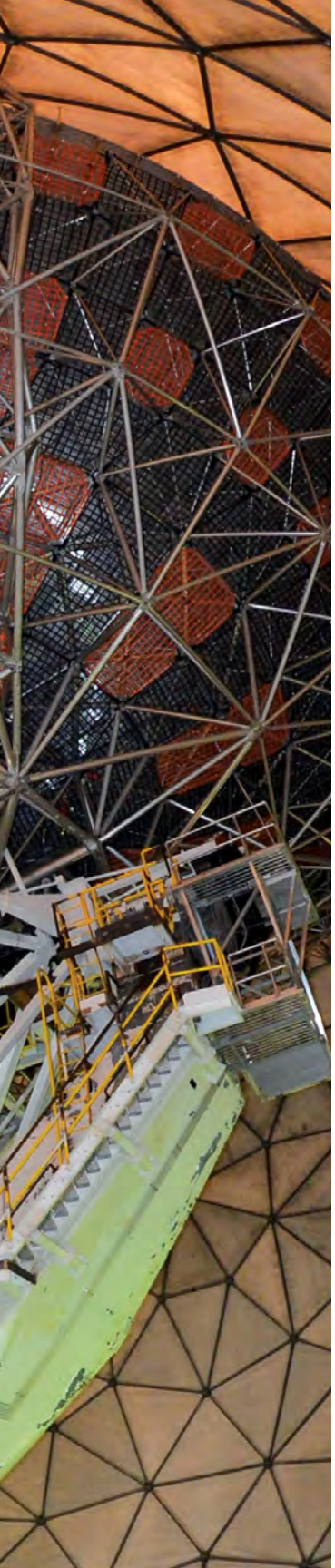
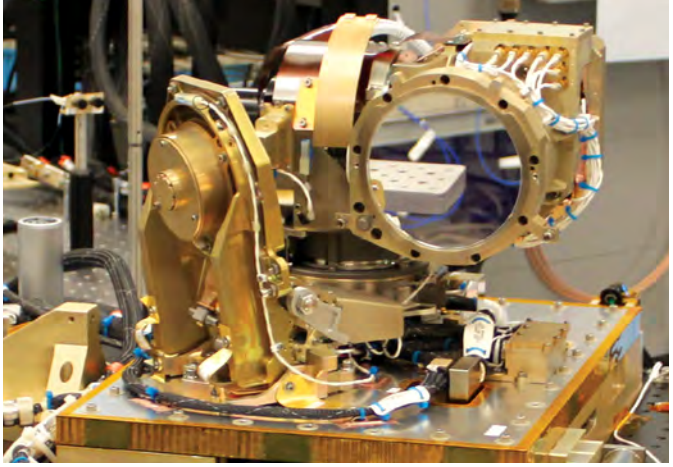
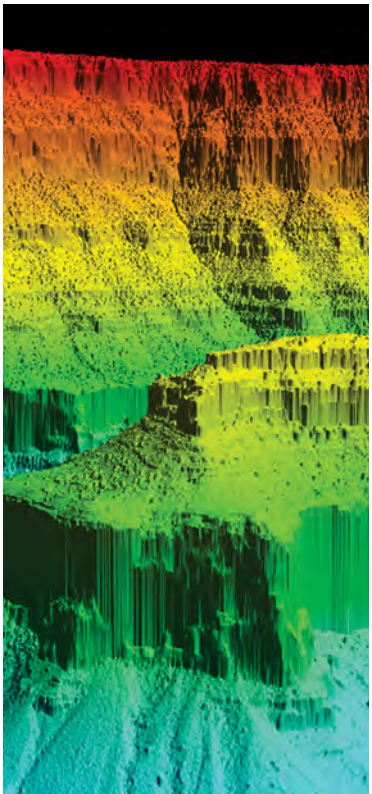


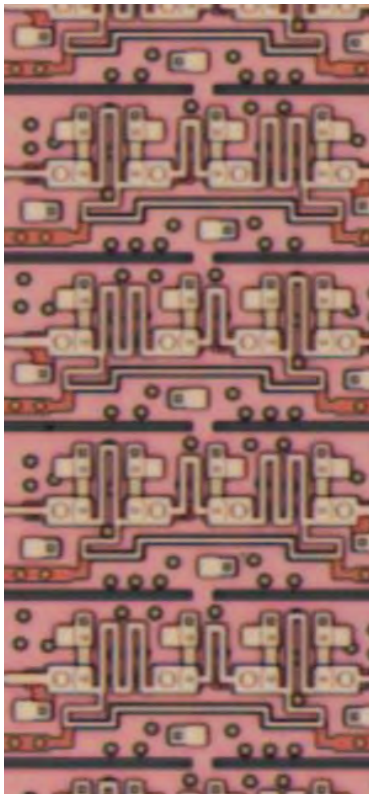


R&D 100 Awards

81
MIT LINCOLN LABORATORY

technologies recognized as among the best innovations of each year, 2010–2022





Technology in Support of National Security

MIT Lincoln Laboratory researches and develops a broad array of advanced technologies to meet critical national security needs. What sets us apart from many national R&D laboratories is our focus on building operational prototypes of the unique systems we design.

Our ability to turn concepts into field-worthy systems is supported by state-of-the-art facilities, such as a world-class semiconductor research and fabrication laboratory, a flight facility with aircraft customized for field-testing airborne systems, and New England's fastest, most powerful supercomputing center.

Behind our innovative R&D are people with exceptional technical abilities and creativity, working in cross-disciplinary teams to develop advanced technologies for diverse needs—for example, defending against missile threats, providing secure communications, monitoring activity in space, and even inventing biomedical devices.

Quick Facts

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

Established
1951

Location
Lexington, Massachusetts

Research areas
- Sensor systems
- Communications
- Advanced imaging
- Cybersecurity
- Data analytics
- Microelectronics
- Bioengineering
- Air and missile defense
- Space systems

www.ll.mit.edu

Letter from the Director

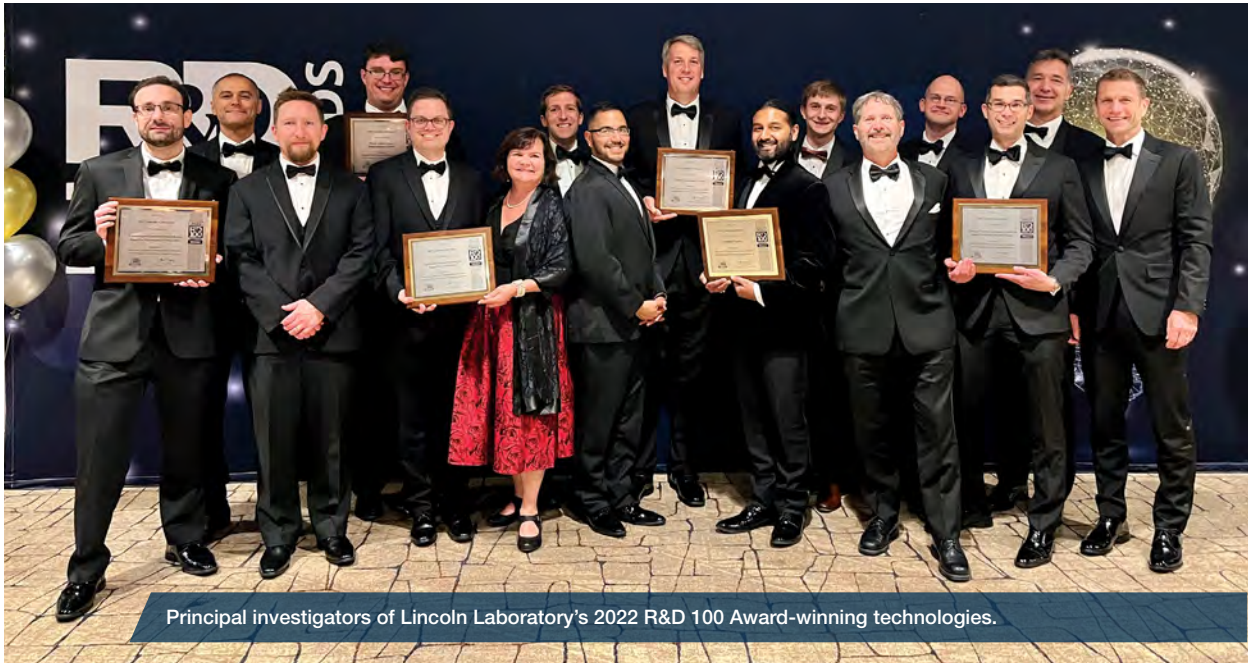
Each year, R&D 100 Awards are awarded to the 100 most innovative technologies transitioned during the year for use in real systems or applications. The awards are selected by a panel of technical editors and subject-matter experts, and they represent a cross section of work from across the research and development community. MIT Lincoln Laboratory is honored to have been selected for 81 of these awards—including two R&D Editor's Choice Awards—over the past 13 years.

Our recognized technologies reflect the wide range of research and development in which Lincoln Laboratory is engaged across our mission areas. Some of the winners come from our long-standing work on radar technology and air traffic control systems, while others come from newer fields, such as microbiome testing and quantum sensing. Many of the technologies began as projects supported by funding from the Under Secretary of Defense for Research and Engineering for investigations into new technology that supports important, new defense capabilities.

This booklet was produced not only to recognize our award-winning technologies but also to applaud the work of the teams behind each of these awardees. Some of the teams collaborated with sponsoring agencies, academic partners, and industry. Many of these teams worked with dozens of contributors for several years to mature their technologies for transition to real systems. These projects represent the commitment of the entire Lincoln Laboratory to technical excellence in support of national security.

Eric D. Evans

Director



Principal investigators of Lincoln Laboratory's 2022 R&D 100 Award-winning technologies.

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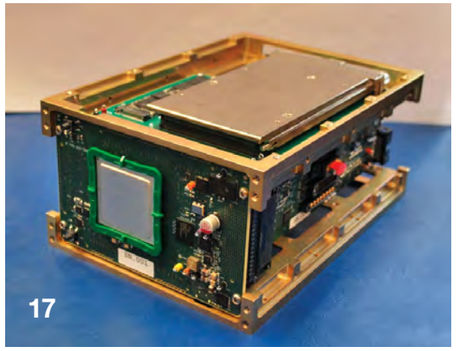
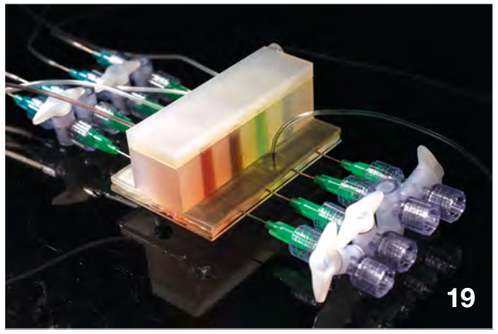
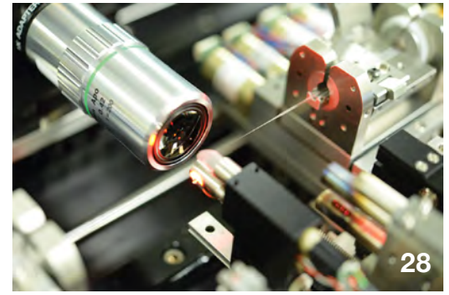




2019



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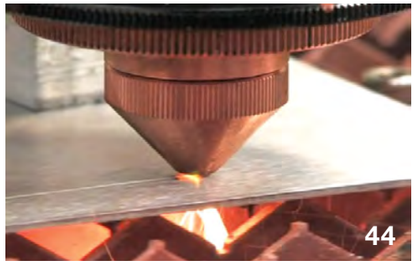
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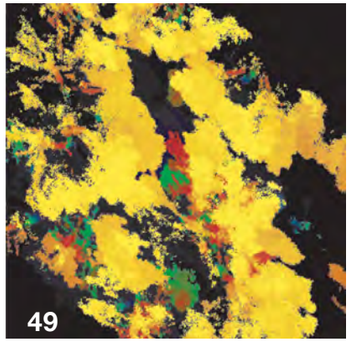
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2022
WINNER

Airborne Collision Avoidance System sXu

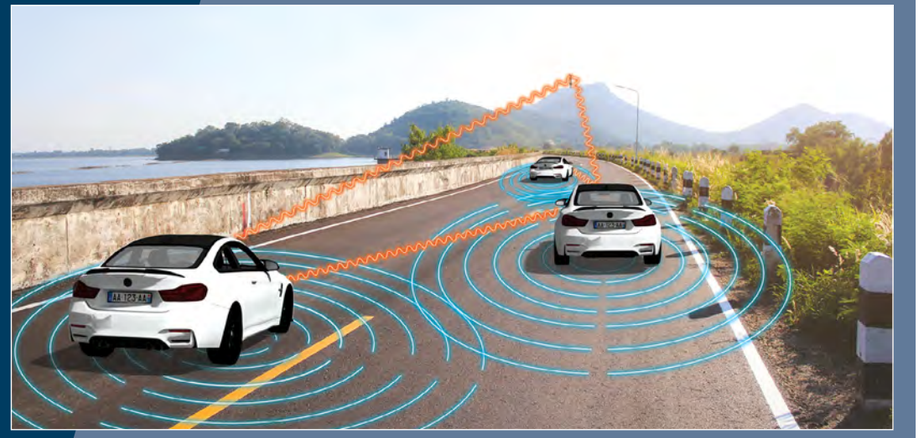
A system that allows small uncrewed aircraft systems to detect other nearby aircraft and maneuver away to avoid a potential midair collision

CODEVELOPERS: RESEARCHERS FROM THE FEDERAL AVIATION ADMINISTRATION, MITRE, AND JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY

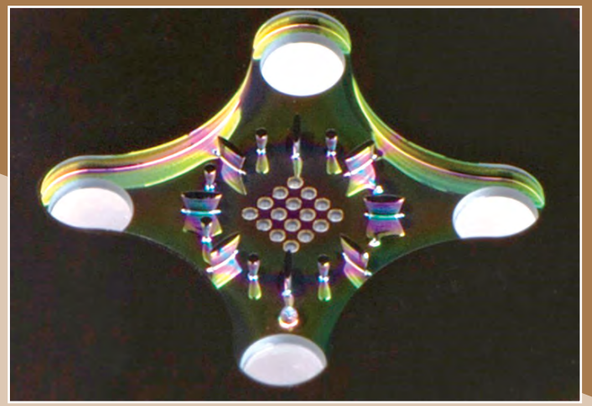
2022
WINNER

Constrained Communications and Radar Dual-Use

A method of designing waveforms that can perform both radar and communications tasks simultaneously, using the same transmitter and receiver



2022
WINNER



Embedded Microjet Cooling for High-Power Electronics

A device that uses arrays of micron-scale fluid jets, embedded directly into the device at the chip level, to drastically improve heat transfer in electronics

2022
WINNER

Timely Address Space Randomization

Software that prevents memory corruption by automatically shuffling, or rerandomizing, the location of code in memory every time the software observes an output from an application

Unprotected server or application

TASR frequently randomizes the memory of a server or application after every possible leakage point

Toroidal Propeller

A propeller designed for commercial drones that is significantly quieter than common multirotor propellers

