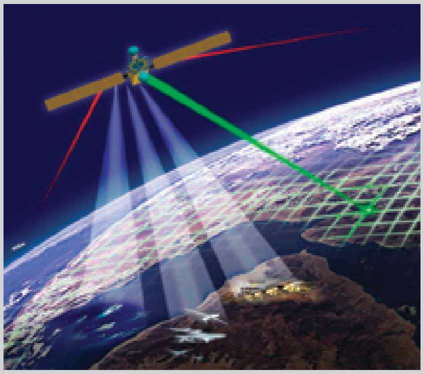
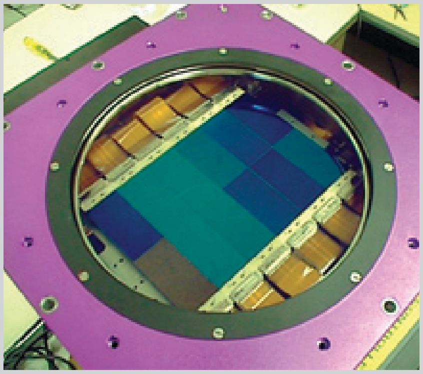
MIT LINCOLN LABORATORY

2007 ANNUAL REPORT




Technology in Support of National Security

Massachusetts Institute of Technology

MIT Lincoln Laboratory

MIT LINCOLN LABORATORY

2007

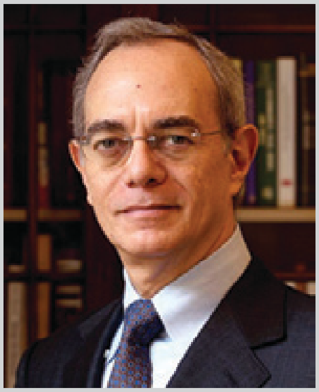
MISSION:
TECHNOLOGY IN SUPPORT OF NATIONAL SECURITY

MIT LINCOLN LABORATORY is chartered to develop some of the nation's best technical talent to support system and technology development for our national security needs. Principal core competencies are sensors, information extraction (signal processing and embedded computing), and communications. Nearly all of the Lincoln Laboratory efforts are housed at the Hanscom Air Force Base complex in Massachusetts.

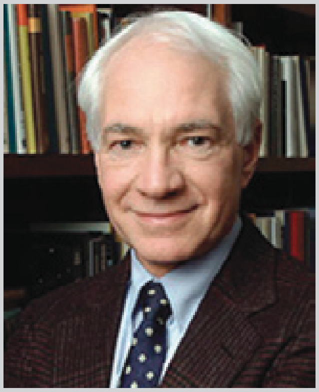
MIT Lincoln Laboratory is designated a Department of Defense (DoD) Federally Funded Research and Development Center (FFRDC) and a "DoD Research and Development Laboratory." The Laboratory conducts research and development pertinent to national defense on behalf of the military Services, the Office of the Secretary of Defense, the Intelligence Community, and other government agencies. Projects undertaken by Lincoln Laboratory focus on the development and prototyping of new technologies and capabilities for which the government cannot rely on in-house or private-sector resources. Program activities extend from fundamental investigations through design, development, and field-testing of prototype systems using new technologies. A strong emphasis is placed on the transition of systems and technology to the private sector. In 2001, the Laboratory celebrated its 50th anniversary of service to the nation and received the Secretary of Defense Medal for Outstanding Public Service in recognition of a half-century of distinguished technical innovation and scientific discoveries.

Massachusetts Institute of Technology

Dr. Susan Hockfield
President



Dr. L. Rafael Reif
Provost



Dr. Claude R. Canizares
Vice President for Research and
Associate Provost

MIT Lincoln Laboratory

Dr. Eric D. Evans
Director

Dr. Antonio F. Pensa
Assistant Director

Mr. Lee O. Upton
Assistant Director

Mr. Anthony P. Sharon
Assistant to the Director
for Administration and Finance

LETTER from the Director of MIT Lincoln Laboratory

MIT Lincoln Laboratory has served the nation for 56 years by developing advanced technology for national security. This annual report summarizes the Laboratory's recent technical accomplishments and future outlook. Lincoln Laboratory continues to focus on long-term technology development as well as rapid system prototyping and demonstration. The Laboratory also continues its long history of working closely with industry to transition new concepts and technology for system development and deployment.

Over the past year, the Laboratory has had a change of leadership. Dr. David L. Briggs retired after 37 years of service and 8 years as Laboratory Director. The Laboratory continued its strong technology development role under Dave's leadership, and I appreciate his assistance through this year's transition. Moving forward, we will continue to emphasize the Laboratory's core values of technical excellence, innovation, and integrity. We also will continue to strengthen our focus on difficult technology challenges related to our national security needs.

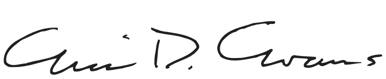
Recently, the Director's Office and senior management completed an update of the Laboratory's strategic plan. We reviewed national-level studies, such as the National Defense Strategy, the Quadrennial Defense Review, and recent Defense Science Board recommendations, to create our plan for the evolution of the Laboratory. As a part of our planning, we developed nine Laboratory strategic directions:

- Identify new mission areas, based on current and emerging national security needs
- Strengthen and evolve the current Laboratory mission areas
- Strengthen the core technology programs
- Increase MIT campus/Lincoln Laboratory collaboration
- Strengthen technology transfer to acquisition and user communities
- Increase outside connectivity and communications
- Improve Laboratory diversity
- Expand community outreach and education
- Continue improving Laboratory engineering services, administration, and infrastructure

We have already made progress in these directions. For example, we have recently realigned a Laboratory Division to focus on the technology needs for Homeland Protection, including homeland air defense and defense against weapons of mass destruction. We have created a Chief Technology Office to strengthen the direction and focus of the Laboratory's development of long-term advanced technology. We are continuing to enhance our research collaboration with the MIT campus through Advanced Concepts Committee initiatives and student internships. We have worked to improve our execution of large hardware integration projects through the creation of a Mission Assurance Office and the adoption of industry mission assurance standards for major projects. And finally, we have implemented *Science on Saturday* and *Education Outreach* programs for K–12 students in local communities. Future Laboratory annual reports will provide updates on our progress in the above directions.

MIT Lincoln Laboratory has a long history of making significant contributions to critical issues of national security. I am looking forward to working with the Laboratory and the MIT campus to continue that legacy.

Sincerely,



Eric D. Evans
Director

Lincoln Laboratory's Millstone Radar is a high-power, L-band radar used for tracking space vehicles and space debris. Millstone provides 50,000 deep-space satellite observations a year, making it a key contributor to the national deep-space surveillance program.

NEW OFFICES

Mr. Zachary J. Lemnios
Chief Technology Officer

Chief Technology Office

The Chief Technology Office is developing the Laboratory's long-term technology strategy. The Office will work closely with the Defense Advanced Research Projects Agency (DARPA), Office of Naval Research (ONR), Army Research Office (ARO), Air Force Research Laboratory (AFRL), and other Service program offices to develop and coordinate technology programs. The Chief Technology Office will also propose and coordinate joint MIT campus and Lincoln Laboratory technology programs.

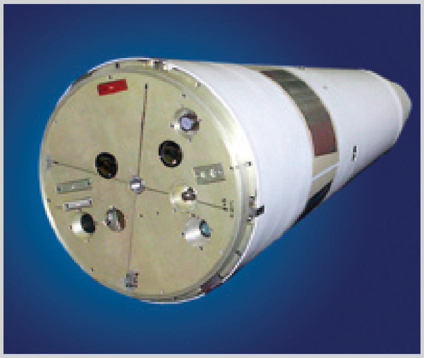
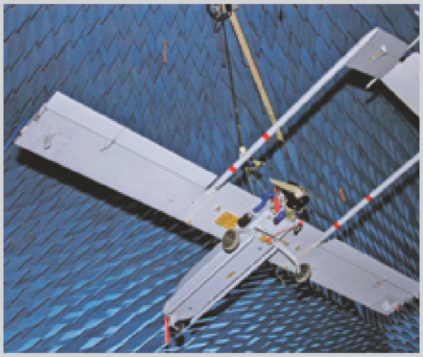
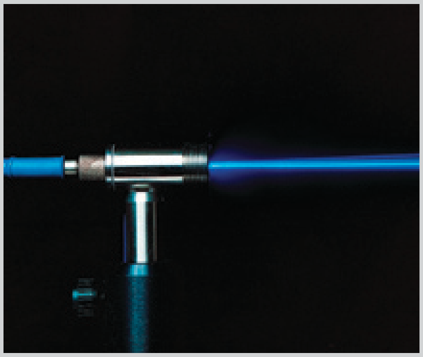
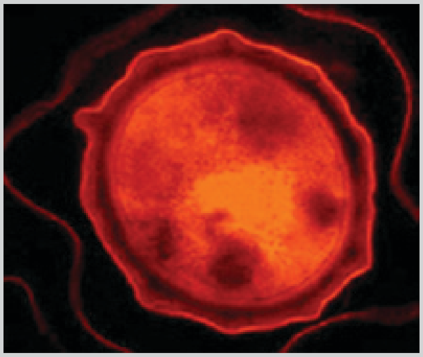
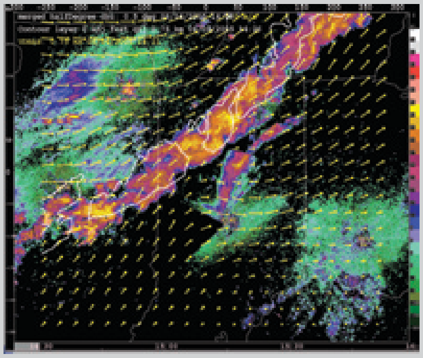
Dr. James W. Wade
Mission Assurance Lead

Mission Assurance Office

The Mission Assurance Office is developing a Lincoln Laboratory implementation of the aerospace AS9100 mission assurance standard. This standard is applied to large hardware and software efforts to enhance program success, satisfy sponsor requirements, maintain configuration control, and identify and mitigate risks.

