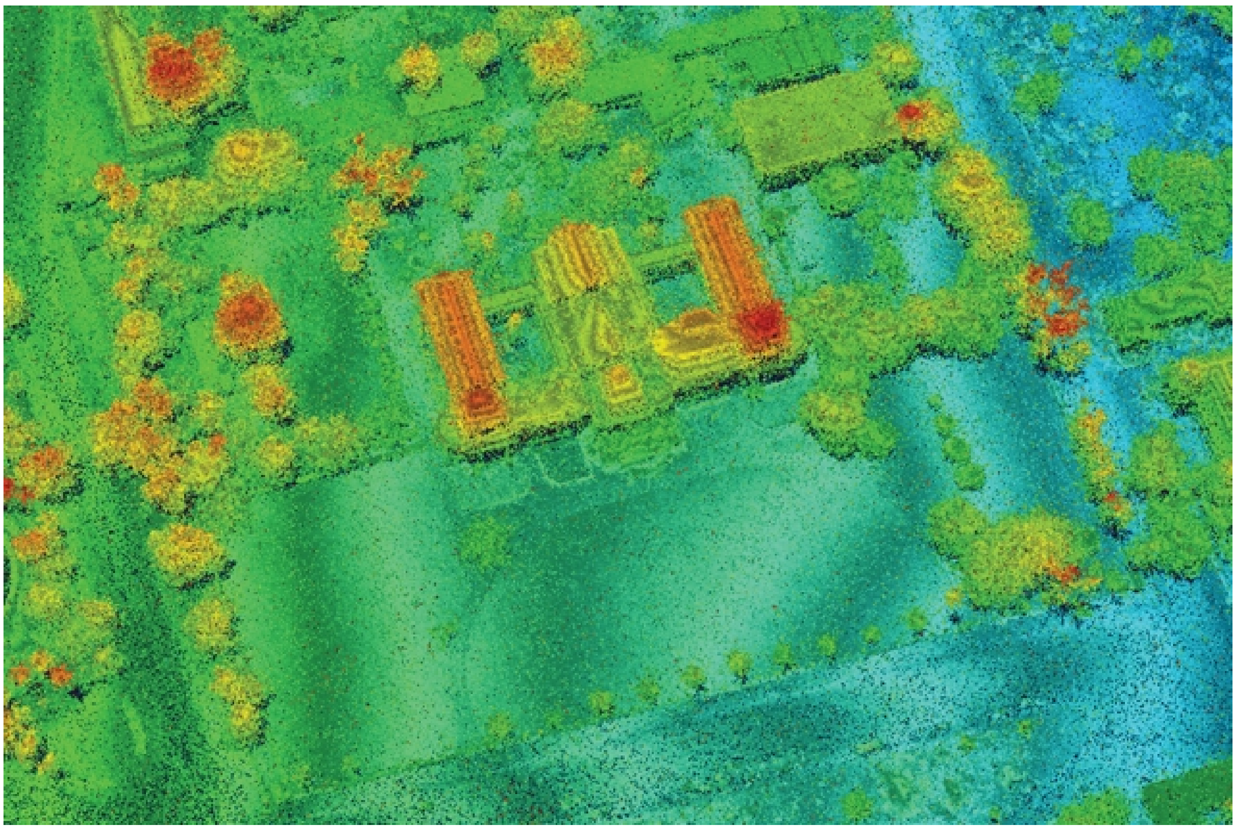
Technology confronts disasters

October 21 2015, by Dorothy Ryan



This image of the National Palace in Haiti is one of the Airborne Ladar Imaging Research Testbed (ALIRT) images taken just after the 2010 earthquake devastated parts of the island of Hispaniola. Credit: MIT Lincoln Laboratory

In 2010, soon after Haiti was devastated by an earthquake, a team from MIT Lincoln Laboratory collected and analyzed information to help the U.S. Southern Command (USSOUTHCOM), the lead military agency responding to the crisis, effectively dispatch vital resources, including food, water, tents, and medical supplies, to the victims of this disaster. The laboratory's capabilities in advanced imaging also aided relief operations: A laser-radar imaging system, the Airborne Ladar Imaging Research Testbed (ALIRT), produced high-resolution, three-dimensional renderings of terrain and infrastructure that were used to generate maps indicating road trafficability, helicopter landing zones, and the changes in populations at camps for displaced persons.

