Department of Aeronautics and Astronautics

Undergraduate Enrollment over the Last Ten Years

	94–95	95–96	96–97	97–98	98–99	99–00	00–01	01–02	02–03	03–04	04–05
Sophomores	36	30	46	40	48	59	68	56	64	72	64[a]
Juniors	37	31	23	33	37	40	53	69	51	59	59[a]
Seniors	38	37	29	24	35	37	45	53	70	61	65[a]
Total	**111**	**98**	**98**	**97**	**120**	**136**	**166**	**178**	**185**	**192**	**188**[a]
Women	31%	29%	26%	30%	33%	30%	32%	33%	35%	34%	30%[a]
Under-represented minorities	19%	16%	18%	22%	15%	12%	21%	22%	30%	30%	27%[b]

[a] Data based on fall 2004 fifth-week enrollment.
[b] Data based on spring 2005 term enrollment.

Undergraduate Awards

The following awards were presented at the Aeronautics and Astronautics Department Senior Recognition Dinner on Monday, May 9, at the University Park Hotel, Cambridge, MA.

The Andrew Morsa Prize, given to an undergraduate student for demonstration of ingenuity and initiative in the application of computers to the field of aeronautics and astronautics, was awarded to Jordan J. McRae '05 for his ingenuity and initiative in designing and integrating the microprocessor software into the SWARM modular spacecraft test bed.

The Yngve Raustein Award, given to a student in unified engineering who best exemplifies the spirit of Yngve Raustein and to recognize significant achievement in unified engineering, was awarded to Nicki L. Lehrer '07, whose positive attitude, sense of community, generosity of spirit, and academic excellence best exemplify the spirit that Yngve Raustein brought to unified engineering.

The David 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 awarded to Thomas M. Coffee '05 to attend the 56th Annual International Astronautical Congress in Fukuoka, Japan; Alexander D. Donaldson '07 to attend a short course on space science and technology at the Umea University in Sweden; to Carl J. Engel '07 and Adam J. Woodworth '07 to enter the 2006 International Micro Air Vehicle Competition; and to Mariel M. John '06 to participate in the engINdia expedition to rural India in the summer of 2005.

The Apollo Award, given to an Aero/Astro student who conducts the best undergraduate research project on the topic of humans in space or for participation in a successful Course 16 design project, was awarded to Amy S. Brzezinski '05 for her contributions to the development of an advanced space suit for human space exploration.

The Thomas Sheridan Award, given 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, was awarded to Jaclyn E. Cichon '05 and John D. Griffith '05 for improvement in human-machine integration through research on the effects of age on automobile driver flexibility.

The Leaders for Manufacturing Prize, awarded to one or at most two 16.622 teams who have used their project to directly deal with issues related to the interaction between manufacturing and engineering through demonstration of modern manufacturing processes, was awarded to Finale P. Doshi '05 and JoHanna N. Przybylowski '05 for ingenuity and high-quality execution in manufacturing internally cooled, hollow compressor vanes with application to high-efficiency power systems; and to John C. Head '06 and Michael R. Heiman '05 for their exhaustive efforts to manufacture the hardware and software for the SWARM modular spacecraft test bed.

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 awarded to Taymour El Chammah '05 and JeanMarc D. Freuler '05 for excellence in the conception, design, implementation, operation, and reporting of a method for wing flutter stabilization using local aerodynamic load sensing for active flap control; and to Benjamin W. Glass '06 for outstanding performance in the design and execution of an innovative project involving an array of 24 electrospray sources for use as a satellite microthruster.

The Admiral Luis De Florez Prize for "original thinking or ingenuity" as demonstrated by the *individual* effort of the student, not the ideas and suggestions of his advisor, instructors, or an advisory team was awarded to Nicholas O. Sidelnik '05 and Brady William Young '06 for originality in the development and use of experimental models of swimmer's hands.

The James Means Award for Excellence in Space Systems Engineering, given to a student for outstanding scholarship, was awarded to Colleen A. Horin '05 for her leadership and excellence in the design of the SWARM modular spacecraft test bed.

The James Means Award for Excellence in Flight Vehicle Engineering, given to a student for outstanding scholarship, was awarded to Craig D. Morales '05 for creative and analytical contributions to the design of a sea-based joint inter-theater airlift concept vehicle.

The Henry Webb Salisbury Award, given in memory of Henry Salisbury to a graduating senior (or seniors) who has achieved superior academic performance in multiple dimensions, was awarded to Brett M. Bethke '05 and Emily Schwartz '05 for superior and multidimensional academic achievements in their undergraduate program.

