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Gunshot Echoes Used to Map Caves' Interior

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BEFORE the US military killed Osama bin Laden last month, it had spent years pursuing him through the rocky landscape of eastern Afghanistan and neighbouring Pakistan. The Al-Qaida leader repeatedly slipped through the soldiers' grasp, thanks in no small part to the labyrinthine, cave-riddled terrain.

Now, where did I leave my gun? (Image: Stephen Alvarez/NGS)

The decade-long search might have gone a little differently, though, if soldiers had access to a new system that can use sound waves from a gunshot to quickly map unknown caves and tunnels. The portable system, developed by David Bowen and others at Acentech in Cambridge, Massachusetts, consists of two microphones placed at the entrance of a cave or tunnel, which are hooked up to a laptop loaded with software designed to decode acoustic signals.

A gun is fired four or five times, with about 5 seconds between each shot. Fifteen to 20 seconds later the map appears on the laptop's screen, with simple graphs that display the area of the cave at different distances, and written explanations of the data, such as "30 feet ahead is a large opening". A portable subwoofer can be used in place of a firearm as the source of the sound waves.

To infer a cave's geometry, the device listens for subtle changes in the way sound reverberates through the chamber's differently sized nooks and crannies. "Every time there is a sudden change in cross-sectional area, it changes the way sound is reflected," Bowen says.

For example, a roomy cave that suddenly narrows into a cramped channel will only permit high frequencies to pass, says Mike Roan of Virginia Polytechnic Institute and State University in Blacksburg. Most of the low frequencies will rebound towards the cave's entrance and the waiting microphones: the more low frequencies bounce back, the tighter the passageway. The device can also determine whether the sound waves struck a dead end or found an exit at the end of a tunnel.

Bowen, who presented his work at last month's meeting of the Acoustical Society of America in Seattle, explains that having two microphones in two different locations - like two ears - is better than one because they hear different aspects of the same sonic event. The front microphone picks up slightly different details in the sound than the one placed a few feet behind it at the cave's entrance.

So far Bowen and his team have tested the device at a railroad underpass, in a mock network of sewer pipes in Georgia - part of a military training facility - and in several outdoor tunnels and caves in and around Boston. The device has obvious military applications for soldiers, but it could also be helpful to miners, pipeline engineers and archaeologists. Bowen next plans to test a high-powered propane canon as a sound source, to see if a louder noise will allow him to build more detailed maps. ■