This Haiti experience demonstrated to Lincoln Laboratory researchers that advanced technology and technical expertise developed for the Department of Defense (DoD) can significantly benefit future humanitarian assistance and disaster relief efforts. And in February, the Laboratory established the Humanitarian Assistance and Disaster Relief (HADR) Systems Group to explore ways to leverage or advance existing capabilities for improving disaster responses.

"With this new group, we are planning to apply technology developed in many areas, including the DoD, to support global needs for humanitarian assistance and disaster relief. We have put together a strong team to develop new systems for this very important need," says Eric Evans, MIT Lincoln Laboratory director.

Recent news coverage of natural disasters has exposed the difficulties and critical importance of effective response operations. Immediate actions in the aftermath of a catastrophic event are crucial to helping people survive, but preparedness for a conceivable disaster helps make a community resilient to the crisis. The HADR Systems Group is seeking to research and develop technology that can help agencies through all stages of disaster management—preparedness, response, and recovery.

According to Gregory Hogan, leader of the new HADR Systems Group, Lincoln Laboratory has a unique combination of abilities that can inform disaster response campaigns: "We have expertise in advanced sensors, communications systems, systems analysis, and systems engineering; an understanding of military operations and culture; a lot of familiarity with remote sensing capabilities and data analysis; and broad experience in technology."

"Our work could be as straightforward as understanding what capabilities already exist and then integrating them into a HADR architecture," Hogan says. For example, the laboratory-developed Wide-Area Infrared System for Persistent Surveillance (WISP), a long-wave infrared imaging system that produces high-resolution panoramic video data, can be used to monitor a disaster site. WISP collects video at a rate of one frame every two seconds, making it a near-real-time observer of the ongoing activity at a site, capturing, for instance, the movement of rescue vehicles through an area.

"Or," Hogan continues, "our work could be more extensive, involving system modifications and improvements, such as the development of a rapidly deployable unclassified communications system that might utilize balloons or unmanned aerial vehicles when the existing communications infrastructure is damaged or destroyed in a disaster."

One system improvement that could be viable for HADR missions is a next-generation ALIRT system known as the Multi-look Airborne Collector for Human Encampment and Terrain Extraction (MACHETE). MACHETE, with its incredible area coverage rate and excellent resolution (400 square km/hour at 25-cm resolution or 1,200 square km/hour at 50-cm resolution), can rapidly map a broad region and supply detailed three-dimensional images of every terrain feature or human-made structure over which it flies. In addition, MACHETE is capable of "seeing" through foliage or dense dust clouds. These enhanced capabilities can provide disaster response teams with even finer situational awareness than supplied by ALIRT during the Haiti mission.

Research and development for humanitarian assistance and disaster relief may seem an unlikely objective for a DoD laboratory commissioned to develop technology in support of national security. However, disruptions to the economic and social stability caused by disasters trigger events that undermine homeland security—as evidenced by the disorder, and sometimes lawlessness, wrought by Hurricane Katrina. Overseas disasters have economic, political, and humanitarian consequences that reverberate throughout the international community.

Consensus among experts in the HADR community is that natural disasters are likely to occur more frequently in the future because of the impacts of global climate change on the environment. Mischa Shattuck, a member of the HADR Systems Group, an affiliate at the Humanitarian Initiative within the Harvard School of Public Health, and a former member of a nongovernmental organization that participated in the Haiti response, has had broad experience with relief organizations. She explains that the continual move of people into densely populated, typically urban, areas leads to the expectation that the consequences of future catastrophic events will be increasingly severe; not only will more people be affected when a disaster hits, but also the growing infrastructure that supports them will necessitate more extensive rebuilding efforts.

