2

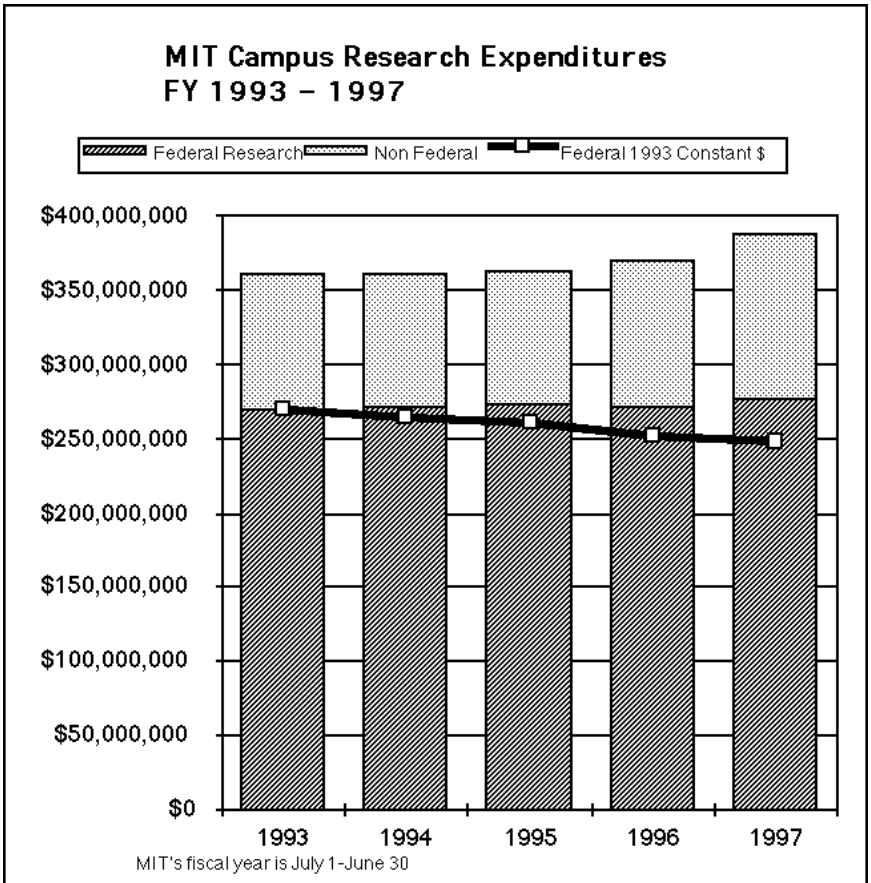
MIT Research Support

MIT is one of the leading research universities in the world. Basic and applied research at MIT is conducted in two principal locations, the MIT campus in Cambridge, Mass. and off-campus at the MIT Lincoln Laboratory, a federally-funded research and development center (FFRDC) in Lexington, Mass.

All research support received by MIT faculty and research staff from federal sources is awarded competitively, based on the scientific and technical merit of proposals. In fiscal year 1997 there were over 1,600 active grants and contracts.

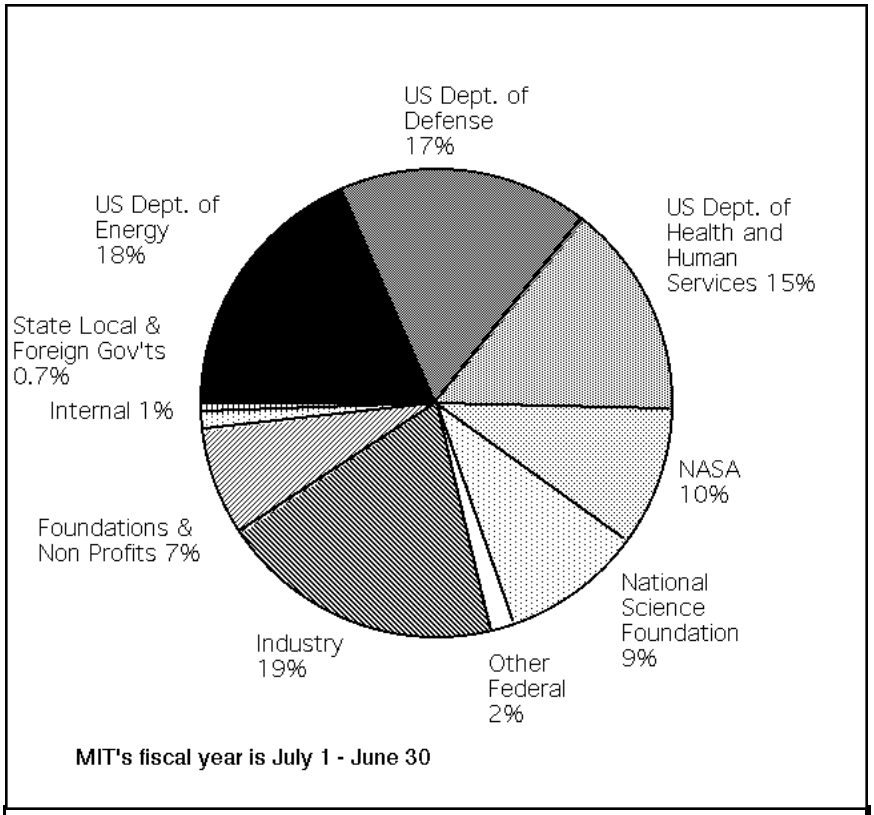
The Charts: The bar graphs for the campus and each major sponsor of research show the amount expended for research projects during MIT's fiscal years (July 1–June 30). The black line represents an adjustment for inflation, based on 1993 dollars.

Campus Research



	1993	1994	1995	1996	1997
Federal Research	$268,206,000	$270,718,000	$273,542,000	$271,544,000	$276,352,000
Non Federal	$93,148,000	$88,956,000	$88,147,000	$98,739,000	$111,528,000
Total Research	$361,354,000	$359,674,000	$361,689,000	$370,283,000	$387,880,000

Campus Research Sponsors FY1994



MIT's fiscal year is July 1 - June 30

Major Sponsor	FY1997 Research Expenditures	% of Total
Department of Energy	$70,753,000	18.2%
Department of Defense	$67,858,000	17.5%
Health and Human Services	$57,215,000	14.8%
NASA	$36,947,000	9.5%
National Science Foundation	$36,347,000	9.4%
Other Federal	$7,232,000	1.9%
Total Federal Research	$276,352,000	71.2%
Industry	$75,194,000	19.4%
Non-Profits	$28,952,000	7.5%
Internal	$4,527,000	1.2%
State Local Foreign Governments	$2,855,000	0.7%
Total Non-Federal Research	$111,528,000	28.8%
Total Research Expenditures	**$387,880,000**	**100%**

Department of Defense Recent MIT Campus Projects

Atom Laser

MIT physicists have created the first atom laser, a device that is analogous to an optical laser but emits atoms instead of light. The new laser could have a variety of applications in fundamental research and in industry. For example, after further developments the atom laser could be used to directly deposit atoms onto computer chips, creating much finer patterns than currently possible. The work was supported by ONR, NSF, the Joint Services Electronics Program (Army Research Office), and the Packard Foundation.

