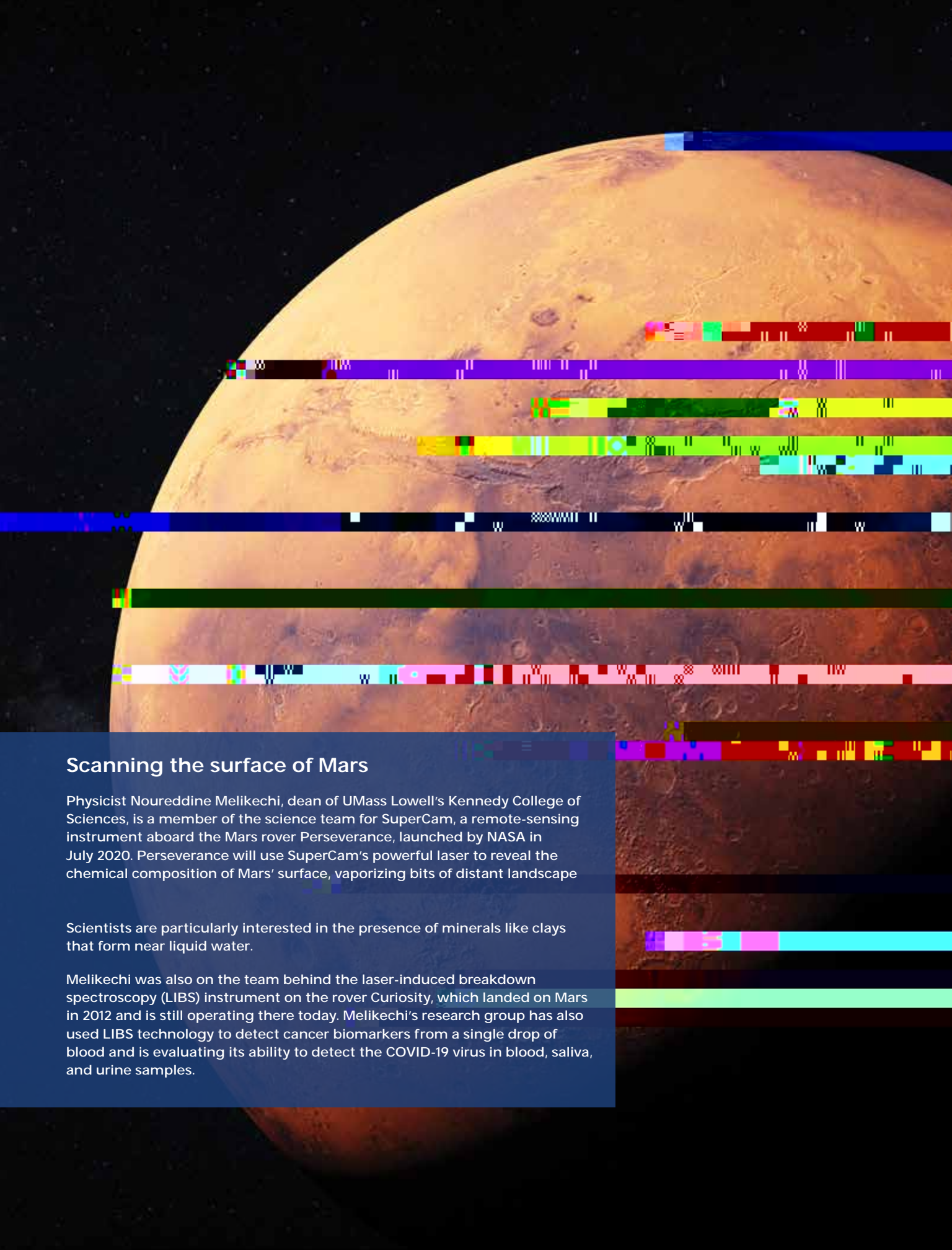


iversity of Massachusetts



Scanning the surface of Mars

Physicist Nouredine Melikechi, dean of UMass Lowell's Kennedy College of Sciences, is a member of the science team for SuperCam, a remote-sensing instrument aboard the Mars rover Perseverance, launched by NASA in July 2020. Perseverance will use SuperCam's powerful laser to reveal the chemical composition of Mars' surface, vaporizing bits of distant landscape

Scientists are particularly interested in the presence of minerals like clays that form near liquid water.

