

MIT LINCOLN LABORATORY

2015 Community Involvement Report



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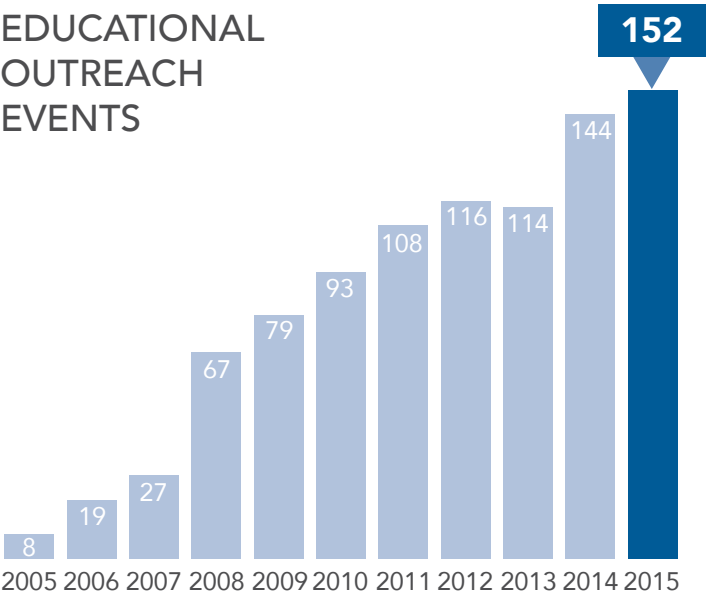
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PROGRAMS
SHOW SIGNIFICANT
GROWTH



Lincoln Laboratory's outreach activities are funded in part through the endowments listed on the plaque above, now permanently hanging in our lobby. Donations to these funds provide ongoing support to educational programs.

About Our Programs

MIT Lincoln Laboratory Giving supports activities directed by the Laboratory's Communications and Community Outreach Office, funding for special STEM events and workshops offered at the Laboratory, and grants to participants in programs run by MIT.

If you would like to support STEM outreach, visit the Give to MIT Lincoln Laboratory website, found on the Support STEM Programs link under the Outreach tab on the Laboratory's external homepage. You can contribute to any of the following funds:

- Roger W. Sudbury Memorial Fund for community outreach
- The John Welch Memorial Fund for educational outreach

- The Barbara P. James Fund for general support
- The Lincoln Laboratory Director's Fund for STEM education
- The Carl E. Nielsen Family Fund for MIT graduate students in electrical engineering and computer science

These endowed and expendable funds enable the Laboratory to support programs that complement its mission of developing technology in support of national security by helping ensure that the U.S. workforce remains preeminent in technology. Contributions in any form sustain efforts to motivate and prepare students to become the next generation of scientists and engineers.



On facing page, Eric Evans (right) celebrates the GEM program (see page 49) with students. Eric Evans (above) explains to pre-schoolers how a rocket works.

A Message From the DIRECTOR

Community and educational outreach programs are important components of the Laboratory's mission. From the beginning, our outreach initiatives have been inspired by employee desires to help people in need and to motivate student interest and participation in engineering, science, and mathematics. There are many opportunities to be involved.

The Laboratory's educational outreach initiatives include delivering Science on Saturday presentations, sponsoring U.S. FIRST robotics programs, and mentoring college and graduate student interns preparing for science and technology careers. Our staff volunteer to serve as judges for local and regional science fairs and science-based activities.

The Laboratory is committed to giving back to the community by sponsoring fundraising and community service events in support of Wounded Warriors, the Jimmy Fund, the American Heart Association, and other charitable organizations. The involvement of the entire Lincoln Laboratory community is encouraged and supported. Please let us know how we can do more.

Eric D. Evans

Eric D. Evans
Director



Educational Outreach

Lincoln Laboratory takes pride in promoting science and engineering education for all grade levels in four main areas:

- K-12 STEM Outreach
- Partnerships with MIT
- Supporting Local Schools and Teachers
- Community Engagement

Attendees at the 2015 Daughters Day watched Lincoln Laboratory's pendulum track Earth's rotation.

Science on Saturday

Each school year, more than 4000 local K-12 students, parents, and teachers attend Science on Saturday demonstrations hosted by Laboratory technical staff volunteers. Since the program's origin in 2006, attendees have enjoyed watching and participating in demonstrations on rockets, robotics, computers, acoustics, archaeology, lasers, thermal imaging, and many other topics.

Over the past year, Lincoln Laboratory's Science on Saturday demonstrations included

- An always-popular robotics demonstration that featured a "robot zoo" of homemade robots, which attendees could control to perform specific tasks.
- A new event, "Electricity, Ions, and Chemistry," that showed attendees how ions exist all around us in many forms and demonstrated how ions produce vivid colors and interesting effects with electricity.
- A hands-on science event that featured activity stations at which students could paint by using pitch and frequency of sounds, watch demonstrations of 3D printers, and simulate missile launches.
- A special Halloween edition, "Cyber Tricks and Cyber Treats," that taught children how to safely use the Internet.
- An off-site radar show at the Lilla G. Frederick Pilot Middle School in Dorchester, Massachusetts, that demonstrated how radar is used to predict the weather, fly an airplane, and determine the speed of a pitch at a baseball game.

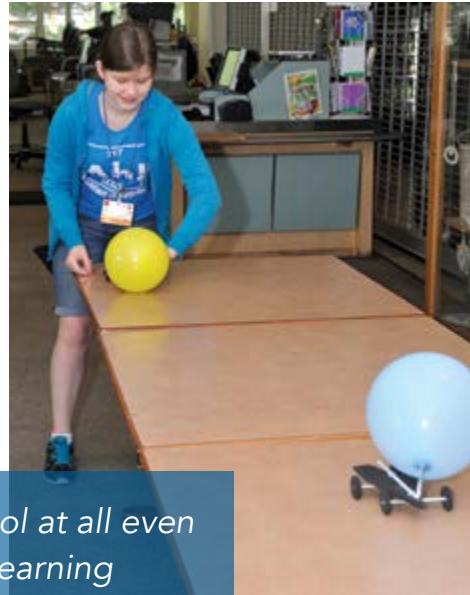


Jude Kelley showed children how to identify ions "hiding" in red cabbage and other products.



Scenes from Science on Saturday events about robotics and hands-on engineering featuring 3D-printed items.

Girls built and raced balloon-powered cars to gain an appreciation for mechanical engineering and precision assembly.



"It wasn't like school at all even though we were learning things the whole time!"



The "DNA Sampler" activity provided a peek into bioengineering. Students extracted DNA by scraping the inside of their cheeks to discover characteristics of cells. Key concepts were taught about the function of DNA and the intervals required for the extraction procedure.

Wow! That's Engineering!

In June, 100 girls in grades 6 through 8 attended a Wow! That's Engineering! workshop cohosted by the Boston chapter of the Society of Women Engineers and Lincoln Laboratory's Technical Women's Network. Through a variety of activities, the girls practiced hands-on engineering and interacted with female scientists and engineers. The goals of the workshop were to "wow" girls by showing them what they can accomplish as engineers and to provide them with a better understanding of what it is like to be an engineer.

"Girls in middle school often lose their enthusiasm for science. The workshop presents engineering as an exciting career choice," said Yari Rodriguez, event coordinator. Rodriguez and several other volunteers, including keynote speaker Kerri Cahoy, Boeing Assistant Professor of Aeronautics and Astronautics at MIT, discussed their engineering careers with the participants.

The girls learned about reverse engineering by taking apart appliances, electrical engineering by connecting a circuit to make a light-emitting diode (LED) flashlight, mechanical engineering by designing a balloon-powered car, and bioengineering by extracting DNA samples from their cheek cells. The activities proved to be educational and entertaining, best exemplified by a participant who said, "It wasn't like school at all even though we were learning things the whole time!"

CyberPatriot National Youth Cyber Defense Competition

In the fall, Lincoln Laboratory sponsored three teams in CyberPatriot, a national competition for high-school students learning defensive computer security. The 14 students (four of whom were new to CyberPatriot) were mentored by Kevin Bauer, Jorge Coll, and John Wilkinson. After learning how to identify malware, "clean" a computer system, and establish a secure network, the teams competed in the statewide competition. One

team advanced to the Northeast regional competition. This competition is a six-hour session in which each team secures a Windows 8 client, a Windows 2008 server, and an Ubuntu Linux 12.4 computer. The teams also complete digital forensics and networking challenges. Every minute of the six hours is filled with team members cleaning systems, rooting out malware, and establishing a secure environment.



The three Laboratory-mentored CyberPatriot teams pause at Beaver Works, where they met weekly to learn how to engage in defensive computer security. Mentor Kevin Bauer is shown on the right.

Scouting at Lincoln Laboratory

The mission of the Scouting at Lincoln Laboratory (S@L) outreach team is to encourage the natural curiosity of youth members about science, technology, engineering, and mathematics (STEM) through activities, educational outreach, and STEM-based merit badge support.

David Radue and Jack Kartel assisted at the Harvard Merit Badge University event with the Harvard College Friends of Scouting, a student-run organization at Harvard University, by guiding scouts through the steps needed to earn the Robotics and Game Design merit badges.

Philip McKinley helped to organize the Math Science Technology Expo in Nashua, New Hampshire. The Expo offers STEM merit badges and career information to more than 250 scouts. Phil also served as an instructor for the Robotics merit badge program, which included a field trip to Boston Dynamics.

For two days in March, 250 scouts participated in a STEM Expo. The event was led by David Ripplinger, with the assistance of many Laboratory staff members. Boy Scouts explored STEM careers by attending a career fair, visiting high-technology companies, and performing merit badge work.

At the inaugural meeting of Explorer Post 1776, scouts reverse engineered (took apart) electromechanical appliances. After learning how to give a business presentation, they created and presented a slideshow about how the appliances work.