Web Wrapping Services

An MIT project to improve the usefulness of the World Wide Web addresses the fact that the Web is a very human-intensive environment — if you want to find ski areas with more than five feet of snow, for instance, you've got to click and click and read and read. Web Wrapping Services overcomes that problem by automatically superimposing a database-like front end on the Web so you can query all registered Web sites. The work is funded by the Defense Advanced Research Projects Agency; experiments testing the technology are funded by TASC/PRIMARK, TRW, and Merrill Lynch.

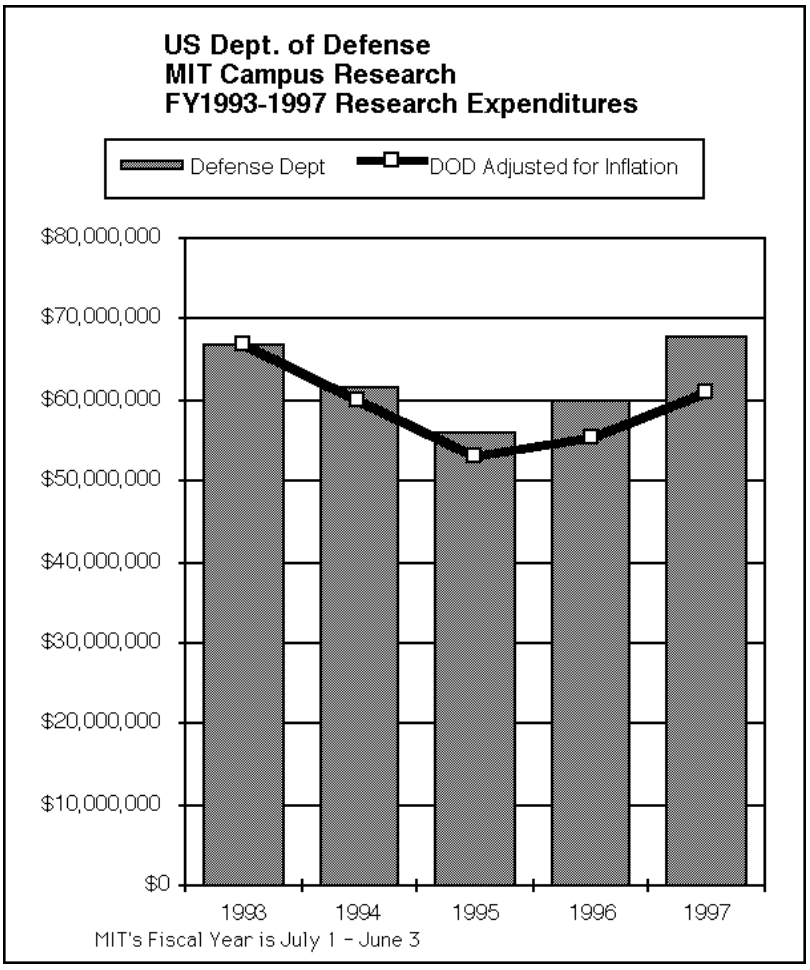
Penguin Boat

The penguin uses two flippers to propel its rigid body quickly and efficiently through the water. Now MIT engineers have applied that "technology" to a man-made vehicle. *Proteus* the Penguin Boat has two "oscillating foils," or flippers, attached to its stern. *Proteus* could lead to ships that move more efficiently — and consume less fuel — than those using propellers. The new system when tested in the laboratory reached up to 87 percent efficiency. The average efficiency of existing ships is at or below about 70 percent. The work is supported by ONR and the MIT Sea Grant College Program.

Robot and Human Tactile Perception

This project is an investigation of human and robotic tactile perception and manipulation. Long-term results are aimed at improved robotic systems, a better understanding of human touch perception and a better description of the requirements for human/machine interfaces. This research is sponsored by the Office of Naval Research.

Department of Defense



Department of Defense funding in FY97 was $67.9 million.

Leading Departments, Centers and Laboratories Receiving Defense Department Support (FY1996 figures)*

Laboratory for Computer Science
Research Laboratory of Electronics
Artificial Intelligence Laboratory
Center for Technology Policy and Industrial Development
Aeronautics and Astronautics Department

*Detailed 1997 figures not available at time of printing.

Other Funding

DOD Fellowships are awarded to support graduate students in fields important to national defense needs. For the 1995–96 year, MIT had 58 National Defense Science and Engineering Graduate Fellows, 3 from the Joint Service Electronics Program, 23 from the Office of Naval Research and 7 from the Air Force Laboratory Program.

Department of Health And Human Services Recent MIT Campus Projects

New Way to Deliver a Shot

This research involves encapsulating a vaccine in microscopic, biodegradable spheres that are injected into the body. Since the microspheres release the vaccine slowly over time, this method eliminates the need for a full course of injections, potentially saving lives of those who don't follow through with the rest of the injections. The work was supported by grants from the World Health Organization and the National Institutes of Health (NIH).

Oil-Eating Bacteria

MIT chemists are studying how certain bacteria consume natural gas and wastes like oil and chlorinated hydrocarbons. Researchers seek to design synthetic systems that do the same thing. Both the natural and synthetic oxygenases will be used to purify chemical waste holding tanks, contaminated water, and other environmentally compromised areas. The work is supported by NIH.

