Department snapshot: Aeronautics and Astronautics

Massachusetts Institute of Technology
Photos: M. Scott Brauer

This is part of an occasional series of features profiling academic departments at MIT.

For decades, many students came to MIT's Department of Aeronautics and Astronautics with one goal in mind: to be an astronaut.

Starting in the 1960s and the Apollo era, sending humans into space was a national priority, and a very real possibility for many students. During this period, MIT graduated more astronauts than any other university, with the exception of the U.S. military academies. Alumni from AeroAstro [1], as the department is known, have participated in one-third of all U.S. space flights, collectively logging more than 10,000 hours in space. And Buzz Aldrin PhD '63, one of the department's stars, is among four AeroAstro graduates to have walked on the surface of the moon.

Today, while some AeroAstro students still dream of becoming the next moonwalker, others are exploring new frontiers in aerospace engineering, from miniature satellite propulsion and fuel-efficient aviation to automated airplane manufacturing and unmanned spacecraft. This last field, in particular, has generated global buzz with this year's landing of the Curiosity rover on Mars.

In fact, several AeroAstro alums had front-row seats to the landing as mission engineers in NASA's control room. During the live feed of the landing, broadcast around the world, flight director Bobak Ferdowsi SM '03 caused an Internet sensation with his red and blue mohawk — a tribute to the American flag, and a look that seemed to say, "This isn't your grandfather's rocket science."

A department, reinvented

Indeed, as the aerospace industry has evolved, so has AeroAstro.

When the department was formally established in 1939, research and education revolved around one main question: What does it take for a vehicle to fly? Faculty and students tackled the then-new fields of propulsion, controls and aerodynamics, and flew experiments in the department's Wright Brothers Wind Tunnel (opened in 1938), a state-of-the-art facility that the U.S. government used during World War II to test military airplanes.

Following the launch of Sputnik in 1957, the department expanded its efforts to include studies in space exploration. Major discoveries made in AeroAstro's

Instrumentation Lab — now the Draper Laboratory [2] — provided the guidance, navigation and control systems that helped shepherd the Apollo spacecraft to the moon.

In the 1980s, human performance in space became a new departmental focus, propelled in part by the launch of NASA's space shuttle program. MIT's Man Vehicle Laboratory [3] began to develop experiments on vestibular function, spatial disorientation and motion sickness in space, tests that were carried out on subsequent shuttle missions.

- Watch: See featured videos about AeroAstro at MIT Video [4]

In recent years, AeroAstro has again expanded its mission to support the latest shift in the country's aerospace enterprise. As the space shuttle program ended, NASA established new targets for space exploration, including near-Earth asteroids and Mars — alien destinations that would first be traversed by intelligent, unmanned vehicles. To advance this new objective, AeroAstro has launched laboratories to build autonomous vehicles and explore intelligent systems. These new fields require expertise in computer science and information technology — relatively recent additions to the department's in-house expertise.

AeroAstro's new focus on autonomy has implications beyond space: Faculty researchers are investigating "smart" military drones for ground and air surveillance, unmanned commercial aircraft, and robotic systems for airplane manufacturing, to name a few applications.

"This whole idea of autonomy hits almost every aspect of things we do," says department head Jaime Peraire, the H.N. Slater Professor of Aeronautics and Astronautics. "Our department in the last 10 to 12 years has been reinvented, and now we're a much more diverse department than we used to be."

Designing from a clean sheet

In addition to robotics and autonomy, AeroAstro researchers are continuing to advance the field of aviation. A major initiative within the department has been to design a "silent" aircraft. The conceptual design blends a plane's wings and body into one smooth fuselage that would produce no more noise than a tractor-trailer truck. The department is also looking at future aircraft concepts such as the "double bubble," nicknamed for its twin-tube fuselage design that could reduce fuel use by up to 70 percent.

"We're essentially working with a clean sheet of paper," Peraire says. "We ask, what type of materials would be available in the future, what types of things will we be able to build, and how would the aircraft look? We are willing to start from scratch and look at new aircraft concepts."

Researchers are also looking beyond the aircraft itself, considering its impact on the environment and society. In the near future, local and international airspace will

become more crowded, with an increasing number of planes taking off daily to keep up with demand. Unmanned aircraft — both military and commercial — may also occupy airspace. AeroAstro researchers are examining aviation's broader impact, from air pollution and fuel consumption to airport traffic and ways to forecast ticket pricing and demand.

