

Exposing Buried Danger

Field tests advance seismic landmine-detection system.

Millions of land mines are buried worldwide, and these weapons were responsible for an estimated 16,000 injuries and deaths in 2002. Georgia Institute of Technology researchers are making progress with a landmine-detection system that could ultimately help prevent such losses. The system uses high-frequency seismic waves to displace soil and objects in it slightly (less than one ten-thousandth of an inch). A non-contacting radar sensor then measures the results, creating a visual representation of the displacement that reveals the buried mines.

This seismic-wave system presents potential advantages over existing electromagnetic-wave techniques used in metal detectors and ground-penetrating radars (GPR). Although metal detectors and GPRs can locate mines successfully, they have

more trouble locating the small, plastic anti-personnel mines that have become more prevalent. Metal detectors and GPRs can also be confused by ground clutter — rocks, sticks or scraps of metal — sometimes resulting in many false alarms. Yet because plastic mines have very different mechanical properties from soil and ground clutter, the seismic waves are capable of detecting and distinguishing these mines from common ground clutter.

This has been demonstrated in laboratory and limited field tests.

“When a wave hits a land mine, resonance builds over the top of the mine, triggering a vibration which is bigger than the wave that excited it — and the vibration persists longer,” says Waymond R. Scott Jr., a professor in Georgia Tech’s School of

Marine Barracks Minefield Maintenance personnel stack deactivated anti-tank and anti-personnel land mines for destruction at a demolition site on Naval Station Guantanamo Bay, Cuba, in 1997.



U.S. NAVY PHOTO BY PETTY OFFICER 1ST CLASS RONALD L. HEPPNER

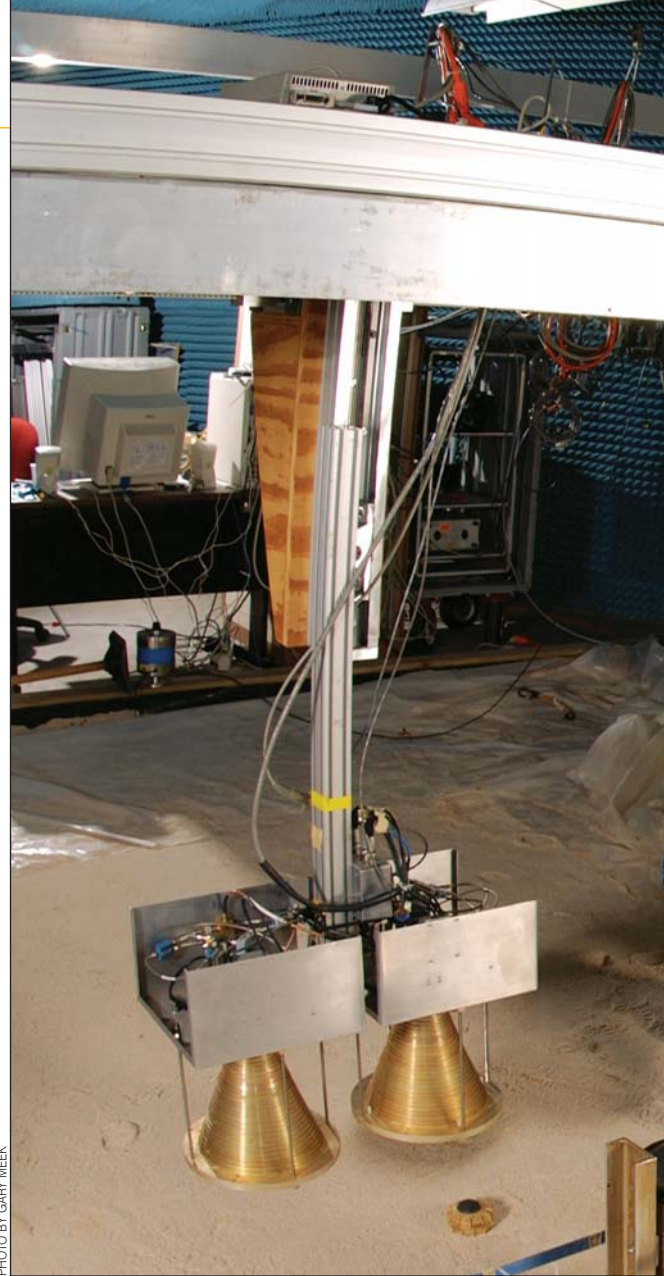


PHOTO BY GARY MEEK

Electrical and Computer Engineering (ECE) and principal investigator on the project.

Sponsored by the U.S. Office of Naval Research, the U.S. Army Research Office and the U.S. Army Night Vision & Electronic Sensors Systems Directorate, the mine-detection project involves researchers from various departments at Georgia Tech. This multidisciplinary team started work in 1997 with computer modeling and lab experiments. Field testing began in fall 2001, and during the past two years, the researchers have conducted tests at six sites.

Testing at Government Facilities

In November 2002, the researchers traveled to a government testing facility in a temperate climate where they detected six different anti-tank and anti-personnel mines. “Our results there were comparable to what we saw in the lab, which was very significant. That was a big hurdle for us,” Scott says.

