CornellEngineering
Sibley School of Mechanical and Aerospace Engineering

# MAE MAGAZINE

2022


## FORKLIFT LEARNING STUDIO ELEVATES ACTIVE LEARNING FOR ENGINEERS

# DAVID ERICKSON

Hello Sibley School Friends,

I hope this letter finds you well.

It's been another exciting year for the Sibley School. I'm happy to report that we were able to host our first full in-person MAE graduation this year since 2019. It was great to see all the parents, faculty and future alumni all together again in Bailey Hall (which we almost filled up). Our newly formed Sibley Advisory Council held their first on-campus meeting in April. We were also happy to celebrate Reunion '22 fully in person – featuring a reunion speech by our friend Bill Nye '77 at his 45th anniversary. Hopefully you will be able to join us on campus someday soon. Also be sure to check out our update on Bill Nye in this issue.

I think what I'm perhaps most excited to let you know about this year is of a very special anniversary we have coming up! The 2023-24 academic year will be Cornell's 150th anniversary of awarding degrees in Mechanical Engineering. To recognize this important milestone we'll be holding several events that year as part of our "MAE 150" celebration. To kick things off we have a special feature in the magazine this year by Professor Frank Moon profiling some of the Sibley School's prominent but less known alumni. Find out about Cornell's first astronaut, the founder of one of the largest aerospace companies in the world, and the inventor of the gyrocompass. To learn more, check out Professor Moon's History of the Sibley College and School.

We have several exciting updates for you this year. First, we will update you on a new program we launched called FLAME – Future Leaders in Aerospace and Mechanical Engineering. The FLAME program supports students from backgrounds that are underrepresented in mechanical or aerospace Ph.D. programs to come to Cornell for a unique multi-lab summer research experience just before their senior year. The program continues after the summer to provide mentoring and support as the cohort continues to explore the potential of pursuing a Ph.D. I'm happy to announce that we graduated our first FLAME cohort this summer. Second, we're going to take you "Inside the Forklift Studio" featuring our new instructional lab partnership with Toyota Materials Handling. This is an exceptionally exciting new direction in undergraduate experiential learning based around studios that are designed to provide more of a systems level learning experience.

This has been a truly banner year for innovation in the Sibley School. In our research news highlights section you can get a sense of the important work we are doing in the department from developing methods of improving cancer detection in Sub-Saharan Africa to improving underwater imaging for the Navy, to understanding the impact of smart thermostats on electricity grids. One particularly unique accomplishment this year was the launch of the Pathfinder for Autonomous Navigation CubeSats into space. These satellites will demonstrate the ability to autonomously navigate and doc together from a distance of 30 meters. This could have significant implications for enabling autonomous in-orbit spacecraft construction or refueling and repairing exiting spacecraft.

In our alumni spotlight, this year we profile Sibley School alum Michelle Stevens '97, learning about her career from Cornell to leadership at Sandia National Labs. We also introduce you to Will Bruey '11, M.Eng. '12, and Wendy Shimata '09 of space manufacturing startup company Varda Space Industries. Varda is a very exciting company looking at how we can manufacture some products more efficiently in gravity-free space than on Earth. Both Will and Wendy got their start in the industry working for Professor Mason Peck in the Space Systems Design Studio.

Finally this year we will also be welcoming two new, very exciting, faculty to the school. Professor Fabien Royer will join us in January 2023 and conduct research in the development of unique structures in space that can allow the creation of new spacecraft architecture and missions. One aspect of his work tries to determine what the ultimate limits are on extremely thin membranes as they unfurl to create very large space structures. Professor Cara Nunez joins the faculty in July 2023 and will conduct research in robotics, specifically focusing on haptics and developing a sense of touch for robots. Cara's work has very broad appeal in several areas but is particularly promising in healthcare, potentially enabling improved at-home care, prosthetics and rehabilitation treatments. We're very excited to welcome Fabien and Cara.

Thanks as always for your engagement with the Sibley School! I hope you enjoy the update.

Best regards,

David Erickson
SC Thomas Sze Director and Sibley College Professor
Sibley School of Mechanical and Aerospace Engineering





## INSIDE THIS ISSUE




**About the Cover**
Cover Design: Robert Kurcoba
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## SUPPORT MAE

### Sibley School Discretionary Fund

The Sibley School's Discretionary Fund supports the people, programs, and places of MAE. Making an unrestricted donation is invaluable to the school's Director. These gifts may be used to update a laboratory for virtual classroom presentations, create opportunities for students to attend conferences, and further faculty research in cutting-edge areas of engineering.

Private gifts are essential and help to ensure the continued excellence, relevance, and impact of initiatives for MAE. For more information on how your support can make a difference, please call Stephen Smith at 607.255.8285, or email him at sjs422@cornell.edu.

To learn more about how your support can impact the Sibley School, visit our Giving Opportunities page.

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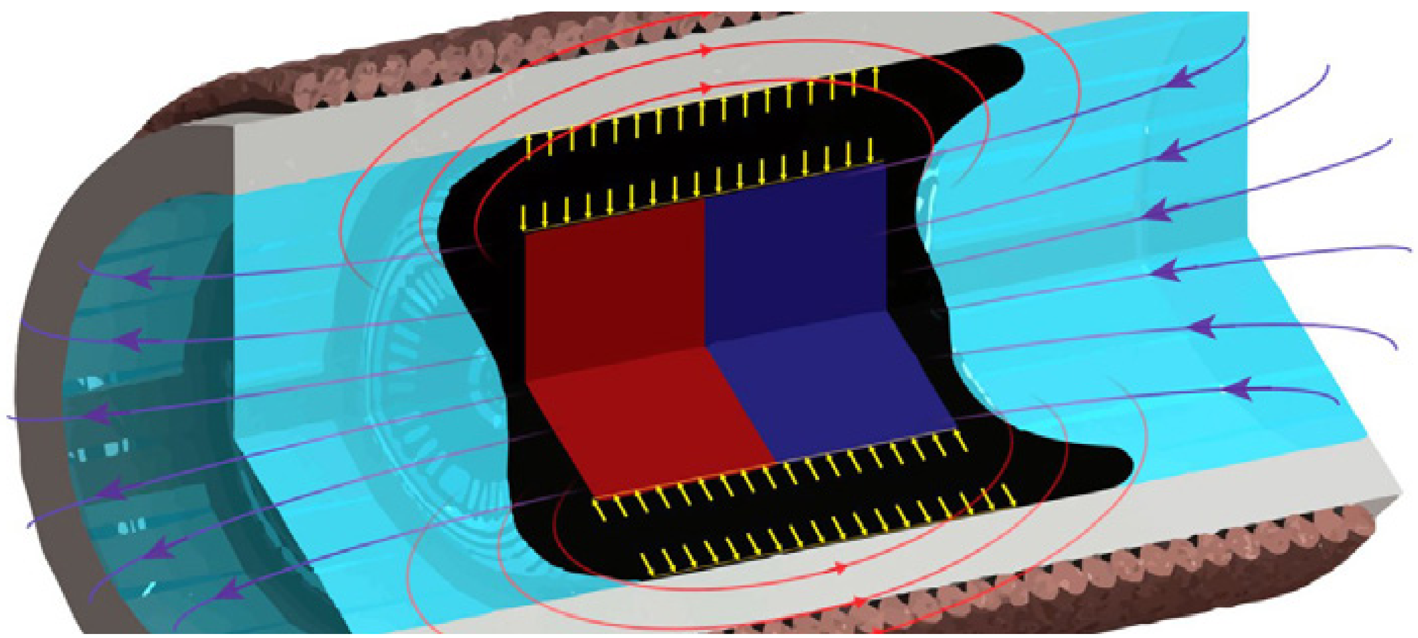
# PORTABLE CANCER TESTING EXPANDS IN SUB-SAHARAN AFRICA