The Aero & Astro Teaching Assistantship Award, given to teaching assistants who have demonstrated conspicuous dedication and skill in helping fulfill an undergraduate or graduate subject's educational objectives, was awarded to Christopher D. Graff (16.810 graduate TA) and Nayden D. Kambouchev (16.07 graduate TA).

The AIAA Undergraduate Advising Award, given by the AIAA Student Chapter to a faculty or staff member who has demonstrated excellence in serving as an academic or project advisor, was awarded to Professor Zoltan S. Spakovszky.

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 awarded to Professor David L. Darmofal.

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 to be a "great teacher," was awarded to Professor Manuel Martínez-Sánchez.

Graduate Program Enrollment Statistics, Academic Year 2004–2005

	February '05	June '05	September '05	Total
Applications	27	8	269	304
Admitted	7	6	130	143
Accepted Admission	6	5	64	75
SM	5	4	60	69
PhD	1	1	8	10
Minority	0	0	2	2
SM	0	0	2	2
PhD	0	0	0	0
Female	0	1	19	20
SM	0	1	19	20
PhD	0	0	0	0
Funding Accepted				
Fellowship (MIT)	0	0	4	4
Fellowship (other)	1	0	7	8
RA & Draper	2	4	20	26
TA	0	0	2	2
Other	0	0	0	0

Aerospace Controls Laboratory

The Aerospace Controls Laboratory (ACL), affiliated with the Department of Aeronautics and Astronautics at MIT, was founded in 2002. The ACL has the mission of developing the technologies to perform autonomous guidance, navigation, and control of aerospace vehicles, including both spacecraft and aircraft. The primary thrust of the research in this laboratory is developing control techniques for groups of vehicles, cooperating to achieve a common objective. In particular, the goal is to distribute the coordination and control amongst the vehicles in the fleet, which shares the computational effort, making the approach more scalable and improving robustness. The objective of the laboratory is to explore innovative concepts for the integration of future aerospace systems and to train a generation of researchers and engineers conversant in this field.

Formation Flying Spacecraft

A key focus of our research is navigation and control issues for a revolutionary new approach to space science that uses distributed arrays of simple but highly coordinated spacecraft. This approach, called formation flying, requires that we accurately maintain a spacecraft's position relative to the other vehicles in the fleet to ensure that they avoid collisions and collect the best possible scientific data. NASA and the Department of Defense are particularly interested in formation flying because it will provide improved space science and offer more flexible mission architectures. The technologies being developed to perform formation flying can be used in many other applications, including autonomous farming, "smart highways," and "free flight" of aircraft. The primary challenges of formation flying are to maintain constant and precise measurements of the relative vehicle states (navigation) and then to apply immediate adjustments (real-time control) to the spacecraft motion to meet stringent performance requirements while preserving fuel. Previous attempts to perform formation flying have been limited by two factors. First is the lack of a sensing system (both hardware and algorithms) that provides precise measurements of the relative positions of the vehicles in the fleet. Second is the lack of online, fuel-efficient, and robust control algorithms for creating and maintaining accurate spacecraft formation geometries while limited by sensing and modeling errors. Our research has developed a novel end-to-end integrated sensing and control approach based on rigorous theory, architectural innovation, component development, and complete system demonstration.

Our recent work builds on a new concept to perform very precise autonomous relative navigation (position, velocity, and timing synchronization) for multiple spacecraft using local radio-frequency (RF) ranging between vehicles to improve navigation accuracy. In particular, we have developed decentralized and hierarchic architectures to perform position estimation for fleets of satellites with reduced computational complexity, communication bandwidth, and synchronization requirements. As a part of this ongoing research, we have designed innovative ways to handle communication delays in the satellite networks. The techniques allow accurate and computationally efficient fusion of delayed information from the network and the high-frequency local sensing measurements. These improvements greatly enhance the scalability, extensibility, and robustness over the previously used centralized and reduced-order filter approaches.