Field tests at government facilities give the



researchers greater credibility because conditions are more realistic, and they can compare results to data from other research teams. What's more, the mines at government test sites have been buried for several years, which complicates detection.

"It's much easier to detect a mine that's been buried recently because you've disturbed the soil," says George McCall, a senior research engineer in the Georgia Tech Research Institute's Electro-Optics, Environment and Materials Laboratory. "After a land mine has been in the ground for a while, the soil becomes weathered and more compact. This makes it harder to find, so it's a better test for our detection system."

In February 2003, the researchers traveled to another government testing facility where the ground was frozen. This test broadened the scope of environmental conditions under which the mine-detection system had been used.

Testing in a variety of sites is important because different environmental conditions affect how far

and how fast seismic waves travel through the earth. That, in turn, affects how waves interact with buried mines and what kind of signal processing is required to image the mines.

First Step Toward Commercialization

The field tests have also given the researchers a chance to develop another aspect of the seismic mine detector — an audio representation of buried mines.

"When the system passes over a mine, you hear a resonance that's easy to distinguish from the incident signal — it's a hollow sound like what you hear when you tap on a wall to find a stud," Scott explains, adding that the operator would listen to this resonance via a headset, or the unit would have a speaker. "In some cases, this audio representation was clearer than the visual representation."

Because of this discovery, Georgia Tech will collaborate with CyTerra Corp. to evaluate the feasibility of incorporating the Georgia Tech seismic

Waymond R. Scott Jr., a professor in Georgia Tech's School of Electrical and Computer Engineering, is the principal investigator on the landmines detection project.



U.S. ARMY PHOTO BY PENTY OFFICER, 1ST CLASS RONALD L. HERPHER

A soldier excavates an area to stack anti-tank and anti-personnel land mines for destruction at a demolition site. The mines on the U.S. side of the fence separating Communist Cuba and the U.S. Naval Base at Guantanamo Bay were removed and replaced by motion and sound sensors to detect intruders.

Georgia Tech's seismic wave landmine detection system presents potential advantages over existing electromagnetic-wave techniques used in metal detectors and ground-penetrating radars, researchers say.

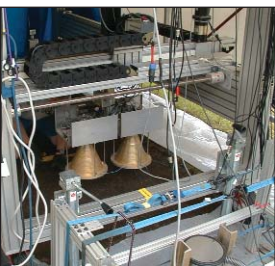


PHOTO BY GARY MEEK

sensor into a handheld mine detector the company is producing for the U.S. Army.

CyTerra's current handheld system combines a metal detector with ground-penetrating radar. "Integrating the capability that Georgia Tech has developed to acoustically measure vibrations will give us a triple-sensor device that should increase our ability to detect mines and reduce false alarms," says William Steinway, executive vice president of CyTerra Corp. based in Waltham, Mass.

"No single sensor has proven capable of detecting mines well with acceptable false alarms in all environmental conditions," Scott says, noting that what works best in a given situation depends on the type of mine and where it's buried. "A fusion of multiple sensors will most likely be necessary to get good performance in all conditions. Our seismic sensor is ideal to fuse with other types of sensors like GPRs and metal detectors."

Going Faster

In June 2003, researchers conducted their eighth field test, traveling to Skidaway Island, Ga. This was the team's third visit to Skidaway, and data derived from this field test was consistent with earlier measurements — an encouraging result.

Even more important, researchers were able to test techniques for making the mine-detection system faster:

- Shortening the acoustical signal. In laboratory tests, researchers had been using a four-second signal to displace the soil. "If you put more sound into the ground, the sound has more interaction with the mine. Yet you pay a penalty because it takes longer to measure," McCall explains. As field tests began, researchers encountered less background noise than they had in the lab, which enabled them to send a shorter signal. At Skidaway, researchers reduced the acoustical signal to one-sixteenth of a second and were still able to detect mines.

- Continuous scanning. With their current prototype system, researchers send a wave, take a measurement, then move the system 2 centimeters and repeat the process — a laborious task when measuring a square meter. At Skidaway, the researchers attempted to scan continuously, which accelerated the measuring process dramatically (by nearly 25 times) and still yielded good data.

"The positioner we used was never intended to do this, so with different hardware we should be able to get better results," says James S. Martin, a senior research engineer from the School of Mechanical Engineering. "Even so, this was much better than the snail's pace at which we had been working."

Two radar sensors have been used in the current system to demonstrate that interactions between multiple sensors are not problematic. But adding more sensors would make the system faster. "Anytime you increase the number of sensors you're using, you can decrease the measurement time," says Gregg Larson, another School of Mechanical Engineering researcher on the project.

Bottom line, researchers say the time required to measure a square meter can be sliced from several hours to less than a minute. Faster measurements are crucial as the team develops a prototype for more extensive field tests.

"We need to measure larger areas and gather more information about different mines, soil properties and environmental conditions," Scott says, noting that data helps the researchers improve their numerical models and signal-processing algorithms. "Testing in different soil properties is important because the soil's complicated structure makes it too difficult to detect mines. You can't just look up the soil parameters we need in a book," he adds. **RH**

— T. J. Becker

■ Contact Waymond Scott at 404-894-3048 or waymond.scott@ece.gatech.edu; or George McCall at 404-894-0303 or george.mccall@gtri.gatech.edu.