2022
WINNER

TROPICS Pathfinder Satellite

A small satellite, or CubeSat, that uses a novel, miniaturized microwave sounder to provide high-resolution weather data over the Earth's tropical belt

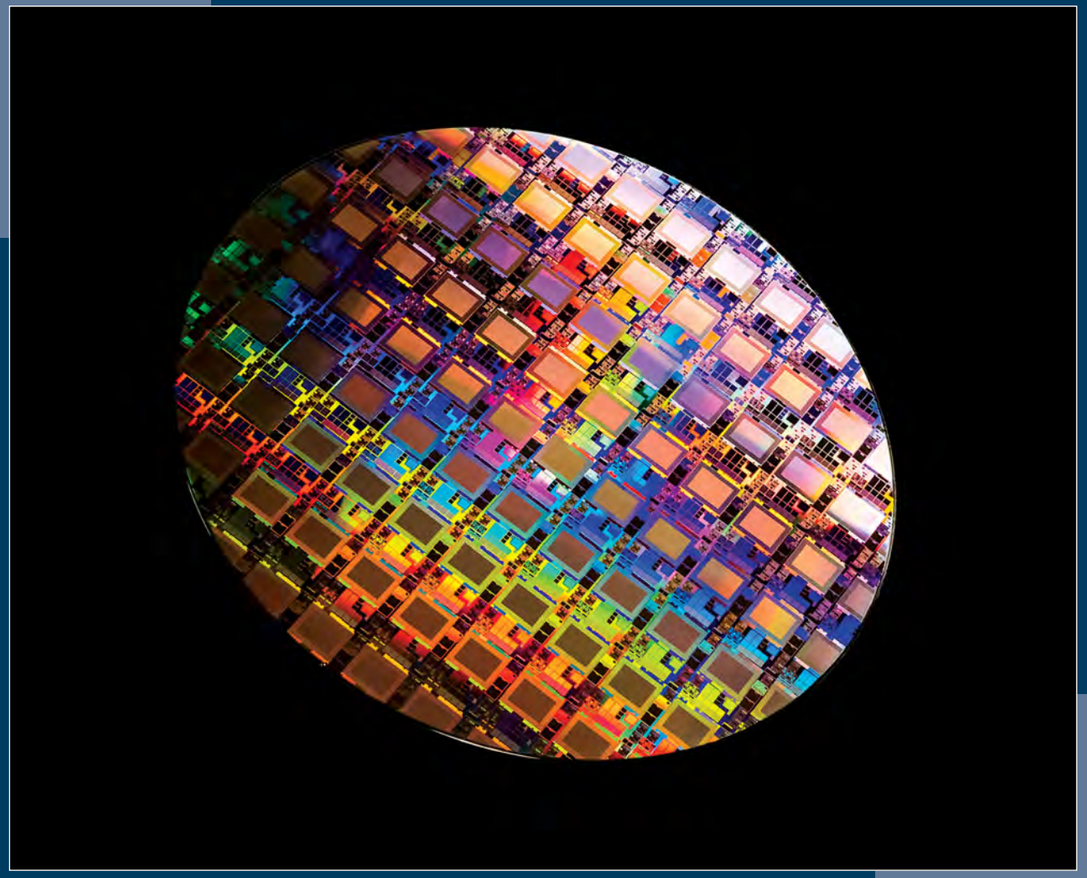
CODEVELOPERS: RESEARCHERS FROM NASA AND BLUE CANYON TECHNOLOGIES

2022
WINNER

2021
WINNER

Field-Programmable Imaging Array

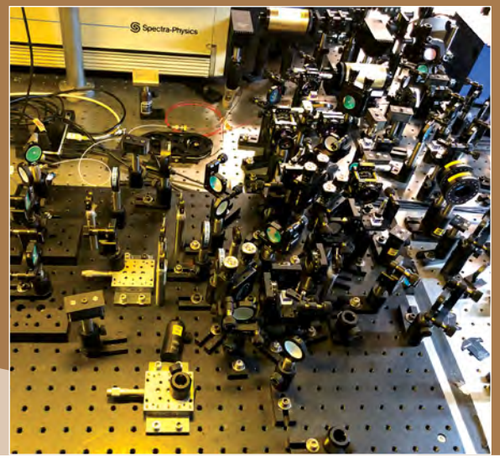
A universal digital back end for camera systems that, when hybridized to an image detector array, results in a flexible and powerful digital processing system-in-package



Free-Space Quantum Network Link Architecture

A system that enables the generation, distribution, and remote interaction of entangled photons across free-space links

2021
WINNER



Global Synthetic Weather Radar

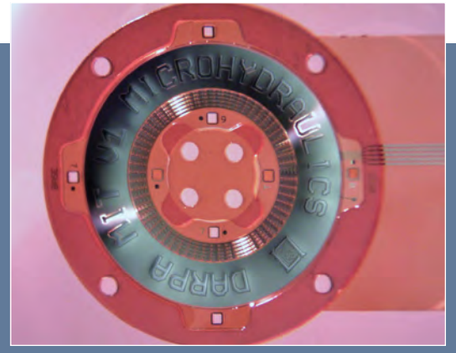
2021
WINNER

A technology that provides radar-like weather imagery and radar-forward forecasts in global regions where actual weather radar are not deployed or available

2021
WINNER

Guided Ultrasound Intervention Device

A handheld tool, utilizing real-time artificial intelligence software, that enables a medic to rapidly and accurately catheterize a central vein or artery in a prehospital environment

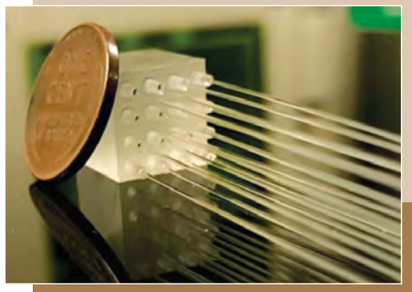


Microhydraulic Motors

A scalable, electrowetting-based actuation platform with a torque density two orders of magnitude higher than that of electric motors

2021
WINNER

Monolithic Fiber Array Launcher



An all-glass, monolithic fiber array launcher that is smaller and more robust than standard arrays

2021
WINNER

2021
WINNER

Motion Under Rubble Measured Using Radar

A lightweight, portable life-detection radar that rapidly senses, ranges, and characterizes survivors trapped beneath rubble

2021
WINNER

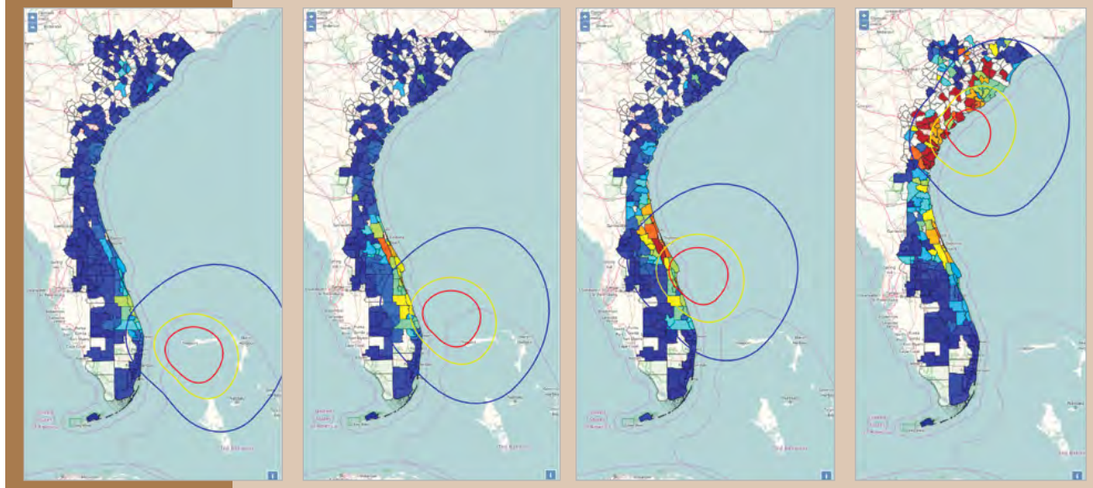
Spectrally Efficient Digital Logic

A set of digital logic families that operate with intrinsically low electromagnetic interference emissions

Traffic Flow Impact Tool

A tool for air traffic control managers that predicts and displays impacts to airspace capacities and traffic flow rates during convective weather

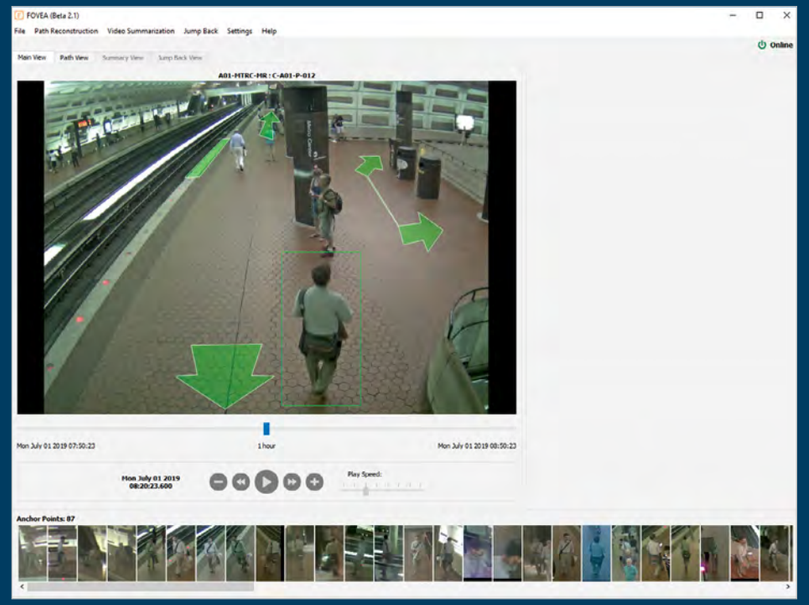
2021
WINNER



2020 WINNER

Cyber Sensing for Power Outage Detection

A system that uses data on internet traffic to rapidly estimate and map the extent and location of power outages across geographic boundaries



2020 WINNER

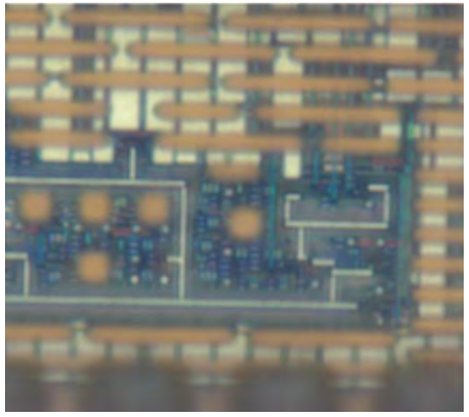
Forensic Video Exploitation and Analysis

A suite of tools that enables users to efficiently analyze video captured by existing large-scale closed-circuit television systems

Defensive Wire Routing for Untrusted Integrated Circuit Fabrication

Techniques that deter an outsourced foundry from maliciously tampering with or modifying the security-critical components of a digital circuit design

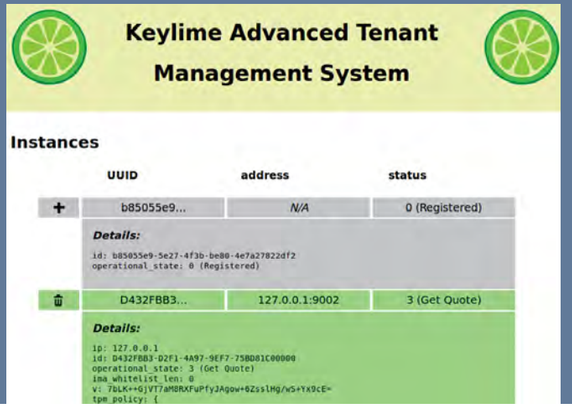
2020 WINNER



Keylime

An open-source key bootstrapping and integrity management software architecture that is designed to increase the security and privacy of edge, cloud, and Internet of Things (IoT) devices

2020 WINNER

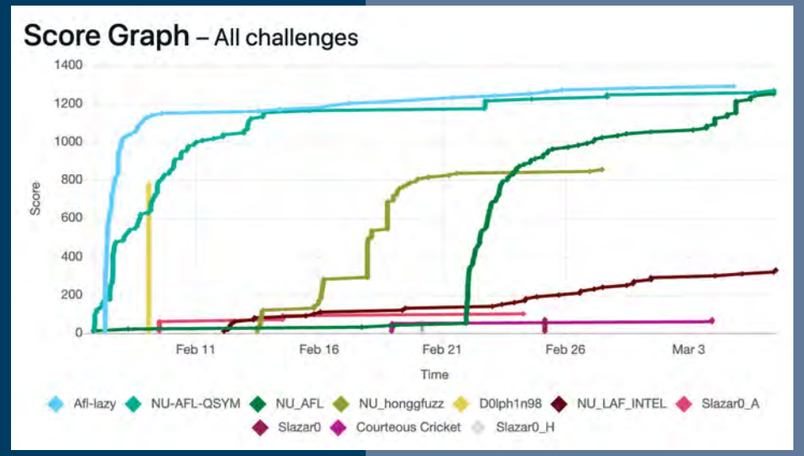


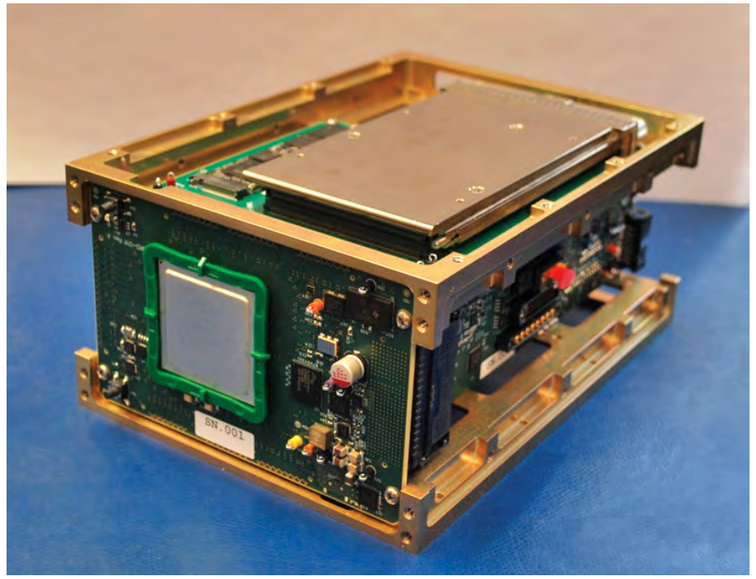
Large-scale Vulnerability Addition

A technique that injects numerous bugs into a program at known locations and constructs triggering inputs for each to create ground truth for evaluating bug-finding systems

CODEVELOPERS: STAFF FROM NEW YORK UNIVERSITY, NORTHEASTERN UNIVERSITY, AND U.S. ARMY

2020
WINNER





TeraByte InfraRed Delivery

An optical communications technology that enables error-free transmission of data from low Earth–orbiting satellites at a rate of 200 gigabits per second