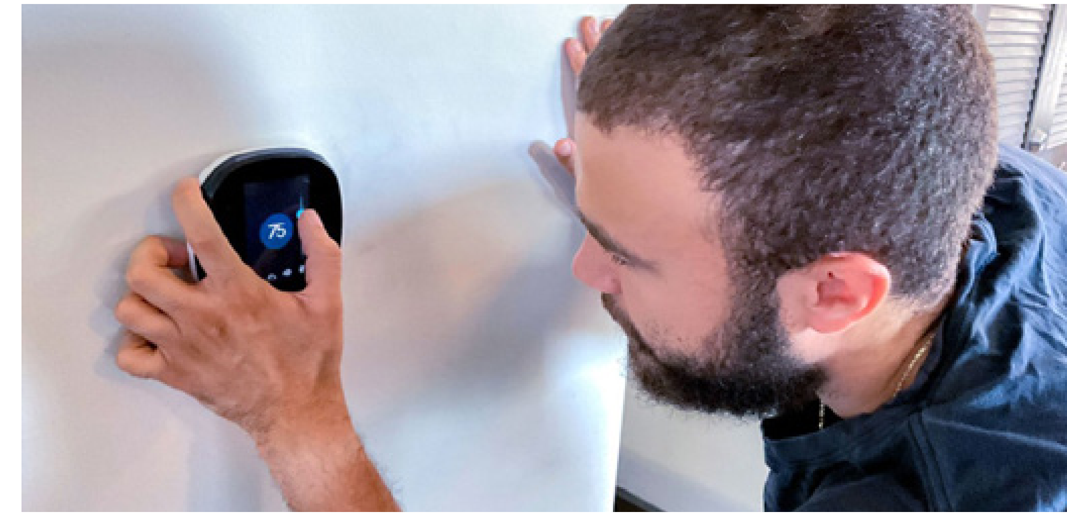

A project between the Sibley School and Weill Cornell Medicine will expand clinical tests of a portable diagnostic device designed at Cornell to identify cases of Kaposi sarcoma, a common yet difficult-to-detect cancer that often signals the presence of HIV infection. A $4 million grant will expand testing to 11 sites throughout sub-Saharan Africa, including locations in Kenya, Tanzania, Rwanda, Botswana and Malawi – where a shortage of diagnostic testing and pathology experts has led to long waits and sometimes erroneous results. "We are looking to deploy a technology that can change the paradigm of the way Kaposi sarcoma is diagnosed in sub-Saharan Africa," said project lead David Erickson, director of the Sibley School, who developed the technology with Dr. Ethel Cesarman, professor of pathology and laboratory medicine at Weill Cornell Medicine.



# DEFORMABLE PUMP GIVES SOFT ROBOTS A HEART

The Tin Man didn't have one. The Grinch's was three sizes too small. And for soft robots, the electronically powered pumps that function as their "hearts" are so bulky and rigid, they must be decoupled from the robot's body – a separation that can leak energy and render the bots less efficient. Now, a collaboration between Sibley School researchers and the U.S. Army Research Laboratory has leveraged hydrodynamic and magnetic forces to drive a rubbery, deformable pump that can provide soft robots with a circulatory system, in effect mimicking the biology of animals. "We're operating at pressures and flow rates that are 100 times what has been done in other soft pumps," said Rob Shepherd, associate professor of mechanical and aerospace engineering, who led the Cornell team.

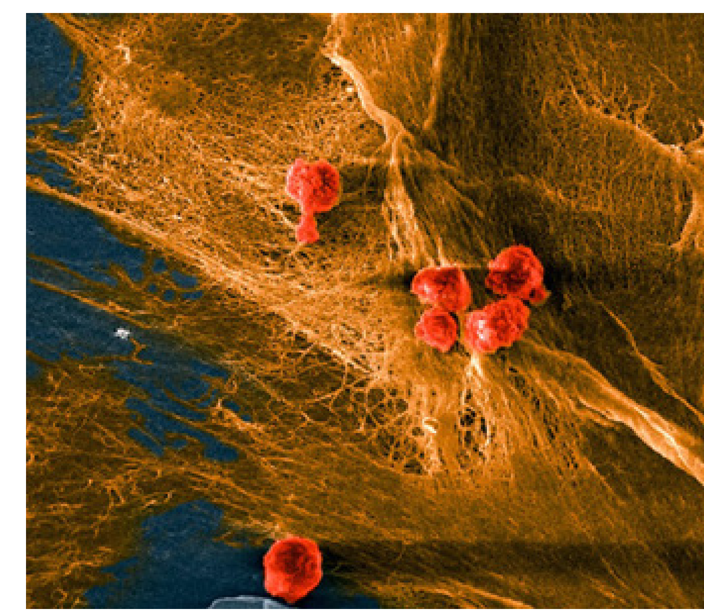
# SMART THERMOSTATS INADVERTENTLY STRAIN ELECTRIC POWER GRIDS



*Alfredo Rodriguez, a doctoral student in engineering who conducts research with Max Zhang, adjusts a smart thermostat.*

Smart thermostats – those inconspicuous wall devices that help homeowners govern electricity usage and save energy – may be falling into a dumb trap by unintentionally working in concert with other thermostats throughout neighborhoods to prompt inadvertent, widespread energy-demand spikes on the grid, according to new research from Sibley School engineers. "Many homes have their smart thermostats turn down temperatures at night in the winter," said Max Zhang, professor of mechanical and aerospace engineering. "The temperature can be programmed to ramp up before you wake up – and you'll have a warm house. That's the smart thing to do. But if everyone keeps their default setting, let's say 6 a.m., the electric grid suffers synchronized demand spikes and that's not smart for the system. That's the challenge." Zhang notes ways to address the growing pressure on the grid, such as educating consumers on how to use smart thermostats and staggering the morning ramp-up times.

# SOFT BUT TOUGH: BIOHYBRID MATERIAL PERFORMS LIKE CARTILAGE



Producing biomaterials that match the performance of cartilage and tendons has been an elusive goal for scientists, but a material created at Cornell demonstrates a promising new approach to mimicking natural tissue. The material consists of two main ingredients: collagen – which gives the material its softness and biocompatibility – and a synthetic zwitterionic hydrogel, which contains positively and negatively charged molecular groups. Nikolaos Bouklas, assistant professor in the Sibley School and co-lead author of the study, said the material's biocompatibility means it can recruit cells and keep them alive. "Ultimately, we want to create something for regenerative medicine purposes, such as a piece of scaffold that can withstand some initial loads until the tissue fully regenerates," Bouklas said. "With this material, you could 3D print a porous scaffold with cells that could eventually create the actual tissue around the scaffold."keep them alive. "Ultimately, we want to create something for regenerative medicine purposes, such as a piece of scaffold that can withstand some initial loads until the tissue fully regenerates," Bouklas said. "With this material, you could 3D print a porous scaffold with cells that could eventually create the actual tissue around the scaffold."

# CORNELL, US NAVY RAISE BAR FOR AUTONOMOUS UNDERWATER IMAGING


*Bird-eye view of the sea tests in Saint Andrew Bay in Panama City, Florida. The red dots show the locations of targets to be identified and the green lines show the pathway taken by the autonomous underwater vehicle, using algorithms developed by Cornell and the U.S. Navy.*

Tests conducted by Cornell and the U.S. Navy used new algorithms to outperform state-of-the-art programming for autonomous underwater sonar imaging, significantly improving the speed and accuracy for identifying objects such as explosive mines, sunken ships, airplane black boxes, pipelines and corrosion on ship hulls. The team, led by of Silvia Ferrari, the John Brancaccio Professor of Mechanical and Aerospace Engineering, created and tested a new imaging approach called informative multi-view planning, which integrates information about where objects might be located with sonar processing algorithms that decide the optimal views, and the most efficient path to obtain those views. The planning algorithms take into account the sonar sensor's field-of-view geometry along with each target's position and orientation, and can make on-the-fly adjustments based on current sea conditions.

*Jin Xu, Ph.D. '14, surveys sand dunes.*

# DESERTS 'BREATHE' WATER VAPOR, STUDY SHOWS

A decades-long research project led by the Sibley School's professor Michel Louge finds that deserts 'breathe' water vapor, and shows for the first time how water vapor penetrates powders and grains, which could have wide-ranging applications far beyond the desert. Special probes engineered for the research will have a number of applications – from studying the way soils imbibe or drain water in agriculture, to calibrating satellite observations over deserts, to exploring extraterrestrial environments that may hold trace amounts of water. But perhaps the most immediate application is the detection of moisture contamination in pharmaceuticals. Since 2018, Louge has been collaborating with Merck to use the probes in continuous manufacturing, which is viewed as a faster, more efficient and less expensive system than batch manufacturing.

# LOW-LEVEL JET MODELS INFORM US OFFSHORE WIND DEVELOPMENT

With the federal government planning to hold the largest sale of offshore wind farm leases in the nation's history, a new Cornell study could help inform the development of offshore wind farms by providing detailed models characterizing the frequency, intensity and height of low-level regions of fast-moving winds over the U.S. Atlantic coastal zone. The study finds that low-level jets – pronounced regions of high wind speeds occurring within a vertical wind-speed profile – do occur low enough to reach wind turbine rotor planes at planned wind farms offshore from the U.S. East Coast, according to co-author Jeanie Aird, doctoral student in the Barthelmie Wind Energy Laboratory in the Sibley School. Prior to this research there was uncertainty about how frequently low-level jets would occur in this area. "Our analysis provides maps of low-level jet occurrence showing these phenomena occur up to 12% of the time in the late spring and early summer when there are strong horizontal temperature gradients," Aird said. "We hope this research will assist offshore wind farm developers and we are working to develop a predictive method for low-level jet occurrence."

