Department of Aeronautics and Astronautics

Through the 20th and into the 21st centuries, MIT's Department of Aeronautics and Astronautics (Aero-Astro) and its people 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 Doolittle, 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 Daedalus 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 programs are our graduates.

The Aero-Astro Department's mission is to 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. 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 in many related technology-intensive fields involving, for example, transportation, information, and the environment.

Academic Program

Aero-Astro offers a comprehensive undergraduate curriculum that prepares students for careers in the aerospace industry or to continue in advanced study. We are immensely proud of our past, but our focus is on the future. 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 and teaching include silent aircraft; shirt button-sized gas turbine engines, highly flexible space suits woven skin-tight on their inhabitants, unmanned aircraft capable of complex maneuvers without human intervention, constellations of tiny satellites that in concert far outperform the single large satellites of the past, and 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.

The Past Year

This year, the faculty paused to identify a set of shared values—principles and qualities to which we collectively aspire. They are:

- Excellence in our research, scholarship, and teaching
- Aerospace as a primary focus of our activities
- Commitment to faculty development, especially junior faculty
- Leadership through professional service
- Commitment to open research
- Mutual respect for our colleagues and a collegial environment

We expect this to be a living list to be periodically revisited and refined.

Looking toward the future, we are embarking on a complete review and revision of our graduate programs, including overall objectives, admissions, curriculum, pedagogy, and financial issues. The extent of this review will be led by Professor David Darmofal. We take pride in the past decade's reformulation of our undergraduate program with the conceive, design, implement, operate (CDIO) framework and look forward to drawing on that experience as we re-examine the graduate program.

During the past three years, the excellence of our faculty has been recognized with many external honors. One highlight was this year's presentation of the Daniel Guggenheim Medal—one of the most prestigious honors in aerospace—to Professor Eugene Covert. The Aero-Astro Department proudly acknowledges the profound awards and recognitions bestowed since 2003 on members of our faculty. Their collective stellar achievements are a gift to our department, to our Institute, and to our society.

Eugene E. Covert	Guggenheim Medal, 2006
Edward F. Crawley	NASA Public Service Medal, 2003 Fellow, Royal Aeronautical Society (UK), 2004 Fellow, Royal Swedish Academy of Engineering Science, 2005 Doctor of Technology, Honoris Causa, Chalmers University, 2006
Mary L. Cummings	AIAA Distinguished Lecturer, 2004–2005
John Dugundji	AIAA Structures, Structural Dynamics & Materials Award, 2006
Alan H. Epstein	Gas Turbine Scholar, ASME IGTI, 2003 ISA, Major C. Bassett Outstanding Paper Award, 2005 ISA, Excellence In Documentation Award, 2005 Fellow, ASME, 2005
Edward M. Greitzer	ASME, R. Tom Sawyer Award, 2005

R. John Hansman	Aviation Week and Space Technology Laurel, 2004 ATCA Kriske Career Award, 2005 AIAA Dryden Lecture in Aviation Research, 2005
Wesley L. Harris	Doctor of Philosophy, Honoris Causa, University of Pretoria, 2006
Daniel E. Hastings	NRO Distinguished Civilian Award, 2003 QEM Giant in Science Award, 2005
Paul A. Lagace	ICCM, Executive Council Honorary Member, 2003 Fellow, ASC, 2005
Nancy G. Leveson	CRA N. A. Habermann Award, 2004 CRA Distinguished Professor, 2004 University of Illinois, Urbana–Champaign, R. T. Chien Lecturer, 2004 ACM SIGSOFT Outstanding Research Award, 2004 NSB Presidential Mentoring Award, 2005 NSB Public Service Award, 2005 Harvey Mudd College Distinguished Lecturer, 2005
Manuel Martinez-Sanchez	ASME Melville Medal, 2003
Earll M. Murman	IAA Engineering Book Award, 2003 Fellow, Royal Aeronautical Society, 2004 Foreign Member, RSAES, 2005
Dava J. Newman	AIAA Distinguished Lecturer, 2003–2004
Deborah J. Nightingale	IAA Engineering Book Award, 2003
Amedeo R. Odoni	Fellow, Institute for Operations Research and Management Science, 2004 Doctor of Philosophy, Honoris Causa, Athens University of Economics and Business, 2006
Jaime Peraire	Fellow IACM, 2004; Fellow, U.S. ACM, 2005
Nicholas Roy	AIAA Distinguished Lecturer, 2004—2005
Zoltan S. Spakovszky	ASME Melville Medal, 2003
Ian A. Waitz	Fellow, AIAA, 2006
Moe Win	IEEE S. A. Schelkunoff Transactions Prize Paper Award, 2003 ONR Young Investigator Award, 2003 PECASE, 2004 Fulbright Foundation Senior Scholar Fellowship Award, 2004 Institute of Advanced Study Natural Sciences and Technology Fellowship, 2004 Fellow, IEEE, 2004 IEEE Distinguished Lecturer, 2005 IEEE E. E. Sumner Award, 2006
Laurence R. Young	Fellow, Biomedical Engineering Society, 2005 Fellow, American Institute of Medical and Biological Engineering, 2005