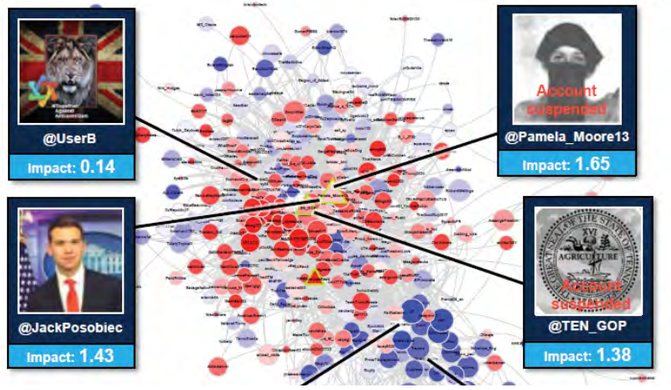
2020
WINNER

2020
WINNER

Reconnaissance of Influence Operations

A software system that automates the detection of disinformation narratives, networks, and influential actors to address the growing threat posed by adversaries using social media for political objectives

CODEVELOPERS: RESEARCHERS FROM HARVARD UNIVERSITY



Timely Randomization Applied to Commodity Executables at Runtime

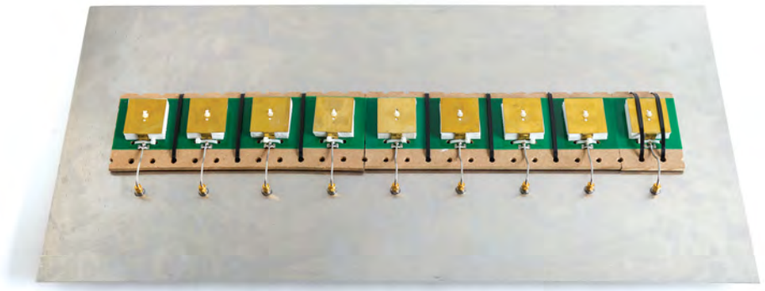
A technique that protects Windows applications against cyberattacks by automatically and transparently re-randomizing the applications' sensitive internal data and layout every time an output is generated

2020
WINNER

2019
WINNER

Aperture-Level Simultaneous Transmit and Receive Phased Array

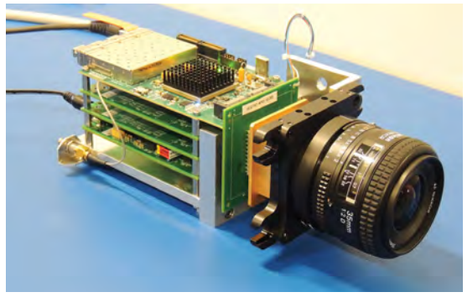
The first-ever demonstration of a phased array antenna system that has sufficient isolation to enable practical multibeam full-duplex communication

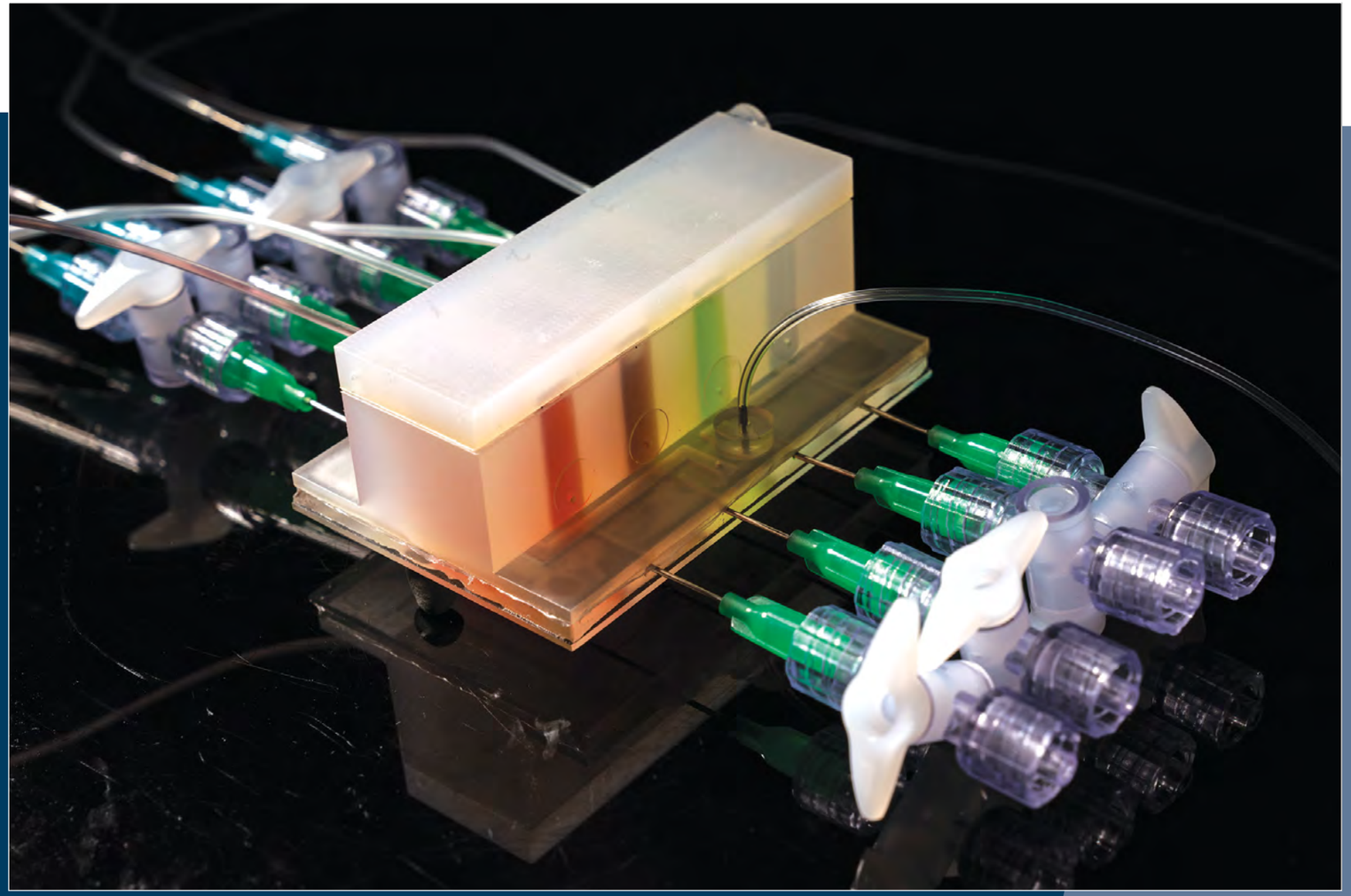


Dual-Mode Imaging Receiver

A camera that integrates the previously disparate functions of high-frame-rate photon-counting imaging and single-photon-sensitive communications into a single optical receiver

2019
WINNER





ArtGut

The first in vitro platform that enables researchers to perform high-resolution, physiologically relevant gut microbiome studies

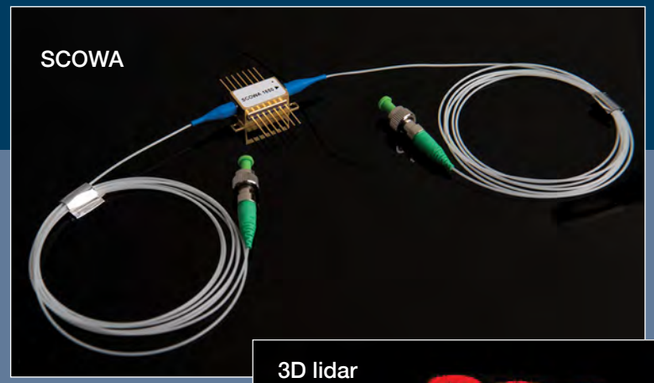
2019
WINNER

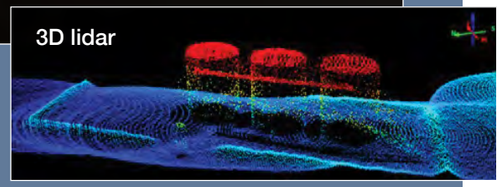
2019
WINNER

Gas Mapping LiDAR™

A sensor, built by Bridger Photonics and enabled by Lincoln Laboratory's slab-coupled optical waveguide amplifier (SCOWA), that remotely detects, locates, and quantifies methane leaks and oil and gas infrastructure status

CODEVELOPERS: STAFF FROM BRIDGER PHOTONICS

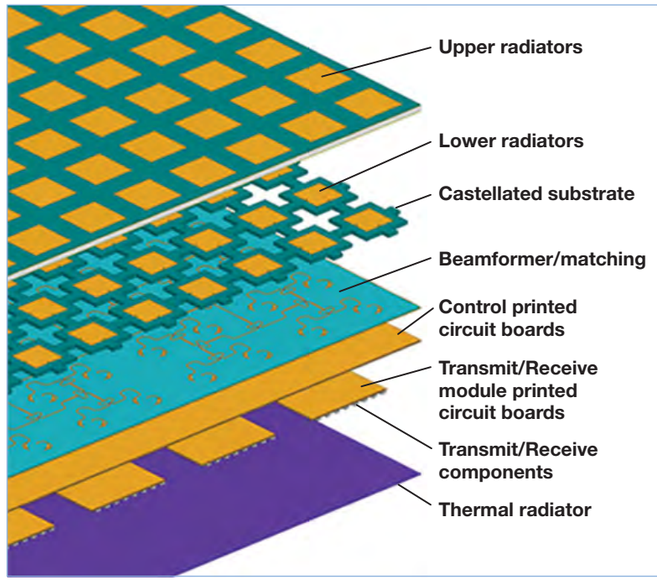




2019
WINNER

Lightweight Deployable Array Panels for Space

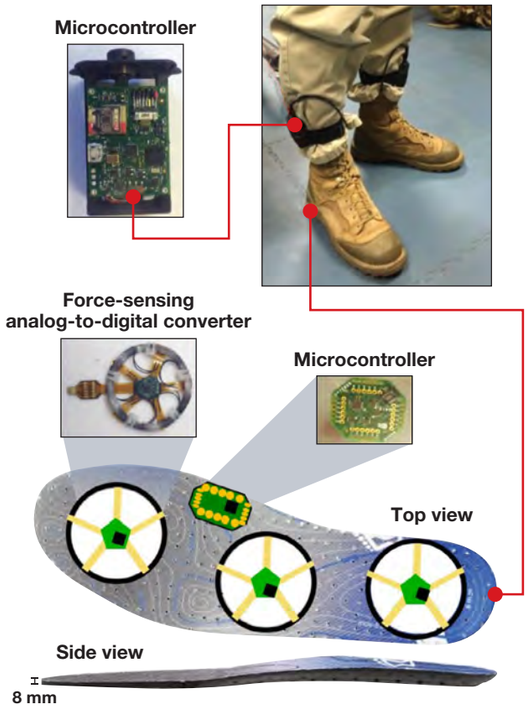
Panels for space-based communications and remote-sensing systems that have minimized weight and size to lower launch costs by reducing fuel needs and increasing capacity to accommodate more systems per launch



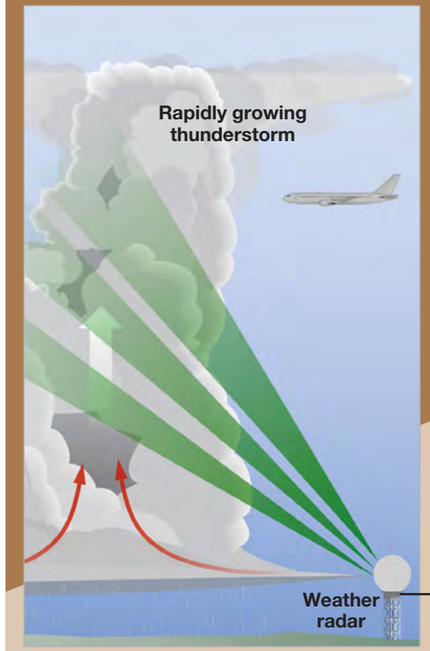
2019
WINNER

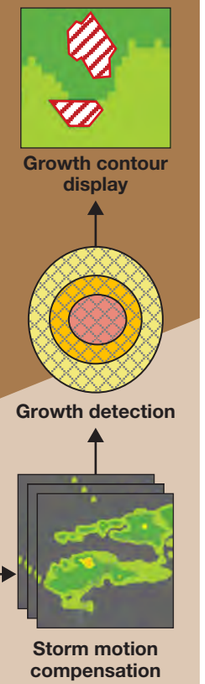
Mobility and Biomechanics Insert for Load Evaluation

Biomechanical sensors that are built into a shoe insert and small ankle package to measure a user's weight and lower leg movements to help guide decisions about load-bearing and gait



2019
WINNER





Rapid Convective Growth Detector

A system that uses tilt-by-tilt processing of weather radar data to identify and display regions of hazardous storm growth 10 times faster than other weather sensors

CODEVELOPERS: STAFF FROM THE FEDERAL AVIATION ADMINISTRATION

2019
WINNER

Tactical Microgrid Standard Open Architecture

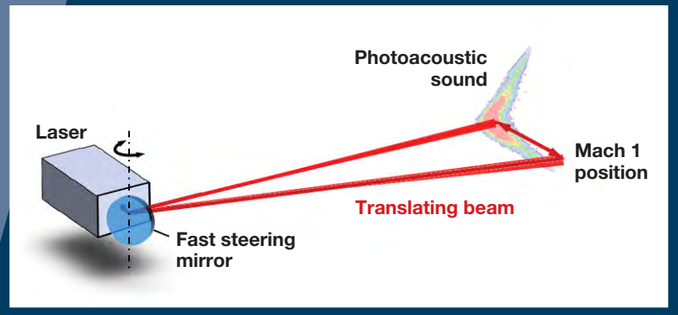
An architecture that was developed by a Department of Defense–led consortium of government, industry, and academic partners to provide an interoperability standard for highly modular, resilient, scalable, and mission-specific microgrid solutions

CODEVELOPERS: STAFF FROM HG ENGINEERS, PARSONS, SCHWEITZER ENGINEERING LABS, U.S. ARMY, AND U.S. MARINE CORPS

2019
WINNER

Targeted Acoustic Laser Communication

A system that uses laser photoacoustics to create audible messages in a person's ear, enabling secure and remote communications with the individual of interest and no one else

