DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

In the MIT Department of Aeronautics and Astronautics (AeroAstro), we look ahead by looking up.

At its core, aerospace empowers connection — interpersonal, international, interdisciplinary, and interplanetary. We seek to foster an inclusive community that values technical excellence, and we research and engineer innovative aerospace systems and technologies that have world-changing impact. We educate the next generation of leaders, creative engineers, and entrepreneurs who will push the boundaries of the possible to shape the future of aerospace. We do these things while holding ourselves to the highest standards of integrity and ethical practice. Working together with our partners in public and private sectors, we aim to expand the benefits of aerospace to create a more sustainable environment, strengthen global security, contribute to a prosperous economy, and explore other worlds for the betterment of humankind.

Our vision: to create an aerospace field that is a diverse and inclusive community, pushing the boundaries of the possible to ensure lasting positive impact on our society, economy, and environment.

MIT AeroAstro is a vibrant community of uniquely talented and passionate faculty, students, researchers, administrators, staff, and alumni. As the oldest program of its kind in the United States, we have a rich tradition of technical excellence, academic rigor, and research scholarship that has led to significant contributions to the field of aerospace for more than a century. Today, we continue to push the boundaries of what is possible to shape the future of air and space transportation, exploration, communications, autonomous systems, education, and national security.

Our department's core research capabilities include the following:

- Autonomous systems and decision-making: autonomy, guidance, navigation, estimation, control, communications, and networks
- Computational science and engineering: computational mathematics and numerical analysis, high-performance computing, model reduction and multifidelity modeling, uncertainty quantification, and optimization approaches to engineering design
- Earth and space sciences: environmental impact of aviation, environmental monitoring, sciences of space and atmosphere, space exploration, Earth observation, energy, plasma physics, aircraft/atmospheric interaction, and astrodynamics
- Human-system collaboration: human-machine systems; interactive robotics for aerospace, medical, and manufacturing; human factors; supervisory control and automation; biomechanics; life support; and astronaut performance
- Systems design and engineering: system architecture, safety, optimization, lifecycle costing, in-space manufacturing, and logistics
- Transportation and exploration: aviation, space flight, aircraft operations, instrumentation, flight information systems, infrastructure, air traffic control, industry analysis, and space missions
- Vehicle design and engineering: fluids, materials, structures, propulsion, energy, durability, turbomachinery, aerodynamics, astrodynamics, thermodynamics, composites, and avionics

In the latest version of the department's strategic plan, we identified seven additional areas of focus, or strategic thrusts, to pursue in tandem with our core capabilities. Strategic thrusts are forward-thinking, high-level initiatives that take into account both the current and future states of the aerospace field.

Our three research thrusts include: integrate autonomy and humans in real-world systems; develop new theory and applications for satellite constellations and swarms; and aerospace environmental mitigation and monitoring. These areas focus on long-term trends rather than specific systems and build upon our strengths while anticipating future changes as the aerospace field continues to evolve. Our two educational thrusts include: lead development of the College of Computing education programs in autonomy and computational science and engineering; and develop education for digital natives and digital immigrants. Both goals leverage the evolving MIT campus landscape as well as the increasing role of computing across society.

Our culture and leadership thrusts include: become the leading department at MIT in mentoring, advising, diversity, and inclusion; and make innovation a key component in MIT AeroAstro leadership. These areas respond to the priorities of our students and alumni while addressing pervasive challenges in the aerospace field.

The AeroAstro undergraduate engineering education model motivates students to master a deep working knowledge of the technical fundamentals while providing the skills, knowledge, and attitude necessary to lead in the creation and operation of products, processes, and systems.

The AeroAstro graduate program offers opportunities for deep and fulfilling research and collaboration in our three department teaching sectors — air, space, and computing — as well as across MIT. Our students work side-by-side with some of the brightest and most motivated colleagues in academia and industry.

Our world-renowned faculty roster includes a former space shuttle astronaut, secretary of the Air Force, NASA deputy administrator, Air Force chief scientist, and NASA chief technologist, and numerous National Academy of Engineering members and American Institute of Aeronautics and Astronautics fellows.

Upon leaving MIT, our students go on to become engineering leaders in the corporate world, in government service, and in education. Our alumni are entrepreneurs who start their own businesses; they are policy-makers shaping the direction of research and development for years to come; they are educators who bring their passion for learning to new generations; they are researchers doing transformative work at the intersection of engineering, technology and science.

Whether you are passionate about flying machines, pushing the boundaries of human civilization in space, or high-integrity, complex systems that operate in remote, unstructured, and dynamic environments, you belong here.

Sectors of Instruction

The department's faculty are organized into three sectors of instruction: air, space, and computing. Typically, a faculty member teaches both undergraduate and graduate subjects in one or more of the sectors.