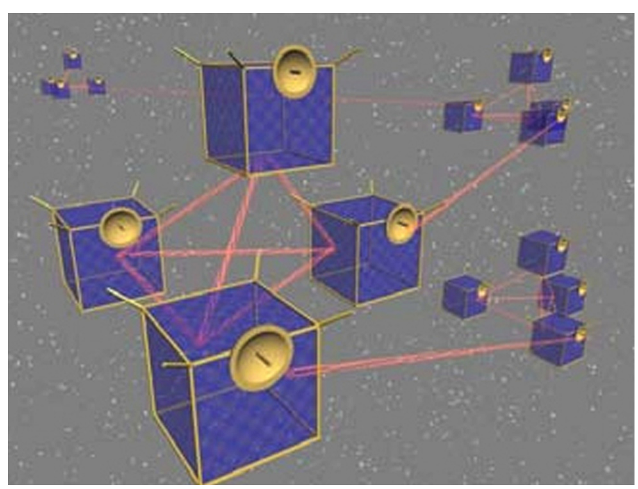
This research has broad set of applications, such as planetary robotic explorations, which rely on sensing data from a distributed sensor network.

We have extended our techniques to control a formation of spacecraft. We have developed an enhanced linear parameter-varying model of the dynamics to design the controllers and integrated techniques to mitigate the effect of sensor noise and environmental disturbances on the control system performance. Our approach uses an online optimization that can easily be solved in real time and guarantees the robustness of the planning system to both process and sensing noise, with fuel costs that are shown to be comparable to the previous approach. Currently we are investigating a new method of finding initial conditions for formation geometries that balances the cost of the formation initialization maneuver against the cost of future restoration maneuvers.

Our algorithms support NASA's Space Exploration Initiative in that they directly address 3 of the 17 enabling technologies identified in the recent report to the president (Report of the President's Commission on Implementation of United States Space Exploration Policy: A Journey to Inspire, Innovate and Discover, June 2004). This work builds on research that received the 2002 Institute of Navigation Burka Award to recognize "outstanding achievement in the preparation of papers contributing to the advancement of navigation and space guidance." Dynamics and estimation advances arising from this research will impact other applications in the field of autonomous rendezvous and docking of spacecraft, both of which are crucial for the next generation space program.

NASA Concept Evaluation and Refinement for Next-Generation Space Missions

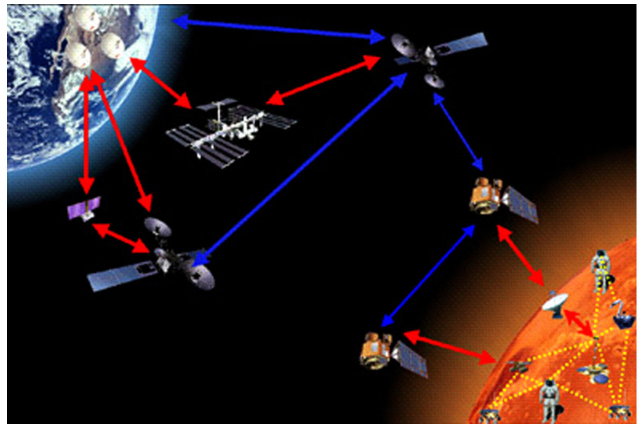
The NASA Concept Evaluation and Refinement (CE&R) project strives to find recommendations for a sustainable plan of human Martian and lunar exploration. Our specific area of research on this department-wide project is the design of communication and navigation architectures that allow precise and rapid exploration of a planetary surface while meeting high-volume scientific data return requirements.



As a part of this effort, we have created a unique set of architectures that utilize integrated navigation and communication capability of on-orbit space assets. Analyzing and ranking these architectures across both design requirements and indicators, we have derived critical recommendations for NASA on minimalist infrastructure development, usage of vision system to augment surface exploration capabilities, and usage of small satellite constellations to provide "earth-like" navigation and communication capability over continental distances.

Our current effort is on designing navigation techniques that will allow previously undemonstrated precision for the entry descent and landing phase of the Mars Mission. This work, in combination with Mars atmospheric entry and hypersonic flight segments, will provide the sensing requirements and the navigation technique recommendations for the design of a Mars lander.