Undergraduate Student Prizes

Undergraduate Enrollment Over The Last Ten Years

	95–96	96–97	97–98	98–99	99–00	00–01	01–02	02–03	03–04	04–05	05–06
Sophomores	30	46	40	48	59	68	56	64	72	64	65
Juniors	31	23	33	37	40	53	69	51	59	59	52
Seniors	37	29	24	35	37	45	53	70	61	65	76
Totals	**98**	**98**	**97**	**120**	**136**	**166**	**178**	**185**	**192**	**188**	**196**
Women, %	29	26	30	33	30	32	33	35	34	30	26
Minorities, %	16	18	22	15	12	21	22	30	30	27	25

Awards presented at the Aero-Astro Class of 2006 Recognition Dinner on Monday, May 16, 2006:

Ash C. Dyer and Barrett S. Mitchell, for excellence in the design of a controller for quadruple robot locomotion over difficult terrain, were awarded the Andrew Morsa Prize, which is given to an undergraduate student for demonstration of ingenuity and initiative in the application of computers to the field of aeronautics and astronautics.

For significant achievement in Unified Engineering, for an infectious enthusiasm and love of aerospace, and for best exemplifying the spirit of Yngve Raustein, Warren (Woody) Hoburg won the Yngve Raustein Award.

The Apollo Award is given to an Aero-Astro student who conducts the best undergraduate research project on the topic of humans in space. Nicholas Y. Chan and Jason S. Ruchelsman were given the prize for excellence in testing and developing a fluid-filled helmet liner.

The Thomas Sheridan Award is awarded to an Aero-Astro or Mechanical Engineering undergraduate student whose research or design project best exemplifies creativity or improvement in human-machine integration or cooperation. Michael R. Francis and Jonathan M. Long won for excellence in the assessment of a hypothesis concerning the relationship of age to font size preference on an in-vehicle telematic display.

The Leaders for Manufacturing Prize is 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. Nii A. Armar, Carl J. Engel, Gaston A. Fiore, Alberto J. Gayon, and Adam J. Woodworth won for outstanding achievement in the design, construction, reporting, and flight of the Team Uno radio-controlled aircraft that competed in the 2006 AIAA/Cessna/ONR Design, Build, Fly Competition.

The Lockheed Martin Prize for Excellence in System Engineering was given to Ryan W. Castonia, Alexander D. Donaldson, Jacqueline A. O'Connor, Thomas K. Walker, and Meredith K. Ward for excellence in the analysis, design, and manufacturing of the Team Ostrich radio-controlled aircraft to meet the specifications of the 2006 AIAA/Cessna/ONR Design, Build, Fly Competition.

The United Technologies Corp. Prize is given to an Aero-Astro student for outstanding achievement in the design, construction, execution, and reporting of an undergraduate experimental project. Ruijie He and Sho Sato won the award for their torque-free rotor propulsion system for a nano air vehicle.

Graduate Program Statistics, Academic Year 2005–2006*

	February '06	September '06	Total
Applications	16	290	**306**
Admitted	8	142	**150**
Accepted admission	7	84**	**91**
SM	4	81	**85**
PhD	3	3	**6**
Minority	0	6	**6**
SM	0	6	**6**
PhD	0	0	**0**
Female	0	12	**12**
SM	0	11	**11**
PhD	0	1	**1**
Funding accepted			
Fellowship (MIT)	0	6	**6**
Fellowship (other)	0	9	**9**
Research assistantship & Draper fellowship	3	27	**30**
Teaching assistantship	0	4	**4**

*Four students accepted for September started their SM in June, but no students applied to start in June.

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

For initiative and ingenuity in the creation and development of an experimental assessment of bat flexibility on batted ball speed, Nabori D. Santiago and Greg R. Williams were awarded the Admiral Luis De Florez Prize, which is 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.

