Department of Aeronautics and Astronautics

MIT's Department of Aeronautics and Astronautics (AeroAstro) has long been one of the world's leading centers of aerospace research and education. With 226 graduate students, 166 undergraduate students, 35 faculty members, and top-ranked graduate and undergraduate educational programs, our community includes a former space shuttle astronaut, a former fighter pilot, former leaders of industry, a former secretary and three former chief scientists of the Air Force, two former NASA associate administrators, 17 National Academy of Engineering members, 15 American Institute of Aeronautics and Astronautics fellows, and two Guggenheim Medal recipients.

AeroAstro is a vibrant department with a strong sense of community. We value collaboration—within the department, across MIT, and with colleagues around the world. Our environment is connected, busy, global, hectic, open, collegial, and fun.

Our mission and values revolve around eight areas that represent grand challenges and grand opportunities for the department and for aerospace. These are:

- space exploration
- autonomous, real-time humans-in-the-loop systems
- aviation environment and energy
- aerospace communications and networks
- aerospace computation, design, and simulation
- air transportation
- fielding large-scale complex systems
- advancing engineering education

Through making advances in these and related areas, MIT AeroAstro is shaping the future of air and space transportation, exploration, communication, and national security.

Mission and Strategy

AeroAstro's mission is to prepare engineers for success and leadership in the conception, design, implementation, and operation of high-performance aerospace and related engineering systems. The department is committed to excellence and to the creation, development, and application of the technologies critical to aerospace vehicle and information engineering, and to the architecture and engineering of complex high-performance systems.

Our strategy has four elements:

1. We are building a stronger faculty by hiring for excellence, mentoring, and promoting collaboration.

2. We are attracting more top-quality graduate students (not more students) through increasing our graduate student fellowship endowment and improving our financial structure.
3. We are improving the short-term and lifelong value of the graduate student experience to both the student and the Institute research enterprise by pursuing an initiative to advance graduate education, graduate student mentoring, and graduate student professional development.
4. We are enhancing excellence in undergraduate education by reinvigorating our commitment to the development, assessment, and continuous improvement of our pedagogy and of our student learning.

Progress in 2010-2011

Promoting Faculty Excellence

- On February 1, 2011, Ian Waitz was named dean of the School of Engineering. Associate department head, Dave Darmofal was appointed interim head of Aeronautics & Astronautics and Eytan Modiano as interim associate head. On June 1, Jaime Peraire was named the next department head of AeroAstro effective July 1, 2011.
- Missy Cummings and Nick Roy were promoted to associate professor with tenure and David Darmofal was promoted to full professor following rigorous faculty promotion and performance review processes.
- The department head and associate head continued to meet regularly throughout the year with junior faculty members as part of an expanded mentoring program and professional development.
- Frequent faculty research talks were used to build connections among faculty.
- The AeroAstro faculty awards and recognition committee remained very active.
- We contributed to major School and Institute initiatives (Computation for Design and Optimization Program, MIT Energy Initiative, Transportation@MIT, SOE Education Committee and the Institute-wide Planning Task Force).

Promoting Excellence in Graduate Education

- Our graduate admissions rate remained steady at 18% of 475 applications. However, out yield increased to 75% of these students accepting admission.
- We continued to require formal end-of-semester progress reviews for all graduate students whereby graduate students and faculty meet at the end of each semester to enhance professional development, feedback, and mentoring.
- We held our third Women in Aerospace Symposium (with Department of Earth, Atmospheric, and Planetary Sciences) to foster a network among top women doctoral students in aerospace from around the United States. Dr. Wanda Austin, president and chief executive officer of The Aerospace Corporation, was on hand to deliver the keynote address.

- The department head and associate head met with the graduate students every other week throughout the year to promote feedback and stronger involvement in department business.

Promoting Excellence in Undergraduate Education

- We introduced a new flexible undergraduate engineering degree, Course 16-ENG, designed to allow students to pursue interdisciplinary and multidisciplinary studies through a six-subject concentration, while still retaining technical rigor and a context of aerospace engineering. Concentrations in the program currently include: autonomous systems; computation; energy; engineering management; environment; space exploration.
- We continue to require reflective memos of all undergraduate instructors as a means for promoting continuous improvement in faculty teaching performance.
- The department head and associate head met with the undergraduates every other week throughout the year to promote feedback and a stronger sense of community.

MIT's 150 Celebration

Many members of the AeroAstro Community played key roles in MIT's 150th celebration. Professor David Mindell chaired the Steering Committee. Ian Waitz was a faculty lead for the Leaders in Science and Engineering: the Women of MIT Symposium that took place in March. Dava Newman, Jeff Hoffman, Dave Mindell and Ian Waitz were faculty leads for the Earth, Air, Ocean and Space: The Future of Exploration Symposium, which brought many of our astronaut alums back to campus in April. Paul Lagace co-chaired the Open House commuttee. At the Insitute's Open House on April 30, AeroAstro's students, faculty and staff led dozens of activities including a demonstration of the TALARIS lunar hopper, tours of the Wright Brothers Wind Tunnel, a chance to program a SPHERES sattelite and control a UAV.

2010-2011 Personnel Achievement

Faculty Highlights

- Professor Amadeo Odoni was elected a member of the National Academy of Engineering in recognition of his contributions to, and leadership in air traffic control and airport systems.
- Professor Nancy Leveson has been named to the Ocean Energy Safety Advisory Committee by Secretary of the Interior Ken Salazar,
- Professors Eytan Modiano, Brian Wardle and Brian Williams have all been elected Associate Fellows of the American Institute of Aeronautics and Astronautics.
- Professor Mark Drela has been chosen as the recipient of the 36h William Littlewood Memorial Lecture Award, an award sponsored jointly by AIAA and SAE International.

- Professors Ed Greitzer and Mark Drela, along with the D-8 Team, were presented with Popular Mechanic's "Breakthrough Award" in October for their super efficient and clean airliner concept
- Professor Moe Win was awarded the IEEE Kiyo Tomiyasu Award for fundamental contributions to high-speed reliable communications over optical and wireless channels.
- Professors Hamsa Balakrishnan and John Hansman (along with PARTNER and ICAT Researchers Ioannis Similiakis, Harshad Khadilkar, Tom Reynolds, Brendan Reilly, and Steve Urlass) won the best paper award at the USA/Europe Air Traffic Management R&D Seminar. Their paper was titled, "Demonstration of Reduced Airport Congestion Through Pushback Rate Control."
- Professor Jon How's paper "Continuous trajectory planning of mobile sensors for informative forecasting," has won an award for "Best Applications Paper Published in Automatica over the last three years." Automatica is a journal of the International Federation of Automatic Control.
- Professor Debbie Nightingale was named the director of MIT's Center for Technology, Policy and Industrial Development.
- Professor Dave Darmofal is the 2011 recipient of the Earll M. Murman Award for Excellence in Undergraduate Advising.
- Professor Ian Waitz is this year's winner of the AIAA Undergraduate Advising Award.
- Professor Youssef Marzouk receive the 2011 AIAA Undergraduate Teaching Award.