Coordination and Control of Multiple Unmanned Aerial Vehicles

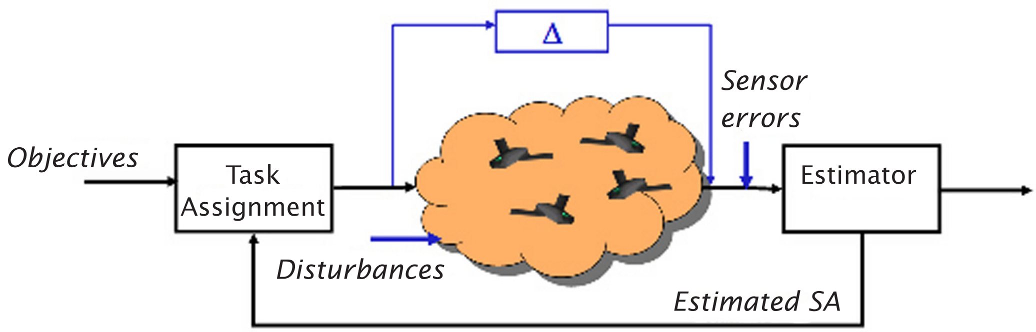


For many vehicles, obstacles, and targets, coordination of a fleet of unmanned aerial vehicles (UAVs) is a highly complicated optimization problem, and the computation time typically increases very rapidly with the problem size. Previous research proposed an approach to decompose this large problem into task assignment and trajectory problems, while capturing key features of the coupling between them. This enabled the control architecture to solve an assignment problem by first determining a sequence of waypoints for each vehicle to visit and then concentrating on designing paths to visit these preassigned waypoints.

Our previous research has extended that approach to the Receding Horizon Task Assignment algorithm, which is much faster and works in a dynamic environment. However, central task assignment for a fleet of UAVs is often not practical due to communication limits, robustness issues, and scalability. Using a decentralized approach can mitigate many of these problems. We have developed a new decentralized approach that replicates the central assignment algorithm on each of the UAVs and allows implicit coordination across the fleet. We also have extended the basic implicit coordination approach to achieve better (i.e., consistent) performance with imperfect data synchronization. The resulting robust decentralized task assignment method assumes some degree of data synchronization but adds a second planning step based on sharing the planning data. The approach is analogous to closing a synchronization loop on the planning process to reduce the sensitivity to exogenous disturbances. Simulation results show the advantages of this method in reducing conflicts in the assignments, generating feasible plans, and increasing the performance of the plan compared to implicit coordination.

Recent work has focused on investigating the role of uncertainty in task assignment algorithms, leading to robust techniques that mitigate this effect on the command and control decisions. Specifically, we have identified methodologies to mitigate the impact of uncertainty in prior information on UAV search and track strategies. The key desirable features of the current approach are its intuitive appeal of visualizing the uncertainty and analytical tractability that can give rise to closed-form expressions for solutions. The new approach results in UAV search and track algorithms resilient to the uncertainty in prior information. Decision making under uncertainty is a common problem in finance, operations research, and the overall operation of complex fields. This fundamental research should lead to many new and interesting directions connecting OR/AI/Controls.

Many of these algorithms have been demonstrated on two unique test beds that have been developed to demonstrate the cooperative control of teams of UAVs. One test bed uses eight rovers and a blimp operated indoors to emulate a team of heterogeneous vehicles performing a combined reconnaissance and strike mission. The second test bed uses eight small aircraft that are flown autonomously using a commercially available autopilot. This combination of test beds provides platforms for both advanced research and realistic demonstrations. This year we have extended our airborne platform with the addition of four Coupe model airplanes. With larger payload capabilities and wider flight envelopes, these aircraft provide the ability to integrate new sensors. Currently we are flight-testing our new UAVs and the camera platforms.



Aerospace Computational Design Laboratory

The Aerospace Computational Design Laboratory's mission is to improve the design of aerospace systems through the advancement of computational methods and tools that incorporate multidisciplinary analysis and optimization, probabilistic and robust design techniques, and next-generation computational fluid dynamics. The laboratory studies a broad range of topics that focus on the design of aircraft and aircraft engines. Faculty and staff include David Darmofal, Mark Drela, Bob Haimes, Ali Merchant, David Venditti, and Karen Willcox. Jaime Peraire directs the lab. Visit the Aerospace Computational Design Lab at http://raphael.mit.edu/.

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 (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 systems 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.

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 to transform commercial air transportation.

GTL participates in research topics related to short, middle, and long-term problems and interacts with almost all of the major gas turbine manufacturers. Research support also comes from several U.S. 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, Ravi Khanna, Carol Livermore, Ali Merchant, Nori

Miki, Manuel Martínez-Sánchez, 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), 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.

Employing human-centered design principles to human supervisory control problems and identifying ways in which humans and computers can leverage the strengths of each 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 (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/index.html.

International Center for Air Transportation

The International Center for Air Transportation (ICAT) undertakes research and educational programs that advance and disseminate the knowledge and tools underlying a global air transportation industry driven by new 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 Cynthia Barnhart, Peter Belobaba, John-Paul Clarke, Eric Feron, and Amedeo Odoni. R. John Hansman directs ICAT. 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 studentbody 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 LIDS' commitment to building a vibrant, interdisciplinary community.

