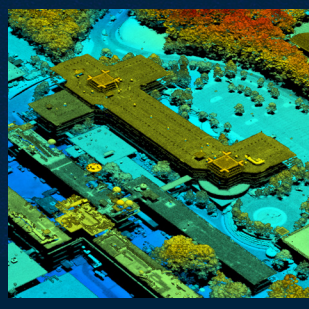
2025

MIT Lincoln Laboratory

IMPACT REPORT



Technology for National Security

Massachusetts Institute of Technology

MIT Lincoln Laboratory

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Lincoln Laboratory: Since 1951

CHAPTER 01

Our Purpose

We solve critical problems of national security with excellence, integrity, and innovation.

DIRECTOR'S MESSAGE

The 2025 National Security Strategy set priorities to ensure that U.S. technology — particularly in artificial intelligence, biotechnology, and quantum computing — drives the world forward. The strategy also calls for modernizing the military and strengthening domestic supply chains. At MIT Lincoln Laboratory, our R&D aligns with these needs. This report highlights some of our recent innovations that have impacted the nation.

In 2025, we executed 55 government-directed technology transitions, transferring technologies directly into military programs or to industry for production. Among them is a drone interceptor that costs one-tenth of current alternatives and assembles in under two hours, helping to counter a growing threat at home and abroad. Supporting U.S. forces in Europe, we established a multinational tactical air defense early-warning capability, and, in the Middle East, our software analyzed hundreds of missile threats to save lives. Our world-class radars tracked 30,000 satellites, providing awareness of an increasingly congested and contested space domain. And to unify forces across all domains, we developed a cybersecure joint communications architecture.

To bolster domestic resilience, we fabricated quantum circuits that are accelerating nationwide research in this important field and delivered integrated photonics to enable next-generation microwave systems. We also were the first to biosynthesize a critical defense material — a significant step toward reducing dependence on foreign supply chains.

Our impact is made possible by exceptional people. Staff earned seven R&D 100 Awards for their breakthrough technologies and inspired nearly 8,000 students through STEM initiatives, including collaborations with MIT campus. Military fellows and veterans embedded within our teams bridged the gap between operational needs and technology solutions.

As we look to 2026, we will reflect on both the Laboratory's 75 years of service and the nation's 250 years of independence. We are proud to support our service members and help build a safer world, and will rise to address new challenges as we continue our vital mission of developing technology for national security.

Sincerely,

Melissa G. Choi
Director

MISSION, VISION, & VALUES

MISSION:

Technology for National Security

We employ some of the nation's best technical talent to support system and technology development for national security needs. Emphasizing emerging technology areas for the U.S. Department of War (DoW), we conduct R&D on behalf of the military services, the Office of the Secretary of War, the intelligence community, and other government agencies.

VISION:

To be the nation's premier laboratory that develops advanced technology and system prototypes for national security problems

VALUES:

How we approach our work

Integrity, excellence, and innovation

How we interact with each other

Belonging, respect, and service

UNIQUE ROLE AS A DoW FFRDC

We are defined by our role as the DoW's largest R&D laboratory federally funded research and development center (FFRDC), uniquely combining state-of-the-art R&D with rapid hardware prototyping capabilities. We focus on end-to-end development of new capabilities that cannot be met as effectively by the government's existing in-house or contractor resources. Once capabilities are developed, we work in close coordination with the U.S. government to transfer them directly to the military services and private industry for production.

This process is central to our FFRDC role, which offers specific advantages to the U.S. government.

- **Special, long-term relationship:** We operate as a strategic partner to the government, maintaining continuity of expertise in critical DoW areas, responding quickly to urgent needs, and sharing our knowledge with the national security community.
- **Freedom from conflicts of interest:** Reducing risk to the U.S. government, we operate free from profit motives and are prohibited from competing with private industry, instead facilitating engagement across the DoW and commercial sector.
- **Objective expertise:** We serve solely in the U.S. government's interest as a trusted, unbiased source of technological capabilities, increasing the pace of innovation necessary to address evolving threats.

MIT Lincoln Laboratory, Lexington, Massachusetts

Lincoln Space Surveillance Complex, Westford, Massachusetts

Reagan Test Site, Kwajalein Atoll, Marshall Islands

ORGANIZATION

Massachusetts Institute of Technology

From left, Anantha P. Chandrakasan, *Provost*; Sally A. Kornbluth, *President*; Ian A. Waitz, *Vice President for Research*

MIT Lincoln Laboratory

From left, Justin J. Brooke, *Assistant Director for R&D*; Robert B. Loynd, *Executive Officer to the Director and Chief of Staff*; Asha Rajagopal, *Chief Technology Transfer Officer*; Chevalier P. Cleaves, *Special Assistant to the Director*; Melissa G. Choi, *Director*; Israel Soibelman, *Chief Strategy Officer*; Heidi C. Perry, *Chief Technology Officer*; C. Scott Anderson, *Assistant Director for Operations*; Marc N. Viera, *Assistant Director for R&D*

Our R&D activities span nine technical divisions, overseen by a Director's Office and supported by six operations departments. As part of our FFRDC structure, MIT operates Lincoln Laboratory in the national interest strictly on a no-loss, no-gain basis, under a prime contract with the U.S. Air Force.

ORGANIZATIONAL CHART

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Assistant Director for R&D

Israel Soibelman
Chief Strategy Officer

Thomas P. Hawkins
Director of Washington Operations

Marc N. Viera
Assistant Director for R&D

Heidi C. Perry
Chief Technology Officer

Chevalier P. Cleaves
Assistant to the Director

C. Scott Anderson
Assistant Director for Operations

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Provost

Ian A. Waitz
Vice President for Research

2025 DoW Joint Advisory Committee (JAC)

The committee annually reviews the Laboratory's proposal for programs to be undertaken in the subsequent fiscal year and five-year plan.

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Deputy Assistant Secretary of the Air Force (Acquisition, Technology and Logistics)

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Acting Director, Defense Advanced Research Projects Agency

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The Advisory Board is appointed by the MIT President and reports to the Provost. The board meets twice a year to review the direction of Laboratory programs.

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Ian A. Waitz
Vice President for Research, MIT; Jerome C. Hunsaker Professor of Aeronautics and Astronautics, MIT

CHAPTER 02

Our Mission Impact

We deliver solutions to U.S. service members, government sponsors, industry partners, and the public.

Researchers evaluate surveillance and tracking systems for air defense of U.S. bases in Europe.

SAFEGUARDING THE SKIES

Lincoln Laboratory was established in 1951 to build the nation's first air defense system. Today, we continue that legacy, innovating advanced sensors, AI-driven software, and low-cost interceptors to surveil and defend U.S. and allied airspace from modern threats including ballistic missiles and drones.

HOMELAND PROTECTION

Integrated air defense fortifies U.S. and NATO base in Europe

The defense of military bases beyond U.S. borders is crucial for protecting our troops, projecting power, and supporting allies. To enhance base protection, the U.S. Air Force has increased its focus on integrated defense — cohesively networking sensors, command and control systems, and physical security measures.

In support of this initiative, Lincoln Laboratory evaluated integrated air defense at Ramstein Air Base in Germany, the headquarters for the U.S. Air Forces in Europe — Air Forces Africa and NATO Allied Air Command. This evaluation led us to establish the Ramstein Air Defense System Integration Laboratory (RADSIL) in 2021.

An engineering and prototyping facility, RADSIL acts as a crucial hub for developing, evaluating, and integrating advanced technologies to enhance air defense against modern threats. Through RADSIL, we worked with industry partners to mature and transition air surveillance capabilities into operations, resulting in Europe's first multinational tactical air defense early-warning capability (EWC).

With EWC deployed in 2025, RADSIL continues to support pivotal assessments of decision support tools and advanced sensors for integration into the base's common operating picture, helping operators manage tracks of interest in the complex airspace over Europe.

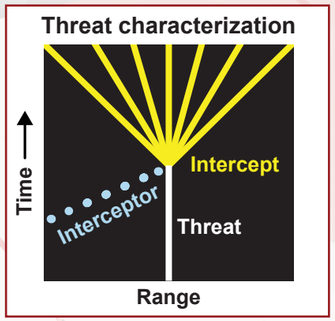
A U.S. airman operates a surveillance system at Ramstein Air Base.
Photo: Staff Sgt. Gaspar Cortez

AIR, MISSILE, & MARITIME DEFENSE TECHNOLOGY

Missile threat analysis and modeling drives life-saving defense system improvements

Adversaries have demonstrated unprecedented use of ballistic missiles across the globe, including in the Middle East, where Iran and Houthi rebels launch near-daily attacks against U.S. warfighters and allies. Lincoln Laboratory developed advanced software that ingests and processes massive volumes of diverse sensor data to characterize hundreds of missile threats and assess the impact of these threats on operational defense system performance. This timely analysis has provided rapid feedback to deployed warfighters and improved intelligence assessments of threat capabilities.

We also leveraged the missile threat data to develop a physics-constrained framework for modeling missile radar signatures, capturing the broad range of potential threat configurations. Transitioned to the Missile Defense Agency and industry partners, this software package enables users to generate large sets of signatures to train and test AI and machine learning algorithms for object classification under fast-evolving decision timelines. The resulting algorithms will enhance the robustness of defense systems, ultimately saving lives.



Notional Representation

Lincoln Laboratory's missile threat characterization software is supporting operational and intelligence assessments in the Middle East.

"The Lincoln Laboratory team has critically provided efficient target-signature data analysis and strategic-level kill assessment, which are often unachievable locally at the unit level."

Ret. LCDR Russell Allen
U.S. Navy

TACTICAL SYSTEMS

Two SICA systems are shown here prior to flight testing. Their 3D-printed X-wing system is 21 × 22 inches, weighs 6 pounds, and can carry an 800-gram payload that may include cameras or other sensors.

Rapidly deployable counter-drone technology keeps the nation safe

As the use of drones for military and civilian purposes continues to rise globally, so too does the necessity for counter-drone technologies to detect and intercept malicious activity. In particular, low-cost surveillance and one-way-attack drones pose a significant threat because adversaries can produce and deploy them at a rate that exceeds the production and employment capabilities of counter-drone systems. To defend against these types of threats, we developed a reusable, low-cost, and easily manufactured interceptor called Small Interceptor, Counter-Air (SICA).

SICAs are assembled using commercial off-the-shelf parts and readily available tools such as a 3D printer, a screwdriver, glue, and a soldering gun. The interceptor body weighs about 6 pounds, has a top speed of 200 miles per hour, a maximum range of 40 km, and supports an instantaneous G-force limit of 12 Gs. The cost of building a SICA is 10 times less than that of current alternatives, and it can be assembled in less than two hours.

Our expertise in rapid prototyping enabled us to develop SICA and demonstrate it to government stakeholders at the OUSW (R&E) Technology Readiness Experimentation exercise in one year. The initial prototype is now evolving to encompass multiple variants with different capabilities.

TOSSIT can be thrown or launched to remotely detect the presence of harmful vapors or aerosols, alerting users of its detections via an app or in-sensor alarms.

ENHANCING MILITARY READINESS

The success of military missions hinges on protected and well-informed warfighters. To enhance human health and performance at the tactical edge, we are developing wearables to monitor sleep, fielding sensors to remotely detect chemical hazards in the air, and evaluating commercial AI data processors for military use.

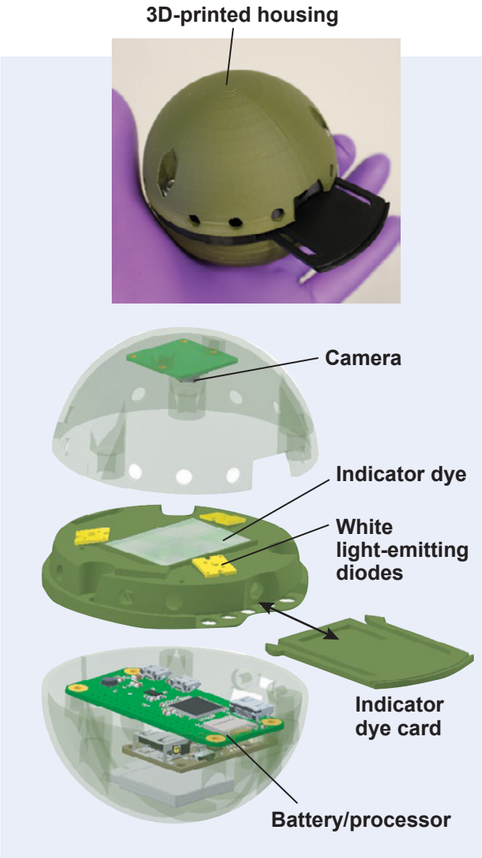
BIOTECHNOLOGY & HUMAN SYSTEMS

Throwable sensor detects chemical and biological threats

The Tactical Optical Spherical Sensor for Interrogating Threats (TOSSIT) is a throwable, baseball-sized sensor that remotely detects hazardous vapors and aerosols. It is designed to alert military service members, as well as first responders and law enforcement, to the presence of chemical threats like nerve and blister agents, industrial chemical accidents, or fentanyl dust. Users can simply toss, drone-drop, or launch TOSSIT into an area of concern. To detect specific chemicals, the sensor samples the air with a built-in fan and uses an internal camera to observe color changes on a removable dye card. If chemicals are present, TOSSIT alerts users wirelessly on an app or via audible, light-up, or vibrational alarms in the sensor.

TOSSIT fills an unmet need in the U.S. military for a kinetically deployable, low-cost sensing option that detects vapors and solid aerosol threats otherwise undetectable by current sensing systems. Our deep knowledge of the current chemical threat environment, paired with our world-class development capabilities, made us uniquely suited to develop and deliver TOSSIT into the hands of service members.

Scan to watch video
Tossing TOSSIT to detect threats



BIOTECHNOLOGY & HUMAN SYSTEMS

Novel system tracks U.S. Navy sailors' sleep to improve operational readiness

Lincoln Laboratory is a national leader in developing human physiological monitoring systems to warn of threats to military missions. From sensors that detect heat injury to software that help diagnose brain trauma, the Laboratory's fielded solutions have impacted thousands of military personnel.

One such technology — the Command Readiness, Endurance, and Watchstanding (CREW) system — passively collects and analyzes data from wearables to help U.S. Naval commanders make quick and informed decisions about sailors' sleep physiology. Developed in partnership with the Naval Health Research Center, the Commander of Naval Surface Forces Pacific, and industry, CREW targets a pressing problem for U.S. Navy fleets: sleep deprivation. Fatigue from lack of sleep can lead to cognitive issues such as poor decision-making, focus, and memory.

Currently, there is no way to collect objective sleep data on sailors while at sea beyond manual reporting and observations. CREW performs this function digitally, where a sailor's wearable data are automatically uploaded to data hubs dispersed throughout their ship. This "closed loop" allows the data to circulate from sailors to Naval digital systems without the need for an internet connection, which is often unavailable at sea. In recent demonstrations, CREW accelerated delivery of actionable insights to leadership from two weeks to two minutes.

CAPT Andrew Koy, Sr., Commanding Officer of the USS Somerset (LPD 25), interacts with a CREW hub for the first time with guidance from staff member Molly Crane.
Photo: Jay Couturier, MIT Lincoln Laboratory

> **"With real-time data from CREW on how well-rested my team is, I can make better informed decisions about workloads and scheduling to ensure our mission success."**
>
> **CAPT Andrew Koy, Sr.**
> **Commanding Officer of the USS Somerset (LPD 25)**

A U.S. Navy sailor views his physiological measurements through a CREW data hub at the start of a 2025 operational demonstration.
Photo: Molly Crane, MIT Lincoln Laboratory

ISR SYSTEMS & TECHNOLOGY

Richard Muri configures multimodal sensors for integration with NorthPole on the ARTB.

Flight testing takes IBM's AI processor to new heights for technology readiness

Artificial intelligence has emerged as a powerful tool for rapidly processing data in challenging environments, providing insights for real-time decision-making. Lincoln Laboratory is evaluating a commercial AI processor developed by IBM for its potential use in various applications, such as automatically identifying objects in airborne images. Called NorthPole, the AI processor can perform complex tasks at high speed and low power in remote settings.

For the evaluation, the team integrated NorthPole into our Airborne Radar Testbed (ARTB), equipped with multimodal sensors. As the ARTB flew over Joint Base Cape Cod and acquired multimodal sensor images, NorthPole accurately detected test vehicles on the ground at the speed of data while consuming significantly less power than other commercial AI processors. This efficiency gain could be leveraged to quickly process additional data or different types of data simultaneously. We are now working with the warfighter community on validating the technology to enhance its effectiveness and efficiency.

A U.S. Navy technician prepares an explosive ordnance disposal (EOD) robot. Integrated into Navy radios on EOD robots, the Laboratory-developed SCM/ECU will ensure robot actions are not communicated to unauthorized persons.
Photo: Jamar Perry, U.S. Navy

ADVANCING THE JOINT FORCE

To achieve decision advantage over adversaries, the U.S. military is shifting its operations away from isolated, service-specific systems and toward a unified network that connects all branches of the armed forces. We are building the common architectures and waveforms needed for secure joint communications under this modern concept.

CYBER SECURITY & INFORMATION SCIENCES

Secure architecture for uncrewed systems becomes DoW standard

Uncrewed systems are integral to modern military operations in the air, at sea, and on land. From force projection and electronic warfare to explosive ordnance disposal and intelligence, surveillance, and reconnaissance, these platforms carry out high-risk, high-impact tasks while reducing danger to warfighters. As their use expands, so does the need to protect their communications against interception or spoofing, especially in contested or disconnected environments.

Meeting this challenge demands a common architecture for secure communications — one that facilitates interoperability, reuse, and streamlined certification across various platforms. In support of this forward-looking vision, Lincoln Laboratory, in collaboration with government and industry partners, led the development of the cybersecurity architecture for the Joint Communications Architecture for Unmanned Systems (JCAUS). In 2022, JCAUS was formally adopted as a DoW standard.

The SCM/ECU is packaged in a compact, tamper-protected box with data and control ports (J1–J4).

Central to the first generation of JCAUS radios is the Security/Cyber Module (SCM) End Cryptographic Unit (ECU), a compact, National Security Agency–certified device that we designed and developed to enable classified communications with encryption and agile, over-the-air keying. In 2024, the SCM ECU was transitioned to industry for production and integration into the Navy's Flexible Cyber-Secure Radio for ground robots — the first of many systems across the DoW expected to be secured under this new architecture. Since then, JCAUS capabilities and technologies have continued to evolve through broader operational adoption, new secure communications implementations, and expansion into emerging mission areas for next-generation uncrewed systems.

COMMUNICATION SYSTEMS

Tactical network testing drives requirements for joint-force interoperability

To achieve decision-making advantage, U.S. and allied forces must be connected across air, land, sea, space, and cyber domains. Realizing Combined Joint All-Domain Command and Control (CJADC2) requires integrating each military service's communication networks into a unified common architecture for rapid data sharing at the tactical edge, where connectivity is often limited or disrupted.

Leveraging networking architectures of the U.S. Air Force and Navy, a government team including Lincoln Laboratory and other defense contractors developed the Joint Tactical Edge Network (JTEN). By overlaying a joint network over existing networks, JTEN enables warfighters to directly communicate with cross-service mobile tactical platforms while sharing data through multiple available paths as needed. A publish-and-subscribe content-routing model ensures JTEN users obtain only relevant data — a benefit especially for disadvantaged users.

Scott Arbiv and Ted Richards monitor network performance as emulated traffic (airplane symbols) generated on an Air Force node is published to JTEN, where disadvantaged users subscribe to content based on geography or entity type (hostile or friendly).

In collaboration with the Air Force, Navy, and Army, we supported JTEN testing at two large-scale military test events: a 2024 risk-reduction exercise and 2025 field training exercise. Our staff co-created joint configurations for an Internet Protocol (IP) router operating over commercial beyond line-of-sight links and DoW-owned line-of-sight links, and prototyped a content router. Utilizing airborne test beds from our Flight Test Facility, participants demonstrated machine-to-machine sensor tasking and executed a joint kill chain through JTEN nodes. Lessons learned are shaping joint interoperability requirements for CJADC2.