Explorer Post

Exploring is a youth development program offered through the Boy Scouts of America. The program is based on a dynamic relationship between youth and the organizations in their communities. Exploring's purpose is to provide experiences to help young people mature and to prepare them to become responsible and caring adults. Explorer Post 1776, chartered by Lincoln Laboratory in October 2015, is organized by John Kuconis, Curtis Heisey, and David Granchelli. The Post consists of seven youth members, who meet monthly to focus on hands-on STEM projects. They will gain an in-depth experience in building engineering systems and will be challenged to build prototypes by using creative problem-solving strategies.



The founding members of Venture Crew 1775 are shown with Sarah Klein (far left) and John Kuconis (third from left) at the Crew's incorporation meeting at Lincoln Laboratory.

Venture Crew

A group of scouts in Lexington, Massachusetts, has formed a new coed Boy Scout organization, Venture Crew, sponsored by Lincoln Laboratory. Venturing, the fastest growing program of the Boy Scouts of America, was developed for young adults who want a broader experience in leadership, vocations, and hobbies. Through the program, young adults learn how to make ethical choices; experience adventures and challenges; engage in high adventure, sports, arts, and hobbies; and develop leadership skills.

Ten scouts in Venture Crew 1775 went on their first adventure outing at Camp Sayre in Milton, Massa-

chusetts, where they practiced leadership skills, team activities, and participated in a high ropes course. Cecile Denton, president of the Venture Crew, explained the different team activities: "Putting puzzles together while blindfolded was a memorable test of the group's verbal communication skills. Another activity tested hand-eye coordination with the task of catching airborne projectiles to demonstrate the importance of delegating responsibilities. It really made us work together as a team."

The Venture Crew also made trips to Woods Hole, Haystack Observatory, and Carter Notch. Laboratory staff member and Venture Crew 1775 leader, Rodney Cole, chaperoned the students.

LLRISE

Out of 222 applicants from across the United States, 18 rising high-school seniors were chosen for the fourth Lincoln Laboratory Radar Introduction for Student Engineers (LLRISE) Workshop, held for two weeks in July.

With the help of nine Lincoln Laboratory scientists and engineers, the participants built their own Doppler and range radars. In addition to learning about radar systems and the history of radar, the students were instructed in computer-aided design, 3D printing, circuit board assembly, electromagnetics, pulse compression, signal processing, antennas, MATLAB programming, electronics, and the principles of physics. In past years, the students tested their radar designs through instructor-designed experiments, but this year, the students designed their own experiments.

Participants resided on MIT campus, where they received practical advice on the college admissions process. In between instructional lectures and engineering activities, the students toured the Laboratory's Flight Test and RF System Test Facility, and the MIT Haystack Observatory in Westford, Massachusetts. Julie Chen, a Kansas native, explained that her experience at the Laboratory positively influenced her view of engineering: "Actually meeting engineers and learning about their work gave me a better understanding of real-world applications for my chosen major, electrical engineering."



The 2015 LLRISE students, shown with their Lincoln Laboratory mentors, prepare for two weeks of college-level courses and hands-on engineering activities.

In February, Lincoln Laboratory hosted a one-day radar workshop version of its popular two-week Lincoln Laboratory Radar Introduction for Student Engineers (LLRISE) program in which students build small radar systems from top to bottom. Held at Beaver Works, the workshop was run by the Lincoln Employees African American Network and was an opportunity for 14 local students to learn about the principles of radar. Part of the motivation behind organizing this effort was the success of LLRISE: last year's program attracted more than 200 applicants. To meet this growing interest, the workshop was offered to local students who had been waitlisted for LLRISE.

The history of radar, radar hardware, radar basics, ranging, MATLAB, Doppler radar, and other lecture topics delivered in the two-week program were presented in condensed form. "Within a few hours, students were able to describe how radar works, interpret plots, and explain their results," said Shakti Davis, one of several Laboratory staff who led the workshop. Because time did not allow for the students to build their own radars as they do in the two-week program, the students instead conducted hands-on experiments with prebuilt radars.



Eric Phelps (right) assists two students in testing the wiring of their radar.

Mentors and volunteers included Raoul Ouedraogo, Alexis Prasov, Wingyan Beverly Wong, Christ Richmond, Crystal Jackson, John Nwagbaraocha, Loren Wood, Shakti Davis, and Eric Phelps. By the end of the workshop, the students gave presentations on their experiments, proving their grasp of the information. Program coordinator Chiamaka Agbasi-Porter said, "This one-day workshop was successful. I think we can further tailor the course, currently designed for rising seniors, for lower grade levels."

LLRISE One-Day Workshop at Beaver Works

provided a condensed introduction to radar for local students unable to attend the two-week course



Shakti Davis, an alumna of New Mexico State University, helps a student determine how best to set up an experiment with his small laptop-operated radar system. She explains how the radar will detect and measure the speed of a spinning bicycle wheel or a person walking.

Radar Workshop in New Mexico

In February, an abbreviated version of Lincoln Laboratory's Build a Small Radar course was offered at New Mexico State University (NMSU). Shakti Davis, an alumna of NMSU, worked with the NMSU College of Engineering and the Klipsch School of Electrical and Computer Engineering to organize a one-day introduction to the basics of radar systems and a hands-on experience taking actual radar measurements.

During the morning session of the Saturday workshop, 26 students attended lectures on the history, uses, and fundamentals of radar systems. They learned about detection and ranging, and ran MATLAB simulations to step through functions of a radar system. In the afternoon, the students performed experiments with

the small radar systems built by participants in Lincoln Laboratory's radar workshops. The teams measured the speed of passing cars, estimated the range of objects, and studied the Doppler signatures of moving objects. "The students were able to see 'through the eyes of the radar,'" said Davis. "Initially for them, the systems were mysterious 'black boxes.' We took some of the mystery out."

NMSU faculty are now interested in developing spin-off programs that are modeled on Lincoln Laboratory's radar workshop: a four-hour radar course for teachers seeking ideas for hands-on science projects and a one- to two-week workshop for students in grades 7 to 12.

Team America Rocketry Challenge



This year's Lincoln Laboratory-sponsored Team America Rocketry Challenge team had seven students, mentored by Francesca Lettang, Jeffrey Koechling, and Adam Attarian. The objective of the competition was to launch and safely recover one egg, with an apogee altitude as close to 800 feet as possible and a flight time between 46 and 48 seconds. Other requirements included a minimum rocket length, a maximum rocket mass, and motor and payload sections that come down in separate pieces. The team designed, built, and tested two candidate rockets. After successful launches, the team experienced a series of setbacks: a motor malfunction, the loss of a rocket in a tree, and delays because of weather. Despite these setbacks, they completed the challenge by building two rockets that achieved altitudes between 765 and 790 feet and flight times between 42.6 and 56.4 seconds during the qualification flights, without damaging any eggs. During the team's best qualification launches, their rocket reached an altitude of 765 feet with a flight time of 43.38 seconds and an altitude of 790 feet with a flight time of 56.36 seconds.

Above, many last-minute adjustments were engineered in the field to achieve the desired rocket flight results. At left, the Lincoln Laboratory-sponsored team was one of almost 700 teams nationwide participating in the Team America Rocketry Challenge.



Robotics Outreach

Robotics Outreach at Lincoln Laboratory (ROLL) is designed to stimulate youth interest in science and technology through hands-on robotics programming. Members of ROLL help sponsor robotic teams participating in regional and national competitions and supply mentors to area schools.

Through the FIRST (For Inspiration and Recognition of Science and Technology) program, ROLL volunteers help children learn how to program robots to complete challenges. The FIRST robotics competition challenges children to program an autonomous robot to complete missions on a playing field containing LEGO-built obstacles and to develop an innovative solution to a unique problem.

In the 2014–15 competition year, 16 Lincoln Laboratory–sponsored teams competed in local and state robotic competitions. Awards are given not only for the best performing robot but also for innovation, teamwork, and inspiring others about STEM and robotics.

137 students participated in Laboratory-sponsored robotics teams in the 2014–15 competition year



Robotics teams meet weekly to design and program a robot to accomplish tasks in a challenge proposed by the FIRST program.

Junior FIRST LEGO League (Jr.FLL)

Grades K–3

Jr.FLL captures young children's inherent curiosity and directs it toward discovering the wonders of science and technology. This program presents a real-world scientific challenge that children explore through research, construction, and imagination. Teams use LEGO bricks to build a model with at least one motorized movable part and develop a poster to illustrate what they learned and built. Beverly Wong, Hemonth Rao, and Stephen Valentine mentored 18 Jr.FLL members on three teams (Tech Titans, Storm, and LEGO League Explorers) in the 2014–15 challenge.

FIRST LEGO League (FLL)

Grades 4–8

In FLL, children are immersed in solving real-world science and technology challenges. The FLL challenge has three parts: the robot game, the project, and the core values. Using LEGO Mindstorms technology, teams build autonomous robots that perform a series of missions. FLL students were mentored by Loretta Bessette, Jacob Huang, Curtis Heisey, and Carol Chiang.

Each team has two and a half minutes to complete as many robot missions as possible and five minutes to present an explanation of their solution to the year's project. This year's project, "Trash Trek," challenged

participants to envision a new way to dispose of or reuse trash to benefit society.

Lincoln Laboratory was represented by 11 FLL teams totaling 95 students: Legosaurus, Bot Vaderz, Flaming Ninja Waffles, Mindstrosity, Anonymous Rulers, RoboOwls, The Crazy 8s, Titanium Lego Dudes, Zero Gravity, EV3s, and EV4s. Mindstrosity competed at the state finals.

FIRST Tech Challenge (FTC)

Grades 7–12

Using a head-to-head sports competition model, FTC teams design, build, and program their robots to compete in an alliance against other teams. Robots are built using a TETRIX platform that is reusable from year to year.

