Laboratory for Advanced Space Systems at Illinois (LASSI), Lembeck's students launched two satellites (CubeSail and SASSI2) and further matured three others (CAPSat, SpaceICE, and LAICE). LASSI also took delivery of seven CubeSat mission feasibility assessments from students in AE 442/443, Senior Spacecraft Design. He also directs graduate student research in satellite hardware, test architectures, and machine learning.



Deborah Levin (Professor / PhD, California Institute of Technology, 1979) was an invited lecturer at the 31st International Symposium on Rarefied Gas Dynamics in Glasgow and was co-author on papers published in *Physics of Fluids, Physics Review E*, and *Physics Review Fluid*s.

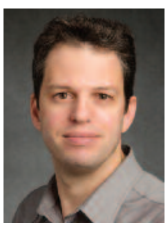
Jason M. Merret (Associate Professor / PhD, University of Illinois, 2004) is working with Phillip Ansell on the NASA-funded Center for Cryogenic High-Efficiency Electrical Technologies for Aircraft, attended the AIAA Design Build Fly Competition as the U of I faculty adviser and pilot, served as technical co-chair for aircraft design at the AIAA Aviation 2019 conference, and is the Forums (Aviation, SciTech, and CADWG) subcommittee chair for the Aircraft Design Type Certificate.

N. Sri Namachchivaya (Research Professor / PhD, University of Waterloo, 1984)

Melkior Ornik (Assistant Professor/ PhD, University of Toronto, 2017) received, along with his co-PI from the University of Texas at Austin, the NASA Early Stage Innovations award for the three-year project "Safety-Constrained and Efficient Learning for Resilient Autonomous Space Systems."

Faculty Highlights

Francesco Panerai (Assistant Professor/ PhD, von Karman Institute for Fluid Dynamics, Università degli Studi di Perugia, 2012) published six peer-reviewed articles in *Statistical Analysis and Data Mining*, the *Journal of Analytical and Applied Pyrolysis*, the *International Journal of Heat and Mass Transfer, and Experimental Thermal* and *Fluid Science.* He received two grants, including the 2019 AFOSR Young Investigator Program award to study hypersonic carbon ablation and he was invited to deliver the Swiss Light Source Photon Science Seminar at the Paul Scherrer Institute.



Marco Panesi (Associate Professor / PhD, von Kármán Institute for Fluid Dynamics and Universita degli Studi di Pisa, 2009) was an invited speaker at the 27th Dynamics of Molecular Collisions conference in Montana and was a co-author on four published papers.

John E. Prussing (Professor Emeritus / Sc.D., Massachusetts Institute of Technology, 1967)

Zachary R. Putnam (Assistant Professor / PhD, Georgia Institute of Technology, 2015) gave invited talks at Rensselaer Polytechnic Institute and the March Aerospace Control and Guidance Systems Committee meeting. He currently serves as the Technical Discipline Chair in Atmospheric Flight Mechanics for AIAA SciTech 2020.

Joshua L. Rovey (Associate Professor / PhD, University of Michigan, 2006) received a $1.2 million award with the U.S. Department of Education's Graduate Assistance in Areas of National Need (GAANN) program. His student, Chris Lyne, won both the National Defense Science and Engineering Graduate Fellowship and the NASA Space Technology Research Fellowship this year.

Theresa A. Saxton-Fox (Assistant Professor/ PhD, California Institute of Technology, 2018) published a paper titled "Effect of Coherent Structures on Aero-Optic Distortion in a Turbulent Boundary Layer" in the *AIAA Journal* and presented at the American Physical Society Division of Fluid Dynamics.

Michael S. Selig (Research Professor and Professor Emeritus / PhD, Pennsylvania State University, 1992) Selig's ARPA-E funded research Segmented Ultralight Morphing Rotor (SUMR) with collaborators from five other institutions (led by University of Virginia) has completed its third year and will be extended for two more years. Testing on a subscale SUMR demonstrator wind turbine is currently underway at NREL in Boulder, Colorado, and research on the demonstrator was presented in a paper at AIAA SciTech 2019.

Huy T. Tran (Research Assistant Professor / PhD, Georgia Institute of Technology, 2015) received three research grants on topics including autonomy and machine learning for networks, led a research project developing AI algorithms for teams of autonomous systems playing competitive games, and gave an invited talk at the University of Purdue on "Harnessing Data for Resilient Systems."

