Director, Lincoln Laboratory

Lincoln Laboratory is a federally funded research and development center (FFRDC) operated by the Massachusetts Institute of Technology for the Department of Defense (DOD). The mission of the laboratory is to advance technology in support of national security. Research and development are carried out in three core areas: sensors, signal processing, and communications supported by a broad research base in advanced electronics.

For the federal fiscal year 2005, Lincoln Laboratory will receive approximately $623 million that will support the efforts of 1,500 professional technical staff and 1,087 support personnel; outside procurement will exceed $300 million. While most of the research is sponsored by the DOD, funding is also received from the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration , and the National Oceanographic and Atmospheric Agency. In addition, Lincoln Laboratory also carries out noncompetitive research with industry under approved cooperative research and development agreements and other collaborative activities with academic institutions.

On April 1, 2005, the Department of Defense awarded a five-year cost reimbursement contract with a five-year option to MIT for the operation and management of Lincoln Laboratory as an FFRDC. MIT has operated Lincoln Laboratory since its inception in 1951 as a Department of Defense research center. The award continues the long-standing and special relationship that has existed between MIT and the US Government in providing innovative technical talent and resources to meet national security challenges.

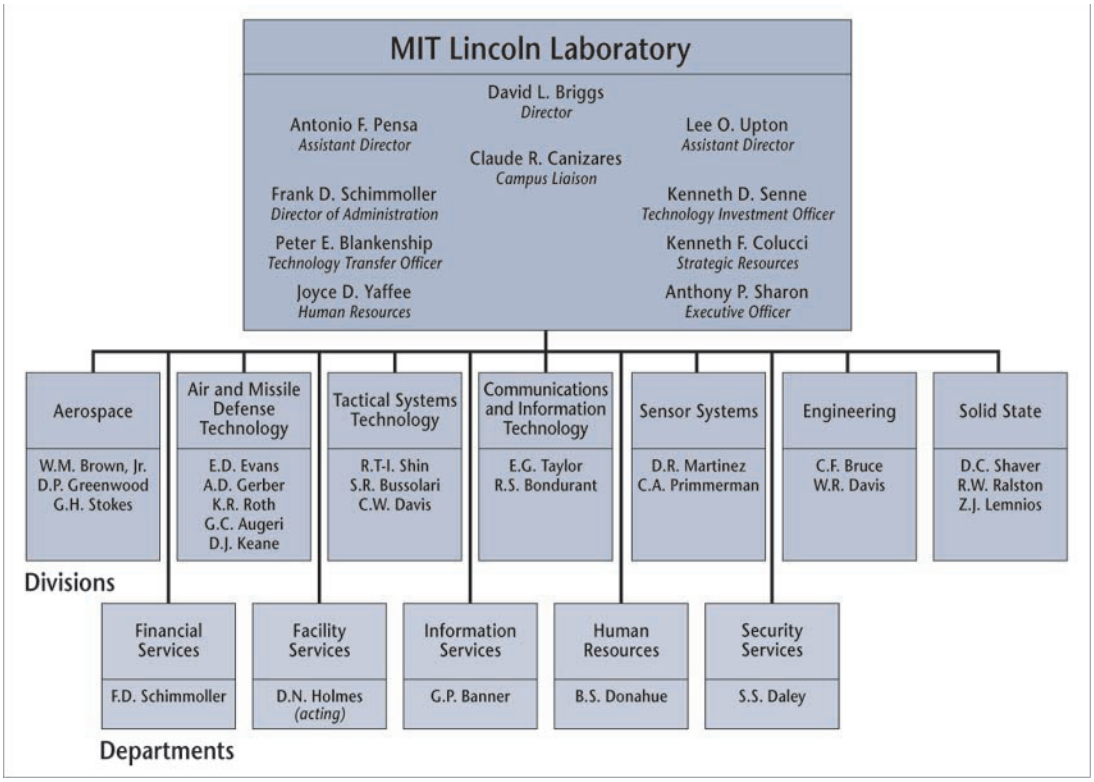
Laboratory Operations

Lincoln Laboratory operations are marked by fundamental attributes: high-caliber staff, a strong alignment with the MIT campus, a streamlined organization structure, and high-quality infrastructure.

Organization

Lincoln Laboratory's performance depends on the creativity of its technical staff. The flat organization structure (Figure 1), consisting of three levels—Director's Office, Divisions, and Groups—encourages the exchange of ideas between staff and line management. There has been an increasing demand upon the laboratory to conduct research and development of more complex, integrated systems. The nature of this work has raised the level of sharing and integration among staff, facilities, and services. Service departments as providers of standardized support allow research teams staffed from across the divisions to quickly draw on key services and permit them to focus on the technical challenges.