Melikechi was also on the team behind the laser-induced breakdown spectroscopy (LIBS) instrument on the rover Curiosity, which landed on Mars in 2012 and is still operating there today. Melikechi's research group has also used LIBS technology to detect cancer biomarkers from a single drop of blood and is evaluating its ability to detect the COVID-19 virus in blood, saliva, and urine samples.

The Internet. Global Positioning Systems. Drones. Much of the most world-changing, ubiquitous technology to emerge over the past 50 years has sprung from research sponsored by the Department of Defense and NASA in partnership with academic institutions like UMass.

Cybersecurity

The US is under constant cyberattack; threats range from email phishing scams to direct takeover of defense systems. Consequently, maintaining dominance in defensive and offensive cyber capabilities is a top priority for the Department of Defense.

Ongoing cyber-operations require cutting-edge research and workforce development—two UMass strengths.

Three of our campuses have developed research centers committed to cybersecurity innovation: the Center for Terrorism and Security Studies, Center for Internet Security and Forensics Education and Research, and New England Cybersecurity Operation and Research Center at UMass Lowell; the Cybersecurity Center at UMass Dartmouth; and UMass Amherst's Cybersecurity Institute, which conducts more than \$5 million in federally sponsored

with these groups collaborate with premier cybersecurity federal R&D centers—MITRE Corp., the Archimedes Center for Medical Device Security at the University of Michigan, MIT's Lincoln Laboratory—and draw upon the system's longstanding strengths in

generation systems and strategies for protecting American interests and residents online.

In 2019, UMass Lowell launched the

Cyber Range—an isolated computer network for cyber defense training and security research. The university is also establishing a Sensitive Compartmented Information Facility for government-sponsored research involving top-secret information.

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Human-performance augmentation and sensing

From sensors that track troop health technologies for monitoring and

human body have transformational potential for defense and beyond. UMass has pioneered augmentation technologies for military and healthcare use—a combined strength that is perhaps unmatched in the US and ideal for developing dual-use applications to serve the citizens of the Commonwealth.

UMass Lowell and DoD are advancing the state of this art together. The Harnessing Emerging Research Opportunities to Empower Soldiers (HEROES) program is a unique collaborative research and development center run in partnership with the U.S. Army Combat Capabilities Development Command Soldier Center (DEVCOM-SC), which has granted UMass Lowell scientists more than \$26 million to

create survival- and endurance-enhancing technologies for troops. Tech developed at HEROES includes a handheld electronic “tongue” for detecting food and water

