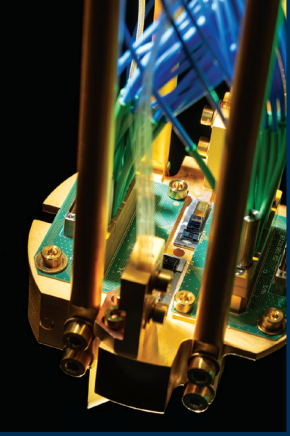

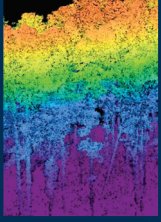

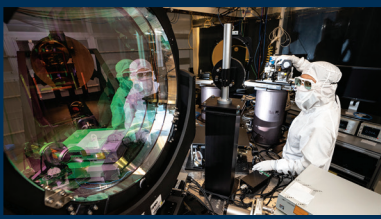

# MIT LINCOLN LABORATORY

## Facts 2024

**www.ll.mit.edu**

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

# MIT LINCOLN LABORATORY

## Facts 2024

244 Wood Street
Lexington, MA 02421-6426
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www.ll.mit.edu

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Comments and requests may be sent to llnews@ll.mit.edu.

MIT Lincoln Laboratory's fundamental mission is to apply science and advanced technology to critical problems of national security. To assure excellence in the fulfillment of this mission, the Laboratory is committed to fostering an environment that embraces and leverages diversity of thought, culture, and experience.

# Contents

## Quick Facts

MIT Lincoln Laboratory is a Department of Defense federally funded research and development center.

**Established**
1951

**Research areas**
Sensors, information extraction (signal processing and embedded computing), bioengineering, communications, integrated sensing and decision support, advanced electronics, cybersecurity, artificial intelligence, climate change, civil space

**Major sponsors**
U.S. Air Force, U.S. Army, U.S. Navy, Missile Defense Agency, Defense Advanced Research Projects Agency, Under Secretary of Defense for Research and Engineering, NASA, Federal Aviation Administration

**Director**
Dr. Melissa G. Choi

**Personnel**
4,516 total personnel: 2,109 professional technical staff; 1,420 support personnel; 540 technical support personnel; and 447 subcontractors

**Location**
*Main campus:* 244 Wood Street, Lexington, Massachusetts
*Auxiliary campus:* 1, 3, and 5 Forbes Road, Lexington, Massachusetts
*Test facilities:* Hanscom Air Force Base, Bedford, Massachusetts
*Space surveillance complex:* Westford, Massachusetts
*Field sites:* 6
*Field offices:* 5

**Patents**
1,578 U.S. patents issued to Lincoln Laboratory technical staff since 1951

# Overview

MIT Lincoln Laboratory is a Department of Defense (DoD) federally funded research and development (R&D) center working on problems critical to national security. The Laboratory's core competencies are in sensors, information extraction (signal processing and embedded computing), bioengineering, communications, integrated sensing and decision support, advanced electronics, cybersecurity, artificial intelligence, climate change, and civil space.

Technology development is geared to the Laboratory's primary mission areas—space security; air, missile, and maritime defense; communication systems; intelligence, surveillance, and reconnaissance systems and technology; biotechnology and human systems; advanced electronics; tactical systems; homeland protection; cybersecurity; and air traffic control.

Two of the Laboratory's principal technical objectives are (1) the development of components and systems for experiments, engineering measurements, and tests under field operating conditions and (2) the dissemination of information to the government, academia, and industry.

Program activities extend from fundamental investigations through the design process and finally to field demonstrations of prototype systems. Emphasis is placed on transitioning systems and technology to industry.

As a DoD R&D laboratory, Lincoln Laboratory focuses on developing and prototyping innovative technologies and enhanced capabilities to meet the evolving needs of the DoD.

Lincoln Laboratory also undertakes government-sponsored, nondefense projects in areas such as the development of systems that the Federal Aviation Administration relies on to improve air traffic control and air safety, and systems that the National Oceanic and Atmospheric Administration uses in weather surveillance.

### Description of FFRDCs

A federally funded research and development center (FFRDC) is an independent, nonprofit entity sponsored and supported by the U.S. government to develop concepts and technologies to meet evolving long-term, and occasionally high-priority short-term, needs that cannot be met as effectively by government or contractor resources. An FFRDC conducts scientific research and analysis, prototype development, and system assessments to provide novel, cost-effective solutions to complex government problems. To ensure objectivity and foster technical excellence, an FFRDC is contractually prohibited from manufacturing products, competing with industry, or working for commercial companies.

All FFRDCs are sponsored by government departments or agencies with whom they work as strategic partners, but they are privately administered by universities and other nonprofit organizations. A strength of FFRDCs is that they draw on the expertise and perspective of government, industry, and academia. These centers work in the fields of defense, energy, aviation, space, health and human services, and tax administration. Lincoln Laboratory is one of 10 DoD FFRDCs.

### Historical Brief

Lincoln Laboratory was established in 1951 to develop an air defense system for the United States. The resulting system, Semi-Automatic Ground Environment (SAGE), was designed to collect, analyze, and relay data from multiple radars quickly enough to initiate a response if an air attack were identified. The Whirlwind computer built at MIT was at the heart of SAGE; the Laboratory's second-generation Whirlwind enabled transmittal and interpretation of enormous amounts of data—virtually in real time. SAGE marked the beginning of the Laboratory's long history of developing innovative technology.

In 2001, Lincoln Laboratory received the Secretary of Defense Medal for Outstanding Public Service in recognition of a half-century of technical innovation and scientific discoveries.

*To learn more about Lincoln Laboratory's history, visit https://www.ll.mit.edu/about/history*

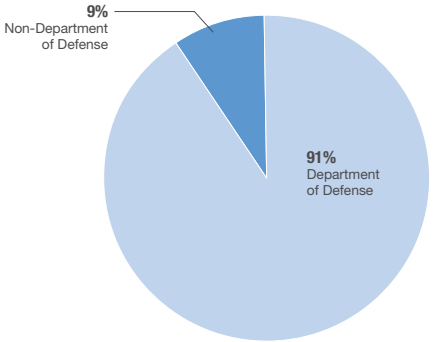
### Location

The main campus of Lincoln Laboratory at 244 Wood Street in Lexington, Massachusetts, is primarily located on the property of Hanscom Air Force Base (AFB); an auxiliary complex is located a couple miles away at Forbes Road. Lincoln Laboratory R&D is supported by approximately 20 onsite special-use labs; facilities on Hanscom AFB for prototype-system flight testing, RF systems testing, and autonomous systems development; a space surveillance complex in Westford, Massachusetts; offsite facilities including the STRIVE Center in Billerica, Massachusetts; and field sites and offices located throughout the country and on Kwajalein Atoll.

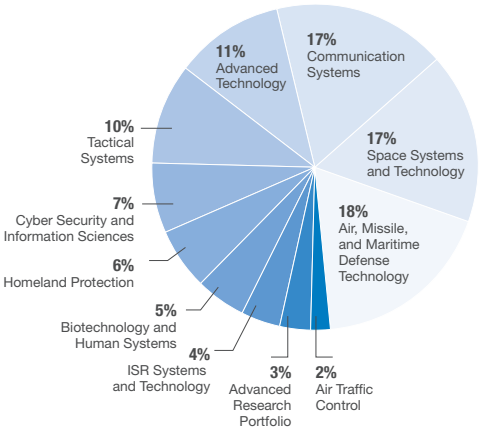
### Funding

Lincoln Laboratory programs are funded by a number of goverment agencies through its prime contract with the Air Force.

Breakdown of Program Funding by Sponsor




Breakdown of Program Funding by Mission Area




## Mission Areas and Research

### Mission Areas

#### SPACE SECURITY

The goal of this mission is to ensure the resilience of the U.S. space enterprise by designing, prototyping, operating, and assessing systems to provide space situational awareness, resilient space capability delivery, active defense, and associated cross-domain battle management.

#### AIR, MISSILE, AND MARITIME DEFENSE TECHNOLOGY

Lincoln Laboratory researchers are investigating system architectures, prototyping pathfinder systems, and demonstrating these advanced, integrated sensor systems that are designed for use on tactical air and maritime platforms to provide defense against missile threats.