COMMUNICATION SYSTEMS

Demonstration of protected tactical waveform secures future of joint warfighter SATCOM

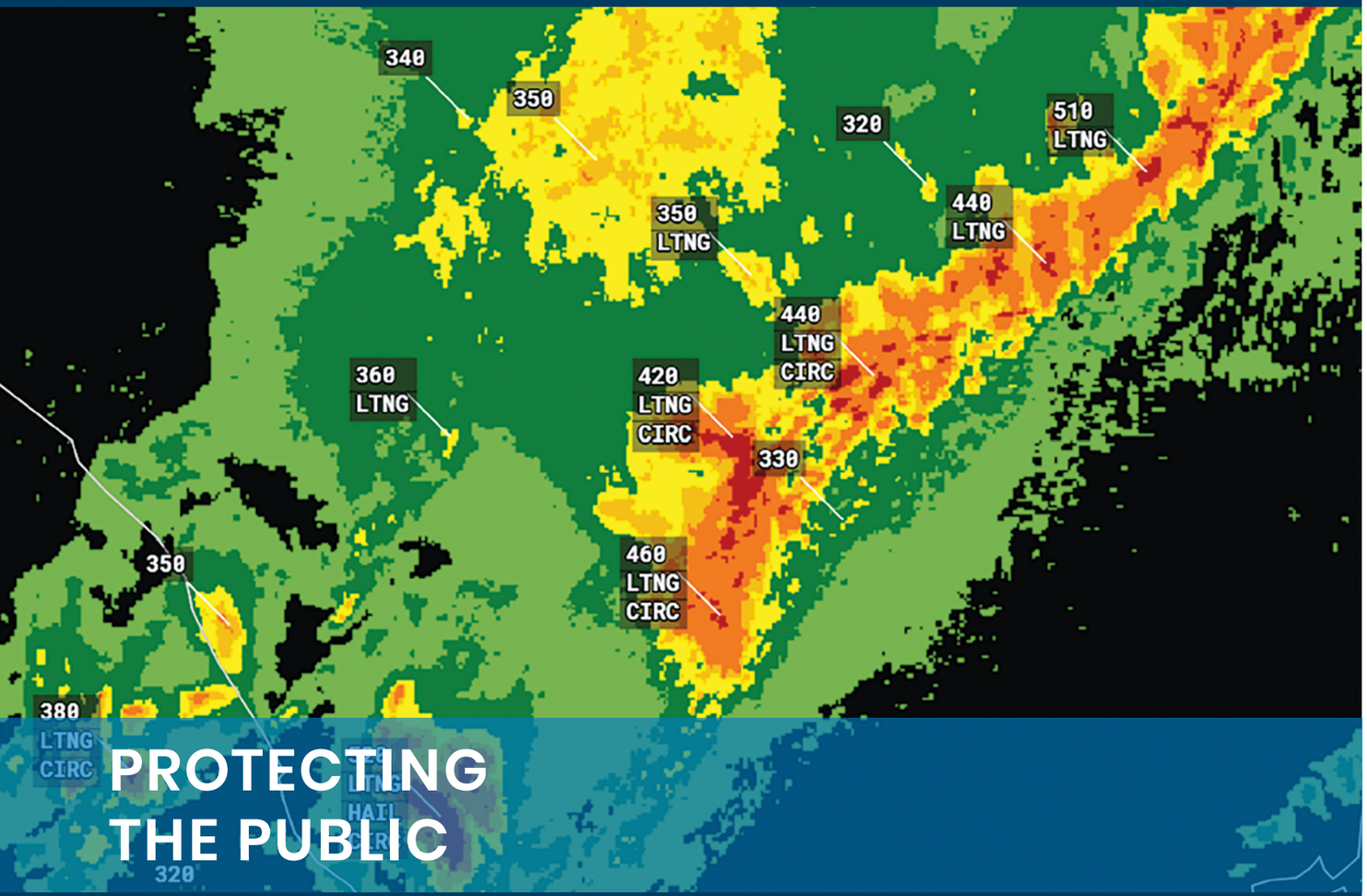
The U.S. Space Force's Space Systems Command is developing the Protected Tactical Enterprise Service (PTES) to provide military personnel with the secure, high-throughput, anti-jam satellite communications (SATCOM) needed to conduct tactical missions over great distances across ground, sea, and air domains. A critical component of PTES is the Protected Tactical Waveform (PTW), which combines frequency hopping (signals rapidly "hop," or switch, between different frequencies in a sequence known to authenticated transmitters and receivers) with advanced security features and adaptability to changing satellite link conditions. Equipped with PTW, PTES ground hubs and user terminals will securely connect warfighters over military and commercial satellite constellations while protecting communications from expanding electronic warfare threats.

Lincoln Laboratory recently led a government partnership with industry to integrate a PTES ground hub's PTW capabilities and demonstrate end-to-end protected tactical SATCOM in the presence of dynamic interference.

> **"This demonstration culminates years of industry and government partnership to realize a modern, anti-jam, low-probability-of-intercept waveform that will underpin future tactical SATCOM operations."**
>
> Erin Carper, former senior program director Space Systems Command

Using industry-produced PTW modems in an operationally relevant scenario, joint warfighters achieved several firsts — frequency hopping at variable interference levels, over-the-air operations via multiple PTW-enabled terminals, a secure Voice over Internet Protocol call, and ground bounce of signals via a commercial SATCOM satellite — which lay the foundation for future operations with PTES.

Lincoln Laboratory's Multi-Band Test Terminal, whose radome housing a SATCOM antenna is illuminated above, supports PTW development and demonstration.



PROTECTING THE PUBLIC

Whether in the physical world or the digital domain, the general public faces safety risks. We are designing hardware and software to enhance security at large venues, forecast severe weather impacting aviation, prevent collisions between rotorcraft, and bolster the resilience of internet-connected devices.

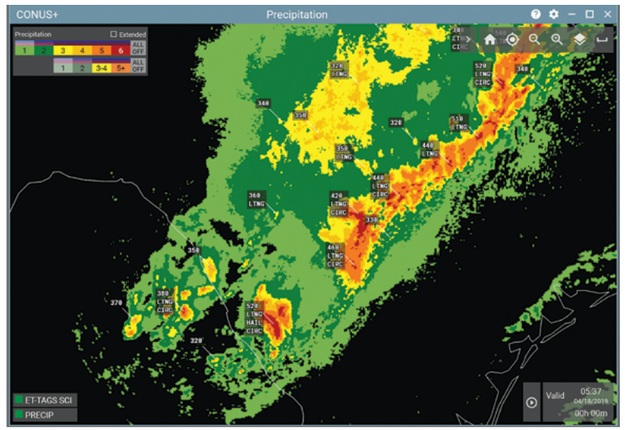
AIR TRAFFIC CONTROL

NextGen Weather Processor supports safe and efficient aviation

A major cause of delays in air transportation is uncertainty surrounding the location and intensity of future severe weather events. In response to this problem, Lincoln Laboratory developed the Next Generation (NextGen) Weather Processor (NWP) algorithms to provide comprehensive weather situational awareness and forecasts for Federal Aviation Administration (FAA) air traffic managers and airlines. In late 2024, NWP reached initial operational capability. The system is now deployed at several FAA facilities, and a nationwide rollout is planned.

By using radar, satellite, lightning, surface observation, and numerical weather model data, NWP detects rapid storm growth, tracks storm-cell motion, and provides confidence metrics to help users assess the reliability of weather forecasts. Radar mosaics update every 25 seconds to accurately depict storms' location, intensity, and height with extremely low latency. Traffic managers use this information to determine how long to delay a flight until a route has cleared or where to direct flights to safely circumvent storms.

We collaborated with the U.S. government and aviation industry stakeholders for many years to develop NWP. The technology builds upon Laboratory-developed legacy systems that were refined through user engagement and iterative prototyping to translate user feedback into improved system requirements. The resulting technology was transitioned into operational use through close partnership with the FAA and RTX Corporation.



The NWP radar mosaic uses colors and tags to indicate storm-cell hazards such as lightning, atmospheric circulation, hail, and echo tops.

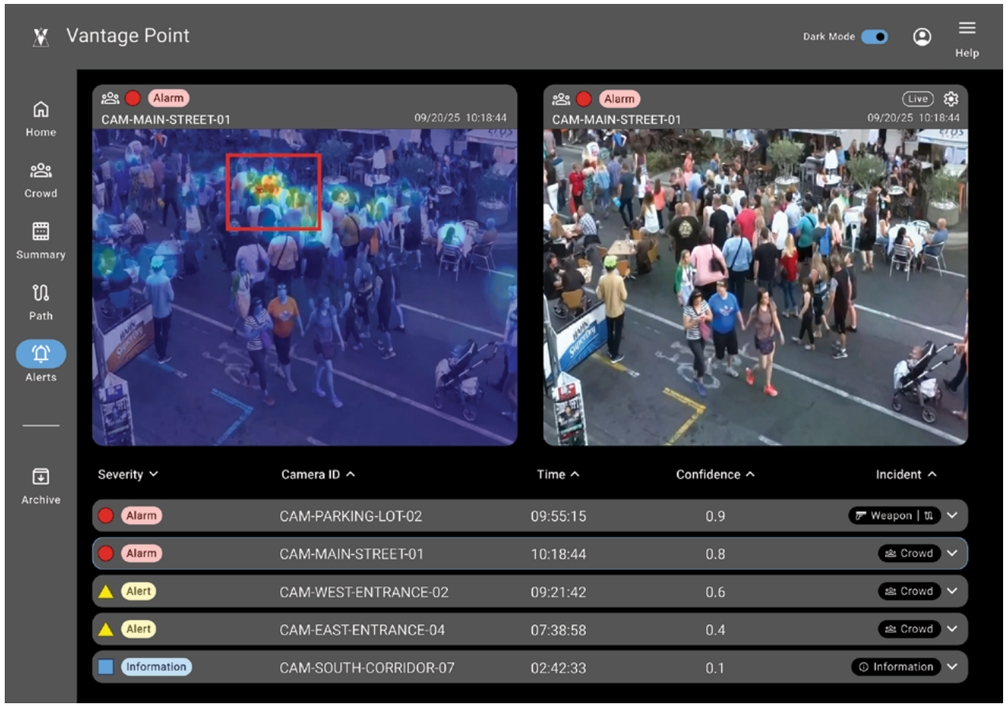
A next-generation sensor system to detect concealed threats on pedestrians undergoes RF testing at Lincoln Laboratory.

HOMELAND PROTECTION

Sensors and AI heighten security in public spaces nationwide

Large, open, and easily accaccessible places such as arenas, fairgrounds, and mass transit systems attract crowds and have limited physical security, making them vulnerable to attacks. Working with the U.S. Department of Homeland Security Science and Technology Directorate, Lincoln Laboratory pioneered two technologies that improve security without disrupting operations: a first-of-its kind sensor system that scans pedestrians for concealed threats like firearms or explosives, and an AI-powered software system that enables operators to rapidly review surveillance video generated by large camera networks. Industry partners are now deploying these technologies at venues nationwide to enhance public safety.

The sensor system generates millimeter-wave imagery 10 times per second at short standoff distances, providing more flexibility than standard stop-and-scan checkpoints. Following successful deployments of the sensor by security company Liberty Defense in arenas, malls, and airports, we are now prototyping a next-generation system that combines higher-fidelity millimeter-wave scans, metal detection, and AI to pinpoint threats.



The software platform, called Vantage Point, allows a variety of venue types to experiment with enhanced live monitoring and video investigation capabilities tailored to their facilities.

The video review software uses advanced AI techniques to automatically parse surveillance video, helping security personnel discover and investigate activities of interest. The technology has been deployed to multiple public facilities, both by our organization and through an industry partnership with Doradus Labs. Enhancements are underway to the configurability of the software, allowing operators to set up a range of real-time monitoring and forensic investigation tasks that suit their needs.

> **“Lincoln Laboratory has been a true partner — bringing deep innovation, technical expertise, and a clear vision for commercial deployment. Together, we’ve brought next-generation technology to market to protect people in public spaces.”**
>
> **Bill Frain**
> **CEO, Liberty Defense**

AIR TRAFFIC CONTROL

A recent NASA/Sikorsky flight test evaluated the performance of the FAA-sponsored ACAS Xr collision-avoidance system, which is intended for both crewed and autonomous rotorcraft.

Advanced collision-avoidance system significantly improves rotorcraft safety

Lincoln Laboratory has continued to develop a new airborne collision-avoidance technology called ACAS X with funding from the FAA and the DoW. The ACAS X technology employs advanced computer science techniques such as machine learning and dynamic programming to flexibly and adaptively meet the collision-avoidance needs of a wide range of vehicles and flight operations. We have created variants of ACAS X to meet the needs of crewed transport aircraft, large uncrewed aircraft, and small uncrewed aircraft. The latest variant for rotorcraft, called ACAS Xr, will be finalized in 2026. The ACAS Xr technology issues alerts to pilots at low altitudes, incorporates turning avoidance maneuvers, considers nearby terrain, and reduces unnecessary alerts that could occur in airspace frequented by helicopters.

When completed, ACAS Xr will be the only certified collision-avoidance capability developed specifically for rotorcraft. Analysis conducted by our researchers predicts that ACAS Xr will reduce the risk of a midair collision by more than 95% while producing alerts that are compatible with typical rotorcraft operations. ACAS Xr will also be a key enabler for advanced air mobility operations, whose vehicles must have a collision-avoidance capability to meet regulatory requirements to fly in the national airspace.

CYBER SECURITY & INFORMATION SCIENCES

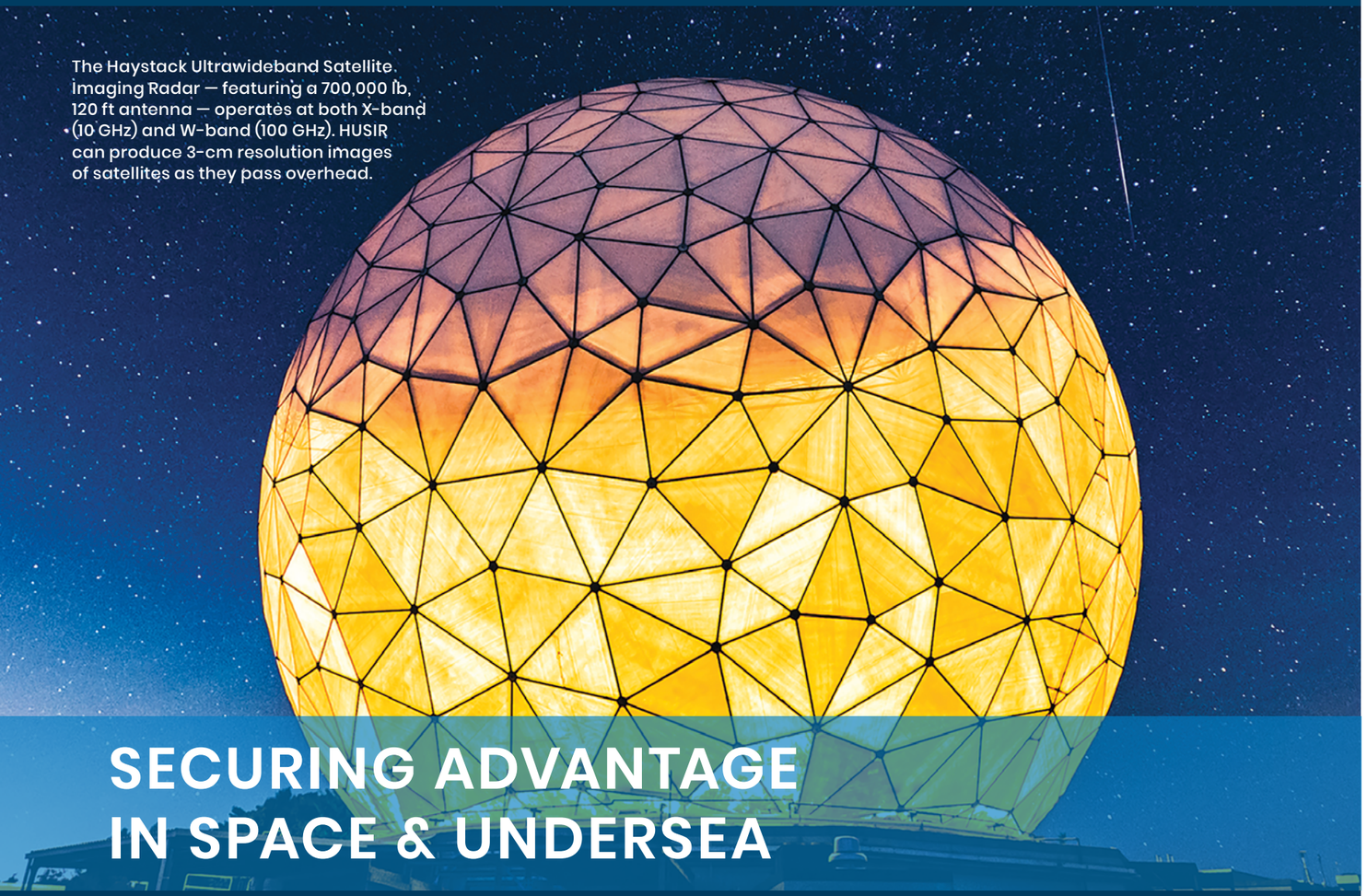
Software emulator helps FBI disrupt botnets

Cyber attackers are increasingly targeting small and home office "embedded" online devices (e.g., routers, security cameras) running on outdated and unpatched software. By exploiting these vulnerabilities, attackers create networks of malware-infected devices (botnets) that they can remotely control to perform malicious activities such as distributed denial-of-service attacks, data theft, and further malware propagation. Botnets often comprise hundreds or thousands of unique devices — each with their own hardware, software, and configuration — making manual, sequential methods of testing mitigations impractical.

To address this challenge, we developed tools for cybersecurity analysts to examine, patch, and test embedded device software without requiring access to the physical hardware. These tools can emulate and test each device configuration in parallel using the computational power of the Lincoln Laboratory Supercomputing Center (LLSC).

At the request of the Federal Bureau of Investigation (FBI), we used this automated capability to test software patches against 300 emulated botnet devices, delivering a full validation of the proposed mitigation within two weeks. This capability was critical to the FBI's court-authorized operation to disrupt the botnet. More than 200 government developers and cyber warfighters have been trained on the tool suite, now a cornerstone for mission-critical cyber defense projects across multiple government agencies.

Home to an AI supercomputer ranked as the most powerful at a U.S. university in 2025, the LLSC provided the high-performance computing environment needed to quickly develop and test a botnet emulator for the FBI. Here, Antonio Rosa inspects equipment inside the LLSC.



The Haystack Ultrawideband Satellite Imaging Radar — featuring a 700,000 lb, 120 ft antenna — operates at both X-band (10 GHz) and W-band (100 GHz). HUSIR can produce 3-cm resolution images of satellites as they pass overhead.

SECURING ADVANTAGE IN SPACE & UNDERSEA

Outer space and the deep ocean are rapidly becoming contested as great powers vie for strategic, military, and economic superiority. To help maintain U.S. dominance in these final frontiers, we are developing optical sensors and radars to track space objects and a sonar system to map the seafloor.

SPACE SYSTEMS & TECHNOLOGY

World-class radars advance U.S. Space Force missions

Lincoln Laboratory has built and operates some of the largest and most sensitive radar systems on the planet at the Lincoln Space Surveillance Complex in Westford, Massachusetts. We use these powerful radars to monitor objects in orbit around the Earth, playing a critical role in providing space domain awareness (SDA) for the nation.

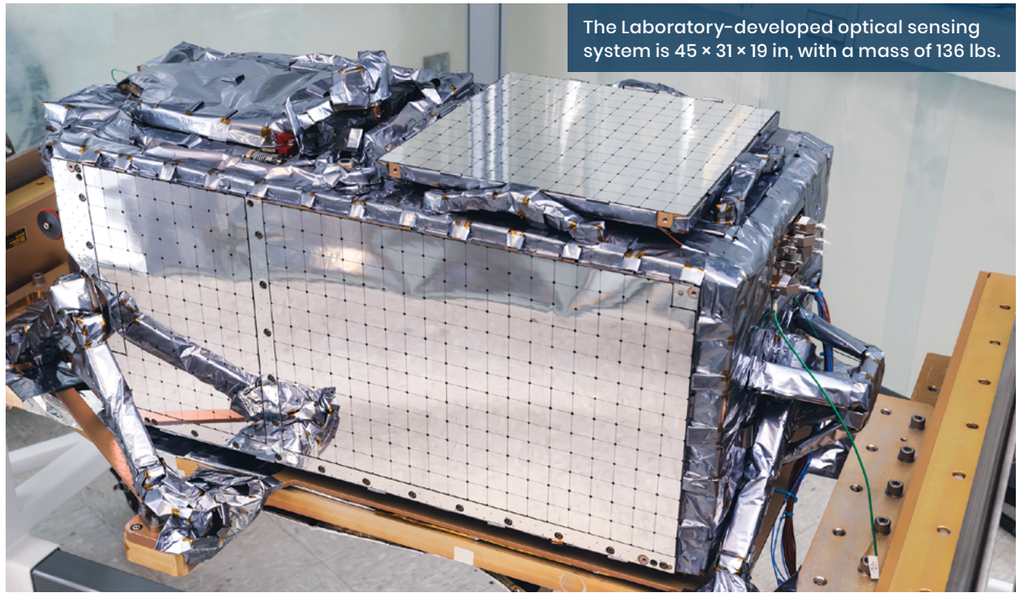
The radars are equipped with specialized transmit hardware that produces extremely high-power signals, sensitive antennas and electronics that can receive weak signals from great distances, and sophisticated signal-processing software — all pioneered by Lincoln Laboratory. We continually upgrade the systems with state-of-the-art technologies to increase their sensitivity and signal processing capabilities. Through these advancements, the radars remain among the most unique and capable systems available to the nation.

