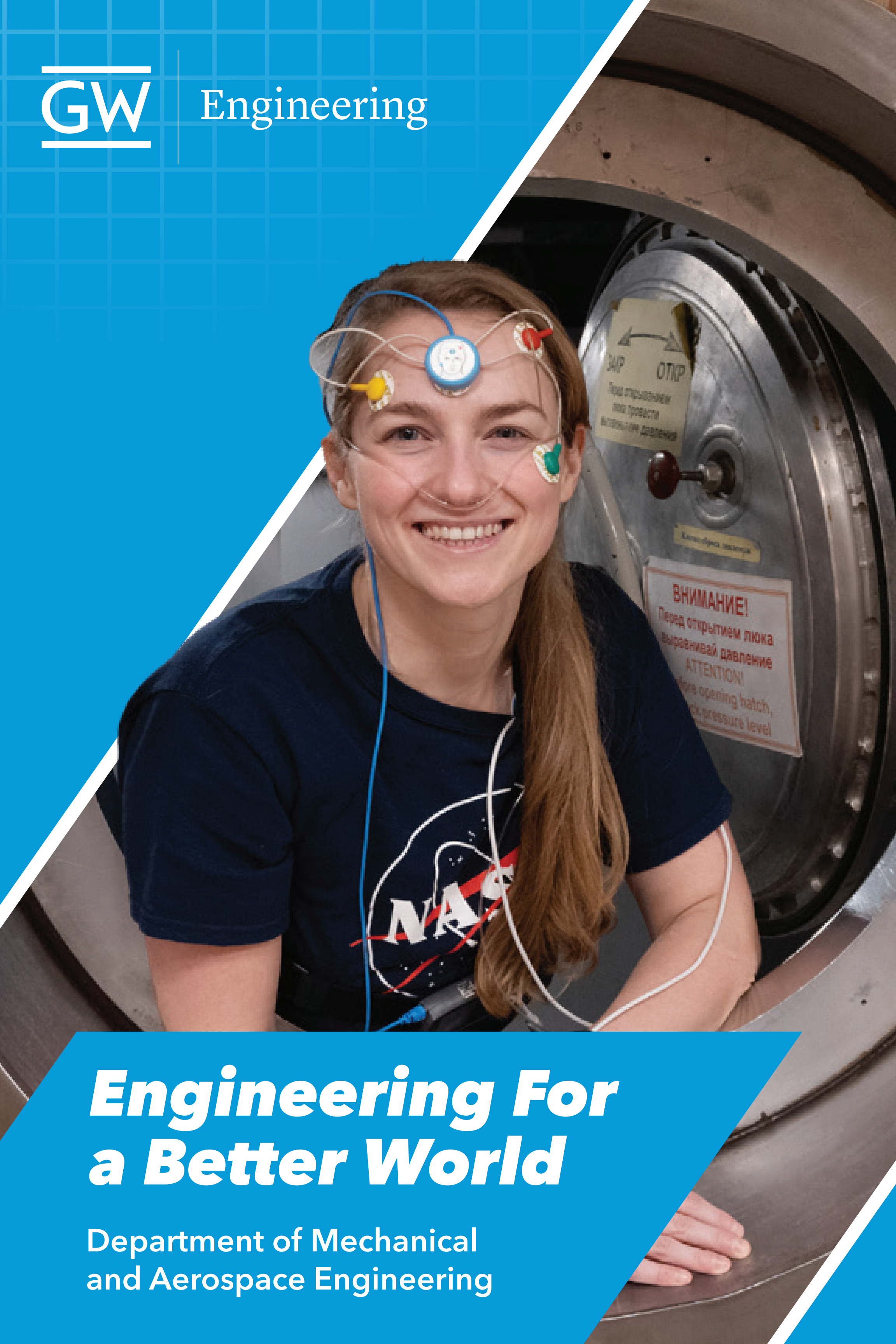
GW | Engineering



Engineering For a Better World

Department of Mechanical and Aerospace Engineering

Letter from the Department Chair

Innovations to Enhance Life in Our Global Society

From developing computer models used to plan surgical treatment of pediatric heart defects to addressing the security challenges of autonomous aircraft in high-density urban airspaces, the technologies that are vital to human life and prosperity arise from engineering innovations happening in GW's MAE Department. Our faculty works across disciplinary boundaries to blend science and art, engineering and medicine, and urban air mobility and cybersecurity. Our diverse students engage in unique, enriching, interdisciplinary, and global experiences in and outside of the classroom. Our alumni are leaders conducting important and pioneering work, such as evaluating habitats for colonization of space. GW Engineering creates a collaborative, interdisciplinary environment for students, faculty, and community stakeholders to innovate and create together – all while leveraging our dynamic location in Washington, DC.

The Department of Mechanical and Aerospace Engineering embodies this spirit of collaborative innovation. Our "Engineering and…" approach connects mechanical and aerospace engineering with the many aspects of our diverse, complex lives. With a deep understanding of how thermal and fluid sciences, manufacturing, materials science, robotics, connected autonomous systems, and design form a foundation for infrastructure and technologies that touch all aspects of our lives, our department's faculty and students build on that foundation to impact business, law, policy, and health. You may see us collecting data in the hospital, developing frameworks for technology regulation in the law school, exploring scientific frontiers with government agencies, and creating global solutions with international NGOs. We showcase a few representative examples that demonstrate how our partnerships with physicians, industries, and government agencies allow us to create relevant, meaningful solutions that impact human life and our environment.

The following profiles and stories exemplify our commitment to leveraging engineering research and education to enhance life and serve our global society. I hope you enjoy reading them.

Michael Plesniak, Ph.D.
Professor and Chair
Department of Mechanical and Aerospace Engineering
School of Engineering and Applied Science
The George Washington University

LETICIA OIWA'S JOURNEY OF GROWTH AND INNOVATION