The Office is applying a mission assurance process to large flight and system integration programs, specifically in space and missile projects such as satellite payloads, Critical Measurements and Countermeasures (CMCM) missile payloads, and the Enhanced Tracking Illuminator (ETILL) laser project. The mission assurance process also includes engineering, fabrication, vendor and parts management, calibration, facilities planning, and safety.



MISSION AREAS

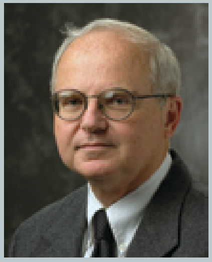
- Space Control
- Air and Missile Defense Technology
- Communications and Information Technology
- Intelligence, Surveillance, and Reconnaissance Systems and Technology
- Advanced Electronics Technology
- Homeland Protection
- Aviation Research

SPACE CONTROL

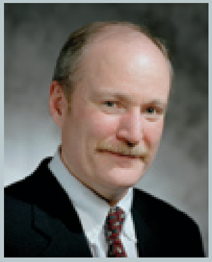
In the Space Control mission, Lincoln Laboratory detects, tracks, and identifies man-made satellites; accomplishes satellite mission and payload assessment; and investigates technology to improve monitoring of the space environment, including space weather and atmospheric and ionospheric effects. The technology focuses are the application of new components and algorithms to enable sensors with greatly enhanced capabilities and to support the development of net-centric processing systems for the nation's Space Surveillance Network.

The Lincoln Space Surveillance Complex in Westford, Massachusetts, constitutes the foundation of the Laboratory's ground-based radar space surveillance programs.

Leadership



Mr. William M. Brown, Jr.



Dr. Grant H. Stokes

Dr. Hsiao-hua K. Burke

Dr. Curt von Braun

Principal 2007 Accomplishments

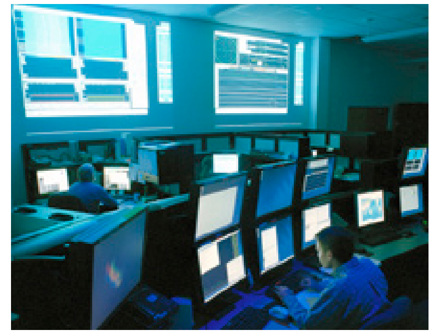
- The Space Systems Analysis Group was established to focus on system-level studies of the U.S. national space enterprise.
- The Extended Space Sensor Architecture (ESSA), a net-centric test bed for space situational awareness, had its first deliveries into the Joint Space Operations Center (JSpOC). This capability provides real-time radar images from the Haystack Auxiliary sensor to JSpOC operators.
- A multistatic radar test bed consisting of Haystack and Haystack Auxiliary illumination radars (components of the Lincoln Space Surveillance Complex), three fixed received sites, and one transportable receive site began operations. The test bed was used to demonstrate wideband bistatic tracking and interferometric 3-D inverse synthetic aperture radar imaging of satellites in low Earth orbits.
- Initial optical processing to shape each of the three large mirrors on the Space Surveillance Telescope (SST) has been completed. The telescope gimbal has been assembled. Operations of the SST are scheduled to begin in late 2009. The SST will possess advanced ground-based optical system capability to enable detection and tracking of objects in space while providing rapid, wide-area search capability.
- The Haystack Ultrawideband Satellite Imaging Radar (HUSIR) low-power driver tube transmitter and signal processor were integrated with a small (2.4 meter) antenna and successfully used to collect data from large, low Earth-orbiting satellites. This early test confirms operational readiness for integration with a 37-meter-diameter dish antenna. The HUSIR system will add significant new imaging capability to our nation's space situational awareness network.
- Millstone Hill radars and the Space-Based Visible sensor have provided space situational awareness data to support more than 50 new launches in the past year.
- Focal plane detectors and readout electronics were delivered for the Extreme ultraViolet Experiment sensor on NASA's Solar Dynamics Observatory.
- A novel 256 × 256 long-wave infrared detector array capable of supporting 30,000 frames per second with pixel-level digitization and image processing was fabricated. This technology will enable the next generation of nighttime wide-area surveillance.
- Fabrication and initial testing were completed for an 880-megapixel visible wavelength imager that enables wide-area persistent surveillance at up to 10 frames per second.

Future Outlook

The Laboratory's focus in the upcoming year includes the following:

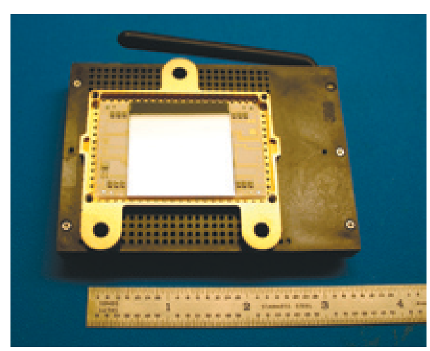
- Continued work in advanced radar development, radar surveillance, space-object identification, electro-optical deep-space surveillance, collaborative sensing, and sensor fusion and processing
- Development of the HUSIR and SST sensor systems, which will bring new capability to the Space Control mission area. Information from these new sensors will be integrated with the ESSA test bed
- Pursuit of new initiatives in the Space Control area, including the next generation of sensor systems and downstream processing/information extraction systems, such as
  - A small-aperture, space-based, space-surveillance system to provide wide-area search of the geosynchronous belt
  - A passive, ground-based, wide-angle "fence" search system for detecting low Earth-orbiting satellites, utilizing unique curved charge-coupled device focal planes to achieve the wide coverage
  - Net-centric machine-aided decision-support algorithms to allow the operators in the Joint Space Operations Center to react to short-timeline, emerging threats to space assets

Lincoln's Experimental Test Site at Socorro, New Mexico, is the world's leading discoverer of asteroids.



The Lexington Space Situational Awareness Center is used to operate sensors at the Lincoln Space Surveillance Complex and to demonstrate near-real-time decision support for space surveillance operations.

The low-power HUSIR transmitter uses a gyroTWT tube that covers 8 GHz bandwidth and produces 1,000 watts peak power.



The Extreme ultraViolet Experiment (EVE) focal plane has high quantum efficiency over a band from 5–105 nm. The focal plane is coupled to a grating to give 0.1 nm energy resolution.

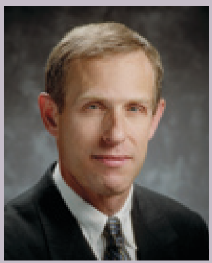
AIR AND MISSILE DEFENSE TECHNOLOGY

In the Air and Missile Defense mission, Lincoln Laboratory works with government, industry, and other laboratories to develop integrated systems for defense against ballistic missiles, cruise missiles, and air vehicles in tactical, strategic, and homeland defense applications. Activities include the investigation of system architectures, development of advanced sensor and decision-support technologies, development of flight-test hardware, extensive field measurements and data analysis, and the verification and assessment of deployed system capabilities. The program includes a focused evaluation of the survivability of U.S. air vehicles against air defense systems. A strong emphasis is placed on the rapid prototyping of sensor and system concepts and algorithms, and the transfer of the resulting technologies to government contractors responsible for the development of operational systems.

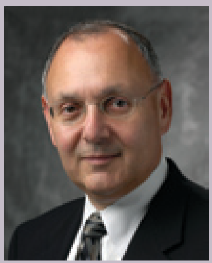
The sensor sidecar (left) developed at Lincoln Laboratory has been deployed to the AN/SPY-1 radar on the Aegis Ballistic Missile Defense cruiser above. Sidecars are adjunct processors that support development and demonstration of advanced software functions by accessing a sensor's data in real time while not interfering with the operation of previously verified sensor processors and software.

Leadership

Dr. Kenneth R. Roth



Dr. Andrew D. Gerber



Mr. Gerald C. Augeri

Mr. Dennis J. Keane

Dr. Eliahu H. Niewood

Principal 2007 Accomplishments

Missile Defense

- A sensor sidecar for the Aegis AN/SPY-1 radar was developed to test discrimination algorithms and architectures for the Aegis Block 08 Ballistic Missile Defense capability. The sidecar was integrated with the AN/SPY-1 radar at a contractor facility and was installed on an Aegis BMD operational cruiser for use in an Aegis BMD intercept test in June 2007.
- The Laboratory completed a successful critical measurements and countermeasures (CMCM-2) flight test at the Pacific Missile Range Facility in Hawaii. A long-range target with advanced countermeasures was launched, and radar and optical data were collected to reduce risk for the development of advanced counter-countermeasure capabilities.
- The Laboratory demonstrated discrimination algorithms and decision logic for the Missile Defense Agency's (MDA's) Forward-Based Radar (FBR) program. This demonstration was executed during the CMCM-2 test on a sidecar within the FBR test bed. The FBR algorithms and decision logic have been successfully transferred to a contractor for incorporation in the Forward-Based Radar.
- The Reagan Test Site (RTS) Distributed Operations project had significant milestones this year, including real-time demonstrations involving the control of RTS radars from Lexington. This new capability will allow operators to view and execute missions from geographically dispersed operational sites.