The Millstone Hill Radar, with an 84 ft antenna and 3 MW of peak power, operates at L-band (1.3 GHz) and is capable of tracking satellites in deep space 30,000 miles from the Earth and beyond.

In the past year, a team of 20 operators supported more than 200 launch missions; tracked approximately 30,000 satellites that passed overhead; and produced nearly 10,000 satellite images. Their work involves pre-mission planning, fast-paced operations, and data analysis and interpretation.

A rise in worldwide launch activity is increasing the volume and complexity of our radar team's work. In response, we are developing new algorithms to simultaneously detect multiple objects in a radar beam, decision support tools to characterize satellites, and novel tactics to address the evolving challenges in SDA today.

SPACE SYSTEMS & TECHNOLOGY



The Laboratory-developed optical sensing system is 45 × 31 × 19 in, with a mass of 136 lbs.

Joint satellite launch with Japan bolsters space awareness

In 2025, the first of two SDA payloads, called the QZS6-HP1, launched from Tanegashima, Japan. Sponsored by the U.S. Space Force, we designed, built, and delivered the two payloads as part of a partnership program between the United States and Japan called the Quasi-Zenith Satellite System Hosted Payload (QZSS-HP). The program formed as a response to the rise in satellite launches across the globe and a shared interest by both nations to fortify SDA in geosynchronous orbit (GEO).

The Space Force engaged Lincoln Laboratory for this program because of our extensive experience in developing SDA sensors, particularly for the ORS-5/SensorSat satellite, which is a small, low-cost alternative to current U.S. capabilities in detecting and tracking objects in GEO. The QZSS payloads leverage SensorSat's compact optical design that allows their sensors to passively survey the sky with high performance. These payloads also accomplish most of their data processing on orbit, causing a 1,000 times reduction in the size of downlinked data, making them an enabling architecture for bandwidth-constrained missions.

The Lincoln Laboratory team is now finalizing on-orbit testing for QZS6-HP1 and preparing for Space Force operations. The second payload has been integrated onto Japan's QZS-7 satellite and is ready for launch.

AIR, MISSILE, & MARITIME DEFENSE TECHNOLOGY

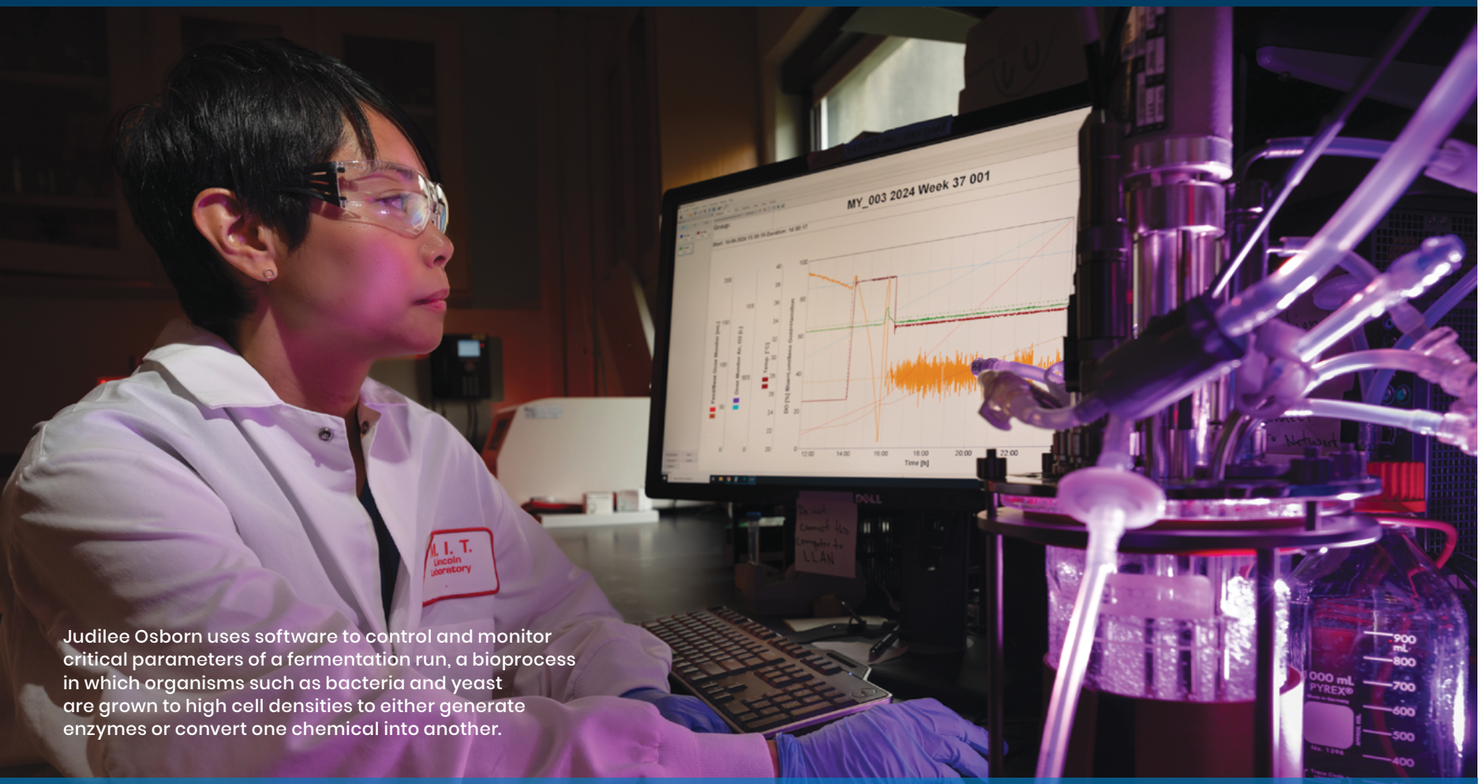
Surface-based sonar could map the deep ocean at unprecedented resolution and speed

Precise and rapid seafloor mapping is important for search and recovery, route optimization, hazard avoidance, and critical infrastructure planning. However, traditional mapping methods cannot simultaneously achieve high resolution and speed. Sonars mounted to autonomous underwater vehicles (AUVs) provide detailed images but move slowly with limited endurance, while sonars mounted to ship hulls cover large areas quickly but fail to capture fine detail.

> **"If proven successful, this technology could greatly improve overall effectiveness of ocean exploration and enable the primary goals of the National Strategy for Ocean Mapping, Exploration, and Characterization."**
>
> **Mashkoor Malik**
> **Chief, Science and Technology Division,**
> **NOAA Office of Ocean Exploration and Research**

We are teaming up with the MIT Department of Mechanical Engineering Ocean Science and Engineering to develop a surface-based sonar system that could map the seabed up to 50 times faster than AUVs and with 100 times the resolution of conventional surface vessels. The final system will feature a fleet of autonomous surface vessels (ASVs) forming a large sonar array. In progressive tests in the Massachusetts Bay area, our team ran their signal processing software to construct precise seafloor maps based on data collected by a large, towed array of sparsely spaced sonar elements, and separately validated that their ASV positioning sensor suite effectively compensated for wave, current, and wind motion that would otherwise corrupt images. Next, we will integrate these capabilities to demonstrate a scalable seafloor mapping system using the towed array and a single independent sonar element on an ASV.

On the Merrimack River, Lincoln Laboratory intern and MIT student Robbie Khazan tests a prototype ASV equipped on the keel with a sonar array for sending and receiving acoustic signals, and above the surface with sensors for relative positioning.



Judilee Osborn uses software to control and monitor critical parameters of a fermentation run, a bioprocess in which organisms such as bacteria and yeast are grown to high cell densities to either generate enzymes or convert one chemical into another.

BOOSTING DOMESTIC INNOVATION

Bringing technology development and manufacturing home is key to driving economic growth and reducing reliance on foreign supply chains. We are strengthening U.S. leadership in technology by fabricating quantum circuits for nationwide research, developing biology-based methods to produce critical defense materials, and advancing next-generation photonic systems for communications and radar.

BIOTECHNOLOGY & HUMAN SYSTEMS

Biomanufacturing secures supply chain for critical defense materials

Access to many critical defense materials, such as rocket propellants and autonomous vehicle protective shielding, is vulnerable to geopolitical conflict. In 2023, the U.S. Government Accountability Office found that more than 90% of defense-critical materials in short supply had only one or no domestic supplier. This lack of supply chain resiliency leaves the nation vulnerable to supply disruptions if mass-producing foreign countries like China cut off access to gain military or commercial advantage.

Lincoln Laboratory has developed new biomanufacturing methods that promise to drive U.S. production of defense-critical materials. These methods use living cells and enzymes as their engines, and abundant, cheap, and domestically available raw materials as their fuel. They break away from traditional chemical synthesis, which relies on expensive materials subject to unstable foreign import conditions and consumes significant energy, leading to high production costs.

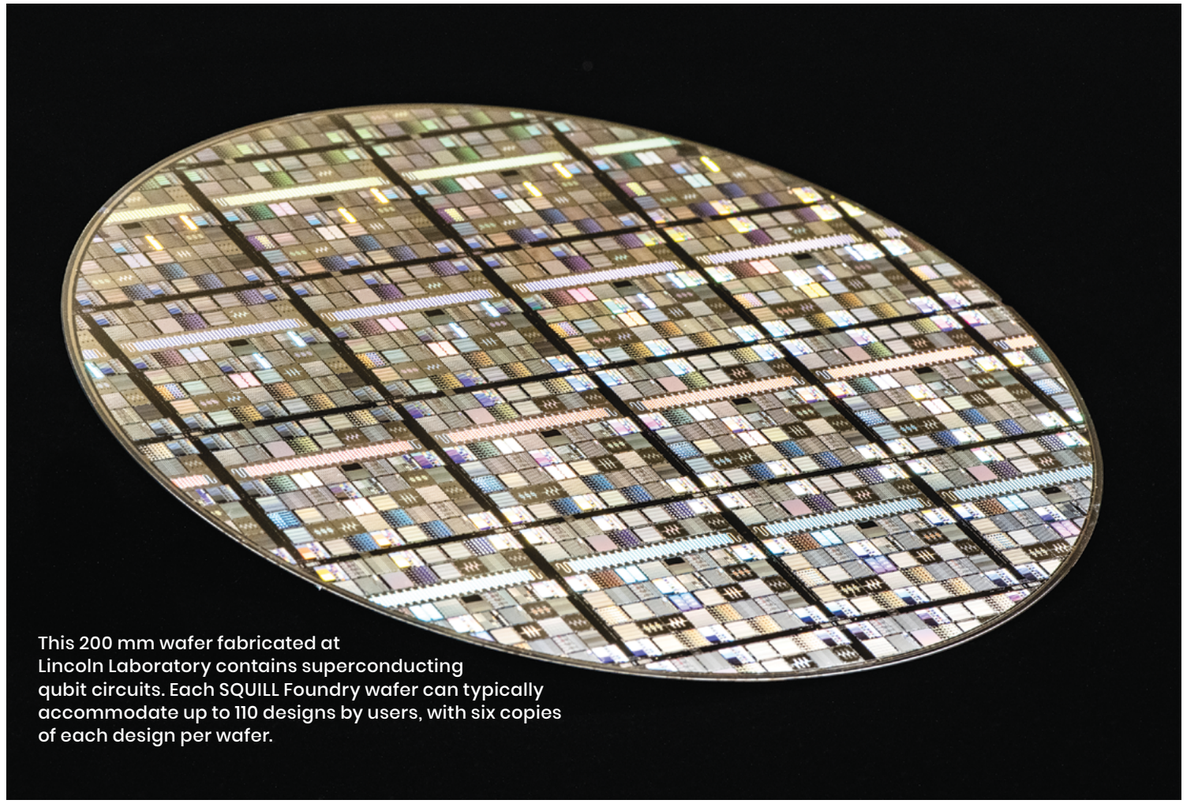
In 2025, the Laboratory became the first to synthesize, through biomanufacturing, a key defense material and critical nitrated products used in propellants.

In 2025, the Laboratory became the first to synthesize, through biomanufacturing, a key defense material and critical nitrated products used in propellants. When scaled, these synthesis techniques could improve U.S. manufacturing self-sufficiency, safety, and hazardous waste management. Next in the pipeline are stronger, cheaper, and on-demand materials for bulletproof applications.

ADVANCED TECHNOLOGY

Superconducting qubit foundry accelerates U.S. quantum research

In the quest to develop a quantum computer, the ability to fabricate high-quality superconducting circuits provides a major advantage. These circuits, when operated at extremely low temperatures, function as quantum bits (qubits), the basic units of data in a quantum computer. However, superconducting qubits are very difficult to fabricate, and a major barrier to groups pursuing this research is the expensive tooling and specialized processes required to make these circuits.



This 200 mm wafer fabricated at Lincoln Laboratory contains superconducting qubit circuits. Each SQUILL Foundry wafer can typically accommodate up to 110 designs by users, with six copies of each design per wafer.

The Superconducting Qubits at Lincoln Laboratory (SQUILL) Foundry is removing this barrier. Sponsored by the Laboratory for Physical Sciences, the program makes our cutting-edge fabrication capabilities available to institutions conducting U.S. government–funded research. Researchers submit quantum circuit designs for fabrication, and the completed circuits are returned to advance scientific inquiry at their home facilities. To date, the SQUILL Foundry has delivered more than 400 fabricated devices to over 30 research groups investigating a range of topics — from probing fundamental questions about quantum information to developing the building blocks of quantum memory.

> **“Through the SQUILL Foundry, we can make complex, coherent devices that enable us to do experiments far beyond what we can achieve with internal fabrication.”**
>
> **Prof. Eli Levenson-Falk**
> **University of Southern California, SQUILL Foundry User**

Lincoln Laboratory has more than 20 years of experience fabricating superconducting qubits with world-class performance. We make the qubits on site at our Microelectronics Laboratory, considered to be one of the U.S. government’s most advanced foundries. SQUILL leverages these tools in a high-mix, low-volume approach that enables the flexibility to produce small quantities of many different devices while maintaining high quality, which is crucial for supporting a large and diverse range of research programs.

SQUILL Foundry BY THE NUMBERS

30
research groups supported across the nation

400
devices delivered to users

20
publications featuring device results

100
academic presentations featuring device results

ADVANCED TECHNOLOGY

Integrated photonics revolutionize microwave systems

Microwave systems are critical to radar and communications, using high frequencies and large bandwidths to enhance target identification, secure data transfer, and counter signal interference. Now, Lincoln Laboratory is delivering photonic integrated circuits (PICs) to advance the next generation of microwave systems.

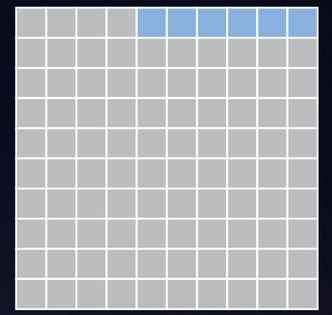
All within a microchip, our PIC platform converts microwave signals into optical signals, processes these signals using photonic components (those that manipulate photons, or light), and then converts them back. Leveraging optical signals offers 180 times larger bandwidth and 1,000 times lower loss compared to conventional electronics. While widely used in telecommunications and data centers, PICs adapted for microwave systems have historically faced performance challenges. After decades of research, our team has now optimized photonic components and materials for microwave applications — developing best-in-class lasers, photodetectors, and modulators, integrating them onto a silicon substrate, and connecting them via waveguides to route light through the chip. The ability to conduct all fabrication steps under one roof is unique to Lincoln Laboratory.

Government and industry are now field-testing and applying our PIC technology in microwave systems. Recent breakthroughs include a microwave filter for isolating desired frequencies and the world's first millimeter-wave tunable down-converting receiver for processing high-frequency signals. Concurrently, we are making our microwave PIC platform available to multiple industry partners, fostering an ecosystem for U.S. microwave innovation.

This photonic integrated circuit (measuring 3 x 0.5 cm) contains all the photonic components required for filtering and frequency down-converting millimeter-wave signals.