At GW Engineering, diversity is central to addressing complex societal challenges, a principle embodied by Leticia Oiwa, a first-generation college student from Brazil. Drawn in by GW's welcoming environment, prime location, financial aid, and robust engineering program, Oiwa has thrived in the MAE Department since 2019.

Finding comfort in the vibrant international community across GW, Oiwa has benefited from support from GW's International Services Office and First Gen United but emphasized that the department's close-knit community has truly made a difference. Her advisor, Prof. Saniya LeBlanc, connected her with fellow international students working in her lab.

In 2021, Oiwa joined LeBlanc's lab conducting simple tasks with thermoelectric devices before collaborating with an industry partner to explore additive manufacturing of high-temperature polymers during her graduate studies. Driven by a desire to deepen her expertise, Oiwa is now gearing up for her Ph.D. studies, where she'll embark on a new project manufacturing quiet hydrodynamic parts.

Oiwa's journey highlights how the department's inclusive community can propel students to academic success and set the foundation for leadership in their respective fields. With the long-term goal of establishing a company that drives sustainable solutions in material science, Oiwa aspires to provide an inclusive space within this company for first-generation students and immigrants to thrive, just as she has at GW Engineering.

Leticia Oiwa at the Naval Surface Warfare Center.

SECURING THE U.S. URBAN AIRSPACE OF THE FUTURE

Prof. Peng Wei on Capitol Hill.

Imagine a world where drones deliver meals or autonomous aircraft whisk you to JFK Airport. Scaling up urban air mobility (UAM) and unmanned aircraft system (UAS) operations could make this a reality. However, the autonomy and coordination of diverse, large-scale aircraft simultaneously introduce vulnerabilities to remote attacks through communication channels like WiFi, and with thousands of UAMs in the sky, it's easy to envision the heightened consequences of such attacks.

To combat these risks, Prof. Peng Wei leads a three-year project funded by NASA's University Leadership Initiative to safeguard autonomous aircraft flying in high-density urban airspaces against cyberattacks. His interdisciplinary team, blending industry and academic partners, specializes in aircraft autonomy, cyber-physical and multi-agent system security, system-level resilience, and more.

The team will leverage their diverse expertise to develop a robust security framework and algorithm foundation, ensuring secure implementation across the entire software stack. This involves integrating secure software components at every level–from applications and services to middleware and real-time operating systems–to build a resilient platform.