Air Defense

- The Laboratory collected and analyzed data from the initial flight tests of the Navy's E-2D Advanced Hawkeye C-130 test bed to verify the performance of the new radar system for the E-2D. A separate test campaign was conducted at the Point Mugu Test Range to examine the performance of advanced waveforms for the E-2D.
- The Laboratory completed development of a signal processing sidecar for a ground-based surveillance radar. The sidecar will be used for testing advanced electronic protection techniques against electronic attack systems. It includes modern displays, auxiliary antennas and receiver channels, and high-speed instrumentation.
- A new pod was developed for the Airborne Seeker Test Bed, enabling captive carry of a variety of man-portable air defense missile seekers. The missile seekers were also tested extensively in the Laboratory's passive optical system test facility, and the measurements were used to validate detailed seeker models.
- The Laboratory is helping the Air Force develop goals and new technology to correct gaps in capabilities against future threats, particularly in the areas of electronic attack and electronic protection. The Laboratory is developing a new airborne test bed based on a converted aircraft to be used for prototyping and testing of advanced threat systems and to test the electronic protection performance of advanced Air Force sensors.

Future Outlook

- The Laboratory will have a large role in characterizing the capabilities and limitations of the recent initial operational deployment of the Ballistic Missile Defense System (BMDS) and in helping to develop, refine, and verify tactics, techniques, and procedures to optimize performance. The Laboratory will also be actively engaged in the analysis, development, testing, and implementation of capabilities for the BMDS beyond the initial deployment. Areas of particular focus will be system-wide tracking and discrimination, system-level testing, and advanced counter-countermeasures techniques.
- The Laboratory will be working with MDA, NORTHCOM/NORAD, and STRATCOM to define architectures for the defense of the U.S. homeland against asymmetric attacks by cruise missiles or short-range ballistic missiles launched from ships off the U.S. coast. An initial prototyping effort is being examined for the National Capital Region as an extension of the Enhanced Regional Situation Awareness (ERSA) system currently in place to provide a defensive capability against these threats.

The Reagan Test Site on Kwajalein Atoll in the Marshall Islands supports ballistic missile defense system testing and evaluation.

The Pacific Missile Range Facility supports experimental and developmental testing for the critical measurements and countermeasures program.

The critical measurements and countermeasures program collects radar and optical data for ballistic missile defense discrimination capabilities development.

The Forward-Based Radar (FBR) test bed program uses a sensor sidecar to develop and test advanced discrimination algorithm technology for the FBR.

COMMUNICATIONS AND INFORMATION TECHNOLOGY

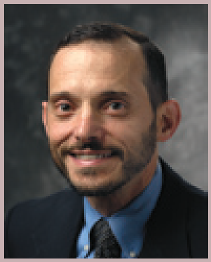
MIT Lincoln Laboratory is working with the DoD, government agencies, and industry to deliver the Global Information Grid vision, including transport, network and data services, information assurance, and applications. Emphasis is on extending a robust networking capability to deployed space, air, land, and marine platforms. The Laboratory identifies, develops, and field-tests new architectures, component technologies, and algorithms for satellite communications, aircraft and vehicle radios, network nodes, wideband sensor networks, network operations centers, and speech processing systems.

Lincoln Laboratory has pioneered apertures and algorithms that provide protected communications on the move.

Leadership

Dr. J. Scott Stadler

Dr. Roy S. Bondurant



Dr. Marc A. Zissman

Mr. Stephan B. Rejto

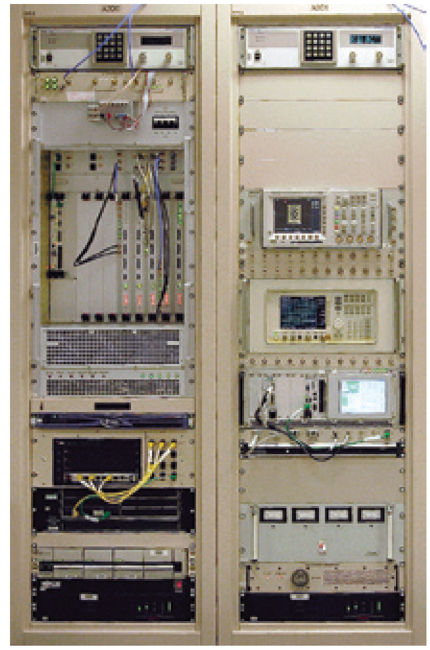
Principal 2007 Accomplishments

- Lincoln Laboratory delivered a test and evaluation capability to validate design standards for critical Transformational Communications technologies, including protected RF waveforms, IP networking, and lasercom. In a collaboration with industry, the test infrastructure was used to verify standards, validate specific implementations, and establish technology readiness.
- Lincoln Laboratory delivered a Ka-band "over-the-air" test capability to Camp Parks, California, for use in early on-orbit checkout of the Wideband Global System payload.
- The Laboratory conducted flight-test campaigns to assess the effectiveness of airborne intelligence, surveillance, and reconnaissance; airborne networking; and network middleware concepts.
- The Laboratory deployed the Lincoln Adaptable Real-time Information Assurance Test bed (LARIAT) to several government facilities. LARIAT provides a high-fidelity emulation of large-scale networks with up to 1,000's of hosts and 10,000's of users to evaluate the effectiveness of information operations tools and techniques.
- Lincoln Laboratory-produced speaker- and language-recognition algorithms achieved world-leading performance in international evaluations conducted by the National Institute of Standards and Technology.
- The Laboratory has demonstrated a system that assesses the security of enterprise networks and automatically recommends changes to eliminate vulnerabilities.
- Lincoln Laboratory continued a series of operator-in-the-loop evaluations of airborne network nodes and architectures. The Laboratory teamed with industry to compare the impact of different network architectures on mission outcome using pilots in real-time, full-motion flight simulators.
- Lincoln Laboratory continues to work closely with industry to realize low-profile, low-cost, multiband antennas for use on wide-body and fighter aircraft. These apertures are designed to support the data rates necessary for network operations while having minimal impact on platform performance.
- A demonstration was completed of an ultra-efficient laser communications link capable of sending 1 megabit per second over 1.6 km with 1 microwatt of transmit power. The receiver can decode 2 bits for each received photon, and the transmitter can control precision pointing of the laser with no moving parts.
- A programmable digital core consisting of field programmable gate arrays, digital signal processors, and a general-purpose computer was completed and delivered. The digital core is capable of processing a wide spectrum of communications waveforms, ranging from line-of-sight radios to protected satellite communications.

Future Outlook

The Laboratory's focus in the upcoming year includes the following:

- Delivery of an interim command-and-control capability and a calibration facility to support the initial operation of the Advanced EHF Satellite
- Addition of functionality to the Transformational Communications technology test beds and their integration to verify end-to-end operation
- Service-oriented architecture techniques for sharing data and enabling dynamic work flows among diverse network-connected sensors, processors, and decision-support tools
- Algorithms for speech, language processing, and information operations techniques for use in Counterterror Social Network Analysis and Intent Recognition
- Field measurement campaigns as part of the U.S. Army C4ISR experiments and Empire Challenge, using the Paul Revere airborne laboratory and the prototype comm-on-the-move vehicles
- Development of test bed and evaluation techniques for two-way English-Arabic and English-Mandarin speech-to-speech translation
- High-sensitivity optical receivers that enable small, high performance lasercom terminals for air, ground, and space applications



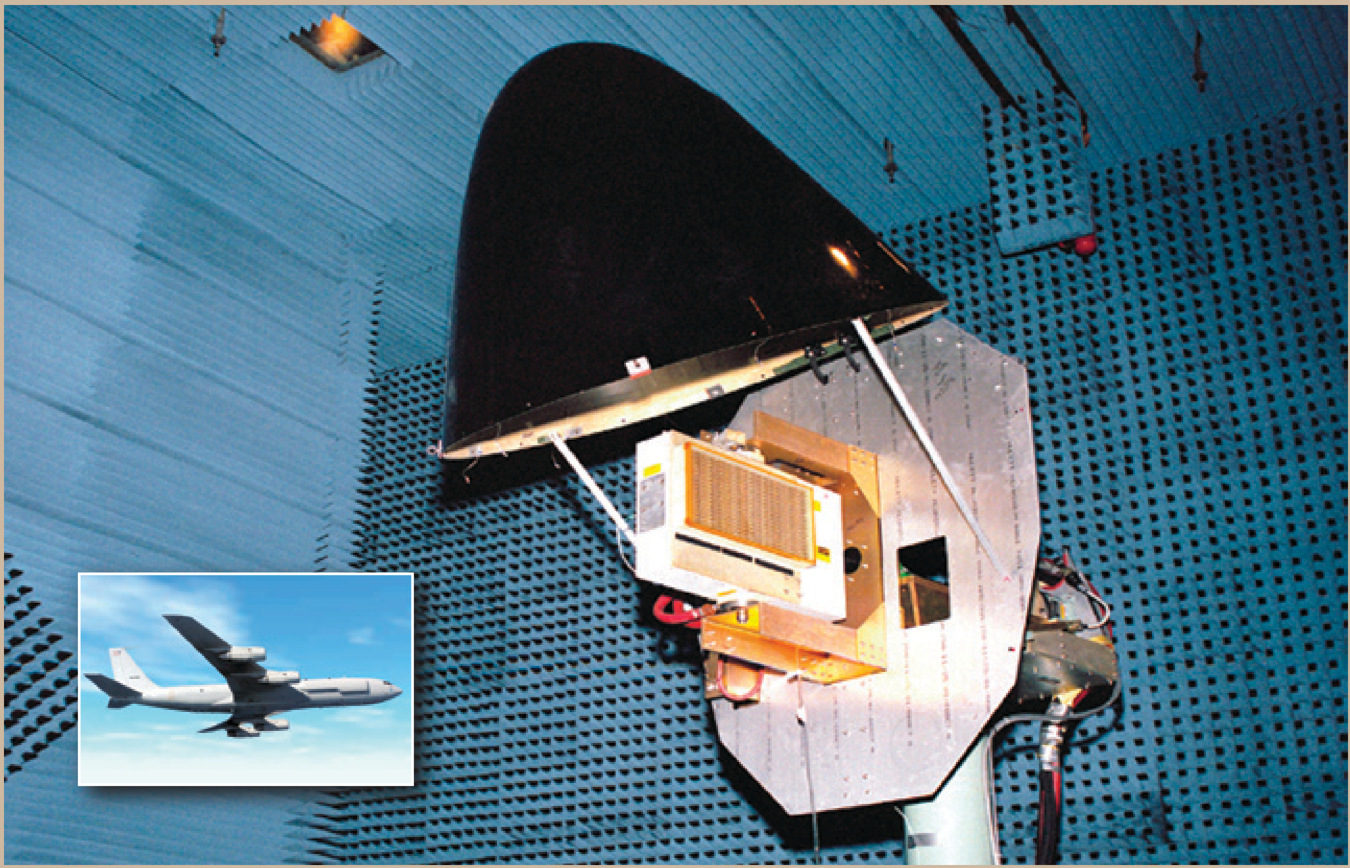
This test terminal uses a programmable digital core to prototype a next-generation network-enabled protected satellite terminal.