conformable photovoltaic devices for

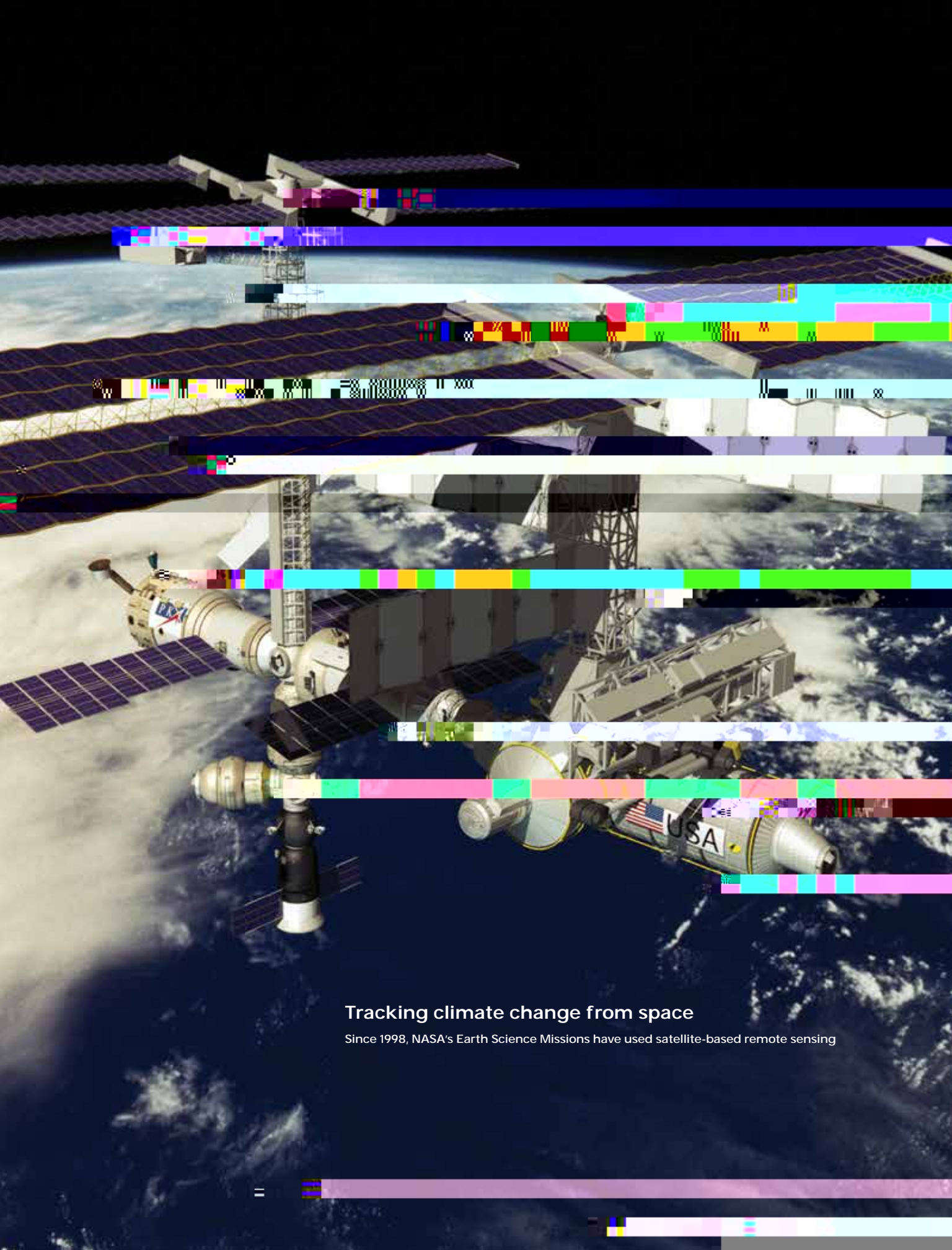
and Robotics Research Laboratory

from a healthcare perspective, both investigating how robotic chip

developed powered lower-leg prosthetics that, unlike standard prosthetics, provide thrust the way an intact limb does, making walking

limbs.

Commercialization of these technologies is also a system strength: UMass Lowell’s and UMass Medical School’s jointly operated Massachusetts Medical Device Development Center helps start-up companies in the Commonwealth develop a wide range of medical devices and bring them to market, including biosensors for cancer diagnosis, injectable cushioning gels for osteoarthritis, and injectable adhesives for repair of fractured bone.



Tracking climate change from space

Since 1998, NASA's Earth Science Missions have used satellite-based remote sensing

Aerospace and undersea sensing and communications

UMass has system-wide strength in sensing, modeling, communications, and antenna innovation that crosses domains—from space to air to undersea.

instrumentation and modeling. UMass Boston's Schaaf and Lee Labs are world leaders in the use of satellite-based remote sensing to monitor the Earth's environment and are major contributors to NASA's ongoing Earth Science missions. UMass Lowell's Center for Space Science and Technology is developing high-speed communications instruments for

2021, one of these "CubeSats" will be launched by Lowell undergraduates to enable transmission of research

of the future. Scientists from UMass Amherst's Institute for Applied Life Sciences will also contribute research efforts related to wearable sensors and mobile health sensing.

Development of multi-domain operations driven by connected devices touches on many other areas of strength across UMass, including

in human and asset monitoring to assess survivability, lethality, and effectiveness of soldiers and squads;

sensors and sensor fusion, and underwater vehicle autonomy at UMass Dartmouth; and modeling

UMass Lowell's HEROES initiative.

strength in antenna technology across the electromagnetic spectrum, through research groups like UMass Amherst's Antennas and Propagation Lab, Quantum Radio Frequency Group, and Remote Hyperspectral Observers Group, as well as UMass Boston's Engineering Department. UMass Boston applied electromagnetics researcher KC Kerby-Patel won a DARPA Young Faculty Award for her work on miniaturization technologies for communication and sensing antennas, which aligns with the miniaturization

Things initiative.

