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Super short baseline system using the mirror transponder
ミラートランスポンダーを用いた SSBL 測位システム

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1. Introduction

Nowadays, the resource nationalism increases and spreads worldwide. In Japan, submarine resouces are begining to attract much attention. To develope and explore submarin resources, Utilizations of autonomous underwater vehicle (AUV) or remotely operated vehicle (ROV) are needed, and the measurement technology of position of AUV and ROV is important. Therefore, we have developed new measurement system to determine the position of AUV and ROV. This paper presents a method using mirror transponder (MT) developed for the seafloor geodetic observation and super short base line (SSBL) which can measure efficiently over wide area with high precision.

2. System Overview

This system consists of on-board unit and four MTs. On-board unit consists of a Ring Laser Gyro (RLG) and SSBL modem. SSBL modem is composed of an acoustic transducer and four acoustic receivers. The prototype of MT was createrd for seafloor geodetic observation that has achieved a positioning precision of several centimeters[1].

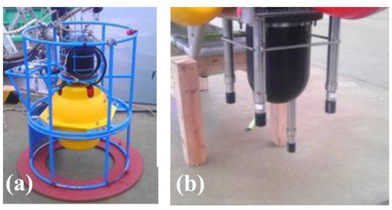

Fig.1 (a) Mirror transponder (b) SSBL modem

Fig.2 shows the communication method between SSBL modem and MT. SSBL modem sends trigger and ranging signals. When MT detects the trriger signal, received signals are recorded. The recorded trigger signal is replaced with ID signal. Then MT sends back ID and rangin signals to the SSBL modem. The travel time is not affected by the fluctuation on set of the recording time.

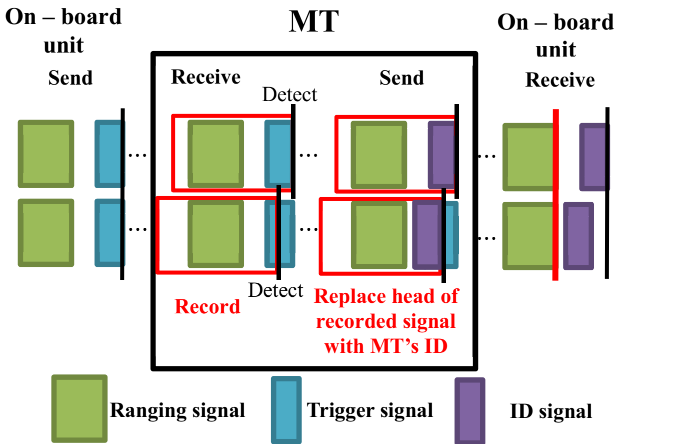

Fig.2 Communication method between MT and SSBL modem. (a) Timing that MT receives trigger signal is accurate (b) Timing that MT receives trigger signal have error

3. Performance Test

We conducted a performance test of the system at Tateyama bay (35°0'N, 139°50'E) in 3rd February 2013. Two MTs were installed on the seafloor and on-board unit was set on the sea surface. In this performance test, GPS was added the on-board unit to compare the positions determined by the present system and GPS.

Fig.3 On-board unit

4. Data processing

First, each CH's travel time was acquired using correlation processing. Second, arraival angle and slant range were calculated using the travel time. Fig.4 shows principle of SSBL.

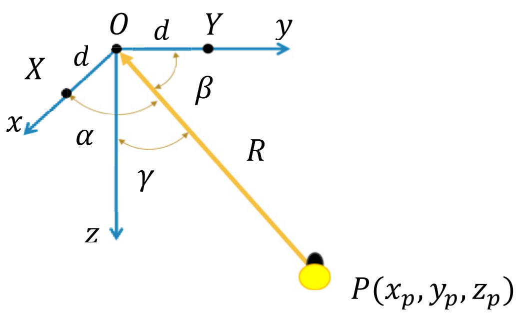

Fig.4 Principle of SSBL

$\cos\alpha$ and $\cos\beta$ are givin by

$$\cos\alpha = c\,\tau_{OX}/d \qquad (1)$$

$$\cos\beta = c\,\tau_{OY}/d \qquad (2)$$

The time delays τ_{OX} is the time diffrence between hydrophone O-X of travel time, and τ_{OY} is the time diffrence between hydrophone O-Y of travel time. Where c is the sound velosity. Therefore $\cos\gamma$ are given by

$$\cos\gamma = \sqrt{1 - \cos^2\alpha - \cos^2\beta} \qquad (3)$$

Slant range R can be obtained from expression:

$$R = (\Delta T - t)c/2 \qquad (4)$$

ΔT is travel time and t is MT's wait time from the time of receiving signal to time of sending signal. the point P are givin by

$$x_p = R\cos\alpha \qquad (5)$$

$$y_p = R\cos\beta \qquad (6)$$

$$z_p = R\cos\gamma \qquad (7)$$

Finaly, attitude (heading, roll, pitch) was corrected by the measurement value of RLG.