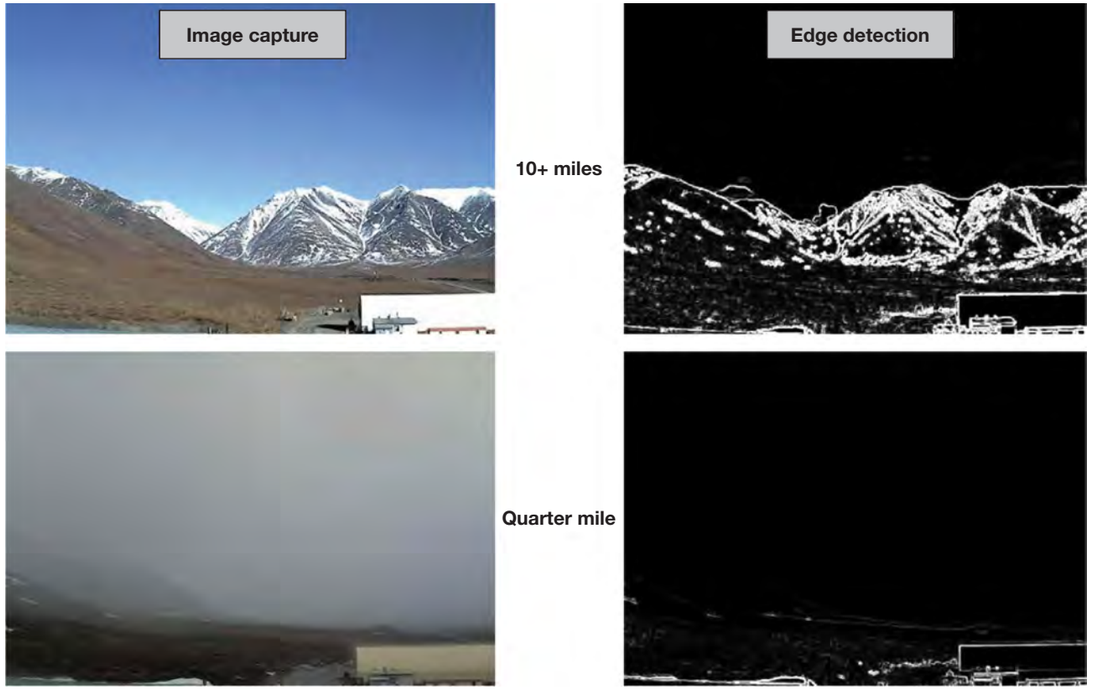


2019
WINNER

Visibility Estimation through Image Analytics

A software system, developed by the Laboratory in partnership with the Federal Aviation Administration, that provides air traffic managers and pilots with an inexpensive, yet effective, way to automatically extract from camera images vital data about meteorological visibility

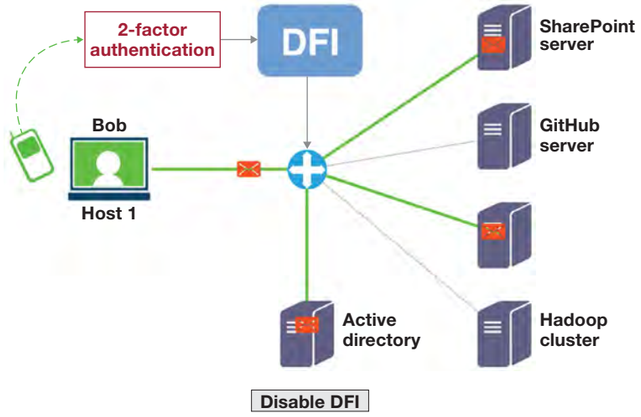
CODEVELOPERS: STAFF FROM THE FEDERAL AVIATION ADMINISTRATION



2018
WINNER

Dynamic Flow Isolation

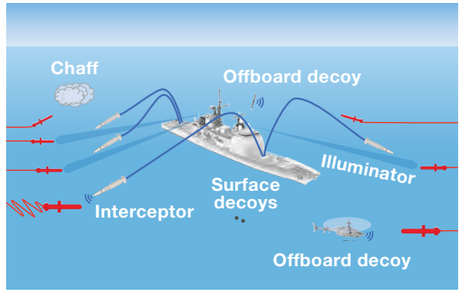
A technique that reduces unauthorized access to networks by restricting user privileges to only the computer resources users need



Human-Machine Collaborative Optimization via Apprenticeship Scheduling

A machine learning algorithm that provides real-time decision support by applying heuristics learned from the observed behavior of human experts

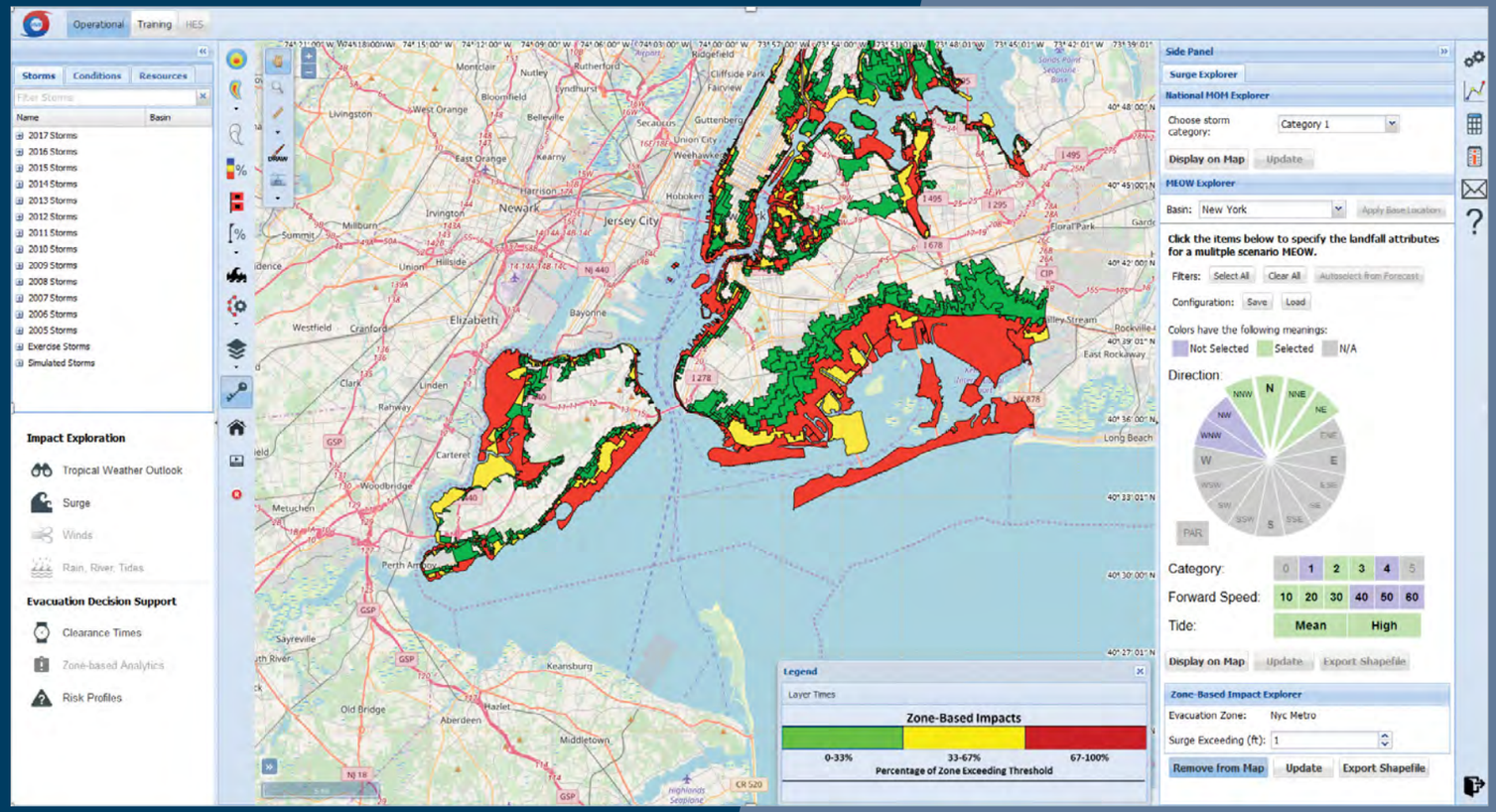
2018
WINNER

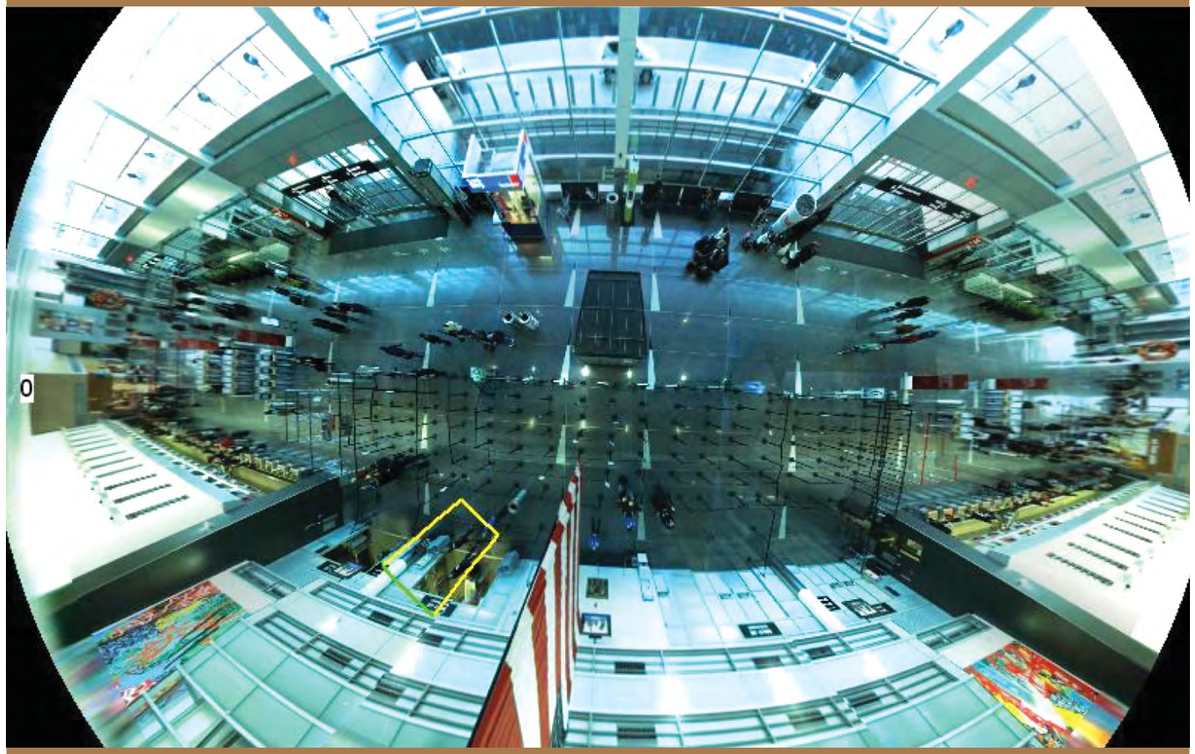


2018
WINNER

Web-Based HURREVAC

An open-source decision support platform that enables emergency managers to plan, train for, and make accurate hurricane evacuation decisions





2018
WINNER

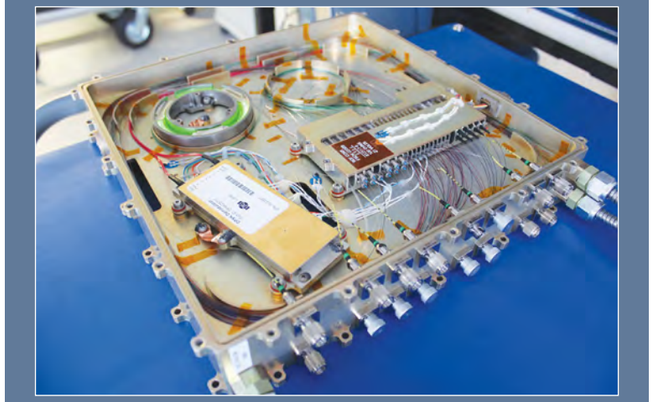
Immersive Imaging System

A wide-area video surveillance system that provides very high-resolution images and 360-degree coverage from a single vantage point

2018
WINNER

Intelligent Power Distribution

An electrical box that improves the efficiency and resiliency of a microgrid operating in austere conditions by coordinating the microgrid's energy resources and loads



Multirate Differential Phase Shift Keying Optical Communications

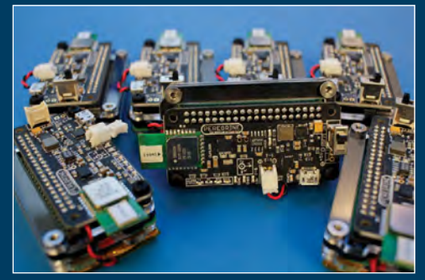
A format that enables efficient free-space laser communications over a wide range of data rates by using a single easy-to-implement transmitter and receiver design

2018
WINNER

Peregrine: Network Navigation

A system of networked deployable devices, powered by cooperative algorithms, that enables highly accurate navigation in environments where GPS is not available, reliable, or precise

CODEVELOPERS: RESEARCHERS FROM MIT

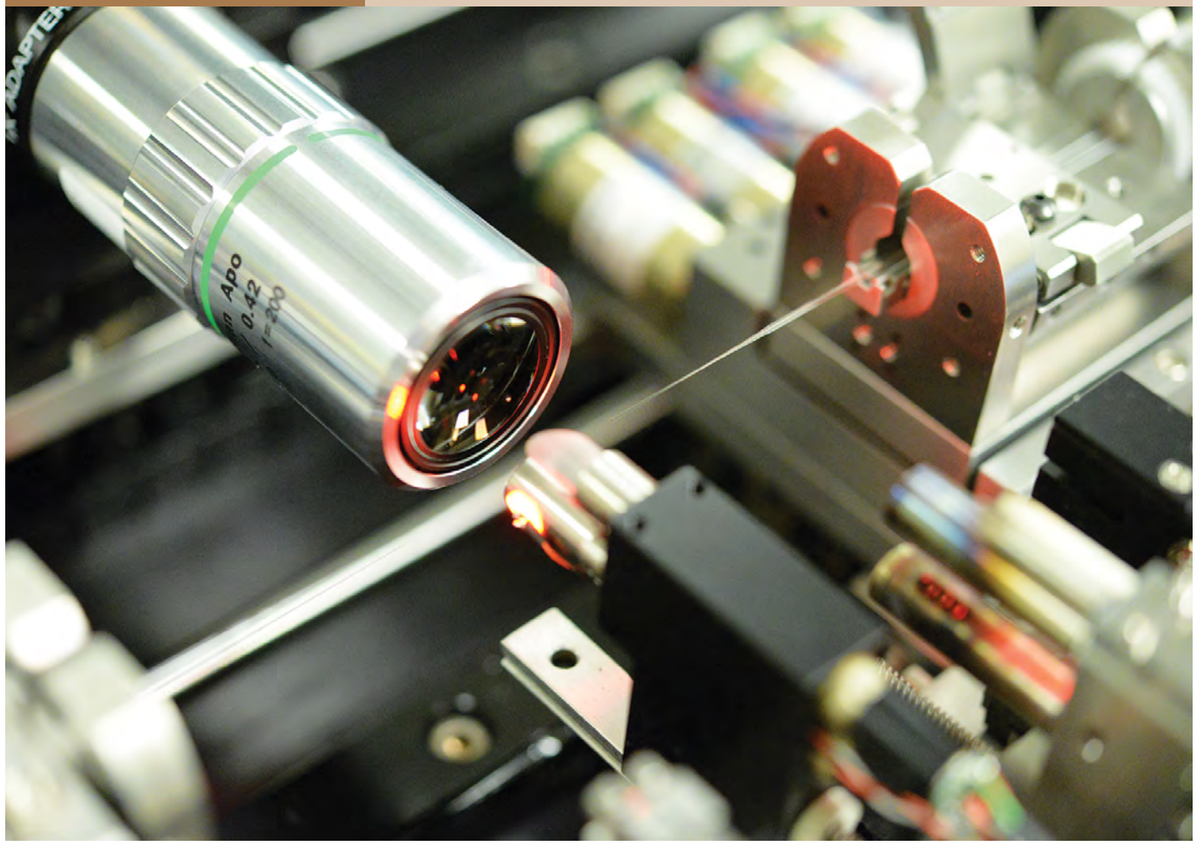


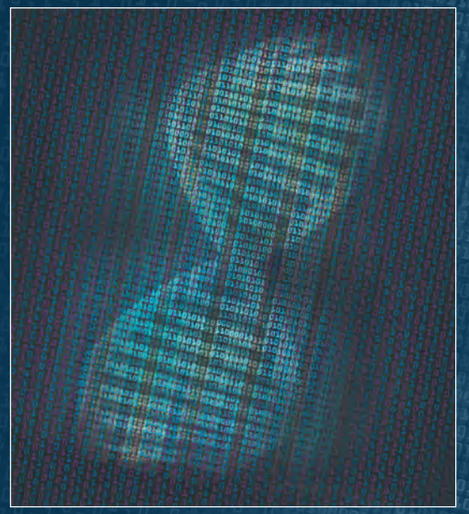
2018
WINNER

2018
WINNER

Photonic Lantern Adaptive Spatial Mode Control

A technology that provides the ability to steer and shape a laser beam, as well as scale its power, in the presence of optical disturbances and turbulence