The Paul Revere airborne laboratory is a highly instrumented aircraft used for field-testing sensor and communications technologies in a realistic operational environment to evaluate net-centric concepts of operations.

The Ka-Band Test Terminal will be used at Camp Parks to evaluate the Wideband Global System payload.

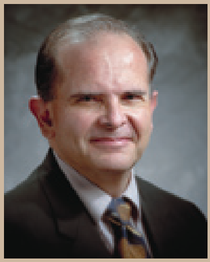
INTELLIGENCE, SURVEILLANCE, & RECONNAISSANCE SYSTEMS AND TECHNOLOGY

The Intelligence, Surveillance, and Reconnaissance (ISR) Systems and Technology mission conducts research and development in advanced sensing concepts, networked sensor architectures, and decision systems. Work encompasses airborne and space-borne radar, high-resolution laser radar, passive geolocation systems, and undersea acoustic surveillance. ISR systems work relies upon the Laboratory's expertise in the enabling technologies of high performance embedded computing, advanced RF and laser sensing, and adaptive signal processing.

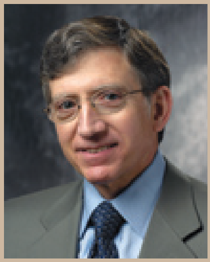


The active electronically scanned array that is part of the Laboratory's airborne sensor test bed is tested inside the Laboratory's antenna measurement facility. This sensor provides radar imagery and ground moving-target detection as part of the Lincoln Multimission ISR Test bed (LiMIT) currently residing on the Laboratory's airborne test bed.

Leadership



Mr. David R. Martinez



Dr. Curt W. Davis III

Dr. James Ward

Principal 2007 Accomplishments

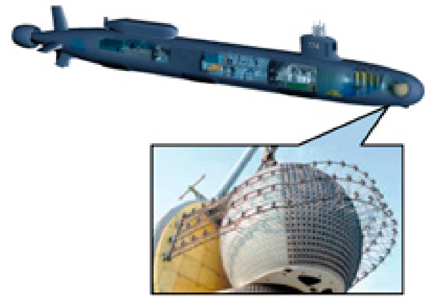
- The Laboratory developed a new airborne radar concept for wide-area detection of moving targets concealed under foliage. This concept uses a multichannel sparse antenna and adaptive signal processing to combine synthetic aperture radar images from each transmit-and-receive channel to reject ground clutter returns. An experimental prototype was designed and successfully tested using the Laboratory's airborne test bed.
- A novel nonlinear equalization algorithm was developed to reduce the nonlinear distortion produced by analog receivers and analog-to-digital converters in the front ends of many ISR systems. Computationally efficient approaches have been developed and shown to provide beyond 20 dB improvement in linear dynamic range. A nonlinear equalization VLSI chip that operates at 1,500 million samples per second is currently in fabrication.
- The Laboratory developed adaptive beamforming algorithms for submarine hydrophone arrays that provide significantly improved detection capability in noisy undersea acoustic environments. The Laboratory also developed a classification algorithm architecture that provides an operator with reliable alerts and the automation to manage large search spaces. The Laboratory utilized operational sensor data and transitioned improved capability to fielded sensor systems.
- Lincoln Laboratory continues to pioneer advanced software technology to provide highly efficient, platform-independent, signal and image processing functions for embedded systems. Development of the next-generation middleware, the Parallel Vector Tiled-Optimized Library (PVTOL), is well underway. PVTOL employs automated mapping and hierarchical memory management to enhance the performance and programmability of the emerging generation of multicore microprocessors.
- A knowledge-management system called Structured Knowledge Spaces was created to automatically link human-generated exploitation products back to their supporting sensor data. The system helps to improve an operator's ability to quickly find and correlate high-level information.
- The Lincoln Laboratory Grid (LLGrid) computing capability was established with the award of a large computing cluster from the DoD High Performance Computing Modernization Office. LLGrid now contains 1,500 processors and nearly a petabyte of disk storage. An integral component of the Laboratory's computing infrastructure, LLGrid is used to conduct large simulations, analyze large data sets, and prototype complex processing algorithms. LLGrid supports several programming languages.
- Laser radar technologies were combined with other sensing modalities such as electro-optics to improve the ability to discriminate targets and structural features in three dimensions.

Future Outlook

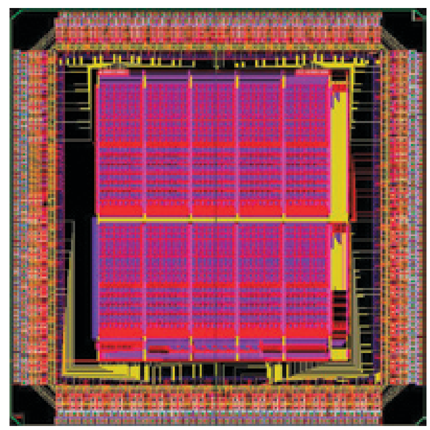
The Laboratory's focus in the upcoming year includes the following:

- Developing digital receiver technology for wideband, high dynamic range needs in passive systems
- Combining RF, video, and laser sensing for enhanced target tracking and identification
- Prototyping sensor payloads for small and medium-sized UAVs
- Furthering development of very-high-resolution laser radar concepts for biometrics
- Developing open network-centric architectures for ISR systems

Laboratory engineers are developing ISR direction-finding systems for an Army ground vehicle.



Adaptive beamforming approaches are being developed for large 3-D submarine sensor arrays such as this spherical array in the bow of a *Virginia*-class submarine.



The wideband nonlinear equalization chip runs at 4,000 megasamples-per-second and compensates for nonlinear distortion to improve system dynamic range.

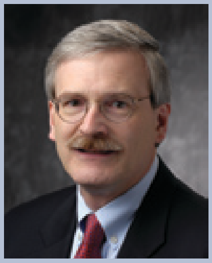
Lincoln Laboratory's Airborne Lidar Test Bed provides simultaneous imagery and wide-area mapping of urban areas.

ADVANCED ELECTRONICS TECHNOLOGY

Research and development in Advanced Electronics Technology involves the invention of new device concepts, the practical realization of those devices, and their integration into subsystems for system demonstrations. The Laboratory's broad electronics expertise includes 3-D integration and silicon microphotonics, optical lithography, and diode and solid state lasers.

The Microelectronics Laboratory develops advanced microelectronic devices in state-of-the-art clean rooms and semiconductor processing hardware.

Leadership



Dr. David C. Shaver

Dr. Richard W. Ralston

Dr. Charles A. Primmerman

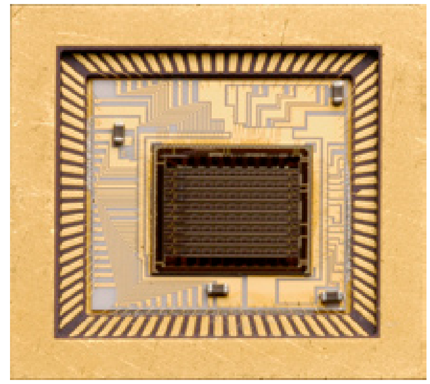
Principal 2007 Accomplishments

- Progress continued in the development of high performance photodetector arrays in which each pixel is sensitive to a single photon. Improved silicon Geiger-mode avalanche photodiodes were used to enable DARPA's Jigsaw ladar sensor to achieve high range resolution in a recent measurement campaign. Expansion of applications from the original ladar to photon-counting passive imaging and high-rate optical communication achieved key in-laboratory validation.
- A 3-D integrated circuit technology, based on the Laboratory's silicon-on-insulator-based process, is being optimized for multicircuit-tier focal planes. In this architecture, the electronics for each pixel reside in tiers behind the high-fill-factor photodetection tier, enabling key improvements.
- A unique orthogonal transfer array has been developed for synoptic space surveys in the Air Force's Panoramic Survey Telescope and Rapid Response System (PanSTARRS). Sixteen orthogonal transfer arrays have been assembled into a 4 x 4 abutted format, and field tests are being initiated at the telescope being built for PanSTARRS.
- Advances in RF performance and reliability of microelectromechanical (MEM) devices have resulted in fully packaged capacitive MEM switches with exceptional low loss and broadband performance across 3 to 110 GHz.
- The Laboratory worked with the Air Force Research Laboratory and a contractor to insert the GaSb-based infrared countermeasure technology into the Advanced Tactical Directed Energy System laser designed for aircraft self-protection.
- Recent advances also include the validation of several specialized charge-coupled device (CCD) imagers for satellite and terrestrial surveillance missions; the first demonstration of a 3-tier focal plane by a 3-D integrated circuit technology; and the preliminary test of large-format, curved focal plane CCD arrays within the Space Surveillance Telescope.

