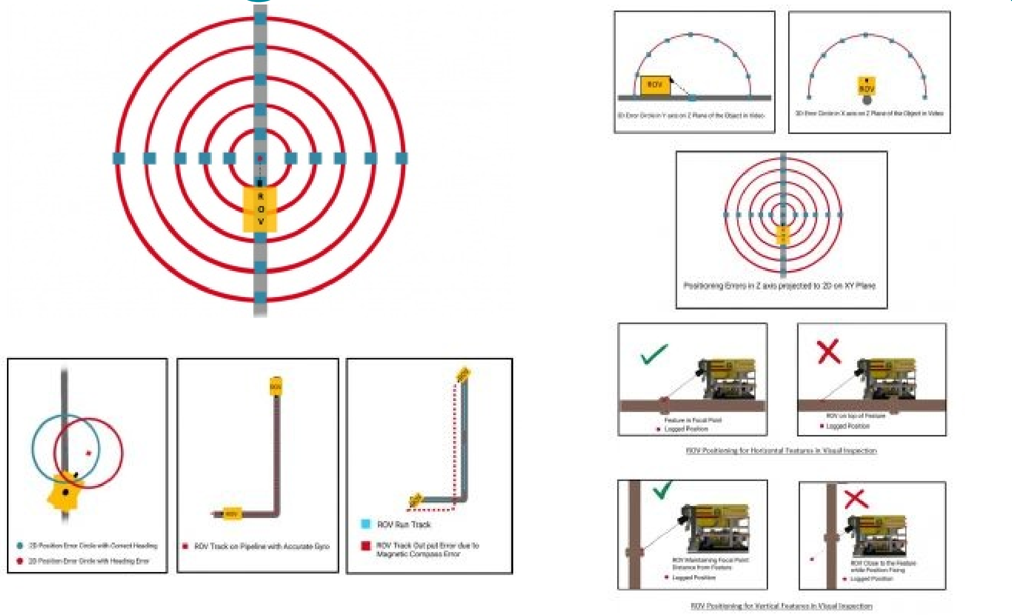
A GUIDE FOR UNDERWATER VIDEO SURVEY PROFESSIONALS

Minimizing positional errors during ROV visual inspection



Underwater positioning with USBL can be accurate in favourable environments. However, it’s often perceived as less precise than land-based positioning. Maintaining high accuracy during mobilization and calibration is crucial. If sub-optimal accuracy is detected, cross-checking the setup for errors is recommended. This article is a guide for survey professionals and video inspection coordinators involved in underwater video surveys, particularly using ROVs.

During video surveys, the end product is always the video containing audio descriptions of the subjects of the survey and a video overlay depicting the time, position and other required data. The descriptions shown in the video overlay must be aligned with the subject in the video at the accuracy level required for the project. To achieve this, we need to understand all of the factors that determine the accuracy of the positioning systems used in any given survey. These must be understood not only by the surveyor, but by the entire crew, to ensure precise positioning.

Two types of positioning systems are used in such surveys:

Surface positioning

This covers GPS, DGPS, DGNSS or any other satellite-based positioning system. The most accurate of these will provide an accuracy of about 1–3mm on a fixed platform and less than 0.5m in surveyable sea conditions. However, the precision maintained in the offset measurement in the vertical and horizontal axes of the vessel can play a major role in achieving the above-mentioned accuracy for calculated positions used during the survey.

Underwater positioning

This covers systems such as USBL and LBL. These are not independent positioning systems; rather, they derive positions based on the range and bearings from or to a known position provided by the surface positioning system. Any error in the surface positioning system or the measurement of the offsets will therefore directly affect the positioning accuracy of the underwater positioning system. Underwater positioning systems are reliable to sub-metre accuracy on static deployment, and the accuracy in normal working environments with accepted levels of disturbance is less than 2m. Any error in the surface positioning system or the measured offsets will increase the error to above 2m, which will be unacceptable in most cases.

Accuracy enhancement in 2D projections

Although positioning errors are in three dimensions, any error in the vertical axis will be less than the error in the horizontal axis when translated to the two-dimensional planes of the survey (Fig. 1). To ensure better accuracy, we must consider the z-axis values accurately while carrying out the offset measurements to achieve a precise position in acceptable roll, pitch and heave conditions.

Figure 1: Translational dilution of errors in 3D plane on projection to 2D plane.