The above factors will influence the achievement of one priority designated in the DoD's 2014 "Quadrennial Defense Review": enhancing global security. Although the DoD involvement in global security is most focused on protecting the nation from external threats, the 2014 review acknowledges that stressors such as poverty, destruction of the environment, depletion of natural resources, and political and social instability all foster violence and terrorism. Mitigating the stressors caused by disasters, therefore, contributes to the DoD's goal of safeguarding both national and global security. Hogan believes that the laboratory can bring advanced technology to bear on disaster mitigation and enable better coordination among the DoD and outside relief agencies.

Lincoln Laboratory HADR efforts

In 2010, staff from Lincoln Laboratory provided data analysis of the vast amounts of information collected in the aftermath of the hugely destructive Haiti earthquake. Analysis results helped the U.S. Southern Command coordinate with other agencies to direct cleanup operations. Credit: Gina Jackson/USAID (left) and Cpl Theodore Ritchie/USMC

"The response stage is where the laboratory has executed programs in the past," says Adam Norige, an assistant leader of the HADR Systems Group. "In this stage, information gathering and communication are vital to first responders."

During the 2010 cleanup of the Deepwater Horizon oil spill in the Gulf of Mexico, Lincoln Laboratory advisors helped the U.S. Coast Guard evaluate the most effective deployment of airborne sensors to survey the spill's movement and severity.

The Next-Generation Incident Command System (NICS), a large-scale data-integration software platform, provides first responders with situational awareness and real-time communication. Developed originally in 2008 to help firefighters share multisourced sensor data, NICS has significantly decreased the time gaps between information collection and dissemination, allowing incident commanders to better coordinate the deployment of personnel and equipment. NICS has been used not only for wildfire responses but also in operations to evacuate flooded neighborhoods in the Riverside and San Bernardino counties of California and to locate victims of the 2014 Oso landslide in Washington.

Today, more than 450 organizations—mainly in the United States but also in Victoria, Australia—are using NICS to improve their management of all types of emergency responses. Under sponsorship of the Department of Homeland Security Science and Technology Directorate (DHS S&T), the HADR Systems Group is continuing to support NICS and to investigate new capabilities such as portable systems for use in regions that lack a communications infrastructure.

The HADR Systems Group is consolidating projects from across the laboratory's technical divisions into a nexus for technologies that address the problems intrinsic to disasters. "Lincoln Laboratory could bring a system-level perspective to understanding how technology can be applied to disaster situations," Hogan says. He explains that during disaster responses in which multiple organizations provide varied assistance, such as search-and-rescue operations, medical care, or supply distribution, what is critical is an informed strategy that coordinates services.

In a program aimed at the preparedness stage of disaster management, a research team in the HADR Systems Group is leveraging Lincoln Laboratory's understanding of decision support technology, computer visualization, and weather-prediction systems to create a tool that helps emergency managers plan for the contingencies of hurricanes. The Lincoln Laboratory team first completed an assessment of the National Hurricane Program's technical capabilities. This study recommended improvements to these capabilities, including significant enhancements to HURREVAC (short for "hurricane evacuation"), the national system for tracking tropical storms and providing up-to-date predictions on storm impacts.

"HURREVAC provides very good situational awareness of storms—location, intensity, projected path, predictions of storm surge heights, wind velocities," says Robert Hallowell, a lead developer on the HURREVAC upgrade. "However, what to do with this information is not intuitive, especially in the context of making local evacuation and resource-staging decisions. Moreover, many critical decisions pertaining to protecting lives and property are made in the absence of specialized analytics."