The James Means Award for Excellence in Flight Vehicle Engineering was given to Benjamin J. Alvarado, Nicholas Y. Chan, Miles R. Colman, and Alasdair Lyn Gardner for excellent aerodynamic design of a radio-controlled aircraft to meet the specifications of the 2006 AIAA/Cessna/ONR Design, Build, Fly Competition.

The Henry Webb Salisbury Award, given in memory of Henry Salisbury to a graduating senior (or seniors) who has achieved superior academic performance in the Course 16 Undergraduate Program, was awarded to Eleanor S. Crane, for superior and multiple-dimensional academic achievements in the undergraduate program.

The Aero & Astro Teaching Assistantship Award is given to a teaching assistant or assistants who has/have demonstrated conspicuous dedication and skill in helping fulfill an undergraduate or graduate subject's educational objectives. George F. Kiwada was given the award for his outstanding support of the 16.821 Flight Vehicle Development teams in their quest to design, construct, and fly competitive aircraft in the

2006 AIAA/Cessna/ONR Design, Build, Fly Competition. David C. Wang was also given the award, in recognition of his excellence in enabling, creating, and sustaining the best possible learning environment for his fellow students. His commitment and dedication have set the benchmark for future teaching assistants.

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 Earll M. Murman**.**

The Sigma Gamma Tau Society Graduate Teaching Award, given by the MIT Student Chapter of the Aero-Astro Honors Society to a faculty or staff member who has exemplified what graduate students consider a “great teacher,” was presented to Professor Jeffrey A. Hoffman**.**

A Review of Aeronautics and Astronautics Department Research

Laboratories

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, aero-acoustics, 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 Jaime Peraire (director), David Darmofal, Mark Drela, Robert Haimes, Ngoc Cuong Nguyen, Per-Olof Persson, and Karen Willcox.

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, and navigation using GPS, robust control, optimal control, and model predictive control. Experimental and applied research is also a major part of ACL. The advanced unmanned aerial vehicle, rover, automobile, and satellite test beds enable students to implement their algorithms in actual hardware and evaluate the proposed techniques.

ACL faculty are Professors Jonathan How and Steven Hall.

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

Complex Systems Research Laboratory

Increasing complexity and coupling as well as the introduction of new digital technology are bringing new challenges for engineering, operations, and sustainment. The Complex Systems Research Laboratory (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 includes 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 turbo machinery. GTL's mission is to advance the state-of-the-art in gas turbines for power and propulsion. Several unique experimental facilities include a blow-down turbine; a blow-down compressor; a shock tube for reacting flow heat transfer analysis; facilities for designing, fabricating, and testing micro-heat 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 turbo machine instabilities; the micro-engine 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-, medium-, 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 the 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-Clifford, 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/.

Humans and Automation Laboratory

Research in the Humans and Automation Laboratory, Aero-Astro's newest research laboratory, 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.

Applying human-centered design principles to human supervisory control problems and identifying ways humans and computers can leverage each other's strengths 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 (objective functions), collaborative human–computer decision making in time-pressured scenarios (for both individuals and teams), human supervisory control of multiple unmanned aerial vehicles, developing metrics for evaluating display complexity, the impact of multiple alarms on driver performance, and display design for autonomous formation flying.

In conjunction with Draper Laboratory, HAL has kicked off the lunar access project. The objective of this program is to develop a baseline lunar landing system design to enable pinpoint "anywhere, anytime" landings. The long-term goal is to develop a lunar lander simulator to test the design. While Draper will concentrate on the guidance, navigation, and control problem, HAL will focus on the operator in the loop, designing the human–

computer interface. Also, the project will conduct trade studies for including the human at different control points such as in the lander, from orbit, or remotely from Earth. Professors Dava Newman and Nicholas Roy will contribute to the lunar lander design effort.

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

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

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 new technologies.

Global information systems are central to 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 includes R. John Hansman (director), Cynthia Barnhart, Peter Belobaba, 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, focused 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.

LIDS recently experienced significant growth. The laboratory moved to the Stata Center in April 2004, a dynamic new space that promotes increased interaction within the lab and with the larger community. Laboratory research volume is now more than $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 10th annual LIDS Student Conference took place in January 2005, showcasing current student work and including keynote speakers. These and other events reflect the LIDS commitment to building a vibrant, interdisciplinary community.