# STUDENT-BUILT CUBESATS TO RENDEZVOUS IN SPACE

*Millie Schwartz '23, Shihao Cao '23 and Andreea Foarce '22 examine one of their CubeSats at Virgin Orbit in Los Angeles.*

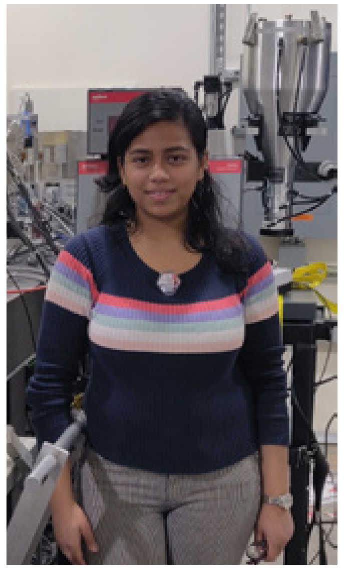
The Pathfinder for Autonomous Navigation (PAN) project, led by Mason Peck, the Stephen J. Fujikawa '77 Professor of Astronautical Engineering, is preparing to launch a pair of small, low-cost, modular satellites, known as CubeSats, into space. Once deployed in low Earth orbit, the two CubeSats will drift apart by up to 30 kilometers and then, using custom software, locate each other's position, fire their thrusters and dock together. By demonstrating that autonomous rendezvous and docking are possible at the small spacecraft scale, the project provides a critical step towards the eventual construction of advanced structures such as space stations, as well as the refueling and repairing of small spacecraft.

*Millie Schwartz '23, Shihao Cao '23 and Andreea Foarce '22 examine one of their CubeSats at Virgin Orbit in Los Angeles.*

# STUDENTS WIN NASA CHALLENGE GRANT WITH 3D-PRINTED SENSOR

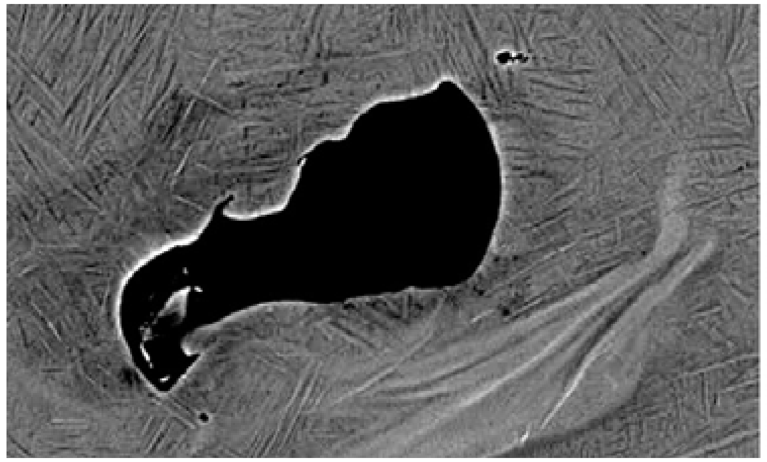
*Graduate students from left to right: Siddharth Patel, MBA '22 (Samuel Curtis Johnson Graduate School of Management), Benjamin Steeper (computer science), Adrita Dass (mechanical engineering) and Chenxi Tian (mechanical engineering). Not pictured: Selina Kirubakar (mechanical engineering).*

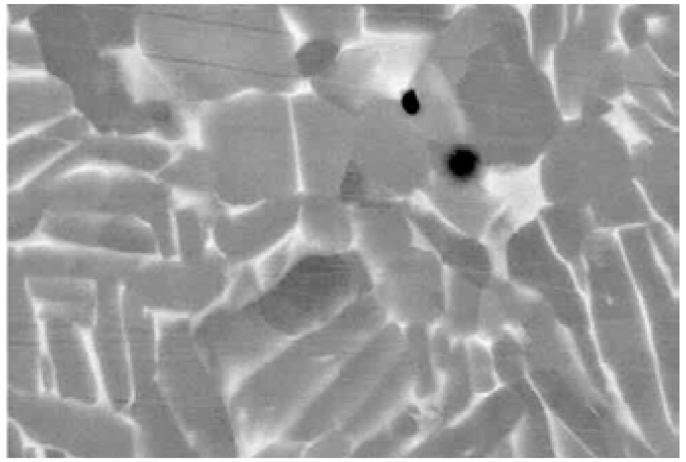
A team of Cornell students has won a grant from NASA's University Student Research Challenge for a proposed sensor that can help 3D printers build better, more reliable products. An interdisciplinary team, led by doctoral student Adrita Dass and advised by assistant professor Atieh Moridi in the Sibley School of Mechanical and Aerospace Engineering, was the first to be selected by NASA this round. The goal of the team is to build a sensor that can detect and report conditions inside an object being 3D printed. Such a sensor could help printers autonomously correct defects and other problems associated with the unpredictability of additive manufacturing.



*Adrita Dass at the CHESS Forming and Shaping Technology Beamline with a laser additive-manufacturing custom setup.*

# WHEN BAD MAKES GOOD: DEFECTS STRENGTHEN 3D-PRINTED MATERIAL





*Cornell researchers deliberately introduced defects into a 3D-printed titanium alloy (seen on the left), then applied a post-processing treatment that uses high temperature and high pressure to transform the alloy's microstructure, resulting in a material (pictured on the right) that is stronger and more ductile than other titanium printed metals.*

Sometimes it's good to be a little bad. Cornell researchers found a counterintuitive way of improving 3D-printed metal alloys. By deliberately introducing more defects into the printing process, followed by a post-processing treatment that uses high temperature and high pressure to change the material's microstructure, they turned the defects into assets, resulting in a stronger, more ductile metal product. The technique, developed in the laboratory of Atieh Moridi, assistant professor in the Sibley School, could potentially be applied to any 3D-printed metal alloy and could be particularly effective for manufacturing products for biomedical and aerospace industries.

# CARA NUNEZ

## ASSISTANT PROFESSOR

### What is your area of research?

My research mainly focuses on developing the principles and tools needed to create robotic and human machine systems, specifically systems that are capable of haptic interaction. Haptics relates to the sense of touch, and in my research this includes the design and control of novel sensors and actuators, as well as an improved understanding of human haptic perception and how we can actually use these haptic systems for improved human-robot interaction. There are a lot of different application areas that I envision my lab working in, but I'm particularly excited about applications in the medical field, including mental health, rehabilitation, prosthetics, and surgical training, among many others. I'm hoping that my work can contribute to improvements in clinical and at-home care, and the growing field of telehealth.

### What are you most looking forward to as a Cornell Engineering faculty member?

There are many reasons why I'm really excited about my new position in Cornell engineering, but I think what excites me the most about joining Cornell is actually the culture of "any person, any study." That became really clear from speaking with different faculty and students as well as visiting campus, that Cornell engineering really takes its founding principle seriously, both from the breadth of research that's being conducted by faculty, as well as ongoing DEI efforts. As somebody whose background and research is pretty diverse and interdisciplinary, it was really exciting to feel as though I found a place where both myself and my students would be truly supported and encouraged.

# FABIEN ROYER

## ASSISTANT PROFESSOR

### What is your area of research?

My research focuses on creating novel structures in space to dramatically increase the capabilities of satellites and infrastructures in orbit. I am particularly motivated by the role novel spacecraft architectures can play in addressing major societal issues such as climate change. For instance, large aperture systems can form better space radars for climate monitoring, and space-based solar power satellites can convert sunlight into microwaves and send them directly where they are needed on Earth. To create these new systems, my work leverages extremely thin fiber composite laminates – thinner than your hair – to form ultra-lightweight and very large structures (max dimension > 50 m). In particular, my research investigates how to predict and overcome these structures' fundamental limitations, how to create new in-space manufacturing and assembly concepts, and how to engineer active structures which do more than just carrying loads.

