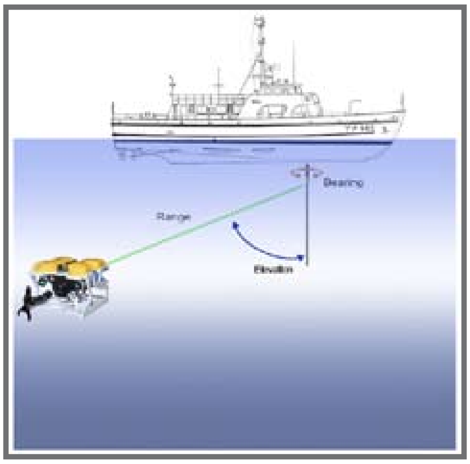
Extending the navigation of ROV to SHALLOW WATERS

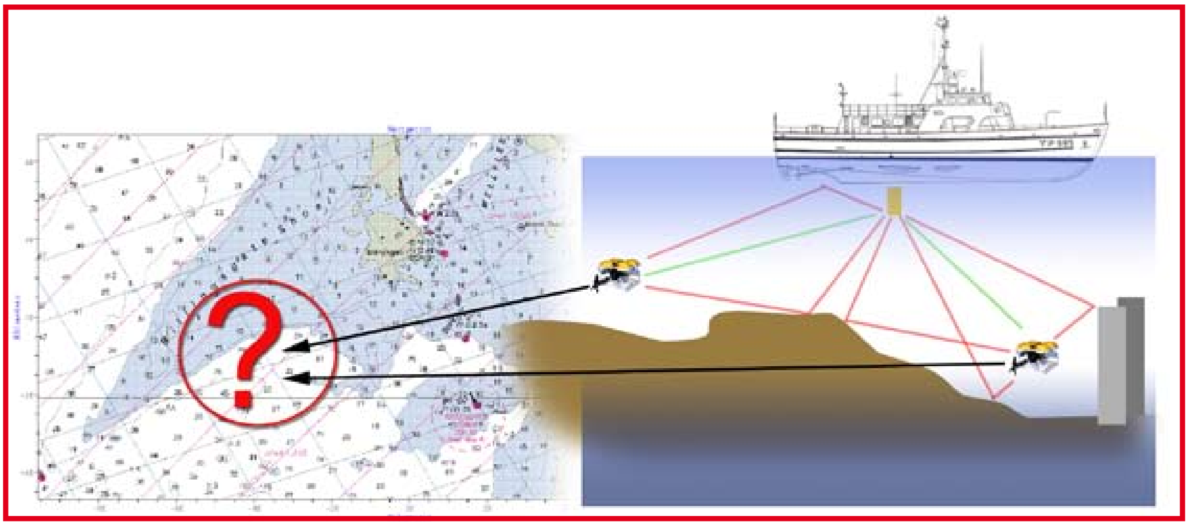
Problems affecting acoustic navigation systems

The navigation of Remotely Operated underwater Vehicles (ROV) is usually achieved by mean of external acoustic references of known location. The most common examples of such techniques are the Ultra Short Baseline (USBL) and the Long Base Line (LBL) systems. USBL systems determine the position of the ROV by transmitting an acoustic signal and evaluating direction of arrival and delay of the response emitted by a transponder installed onboard the ROV. In LBL systems, conversely, transponders are mounted in buoys of known location and the position of the underwater vehicle is determined by triangulating the responses coming form the buoys.

The above described underwater navigation systems are able to provide the position of the ROV with a good accuracy, typically with an error between 5 and 1% of the distance between the ROV and the acoustic reference being used (mother ship or buoys). This accuracy, however, is provided only under the assumption that the two ways acoustic signal (interrogation and response) is able to follow reasonably straight and unobstructed paths. When this assumption is no longer valid, the acoustic navigation system receives acoustic responses coming from wrong directions and ranges: under these conditions the position of the ROV, if still provided, is no longer reliable.



The following figure displays two typical situations leading to unacceptable navigation errors: operation of ROV in shallow waters or in presence of underwater constructions (such as within the pylons of an oil platform). In both cases the ROV still has an unobstructed view of the mother ship's USBL transducer but both the incoming and the returning signals are affected by multi-path effects. Such effects, generated by acoustic waves propagating isotropically and bouncing on obstacles, make impossible to determine the real position of the ROV with adequate accuracy.
Typically, USBL systems begin to experience reduced position accuracy starting from water depths of 30/40 meters. Beyond that limit, as the water depth decreases, the accuracy becomes quickly worse.