#### BIOTECHNOLOGY AND HUMAN SYSTEMS

This mission seeks to improve human conditions on many fronts. The technologies and systems developed under this mission enhance disaster response capabilities, address impacts of climate change, advance defenses against biological and chemical threats, and improve the health and performance of the nation's servicemembers and civilians.

#### COMMUNICATION SYSTEMS

The focus of this mission area is to develop and demonstrate RF military satellite communications, free-space laser communications, tactical network radios, and quantum systems to expand and protect the nation's global defense networks.

### CYBER SECURITY AND INFORMATION SCIENCES

Lincoln Laboratory conducts research, development, and evaluation of cyber components and systems, and develops solutions for processing large, high-dimensional datasets acquired from diverse sources, including speech, imagery, text, and network traffic.

### ISR SYSTEMS AND TECHNOLOGY

Lincoln Laboratory carries out R&D in advanced sensing, signal and image processing, decision support technology, and high-performance embedded computing to enhance capabilities in intelligence, surveillance, and reconnaissance (ISR).

### TACTICAL SYSTEMS

The goals of this mission are to improve the development of tactical air and counterterrorism systems through systems analysis that assesses the impact of technologies on real-world scenarios; rapidly develop prototype tactical systems; and conduct precise instrumented testing of systems.

### ADVANCED TECHNOLOGY

Lincoln Laboratory research teams leverage solid-state electronic and electro-optical technologies, chemistry, materials science, advanced RF technology, and quantum information science to develop innovative system applications and components.

### HOMELAND PROTECTION

Lincoln Laboratory is innovating technology and architectures to help prevent terrorist attacks within the United States, to reduce the vulnerability of the nation to terrorism, to minimize the damage from terrorist attacks, and to facilitate recovery from human-made and natural disasters.

### AIR TRAFFIC CONTROL

Lincoln Laboratory is developing advanced technologies and decision support architectures for aircraft surveillance, integrated weather sensing and processing, collaborative air traffic management, and information security to support the nation's air transportation system.

### ENGINEERING

To support R&D across Lincoln Laboratory, staff in this mission employ their expertise in electrical, mechanical, structural, thermal, aeronautical, optical, and control systems engineering to build, integrate, and test prototype systems for applications in space control, energy, communications, and autonomy.

*For more information about the Laboratory's mission areas, visit https://www.ll.mit.edu/r-d*

**Major Capabilities**

- Adaptive signal processing
- Advanced imaging
- Advanced microelectronics and microsystems
- Advanced radar technology
- Advanced RF technology
- Artificial intelligence (AI) and machine learning
- Big data analytics and architectures
- Bioengineering
- Biological/chemical agent detection and identification
- Communication systems
- Cybersecurity
- Decision support technologies
- Environmental monitoring
- Homeland protection systems
- Human language technologies
- Humanitarian assistance and disaster relief
- Laser communications
- Optics and laser systems
- Quantum technologies

- Rapid prototyping
- Space domain awareness
- Supercomputing
- Systems analysis
- Threat assessment
- Weather sensing

## Research Initiatives

Advanced R&D at Lincoln Laboratory is supported through a congressionally appropriated source of funding administered by the Office of the Under Secretary of Defense for Research and Engineering. This funding supports the development of long-term strategic technologies. Research projects are chosen to address both current and evolving critical problems in national security.

This funding fosters innovative research that often leads to further sponsored program development. It supports mission-specific research needs and the development of new initiatives. In addition, this funding finances a limited portfolio of collaborative academic research with universities. Through these collaborations, the Laboratory gains access to leading-edge research pertinent to mission-area needs, and university students have the opportunity to work on timely, relevant problems.

In 2024, the Laboratory is funding novel work in optical systems and technology; cybersecurity; laser communications; quantum systems and technology; novel engineered materials; biotechnology; humanitarian assistance; and AI. These technology areas provide critical capabilities that support all the DoD mission areas pursued at the Laboratory and address difficult emerging problems.



Key Initiatives

### Civil Space Systems and Technology

The Civil Space Systems and Technology Office was established to leverage Lincoln Laboratory's technologies and expertise to enable next-generation civilian space missions. Many space technologies and capabilities relevant for national security needs have applicability to nonmilitary missions such as homeland security, agriculture, commerce, health, and science. The office aims to contribute to these missions by developing and delivering these technologies in partnership with stakeholders and end users.

### Climate Change Technology for National Security

Climate change is one of the most pressing issues of our time, posing risks to national and global security. The effects of a warming planet are destroying ecosystems, threatening critical infrastructure, intensifying weather, and creating conditions incompatible with human life. Lincoln Laboratory established this major research initiative to tackle some of the most crucial and challenging technical problems in this area. This initiative is growing the Laboratory's investments in climate change R&D and increasing its U.S. and international collaborations to innovate solutions. Across these efforts, the Laboratory is bringing together multidisciplinary expertise—in areas such as systems analysis, sensing, AI, data analytics, and decision support—to contribute to the global response to the climate change threat.

## Organization

Lincoln Laboratory is led by the director, the assistant director, and the assistant director for operations in conjunction with a Steering Committee consisting of the Director's Office and the heads of the technical divisions. The Laboratory reports to the MIT Office of the President. An annual review of Lincoln Laboratory is conducted by a Joint Advisory Committee composed of representatives from the Laboratory's major sponsors.

The Laboratory operates nine mission-specific technical divisions. Projects are often multidisciplinary and involve interdivisional collaborations. The technical work of the Laboratory is supported by six service departments.

### Technical Divisions

Division 2–Biotechnology and Human Systems
Division 3–Air, Missile, and Maritime Defense Technology
Division 4–Homeland Protection and Air Traffic Control
Division 5–Cyber Security and Information Sciences
Division 6–Communication Systems
Division 7–Engineering
Division 8–Advanced Technology
Division 9–Space Systems and Technology
Division 10–Intelligence, Surveillance, and Reconnaissance and Tactical Systems

### Service Departments

Contracting Services, Facility Services, Financial Services, Human Resources, Information Services, Security Services

## People and Culture

Lincoln Laboratory's reputation has been built on the strength and quality of its technical staff. Approximately 2,000 professional technical staff members conduct research, build prototypes, and perform field demonstrations. The technical staff come from a broad range of scientific and engineering fields. The majority of this professional staff hold advanced degrees.

The Laboratory also employs about the same number of people to provide the strong technical support, and infrastructure and administrative functions that support the research and demonstration activities behind the development of new devices and technologies.

### Technical Positions

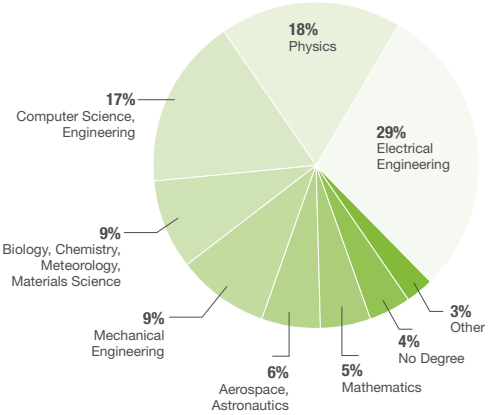
Lincoln Laboratory technical staff members come from many scientific and engineering fields; electrical engineering, physics, and computer science are three of the most common disciplines represented at the Laboratory.

Positions filled by engineers and scientists at Lincoln Laboratory require problem-solving ability, analytical skills, and creativity.

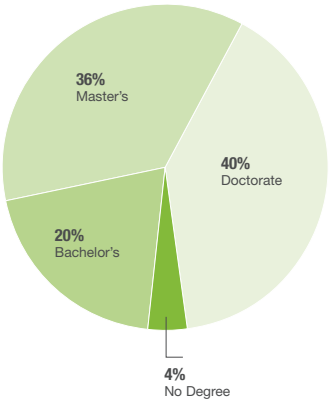
*For information on available positions at Lincoln Laboratory, visit https://www.ll.mit.edu/careers*

## Profile of Professional Technical Staff

Academic Discipline




Academic Degree




## Professional Development

Lincoln Laboratory's commitment to the professional development of its staff is founded on the recognition that the Laboratory's extensive R&D contributions are made possible through the staff's continuing excellence and accomplishments.

