Underwater Vision

Miniature imaging sonar technology will aid homeland security missions

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Hand-held Homeland Security Aid

Newer, forward-looking, multibeam imaging sonars essentially create a streaming video of submerged objects, divers, fish and the sea bottom.

- Developed, in part, through contracts with the U.S. Navy, the systems are gaining the attention of the Coast Guard and port authorities.
- Coast Guard field evaluations of the systems performing underwater inspections to find improvised explosive devices were successful.
- Other homeland security uses include port and hull inspections, harbor surveillance and search-and-recovery operations.

A technology breakthrough in a miniature imaging sonar originally developed for the U.S. Navy may now prove useful to the Coast Guard and port authorities. High-definition multibeam imaging sonar capabilities are available for the first time in a line of affordable, compact, low-power commercial products that are proving highly effective in port and hull inspections, harbor surveillance and search-and-recovery operations. The miniature imaging sonar scored high marks in Coast Guard evaluations late last year.

Traditional depth-sounder sonars generate a single sound wave or beam directly below a boat. Multiple single-beam returns from multiple sonar transmissions are then stacked up side by side to create a profile of the bottom of the boat as it passes over. Side-scan sonar also uses multiple transmissions to build an image, but by looking to the side of the boat.

Newer, forward-looking, multibeam imaging sonars generate many narrow beams on each transmission, producing several images per second, creating streaming video of submerged objects, divers, fish and the sea bottom. Compared with its predecessors, however, the commercial-off-the-shelf ProViewer line of miniature imaging sonars are lighter, less expensive and require less power to operate.

Lee Thompson developed the miniaturized multibeam sonar technology while at the University of Washington's Applied Physics Laboratory. The university licensed it for commercial applications in late 2004 to a start-up company in which it is a significant shareholder — BlueView Technologies of Seattle.

BlueView converted the technology into the ProViewer line of products, in large part through significant private-sector investment and a succession of 10 contracts to deliver custom sonar systems. These contracts, awarded over the past two years, came from the Office of Naval Research, the Naval Postgraduate School, and the Program Management Offices for Explosive Ordnance Disposal and Naval Special Warfare under the Program Executive Office for Littoral and Mine Warfare at Naval Sea Systems Command.

"The ability to generate multibeam sonar is not new," said Thompson, BlueView's chief executive officer. "What's really new about what we offer is that we provide multibeam, high-definition sonar in such a small package at such low power. Its flexibility of use opens up a host of new operational capabilities. In addition, our products provide very-high-resolution imagery, with a very good contrast ratio compared to the imagery delivered by conventional sonar systems."

BlueView's ProViewer sonar heads, which can be held in one hand, are one-fifth to one-tenth the size, weight and cost of other multibeam sonars, he said, and require only 10 watts of power. This allows them to be mounted for the first time on small unmanned underwater vehicles (UUVs) and remotely operated vehicles (ROVs) as well as used on diver hand-held systems.

BLUEVIEW TECHNOLOGIES

BlueView Technologies' ProViewer sonar heads are compact and can operate at low power, allowing them to be mounted on small unmanned underwater vehicles and remotely operated vehicles, and used on diver hand-held systems.

The first commercial sonar introduced in 2005 by BlueView was its P450E. It operates at 450 kilohertz to a range of 450 feet, producing up to 10 frames per second with resolution down to two inches. The P450E sonar module measures 9.6 inches tall, 7 inches wide and 4.4 inches long, and weighs 5.7 pounds.

In December 2006, the company introduced its P900E, which operates at a higher frequency — 900 kilohertz — producing up to 10 frames per second with one-inch resolution out to a range of 180 feet. This makes it ideal for close-range identification of submerged objects during hull inspections, while the P450E is designed to help spot objects or divers at longer ranges during wide-area searches.

The cylindrical P900E is 7 inches long and 4 inches in diameter. Both sonars have a 45-by-15-degree field of view and can "see" through murky waters, which often limit the utility of optical video cameras used on ROVs, because they use sound instead of light to create images.

The Coast Guard held field evaluations last November of sensor systems that can be used for underwater inspections to find improvised explosive devices. Simulated improvised explosive devices were placed around pilings, sea walls and on the harbor bottom in St. Petersburg, Fla., to simulate a potential terrorist event at a port.

John Kloske, who ran the evaluations for the Coast Guard as the director of operations for the University of South Florida's Center for Ocean Technology, told *Seapower* that BlueView's P900E successfully detected and inspected the targets with the sonar head mounted both on a patrol vessel and an ROV.

"The nice thing about the P900 was just how easy it was to incorporate it into our shipboard, ROV and Internet-mapping systems," he added.

Industry sources said the Coast Guard conducted the sonar evaluations to assess the sensor capabilities available for a mini-ROV it plans to procure competitively in quantity later this year. The Coast Guard itself would not comment on potential procurements.

Coast Guard spokesman Steve Blando said the service could not comment on the results of its evaluation of sonars, citing national security reasons.

A total of 22 ProViewer units have been purchased to date for use by port authorities or law-enforcement agencies in 11 major U.S. ports, including Los Angeles and Long Beach, Calif.; New York; Boston; Charleston, S.C. and Seattle. For example, in July 2005, the Los Angeles Port Police acquired two patrol boats from Port Orchard, Wash.-based SAFE Boats International fitted with ProViewer sonars.