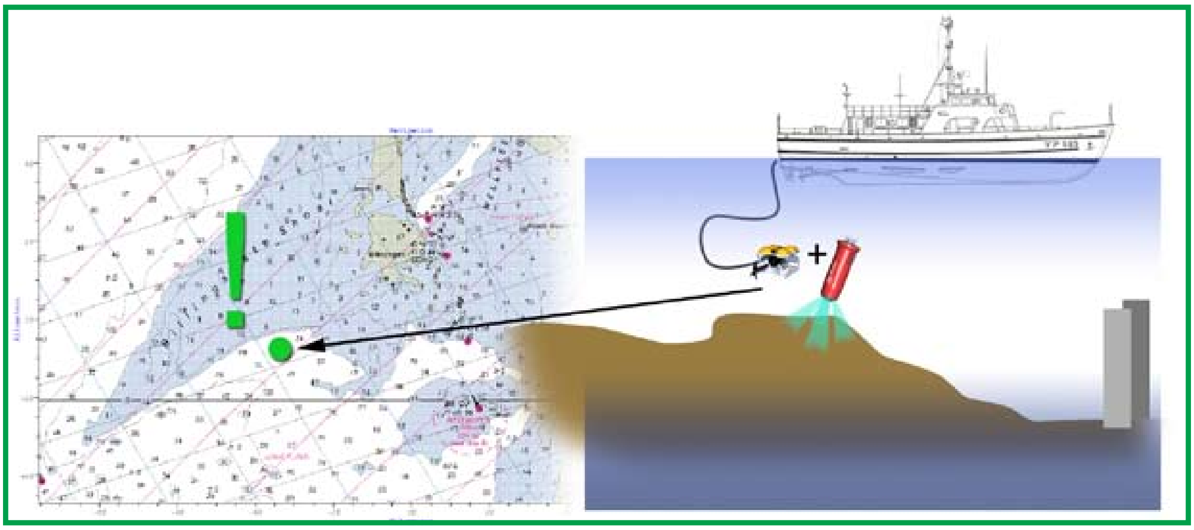


ROV & DIVER TRACKER

ROV navigation with the ROV TRACKER

The ROV TRACKER is an underwater navigation system fully independent from any external acoustic reference. As such, it is not affected by the multi-path effects described above and it provides the ROV pilot with accurate navigation even in the most acoustically hostile environments.
The ROV TRACKER consists of a single, self enclosed sensors' pod that is mounted onboard the ROV and communicates its position to the pilot through the umbilical cable.
While still at the surface, the TRACKER automatically acquires its initial position with a GPS fix and, once submerged, it computes the position of the ROV by measuring its movements away from the known initial position.

Alternatively to the built-in GPS, the initial position fix can be manually entered by the ROV pilot. Either ways, after submersion, the movements of ROV are measured with appropriate sensors for depth, heading & attitude and with a Doppler Velocity Log (DVL).

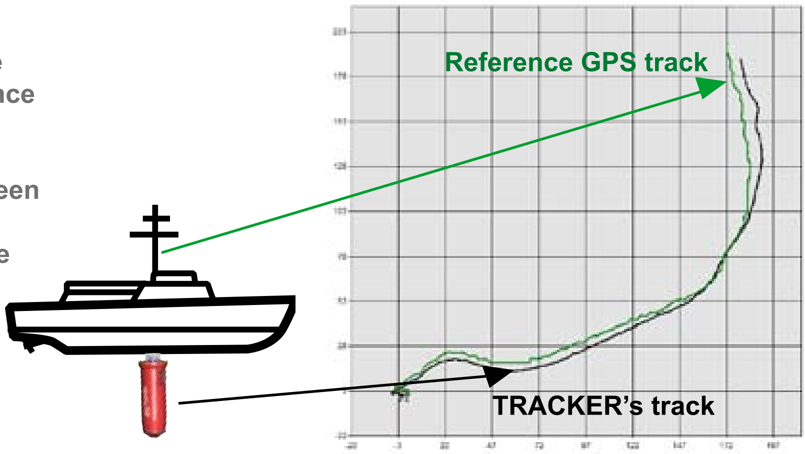


The DVL is a sonar system that detects the bottom and provides accurate velocity information referenced to the sea floor. The DVL of the ROV TRACKER is able to track the bottom from an altitude up to 70 meters down to 25 centimeters, thus allowing accurate underwater navigation even into extremely shallow waters. In addition, for altitudes above 70 meters, the TRACKER still provides ROV position data but, in this case, the movements are measured with reference to a wide layer of water and, hence, are potentially affected by the error due to the velocity of water currents. This error, however, is measured and cancelled out if a valid bottom track was obtained before flying over the deeper waters.

The TRACKER is therefore suitable for nearly any kind of underwater navigation but it is certainly optimal for shallow waters, construction areas or even for driving the ROV inside water ducts or any other underwater location otherwise inaccessible to acoustic positioning systems. As long as a minimal water altitude is available, the TRACKER provides an accurate and reliable ROV navigation.

Accuracy of the ROV TRACKER

The accuracy of the position data provided by the ROV TRACKER is equal to ± 1% of the total distance run from the initial deployment position (GPS or operator fix).
The following figure provides a comparison between the GPS track of a boat (green line) and the track obtained with the TRACKER submerged under the hull of the same boat.



