Deployment of a Deep Tow Synthetic Aperture Sonar System

PROSAS Surveyor 60 Operates at Longer Ranges, Greater Depths than Similar SAS Systems

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Deepwater exploration and surveying is dominated by specialized equipment and extreme technological challenges. Difficulties with communications, sensor tracking and data monitoring are exacerbated by the physical separation between the sensor, the seabed and the host surveying platform. In recent years, the introduction of AUV technology has seemed to offer the most cost-efficient solution to deepwater surveying. The time required to move from survey line to survey line is short when compared with the turning circles of a ship with a towfish on a long umbilical. Even when considering the need to recover the vehicle every few hours to recharge batteries and upload data, AUVs still win out as a cost-effective technology for deep water.

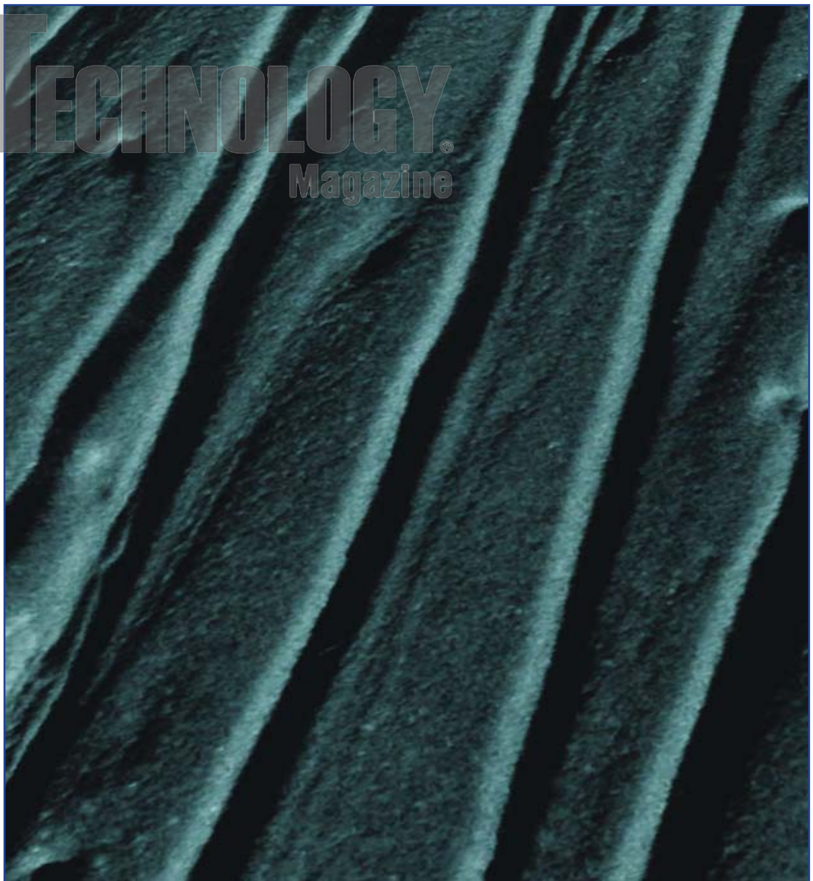
In 2011, a new sensor technology, the PROSAS Surveyor 60 (PS60), was deployed in more than 4,000 meters of water off the U.S. Eastern Seaboard and demonstrated operating at 1,100 meters per side (2,200-meter total swath width). The use of such technology might at least cause a pause for thought before jumping to the conclusion that AUVs are the answer to every surveyor's prayer.

Development and Initial Deployments

The PS60 is a deep tow synthetic aperture and bathymetric imaging system designed by Raytheon Applied Signal Technology Inc. in conjunction with Williamson & Associates (Seattle, Washington) and SL Hydrospheric (Whitefish, Montana). The system provides imagery at resolutions on the order of 10 centimeters by 10 centimeters at ranges of up to 1,500 meters per side.

On this initial deployment, two synthetic aperture sonar (SAS) records were broken. The system was operating at a longer range than any previous SAS imaging system and at a greater depth than any similar system had previously been deployed.