Teams strategize and build robots by using sound engineering principles. The challenge for the 2014–15 competition included robotic tasks to be performed autonomously and under driver control. Allied teams had opportunities to complete specialized tasks for extra points.

Lincoln Laboratory sponsored two FTC teams comprising 24 students, who were mentored by Jacob Huang and Jenifer Evans. FTC Team 2875, Mightybots, and FTC Team 7297, LiMITless, met 24 times throughout the season, spending 384 hours building, testing, and competing with their robots. The Mightybots team competed at the state finals.



The Control Freaks of Wayland pause after winning trophies at the state finals to thank those who offered financial support and mentorship.

Sister Robotics Teams

ROLL has continuing collaborations with robotics teams from Roxbury, Wayland, Waltham, Lexington, Weston, Manchester-by-the-Sea, and Shrewsbury, Massachusetts, as well as from Hanscom Air Force Base. ROLL ensures that these teams have adequate supplies, funds, and mentorship to design, build, and program their robots. The Laboratory teams assist their sister teams by staging scrimmages and sharing design concepts and programming tips. Some sister teams visit the Laboratory to demonstrate their robots and to tour the facility.

Massachusetts FTC (MASSFTC)

All high-school-level Lincoln Laboratory robotics teams and sister robotics teams belong to the Massachusetts FTC, organized by the Laboratory's own Loretta Bessette and Jacob Huang. ROLL teams hold workshops and scrimmages to promote interleague cooperation prior to competitions. In February, Bessette and Huang host the state championship, assisted by James Streitman, Nancy List, Joseph Usoff, Peter Klein, David Blocher, and Nicholas Stanisha, among others. ROLL provides volunteers, referees, and judges for each MASSFTC event.

SPOTLIGHT: All-Girls Robotics Team

Among the many FIRST LEGO League (FLL) robotics teams sponsored by the Laboratory is an all-girls team. Coached by staff members Elisabeth Daley and Leslie Watkins, these 10 girls, ages 9 to 14, started each practice session by evaluating a robot built by another team in an effort to understand other designs. The girls were eager to test the robots by analyzing speed, efficiency, and durability. According to Daley, this process helped them think more strategically about the competition: "There are some exciting but tricky missions, and seeing the girls figure out the practicalities of what they can accomplish is a big part of the learning curve." Laboratory volunteers Meredith Drennan, Chelsea Curran, Tina Chen, and Allison King assisted in mentoring and instruction each week.

"Robotics is the easy part of coaching a robotics team. The hard part is making sure the girls are having fun and learning," says Watkins, who believes that lessons learned along the way will stay with team members well after the competition.

"I hope that we were able to give our girls a positive, engaging experience in which they can make mistakes and use them as opportunities to learn, and that they leave confident and willing to try new things. Hopefully by having this experience so early on, the girls will be empowered to do even more amazing things in high school," says Daley.



Above, Leslie Watkins explains the basics of robot assembly to her team. Below, FIRST LEGO League team members, guided by coaches, discover engineering possibilities.



High-school students listened to Spencer Johnson describe how he found his way to a career in engineering and discuss the role of technical careers in the American job market.



MIT Office of Engineering Outreach Programs (OEOP)

The MIT OEOP in the School of Engineering offers deserving students rigorous academic experiences that encourage the pursuit of careers in technical fields and provide a hands-on curriculum that strengthens foundational math, science, and communication skills in a challenging learning environment. Lincoln Laboratory plays a part in three OEOPs: STEM, SEED, and MITES.

Science, Technology, Engineering and Mathematics (STEM)

STEM is a year-round academic enrichment program for talented local middle-school students who want to get ahead in math and science. The courses use lectures, projects, and experiments to help participants develop mathematical thinking and problem-solving abilities. Lincoln Laboratory sponsored a robotics course and provided facility tours. Brandon Matthews and John Nwagbaraocha presented briefings on their career choices, each highlighting the importance of a technical career path.

Saturday Engineering Enrichment and Discovery (SEED) Academy

The SEED Academy is a seven-semester technical career exploration program for underserved high-school students in Boston, Lawrence, and Cambridge, Massachusetts. Lincoln Laboratory sponsored two students and an aeronautics and astrophysics course. Laboratory staff member John Nwagbaraocha presented a talk on what he does at work and how he has benefited from a technical career.

Minority Introduction to Engineering and Science (MITES)

In June, 68 promising high-school seniors from across the country arrived at MIT to participate in MITES, a residential academic enrichment program. Over



While touring Lincoln Laboratory, students in the STEM program watched demonstrations on robotics (above, given by Byron Stanley), decision support software for air traffic control, and microelectronics.

six weeks, students were immersed in college-level courses in math, physics, life sciences, engineering, and humanities. This year marked the 40th anniversary of the program, which stresses the value of pursuing advanced technical degrees and helps students develop the skills necessary to achieve success in science and engineering.

Lincoln Laboratory sponsors two students in this program and hosts a guided tour of Laboratory facilities. MITES students listened to presentations by Laboratory staff members Shannon Roberts and Spencer Johnson, who explained how they chose their respective career paths and why jobs in the technical field are important.



“Make Your Own Wearables” Workshop

In December 2014, Kristen Railey organized and led a new full-day engineering workshop for 50 high-school girls at Lincoln Laboratory. The workshop introduced girls to engineering by having them make their own wearables—apparel and accessories that incorporate computer and electronic technologies. The girls

learned about the applications of 3D printers and various machine shop tools; attended a session on SOLIDWORKS computer-aided design (CAD) software; created 3D models of bracelets; and programmed light-emitting diodes for a

self-built electronic circuit for shoes. Presenting some of the real-world applications of wearable technology were two guest speakers: a prosthetic foot designer and the co-inventor of Wristify, a thermoelectric bracelet. “I really liked SOLIDWORKS,” said one participant. “We had fun designing the bracelets,” she continued. A team of Laboratory volunteers discussed how they

“I learned a lot about different areas of engineering that I didn’t even know existed.”

— Participant in the Make Your Own Wearables Workshop



Kristen Railey explains the different pins, or electrical contacts, for inputs and outputs (e.g., pressure sensor, battery power, lights) on the FLORA circuit board that the girls used to build their shoe-wearable electronic circuits (shown at left).

got started in engineering and what kind of work they are involved in as mechanical engineers.

“I want girls to realize that engineers look like me and them,” said Railey. The girls not only left the workshop with 3D-printed bracelets but also with basic skills in CAD, computer programming, and circuitry. “The conversation does not end here with the workshop,” said Railey. “I want to create a community through my Girls Who Build website that connects girls to local engineering workshops and summer camps, female role models, and educators. It is my hope that by exposing girls to STEM early on and engaging them over the years, the number of women engineers and scientists will rise,” said Railey.

LLCipher

In August, Lincoln Laboratory pioneered a new outreach program, LLCipher. Offered at Beaver Works, this one-week workshop provided an introduction to modern cryptography—a math-based, theoretical approach to securing data. The idea for the course came from Bradley Orchard. Sophia Yakoubov developed the course and served as the lead instructor, with the help of Emily Shen and David Wilson.

Lessons in abstract algebra, number theory, and complexity theory provided students with the foundational knowledge needed to understand theoretical cryptography. Students built on that knowledge to construct provably secure encryption and digital signature schemes. On the last day, students learned

about zero-knowledge proofs (proving a statement is true without revealing any information beyond the truth of the statement) and multiparty computation (computing a function over multiple parties’ inputs while keeping the inputs private). When asked about the most interesting thing he learned, one student replied, “Zero-knowledge proofs, as they seemed impossible. The idea of proving knowledge without sharing it is fascinating.”

According to Orchard, “The students were engaged, asking questions, and demonstrating that they understood the material, and, most importantly, having fun.” Yakoubov says that the first LLCipher workshop was clearly a success: “The most common suggestion among students was to extend the length of the program, so we plan to add more activities into next year’s workshop.”



Workshop designer and instructor Sophia Yakoubov (standing) makes her way through the classroom as the students learn about cryptography.



Two of the four Lexington High School students who helped with the project—Videh Seksaria (center left) and Mia Kobs (center right)—attended the December event to unveil the pendulum exhibit. Also present at the grand opening of this exhibit are Eric Evans, director of Lincoln Laboratory (left), and David Scott, manager of the Technology Office Innovation Laboratory (right).

Pendulum Exhibit

On 15 December 2014, a pendulum installed in Lincoln Laboratory's East Atrium was released for its inaugural "swing." The Laboratory's pendulum replicates the experiment that French scientist Jean Bernard Léon Foucault performed in 1851, proving that Earth rotates about its axis. The Laboratory's pendulum shows that the Earth is rotating by the sequential tumbling of pegs arranged at the edge of the pendulum's arc. The exhibit includes an additional twist—radar tracking of the pendulum's movements, supplied by two small radar units set up at corners of the base.

The installation of the pendulum was a collaborative project that enlisted a multidisciplinary team from the Laboratory and four physics students from Lexington High School to develop a museum-quality display about Foucault's experiment and the science behind it. The goals of the project were to involve students in an engineering activity and to create an attraction that would engage the curiosity of the many middle- and high-school students who come to Lincoln Laboratory for outreach programs.

The students, Videh Seksaria, Mia Kobs, and May Zhou, designed sample 3D-printed components for the display, working with David Scott in the Technology Office Innovation Laboratory. Jerrick Chen took measurements that the engineering team used to assess the performance of the radars. The project met its goals: the exhibit provides an interesting learning experience, and the development of it inspired the students, who agreed with May: "This experience solidified my interest in becoming an engineer."

"The pendulum exhibit is not only a tool to teach science but also a model for a successful, community outreach undertaking. We are looking forward to starting other projects like this one for local high-school students."