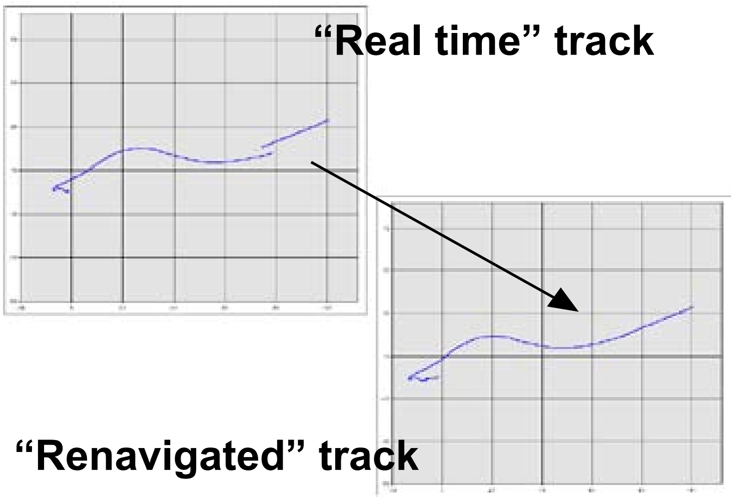
Further improving position accuracy: built in tools

Since the navigation performed by the TRACKER is independent from external references and based on the navigation data previously computed (dead reckoning), the navigation error increase with the total distance run (e.g.: ± 1 meter after 100 m. of distance run, ± 10 m. after 1000 m., etc.). When the error becomes unacceptable, however, the ROV operator can easily bring back the error to zero with either one of the two following actions:

- Driving the ROV at the surface: as the ROV surfaces, the TRACKER automatically acquires a new GPS fix and instantly resets its position; at this point the operator can have the ROV dive and resume its underwater mission. This procedure is particularly suited for operations in shallow waters.

- Entering the position of a point of known location that the ROV sees with its sensors (such as a pre-surveyed target or a charted wreck): also in this case the ROV, while still underwater, resets its position to the newer location and the underwater mission continues with no break.

Whether action is performed to reset the position of the TRACKER, a discontinuity in the recorded track is introduced. A typical example of discontinuity is displayed in the first part of the following figure. As shown in the second part of figure, however, the software of the TRACKER provides the ability of "renavigating" the track. The available "renavigation" tools allow all track's fixes to be repositioned so as to take into account all the information that became available after the occurrence of any given position fix. The result is an accuracy of the track that is virtually unlimited.



This tool, besides providing the possibility of using the TRACKER for mapping purposes, allows the TRACKER to identify with extreme accuracy underwater references that can be later used for resetting the position of the TRACKER while still underwater. In this way, even in case of extended operations in an area where no underwater reference was previously known, very few rises to the surface are really required in order to always keep the precision of navigation within the limits required by the mission.

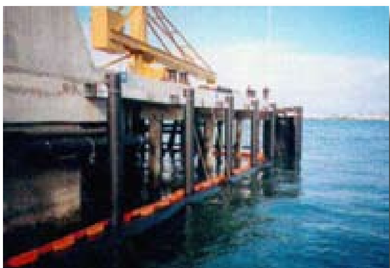
Further improving position accuracy: integration with USBL

Sometimes the pace of underwater works does not allow the execution of the above described position update process but, still, highly accurate ROV positioning information are required. This is the case, for example, of touch down monitoring operations during the lay down of pipes or cables from barges in shallow waters.
In order to support this kind of requirements, the TRACKER also supports a fully automated position update process that doesn't involve any intervention of the operator. If its surface based computer is connected to a USBL system, indeed, the TRACKER still performs its autonomous DVL aided dead reckoning navigation, but it automatically corrects its long term positioning error.
To this extent, the TRACKER evaluates the USBL fixes that become available from time to time, discards those that are obviously wrong and properly processes the ones eligible for providing a long term position update.
The result is a smooth navigation, accurate both in the short and the long terms and still unaffected by acoustic multi-path problems.

Applications

With either the manual or the automated methods available to keep the accuracy of navigation always within any desired limit, an ROV equipped with the TRACKER can be employed equally well from any kind of platform: from super-equipped oil & gas barges to any kind of small boat or even from piers with no need for any additional navigation equipment.
The intrinsic independence of the TRACKER from any external acoustic reference and its flexibility of use make it the ideal navigation system for a wide variety of applications in shallow waters, high density construction areas or any kind of restricted underwater locations. Such applications include:

- Touchdown monitoring of pipes or cables in shallow waters
- Inspection of conduits in shallow waters
- Inspection of platform pylons and moorings
- Inspection of ship's keels
- Monitoring of harbors' environment and structures
- Works in underwater manufacture areas
- Search operations in estuaries, lakes or rivers
- Inspection inside sewage conduits
- ROV operations in pools, dams, water tanks, etc.



Studio Ing. Banfi SAS
Operations:
Viale Giulio Cesare 118/B
00192 Roma, ITALY
Tel. (+39) 349.53.35.920
Tel./fax. (+39) 06.37.22.929
mauriziobanfi@tiscali.it
www.rovtracker.com