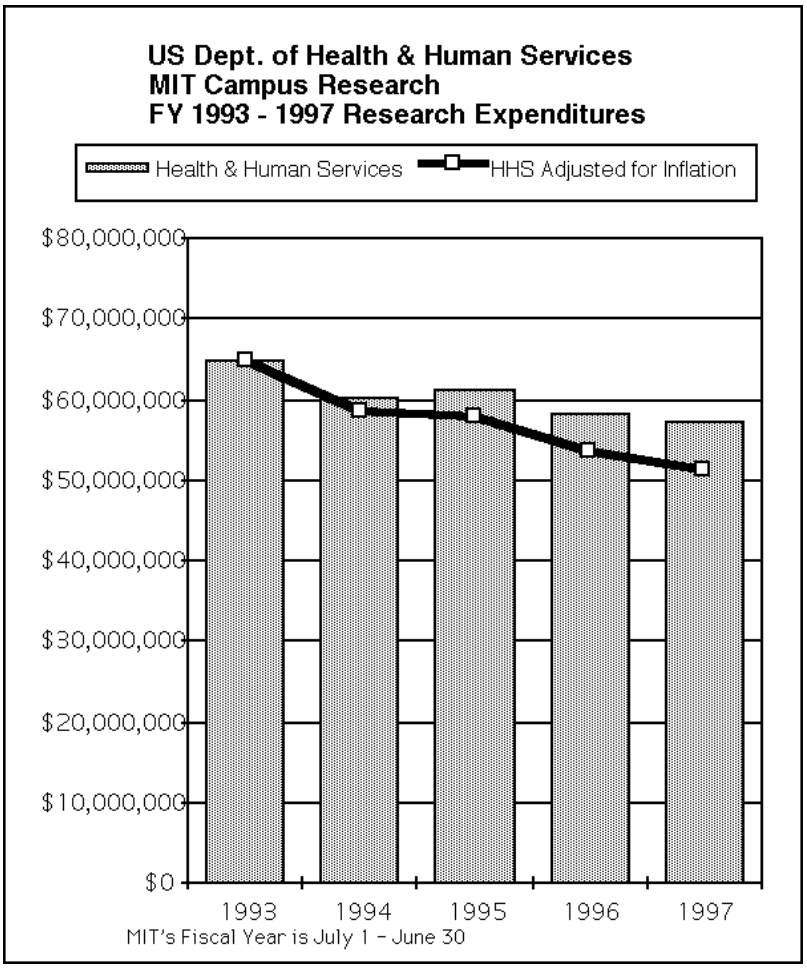
Genetic Link to Memory

Using new genetic and multiple-cell monitoring technologies, MIT scientists have demonstrated how animals form memory for places, which may directly relate to the same ability in humans. This latest "regional gene knockout" technology, through which scientists can develop a breed of mice in which a gene is eliminated in a specific area or only in one particular type of cell, will be valuable in the study of neurological diseases such as Alzheimer's, Huntington's, and drug addictions. The nine-person team at MIT's Center for Learning and Memory obtained evidence showing that strengthened connections between groups or ensembles of neurons enable the formation of internal "maps" of a space which allow the animals to remember that environment, whether it is a room or a pond. The research was supported by the National Institutes of Health, gifts from the Shionogi Institute of Medical Science in Japan, Amgen, Inc., the Seaver Institute and the Sloan Foundation.

Cancer Drug Analysis

Researchers are studying the drug cisplatin — one of the most widely used anti-cancer drugs — to understand how it works so that additional platinum-based anti-cancer drugs can be developed. Cisplatin binds to the DNA in a cancer cell and causes damage to the structure of the DNA. The platinum renders the DNA unable to duplicate itself and spread the cancer. The role of proteins which bind to the damaged DNA is one of the areas of investigation. Cisplatin is widely used to treat testicular and ovarian cancers as well as some cancers of the head and neck.

Department of Health and Human Services



Department of Health and Human Services funding in FY97 was $57.2 million.

Leading Departments, Centers and Laboratories Receiving Health and Human Services Department Support (FY1996 figures)

Biology Department
Center for Cancer Research
Center for Environmental Health Sciences
Chemistry Department
Brain and Cognitive Science Department

Department of Energy Recent MIT Campus Projects

Toxic Waste Treated by Plasmas

MIT's Plasma Science and Fusion Center has used plasmas — high-temperature electrically charged conducting gases — to change the chemical composition of toxic wastes into benign substances. The present effort in the waste treatment area is the development of new environmental monitoring technology. There is also a program which involves the use of plasma technology to produce hydrogen-rich gas from hydrocarbon fuels. This program could result in approaches to reduce significantly pollution from power generation systems and vehicles.

CO_2 Cleanup

One possible option for reducing a major source of atmospheric carbon dioxide (CO_2) emissions is to capture and sequester the CO_2 emitted from fossil fuel electric power plants. MIT researchers are looking at potential deep ocean disposal systems. Planning is underway for a Joint Research Program, as part of the Climate Technology Initiative, that will involve Japan, Norway, and the United States in larger-scale collaborations on ocean disposal field experiments.

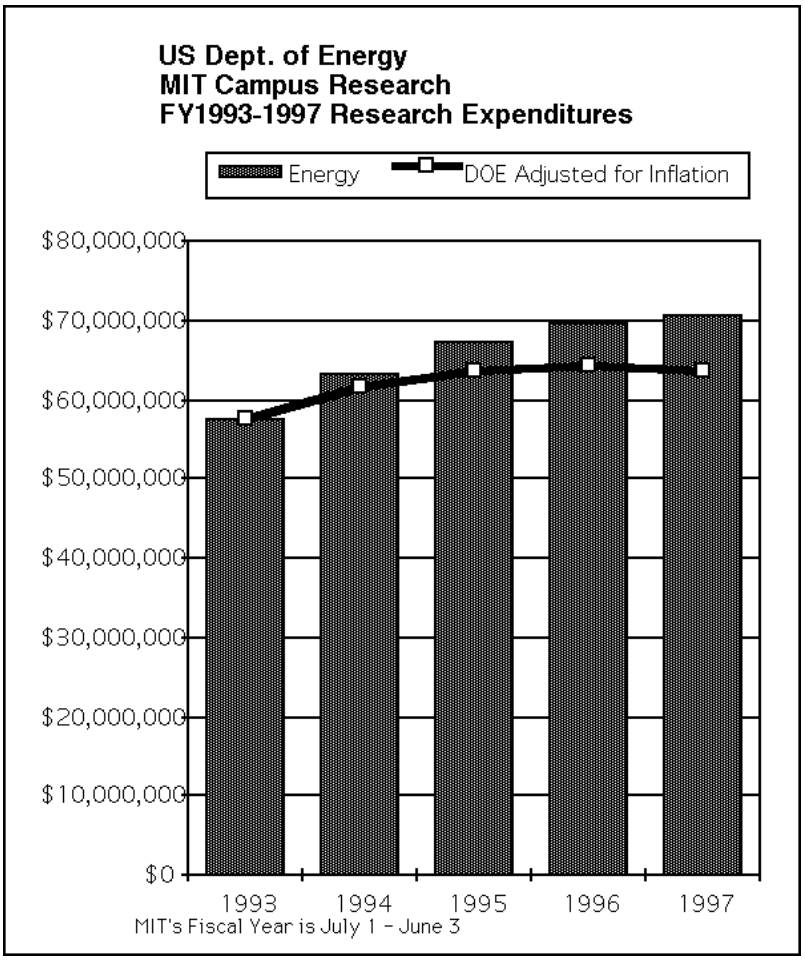
Detecting Cracks in Concrete Structures

MIT researchers and colleagues are designing new optical fiber sensors to detect cracks in concrete structures from bridges to the protective walls surrounding hazardous-waste dumps. In a bridge, the fibers would be embedded in a plastic sheath and glued securely to the bottom of the bridge deck. When a crack forms across a fiber, the fiber will bend, causing a sudden loss in signal as some energy escapes from the fiber core. To detect the cracks, the signal is monitored.

