Detecting land mines with sound

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Researchers at MIT's Lincoln Laboratory are developing a highly pinpointed sound beam that can detect buried land mines from a safe distance. The new beam will use sound to seek out land mines like a bat uses sonar to hunt its prey.

The researchers built a prototype detector and tested it at the Cold Regions Research and Engineering Laboratory Army Corps of Engineers land-mine facility in New Hampshire. They were able to detect both metal and plastic mines but said that the system will have to get a major boost in acoustic power before minefield searchers can use it safely.

Robert W. Haupt, a technical staff member at Lincoln Lab, explores innovative ways to find and reduce the large number of land mines abandoned in war-torn countries. An estimated 26,000 people are killed or maimed every year by 60 to 70 million undetected land mines in 70 countries. Those casualties include military troops but most are civilians--half of them children under age 16--who step on uncleared minefields after a war.

Many existing prototype mine detection systems can detect only metal, have limited range or are impractical in the field. "Reliable methods that quickly and accurately locate land mines made of metal and plastic, unexploded ordnance and other mine-like targets are desperately needed," Haupt said.

Haupt and fellow Lincoln Lab staff member Ken Rolt developed a high-powered sound transmitter that looks like a stop sign studded with 35mm film canisters or prescription pill containers. This is called a parametric acoustic array, and Haupt and Rolt have built one of the most powerful ones around.

The array is made up of ceramic transducers--devices that emit a powerful narrow acoustic beam at ultrasonic frequencies. One meter away, the ultrasonic pressure level measures 155 decibels--more acoustic power than a jet engine. Immediately outside the beam, the acoustic intensity dies away to almost nothing.

By a process know as self-demodulation, the air in front of the acoustic beam converts the ultrasound to much lower frequency audible tones that sound like extremely loud tuning forks. Unlike ultrasound, the low-frequency sound can penetrate the ground, causing detectable vibrations in the mine's plungers and membranes.

"The use of ultrasound allows us to make a very narrow and highly directional beam, like a sound flashlight," Haupt said. It would take a huge number of conventional loudspeakers to do the same trick, and they would weigh too much, take up too much space and use too much power to be practical, he said. Plus, they would deafen anyone within earshot. "Using a narrow sound beam, we can put sound just where we want it, and we can minimize sound levels outside the beam to avoid harming the operators or people nearby," he said.

Once the sound beam "hits" buried ordnance, the vibrations from the mine, resonating from the sound waves, push up on the ground and can be measured remotely with a laser system called a Doppler vibrometer. The sound signature of a mine looks like a mountain range of spikes compared with the flat-line response of the rocks and dirt around it.

"It turns out that mines will vibrate quite differently from anything else," Haupt said. "You can determine what types of mines there are--and which countries made them--by their unique signatures."

Haupt also is working with Oral Buyukozturk, professor of civil engineering at MIT, to tailor the system to detect damage in cement bridge piers from as far away as the shore.

A paper on the land-mines work by Haupt and Rolt appeared in a 2005 issue of the MIT Lincoln Laboratory Journal. A second paper by Haupt was published in 2004 by the International Society for Optical Engineering.

Source: MIT