Ultrafast Computational Methods for Searching DNA Databases

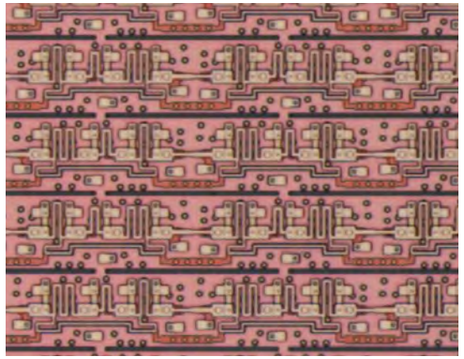
Algorithms that drastically reduce the compute time required to compare a large number of unknown DNA profiles against a large dataset of millions of reference DNA profiles

2018
WINNER

2018
WINNER

Very Large-Scale Integration Process for Superconducting Electronics

A fabrication process that taps into superconductivity to provide fast, energy-efficient integrated circuits for advanced computing, digital signal processing, quantum metrology, and sensing



2017
WINNER

CO_2/O_2 Breath and Respiration Analyzer

A wireless, low-cost sensor that determines from a person's breath the fraction of metabolic energy produced by carbohydrate versus fat oxidation, providing information to guide weight loss and training

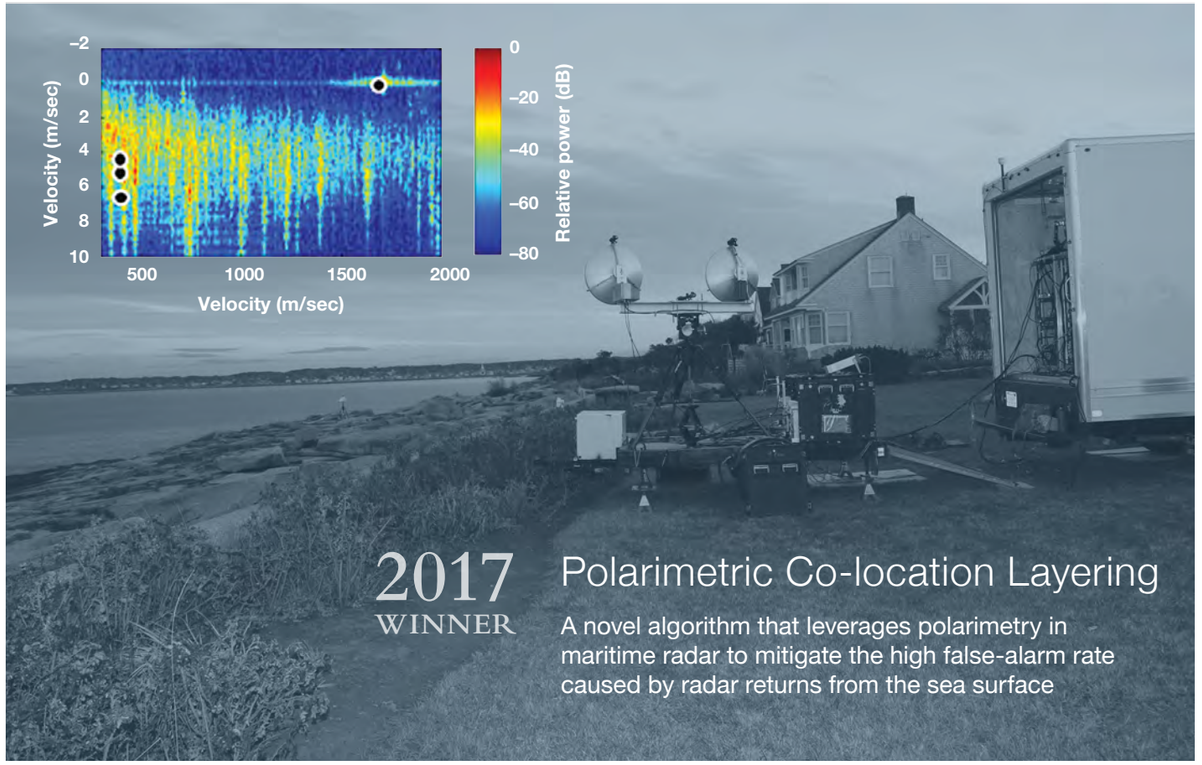
CODEVELOPERS: STAFF FROM THE U.S. ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

2017
WINNER

Ground-Based Sense-and-Avoid System for Unmanned Aircraft Systems

A first-in-production ground radar system that enables unmanned aircraft to see and avoid other aircraft

CODEVELOPERS: STAFF FROM THE U.S. ARMY, SRC INC., AND KUTTA TECHNOLOGIES



2017
WINNER

Polarimetric Co-location Layering

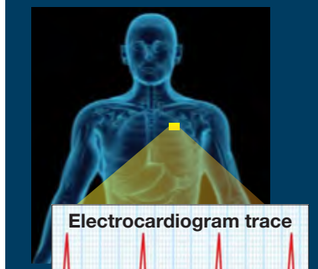
A novel algorithm that leverages polarimetry in maritime radar to mitigate the high false-alarm rate caused by radar returns from the sea surface

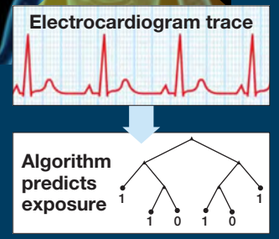
2017
WINNER

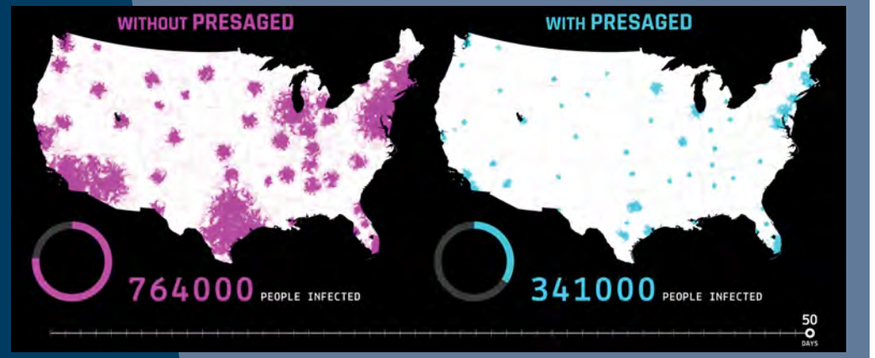
Presymptomatic Agent Exposure Detection

An algorithm that exploits data from noninvasive wearable medical sensors to detect if a person had been exposed to viruses or bacteria several days before overt symptoms, such as fever, appear

CODEVELOPERS: STAFF FROM THE NATIONAL INSTITUTES OF HEALTH AND U.S. ARMY MEDICAL RESEARCH INSTITUTE OF INFECTIOUS DISEASES



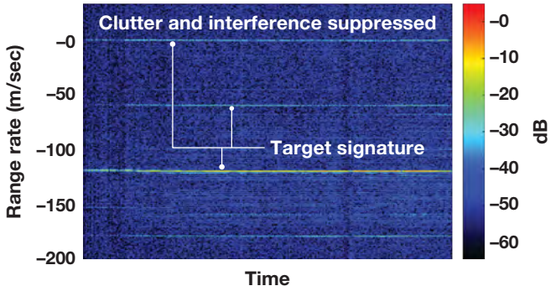




Pulse-to-Pulse Phase Diversity Processing for Interference Suppression and Range Disambiguation

A low-cost technique that uses phase-diverse waveforms and specialized processing to help mitigate the interference that wind turbines can impose on radars that track aircraft and weather

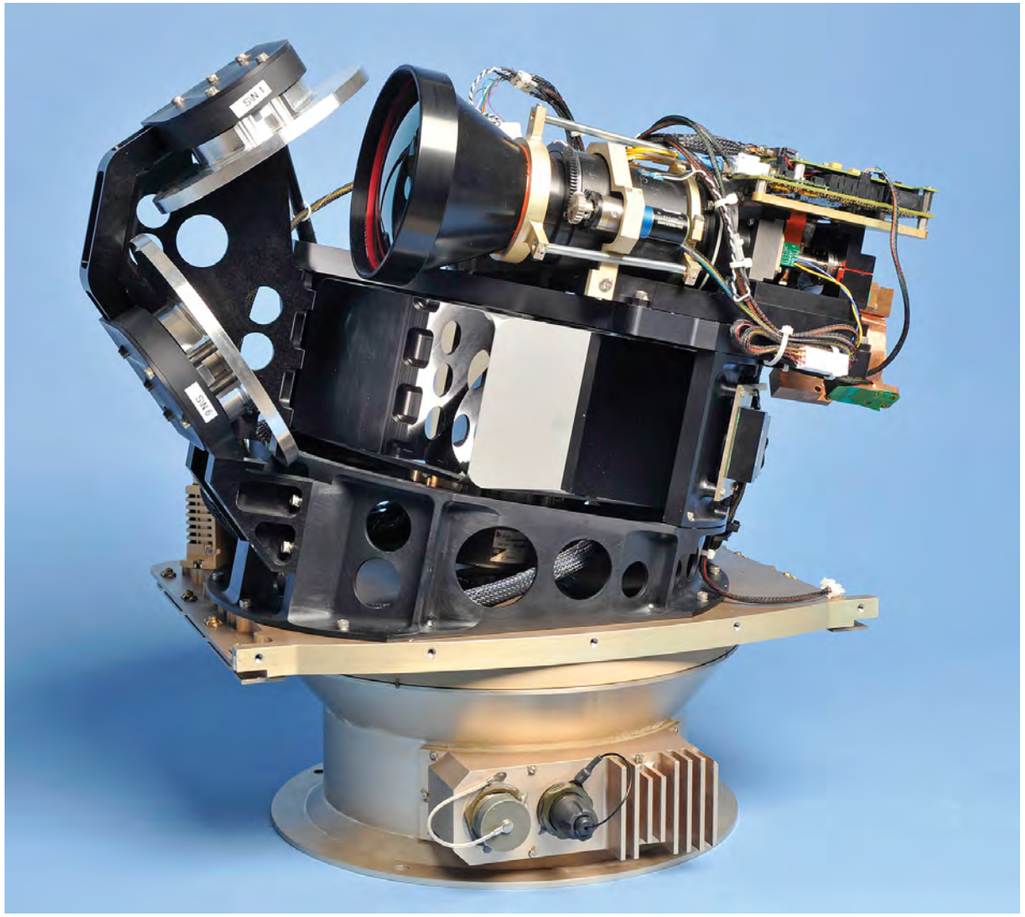
2017
WINNER



2017
WINNER

Wide-Area Infrared System for Persistent Surveillance

A portable system that detects and alerts operators to all moving objects in a monitored area during both day and night surveillance

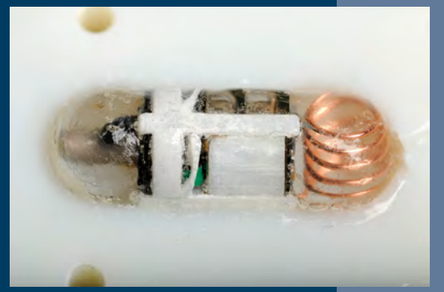


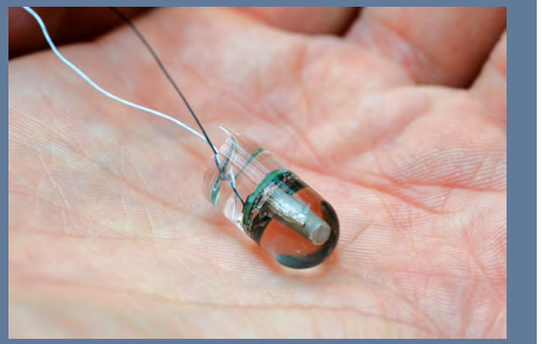
2016
WINNER

Airborne Collision Avoidance System for Unmanned Aircraft

A system that processes multisensor data to allow unmanned aircraft to detect and track nearby aircraft and to enable ground operators to direct safe separation between unmanned vehicles and other air traffic

CODEVELOPERS: STAFF FROM THE FEDERAL AVIATION ADMINISTRATION, STANFORD UNIVERSITY, JOHNS HOPKINS APPLIED PHYSICS LABORATORY, AND MITRE



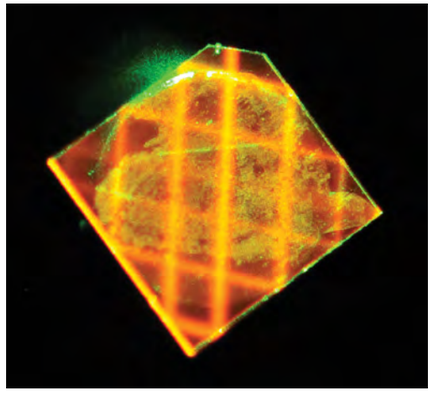


2016
WINNER

EnteroPhone™

A wireless, ingestible device that monitors heart and breathing rates by listening to the body's sounds and that senses core temperature, all from within the gastrointestinal tract

CODEVELOPERS: RESEARCHERS FROM MIT



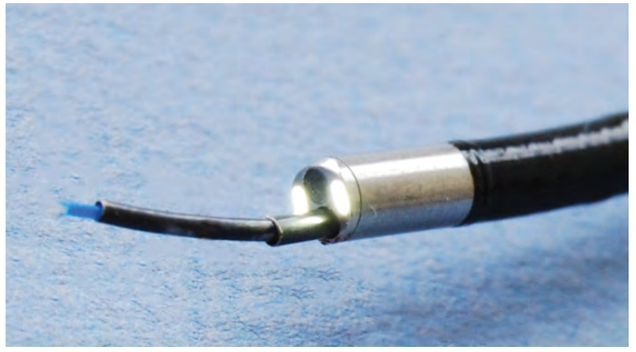
2016
WINNER

Broadband Magnetometry and Temperature Sensing with a Light-Trapping Diamond Waveguide