### What are you most looking forward to as a Cornell Engineering faculty member?

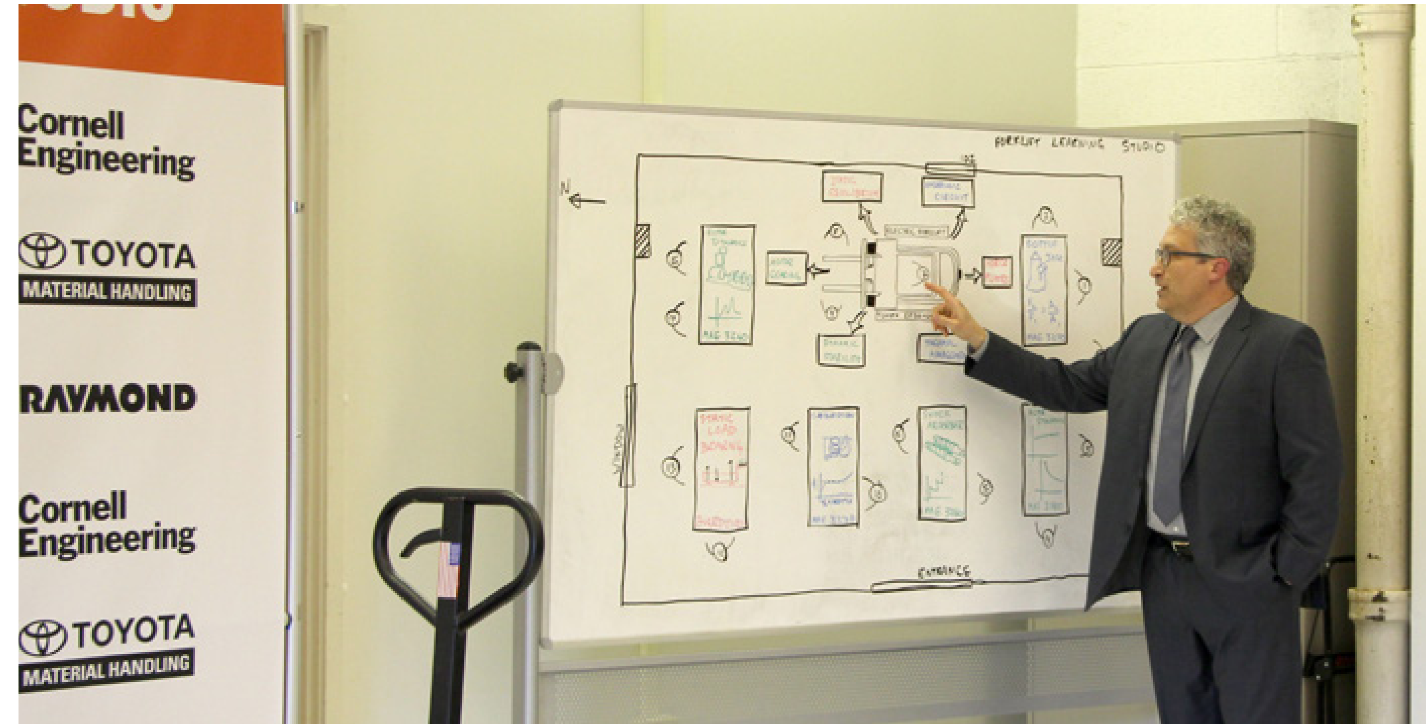
I'm extremely excited by how collaborative and interdisciplinary the MAE department is. In particular, MAE is conducting leading research in space engineering, mechanical engineering and materials. Since my research is at the interface between these disciplines, it is hard for me to imagine a better place to create my research group. I cannot wait to learn from my colleagues and see how my research will benefit from all the breakthroughs happening in the same building and beyond. I'm also looking forward to working with the passionate and highly motivated students MAE has.

# FORKLIFT LEARNING STUDIO ELEVATES ACTIVE LEARNING FOR ENGINEERS

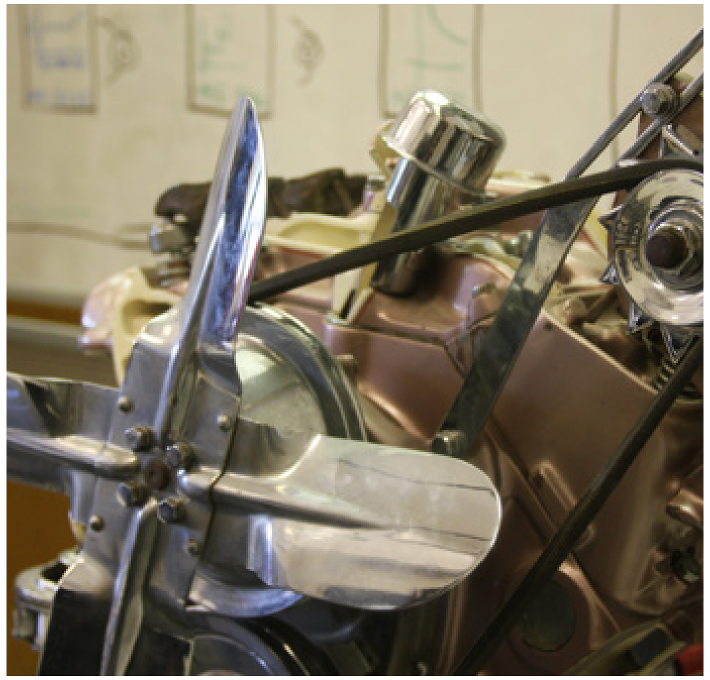
*By Eric Laine*

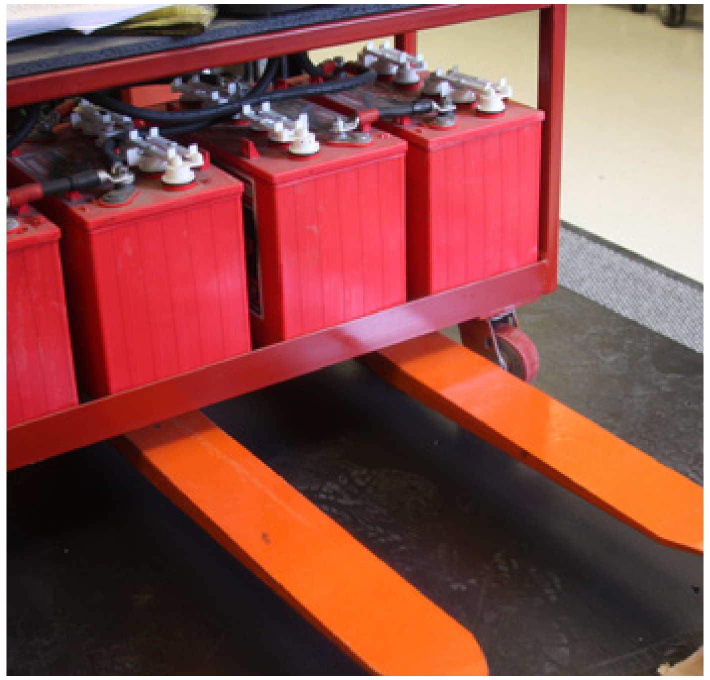

Forklifts are most often used for moving goods and materials, but a new Forklift Learning Studio at Cornell will be used to elevate engineering education, turning the vehicles into interactive tools for studying thermofluids, modeling structural mechanics, and experimenting with control dynamics.

Located on the first floor of Thurston Hall, the studio launched in April thanks to a partnership with Toyota Material Handling, which donated three models of forklifts as well as components and parts. The studio is being used this fall for ENGRD2020 (statics), MAE3230 (fluid mechanics), and MAE4272 (senior fluids/heat transfer lab).




The Forklift Learning Studio was born from discussions between Brett Wood '85, president and CEO of Toyota Material Handling North America, and Brian Kirby, the Meinig Family Professor in the Sibley School of Mechanical and Aerospace Engineering (pictured above). They wanted to build a learning space using an integrated system with enough complexity to serve a wide range of students, from first-year students to seniors. During summer 2022, Professor Kirby and Matt Ulinski, along with teaching support specialists David Hartino, Liran Gazit, and Patrick Wick, worked with a team of 13 undergraduate and M.Eng. students to build up several aspects of the instructional laboratories.





Inside the learning studio, students deconstruct and assemble forklifts and their components to learn about mechanical properties and how they integrate into a larger system. For instance, students might observe the aerodynamic forces of a spinning-cylinder Flettner rotor, while others might get hands-on with a Venturi vacuum system as part of the MAE3230 fluid mechanics course.


In one introductory fluid mechanics lab unit, exercises are aimed at understanding flow distribution. Students use anemometers to measure the flow field of box fans, a large-scale stand-in for a common component in forklifts and many other vehicles and devices. Upcoming lab units will focus on hydraulic jacks and rams, as well as other mechanical systems found in a forklift.

"I think students are going to be way more excited about fluid mechanical principles when I teach it next to a forklift with a big hydraulic ram," Kirby said. "We want students to see the links between fluid mechanics and heat transfer and system dynamics in a way that they don't if the labs are isolated from the class."