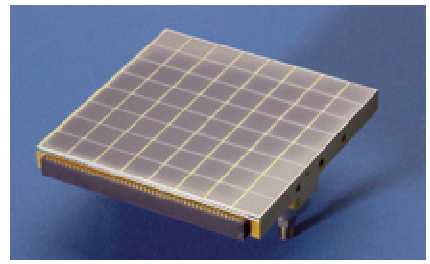
Future Outlook

The Laboratory's focus in the upcoming year includes the following:

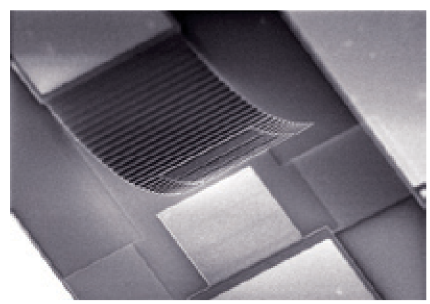
- Imaging and RF technologies for DoD and civilian remote sensing applications
- Laser technologies supporting communication and targeting systems
- Cryoelectronics for longer-term impact in infrared sensing and high-speed computation
- Advanced packaging technologies for large tiled focal planes, miniaturized low-power RF systems, and optoelectronics
- New devices, processes, and design methodologies to enable lower-power, higher-performance digital electronics sensors to detect explosives and improvised explosive devices



A vertical cavity surface-emitting laser array bonded to a CMOS control circuit.



A 22 Mpixel orthogonal transfer imaging tile, one of 60 that will be arrayed to form a 1.4 Gpixel focal plane in each PanSTARRS telescope. The orthogonal transfer architecture can reduce image blur from atmospheric turbulence.



This scanning electron microscope image shows a capacitive microelectromechanical (MEM) switch in its open state. These switches, fabricated at Lincoln Laboratory, are suitable for radio frequency systems in the range of 3 to 110 GHz at RF power exceeding 1 watt.

A technical staff member works on advanced lithography and microelectronics fabrication.

HOMELAND PROTECTION

The Homeland Protection mission is developing technology and systems to prevent terrorist attacks within the U.S., to reduce the vulnerability of the U.S. to terrorism, and to minimize the damage and assist in the recovery from terrorist attacks. Current sponsors for this mission area include the Department of Homeland Security, Department of Defense, and other federal, state, and local entities. Efforts include architecture studies for the defense of civilians and facilities against potential biological attacks, development of the Enhanced Regional Situation Awareness system for the air defense of the National Capital Region, development of cyber-security technology for critical infrastructure protection, and development of collision-avoidance technology to enable the use of UAVs in support of homeland protection.

The Enhanced Regional Situation Awareness Visual Warning System depicted above is utilized to aid in situational awareness around the National Capital Region.

Leadership

Dr. Robert T.-I. Shin

Dr. Darryl P. Greenwood

Dr. Israel Soibelman

Dr. Bernadette Johnson

Principal 2007 Accomplishments

- Lincoln Laboratory demonstrated initial operation of a test bed designed to test potential chemical and biological sensors and protection methods.
- The Laboratory completed homeland security system architectures for biological defense in domestic settings, including indoor and outdoor attacks, a variety of bioagents, and various response strategies.
- The Laboratory completed the first phase of a border sensor architecture study for the southern border.
- New features were added to the Enhanced Regional Situation Awareness (ERSA) system of radar and EO/IR sensors, track fusion logic, and evidence accrual tools. ERSA is deployed to the National Capital Region to provide enhanced air defense surveillance capabilities.
- The Laboratory completed a first-phase study to define architectures for the defense of the homeland against attacks by cruise and short-range missiles as well as unmanned aerial vehicles launched from ships off the U.S. coast.
- Lincoln Laboratory developed an analysis methodology and software tools to evaluate ground sensor fusion concepts to provide an accurate air traffic picture to UAV operators.
- A suite of air-vehicle identification algorithms was rapidly developed to support homeland air defense applications. This effort leveraged a data-collection sensor built to support algorithm development and used to collect a rich set of commercial air-vehicle signatures. Algorithms specifically tailored to the domestic airspace environment were implemented, tested, and characterized with this data. The result was substantial intellectual property usable in future domestic air defense applications.
- In support of Department of Homeland Security (DHS) cyber-security efforts, the Laboratory developed a system, named DEADBOLT, that detects and locates buffer overflows in C and C++ programs.

Future Outlook

The Laboratory's focus in the upcoming year includes the following:

- Continued emphasis on biological and chemical agent sensing technologies
- Architecture studies, system development, and system evaluations for biological and chemical defense
- Expansion of sensor architecture studies for the prevention of terrorist entry across the southern and northern U.S. borders
- Evaluation of fused ground sensor system concepts for the Ft. Huachuca/Arizona border region
- Application of persistent surveillance technology to border surveillance and maritime domain awareness
- Oversight of a program to ensure the survivability and recovery of process control systems
- Development of additional capabilities for the ERSA system in support of air defense of the National Capital Region
- Application of airspace models to evaluate airborne collision-avoidance systems being developed for the DHS UAV operations

Studies have been conducted on UAV integration into civilian airspace for Homeland Security.

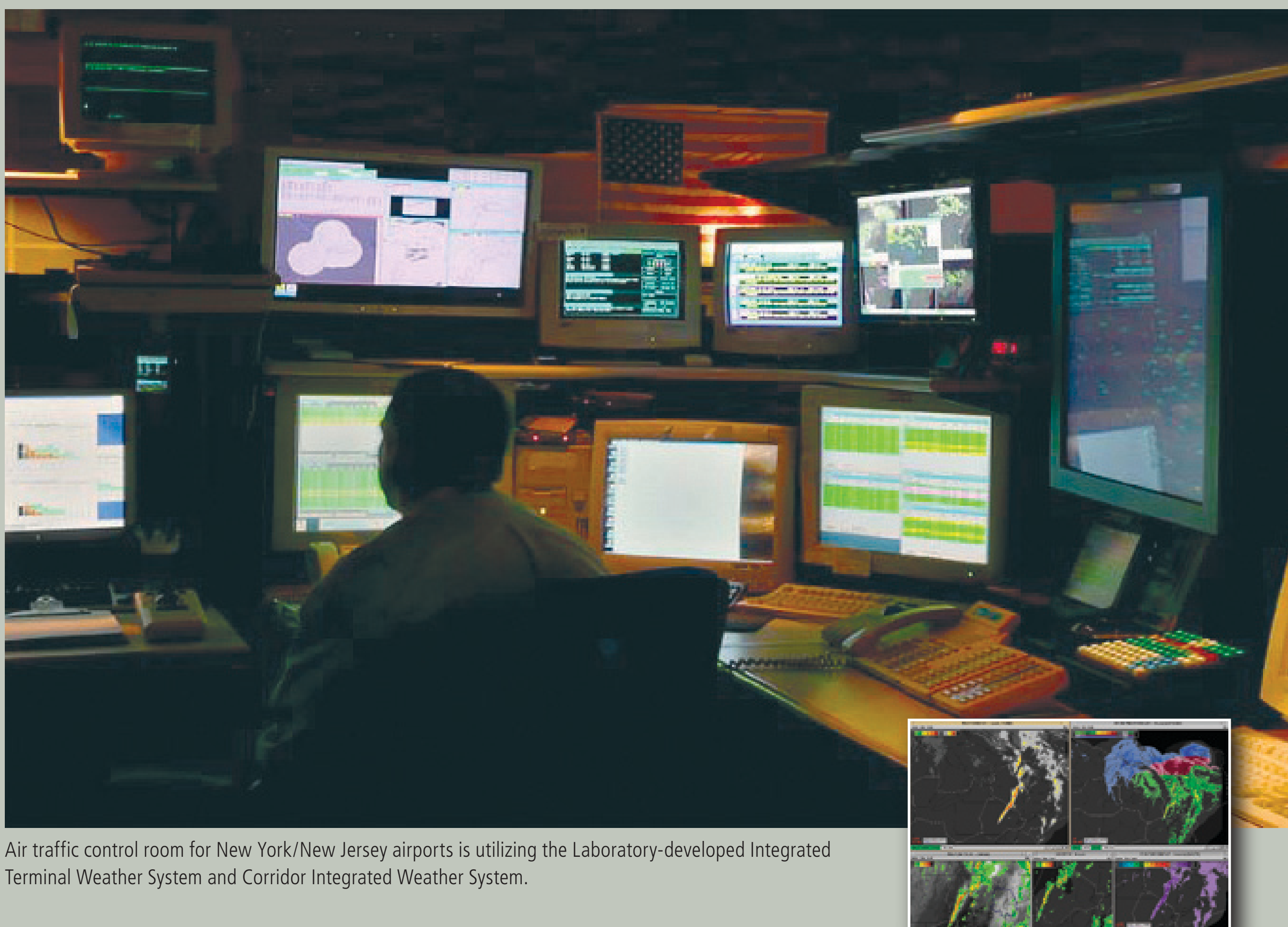
Existing ERSA sensors include FAA radars, elevated Sentinel radars, and EO/IR sensors.

Field measurements of biological and chemical backgrounds are used to better define realistic requirements for sensor systems.

Staff biologists collect soil samples in order to perform rapid field-testing for biological agents.