Other Accomplishments

- Dr. Chuck Oman has been elected to full membership in the International Academy of Astronautics.
- NASA's Office of the Chief Technologist has selected Chase Coffman, Daniel Handlin, Brad Holschuh, Chris Pong, Matt Smith and Sunny Wicks for its inaugural class of Space Technology Research Fellows.
- Jonathan Parham, Matthew Fitzgerald and Elena de la Rosa Blanco were the Region 1 (New England) first place winners of the 2010 AIAA Regional Student Conference technical paper competition, undergraduate division.
- Sertac Karaman is the winner of the 2011 AIAA Orville and Wilbur Wright Graduate Award.
- Masayuki Yano is the recipient of a Singapore-MIT Alliance Graduate Fellowship in Computational Engineering.
- SM Student Hui Ying Wen won the best presentation award at the Human Factors and ergonomics Society New England Chapter's 2010 Student Conference for her paper "Simulating Human-Automation Task Allocations for Safety System Design".

- Mary Knapp and Ian Sugel won 2nd prize in the Nanosatellite Constellation Mission Idea Contest.
- Vicky Thomas won the Frederick Gardiner Fassett Jr. Award for spirit, dedication, and service in furthering the ideals MIT fraternity brotherhood and sisterhood.
- Ulric Ferner, Chelsea He and Amy Bilton were recipients of the Williams L. Stewart Jr. Award for outstanding contributions to co-curricular activities and events.
- Jose Marquez won the Albert G. Hill Prize for a minority undergraduate junior or senior student who has maintained high academic standards and made continued contributions to the improvement of the quality of life.
- The AeroAstro Graduate Teaching Assistantship Award was given to Brandon Luders and Lei Qiao.
- The Rene H. Miller Prize in Systems Engineering was given to the TERSat leadership team: Emilay Calandrelli, Maria De Soria-Santacruz Pich, Carla Perez Martinez and Jonathan Battat.
- David Butts was the winner at the department's first annual Technical Communications Research Competition which highlighted the best graduate student research in the department.
- Dan Buckland has been named recipient of the Space Medicine Association Jeffrey R. Davis Scholarship.
- AeroAstro students captured both first and second prizes in the XCOR Exploration Competition, held as part of MIT's 150 Celebration. Mary Knapp took the grand prize for her project, "SOLARA: Exploring the Last Frontier of the EM Spectrum." Second place went to graduate students Rachel Forman and Aaron Johnson for their project "Lifelike Robotic Birds for Remote Exploration of the Amazon Rainforest".
- Jean Sofronas was the recipient of the 2011 Wings Award "for her support of Unified Engineering while maintaining exceptional service to the Aerospace Computational Design Laboratory."
- Anne Maynard won the Spirit of XVI Award "for sustained, outstanding performance and invaluable advice to AeroAstro faculty, staff and students."
- Sue Whitehead won this year's Vickie Kerrebrock Award "for exceptional dedication to fostering a sense of community in AeroAstro."

Research

AeroAstro faculty and students are engaged in hundreds of research projects under the auspices of our department's laboratories and centers. Many of the department's research projects are open to undergraduates through the Undergraduate Research Opportunities Program. In addition, research activities in other MIT laboratories and centers are open to students registered in aeronautics and astronautics.

Aerospace Computational Design Laboratory

The Aerospace Computational Design Laboratory's mission is the advancement and application of computational engineering for aerospace system design and optimization. ACDL researches topics in advanced computational fluid dynamics and reacting flow, methods for uncertainty quantification and control, and simulation-based design techniques.

The use of advanced computational fluid dynamics for complex 3D configurations allows for significant reductions in time from geometry-to-solution. Specific research interests include aerodynamics, aeroacoustics, flow and process control, fluid structure interactions, hypersonic flows, high-order methods, multi-level solution techniques, large eddy simulation, and scientific visualization. Research interests also extend to chemical kinetics, transport-chemistry interactions, and other reacting flow phenomena.

Uncertainty quantification and control is aimed at improving the efficiency and reliability of simulation-based analysis as well as supporting decision under uncertainty. Research is focused on error estimation, adaptive methods, ODEs/PDEs with random inputs, certification of computer simulations, and robust statistical frameworks for estimating and improving physical models from observational data.

The creation of computational decision-aiding tools in support of the design process is the objective of a number of methodologies the lab pursues. These include PDE-constrained optimization, real time simulation and optimization of systems governed by PDEs, multiscale optimization, model order reduction, geometry management, and fidelity management. ACDL applies these methodologies to aircraft design and to the development of tools for assessing aviation environmental impact.

ACDL faculty and staff include: Dave Darmofal (director), Doug Allaire, David Darmofal, Mark Drela, Robert Haimes, Youssef Marzouk, Cuong Nguyen, Jaime Peraire, QiQi Wang, and Karen Willcox.

Aerospace Controls Laboratory

The Aerospace Controls Laboratory researches autonomous systems and control design for aircraft, spacecraft, and ground vehicles. Theoretical research is pursued in areas such as decision making under uncertainty; path planning, activity, and task assignment; mission planning for unmanned aerial vehicles; sensor network design; and robust, adaptive, and nonlinear control. A key aspect of ACL is RAVEN (Real-time indoor Autonomous Vehicle test ENvironment), a unique experimental facility that uses a motion capture system to enable rapid prototyping of aerobatic flight controllers for helicopters and aircraft, and robust coordination algorithms for multiple vehicles. Recent research includes the following:

Robust Planning. ACL developed a distributed task-planning algorithm that provides provably good, conflict-free, approximate solutions for heterogeneous multi-agent/multi-task allocation problems on random network structures. The consensus-based bundle algorithm has since been extended to include task time-windows, coupled agent constraints, asynchronous communications, and limited network connectivity. CBBA has been used to plan for both networked UAV/UGV teams and human-robot teams, and real-time performance has been validated through flight test experiments. Recent path planning research has yielded chance constrained rapidly-exploring random trees, a robust planning algorithm to efficiently identify trajectories that satisfy all problem constraints with some minimum probability. Finally, in collaboration with Professor Nick Roy's group, ACL developed an efficient approach for modeling dynamic obstacles with uncertain future trajectories, through the use of Gaussian processes coupled with an RRT-based reachability evaluation.