— Lincoln Laboratory
Director Eric Evans

At the Senior Internship Exhibition Night at Google Cambridge, Community Charter School of Cambridge students Kyania Burke and Trevon Bennett (center) explained the building process used to create the Turing machine replica. They are flanked by their Lincoln Laboratory mentors, Timothy Greer (left), Chad Spensky (right), and Benjamin Nahill (far right), who helped the students approach how to build their Turing machine.



Turing Machine Exhibit

A team of Lincoln Laboratory scientists helped two high-school seniors from the Community Charter School of Cambridge, Massachusetts, build a version of a Turing machine, a theoretical computing system proposed by Alan Turing as a means to mathematically calculate anything. This project helped the students satisfy an internship requirement.

Chad Spensky, Benjamin Nahill, Stuart Baker, Timothy Greer, and Jack Lepird served as mentors, teaching Trevon Bennett and Kyania Burke about basic electrical engineering, mathematical concepts, and product development. Bennett appreciated the guidance from his mentors: "While we had never built one of

these machines, the mentors were able to use their experience to come up with ideas and direct us through the process. Kyania and I were able to add our ideas as well."

The students learned how to work with the Python programming language, Raspberry Pi single-board computers, the Arduino electronic prototyping platform, and machine tools. They also developed the embedded microcontrollers, numerous motors and sensors, and code to control the machine. The Laboratory staff plan to continue working to deploy a polished machine at Lincoln Laboratory as a long-term exhibit.

Daughters and Sons Days

Lincoln Laboratory extends its outreach to the students of many local schools by way of the annual Daughters and Sons Days offered for employees' children. In 2015, children enjoyed stations that offered interactive demonstrations and tours of a fabrication lab, a clean room, a robotics lab, and a machine shop, and a science fair of demonstrations on vibration,

optical illusions, laser communications, and 3D imaging. Staff members demonstrated scientific principles of sound and light, and conducted an experiment to see how infrared sensors can track an object. Parents enjoy this opportunity to create excitement about STEM. Presentations were given by Yari Rodriguez, Crystal Jackson, and Matthew Johnson.



Children learned how special cameras can detect levels of radiation (i.e., heat and cold).

Ceres Connection

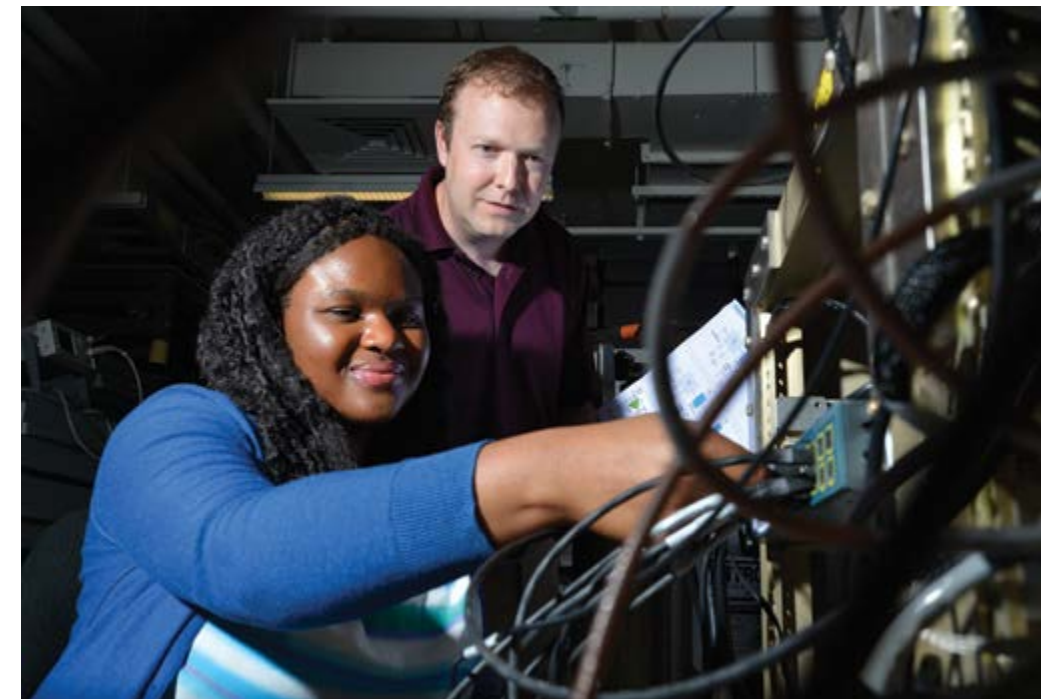
More than a decade ago, Lincoln Laboratory partnered with the Society for Science & the Public to promote science education through the Ceres Connection program. This program names minor planets in honor of students in grades 5 through 12 and their teachers. Students and teachers are selected through worldwide science competitions, such as Broadcom MASTERS, the Intel Science Talent Search, and the Intel International Science and Engineering Fair. Since 2003, more than 3250 students and their teachers have been honored. Each year, the Ceres Connection program awards this honor to about 250 students.

Nahom Ghile verifies that the cross-dipole antenna feeds were connected correctly. He is monitoring both horizontally and vertically polarized environmental noise from the antenna.



"This internship has reinforced my interest in engineering and made me realize how complex it is."

— Nahom Ghile,
AFCEA intern



Derrick Feld looks on as Chi Chi Nwodoh connects wires on the test terminal she helped build. The terminal will be used aboard the Lincoln Laboratory Paul Revere Boeing 707 testbed during flight demonstrations.

AFCEA International

The Lexington Chapter of the Armed Forces Communications and Electronics Association (AFCEA) arranges internship opportunities for graduating high-school seniors interested in science, technology, engineering, or mathematics. Each summer, Lincoln Laboratory selects two applicants to work with industry experts who mentor the students in real hands-on work in their fields of interest.

In 2015, two local Massachusetts graduating high-school seniors worked at the Laboratory under an

AFCEA internship program. Mentored by Derrick Feld, Chi Chi Nwodoh assisted in the mechanical construction of satellite terminal prototypes for a newly developed satellite system. Nahom Ghile, who helped Josh Erling and Andrew Daigle develop software to control and configure a system to record and measure radio-frequency (RF) data, participated in open-air testing of the system to characterize the noise levels present in the RF spectral band. Ghile said, "There is so much that I have been able to learn, and this experience has made me eager for the start of college in the fall."

Massachusetts State Science and Engineering Fair

Lincoln Laboratory has supported the Massachusetts State Science and Engineering Fair (MSSEF) for 15 years, serving as a bronze donor to the event by awarding \$500 scholarships from the John Welch Memorial Fund to the second-place winners in the physics and engineering competitions. This fund, among others, is part of the MIT Lincoln Laboratory Giving Program. Technical staff members from Lincoln Laboratory support the MSSEF by volunteering as judges in their field of expertise. This May, Eric Austin, David Brown, Joshua Dettman, Sean O'Melia, Philip Evans, Aradhana Narula-Tam, Jean Piou, Roland Weibel, Alexandra Wright, and Shourov Chatterji judged science fair projects.

Local School Science Fairs

Technical staff members from Lincoln Laboratory support Lexington High School and Carlisle Middle School by volunteering as judges for the schools' respective science fairs. Countless other schools are supported by Laboratory employees contributing to their children's school science fairs or career days without deliberately representing Lincoln Laboratory. Their participation supports community outreach and STEM education on a local level.



Raoul Ouedraogo (far left) sets up the coffee-can radar for display. The "do-it-yourself" radar acts as a Doppler radar and a synthetic aperture radar. A young participant (left) tries on 3D-printed robotic gloves at the MIT Museum during Cambridge Science Festival's 3D-printing exhibit.

Cambridge Science Festival

Lincoln Laboratory volunteers enjoyed interacting with some of the 15,000 attendees of the Cambridge Science Festival, an annual, weeklong, citywide event. Mentors from the Robotics Outreach at Lincoln Laboratory program showcased a competition robot fabricated by high-school students. Spectators were able to guide the robot around a mini obstacle course. At the MIT Museum, David Scott of the Technology Office Innovation Laboratory displayed 3D-printing capabilities while Raoul Ouedraogo explained the small radars built by high-school students during a Laboratory summer workshop. Beaver Works offered an open house for attendees to tour the innovative workspace and to view the unmanned aerial vehicles built by MIT students at the facility.

iGEM

The International Genetically Engineered Machine (iGEM) Foundation is dedicated to the advancement of synthetic biology through education and competition. iGEM, originally a month-long course offered in 2003 during MIT's Independent Activities Period, spun out of MIT in 2012 and became an independent nonprofit organization located in Cambridge, Massachusetts. The iGEM Foundation fosters scientific research and education through the annual iGEM Competition, the premier synthetic biology competition for high school, undergraduate, and graduate students.

Student teams are given a kit of standard biological parts and spend the summer building biological systems that function in living cells. In the fall, participants present their work at the Giant Jamboree. This year, 259 teams comprising more than 2700 students from 39 countries attended the Giant Jamboree, held at the Hynes Convention Center in Boston, Massachusetts, from September 24–28. The projects were evaluated by a panel of 130 judges from academia, government, and industry.

Peter Carr, who leads the synthetic biology research program at Lincoln Laboratory, began judging the competition in 2006; in 2011, he was appointed head judge. Now, as iGEM's director of judging, Carr oversees the judging process for the competition, trains and advises head judges, and chairs the Responsible Conduct Committee.

In 2014, Lincoln Laboratory synthetic biologist David Sun Kong founded the iGEM microfluidics "track" (a



Peter Carr accepts a gift thanking him for his efforts as the director of judging for the 2015 iGEM Giant Jamboree.

specific subject area within synthetic biology), which became part of the 2015 competition. Kong has supported iGEM in several other capacities, including through sharing his talents as a DJ and a photographer.

