Department of Aeronautics and Astronautics

Through the 20th and into the 21st centuries, MIT Aeronautics and Astronautics (Aero-Astro) and its stakeholders have been in the forefront of the most exciting developments in air and space technology: Jerome Hunsaker, the founder of our Department, who designed the first aircraft to cross the Atlantic; famed aviator Jimmy Dolittle, who pioneered flying by instrument; our faculty who designed the computers and software that guided Apollo to the moon; and our faculty and students who built the famed human-powered Daedelus aircraft. One-third of the astronauts to traverse the moon's surface, including pioneer lunar explorer Buzz Aldrin, are Aero-Astro alums. Five of our faculty were chief scientists of the US Air Force. More than a quarter of the professors in American aerospace university programs are our graduates.

The Aero-Astro Department's mission is to (1) prepare engineers in the fundamental principles and disciplines necessary for success and leadership in the conception, design, implementation, and operation of aerospace and related engineering systems; and (2) prepare outstanding academicians to serve as stewards of the discipline. Integral to this mission is creating technologies critical to aerospace vehicle and information engineering and developing the architecture and engineering of complex high-performance systems. Aero-Astro graduates are prepared for careers in aircraft and spacecraft engineering, space exploration, air and space-based telecommunication industries, teaching, research, military service, and many related technology-intensive fields involving, for example, transportation, information, and the environment.

Academic Program

Aero-Astro offers comprehensive undergraduate and graduate curricula that prepare students for careers in the aerospace industry and the academy. Our curricula are linked through three primary themes: (1) aerospace information technology, (2) aerospace systems, and (3) vehicle technology. Recently, we reorganized our teaching divisions into three interdisciplinary sectors: the information sector, systems sector, and vehicles technology sector. The Department also offers exciting graduate level opportunities.

Research

Our research ranges from silent aircraft; to shirt-button-sized gas turbine engines; to highly flexible space suits woven skin-tight on their inhabitants; to unmanned aircraft capable of complex maneuvers without human intervention; to constellations of tiny satellites that, in concert, far outperform the single, large satellites of the past; to the development of ultrawide bandwidth communications. These projects will make our environment cleaner and quieter, improve our health and safety, increase our mobility, heighten our efficiency, and enable us to explore frontiers far beyond our current limitations.

This Past Year

Faculty

Three outstanding junior faculty members joined the Department. Hamsa Balakrishnan, who comes to us from Stanford via the National Aeronautics and Space Administration Ames Research Center (NASA Ames), specializes in air traffic control, traffic flow management, airport operations scheduling, and hybrid systems. Emilio Frazzoli, who gained his PhD at MIT but has been an assistant professor at the University of California, Los Angeles, has expertise in aerospace control systems, autonomous air/space/ground vehicles, mobile robotics, systems and control theory, optimization algorithms, real-time, and embedded systems. Paulo Lozano, the Charles Stark Draper Assistant Professor of Aeronautics and Astronautics, an MIT PhD, and a former research scientist with this Department, has interests in electric propulsion, electrosprays, thruster physics, electrochemical microfabrication, engine health monitoring, and space mission design.

Academic Program

With generous support from engineering dean Thomas Magnanti, we are developing two new initiatives. One of these is focused on unmanned aerial vehicles (UAVs). The other addresses the engineering of small satellites. These two initiatives are evolving into major projects that involve multiple faculty members.

Our undergraduate enrollment remained strong: 62 sophomores, 60 juniors, and 61 seniors. And, we produced 28 doctorates by June, the highest number in the past 5 years.

The Department shared the top ranking (with Stanford and Caltech) in the recent *U.S. News and World Report* listings of aerospace graduate programs.