UAV Mission Technologies. ACL has developed a novel hovering vehicle concept capable of agile, acrobatic maneuvers in cluttered indoor spaces. The vehicle is a quadrotor whose rotor tilt angles can be actuated, enabling upside-down hovering flight with appropriate control algorithms. As part of research on long-duration UAV mission planning, ACL has also constructed an autonomous recharge platform, capable of autonomous battery replacement for small UAVs.

Information-Gathering Networks. Recent ACL research has addressed maximizing information gathering in complex dynamic environments, through the use of mobile sensing agents. The primary challenge in such planning is the computational complexity, due to both the large size of the information space and the cost of propagating sensing data into the future. ACL developed new methodologies that correctly and efficiently quantify the value of information in large information spaces, such as a weather system, leading to a systematic architecture for mobile sensor network design. Recently-developed algorithms embed information planning within RRTs to quickly identify safe information-gathering trajectories for teams of sensing agents, subject to arbitrary constraints and sensor models.

Multi-Agent Decision-Making. Markov Decision Processes are a natural framework for formulating many decision problems of interest; ACL has identified approximate solution techniques which can utilize this framework while overcoming the curse of dimensionality typically encountered for exact solutions. By exploiting flexible, kernel-based cost approximation architectures, ACL's Bellman Residual Minimization algorithm computes an approximate policy by minimizing the error incurred in solving Bellman's equation over sampled states. For online systems, ACL introduced incremental Feature Dependency Discovery algorithm that expands the representation in areas where the sampled Bellman error persist. iFDD is convergent and computationally cheap, hence amenable to systems with restricted thinking time between actions. Finally, ACL has developed fast, real-time algorithms for solving constrained MDPs in uncertain and risky environments while maintaining probabilistic safety guarantees.

ACL faculty are Jonathan How and Steven Hall.

Communications and Networking Research Group

The Communications and Networking Research Group's primary goal is the design of network architectures that are cost effective, scalable, and meet emerging needs for high data-rate and reliable communications. To meet emerging critical needs for military communications, space exploration, and internet access for remote and mobile users, future aerospace networks will depend upon satellite, wireless and optical components. Satellite networks are essential for providing access to remote locations lacking in communications infrastructure, wireless networks are needed for communication between untethered nodes (such as autonomous air vehicles), and optical networks are critical to the network backbone and in high performance local area networks.

The group is working on a wide range of projects in the area of data communication and networks with application to satellite, wireless, and optical networks. Over the past year, the group continued to work on a Department of Defense-funded project toward the design of highly robust telecommunication networks that can survive a massive disruption that may result from natural disasters or intentional attack. The project examines the impact of large scale, geographically correlated failures, on network survivability and design. In a related project, funded by the National Science Foundation, the group is studying survivability in layered networks; with the goal of preventing failures from propagating across layers.

The group is also working on an Army MURI (Multidisciplinary University Research Initiative) project titled "MAASCOM : Modeling, Analysis, and Algorithms for Stochastic Control of Multi-Scale Networks." The project deals with control of communication networks and develops novel network control algorithms using techniques from stochastic control of dynamical systems. The project is a collaboration among MIT, Ohio State University, University of Maryland, University of Illinois, Purdue University, and Cornell University. In a related project funded by the National Science Foundation the group is exploring distributed network control algorithms that can be implemented with low computation and communication complexities.

CNRG's research crosses disciplinary boundaries by combining techniques from network optimization, queueing theory, graph theory, network protocols and algorithms, hardware design, and physical layer communications.

Eytan Modiano directs the Communications and Networking Research Group.

Complex Systems Research Laboratory

Increasing complexity and coupling as well as the introduction of new digital technology are introducing new challenges for engineering, operations, and sustainment. The Complex Systems Research Lab designs system modeling, analysis, and visualization theory and tools to assist in the design and operation of safer systems with greater capability. To accomplish these goals, the lab applies a system's approach to engineering that includes building technical foundations and knowledge and integrating these with the organizational, political, and cultural aspects of system construction and operation.

While CSRL's main emphasis is aerospace systems and applications, its research results are applicable to complex systems in such domains as transportation, energy, and health. Current research projects include accident modeling and design for safety, model-based system and software engineering, reusable, component-based system architectures, interactive visualization, human-centered system design, system diagnosis and fault tolerance, system sustainment, and organizational factors in engineering and project management.

Nancy Leveson directs the Complex Systems Research Laboratory.

Gas Turbine Laboratory

The MIT Gas Turbine Laboratory has had a worldwide reputation for research and teaching at the forefront of gas turbine technology for more than 60 years. GTL's mission is to advance the state-of-the-art in fluid machinery for power and propulsion. The research is focused on advanced propulsion systems, energy conversion and power, with activities in computational, theoretical, and experimental study of: loss mechanisms and unsteady flows in fluid machinery; dynamic behavior and stability of compression systems; instrumentation and diagnostics; advanced centrifugal compressors and pumps for energy conversion; gas turbine engine and fluid machinery noise reduction and aero-acoustics; novel aircraft and propulsion system concepts for reduced environmental impact.

Examples of current and past research projects include: engine diagnostics and smart engines, aerodynamically induced compressor rotor whirl, a criterion for axial compressor hub-corner separation, axial and centrifugal compressor stability prediction, losses in centrifugal pumps, loss generation mechanisms in axial turbomachinery, the Silent Aircraft Initiative (a collaborative project with Cambridge University, Boeing, Rolls Royce, and other industrial partners), hybrid-wing-body airframe design and propulsion system integration for reduced environmental impact (NASA N+2), counter-rotating propfan aerodynamics and acoustics, an engine air-brake for quiet aircraft, inlet distortion noise prediction for embedded propulsion systems, novel aircraft concepts for 2035 (NASA N+3), high-speed micro gas bearings for MEMS turbomachinery, small gas turbines and energy concepts for portable power, and carbon-nano-tube bearings.

Faculty and research staff include: Elena de la Rosa Blanco, Fredric Ehrich, Alan Epstein (emeritus), Edward Greitzer, Claudio Lettieri, Jürg Schiffmann, Zoltan Spakovszky (director), Alejandra Uranga, and Choon Tan.