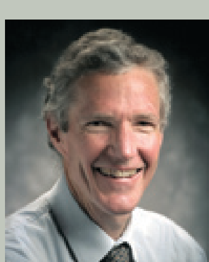
AVIATION RESEARCH

MIT Lincoln Laboratory continues to support the Federal Aviation Administration in the development of new technology for air traffic control. Work historically has focused on aircraft surveillance and weather sensing, collision avoidance, and air/ground datalink communications. Emphasis has now shifted to the development of advanced integrated weather systems, decision-support technologies to improve aviation safety, open system architecture applied to air surveillance sensors, information security, and collaborative approaches to air traffic management.



Air traffic control room for New York/New Jersey airports is utilizing the Laboratory-developed Integrated Terminal Weather System and Corridor Integrated Weather System.

Leadership



Dr. Mark E. Weber

Mr. James M. Flavin

Dr. Marilyn M. Wolfson

Dr. James E. Evans

Principal 2007 Accomplishments

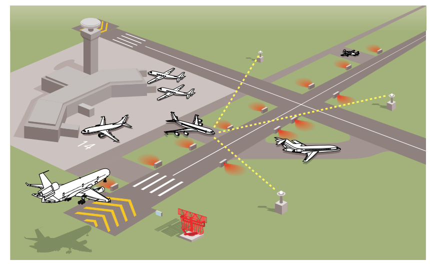
- The FAA's production Integrated Terminal Weather System with the 1-hour Terminal Convective Weather Forecast was deployed in New York, Dallas, Orlando, and Memphis this year. This marks the completion of Lincoln Laboratory's work on an FAA system from concept, research, and prototype to technology transfer, contractor development, production, and certified operations.
- Progress continued on the Corridor Integrated Weather System (CIWS) Demonstration, now in use in the northeast U.S. at eight en route centers, six major terminal control areas, and the Air Traffic Control System Command Center. A large software engineering effort to restructure the CIWS prototype will enable CONUS coverage by 2008.
- The Route Availability Planning Tool (RAPT) represents the Laboratory's first work in the area of coupling weather forecast information into Air Traffic Management decision-support tools. A live RAPT demonstration in New York and a benefits assessment of RAPT began in May. Application to other major U.S. airports (Chicago's O'Hare and Atlanta's Hartsfield-Jackson) will begin.
- The Runway Status Lights operational evaluation at Dallas/Fort Worth International Airport is being extended to include more runways as well as testing at Chicago's O'Hare airport. This system reduces the number and severity of runway incursions and helps prevent accidents.
- In support of the U.S. Department of Defense, the Laboratory is developing technologies and certification procedures that will permit unmanned aerial vehicles efficient access to the National Airspace System. Key technologies include sense-and-avoid and collision-avoidance systems.
- The Laboratory commenced support to the FAA in the development of required surveillance performance and fusion algorithms for Automatic Dependent Surveillance-Broadcast (ADS-B), the primary next-generation air traffic control (ATC) surveillance system.

Future Outlook

The Laboratory's focus in the upcoming year includes the following:

- Modern FAA communications architecture for weather information, including network-enabled weather for the National Airspace System
- New architecture for terminal and en route weather systems and sensors
- Broader coupling of weather and air traffic information, including prototype decision-support tools that incorporate weather and estimates of weather forecast uncertainty
- Improved assessment of performance and efficiency in the National Airspace System, including benefits of integrated weather systems and assessment of avoidable delay
- Demonstrations of enhanced surveillance capabilities with the Multifunction Phased Array Radar for air surveillance
- Development of integrated, net-centric surveillance architecture supporting ATC and homeland defense missions. Key sensor inputs include the ADS-B, operational ATC radar networks, and surge sensors

Lincoln Laboratory technical staff in the control room for the FAA Corridor Integrated Weather System analyze a convective weather forecast in the congested northeast U.S. airspace. Convective weather is the largest cause of air traffic delay in the National Airspace System.



Runway Status Lights, under operational evaluation at Dallas/ Fort Worth International Airport, illuminate red to indicate that a runway is unsafe to enter or for departure. The lights operate automatically in response to real-time surveillance, providing improved situational awareness in the runway environment.

A Laboratory open systems architecture has been developed for the FAA Terminal Doppler Weather Radar (transmitter/receiver/antenna control subsystems and the digital signal processor). The new systems are being fabricated at the FAA program support facility and deployed on operational Terminal Doppler Weather Radars (TDWRs) in the challenging detection environments of Salt Lake City, Utah, and Las Vegas, Nevada.

MIT AND LINCOLN LABORATORY COLLABORATIONS

A unique collaboration between Lincoln Laboratory and the MIT campus is the Integrated Photonics Initiative, a multiyear, Laboratory-funded effort that enhances the research experience for Ph.D. candidates working on integrated photonics devices and subsystems for potential insertion into advanced communications systems. The program also gives students a broader awareness of the DoD's communications mission and needs. The Laboratory's specialized facilities and expertise in applied research add another dimension to the students' thesis development.

Joe Rumpler has been working with the Electro-Optical Materials and Devices Group at Lincoln Laboratory. The group is supplying InP waveguide etching and cleaving support for his thesis project on hybrid optoelectronics integration. The Laboratory's etching tools have enabled results not currently obtained on the campus.

Ryan Williams, whose thesis is in photonic device design and fabrication, has also been getting etching and cleaving support from the Electro-Optical Materials and Devices Group. In addition, the Laboratory's Optical Communications Group will be characterizing the optical switches Williams fabricated and incorporating them into a system demonstration.

Jade Wang, a student of Prof. Erich Ippen, is working with Scott Hamilton of the Optical Communications Group on her thesis in ultrafast optical communications. She is investigating the performance of semiconductor optical amplifier (SOA) for ultrafast all-optical switches.

ALIGNMENT WITH THE CAMPUS

Lincoln Laboratory strengthens its ties and alignment with the MIT campus through a Campus Interaction Committee. The Committee's principal focus is joint research and policy seminars.

Graduate students gain hands-on laboratory experience, such as in this high-power laser system lab.

Joint Research

Emerging collaborative areas include photon integration, superconducting photon counters, advanced signal processing, decision networks, and advanced energy technology.

Support for Graduate Students

Laboratory staff members were involved with 12 MIT graduate thesis projects and participated in technical seminars on campus. This year eight MIT graduates became staff members at Lincoln Laboratory.

STUDENT INTERNSHIPS

The Laboratory, under a sponsored-research program, hosted over 53 graduate and 34 undergraduate students from various colleges. In addition, the Laboratory supports technical education by participating in cooperative programs with local universities.

College students work on real-world problems at Lincoln Laboratory.

Opportunities for Local Area College Students

The Laboratory hosts ten MIT students in the VI-A M.Eng. Thesis Program and two MIT students from the Undergraduate Research Opportunities and Undergraduate Practical Opportunities programs. The Laboratory has an ongoing collaboration with the Worcester Polytechnic Institute, enabling 16 seniors to complete their major qualifying projects at Lincoln Laboratory. A collaboration with Tufts University's Department of Electrical and Computer Engineering has been initiated, with four students carrying out research projects at Lincoln Laboratory.

Northeastern Co-op Program

Technical groups at Lincoln Laboratory employ 32 co-op students from Northeastern University and other area colleges. Students majoring in engineering and the sciences are given opportunities to gain research experience in areas such as advanced electronics, satellite tracking, advanced radar development, biological sensors, signal processing, and network security. Co-ops help solve problems, build prototypes, and test applications in the field. Lincoln Laboratory was recognized by Northeastern University at the fifth annual Northeastern University Co-op Partner Awards on October 18, 2006, for its leadership and commitment to the development of its co-op students in the fields of science, technology, engineering, and mathematics.

WORKSHOPS AND SEMINARS

Lincoln Laboratory hosts annual conferences, workshops, and meetings that bring together members of technical and defense communities to share advancements and ideas. These events, a number of which are described below, foster a continuing dialogue that enhances technology development and provides direction for future research.

High Performance Embedded Computing (HPEC) Workshop — September 2006

The HPEC Workshop provided U.S. government-funded researchers from academia, industry, and government an opportunity to discuss techniques, approaches, and ongoing developments with relevance to real-time embedded military signal processors.

Surface Surveillance Technology (SST) Workshop — October 2006

The SST Workshop focused on emerging sensor technologies for countering obscured targets and difficult targets in the clear. Topics included user needs, counterinsurgency, wide-area surveillance, sensors for target classification and identification, data fusion and exploitation, and field test beds and experimentation.

Project Hercules Program Review — November 2006

The Project Hercules Review presented the current program in decision algorithm development to the Missile Defense Agency community.

Bio-Chem Defense Systems Workshop — November 2006

The Bio-Chem Defense Systems Workshop presented the latest developments in technologies to address chemical and biological threats, with an emphasis on advanced sensing techniques.

Flight Test Campaign (FTC)-02 Data Analysis Workshop — January 2007

The FTC-02 Data Analysis Workshop presented the results of a major field measurements/data analysis campaign and its applications to both missile defense elements and related countermeasure mitigation concepts and techniques.

Advanced Electronics Technology (AET) Technical Seminar — February 2007

The AET Technical Seminar provided an overview of current developments in areas such as advanced imaging, analog signal processing, electro-optical materials and devices, submicrometer technology, quantum electronics, and advanced silicon technology.

Lincoln Laboratory's auditorium is host to many technical conferences, workshops, and other events throughout the year.

Defense Technology Seminar (DTS) attendees include military officers and Defense Department civilians.