Collaborating with NASA's System-Wide Safety Project, the team will develop online workshops to promote technology transfer into the broader aviation community. The project also serves as a training ground for MAE students in cybersecurity and artificial intelligence. In June 2024, Wei highlighted this project's national security significance to lawmakers, emphasizing its role in promoting innovation while ensuring urban airspace safety and security.

Blending Aerospace Engineering and International Affairs for Success

(TOP) **Ashley Kowalski, B.S. '11, M.S. '12.**
(RIGHT) **Kowalski using NASA glovebox to analyze "lunar regolith" collected during her "lunar surface EVA" as part of SIRIUS-21 mission.**

GW Engineering alums are distinguished by their passion for engineering and diverse interests across various disciplines. Ashley Kowalski, B.S. '11, M.S. '12, is one such alumnus who began her academic journey unsure of her career path but dedicated to becoming a well-rounded engineer. In addition to providing technical depth, the MAE Department curates "engineering and…" learning experiences that allowed Kowalski to merge her interests, uniquely preparing her for a career as an international aerospace leader.

"It was of utmost importance to me to mold my background and experiences to cultivate a career that combined a technical engineering background with my interest in human spaceflight, international affairs, foreign languages, and space policy," said Kowalski.

Kowalski explored her interests through the department's interdisciplinary curriculum. Through the combination of her language and international affairs courses, GW Engineering's diverse population, MAE faculty-facilitated fellowships in Germany and China, and a post-graduate fellowship in Russia later in her career, she learned to collaborate across cultural and linguistic differences and appreciate varied problem-solving approaches. As a Project Leader at The Aerospace Corporation, she leverages this knowledge daily to aid the U.S. Space Force in international collaborations.

Kowalski served as the Flight Engineer for NASA's SIRIUS-21, a 240-day simulated lunar mission that studied the effects of isolation and confinement on the human body. During SIRIUS-21, Kowalski was pivotal in executing 70+ psychological, physiological, immunological, microbiological, and operational experiments, thus furthering our understanding of the human body for long-duration human spaceflight. These included understanding the value of virtual reality for skills maintenance and psychological support, documenting team dynamics, collecting bodily samples, and experiencing sleep deprivation and delayed communications, among others. Kowalski's language skills were also crucial as the working language was split between English and Russian. After SIRIUS-21, she was the Crew Engineer in the first all-Aerospace analog mission at the Mars Desert Research Station, further showcasing her dedication to space exploration.

From uncertainty to a successful career in aerospace engineering, Kowalski's journey showcases the value of a well-rounded engineering education and exemplifies how the department's commitment to an interdisciplinary education empowers students to thrive in diverse careers.

(RIGHT) **Formation of a ring vortex (colored iso-surface) during the filling of a child's right ventricle. Light gray marks the ventricular walls, and dark gray represents the tricuspid valve. This visualization is from a patient-specific direct numerical simulation performed on the Pegasus supercomputer at GW, capturing blood flow and pressure data across 1 billion points.**

Improving the Diagnosis and Treatment of Pediatric Heart Defects

Every 15 minutes, a baby is born with a congenital heart defect (CHD) in the U.S. To diagnose and treat these conditions, clinicians rely on advanced imaging technologies to detail the heart's geometry and blood flow properties. However, the images have limited spatiotemporal resolution and lack critical biomarkers like blood flow gradient, hindering the discovery of new metrics better correlated to clinical outcomes. Over the past five years, Prof. Elias Balaras has collaborated with the Children's National Hospital to merge imaging with mathematical modeling to address these limitations and achieve enhanced care for various pediatric heart defects.

Balaras uses these images as boundary conditions to perform blood flow computations using advanced in-house solvers. Collaborating with cardiologists is vital, as imaging tool manufacturers often restrict access to the format of their data, requiring improvisation. Clinical partnerships ensure the model is aligned with clinical reality and enable real-time feedback and adjustments. Balaras also leverages Children's Hospital's extensive database of CHD cases as the basis for his research.