To encourage professional development, the Laboratory supports a variety of opportunities for employees:

- Tuition assistance program
- The competitive Lincoln Scholars Program to enable the pursuit of advanced degrees on a full-time basis
- Part-Time Graduate Studies program, which includes distance learning programs with universities and flexible scheduling programs at local universities
- In-house Technical Education Committee Program
- In-house training in computer applications; seminars on topics in management
- Technical seminar series with MIT, Northeastern University, other universities, and industry
- Technical seminars on innovative work, given weekly by staff members

Support for professional activities is strong. The Laboratory encourages staff to publish in technical journals, attend conferences, and participate in activities of their professional societies. In addition, interdisciplinary projects allow staff to grow professionally.

The onsite library offers a highly focused collection of technical books, reports, and electronic journals and databases in all Laboratory technology areas. In addition, the resources of the main MIT library system are available to staff.

## Diversity and Inclusion

Lincoln Laboratory is committed to diversity and inclusion in the workforce. The Laboratory recognizes that its continuing success is achieved through the appreciation and support of the diverse talents, ideas, cultures, and experiences of its employees.

The Diversity and Inclusion Office seeks to

- Recruit the best technical and support talent from the diverse national pool of candidates
- Foster a work environment built on trust and inclusion
- Develop all aspects of the Laboratory community through improved mentorship, networking, and staff development
- Adapt training and development approaches to ensure the professional growth of the Laboratory's diverse staff
- Build external and internal relationships that align with the Laboratory's diversity initiatives

### Diversity and Inclusion Initiatives

- Networking groups help new employees transition to the Laboratory, promote professional development, and encourage involvement in the community. The Black Experience and Cultural Organization Network, Women's Network, Hispanic/Latinx Network, Veterans Network, Black Experience and Cultural Organization Network, Out and Proud Employee Network, Pan Asian Laboratory Staff Network, Recent College Graduates, and Lincoln Laboratory ACCESS are fostering an inclusive environment.
- Lincoln Laboratory's four formal mentorship programs complement efforts to create an inclusive community. The New Employee Guides program focuses on acquainting employees with their groups, divisions, or departments during their early months at the Laboratory. Staff can later choose to participate in more specialized mentoring programs:
  - Early Career Mentoring provides one-on-one mentorship to help technical and administrative professionals with early career development.
  - Circle Mentoring small discussion groups are led by experienced employees and address topics relevant to professional growth.
  - By partnering a new assistant group leader with an experienced group leader, the New Assistant Group Leader Mentoring helps technical staff members transition into their new responsibilities.
- The RE$^2$ACT (Research, Educate, Empathize, Act, Transform) initiative helps the Lincoln Laboratory community develop strategies to respond to the challenge of systemic racism while building a diverse, inclusive, and safe environment. RE$^2$ACT's ultimate goal is to advance organizational success and is achieved through a variety of seminars, panel discussions, and study groups that explore the effects of stereotyping and suggest mitigations to biased behaviors.

## Work-Life Balance

Lincoln Laboratory recognizes that a balance between work and personal life is essential for employees' well-being. The Laboratory offers a number of services to assist employees in maintaining such a balance.

### Job Flexibility

Through flexible work schedules, part-time employment, and telecommuting opportunities, employees can serve their work-life needs.

### Childcare

The Lincoln Laboratory Childcare Center in Lexington is just 1.3 miles from the Laboratory and provides developmentally based infant, toddler, and preschool

programs for children from 8 weeks to 5–6 years old. The center is one of the five Technology Childcare Centers managed by Bright Horizons and overseen by the MIT Work-Life Center.

### Health and Wellness Center

The Health and Wellness Center houses a medical facility operated by MIT Medical and a fitness center. The medical center offers primary care services for members of the MIT Health Plan and brief medical assistance for employees. The Fitness Center, which all employees are eligible to join, is run by the MIT Athletic Department.

### Professional and Community Enhancement (PACE) Committee

The PACE Committee helps Lincoln Laboratory's director ensure a productive workplace and a supportive and diverse community. The PACE Committee advises on decisions about the childcare facility, professional development opportunities, mentoring, and other workplace concerns.

### Commuter Services

Lincoln Laboratory encourages sharing transportation to work and using public transportation through several programs that offer employees assistance with commuting:

- Van pool and car pool programs
- Guaranteed ride home program
- MBTA pass program

### The Ombudspersons Program

Ombudspersons are employees who have been appointed by the Laboratory's director to help resolve employee concerns. Ombudspersons provide informal, impartial assistance that may facilitate fair and equitable resolutions of problems or disputes. Ombudspersons do not represent anyone; they act as neutral parties and respect the rights of privacy of individuals they are helping.

### Personal Sustainability Interest Group

The Personal Sustainability Interest Group seeks to increase awareness of lifestyle choices that promote environmental friendliness and are of personal benefit. The group provides information and support for employees who are interested in contributing to the sustainability of the planet. At the group's monthly meetings, employees share their "green" experiences, such as adding solar panels to their homes or building an ecofriendly garden. The group also participates in Lincoln Laboratory's Earth Day fair and occasionally arranges for guest speakers to present talks on sustainability issues to the Laboratory community.

## Facilities and Field Sites and Offices

### Facilities

#### AI Processing, Exploitation, and Dissemination Laboratory

In this software integration laboratory, researchers can apply machine learning to the automation of processes that transform raw data into usable information. The laboratory supports the development, demonstration, and refinement of prototype systems that can process, analyze, and integrate data from many types of sensors (e.g., radar, electro-optical, video, and RF) as well as from people, publications, and the Internet.

#### Air Traffic Control Automation and Aviation Weather Decision Support Laboratories

Staff use these laboratories to test prototype systems for air traffic control (ATC) and to collect weather data that will help inform improvements to flight safety. The ATC Automation Laboratory currently comprises a control tower simulator and the Trajectory Based Operations/Weather Testbed; the Aviation Weather Decision Support Laboratory introduces a range of advanced weather products and associated air traffic impact tools being developed to support current and future aviation system needs.

#### Autonomous Systems Development Facility

The Autonomous Systems Development Facility enables the development and testing of autonomy algorithms and capabilities. The 17,000-square-foot indoor test facility is housed in a building on Hanscom Air Force Base and accommodates the prototyping and testing of ground-based, aerial, and undersea autonomous systems. Vertically retractable nets act as safety barriers and dividers that allow multiple programs to use the facility at the same time. Staff across the Laboratory use the facility to dry run systems before major outdoor field tests.

#### Beaver Works Center

This center supports Beaver Works, the joint educational venture between Lincoln Laboratory and the MIT School of Engineering that promotes hands-on learning through capstone projects and research initiatives. The center comprises a flagship facility just off MIT campus and a second facility on MIT campus. The facilities are equipped with 3D printers, laser cutters, machine shop equipment, and an array of system assembly tools.

#### Biological and Chemical Laboratories

A variety of Biosafety Level 2 laboratories support biological and chemical R&D at Lincoln Laboratory. For wet biology needs, the labs are used for R&D in genetic sequencing, synthetic biology, microfluidics, biochemistry, virology, tissue-injury spectroscopy, and ultrasonic shear-wave testing. The facilities support the Laboratory's work in biomedical speech and hearing analysis, neurocognitive analysis, acoustic simulation, research on mild traumatic brain injury, prototyping of medical sensors, biometrics, physiological monitoring, and biomechanics.

### Biophotonic, Electric, Acoustic, and Magnetic Measurement Laboratory

Staff across the Laboratory use this facility—designed for experimenting at the interface of technology and biological materials—to support research, such as scanning cells with a novel hyperspectral microscope to see inside without destroying the cells and analyzing tissue images with deep learning. The 320-square-foot Biosafety Level 2 facility can support the study of human tissue and cell lines. Researchers have access to optics, lasers, RF signals, and magnetic fields to conduct their research.

### Defense Fabric Discovery Center

At this prototyping facility, researchers from Lincoln Laboratory develop advanced fiber and fabric technology that can provide soliders with wearable capabilities. The center is equipped to design and produce fabrics with embedded microelectronics, enabling these fabrics to change color, store energy, emit and detect light, monitor health, or facilitate communication. Here, researchers can complete all the prototyping steps under one roof. The center was built through a partnership between the Laboratory, the Commonwealth of Massachusetts, the Combat Capabilities Development Command Soldier Center, and the nonprofit Advanced Functional Fabrics of America at MIT.