Laura Villafañe Roca (Assistant Professor/ PhD, von Karman Institute for Fluid Dynamics, Universitat Politècnica de València, 2014) published articles in *Experimental Thermal and Fluid Science* and the *Journal of Quantitative Spectroscopy and Radiative Transfer*. She participated in the CTR Summer Program in Stanford and in the NSF funded FDSI workshop in Boulder, Colorado. She continues to serve as Associate Editor of the journal *Measurement.*

Petros G. Voulgaris (Professor / PhD, Massachusetts Institute of Technology, 1991) was a co-author on six published papers and proceedings.

Brian S. Woodard (Director of Undergraduate Programs / PhD, University of Illinois, 2012) with his research team, improved the understanding of the aerodynamic impact of ice accretions of swept-wing aircraft by completing two major wind tunnel test campaigns as part of an eight-year partnership between a team of universities, the FAA, and NASA. Along with Laura Gerhold, undergraduate adviser, developed AE's first short-term, faculty-led study abroad program. Students participated in a pre-departure course before spending 12 days in Brazil working with university students and visiting several aerospace industry companies.

Faculty Research Areas

Aeroacoustics
Daniel Bodony
Jonathan Freund

Aeroelasticity
Lawrence Bergman
Daniel Bodony
Philippe Geubelle
Andres Goza
Harry Hilton
Kai James

Aerospace Materials
Ioannis Chasiotis
Huck Beng Chew
Philippe Geubelle
Harry Hilton
Kai James
John Lambros
Francesco Panerai

Aerospace Structures
Lawrence Bergman
Harry Hilton
Kai James

Aerospace Systems Design and Simulation
Phillip Ansell
Harry Hilton
Kai James
Jason Merret
Zachary Putnam
Michael Selig
Huy Tran

Applied Aerodynamics
Phillip Ansell
Daniel Bodony
Gregory Elliott
Andres Goza
Theresa Saxton-Fox
Michael Selig
Laura Villafañe Roca
Brian Woodard

Astrodynamics
Christian Chilan
Bruce Conway
Michael Lembeck
John Prussing
Zachary Putnam

Combustion and Propulsion
Daniel Bodony
Rodney Burton
Gregory Elliott
Jonathan Freund
Philippe Geubelle
Deborah Levin
Marco Panesi
Joshua Rovey

Computational Fluid Dynamics
Daniel Bodony
Jonathan Freund
Andres Goza
Deborah Levin
Francesco Panerai

Controls, Dynamical Systems and Estimation
Timothy Bretl
Christian Chilan
Cedric Langbort
Melkior Ornik
Zachary Putnam
Petros Voulgaris

Experimental Fluid Mechanics
Phillip Ansell
J. Craig Dutton
Gregory Elliot
Melkior Ornik
Francesco Panerai

Flow Control
Phillip Ansell
Daniel Bodony
J. Craig Dutton
Gregory Elliott
Jonathan Freund
Andres Goza
Theresa Saxton-Fox
Laura Villafañe Roca

Global Positioning Systems
Timothy Bretl

Hypersonics
Deborah Levin
Francesco Panerai
Marco Panesi
Zachary Putnam

Nanosatellites
Rodney Burton
Michael Lembeck
Deborah Levin
Zachary Putnam
Joshua Rovey

Space Systems
Timothy Bretl
Rodney Burton
Christian Chilan
Michael Lembeck
Deborah Levin
Melkior Ornik
Zachary Putnam
Joshua Rovey

Unmanned Aerial Vehicles
Phillip Ansell
Timothy Bretl
Gregory Elliott
Melkior Ornik
Michael Selig

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AEROSPACE ENGINEERING AT ILLINOIS ADDS UP IN 2019

RANKINGS

7 ranked undergraduate program in the nation
7 ranked graduate program in the nation

FACULTY

25 faculty members; **6** active emeritus faculty
90+ current research grants
3 NASA Space Technology Research Grants
1 NSF CAREER award
1 Young Investigator Program award

FUNDING AND FACILITIES

$9.8 million research expenditures
25+ laboratories and research centers
9 interdisciplinary research centers
3,800 sq. ft. new educational labs (coming 2020)

STUDENTS

32 average ACT score of incoming freshmen
520 undergraduate students
167 graduate students
9 registered student organizations

GRADUATES

$65,000 to $75,000 starting salary with a BS
4,694 alumni worldwide, including 3 astronauts