Humans and Automation Laboratory

Research in the Humans and Automation Laboratory focuses on the multifaceted interactions of human and computer decision-making in complex socio-technical systems. With the explosion of automated technology, the need for humans as supervisors of complex automatic control systems has replaced the need for humans in direct manual control. A consequence of complex, highly-automated domains in which the human decision-maker is more on-the-loop than in-the-loop is that the level of required cognition has moved from that of well-rehearsed skill execution and rule following to higher, more abstract levels of knowledge synthesis, judgment, and reasoning. Employing human-centered design principles to human supervisory control problems, and identifying ways in which humans and computers can leverage the strengths of the other to achieve superior decisions together is HAL's central focus.

Current research projects include investigation of human understanding of complex optimization algorithms and visualization of cost functions, human performance modeling with hidden markov models, collaborative human-computer decision making in time-pressured scenarios (for both individuals and teams), human supervisory control of multiple unmanned vehicles, and designing displays that reduce training time. Lab equipment includes an experimental testbed for future command and control decision support systems, intended to aid in the development of human-computer interface design recommendations for future unmanned vehicle systems. In addition, the lab hosts a state-of-the-art multi-workstation collaborative teaming operations center, as well as a mobile command and control experimental test bed mounted in a Dodge Sprinter van awarded through the Office of Naval Research. Current research sponsors include the Office of Naval Research, the U.S. Army, Lincoln Laboratory, Boeing, the Air Force Research Laboratory, the Air Force Office of Scientific Research, Alstom, and the Nuclear Regulatory Commission.

HAL faculty include Mary L. Cummings (director), Nicholas Roy, and Thomas Sheridan.

International Center for Air Transportation

The International Center for Air Transportation undertakes research and educational programs that discover and disseminate the knowledge and tools underlying a global air transportation industry driven by technologies. Global information systems are central to the future operation of international air transportation. Modern information technology systems of interest to ICAT include global communication and positioning; international air traffic management; scheduling, dispatch, and maintenance support; vehicle management; passenger information and communication; and real-time vehicle diagnostics.

Airline operations are also undergoing major transformations. Airline management, airport security, air transportation economics, fleet scheduling, traffic flow management, and airport facilities development, represent areas of great interest to the MIT faculty and are of vital importance to international air transportation. ICAT is a physical and intellectual home for these activities. ICAT, and its predecessors, the Aeronautical Systems Laboratory and Flight Transportation Laboratory, pioneered concepts in air traffic management and flight deck automation and displays that are now in common use.

ICAT faculty include R. John Hansman (director), Cynthia Barnhart, Peter Belobaba, and Amedeo Odoni.

Laboratory for Information and Decision Systems

The Laboratory for Information and Decision Systems at MIT is an interdepartmental research center committed to advancing research and education in the analytical information and decision sciences, specifically: systems and control, communications and networks, and inference and statistical data processing.

Dating back to 1939, LIDS has been at the forefront of major methodological developments, relevant to diverse areas of national and worldwide importance, such as telecommunications, information technology, the automotive industry, energy, defense, and human health. Building on past innovation and bolstered by a collaborative atmosphere, LIDS members continue to make breakthroughs that cut across traditional boundaries.

Members of the LIDS community share a common approach to solving problems and recognize the fundamental role that mathematics, physics, and computation play in their research. Their pursuits are strengthened by the laboratory's affiliations with colleagues across MIT and throughout the world, as well as with leading industrial and government organizations.

LIDS is based in MIT's Stata Center, a dynamic space that promotes a high level of interaction within the lab and with the larger MIT community. Currently 17 faculty are affiliated with the laboratory, including Emilio Frazzoli, Jonathan How, Eytan Modiano, and Moe Win.

Lean Advancement Initiative

The Lean Advancement Initiative s a learning and research consortium focused on enterprise transformation; its members include key stakeholders from industry, government, and academia. LAI is headquartered in AeroAstro, works in collaboration with the Sloan School of Management, and is managed under the auspices of the Center for Technology, Policy and Industrial Development, an MIT-wide interdisciplinary research center.

LAI began in 1993 as the Lean Aircraft Initiative when leaders from the US Air Force, MIT, labor unions, and defense aerospace businesses created a partnership to transform the U.S. aerospace industry using an operational philosophy known as "lean." LAI is now in its sixth phase and focuses on a holistic approach to transforming entire enterprises across a variety of industries. Through collaborative stakeholder engagement, along with the development and promulgation of knowledge, practices, and tools, LAI enables enterprises to effectively, efficiently, and reliably create value in complex and rapidly changing environments. Consortium members work collaboratively through the neutral LAI forum toward enterprise excellence, and the results are radical improvements, lifecycle cost savings, and increased stakeholder value. LAI's international Educational Network provides LAI members with unmatched educational outreach and training capabilities and includes more than 60 educational institutions around the world.

AeroAstro LAI participants include Deborah Nightingale (co-director), Earll Murman, and Annalisa Weigel.

Man Vehicle Laboratory

The Man Vehicle Laboratory addresses human-vehicle and human-robotic system safety and effectiveness by improving understanding of human physiological and cognitive capabilities. MVL develops countermeasures and display designs to aid pilots, astronauts, and others. Research is interdisciplinary, and uses techniques from manual and supervisory control, signal processing, estimation, robotics, sensory-motor physiology, sensory and cognitive psychology, biomechanics, human factors engineering, artificial intelligence, and biostatistics. MVL has flown experiments on Space Shuttle missions, the Mir Space Station, and on many parabolic flights, and developed experiments for the International Space Station.

MVL has five faculty and 20 affiliated graduate students. Research sponsors include NASA, the National Space Biomedical Research Institute, the Office of Naval Research, the Department of Transportation's FAA and FRA, the Center for Integration of Medicine and Innovative Technology, the Deshpande Center, and the MIT Portugal Program. Space projects focus on advanced space suit design and dynamics of astronaut motion, adaptation to rotating artificial gravity, mathematical models for human spatial disorientation accident analysis, artificial intelligence, and space telerobotics training. New major projects include a collaborative study with Draper laboratory on manual and supervisory control of lunar/planetary landings, and a study of fatigue effects on space teleoperation performance, in collaboration with colleagues at the Brigham and Women's Hospital. Non-aerospace projects include performance and fatigue effects in locomotive engineers, and advanced helmet designs for brain protection in sports and against explosive blasts. The laboratory also collaborates with the Volpe Transportation Research Center, and the Jenks Vestibular Physiology Laboratory of the Massachusetts Eye and Ear Infirmary.

This past year, MVL faculty and graduate students took lead roles in the MIT 150th anniversary celebration's Exploration Symposium. The laboratory's "Bioastronautics Journal Seminar" enrolled 18 graduate students. For the eighth time, MVL MIT Independent Activities Period activities included a popular course on Boeing 767 Systems and Automation and Aircraft Accident Investigation, co-taught with B N. Nield, Boeing's chief engineer for Aviation Systems Safety.