Research

Our research is generating interest and excitement around the world. We offer some examples. David Darmofal and his students have developed an adaptive finite-element method for aerodynamics and are collaborating with Boeing and NASA to apply the method to the design of supersonic aircraft. Nancy Leveson's Complex Systems Research Lab is doing landmark work with system modeling, analysis, and visualization theory and tools to assist in the creation of safer systems with greater capability. David Miller's SPHEREs microsats are undergoing rigorous testing aboard the International Space Station. Jaime Peraire's Aerospace Computational Design Laboratory is producing novel computational techniques for advanced simulation. Ian Waitz's Partnership for Air Transportation Noise and Emissions Reduction research collaborative is developing landmark tools to assess the costs and benefits of various strategies to provide for policy makers who must address aviation's environmental impact. Jonathan How's advancements in autonomous multivehicle operation are bringing us closer to the day when formations of UAVs will serve for border security, military convoy protection, and a host of other applications enhancing our safety and security. And, Karen Willcox's reduced-order modeling will offer researchers powerful new techniques for the creation of small, yet accurate, models of complicated systems.

Undergraduate Student Prizes

Undergraduate Enrollment over the Last 10 Years

	97–98	98–99	99–00	00–01	01–02	02–03	03–04	04–05	05–06	06–07
Sophomores	40	48	59	68	56	64	72	64*	65	65
Juniors	33	37	40	53	69	51	59	59*	52	60
Seniors	24	35	37	45	53	70	61	65*	76	56
Total	**97**	**120**	**136**	**166**	**178**	**185**	**192**	**188***	**196**	**181**
Women	30%	33%	30%	32%	33%	35%	34%	30%	26%	31%
Underrepresented minorities	22%	15%	12%	21%	22%	30%	30%	27%	25%	19%

Data based on the fall fifth-week enrollment.

Awards presented at the Aero-Astro class of 2006 recognition dinner on Monday, May 17, 2007:

The Andrew Morsa Prize for demonstration of ingenuity and initiative in the application of computers to the field of aeronautics and astronautics was presented to Jacob G. Katz and Cristina M. Wilcox for outstanding ingenuity and initiative in the analysis, design, and development of the overall autonomy architecture and locomotion software for the MoRETA Rover project; and to Mikel J. Graham and Ruijie He for successfully closing a control loop around a laser range finder with an embedded processor to stabilize an indoor helicopter.

The Yngve Raustein Award given to a Unified Engineering student who best exemplifies the spirit of Yngve Raustein and to recognize significant achievement in Unified Engineering was presented to Ryan W. Castonia for being the epitome of a superb student citizen, an outstanding scholar, and team leader and player, and for his community building within and beyond MIT.

The Apollo Award given to an Aero-Astro student who conducts the best undergraduate research project on the topic of humans in space was presented to Bradley T. Holschuh for his contributions to robotic and human space exploration.

The David J. Shapiro Award given to Aero-Astro undergraduate students to pursue special aeronautical projects that are student-initiated and/or to support foreign travel for the enhancement of scientific/technical studies and research opportunities was presented to Ryan W. Castonia to travel to the University of Pretoria, South Africa, to work on their UAV project and 2007 Space and Aviation Challenge and to Christine Fanchiang to travel to Beijing, China, to attend the 16th International Academy of Astronautics Symposium.

The Leaders for Manufacturing Award, given to a team or student who uses their project to directly deal with issues related to the interaction between manufacturing and engineering through demonstration of modern manufacturing processes, was presented to Mario R. Martinez for outstanding accomplishments as the manufacturing engineer in the analysis and use of modern engineering and manufacturing processes for the MoRETA Rover project and to Rachel Ellman and Nicki L. Lehrer for the design, analysis, and proof-of-concept demonstration of a negative pressure device for open wound therapy affordable for third-world populations.

The Lockheed Martin Prize for Excellence in System Engineering awarded to an undergraduate team that has exhibited a superior level of accomplishment in engineering innovation, product development, and team organization was presented to Nii A. Armar, Ryan W. Castonia, Carl J. Engel, Fuzhou Hu, George Ford Kiwada, David A. Sanchez, Brandon H. Suarez, and Adam J. Woodworth for outstanding achievement in the analysis, design, construction, and successful flight testing of a high-performance, low-cost, solar-powered UAV.

