Initial positioning accuracy of the Quasi-Zenith Satellite MICHIBIKI in L1-SAIF

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ABSTRACT: We evaluated the initial positioning accuracy of the 1st quasi-zenith satellite (QZS) L1-SAIF signal. QZS called Japanese name MICHIBIKI was launched by Japanese Government in September 2010. QZS goes through near the zenith of the Japanese sky and sends some navigation signals as same as the GPS signal. By using QZS, GNSS positioning will be expected that the improvement of accuracy, expanding of available area and increasing of available time. Because, QZS has functions to complement and reinforce GPS. QZS has basically three kinds of signals, such as L1-CA, L1-SAIF and LEX. L1-CA signal is to complement GPS. That means QZS is used to one of GPS. Since QZS in the quasi-zenith sky, a range of observations will be expanded. L1-SAIF signal is to reinforce GPS. LEX signal is one of RTK-GPS for survey. L1-CA and L1-SAIF for mobile positioning are target in this study. Positioning accuracy by single mode GPS depends on the distance accuracy from GPS to receiver antenna. The distance accuracy is affected by the delay by the ionosphere and water vapor. The amount of compensation of distance is computed using Electronic Ground Control Points (EGCP). Approximately 1200 EGCP are arranged in Japan. So, L1-SAIF positioning has the capability below 1m. QZS positioning compared with one of GPS under various conditions. As results, L1-SAIF signal is higher accurate than GPS in the fixed-point observation. However, we didn't acquire the expected accuracy of the sub-meter class under some conditions. Also, L1-SAIF signal is confirmed to be higher accurate than GPS in the kinematic positioning.

1. Introduction

On September 11 2010, a quasi-zenith satellite MICHIBIKI was launched. It is the first own self positioning satellite in Japan. Implementing establish a quasi-zenith satellite system (QZSS), Japan aims to improve the location accuracy and expand the utilizable area by establish an independent system. Four or more positioning satellites are necessary to measure the location accuracy of the received point. But if the received point is obscured by mountain or buildings, the satellite signal doesn't reach the received point, so it is difficult to get four or more satellite signals. MICHIBIKI is designed to pass over Japan, near zenith so it is expected to get an unobstructed satellite signal . QZSS sends the signal almost the same way as GPS, so it is expected to expand the utilizable area and extend the utilizable time. And QZSS can correct accident errors caused by natural environmental factors by working together with a ground-based station, so it is expected to improve the location accuracy.
However at this time, because MICHIBIKI is a first satellite in QZSS, it is necessary to demonstrate its technology. Therefore it is necessary to prove that QZSS can measure the designed accuracy. We are conducting demonstration experiments to compare the accuracy of L1-SAIF, the signal that aims to improve the position accuracy, to the accuracy of the Sub-meter.

2. The feature of the MICHIBIKI satellite and the role of the reinforcement signal

In order for the MICHIBIKI satellite to receive the satellite signal easily, it is designed to pass the zenith parts of the Japan in a figure eight shaped orbit. There are two kinds of signals for MICHIBIKI satellite, complement and reinforcement. LEX signal and L1-SAIF signal are called reinforcement. Reinforcement has worked to improve the errors caused by the influence of the ionosphere and troposphere called to propagation of errors receives location information from the positioning satellites.LEX signal called centimeter class has the expected positioning accuracy of centimeters. L1-SAIF signal called sub-meter class has the expected in the positioning accuracy of meters.

3. Verification Item

The purpose of this research is to perform accuracy evaluation of an L1-SAIF signal. In order to verify positioning accuracy, two kinds of averages standard deviations, and the maximum error from GPS single positioning and L1-SAIF (reinforcement) is evaluated.