The system can survey 177 square kilometers of seabed in a 24-hour period, operate in water depths of up to 6,000 meters and collect simultaneous side scan, SAS and bathymetric data. Consistently producing high-resolution imagery across wide swaths was the primary goal of the PS60 system.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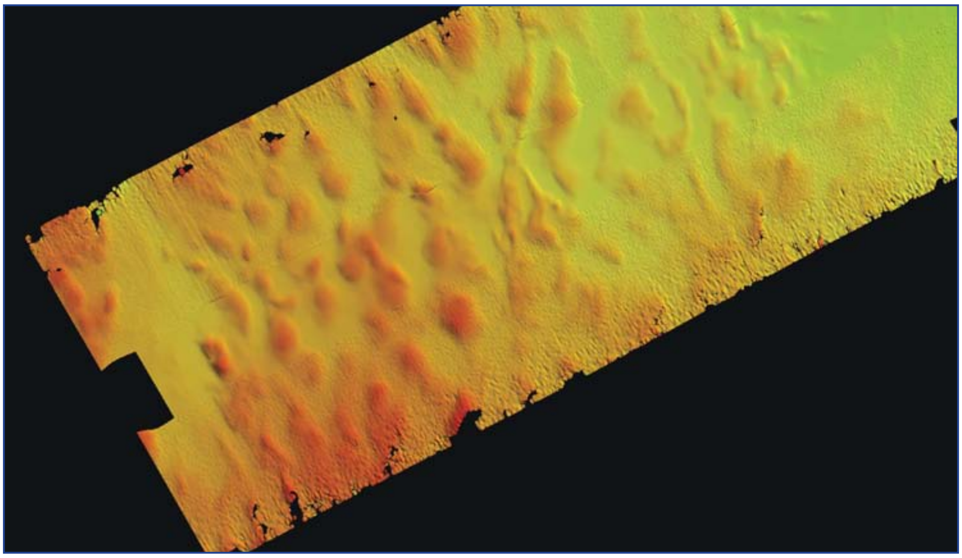
Furrow bedforms, 50 meters apart and 1 meter high, are shown at 4,000 meters' depth. Using data collected by the PROSAS Surveyor 60 deployed off the U.S. East Coast, the SAS imagery is draped over interferometric bathymetry at a 500-meter range.



(Left) Multibeam and interferometric bathymetric data fusion. This bathymetric image was gathered during a survey offshore Australia in approximately 1,400 meters of water with a 1,400-meter swath.

(Below) A sunken Grumman F6F-5 Hellcat found off the Channel Islands in California.

In tests carried out in the Channel Islands off the coast of California, this capability was demonstrated by the discovery of a World War II F6F-5 Hellcat fighter plane, which lies beneath approximately 300 meters of water. In an image was taken at a range of 500 meters, the propeller was clearly visible, as was damage to the plane's fuselage and one of its wings.

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After initial detection, an ROV was sent down with a camera to verify the find. Photographs showing the propeller, damage to the main fuselage just aft of the cockpit and to the port wing confirmed the initial analysis of the SAS data.

For scale, the propeller blade on an F6F-5 Hellcat is 1.3 meters in length, clearly demonstrating the resolution of the system at a 500-meter range.

Bathymetry Processing

Part of the PS60 system's viability as a survey tool is the ability to process interferometric bathymetry concurrently with SAS images. The long-range capabilities of the system mean that the vehicle is flying much higher than a traditional side scan sonar system, sometimes at excess of 100 meters above the seafloor. The result of this is that the swath footprint of the conventional interferometer is much more affected by the motion of the vehicle than when at a lower altitude.

To compensate for the motion of the vehicle, the bathymetric beams from the system are steered to correct for both yaw and pitch. Three parallel compensated beams of bathymetric data are gathered for each ping that is put in the water, resulting in an even, high-density bathymetric sample set. The