### Electronic-Photonic Integration Facility

Both Laboratory researchers and external partners use this facility to develop optoelectronic components and photonic integrated circuits, photonic integrated circuits, complementary metal-oxide semiconductor (CMOS) electronic integrated circuits, and hybrid electronic-photonic integrated subsystems for a variety of sensing, communication, and signal processing applications. The facility has internal capabilities for epitaxial materials growth, fabrication, packaging, and characterization of components and integrated subsystems.

### Environmental Test Laboratory

This laboratory is one of the Engineering Division's facilities used by coalition project teams for demonstrating novel ground-based, sea-based, airborne, and space-based systems. This laboratory supports both small rapid development efforts and large systems development. The laboratory's vibration systems are used for sinusoidal, random vibration, and shock-response testing. The vacuum systems test high-altitude and satellite hardware. Thermal chambers test hardware limits at hot and cold temperatures.

### Flight Test Facility

The Lincoln Laboratory Flight Test Facility provides airborne platforms in support of R&D programs. The facility enables researchers to validate airborne systems with actual field-collected data. Research aircraft are flown, maintained, and managed by a professional staff of pilots, certified maintenance technicians, and administrative personnel. All flight operations are conducted using procedures and equipment that meet or exceed all Federal Aviation Administration requirements.

### Lincoln Laboratory Supercomputing Center

An interactive, on-demand parallel computing system uses large computing clusters to enable

Laboratory researchers to augment the power of desktop systems to process large sets of sensor data, create high-fidelity simulations, and develop entirely new algorithms. The facility is connected to a data center in Holyoke, Massachusetts, that is powered by hydroelectric, wind, solar, and nuclear sources, allowing for the system to run 100% carbon free.

### Lincoln Research Network Operations Center

At this center, researchers prototype cyber analysis tools by processing the Laboratory's own operational network traffic, security system alerts, information technology system logs, and configuration data. The center serves as a test bed for exploring and evaluating new techniques prior to prototype deployment on DoD networks.

### Lincoln Space Surveillance Complex

This complex in Westford, Massachusetts, has played a key role in space situational awareness and the Laboratory's overall space surveillance mission. The site comprises three major radars—the Millstone Deep-Space Tracking Radar (L band), Haystack Ultrawideband Satellite Imaging Radar (HUSIR) (X and W bands), and Haystack Auxiliary Radar (Ku band). The Millstone Hill Radar is used for tracking space vehicles and space debris. Like Millstone, HUSIR is a contributing sensor to the U.S. Space Surveillance Network, collecting radar data on space objects.

### Microelectronics Laboratory

The Lincoln Laboratory Microelectronics Laboratory is a state-of-the-art semiconductor research and fabrication facility supporting a wide range of Lincoln Laboratory programs. The 70,000 square-foot facility has 8,100 square feet of class-10 and 10,000 square feet of class-100 cleanroom areas. The equipment set in this laboratory is continually updated and includes a production-class complementary metal-oxide semiconductor (CMOS) toolset with angled ion-implantation, cluster-metallization, and dry-etch equipment; chemical-mechanical planarization equipment; and rapid thermal processing and advanced lithography capabilities. A molecular-beam epitaxy system is used to provide high sensitivity and highly stable back-illuminated devices in the ultraviolet and extreme-ultraviolet ranges. In addition, the Microelectronics Laboratory supports advanced packaging with a precision multichip module technology and an advanced 3D circuit-stacking technology.

### Mobile Device Lab

The lab enables the exploration of cellular, Bluetooth, Wi-Fi, and GPS technologies in a private, isolated environment in which researchers can emulate a small-scale wireless network. Researchers can test location-based service applications, model protocols for packet loss, and practice mobile malware triage without interfering with public wireless networks. In this setting, staff can explore the impacts of various RF signals on systems, the current limitations of devices, and the effects of RF congestion.

### Multi-Band Test Terminal

The Multi-Band Test Terminal (MBTT)— a 20,000-pound, 20-foot-diameter antenna—enables testing of satellites, satellite terminal equipment, and new satellite communications (SATCOM) technologies in the presence of jamming and other types of interference. The MBTT antenna can be

easily reconfigured to transmit and receive signals over four commonly used RF bands for both military and commercial SATCOM, and additional antenna feeds can be designed to enable testing on other bands.

### Optical Systems Test Facility

This facility houses four specialized spaces for developing and testing diverse electro-optical systems: an active range (laser radar sensors), a passive range (passive optical detectors and imaging systems), an optical materials measurements range, and an aerosol imaging test bed (chemical or biological agents).

### Optical Terminal Verification Testbed

The Optical Terminal Verification Testbed (OTVT) is the nation's leading independent laboratory for testing free-space laser communications terminals against emerging interoperability standards and interface control documents. The U.S. government leverages OTVT to assess the interoperability of third-party terminals, while Laboratory staff use OTVT to test new, in-house-developed terminal designs.

### Quantum Computing Laboratory

This laboratory consists of two facilities used by researchers exploring the potential of quantum physics to expand the processing performance of computers. The trapped-ion quantum computing facility contains several cryogenically cooled ultrahigh- vacuum systems housing microfabricated chips that trap individual strontium and calcium ions above their surface. Researchers manipulate the trapped ions, using lasers and other electromagnetic fields, to perform quantum-processing operations. The superconducting quantum computing facility contains several cryogenic dilution refrigerators and microwave test and measurement equipment for controlling and measuring superconducting quantum bits (qubits) at temperatures of 20 milli-Kelvin and below.

### Rapid Hardware Integration Facility

Lincoln Laboratory's 3,900-square-foot hardware-integration facility supports the rapid integration and fielding of specialized systems. It provides the appropriate tools, collaborative environment, and required infrastructure for rapidly prototyping systems. This facility, spread over two floors, minimizes the time to iterate through the design-build-test cycle by collocating spaces for fabrication and integration. The facility is divided into areas for system integration, electronic assembly, additive manufacturing (3D printing), and conventional machining. It can accommodate the development of about five to eight systems, all with concept-to-system delivery timelines of less than 12 months.

### RF Systems Test Facility

This rapid prototyping facility offers resources to design, fabricate, and measure antennas and radar targets for surface, airborne, and space applications. It comprises six anechoic chambers—tapered, millimeter wave, system test, compact range, and small and large near-filed scanners; a system integration lab; a high-bay staging area; a rapid prototyping shop with machining tools; and an RF laboratory. The facility is co-located with the Flight Test Facility, allowing for rapid integration of RF sensors with airborne platforms.

### Sensorimotor Technology Realization in Immersive Virtual Environments (STRIVE) Center

The STRIVE Center is a multimodal immersive laboratory used for noninvasive cognitive and physiological monitoring research. The laboratory can comprehensively quantify an individual's physical responses in realistic operational environments or rehabilitation scenarios. The facility includes the Computer Assisted Rehabilitation Environment (CAREN), a 27-foot virtual-reality dome that features 360-degree visualization; motion capture via 18 cameras; a reversible, dual-belt, high-acceleration treadmill with integrated force plates and six-degrees-of-freedom actuation; and wearable sensors.

### Sound Room

This resource allows Laboratory staff to replicate acoustic environments in a laboratory setting. Engineers can test technology, such as a voice communication or translation system, in the same conditions under which a human operator would use it. The facility's command center allows a person to control the audio signals being fed into the acoustic isolation room and to analyze the data being recorded inside. A variety of microphones and biometric devices, such as eye trackers, enable a range of research applications and human studies—for example, characterizing audio channels, studying speech patterns, evaluating machine translation systems, and testing acoustically triggered sensors.

### Technology Office Innovation Laboratory (TOIL)

TOIL is a makerspace in which Lincoln Laboratory staff can design and build experimental hardware. TOIL allows researchers to perform early concept validation and engage in unstructured, curiosity-driven tinkering. The facility has design tools, like SOLIDWORKS and AutoCAD, and several manufacturing tools, including 3D printers, laser cutters, and traditional machining systems. Engineers can characterize the behavior of their hardware with spectrum and network analyzers, oscilloscopes, waveform generators, and other electronics. In TOIL, staff can rapidly prototype innovative devices or create custom components for new systems.

### Virtual Integration Technology Lab

In this space, Laboratory engineers and scientists develop advanced healthcare technologies. Capabilities include those for the design of electrical and mechanical components, mechanical fabrication, and electronics assembly and testing. Developers can also assemble system-level prototypes and perform initial device demonstration and user testing on medical phantoms. The lab supports a virtual connection to clinical collaborators to provide feedback throughout the engineering process.