Breakdown of Laboratory Program Funding

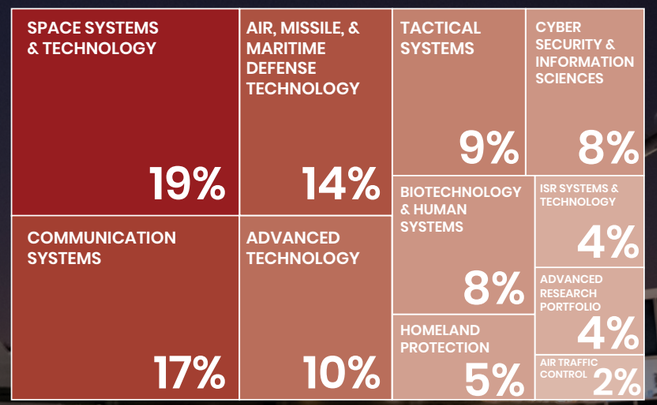
OUR FUNDING BY SPONSOR



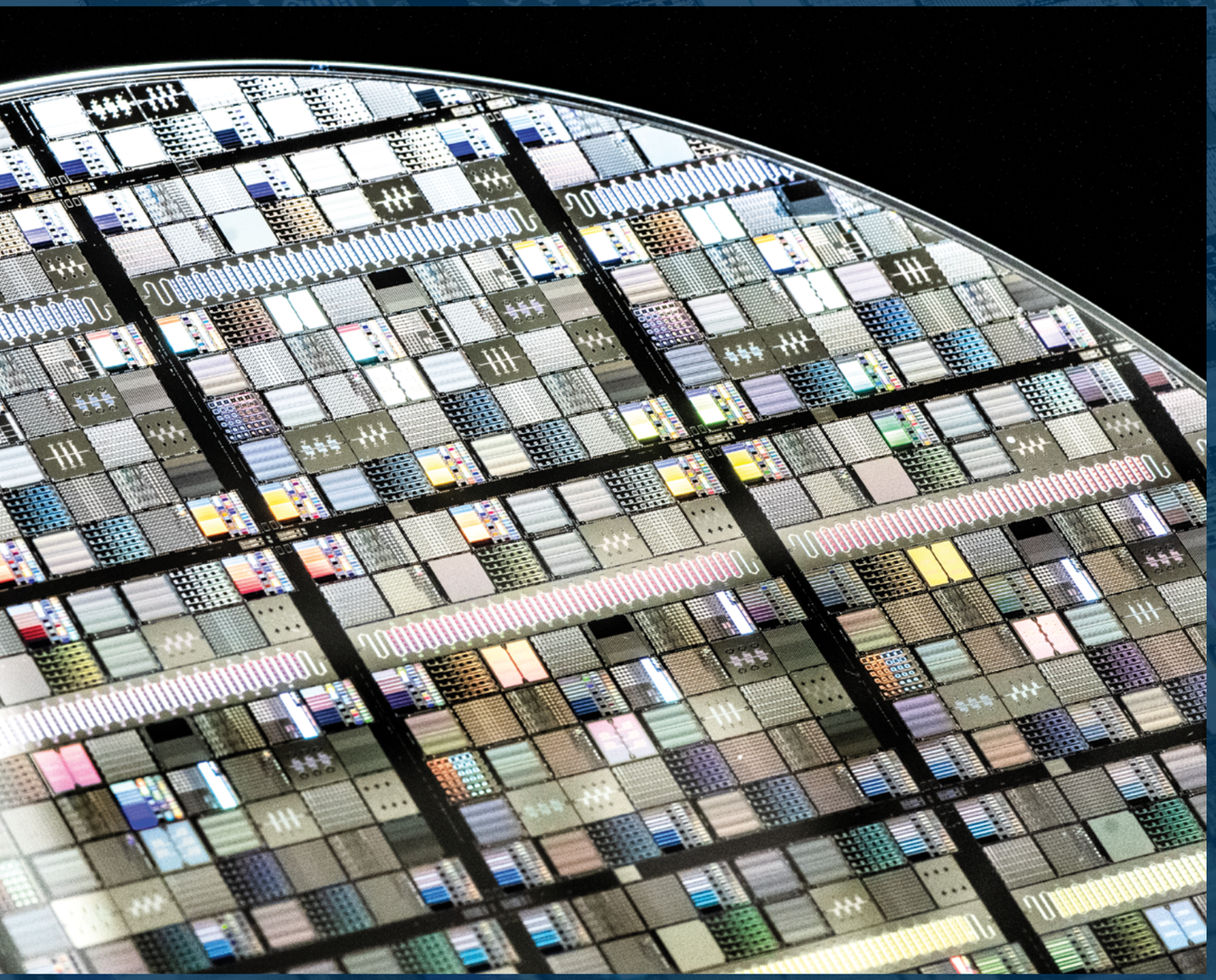
94% Department of War

6% Non-Department of War

OUR FUNDING BY MISSION AREA



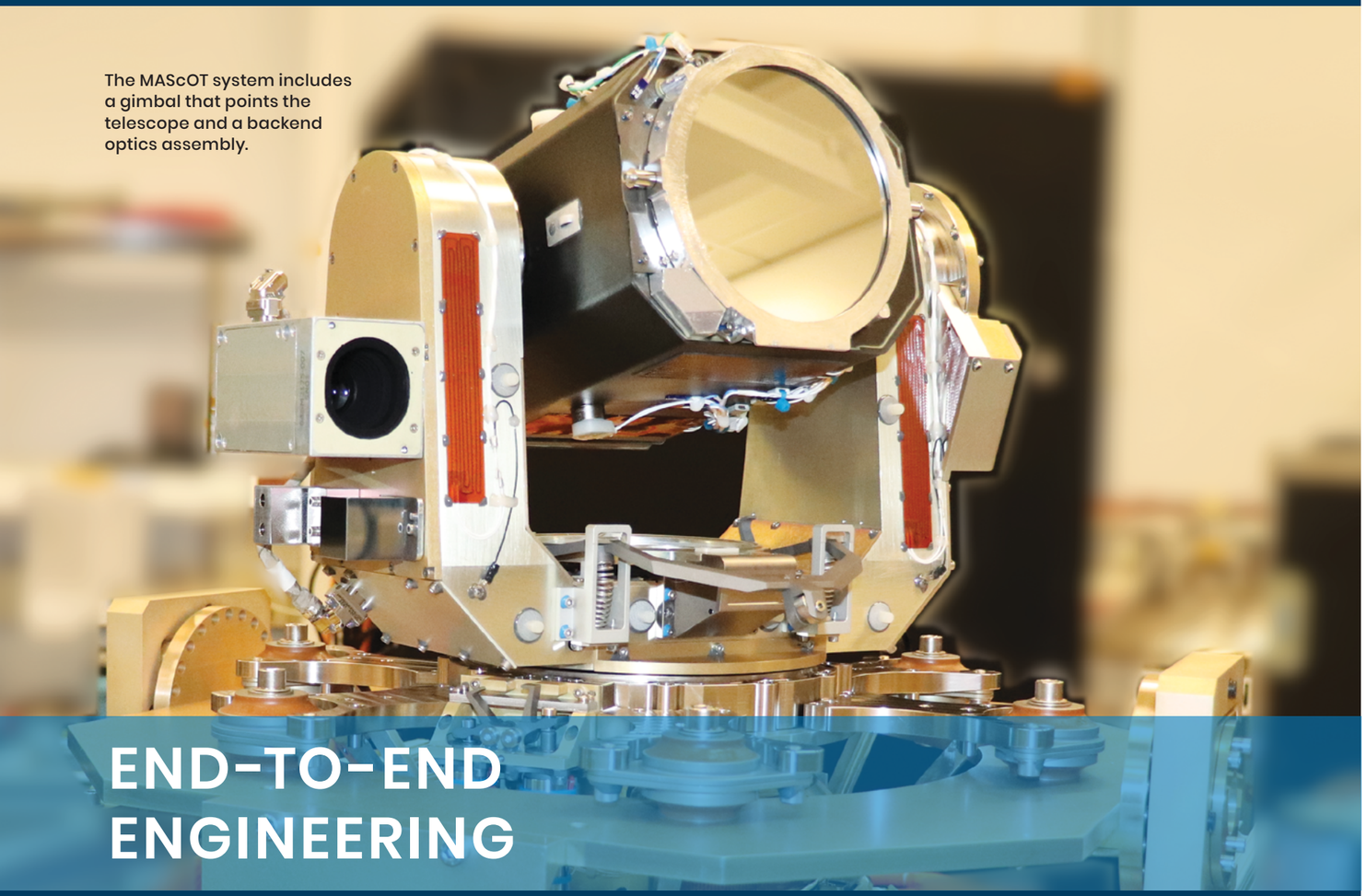
An ultrahigh-frequency radar antenna sits atop a Laboratory building.



CHAPTER 03

Our R&D Engine

We transform bold ideas into prototypes, harness collaborations, and transition technology to real-world use.



The MAScOT system includes a gimbal that points the telescope and a backend optics assembly.

END-TO-END ENGINEERING

Prototype engineering is at the core of Lincoln Laboratory's work, involving 60% of programs and yielding more than 11,000 manufactured parts in 2025. Our skilled workforce and vertically integrated facility ensure rapid development cycles, deliver operational capabilities, and support technology transfer to industry.

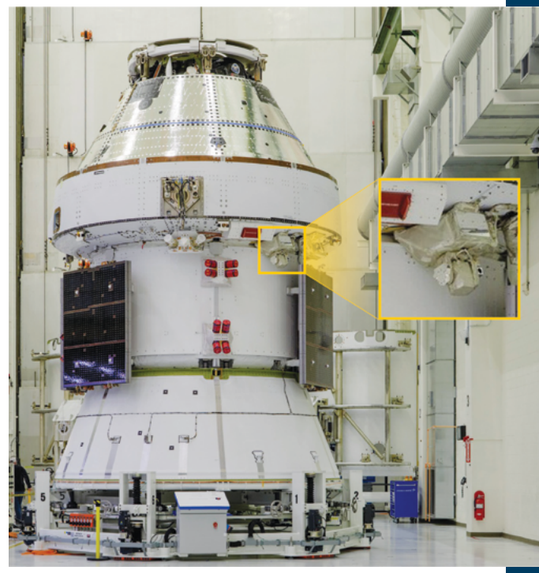
COMMUNICATION SYSTEMS | ENGINEERING

Optical terminal serves as NASA's next-generation lunar laser communication system

Developed at Lincoln Laboratory through its advanced engineering capabilities, the Modular, Agile, Scalable Optical Terminal (MAScOT) was installed on NASA's Artemis II Orion spacecraft at Kennedy Space Center in 2025. The terminal was designed to demonstrate laser communication (lasercom) technologies, which are poised to revolutionize how spacecraft communicate.

About the size of a house cat, MAScOT integrates a four-inch telescope mounted on a two-axis gimbal for precise pointing and tracking of laser beams. Its backend optics assembly includes light-focusing lenses, tracking sensors, fast-steering mirrors, and other components that enable fine control of the laser beam for high-speed data transmission.

MAScOT first demonstrated its capabilities as part of the Integrated Laser Communications Relay Demonstration (LCRD) Low Earth Orbit (LEO) User Modem and Amplifier Terminal (ILLUMA-T), which launched to the International Space Station in November 2023. ILLUMA-T transmitted data to NASA's LCRD satellite 22,000 miles above Earth's surface, and LCRD subsequently relayed the communications to ground stations, successfully demonstrating the first two-way, end-to-end lasercom relay system.



MAScOT is shown installed on the exterior of the Artemis II Orion spacecraft.
Photo: Rad Sinyak, NASA

Our engineers seamlessly integrated design, fabrication, analysis, controls, rapid prototyping, and optical and digital engineering to realize a single terminal that could be deployed in LEO for ILLUMA-T and cislunar orbit for Artemis II. This multidisciplinary approach has ensured MAScOT's reliability and performance for these vital missions and is poised to enable industry to replicate the terminal for future space communications.

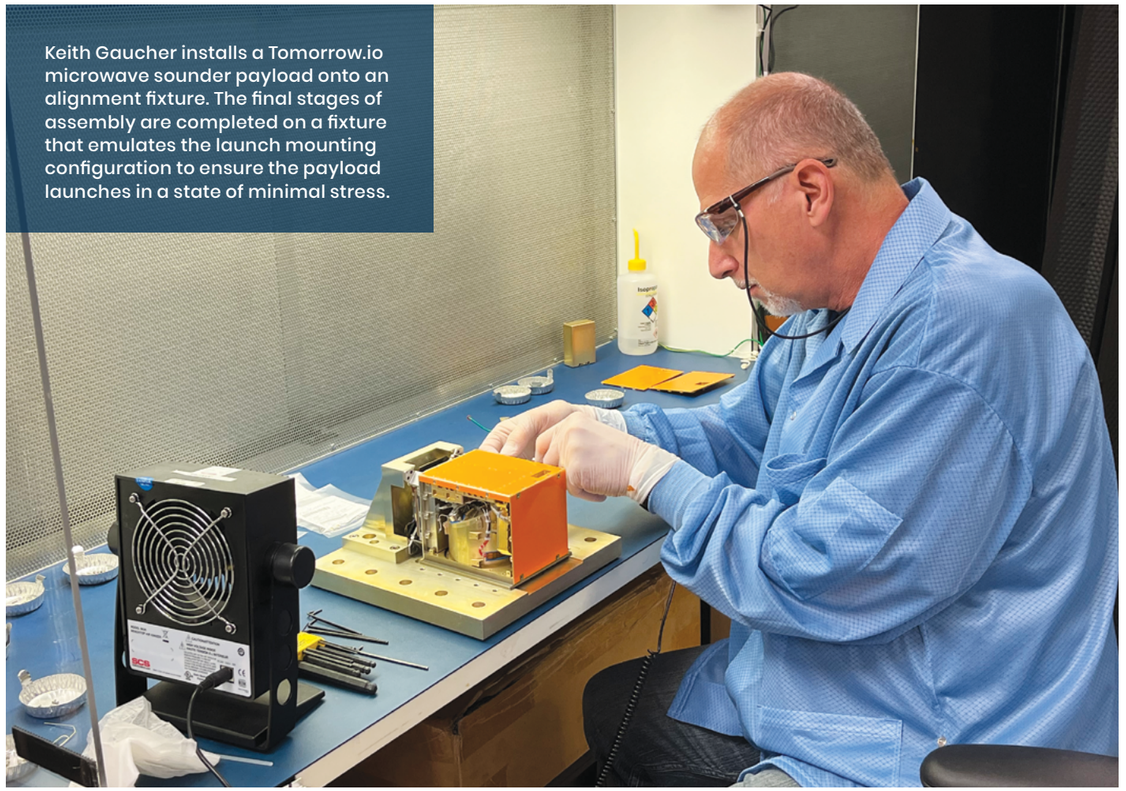
SPACE SYSTEMS & TECHNOLOGY | ENGINEERING

High-performance weather instruments transition to industry

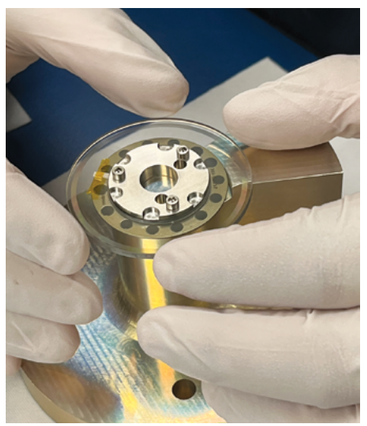
In 2023, Lincoln Laboratory commissioned a five-satellite constellation for NASA's TROPICS (Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of SmallSats) mission. The satellites hosted a unique, miniaturized version of an instrument called a microwave sounder, which typically makes measurements of atmospheric humidity, temperature, and precipitation from very large, multibillion-dollar satellites.

Through years of iterative prototyping, our researchers and engineers developed and ruggedized a miniature microwave sounder. The resulting sensor is 100 times smaller than a traditional sounder at just 2% of the cost, making it ideal for low-cost CubeSat constellations. By distributing sounder functionality across multiple smaller satellites, constellations enhance forecasting through higher revisit rates over rapidly intensifying storms and mitigate mission risks from single-satellite failures. Our vertically integrated engineering facility enabled in-house design, analysis, machining, assembly, and testing of the miniaturized payload, ensuring the success of the TROPICS mission.

A commercial company, Tomorrow.io, has since licensed the microwave sounder technology. Transitioning our expertise to industry required engineer-to-engineer training and technician-to-technician interactions to transfer the nuances of a vertically integrated prototyping facility to a team of multiple industry vendors. Tomorrow.io has completed its fully operational constellation and will continue to replenish the constellation of more than 20 sounder-equipped CubeSats by 2028. Tomorrow.io will continue to improve weather forecasts for global customers, including the U.S. government.



Keith Gaucher installs a Tomorrow.io microwave sounder payload onto an alignment fixture. The final stages of assembly are completed on a fixture that emulates the launch mounting configuration to ensure the payload launches in a state of minimal stress.

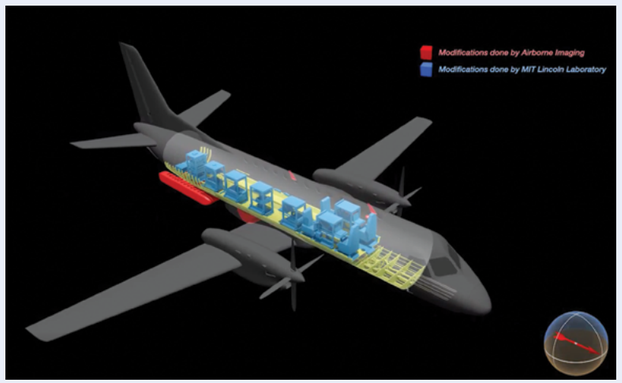


Buried deep in the rotating portion of the payload is an optical encoder. A laser reads a reflective signal off of a precision pattern around the outer diameter of the glass disc shown here.

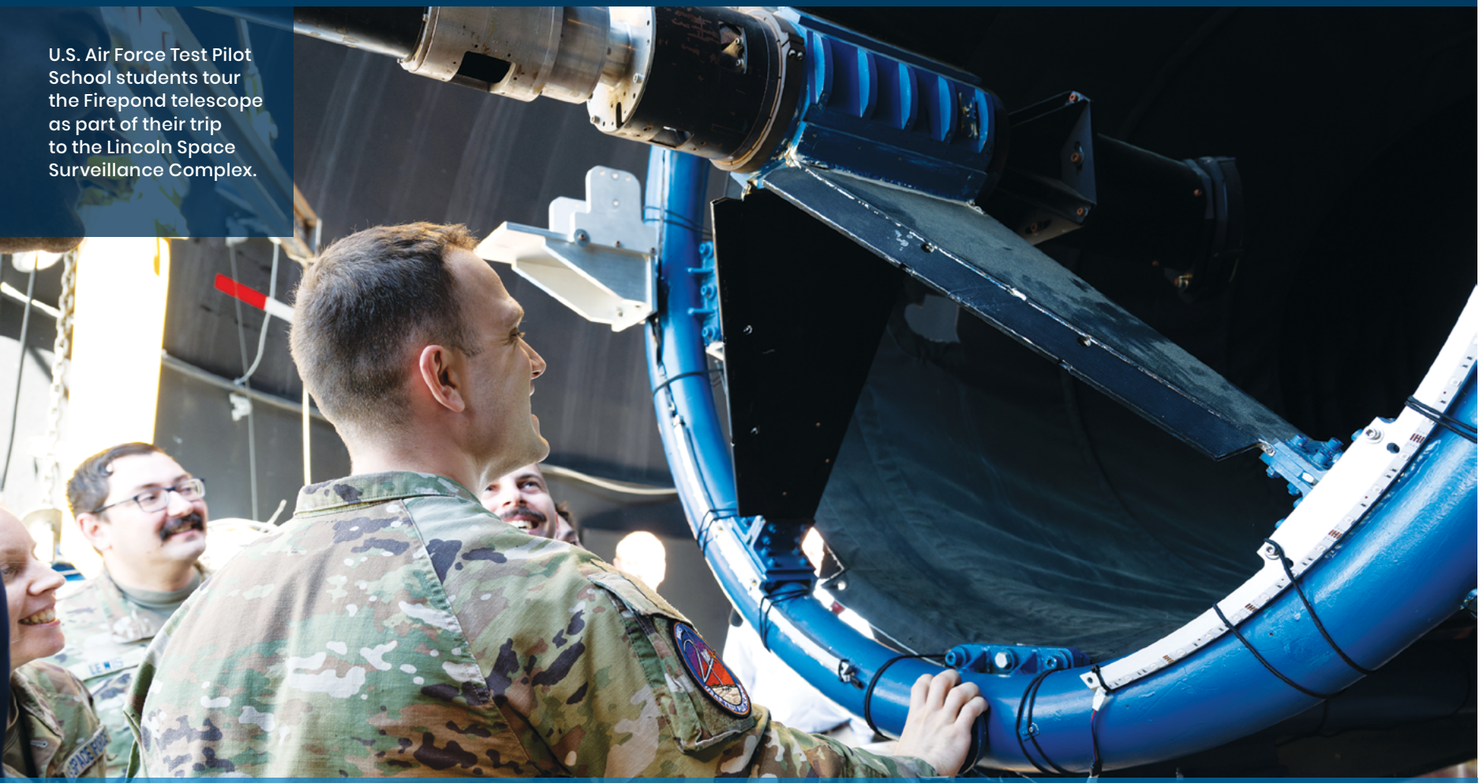
Digital engineering streamlines development

As part of our Laboratory-wide digital transformation initiative, we are leveraging digital engineering tools to streamline design and development processes. During the development of a test bed aircraft, digital engineering tools and augmented reality (AR) headsets enabled immersive design reviews. Representatives from the sponsor organization toured an AR model of the aircraft, providing real-time feedback on equipment placement and human factors considerations. This process eliminated the need for design change orders, accelerating development timelines.

Building on the success of the test bed's design phase, we used our latest investments in product lifecycle management tools to track equipment and software configurations from each test event. This capability is further accelerating development processes and providing agile flight services while maintaining compliance with FAA rules and regulations.



Digital engineering tools allow researchers to use virtual 3D models for simulating modifications to test beds, such as the Lincoln Laboratory Airborne Radar Testbed hosted on a Saab 340B aircraft.



U.S. Air Force Test Pilot School students tour the Firepond telescope as part of their trip to the Lincoln Space Surveillance Complex.

MILITARY & ACADEMIC COLLABORATIONS

Through a combination of military fellowships, educational partnerships, and joint research programs, we connect military officers with cutting-edge technology and apply academic breakthroughs to national security challenges. These engagements help us bridge the gap between research and operations.

Training future leaders of the Space Force

We partner extensively with the U.S. Space Force to develop the next generation of technology-savvy Guardians. The Space Force sends approximately 50 students to Lincoln Laboratory each year to participate in educational opportunities.

Graduate Degree Programs

Through Lincoln Laboratory's Military Fellows program, the Space Force funds Guardians to study at MIT for an advanced academic degree. We offer co-advisors and research opportunities to each student in the program. To date, nearly 50 advanced degrees have been awarded to Space Force graduates.

Space Technology Acquisition and Research Course

Lincoln Laboratory has hosted a military Training and Education Detachment on site since 2016. Each year, the detachment hosts four 30-day courses for competitively selected Guardians who visit the Laboratory to learn about space security. The objective is for students to understand the use of advanced technology for their missions and return to the Space Force with ideas for how technology can shape future operations.

Space Test Course

As part of the Air Force Test Pilot School's Space Test Course, students visit Lincoln Laboratory to learn about effective space testing through briefings, a tour of the Lincoln Space Surveillance Complex, and hands-on exercises. For example, the students plan and execute radar collections, analyze test data, and mitigate electromagnetic interference.

> **"Our visit to Lincoln Laboratory was by far the best learning experience in the Space Test Course. I appreciated being able to truly focus on executing a test — going from theory to simulation, working from hardware-in-the-loop testing, and then progressing to live testing."**
>
> — **Test Pilot School student**

Military Fellows

Each year, the Lincoln Laboratory Military Fellows Program awards fellowships to active-duty military officers who are enrolled in a graduate school program in the Boston area or who are completing requirements for advanced education at senior service schools.

The program seeks to support the education of service members while involving them in R&D that addresses critical technology needs of the military. A few of their research projects from this year are highlighted below.

500+
military fellows have worked at the Laboratory since 2011

23
military fellows participated in 2025

Securing AI systems against cyberattacks

The U.S. Army has been increasingly using AI systems for intelligence and command and control operations, but these systems can be vulnerable to adversary interference. Army Col. and military fellow Ian Fleischmann conducts research on counter-AI, or how AI for defense systems can be made more resilient against attacks.

Military fellow Ian Fleischmann researches ways in which the Army can better protect its AI systems against cyberattacks.

"My research is focused on how the Army will need to adapt organizations and policies to effectively implement the counter-AI protocols required by emerging threats," Fleischmann says. He alternates between taking courses in the MIT Security Studies Program and coming to the Laboratory to review literature, interview staff, and attend technical seminars that could aid his research.