Role of gyro in maintaining survey accuracy

There was a time when we relied on magnetic compasses for angular measurements. However, technology has given us the luxury of precise angular measurements or headings with a very high update rate. In hydrographic surveys worldwide and onboard vessels, magnetic compasses have been replaced by gyros and many have migrated to state-of-the-art optical gyros with integrated heave compensators.

Since we rely on calculated positions with reference to a precise positioning system during surveys, the heading accuracy and the update rate play a crucial role in the total accuracy of the survey. Even if we use a calibration-free gyro, it is important to carry out gyro verification accurately to remove any mounting errors during the mobilization of equipment for the project. ROVs generally use magnetic compasses/fluxgates since they are only needed to navigate the ROV. However, if the ROV is used for video inspection purposes where calculated positions are used for camera offsets/the focal point, more accurate heading information is a must. Fluxgates are prone to erratic readings in areas with high magnetic flux, adversely affecting the accuracy of the survey. During pipeline inspections, the ROV might skip tracing the pipeline lay and length accurately due to positioning errors, especially when surveying sharp turns or spools in the pipeline. The only way to overcome this is to ensure that the ROV is fitted with a gyro (Fig. 2).

Figure 2: Position errors due to compass heading error.

Calibration and verification

When a vessel is mobilized for visual inspection, special attention must be paid to calibration and verification of the equipment and data exchange. This must be done after full mobilization of the vessel. The calibration and verification must be carried out in the most suitable sea conditions available and as accurately as possible. Any anomaly found in the process must be addressed, and not ignored because the error is within project specifications. The reason for this is that precision during calibration will provide ample error allowance during the actual survey and therefore ultimately save time and resources. Any change in the configuration or equipment after calibration and verification is not advisable. However, if it cannot be avoided, verification should be repeated after any change.

Surveyors around the world use different methods for gyro calibration. If the vessel is in dry dock, sunshot or angular measurements using a total station can be adapted for gyro calibration, while the taped offset method provides the best results for small vessels alongside berths. Sunshot or total station methods are prone to errors in this scenario.

During any surveys involving offset logging, special attention must be paid while measuring the offsets and feeding the values into the system. A gyro error of two degrees will cause an error of 1.5m over a 50m-long baseline, while an offset measurement error of 1m in the same scenario will increase the error to 2.5m or more.

ROV mobilization for visual inspection

During visual inspection using an ROV, the utmost attention should be paid to mobilizing the ROV since the end result of the survey is the video collected using the ROV. Visual inspection carried out by a diver, with positions acquired by placing the equipment/USBL beacon on top of the feature in the video, provides the most accurate position, which is seen in the video as a video overlay. However, an ROV cannot achieve that kind of accuracy due to accessibility constraints during the survey.

The ROV is mounted with a USBL beacon, but pilots cannot always position this beacon exactly on top of the feature. To overcome this, an offset position is created for the ROV beacon that provides the position of a point slightly ahead of the ROV. This point is usually made to align with the focal point of the centre camera at the normal tilt angle used during the survey. As a result, the position received during the survey will be of the object that falls in the centre of the centre camera video output. This provides a much higher precision than an ROV sitting on top of the feature, assuming that this is even possible.

Figure 3: ROV positioning for horizontal (above) and vertical features (below) in visual inspection.

In this set-up, the ROV crew must ensure that all the position fixes acquired with the centre camera have the same pan and tilt as during the offset measurements, to ensure the accuracy of the focal point position (Fig. 3). The accuracy of the gyro and the offset measurements of ROV nodes are equally crucial in attaining the best result.

Guidelines for mobilization and calibration for visual inspection

1. Rig up the equipment following project requirements
2. Carry out offset measurement precisely in 3D
3. Carry out gyro calibration and feed the accepted corrections into the survey system
4. Carry out ROV gyro comparison with survey gyro and apply corrections if necessary
5. Carry out DGNSS verification and node verification
6. Collect SVP data and update the SV profile in the USBL system
7. Perform static node verification for USBL using beacons
8. Carry out transit checks to verify surface positioning system accuracy
9. Carry out USBL box-in and spin checks and apply corrections to the USBL system
10. Carry out four beacon fixes around a known object 90 degrees apart and verify the accuracy
11. Compare the position of the known object on the centre of the GVI main screen with the overlay display

These procedures ensure the most reliable data acquisition, and any error occurring due to non-compliance may be regarded as a manual/human error since these can be corrected by adhering to the procedure described above. Other errors due to factors that cannot be corrected will determine the actual accuracy of the survey. If the result of these procedures is an accuracy that meets the industry standard, the survey can begin. Above all, it takes good team work and understanding to produce the best results during visual inspection involving ROVs.