An ultrasensitive magnetic-field detector and temperature sensor that is 1,000 times more energy-efficient than previous diamond-based magnetometers

CODEVELOPERS: RESEARCHERS FROM MIT

2016
WINNER



Laserscope

A tool set that offers surgical navigation and precise laser targeting within the spinal cavity to enable treatment of back pain with an outpatient procedure instead of with open back surgery

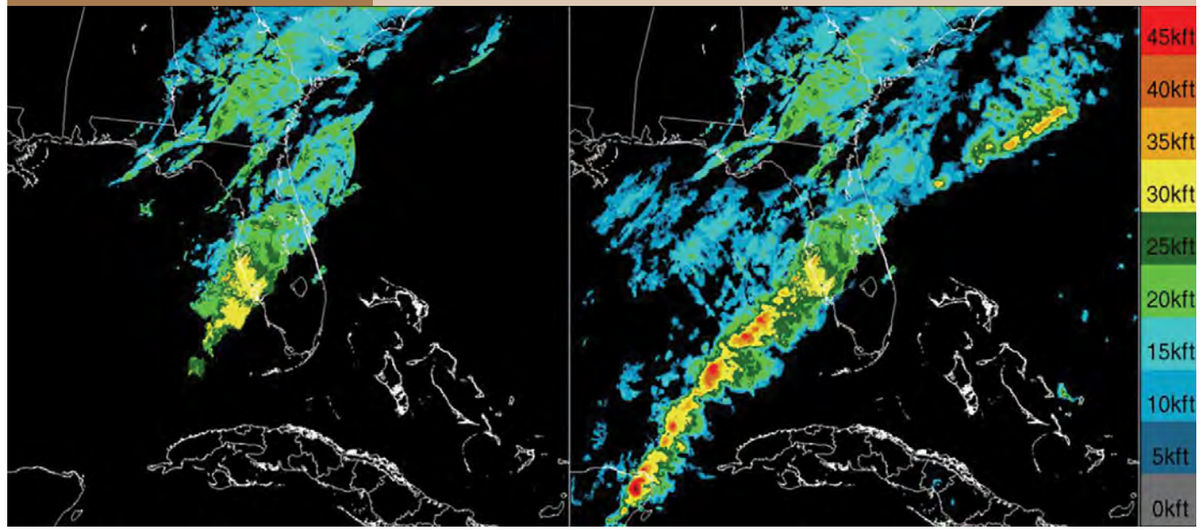
CODEVELOPERS: STAFF FROM MASSACHUSETTS GENERAL HOSPITAL AND DUKE UNIVERSITY

2016
WINNER

Offshore Precipitation Capability

A system that provides weather information for air traffic controllers by generating “radar-like” depictions of storms in offshore regions that are outside radar coverage

CODEVELOPERS: STAFF FROM THE FEDERAL AVIATION ADMINISTRATION

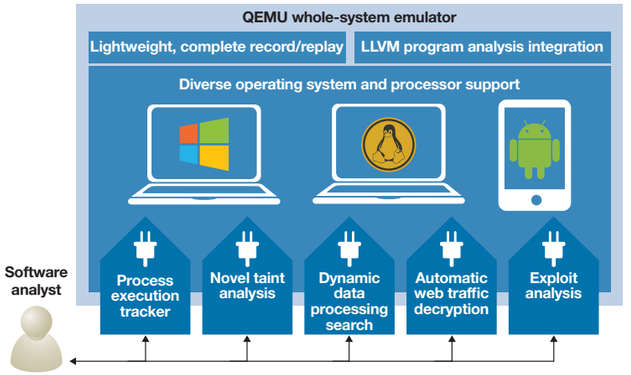


2016
WINNER

Small Airport Surveillance Sensor

A low-cost secondary surveillance system that provides airport tower controllers with situational awareness of aircraft on the airport surface and in nearby airspace

Platform for Architecture-Neutral Dynamic Analysis



An open-source, plug-in software analysis framework that enables computer engineers to observe code as a program executes so they can understand and mitigate vulnerabilities or faults in the code

CODEVELOPERS: RESEARCHERS FROM NEW YORK UNIVERSITY’S TANDON SCHOOL OF ENGINEERING, GEORGIA INSTITUTE OF TECHNOLOGY, AND NORTHEASTERN UNIVERSITY

2015
WINNER

2015
WINNER

Video Content Summarization Tool

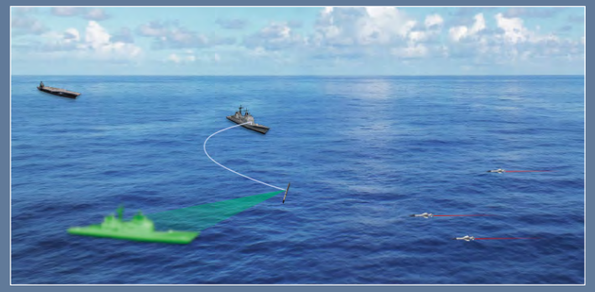
A software application that creates summary views of long-duration surveillance videos so analysts can quickly identify activity of interest

Self-Defense Distributed Engagement Coordinator

An automated decision support tool that guides naval personnel on how to efficiently allocate resources in response to anti-ship missile threats

CODEVELOPERS: RESEARCHERS FROM MIT

2015
WINNER



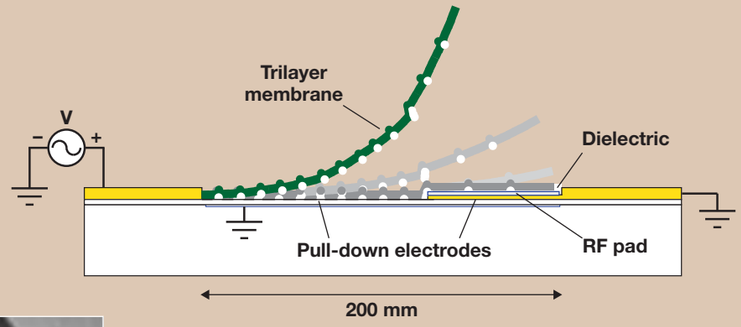
2014
WINNER

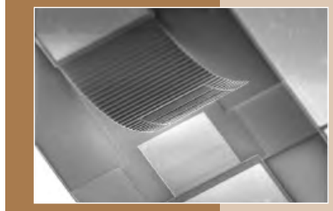
Airborne Sense-and-Avoid Radar Panel

A novel stepped-notch antenna array that supports aircraft and weather detection and tracking modes in a single multifunction aperture

2014
WINNER

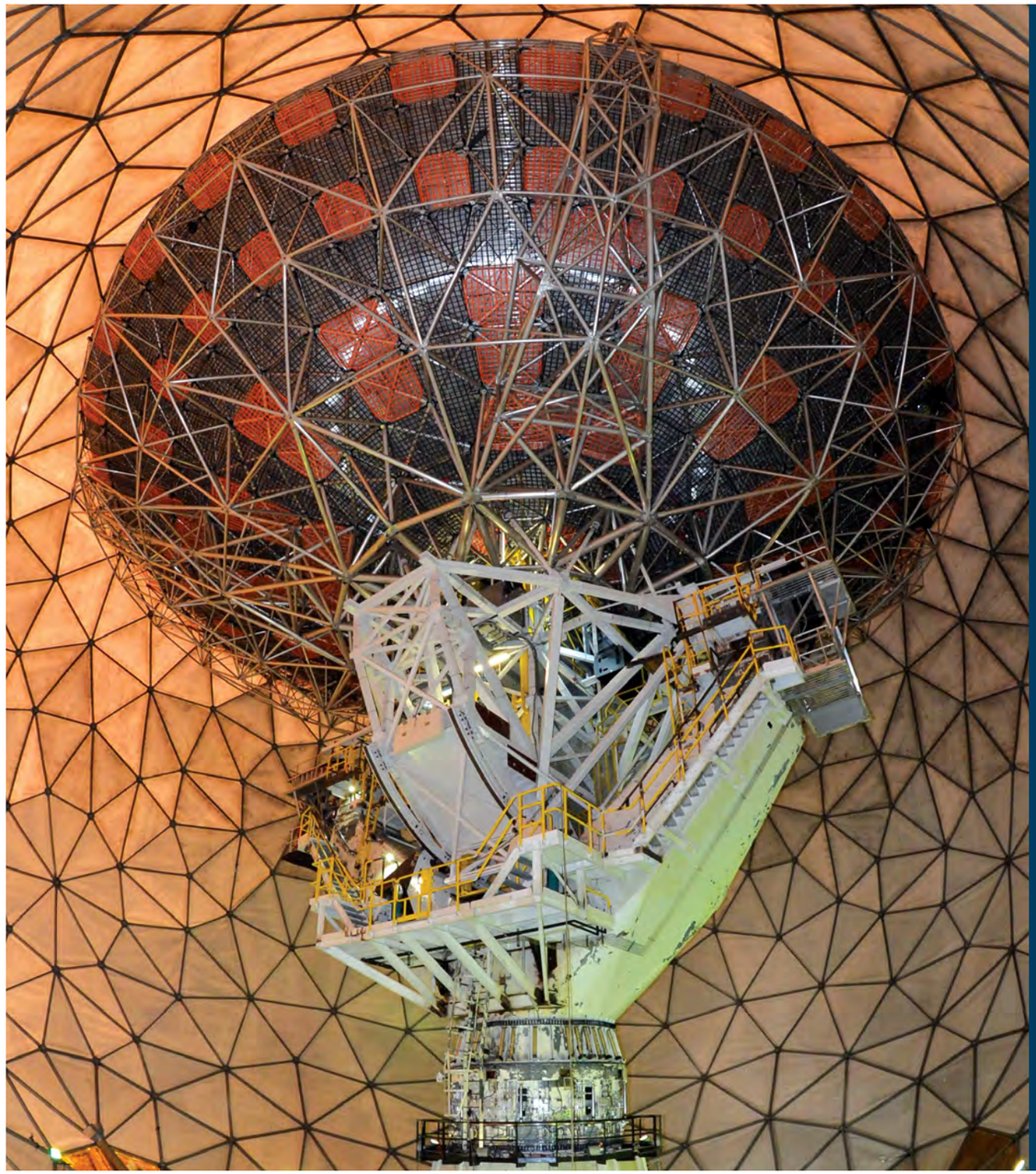
Curled Microelectromechanical Switch





A curled-electrode switch that eliminates the sticking and contamination issues inherent in traditional electromechanical switches

CODEVELOPERS: STAFF FROM INNOVATIVE MICRO TECHNOLOGY



2014
WINNER

Haystack Ultrawideband Satellite Imaging Radar

A ground-based, dual X- and W-band sensor that can produce very high-resolution images of objects orbiting Earth

CODEVELOPERS: STAFF FROM SIMPSON, GUMPERTZ, AND HEGER, AND COMMUNICATIONS AND POWER INDUSTRIES

EDITOR'S CHOICE AWARD WINNER

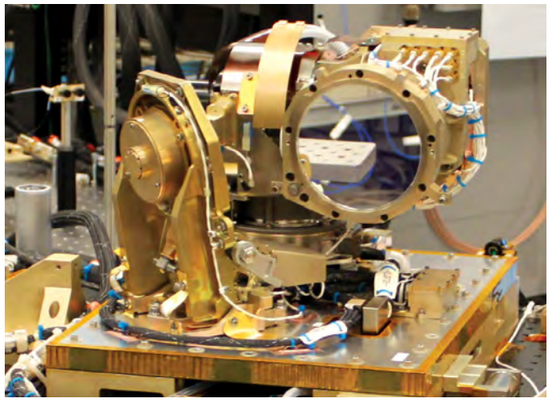
This technology was also the winner of an R&D Editor's Choice Award, which is given to the three R&D 100 Award winners that the magazine's editors believe are the most innovative and impactful

2014
WINNER

Lunar Laser Communication System

An optical system that achieves very high uplink and downlink data rates between an Earth terminal and a distant satellite

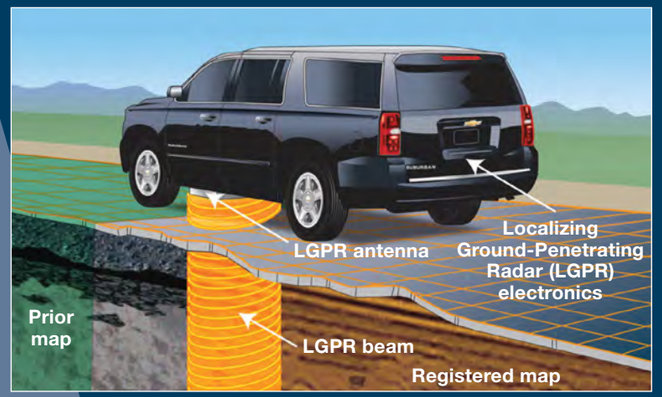
CODEVELOPERS: STAFF FROM NASA'S GODDARD SPACE FLIGHT CENTER AND NASA'S SPACE COMMUNICATIONS AND NAVIGATION PROGRAM OFFICE

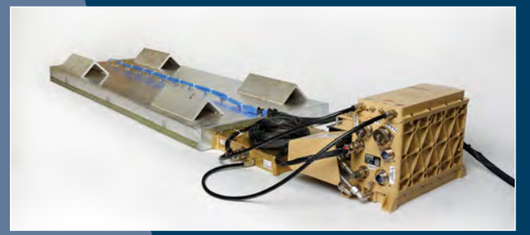


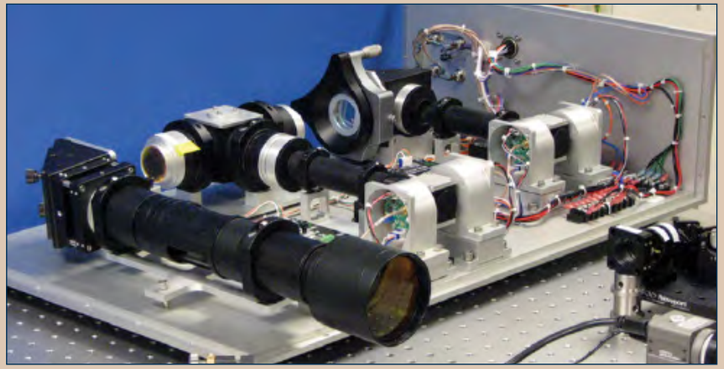
2014
WINNER

Localizing Ground-Penetrating Radar

A robust sensor that provides highly accurate, real-time vehicular position estimates based on prior mapping of subsurface features