The United Technologies Corp. Prize given to an Aero-Astro student for outstanding achievement in the design, construction, execution, and reporting of an undergraduate experimental project was presented to Carl J. Engel and Adam J. Woodworth for outstanding achievement in the analysis, design, construction, and successful flight testing of a high-performance, low-cost, solar-powered UAV and to Terrence M. McKenna and Yonas M. Tesfaye for outstanding achievement in the analysis, design, fabrication, and testing of the microcomputer controller, control system software, and associated electronics for the leg/hip/wheel assemblies for the MoRETA Rover project.

The Admiral Luis De Florez Prize given for original thinking or ingenuity as demonstrated by the individual effort of the student, not the ideas and suggestions of his or her advisor, instructors, or an advisory team, was presented to Nestor I. Lara and Chad E. Lieberman for initiative, ingenuity, and high-quality execution of a project to design, build, and control an Acrobot robotic arm and to Bernard J. Michini and Sean M. Torrez for ingenuity in the design, development, construction, and demonstration of a stabilized, autonomous bicycle.

The James Means Award for Excellence in Flight Vehicle Engineering was presented to Alexandra E. Coso for outstanding efforts as the systems engineer, budget manager, and documentation leader, as well as avionics engineer, for the MoRETA Rover project.

The Aero-Astro Teaching Assistantship Award given to a teaching assistant(s) who has demonstrated conspicuous dedication and skill in helping fulfill an undergraduate or graduate subject's educational objectives was presented to Bradley T. Holschuh and Sho Sato for their consistent support and unselfish dedication to the progress of undergraduate students in the execution of experimental projects.

The Henry Webb Salisbury Award given in memory of Henry Salisbury to a graduating senior(s) who has achieved superior academic performance in the Course 16 Undergraduate Program was presented to Sho Sato and to Dawn D. Wheeler for superior and multiple-dimensional academic achievements in the undergraduate program.

The AIAA Undergraduate Advising Award given by the American Institute of Aeronautics and Astronautics (AIAA) Student Chapter to a faculty or staff member who has demonstrated excellence in serving as an academic or 16.621/16.622 advisor and has made a real positive impact on a student's time in the Aero-Astro Department was presented to Col. John E. Keesee.

The AIAA Undergraduate Teaching Award given by the AIAA Student Chapter to a faculty or staff member who has exemplified the role of a "great teacher" was presented to professor Mark Drela.

Graduate Program

The Aero-Astro graduate program continues to gather interest from across the globe. The following is a breakdown of our applicants and admits for the last two years. Note that, starting in 2007, the Department offers only one admission period per year.

Graduate Program Statistics, Academic Year 2006–2007

	September 2006	September 2007
Applications	290	319
Admitted	142	132
Accepted Admission	84*	91**
SM	81	78
PhD	3	13
Minority		
SM	6	2
PhD	0	1
Female		
SM	11	21
PhD	1	2
Funding Accepted		
Fellowship (MIT)	6	6
Fellowship (Other)	9	4
RA & Draper	27	22
TA	4	2
Other	0	4

* Does not include 11 students who accepted offer of admission but deferred start to 2007.

** Includes 14 students who accepted offer of admission but deferred start to 2008.

A Review of Aeronautics and Astronautics Department Research

Aerospace Computational Design Laboratory

The mission of the Aerospace Computational Design Laboratory (ACDL) is to lead the advancement and application of computational engineering for aerospace system design and optimization. ACDL research addresses a comprehensive range of topics in advanced computational fluid dynamics, methods for uncertainty quantification and control, and simulation-based design techniques.

The use of advanced computational fluid dynamics for complex three-dimensional 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, multilevel solution techniques, large eddy simulation, and scientific visualization.

Uncertainty quantification and control are aimed at improving the efficiency and reliability of simulation-based analysis. Research is focused on error estimation and adaptive methods as well as certification of computer simulations.

The creation of computational decision-aiding tools in support of the design process is the objective of a number of methodologies currently pursued in the lab. 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 is applying these methodologies to aircraft design and to the development of tools for assessing aviation environmental impact. ACDL faculty and staff include Luis Cueto, David Darmofal, Mark Drela, Robert Haimes, Cuong Nguyen, Jaime Peraire (director), Per-Olof Persson, Thomas Richter, Karen Willcox, and David Willis.

Visit the Aerospace Computational Design Laboratory at http://acdl.mit.edu/.

