INNOVATIVE TECHNOLOGY OF A PRECISE LAYING BY REAL-TIME 3-D SIMULATION SYSTEM

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Abstract: A demand for laying an observation cable system on a planned route position precisely has become higher and higher. JOGMEC, JGI, OCC and KCS carried out a methane hydrate dissociation monitoring survey under the seabed by using DSS (Deep-sea Seismic System) last year. The laying position of the seismometer located in the central of the DSS was required to lay at a distance of 40 m from the methane hydrate production well at the water depth of about 1,000 m. KCS has successfully achieved the DSS laying within the targeted deviation. The paper describes the details of the developed simulation system and successful laying / burial operation.

1. INSTRODUCTION

In recent years the demand for the seabed observation project that utilizes an optical submarine cable technology has been increasing rapidly. This cable system can supply electrical power to submerged observation equipment and provide the seabed observation data of the geology and the stratum in real-time.

JOGMEC (Japan Oil, Gas and Metals National Corporation), JGI (JGI, Inc.), OCC (OCC Corporation) and KCS (Kokusai Cable Ship Co., Ltd.) began the preparation of the methane hydrate dissociation monitoring system in 2009 and carried out the methane hydrate dissociation monitoring system trial and actual survey under the seabed by using the DSS with the submarine cable technology from 2011 through 2012. The purpose was to get the methane hydrate deposit and the sea bottom structure situations before and after the production.

The DSS is the reflection seismic cable system which has 36 seismometers at intervals of 25 m. The configuration of the DSS is shown in Figure 1.

The DSS was laid and buried at the water depth of about 1,000 m. The requirement of the targeted laying position of the central seismometer was to deploy at a distance of 40 m point from the methane hydrate production well. The reason for setting the target position is to secure the quality of data in real-time and avoid an interference around production well.

Furthermore, it was required to bury the seismometers under the sea bottom of about 50 cm in order not to get any influences of current on the data received via the seismometers.

Consequently, very high laying accuracy was required.

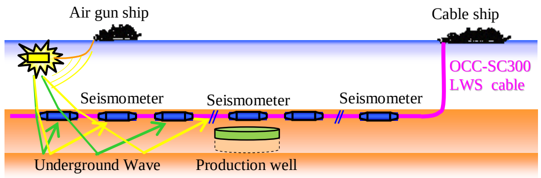


Figure 1: Configuration of the DSS

2. TRIAL RESULT

We conducted the laying trial at the water depth of 1,000 m in November, 2011 to achieve the requirements mentioned above by applying the existing laying and burial techniques. The standard submarine cable system has optical amplifier repeater at intervals of more than 10 km, but the DSS is composed of 36 seismometers at intervals of 25 m. As a result of our trial, we encountered the fact that there are many issues to be solved in order to meet the requirements.

3. TECHNICAL PROBLEMS TO BE SOLVED

The technical problems that must be solved became clearer as follows and the development of the real-time 3-D plotting system technology was required.

(1) Simulation technique

The simulation system was not able to operate properly because the simulation was developed based on the standard submarine cable system model. The result of simulation is shown in Figure 2.

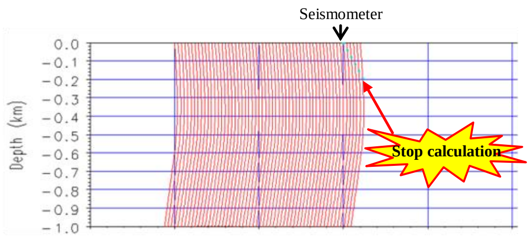


Figure 2: Result of simulation

(2) Transponder (Short Base Line type)

When the transponder was located at the depth of deeper than water 700 m, the transducer attached to the bottom of the ship was not able to receive the data from the transponder continually. The track of transponder data is shown in Figure 3.

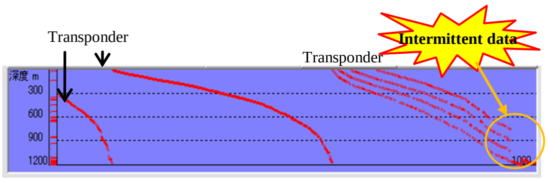


Figure 3: Track of transponder data

(3) Cable handling technique

It was necessary to establish a handling method for laying and recovery of 36 seismometers at intervals of 25 m because the handling facilities of the ship were designed for the standard submarine cable system.

(4) Seismometer burial technique by ROV, Remotely Operated Vehicle

Basically the burial is applied to armoured cables. In contrast, DSS was comprised of a non-armoured cable, and it was not good for the burial with a use of ROV. Furthermore, since the materials of ROV tools which directly contact to the cable were metal, it was vulnerable to damage the cable.

(5) Real-time 3-D plotting system

In the existing facilities, the track of transponder and the ship positions and the planned route were shown separately because each data were processed by different softwares. The development of integrated real-time software was required for continuous 3-D plotting during the DSS laying.