"Inspiration comes in lots of ways, and some of the most thought-provoking ideas I've encountered have come from attending seminars at the Laboratory that I otherwise would have never had the opportunity to hear," Fleischmann says. "There are a ton of projects here that would be hugely beneficial to the Army. Someday, I'd love to convince the Army to send me back to the Laboratory as a liaison to help connect teams to potential sponsors."


Military fellow Kelsey Monaghan-Bergson works alongside Laboratory staff to analyze information operations in the Arctic.

> **"The goal is to design systems that adapt to human communication patterns, helping Space Force operators process information quickly; avoid misinterpretation; and make clear, confident decisions in uncertain or contested information environments."**
>
> **Military fellow Kelsey Monaghan-Bergson**

Communicating in extreme environments

The military, civilian, and scientific communities in the Arctic rely on information from satellite systems for many functions. But the harsh Arctic conditions present challenges for properly receiving, interpreting, and protecting this information. As a military fellow, U.S. Space Force 2d Lt Kelsey "Zippy" Monaghan-Bergson is studying how approaches for U.S. space systems defense can better account for the unique challenges of operations in the Arctic — in particular, the need to safeguard orbital veracity, or the reliability and integrity of information produced or transmitted by space-based systems. On a micro level, Monaghan-Bergson seeks to understand how narrative choices in a message impact perception, legitimacy, and decision-making under stress. The objective is to strengthen how the military communicates, counters adversarial narratives, and preserves informational advantage in contested environments.

Working at the Laboratory reinforced for Monaghan-Bergson an important lesson: today's challenges cannot be solved by technology alone — they require human-centered approaches that consider ethics, culture, and the lived realities of the people these systems ultimately affect.

"This fellowship has been a testament to the inseparable bond between STEM and the humanities and social sciences. Too often, we frame them as opposites, when, in reality, they are codependent forces shaping how we understand, design, and defend our world," she says.

AI for the Air Force

The AI Accelerator is a three-way collaboration between Lincoln Laboratory, MIT, and the Department of the Air Force to make fundamental advances in AI for defense.

Autonomy for rescue missions

One project is developing algorithms for autonomous vehicles to support personnel recovery missions in conflict and disaster zones. The envisioned fleet will locate distressed individuals and provide rescuers with real-time data analysis for safe recovery. The project team earned the 2025 AI Accelerator Directors' Award for its exceptional collaboration with the Air Force Special Operations Command.

At the Devens Reserve Forces Training Area in Lancaster, Massachusetts, researchers collect flight data from a small autonomous aircraft. Photo: Major Stephanie Riley, U.S. Air Force

> **"The close collaboration between Airmen and Guardians; the faculty, researchers, and students at MIT; and MIT Lincoln Laboratory continues to pay dividends for national security."**
>
> **Col. Scott Ruppel**
> **Department of the Air Force director of the AI Accelerator**

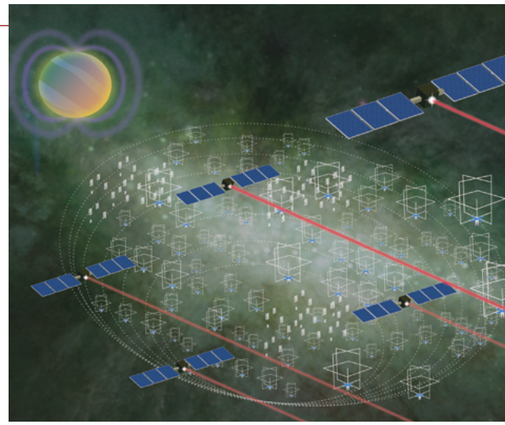
Techniques to secure networks

Another project is combatting cyberattacks through innovations in network sensing and analysis. Capabilities have been adopted by leading AI companies such as Nvidia, integrated into the U.S. Cyber Command's cyber training environment, and used by the Air Force to uncover massive spoofing capabilities. In addition, the team's AI policy analyses have influenced government policy, Air Force doctrine, and global copyright practices. For these achievements, the team received the 2025 AI Accelerator Transition Award.

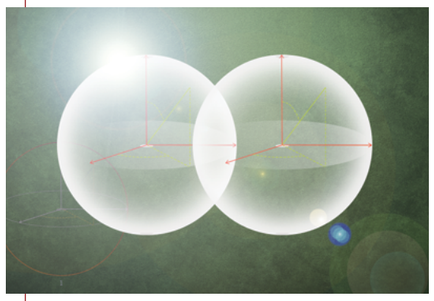
MIT research highlights

A new telescope for the cosmos

In collaboration with the MIT Haystack Observatory and Lowell Observatory, we are designing a telescope comprising thousands of tiny satellites that will work together to reveal low-frequency radio waves in space for the first time. Called the Great Observatory for Long Wavelengths (GO-LoW), the satellite constellation will yield detailed data about exoplanets in the solar neighborhood. The NASA-funded concept study is one example of Lincoln Laboratory technology finding dual use for civil space missions. "Like landing on the Moon in 1969 or launching Hubble in 1990, GO-LoW is envisioned to let us see something we've never seen before," says Laboratory scientist Kat Kononov.



The Go-LoW telescope's approach uses a constellation of small satellites to study objects in space that emit low-frequency radio waves.
Illustration: Nancy Kotary, MIT Haystack Observatory



Researchers demonstrated extremely strong nonlinear light-matter coupling in a quantum circuit.
Image: Christine Daniloff, MIT

Practical quantum applications

We are participating in a new MIT initiative aimed at advancing the most significant practical applications of quantum technology for science, industry, and national security. Called QMIT, the initiative is a natural expansion of the Center for Quantum Engineering, a research powerhouse that engages more than 80 principal investigators across Lincoln Laboratory and MIT. One collaborative project in 2025 achieved a significant breakthrough toward building a fault-tolerant quantum computer. Researchers achieved a type of coupling between artificial atoms and photons that could enable readout and processing of quantum information in a few nanoseconds.

Solutions for SOCOM

Launched in collaboration with the Special Operations Command's Acquisition, Technology, and Logistics (SOCOM AT&L) directorate, the SOCOM Ignite program addresses challenges facing warfighters while fostering ingenuity in future military leaders. Starting in 2020 with just eight Reserve Officers Training Corps cadets, the program has now grown to host more than 100 cadets annually from universities and service academies across the country. These cadets collaborate year-round with Lincoln Laboratory technical mentors and Special Operations Forces operators to develop technology solutions, ranging from an autonomous surface vessel kit to a LEO satellite tracker. For the first time in 2025, all joint components of SOCOM participated in the program.

This 200 mm wafer features superconducting quantum circuits supporting a project to improve computer power efficiency by orders of magnitude.

TECHNOLOGY INVESTMENTS

We invest in emerging concepts and mission-critical technology, opening new possibilities for the nation. Through a selective process, technical staff pursue projects that pose ambitious questions across critical research areas, from quantum systems to biotechnology.

Technology Office

The Technology Office oversees Lincoln Laboratory's strategic technology investments and cultivates technical partnerships beyond the Laboratory. By regularly engaging with the Office of the Under Secretary of War for Research and Engineering (OUSW [R&E]) and other government entities, we identify both long-term and emerging national security priorities. We then administer funding provided by OUSW (R&E) to drive the development of new capabilities to address those needs.

This R&D funding, which is independent of our government-sponsored research program funding, fosters an innovation pipeline. Technologies initiated through this investment portfolio often progress into sponsored research programs within a core mission area; are acquired at a classified level by the DoW; or are licensed and commercialized for the benefit of the U.S. economy, security, and society.

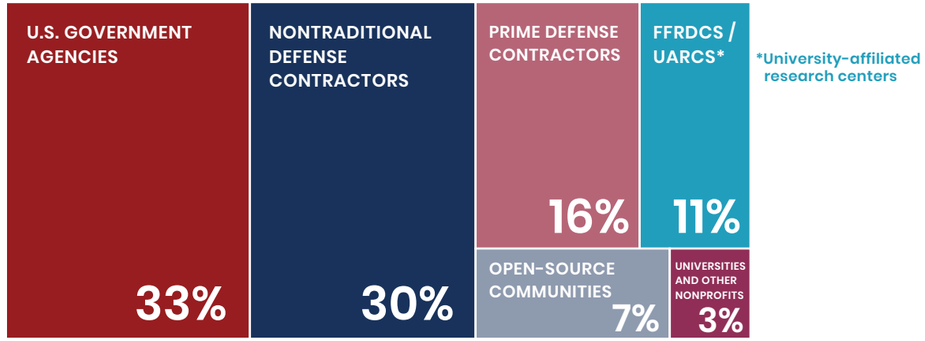
30%

of the Laboratory's sponsored programs each year can be traced to R&D that began with Technology Office investment

To support these objectives, the Technology Office also fosters collaborations with MIT and other universities, and spearheads initiatives to encourage an innovative culture at the Laboratory.

Technology investment outcomes

Our internal portfolio advances capabilities across the defense and innovation ecosystem. From 2021 to 2025, Technology Office investments resulted in 123 technology transfers to recipients in the following categories.

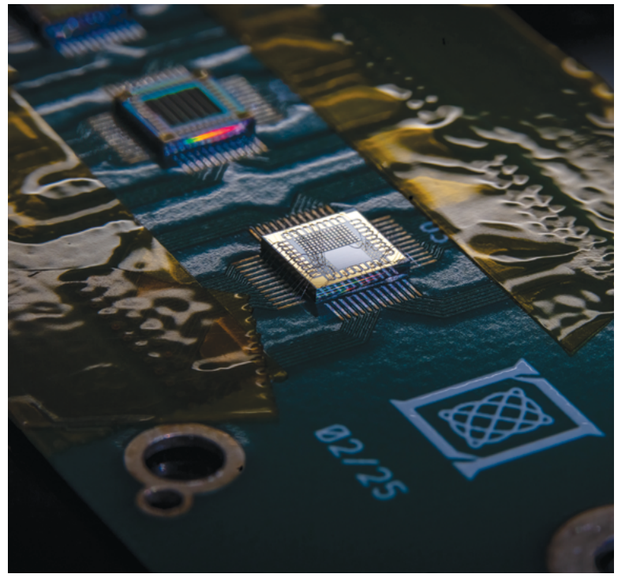


ADVANCED DEVICES

Can superconducting computing power the next generation of AI?

Modern data centers consume enormous amounts of power. As AI applications expand, more powerful and efficient computing infrastructure is needed to meet growing demands. Superconducting electronics, using quantum effects of Josephson junctions rather than transistors, use 100,000 times less power than conventional transistors per basic switching operation. Once cooled to cryogenic temperatures, superconducting computing chips could in principle reduce power consumption by up to 100 times compared to traditional semiconductors. This efficiency could also enable powerful AI capabilities at the tactical edge where power is limited.

We are tackling the technological challenges of scaling superconducting electronics to deployable and data-center-sized systems. In 2025, we achieved a significant milestone: fabrication of our first-generation superconducting computing core chip. Comprising 15,000 Josephson junctions and 50,000 inductors, the chip is now undergoing evaluation at the Laboratory to test key capabilities, such as memory storage and floating-point instructions. Building on this work, we will continue to improve superconducting chip architectures, memory systems, and multicore interconnects — scaling to compete with cutting-edge silicon graphics processing units and tensor processing units.



This wire-bonded chip contains superconducting circuits designed to drive radical advancement in computer power efficiency.

In 2025, we fabricated a first-generation superconducting computing core chip. Comprising 15,000 Josephson junctions and 50,000 inductors, the chip is now undergoing evaluation at the Laboratory to test key capabilities.

In collaboration with the MIT Center for Bits and Atoms, researchers are spinning out a startup company, Adiabatic Machines, to accelerate the commercial transition of this technology.

CRITICAL INFRASTRUCTURE TECHNOLOGIES

Can growing vine robots reach where humans can't?

When buildings collapse, victims can become trapped within unstable, inaccessible piles of rubble. To assist responders in navigating these hazardous environments, we are developing soft, growing "vine" robots capable of extending into tight, confined spaces while carrying sensors along their length. Unlike rigid tools such as telescoping cameras, these flexible robots can safely maneuver through complex environments — pipelines, engines, and collapsed structures — without endangering human lives.

Capable of extending dozens of meters, our vine robots represent a significant advancement in continuum-robot design, control, and embedded sensing. Integrated fibers equipped with acoustic and inertial sensors collect environmental data at multiple points along the robot's body, enabling precise navigation and real-time information sharing with operators. Advanced algorithms fuse auditory and positional data, allowing the robots to locate sound sources in confined spaces.

This technology has broad applications in national security, including battle damage assessment, infrastructure inspection, and urban search and rescue. In collaboration with researchers at Notre Dame University, we have prototyped a vine robot system that is now undergoing field testing.

The prototype vine robot penetrates void spaces in an engineered collapsed building at the Massachusetts Task Force 1 training facility in Beverly, Massachusetts.

AUTONOMOUS SYSTEMS

Can game theory outmaneuver adversaries in real time?

Military combat operations such as aerial dogfighting require split-second decisions and high-skill maneuvers against intelligent adversaries. Such demands have long kept these operations under human control. More recently, efforts in autonomous decision-making for adversarial scenarios have relied on machine learning techniques that require massive amounts of training data and can behave unexplainably. Our Edge-Compute Differential Game Solver (EDGES) offers a fundamentally different solution. Using differential game theory, EDGES mathematically models competing agents' dynamics and then leverages optimal control principles to solve for the best action against multiple adversaries at any moment in time. By repeatedly solving this problem with real-time feedback, EDGES keeps a combat agent's tactics current with opponents' latest maneuvers.

Above Edwards Air Force Base, the X-62A VISTA test aircraft (red) demonstrated the first AI-piloted dogfight in 2024. EDGES builds on this work, using game theory to compute optimal actions in real time. Photo: Richard Gonzales, U.S. Air Force

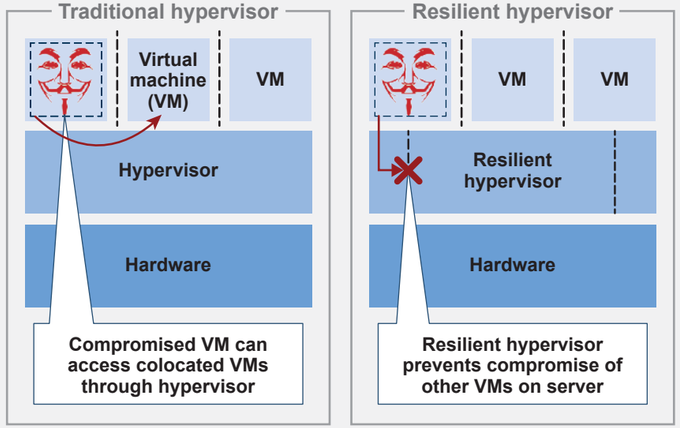
EDGES algorithms can produce decisions in fractions of a second on board an aircraft. In 2025, EDGES solved simulated fighter maneuvers between two F-16 aircraft, one of the most complex problems ever tackled with game theory. Looking ahead, we will also apply EDGES to improve counter-drone swarm planning and support autonomous satellite maneuvering.

CYBERSECURITY

Can cloud and virtual machines be mission secure?

Hypervisors are a type of software foundational to cloud computing, enabling data centers to manage thousands of virtual machines. Both the DoW and the intelligence community rely on cloud infrastructure and virtualized environments for mission-critical operations. However, our study on zero-trust security has identified that hypervisors require fundamental redesigns to achieve true resilience against cyberattacks. Current hypervisor security relies on eliminating vulnerabilities through bug-finding techniques and specialized hardware. In contrast, our resilient hypervisor, Hy-Rez, acknowledges that vulnerabilities are inevitable and neutralizes them to prevent exploitation. Hy-Rez achieves resilience through compartmentalization, dividing the hypervisor into smaller, isolated components with limited privileges. This design ensures that a vulnerability in one component cannot compromise an entire system.

Today, modernization efforts across the DoW are shifting to cloud and virtualized setups, making a resilient hypervisor increasingly critical. Hypervisors will underly swaths of capabilities, from submarines to satellite ground systems, and form the backbone of Joint Cyber Warfighting Architecture and Joint All-Domain Command and Control networks unifying warfighters and their systems. To transition Hy-Rez into operational use, we are pursuing open-source commoditization and collaborating with industry leaders such as Amazon Web Services, Google, and Red Hat to accelerate adoption.



The Hy-Rez technology uses compartmentalization techniques to isolate compromised virtual machines.

AUTONOMOUS SYSTEMS

Can human-AI teaming dive underwater?

Advances in AI are enabling intelligent teamwork between humans and machines. But this teaming has yet to be brought underwater because of significant hurdles in real-time communication, perception, and navigation. Working with the MIT CSAIL Marine Robotics Group, we are developing navigation and AI perception algorithms and supporting hardware that integrate the complementary strengths of humans and autonomous underwater vehicles (AUVs). Humans excel at interpreting ambiguous information and classifying objects, while AUVs are adept at collecting, processing, and distilling quantitative sensor data. By bridging these strengths, we aim to optimize diver-robot teaming during critical infrastructure inspection and repair, search and rescue, harbor entry, countermine operations, and other maritime missions of the U.S. military.

Ella Wawrzynek, Madeline Miller, and David Whelihan deploy their sensor-equipped AUV into the Atlantic Ocean.

Scan to watch video
Human-machine teaming dives underwater

BIOMEDICAL SCIENCES & TECHNOLOGIES

Morgan Burt extracts a sample from enzyme-converted O whole blood for downstream analysis.

Can all blood types be universal?

Imagine a future where medics, whether on the battlefield or in remote disaster zones, can make any blood donation compatible with any recipient. Each year, a unique Technology Office Challenge is presented to the Laboratory community to tackle an emerging national security problem. The 5T (Triage, Transmit, Track, Transport, and Train) Casualty Care Challenge focused on enhancing the DoW's capabilities to respond to mass-casualty events. The winning concept proposed using enzymes to cleave B and A blood antigens, thereby making any blood type universally compatible.

Now funded under our investment portfolio, this concept could bolster blood supplies in combat and disaster-response scenarios, addressing needs identified by the Defense Health Agency. The research team is initially focused on converting type B whole blood into universal type O whole blood, with the long-term goal of expanding universal compatibility to 99% of blood donations. The team is also building portable blood-conversion devices that can be deployed in the field to support blood-type conversions at the point of injury. Ensuring that donor blood is available to anyone, anywhere, represents a major frontier in emergency medicine.

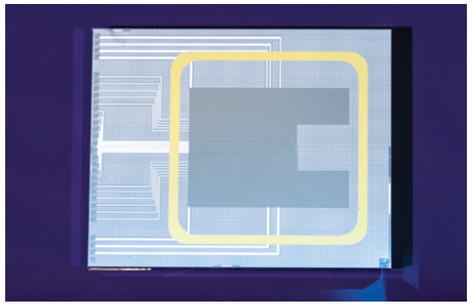
Blood is applied to an EldonCard to verify successful B-to-O conversion.

QUANTUM SYSTEM SCIENCES | INTEGRATED SYSTEMS

Can optical clocks be truly portable?

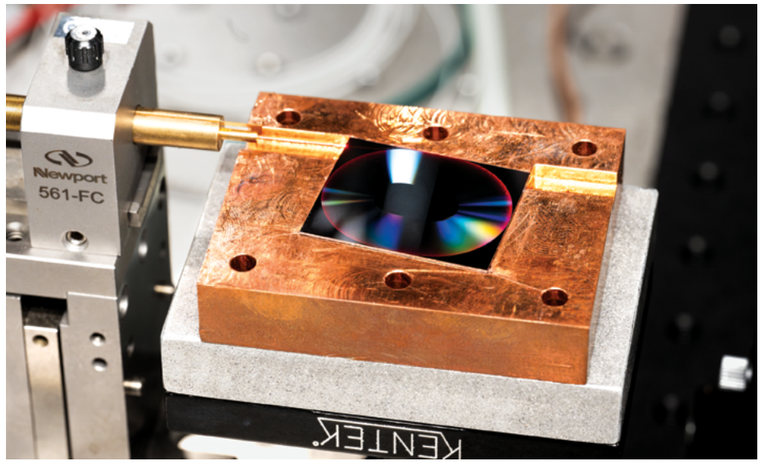
Optical clocks achieve exceptional precision by using lasers to monitor narrow optical transitions of ions or atoms, making them 100 to 1,000 times more accurate than microwave clocks. However, optical clocks typically require bulky and stable setups, making them impractical to field. In collaboration with NASA's Jet Propulsion Laboratory (JPL), we are developing a compact optical clock system that fits within a cubic-liter-scale package.

Our team is contributing the clock's ion trap integrated with photonics. Within a small chip, integrated waveguides deliver and focus laser light on an ion confined above the chip's surface to probe and read out its frequency. We are also developing an ultrastable integrated resonator to enable an on-chip narrow-linewidth laser that serves as the clock's local oscillator. Concurrently, JPL is designing a miniature, all-titanium vacuum package to provide a controlled environment to house the ion trap. We aim to demonstrate clock stability with errors as small as 10^{-16}, far exceeding the performance of previous-generation microwave clocks or masers.