Aerospace Controls Laboratory

The Aerospace Controls Laboratory (ACL) is involved in research topics related to control design and synthesis for aircraft and spacecraft. Theoretical research is pursued in areas such as high-level decision making, estimation, navigation using GPS, robust control, optimal control, and model predictive control. Experimental and applied research is also a major part of ACL. The advanced UAV, rover, automobile, and satellite testbeds enable students to implement their algorithms in actual hardware and evaluate the proposed techniques.

ACL faculty are Jonathan How and Steven Hall.

Visit the Aerospace Controls Laboratory at http://acl.mit.edu/.

Communications and Networking Research Group

The primary goal of the Communications and Networking Research Group is to design network architectures that are cost-effective and scalable and that 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 on 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. An important aspect of the group's research is the development of architectures and algorithms that are optimized across multiple layers of the protocol stack, such as the design of network protocols that are aware of the physical layer channel conditions. For example, together with researchers at the Jet Propulsion Laboratory, the group recently demonstrated tremendous gains in network performance through the application of novel cross-layer resource allocation algorithms to Mars communications. The group's research crosses disciplinary boundaries by combining techniques from network optimization, queuing theory, graph theory, network protocols and algorithms, hardware design, and physical layer communications.

Eytan Modiano directs the Communications and Networking Research Group.

Visit the Communications and Networking Research Group at http://web.mit.edu/aeroastro/labs/cnrg/.

Complex Systems Research Laboratory

Increasing complexity and coupling as well as the introduction of digital technology are providing challenges for engineering, operations, and sustainment. The Complex Systems Research Lab (CSRL) 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 them 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 domains such 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.

CSRL faculty include Nancy Leveson (director), Charles Coleman, Mary Cummings, Wesley Harris, and Paul Lagace.

Visit the Complex Systems Research Laboratory at http://sunnyday.mit.edu/csrl.html.

Gas Turbine Laboratory

The MIT Gas Turbine Laboratory (GTL) is the largest university laboratory of its kind, focusing on all aspects of advanced propulsion systems and turbomachinery. GTL's mission is to advance the state-of-the-art in gas turbines for power and propulsion. Several unique experimental facilities include a blowdown turbine; a blowdown compressor; a shock tube for reacting flow heat transfer analysis; facilities for designing, fabricating, and testing microheat engines; and a range of one-of-a-kind experimental diagnostics. GTL also has unique computational and theoretical modeling capabilities in the areas of gas turbine fluid mechanics, aircraft noise, emissions, heat transfer, and robust design. Three examples of the lab's work are the development of Smart Engines, in particular active control of turbomachine instabilities; the Microengine Project, which involves extensive collaboration with the Department of Electrical Engineering and Computer Science—these are shirt-button-sized high-power density gas turbine and rocket engines fabricated using silicon chip manufacturing technology; and the Silent Aircraft Initiative, an effort to dramatically reduce aircraft noise with the goal of transforming commercial air transportation.

GTL participates in research topics related to short-, mid-, and long-term problems and interacts with almost all the major gas turbine manufacturers. Research support also comes from several Army, Navy, and Air Force agencies as well as from different NASA research centers.

Alan Epstein is director of the lab. GTL faculty and research staff include David Darmofal, Mark Drela, Fredric Ehrich, Yifang Gong, Edward Greitzer, Gerald Guenette, Stuart Jacobson, Jack Kerrebrock, Carol Livermore, Ali Merchant, Manuel Martinez-Sanchez, James Paduano, Zoltan Spakovszky, Choon Tan, Ian Waitz, and Karen Willcox.

Visit the Gas Turbine Lab at http://web.mit.edu/aeroastro/www/labs/GTL/index.html.

Humans and Automation Laboratory

Research in the Humans and Automation Laboratory (HAL) focuses on the multifaceted interactions of human and computer decision making in complex sociotechnical 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 humans and computers can leverage the strengths of the other to achieve superior decisions together, is the central focus of HAL.