## Field Sites

### Colorado Springs Field Site, Colorado Springs, Colorado

Colorado Springs is home to key sponsors of many space-related programs and numerous operational units that rely on Lincoln Laboratory–developed technologies to conduct their missions. The Colorado Springs Field Site supports multiple government organizations, including the National Space Defense Center, National Space Test and Training Complex, and the Space Security and Defense Program. Field site staff serve in various roles, including systems analysis, software

development, test planning and execution, and high-level sponsor liaising.

### Experimental Test Site, White Sands Missile Range, New Mexico

The Experimental Test Site (ETS) is an electro-optical test facility located on the grounds of the White Sands Missile Range in Socorro, New Mexico. Situated next to the U.S. Air Force's Ground-based Electro-Optical Deep Space Surveillance field site, the ETS is operated by the Laboratory for the Department of the Air Force. The principal mission of the ETS is the development, evaluation, and transfer of advanced electro-optical space surveillance technologies. It is a national resource that supports measurements and operational surveillance tasking for programs such as those involving near-Earth and deep-space objects.

### Fort Meade Field Site, Annapolis Junction, Maryland

The Fort Meade Field Site supports R&D of new cyber technologies for the National Security Agency, U.S. Cyber Command, Defense Information Systems Agency, and other DoD and intelligence community organizations. The 7,000-square-foot facility is located across from the U.S. Army's Fort George G. Meade, the DoD's principal center for information, intelligence, and cyber operations. The site enables use of important government data to validate new technology concepts and operational personnel to transition Laboratory technology. The site includes a hardware security R&D laboratory and is a node on a multi-organizational test bed for researching security Internet-of-Things devices.

### Huntsville Field Site, Huntsville, Alabama

The Huntsville Field Site is located near the U.S. Army Garrison – Redstone Arsenal and a host of government agencies and sponsors, including the Missile Defense Agency and U.S. Army Space and Missile Defense Command. The site features collaboration and conference space, and supports up to 25 technical staff who execute research and provide technical leadership to Laboratory sponsors in the areas of architecture development, future technology exploration, and human-machine teaming. The site's proximity to the sponsor and warfighter communities enables rapid engagement and technology transfer to both the government and industry.

### Kwajalein Field Site, Kwajalein Atoll, Marshall Islands

Kwajalein Field Site serves as the scientific advisor to the Reagan Test Site at the U.S. Army Garrison – Kwajalein Atoll, located 2,500 miles west-southwest of Hawaii. At any given time, about 15 Laboratory personnel are stationed on Kwajalein, serving two- to five-year assignments before returning to the Laboratory's main campus in Lexington, Massachusetts. The site's radars, optics, and telemetry systems support missile testing, space surveillance and testing, satellite launches, and scientific measurements. In addition, the site is a test bed for technology development, and its remote location enables testing that cannot be done in the United States.

### Nevada Field Site, Henderson, Nevada

The Nevada Field Site conducts work in support of the Department of the Air Force. The primary mission of this site is to perform field testing to validate modeling and performance,

quantify unknowns, and better understand the phenomenology of developmental Air Force assets. With its proximity to multiple test and training locations, the site offers support through test ideation, test planning and logistics, data collection, and data analysis. The site is staffed by about a dozen Laboratory employees, who typically serve assignments of three to four years.

### Field Offices

- Aviation Liaison Office, Washington, D.C.
- Crystal City Field Office, Arlington, Virginia
- Space and Missile Systems Center Liaison Office, El Segundo, California
- U.S. Transportation Command Field Office, Scott Air Force Base, Illinois
- Vandenberg Air Force Base Field Office, Vandenberg Air Force Base, California

## Technology Transfer

Lincoln Laboratory has a long history of promoting technology transfer to the defense and civil sectors. Many technologies initially developed to support DoD needs have been adopted for commercial use. For example, optical projection lithography at 193 nm, pioneered by Lincoln Laboratory, became the industry standard by the early 2000s and remains the prevailing patterning technique used for critical-level integrated circuit device fabrication.

Lincoln Laboratory's focus on adapting and demonstrating new, advanced capabilities to enhance existing systems results in important technology transfer opportunities. A common strategy for achieving transition is to share the "architectural recipe" and work with commercial component and subsystem suppliers to assure that technology advances demonstrated by the Laboratory can be duplicated by industry.

One reason for the Laboratory's success in transferring technology is its participation in sponsor-supported programs with industry. Such programs complement the Laboratory's work on developing and prototyping new device concepts.

Transfer of technology is accomplished in several ways as circumstances allow:

- Direct transfer of designs and specifications
- One-on-one technical meetings
- Funded industrial development of Lincoln Laboratory–designed subsystems
- Open technical seminars
- Industry-wide workshops in areas of the Laboratory's expertise
- Establishment of advanced test bed systems against which industry can develop systems and verify performance

### Spinout Companies

One measure of the Laboratory's contribution to the nation's economy is its success in transferring technology to spinout companies. Since the Laboratory's inception, more than 110 high-technology companies have evolved from the Laboratory's technology development. These companies' services and products range from multimedia software services to advanced semiconductor lithography. The spinout companies are large organizations such as MITRE, a not-for-profit R&D corporation, and small businesses such as SimSpace, a cybersecurity consulting firm, and are found not only in Massachusetts but also in states beyond.

#### Notable Spinout Companies

Allthenticate
American Power Conversion Corporation (acquired by Schneider Electric)
AutonomUS LLC
Butterfly Network
Copious Imaging (acquired by Anduril)
Digital Equipment Corporation (acquired by Compaq, later Hewlett Packard)
Generation NYX
GPR
JetCool Technologies
Kendall Square Sciences
Kopin Corporation
Liberty Defense
LightLab Imaging (acquired by Goodman Corporation, later St. Jude Medical, later Abbott Medical)
MITRE Corporation
NanoSemi, Inc. (acquired by MaxLinear)
Sangtera
SimSpace
Teradiode (acquired by Panasonic)
Worldwide Incident Command Services, Inc.

### Patents

Lincoln Laboratory has contributed to the nation's and the world's technical knowledge base through the patents issued for its technologies. Laboratory technical innovations licensed to industry have enabled many commercial-sector applications, from air traffic management systems to semiconductor processing to biological-agent sensors. Since 1951, approximately 1,600 U.S. patents have been issued for advancements and inventions developed by Lincoln Laboratory researchers.

### Subcontracts with Businesses and Universities

Lincoln Laboratory contracts with companies to design and fabricate developmental hardware and material. The technical expertise developed by companies during the Laboratory-funded proof-of-concept phase is carried forward to the production phase. Often, this prototype work results in business for companies who later produce the hardware or material commercially.

The Laboratory also contracts with universities for basic and applied research. These partnerships promote mutual knowledge exchange and technology transfer.

### Commercial Solutions Openings

Small businesses and nontraditional defense contractors can submit their ideas for solving national security challenges by responding to open topics of interest posted by Lincoln Laboratory. The Laboratory will issue research subcontracts to award funding for successful proposals.

### Cooperative Research and Development Agreements (CRADAs)

Through CRADAs, Lincoln Laboratory and private companies work on joint R&D projects addressing national security needs. The Laboratory enters into CRADAs when collaborative research supports its mission and program objectives.

### Small Business

Lincoln Laboratory has an aggressive program designed to give small businesses the greatest possible opportunity to participate in Laboratory acquisitions and obtain awards. The Laboratory may engage in Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) program arrangements if the U.S. government agency announcement aligns with the strategic goals of the Laboratory.

### Test Agreements

Organizations unable to access test facilities in the private sector can enter into test agreements with Lincoln Laboratory. These agreements allow for technology testing in some of Lincoln Laboratory's state-of-the-art facilities.

*For more information about working with Lincoln Laboratory, visit https://www.ll.mit.edu/partner-us*

## University Collaborations

### Research

Research collaborations foster knowledge exchange between universities and Lincoln Laboratory, strengthen the research conducted at all partnering institutions, and enhance the professional development of participating scientists and engineers. Multiple mechanisms support these collaborations; some of them are highlighted here.