Bates Large Acceptance Spectrometer Toroid

The Division of Nuclear Physics of the Department of Energy has approved funding to begin construction of the Bates Large Acceptance Spectrometer Toroid (BLAST) project at the MIT Bates Linear Accelerator Center in Middleton, MA. BLAST, a detector designed specifically to work in new Bates South Hall Ring, will help an international collaboration of 40 scientists to study the structure of protons, neutrons, and light nuclei.

Department of Energy



Department of Energy funding in FY97 was $70.8 million.

Leading Departments, Centers and Laboratories Receiving Energy Department Support (FY1996 figures)

Plasma Science and Fusion Center
Laboratory for Nuclear Science
Energy Laboratory
Earth, Atmospheric and Planetary Science Department
Materials Science & Engineering Department

Audio Notebook

The Audio Notebook is a new tool for rapidly accessing recorded notes. On top of the notebook is a pad of paper. As you take notes, the device records audio while sensors under the pad synchronize your note taking with the recording. When you are reconstructing your notes you can, among other options, touch your pen to a quoted word written on your notepad, and it will start playing back at that very spot. The work is sponsored by the NSF, AT&T, and two consortia at the MIT Media Lab.

Environmentally Friendly Gases

Key to making computer chips and other products of the microelectronics industry are gases known as perfluorocompounds (PFCs). PFCs, however, are suspected of contributing to global warming. As a result, scientists are exploring options toward reducing their use. MIT researchers and colleagues are tackling one approach. They are looking for alternative gases that could do the same job but are environmentally more benign. The MIT team has found a few chemicals that look promising. The work is funded by the NSF-SRC (Semiconductor Research Corporation) Engineering Research Center for Environmentally Benign Semiconductor Manufacturing.

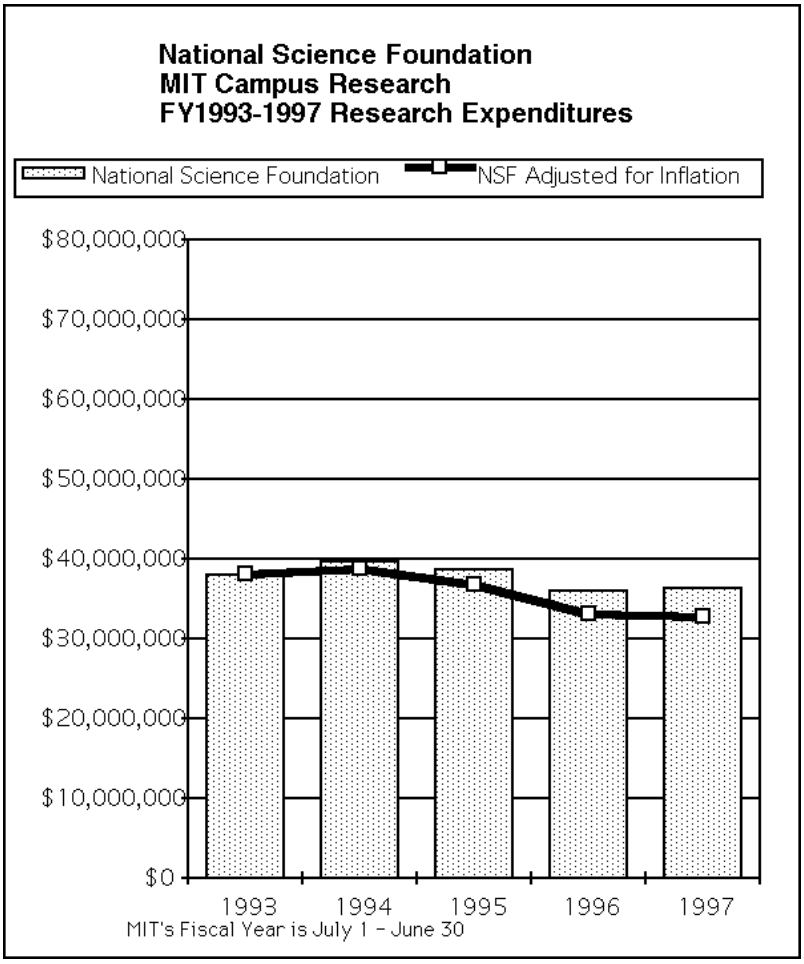
Language Structure

The Department of Linguistics and Philosophy and the Department of Brain and Cognitive Science have undertaken a joint project to give graduate students intensive research training in language structure, acquisition and use. Traditionally, the study of language acquisition at MIT has been pursued separately as part of linguistics and as part of cognitive science. This project is funded by an NSF grant designed for programs that train students in rapidly advancing areas that transcend a single academic discipline.

Violent Beginnings for Some Planets

The dozen or so new planets discovered within the past year probably had violent beginnings, mainly because they were born in solar systems with two or more massive planets the size of Jupiter, according to MIT astrophysicists. The properties of the new planets, which are completely different from those in our solar system, may be the result of instabilities that developed when they formed. These instabilities were caused by the planets' close proximity to one or more Jupiter-sized planets in their planetary systems. Supercomputer simulations for the research were done by the MIT scientists at the Cornell Theory Center, which receives major funding from the NSF and New York State.

National Science Foundation



The National Science Foundation funding in FY97 was $36.3 million.