# BILL NYE '77: BRINGING SUNLIGHT TO CAMPUS AND HOPE TO TELEVISION

*Senior lecturer Joe Skovira and Cornell Maker Club co-president Smith Charles '23 with Bill Nye '77 in the Phillips Hall Maker Space*

Bill Nye '77 has seen the end of the world.

In the first half of each episode of "The End is Nye," his new streaming series on Peacock, life on Earth — and Nye along with it — is destroyed in a dramatic, yet all-too-plausible fashion. In the second half, television's beloved "Science Guy" lays strategies for averting such disasters and restoring a more harmonious relationship between humans and our planet.

Ultimately, the show's premise is a hopeful one. He makes the case that the new technologies and young minds coming out of institutions like Cornell can indeed save the world. And he doesn't merely tout them on TV. When Nye, who majored in mechanical engineering, returns to campus (which is not infrequently), he can most likely be found enthusiastically engaging with students — including those supported by scholarships he funds — and faculty about their work to solve a range of pressing problems.

*Bill Nye, '77 speaks lectures an astronomy class during a visit to campus last spring.*

"That's what changed my life, my undergraduate degree in engineering," Nye said during a visit in March 2022.

While in Ithaca, he was able to inspect the work done by students to refurbish the Bill Nye Solar Noon Clock, a large timepiece prominently displayed on top of Rhodes Hall. Even on Ithaca's cloudiest days, the clock, which Nye designed and donated in 2011, marks the Sun's highest daily position by emitting a beam of actual sunlight.

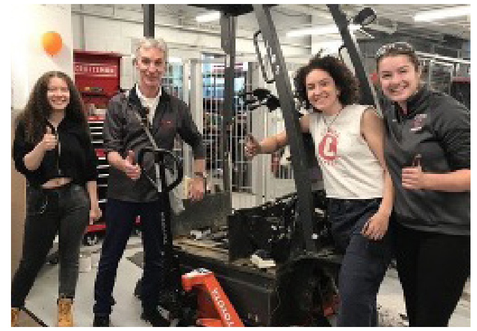
In April 2019, the software controlling the clock's solar noon indicator failed, and repairs — like many things — were delayed by the COVID-19 pandemic. This year, a team of engineering students got the clock working again, designing a replacement control system, developing new software, and adding redundancies for stability and backup.

Nye intends for his clock to continue educating and sparking wonder in the Cornell community. "I hope it gives you pause for thought about your place in space," he told a crowd of students who surrounded him as he watched the new Solar Noon Indicator in action from Hoy Field.

A few months later, returning to campus as a featured speaker at Reunion, Nye stopped by the Sibley School's new Forklift Learning Studio as it was being assembled. The innovative new space is centered around forklifts donated by Toyota Material Handling, which it uses as interactive tools for studying thermofluids, modeling structural mechanics, and experimenting with control dynamics.

When he stopped by, he later observed, all of the engineers engaged in dismantling the forklifts "with hydraulic oil up to their elbows" were women. While Cornell Engineering's undergraduate population has been at gender parity since 2018, this was something Nye said "would never have happened" when he was a student.

And it's that kind of progress that fuels his optimism that the end of the world is not as nigh after all.



*Bill Nye '77 met with students to learn about the Forklift Learning Studio.*

# SPACE SYSTEMS DESING STUDIO ALUM CREATES A GRAVITY-OFF SWITCH IN ORBIT


*In this artist's rendering of the launch booked for April 2023, Varda Space Industries' capsule is departing from its manufacturing satellite, and heading back to Earth.*

There's a new star in the aerospace industry and it's bringing a gravity-off switch to manufacturing. Varda Space Industries, co-founded and led by a Cornell Engineering alum, is sending satellites to space, where products used on Earth can be created in a zero-gravity, dust-free environment. "We're a microgravity platform for any type of manufacturing," explains Will Bruey '11, M.Eng. '12, CEO of Varda Space Industries, a company he founded in 2020 with Delian Asparouhov, and has since garnered more than $53 million in startup capital. Space manufacturing has been around for decades, dating back to 1969 when Russian cosmonauts determined that the environment of space "may solve many welding problems." Starting in the 1970s, space manufacturing took the form of experimental attempts done primarily at Skylab2, and later at Spacelab and the International Space Station. Only recently has the cost to go to space fallen to a point where it can now be economical to commercially produce some products in space. This is in part due to reusable rockets that have lowered the cost of access to space and opened up a range of in-space activities. "After our satellites separate from the rocket, they perform operations such as mixing or heating chemicals," Bruey explains, "and then, after those operations are complete, we do a deorbit burn to send small capsules back to Earth with the materials produced. Our capsules—about 1 meter in diameter—survive re-entry, deploy parachutes, and land with the manufactured contents that we then deliver to our customers.

## MAKING MATERIALS IN MICROGRAVITY

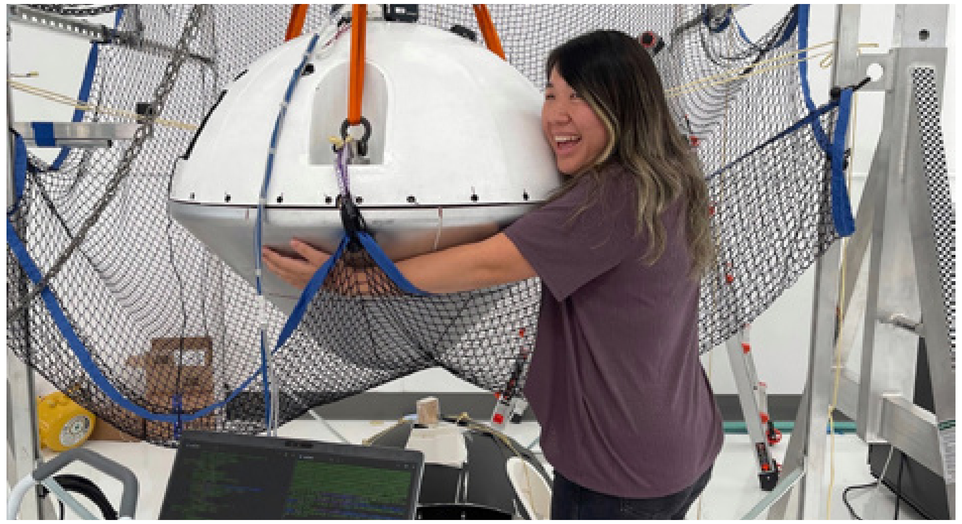
One such set of products serves the pharmaceutical industry: drugs formulated using microgravity. "The ideal application for our capsules is manufacturing high-value chemicals in space," says Bruey. "There are a lot of things we can do in space to create value for chemists on Earth, for example, drug molecules crystallize differently in microgravity than they do here on Earth. This can improve parameters of high interest, such as solubility. The reason we manufacture in space is because of the unique way microgravity influences chemistry." Crystal growth behavior—both morphology and growth rate—are different in microgravity than an equivalent setup experiencing the Earth's gravity. This is partly because as crystals grow they release heat, and that heat causes convective currents in the solution. A growing crystal that sinks due to its own weight would also create convective currents from its sinking motion. In microgravity, there is less of this convective transport. As a result, crystals grow differently, creating different geometric lattice shapes as their molecules fit and stack together in a repeating sequence. This can also create unique ratios between their morphologies as well. "This is important because the morphology of a crystal defines many of its macroscopic properties," Bruey says. "In the pharmaceutical world, solubility, or how fast the drug dissolves in the body, is a particularly important property. Space manufacturing in microgravity allows us to alter the outcome of crystal growth to influence properties like solubility."

But the applications don't stop at medicine. The International Space Station has hosted countless experiments using the unique environment of microgravity to produce unique results. Things like fiber optics, silicon wafers, and special metal alloys all have unique benefits from being fabricated in microgravity. And since gravity is a fundamental force of physics, Varda's platform can be useful across all disciplines of engineering.

## AN INDUSTRIAL PARK IN SPACE

In the long term, Bruey wants Varda to build the first off-planet industrial park at-scale. Now that rockets are reusable and the costs have dropped accordingly, there are no significant technical or economic barriers to this goal. "We're not really a typical aerospace company," he says, "because our customers don't care that we're going to space. They only care that we can turn off gravity for them." For Varda, that means manufacturing mostly small things like expensive chemicals or small products in the short-term as the space industry continues to grow. But as launch costs continue to drop, Bruey hopes to scale up both the range of products Varda creates as well as the size of each. Right now, the telecom and remote sensing industries are the primary users of space commercially. Varda wants to be at the forefront of the next innovation, which they're predicting will be the first off-planet industrial park. Bruey envisions a distributed industrial park, rather than a single large "station." Bruey envisions a set of robotic production satellites orbiting Earth, with each satellite creating a different product: drug molecules, fiber optics, etcetera.

