SHORTEN THE DISTANCE BETWEEN PLUP/PLDN POSITION AND EXISTING CABLE/PIPELINE

Kyle Li (Huawei Marine Networks)
Email: kyle.likang@huawei.com

Huawei Marine Networks Co., Ltd/ 5/F, MSD-B2 Tower, 62 Second Avenue, TEDA, Tianjin 300457, China

Abstract: According to the normal practice, we design plough up (PLUP) and plough down (PLDN) position 500m from existing in service fibre optic cable/power cable/pipeline in cable burial area, which is normally in water depth less than 1000m. According to ICPC recommendation 'ICPC 02 Route Report Recommendation_02_Iss_11', 2.8 Burial Procedures (i) [..] In some circumstances it may be acceptable to reduce this clearance, following discussions with the Maintenance Authority of the crossed cable and the agreement of all parties involved in the installation process […].
This article discusses technically, what is the shortest safe limitation distance from PLUP/PLDN position to existing cable/pipeline. On one hand, accuracy of survey equipment such as DGPS, Gyro, motion sensor, magnetometer, USBL will affect the accuracy of positioning existing cable/pipeline; On the other hand, accuracy of equipment on cable installation vessel such as DGPS, Gyro, motion sensor, USBL will heavily affect the accuracy of positioning plough/ROV. Only after we have fully understand of these two scenarios we can get the conclusion of this safe limitation distance correctly.

1. INTRODUCTION

According to the normal practice, we design plough up (PLUP) and plough down (PLDN) position 500m from existing in service fibre optic cable/power cable/pipeline in cable burial area (normally in water depth less than 1000m), then we will use post lay inspection and burial (PLIB) method by ROV to inspect and bury the cable around 1km between PLUP and PLDN position.

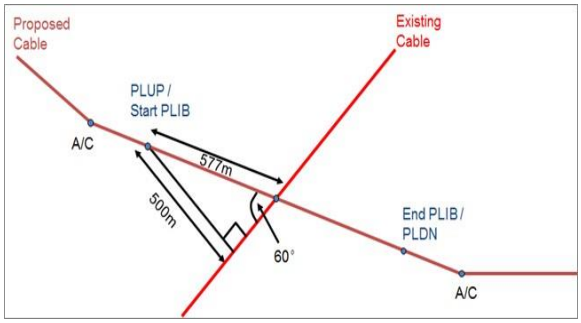

Figure 1: Cable Crossing at 60°

Comparing with plough burial, PLIB takes longer time (thus much more expensive) and can only achieve target burial depth in ideal seabed conditions. It has economic benefits to reduce PLIB and increase plough burial distance at cable installation stage, which is also much safer for the new cable system.

Technically, if we plan to PULP/PLDN at a closer location with existing cable/pipeline, first of all we have to successfully locate it at marine survey stage, then locate the plough successfully when we bury the cable. If these two positions can be located exactly enough, theoretically plough can be pulled up suddenly before it touches the existing cable/pipeline (Of course cable installer and cable owner won't agree to do so). To have those exact locations we have to take fully consideration of all these factors: errors exists when we locate existing cable/pipeline at marine survey stage, errors also exists when we locate plough position, at last a

buffer zone should be given to PLUP and PLDN operation. (Which is very important in deep water area)

In the following, we start to discuss the positioning errors at survey and installation stage.

2. ACCURACY OF POSITIONING EXISTING CABLES/PIPELINES AT SURVEY STAGE

A magnetometer towed close to the seabed is frequently used to find buried cables and pipelines. Accuracy of cables/pipeline positions depends on two factors: USBL accuracy to locate magnetometer's absolute position and magnetometer accuracy to locate the relative position of existing cables/pipelines.

Before marine survey starts, USBL calibration will be carried out. According to XXX project Sonardyne Ranger USBL calibration result, the beacon is in water depth 112m, 98.2% beacon positions by USBL were within 1.9m radius, around 1.66% of water depth. The absolute positioning accuracy is mainly affected by these factors: Surface positioning (GPS), Vessel attitude measurements, Sound velocity measurements, and USBL transceiver performance. Above all of these factors, sound velocity measurements takes the decisive role, which is around +/-1% under reasonable estimation, GPS (+/-0.5m horizontally), vessel attitude measurement (Heading: +/-0.2°, Roll & Pitch: +/- 0.02°) and USBL transceiver performance (+/-0.4% of the slant range) takes secondary or tertiary role. The reason is although every sound velocity profiler (SVP) measurement can be made very accurately (better than 0.2 m/sec), such operation cannot be conducted continuously along with the underwater positioning and SVP in seawater varies with time and location, intervals between regular measurements will inevitably result in errors. Assuming each sub-system provides measurements independently, the radius of the underwater positioning uncertainty circle can be calculated around 1.1% of slant range (approximately equal to tow cable out). (All of the data above within a 95% confidence interval (+/-(1.96 x Sigma)).

When we use magnetometer to locate existing cables/pipelines, tow fish of magnetometer should be as close as to seabed if safety allows, which helps to detect very small anomaly and also get more accurate positioning. The survey vessel speed should be as low as possible and crossings should be direct, this helps to make the distance smallest between two samplings when magnetometer pass existing cable/pipeline. For example, SeaSPY2 magnetometer sampling range is 4 Hz, if vessel speed is 4 knots, the distance between two samplings is 0.5m. Thus if the magnetic anomaly of existing cable/pipeline can be detected, the accuracy of relative position of existing cable/pipeline with magnetometer is within two times samplings distance (for example, 1m if vessel speed is 4 knots, with 4 Hz sampling range). Absolute location of magnetometer is decided by USBL positioning accuracy, as discussion above this value is around 1.1% of slant range (approximately equal to tow cable out).

