LBL Underwater Positioning

Long baseline (LBL) positioning has many applications both commercially and in research, from surveying a ship hull to positioning offshore platforms in deeper waters. The technique consistently provides accuracies in the order of decimetres over large areas, independent of depth. Recent advances include the integration with other acoustic techniques or with inertial navigation systems for greater levels of accuracy.

Since navigation by GPS isbased on electromagnetic signals that cannot penetrate water, subsea positioning requires a different approach. As sounds waves travel through the sea they alternately compress and decompress the water molecules; these compressions/decompressions are detected as changes in pressure. By deploying beacons on the sea floor to receive and transmit acoustic signals, distances (range) can be measured. Ocean acoustics is therefore the method by which positioning is determined under water.

LBL Technique

Long baseline (LBL) acoustic underwater positioning involves the use of an array of transponder beacons located on the seabed and an acoustic transducer that can be fixed to a vessel. The distances between the beacons within the calibrated network are referred to as the baselines, in the order of 50–2000 metres. The transducer – which can also be located on a towfish, remotely operated vehicle (ROV) or autonomous underwater vehicle (AUV) – transmits an acoustic signal, which is detected by the transponder. The transponder transmits a response, and the time between transmission of the first signal and reception of the second allows the distance between the transducer and transponder to be calculated.
The basic technique with an additional transducer located on an ROV consists of a cable joining the ROV and ship, through which power and control commands are relayed. The minimum number of seabed beacons required for unambiguous navigation is three. A fourth will provide a degree of redundancy and quality check, however.

Advantages of Deployment

As demonstrated from a wide range of applications, LBL positioning is designed to provide uniformly high levels of accuracy over a wide area. LBL accuracy is independent of depth. The method is suitable for a large range of depths from the order of metres (e.g. hull inspections) to kilometres (e.g. offshore industry). Modern systems offer good repeatability, high reliability and are extremely robust. Although the ultra-short baseline (USBL) system is simpler, as there is no need to deploy and calibrate an array of transponders, system error increases with range. In the case of USBL positioning, an array of transducers is fixed to a vessel and the position of the beacon is determined from both range and angle measurements. Depending on the application and accuracy required, therefore, a combination of LBL and USBL techniques may be utilised.

Applications

Oil and Gas - LBL technology is the favoured method for positioning multiple offshore targets due to the large depths involved. The position of the platform or subsea vessel can be measured to an accuracy of decimetres within depths of up to 7,000 metres. LBL is a valued technique for construction, survey and metrology within the offshore industry.

Piloted Submersible/AUV/ROV Tracking in Ocean Science

Piloted submersibles enable areas well below safe diving levels to be explored, yielding new information about marine species or inspecting coral reefs. The DeepWorker submersible depicted in Figure 3 explored deep cold seeps in the Gulf of Mexico in 2005. The positioning information from the LBL array is a valuable supplement to the biological data.
Salvage and Archaeology - It is possible to survey wreckage at high accuracy and speed, compared with previous techniques involving tape measures.

Ship Hull Investigations

Dry docking a vessel to check for damage or corrosion is expensive and time-consuming. However, the system DiveBase ShipHull by Desert Star is designed for inspection of the hull in shallow water. Four baseline stations are submerged about 2 metres below the ship, providing complete coverage of the hull.

Overcoming Limitations

Acoustic positioning systems are dependent on knowledge of the speed of sound within water, usually in the order of 1,500m/s. However, sound waves may not follow a straight path in conditions of strong currents, may experience deflection at thermoclines and can be affected by noise generated by the vessel and/or other objects.
Advances in techniques mean that these factors can be accounted for, however. Many models now support multiple frequency bands (EHF, MF and LF). Targets can be located using all frequencies simultaneously, reducing the risks of noise pollution.
Locating the transducer on an AUV is another method of eliminating acoustic interference between communications and the positioning system. For example, the LinkQuest transceiver/modem installed on an AUV is capable of receiving messages and commands from the

ship and broadcasting messages to other AUVs.

Advances in Techniques

Improvements in Equipment - A drawback of LBL positioning is considered to be the setting up and calibration of the array of transponders on the seabed. However, improvements in equipment and software mean that these tasks can be executed at greater speed, saving costs. The core software of many systems is also designed to be fully adaptable for use with more than one type of system, as described below. Integration with other Acoustic Methods - As mentioned previously, the position error of the USBL system increases with range to the transponder. Combining a USBL and LBL system improves position accuracy. For example, Sonardyne's Data Fusion Engine can function as both a USBL transceiver for the accurate positioning of transponders up to 7,000 metres, as well as a multi-user LBL transceiver.

Multi-user LBL

Multi-user functionality is available on many models, such as Kongsberg's HiPAP (high-precision acoustic positioning) system. The location of several vessels and ROVs can be calculated using the same transponder array. Benefits include high position accuracy, high position update rate (every 2 seconds), avoidance of transponder frequency collisions and the use of standard LBL transponders in multi-user LBL mode.

Integration with INS

An inertial navigation system (INS) computes the position, velocity and attitude (roll, pitch and heading) using the output of three accelerometers and three gyros. The three accelerometers are mounted perpendicular to each other, each measuring acceleration relative to inertial space. The three gyros are mounted in the same way, each measuring the angular rate relative to inertial space.?Acoustic and INS systems complement each other perfectly since relatively high noise but no drift are characteristics of the former, while very low noise but relatively large drift are properties of the latter. Kongsberg's HAIN (hydroacoustic aided inertial navigation) system, for example, improves accuracy by a factor of 2–3. HAIN LBL has a standard deviation of ±0.5 metres and an update rate of 2.5 seconds.

Future developments

Wideband signal technology

Over just a few recent years, wideband technology has been adopted for both LBL and USBL operations. By separating the signals in both frequency and code, the number of unique signals that can be supported within a defined bandwidth is greatly increased. Truly independent multi-user capability through the availability of hundreds of operating channels has been made available. The benefits of such a system are apparent in deep-water field developments involving drilling and installation activities, where a multi-user multi-vessel LBL positioning system may be in operation. Transponder commands transmitted using wideband telemetry, addressed to individual units directly, are far more secure than previously used tone bursts, which use a common command frequency. The increased ranging precision of wideband also means that it is possible to obtain positional accuracy at MF as well as EHF, optimising engineering solutions.

Applications

Examples of application areas likely to expand in the near future include environmental surveying, and search and rescue. For example, instead of using satellite imagery to map the extent of an oil spill, an ROV with an integrated positioning system could determine damage to the sea floor. Similar technology could be used to survey larger areas for longer periods compared with professional divers in the case of missing divers.

Concluding Remarks

LBL positioning has many applications in offshore technology. The specifications of the many different systems commercially available provide an indication of the intended application. The most important properties are operating frequency (which specifies range, i.e. depth) and accuracy. The higher the operating frequency, the lower the range at which the system can function. For example, the HF and LF LBL systems offered by LinkQuest operate at around 26–45kHz and 8–13kHz, respectively, and have a range of up to 1,000 and 7,000 metres, respectively. If the project calls for the shallow-water surveying of wreckage or a damaged hull, then transponder dimension would be a priority. The battery life of a baseline station may also be a consideration, as a short battery life would not be very cost-effective in the case of extended or repeated surveying. Finally, positioning accuracy can be greatly enhanced by integration either with other acoustic methods or with, for example, an inertial navigation system.

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