MVL faculty include Charles Oman (director), Jeffrey Hoffman, Dava Newman, Laurence Young, and Julie Shah. They teach subjects in human factors engineering, space systems engineering, real-time systems and software, space policy, flight simulation, space physiology, aerospace biomedical engineering, the physiology of human spatial orientation, and leadership. The MVL also serves as the office of the Director for the NSBRI-sponsored HST Graduate Program in Bioastronautics (Young), the Massachusetts Space Grant Consortium (Hoffman), NSBRI Sensory-Motor Adaptation Team (Oman), the MIT-Volpe Program in Transportation Human Factors (Oman), and the MIT Portugal Program's Bioengineering Systems focus area (Newman).

The Partnership for AiR Transportation Noise and Emissions Reduction

The Partnership for AiR Transportation Noise and Emissions Reduction is an MIT-led FAA Center of Excellence sponsored by the FAA, NASA, Transport Canada, the US Department of Defense, and the Environmental Protection Agency. PARTNER research addresses environmental challenges facing aviation through analyzing community noise and emission impacts on climate and air quality. PARTNER also studies a range of environmental impact potential mitigation options including aircraft technologies, fuels, operational procedures, and policies. PARTNER combines the talents of 12 universities, five government agencies, and more than 50 advisory board members, the latter spanning a range of interests from local government, to industry, to citizens' community groups.

MIT's most prominent research role within PARTNER is in analyzing environmental impacts and developing research tools that provide rigorous guidance to policy-makers who must decide among alternatives to address aviation's environmental impact. The MIT researchers collaborate with an international team in developing aircraft-level and aviation system level tools to assess the costs and benefits of different policies and mitigation options.

Other PARTNER initiatives in which MIT participates include estimating the lifecycle impacts of alternative fuels for aircraft; studies of aircraft particulate matter microphysics and chemistry; and economic analysis of policies. PARTNER's most recent reports emanating from MIT research are "The Impact of Climate Policy on US Aviation," (with the MIT Joint Program on the Science and Policy of Global Change), and "Assessment of CO_2 Emission Metrics for a Commercial Aircraft Certification Requirement." (with the Georgia Institute of Technology). These may be downloaded at http://web.mit.edu/aeroastro/partner/reports.

PARTNER MIT personnel include Ian Waitz (director), James Hileman (associate director), Hamsa Balakrishnan, Steven Barrett, John Hansman, Thomas Reynolds, Karen Willcox, William Litant (communications director), Jennifer Leith (program coordinator), and 15-20 graduate students and post docs.

Space Propulsion Laboratory

The Space Propulsion Laboratory studies and develops systems for increasing performance and reducing costs of space propulsion and related technologies. A major area of interest to the lab is electric propulsion in which electrical, rather than chemical, energy propels spacecraft. The benefits are numerous; hence the reason electric propulsion systems are increasingly applied to communication satellites and scientific space missions. These efficient engines allow exploration in more detail of the structure of the universe, increase the lifetime of commercial payloads, and look for signs of life in far away places. Areas of research include plasma thrusters and plumes, and their interaction with spacecraft; numerical and experimental models of magnetic cusped thrusters; and space electrodynamic tethers, including their use as antennas for launching electromagnetic waves to remove high-energy particles from earth's Van Allen radiation belts. SPL students also work on ultra-fast (nanosecond) high voltage discharges to trigger combustion reactions and eventually reduce aircraft engine pollution. SPL also has a significant role in designing and building micropropulsion electrospray thrusters. In addition to providing efficient propulsion for very small satellites in the 1 kg category (such as CubeSats), such engines will enable distributed propulsion for the control of large space structures, like deformable mirrors and apertures. SPL facilities include a supercomputer cluster where plasma and molecular dynamics codes are routinely executed and a state-of-the-art laboratory including three vacuum chambers, clean room environment benches, electron microscope and electronic diagnostic tools to support ongoing research efforts.

Manuel Martinez-Sanchez directs the SPL. Paulo Lozano is the associate director.

Space Systems Laboratory

Space Systems Laboratory research contributes to the exploration and development of space. SSL's mission is to explore innovative space systems concepts while training researchers to be conversant in this field. The major programs include systems analysis studies and tool development, precision optical systems for space telescopes, microgravity experiments operated aboard the International Space Station, and leading the AeroAstro efforts on student-built small satellites. Research encompasses an array of topics that comprise a majority of space systems: systems architecting, dynamics and control, active structural control, thermal analysis, space power and propulsion, microelectromechanical systems, modular space systems design, micro-satellite design, real-time embedded systems, and software development.

Major SSL initiatives study the development of formation flight technology. Significant research has been conducted using the Synchronized Position Hold Engage and Reorient Experimental Satellites (SPHERES) facility, in the areas of distributed satellites systems, including telescope formation flight, docking, and reconfiguration. The SPHERES facility consists of three small satellites 20 centimeters in diameter that have flown inside the International Space Station since May 2006. They are used to test advanced control software in support of future space missions that require autonomous inspection, docking, assembly and precision formation flight. Over the past four years SSL hassuccessfully completed 21 test sessions with eight astronauts. In 2009 we expanded the uses of SPHERES to include STEM outreach. In the fall of 2009 we began an exciting program called "Zero Robotics" to engage High School students in a competition aboard the ISS using SPHERES. In December 2010 ten students from two Idaho schools came to MIT and saw their algorithms compete against each other in a live feed from the ISS. We look forward to expanding this competition to a national scale.

SSL is in the third year of the SEA program; the Space Engineering Academy immerses junior Air Force officers in the actual development of flight hardware providing first hand experience in implementing best (and avoiding worst) practices in space system procurement. It is a two year, end-to-end, flight-worthy satellite conceive, design, build, integrate, test, and operate program. The SEA students, together with several other SSL graduate assistants, formed a robust group of teaching assistants for the 16.83 capstone satellite design-build course. This year the course tackled two projects: the MIT Satellite team entry to the University Nanosatellite Program and conceptual design of the Exo-Planet cubesat to detect planets in other solar systems. The UNP entry, named CASTOR, is being developed jointly with the Space Propulsion Laboratory to demonstrate an innovative electric thruster. The propulsion system will be demonstrated in LEO with up to 1 km/s delta-V; if successful a 2 km/s delta-V spacecraft could be built to reach the moon! The Exo-Planet spacecraft is a cooperation between the SSL and faculty in EAPS and the Kavli Institute; it uses an innovative sensor with staged control to detect the presence of planets as they orbit around their stars.