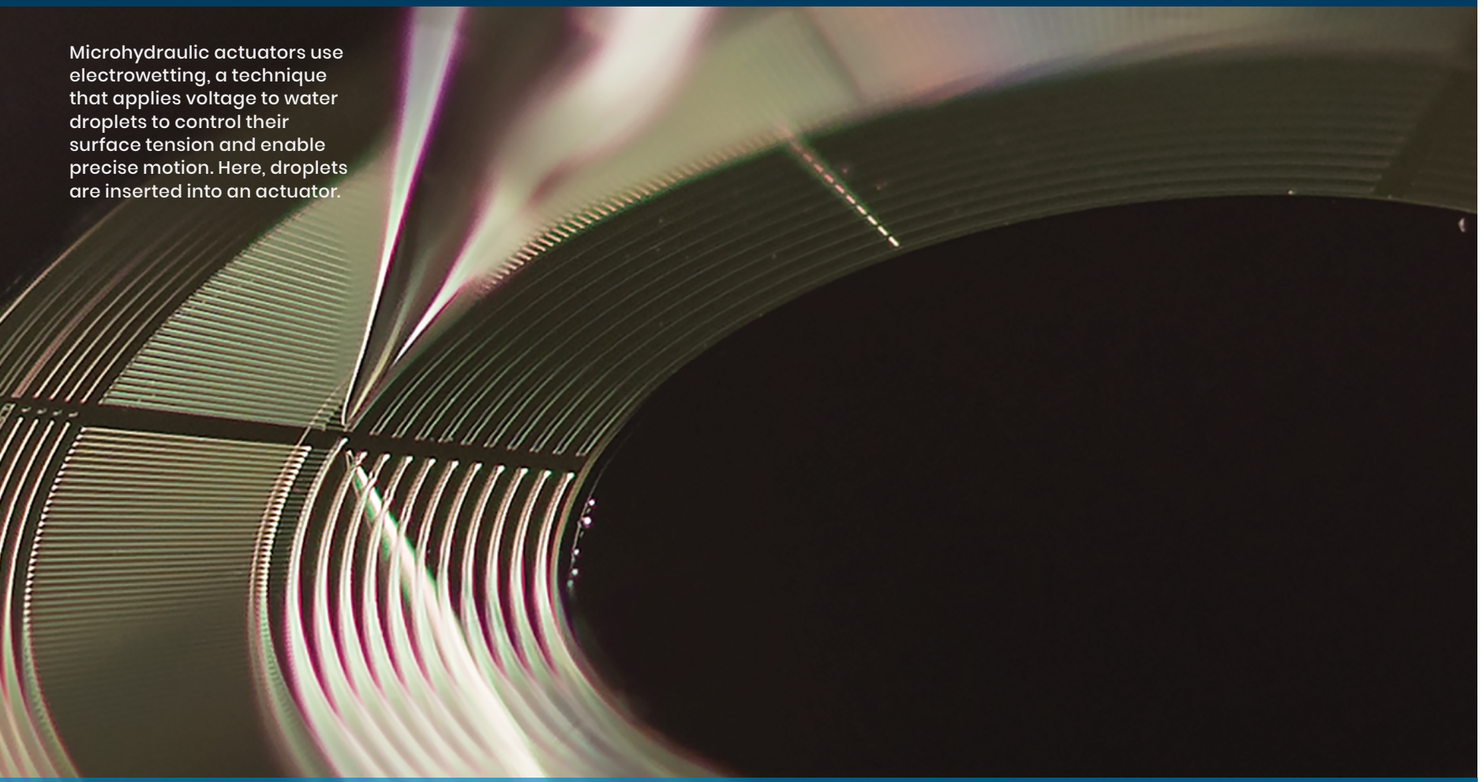


The gold sealing ring deposited on top of our ion trap enables a vacuum-tight connection to JPL's all-titanium package.

Truly portable optical clocks would support key national security applications — enabling precise synchronization of distributed radar systems to detect objects at greater range or providing extended timing holdover in systems if GPS signals are disrupted, for example.



Our integrated resonator, shown on the copper mount at left, enables laser linewidths below 20 Hz, sufficient to serve as the local oscillator for an ultrastable optical atomic clock.



Microhydraulic actuators use electrowetting, a technique that applies voltage to water droplets to control their surface tension and enable precise motion. Here, droplets are inserted into an actuator.

TECHNOLOGY TRANSFER

We strategically manage the transition of our innovations for government and commercial use. With each technology transferred, we help U.S. government and industries deliver new capabilities, drive economic growth, and strengthen the nation's technological leadership.

Technology Transfer Office

The Technology Transfer Office oversees the full technology lifecycle — from disclosure and protection of intellectual property (IP) to transition, licensing, and long-term stewardship. This comprehensive approach ensures that Lincoln Laboratory inventions achieve maximum impact.

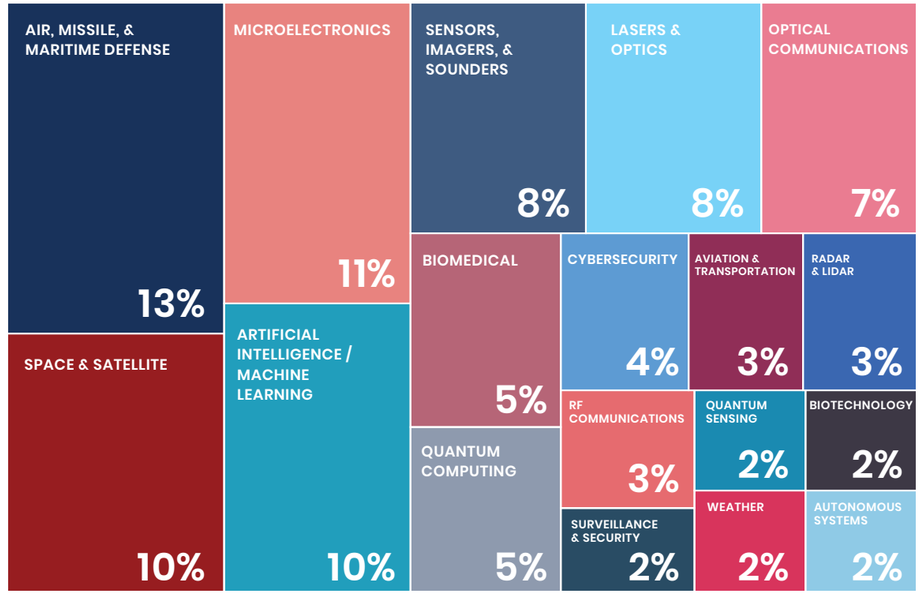
FY25 technology transfer by the numbers

We advanced a diverse portfolio of IP for transition to and use by government and industry partners.

59	104	42	32
invention disclosures filed	software/non-software copyright disclosures filed	patents filed	patents issued

FY25 IP portfolio by technical domain

Our IP portfolio spans nearly 20 research domains, reflecting our multidisciplinary contributions to national defense and scientific advancement with broad national impact.



FY25 technology transitions by pathway

Several transfer pathways connected our research outcomes to real-world use across government, industry, and open-source communities.

55 Government-Directed Transfers

Technologies transition to government sponsors or their designated contractors for continued development, production, or operational use.

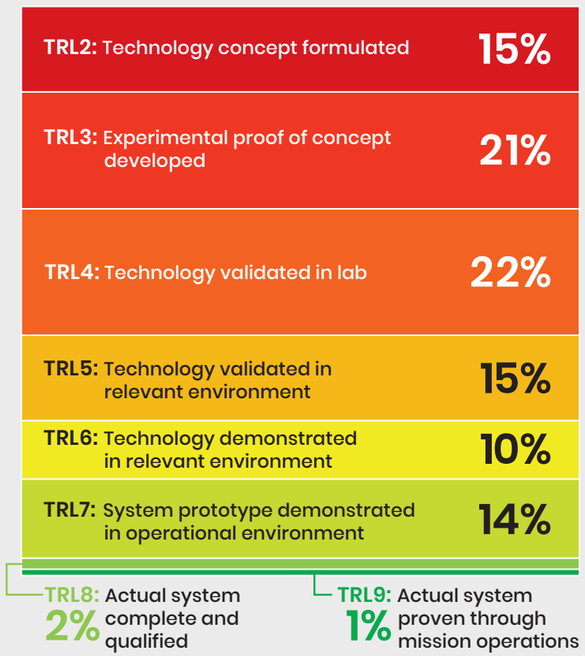
ACCELERATING F-35 CAPABILITIES

The **Knowledge Management Analysis and Architecture Support F-35 Tracker Test Bed Code** streamlines the evaluation of F-35 software upgrades. It autonomously assesses these upgrades and provides real-time feedback to both the software vendor and warfighter, ensuring faster insights into capability improvements. By cutting data analysts' workload by 80%, the code allows for the evaluation of more missions and data, increasing the delivery of reliable, capable products to the military. Shared through a military software consortium, this tool supports the Air Force Operational Test and Evaluation Center's shift toward modern, agile acquisition processes — helping deliver F-35 capabilities to the warfighter with greater speed and effectiveness.

New test bed code is accelerating software upgrade assessments for F-35 aircraft.
Photo: Staff Sgt. Darlene Seltmann
U.S. Air Force

Technology readiness levels

Technology readiness levels (TRLs) provide a common framework for evaluating how far a technology has progressed from basic research to operational use, with each level (1–9) representing increasing levels of proof and validation. In 2025, our innovations transitioned at nearly every stage of development, as shown in the graphic at right. Early-stage technologies moved to collaborators for co-development while mature technologies advanced toward commercialization or operational use.

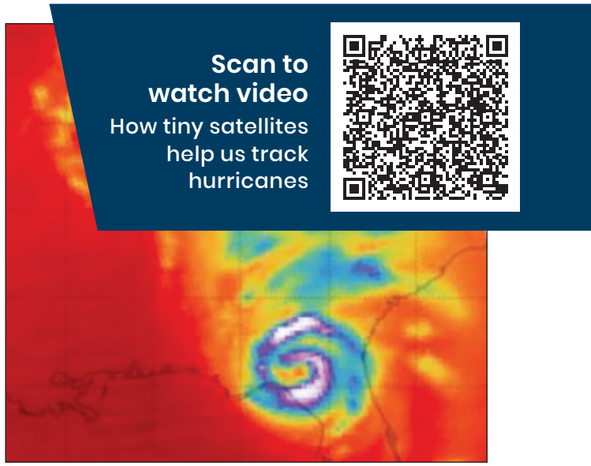


15 Collaborative R&D Agreements (CRADAs)

Partnering with industry through cooperative research advances dual-use and commercial technologies that strengthen both defense and civilian sectors.

EXPANDING WEATHER INTELLIGENCE

Miniaturized microwave sounders are enhancing the delivery of timely storm information to global agencies and industries. First pioneered for the TROPICS NASA science mission, the technology was transitioned via a CRADA to Tomorrow.io, a leading provider of weather intelligence, for integration on a large constellation of CubeSats. In May 2025, Tomorrow.io announced that its operating sensors were providing 45% of the most recent atmospheric soundings from space. The full constellation is expected to achieve global coverage at unprecedented revisit rates of under 60 minutes. This level of coverage — particularly over oceans and other radar-sparse regions — will significantly improve the accuracy of predictive forecasting.



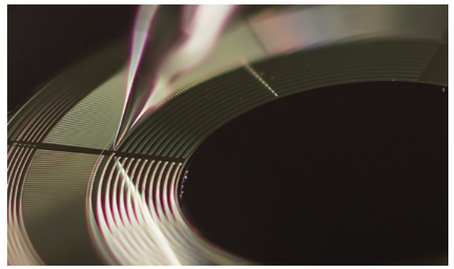
Tomorrow.io's sensors captured high-resolution microwave imagery of Hurricane Helene over Florida in September 2024. Photo: Tomorrow.io

9 Commercial Actions

Granting commercial entities the rights to manufacture, sell, or apply our technologies turns government-funded research into deployable products.

ADVANCING SEMICONDUCTOR PACKAGING

Microhydraulic actuators take advantage of surface tension to offer highly efficient, powerful, and precise movement in microsystems, with wide applicability in areas such as robotics and industrial operations. Spinout company Sangtera has licensed the technology for its applications in advanced semiconductor packaging. The National Science Foundation is funding Sangtera to develop high-throughput chiplet-to-wafer bonding equipment to support next-generation semiconductor fabrication needs, promoting domestic leadership in microelectronics manufacturing.



Microhydraulic actuators use electrowetting, a technique that applies voltage to water droplets to control their surface tension and enable precise motion. Here, droplets are inserted into an actuator.

32 Small Business Innovation Research Awards (SBIR/STTR)

Working with small businesses through competitive federal R&D programs matures emerging technologies and strengthens the national industrial base.

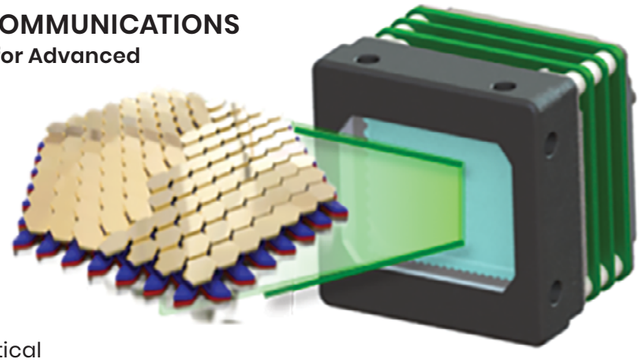
SAVING LIVES IN EMERGENCIES

The **Artificial Intelligence-Guided Ultrasound Intervention Device** (AI-GUIDE), which we developed in collaboration with Massachusetts General Hospital, helps emergency responders quickly and accurately access blood vessels in trauma patients to administer life-saving interventions. Demonstrated during exercises at Fort Bragg, AI-GUIDE received overwhelming support from U.S. Army Special Operations Command assault medics for its utility in post-injury care environments. The device transitioned to spinout company AutonomUS Medical Technologies, which is advancing AI-GUIDE toward commercial availability for use in emergency, military, and trauma care settings.

AI-GUIDE is a handheld device combining ultrasound, a user-guidance screen, blood-detecting optics, and a cartridge preloaded with a guide wire for accessing major blood vessels.

INNOVATING AIRBORNE LASER COMMUNICATIONS

The **Optical Communications Terminal for Advanced Networking** (OCTANE) program aims to develop a compact, lightweight, and low-power laser communications terminal for airborne platforms, utilizing a novel micro-mirror beam-steering device called the Lightfield Directing Array (LDA), made by Bright Silicon Technologies. Through a Phase III SBIR, we are teaming with Bright Silicon Technologies to create cutting-edge optical communications terminals, next-generation control systems, and breakthrough LDA-powered tracking algorithms to deliver secure and resilient optical connectivity for dynamic mission environments.



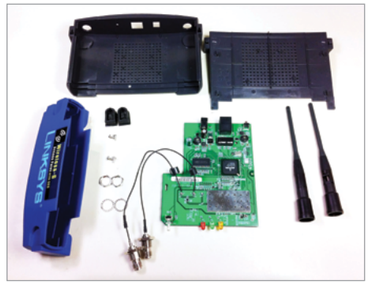
The LDA is a micro-mirror beam-steering device that enables ultrafast, large field-of-regard, digitally controlled beam pointing without a mechanical gimbal.

22 Open-Source Projects

Releasing our software accelerates innovation across sectors, promotes transparency, and maximizes taxpayer investment.

VERIFYING DEVICE SECURITY

The **Igloo Rehosting Platform** allows users to recreate the runtime environment in devices like routers, cameras, and industrial sensors to analyze their security properties without needing the original hardware. The U.S. government sponsor of this platform requested its open-source release, allowing us to work with partners to apply the tool to various use cases and build a community around this innovative security analysis capability.



Reverse engineering embedded Linux systems such as this wireless router often requires access to the physical hardware. The Igloo Rehosting Platform allows users to reverse engineer embedded systems without having a physical copy of the device.
Photo: Mathew Fuller, iFixit.com

Transition Tracking Action Group

In accordance with the DoW's new Transition Tracking Action Group initiative, we are collecting metrics to help the DoW and other government stakeholders evaluate how innovations from FFRDCs like Lincoln Laboratory move from research to real-world use. In this first year of tracking, the group established a framework to measure the downstream impact of each transfer in terms of advancing a defense program, enabling a new sponsor capability, or accelerating commercial adoption. Using this framework, we evaluated our 55 government-directed technology transfers in 2025, with the following results:

- **77%** were inserted into a DoW program
- **80%** were implemented in a new or existing software system
- **60%** were transitioned to industry for further development or production
- **70%** were delivered to the original funding sponsor
- **37%** were delivered to a non-funding government agency for continued use
- **30%** were fielded for operational use

FUTURE VISION

In the years ahead, we will continue strengthening how we protect and deploy innovation, aligning our practices with DoW Instruction 5535.08 (DoW Domestic Technology Transfer Program) to establish a consistent federal framework for domestic technology access through licensing and partnerships. This approach promotes the U.S. adoption of federally developed technologies while safeguarding sponsor interests, protecting national security, and upholding FFRDC obligations.

The PMI and Lincoln Laboratory research team commemorate the first meeting of their partnership in Lexington, Massachusetts.

EFFICIENT OPERATIONS

We continuously modernize operations to streamline workflows, reduce costs, and empower our teams to excel in the business of research.

Service departments provide essential infrastructure and specialized support for enabling the efficient execution of our national security mission.

Business Transformation Office

Business Transformation Office continued progress on the Digital Enterprise Transformation, a multiyear initiative aimed at modernizing internal operations by leveraging digital tools and streamlined processes. Recent upgrades include robust toolkits to improve department operation execution and a project management playbook to assist project leads. Additionally, a space modernization initiative improved workspace management and planning.

Human Resources Department

Human Resources Department updated its systems and processes to include good-faith salary estimates in all job postings. These changes enabled compliance with a new state wage transparency law.

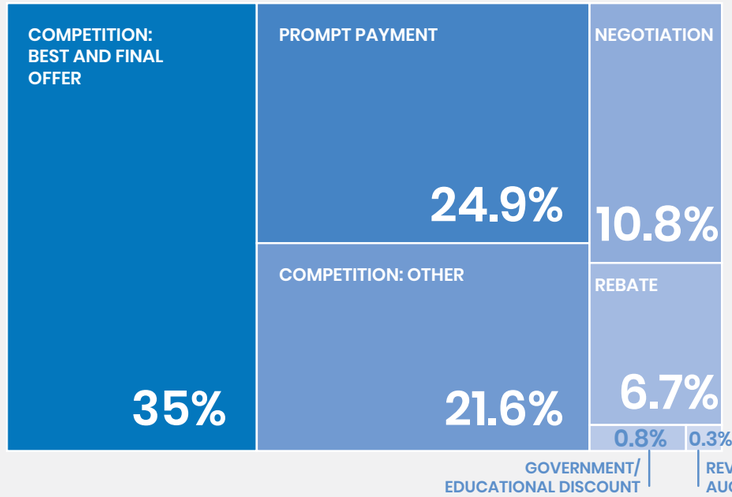
Information Services Department

Information Services Department expanded adoption of the ServiceNow platform to connect people, functions, and systems across the organization. The platform speeds up request resolution, improves communication, tracks status updates, and centralizes access to self-service resources, marking a significant milestone in modernizing service delivery. In addition, a new initiative is enabling researchers to automate software testing and deployment and centralize artifact management.

Contracting Services Department

Contracting Services Department helped secure $8.8M in savings resulting from the Better Buying Power initiative, which helped us negotiate prices, receive rebates, and achieve discounted payment terms. These FY25 savings were also attained through competition, reverse auctions, and best and final offers.

FY25 TOTAL SAVINGS: $8.8M



Project Management Office

Project Management Office partnered with the nonprofit Project Management Institute (PMI) on a two-year research initiative to explore new practices for improving outcomes and effectiveness in complex national defense projects. Our partnership with the PMI will allow us to play a key role in advancing the science of project success.

Security Services Department

Security Services Department conducted ongoing training and education to ensure secure operations, keeping employees vigilant to phishing attempts, cyber and insider threats, foreign intelligence recruitment, and counterintelligence activities. In addition, the Information Technology Security Council facilitated information exchange among IT security practitioners, providing strategic guidance on information security, risk management, cybersecurity threats, data protection, and compliance related to defense industry regulations.

Capital Projects Office

Capital Projects Office advanced three major facility modernization efforts:

- The Electrical Infrastructure Upgrade Project, completed in January 2026, upgraded high-voltage infrastructure and established redundant power systems.
- The Compound Semiconductor Laboratory–Microsystem Integration Facility, under construction with completion expected in late 2027, will support complex microelectronic systems development.
- The Engineering Prototyping Facility, in the initial design phase, will enhance system prototyping capabilities and efficiencies.

