â€˜Outside the Boxâ€™: Survey by AUV

Autonomous Underwater Vehicles (AUVs) have shown that they can perform the same work as a deep tow system and more quickly. Based on experience with the EchoRanger, they are just starting to show us what else they can do.

The geologic environment of the continental shelf has proven to be significantly more severe and complex than the generally featureless shallow water shelf. As the industry progressed into these deeper water depths, the need for improved information to identify faults, steep slopes, gas seeps and other geologic features could not be addressed by simply extending shallow-water survey techniques.

First Deep Tow

In the mid-1980s the first â€˜deep towâ€™ system was introduced into the Gulf of Mexico. This system consisted of bathymetric, side-scan, and sub-bottom profiler sensors mounted in a tethered, buoyant tow-body. The tether was attached to a heavy chain which when dragged along the sea bottom allowed the suspended vehicle to collect high-quality data at a constant 30-metre altitude, regardless of water depth or seafloor complexity. Real-time data was transmitted up the tether to the tow vessel.
Precise geodetic positioning of the deep tow was provided with an acoustic transponder array on the seafloor. Alternatively, a second vessel, a â€˜chase boatâ€™, would follow the vehicle and track it using a hull-mounted Ultra-Short-Baseline (USBL) to supply positioning. USBL positioning was often used for route surveys due to the time and cost of setting up the seafloor acoustic array.

Deeper Water, Longer Cable

While upgrades were made to the sensors over the years, the basic operational (towing) technique remained the same for nearly two decades. During this time the industry was working its way into increasingly deeper water. Since the cable length required for deep tow is two to three times the water depth, the amount of cable in the water also increased, at times to almost ten thousand metres. The drag on such a cable length required tow speeds of 2 knots or less. In addition, with the vehicle as much as 5km behind the tow vessel the time spent in line turns could exceed four hours per turn and often exceeded the time spent collecting data.

Losing the Tether

The recent introduction of AUV technology in the commercial survey sector has facilitated a significant advance in deepwater survey operations. Boeing, Fugro GeoServices, and Oceaneering Intl. jointly began planning a deep-water survey AUV in early 2001. The team combined their knowledge and experience in autonomous underwater vehicles, geophysical surveying and marine underwater equipment operations to develop the EchoRanger. The goal of the EchoRanger was to provide a more efficient means of acquiring bathymetric and near seafloor geophysical data in up to 3,000m of water while incorporating reliable and proven geophysical sensor packages. The sensor package used in the EchoRanger is essentially the same as the â€˜deep towâ€™: side-scan sonar, a sub-bottom profiler and a multi-beam bathymetry system.

The EchoRanger

Becoming fully operational in April 2003, the EchoRanger quickly confirmed improved operational efficiency. A deep tow survey job that would have required five to seven days on location was easily completed in less than two days with the AUV. As previously noted, deep tow survey costs are dominated by time spent on line and in line-turns. The AUV cuts the time needed to run lines by increasing survey speed to 4 knots and by cutting turn time to mere minutes, resulting in significant improvements in survey efficiency.

Inertial Navigation

The key to AUV technology is the inertial navigation system. With deep tow, the navigation choices are either a seafloor-based long baseline acoustic array that provides excellent positioning at the expense of extensive deployment and calibration time, or a USBL system which requires a chase boat and suffers degrading positioning accuracy with increasing water depth. The AUV inertial navigation system allows the vehicle to autonomously maintain a true course and speed with only occasional updates from an external navigation reference. This external reference may be a USBL with position updates sent by acoustic telemetry to the AUV. The external reference may also come from one or more seafloor-based transponders, which provides very high relative accuracy and which has allowed the AUV to complete entire surveys completely autonomously from the support vessel.

Beyond Deep Tow

A surprising by-product of completing the work faster is that getting to and from location can now represent as much as 50% of the vessel time for a job. A second, less surprising, by-product is that more work is required to keep an AUV gainfully employed. Since an AUV completes work twice as fast as the deep tow it needs twice as much work to maintain the same level of utilisation. If all we do is to replace conventional deep tow work, there will be a lot of AUV idle time.

Designer Surveys

The combination of a sophisticated inertial navigation system capable of true autonomous operation and the freedom from a tow cable, it becomes obvious that AUVs are capable of doing surveys that would be cost prohibitive or just plain impossible for a deep tow system. The success stories that follow highlight these new survey capabilities possible with the EchoRanger. Each began with a problem to be solved and required a client and survey team open to new ideas and concepts and willingness to survey â€˜outside the boxâ€™.

Circular Survey

One of the first surveys completed by the Echo Ranger was for a client who required investigation of sea-floor hazards for a potential anchor pattern. In particular, this client wanted sufficient seafloor data to allow designers to rotate the anchor pattern as needed, whilst controlling survey costs. The solution was to survey a series of concentric circles about the drilling platforms future location to provide a circular survey swath centred on the planned anchor radius. Previous technology would have provided a large rectangular grid pattern survey, much of the data being irrelevant to the clientâ€™s needs.

Within the Anchor Pattern

Another application required the collection of foundation data for the design of anchor piles for a production structure. Complicating the situation was an anchored semi-submersible, on-station and drilling. The drill â€˜semiâ€™ had a spread mooring pattern encompassing the anchor pile locations to be surveyed and was to remain on location for several months. An innovative survey approach was needed to work inside the anchor pattern and beneath the mooring leg catenaries. Detailed information and computer models of the anchor cable catenaries were prepared and used with the EchoRanger AUV mission simulation software to assure adequate clearance while working beneath the anchor pattern. The survey was completed under the catenaries without impact upon drilling operations.

Micro 3-D Survey

Another survey example showcased the precise navigation and tight efficient turns obtainable with the Echo Ranger. The survey started with the requirement to place anchor piles in a complex area with a heavily faulted seafloor. In order to avoid these faults very precise mapping was required. The solution was a â€˜Micro 3-Dâ€™ survey. A series of very closely spaced lines was surveyed (nominally 10m). The sub-bottom profiler data was then processed as if it were a 3D seismic data volume and the results were used along with geotechnical engineering analyses to safely and accurately determine suitable suction pile locations. The sub-bottom survey, which consisted of 51 survey lines across an 875 x 440m area, was completed in less than nine hours.

Outside the Box

For deep water AUVs to be a commercial success as well as a technical one, we need to continue looking beyond simply replacing the deep tow survey box. The examples discussed here: surveying in circles, surveying within anchor patterns and the micro 3-D survey are just the beginning.