#### Beaver Works

Beaver Works, a joint venture between Lincoln Laboratory and the MIT School of Engineering, was established as an incubator for innovative research. Beaver Works facilitates project-based learning, a hallmark of an MIT education, and leverages the expertise of MIT faculty, students, and researchers, and Lincoln Laboratory staff to broaden research and educational partnerships. By encouraging collaborative projects, Beaver Works strengthens the potential of both institutions to make an impact on global problems.

The Beaver Works centers on and near MIT campus provide facilities for various educational activities: areas for collaborative brainstorming; workshops and tools for the fabrication of prototype systems; and space for classroom-style instruction. Beaver Works supports student involvement in a broad range of research and educational pursuits, including two-semester, course-based capstone projects; joint and individual research initiatives; and Undergraduate Research Opportunities Program internships.

#### Center for Quantum Engineering

The MIT Research Laboratory of Electronics (RLE) and Lincoln Laboratory launched the Center for Quantum Engineering, which is housed at RLE on the MIT campus. Quantum engineering is bridging the traditional fields of computer science, mathematics, physics, and engineering. The center unites the expertise, infrastructure, and resources of the Laboratory and MIT campus to explore the development of quantum science and its application to quantum technologies. Such technologies could transform cybersecurity, drug discovery, machine learning, communications systems, magnetometry, and navigation.

#### Advanced Concepts Committee

The Lincoln Laboratory Advanced Concepts Committee (ACC) supports the development of innovative concepts that address important technical problems of national interest. Collaborative efforts between Lincoln Laboratory and MIT's research laboratories are encouraged. The ACC provides seed funding, as well as technical and programmatic support, to investigators with new technology ideas.

#### MIT Climate Grand Challenges

Launched in 2020, this whole-of-MIT initiative aims to deliver high-impact climate solutions for the world. In 2022, MIT selected five flagship projects from among nearly 100 initial proposals for its first-ever Climate Grand Challenges competition. Lincoln Laboratory is co-leading one of these projects, which seeks to reinvent climate change adaptation: the Jameel Observatory Climate Resilience Early Warning System

(Jameel Observatory-CREWSnet). This cutting-edge forecasting technology empowers underserved communities to interpret local climate risk; proactively plan for their futures by incorporating resilience strategies; and minimize loss of life, livelihood, and property. Jameel Observatory-CREWSnet will initially pilot in Bangladesh, serving as a model for similarly threatened regions around the world. Campus collaborations are expected to increase with the launch of the Climate Project at MIT, leveraging Lincoln Laboratory's capabilities for rapid prototyping and scaling.

## Advanced Education

### MIT Independent Activities Period Courses

Lincoln Laboratory technical staff develop and lead activities offered during MIT's Independent Activities Period (IAP), a four-week term spanning the January semester break. Under the IAP program, for-credit classes are available for registered MIT students, and noncredit activities are open to all members of the MIT community. IAP offerings range from academic seminars to hands-on engineering projects to artistic pursuits. The activities are, as the IAP website states, "distinguished by their variety, innovative spirit, and fusion of fun and learning." Lincoln Laboratory staff have offered courses in radar design, robotics, imaging technologies, laser systems, and supercomputing.

### MIT Professional Education—Short Programs

Lincoln Laboratory is collaborating on courses offered through MIT's Professional Education Short Programs. Short Programs usually run during the summer and bring participants from industry, government, and business to the campus for intensive, week-long courses designed to expand participants' familiarity with emerging technologies. Through this partnership, technical staff members from the Laboratory have co-led courses on radar and laser radar design.

### Technical Seminar Series

Members of the technical staff at Lincoln Laboratory present seminars to interested college and university groups. The currently available seminars from which interested university groups can choose include ones in air traffic control, radar and signal processing, solid-state devices and materials, cybersecurity, communications systems, and space control technology.

*For a listing of available seminars, visit https://www.ll.mit.edu/careers/student-opportunities/technical-seminar-series*

### Military Fellows Programs

Lincoln Laboratory provides fellowships to active-duty U.S. military officers who are enrolled in a graduate school program, often at MIT, or are completing requirements for advanced education at Senior Service Schools or the U.S. Army's Training with Industry (TWI) program. For graduate students, the military fellowships cover tuition and fees, and require that the students perform thesis research at Lincoln Laboratory. Officers enrolled in a Service School program do research at the Laboratory while taking courses in national security management at MIT. Officers in the TWI program work full time in a Lincoln Laboratory group that specializes in areas that complement the officers' careers.

*For more information on the Military Fellows Programs, visit https://www.ll.mit.edu/careers/programs-military-officers*

### MIT Undergraduate Research Opportunities Program

Lincoln Laboratory is one of the centers with which undergraduates may partner under MIT's Undergraduate Research Opportunities Program (UROP). UROP cultivates research partnerships

between MIT undergraduates and faculty, offering students the chance to work on cutting-edge research and participate in each phase of standard research activity.

### MIT Undergraduate Practice Opportunities Program

Lincoln Laboratory participates in MIT's Undergraduate Practice Opportunities Program (UPOP). This full-year program for MIT sophomores is an introduction to the workplace skills that complement students' academic training. An important facet of the program is a 10- to 12-week summer internship in industry, government, or a nonprofit institution. As a UPOP partner, the Laboratory offers a limited number of such internships.

### MIT 6-A Master of Engineering Thesis Program

Lincoln Laboratory is a partner of MIT's Department of Electrical Engineering and Computer Science 6-A Master of Engineering Thesis Program, which matches industry mentors with undergraduate students. Students in the 6-A program spend two summers as paid interns, participating in projects related to their fields. Then, the students move on to developing their master of engineering theses under the supervision of both Laboratory engineers and MIT faculty.

### MIT Research Assistants

As part of the research collaboration between MIT campus and Lincoln Laboratory, MIT graduate students are supported as research assistants while working on Laboratory programs.

### University Cooperative Education Program

Technical groups at Lincoln Laboratory employ students from MIT, Northeastern University, and other area colleges as co-ops working full time with mentors during the summer or work/study semesters and part time during academic terms.

### Summer Research Program

Lincoln Laboratory offers undergraduate and graduate students the opportunity to gain hands-on experience in a leading-edge research environment. Program participants contribute to projects and gain experience that complements their courses of study. Each summer, the Laboratory hires, on average, approximately 200 paid interns from top universities.

### WPI Major Qualifying Project Program

Lincoln Laboratory collaborates with Worcester Polytechnic Institute (WPI) in its Major Qualifying Project program, which requires students to complete an undergraduate project equivalent to a senior thesis. Students participating in the program spend nine weeks during the fall term working on their projects full time at Lincoln Laboratory.

### National GEM Consortium Fellowships

Through collaborations with universities and businesses, the National Consortium for Graduate Degrees for Minorities in Engineering and Science (GEM) provides support to students from underrepresented groups who are seeking advanced degrees in science and engineering fields. Lincoln Laboratory, as a GEM partner, offers paid summer internships to students who are pursuing graduate studies through the GEM Fellowship Program, which is committed to increasing the number of science and engineering students nationwide.

### Harvey Mudd College Clinic Program

The Laboratory has an ongoing collaboration with this program, which engages the college's juniors and seniors in solving real-world technical problems for companies and organizations. Teams of four to five students complete computer science, engineering, mathematics, physics, or multidisciplinary projects to complement their academic studies. The progam's goal is to help students see the impact of their work on society as they move their skills into applied situations with deliverables of value to sponsors.

### Activate Fellowship Program

The two-year Activate Fellowship embeds science and engineering entrepreneurs within national organizations to learn the fundamentals of building a startup. Fellows are funded by the Defense Advanced Research Projects Agency and are managed by the nonprofit Activate. Fellows embedded at the Laboratory have access to state-of-the-art facilities and equipment, expert staff, and networking opportunities. Companies developed by Laboratory Activate Fellows span a range of technology fields, from cloud computing and cybersecurity to automotive safety, telecommunications, wearables, and environmental emissions mitigation.

### Massachusetts Microelectronics Internship Program (MIMP)

Lincoln Laboratory hosts students enrolled in MIMP, a 10-week, full-time microelectronics internship for freshmen and sophomores registered at Massachusetts universities. Launched in 2022, the program seeks to encourage students to consider a career in semiconductors and microelectronics and ultimately promote growth in the U.S. microelectronics workforce. At the Laboratory, interns conduct experiments to improve fabrication processes in the Microelectronics Laboratory.

