Small AUV with Side-Scan Sonar/PDBS

Bathymetric and Magnetometer Payloads Prove Capable in Littoral Zone

By Garry Kozak, EdgeTech

Surveying in shallow nearshore littoral zones has been problematic, requiring small vessels with shallow drafts. Small vessels are heavily influenced by surface wave conditions, and the collection of side-scan sonar, bathymetry or magnetometer datasets is degraded as wave height increases from vessel heave and surge. Autonomous Underwater Vehicles (AUVs) have the advantage of decoupling the sensors from the surface vessel, resulting in higher quality constant altitude datasets. The introduction of small, low-cost AUVs is attractive; however, it has been challenging to install sonar and magnetometer payloads that could actually fit on the small AUVs and produce the quality of data needed for Navy mine countermeasure (MCM) bottom characterization and mine-like object (MLO) target detection missions. The introduction of the new EdgeTech 2205 combined very high-frequency side-scan sonar with interferometric bathymetry, and Marine Magnetics' Explorer magnetometer has solved the payload size and power restrictions on small AUVs while producing data quality that exceeds all previously available systems. A proof of concept trial to demonstrate new commercial technologies was staged in San Diego during May 2013 under the direction of the Naval Underwater Warfare Center (NUWC), Rhode Island. Water depths in the trial area varied between 10 and 20 m.

AUV and Payloads

The small AUV selected for the trial was an Ocean Server IVER 2. The IVER 2 is one of the smallest and lightest weight AUVs on the market today, making it ideal for hand deployment from small, rigid hull inflatable boats (RHIBs) or direct beach launching. The AUV has a standard depth rating of 100 m with an 8- to 14-hr endurance, depending on battery capacity options selected. The AUV uses Global Positioning System (GPS) for surface navigation. For subsurface navigation, it uses Doppler Velocity Log (DVL) and dead reckoning with compass, depth sensors, and vehicle speed tables. The sonar payload was the newly introduced EdgeTech 2205, which combines side-scan sonar with an interferometric phase differencing bathymetry system (PDBS). The side-scan sonar is a dual simultaneous 600/1600 kHz while the interferometric bathymetry operates at 600 kHz. The 2205 system is state-of-the-art and designed for both low volume and low power, making it ideal for all AUVs right down to the smallest as used during the Navy trial. The sonar system is built with active arrays, significantly cutting down on noise and extending the range performance of the sonar when installed on AUVs. Integrated to the IVER 2 was also an Explorer magnetometer from Marine Magnetics. The mission goal was to collect three fully co-registered datasets of side-scan sonar, bathymetry, and magnetometer together. The magnetometer was streamed a short distance behind the vehicle so that its high sensitivity would not be degraded by the influence of the AUV. Figure 1 shows the complete AUV with installed payloads.

Fig. 1. IVER 2 AUV with EdgeTech 600/1600 kHz side-scan sonar, phase differencing bathymetry system, and an Explorer magnetometer.

Side-scan Sonar and Interferometric Bathymetry Performance

The EdgeTech 2205 side-scan sonar data quality was of very high resolution and fidelity. The active arrays improvement of reducing noise and extending range was clearly evident. Area mapping and target detection were performed using a 75-m range scale (150-m swath). The EdgeTech swath interferometric bathymetric sonar (PDBS) is the only system on the market that produces bathymetry data with no nadir gap. This is significant because it means extra survey lines do not need to be run in order to cover the nadir gap area, thus saving time and survey costs. Figure 2 shows the bathymetry results of the EdgeTech PDBS system nadir advantage compared to another PDBS system and a typical multi-beam bathymetric system used on the trial.

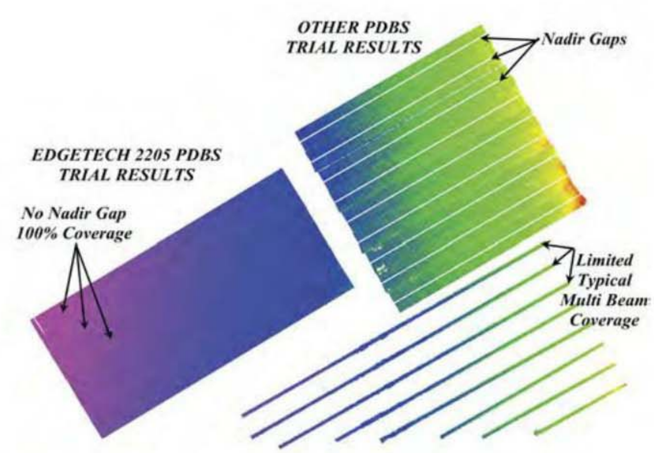

Fig. 2. PDBS system nadir coverage comparison and the poor multi-beam bathymetric coverage in shallow water zones.

The other PDBS system trialed had significant missed data in the nadir zone, and the multi-beam system used during the trial had very narrow swath coverage in the shallow water depths. The 2205 bathymetric data were processed in Hypack® software, and the low-profile anchors and chain as imaged by the side-scan sonar are detected in the high-resolution bathymetric data. Figure 3 shows an example of the side-scan sonar data processed in SonarWiz software to generate a geo-referenced mosaic of the area with three anchors on the seafloor along with the co-registered bathymetric data of the same area. The anchors and chain are clearly seen in both datasets. MLOs were easily detected, and target positions were logged to be used later in very high-resolution classification missions. The high-resolution classification images of MLOs exceeded all expectations participating in the trial. The resulting MLO images are shown in Figure 4.