5. Result

Fig.5-7 show results of coarse measurement of position.

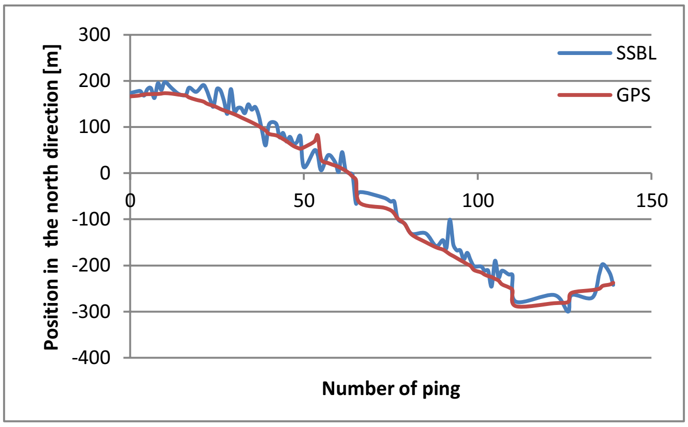

Fig.5 Result of coarse measurement of position in the north direction.

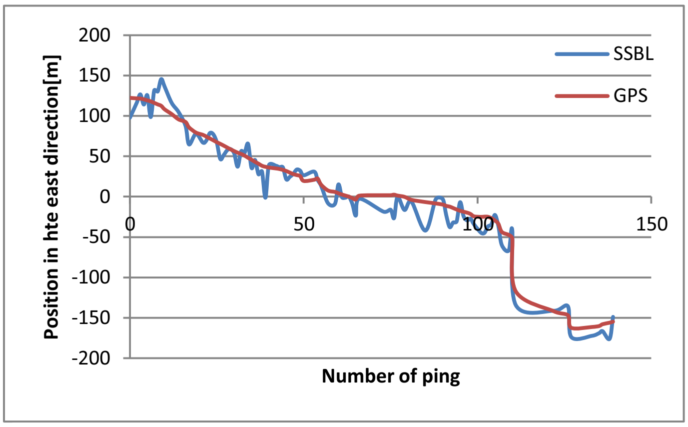

Fig.6 Result of coarse measurement of position in the east direction.

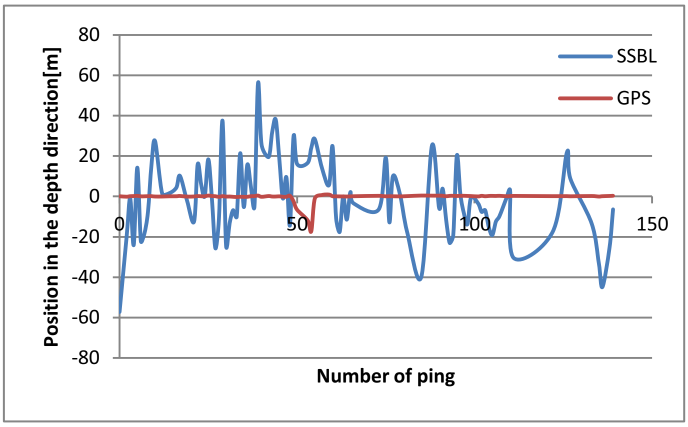

Fig.7 Result of coarse measurement of position in the depth direction.

Table.1 RMS error of mesurement of position

Direction	North	East	Depth
Average Error[m]	10.68	18.40	15.65
RMS error[m]	13.49	23.12	19.91

The result of maesurement of position using SSBL is somewhat simmilar to that using GPS. Then this system is somewhat reliable. However, This result isn't complete result and some errors aren't removed in this analysis. The largest error factor is thought to be error of the time delays used for measurement of arrival angle. When this error is removed, the analysis result is expected to be considerably improved.

6. Conclusion

We deveploped SSBL system using MT. In addition, we conducted performance test in Tateyama bay and analyzed recorded data. The result of maesurement of position using SSBL is somewhat simmilar to that using GPS.

In future, we will improve algorism for acquisition of travel time and remove large error. Thus, we will achieve pricise measurement of position.

Acknowledgment

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Reference

1. M. Sato, T. Ishikawa, N. Ujihara, S. Yoshida, M. Fujita, M. Mochizuki, A. Asada: Science. **332**(2011) 1395