Leading Departments, Centers and Laboratories Receiving National Science Foundation Support (FY1996 figures)

Department of Earth, Atmospheric & Planetary Science
Center for Materials Science and Engineering
Chemistry Department
Biotechnology Process Engineering Center
Francis Bitter Magnet Laboratory

Other Funding

NSF Fellows: These distinguished graduate students may enroll in any accredited, nonprofit U.S. or foreign institution offering advanced degrees in science or engineering. MIT is one of the top three institutions chosen by Fellows. For 1996–97 MIT had 262 NSF Fellows, 222 on active status and 40 on reserve status. Under this program, NSF provides $8,600 toward tuition for each active Fellow, a total of $1.86 million. MIT provides approximately $19,100 per year for each Fellow to cover tuition and health insurance, a total of $4.1 million. In addition, NSF provides each Fellow with a stipend of $14,400 for 12 months, a total of $3.1 million.

From Locating Stars to Emergency Calls

MIT scientists have developed equipment that allows a worldwide network of radio telescopes to record and process data faster. The synchronized telescopes allow the precise location and imaging of quasars and the monitoring of the movement of the Earth's tectonic plates. The work was sponsored by the NSF and NASA. A recent spin-off of the technology allows the accurate location of 911 emergency calls from cellular phones. This system has been successfully tested at various locations in the northeastern U.S.

Understanding Solar Bursts

Two MIT instruments are helping scientists understand the impact of solar bursts from the Sun on the near-Earth space environment. The instruments, which are aboard the Wind satellite, for the first time have allowed scientists to verify whether particular solar clouds seen leaving the Sun actually arrive at Earth. The instruments eventually may help scientists predict "weather" caused by these clouds that can disrupt communications and/or damage satellite hardware.

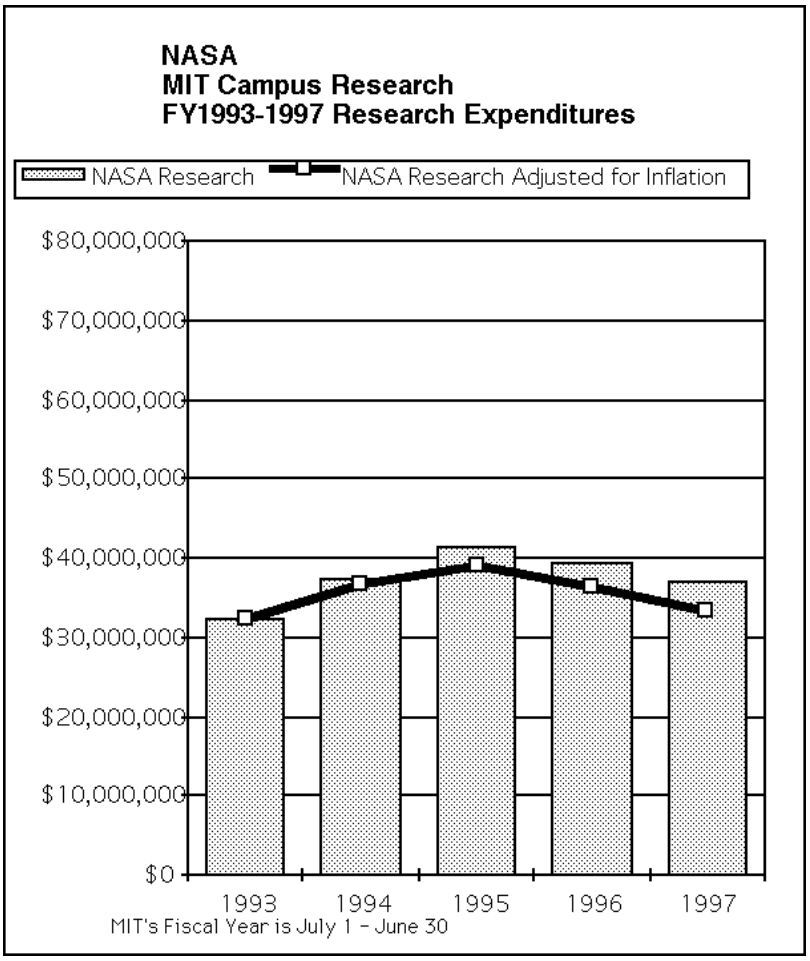
X-Ray Astronomy Satellites

The Institute of Space and Astronomical Science of Japan is building a series of X-ray astronomy satellites. The Astro-E is scheduled to be launched in early 2000. MIT is now under contract with NASA for the development and testing of Charge Coupled Device focal plane assemblies and associated systems for the X-ray Imaging Spectrometer to be flown on this mission. The effort includes pre-flight software simulators and prototype hardware as well as ground support equipment.

Darts in Space

An MIT experiment that ran aboard the Russian space station *Mir* involved videotaping crew members playing darts to study how they adapt to zero gravity. In a second part of the experiment, the researchers collected data on how crew members physically affect their environment. That data could save millions in the design of future space structures. Currently there is very little data on the forces astronauts exert on spaceships, so engineers must over-design the racks housing sensitive experiments that could be disturbed by astronauts' movements.

NASA



The National Aeronautics and Space Administration funding for FY97 was $36.9 million.

Leading Departments, Centers and Laboratories Receiving NASA Support (FY1996 figures)

Center for Space Research
Aeronautics & Astronautics Department
Department of Earth, Atmospheric & Planetary Sciences
Haystack Observatory
Health, Science and Technology

Advanced Traveler Information Systems

ATIS uses the latest technology to provide accurate traffic information and navigation aid to travelers to avoid congestion, accidents, or road repairs. In this project, sponsored by the Department of Transportation, researchers are analyzing the behavior of travelers in acquiring and processing information, as well as their adjustments to daily and en-route travel choices.

Cleaning Up Groundwater Pollutants

In work that could lead to better ways of cleaning up certain pollutants from groundwater, MIT researchers are looking at the interactions between those pollutants and the soils and water they move through. Groundwater contaminants like carbon tetrachloride that are in the form of nonaqueous phase liquids (NAPLs) are extremely challenging to clean up, because the behavior of NAPLs in the subsurface is very complex. The researchers are exploring that behavior via several different projects. The work is sponsored by the EPA's Northeast Hazardous Substance Research Center.