*Will Bruey, AEP '11, M.Eng. '12, CEO and co-founder of Varda Space Industries.*



*Wendy Shimata '09, is the Director of Autonomous Systems at Varda Space Industries.*

"We can bring the raw materials to those production satellites with our Varda spacecraft, and bring back finished products with our reentry capsules." Bruey adds: "It's hard to say what's next in any industry, because it's all speculation, but I think what we can say about Varda's future is that it has a very real chance of benefiting people on Earth in ways that simply can't be done any other way. If successful, we'll end up inciting a positive feedback loop to drive human activity in space." By manufacturing those first few products, Bruey hopes he can drive demand for launches, setting that positive feedback loop in motion to decrease launch costs and increase the economical products Varda can offer.

## ROOTS IN MAE'S SPACE SYSTEMS DESIGN STUDIO

Cornell Engineering is renowned for its multidisciplinary faculty, students, and alumni, and Bruey is no exception. As an applied and engineering physics undergraduate who also received an M.Eng. in systems engineering, much of Bruey's time at Cornell was spent in the Space Systems Design Studio directed by Mason Peck, the Stephen J. Fujikawa '77 Professor of Astronautical Engineering in the Sibley School. It was there that Bruey worked on his first space project, the Violet Satellite, a first-of-its-kind nanosatellite that launched into space in 2012.

"I was really having fun when I was designing two parts of the space program," said Bruey, who was the project's attitude and control subsystem lead. "I built a charge-discharge simulation to determine battery life as a function of spacecraft attitude and position throughout its life in space. I also built an algorithm for detumbling the spacecraft using our magnetic torque rods."

*Varda employees integrate one of Varda's first spacecraft.*

Another alum of the Space Systems Design Studio is Wendy Shimata '09. At Cornell, most of Shimata's electives were space-oriented: control theory, aerospace, and GPS. She was also part of Professor Peck's project team for the CUsat Satellite, a nanosatellite designed to help calibrate global positioning systems with pinpoint accuracy. The satellite launched into orbit in 2013.

"I loved building out the first concept of what mission operations would look like to fly our vehicle, which marries all aspects of hardware and software together," said Shimata, who served on the project's attitude control subsystem team before becoming its mission operations and software lead. It was that experience that taught her valuable lessons in design, and how to address challenges along the way. "There were many late nights and weekends of realizing things like the hardware was out of spec, performance was not what we thought, the schedule didn't close, and we had to find engineering solutions to each of those things," Shimata said.

After Cornell, Shimata worked at Boeing in the guidance, navigation, and controls department for about seven years, and then accepted a job at SpaceX in the software department, eventually leading the Dragon Software team. That's where she met Bruey, and the two worked together in mission control. After founding Varda, Bruey reached out to his fellow applied and engineering physics alum to bring her on the team. Now, the two are using their Cornell education to operate one of the most innovative new aerospace companies in the industry.

"The question is, how can we be creative and innovative, because that's what really drives our industry and pushes it to new heights," said Shimata. "Cornell taught me to think about and understand almost any engineering problem, and it gave me a great toolbox of skills to do exactly that in my career."

# 7 AMAZING MAE ALUMNI YOU NEED TO KNOW

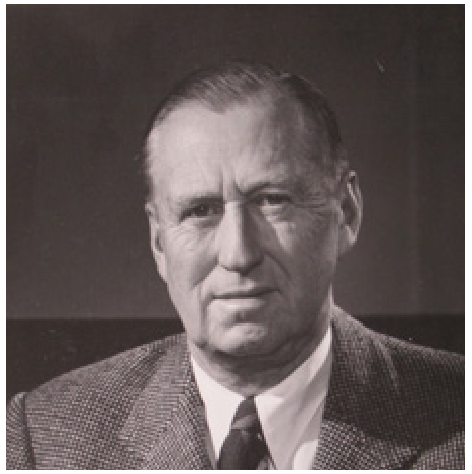
*By Syl Kacapyr and Frank Moon*

Next academic year the Sibley School will be celebrating 150 years of alumni. While engineering and mechanic arts students were studying at Cornell as early as 1868, it wasn't until the 1873-74 academic year that a four-year Bachelor of Mechanical Engineering degree was offered by what was then the Sibley College of the Mechanic Arts.

There have been many extraordinary engineers to receive the degree throughout the Sibley School's history – some, like Willis Carrier, Class of 1901, and Bill Nye '77, are well known among the Cornell community, but many other exceptional alumni have made their mark on the world with less fanfare.

Sibley School historian and emeritus professor Francis Moon was asked to list some of his favorite, lesser known alumni and their achievements. Moon, a member of the National Academy of Engineering, is author of "A Brief History of the Sibley College and School of Mechanical Engineering at Cornell," which can be found on the Cornell Engineering website. He is currently working on a book detailing the history of the Sibley School in greater detail.

Here are seven amazing Sibley School alumni you should know:



## Leroy Grumman, Class of 1916

Although Ohio is often called the cradle of aviation as home to the Wright brothers, Upstate New York can also claim co-cradle status thanks in part to several alumni of the Sibley School.

One of these was Leroy Randle Grumman who was a 1916 graduate. As salutatorian at his high-school graduation, he said, "The final perfection of the airplane will be one of the greatest triumphs that man has gained over matter." After finishing at Cornell, he would later enlist as a Navy pilot in World War I and eventually create his own aircraft company centered in Long Island.

Grumman became an expert in lightweight aircraft structures which earned Grumman Aircraft Company Navy contracts. He developed carrier-based aircraft and perfected the folded wing and retractable landing gear before and during World War II. In 1958, Grumman's company manufactured the Gulfstream, the world's first business jet, and would go on to build the Lunar Excursion Module for the NASA Moon missions. The company exists today as industry giant Northrop-Grumman.

In the 1950, Leroy Grumman and his family donated funds to Cornell to build Grumman Hall.

## Dorothy Allison Carlin, Class of 1924

While many know Kate Gleason as Cornell's first woman mechanical engineering student, Dorothy Allison Carlin was the seventh woman to study engineering at Cornell, and would have a hand in building some of the most traveled transportation hubs in the world.

According to newspaper clippings shared by historian Fran Becque, Allison Carlin became the first woman civil engineer employed by the Philadelphia Transit Department after graduating from the Sibley School in 1924. As a structural draftswoman, Allison Carlin helped to create the high-speed rail connecting Philadelphia to New Jersey. An article in the Philadelphia Inquirer reported that her hiring caused a "flutter" among her male counterparts, who wondered if they should start wearing coats during work hours. Allison Carlin, who was offered the job on the merits of her Sibley School degree, was reported to announce, "It's coats off."

Allison Carlin later served as an engineer with famed architect Eero Saarinen on projects at Dulles International Airport, JFK Airport, and the iconic St. Louis Gateway Arch.

## Elmer Sperry and sons, circa 1876-1917

Elmer A. Sperry, inventor of the navigation gyro compass in 1908, was a part time student at the Sibley School circa 1876 to 1880, and worked with Professor William Anthony to build the Gramm dynamo that powered an electric lighting system on the Cornell campus, the first outdoor electric lights at a university.

Sperry – a Cortland, N.Y., native – later founded an electric generator company in Chicago. After creating over 200 patents, his greater fame was based on his invention of a gyro navigation system and stabilizer. He subsequently founded the Sperry Gyroscope Company, and the gyro-based technology was eventually adapted for flying aircraft.

Sperry had three sons, two of whom studied mechanical engineering at Cornell: Edward, Class of 1915, and Elmer, Class of 1917. They each played roles in the company. Ahead of his time, Sperry also produced an electric battery powered automobile with a 100-mile range, that was exhibited in Paris in 1896.

## G. David Low '80

Mae Jemison, M.D. '81, may be Cornell's most popular astronaut, but G. David Low was the university's first.

Low graduated from the Sibley School in 1980, and after working for NASA's Jet Propulsion Laboratory, would become an astronaut and fly three space missions: STS-32 [1990], STS-43 [1991] and STS-57 [1993]. On his first NASA flight into space, he took a pair of Ezra Cornell's silk wedding socks with him. These 'space socks' are still in the Cornell archives.

"There's not a lot of research value, but it's just one of those things that is really cool," said university archivist Evan Earle '02, M.S. '14, of the socks.

The flight aboard the Columbia wasn't all fun and games for Low, who led the deployment of the SYNCOM IV-5 Navy communications satellite and conducted all of the medical experiments for the mission. Between all of his flights, Low logged more than 700 hours in space.

After retiring as an astronaut, Low joined Orbital Sciences Corporation and managed the company's commercial space transportation program.

## Chih-Kung Lee, Ph.D. '87

If there is one thing that characterizes Sibley School alumni it is leadership.