The Electromagnetic Formation Flight testbed is a proof-of-concept demonstration for a formation flight system that has no consumables; a space-qualified version is under study. The MOST project completed architectural studies for lightweight segmented mirror space telescopes using active structural control. Multiple programs research the synthesis and analysis of architectural options for future manned and robotic exploration of the Earth-Moon-Mars system.

SSL continues to lead the development of methodologies and tools for space logistics. Jointly with Aurora Flight Sciences, SSL is developing prototypes for automated asset tracking and management systems for ISS based on radio frequency identification technology. Together with the Jet Propulsion Laboratory, SSL is editing a new AIAA Progress in Aeronautics and Astronautics Volume on Space Logistics that summarizes the current state of the art and future directions in the field.

SSL personnel include David W. Miller (director), John Keesee, Olivier de Weck, Jeffrey Hoffman, Edward F. Crawley, Daniel Hastings, Annalisa Weigel, Manuel Martinez-Sanchez, Paulo Lozano, Alvar Saenz-Otero, Paul Bauer (research specialist), SharonLeah Brown (administrator and outreach coordinator), Brían O'Conaill (fiscal officer), Marilyn E. Good (administrative assistant), and Deatrice Moore (financial assistant)

Technology Laboratory for Advanced Materials and Structures

A dedicated and multidisciplinary group of researchers constitute the Technology Laboratory for Advanced Materials and Structures. They work cooperatively to advance the knowledge base and understanding that will help facilitate and accelerate advanced materials systems development and use in various advanced structural applications and devices.

TELAMS has broadened its interests from a strong historical background in composite materials, and this is reflected in the name change from the former Technology Laboratory for Advanced Composites. A significant initiative involves engineering materials systems at the nanoscale, particularly focusing on aligned carbon nanotubes as a constituent in new materials and structures. This initiative is in partnership with industry through the Nano-Engineered Composite aerospace STructures Consortium founded at MIT in 2007. Thus, the research interests and ongoing work in the laboratory represent a diverse and growing set of areas and associations. Areas of interest include:

- nano-engineered hybrid advanced composite design, fabrication, and testing
- fundamental investigations of mechanical and transport properties of polymer nanocomposites
- characterization of carbon nanotube bulk engineering properties
- carbon nanotube synthesis and catalyst development
- composite tubular structural and laminate failures
- MEMS-scale mechanical energy harvesting modeling, design, and testing
- MEMS device modeling and testing, including bioNEMS/MEMS
- structural health monitoring system development and durability assessment
- thermostructural design, manufacture, and testing of composite thin films and associated fundamental mechanical and microstructural characterization

- continued efforts on addressing the roles of lengthscale in the failure of composite structures
- numerical and analytical solid modeling to inform, and be informed by, experiments
- continued engagement in the overall issues of the design of composite structures with a focus on failure and durability, particularly within the context of safety

In supporting this work, TELAMS has complete facilities for the fabrication of structural specimens such as coupons, shells, shafts, stiffened panels, and pressurized cylinders, made of composites, active, and other materials. A recent addition includes several reactors for synthesizing carbon nanotubes. TELAMS testing capabilities include a battery of servohydraulic machines for cyclic and static testing, a unit for the catastrophic burst testing of pressure vessels, and an impact testing facility. TELAMS maintains capabilities for environmental conditioning, testing at low and high temperature, and in hostile and other controlled environments. There are facilities for nano and microscopic inspection, nondestructive inspection, high-fidelity characterization of MEMS materials and devices, and a laser vibrometer for dynamic device and structural characterization.

With its linked and coordinated efforts, both internal and external, the laboratory continues its commitment to leadership in the advancement of the knowledge and capabilities of the materials and structures community through education of students, original research, and interactions with the community. There has been a broadening of this commitment consistent with the broadening of the interest areas in the laboratory. This commitment is exemplified in the newly formed NECST Consortium, an industry-supported center for developing hybrid advanced polymeric composites. In all these efforts, the laboratory and its members continue their extensive collaborations with industry, government organizations, other academic institutions, and other groups and faculty within the MIT community.

TELAMS faculty include Paul A. Lagacé, Brian L. Wardle, John Dugundji (emeritus), and visitors Antonio Miravete, Desiree Plata, and Junichiro Shiomi.

Wireless Communication and Network Sciences Group

The Wireless Communication and Network Sciences Group is involved in multidisciplinary research that encompasses developing fundamental theories, designing algorithms, and conducting experiments for a broad range of real-world problems. Its current research topics include location-aware networks, network synchronization, aggregate interference, intrinsically-secure networks, time-varying channels, multiple antenna systems, ultra-wide bandwidth systems, optical transmission systems, and space communications systems. Details of a few specific projects are given below.

The group is working on location-aware networks in GPS-denied environments, which provide highly accurate and robust positioning capabilities for military and commercial aerospace networks. It has developed a foundation for the design and analysis of large-scale location-aware networks from the perspective of theory, algorithms, and experimentation. This includes derivation of performance bounds for cooperative localization, development of a geometric interpretation for these bounds, and the design of practical, near-optimal cooperative localization algorithms. It is currently validating the algorithms in a realistic network environment through experimentation in the lab.

The lab has been engaged in the development of a state-of-the-art apparatus that enables automated channel measurements. The apparatus makes use of a vector network analyzer and two vertically polarized, omni-directional wideband antennas to measure wireless channels over a range of 2–18 GHz. It is unique in that extremely wide bandwidth data, more than twice the bandwidth of conventional ultra-wideband systems, can be captured with high-precision positioning capabilities. Data collected with this apparatus facilitates the efficient and accurate experimental validation of proposed theories and enables the development of realistic wideband channel models. Work is underway to analyze the vast amounts of data collected during an extensive measurement campaign that was completed in early 2009.

Lab students are also investigating physical-layer security in large-scale wireless networks. Such security schemes will play increasingly important roles in new paradigms for guidance, navigation, and control of unmanned aerial vehicle networks. The framework they have developed introduces the notion of a secure communications graph, which captures the information-theoretically secure links that can be established in a wireless network. They have characterized the s-graph in terms of local and global connectivity, as well as the secrecy capacity of connections. They also proposed various strategies for improving secure connectivity, such as eavesdropper neutralization and sectorized transmission. Lastly, they analyzed the capability for secure communication in the presence of colluding eavesdroppers.

Lab director Moe Win and a team of undergraduate and graduate students competed in the Institute of Soldier Nanotechnologies Soldier Design Competition. In this contest they demonstrated the first cooperative location-aware network for GPS-denied environments, using ultra-wideband technology, leading to the team winning the L3 Communications Prize. They are now advancing the localization algorithms in terms of scalability, robustness to failure, and tracking accuracy.