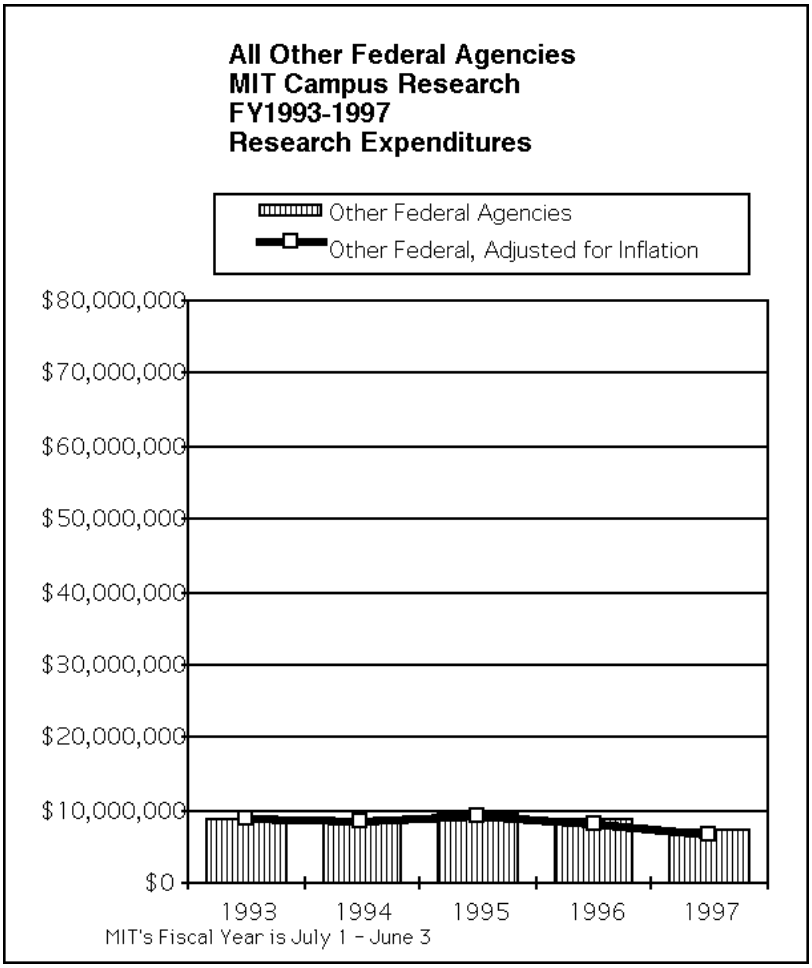
Deep-Sea Biodiversity

Changes in climate affect the biodiversity of even the deepest-dwelling animal communities in the ocean, according to an MIT scientist and colleague. The research counters the long-held hypothesis that deep-sea life — three kilometers or more beneath the surface of the ocean — is insulated and relatively impervious to large-scale climatic changes at the water's surface. The research was funded by the U.S. Geodetic Survey and the American Chemical Society.

A New Corn-Plastic Material

Plastic is popular because it is flexible, waterproof and inexpensive, but it is not biodegradable. An MIT professor has developed a more environment-friendly material combining corn starch and poly(ethylene vinyl alcohol) or EVOH. However, this material can become soft or brittle with changing atmospheric conditions. Consequently, the scientist has focused on creating a thin surface coating with the protective properties of pure plastic. Once the product is discarded and shredded, the biodegradable interior will be exposed to the elements. The research is funded by the U.S. Department of Agriculture, Warner Lambert, the National Association of Wheat Growers and NSF.

Other Federal Agencies



The funding from other federal agencies in FY97 was $7.2 million.

Leading Departments, Centers and Laboratories Receiving Other Federal Agency Support (FY1996 figures)

Sea Grant College
Center for Transportation Studies
Energy Laboratory
Microsystems Technology Laboratory
Department of Earth, Atmospheric and Planetary Sciences

Other Funding

The Arts: MIT's List Visual Arts Center received $35,500 from the National Endowment for the Arts in Fiscal Year 1996 to support exhibition funding.

Solving Transportation Problems Using Genetic Algorithms

With a grant from the UPS Foundation, the charitable arm of United Postal Service, MIT researchers are looking for improved techniques for determining the best transportation route for package delivery services. They are using genetic algorithms (GAs) to aid in the search for optimal or nearly optimal solutions. Genetic algorithms are a general-purpose approach for solving problems that rely on ideas from evolutionary biology.

Productivity Enhancement

The overhead involved in managing and integrating relevant pieces of information in information systems has become a major barrier to enhancing productivity. To attack the problem, researchers have established an initiative, called Productivity from Information Technology (PROFIT), which seeks to enhance productivity in private and public sector areas ranging from finance to transportation, manufacturing, and telecommunications. The research is supported by funds from Defense Advanced Research Projects Agency (DARPA), Ishikawajima-Harima Heavy Industries Co., and other sponsors.

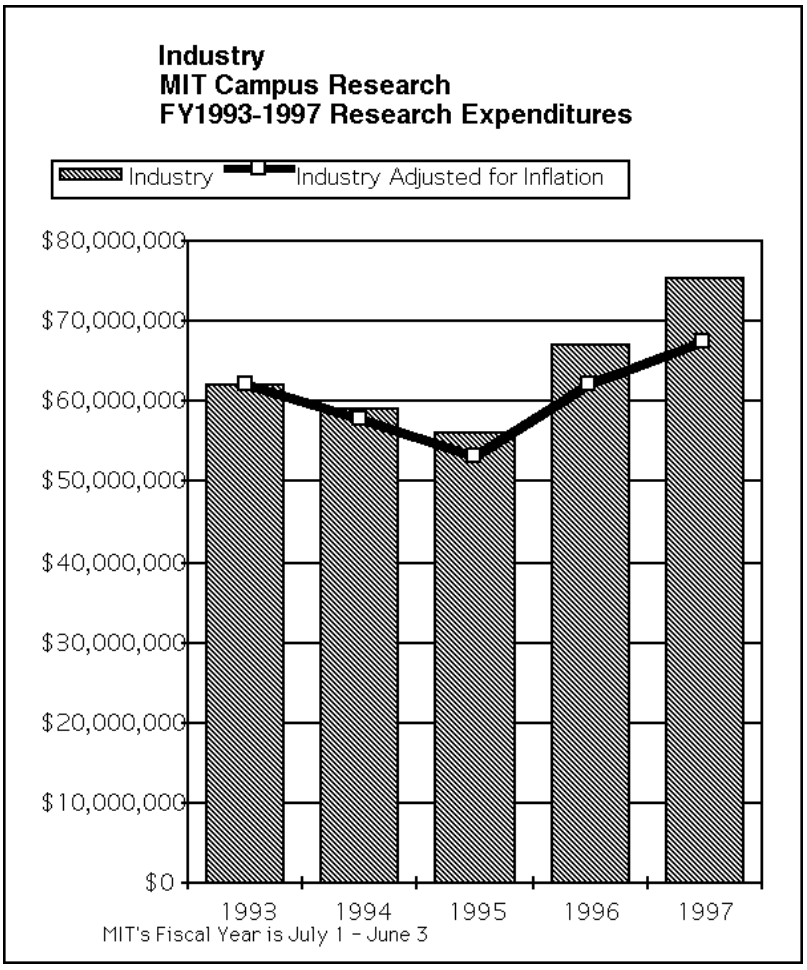
High-Performance SMP Computing

The recent donation of nine Sun Microsystems Ultra Enterprise 5000 symmetric multiprocessor servers (SMPs) to MIT will enable collaborative work with corporate and government partners in developing software and hardware for scalable clusters of SMPs, which MIT researchers believe provide the most promising path to affordable high-performance computing. Applications by the MIT scientists include establishing fundamental understanding of the properties, behavior, and aging of materials, and determining the long-term behavior of the ocean and its impact on Earth's climate.