Group Tours

As part of the Lincoln Laboratory Community Outreach initiative, tours of Laboratory facilities, such as the Microelectronics Laboratory, the Air Traffic Management Laboratory, the Rapid Hardware Integration Facility, Radio-Frequency (RF) System Test Facility, and Flight Test Facility, are given annually to a number of groups. In 2014, tours were given to

- Students participating in the AFCEA Diversity Career Day at Hanscom Air Force Base
- UMass–Lowell U.S. Air Force Reserve Officer Training Corps (ROTC) students
- Research Science Institute program students
- U.S. Air Force cadets
- U.S. Association of Former Members of Congress
- ROTC students
- U.S. Army Test and Evaluation Command
- U.S. Army Soldier Systems Center
- U.S. Military Academy at West Point
- National Reconnaissance Office fellows
- Congressional and executive branch staffers
- Electronic Systems Center at Hanscom Air Force Base





In 2015, the Laboratory hosted its largest group of Service Academy students to date—50 cadets and midshipmen.

Educational Collaborations

Inspired by employee desires to connect with the community and to motivate student interest in science, technology, engineering, and mathematics, our outreach initiatives include

- Technical Staff Programs
- Military Student Programs
- Student Programs
- MIT Student Programs

Continued Learning Programs

Lincoln Laboratory is committed to the professional growth of its staff members in the interests of enhanced knowledge of staff and the Laboratory enterprise, and its benefit to our sponsors. This goal is achieved through in-house technical seminars, special educational opportunities, graduate studies, and continued technical education.

Part-Time Graduate Studies Program

The Part-Time Graduate Studies Program enables staff to earn master's degrees on a part-time basis while continuing to work full time at the Laboratory. Technical or nontechnical graduate studies can be pursued via distance learning or at local universities. As of the fall 2015 term, 16 staff members are participating in the program.

Boston University Program

Boston University (BU) offers courses from its master's program in computer science onsite at Hanscom Air Force Base. These courses can be taken independently or as part of a certificate or master's degree program through BU. Courses have included Computer Networks, Cryptography, and Software Engineering. Since the program started in 2013, 100 staff members have enrolled.



Technical staff from the Laboratory and nationally prominent guest speakers routinely present seminars on new technologies.

Technical Seminars

Seminar series motivate and inspire staff while facilitating working relationships. The Technology Office Seminar Series invites nationally known experts to the Laboratory. Each seminar is designed to offer specific technology insights, provide a forum to develop technology applications, and foster future collaborative efforts. The seminars offered in 2015 covered a variety of leading-edge topics and trends in technology:

- Fundamental Physics through Laser Ranging to the Moon
- Sony's SmartEyeGlass
- Underwater Wireless Communications
- MIT's Entry in the Defense Advanced Research Projects Agency (DARPA) Robotics Challenge
- The Giant Magellan Telescope: An Overview and Status Update
- CLARITY and Beyond: Tools for Integrated Brain Mapping
- Department of Defense Climate Change Technology Study Results
- Progress, Prospects, and Challenges in the Water-Energy-Land Research Nexus under Global Change

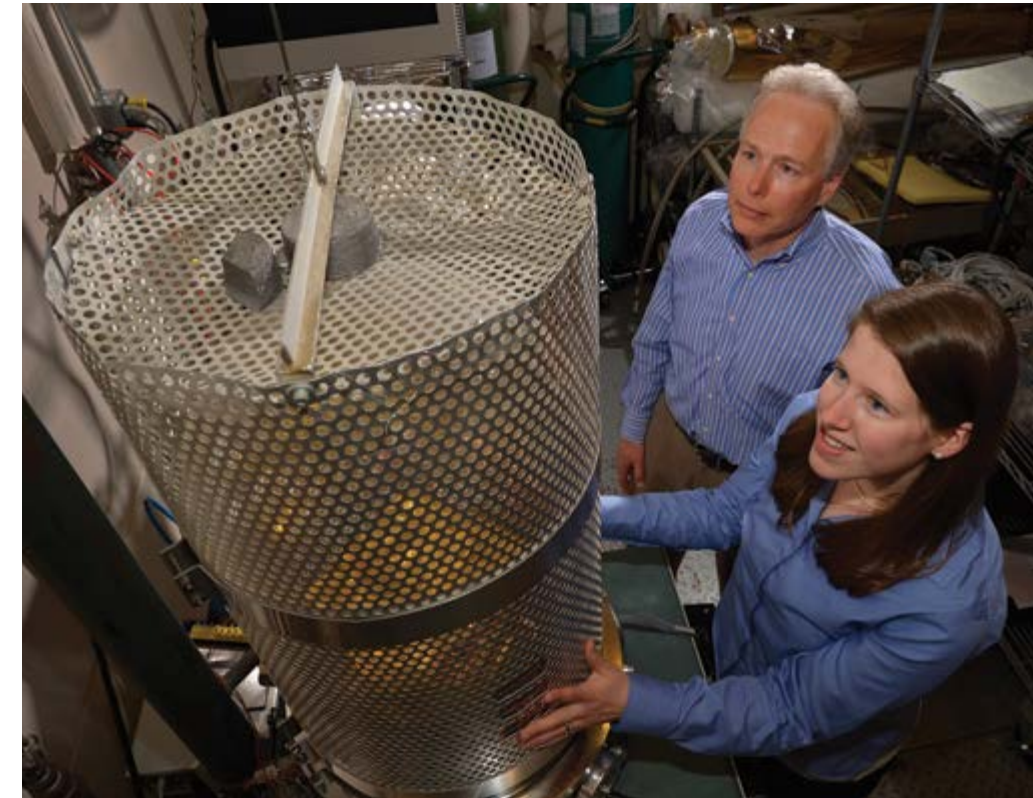
In-House Learning

Continued education, required training, and professional development are important parts of Lincoln Laboratory's commitment to maintaining and enhancing technical excellence and regulatory compliance.

- An in-house education program presents courses in professional and leadership development, business operations, mission assurance, fabrication engineering, security awareness, and software applications.
- One-day technical seminars, workshops, and short courses are offered in many different subject areas, such as Fourier optics on the computer, statistical signal processing, programming, and fundamentals of flight.
- Monthly seminar series are given in the areas of biomedical signal and image processing; imaging sciences; and processing, exploitation, and dissemination.
- Guest lecturers, distinguished in their fields, are frequently invited to the Laboratory to present their research or to explore current industry trends.
- Annual workshops and courses on topics such as networking and communications, radar systems, and ballistic missile defense technology are hosted by technical groups and divisions.



On any given day, Lincoln Laboratory offers some type of seminar to complement staff members' technical or personal background.



Lincoln Scholar Emily Clements is assisted by her mentor, Mark Padula, in testing an environmental test chamber.

Lincoln Scholars Program

Technical staff members interested in pursuing degrees at either the master's or doctoral level can apply to the competitive Lincoln Scholars Program, which supports full-time graduate study at Boston-area universities. During the academic year, the scholars attend on-campus courses and continue to contribute to Laboratory programs on a weekly basis under terms arranged with the Graduate Education Committee; in between semesters and after receiving their degrees, they work at the Laboratory full time. Each scholar is paired with a mentor who oversees his or her academic progress and ongoing contributions to the Laboratory. Currently, 24 staff members are Lincoln Scholars.



Above, Dennis Blejer mentored midshipman Christopher Panuski in analyzing data collected from a Ku-band radar to determine the radar signature of a maneuvering octocopter. At right, Service Academy summer intern Caroline Bates tightens the optics for a compact, foldable antenna telescope being tested for space readiness.



Service Academy Summer Internship Program

Lincoln Laboratory offers summer internships to students from the U.S. Air Force, Army, Naval, Coast Guard, and Merchant Marine Service Academies. Service Academy students are assigned to a Laboratory technical group for a three- to five-week span. Participation in this summer research program, which has been offered for decades at a small-scale level, continues to grow steadily each year. In 2015, the Laboratory hosted its largest group of Service Academy students to date—50 cadets and midshipmen. These students pursued a wide variety of research efforts, including the demonstration of a low-cost, high-performance airborne lasercom terminal; the design of laser communications interoperability standards; the design of a microsatellite payload; and the determination of mechanical load on spacecraft. While gaining hands-on experience in a research environment, the students contributed to projects that complement their courses of study.

“The diverse, collaborative nature of work done at the Lab makes it easy to find a project that stimulates an entirely new interest.”

— Christopher Panuski
Service Academy intern

Military University Electives

Laboratory staff teach elective courses to the O-4 and O-5 level officers attending the Naval War College in Newport, Rhode Island. The courses help students think analytically about the technology and policy challenges they will face.

The Ballistic Missile Defense course has been led annually by Claude Noiseux since 2002 with lectures drawn from the Air, Missile, & Maritime Defense Technology Division. This course explores the critical technologies, capabilities, operational concepts, and policies that will influence how ballistic missile defense affects the military capabilities of the United States.

Space Technology and Policy has recently been taught by Robert Guerriero. This seminar explores the critical space technologies, capabilities, and policies that shape how the United States uses space for military and government purposes.

The Cyber Security course, taught by Reed Porada and Jeffrey Gottschalk, provides an overview of cyber operations and cyber threats and enhances understanding of how to defend critical systems and information. This course proved so popular that a similar course is being developed for the Air Force’s Logistics Management Center at Hanscom Air Force Base.



Colonel William E. Young, Jr. is applying system-theoretic approaches to improve systems engineering, operational design, red teaming, and campaign-level mission assurance in the cyberspace domain.

Military Fellows Program

Lincoln Laboratory awards fellowships to support the educational pursuits of active-duty military officers from all of the Service branches. This partnership acquaints military officers with the process of developing technologies that directly impact national security while providing the Laboratory with constructive insights of the officers. Officers enrolled in a Senior Service School work in research programs at the Laboratory and take national security management courses at MIT campus. Senior officers participating in the Army’s Training with Industry Program are assigned full time to a Laboratory technical group. Fellows pursuing graduate degrees work on Laboratory-sponsored programs that complement their thesis research.