4. SOLUTIONS

(1) Simulation technique

We improved the simulation to calculate 36 seismometers at intervals of 25 m by calculation function expansion and parameter optimization.

The result after the improvement of simulation is shown in Figure 4.

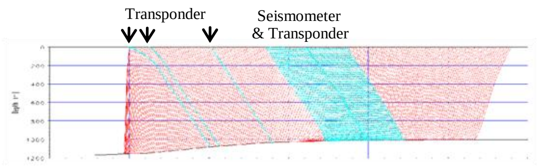


Figure 4: Result after the improvement of simulation

(2) Transponder

The deeper the transponder sinks, the more the error of data from the transponder increases. In order to decrease the error from the transponder we changed the transmission method between transducer and transponder. Furthermore, we put the umbrella type cover with noise absorber above the transducer for reduction of sea surface reflection and the hull emission noise and vibration. The track after the improvement of transponder data is shown in Figure 5.

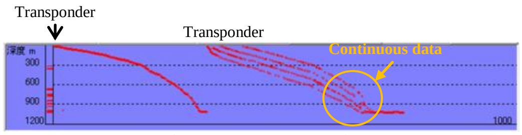


Figure 5: Track after the improvement of transponder data

(3) Cable handling technique

We performed trials for laying and recovering of DSS onboard our ship several times. As a result of our trials we found the appropriate stowage, arrangement and operative speed with the existing facilities. The seismometer on the drum cable engine is shown in Photo 1. The loaded arrangement of DSS is shown in Photo 2.

In addition, we applied the roller-type conveyer to avoid a shock to seismometers passing from the stowage to the drum cable engine. The seismometer on the conveyer is shown in Photo 3.

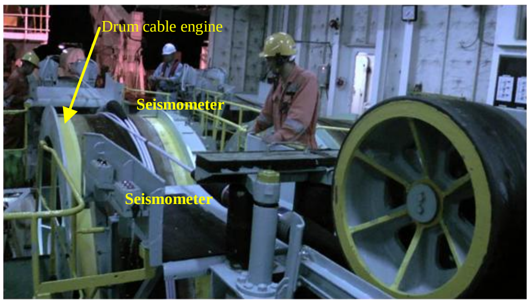


Photo 1: The seismometer on the drum cable engine

Photo 2: The loaded arrangement of DSS

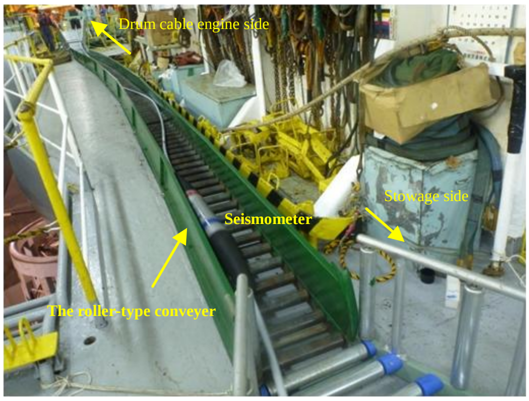


Photo 3: The seismometer on the conveyer

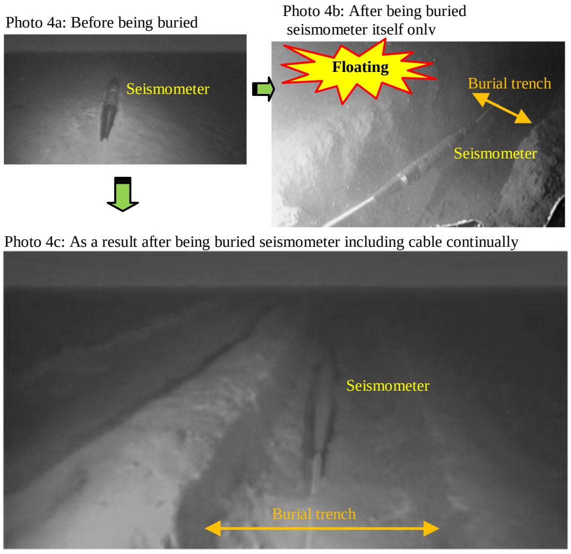
(4) Seismometer burial technique by ROV

Firstly we buried a seismometer itself only because burial tools of ROV were vulnerable to damage the cable. The result, the seismometer was floating above a trench excavated by ROV. Photo 4a shows a seismometer before being buried. Photo 4b shows the seismometer after being buried.

Consequently, we adopted a method to bury a seismometer including a cable continually. We have tried various burial methods. Then we took the following measures which will not damage a non-armoured cable.