4. Measurement by a fixed point observation

4.1 The measurement method

The measurement method measured GPS and L1-SAIF (reinforcement) at a same place point and the same time, and compared two data to carry out the accuracy evaluation. A measurement point is a reference point (59033.3235m in latitude, 48299.2964m in longitude) located within the university. The measurement point made the reference point the Kanazawa Institute of Technology LC pond front (Fig.1), and took measurements for about 1 hour. Moreover, in order to also conduct a comparison with a receiving antenna, the measurement time by the beta-Ⅱ version and the beta-Ⅲ version was also published. (Fig. 2, Fig. 3)

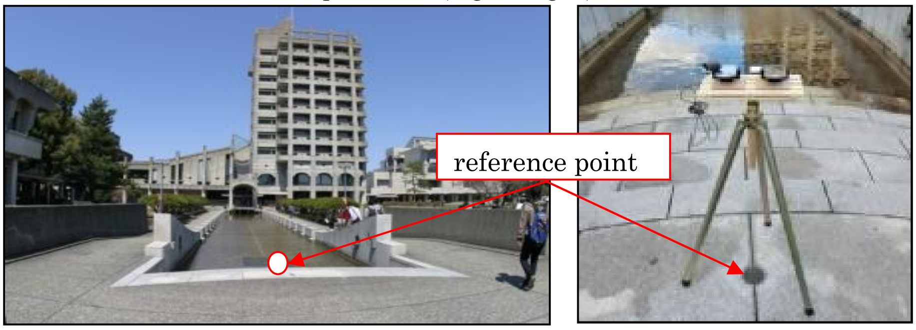

Fig.1 Measurement place scenery (Kanazawa Institute of Technology in the university)

4.2 Result and Consideration

Figure 2 and Figure 3 show the measurement data in β-version Ⅱ and β-Ⅲ version. A vertical axis represents the north-south direction, while the horizontal axis expresses the data of the direction of east-west. Accuracy evaluation of GPS and L1-SAIF showed that the accuracy of L1-SAIF was higher than the accuracy of GPS. Thereby, the data of L1-SAIF proof of accuracy of position to be rectified by the reinforcement signal. However, in this study, L1-SAIF was not able to acquire the accuracy of the sub-meter class. Furthermore, β-Ⅱ version resulted in higher accuracy than β-Ⅲ version. The β-Ⅲ version data were converging in the distant position from a reference point. There are a number of observations that can be made regarding the causes.
The first is the problem of the satellite situation. **Since** QZSS was launched in order to complement a GPS satellite, the positioning accuracy is influenced by the GPS satellite positioning. The author thinks that it is one of the causes. One more point is the problem of the receiving antenna.
The β-Ⅲ version is considered to be multipath which may have caused a system error to occur, in turn causing the error to arise.