In addition to a full-time staff of 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, Eric Feron, Daniel Hastings, Eytan Modiano, and Moe Win. The laboratory is directed by Vincent Chan. Visit LIDS at http://lids.mit.edu/.

Lean Aerospace Initiative

The Lean Aerospace Initiative (LAI) is a continuously 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 U.S. Air Force, MIT, labor unions, and defense aerospace businesses forged a partnership to transform the U.S. aerospace industry, reinvigorate its workplace, and reinvest in America, using an overarching operational philosophy called "lean."

Now approaching its fifth and most important phase—the transformation not of discrete units of divisions but of entire enterprises—LAI's mission is to research, develop, and promulgate practices, tools, and knowledge that enable and accelerate the envisioned transformation of the greater U.S. aerospace enterprise through people and processes. As a consequence, LAI is now in the Enterprise Value Phase, engaged in transforming aerospace entities into total lean enterprises, delivering far more value to all stakeholders than would be possible through conventional approaches.

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 aerospace enterprise, in the process eliminating 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 all strive for across-the-board lean performance, thus transforming that entity into a total lean enterprise.

Aero/Astro LAI participants include Professors Deborah Nightingale (director), John Deyst, Wesley Harris, Earll Murman, and Sheila Widnall and Dr. Hugh McManus. 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 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 Jeffrey Hoffman, Dava Newman, Laurence Young, and the director, Charles Oman. 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/.

Technology Laboratory for Advanced Composites

This was a year of substantial change in the Technology Laboratory for Advanced Composites (TELAC). At the beginning of this period, there were four faculty (Lagace, Radovitzky, Spearing, and Wardle) involved in the laboratory, but the end of this year found only two of these (Lagace and Wardle) actively participating in its activities. Spearing had announced in the spring of 2004 that he was leaving MIT and returning to his home country of Great Britain to take a position at the University of Southampton. He did so in the summer of 2004. Based on his desires and associated changes, Radovitzky felt it better to pursue his interests and the work of his students outside the environment of the laboratory. This was manifested early in the academic year. With these two changes, the overall number of personnel involved in the laboratory was less than in past years. During AY2005, on the order of a dozen students were involved in TELAC, with the two associated faculty of Lagace and Wardle, including seven graduate students and several UROPers. Two students in 16.621/2 performed their projects in TELAC during this year. One student finished a master's thesis in the laboratory during this period, but no doctorates were completed. Two postdoctoral associates and one visiting scientist were involved in the laboratory throughout the year. In addition to this, as usual, the laboratory was host to occasional visits from international scholars during the year. The laboratory issued over a dozen reports during this period, including several accepted for publication in journals and proceedings. Laboratory personnel participated in conferences and meetings at the national and international level, giving more than a dozen presentations.

The laboratory personnel continue to have a diverse set of research interests, and these are manifested in the work that is pursued, the variety of sources from which funding is acquired, and the range of organizations and personnel with whom they pursue their work. Important progress was made in a number of research areas throughout the year. These include composite tubular structural and laminate failures; MEMS–scale mechanical energy harvesting modeling, design, and testing; work on the use of piezo-actuation to induce fatigue in solders and adhesives; nano-engineered composite fabrication and modeling; durability testing of structural health monitoring systems; fundamental mechanical and microstructural characterizations of thin-film nanocrystalline solid oxide fuel cell materials; thermostructural design, manufacture, and testing of composite thin films for a microscale solid oxide fuel cell (μSOFC); continued efforts on addressing issues related to lengthscale in the failure of composite structures; and a further reengagement in the overall issues of the design of composite structures with a focus on failure and durability. In performing this work, the laboratory and its members continued to have extensive collaborations with industry (Rockwell Scientific, Boeing, Schlumberger, China Steel, Metis Design Corporation), government organizations (AFOSR, ARO, FAA, NASA), other academic institutions (Cambridge University, Georgia Tech, University of Southampton), and other groups and faculty within the Institute (Singapore-MIT Alliance, Cambridge-MIT Institute, Microsystems Technology Laboratory, Chemical Engineering, Department of Materials Science and Engineering, Mechanical Engineering).

With the changes associated with the laboratory, as well as a further broadening of interest in the world of structural applications, the laboratory faculty decided to change the name of the laboratory to properly encompass this broader perspective. The laboratory will become known as the Technology Laboratory for Advanced Materials and Structures (TELAMS). Since its inception, the laboratory has always provided 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 at large. As the focus of the laboratory has broadened, this leadership will continue and broaden, with an emphasis on composite materials. As the current academic year comes to a close, this decision has been reached, and plans are underway to implement it in the year ahead.