To advocate outreach and diversity, the group is committed to attracting undergraduates and underrepresented minorities, giving them exposure to theoretical and experimental research at all levels. For example, the group has a strong track record for hosting students from both the Undergraduate Research Opportunities Program and the MIT Summer Research Program (MSRP). Professor Win maintains dynamic collaborations and partnerships with academia and industry, including the University of Bologna and Ferrara in Italy, University of Lund in Sweden, University of Oulu in Finland, National University of Singapore, Nanyang Technological University in Singapore, Draper Laboratory, the Jet Propulsion Laboratory, and Mitsubishi Electric Research Laboratories.

Moe Win directs the Wireless Communication and Network Sciences Group.

Wright Brothers Wind Tunnel

Since its opening in September 1938, the Wright Brothers Wind Tunnel has played a major role in the development of aerospace, civil engineering and architectural systems. In recent years, faculty research interests generated long-range studies of unsteady airfoil flow fields, jet engine inlet-vortex behavior, aeroelastic tests of unducted propeller fans, and panel methods for tunnel wall interaction effects. Industrial testing has ranged over auxiliary propulsion burner units, helicopter antenna pods, and in-flight trailing cables, as well as concepts for roofing attachments, a variety of stationary and vehicle mounted ground antenna configurations, the aeroelastic dynamics of airport control tower configurations for the Federal Aviation Authority, and the less anticipated live tests in Olympic ski gear, space suits for tare evaluations related to underwater simulations of weightless space activity, racing bicycles, subway station entrances, and Olympic rowing shells for oarlock system drag comparisons.

In its more than 70 years of operations, Wright Brothers Wind Tunnel work has been recorded in hundreds of theses and more than 1,000 technical reports.

WBWT faculty and staff include Mark Drela and Richard Perdichizzi.

Education

Undergraduate Program

Several years ago, working closely with student, alumni, industry, government, and academic stakeholders around the world, the AeroAstro Department developed and implemented a landmark educational initiative for our degree programs. It was determined that graduates must be knowledgeable in all phases of the aerospace system life cycle: conceiving, designing, implementing, and operating (CDIO). A new form of undergraduate engineering education was adopted, motivating students to master a deep working knowledge of the technical fundamentals while giving them the skills, knowledge, and attitudes necessary to lead in the creation and operation of products, processes, and systems. The department reformed the way it teaches, redesigned its curriculum, and performed a $20 million state-of-the-art reconstruction of its teaching laboratories. The academic program and its facilities now serve as models for 33 engineering schools on four continents (see http://www.cdio.org/).

This year, the Department introduced the new Course 16-ENG degree to complement our existing aerospace engineering degrees (Course 16-1 and 16-2). The 16-ENG curriculum is designed to offer flexibility within the context of aerospace engineering. This aerospace context is achieved in two ways:

- The inclusion of Unified Engineering, our integrative, foundational subject in aerospace disciplines
- The use of our existing aerospace laboratory and capstone subject sequences, which emphasize authentic project-based learning within the aerospace context, in multi-semester team environments with integral communications education

These are essential elements of our MIT AeroAstro educational program. They also combine well with any number of aerospace-related concentration areas. The technical depth of the concentration areas is ensured in part by a requirement that of the 72 units in the concentration, 42 must be engineering and 12 must be math/science. We are excited about the educational opportunities brought by this new degree. Undergraduate students who pursue 16-ENG will receive a more multi-disciplinary or interdisciplinary engineering education, but one that still features the rigor and technical depth of the department's traditional aerospace engineering degrees.

Learning Lab

The AeroAstro Learning Laboratory, located in Building 33, is a world-class facility developed to promote student learning by providing an environment for hands-on activities that span our conceive-design-implement-operate educational paradigm.

The Learning Lab comprises four main areas:

Robert C. Seamans Jr. Laboratory. The Seamans Laboratory occupies the first floor. It includes:

- *The Concept Forum*—a multipurpose room for meetings, presentations, lectures, videoconferences and collaboration, distance learning, and informal social functions. In the Forum, students work together to develop multidisciplinary concepts, and learn about program reviews and management.
- Two *Project Offices*—team-focused work and meeting spaces, which may be assigned to teams for weeks or months, or kept available as needed. These rooms support individual study, group design work, online work, and telecommunication.
- *Al Shaw Student Lounge*—a large, open space for social interaction and operations.

Arthur and Linda Gelb Laboratory. Located in the building's lower level, the Gelb Laboratory includes the Gelb Machine Shop, Instrumentation Laboratory, Mechanical Projects Area, Projects Space, and the Composite Fabrication-Design Shop. The Gelb Laboratory provides facilities for students to conduct hands-on experiential learning through diverse engineering projects starting as first-year students and continuing through the last year. The Gelb facilities are designed to foster teamwork with a variety of resources to meet the needs of curricular and extra-curricular projects.

Gerhard Neumann Hangar. The Gerhard Neumann Hangar is a high bay space with an arching roof. This space lets students work on large-scale projects that take considerable floor and table space. Typical of these projects are planetary rovers, autonomous vehicles, and re-entry impact experiments. The structure also houses low-speed and supersonic wind tunnels. A balcony-like mezzanine level is used for multi-semester engineering projects, such as the experimental three-term senior capstone course, and is outfitted with a number of flight simulator computer stations.

Digital Design Studio. The Digital Design Studio, located on the second floor, is a large room with multiple computer stations arranged around reconfigurable conference tables. Here, students conduct engineering evaluations and design work, and exchange computerized databases as system and subsystem trades are conducted during the development cycle. The room is equipped with information technologies that facilitate teaching and learning in a team-based environment. Adjacent and networked to the main Design Studio are two smaller design rooms: the AA Department Design Room, and the Arthur W. Vogeley Design Room. These rooms are reserved for the use of individual design teams and for record storage. The department's IT systems administrator is positioned for convenient assistance in an office adjacent to the Design Center, positioning him for convenient assistance.

The Experimental Projects course (Course 16.62X) is a major user of the teaching labs, from experiments using the Neumann Hangar's low-speed wind tunnel to the workspaces in the Gelb laboratory, with a number of excellent projects as outcomes. The motivation for these projects come from a variety of sources including faculty research interests, interactions with companies (e.g. Aurora Flight Sciences), and student-generated ideas.

Another major use of the Learning Lab is in our capstone design sequences: on the aeronautics side 16.82-16.821, and on the space side 16.83-16.832. These multi-semester capstone subjects take students through an entire life cycle of a product from conception to design to implementation and operation.