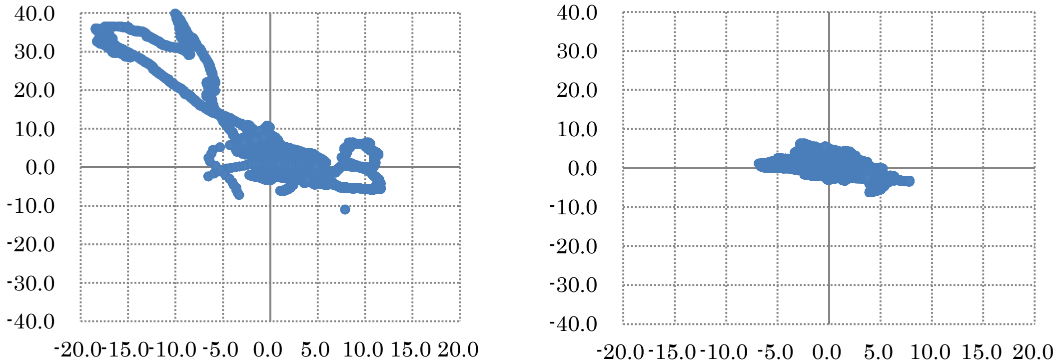

Fig.2 Measurement data of β-Ⅱ version (Left)GPS (Right)L1-SAIF

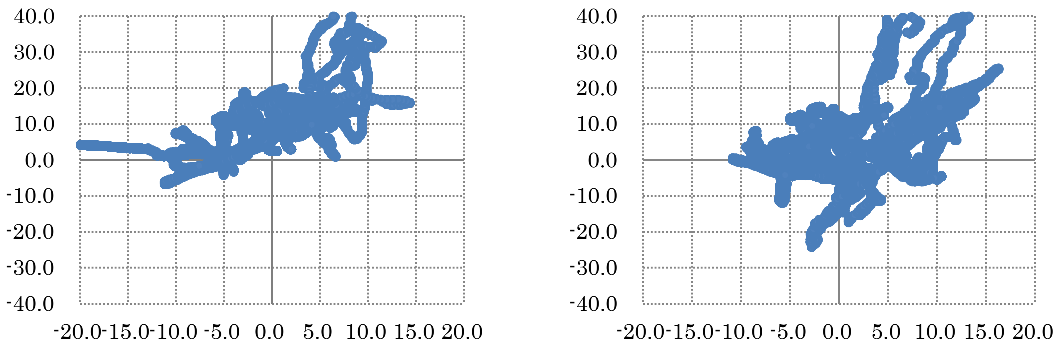

Fig.3 Measurement data of β-Ⅲ version (Left)GPS (Right)L1-SAIF

5. Measurement by high-speed mobile observation

5.1 measurement method

In this experiment, the measurement data of VRS-GPS was prepared as a reference point. VRS-GPS expected was not good accurate place and VRS-GPS installation position and position correct to the error which arises between PDA installation positions was computed by an ambiguous method. Therefore, in this measurement by comparing it with GPS, we have verified the accuracy of the L1-SAIF.

Fig.4 VRS-GPS and PDA attachment position

5.2 The results of measurement and considerations after conducting high-speed mobile observation

The measurement results have proved that L1-SAIF signal is more accurate than GPS. (Fig 5) However, differing by place of there were points at which L1-SAIF gave gross errors some locations where the GPS signal was more accurate than L1-SAIF was also observed. We consider the relation to the positioning error from some for observation point acquired from measurement data in this paper.

	Observation point ①			Observation point ②	
	GPS	L1-SAIF		GPS	L1-SAIF
Positioning error (m)	6.35	4.92	Positioning error (m)	26.46	9.10