A two-way street

Faculty are also reaching across campus to work with other departments and research centers, including the Laboratory for Information and Decision Sciences [5], the Computer Science and Artificial Intelligence Laboratory [6], and most recently, the Department of Earth, Atmospheric and Planetary Sciences (EAPS [7]). In this last collaboration, AeroAstro and EAPS researchers are designing next-generation satellites to monitor Earth, as well as deep-space probes to search for faraway celestial objects and exoplanets.

"We are a rather small department, yet we are incredibly broad," Peraire says. "Our strength really comes from working together, and connecting among each other."

Collaboration, both on campus and outside MIT, is a hallmark of AeroAstro. Since the department's early years, its faculty have worked closely with outside partners to address each successive era's foremost problems in aerospace. Today, faculty members sit on committees at NASA and the U.S. Air Force, and many come from key positions in industry and government, at places such as Boeing, Pratt & Whitney, and the Federal Aviation Administration.

Such close ties, Peraire says, have helped the department keep up with the latest industry objectives, as well as fast-tracking AeroAstro research to commercial partners.

"Whenever we need to make strategic decisions, we talk to our partners in industry and government," Peraire says. "And to a certain level, what they do is also informed by things we do … It's a two-way street of information. And this is part of why we're able to tackle important problems."

Esprit de corps

The companies and agencies that serve as research partners are also major employers of AeroAstro alumni. Boeing sends representatives each year to recruit AeroAstro students. At the end of the recruiting process, the company's chief technology officer travels to MIT to personally hand students job offers. It's a beneficial arrangement for both parties: Employers such as Boeing gain a new crop of talent, while the department gains new contacts in the corporate world.

Increasingly, AeroAstro alumni are pursuing careers in the commercial space transportation industry, joining companies in this rising field such as SpaceX, Aurora Flight Sciences and Blue Origin.

Alumni return regularly to talk with AeroAstro students about their professions —

including former astronauts and military test pilots, and most recently, mission engineers for the Mars Curiosity rover. Peraire says what draws alumni back to campus is the sense of community they developed as students. AeroAstro's undergraduate program — known on campus as Course 16, established before the department in 1926 — is recognized for establishing a particularly close-knit cohort. Students start the program as sophomores, learning the fundamentals of aerospace engineering in a rigorous course called Unified Engineering. Unlike other programs that break students into separate sections, students taking Unified move through each subject as one group.

"If you ask our alumni what do they remember of MIT, Unified is going to come first or second on their list," Peraire says. "Some of them loved it, some of them didn't like it so much, but the reality is, it really creates this esprit de corps."

Many AeroAstro students also have the opportunity to work on projects with commercial and military applications. A popular program within the department is the Beaverworks team, a collaboration with MIT's Lincoln Laboratory that challenges students to invent solutions to current engineering problems. A recent invention — swarms of tiny, atmospheric data-collecting drones designed to launch from aircraft flare dispensers — is now under further exploration by the U.S. Air Force.

'Our students are our best advertisement'

Several years ago, AeroAstro experienced a drop in student enrollment. At first a slow decline, the drop turned into a "red alarm," evoking for Peraire an aviation analogy: "The light was flashing, and enrollment was just like, 'Pull up, pull up!'"

In response, AeroAstro made a concerted effort to reach out to MIT freshmen still contemplating majors. The department held preorientation programs for incoming freshmen, and hosted informational fairs to introduce students to AeroAstro activities.

"I think at some level we are still a rather introverted department," Peraire admits. "We like what we do, and if people come ask us about things, we show them. But this past year, we made a deliberate effort to really try to reach out to the outside community and explain what we do."

This conscious endeavor reaped results this year, as the number of undergraduates declaring an AeroAstro major increased by 50 percent — the first enrollment spike in a number of years.

Educational outreach has become a major focus for the department: Faculty and graduate students regularly visit local high schools, demonstrating flight dynamics in a portable wind tunnel and explaining how rockets work. Graduate students answer letters submitted to the department from high school students on a host of topics, from what it takes to be an engineer to what makes an airplane tilt. Each year, the department sponsors an international competition called Zero Robotics [8], challenging high school teams to write computer programs that direct minisatellites. The competition final, held on MIT's campus, features a live downlink

to the International Space Station, where finalists watch their programs control minisatellites. The contest has drawn hundreds of participants — who Peraire hopes to see in AeroAstro's hallways as future students.

"Our students are our best advertisement," Peraire says. "There's a responsibility of the department to really contribute to changing the trend of STEM [science, technology, engineering and mathematics] education, and engineering overall. This is a type of thing that helps the community enormously. Whatever we can do in that respect, I think we should try to help."

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