In one project, Balaras examines before and after cases of Tetralogy of Fallot, particularly focusing on the absence of the pulmonary valve. Surgeons must delay replacing it with a prosthetic valve until the child grows older, leading to widespread debate over the timing of this surgery. Using his models, Balaras conducts "what if" scenarios to identify the biomarkers that simulations can compute and determine if they better correlate with the already known clinical outcomes. In this instance, this knowledge may allow clinicians to identify specific biomarkers as criteria for when surgery is needed to replace the valve.

Preliminary results show Balaras' image-driven direct numerical simulations offer a higher resolution of one to two orders of magnitude than the original images. Further validation is needed, which he will pursue through ongoing collaboration with Children's Hospital and expanding to additional facilities. As computing capabilities improve and costs decrease, Balaras' approach promises physicians better, faster results for diagnosing and treating CHD, meeting the urgent need for improved outcomes for our youngest patients.

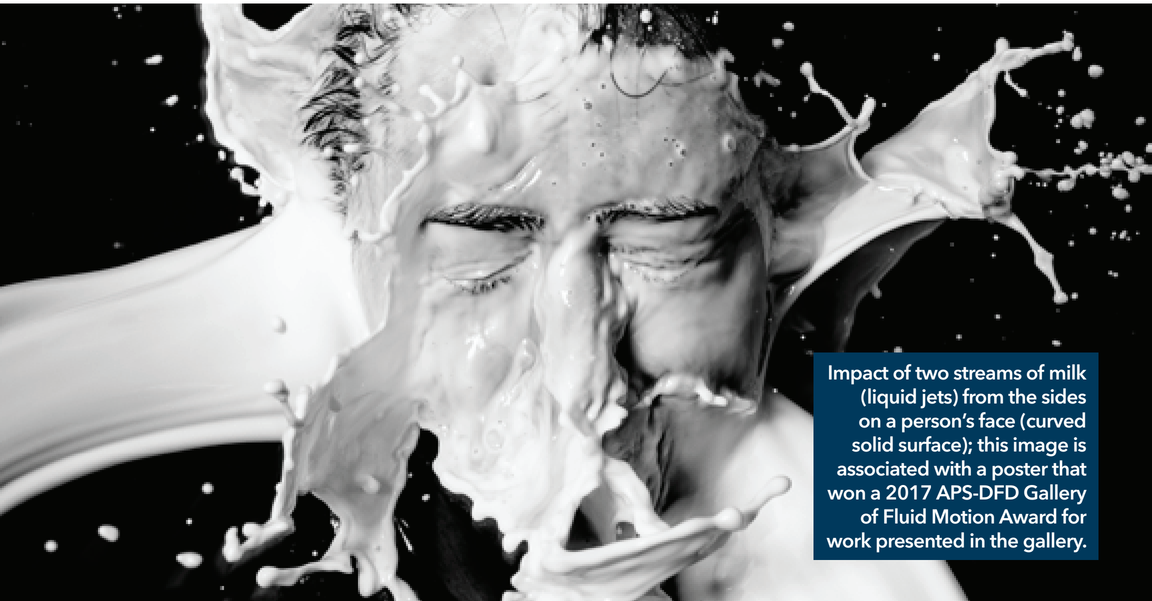
Artful Flow Visualizations Broaden Appreciation of Fluid Mechanics

From mixing cream with coffee to blood flow, ocean currents, and atmospheric winds, fluid mechanics aims to study the invisible forces that shape our world. Integrating engineering and art can produce powerful visualizations of these complex scientific concepts, making their collaborations invaluable for engaging diverse audiences. Prof. Azar Panah, one of the women comprising 30% of MAE full-time faculty--nearly double the national average of 15.7% as reported by ASEE in 2022--pioneers this interdisciplinary field, fostering a broader appreciation for fluid mechanics across the school, university, and nation.

Fascinated with bird flight, Panah's research focuses on understanding natural locomotion in fluids. She notes her path into flow visualization stems from her passion for fluid motion and finding beauty in physical phenomena, making collaborations with artists and photographers a natural extension. Since 2021, she has served as Coordinator of the Gallery of Fluid Motion at the American Physical Society—Division of Fluid Dynamics.