Fig.5 Positioning error for each observation point

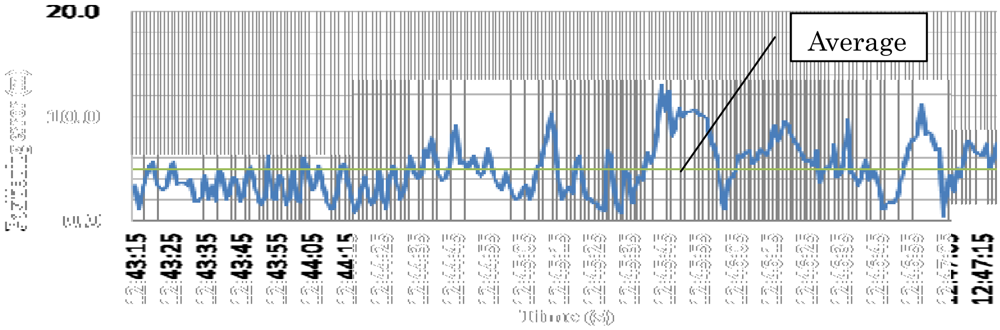

Fig.6 Measurement data of the observation point①

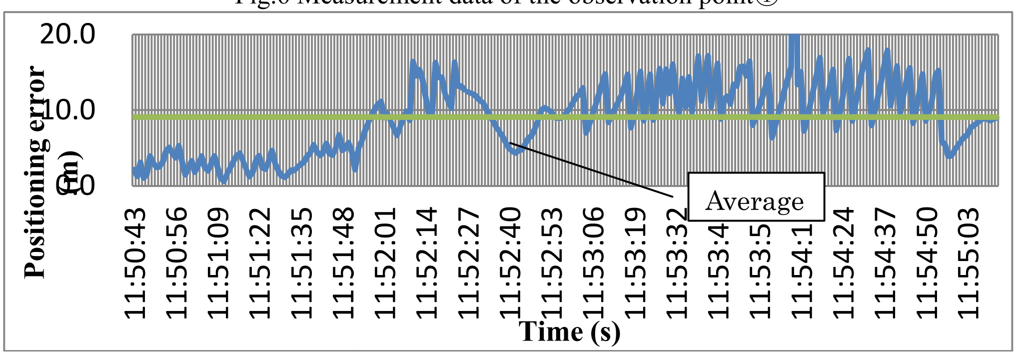

Fig.7 Measurement data of the observation point③

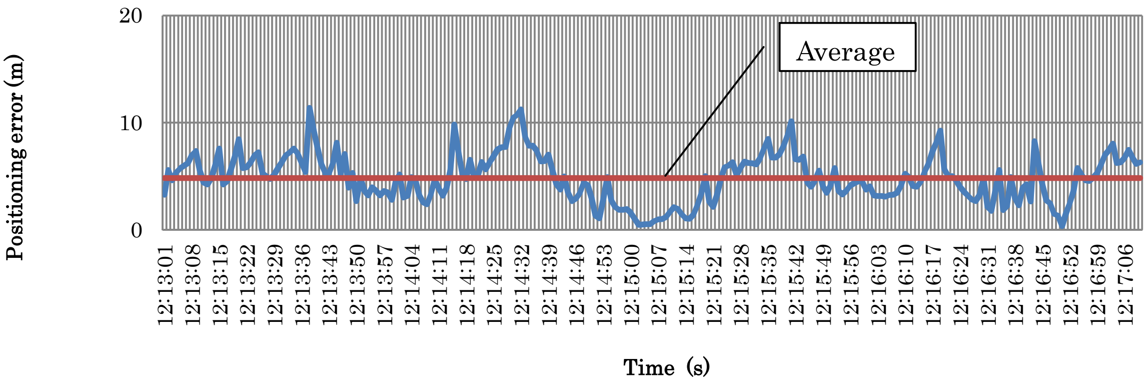

Fig.8 Measurement data of the observation point④

5.3 The inference of the satellite acquisition environment of the spot through a photograph

This data (Fig. 8) were generated gross error point for the positioning environment of a satellite is inferred from the photograph of Figure 9.

① ② ③ ④

Fig.9 Scenery of a measurement point④

From the left there are the times that we took a picture at 12:13 01 seconds, 12:13 51 seconds, 12:15 21 seconds, 12:16 53 seconds. Picture No. ① and No. ② were in environments with comparatively open skies. Therefore, satellite signal tended to be easily received. Picture No③ picture is same as No①and②, but with the cause in the woods which are ahead visible was an the environment in which a satellite signal isn't easily received. Picture No ④ reception of the satellite signal is difficult since the circumference is surrounded by trees. This time is verifies for the point at which many errors appeared. The point at which accuracy was high (near the 12:15) was in open skies and it is thought that the receiving condition of the satellite signal was also good. The point at which errors appeared were perhaps caused by the positioning of the satellite signal in a problematic environment which resulted in lower accuracy seen in the photograph of Figure 9. From this result, it is thought that the positioning environment of a satellite influence error. However, only reading the satellite acquisition situation from a picture is insufficient to make an accurate judgment. In the future, it is necessary to verify in consideration of the DOP value of the point at which the error appeared in the measurement data.

6. Conclusions

In this study, we were not able to get the accuracy of L1-SAIF to the same degree as the sub-meter. But we were able to find the accuracy of L1-SAIF to be better than the accuracy of the GPS. Furthermore at this time, QZSS is constituted by only a single satellite, so an accidental errors can arise according to the position of a GPS satellite. It is important to report the result to SPAC and to improve the accuracy of QZSS.

Acknowledgement

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