The laboratory's director is Paul A. Lagace.

The Partnership for Air Transportation Noise and Emissions Reduction

The Partnership for Air Transportation Noise and Emissions Reduction (PARTNER), which was launched in 2004, 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 that 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 nine universities, three federal agencies, and 29 organizations spanning a range of interests from local government to industry. Industry participants include General Electric, Pratt & Whitney, Rolls-Royce, Boeing, Bell Helicopter, Cessna, Delta Airlines, UPS, Gulfstream, Lockheed-Martin, Sikorsky, the Air Transport Association, and other smaller organizations.

During its first 18 months, PARTNER conducted continuous descent approach flight-tests with more than 100 UPS aircraft at the Louisville International Airport, made particulate matter measurements on hundreds of aircraft at another major U.S. airport, conducted a field study of low-frequency noise at Dulles International Airport, and led the drafting of the *Report to the U.S. Congress, Aviation and the Environment: A National Vision Statement, Framework for Goals and Recommended Actions.* PARTNER has many other current projects, and its research portfolio is growing.

PARTNER is directed by Aero/Astro professor Ian Waitz. Other MIT participants include Professors Peter Belobaba, John-Paul Clarke, Edward Greitzer, Henry Jacoby (Sloan School of Management), Karen Polenske (Urban Studies and Planning), Jack Kerrebrock, Karen Willcox, and senior research scientist 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://web.mit.edu/aeroastro/www/partner/ or http://mit.edu/aeroastro/www/people/waitz/ for related research activities.

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, which explains why many communication satellites and scientific missions are turning to electric propulsion systems. In the future, these plasma engines will allow people to do such things as explore in more detail the structure of the universe, increase the lifetime of commercial payloads, or look for signs of life in faraway places. Other areas of research include microfabrication, numerical simulation, arcjet thrusters, numerical simulation, hall thrusters, space tethers, orbit optimization, and spacecraft-thruster interaction. Manuel Martínez-Sánchez directs the SPL research group. Visit the SPL at http://web.mit.edu/dept/aeroastro/www/labs/SPL/home.htm.

Space Systems Laboratory

SPHERES

The synchronized position hold engage and reorient experimental satellites (SPHERES) formation flight test bed was developed by the MIT Space Systems Laboratory (SSL) under the sponsorship of Defense Advance Research Projects Agency (DARPA) and NASA to develop and test formation flight and docking algorithms for future spaceflight programs. The test bed consists of five small, self-contained vehicles and is designed to enable the test and verification of control, estimation, and autonomy algorithms that are important for formation flight and docking maneuvers. Three of these vehicles will be launched on a Space Shuttle to the International Space Station (ISS), where they will be used to demonstrate coordinated maneuvers representative of those planned for NASA's Terrestrial Planet Finder mission and DARPA's Orbital Express mission. These tests will be performed inside the station and supervised by astronauts. Because the test bed will be operated in a controlled environment, it has a high degree of fault tolerance that cannot be achieved in standard space missions, enabling researchers to test a wide range of algorithms and maneuver profiles without the possibility of causing mission failure.

To support this wide range of research topics, the SPHERES design contemplated the need to support multiple researchers, as echoed from both the hardware and software designs. Through its Guest Scientist Program, the SPHERES operational plan facilitates the development of algorithms by multiple researchers, while the operational locations incrementally increase the ability of the tests to operate in a representative environment.

Though SPHERES has yet to launch to the ISS, future flight programs have already been planned. Through its expansion port, small mission-specific payloads can be launched and augmented to the original SPHERE satellites. Current plans involve the development of a tether and reaction wheel payload to study the dynamics and controls of a tethered-formation flight test bed to support NASA's SPECS mission, development of a capture cone mechanism to study the spacecraft contact dynamics for NASA's Mars Orbit Sample Return mission, and development of a precision-pointing payload to accommodate the development of multistaged control systems for a separated spacecraft interferometer system. Flight development of these programs is currently scheduled for 2007, with the original SPHERES mission manifested for launch on STS-116, scheduled for launch in September 2005, with experimental operations beginning in November 2005.

David W. Miller is SPHERES's primary investigator. SPHERES staff include research scientist Edmond Kong, postdoc Alvar Saenz-Otero, and graduate students Simon Nolet, Mark Hilstad, Soon-Jo Chung, Ryan Lim, and Lennon Rodgers.

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 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 Federal Aviation Authority, 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 thanA thousand technical reports. 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.

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