A notable example is Chih-Kung Lee, who received his doctorate in 1987 and has risen from IBM research engineer, to professor at National Taiwan University, to Taiwan's Minister of Economic Affairs.

As a doctoral student, Lee worked with Professor Francis Moon and together they were awarded a patent for a piezo vibration sensor based on Lee's research. He later worked at the IBM Research Center in San Jose, C.A., on magnetic disc drives and optoelectronic systems, receiving two distinguished invention awards.

Lee returned to Taiwan as a professor at the Institute of Applied Mechanics, NTU, and established a nano-bio MEMS group. His creative energy in research led him to many leadership positions, including Minister for Economic Affairs in Taiwan. Today he serves as Chairman of the Industrial Technology Research Institute of Taiwan.

Always with a smile on his face, Lee acknowledges his Cornell education by sending professor Moon a gift of Taiwan tea annually on Chinese Teacher's Day.

### Nadine Aubry, Ph.D. '87

When it comes to accolades, Nadine Aubry has more than a few.

The professor of mechanical engineering at Tufts University is an elected member of the National Academy of Engineering – one of the highest honors for an engineer – for her contributions to low-dimensional models of turbulence and microfluidic devices, and for leadership in engineering education.

Coming from France, Aubry enrolled as a graduate student in the Sibley School, working with world expert on fluid turbulence, Professor John Lumley.

Aubry is also an elected member of the American Academy of Arts and Sciences, and is a fellow of the American Physical Society, the American Society of Mechanical Engineers, the American Association for the Advancement of Science, the American Institute of Aeronautics and Astronautics, the American Academy of Mechanics, and the U.S. National Academy of Inventors.

Aubry is a former provost and senior vice president at Tufts, had served as dean of Northeastern University's College of Engineering, and was head of its Department of Mechanical Engineering, among other titles.

### Swati Mohan '04

For a moment in time on Feb. 18, 2021, millions of people – 14 million on YouTube alone – were hanging on to every word spoken by Swati Mohan.

"Touchdown confirmed," said the 2004 Sibley School graduate, who narrated the historic landing of the NASA Perseverance rover on Mars. Broadcasting to the public from mission control at NASA's Jet Propulsion Laboratory, Mohan concluded, "Perseverance is safely on the surface of Mars, ready to begin seeking the signs of past life."

Mohan had worked on the Perseverance team since 2013, when the mission began, and called the landing as the mission's guidance, navigation and controls operations lead. She also worked on NASA's Cassini mission just as the spacecraft took its first images of Saturn, and on NASA's Gravity Recovery and Interior Laboratory mission, which used a spacecraft to map the gravitational field of the moon and determine its interior structure.

In an article for the MAE Newsletter, Mohan said a CubeSat project at Cornell "helped me find my niche that I've continued in throughout my career so far."





# FLAME PROGRAM AN 'EXCITING NEW MODEL' FOR BUILDING FUTURE LEADERS

*Associate Professor Nelly Andarawis-Puri (right) with two students from the FLAME program.*

The Cornell FLAME Summer Program (Future Leaders in Aerospace and Mechanical Engineering) provides rising college seniors from historically underrepresented backgrounds a unique opportunity to launch into a Ph.D. degree through enhanced summer research experience. The program also offers participants a subsequent fast-tracked and prioritized admission into the Cornell MAE Ph.D. program with tailored programmatic and financial support.

FLAME was launched last summer in the Sibley School of Mechanical and Aerospace Engineering by Nelly Andarawis-Puri, the Clare Boothe Luce Associate Professor and director of graduate studies.

"We welcomed our first talented cohort of two FLAME students all the way from the west coast," Andarawis-Puri said. "They participated in cutting-edge research in the areas of biomechanics of orthopaedic soft tissue injuries, optimization and visualization of GEDI devices with a view toward optimizing repeatability of cancer cell capture, utilization of UV light to minimize biofouling of polymers, and bio-inspired analysis of maneuverability. It's clear that FLAME can have an impact on ensuring our best and brightest consider a graduate degree in engineering at Cornell."

Andarawis-Puri added that the program will grow to nine students next summer.

The FLAME website describes the program as "an exciting new model that combines some of the best elements of summer research programs and longer-duration bridge programs to provide selected students with intensive mentoring and community development experiences. It also provides students with a pathway for early admission into the mechanical engineering and aerospace engineering Ph.D. programs."

FLAME is designed for students interested in advanced manufacturing and materials, biomechanics, bioengineering, energy and sustainability, robotics and autonomy, and space science and engineering.

Applications are now open for the next cohort, with the program running from June 11 to Aug. 11.

# AT THE FOREFRONT OF NATIONAL SECURITY

## Q&A with Michelle Stevens '97, director for the Weapons Design and Assurance Center at Sandia National Laboratories

*Michelle Stevens*

For over 15 years, Michelle Stevens '97 has made significant contributions to multiple mission areas at Sandia National Laboratories. She currently serves as the director for the Weapons Design and Assurance Center, which delivers consistent, high-quality components for applications that support the U.S. National Security Mission.

In previous roles at Sandia, Stevens was responsible for the governance of our nuclear weapons programs and provided independent technical analyses to an executive team in support of well informed, risk-based decisions. She also led the Independent Surety Assessment group responsible for assessing the technical performance of the U.S. nuclear weapons stockpile and modernization programs. Prior to that, she supported Sandia's role in NNSA's Global Threat Reduction Initiative which was focused on securing potentially vulnerable radiological and nuclear material from theft or misuse.

Prior to Sandia, Stevens spent six years as a product development engineer at Ford Motor Company where she was responsible for component designs ranging from rear suspensions in Super Duty trucks to the body and trim of the Ford Focus and Mustang.

Stevens earned her B.S. degree in mechanical engineering from Cornell University and later earned her M.S. degree in systems engineering and management at Massachusetts Institute of Technology.

**When you were looking at colleges, what interested you in Cornell University and, in particular, Cornell Engineering?**

To be honest, Cornell wasn't on my radar because I thought it was too big. I thought I wanted to go to Princeton. As we were driving there for a visit from Ohio, my dad suggested we stop at Cornell since it was on our way, and I absolutely loved it. It has such a beautiful campus. I got a great vibe, so I applied early decision and was accepted. I was absolutely ecstatic the day I learned I was accepted.

Cornell has a great focus on academics and you can't beat the ethos.

**Can you tell us about your journey to this point in your career? What was your trajectory into your current position?**

I started out in the automotive industry at Ford Motor Company. I was a MechE concentrating in biomechanics with Dr. Don Bartell, back in the day when he was an active professor at Cornell. I had a lot of fun as a mechanical engineer working for Ford Motor Company designing cars, playing on a test track conducting design evaluations for vehicles. But at the end of the day, while I'm glad that we have a profit industry for certain things, it just wasn't very motivating for me.

I went back to school and got my Master's in system design from MIT, learning how to engineer large-scale systems. After that, I interviewed with Sandia National Labs whose mission is "exceptional service in the national interest." I felt very captivated by that. It has been part of Sandia's DNA since the founding and it really motivates us as a laboratory, nonprofit organization, serving in the best interests of the U.S. government. At Sandia, I moved through a number of different rotations relatively quickly and ultimately moved into management. Partly because that was my training and partly because that's what I gravitate towards. I was working with multidisciplinary engineering teams, spending some time securing radiological and nuclear materials both domestically and internationally, then went over to our nuclear weapons work. From a nuclear weapons perspective, what we do is increase the security and safety of our nuclear weapons so that they always work when we expect them to and never operable in any other scenario. I found myself energetically able to get behind making our weapons more secure and safer. There has also been a big push for modernization of the stockpile of which I have been involved in for the past several years. I have also done some other work to make sure I understand the world around us and the drivers for a nuclear deterrence. I'm currently in a director role, where I'm responsible for delivering what we call non-nuclear components for our nuclear weapons, again, making them more safe and more secure.

I would say my time in industry really helped me understand the difference between the ways corporate America provides a very vital role, and then the unique role that we play at the national labs. We are what's called an FFRDC, a federally-funded research and development center which is a nonprofit organization dedicated to providing the nation with premier science and engineering for national security and technology innovation. I find that aspect very compelling and fulfilling.

**Please share with us some of the research (non-classified) you are currently involved in at Sandia National Labs.**

What's fascinating is most of the projects engineers work on in industry are devices that provide real-time data and feedback from being used. Automobiles, for example, are operational, so you get real-time operational feedback. Nuclear weapons, on the other hand, provide a very unique challenge. Weapons are fielded for extended periods of time and you must validate the safety, security and reliability of these systems for decades, even though they are in a dormant state. That's very fascinating from an engineering perspective; building in confidence in performance over decades, without the more traditional feedback loops that you get in most engineering industries.