Printing Drugs

Using a three-dimensional printing device similar to a computer ink-jet printer, MIT scientists are "printing" drugs into pills, creating highly precise doses they say will be more effective and have fewer adverse side effects. Two MIT professors developed 3-D printing eight years ago to produce solid parts with intricate architectures. It originally was used to make ceramic molds for investment-cast car and airplane components. The drug-printing work is sponsored by Therics, Inc.

Industry



The funding from industry in FY97 was $75.2 million.

Leading Departments, Centers and Laboratories Receiving Industry Support (FY1996 figures)

Media Laboratory
Energy Laboratory
Laboratory for Computer Science
Center for Transportation Studies
Mechanical Engineering Department
Chemical Engineering Department
Lab for Manufacturing and Productivity
Organizational Learning Center
Whitaker College
Microsystems Technology Laboratory

MIT Lincoln Laboratory at Hanscom Air Force Base

Research Support

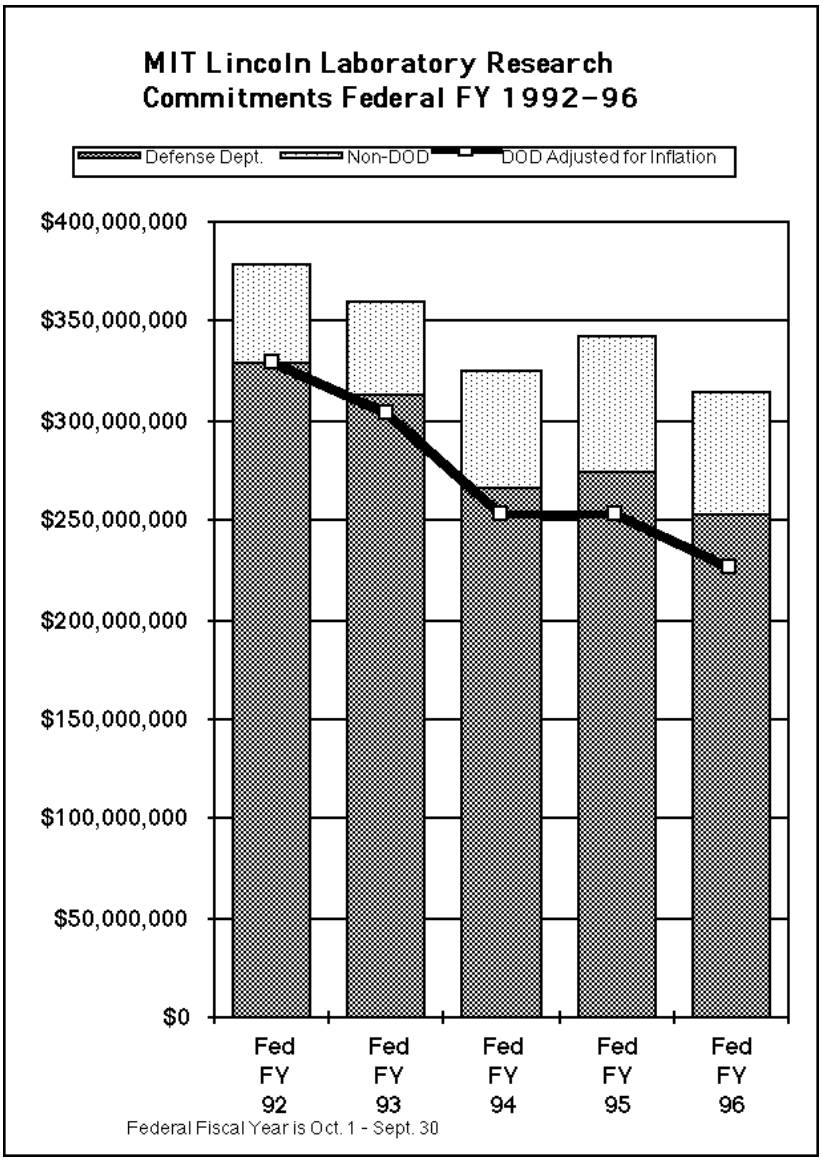
MIT Lincoln Laboratory is a federally-funded research and development center (FFRDC) operated on Hanscom Air Force Base in Lexington, Mass. by MIT under a contract with the Department of Defense. MIT established the laboratory in 1951 after Air Force Chief of Staff Gen. Hoyt S. Vandenberg wrote MIT President James R. Killian, Jr. that MIT was "almost uniquely qualified" to conduct the air defense work needed. Dr. Killian said MIT would agree to do it "on a no-gain, no-loss basis."

In defense work, Lincoln Laboratory is noted for its developments of the SAGE air defense systems and the Distant Early Warning (DEW) Line of surveillance radars in the 1950s. In more recent times, the Laboratory has developed satellite communication technology, advances in air defense, surveillance radars, missile defense, air traffic control systems, environmental sensing and a wide variety of contributions in the area of advanced electronics technology.