Air Sector

The Air Sector is concerned with advancing a world that is mobile, sustainable, and secure. Achieving these objectives is a multidisciplinary challenge spanning the engineering sciences and systems engineering, as well as fields such as economics and environmental sciences.

Air vehicles and associated systems provide for the safe mobility of people, goods, and services covering urban to global distances. While this mobility allows for greater economic opportunity and connects people and cultures, it is also the most energy-intensive and fastest growing form of transportation. For this reason, much of the research and teaching in the Air Sector is motivated by the need to reduce energy use, emissions, and noise. Examples of research topics include improving aircraft operations, lightweight aerostructures, efficient engines, advanced aerodynamics, and quiet urban air vehicles. Air vehicles and associated systems also provide for critical national security and environmental observation capabilities. As such research and teaching in the sector are also concerned with topics including designing air vehicles for specialized missions, high-speed aerodynamics, advanced materials, and environmental monitoring platforms.

Teaching in the Air Sector includes subjects on aerodynamics, materials and structures, thermodynamics, air-breathing propulsion, plasmas, energy and the environment, aircraft systems engineering, and air transportation systems.

Space Sector

The design, development, and operation of space systems require a depth of expertise in a number of disciplines and the ability to integrate and optimize across all of these stages. The Space Sector faculty represent, in both research and teaching, a broad range of disciplines united under the common goal to develop space technologies and systems for applications ranging from communications and Earth observation, to human and robotic exploration. The research footprint of the sector spans the fundamental science and the rigorous engineering required to successfully create and deploy complex space systems. There is also substantive research engagement with industry and government, both in the sponsorship of projects and through collaboration.

The research expertise of the Space Sector faculty includes human and robotic space exploration, space propulsion, orbital communications, distributed satellite systems, enterprise architecture, systems engineering, the integrated design of space-based optical systems, reduced gravity research into human physiology, and software development methods for mission-critical systems. Numerous Space Sector faculty design, build, and fly spaceflight experiments ranging from small satellites to astronaut space missions. Beyond these topics, there is outreach and interest in leveraging our skills into applications that lie outside the traditional boundaries of aerospace.

Academically, the Space Sector organizes subjects relevant to address the learning objectives of students interested in the fundamental and applied aspects of space engineering theories, devices, and processes. This includes courses in astrodynamics, space propulsion, space systems engineering, plasma physics, and humans in space.

Computing Sector

Most aerospace systems critically depend upon, and continue to be transformed by, advances in computing. The missions of many aerospace systems are fundamentally centered on gathering, processing, and transmitting information. Aerospace systems rely on computing-intensive subsystems to provide essential on-board functions, including navigation, autonomous or semi-autonomous guidance and control, cooperative action (including formation flight), and health monitoring systems. Computing technologies are also central to communication satellites, surveillance and reconnaissance aircraft and satellites, planetary rovers, global positioning satellites, transportation systems, and integrated defense systems. Almost every aircraft or satellite is one system within a larger system, and information plays a central role in the interoperability of these subsystems. Equally important is the role that computing plays in the design of aerospace vehicles and systems.

Faculty members in the Computing Sector teach and conduct research on a broad range of areas, including guidance, navigation, control, autonomy and robotics, space and airborne communication networks, air and space traffic management, real-time mission-critical software and hardware, and the computational design, optimization, and simulation of fluid, material, and structural systems. In many instances, the functions provided by aerospace computing technologies are critical to life or mission success. Hence, uncertainty quantification, safety, fault-tolerance, verification, and validation of large-scale engineering systems are significant areas of inquiry.

The Computing Sector has linkages with the other sectors through a common interest in research on autonomous air and space operations, methodologies for large-scale design and simulation, and human-automation interactions in the aerospace context.

Moreover, the sector has strong links to the Department of Electrical Engineering and Computer Science and the Schwarzman College of Computing through joint teaching and collaborative research programs.

Research Laboratories and Activities

The department's faculty, staff, and students are engaged in a wide variety of research projects. Graduate students participate in all the research projects. Projects are also open to undergraduates through the Undergraduate Research Opportunities Program (UROP) (*https://catalog.mit.edu/mit/undergraduate-education/academic-research-options/undergraduate-research-opportunities-program*). Some projects are carried out in an unstructured environment by individual professors working with a few students. Most projects are found within the departmental laboratories and centers (*http://aeroastro.mit.edu/research-labs*). Faculty also undertake research in or collaborate with colleagues in the Computer Science and Artificial Intelligence Laboratory, Draper Laboratory, Laboratory for Information and Decisions Systems, MIT Lincoln Laboratory, Operations Research Center, Research Laboratory of Electronics, and the Program in Science, Technology, and Society, as well as in interdepartmental laboratories and centers listed in the introduction to the School of Engineering (*https://catalog.mit.edu/schools/engineering*).