Director, Lincoln Laboratory

Lincoln Laboratory is a federally funded research and development center (FFRDC) laboratory 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. Three core areas comprise the research and development carried out here: sensors, signal processing, and communications, all supported by a broad research base in advanced electronics.

For the federal fiscal year 2006, Lincoln Laboratory received $625.7 million to support the efforts of approximately 1,500 professional technical staff and 1,000 support personnel; outside procurement was just over $271 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 Administration. 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 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. 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 in meeting national security challenges.

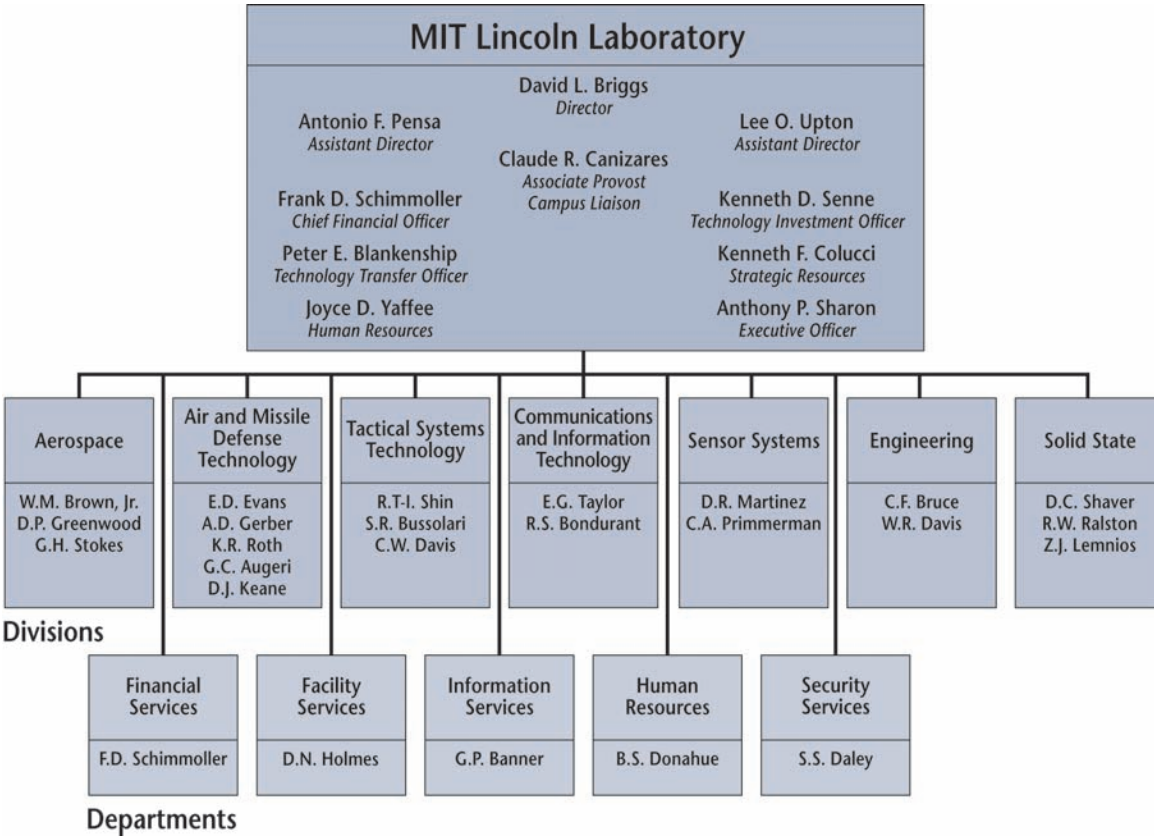
Laboratory Operations

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

Organization

The Laboratory's performance depends on the creativity of its technical staff. The flat organizational structure, consisting of three levels—Director's Office, divisions, and groups—encourages the exchange of ideas between staff and line management (Figure 1). The increasing demand upon the Laboratory to conduct research and development of more complex, integrated systems 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 to focus on the technical challenges.

Figure 1. MIT Lincoln Laboratory Organizational Structure.