**What are you looking for when you are recruiting new talent? What insights can you give current Cornell Engineering students?**

What we look for is technical excellence, which is part of what Cornell provides. Students who come out of Cornell are exceptional on the technical front. And along with the technical skills is also that curiosity, and that sense of being able to tackle open ended, ambiguous problems. Cornell Engineering doesn't do test sets that are from the book, and that helps to build students who are able to think critically for themselves and to apply concepts in new domains and new areas. What's also important is all the team projects that are done at Cornell are outstanding preparation for real world. Everything we do is team based; there's almost nothing that gets done by one or two people at the labs as we are tackling very challenging problems. And the ability to function with other engineers in different domains is incredibly important, because very few problems that we solve are strictly mechanical, electrical, or computer science. Additionally, we look for people with the right mindset – people who are great team players, are motivated by tough challenges, and are motivated by service in the national interest.

**What insights can you give current engineering students to prepare themselves for the next step?**

One of the things that we're noticing is sometimes students are trained to get the right answer. And if they don't have the right answer, then they failed, right? What we need is to have a workforce that is willing to put their designs out there and find out what's wrong with them; put them up under critical review and not feel like they are personally being judged for their capability. It's about getting the design right, not actually being right. That ability to be resilient in the face of your design not being perfect in early stages is what we really need. If you're going to work on cutting edge things or pushing boundaries, you're going to get it wrong sometimes; invite critical thinkers to come and critique your design to ensure it's the best solution we can offer to the nation.

What makes you proud to be a Cornell alumnus?

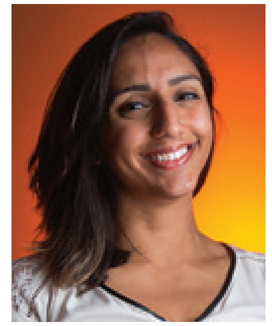
Cornell taught me critical thinking and perseverance. Cornell also taught me how to operate with humility and be more comfortable in ambiguity. I'm very thankful for those lessons.

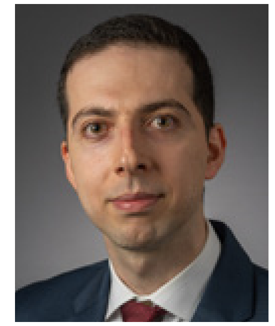
# FACULTY AWARDS


Nikolaos Bouklas


David Erickson


Silvia Ferrari


Maha Haji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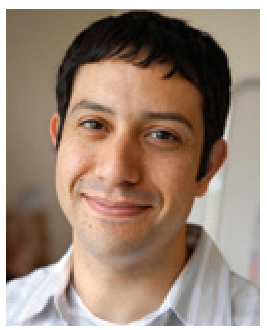
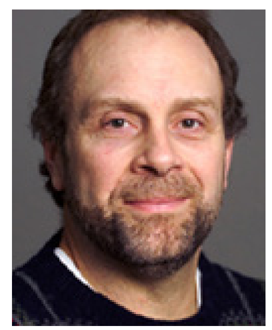
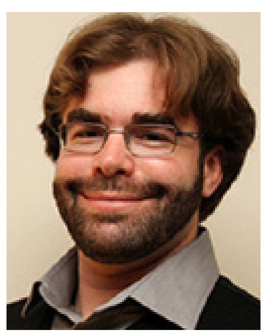

Chris Hernandez

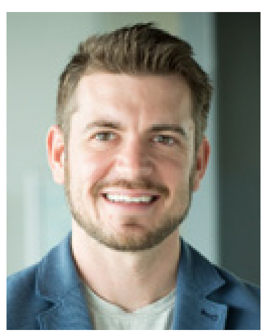

Guy Hoffman


Michel Louge


Matt Miller


Atieh Moridi


Dmitry Savransky


Rob Shepherd


Sadaf Sobhani


Zhiting Tian


Charles Williamson

**Nikolaos Bouklas, assistant professor,** received an Air Force Research Laboratory Young Investigator Award for his proposal "Machine Learning Enabled Structural Mechanics."

**David Erickson, S.C. Thomas Sze Director and Sibley College Professor,** was elected to the American Institute for Medical and Biological Engineering College of Fellows.

**Silvia Ferrari, the John Brancaccio Professor of Mechanical and Aerospace Engineering,** was named the inaugural associate dean for cross-campus engineering research. This newly created role is designed to develop impactful initiatives and cross-campus research partnerships that lead to research centers of excellence that span the Ithaca and New York City campuses.

**Maha Haji, assistant professor,** was awarded a grant from The Northeast Sea Grant Consortium in partnership with the U.S. Department of Energy's Wind Energy Technologies Office and Water Power Technologies Office, and NOAA's Northeast Fisheries Science Center.

**Mostafa Hassani, assistant professor,** received a National Science Foundation Early Career Development Award for his proposal "Understanding Bond Formation, Microstructural Development, and Mechanical Properties in Cold Spray Additive Manufacturing – A Unified Experimental and Numerical Approach."

**Chris Hernandez, professor,** was one of three researchers nationwide named to the inaugural class of NSF BRITE Fellows. The award comes with $1 million, which he'll use to research engineered living materials. He was also elected a fellow of the Biomedical Engineering Society for his contributions to the field of biomedical engineering, and was named Educator of the Year (Higher Education) by the Society of Hispanic Professional Engineers.

**Guy Hoffman, associate professor,** had his research "The wearable robotic forearm: Design and Predictive Control of a Collaborative Supernumerary Robot" featured on the cover of Robotics MDPI.

**Michel Louge, professor,** was approved by the Cornell Board of Trustees for Emeritus status.

**Matt Miller, professor,** was elected the Willis H. Carrier Professor in Engineering, succeeding professor Charles Williamson who retired in June.

**Atieh Moridi, assistant professor,** won a 2022 Early Career Research Award from the U.S. Department of Energy's Office of Science for her proposal "Isotropic Microstructure and Defect Tolerance in Additive Manufacturing by Leveraging Metastability in Alloy Design." She also received an Office of Naval Research Young Investigator award.

**Dmitry Savransky, associate professor,** received the Dennis G. Shepherd Teaching and Advising Award from Cornell Engineering.

**Rob Shepherd, associate professor,** was named a Senior Member of the National Academy of Inventors.

**Sadaf Sobhani, assistant professor,** is leading a FuzeHub grant in partnership with ceramic 3D-printing company Lithoz America and energy startup Dimensional Energy to develop 3D-printed ceramics for clean energy reactors.

**Zhiting Tian, associate professor,** received a NASA Space Technology Research Grant to investigate advanced materials for power transmission on the moon; an Air Force Research Laboratory Young Investigator Award for her proposal "Limiting Phonon-Induced Decoherence in Superconducting Qubits"; and a Thomas Jefferson Fund from the FACE Foundation for her project "Unveiling Thermal Channels in Disordered Macromolecules."

**Charles Williamson, formerly the Willis Carrier Professor,** was approved by the Cornell Board of Trustees for Emeritus status.

# STUDENT AWARDS

**Govind Chari** received the Sibley Prize, given to an undergraduate student with the highest cumulative GPA.

**Ezra Brody** received the Sibley Prize for Excellence in Graduate Teaching Assistance, given to a student recognized as an outstanding TA.

**Chase Fang** received the Outstanding Achievement Award, given to the student with the highest cumulative GPA in the Master of Engineering Program.

**Mohammad Ali Moghaddasi** received the Outstanding Senior Award for distinction in leadership and engagement.

**Nate Thompson** received the Frank O. Ellenwood Prize, given to the senior who achieved the highest GPA in heat and power courses.

**Tanner Hallet and Kenneth Cheung** received the R.N. Janeway Automotive Engineering Award, given to an undergraduate or M.Eng. student who writes the best technical paper presenting an original proposal for an improvement in automotive engineering.

**Rebecca McCabe and Olivia Murphy** received that Bart Conta Prize in Energy and Environment, given to an undergraduate or M.Eng. student who demonstrates excellence in energy-related studies and research.

**Evan Wilt** received the Thomas J. and Joan T. Kelly Prize, given to an undergraduate or M.Eng. student that demonstrates excellence in aerospace engineering.

**Andy Tan** received the Walter Werring Prize for Excellence in Studies, given to a student who demonstrates excellence in mechanical engineering.

**Kiet Cao, Alex Derry, Kathy Nguyen, LM Nawrocki, Jerry Jin, Tina Zhang, and Elaine Zheng** received the McManus Design Award, given to students who develop an original solution to a design problem.

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Sibley School of Mechanical and Aerospace Engineering

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