AUV X Deep Towed systems: a comparison of survey systems

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Abstract

The Marine Installation and Projects sector (PIM) of Petrobras has conducted an ultra-deep water site survey at the Campos Basin using an AUV system belonging to C&C Technologies. For such a kind of projects Petrobras has a vessel fully mobilized with a deep-towed geophysical systems, with operating depth conditions ranging from 20 to 3000 meters.

Autonomous Underwater Vehicles (AUV) is the top technology for site surveys and this project was primarily contracted in order to perform a survey at a very obstructed area at the Marlim field, where deep-towed system operations are very complicated and to check the data quality of the system compared to the Petrobras system.
The results showed that the AUV system is a very reliable system regarding to operations on production areas where platforms with its mooring lines and anchors, and pipeline infrastructure make common deep-towed operations difficult or quite impossible. Moreover the positioning quality of the AUV system is considerably better compared to deep-towed system. The quality of the side-scan-sonar as well as the sub-bottom data are quite similar for both systems. Multi-beam bathymetric data are a valuable tool for engineering projects and if compared to the Petrobras single-beam system considerably enhanced the final results of the survey. Survey time is also reduced with the AUV system but its higher operational costs must be taken into account before a final decision.

Introduction

The main objectives of site surveys are to identify potential man-made and natural hazards or engineering constraints and to determine seafloor and sub-bottom conditions within the survey areas before exploration and/or production facilities are installed. To survey a certain area, several geophysical equipments, from very specific to more general purpose ones, have been developed by different companies all over the world. Basically two kinds of technology are currently in use: the deep-towed system and the Autonomous Underwater Vehicle (AUV).

The AUV technology is a self-propelled vehicle controlled by an on-board computer connected with the main ship by acoustic modem. Inside the AUV a powerfull acquisition system is composed by a side scan sonar, swath bathymetry and a single bottom profiler. To do this job the HUGIN 3000 system provided swath bathymetric mapping (Simrad EM2000), high-resolution sonar imagery (120 / 410 kHz Chirp frequency system) and Chirp sub-bottom profiler (2 / 8 kHz). The positioning of the AUV is basically made using a Simrad HiPAP USBL system coupled to a DGPS on board the support vessel. The HUGIN 3000 also has a motion reference unit and single-beam altimeter (among other sensors) that gives information for the correction of bathymetric data and vehicle position. The AUV HUGIN 3000 system was provided by C&C Technologies and operations were conducted during 11 days in December 2002 using the M/V Rig Supporter as a support vessel for field operations.

On the other hand Petrobras has under permanent contract a 56-meter in length opportunity vessel fully mobilized with geophysical systems able to operate up to 3000 meters water depth, namely a single-beam Simrad EA 500 echo-sounder, a deep-towed Datasonics SIS 3000 side-scan sonar and a sub-bottom system. Positioning is made using an ORE Trackpoint II USBL system coupled to a DGPS. A 3D motion sensor model TSS 333 is installed on the vessel allowing heave, pitch and roll compensation of bathymetric data.

Petrobras has re-surveyed with its own system four AUV survey lines in water depths averaging 2800 meters and has compared the quality of positioning and geophysical data. This was made in order to check the cost-benefit relationship of the two survey techniques.

Results

By comparing both data it was possible to achieve the following conclusions:

1. *Positioning:*

   To determine the position of deep-towed equipments in deep water areas remains a challenge. USBL systems work very well to determine the position of equipments below the ship. To properly work with a towed system at 3000 meters water depth one need approximately 6000 meters of towing cable to be deployed resulting in layback distances of approximately 4500 meters. That distance does not allow USBL system to precisely calculate the position of the towed vehicle. The layback may be reduced by controlling the vessel's velocity, either by choosing the better course for survey lines according to the

direction of sea currents or by simply reducing velocity to as low as possible. Since most survey vessels do not have dynamic positioning the first choice is preferably used. This choice however considerably increase survey time. Alternative solutions like using a second vessel or deploying a LBL array are too expensive and/or time consuming increasing final survey costs.

The HUGIN 3000 system use a similar USBL system for positioning but since it has no tow cable the ship can navigate right above the vehicle optimizing the conditions to correctly determine the coordinates of the AUV. Also, the AUV can survey with speeds up to 4 knots, compared with 1,5 – 2 knots for a deep-towed equipment and line turns are made in minutes while an average of 2 hours is needed with a deep-towed system (for 6000 meter tow cable). Both survey velocity and line turn time heavily contributes to reduce survey time. However, the underwater endurance of the AUV is about 40 hours so that the vehicle has to be brought on board to replace batteries and make the upload of the recorded data. This operation may take up to 5 hours and the launching and recovery of the vehicle is restricted by weather conditions. On the other hand, with the exception of very rough weather or electronic problems a deep-towed system can stay in the water as much time as needed to end the survey.