At first, metal parts on ROV directly contacting to a cable were covered with non-metal materials such as rubber. And then we put an underwater camera at the most suitable position so that we can monitor the relative position between ROV vehicle and the cable. In addition, we secured the burial depth and the front visibility of ROV by adjusting the water-jet stream direction and flow volume from the jetting tool of ROV.

As a result, we were able to bury seismometers and cable continually without the seismometer being floated as shown in Photo 4c.



(5) Real-time 3-D plotting system

We received a vessel position data from the Integrated Cable Lay and Burial System and the transponder data from the Underwater Positioning System. Finally we developed the system which can show a plan and the real-time laying situation of the above data simultaneously. The configuration of the real-time 3-D plotting system is shown in Figure 6. The track of the transponders during the deployment is shown in Figure 7.

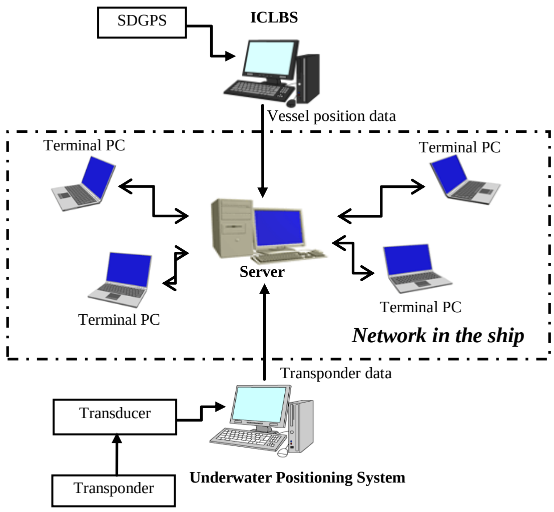


Figure 6: Configuration of real-time 3-D plotting system

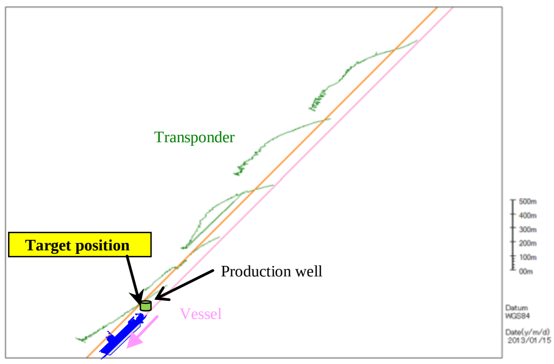


Figure 7: Track of the transponders during the deployment

5. CONCLUSION

We laid the DSS by the technique mentioned above in August, 2012 at the water depth of 1,000 m in the vicinity of the methane hydrate production well. After laying, we verified the DSS position from a simulation result, triangulation results and position relations with the production well.

As a result, we could successfully lay the central seismometer at the distance of 37 m from the target position. In detail, the deviation for in-line direction was 29 m south-west-ward and for cross-line direction was 23 m north-west-ward respectively. In conclusion, the deviation to the water depth of 1,000 m was 3.7 %. The result of the DSS laying is indicated in Figure 8.

Furthermore, we achieved to bury the DSS under the seabed by ROV without any damage to the cable.

It was informed that the data obtained from the DSS are of high quality. Moreover, since we could lay the DSS within the customer's requirements, we obtained a good reputation in laying and burial technology for DSS.

However, it is found that the laying route became the curve form as indicated in Figure 8. We consider that we need further development of our laying method in order to make straight laying form.

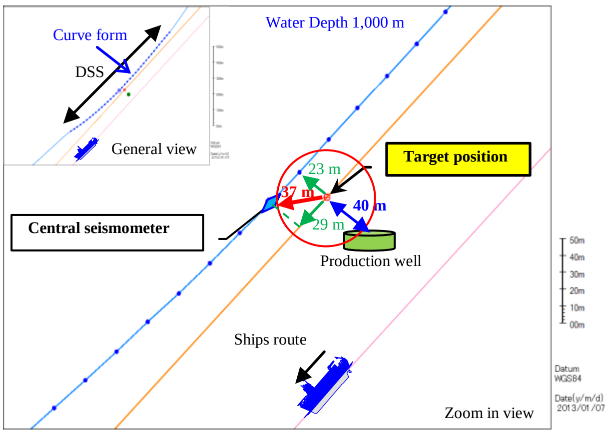


Figure 8: Result of the DSS laying

6. ACKNOWLEDGEMENT

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7. REFERENCES

[1] Optical Submarine Cable Writing Committee 'Optical Submarine Cable', PARADE Inc., May 2010.

[2] Y.Ejiri, 'Outline of Cable Ship KDD PACIFIC LINK', KDD R&D Report No.160, pp. 69-78, Sept. 1998.

[3] Y.Ogasawara, 'Experimental results of the Real Time Simulation System (RTSS) for cable installation employing a Kalman filter algorithm', Proc. of Suboptic '07, 2007.