Figure 1. The organizational structure of MIT Lincoln Laboratory



Key Changes to the Senior Management Council

Milan Vlajinac, head of the Engineering Division, retired, and Charles Bruce has been appointed head of the Engineering Division. William R. Davis was appointed assistant head of the division.

Lewis Thurman of the Tactical Systems Technology Division stepped down as the head and has been replaced by Robert Shin. Steven Bussolari was appointed associate head of the division.

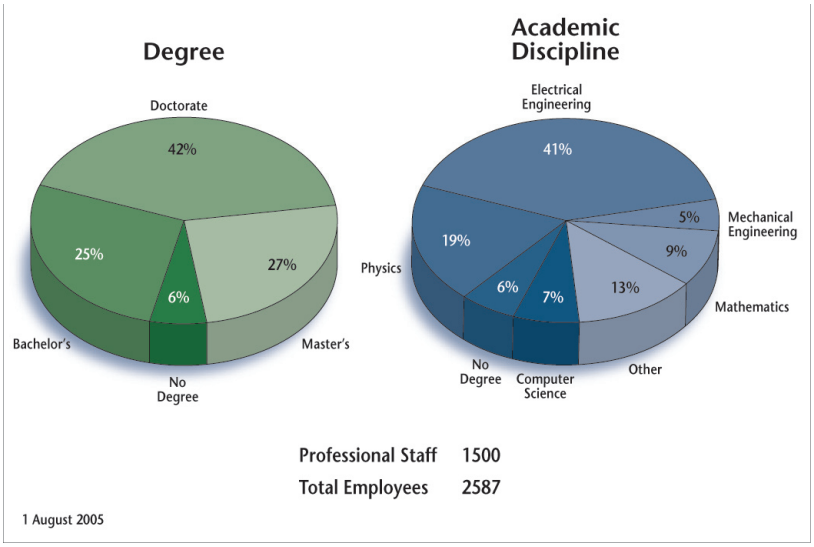
In a realignment of sensor and air defense development activity, David Martinez was appointed head of the Sensor Systems Division, and Charles Primmerman was named assistant head. Andrew Gerber was appointed associate head of the Air and Missile Defense Technology Division, and Gerald Augeri was appointed assistant head.

Charles Niessen, associate head, Communications and Information Technology Division, has stepped down from the Senior Management Council.

Staff

A key factor in maintaining excellence at Lincoln Laboratory is the quality of its staff. The laboratory obtains 60–75 percent of its new staff directly from the nation's leading technical universities. The laboratory conducted on-campus interviews at over 50 universities this past year. The makeup of the laboratory staff by degree and academic discipline is shown in Figure 2.

Figure 2. Composition of professional staff at MIT Lincoln Laboratory



Under this year's sponsored research program, Lincoln Laboratory hosted 35 graduate and 41 undergraduate students. Specific to MIT, the laboratory is hosting 11 VI-A students, one Undergraduate Research Opportunities Program student, and one Undergraduate Practice Opportunities Program student. The laboratory has an ongoing collaboration with the Worcester Polytechnic Institute for 20 seniors to complete their major qualifying projects at Lincoln Laboratory. A new collaboration with Tufts University's Department of Electrical and Computer Engineering has been initiated with four students carrying out research projects at Lincoln Laboratory. In addition, 31 students from Northeastern University's cooperative study program are at Lincoln Laboratory.

To help its staff keep pace with the rapid changes in science and technology, Lincoln laboratory offers a program of on-site courses, and for highly qualified candidates the laboratory offers the chance to pursue an advanced degree under the Lincoln Scholars program. Recently completed on-site courses include Spacecraft Design, Electromagnetics, Digital Signal Processing, and Optical Discrimination. The Lincoln Scholars program currently has seven doctoral candidates and 14 master's candidates, primarily in electrical engineering and computer science. Five of these candidates are at MIT. This year seven Lincoln Laboratory staff members completed their master's degrees, and one completed a doctorate.

Lincoln Laboratory staff members maintain close ties with professional societies, serving as officers, symposia chairs, and committee contributors. This year the laboratory was pleased to announce that Joseph Campbell, Alan McCree, and James Ward were elected as Institute of Electrical and Electronics Engineers fellows, and Dr. Leslie Servi was named a fellow of the Institute for Operations Research and Management Sciences.

In addition, Mr. Zachary Lemnios was awarded the Office of the Secretary of Defense Medal for Exceptional Public Service.