### MassCyber Center Cybersecurity Mentorship Program

Through this program, undergraduates at Massachusetts universities and colleges learn about cybersecurity careers and develop professional networks through direct engagement with industry professionals. The program is intended to help address the unmet demand for cybersecurity professionals in the state. Lincoln Laboratory is one of 55 participating organizations whose staff volunteer as mentors.

*For more information on student programs, visit https://www.ll.mit.edu/careers/student-opportunities*

## Workshops and Technical Education

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

### Onsite Workshops

Attendance at workshops and seminars at Lincoln Laboratory is by invitation; participants must complete and submit the Laboratory's security authorization form.

#### A2/AD Systems and Technology Workshop

The workshop provides an overview of anti-access/area denial (A2/AD) challenges facing the DoD and intelligence communities. Laboratory presenters and invited guest speakers examine systems, tactics, and technologies to counter emerging A2/AD threats. Topics under discussion may include base and fleet defense; contested airspace; space control; cyber warfare; communications; and ISR architectures and systems.

#### Advanced Prototype Engineering Technology Symposium

The symposium is an opportunity for engineers and system developers to discuss developments in advanced integrated analysis and testing, additive manufacturing, advanced materials, and optical testing.

#### Advanced Research and Technology Symposium

The symposium is designed to showcase innovative technologies developed at Lincoln Laboratory and in partnership with MIT researchers. Themes each year reflect current and evolving areas of R&D. The symposium consists of short talks, interactive poster sessions, and keynote lectures in each of the theme areas.

#### Advanced Technology for National Security Workshop

This forum helps architects of government systems to understand how new technology can have a profound impact on future systems critical to national security.

#### Air, Missile, and Maritime Defense Technology Workshop

This workshop provides an overview of current developments in areas such as air, missile, and maritime defense elements; air and missile defense architectures; advanced concepts and technology; test infrastructures; and intelligence capabilities.

#### Air Vehicle Survivability Workshop

The workshop presents the air vehicle survivability community with an update on recent analysis and testing, and provides a forum for relevant briefings from active members of this community.

#### Biotechnology and Resilient Human Systems Workshop

Sessions in this two-day event highlight critical national needs and R&D aimed at building resilience to emerging chemical and biological threats, and naturally occurring disease outbreaks.

#### Civil Space Tech Expo

Professors and researchers from Boston-area universities learn about Lincoln Laboratory's space-related technologies and explore potential partnerships for future civilian space missions.

### Counter-Human Trafficking Technology Workshop

This invite-only workshop brings together an interdisciplinary group of stakeholders, practitioners, researchers, and technology providers to examine the ways technology is currently used to combat human trafficking, and discuss how recent advances in data science can bring about transformational improvements in capability and impact.

### Cyber Technology for National Security

This forum discusses the latest research, prototyping, assessment, and operational uses of cyber technology in the interest of national security, with a focus on military and national mission systems. The program includes talks, demonstrations, and keynote addresses.

### Defense Technology Seminar

This week-long seminar focuses on technologies for the warfighter. Major sessions are devoted to air defense and space situational awareness. New national security challenges in counterinsurgency warfare, homeland security, and network-centric operations are part of the discussion.

### Defense Technology Seminar for Military Fellows

During this annual one-day seminar, military fellows studying at local-area colleges and universities receive an overview of Laboratory programs, attend technical talks by Laboratory staff, and tour Laboratory facilities.

### Graph Exploitation

The symposium brings together leading experts from universities, industry, and government to explore the state of the art and define a future road map in network science.

### Homeland Protection Workshop Series

This workshop series covers three topics: chemical, biological, and explosive defense; air, borders, and maritime security; and incident response and disaster management.

### Human Language Technology and Applications Workshop

Users and developers of human language technologies come together to share ideas on technical challenges and lessons learned from applying such technologies to U.S. government applications.

### Human-Machine Collaboration for National Security Workshop

This workshop offers sessions in human-in-the-loop experimentation, human science, AI, and human-machine interfaces. Technical presentations given by speakers from government, federal labs, academia, and commercial companies cover a range of applications.

### Intelligence, Surveillance, and Reconnaissance Systems and Technology Workshop

This national forum is an opportunity for system developers and operational users to present and discuss technology developments and new system concepts in ISR.

### Lincoln Laboratory Communications Workshop

The two-day workshop offers users, developers, and researchers of DoD communication systems the opportunity to exchange ideas on current trends and technical challenges in developing future DoD communication architectures.

### Next Generation Information Awareness (NGIA) Technology Workshop

This workshop offers an open forum for discussing the latest developments and new requirements of the U.S. Special Operations Command initiative.

### Recent Advances in Artificial Intelligence for National Security

This workshop focuses on emerging state-of-the-art challenges, responsibilities, opportunities, and concerns in applying AI to national defense. The workshop showcases several examples of significant progress in applying AI and provides a glimpse into future directions that promise to have a profound impact on national security.

### Space Control Conference

This longstanding conference brings together the space control community to address current capabilities, future needs, and technology development.

*For information on upcoming workshops at Lincoln Laboratory, visit https://www.ll.mit.edu/conferences-events*

## Offsite Workshops

The Laboratory also coordinates offsite workshops with partnering organizations. Laboratory involvement may be cochairmanship of events, technical leadership of sessions, or cosponsorship of workshops.

### Air Traffic Control Workshop

The workshop, held at the Federal Aviation Administration's headquarters in Washington, D.C., brings together speakers from Lincoln Laboratory, government, industry, academia, and FFRDCs to present research on advanced concepts, technology, and systems development supporting the Next Generation Air Transportation System.

### IEEE High Performance Extreme Computing Conference

IEEE hosts the High Performance Extreme Computing Conference that is traditionally held in September in Waltham, Massachusetts. Lincoln Laboratory serves as the technical organizer for this forum that fosters dialog among members of the computing community.

### Cyber Endeavour Workshop

Cyber Endeavour is a multiday event exploring critical cyber challenges and potential solutions. The workshop consists of a Leadership Symposium at which authorities from the government, military services, academia, and industry discuss current issues, and the Cyber-X Games in which participants attempt to solve cybersecurity problems through interactive gaming. Lincoln Laboratory assists with the infrastructure and environment for the cyber warfighter training part of the Cyber-X Games.

### IEEE International Conference on Wearable and Implantable Body Sensor Networks

This forum gives researchers an opportunity to discuss recent R&D and innovative solutions for sensors, communications, and algorithms used in body-worn medical/healthcare systems and networks.

### IEEE International Symposium on Technologies for Homeland Security

This symposium, hosted by IEEE and held in the Greater Boston area, brings together innovators from academia, industry, Homeland Security Centers of Excellence, and government to discuss novel concepts for protecting the nation and to review experimental results of new programs.

### MultiEarth Workshop

The Multimodal Learning for Earth and Environment (MultiEarth) Workshop gathers researchers in academia, industry, and related fields to leverage remote sensing images collected by multiple sensors for positive environmental impact. The workshop is part of the IEEE/Computer Vision Foundation Computer Vision and Pattern Recognition Conference.

## Technical Education Courses—Invited

Lincoln Laboratory presents technical courses designed for military personnel and government-employed civilians. These by-invitation courses typically run from three to five days and include seminars and tours at the Laboratory's specialized facilities.

### Ballistic Missile Defense (BMD) Technology

The BMD Technology course provides an understanding of BMD systems concepts and technologies to military officers and DoD civilians involved in BMD systems development and acquisition.

### Introduction to ISR Systems and Technology

This course introduces DoD civilians and military officers to the fundamentals of ISR systems and platforms, and data processing, exploitation, and dissemination. The three-day course was developed in response to the critical role ISR plays in military conflicts abroad and in homeland defense.

### Introduction to Radar Systems

This three-day course provides an understanding of radar system concepts and technologies to military officers and DoD civilians involved in radar system development and acquisition.

### Networking and Communications

Through lectures, demonstrations, and tours, the course provides fundamentals and advanced concepts of networks and communications systems for military officers and DoD civilians.

## Technical Education Courses—Online

Lincoln Laboratory online courses consist of video lectures and accompanying PowerPoint lecture notes and charts.