Key Changes to the Laboratory's Senior Management Council

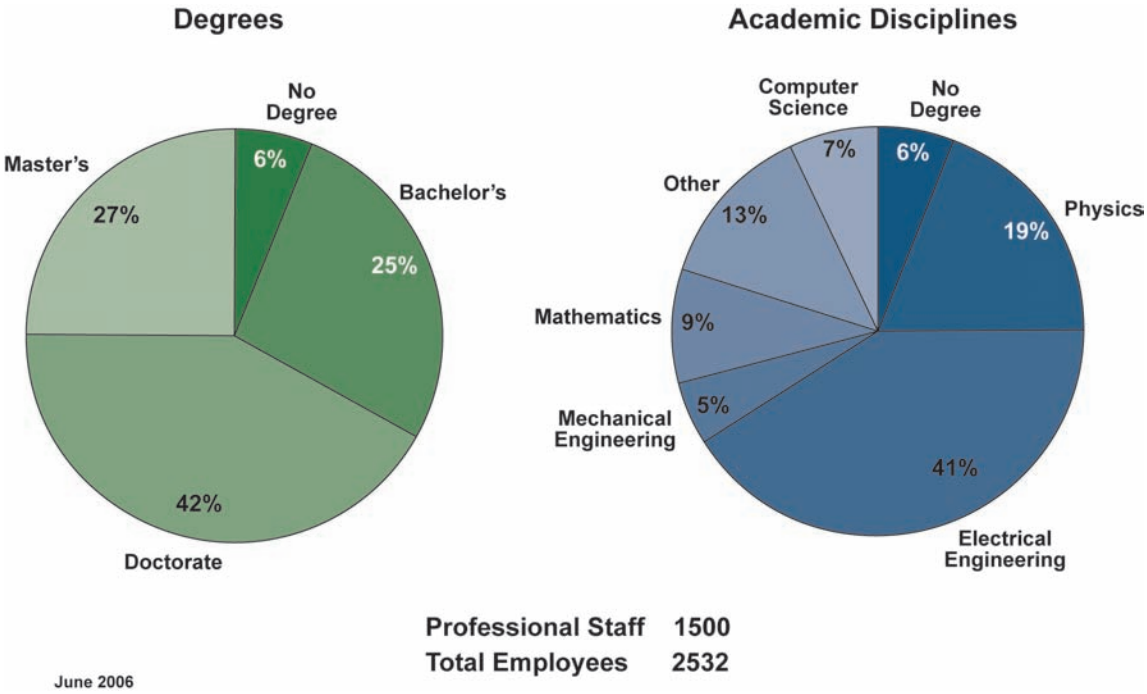
Dr. David L. Briggs stepped down as director of the Laboratory and was succeeded by Dr. Eric D. Evans on July 1, 2006.

Ms. Hsiao-Hua Burke was appointed assistant head of Tactical Systems Technology, Division 4.

Staff

A key factor in maintaining excellence at Lincoln Laboratory is the quality of our staff. The Laboratory obtains 65–75 percent of its new staff directly from the nation's leading technical universities. We conducted on-campus interviews at over 50 universities this past year. The makeup of our staff by degree and academic discipline is shown in Figure 2.

Figure 2. Composition of Professional Staff at MIT's Lincoln Laboratory.



This year under the sponsored research program, the Laboratory hosted 35 graduate and 41 undergraduate students. Specific to MIT, we recently hosted 11 6-A students, one Undergraduate Research Opportunities Program student, and one Undergraduate Practice Opportunities Program student. We also have an ongoing collaboration with the Worcester Polytechnic Institute for 19 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, 35 students from Northeastern University's cooperative study program are at the Lab.

To help its staff keep pace with the rapid changes in science and technology, the Laboratory offers a program of on-site courses, and for highly qualified candidates it offers the chance to pursue an advanced degree under the Lincoln Scholars program. Recently completed on-site courses include GPS Technology and Applications, Light Detection and Imaging, and Multiresolution Markov Models, Graphical Models, and Sensor Networks. The Lincoln Scholars program currently has seven doctoral candidates and seven master's candidates, primarily in electrical engineering and computer science. Six of these candidates are at MIT. This year nine Lincoln Laboratory staff members completed their master's degrees and one completed a doctorate.