The goal of this program, sponsored by DHS S&T in conjunction with the Federal Emergency Management Agency (FEMA), is to combine weather reports from the National Hurricane Center with other pertinent data to create information that decision makers can readily use. One such information product targeted in this program is a real-time analysis of specific storm impacts for each local hurricane jurisdiction and associated evacuation zones. Understanding the potential impacts at a local level will allow decision-makers to plan and implement efficient, effective protective actions.

So far, Lincoln Laboratory has had little involvement in developing technology for the recovery phase of disaster management, which can be the longest and most costly stretch of the disaster cycle. "This stage requires the collection of significant amounts of data and the subsequent analysis to determine if recovery efforts are actually making improvements from a systems perspective," Norige says.

Shattuck agrees with Norige that the recovery phase depends heavily on the evaluation of the abundance of data gathered during the earlier phases of disaster response. "At first, you need so much information—what is happening, where are people, where are resources. Then, you need to analyze all the data, but there is no time." She sees the Laboratory's expertise in data exploitation and automated decision support systems as valuable assets to agencies overwhelmed with data but strapped for time to coordinate all the information into a coherent, effective plan.

The Lincoln Laboratory-developed Airborne Ladar Imaging Research Testbed (ALIRT, at left) employs innovative Geiger-mode avalanche photodiode arrays to provide wide-area 3-D imagery. ALIRT was used to image the National Palace in Haiti (right) after the 2010 earthquake there. Credit: MIT Lincoln Laboratory

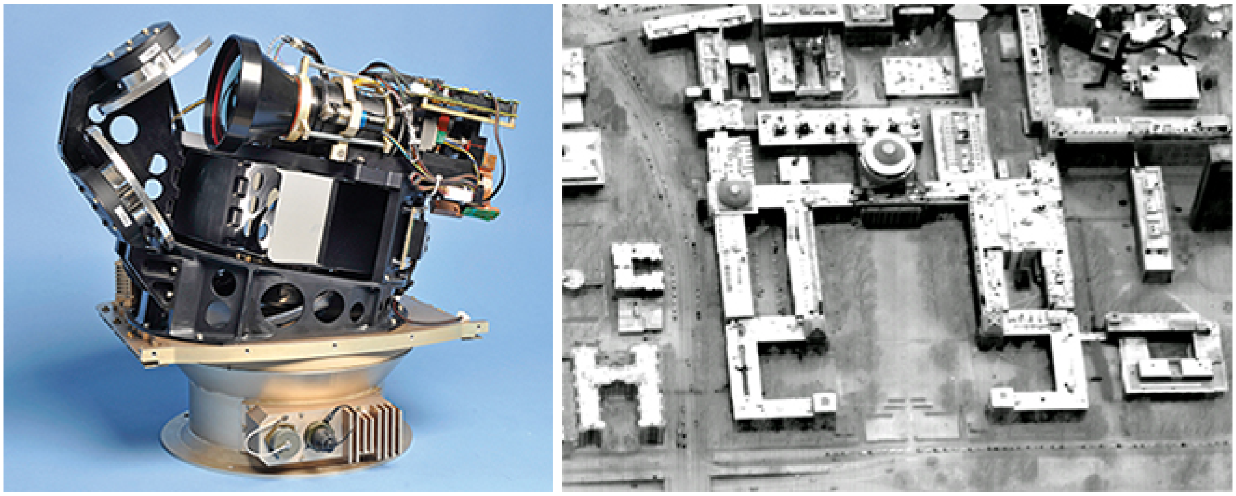
Through the development of new technologies to instrument and assess recovery efforts, the laboratory is growing its capabilities to improve such efforts. Additionally, ongoing research in the HADR Systems Group is directed at identifying potential uses for Lincoln Laboratory-developed technologies in recovery missions. The ultimate goal of all this work is to strengthen a nation's post-disaster resiliency. "We are looking at how we can leverage the Laboratory's capabilities in such areas as remote sensing or ladar imaging to help agencies better coordinate relief and recovery operations," says Karen Springford, an assistant leader of the HADR Group. "Domestic disasters are our first focus, but we are also interested in future partnerships with organizations such as USAID [the United States Agency for International Development] that provide assistance during international, large-scale disasters."