Current research projects include investigation of human understanding of complex optimization algorithms and visualization of cost functions, collaborative human-computer decision making in time-pressured scenarios (for individuals and teams), human supervisory control of multiple unmanned vehicles, and designing decision support displays for direct-perception interaction as well as assistive collaboration technologies, including activity awareness, interface technologies, and interruption assistance technologies. Equipment in the lab 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 multiworkstation collaborative teaming operations center as well as a mobile command and control experimental testbed mounted in a Dodge Sprint van awarded through the ONR DURIP program.

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

Visit the Humans and Automation Laboratory at http://mit.edu/aeroastro/www/labs/halab/index.html.

International Center for Air Transportation

The International Center for Air Transportation (ICAT) 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 vitally important 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, Hamsa Balakrishnan, and Amedeo Odoni.

Visit the International Center for Air Transportation at http://web.mit.edu/aeroastro/www/labs/ICAT/.

Laboratory for Information and Decision Systems

The Laboratory for Information and Decision Systems (LIDS) is an interdepartmental research laboratory that began in 1939 as the Servomechanisms Laboratory, focusing on guided missile control, radar, and flight trainer technology. Today, LIDS conducts theoretical studies in communication and control and is committed to advancing the state of knowledge of technologically important areas such as atmospheric optical communications and multivariable robust control. In April 2004, LIDS moved to MIT's Stata Center, a dynamic space that promotes increased interaction within the lab and with the larger community. Laboratory research volume is approximately $6.5 million, and the size of the faculty and student body has tripled in recent years. LIDS continues to host events, notably weekly colloquia that feature leading scholars from the laboratory's research areas. The 12th annual LIDS Student Conference took place in January 2007, showcasing current student work and including keynote speakers. These and other events reflect LIDS' commitment to building a vibrant, interdisciplinary community. In addition to a full-time staff of faculty, support personnel, and graduate assistants, scientists from around the globe visit LIDS to participate in its research program. Currently, 17 faculty members and approximately 100 graduate students are associated with the laboratory.

Aero-Astro/LIDS faculty includes Emilio Frazzoli, John Deyst, and Moe Win. Vincent Chan directs the laboratory.

Visit LIDS at http://lids.mit.edu/.

Lean Aerospace Initiative

The Lean Aerospace Initiative (LAI) is an evolving learning and research community that brings together key aerospace stakeholders from industry, government, organized labor, and academia. A consortium-guided research program, headquartered in Aero-Astro and working in close collaboration with the Sloan School of Management, LAI is managed under the auspices of the Center for Technology, Policy and Industrial Development, an MIT-wide interdisciplinary research center.

The Initiative was formally launched as the Lean Aircraft Initiative in 1993 when leaders from the US Air Force, MIT, labor unions, and defense aerospace businesses forged a partnership to transform the US aerospace industry, reinvigorate its workplace, and reinvest in America, using an overarching operational philosophy called "lean."

LAI is now in its fifth and most important phase, having moved beyond the transformation of business units toward that of entire enterprises. This will be accomplished through research and the development and promulgation of practices, tools, and knowledge that enable enterprises to effectively, efficiently, and reliably create value in a complex and rapidly changing environment. The stated mission of LAI in this fifth phase is to "enable focused and accelerated transformation of complex enterprises through the collaborative engagement of all stakeholders to develop and institutionalize principles, processes, behaviors and tools for enterprise excellence."

LAI accelerates lean deployment through identified best practices, shared communication, common goals, and strategic and implementation tools honed from collaborative experience. LAI also promotes cooperation at all levels and facets of an enterprise and, in the process, eliminates traditional barriers to improving industry and government teamwork.

The greatest benefits of lean are realized when the operating, technical, business, and administrative units of an aerospace entity strive for across-the-board lean performance, transforming that entity into a total lean enterprise.

Aero-Astro LAI participants include Deborah Nightingale (co-director), Earll Murman, Dan Hastings, Annalisa Weigel, and Sheila Widnall. John Carroll (co-director) joins LAI from the Sloan School of Management. Warren Seering and Joe Sussman represent the Engineering Systems Division.

Visit the Lean Aerospace Initiative at http://lean.mit.edu/.