Laboratory staff members maintain close ties with their professional societies, serving as officers, symposia chairs, and committee contributors. This year the Laboratory was pleased to announce that Dr. Eric D. Evans and Dr. Donald Clark were elected as Institute of Electrical and Electronics Engineers (IEEE) fellows in recognition of their work in air and missile defense systems and radar systems, respectively. Mr. Charles E.

Muehe also received the 2005 IEEE Aerospace and Electronic Systems Society's Pioneer Award for his invention of the Moving Target Detector digital signal processor for aircraft surveillance radar.

At the 4th Annual U.S. Missile Defense Conference on March 24, 2006, Mr. William Lemnios, retired former head of the Radar Measurement Division, was a member of the team receiving a Technology Pioneer Award for missile defense X-band radar development.

The National Capital Region Integrated Air Defense Team, which included Lincoln Laboratory's Division 4 Enhanced Regional Situation Awareness team, was presented the Secretary of the Air Force Acquisitions Team of the Year Award by Lt. Gen. John Corley on May 6, 2005.

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 is chaired by Professor Jeffrey Shapiro. As a result, Laboratory staff members were involved with 12 MIT graduate theses and two seminars on campus. Emerging collaborative areas include:

- Photon integration: Professor Rajeev Ram
- Superconducting photon counters: Professor Karl Berggren
- Decision modeling: Professor Alan Willsky
- Multi–unmanned aerial vehicle (UAV) tasking: Professor Mary Cummings
- Cache-oblivious algorithms for stream processing: Professor Charles Leiserson
- Medium-wavelength infrared (MWIR) sources: Professor Erich Ippen
- Electromagnetic systems: Professor Jin A. Kong
- Advanced signal processing: Professor Alan Oppenheim

Another avenue for enhancing the 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 practices. Current studies and research and development include:

- Model validation for millimeter-wave precipitation mapping
- Advanced fast steering mirrors
- 3-D laser radar (ladar) read-out integrated circuit (ROIC) architecture with multistate storage registers
- Security studies

- Multispectral infrared detector arrays using amorphous semiconductors (MIDAS)
- Blind calibration algorithms for a digitally enhanced high-speed analog-to-digital converter architecture
- Iterative algorithms for sparse aperture 3-D synthetic aperture radar (SAR) imaging
- 2 μm photon-counting detectors
- Nanotube dispersions in polymer matrices
- Wafer-scale packaging for complementary metal-oxide semiconductor (CMOS) and III-V integration
- Charge chemisorption process for back-side passivation of detectors
- Demonstration and characterization of agile-beam vertical-cavity surface-emitting laser (VCSEL) arrays

Professor Rajeev Ram has been a member of the committee since November 2004. Professor Martin Rinard joined the committee in April 2006.

The Laboratory also supports activities conducted by the Industrial Liaison Program staff through presentations by our staff on cooperative research and development opportunities and technical licensing options. Working through the MIT Technology Licensing Office, the Laboratory has made 29 technology disclosures, applied for nine patents, and was awarded six 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.

The Laboratory also initiated an expanded community outreach program with a focus on education. This spring we hosted two Science on Saturday seminars for middle and junior high school students; over 150 visitors attended each seminar. In addition, we hosted two high school science teachers as part of a Massachusetts-sponsored teacher "extern" program for strengthening the quality of high school science education.

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 serves as an incentive for attracting top technical talent. A new research building was opened on Katahdin Hill, and the radio frequency (RF) system test facility's upgrade was completed.

Technical Program Highlights

Research at Lincoln Laboratory focuses on national security tasks involving surveillance technology, biological-chemical defense, communications and information technology, and advanced electronics technology. In addition, for other government agencies the

Laboratory undertakes related nondefense work, including air traffic control. Two principal activities of our 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 Seminar, the High Performance Embedded Computing Workshop, the Adaptive Sensor Array Processing Workshop, and the Biological-Chemical Defense Systems Workshop. During the year, Lincoln Laboratory staff published 110 technical articles in professional journals. We also publish the *Lincoln Laboratory Journal,* a recent issue of which was a thematic volume covering advances in hyperspectral sensing.

The Laboratory has over 250 specific engineering development projects under way. Notable highlights are listed below.