Fig. 3 Sidescan Sonar Mosaic (left) and Bathymetry (right) of Area with 3 Anchors

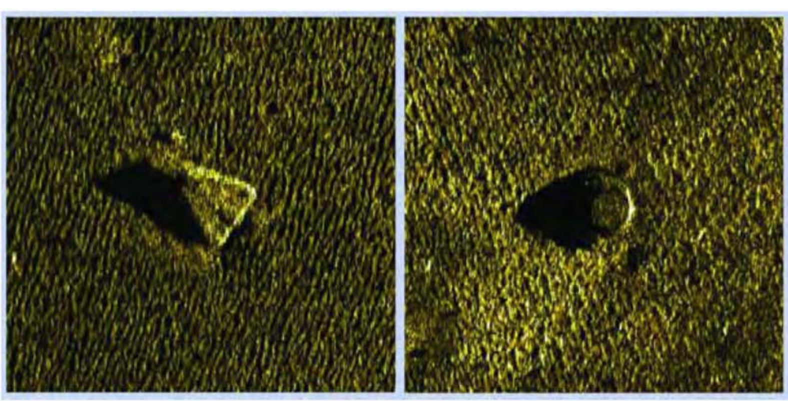

Fig. 4 Side-scan sonar images of two different MLO types, dimensions less than 1 m.

Magnetometer Results

The Marine Magnetics' Explorer magnetometer is a small, lightweight, high-sensitivity unit that should not impact the ability of the small Iver 2 to navigate nor influence vehicle stability. The field results confirmed that the AUV was fully capable of towing the magnetometer sensor and that it had virtually no influence on the AUV performance. The magnetometer data were processed in SonarWiz and put into a contour map. Then, both the side-scan sonar and bathymetry data were added as background layers for visual analysis. The advantage of having the three co-registered datasets merged into one workspace results is easier and more efficient data analysis. Figure 5 shows the contoured processed magnetometer data layered onto the co-registered bathymetric data as well as a color contoured map showing very clearly the three magnetic anomalies resulting from the anchors on the seafloor

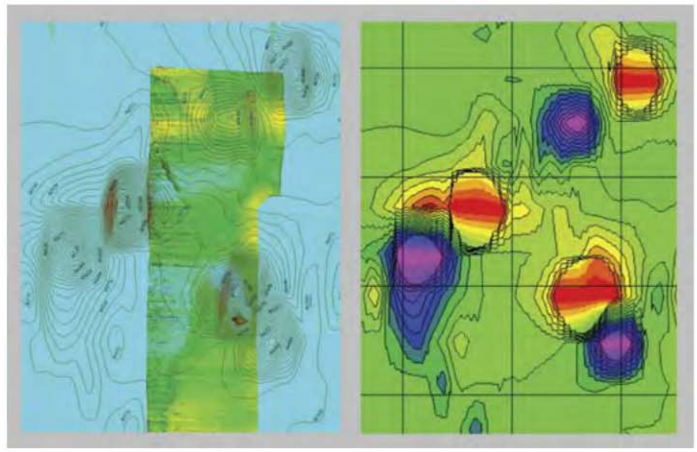

Fig. 5 Magnetometer Contour Data layered on Bathy (left) and Color Magnetometer Contour Map (right) showing the magnetic anomalies from the 3 Anchors.

Target Position CEP

Target position uncertainty was one of the metrics that was of high importance. Targets were selected, and the positions were compiled from several runs and missions to calculate a CEP. The example in Figure 6 shows an average CEP of ±6 m on an MLO.

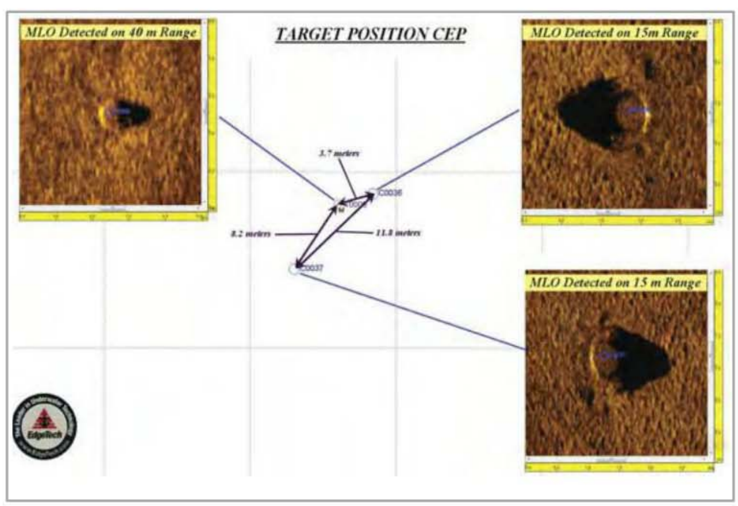

Fig. 6. Target position CEP

Conclusion

The week of trials in San Diego confirmed that small AUVs can be equipped with multiple high-performance sensors and that they are capable of collecting data of very high quality in the littoral arena. The ability to collect three co-registered datasets is a distinct advantage for the mission analyst to better assess bottom conditions and in locating targets of interest. Navies and others who work in shallow coastal waters now have a cost-effective solution that is compact, lightweight, and delivers data quality of the highest order.