West Point Collaboration

Lincoln Laboratory partners with the U.S. Military Academy at West Point to offer real-world experience to cadets.

Kent Patterson and Bruce Bray of the Laboratory worked with West Point faculty advisor Major Stacy Godshall to lead cadets David Piatt and Marco Zamora in developing a radar calibration satellite for important radar assets. On the basis of initial work previously conducted by cadets, prototypes were fabricated using candidate materials and processes, measurements were made in the Laboratory's radio-frequency anechoic chamber, and material properties were tested to facilitate evaluation of the design to sustain launch environments. This work was conducted as part an elective course on essential features of independent research in physics.

The Laboratory also hosts West Point cadets for a day of technology demonstrations. Through this partnership, Laboratory staff have talked with cadets about their goal to design active mounts for off-road operation of autonomous ground vehicles using localizing ground-penetrating radar. Byron Stanley, who organizes the cadets' visit to the Laboratory each year, explained why the collaboration is important: "Building and maintaining connections with the cadets and officers will help us better serve the U.S. military in the future."



SPOTLIGHT:

Sharing Laboratory Lessons at West Point

For the 2015–2016 academic year, Laboratory staff member Amy Hughes has been teaching Computer Science Fundamentals, an introductory programming course that is part of the United States Military Academy (USMA) Information Technology (IT) program. She described teaching students, many of them IT and computer science majors. "For some cadets, this course is the first time they have interacted with anything other than a smartphone or Windows computer," Hughes explained.

The chance to teach at USMA arose after the launch of West Point's Army Cyber Institute last fall left a shortage of computer science faculty, said Hughes. "They looked to laboratories and research institutes that the Army works with to find subject-matter experts able to spend a year at West Point. Hughes' experiences teaching a course at the University of Southern California while earning her doctorate and presenting short-term Laboratory seminars, prepared her to accept this opportunity.

Hughes has found that her Laboratory background has helped students realize the real-world applications of their lessons. One such lesson was on packet sniffing, which can leave users potentially vulnerable to data theft on Wi-Fi networks in places such as coffee shops. "Because I did packet sniffing at the Laboratory, I was able to show the cadets what to look for in the data. The cadets were fascinated by how it could not only be used for analyzing network problems but also for finding evidence of malicious data theft."



Amy Hughes is spending the academic year at West Point as a faculty member.

Next semester at USMA, Hughes will teach the Cyber Security Engineering course, which she expects will have greater crossover to her specific area of expertise. "That course is much more relevant to my skills because it covers network defense and intrusion detection, protocols, and packet traces," she noted.

Hughes remains enthusiastic about encouraging the cadets to apply for internships with the Laboratory. "I know they would be eager to intern if we can find the right projects for them." During her time at West Point, Hughes is also making an effort to interact with faculty from the Army Cyber Institute. "I think it will be helpful for the Laboratory to have a better understanding of how the Army Cyber Institute is approaching the cyber problem."

Summer Research Program

Since 1975, the Summer Research Program has offered students the opportunity to work with national experts and use state-of-the-art equipment to help solve real-world challenges. In 2015, the Laboratory welcomed 236 students from 79 different schools across the country. During the two-month program, participants work in technical groups, attend technical briefings, collaborate with mentors, and get hands-on experience to complement their course of study. This year's student projects ranged from modularizing an unmanned aerial vehicle payload to visualizing civilian air traffic.

Gary Hackett, manager of the Summer Research Program, maintains that the program, now in its 40th year, delivers outstanding internship opportunities: "The Laboratory's internship experience continues to set the standard for internship opportunities because of the Laboratory's accomplished technical staff, research programs, top-notch facilities, and abundant resources." Describing the students accepted in this program, Hackett said, "Each year I continue to be amazed by the students' curiosity, drive, and interest in continuing their work."

"Participating in the Laboratory's Summer Research Program provides valuable experience available at very few research organizations in the world. One of the Laboratory's greatest strengths is guaranteeing a great community to work in with incredible, intelligent people doing very important, rewarding work."

— Keith Krenek
Harvard University intern



The Summer Research Program grows each year. The 2015 program saw an increase of more than 50 participants compared to the prior year.

Fayetteville State University Internship Program



Malik Oliver, FSU intern, loads samples into a centrifuge.

Fayetteville State University (FSU) student Malik Oliver joined the Laboratory for the summer (as he did in 2014) in the Chemical and Biological Defense Systems Group. Malik is an FSU Center for Defense and Homeland Security STEM scholar. Whitney Young, a mentor to Oliver, described her appreciation for the summer research program: "This type of program is instrumental in encouraging future generations to become involved in technical fields."

University Cooperative Education Program

Lincoln Laboratory employs students from area colleges for full-time co-ops during the summer and part-time co-ops during academic terms. Highly qualified students selected for co-ops become significant contributors to project teams. In 2015, 60 cooperative students worked in divisions and departments at the Laboratory. Colleges and universities that regularly partner with Lincoln Laboratory in this program are Northeastern University, Wentworth Institute of Technology, University of Massachusetts-Lowell, Boston Architectural College, and Rochester Institute of Technology.

"Allowing students to work on real problems helps get them excited about what they can do with their degrees and how much of an impact they can have."

— Whitney Young,
Intern mentor

WPI Major Qualifying Project Program



WPI student Orland Lamce (left), mentored at the Laboratory by Adam Shabshelowitz and Jesse Mills, prepares to test a small monopropellant rocket motor on a torsional thrust stand instrumented with pressure and temperature sensors to monitor the rocket motor's performance. The rocket motor is intended for use in nanosatellites or in similarly sized platforms.

In summer 2015, ten Worcester Polytechnic Institute (WPI) undergraduates majoring in electrical engineering, physics, math, mechanical engineering, and aerospace engineering were accepted as Laboratory interns under WPI's Major Qualifying Project Program. This program requires students to complete a project equivalent to a senior thesis. Students demonstrate the application of skills, methods, and knowledge to problems typical of those encountered in industry. This year's capstone projects, reflecting nine weeks of work at Lincoln Laboratory, included

- Six-Axis Monopropellant Propulsion System for Pico-Satellites
- An Assessment of Track Fusion Algorithms
- Ku-band Instrumentation SAR System
- Digital Programmable Gaussian Noise Generator

Katherine Haas, a WPI alumna, was asked by former professors to present a talk at the Mathematics Institute for Secondary Teaching Workshop to show high-school math teachers ways that math is used in the workplace. She spoke about how math relates to the function and use of radars.

Venancio Capelle, foreground, will use what he learned during the program to improve the computer network at the Ebeye Public School.



"We want to encourage Marshallese students to go into IT and to keep learning. At Lincoln Laboratory we have a culture of continuing education."

— Melina Lake,
Marshallese Internship Program
technical advisor

Marshallese Internship Program

Three Marshallese students were selected for a 10-week internship that gives Republic of the Marshall Islands students opportunities to advance their careers in the information technology field. The program takes place at Lincoln Laboratory's field site at the Reagan Test Site (RTS) on U.S. Army Garrison Kwajalein Atoll (USAG-KA).

The interns—Wilson Kaisha, Neire Heine, and Venancio Capelle—worked with Ranny Ranis and Melina Lake, getting experience with assembling computers from the ground up, configuring and troubleshooting networks, and installing and running a Linux operating system. They also toured the Kiernan Reentry Measurement Site on Roi-Namur and the RTS Weather Station, learning about the systems on USAG-KA and how information technology is employed across

the spectrum of technology-related fields. Kaisha, who plans to work as an IT technician on Majuro in the future, said "the opportunity to get in-depth, daily instruction on computer networking was priceless."

The ultimate goal of the internship program is to propel the students into successful careers for decades to come. In the Marshall Islands, the Laboratory staff has a culture of spreading the seeds of technology education and giving participants a serious boost down the path to a fulfilling and useful career. The program, now in its eighth year, has mentored 17 students since 2008, all of whom have used the internship experience to steer them toward higher education opportunities in information technology or to gain employment in better jobs in the industry.

National GEM Consortium

The Laboratory supports the National Consortium for Graduate Degrees for Minorities in Engineering and Science (GEM). By offering partnerships with universities and industries, GEM provides support to students from underrepresented groups who are seeking advanced degrees in science and engineering fields. "One of the Laboratory's goals is to find the best talent nationally," said William Kindred, manager of the Laboratory's diversity and inclusion programs. "Connecting with GEM has given us the ability to reach exceptional engineers and scientists who may not have otherwise considered the Laboratory."

As an employer member of the National GEM Consortium, Lincoln Laboratory offers paid summer internships to students from underrepresented minorities who are pursuing graduate study in STEM through the GEM Fellowship Program. The goal of the program is to increase the number of STEM students nationwide. Ten GEM fellows performed research at the Laboratory in summer 2015.

Austin Murdock, a second-year GEM fellow attending the University of California, Berkeley, focused his research on computer security and network intrusion-detection and intrusion-prevention systems. "Being a GEM fellow was a great way to be paired with a good mentor, have access to the right tools, and get hands-on experience in the cybersecurity field," says Murdock.

As part of its participation in GEM, the Laboratory sends representatives to the Annual GEM Board Meeting and Conference to engage GEM officers and partnering organizations in discussions on strategies



Mentored by Leslie Watkins (back), GEM fellow Marissa Garcia investigates small propeller motors in preparation for miniaturizing a camera payload for a micro-unmanned aerial vehicle platform.

for transforming how the United States educates and prepares the next generation of engineers and scientists. Laboratory Director Eric Evans, president of the GEM Executive Committee, and Kindred attended the 2015 event at the John F. Kennedy Presidential Library and Museum in Boston, Massachusetts. The Laboratory sponsored an Executive Committee meeting and a tour of its Lexington, Massachusetts, facility and cosponsored the opening reception, at which Evans delivered a welcome address.