2014
WINNER

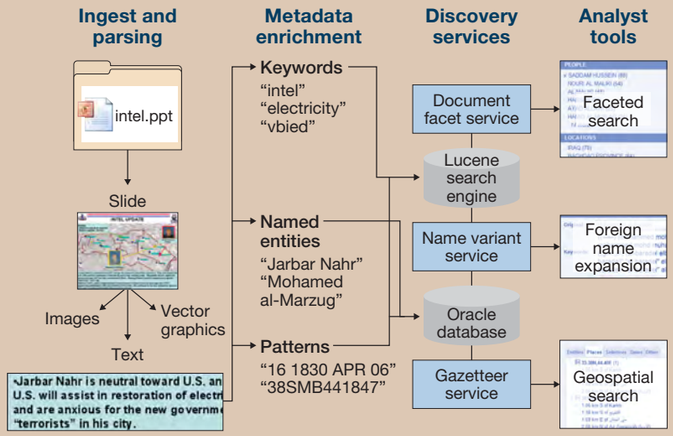
Wide-Area Chemical Sensor

A highly precise, self-referencing spectrometer that measures the concentrations of specified target gases within the atmosphere

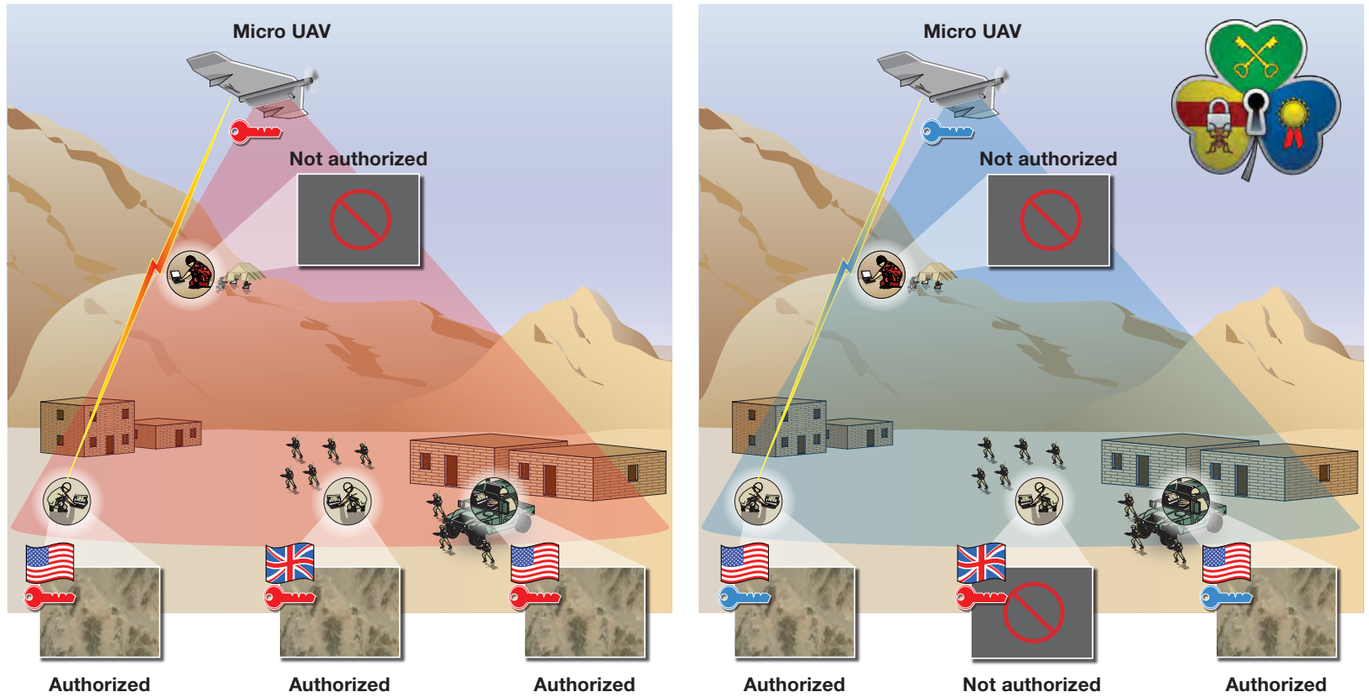
2013
WINNER

Structured Knowledge Space

A software and information system that enables analysts to mine the vast store of intelligence reports available to government decision makers



2012
WINNER



Lincoln Open Cryptographic Key Management Architecture

A highly portable software library that enables cryptographic protection for communication devices

Unmanned aerial vehicle (UAV) video accessible only to authorized terminals

Ground command center operator can modify access during a mission

2013
WINNER

Photoacoustic Sensing of Explosives

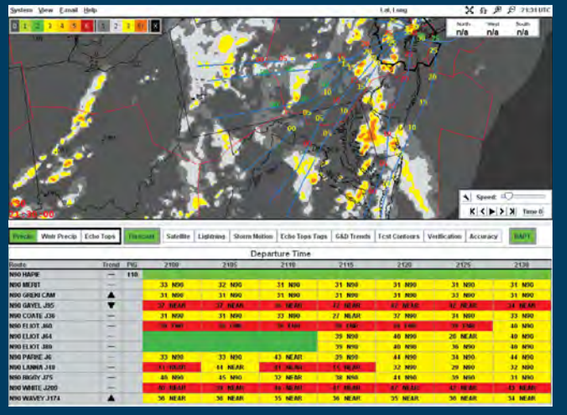
A system that detects and discriminates trace amounts of explosives from significant standoff distances

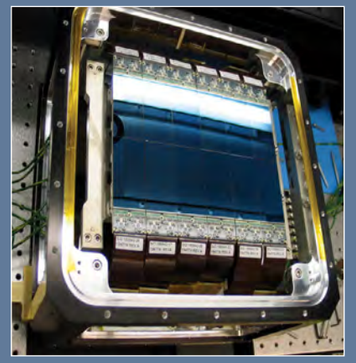
2012
WINNER

Route Availability Planning Tool

An automated decision support tool that predicts the availability of air traffic routes during thunderstorms

CODEVELOPERS: STAFF FROM THE FEDERAL AVIATION ADMINISTRATION





2012
WINNER

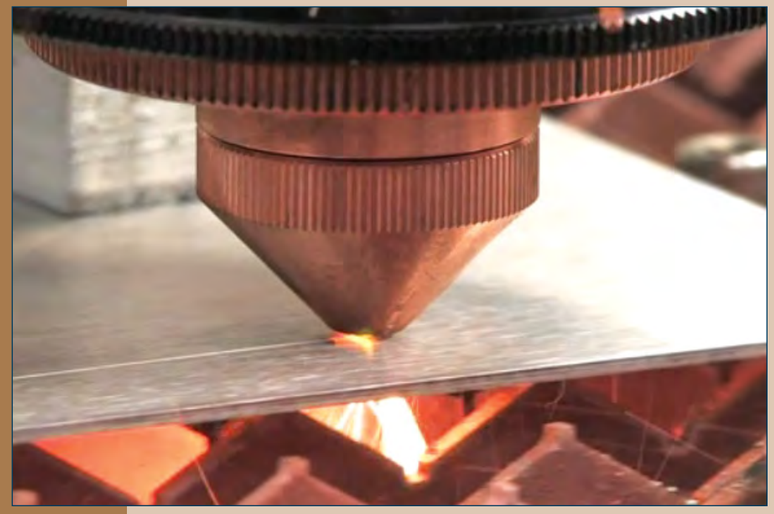
Wide Field-of-View Curved Focal Plane Array

A curved, charge-coupled device that corrects for inherent aberrations of the mirrors and lenses in optical systems

CODEVELOPERS: STAFF FROM GL SCIENTIFIC

2012
WINNER

Wavelength Beam-Combining Fiber-Coupled Diode Laser



A high-intensity diode laser that combines unprecedented brightness, efficiency, and reliability

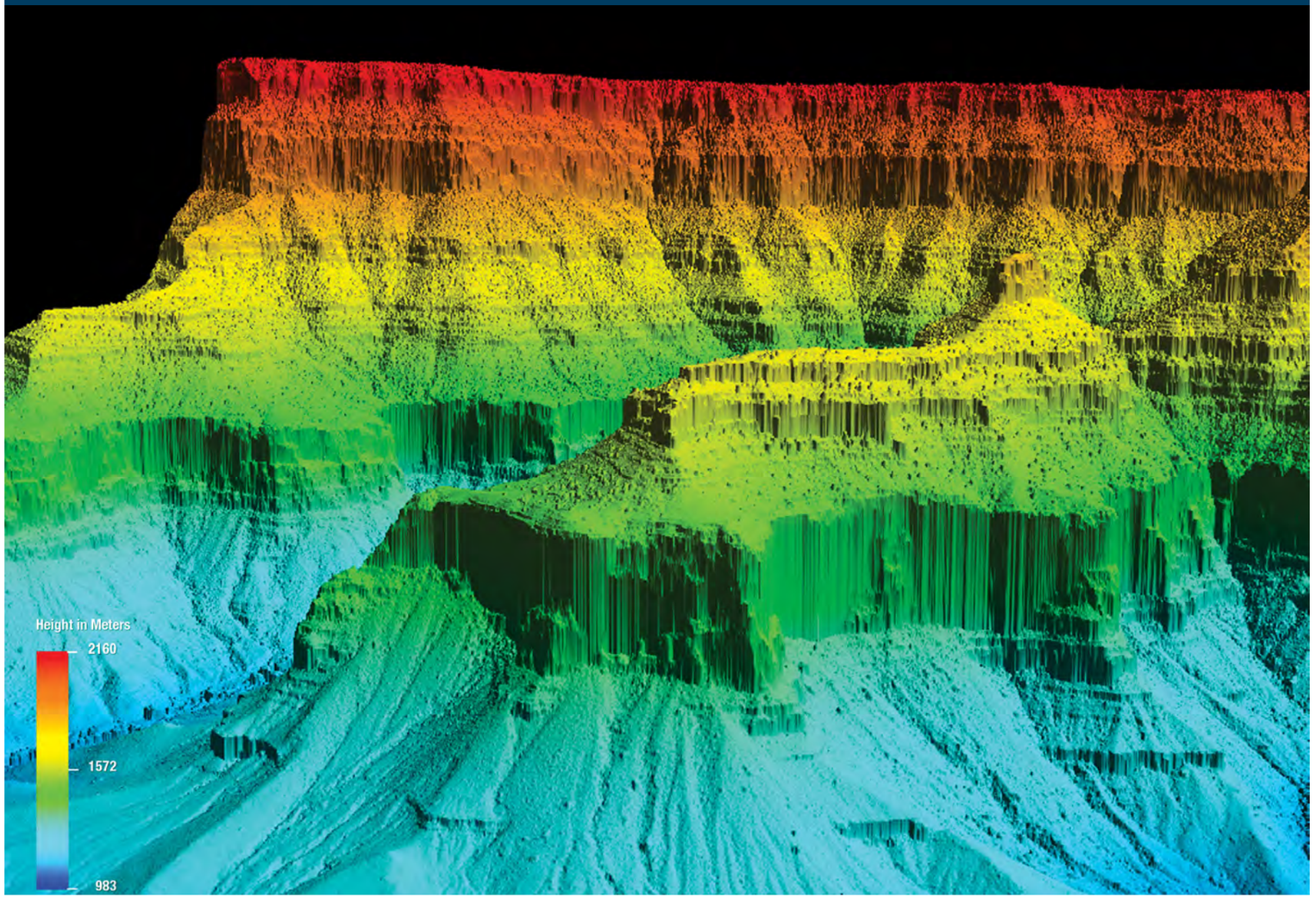
CODEVELOPERS: STAFF FROM TERADIODE

Airborne Ladar Imaging Research Testbed

2011
WINNER

An airborne laser radar that rapidly collects high-resolution three-dimensional imagery of wide-area terrains

CODEVELOPERS: STAFF FROM SUNSHINE AERO INDUSTRIES



EDITOR'S CHOICE AWARD WINNER

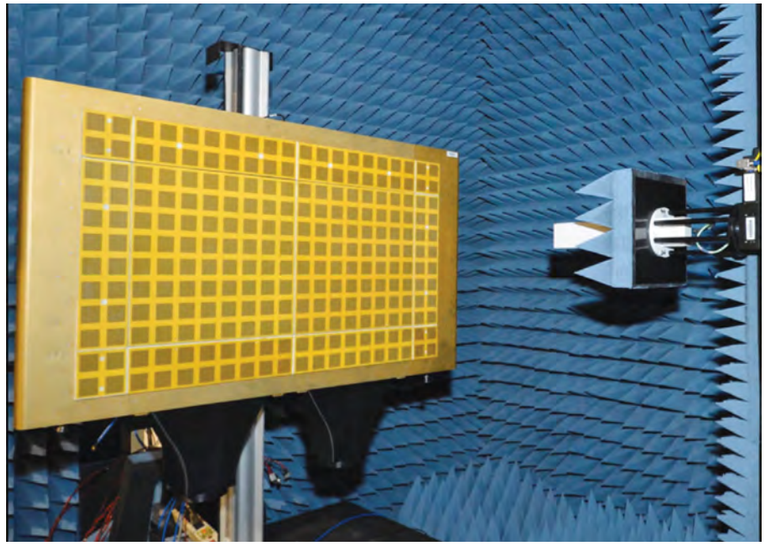
This technology was also the winner of an R&D Editor's Choice Award, which is given to the three R&D 100 Award winners that the magazine's editors believe are the most innovative and impactful

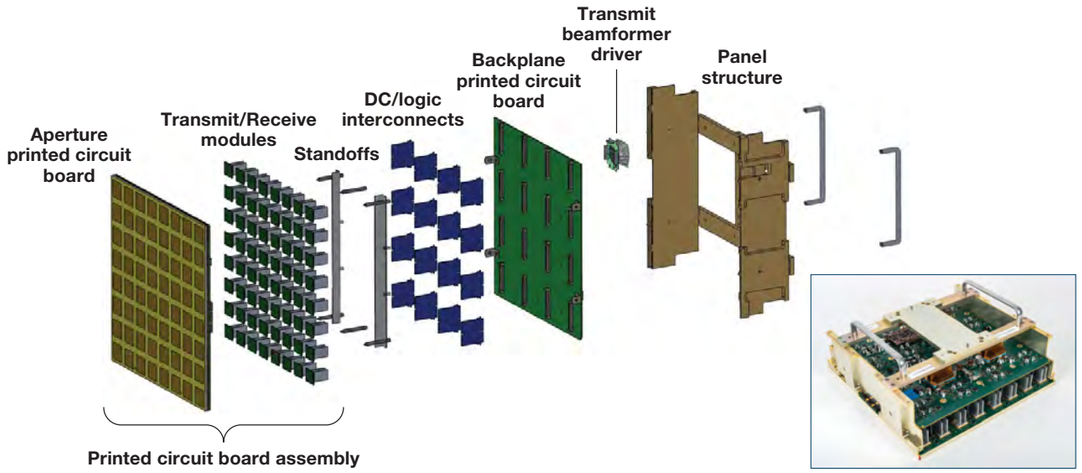
2011
WINNER

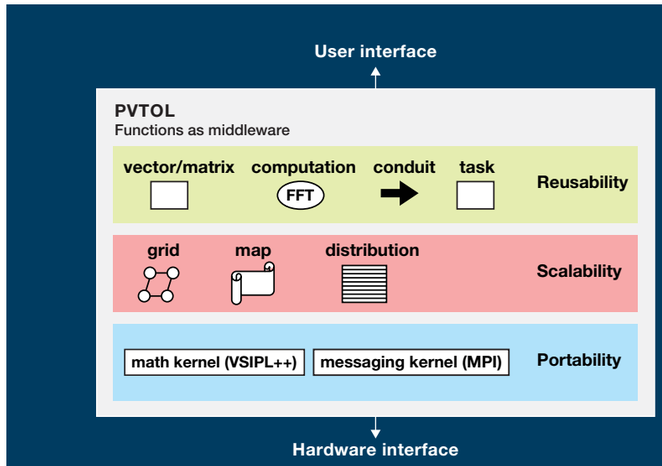
Multifunction Phased Array Radar Panel

A panel of phased arrays that exploits dual polarization and digital beamforming to provide efficient radar detection and tracking of aircraft and weather targets