Man Vehicle Laboratory

The Man Vehicle Laboratory (MVL) optimizes human-vehicle system safety and effectiveness by improving understanding of human physiological and cognitive capabilities and developing appropriate countermeasures and evidence-based engineering design criteria. Research is interdisciplinary and uses techniques from manual and supervisory control, signal processing, estimation, sensory-motor physiology, sensory and cognitive psychology, biomechanics, human factor engineering, artificial intelligence, and biostatistics. MVL has flown experiments on Space Shuttle Spacelab missions and parabolic flights and has several flight experiments in development for the International Space Station. NASA, the National Space Biomedical Institute, and the Federal Aviation Administration (FAA) sponsored ground-based research. Projects focus on advanced space suit design and dynamics of astronaut motion, adaptation to rotating artificial gravity environments, spatial disorientation and navigation, teleoperation, design of aircraft and spacecraft displays and controls, and cockpit human factors. Annual MVL MIT Independent Activities Period activities include ski safety research and an introductory course on Boeing 767 systems and automation.

MVL faculty include Charles Oman (director), Jeffrey Hoffman, Dava Newman, and Laurence Young. They also teach subjects in human factors engineering, space systems engineering, space policy, flight simulation, space physiology, aerospace biomedical and life support engineering, and the physiology of human spatial orientation.

Visit the Man Vehicle Laboratory at http://mvl.mit.edu/.

The Partnership for Air Transportation Noise and Emissions Reduction

The Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) is an MIT-led FAA/NASA/Transport Canada-sponsored Center of Excellence. PARTNER fosters breakthrough technological, operational, policy, and workforce advances for the betterment of mobility, economy, national security, and the environment. PARTNER represents the combined talents of 12 universities, 3 federal agencies, and 50 advisory board members, the latter spanning a range of interests from local government to industry to citizens' community groups. During 2006–2007, PARTNER continued to expand its research portfolio, added participating universities and advisory board members, and forged international collaborations. Harvard University's School of Public Health and the University of North Carolina joined PARTNER.

Among major PARTNER projects are a landmark aviation and environment report to the US Congress; testing alternative descent patterns to reduce aircraft landing noise, fuel consumption, and pollutant emissions; and development of simulations to assess policies, technologies, and operational options for enabling environmentally responsible and economically viable air transportation growth.

MIT's most prominent role within PARTNER is developing tools that provide rigorous guidance to policy makers who must decide among alternatives for addressing 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 research and development investment strategies.

Other PARTNER initiatives in which MIT participates include exploring mitigating aviation environmental impacts via the use of alternative fuels for aircraft; studies of aircraft particulate matter microphysics and chemistry; and a study of reducing vertical separations required between commercial aircraft, which may enhance operating efficiency by making available more fuel/time-efficient flight levels and enhancing air traffic control flexibility and airspace capacity.

Current PARTNER MIT personnel include Ian Waitz, who directs the organization, Karen Willcox, James Hileman, Christine Taylor, Karen Marais, Malcolm Weiss, Stephen Connors, William Litant (communications director), Jennifer Leith (program coordinator), and 10–15 graduate students.

Visit The Partnership for Air Transportation Noise and Emissions Reduction at http://www.partner.aero/.

Space Propulsion Laboratory

The Space Propulsion Laboratory (SPL), part of the Space Systems Lab, studies and develops systems for increasing performance and reducing costs of space propulsion. A major area of interest to the lab is electric propulsion in which electrical, rather than chemical, energy propels spacecraft. The benefits are numerous and important; hence, the reason electric propulsion systems are increasingly applied to communication satellites and scientific space missions. In the future, these efficient engines will allow exploration in more detail of the structure of the universe, increase the lifetime of commercial payloads, and look for signs of life in faraway places. Areas of research include Hall thrusters; plasma plumes and their interaction with spacecraft; electrospray physics, mainly as it relates to propulsion; microfabrication of electrospray thruster arrays; Helicon and other radio frequency plasma devices; and space electrodynamic tethers. Manuel Martinez-Sanchez directs the SPL research group, and Paulo Lozano and Oleg Batishchev are key participants.

Visit the Space Propulsion Laboratory at http://web.mit.edu/dept/aeroastro/www/labs/SPL/home.htm.