At the 6th Biennial USA/Europe Air Traffic Management Research and Development Seminar in Baltimore, Lincoln Laboratory garnered several significant awards: Best Paper for Decision Support went to James Evans and Michael Robinson for their paper "Quantifying Convective Delay Reduction Benefits for Weather/ATM Systems"; Best Paper in Safety went to John Andrews, Gerald Welch, and Heinz Erzberger for their paper "Safety Analysis of Advanced Separation Concepts." In addition, a special award for the "most promising technology implementation" improving the air traffic management system was presented by the European Air Traffic Management R&D Association for the Andrews-Welch-Erzberger paper.

In January 2005, the director of Lincoln Laboratory, David Briggs, presented the laboratory's Technical Excellence Award to two staff members—Marilyn Wolfson, for her work in the application of meteorology and, in particular, convective weather forecasts to the problem of improving air traffic control at the national level; and Stephen Weiner, for creative insights, technical depth, and systems perspectives that have yielded significant contributions to the many phases of missile defense development.

Alignment with the Campus

Lincoln Laboratory uses a Campus Interaction Committee to strengthen its ties and alignment with the MIT campus. The committee's principal focus is joint research and policy seminars, and it is chaired by Professor Jeffrey Shapiro. As a result, laboratory staff members were involved with 32 MIT graduate theses and participated in one course and three seminars on campus. Emerging areas of collaboration include

- Electromagnetics–Professor Kong
- Decision modeling–Professor Willsky
- Space science–Professor Zuber
- Signal processing–Professor Oppenheim

Another avenue for enhancing Lincoln Laboratory's ties with the campus is through the Advanced Concepts Committee. The committee provides funding and proactive technical and liaison support for developing advanced concepts that address high-priority national problems. These concepts may enable new systems or promote significant improvement of current practice. Current studies and research and development include

- Convex optimization of integrated communications systems
- Air traffic management with weather-induced capacity constraint
- Magneto-optical materials for integrated optical isolators
- Multi-spectral infrared detector arrays using amorphous semiconductors
- Blind calibration algorithms for a digitally enhanced high-speed analog-to-digital converter architecture
- Nanotube dispersions in polymer matrices

Professor Rajeev Ram has been a member of the committee since November 2004.

Lincoln Laboratory also supports activities conducted by the Industrial Liaison Program through presentations by laboratory staff on cooperative research and development

opportunities and technical licensing options. Working through the MIT Technical Licensing Office, the laboratory has made 28 technology disclosures, applied for 19 patents, and has been awarded 23 patents.

One of our most valued ties to the campus is the exceptional alumni who join the laboratory. This year eight MIT graduates became staff members at Lincoln Laboratory.

Technical Facilities and Infrastructure

Rapidly changing technology and fast, new research opportunities demand a first-rate infrastructure. In addition, the high quality of our laboratories and research equipment serve as an incentive for attracting top technical talent. Four major infrastructure improvements were completed this year. First, an electro-optic test range was constructed to support efforts such as laser radar and imaging devices. Second, a space situational awareness center was developed to fuse data from worldwide sensors in near real time to support research on improved methods for tracking and identifying space objects. Third, a new communications laboratory was built to support optical communications research. And fourth, an RF system test facility was developed to support rapid prototyping and testing on the ground and in an airborne platform.

The laboratory's infrastructure also enhances the quality of life at Lincoln Laboratory. In January 2005 the laboratory opened a newly renovated cafeteria with expanded food services and a sundry store.

Technical Program Highlights

Research at Lincoln Laboratory focuses on national security tasks involving air defense, ballistic missile defense, space control, tactical technology, biological-chemical defense, communications and information technology, and advanced electronic technology. In addition, the laboratory undertakes related non-defense work for other government agencies, including air traffic control. Two principal activities in the laboratory's technical mission are, first, the development of components and systems for experiments, engineering measurements, and tests under field operating conditions, and second, the dissemination of information to the government, academia, and industry.

Maximum dissemination of technical information is achieved through a series of annual technical seminars hosted at Lincoln Laboratory and the staff's contribution of technical articles to peer-reviewed journals. Nine technical seminars were attended by over 2,500 researchers, engineers, and technical planning and policy administrators. Key seminars this year included the Advanced Electronics Technology Workshop, the High Performance Embedded Computing Workshop, the Adaptive Sensor Array Processing Workshop, and the Biological-Chemical Defense Seminar. In addition to the seminars, laboratory staff published 110 technical articles in professional journals. The laboratory also publishes the *Lincoln Laboratory Journal*, one of which was a recent thematic volume covering advances in hyperspectral sensing.

Lincoln Laboratory has more than 500 specific engineering development projects under way. Notable highlights are listed below.

Advanced Electronics Technology

The FY2005 program achieved many important milestones, including tiled charge-coupled sensor arrays accurately curved to a spherical focal surface for a large-aperture space surveillance telescope; infrared photon-counting detector arrays at several wavelengths for unique imaging and communication systems; and a wavelength-combined 100-element semiconductor laser-diode array, which produced a record 35 watts with a near-ideal diffraction-limited beam. In addition, liquid-immersion optical lithography technology is currently being transitioned to industry and targeted at volume IC manufacture in 2007.