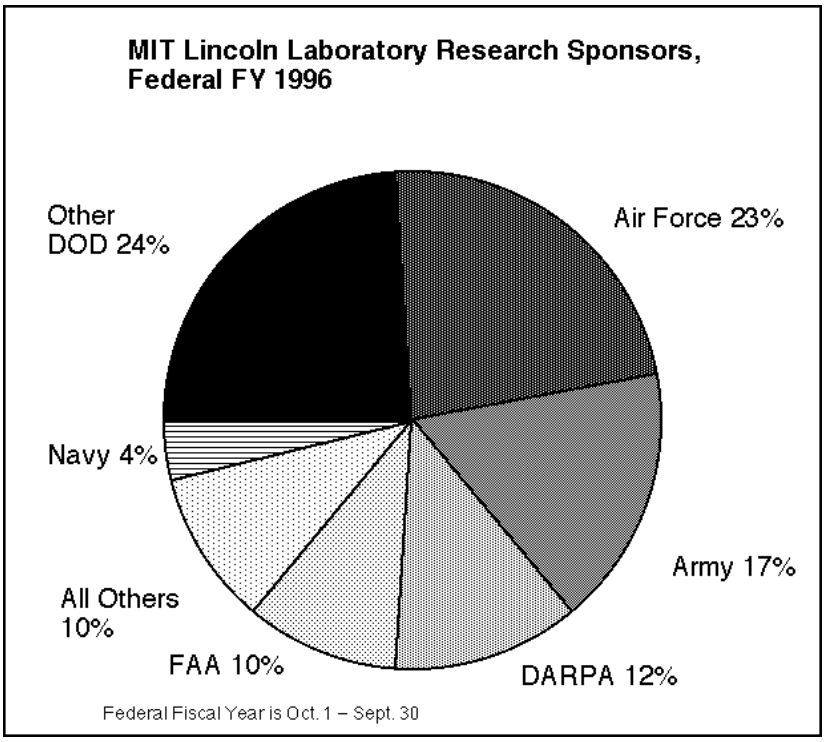
Lincoln Laboratory has created thousands of spin-off jobs in the civilian sector. Former lab engineers and scientists, and patented technology from the lab, have created more than 67 companies and over 130,000 jobs across the nation.

The Defense Department's projects for the Army, Navy, Air Force, the Defense Advanced Research Projects Agency (DARPA) and the Ballistic Missile Defense Organization (BMDO) as well as other federal agencies (principally the Federal Aviation Administration (FAA), National Oceanographic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA)) are channeled through Lincoln Laboratory's contract with the Air Force. Defense Department projects accounted for 80% of Lincoln Laboratory funding in FY96 (Federal). The Office of the Secretary of Defense also provides through the Director of Defense Research and Engineering sustained funding for the development of advanced electronic technology. DOD funding had been decreased from a FY90 peak of $385 million to a FY96 funding ceiling restrained level of $252.3 million. In FY97, the DOD funding ceiling has been increased to $258 million with additional funding for equipment purchases permitted. Funding has increased for non-DOD programs including the recently permitted mechanism for the cooperative research and development agreement (CRDA) with industry. Lincoln Laboratory has had 26 CRDAs approved to date. Employment at Lincoln Laboratory has decreased from a peak of almost 2,900 to approximately 2,050 today. The technical professional staff is approximately 1,000 with 40% holding PhDs.

Trend



The Department of Defense funding for Lincoln Laboratory in Federal FY96 was $252 million and is projected to be $258 million plus additional funding for equipment purchases in Federal FY97. The total funding for Lincoln Laboratory in Federal FY96 was $318 million, down from $352 million in Federal FY95.



Recent Projects

Lincoln Laboratory continues as a premier national research and development facility to carry out work in broad mission areas of ballistic missile defense, communications, space surveillance, tactical surveillance, air defense, civilian air traffic control and environmental sensing, all of which are supported by an advanced electronic technology program. While Lincoln Laboratory is a classified facility and works on classified programs, the majority of the work is unclassified. Recent unclassified activities include:

Microelectronics Facility

Lincoln Laboratory's new microelectronics facility is designed to permit fabrication of advanced semiconductor devices and develop a future state-of-the-art semiconductor process for U.S. industry. This facility has 8,100 square feet of Class 10 clean rooms and houses the newly developed excimer-laser lithographic stepper which is being used with industry for development of very high-density semiconductor wafer fabrication. Processes are being developed to improve the semiconductor industry's capability to produce semiconductor features that are smaller than 0.25 microns. Semitech and semiconductor companies are working cooperatively with Lincoln Laboratory on lithography and photo-resist technology.

Semiconductor silicon charge coupled devices are being developed in the microelectronics facility for low light-level imaging cameras. Focal plane arrays of 5 million pixels on a single wafer are being fabricated in the facility with existing technology.

Wideband All-Optical Network

In the communications area, researchers are working to enhance the capabilities of military communications through the design of future lightweight, high-performance, interference-resistant satellites and small mobile terminals. In addition, optical communication technology is also

being pursued. A DARPA-sponsored consortium of MIT, MIT Lincoln Laboratory, American Telephone and Telegraph and Digital Equipment Corporation is working to establish an all-optical network. A wideband optical link between the Laboratory and the Campus has been established and a test bed is being developed to demonstrate the capability of the equipment developed.

High-Resolution SAR for Critical Target Identification

Surveillance and detection of critical targets is a major activity of Lincoln Laboratory. The need to detect and classify military targets is of increasing interest because the need for precision strikes in limited warfare is an important part of our defense posture. Lincoln Laboratory has developed high-resolution synthetic-aperture radar (SAR) imagery to aid automatic target recognition and is developing algorithms for field testing for correct classification. Neural networks are also being explored for these applications.

Improved Air-Traffic Control

Lincoln Laboratory has played a major role in developing new technology for air-traffic control. FAA has sponsored the improvement of terminal radars, hazardous weather detection and collision avoidance systems at the Laboratory. Lincoln Laboratory built the first Mode S sensor and also built and flew the first TCAS collision avoidance system being installed on all air carrier aircraft. Current activity includes Airport Surface Traffic Automation to aid controllers and pilots in preventing errors that lead to runway incursions and accidents, and also to reduce surface delays. Additionally, the laboratory has demonstrated a radar system to improve monitoring of aircraft during final approach, thus allowing independent approaches.

Utilization of the Global Positioning System (GPS) to allow aircraft to provide position information in their Mode S spontaneous periodic broadcast (squitter) has been successfully demonstrated. This GPS squitter technology offers significant advantage in the merging of automatic dependent surveillance and the Mode S beacon system.

Weather Guidance for Pilots

Researchers are developing the Graphic Weather Service, a system to deliver real-time weather images to the cockpits of commercial and private aircraft. The system digitizes and compresses weather images and transmits them via radio data link. The cockpit display would include weather radar, lightning, turbulence, icing, and wind shear.

Lincoln Laboratory has also been testing air terminal weather information systems. Terminal Doppler Weather Radar systems have been tested in Denver, Kansas City, Orlando, and Dallas, and Airport Surveillance Radar systems have been tested in Huntsville, Kansas City, Orlando and Albuquerque. This work is leading to a fully Integrated Terminal Weather System (ITWS). Demonstration ITWS systems being tested in Orlando, Memphis and Dallas are generating information used in real-time to provide critical weather information to air-traffic controller managers, to pilots and to airliners. The system will provide benefits to improved terminal operations in the presence of adverse weather.