3. CABLE/PIPELINE CROSSING PROCEDURE AND ACCURACY OF PLOUGH LOCATION

Generally, when we install submarine cable in burial area, the main installation tool is plough, with ROV as a secondary burial tool. (One function of ROV is to post-lay bury submarine cable in the area where plough burial can't be achieved, or in high risk area such as hard seabed. The other function is to post-lay bury near cable crossing point.)

When we lay a new cable to cross an existing cable/pipeline in burial area, plough is pulled up around 500m from existing cables/pipelines, the cable will then be

surface laid until pass existing cables/pipelines, then lay the plough down 500m after crossed cable and restart plough burial. ROV will go back to post lay inspection and burial the surface lay cable segment at later stage. When PLIB is carried out, three times post lay burial will be carried out along cable, and one time inspection to check if the burial depth is achieved. Of course the small segment at crossing point will be burial to a shallower depth than crossed cable for the safety reason. As the example in introduction, the distance of PLIB (one run) is around 1154m, which is a very time-consuming work. (Post lay burial speed is around 200m/hour if seabed is not very hard)

A magnetometer such as TSS440 on ROV will be used to locate the position of crossed cables/pipelines before post-lay burial operation. Although the absolute accurate position of crossed cables/pipelines will be decided by USBL accuracy to positioning ROV, (For example HiPAP system, which is the widely used USBL under water positioning system on cable installation vessel.) the relative location of ROV and crossed cable/pipeline is very accurate due to TSS440 is fixed on ROV.

With regard to using USBL to positioning underwater plough and ROV, the accuracy is also affected by surface positioning (GPS), vessel attitude measurements, sound velocity measurements, and USBL transceiver performance, as discussed in chapter 2, the radius of the uncertainty circle of USBL which positioning plough is around 1.1% slant range (within a 95% confidence interval) which is approximately equal to plough tow wire distance.

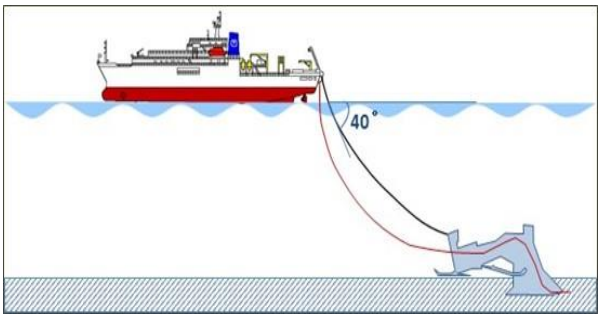

Figure 2: Plough tow wire angle

Comparing with survey equipment, plough tow wire is shorter in same water depth. Generally, if seabed is flat, angle between plough tow wire and sea surface is around 40 degree (angle is bigger in shallower water and smaller in deeper water, will also change in slope area). According to trigonometric, distance of plough tow wire is around 1.5 times water depth (1.5 WD).

4. DISCUSSION AND CONCLUSION

According to ICPC recommendation 'ICPC 02 Route Report Recommendation_02_Iss_11', 2.8 Burial Procedures (i)

> […] In some circumstances it may be acceptable to reduce this clearance, following discussions with the Maintenance Authority of the crossed cable and the agreement of all parties involved in the installation process […].

For example, the distance from plough up/plough down might be reduced for cables on the continental shelf where the route of the cable to be crossed has been positively identified and located during marine survey.'

Technically, if crossed cable is successfully positioned by magnetometer at survey stage, the uncertainty radius is around 1.1%, in shallow water (100m WD) where 300m cable out is assumed, the radius of the uncertainty circle is around 3.5m at survey stage (take DGPS uncertainty into consideration). Meanwhile plough tow wire is around 150m in 100m WD, which is shorter than survey equipment, the radius of

the uncertainty circle is around 2.0m. (All data discussed above within 95% confidence interval (+/- (1.96 x Sigma)). Technically, the offset is less than 10m between two observations on the same existing cable/pipeline (1.1% * (300m+150m) = 4.95m). Even if we add buffer zone to PLUP and PLDN operation with existing cable/pipeline, this distance won't more than 50m. In 100m WD keep PLUP and PLDN position 500m from existing cable/pipeline is far beyond required safety range. If all parties such as crossed cable owner and installer agree, this distance can be reduced largely, as 100m or even 50m. Based on the same assumption, in deep water area (1000m WD) where 3000m cable out is assumed at survey stage, the radius of the uncertainty circle is around 33m. Meanwhile plough tow wire is around 1500m in the same water depth, the radius of the uncertainty circle is around 16.5m. We should have the offset is less than 100m between two observations on the same crossed cable/pipeline (1.1% * (3000m+1500m) = 49.5m). Again if we add some buffer zone to PLUP and PLDN operation with existing cables/pipelines, this distance won't more than 300m. Technically, the 500m distance that PLUP and PLDN from existing cable can also be reduced in burial area less than 1000m WD.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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