MIT Research Assistantships

Lincoln Laboratory employs a limited number of research assistants from MIT. Working with engineers and scientists, these students contribute to sponsored programs while investigating the questions that evolve into their doctoral theses. The facilities, the research thrusts, and the reputations of staff members are prime inducements behind the graduate students' decision to spend three to five years as research assistants in a technical group.

MIT VI-A Master of Engineering Thesis Program

The Laboratory is an industry partner of MIT's VI-A Master of Engineering Thesis Program. Students in the program spend two summers as paid interns at Lincoln Laboratory, contributing in projects related to their courses of study. Then, the students work as research assistants while developing their master of engineering theses. In 2015, five VI-A students participated in the program, gaining experience in testing, design, development, research, and programming.

MIT Undergraduate Programs

Lincoln Laboratory partners with MIT's Undergraduate Research Opportunities Program (UROP) and Undergraduate Practice Opportunities Program (UPOP). Students undertaking a UROP or UPOP assignment may choose to do a research project for course credit or accept a paid internship. The students at the Laboratory engage in every aspect of onsite research. In



MIT VI-A Joeseph Colosimo (right) developed a doppler channel emulation of high-bandwidth signal with the help of his mentor, Matthew Kercher.

summer 2015, 12 undergraduates were hired as UROP interns and 7 as UPOP interns.

MIT Professional Education

Lincoln Laboratory collaborates with MIT faculty to offer courses through MIT's Professional Education Short Programs, which brings participants from industry and business to the campus for courses designed to expand familiarity with emerging technologies. Lincoln Laboratory staff led two such courses in 2015: Build a Small Radar System, and Rapid Robotics: Autonomous Systems with Open-Source Software.



In January, IAP activities led by Lincoln Laboratory staff were conducted at Beaver Works. The flexible spaces adapted well to both lecture-style classes and prototyping workshops.

MIT Independent Activities Period

During MIT's Independent Activity Period (IAP), a four-week term between semesters, Lincoln Laboratory technical staff lead activities ranging from academic seminars to hands-on engineering projects. Many of this year's activities were held at Beaver Works, using the 3D-printing capabilities and the prototyping shop at the facility. During the 2015 IAP, Lincoln Laboratory staff members organized the following classes or activities, all but the last three of which are new: Fluidics for Synthetic Biology: Prototyping Microbial Communities, The Innovation Tournament, Introduction to Lasercom: Build Your Own Laser Audio Transmitter, Rapid Autonomous Complex-Environment Competing Ackermann-steering Robot workshop, Software Radio, Build a Small Radar System, Build a Small Phased Array Radar System, and Hands-on Holography.

MIT Lincoln Laboratory Beaver Works

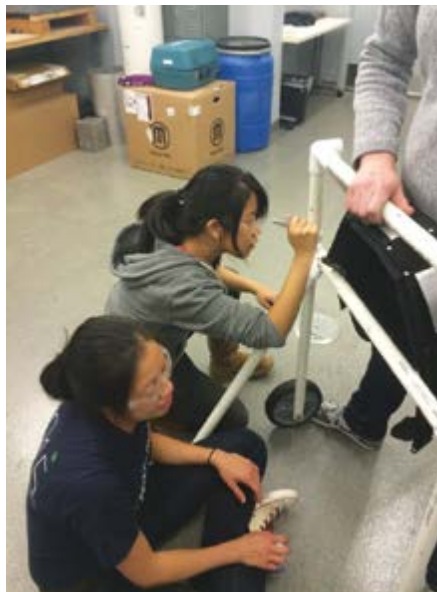
Beaver Works, an initiative between Lincoln Laboratory and the MIT School of Engineering, provides students with space and mentors for project-based learning opportunities. MIT faculty and Lincoln Laboratory staff work together at Beaver Works to strengthen research and educational partnerships.

The main Beaver Works collaboration is the capstone course, an MIT engineering class which features a project to develop technology that solves a real-world problem. During two semesters, the students design a system that addresses a need, and then fabricate a prototype system. In fall 2014 and spring 2015, MIT ran two capstone courses: Mobile Tactical Power Systems and Environmental Awareness in the Maritime Domain.

In February, 70 MIT students participated in the Assistive Technologies Hackathon (ATHack) at Beaver Works. Teams of students met with local people who live with disabilities and prototyped engineering solutions to problems faced by their “clients,” creating such devices as a voice-activated cane and a hands-free walker.

Between fall 2014 and spring 2015, nine groups were involved in different science, technology, engineering, and mathematics (STEM) programs held at the center. Among these offerings have been a one-day build-a-radar workshop directed by instructors from the Lincoln Laboratory Radar Introduction for Student Engineers (LLRISE); weekly practices for the Lincoln Laboratory teams that participate in the national CyberPatriot computer-network security challenges; and an ongoing mentorship program with the Community Charter School of Cambridge.

The team prototyping a hands-free walker fits PVC pieces together and bends metal plates during the assembly stage of the Assistive Technologies Hackathon at Beaver Works.



A prototype seaplane developed by students in a capstone course at Beaver Works was field-tested on the Charles River, Cambridge, Massachusetts.



Community Giving

Laboratory employees walk, run, bike, bake, and give to support local and national causes throughout the year. The Laboratory community is happy to engage in

- Helping Those In Need
- Helping Those Who Help Others
- Feeding Body and Soul

Some volunteers from the Lincoln Employees' African American Network (LEAN) gather donations prior to delivering nonperishable goods to the Greater Boston Food Bank.

Coats for Kids

Each year, at the onset of cold weather, Alicia LaDuke organizes Lincoln Laboratory's participation in a coat drive run by Anton's Cleaners. She collects gently used warm items from the Laboratory community and, with the help of James Armao, delivers all donations to Anton's Cleaners. Through this donation opportunity, the Laboratory typically gives 500 coats per year to Anton's to be cleaned and distributed to needy families in the Greater Boston area.



Laboratory employees gather donations for the Coats for Kids Program.

Santa for Seniors

Just in its second year at the Laboratory, Santa for Seniors collects donations to fill holiday gift bags distributed to senior citizens in Cambridge, Massachusetts, on Christmas Eve. This program hopes to shed light on the fact that many elderly are alone during the holidays and welcome the interaction and celebration with the volunteers. Traci Swartz, program coordinator for Community Giving at MIT, requested the Laboratory's help in collecting gifts for this program, organized by the Cambridge Police Department. Swartz says, "The Laboratory's willing and quick response is indicative of the thoughtful and kind attitude of the Laboratory community, which will pay off in good will to the larger community."

Toys for Tots

The MIT Credit Union at Lincoln Laboratory serves as a drop-off point for the United States Marines' Toys for Tots holiday toy drive. This annual event provides more than 400 toys and holiday gifts for needy families each December. This toy drive has been an annual event at the Laboratory for well over 20 years. The Laboratory has recently accommodated a second Toys for Tots drive for the Hanscom Air Force Base community.

SPOTLIGHT: Giving Tree

For the past nine Decembers in locations around Lincoln Laboratory, Paula Mason has set up Christmas trees tagged with specific gift requests from underprivileged members of the Boston community. These "Giving Trees" encourage the spirit of generosity toward those in need. "I was a recipient of a Giving Tree gift many years ago," says Mason, "and I never forgot the blessing of receiving not only gifts for my children but also household products that my budget didn't allow for."

The 150 local citizens who benefit from the Giving Trees vary in age and circumstance—the elderly, children, single parents, and veterans. "For some recipients," says Mason, "this is the only gift they will get." She hopes that Laboratory participation in this program continues to grow. It offers a simple way to make a small but lasting impact.

Paula Mason prepares the Giving Tree each year at the Laboratory.





Seven members of the Lincoln Laboratory team, shown above, landed on the “Top 100 Walkers” list for the Greater Boston Walk to End Alzheimer’s.

Walk to End Alzheimer’s

Lincoln Laboratory’s Alzheimer’s Awareness and Outreach Team, led by Catherine Holland, is dedicated to providing support and information to those in the Laboratory community who have been impacted by Alzheimer’s disease. In 2015, the team raised \$37,137 in the Greater Boston Walk to End Alzheimer’s, ranking them 2nd in the Boston Walk, 3rd among 1970 teams in the region, and 32nd in the nation for fundraising.

In a separate event in July, a team of 11 Lincoln Laboratory cyclists pedaled their way to a highly successful Ride to End Alzheimer’s. The ride, sponsored by the Alzheimer’s Association, raises funds for research and for programs and services for patients and families in the region. The team raised \$15,500, ranking it 2nd in fundraising among 84 teams in the event—the best showing ever by the Lincoln Laboratory cycling team.

TeamWalk for CancerCare

Five years ago, Julie Arloro-Mehta formed a team for Lowell General Hospital’s TeamWalk for CancerCare in memory of her father, who had played a major role in establishing the walk. The eight-member Lincoln Laboratory Team has met or exceeded their fundraising goals every year. In 2015, the team raised \$5100 to better the lives of those being treated for cancer at Lowell General Hospital.

Walk for Hunger

Seth Trotz invited Laboratory personnel to join him in Project Bread’s 2015 Walk for Hunger. This annual event gathers more than 40,000 walkers seeking to provide immediate and long-term relief to families for whom hunger is a constant part of life. “The Walk for Hunger is a great opportunity to support a deserving cause and to enjoy Boston,” said Trotz. Trotz’s three sons have accompanied him on the 20-mile walk each year since 2007.



The Lincoln Laboratory Heart Walk team, pictured here at the American Heart Association’s Heart Walk in Boston, stands together in the effort to educate people about heart disease.