High-performance materials and sensors for challenging environments

UMass Lowell's HEROES initiative, in collaboration with DEVCOM Solider Center, is a leader in the development of advanced materials that protect soldiers from harsh and dangerous environments.

Fabrics developed at HEROES

environments, providing protection that enables enhanced performance

multifunctional Army uniforms,

antimicrobial, and insect-repelling characteristics, while—vitality—

Multi-functionality is a guiding principle here; clothing that serves more than one purpose can reduce the equipment load that soldiers must

Other materials from HEROES include garments that harvest electrical power from light, transparent armor,

Center for Emerging Materials Research (UMass Lowell) and the Center for Emerging Materials Research (UMass Lowell) are leading the way in developing advanced materials that protect soldiers from harsh and dangerous environments.

Tomorrow's frontiers

Our strengths position UMass to make important contributions to these critical research frontiers:

across multi-human-robot teams—
increasing the safety, capabilities,
and effectiveness of our soldiers and
creating powerful yet human-friendly
tech that will eventually lead to
advances for civilians as well.

Next frontier 3:

Pervasive awareness and monitoring

Over the coming decade, UMass
engineers will continue to develop and
evolve sensing technologies that can
provide soldiers and command with

space-to-ground and inter-satellite data transfer will also increase. This unmet need for commercial as well as defense applications will be an important area of innovation going forward.

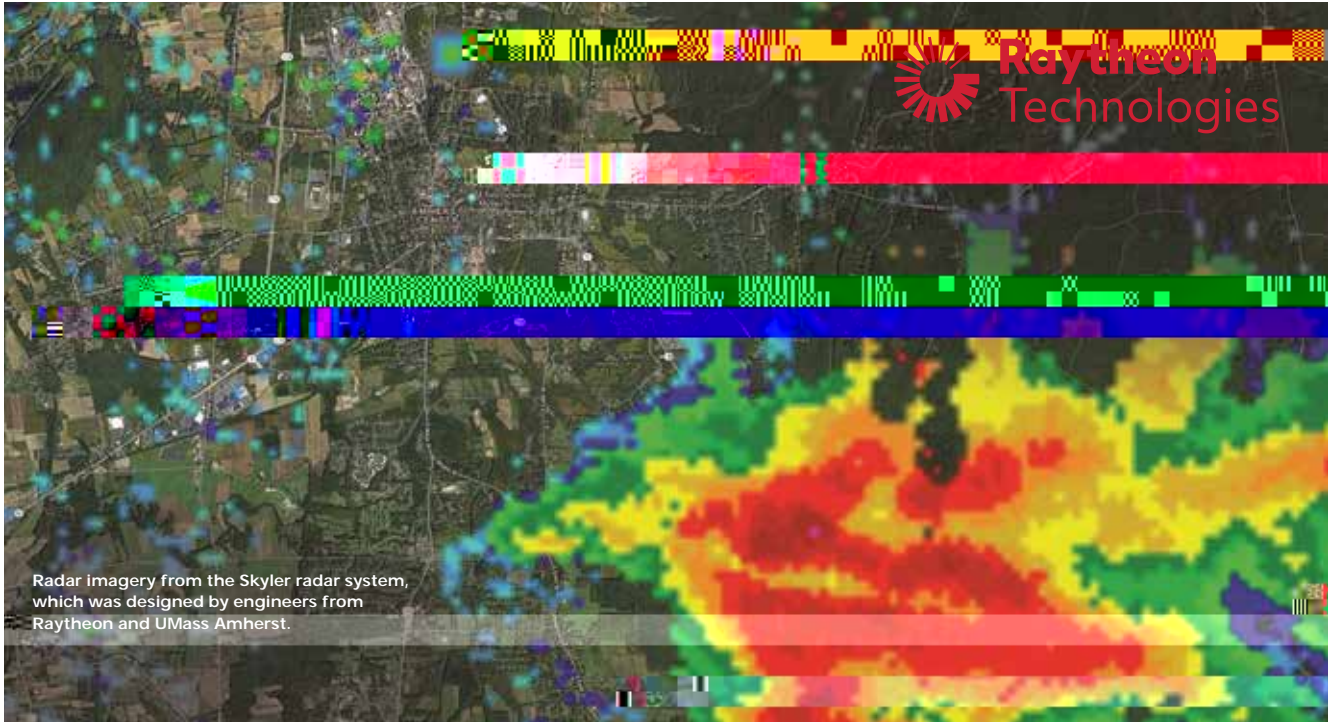
We must also strive for dominance in the electromagnetic spectrum—an increasingly contested and vital battle space—which will require cutting-edge sensing, communications, and electronic warfare capabilities.