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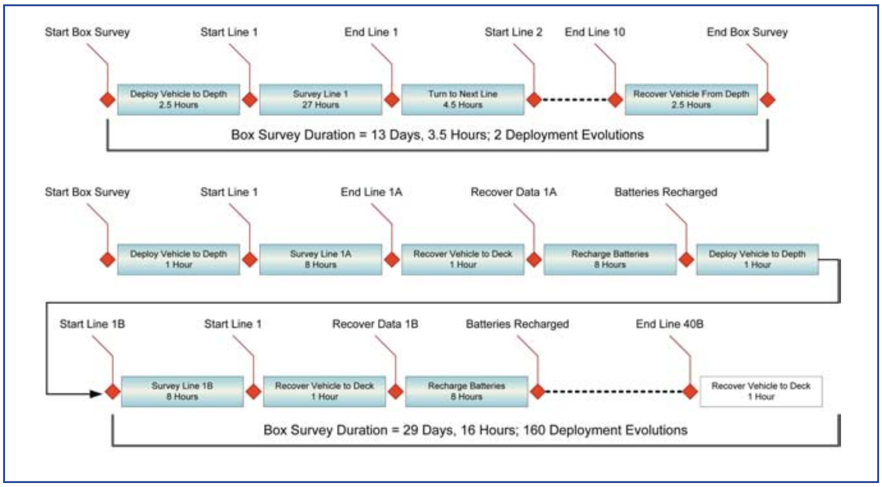
(Left) The PROSAS Surveyor 60 deep tow vehicle.

(Below) Comparative time lines for a survey with an AUV and towed system.



high data densities provided by the interferometric system operating at long ranges were initially a challenge for bathymetric data processors, which are much more familiar with multibeam data sets.

Tools have been developed for the decimation and filtering of interferometric data to allow efficient processing and production of bathymetric chart products and third-party processors, including CARIS (Fredericton, Canada), QPS BV's QINSy (Zeist, Netherlands) and HYPACK Inc. (Middletown, Connecticut) who have all written drivers to accept and process data from the PS60 system.

Following on from the testing in the Atlantic, the system was configured with an R2Sonic LLC (Santa Barbara, California) multibeam echosounder as a gap-filling bathymetry sensor and a sub-bottom profiler. Tests carried out in Puget Sound in 2011 demonstrated the use of the bathymetry system and the ability to combine both multibeam and interferometric data sets into a consistent surface.

The PS60 system has been deployed with this configuration by Neptune Marine Services Ltd. (Perth, Australia) as a part of gas pipeline prelay survey in the Equus gas field development, 180 kilometers north of Exmouth, Australia, on the country's North West Shelf.

The data from the interferometer and from the multibeam were combined into a single surface, demonstrating consistency between the two sensors even though the sampling density of the interferometer is much higher than that of the multibeam.

Advantages of Towed Systems

An argument for the success of a survey tool such as the PS60 cannot be made on its technical abilities alone; it must also win jobs in the competitive survey marketplace.

With that in mind, the PS60 was designed to be more time efficient underwater and to produce data that require less processing to construct the final product.

Economics. Consider a hypothetical survey area of 20 kilometers by 100 kilometers. At a tow speed of 2 knots, the PS60 covers a swath of 2,200 meters in a single pass. Allowing for 200 meters of overlap at the edge of swath, a line spacing of 2 kilometers will provide full seabed coverage.

Operating in 2,000 meters of water, the towfish will take approximately 2.5 hours to deploy and recover, and four hours to carry out a turn at the end of a line. Given the size of the survey area, the PS60 could complete the survey within 13 days.

Using an AUV, the line spacing would be reduced to around 500 meters, although the resolution of the side scan imagery at this range would be inferior to that of an SAS system at 1,000 meters. The AUV would take around an hour to deploy from the surface to an operational depth of 2,000