Heart Walk

The Lincoln Laboratory Heart Walk team formed in 2012 to support efforts to combat cardiovascular disease and stroke. Susan Curry and Sandra McLellan work throughout the year to solicit donations for the American Heart Association’s Heart Walk in Boston, held each September. Fundraising begins in February with the Laboratory’s participation in the national Wear Red Day to raise awareness that heart disease often goes undetected. In 2015, the eight-member team raised \$4864 to help promote physical activity as part of a heart-healthy lifestyle.

“We could not keep going without the community at the Laboratory.”

— Kim Hebert,
Lincoln Laboratory team,
Pan-Mass challenge



Pan-Mass Challenge

In August, Marc Burke, Kim Hebert, Craig Perini, Robert Schulein, and Joseph Scozzafava completed the Pan-Mass Challenge by biking 190 miles from Sturbridge to Provincetown, Massachusetts. The Lincoln Laboratory community helped this team raise \$41,879 for cancer research and treatment at the Dana-Farber Cancer Institute.

Kim Hebert and Bob Schulein, seen at the Pan-Mass Challenge photo booth, are two of the Laboratory team who ride to honor the survivors of cancer.

Autumn Escape Bike Trek

Over three days in September, the Lincoln Laboratory team rode 160 miles from Plymouth to Provincetown, Massachusetts, to support the American Lung Association (ALA). The team raised \$3915 and grew from its inaugural four members to nine riders and two volunteers.

Bike & Hike the Berkshires

Team MIT Lincoln Laboratory supported the Multiple Sclerosis Society for the ninth year by participating in the Multiple Sclerosis Society Bike and Hike the Berkshires. Led by cocaptains David Granchelli and John Kuconis, the Laboratory effort raised \$2980 to help strike out multiple sclerosis.

Jimmy Fund Walk

As the highest-fundraising single-day walk in the nation, the Boston Marathon Jimmy Fund Walk has raised more than \$100 million since 1989. The Jimmy Fund Walk follows the same route as the Boston Marathon. Participants support the Dana-Farber Cancer Institute’s mission to conquer all forms of cancer in children and adults.



The newly formed three-member Lincoln Laboratory Jimmy Fund Walk team walked a combined 87 miles to raise \$2700.



Members and allies of OPEN joined in the Pride Parade in Boston in June.

Out Professional Employee Network (OPEN) Outreach

OPEN contributed to several different outreach and giving events in 2015, including sorting food at the Greater Boston Food Bank and supporting the Trevor Project, an organization that provides lifesaving and life-affirming services to LGBTQ (lesbian, gay, bisexual, transgender, and queer) youth. At the Lincoln Laboratory Outreach Fair, OPEN hosted a table to raise awareness and gain support for the Trevor Project and to encourage volunteerism.



Laboratory staff sort the donated gifts during the packing party.



The Hispanic-Latino Network assists the LLVETS by staging a separate Support Our Troops donation and packing event.

Support Our Troops

In December, the Lincoln Laboratory Veterans Network (LLVETS) sponsored an effort to give back to those who serve our nation. LLVETS asked Laboratory staff to unite in a common goal: send holiday cards and care packages to U.S. troops in Afghanistan and Iraq. This effort brightens the days of those fighting for the nation's safety and brings a bit of home into their lives. Many troops are out of touch with family or friends for long periods, and such long absences from home are especially trying during the holiday season. Support Our Troops seeks to lighten soldiers' emotional burden and put a smile on their faces.

This year, Laboratory staff packed 58 care packages during the event. Additionally, nearly 100 pounds of Halloween candy was sent to the troops. One participant in the LLVETS initiative, Linda Veneto, shared her motivation to help send



At left, service members received two of 200 handwritten holiday cards prepared by Laboratory staff. The cards accompanied a special holiday mailing with a filled stocking and candy. Above, First Lieutenant Amberly Glitz Weber, U.S. Army, deployed overseas, receives a package filled with sentiments from home.

parcels of happiness abroad: "Aside from having several family members who are veterans, including my father (U.S. Navy) and grandfather (U.S. Army), I am in constant awe of the military and all that they do for us. The sacrifice that service members and their families make is one I could never repay. Donating my time is the very least I can do and, quite frankly, it is an honor to have the opportunity."

Linda Weeks, another volunteer, explained her connection to Support Our Troops: "I grew up in a Navy family. My dad served for over 20 years, and my husband was in the military for over 23 years." Weeks, who strives to recognize the loyal service of troops, added, "I will always do what I can to acknowledge their service with gratitude, pride, and humility."

"For all of us over here, we all appreciate the love and support that people like you give to us. Thank you for the delicious candy, lovingly worded cards, and all the other much-appreciated items."

— Staff Sergeant Chris Rintelmann, currently stationed overseas, recipient of a special holiday package from the Laboratory's Support Our Troops effort

Veterans Network Outreach

Lincoln Laboratory's Veterans Network (LLVETS) strives to find ways to honor those who have served our country. The group, made up of veterans who work at the Laboratory, totals almost 10 percent of the Laboratory workforce.

In August, LLVETS member Daniel O'Gorman raised more than \$3000 for his participation in Run to Home Base, an event that brings in funds to help veterans with combat stress and traumatic brain injury. O'Gorman ran 9 km through Boston, finishing at Fenway Park across homeplate.

To benefit the Wounded Warrior Project, LLVETS supported two events: the Soldier Ride Boston, in which cyclists rode 30 to 60 miles through Lexington and Concord, Massachusetts, and the Wounded Warrior Disc Golf Tournament on Hanscom Air Force Base. Norman Peterson coordinated the Laboratory's participation in both events. A nine-person team of veterans from the Laboratory raised \$2100 at the Soldier Ride. Twenty-six people played in the disc golf tournament and raised \$300 to support the Wounded Warrior Project.

LLVETS members participate each year in the Veterans Fun Run to support soldiers deployed overseas and their families in the local community. The event is held on Veterans Day weekend at the Edith Nourse Rogers Memorial Veterans Hospital in Bedford, Massachusetts, and is sponsored by the Air Force Association.

For the first time, Lincoln Laboratory led a team at Stairs 4 Troops, a fitness event that funds Homes for



Steven Smith and friends gather before climbing stairs at the Stairs 4 Troops event at Harvard University in Cambridge, Massachusetts.

Our Troops, a program that builds specially adapted homes for injured veterans. To honor the service and sacrifice of many veterans, Stairs 4 Troops participants cheer, climb, hold American flags, and carry cement-filled boots while climbing the stadium stairs at Harvard University. The \$1175 raised for Homes for Our Troops by Steven Smith and his team will be used to build a home for Sergeant Chris Gomes of New Bedford, Massachusetts.



Members of LLVETS join in supporting veterans in need during the Veterans Day Fun Run in November.

Thanksgiving Pies

In the weeks leading up to Thanksgiving each year, the Lincoln Laboratory Pie Team (LL Pi) holds their annual Pie in the Sky fundraiser in support of Community Servings, an organization that delivers meals to the critically ill. This year, the 19-person Laboratory team sold 191 pies, donated by local bakeries, restaurants, hotels, and caterers, and raised \$5353. “Every pie sold will pay for a week of home-delivered healthy meals for homebound individuals and families struggling with life-threatening illnesses. This year was our biggest year yet!” said team leader Dinara Doyle. “Over the last three years, the LL Pi team has raised \$11,460.



The Laboratory team of pie sellers sold 191 pies this year to offset costs of home-delivered meals for the critically ill in 20 Massachusetts towns.



Members from LEAN and OPEN convene while volunteering at the Greater Boston Food Bank. In the summer, the Hispanic Latino Network sponsored a food drive to help offset the Merrimack Valley Food Bank's increased summertime demand for meals for children who rely on free school lunches during the school year.

Food Drives

Thanks to the generosity of Laboratory staff, the November Food Drive to benefit the Greater Boston Food Bank experienced another successful year. This initiative, jointly sponsored by the Lincoln Employees African American Network (LEAN) and Out Professional Employee Network (OPEN), collected 354 pounds of food, which equals 295 meals for Massachusetts families. Additionally, many Laboratory volunteers work in the food bank's warehouse, inspecting, sorting, and packing food and grocery products. Others work as a team on an assembly line, loading boxes onto conveyer belts and checking and labeling boxes.

Other Community Outreach Events

The Laboratory encourages its staff to support a variety of causes on their own and to join colleagues in their charitable efforts. In the past year, Lincoln Laboratory staff members have supported several charities or events:

- St. Baldrick's Foundation
- American Red Cross
- Avon Walk for Breast Cancer
- AFCEA Golf Tournament
- Bedford Special Education Parents Advisory Council 5K and Fun Run
- Emily Letourneau Memorial Volleyball Tournament
- American Diabetes Association's Tour de Cure
- National Multiple Sclerosis Society's MuckFest



Intricately carved statues of sea life common around the Marshall Islands were among the most popular purchases of islander crafts during the annual outreach fair.

Marshallese Handicrafts Sale

The Marshallese Outreach Program holds an annual sale of items crafted by the people of the Marshall Islands, raising almost \$800. The most popular items were ornaments woven from pandanus and coconut palm. Woven baskets, ivory nut necklaces, and wall hangings were also sold. Profits from the sale of these items are distributed back to the communities in the form of educational grants for schools throughout the Marshall Islands and Micronesia.



About Our Volunteers

The Laboratory thanks those who have offered their time, talents, and support this past year. We are proud to say that volunteerism among Laboratory employees grows each year. The Lincoln Laboratory Community Outreach Committee will continue to offer many opportunities for employees to participate in educational outreach and community giving events. The involvement of the entire Lincoln Laboratory community is encouraged.

If you engage in outreach or are interested in starting a new outreach program, please contact the Communications and Community Outreach Office and let them know.

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Approved for public release; distribution unlimited. This material is based upon work supported by the Department of the Air Force under Air Force Contract No. FA8702-15-D-0001. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the U.S. Air Force.

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