CODEVELOPERS: STAFF FROM M/A-COM TECHNOLOGY SOLUTIONS







2011
WINNER

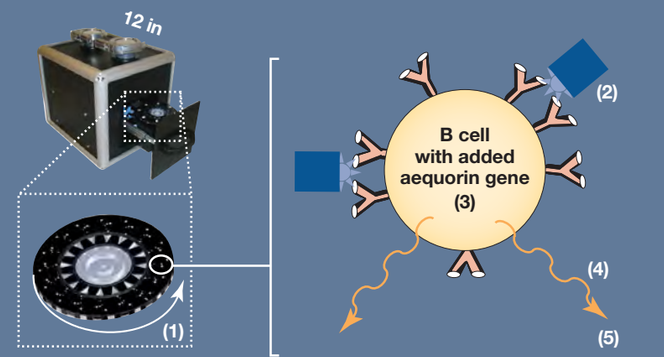
Parallel Vector Tile Optimizing Library

A real-time signal processing library that enables cross-platform portability of programs without sacrificing high performance

2011
WINNER

Pathogen Analyzer for Threatening Environmental Releases

A highly sensitive sensor that uses genetically modified white blood cells to rapidly detect and identify pathogens and toxins



Detection Process

(1) Bioagent-containing aerosol is collected; disc is spun after collection to release B cells

(2) Pathogens crosslink antibodies

(3) Biochemical signal amplification releases Ca^{2+}

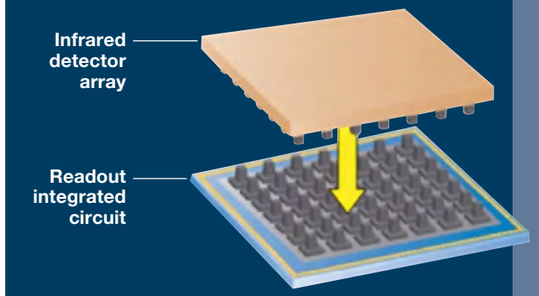
(4) Ca^{2+} prompts aequorin to emit photons

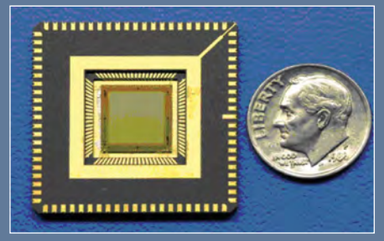
(5) Photons are detected by sensor

2010
WINNER

Digital-Pixel Focal Plane Array

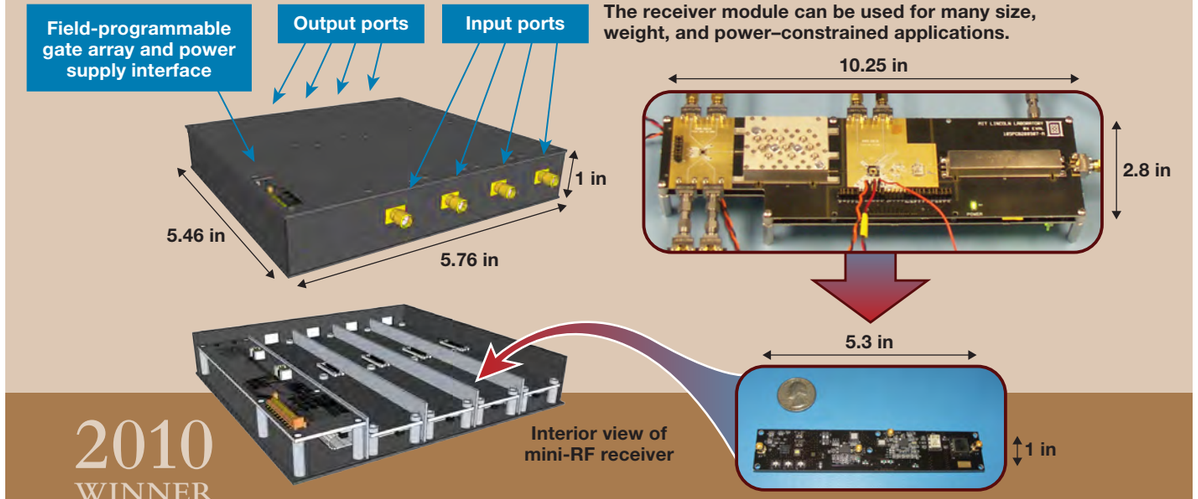
A complementary metal-oxide semiconductor readout integrated circuit for infrared imaging that is capable of an extreme dynamic range





Miniaturized Radio-Frequency Four-Channel Receiver

The smallest, least power-demanding receiver that can detect frequencies over a six-octave range

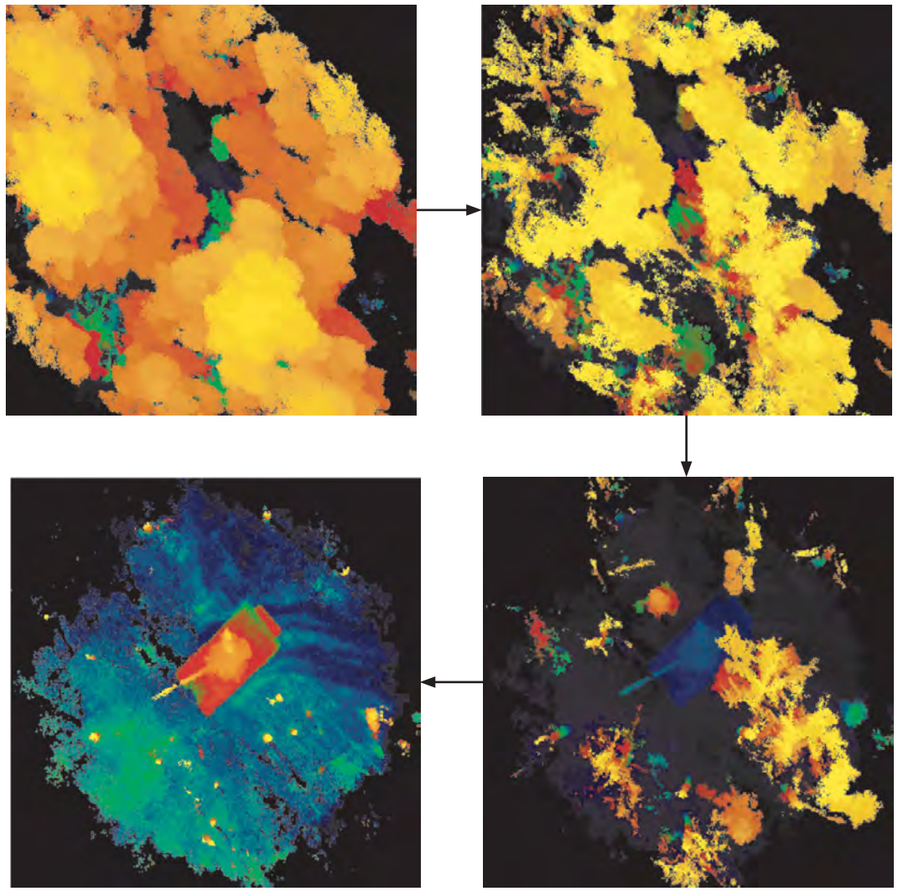


2010
WINNER

2010
WINNER

Geiger-Mode Avalanche Photodiode Detector Focal Plane Array

A two-dimensional array of ultrasensitive solid-state photodetectors, each of which can measure the arrival time of single photons



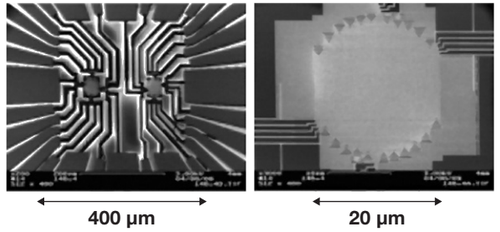
2010
WINNER

Runway Status Lights

A system integrating data from airport surveillance sources to control in-pavement lights that directly alert pilots to potential runway incursions

2010
WINNER

Subwavelength-Separated Superconducting Nanowire Single-Photon Detector Array



A component in an optical detection system that enables broadband single-photon detection with high efficiency and low noise at rates exceeding one billion photons per second

CODEVELOPERS: RESEARCHERS FROM MIT

Earlier R&D 100 Award Winners

In addition, Lincoln Laboratory received two earlier R&D 100 Awards:

1998 jointly with Cyra Technologies and Los Alamos National Laboratory for a three-dimensional laser mapping and imaging system

1995 for a technology that determines a plane's position by using GPS

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Continues on next page

Communications (cont.)

Computing & Software

Decision Support

Energy

Engineering

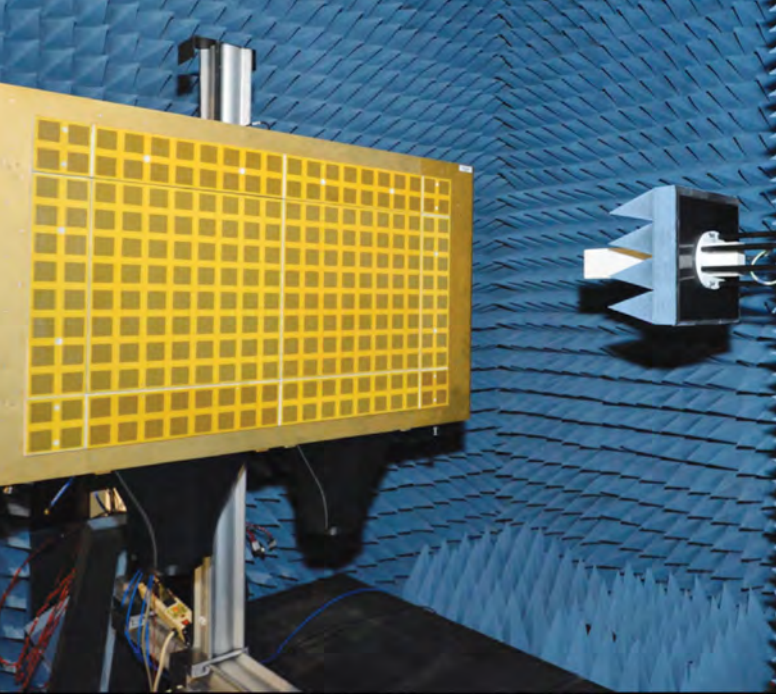
Lasers

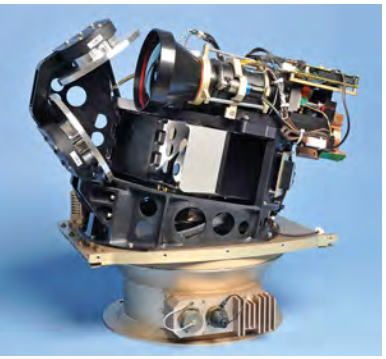
Magnetometry

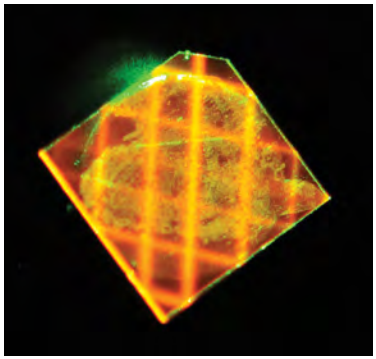
Radar Technology

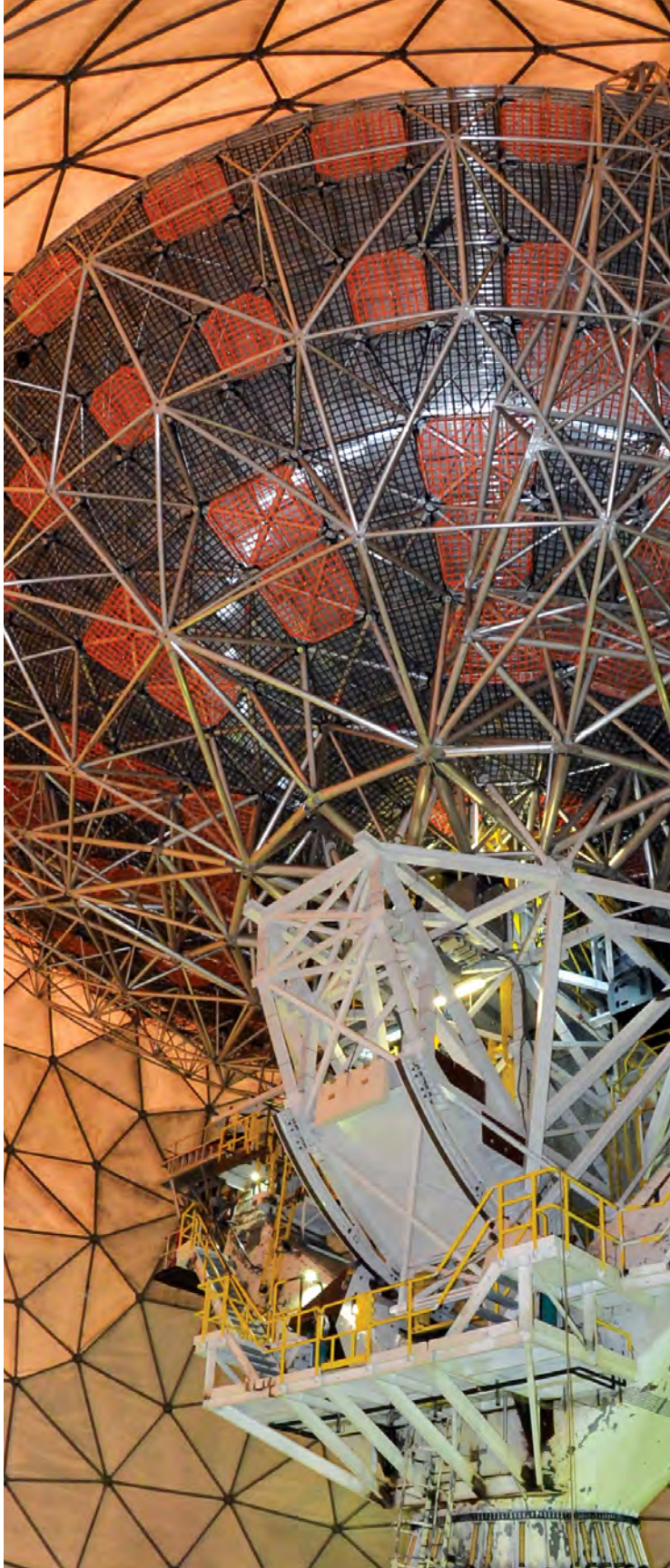
Space Systems


LINCOLN LABORATORY









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