2. *Bathymetry:*

The multi-beam bathymetry has provided much more reliable informations about the seafloor morphology. The ability of keeping a fixed low altitude above seafloor basically neutralizing the effects of ships motion (pitch, roll and heave) as well as the effects of termocline or fish schools at the water column, as well as allowing the operation within higher frequency ranges contributes to a better resolution of the bathymetric information. A hull-mounted echo-sounder despite some clear advantages has basically the disadvantage of having to use different frequencies according to water depth. This may input some differences while surveying pipeline routes with large bathymetric ranges. Moreover, working in deep water areas may be critical with bad weather conditions due the survey vessel movements degrading signal's directivity generating "spikes" or lost of data.

3. *Sonar imagery:*

Sonographic images obtained by the AUV system are very similar to the images acquired by deep-towed system. The main difference in quality between the two are basically due to the possibility of maintaining the AUV vehicle at a constant altitude above the seafloor so that image resolution is not affected by differences in altitude. The main advantage of the SIS 3000 system is that one can choose different swath ranges while the AUV has a swath range restricted to swath of the bathymetric system (7.4 times the altitude) which, in order to have a complete coverage of the area, basically determines the line spacing of the survey program.

Acquisition, processing and visualization softwares were the same for both methods so that errors due to processing techniques are not considered.

4. *Seismic:*

The high-resolution 3,5 kHz seismic data, like the sonar images, from both systems are very similar in quality and resolution. Every information regarding geological structures at and/or below seafloor are clearly seen in both records. Variations in altitude of the seismic transducer are not critical for the final quality of the data.

5. *Costs:*

Survey costs are basically a function of survey time. This, in turn, is determined by the line spacing and survey velocity. As higher the level of detail needed for the project the smaller the swath range for the side-scan-sonar and, consequently, the closer are the line surveys. That means that more lines have to be navigated in order to completely cover the survey area.

The area surveyed by the AUV system was approximately 35.6 km² and the survey grid was composed of 24 NE-SW tracklines, 3 NW-SE tie-lines and 9 additional lines for filling survey coverage gaps, comprising a total of approximately 275 km of survey. Sixty-six hours were necessary to accomplish the survey resulting in an average survey velocity of was 2.2 knots.

The average daily survey production rate for the ship working for Petrobras is approximately 60 km per day, resulting in an average survey velocity of 1.3 knots for the same water depth range.

Considering these survey velocities Petrobras would have taken about 114 hours (72% more) to complete the same survey performed with the AUV system. However, the daily operational cost of the AUV system for this project was about 8 times more expensive than the daily operational rate for the Petrobras system. Finally, the overall budget for this specific survey was about 4.6 times more expensive using the AUV system than using Petrobras deep-towed system.

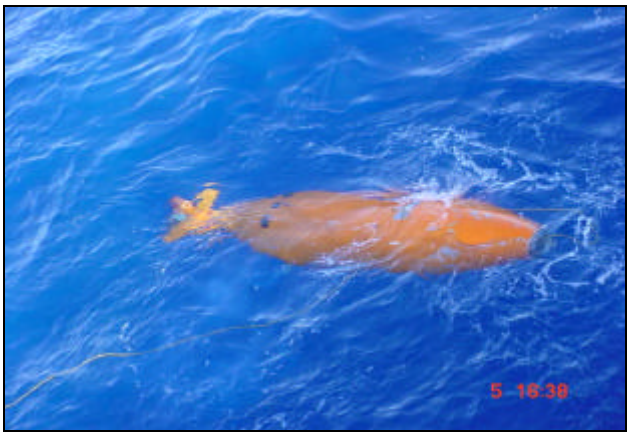
Conclusions

Comparison of the results of the two survey systems have shown that AUV systems are very superior regarding the problem of determining the correct position of deep-towed geophysical equipments. This is also a considerable advantage in areas where production facilities are already installed. The multi-beam bathymetric system within the

AUV also gives more reliable information about seafloor morphology than Petrobras single-beam equipment. Sonar imagery and high-resolution seismic data are quite equivalent in quality and processing capacities since they are acquired in the same format and with the same softwares.

Despite the considerably higher operational costs of the AUV system it is important to say that for larger survey areas (longer survey period) daily prices could be reduced.

If survey time is critical for the project choosing the AUV system would be a better choice.



AUV from C&C Technologies

Deep-towed system from Petrobras