Recently, the HADR Systems Group has been exploring ways to support the U.S. Pacific Command (PACOM) and USSOUTHCOM, the geographic combatant commands most frequently called upon to participate in large-scale foreign humanitarian assistance operations. A Lincoln Laboratory team was invited to participate at PACOM headquarters during the Nepal earthquake response as part of the Office of Foreign Disaster Assistance's civil and military liaison team. Members of the group were also engaged in disaster response exercises this past June, serving as investigative observers at USSOUTHCOM during the 2015 Medical Readiness Training Exercise in Honduras and during PACOM's Vigilant Guard 2015 exercise held in Hawaii. Going forward, the group's intention is to broaden development partnerships at PACOM, USSOUTHCOM, and USAID to begin addressing the technology challenges these organizations face in their emergency response efforts.

One such initiative is the laboratory's development of technology for USSOUTHCOM's peacekeeping operation that addresses the prevalence of improvised explosive devices (IED) in Colombia. These IEDs, placed around sensitive areas by the insurgency group Fuerzas Armadas Revolucionarias de Colombia, annually cause many civilian injuries and deaths. The laboratory is extending its NICS decision support ecosystem to enable forward-deployed personnel to identify suspected IED locations and to communicate that information to a higher command that directs the remediation of these threats.

In July 2014, staff from the HADR Systems Group and members of DHS S&T participated with representatives from Croatia, Bosnia-Herzegovina, and Montenegro in a two-day workshop sponsored by the North Atlantic Treaty Organization's (NATO) Science for Peace and Security Program. The objective of the workshop was to discuss the potential for a multiyear effort that will enhance the emergency management capabilities in the eastern Balkan region, which in 2014 experienced devastating floods that crossed country borders. The workshop led to a proposal to the Science for Peace and Security Program for developing a system for coordinating multinational responses among the Balkan states. All 28 allies in NATO have unanimously approved this proposal, and the project is set to commence later this year. With the success of this pilot, NATO envisions NICS eventually being available across these 28 countries.