Communications and Information Technology

To support the design of the next generation of communication satellites, Lincoln Laboratory has developed a system-of-systems test infrastructure to evaluate free-space optical links, high-bandwidth signaling, and dynamic resource allocation. Additional free-space optical work includes research into multiaccess wide-field-of-view terminals. Lasercom links between aircraft and satellites can operate at extremely high data rates; but to be efficient, it is necessary to develop satellite-based lasercom terminals to service multiple users over a wide field of view. Lincoln Laboratory will help assess technical performance and vulnerabilities, set design standards, and develop advanced components for the system.

Recent advances in speech recognition and machine translation technologies have made it possible to construct a speech-input, speech-output translation system, at least in domains with limited vocabulary. Based on Lincoln Laboratory's work in these areas over many years, the laboratory will construct such a system and evaluate its technical performance and practical utility to untrained users.

Missile Defense

Lincoln Laboratory continues research on system concepts, sensor technology, decision architecture, and field testing, along with measurements of long-range radar, optical sensors, and networks for defensive systems. This year, increased emphasis was placed on the development of open systems for air and missile defense decision support.

Surveillance Technology

Key programs for this year included the development of signal processing technologies for a hovering unmanned vehicle to detect objects under foliage cover. Similar objectives are being investigated utilizing high-resolution 3-D ladar systems based on very sensitive avalanche photodiode arrays developed at the laboratory. These ladar systems work over relatively small areas on the ground and need to be cued by wide-area surveillance systems' signal processing.

Many of the technologies employed in the surface surveillance and active sensing submission area are based on multichannel arrays of sensors. These techniques are also relevant to providing improved communications in very dense environments, such as urban terrains. Lincoln Laboratory is leveraging these technologies in a program to

demonstrate high spectral density to achieve high communication bandwidth by using multiple antenna inputs and outputs.

Biological-Chemical Detection

The research emphasis this year was placed on architecture development, modeling, sensors, and field testing. This resulted in significant contributions to the following areas: improving upon current means for sensing bio- and chem-agents; measuring background contaminants to assess and optimize new sensors; networking biological aerosol sensors for use in real-time facility defense; and developing broad-spectrum treatments against biowarfare agents.

Space Surveillance

Significant progress was made in the development of Deep-View Wideband Imaging Radar located at MIT's Millstone Complex in Westford, MA. A medium-power gyrotron traveling wave tube (gyro-TWT) has been fabricated and successfully operated over the 92–100 GHz band. The algorithms for filling the frequency gaps in sparse-band transmitter waveforms were successfully demonstrated using Haystack Auxiliary radar data. Images were produced with the gapped waveforms and were indistinguishable from images produced using a conventional non-gapped waveform. The antenna design has been completed and has passed the critical design review. Over the next year, the antenna components will be fabricated. The final assembly and installation of the new antenna are planned to start in the spring of 2006. In addition to serving the DOD sponsor, this system will enhance the Institute's capability to conduct radio astronomy.

Air Traffic Control

Air traffic control research and development represents a long-term effort to support the Federal Aviation Administration in the areas of flight safety and weather prediction. To increase safety and efficiency of airport ground operations, Lincoln Laboratory completed the installation and initial evaluation of a Runway Status Light System (RSLS) at the Dallas/Fort Worth airport. The FAA initiated the RSLS program to explore the potential use of emerging surveillance technologies to create a fully automatic lighting system that informs pilots when runways are in use. If successful, this system will improve aviation safety by reducing the frequency and severity of runway incursions at busy airports. In the area of weather prediction, a benefits study published this year showed that the Lincoln Laboratory–developed Corridor Integrated Weather System prototype produced $152–260 million of delay-reduction benefits to airlines in 2003. The prototype coverage was expanded to include the FAA en route centers at Minneapolis and Kansas City as well as airspace in southern Canada.

Summary

The demand for Lincoln Laboratory's research contributions remains very strong. Its programs cover a broad spectrum, from fundamental investigations to developmental engineering, and there is a healthy diversity in the sources of sponsorship. The prototyping efforts in the laboratory have had significant growth over the past few years, indicative of the laboratory's critical roles in technology development and transfer of knowledge to industry. The increase in development programs has proved to be

a valuable asset in attracting new talent to the laboratory. With the award of the new contract in April, Lincoln Laboratory is well positioned to commence another five years of research and engineering in support of MIT's mission of service to the nation.

David L. Briggs
Director

More information about Lincoln Laboratory can be found online at http://www.ll.mit.edu/.