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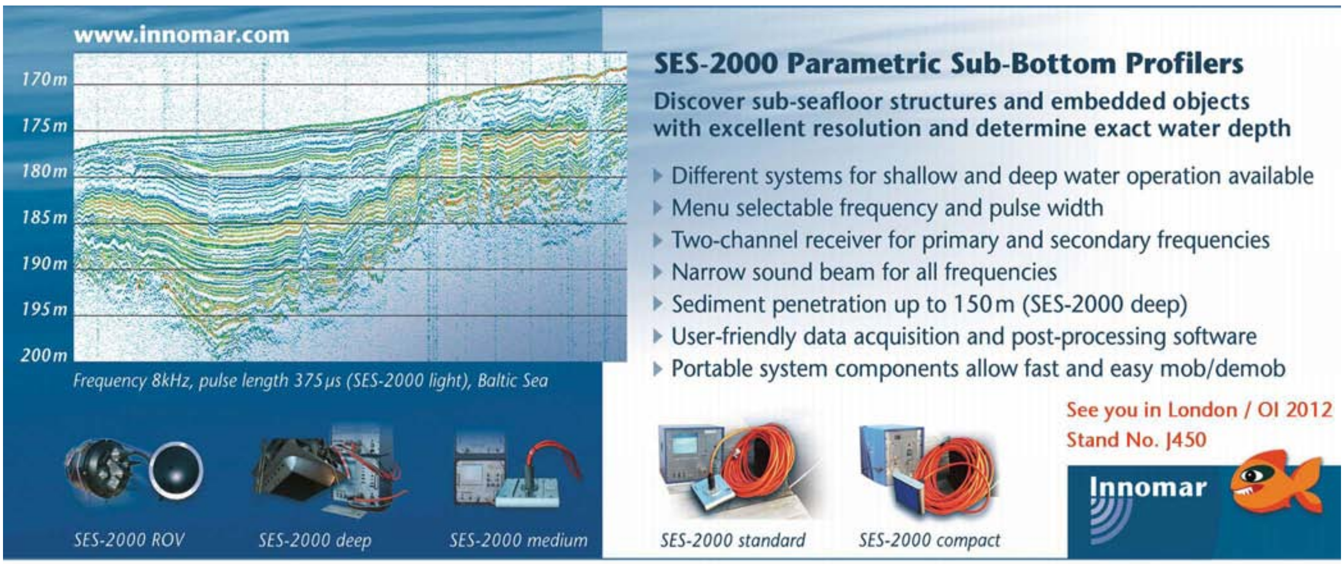

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meters and the same to recover to the surface.

At a speed of 3.5 knots, depending on the battery configuration of the AUV, at least two deployments would be necessary per 100 kilometers of survey line (this assumes a 10-hour operational battery life at 3.5 knots). At the end of each deployment, the AUV would need to be recharged, taking eight hours. It would take the AUV 29 days to complete the same survey box.

It can be seen that the time taken to survey the box using an AUV is dominated by the time taken to recover, refuel/recharge and redeploy the vehicle. Vehicle technology is improving, and the use of alternative power sources, such as replaceable batteries or fuel cell technology, and advances in vehicle efficiency will certainly affect the model, but the difference in time lines is so marked that even with these modifications, a deep tow system is likely to compete well with AUV technology in a large area search scenario.

Safety. There is one final difference between AUV and towed operations that should not be overlooked. During the course of the survey example described above, the AUV needed 160 deployment or recovery operations while the towed system needed only two such exercises. Even though launch and recovery systems are improving, any time equipment needs to be taken out of the water is a time of increased risk to both equipment and personnel. It is also an activity that is dependent on weather and sea state, which are beyond the control of the program.

The ability of a towed system, such as the PS60, to remain on station for long periods without needing to refuel and where the operator can choose to wait for a break in inclement weather, offers a significant advantage. With an AUV, after the battery is empty, there is no choice but to recover the vehicle, whatever the weather. Given the large number of deployments and recoveries required to keep an AUV serviced, reliability of equipment and durability to withstand the rigors of manual handling are a significant safety concern.

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Conclusions

The evolution of AUV technology has rightly been a major cause for excitement in the survey industry and its application to the deepwater marketplace is clearly important. However, the development of long-range, deep tow systems with improved resolution afforded by synthetic aperture processing offer an alternative technology that can, in some circumstances, offer significant cost savings over the use of an AUV equipped with a shorter range sensor suite.

The PS60's modular SAS design has meant that the technology is largely independent of the platform itself and could just as well be fitted to a large-diameter AUV. However, the need for a long physical array to support long-range SAS at manageable speeds will mean a very long AUV would be required. Perhaps such a system will offer even greater efficiency advantages to the surveyor of tomorrow. ■

Andy Wilby is chief engineer for sensor systems at Raytheon Applied Signal Technology and lives in Redondo Beach, California. Educated in the U.K., he has worked in the sonar industry for 25 years, delivering sensors and sensor processing systems across the full spectrum of the underwater acoustic domain.