In addition to a full-time staff, faculty, support personnel, and graduate assistants, every year several scientists from around the globe visit LIDS to participate in its research program. Currently, 17 faculty members, 20 research staff members, and approximately 110 graduate students are associated with the laboratory.

Aero-Astro LIDS faculty are John Deyst, Daniel Hastings, Eytan Modiano, and Moe Win. The laboratory is directed by Vincent Chan.

Visit the Laboratory for Information and Decision Systems 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 phase 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 deployment are realized when the operating, technical, business, and administrative units of an aerospace entity all strive for across-the-board lean performance, thus transforming that entity into a total lean enterprise. Aero-Astro LAI participants include Deborah Nightingale (codirector), Earll Murman, Daniel Hastings, Annalisa Weigel, and Sheila Widnall. John Carroll (codirector) joins LAI from the Sloan School of Management. Warren Seering and Joseph 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 ground-based research sponsored by the Federal Aviation Administration (FAA). 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 includes 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's goal is to be a world-class research organization closely aligned with national and international needs. PARTNER leverages a broad range of stakeholder capabilities, thereby fostering breakthrough technological, operational, policy, and workforce advances for the betterment of mobility, economy, national security, and the environment. PARTNER represents the combined talents of 10 universities, 3 federal agencies, and 50 advisory board members spanning a range of interests from local government, to industry, to citizens' community groups. Industry participants include General Electric, Pratt & Whitney, Rolls-Royce, Snecma, Boeing, Airbus, Bell Helicopter, Cessna, Delta Airlines, UPS, Gulfstream, Lockheed-Martin, Sikorsky, the Air Transport

Association, Aerospace Industries Association, Airports Council International, and other smaller organizations.

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.

PARTNER is directed by Professor Ian Waitz of Aero-Astro. Other MIT participants include Professors Peter Belobaba, Edward Greitzer, Henry Jacoby (Sloan School of Management), Karen Polenske (Urban Studies and Planning), Jack Kerrebrock, Karen Willcox, and Joel Cutcher-Gershenfeld (Sloan School of Management) as well as many research engineers, postdocs, and graduate students.

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

Space Propulsion Laboratory

The Space Propulsion Laboratory, 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 more detailed exploration 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.

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) engages in cutting-edge research projects with the goal of directly contributing to current and future exploration and development of space. SSL's mission is to explore innovative concepts for integration of and into future space systems and to train a generation of researchers and engineers conversant in this field. General areas include developing the technologies and systems analyses associated with small spacecraft, precision optical systems, International Space Station experiments, and planetary exploration. The laboratory encompasses expertise in systems architecting, dynamics and control, thermal analysis, space power and propulsion, microelectromechanical systems, and software development. Major activities in the SSL are the development of formation flight technology test beds and involvement in the NASA Concept Evaluation and Refinement (CE&R) study with the

Charles Stark Draper Laboratory. The first of these activities has produced SPHERES, which will be launched to the International Space Station; EMFF, a system that uses electromagnets instead of thrusters for spacecraft formation control; and SWARM, a new demonstration of modular, wireless spacecraft docking and assembly. The CE&R study focuses on synthesizing and analyzing 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, the SSL is developing technologies for interferometric space-based telescopes, low-cost star trackers and mappers, stereographic imaging systems, and space nuclear power and propulsion.

SSL faculty and research staff include David Miller (director), Ray Sedwick (associate director), Edmund Kong, John Keesee, Olivier de Weck, Edward Crawley, Daniel Hastings, Annalisa Weigel, Manuel Martinez-Sanchez, Jonathon How, Paul Bauer, and Paul Wooster.

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

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.

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

- nanoengineered hybrid advanced composite design, fabrication, and testing
- 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 in addressing the roles of length scale in the failure of composite structures
- 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 specimens such as coupons, shafts, stiffened panels, and pressurized cylinders, made of composites, active, and other materials. TELAMS testing capabilities include a battery of servo hydraulic 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 general and

hostile environments. There are facilities for microscopic inspection, for high-fidelity characterization of MEMS structures and devices, and a laser vibrometer for mechanical and electrical testing of electromechanical materials and devices.
With its ongoing, linked, and coordinated internal and external efforts, the laboratory has renewed its commitment to leadership in the advancement of 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. In these efforts, the laboratory and its members continue their extensive collaborations with industry, government organizations, other academic institutions, and other groups and faculty within MIT.

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/.

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 included auxiliary propulsion burner units, helicopter antenna pods, and in-flight trailing cables as well as new 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/index.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/www/.