ECONOMIC IMPACT

We serve as an economic engine for the region and the nation through the procurement of equipment and technical services.

During FY25, we issued subcontracts with a total value of $712.7M to businesses in all 50 states and Washington, D.C. We purchased $332.7M in goods and services from New England companies, with $240.4M in contracts awarded to Massachusetts businesses. We also contracted with universities outside of MIT for basic and applied research. These research subcontracts included expert consulting, analysis, and technical support.

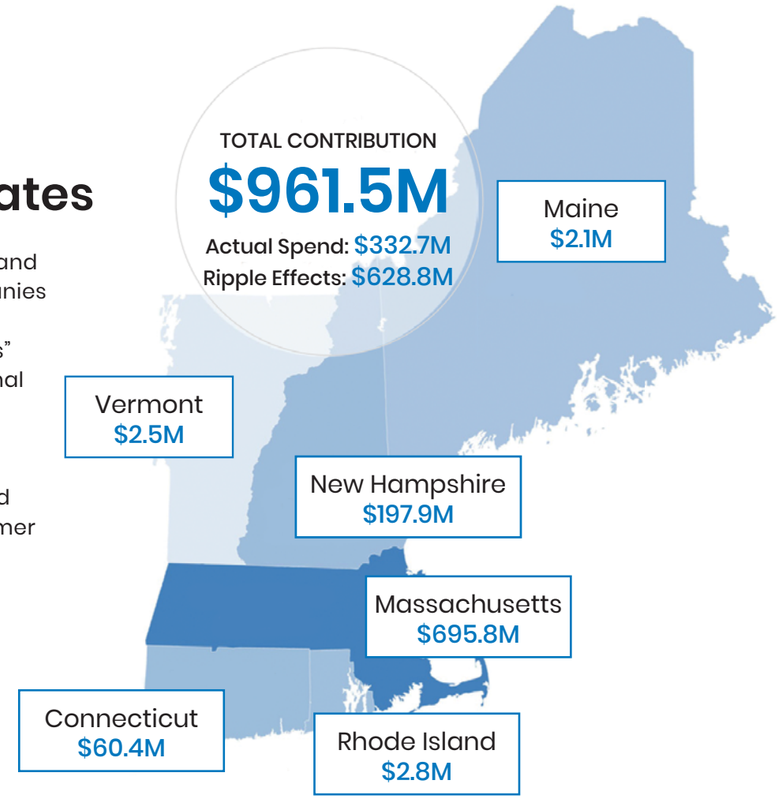
TOP PROCUREMENT AWARDS BY STATE

State	$MILLION
Massachusetts	240.4
California	91.0
New Hampshire	67.4
New Jersey	60.6
Maryland	45.2
Colorado	31.1
Texas	27.8
All Other	149.2
Total*	712.7

*Includes orders to MIT of $7.8M

Economic contribution to New England states

Our purchase of $332.7M in goods and services from New England companies triggered $628.8M in additional economic activity or "ripple effects" across the region, for a total regional economic contribution of $961.5M. Ripple effects include regional business-to-business purchases along the supply chain, wages paid to industry employees, and consumer spending by industry employees.



Economic achievements

- MIT was awarded an FFRDC prime contract for the continued operation of Lincoln Laboratory, establishing a five-year basic operating period through March 2030 and a five-year option through March 2035, with performance authorized through 2040. The award reflects a ceiling increase over the prior contract and recognizes the Laboratory's vital national security mission.
- FY25 ended with 893 active R&D programs. The estimated value of authorized programs increased by $1.06B.
- Lincoln Laboratory obligated $1.42B across contracts — the ninth year in a row with more than $1B in obligations.
- More than 33% of subcontracts were awarded to small businesses of all types in FY25.

CHAPTER 04

Our People

We promote a culture of excellence and achievement, and inspire rising STEM talent.

Two small satellites (approximately 20 × 10 × 30 cm) shown here each contain a miniaturized microwave sounder.
Photo: Tomorrow.io

RECOGNIZING EXCELLENCE

Honors and awards celebrated the talents of our staff, the impact of our technologies, and the quality of our workplace.

10th AWARD FOR EXCELLENCE IN TECHNOLOGY TRANSFER

The Federal Laboratory Consortium (FLC) recognized Lincoln Laboratory with an Excellence in Technology Transfer Award for hurricane-tracking microwave sounders. Initially developed for a NASA-sponsored program, the sounders are now licensed to the company Tomorrow.io, which will launch a large constellation of sounder-equipped satellites to enhance hurricane prediction and expand global weather coverage. This award marks our tenth recognition from the FLC.

5 PROFESSIONAL SOCIETY ELEVATIONS

James Jones

Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA) for developing air traffic management decision support technologies that leverage artificial intelligence and machine learning.

Idahosa Osaretin

Associate Fellow of the AIAA for developing miniaturized sensor technologies and enabling the proliferation of low-cost, mission-flexible, and rapidly deployable spaceborne sensors.

Jeffrey Palmer

Fellow of the American Institute for Medical and Biological Engineering for his innovation in wearable physiological sensors, significant contributions to technology translation, and international leadership for engineering in medicine and biology.

Thomas Quatieri

Fellow of the International Speech Communication Association for his contributions to speech signal processing, speech motor control, and vocal biomarkers discovery and their health applications.

Steven Vitale

Fellow of the American Vacuum Society (AVS) for his contributions to plasma physics and solid-state devices, including the development of processing technology to create fast-switching and ultralow-power microelectronics for national security.

19th AWARD FOR SUPERIOR SECURITY

The U.S. Air Force granted Lincoln Laboratory a "Superior" security rating for the 19th consecutive year. This rating, which is the highest that can be awarded under the National Industrial Security Program, represents our commitment to safeguarding sensitive and classified information.

6th AWARD FOR DEDICATION TO HIRING VETS

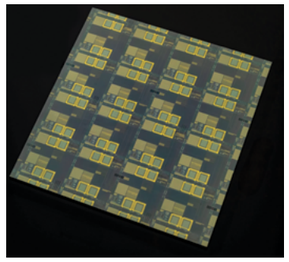
HIRE Vets awarded Lincoln Laboratory its Platinum Medallion Award in 2025. This award recognizes companies committed to recruiting, employing, and retaining the nation's veterans. This year marks the second time we have achieved the Platinum Award, after earning the Gold Award for four consecutive years.

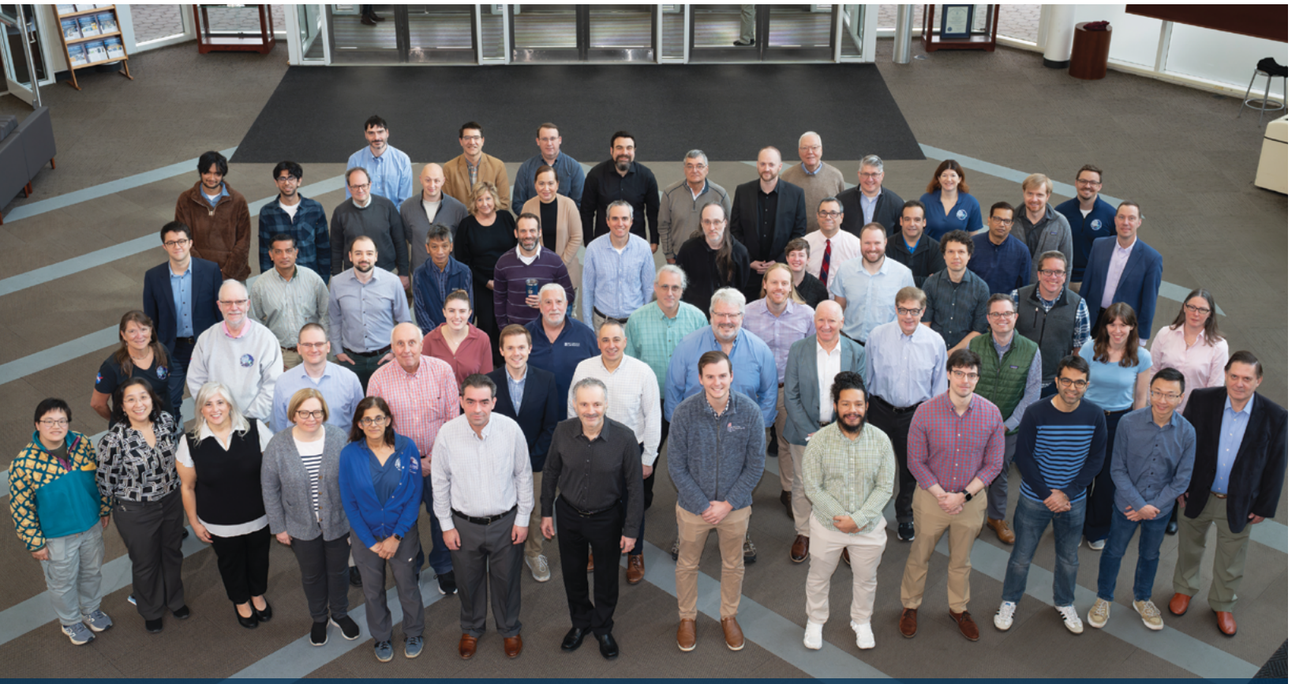
R&D 100 Awards

Each year, R&D World presents awards to the 100 most innovative technologies transitioned during the year for use in real systems or available to license. The awards are selected by a panel of technical editors and subject-matter experts, and they represent a cross section of work from across the world's R&D community. In 2025, Lincoln Laboratory received seven R&D 100 Awards.

Bumpless Integration of Chiplets to AI-Optimized Fabric

A fabrication approach that enables a 3D circuit integrated with a massive number of specialized chips for improved data-processing speed and power efficiency

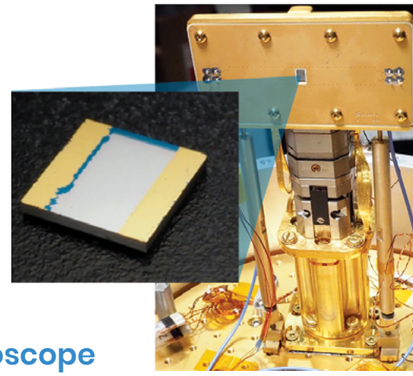




Researchers and engineers gather in recognition of their 2025 R&D 100 Award–winning technologies.

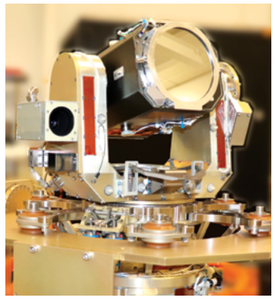
Lincoln Laboratory Radio Frequency Situational Awareness Model

A spectrum sensing and classification model that provides users with information on nearby waveforms and their originating devices



Quantum Diamond Magnetic Cryomicroscope

An instrument that leverages nitrogen-vacancy color centers in diamond to achieve high-sensitivity magnetic field imaging at cryogenic temperatures

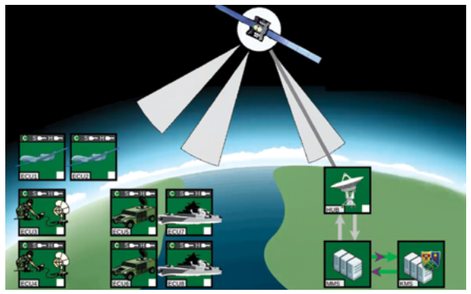


Modular, Agile, Scalable Optical Terminal

A next-generation laser communications terminal architecture that streamlines technology development with industry partners

Protected Anti-jam Tactical SATCOM Key Management System Prototype

A cryptographic server that keeps service members connected during satellite communication (SATCOM) terminal rekeying, compromise, or jamming



Tactical Optical Spherical Sensor for Interrogating Threats

A baseball-sized chemical sensor that can be thrown or launched into an area to remotely detect hazardous vapors or aerosols

Wideband Selective Propagation Radar

A millimeter-wave radar that protects U.S. Army armored vehicles from kinetic threats while enabling covert communications

At a panel discussion on August 26, Laboratory staff members share advice for their early-career colleagues.

FOSTERING AN ENGAGING WORKPLACE

Educational programs, seminars, events, and resources support our employees' professional development and sense of belonging.

OUR WORKFORCE

2,133	Professional Technical Staff
1,479	Support Personnel
529	Technical Support Personnel
441	Subcontractors
4,582	**Total Employees**

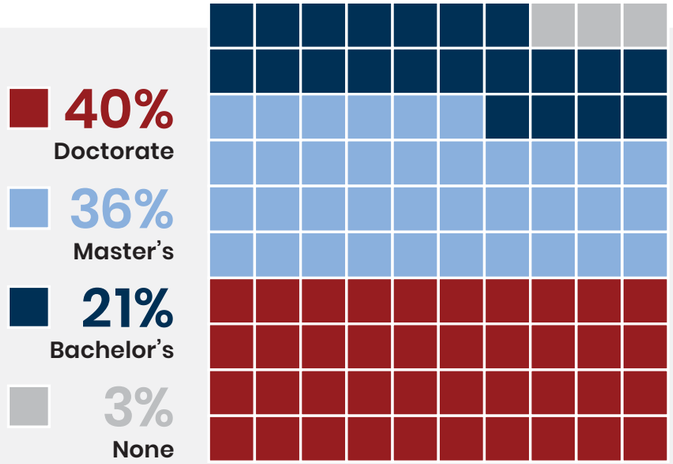
185 interns from top universities contributed to real-world projects in 2025

Scan to watch video
Intern spotlight: Coding for underwater robotics

Career navigation

Lincoln Laboratory established the Career Navigation Network, or CareerNav (formerly called Recent College Graduates), employee resource group to support early-career professionals and to help employees during periods of career transition, development, and exploration. From August 25 to September 5, CareerNav hosted its annual Professional Development Series, featuring panel discussions providing early-career and leadership advice, courses on relationship building and communication, and workshops on goal setting and performance improvement. CareerNav aims to offer resources and guidance to employees who wish to connect with other jobs and missions within the Laboratory, allowing them to shape their careers and derive greater fulfillment from their work.

OUR COMPOSITION OF TECHNICAL STAFF BY DEGREE

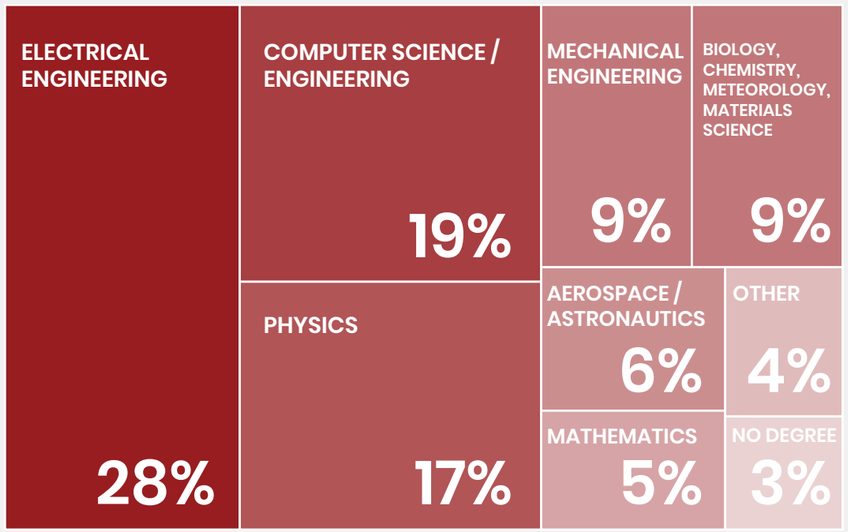


Cultivating Leadership, Achievement, and Success Symposium

Cultivating Leadership, Achievement, and Success (CLAS) is an annual Laboratory-wide symposium that focuses on promoting employees' leadership, growth, personal and professional development, and success through courses, panel discussions, and keynote speeches. The event also recognizes employees who have positively impacted the Laboratory's culture. The theme for this year's symposium, held March 11 to 13, was "Resilience through Change." To open the CLAS symposium, telescope specialist Erika Hamden, a professor of astrophysics at the University of Arizona and the director of the University of Arizona Space Institute, discussed resiliency in overcoming setbacks while developing technology. Kanwar Singh, the chief executive officer of Skyline Nav AI, closed out the symposium with a speech about exercising courage to persist through failures and rejections.

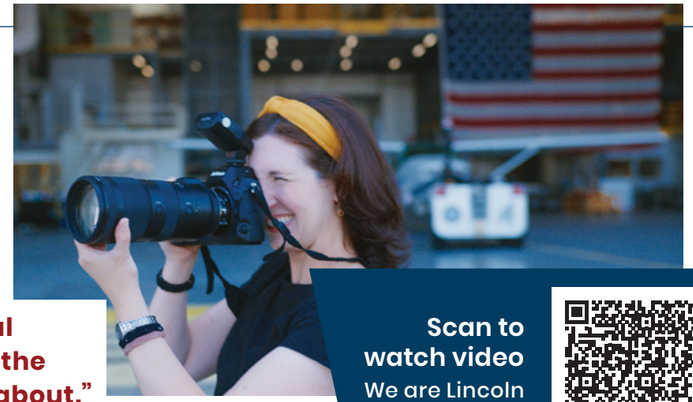
Kanwar Singh delivers the closing speech at the CLAS symposium.

OUR COMPOSITION OF TECHNICAL STAFF BY ACADEMIC DISCIPLINE



Employee stories

In this video spotlight series, staff reflect on their work at the Laboratory.



> **"For me, a successful portrait is one that the subject feels good about."**
>
> Niki Fandel
> Laboratory photographer

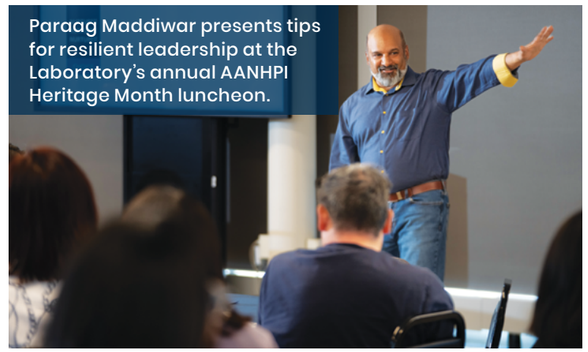
Scan to watch video
We are Lincoln Laboratory: Niki Fandel

Community building

Each year, a Martin Luther King Jr. event honors King's legacy and reaffirms the values the Laboratory shares with King, including collaboration and respect for one another. The year's theme, "Bridging Divides, Building Communities," encapsulated the idea that communities are strongest when their members connect and find common ground. During the event, guest speakers discussed the relationship between storytelling and science and how media such as books and films can foster audiences' interest in STEM. The discussion highlighted the necessity of explaining scientific concepts at different levels and through different mediums to inspire people of all ages and backgrounds to pursue their passions.

Resilient leadership

In May, guest speaker Paraag Maddiwar, former director of professional programs for the Society of Asian Scientists and Engineers, delivered a keynote speech for Asian American, Native Hawaiian, and Pacific Islander (AANHPI) Heritage Month. The heritage month's theme, "A Legacy of Leadership and Resilience," honored AANHPI leaders and the groundwork they laid for their successors. Drawing from his own experiences, Maddiwar offered strategies for becoming a better leader, emphasizing adapting to change, taking risks, tailoring communication to the environment, and voicing one's thoughts in meetings to signal to others they are listening.



Paraag Maddiwar presents tips for resilient leadership at the Laboratory's annual AANHPI Heritage Month luncheon.

Ian McQuoid stands at the ready to help LLCipher students as they work through a challenge to decipher a secret message without the associated secret key.

INSPIRING RISING STEM STUDENTS

Through the dedication of staff volunteers, 180 K–12 educational events impacted nearly 8,000 students nationwide. Spanning from Boston to Kwajalein Atoll, programs provided hands-on experiences in cryptography, radar systems, robotics, and other advanced topics.

LLCipher

Every year in early August, the Lincoln Laboratory Cipher (LLCipher) workshop introduces 25 high school students to cryptography. First-time instructor Joshna Iyengar says, "LLCipher is such a cool program because we teach cryptographic concepts that are often not taught until college."

The program offers lessons in abstract algebra and number theory that students use to understand theoretical cryptography. Applying what they learned in lectures, the students built a secure encryption scheme and digital signature. Then, they investigated recent developments in cryptography, like homomorphic encryption and multiparty computation, both of which enable computation over secret data without revealing those data.