For 16.82x, the collaboration in real world design build projects for students initiated last year between Lincoln Lab and the department was extended to include a second project. In the collaboration Lincoln Lab and the U.S. Air Force have commissioned and provided funding for the design, construction, and testing of 2 Unmanned Air Vehicle systems. The first UAV System (AY09/10) was designed to fly calibration payloads through sensors in Air Force test ranges. The second UAV System (AY10/11) was a small deployable UAV which could be launched from standard countermeasure dispensers on existing aircraft and fly environmental sampling missions. The students were highly motivated by the opportunity to develop a vehicle with a real customer. In the Fall semester, 16.82 and our graduate aircraft system engineering course (16.885) were combined into a team which developed an initial design for the aircraft working in collaboration with Lincoln staff. Construction was begun by a group of students during IAP and continued in the Spring semester in the follow-on laboratory course (16.821 and a special graduate course). In both years the aircraft were successfully flown during the Spring semester in a series of flight tests designed and executed by the students. The students presented the results at an Air Force testing conference with extremely favorable reviews. Based on the successful results of this pilot project, additional aircraft and spacecraft collaboration projects have been initiated for the current academic year.

Graduate Program

Over the past three years, we have made significant revisions to enhance the excellence of our already top-ranked graduate program. These changes occurred throughout the program from graduate admissions to improved mentoring to the requirements of the doctoral program. Some highlights from the past year include:

- Our graduate admissions rate remained at our most selective ever at 18%. Of the admits, 75% of these students accepted admission, also an all-time AeroAstro high.
- Our department continues to have formal Fall and Spring end-of-semester research progress reviews required of all graduate students. These reviews are between the student and advisor and are an opportunity to set goals, consider progress first past goals, clarify funding needs and availability, and discuss career plans. A recent survey of our students showed that 80% of the respondents believe the review process is a valuable part of their education.

Graduate Enrollment*

	05-06	06-07	07-08	08-09	09-10	10-11
Total Graduate Student Body	223	223	226	236	226	226
SM**	124	135	146	148	130	111
PhD***	99	88	80	88	96	115
Minority						
SM	7	9	8	8	9	7
PhD	4	3	5	6	4	6
Female						
SM	31	26	29	32	30	22
PhD	25	19	19	23	17	20

*Numbers based on fifth-week enrollment data.

** Includes students pursuing only the master's degree and students who have not yet passed the doctoral qualifying exam.

***Students who have passed the doctoral qualifying exam.

Degrees

The Bachelor of Science (SB) degree is a four-year program preparing the graduate for an entry-level position in the aerospace field and for further education at the master's level. Three degrees are available, one that emphasizes the disciplines that relate to the engineering of aerospace vehicles (Course 16-1), a second that defines a specialization in aerospace information technology (Course 16-2), and our new flexible engineering program described above (Course 16-ENG). All three degrees retain an emphasis on the fundamentals and provide strong integration with the overarching CDIO context.

The Master of Science (SM) degree is a one- to two-year graduate program with a beginning research or design experience represented by the S.M. thesis. This degree prepares the graduate for an advanced position in the aerospace field, and it forms a solid foundation for future doctoral study.

AeroAstro offers doctoral degrees (PhD and ScD) that emphasize in-depth study with a significant research project in a focused area. Entrance to the doctoral program requires students to pass a graduate-level examination in a field of aerospace engineering as well as to demonstrate an ability to conduct research in the field. The doctoral degree is awarded after completion of an individual course of study, submission and defense of a thesis proposal, and submission and defense of a thesis embodying an original research contribution.

In addition, the department participates in a variety of interdisciplinary graduate programs.

Undergraduate Enrollment*

	01-02	*02-03*	*03-04*	*04-05*	*05-06*	*06-07*	*07-08*	*08-09*	*09-10*	*10-11*
Sophomores	56	64	72	64	65	65	65	74	57	51
Juniors	69	51	59	59	52	60	66	55	65	47
Seniors	53	70	61	65	76	56	66	62	58	68
Totals	**178**	**185**	**192**	**188**	**196**	**181**	**189**	**191**	**180**	**166**
% Women	33%	35%	34%	30%	26%	31%	30%	30%	34%	29%
% Underrepresented minorities	22%	30%	30%	27%	25%	26%	24%	32%	40%	28%

*Data based on the fall fifth-week enrollment.

Undergraduate Student Prizes

Awards presented at the AeroAstro Class of 2011 Recognition Dinner on Monday, May 9, 2011:

The Andrew Morsa Prize—awarded for demonstration of ingenuity and initiative in the application of computers to the field of aeronautics and astronautics: Michael Munoz, Jameson Nash and Spancer Parra

The Yvnge Raustein Award—given to a unified engineering student who best exemplifies the spirit of Yngve Raustein and to recognize significant achievement in unified engineering: Kieran Mclaughlin

The David J. Shapiro Memorial Award – given to AeroAsrtro undergraduate students to pursue special aeronautical projects and/or to support foreign travel for the enhancement of scientific/technical studies and research opportunities: Thomas W. Fronk

The Apollo Award—given to an AeroAstro student who conducts the best undergraduate research project on the topic of humans in space: Eric D. Peters

The Leaders for Manufacturing Prize—awarded to a team that uses its project to directly deal with issues related to the interaction between manufacturing and engineering through demonstration of modern manufacturing processes: Stephen Howland and Eric Peters

The Lockheed Martin Prize for Excellence in Systems Engineering Teamwork: Rebecca Jensen-Clem and Joseph A. McCarter

The United Technologies Corporation Prize—awarded to an AeroAstro student for outstanding achievement in the design, construction, execution, and reporting of an undergraduate experimental project: Maximilian Brand and Anjaney Kottapalli

The Admiral Luis De Florez Prize—awarded for "original thinking or ingenuity" as demonstrated by the individual effort of the student, not the ideas and suggestions of an advisor, instructors, or an advisory team: Bruno Alvisio and Lucas de la Garza

The James Means Award for Excellence in Flight Vehicle Engineering: Mark Thompson

The AeroAstro Undergraduate Teaching Assistantship Award – given to an undergraduate teaching assistant who has demonstrated conspicuous dedication and skill in helping fulfill an undergraduate subject's educational objectives: Ian Sugel

The Henry Webb Salisbury Award—given in memory of Henry Salisbury to a graduating senior who has achieved superior academic performance in the Course 16 undergraduate program: Carla Perez Martinez and Andrew Wang

Jaime Peraire
Department Head
H. N. Slater Professor of Aeronautics and Astronautics