In 2023, Panah organized the museum-like exhibition, "Chaosmosis: Assigning Rhythm to the Turbulent," at the National Academy of Sciences in Washington, D.C., showcasing curated works in photography, video, sculpture, and sound. This year, she will organize another exhibition at The Leonardo Museum in Utah. The exhibitions merge technical expertise with artistic insights, using visual composition, color dynamics, and emotional impact to enhance public understanding of the dynamic forces around us. Showcasing "Chaosmosis" at such a prestigious venue highlights the growing appreciation for crossing traditional boundaries in research. Panah arranged for a composition of images from the exhibition to be given to the President of the United States, with a copy to be displayed in the Science & Engineering Hall.

In the classroom, Panah encourages students to look beyond their fields, emphasizing the importance of creativity, collaboration, and communication in solving complex problems. Her experimental course on the photography and science of flow visualizations teaches not only engineering students but also students from other disciplines to bridge this gap through practical and creative assignments. Through her research, Panah contributes to advancements in green energy, flapping flight, and fish swimming. Simultaneously, her artistic collaborations and teaching efforts ensure these advancements are communicated in ways that resonate with broader audiences.



Impact of two streams of milk (liquid jets) from the sides on a person's face (curved solid surface); this image is associated with a poster that won a 2017 APS-DFD Gallery of Fluid Motion Award for work presented in the gallery.

On their first day in Sweden, Vergara and other FDIB members attended a presentation by Lena Sellgren, Chief Economist of Business Sweden, who set the stage for understanding the Swedish sustainable energy business landscape.

Educating Engineers to Protect the Nation and Serve the Global Good

Education in the MAE Department goes beyond engineering fundamentals to prepare students to protect and advance our nation while advancing global welfare. This is accomplished through initiatives like the Consortium on Naval Enterprise Pathways (CoNEP), which equips a diverse group of future leaders to tackle complex naval challenges, and through global experiences like Ph.D. candidate Benedict Vergara's presentation at the Faculty Development in International Business program focused on Scandinavian innovation and sustainability.

In June 2024, CoNEP hosted the inaugural Naval Power and Security Bootcamp, a week-long residential course designed for Ph.D. candidates and post-doctoral researchers to explore the intersection of national security and naval power. Representing legislative and executive branches of the federal government, think tanks, industry, and academia, the 21 speakers provided insights into policy, security, and technical issues at this nexus. The topics addressed sea power's strategic and diplomatic values, the importance of oceans to national security, and applying scientific and engineering advancements to policy-making, demonstrating to students how they can directly advance the Navy's mission–and, by extension, national security–through their engineering careers.

By developing an energy analysis tool to compare multiple low-carbon technologies simultaneously, Vergara is helping to increase the energy efficiency of naval ships. At the Roslagen Clean Energy Symposium organized by GW-CIBER, he shared this research with an interdisciplinary group of professionals in business, finance, and economics in Sweden on behalf of the principal investigator, Prof. Saniya LeBlanc. Vergara tailored his presentation to this audience by using the boat that took them on a Baltic Sea cruise the night before as an example of applying his work for the Navy to ships worldwide. His work not only supports the U.S. Navy's environmental goals but also demonstrates the value of understanding how technical innovations integrate with other disciplines and broader sustainability efforts.

Dr. Rebecca Pinus, Director of the Polar Institute at the Wilson Center, discusses new challenges for the U.S. Navy in the Arctic.

Through these combined efforts, GW Engineering cultivates a diverse workforce of students to bolster U.S. global leadership in innovation, particularly in naval power. As a result, MAE students graduate equipped to protect the nation and serve the global good.

THE GEORGE WASHINGTON UNIVERSITY

WASHINGTON, DC

School of Engineering and Applied Science

Department of Mechanical and Aerospace Engineering

800 22nd Street, NW
Suite 3000
Washington, DC 20052

mae.engineering.gwu.edu

202-994-6749

gwuengineering

gwuengineering

gwuengineering