> **"The students were engaged, interested in the concepts, and proactive in the classroom."**
>
> **Ian McQuoid**
> **LLCipher instructor**

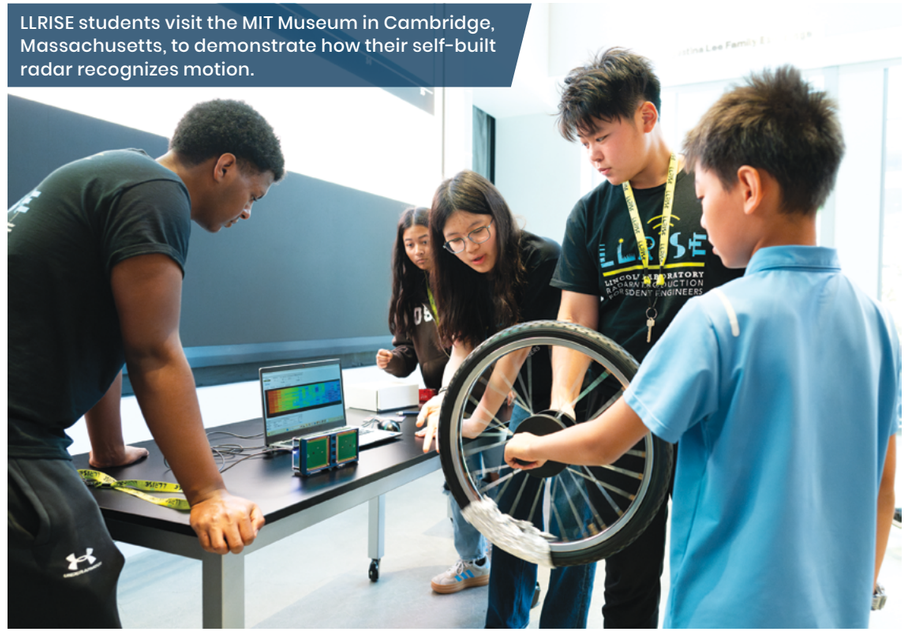
Ian McQuoid, a first-time instructor, enjoyed volunteering for this experience: "The students were engaged, interested in the concepts, and proactive in the classroom. I believe that having an understanding of secure and private communication is especially necessary in our computer-driven age, and it's very rewarding to instill an interest in and provide education on this important topic."

Nicholas Cunningham, an LLCipher instructor since 2017, helps students understand how frequency analysis is used for breaking classical ciphers by examining letter patterns.

Lincoln Laboratory Radar Introduction for Student Engineers

LLRISE - Summer

The LLRISE - Summer program marked its 14th year and accepted 26 students nationwide out of 800 applicants. Rising high school seniors in the program take college-level courses in electromagnetic signal processing, RF design, pulse compression and ranging, and synthetic aperture radar and learn about Lincoln Laboratory's role in radar development. They design their own small radar systems while learning how to populate a circuit board, code in Python, solder a radar antenna, and 3D print an antenna frame. "Students not only learn how to design a radar but also build one from scratch," says Chiamaka Porter, LLRISE coordinator. They then design and execute an experiment using their radar and present the results.



LLRISE students visit the MIT Museum in Cambridge, Massachusetts, to demonstrate how their self-built radar recognizes motion.

Reflecting on his experience, one student shared, "Through LLRISE, I was able to apply my STEM knowledge by collaborating with like-minded students on projects and homework, and by speaking with professionals. It was a fun and fulfilling experience for me and had a great impact on my STEM career."

Scan to watch video
Hear from our students: LLRISE program

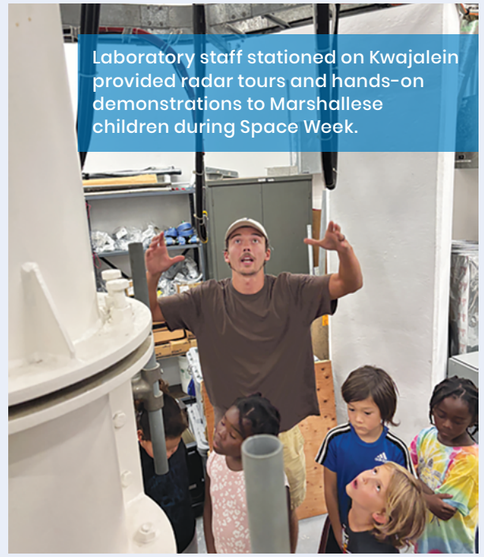
"I've learned a lot at LLRISE about radar and its applications, more than I've ever been able to before."
— LLRISE student

LLRISE - Spring

The LLRISE – Spring session gives students a whirlwind tour of engineering projects. Focusing on pulse compression and ranging, this abridged version of the two-week LLRISE – Summer program spanned five Saturdays. Twenty students learned the basics of radar and coding, and then soldered a prepopulated circuit board inside their own self-built continuous-wave radar. After completing assembly, teams of students designed and performed pulse compression and ranging experiments.

Students leave with a better understanding of STEM concepts, an increased interest in STEM, and deeper insight into STEM career pathways. Dinesh Babu, a 2024 LLRISE student who returned in 2025 to serve as a teaching assistant, said, "When I first heard of LLRISE, I thought it was a niche radar program. I didn't expect to be exposed to advanced technologies. LLRISE was a true eye-opener, revealing the many career pathways involving radar systems. Returning as a teacher assistant solidified my passion for autonomous systems that leverage radar."

Participants in the LLRISE-Spring session test their self-built radar to detect movement down a long hallway.



Laboratory staff stationed on Kwajalein provided radar tours and hands-on demonstrations to Marshallese children during Space Week.

Kwajalein Space Week

In 2024, the Kwajalein School System developed a first-ever weeklong event focused on space. The resulting Space Week brought more than 200 K–12 students to the Ground-Based Radar (GBR). Laboratory staff working at the GBR reprised the tour this year, bringing local students into the radome and onto the radar platform and explaining to them how the radar keeps track of satellites and space debris. The staff also offered special in-school interactive lessons on orbital mechanics and other radar topics. Adam Gjersvik looks forward to hosting this event annually. He said, "Talking with students about how the GBR can observe objects flying in space was an excellent way to connect with the broader island community about our mission on Kwajalein."

Beaver Works Summer Institute

Designing a motion-tracking sleeve, building a submersible robot, and applying machine learning to predict hypothyroidism — these projects are just a few that students worked on during the 2025 Beaver Works Summer Institute (BWSI). This four-week program, which started in 2015 with a single course and 46 students, engages rising high school seniors in hands-on STEM projects. Celebrating its 10th year in 2025, BWSI ran 14 courses serving 450 students virtually and in person. The in-person program, hosted at the Beaver Works Center in Cambridge, Massachusetts, featured daily talks by industry leaders in STEM careers and culminated in a final day of competitions and demonstrations.

The following courses were offered in the 2025 program:

- Autonomous RACECAR (Rapid Autonomous Complex Environment Competing Ackermann steeRing Robot) Grand Prix
- Autonomous Underwater Vehicles Challenge
- Medlytics
- Microelectronics and Hardware Development
- Unmanned Air System–Synthetic Aperture Radar
- Embedded Security and Hardware Hacking
- Cyber Operations
- Quantum Software
- Basics of ASICs (Application-Specific Integrated Circuits)
- Autonomous Cognitive Assistant (CogWorks)
- Remote Sensing for Disaster Response
- Serious Games Development with Artificial Intelligence
- E-Textiles and Wearable Technology

BWSI students in the Autonomous Underwater Vehicles Challenge make programming adjustments and check the build of their submersible to ensure it can move efficiently underwater.

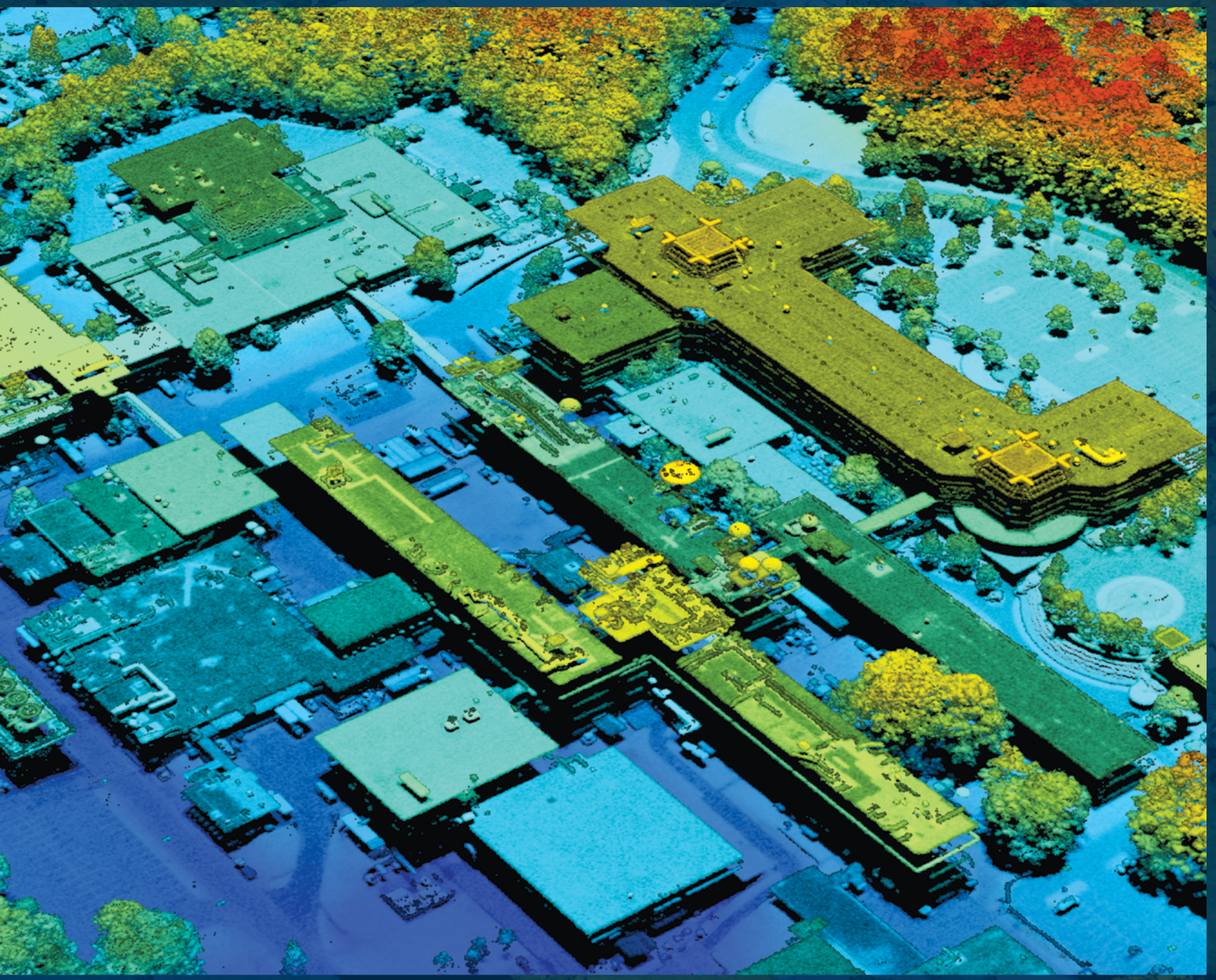
5,400+

students have participated in BWSI since its debut in 2015

Student radar reflectors imaged from space

Staff leading the BWSI course on synthetic aperture radar (SAR) collaborated with the commercial satellite company Umbra to give students the opportunity to have their work imaged by a satellite. The four-week Unmanned Air System–SAR course offered 26 students the experience of building a radar imaging system. The satellite passed over MIT campus on July 25 and imaged radar reflectors the students had created out of cardboard and aluminum foil. Beaver Works Operations Manager Lisa Kelly says, "This experience reflects the type of innovative learning that makes BWSI so impactful and continues to set the program apart."

Students arrange their reflectors to spell out "LL" for "Lincoln Laboratory." The reflectors were successfully imaged by Umbra's SAR satellite.



CHAPTER 05

Our Future

We anticipate new threats and align emerging capabilities to address a rapidly evolving national security landscape.

MISSION OUTLOOK

Our R&D mission areas are positioned to mitigate national security challenges on the horizon:

BOLSTERING AIR, MISSILE, & MARITIME DEFENSE

The United States faces a complex, multilayered security environment requiring air, missile, and maritime defenses against both traditional great-power competition and modern unconventional warfare. Through initiatives such as Golden Dome for America, the U.S. Navy's Next-Generation Attack Submarine, and low-cost autonomous systems programs across the DoW, we will continue to shape future architectures, mitigate technical risks, and collaborate with industry to address these threats. Focus areas will include advanced sensors, AI-enabled decision architectures, electronic warfare systems, scalable technologies for asymmetric deterrence, and realistic prototyping and test environments. By prioritizing these areas, we seek to increase U.S. military agility and flexibility for closing long-range engagements across all domains.

SECURING CYBER SYSTEMS

We will research and develop new tactical signals intelligence capabilities to enhance situational awareness for U.S. deployed forces in contested environments. To defend the nation's most critical AI-enabled missions, we will work in partnership with the DoW and intelligence community to create effective processes for assessing and improving AI system security and reliability. We will continue constructing secure-by-design, formally verified, mission-specific integrated hardware-software computer stacks to ensure the cyber resiliency of next-generation platforms such as uncrewed robots and small satellites. Additionally, we will lead a consortium of FFRDCs and university-affiliated research centers to guide U.S. Cyber Command in advancing future generations of the Joint Cyber Warfighting Architecture.

TRANSFORMING ISR & TACTICAL SYSTEMS

We will continue to conduct systems analysis, technology development, prototyping, and field and flight testing to enable revolutionary new capabilities for ISR and tactical systems missions. Assessments of U.S. and adversary systems and recommendations for future development will address areas including stand-in and stand-off surveillance; RF, infrared, and optical sensing; electronic attack and protection; and survivable distributed architectures for contested environments. Emphasis will be placed on emerging concepts for breakthrough ISR and tactical systems that leverage cost asymmetries and U.S. technological advantage. Collaborative research and technology transfer with the U.S. industrial base will support service and joint force needs.

PROTECTING THE HOMELAND

The Golden Dome for America initiative renews emphasis on safeguarding the homeland from missile and drone threats. Countering drug trafficking across land and maritime borders is also an increasing priority. Toward these priorities, we will create new ways to defeat drone incursions and protect military bases, critical infrastructure, and border operations.

These approaches will include advanced drone technology; low-cost RF and electro-optical sensors, and AI-enabled automation for rapid response. We will also explore a holistic approach to air, border, and maritime security to include solutions that expand beyond end-game defeat. The advancement of AI algorithms will help operators rapidly fuse data from diverse sources and make actionable decisions with certainty.

ADVANCING COMMUNICATIONS

The evolution of air platforms such as the B-21 bomber, collaborative combat aircraft, uncrewed aerial systems, and F-47 fighter jet combined with the maturation of joint operations will accelerate the development of multifunction communications equipment and the deployment of networked capabilities at the forward edge. The emergence of space as an operational domain and the national priority on space-based long-range effects will drive communications to large numbers of small platforms as well as networking across mission systems for real-time control. In addition, AI-enabled SATCOM terminals will be needed to create agility across best-of-class commercial systems and specialized space systems reserved for military use cases, such as highly contested environments and nuclear command and control.

MODERNIZING AIR TRAFFIC OPERATIONS

As the nation undertakes a major air traffic control modernization initiative, we will advise the government and engage with industry to support rapid and effective deployment of new capabilities. Research and development will focus on air and surface surveillance, collision avoidance, weather sensing, traffic management automation, AI, cybersecurity, and resilient logistics. We will maintain a strong emphasis on achieving national and international approval, technology transition, and operational deployment for these technologies. Beyond our work in conventional aviation, we will pursue methods and technologies to approve and integrate new entrants — including large and small uncrewed aircraft systems, commercial space transportation, and advanced air mobility systems — into the national airspace.

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ENSURING RESILIENT HUMAN SYSTEMS

Sustaining the health and resilience of service members and civilians is essential for national security. We will continue our work with the military health system and combatant commands to deliver field-forward medical diagnostic, treatment, and logistics capabilities that protect the well-being of deployed forces. To enable rapid response to natural or human-made biothreats, we will develop and transition biosurveillance technologies and AI-enabled tools that provide early warning of illness. Beyond supporting health, we are partnering with the government and industry to bolster the nation's biomanufacturing capabilities. These R&D efforts will help secure the domestic production of materials critical to national security.

SECURING SPACE ENTERPRISE RESILIENCE

The nation's military and intelligence missions increasingly rely on services provided from space. We will continue to shape future architectures to protect U.S. and allied interests in space and to assure space service availability for the joint force. We will develop and deploy new sensor systems, prototype modern data-fusion and -exploitation approaches, and provide mission support to improve space domain awareness. We will mature instrumentation and experimentation capabilities for the space test community and enable development of U.S. Space Force tactics. In addition, we will partner with industry to effectively employ the wide range of commercially available capabilities for the national interest.

ACCELERATING COMPLEX ENGINEERING

Our increasing use of digital engineering enablers — such as model-based practices, integrated modeling and simulation, connected planning and execution, digital twin technology, and AI — will accelerate the development of innovative prototypes. We will also expand our participation in relevant DoW strategic initiatives to develop and deliver capabilities that rapidly address emerging threats and technology gaps. We continue to finalize the design of the new Engineering Prototyping Facility, which will enable Lincoln Laboratory to develop increasingly complex prototypes for future national security needs. Construction is expected to start in 2028, and the building is scheduled to open in 2030.

ADVANCING TECHNOLOGY

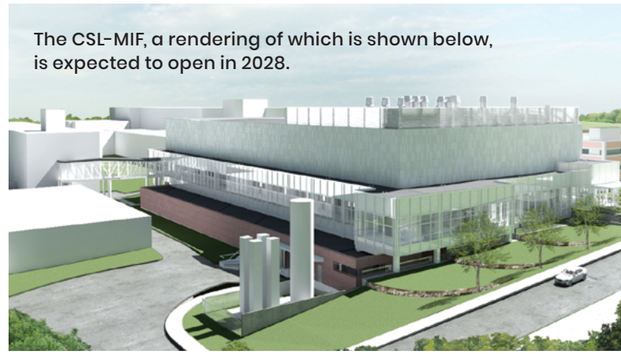
We will continue to pioneer foundational technology that enables new capabilities critical to maintaining U.S. technological edge. Our staff are developing extreme-ultraviolet lithography techniques to usher in a new generation of microelectronics manufacturing. Concurrently, we are leading the design and fabrication of quantum circuits to drive advances in quantum computing and sensing. Our teams are also advancing superconducting imaging arrays sensitive to single photons and progressing microwave photonics to enable faster, higher-bandwidth systems for defense and commercial applications. Pivotal to our future work, the Compound Semiconductor Laboratory–Microsystems Integration Facility, set to open in 2028, will serve as the nation's premier laboratory for prototyping advanced microsystems and integrating them into field-ready platforms.

FACILITY MODERNIZATION

Lincoln Laboratory's future facilities represent critical investments in national security. These state-of-the-art facilities will enable us to design, test, and deliver advanced prototypes for ground, sea, air, and space systems for decades to come.

Compound Semiconductor Laboratory–Microsystem Integration Facility (CSL-MIF)

The CSL-MIF will provide 160,000 square feet of cleanroom space for developing complex electronic prototypes for DoW systems. Scientists and engineers will fabricate semiconductors made of two or more elements (compound semiconductors) and package specialized heterogeneously integrated electronics. Integrating different semiconductor materials and devices enables customizable microsystems for varied applications. Focus technologies include 3D-integrated focal plane arrays for surveillance, electro-optical systems for space-based optical communication, and superconducting microsystems for quantum computing. The CSL-MIF will complement our existing Microelectronics Laboratory, the U.S. government's most advanced silicon-based research facility.



The CSL-MIF, a rendering of which is shown below, is expected to open in 2028.

Engineering Prototyping Facility (EPF)

The EPF will provide 290,000 square feet of infrastructure to support all phases of rapid and complex prototype development. Engineers and technicians will use this integrated space to design, simulate, fabricate, integrate, and test next-generation systems. Key spaces include assembly and integration labs, mechanical and electronic fabrication shops, vibration and environmental test labs, and secure prototyping spaces. Its flexible layout will accommodate work on emerging technologies while allowing rapid response to DoW prototyping needs.

The EPF, currently in the design phase, is shown in the rendering above.

Scan to access the digital 2025 Impact Report.

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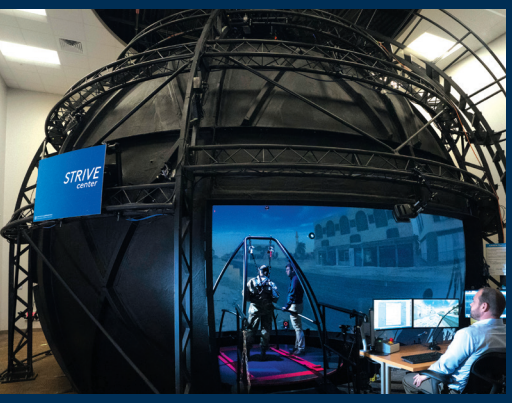

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