Collaboration with MIT

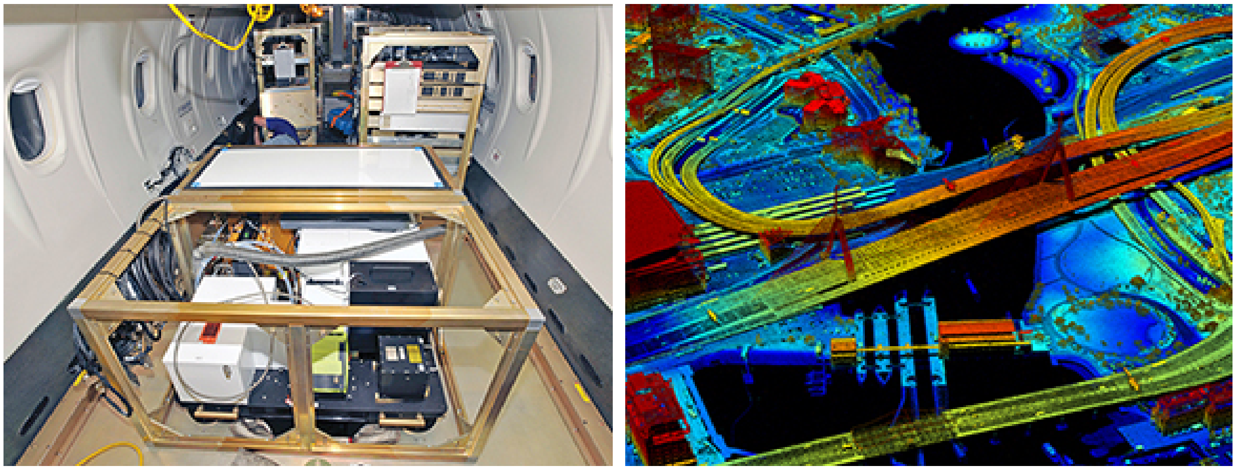


The Wide-Area Infrared System for Persistent Surveillance (WISP) camera at left uses a novel digital focal plane array, developed at Lincoln Laboratory, to capture 360-degree wide-area motion imagery of a scanned scene. The zoomed-in aerial image of the MIT campus at right was extracted from WISP video footage of Cambridge, Massachusetts, shot at night from an altitude of 9,000 feet. Credit: MIT Lincoln Laboratory

Lincoln Laboratory is also connecting with resources at the MIT campus to extend its understanding of the dynamics of HADR operations and of the potential role for the laboratory in such operations. In 2014 MIT and Lincoln Laboratory sponsored two workshops that brought together representatives from research institutes, humanitarian organizations, and industry to discuss the role advanced technology could play in HADR operations. Subsequently, an internal Lincoln Laboratory study identified research areas with the potential for changing disaster responses and concluded that technology could improve all phases of disaster management. The study also characterized Lincoln Laboratory as a unique organization that could bridge HADR research across nongovernmental organizations, the government, and academia because of its deep relationships with the DoD and with MIT and the broader research community.

The Laboratory has collaborated with the MIT Humanitarian Response Lab (HRL) to explore opportunities that will leverage campus assets and laboratory capabilities. For example, after the Nepal earthquake, through its connection with HRL, Lincoln Laboratory researchers from the HADR Systems Group engaged with the MIT community, including the Nepalese Students' Association and MIT's Office of the President, to explore how three-dimensional imaging technology may be used to identify areas of Nepal that could be at high risk for post-earthquake landslides. From this interaction with students who had direct contact with relatives dealing with the earthquake's aftermath, laboratory staff gained insights on a difficult disaster response environment. The laboratory incorporated the concerns and ideas from the MIT community into its interactions with the U.S. government regarding response activities in Nepal.

In addition, Lincoln Laboratory funded two graduate students in MIT's Technology and Policy Program to work with the MIT Humanitarian Response Lab conducting research on disaster management problems: Julia Moline's thesis analyzed the ways decision support systems can be most useful in deploying resources during a recovery, and Lauren Seebach's thesis designed the initial framework for the continuous assessment of a jurisdiction's capability to allocate needed commodities after a disaster.



The MACHETE ladar and subsystems (left) are installed on a De Havilland Canada (DHC)-8 aircraft. At right, an image of a Boston artery shows the exceptional detail the MACHETE system captures. Credit: MIT Lincoln Laboratory

Several early collaborations with other MIT research groups are investigating new applications of technology to disaster responses. Professors for the flight vehicle engineering course offered by the MIT Department of Aeronautics and Astronautics (AeroAstro) teamed with laboratory engineers in developing a capstone project in which students designed a low-cost UAV that could deliver materials to HADR missions; in the planning stages is an AeroAstro capstone project to prototype a UAV that carries a system to enable communications in an environment with limited or disrupted service.

Through a wide array of initiatives, the HADR Systems Group is taking on a new, and potentially global, mission for Lincoln Laboratory: "The hope is that an increased emphasis on improved interagency communication and collaboration will result in humanitarian aid efforts and disaster responses that are targeted accurately, executed efficiently, and have significant impact," Norige says.

The Next-Generation Incident Command System (NICS) was initially applied to wildfire suppression efforts in California to prevent forest fires like this one from spreading to densely populated communities. Credit: Jeff Turner

This story is republished courtesy of MIT News (web.mit.edu/newsoffice/), a popular site that covers news about MIT research, innovation and teaching.

Provided by Massachusetts Institute of Technology

Citation: Technology confronts disasters (2015, October 21) retrieved 26 April 2024 from https://phys.org/news/2015-10-technology-disasters.html