Capt. Ralph Tracy of the L.A. Port Police said, "We needed a solution that would increase our harbor patrol's ability to proactively protect our seaport's water perimeter. SAFE Boats and BlueView Technologies give us a detection and response advantage. With this combination our team gains agility on the surface and real-time vision underwater."

SAFE Boats' Scott Peterson said his company selected the ProViewer sonar because "it offered a performance advantage over other sonar solutions. With it side-mounted on the boat with a quick-release pole system, boat operators digitally control the sonar from the ProViewer console and can easily maneuver it in and out of the water and access movie-like imagery."

In February 2006, the L.A. Port Police used the ProViewer to rapidly locate and direct divers to the body of a fisherman underwater after other boats and helicopters had searched unsuccessfully for several hours.

BlueView's sonars, which come with a Windows-based software package, work whether in motion or stationary. During operations on patrol vessels, they typically use the quick-release pole mount, in which the P450E or P900E sonar head is affixed to the bottom of a vertical pole attached to the side of the boat near its stern, Thompson said. The pole features a pan-and-tilt mechanism that allows the sonar to be aimed in a particular direction.

The BlueView sonar heads also plug directly into most of the major portable micro-ROVs and larger observation-class ROVs available on the commercial market, such as the VideoRay mini-ROVs produced by VideoRay LLC in Phoenixville, Pa., and acquired for the U.S. Coast Guard's Maritime Safety and Security Teams, and the LBV mini-ROV built by SeaBotix of San Diego.

For example, the VideoRay Pro GTO weighs just 10 pounds, measures 12-by-9-by-9 inches and has a 1,000-foot tether. It features a forward-facing wide-angle color video camera and a rear-facing black-and-white video camera as well as external lights. Either the P450E or the P900E sonar head can be affixed to its belly in seconds. The two sonars are often swapped

out quickly during an operation to gain the benefits of their respective operating frequencies, according to VideoRay literature.

Or the same sonar head can be moved from a pole mount to the micro-ROV. When the camera is unable to see through murky water, the sonar can be used to detect objects at a distance and bring the ROV in close enough that the color camera can be used effectively. These capabilities were demonstrated by BlueView at the annual meeting of the International Association of Airport & Seaport Police in Washington June 6-9.

Naval Sea Systems Command is evaluating the BlueView P450E and P900E sonars installed on a VideoRay Pro GTO ROV for purchase for all of the Navy's dive lockers at its major naval bases. Navy dive teams can use the systems to inspect the hulls of ships when they come into port and when they prepare to deploy. Naval Base Pearl Harbor was the first to use them, and reported to BlueView that its divers could check a hull in one-fifth the time of their traditional method.

The price of the P450E sonar head is currently $21,500, while the P900E costs $24,500. This compares with other larger multibeam imaging sonars that cost hundreds of thousands of dollars, Thompson said.

He said his company can build its multibeam sonars with operating frequencies ranging from 100 kilohertz up to 3 megahertz.

"The technology itself is unique, because we have a very broad frequency range," Thompson said, noting that the base architecture developed for the BlueView sonars makes them readily scalable in frequency. He said BlueView has supplied multibeam sonars to the Navy that operate up to 2.7 megahertz.

Thompson said most of BlueView's 10 Navy contracts have involved supplying custom sonars for various research models of battery-powered UUVs, with the sonars intended for obstacle-avoidance or mine-countermeasure applications. BlueView has supplied four obstacle-avoidance sonars to be fitted on Navy portable 5-foot-long REMUS UUVs, which are built by Hydroid LLC in Pocasset, Mass.

BlueView also has built prototypes of new 3-D sonars for the Navy (the company's commercial sonars currently all are 2-D). These can generate even higher resolution imagery, which is desired for even more effective hull inspections by Navy divers.

During the annual Navy-sponsored AUV Fest June 4-15 in Panama City, Fla., BlueView sonars were used in a number of UUV demonstrations conducted by various teams from industry, Navy labs and academia. For example, a Naval Postgraduate School REMUS used a BlueView N450X and NPS software algorithms for obstacle avoidance, autonomously navigating around a shipwreck in all seven attempts.

STEVE VAN METER

ProViewer sonar heads have been tested in concert with VideoRay portable remotely operated vehicles that have been used by U.S. Coast Guard Maritime Safety and Security Teams for conducting ship hull inspections and other operations.

Douglas Horner, research assistant professor in the Naval Postgraduate School's Mechanical and Aeronautical Engineering department, developed the algorithms.

"BlueView sonars hold great promise for increasing UUV autonomy," he said. "The combination of a high-quality imaging sonar in a small package with low-power requirements makes them appropriate for smaller vehicles. The information that can be retrieved from applying computer vision techniques to the sonar images can be combined with vehicle attitude information to enable the vehicle to navigate more accurately and autonomously react to unanticipated obstacles. This increased 'intelligence' in underwater robotic systems would not be possible without a high-quality forward-looking sonar system."

In other AUV Fest demonstrations, a Transphibian UUV from Nekton Research LLC used a BlueView N900X sonar to image mine targets, and two Nekton Research Ranger UUVs, each fitted with a BlueView N900X, demonstrated automated homing on simulated mine targets. Finally, in a feature-based navigation experiment, two Ranger UUVs equipped with an N900X used Massachusetts Institute of Technology-developed algorithms to automatically detect and track sonar image features in 46 successful data-collection missions. ■