### Adaptive Antennas and Phased Arrays

The 16 lectures in this course cover both theory and experiments; lectures 1 to 7 discuss adaptive antennas, and the remaining nine lectures are on phased arrays.

### Introduction to Radar Systems

This 10-lecture video course, about 11 hours in duration, was excerpted from the three-day radar course listed above.

*To learn more about the video courses, visit https://www.ll.mit.edu/outreach and search for online STEM courses*

## Community Outreach

Lincoln Laboratory Community Outreach (LLCO) encourages community service and promotes K–12 education through a variety of initiatives, some in cooperation with the MIT Public Service Center.

### Educational Outreach

Lincoln Laboratory has built a strong portfolio of educational outreach programs that encourage students to explore STEM fields. Through these programs, young people gain confidence in their ability to tackle technical challenges. The Laboratory sees such outreach as vital to our nation's technological future.

#### Lincoln Laboratory Radar Introduction for Student Engineers

Lincoln Laboratory Radar Introduction for Student Engineers (LLRISE) is a two-week residential program for high school students entering their senior year. The program includes instructional sessions on the basics of radar systems and radar imaging; workshops to build radar systems that can perform range-Doppler imaging; and hands-on exercises using the radars built in the workshops. During the two weeks, students are typically housed in a dormitory at MIT and attend sessions on campus to learn more about the college application and financial aid processes.

#### LLRISE: Spring Break

This abridged week-long version of the LLRISE summer program started virtually in 2021 through a partnership with the Texas Alliance for Minorities in Engineering (TAME). LLRISE: Spring Break is now held in person at Beaver Works. All participants are encouraged to apply to the full two-week LLRISE.

#### Science on Saturday

Laboratory technical staff give lively, interactive demonstrations for local-area students, their parents, and teachers. These popular events have ranged from hands-on engineering activities, such as building gumdrop towers, to demonstrations on the "magic" of chemistry, lasers and optics, and computers. Annually, hundreds of people attend these sessions offered four times during the school year.

#### Robotics Outreach at Lincoln Laboratory

Robotics Outreach at Lincoln Laboratory (ROLL) takes advantage of the current popularity of robotics to interest K–12 students in science and technology. ROLL is sponsoring teams in the FIRST (For Inspiration and Recognition of Science and Technology) competitions, hosting robotics workshops at the Laboratory, and providing technical mentors to local-area schools and groups. More than 135 students have participated on 16 Laboratory-mentored teams.

#### Beaver Works Summer Institute

The Beaver Works Summer Institute (BWSI) is a four-week program of project-based courses for high school seniors. Prerequisite online courses provide fundamentals in Python, ROS (Robot Operating System), and specific technologies that students will need to familiarize themselves with before tackling their choice of summer workshops offered at MIT. The range of courses offered each year is diverse. By employing newfound skills in programming and machine learning, students work on projects such

as building an application that understands voice commands, creating a flu forecast by understanding disease propagation, directing a robotic car to navigate an obstacle course, or discovering cyberbullying in tweets. The summer workshops encourage students to develop their learning with competitions and challenges that build toward a final team project. An installment of BWSI is also run on Kwajalein Atoll.

For teachers and other nonprofit organizations, BWSI shares its curriculum that can be used to help students prepare for college and beyond. BWSI helps other institutions create similar programs and is working to build a network of schools that will collectively improve engineering education worldwide.

### Lincoln Laboratory Courses for Accessible, Technical Education (LL EduCATE)

The LL EduCATE program introduces students at underserved schools to core engineering skills and highlights how STEM topics can apply to their own lives. The initial course featured labs on particle filtration, Clausewitzian chess, and Bluetooth technology. A second course will focus on the Internet and online safety.

### Lincoln Laboratory Cipher

The one-week LLCipher workshop presents high school students with an introduction to modern cryptography—a math-based approach to securing data. Lessons in abstract algebra, number theory, and complexity theory provide students with the foundational knowledge needed to understand theoretical cryptography. Students then construct provably secure encryption and digital-signature schemes.

### Lincoln Coders

Volunteers from the Laboratory's Recent College Graduates and Hanscom Air Force Base teach sixth and seventh graders to use a programming language (Scratch, JavaScript, or Python) over the course of seven sessions. The students work on a single project that they present at the end of the program.

### MIT Office of Engineering Outreach Programs

Lincoln Laboratory is collaborating with MIT's Office of Engineering Outreach Programs, which runs four enrichment programs for either middle or high school students. These programs are aimed at encouraging students, particularly in underserved populations, to pursue STEM careers.

### Armed Forces Communications and Electronics Association

Lincoln Laboratory participates in an Armed Forces Communications and Electronics Association (AFCEA) educational program by providing two summer employment internships for graduating high school seniors interested in STEM.

### Summer High School Internship Program

Through this program, rising seniors in the New England area experience and explore STEM careers before committing to an area of study in college. Interns not only engage in hands-on research aligned with their interests but also receive mentoring on educational and career paths, develop interpersonal skills in a professional workplace environment, and network with staff across the Laboratory.

### Girls' Innovation Research Laboratory (G.I.R.L.)

G.I.R.L. hosts hands-on workshops throughout the year to empower girls (though events are co-ed) with the skills, knowledge, resources, and confidence

to pursue STEM careers. Since its inception in 2019, G.I.R.L. has reached hundreds of middle and high school students from Greater Boston schools and organizations. Workshop topics have included programming and circuits, AI, chemistry, cybersecurity, space science, and forensics.

## Community Service and Giving

Many individuals from the Lincoln Laboratory community offer their time, talents, and support to charitable organizations. While dozens of charities benefit from this generosity, the following programs are long-standing volunteer efforts of Laboratory employees.

### Alzheimer's Awareness and Outreach

This informal volunteer group provides support and useful information to fellow employees who are experiencing the significant impact Alzheimer's disease has on individuals and families. They also raise funds to benefit the Massachusetts/New Hampshire chapter of the Alzheimer's Association, which supports research into the disease, patient care, and awareness programs. The Laboratory teams who participate in the Ride and Walk to End Alzheimer's are consistently among the region's most successful fundraisers.

### Autumn Escape Bike Trek

The Autumn Escape Bike Trek is a one- to three-day September bicycle tour across Cape Cod, Massachusetts. Participants are challenged to ride either 35 or 60 miles. Funds pledged to sponsor the cyclists are used to research ways to combat diseases such as lung cancer and asthma.

### Food and Clothing Drives

The LLCO supports employees' participation in food and clothing drives that help local charities. Food items are distributed to food pantries in the area, and clothing is given to a number of shelters and the Salvation Army.

### Support Our Troops

Lincoln Laboratory runs an ongoing campaign of support for deployed U.S. troops. Donations of food, toiletries, books, and games are collected daily, boxed by volunteers, and mailed weekly. In addition, the program has sent care packages to the children of villages in the Middle East where U.S. troops are serving.

### Veterans Support

The Lincoln Laboratory Veterans Network (LLVETS) not only offers support to employees who are transitioning to the Laboratory directly from the military but also engages in outreach to local active-duty troops and veterans organizations. For example, LLVETS supports the efforts of the Wounded Warrior Project, which helps injured servicemen and women deal with physical, emotional, and financial challenges, and Fisher House, which makes housing available to families of soldiers being treated at medical centers.

### Toys for Tots

The Toys for Tots donation drive has been a fixture at Lincoln Laboratory for more than 20 years. Volunteers take the toys donated by the Laboratory community to distribution centers in Middlesex and Essex Counties. There, local organizations pick up the toys and deliver them to where the need is greatest.

### Holiday Giving Tree

During the winter holiday season, Laboratory employees donate gifts to area residents in need.

Gifts are distributed by the charitable organization Somebody Cares.

### Marshallese Outreach

The Marshallese Outreach program was developed to enrich educational and life experiences of the people of the Marshall Islands, particularly those from Kwajalein Atoll, where Lincoln Laboratory staff work as scientific advisors to the Reagan Test Site located there. Sales of Micronesian handicrafts are held throughout the year, supporting artisans and schools throughout the Marshall Islands and Micronesia.

### United Way

Lincoln Laboratory participates in MIT's annual United Way campaign that raises funds to aid local human-service agencies that provide assistance to families in need and operate programs to help children and young adults having difficulties in school and at home.

*For more information on the educational outreach and community service programs of LLCO, visit https://www.ll.mit.edu/outreach*

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