Defense Technology Seminar (DTS) — March 2007

The DTS Seminar on advanced electronics systems technology provided a broad technical perspective on research areas critical to future national security. In keeping with Lincoln Laboratory's mission to facilitate technology transfer, this week-long seminar, held annually, informs attendees and seeks their views for future Laboratory planning.

Integrated Sensing and Decision Support (ISDS) Workshop — April 2007

The ISDS Workshop presented project and technology advancements to the ISDS community. The theme of the 2007 workshop was "Building Shared Awareness."

Space Control Conference — May 2007

The Space Control Conference presented current capabilities, future needs, and technology development plans to the space control community.

Air Vehicle Survivability (AVS) Workshop — May 2007

The AVS Workshop provided discussion of electronic countermeasures, radar polarization issues, and space situational awareness as it applies to the survivability of air vehicles.

Ballistic Missile Defense (BMD) Technical Seminar — May 2007

The BMD Technical Seminar provided the BMD community with an overview of current developments in areas such as missile defense elements, missile defense architectures, advanced concepts and technology, test infrastructures, and intelligence capabilities.

Adaptive Sensor Array Processing (ASAP) Workshop — June 2007

The Fifteenth Annual ASAP Workshop presented the latest advances in adaptive signal processing applied to military and commercial sensor systems. Presentations discussed new adaptive algorithms for single- or multichannel processing, technical challenges to algorithms posed by new system concepts, nontraditional applications of adaptive algorithms, performance analysis, target tracking and distributed sensing methods, and experimental results.

Communications and Networking Workshop (CNW) — June 2007

The Communications and Networking Workshop provided the user, acquisition, research, and developer communities with discussions on lessons learned, current trends, technical challenges, and the road ahead.

TECHNICAL EDUCATION

The Laboratory serves the military and DoD civilians by hosting technical education courses.

Ballistic Missile Defense (BMD) Technology Course

The BMD Technology Course provides an understanding of ballistic missile defense systems and concepts and technologies to military officers, government civilians, and subcontractors involved in BMD systems development, acquisition, and related fields. The three-day program consists of lectures, demonstrations, laboratory sessions, and tours designed to instill a basic working knowledge of BMD systems.

Introduction to Radar Systems

This three-day program of lectures, demonstrations, laboratory sessions, and tours is designed for military officers and DoD civilians involved in radar systems development, acquisition, and related fields. The course provides a basic working knowledge of radar systems. Different radar systems are described with emphasis on design characteristics, and future trends in radar systems are examined.

Homeland Defense and Counterterrorism Course at the Naval War College, Newport, Rhode Island

Lincoln Laboratory recently initiated a series of courses in conjunction with the Naval War College. The course, focused on homeland defense and counterterrorism, is a graduate-level course that balances the Laboratory's technical expertise with the Naval War College's strategic and operational emphasis.

Tom Macdonald from the Laboratory's Wideband Tactical Networking Group and Bill Delaney, Director's Office Fellow, talk to West Point cadets about mobile tactical communications on a Satcom-equipped Laboratory HMMWV. The cadets were at the Laboratory for a defense technology seminar.

Kevin Kelly from the Net-centric Integration Group explains to West Point cadets communications and data collection systems onboard the group's Paul Revere airborne laboratory during a tour of the Laboratory's Flight and Antenna Test Facility.

ADVANCED CONCEPTS COMMITTEE (ACC)

The Advanced Concepts Committee supports the development of innovative concepts that address important technical problems of national interest.

The Lincoln Laboratory Advanced Concepts Committee provides seed funding, as well as technical and programmatic support, to investigators with new technology ideas. These ideas are typically high risk, but offer the potential to significantly impact national needs by enabling new systems or improving existing capabilities. Projects are scoped to demonstrate concept feasibility and typically last 9 to 12 months. The ACC encourages collaborative efforts between Lincoln Laboratory and MIT campus.

Recent ACC initiatives include technologies for detecting genotoxins and other harmful agents. The ACC is also currently supporting the development of advanced electronic devices, such as a quantum-limited charge-coupled device (CCD) imager that enables wide dynamic range day/night imaging and a 3-D organic solar cell for portable low-cost power.

The Advanced Concepts Committee sponsors a Defense Studies Seminar Series that includes speakers associated with the MIT Security Studies Program. The 2007 seminars were as follows:

January 5, 2007	*Proliferation Diplomacy and North Korea* **Dr. Jim Walsh,** Research Associate, MIT Security Studies Program
March 2, 2007	*A New Strategy for Iraq* **Professor Barry R. Posen,** Director, MIT Security Studies Program
April 13, 2007	*Strike Warfare Trends in Naval Aviation* **Dr. Owen R. Coté, Jr.,** Associate Director, MIT Security Studies Program
May 25, 2007	*Counterinsurgency and the Role of Population Relocation* **Assistant Professor Kelly M. Greenhill,** Wesleyan University

NEW TECHNOLOGY INITIATIVES PROGRAM (NTIP)

The NTIP supports initiatives to significantly extend the application of new technologies and approaches to the DoD's current and future problems.

The Lincoln Laboratory New Technology Initiatives Program is one of several internal technology innovation mechanisms. Technologies emerging from this program are critically important to shaping the Laboratory's technology strategy.

Potential new technologies involve human terrain preparation such as social/cultural modeling and automated language processing; ubiquitous observation such as close-in sensor and tagging systems and soldiers-as-sensors; contextual exploitation such as situation-dependent information extraction; and scalable actions such as consequence-modeled decision making.

A special Laboratory seminar, sponsored by the New Technology Initiatives Program, featured Team MIT and their entry in the DARPA Urban Challenge. The goal of the Urban Challenege is to create an autonomous ground vehicle that is capable of maneuvering in both open and urban environments.

AWARDS AND RECOGNITION

2007 MDA Technology Pioneer Award

Dr. David L. Briggs, Director Emeritus of MIT Lincoln Laboratory, for significant and sustained technical contributions to missile defense systems, and **Dr. Joseph C. Chow**, former Group Leader in the Aerospace Division, for significant technical contributions to the Midcourse Space Experiment program in the mid-1990s.


MDA Technology Pioneer Award recipients: **Dr. David L. Briggs** (left) and **Dr. Joseph C. Chow** (right).

2007 IEEE Aerospace and Electronic Systems Society Appointment

Dr. Robert M. O'Donnell has been appointed to Vice President for Education.

2007 MIT Lincoln Laboratory Technical Excellence Award

Dr. Robert G. Atkins for his leadership in developing advanced system architectures and his ability to develop new architectures for addressing complex, nontraditional problems.

Lawrence M. Candell for his contribution to developing new optical and radar sensors for communications and surveillance systems.


Technical Excellence Award winners: **Dr. Robert G. Atkins** (left) and **Lawrence M. Candell** (right).

2007 MIT Excellence Awards

Serving the Client Awards: **Cynthia McLain**, *Information Systems Technology Group*, and **Dr. Dieter Willner**, *Intelligence, Test, and Evaluation Group*.

Unsung Hero Awards: **Gary Pascucci**, *Procurement and Travel Services,* and **Patricia Shea**, *Net-centric Integration Group*.

2006 IEEE Fellow

Dr. Pratap N. Misra for contributions to global satellite navigation systems.

2006 IEEE Alexander Graham Bell Medal

Dr. John Wozencraft, former Head of the Communications and Information Technology Division, for the development of sequential decoding and the signal space approach to digital communications.

2006 MDA Technology Pioneer Award

William Z. Lemnios, retired Head of the former Radar Measurements Division, for participation on a team developing missile defense X-band radar.

2006 Optical Society of America Fellow

Dr. Jinendra K. Ranka for outstanding contributions to ultrafast nonlinear optics, including the discovery of supercontinuum generation in photonic crystal fibers.

2006 NASA-Ames Honor Award

Dr. Kevin P. Cohen, **Victor J. Cyrkler**, **Allyn E. Dillighan**, **James C. Dunn**, **Kenneth L. Gregson**, **Kevin S. Johnson**, **Danial A. Lane**, **Charles J. Magnarelli**, **Robert L. Maynard**, **Bonnie A. McKowen**, **Lance F. Michael**, **Walter A. Moquin**, **Dr. Eliahu H. Niewood**, **Albert J. Theriault, Jr.**, **Dr. James L. Truitt**, and **David P. Ventura**, for participation in the 2006 Joint Flight Demonstration.

2006 Multiple Sclerosis Society Bike and Hike Award

MIT Lincoln Laboratory, through coordination with the Lincoln Laboratory Community Outreach Committee, for exceptional efforts in the 2006 Bike and Hike the Berkshires fund-raiser.

Best Paper Awards

2005 Tri-Service Radar Symposium Best Presented Paper: **Dr. Scott D. Coutts**

2006 Tri-Service Radar Symposium Best Presented Paper Honorable Mention: **Dr. Kevin Cuomo**, **Linda J. Maciel**, and **Dr. Jean E. Piou**

2006 AIAA Aviation Technology, Integration and Operations Conference Best Paper: **Dr. Jerry D. Welch**

Superior Security Rating

To MIT Lincoln Laboratory's collateral security program from the Commander of the 66th Security Forces Squadron at Hanscom Air Force Base.