Space Systems Laboratory

The Space Systems Laboratory (SSL) cutting-edge research contributes to the current and future 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 at the SSL conduct systems analysis studies and tool development, precision optical systems for space telescopes, microgravity experiments operated aboard the International Space Station, and robotic operations in Mars and beyond. Research at the SSL encompasses a wide array of topics that together comprise most space systems: systems architecting, dynamics and control, active structural control, thermal analysis, space power and propulsion, microelectromechanical systems, modular space systems design, microsatellite design, and software development.

Major SSL initiatives study the development of formation flight technology. The SPHERES facility, which began operations aboard the International Space Station on May 2006, enables research of algorithms for distributed satellites systems, including telescope formation flight, docking, and stack reconfiguration. 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 studies multiple architectures for light-weight segmented mirror space telescopes using active structural control; its final product will be a ground-prototype demonstrator. Multiple programs research the synthesis and analysis of architectural options for future manned and robotic exploration of the Earth-Moon-Mars system as well as real options analysis for Earth-to-orbit launch and assembly. In addition, SSL is developing technologies for low-cost star trackers and mappers, stereographic imaging systems, and space propulsion.

SSL faculty and staff include David W. Miller, director; Raymond J. Sedwick, associate director; John Keesee, Olivier de Weck, Edward F. Crawley, Daniel Hastings, Annalisa Weigel, Manuel Martinez-Sanchez, Paulo Lozano, Oleg Batishchev, Alvar Saenz-Otero, Paul Bauer, SharonLeah Brown, Margaret Bryan, and Marilyn E. Good.

Visit the Space Systems Laboratory at http://ssl.mit.edu/.

Technology Laboratory for Advanced Materials and Structures

An enthusiastic group of researchers constitute the Technology Laboratory for Advanced Materials and Structures (TELAMS). They work cooperatively to advance the knowledge base and understanding that will help facilitate and hasten the exploitation of advanced materials systems in, and the use of, various advanced structural applications and devices.

The laboratory has recently broadened its interests from a strong historical background in composite materials, and the name change from the former Technology Laboratory for Advanced Composites reflects that. The research interests and ongoing work thus represent a diverse and growing set of areas and associations. Areas of interest include the following:

- Nano-engineered hybrid advanced composite design, fabrication, and testing
- Characterization of carbon nanotube bulk engineering properties
- Composite tubular structural and laminate failures
- MEMS-scale mechanical energy harvesting modeling, design, and testing
- Durability testing of structural health monitoring systems
- Thermostructural design, manufacture, and testing of composite thin films and associated fundamental mechanical and microstructural characterization
- Continued efforts on addressing the roles of length scale in the failure of composite structures

- Numerical and analytical solid modeling to inform, and be informed by, experiments
- Further reengagement 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 is a facility 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 testing in general and hostile environments. There are facilities for microscopic inspection, nondestructive inspection, high-fidelity characterization of MEMS materials and devices, and a laser vibrometer for dynamic device and structural characterization.

With its ongoing linked and coordinated efforts, both internal and external, the laboratory has renewed its commitment to leadership in advancing the knowledge and capabilities of the composites 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 Nano-engineered Composite Aerospace Structures Consortium, an industry-supported center for developing hybrid advanced 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. Lagace (director), Brian L. Wardle, and visitor Antonio Miravete.

Visit the Technology Laboratory for Advanced Materials and Structures at http://web.mit.edu/telams/index.html.

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 FAA, and the less anticipated live tests in Olympic ski gear, astronauts' 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 more than a half century of operations, Wright Brothers Wind Tunnel work has been recorded in several hundred theses and more than 1,000 technical reports.

Wright Brothers Wind Tunnel faculty and staff include Mark Drela and Richard Perdichizzi.

Visit the Wright Brothers Wind Tunnel at http://web.mit.edu/aeroastro/www/labs/WBWT/wbwt.html.

Wesley L. Harris
Department Head
Charles Stark Draper Professor of Aeronautics & Astronautics

More information about the Department of Aeronautics and Astronautics can be found at http://web.mit.edu/aeroastro/.