Advanced Electronics Technology

In FY2006, many advances were made, including progress with high-performance photodetector arrays; the validation of several specialized charge-coupled device (CCD) imagers for satellite and terrestrial surveillance missions; the first demonstration of a three-tier focal plane by 3-D integrated circuit technology; the preliminary test of large-format, curved focal plane CCD arrays within the Space Surveillance Telescope funded by the Defense Advanced Research Projects Agency (DARPA); and the recent demonstration of the Slab-Coupled Optical Waveguide Laser, which showed a 90 W continuous wave output from a 100-element array, a breakthrough that will enable efficient pump sources for high-energy, fiber-based lasers.

Communications and Information Technology

Significant progress was made in the deployment of the Advanced Extremely High Frequency (AEHF) system's test and evaluation master plan infrastructure and netted link testing hardware. The AEHF system was deployed to six research and development facilities nationwide.

Design standards were drafted for four critical areas related to transformational communications: RF signaling waveforms and formats, internet protocol network capacity control, optical-signaling waveforms and formats, and high-speed electronics. The performance of data networks was experimentally explored on platforms including aircraft, mobile ground terminals, and satellites.

Techniques for building a network using synergistic multiple links were developed, deployed, and evaluated in real-world experiments. In FY2006, the Laboratory contributed to deployments of four field demonstrations across the country.

We built and evaluated a programmable digital core to be deployed for field testing in FY2007 in both air and ground configurations. The core is capable of processing a wide spectrum of waveforms that previously required multiple dedicated hardware chains.

Surveillance Technology

Current programs in surface surveillance and active sensing include efforts to demonstrate a hovering unmanned vehicle's ability to detect ground vehicle motion using signal processing technologies. Similar objectives are being investigated using high-resolution 3-D ladar systems.

The Laboratory is currently supporting major system development programs related to the study of directed energy.

The theme of large projects was continued in the FY2006 space surveillance area. The large optics and mechanical structure of the Space Surveillance Telescope will be fabricated to support a first light in 2008, and the new antenna for the Haystack radar is scheduled for fabrication. The Extended Space Sensor Architecture is being developed to bring space situational awareness into the net-centric realm. Lincoln Laboratory–operated sensor data will be registered and discoverable, and the information exploitation engines will be developed to feed off the databases and sensors.

Biological-Chemical Detection

The Laboratory field-demonstrated the world's first detect-to-warn biological identification sensors, providing warning of low-level attacks in less than two minutes with exceptional sensitivity and false-alarm performance. We have so far developed assays for nine high-threat agents. The DARPA Biological Agent Sensor Testbed resulted in the first demonstrated detection of aerosolized bioagent simulants using ultraviolet light-emitting diode (UV-LED) excitation, which should lead to lower-cost systems.

In addition, under U.S. Air Force funding, inexpensive, simple-to-use cartridges were developed for field use to purify DNA from contaminated samples. Cartridges provide clean DNA in a fraction of the time needed by other technologies.

Under the Defense Threat Reduction Agency's medical program, the dsRNA–activated-caspase treatment was shown to both prevent and cure various respiratory viruses in vitro. Work is now progressing toward animal trials.

Air Traffic Control

The Laboratory's air traffic control research and development efforts support the FAA in the areas of system modernization, flight safety, and weather prediction. Current major activities include surveillance radar enhancements, advanced weather forecasting technologies, and integrated sensing and decision support systems that address weather impacts and airport ground operations safety. Our work in these areas is providing major operational benefits. For example, successful demonstration of the Runway Status Light System at the Dallas/Fort Worth International Airport has led the FAA to ask Lincoln Laboratory to extend the safety logic to airports with other runway geometries.

If successful, the system will be transitioned to industry and deployed at a number of U.S. airports, thereby significantly reducing the frequency and severity of runway incursions at busy airports. Laboratory-developed integrated weather systems covering both terminal and en route operations are providing airlines with total delay-reduction benefits in excess of $1 billion per year. The Corridor Integrated Weather System will be used as the technical exhibit for the FAA's planned next-generation General Weather Processor.

Summary

The demand for the Laboratory's research contributions remains very strong. The 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 experienced significant growth over the past few years, indicative of our 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. The Laboratory is well postured to commence another four 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 at http://www.ll.mit.edu/.