RECENT PATENTS

Method and Apparatus for Short-Term Prediction of Convective Weather
U.S. Patent No. 7,062,066
Marilyn M. Wolfson, Richard J. Johnson, Barbara E. Forman, William J. Dupree, Kim E. Theriault, Robert A. Boldi, Carol A. Wilson, Robert G. Hallowell, and Richard L. Delanoy

Charge-Domain A/D Converter Employing Multiple Pipelines for Improved Precision
U.S. Patent No. 7,015,854
Michael P. Anthony

Method and Apparatus for Protecting Data
U.S. Patent No. 7,032,166
Leslie Servi, Eushiuan Tsung, Joseph A. Cooley, and Jeremy L. Mineweaser

Optical Imaging Systems and Methods Using Polarized Illumination and Coordinated Pupil Filter
U.S. Patent No. 6,965,484
David C. Shaver

Thermoelectric Device Test Structure
U.S. Patent No. 6,856,136
Theodore C. Harman

High Sensitivity X-Ray Photoresist
U.S. Patent No. 6,872,504
Theodore H. Fedynyshyn

Surface Modified Encapsulated Inorganic Resist
U.S. Patent No. 6,913,865
Theodore H. Fedynyshyn

Methods and Apparatus for Improving Resolution and Reducing the Effects of Signal Coupling in an Electronic Imager
U.S. Patent No. 6,884,982
John U. Beusch

Method and System of Lithography Using Masks Having Gray-tone Features
U.S. Patent No. 6,884,551
Michael Fritze and Brian M. Tyrrell

Electromagnetic Coupling Connector for Three-Dimensional Electronic Circuits
U.S. Patent No. 6,891,447
William S. Song

Apparatus and Methods for Optically Monitoring Thickness
U.S. Patent No. 6,937,350
Lyle G. Shirley

Apparatus and Methods for Surface Contour Measurements
U.S. Patent No. 6,952,270
Lyle G. Shirley

Polarization-Stabilized All-Optical Switch
U.S. Patent No. 6,937,782
Bryan S. Robinson, Shelby J. Savage, Scott A. Hamilton, and Erich P. Ippen

Method of Fabrication for III–IV Semiconductor Surface Passivation
U.S. Patent No. 6,933,244
William D. Goodhue

Tunable Microwave Magnetic Devices
U.S. Patent No. 6,919,783
Gerald F. Dionne and Daniel E. Oates

Slab-Coupled Optical Waveguide Laser and Amplifier
U.S. Patent No. 6,928,223
James N. Walpole, Joseph P. Donnelly, and Stephen R. Chinn

COMMUNITY OUTREACH

MIT Lincoln Laboratory employees volunteer their time and expertise to reach out to the local community in civic and educational programs. The Laboratory's outreach initiatives promote service and education in partnership with the MIT Public Service Center.

Community Giving at Lincoln Laboratory and MIT

The Lincoln Laboratory Community Outreach (LLCO) promotes community service in partnership with the MIT Public Service Center. Proceeds from events such as a 5K fun run, used book drives, and new book sales are divided equally between the United Way and the MIT Community Service Fund, which offers grants to charities in Boston and Cambridge. Additionally, the LLCO has participated in the following:

- Food donation drives for the Food for Free organization
- Used clothing drives for local shelters—Shelter, Inc., On the Rise, the Salvation Army, and CASPAR
- A national multiple sclerosis benefit bike tour
- A Support Our Troops drive in which hundreds of goods were collected and packaged at the Laboratory and sent to U.S. soldiers overseas.

Lincoln Laboratory employees help pack goods collected for troops overseas.

Educational Outreach

The Laboratory has developed K–12 science education outreach initiatives. **Science on Saturday** features science lectures and demonstrations by Laboratory technical staff on site. Over 1,400 local K–12 students, their parents, and teachers have enjoyed demonstrations on the principles of cryogenics and liquid nitrogen, electricity and magnetism, properties and applications of sound waves, the "magic" of chemistry, and lasers and optics. Under the Laboratory's **Science Seminar Series,** technical staff have visited local K–12 schools, giving presentations on science and engineering to over 1,000 students. Specific topics included geology, biology, chemistry, physics, engineering, robotics, satellite networks, and lasers and optics.

The Laboratory also conducts **tours** for local-area high-school students and organizations. Participants learn about research in areas such as microelectronics fabrication, air traffic surveillance technology, chemical and biological detection, and satellite communications on the move.

Dr. Todd Rider teaching sixth graders at a local school to identify and date different types of fossils.

LIFT^2 Program

MIT Lincoln Laboratory has joined a group of companies in sponsoring **Leadership Initiatives for Teaching and Technology (LIFT^2)** externships. LIFT^2, an innovative professional learning program for science, technology, and math teachers, serves Massachusetts metro south/west region. The program is designed to address the decreasing numbers of the workforce properly equipped with an education to support a technology-driven economy. The LIFT^2 program seeks to improve the academic preparation of students for math- and engineering-related jobs, and to encourage women and minorities to enter technical fields. Teachers from middle and high schools are provided with a paid summer externship to do hands-on work at technology centers such as MIT Lincoln Laboratory.

Last summer, the Laboratory employed Bruno Nosiglia, a former electrical engineer and now a teacher at the Horace Mann Middle School in Franklin, Massachusetts, and Shannon Galant Ansari, a teacher in Maynard, Massachusetts. Nosiglia, working in the Advanced Space Systems and Concepts Group, used small telescopes to collect imagery of satellites orbiting the Earth and used lasers to test hardware to be deployed on a rocket. Nosiglia summed up the value of LIFT^2:

> "This [program] offers me an opportunity to keep my engineering side sharp while learning new techniques that I can teach to my students. It also provides me with an opportunity to make contacts that can help me bring more science and engineering to the students at our school."

Science on Saturday

Dr. Roderick Kunz's demonstration,
"Chemistry Magic Show"

Dr. Andrew Siegel's demonstration,
"Plasma and Ions"

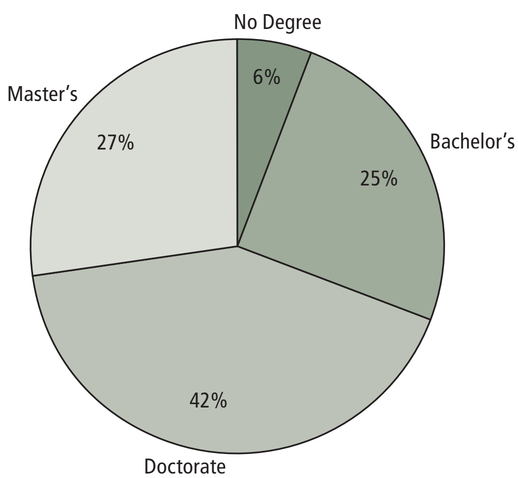
Dr. Richard Williamson's demonstration,
"Cryogenics and Liquid Nitrogen"

Dr. Jeffrey Roth's demonstration,
"Lasers and Optics"

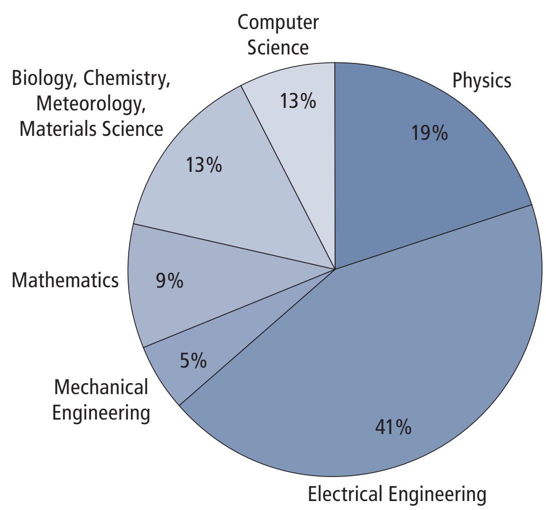
COMPOSITION OF PROFESSIONAL STAFF

Staff Technical Equivalents:	1,405
Support:	1,025
Technical Support:	151
Subcontractors:	450
Total Employees:	3,031

by Degree



by Academic Discipline



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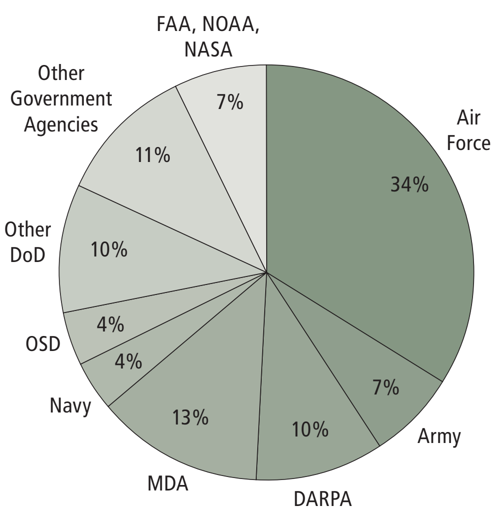

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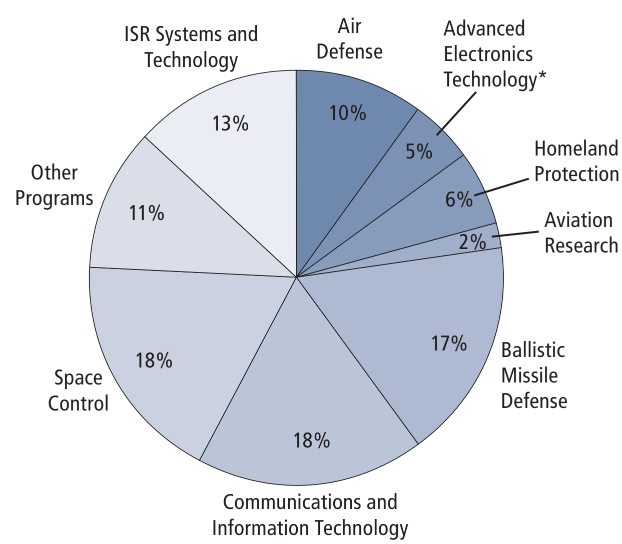

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The work described in this document is performed under the prime contract with the U.S. Air Force, FA8721-05-C-0002.