Swarms are also coming: coordinated groups of small satellites, unmanned aerial vehicles, or undersea autonomous vehicles working cooperatively and across platforms for purposes including, but not limited to, intelligence, surveillance, and reconnaissance. The emergence of

technology—an area of emphasis at both NASA and DoD—has launched a “space race” in satellite swarms:

SpaceX has launched 955 of a planned 12,000 satellites in its Starlink constellation; Amazon has FCC approval for its own constellation of 3,236 satellites. Swarms present a number of technological challenges, including issues of control, data processing, and sensor fusion. UMass Dartmouth’s School for Marine Science & Technology is ahead

built and deployed ionosphere-
sensing space weather instruments on



Radar imagery from the Skyler radar system, which was designed by engineers from Raytheon and UMass Amherst.

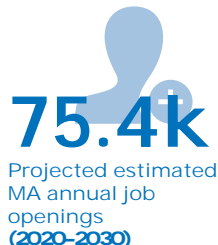
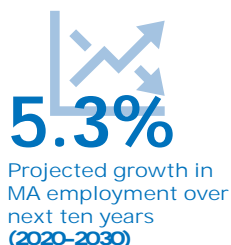
Shared success

University-industry partnerships are powerful forces for advancing applied science.

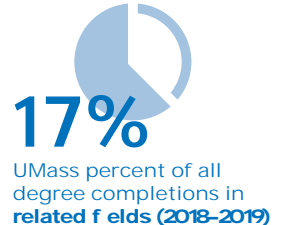
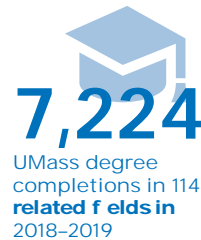
Over a 40-year period, UMass Amherst helped build Raytheon's industry-leading radar program—and vice versa. In 1980, the university and Raytheon launched the Advanced Studies Program, through which annual cohorts of Raytheon employees spend a year on campus, earning master's degrees in microwave engineering from the university's electrical and computer engineering department. Today 400+ UMass Amherst alumni work at Raytheon, and the university's microwave engineering program is among the best in the country. Raytheon also partners in the department's research, and recently loaned the Microwave Remote Sensing Laboratory a prototype of the company's next-generation Skyler radar unit—which UMass Amherst researchers helped design—to use in the lab's storm-tracking research.

Raytheon engineers work closely with UMass faculty on both internal and government-funded research projects at the Raytheon-UMass Lowell Research Institute (RURI), an on-campus research partnership that develops additive manufacturing for defense electronics. Raytheon is a key member of the university's academic-industry Printed Electronics Research Collaborative, which has been successful in training future engineers for work in the defense, manufacturing, and aerospace sectors.

Massachusetts employment data in occupations related to defense/space/naval technologies



UMass degree completions in fields related to defense/space/naval technologies



The University of Massachusetts' longstanding partnerships with the Army, Navy, Air Force, and NASA are spawning innovations with tremendous potential for human impact. These range from cybersecurity techniques that can ward off US adversaries and sexual abusers to ocean-process models that increase the safety of naval vessels and millions of people in India facing life-threatening monsoons.

Department of Defense and NASA in creating the technologies that will shape the future of

mutual investments that we have made in collaborative research to date will continue to yield dividends in discovery, workforce development, job creation, and economic prosperity for the Commonwealth.

Government partnerships amplify the work of our faculty, staff, and students, taking it from

civilians in their everyday lives. The University of Massachusetts is proud to serve as a vital backbone for these advances, and looks forward to ongoing collaboration at the frontiers of applied science.



Seeing past star-shine

Imaging planets around even the nearest stars, says UMass Lowell's Center for Space Science and Technology director Supriya Chakrabarti, is like taking a picture from San Francisco of an insect

Cape Cod. But with a \$5.6 million

Dig deeper

Find out more about some of the work going on across the state and the researchers

Cybersecurity

Human-performance augmentation and sensing

Multi-domain awareness and operation

Aerospace and undersea sensing and communications

High-performance materials and sensors for
challenging environments



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