Evaluation on Positioning Accuracy of MICHIBIKI Satellite L1-SAIF

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ABSTRACT: GPS signals are interrupted by a building in urban area and the mountain slope. Therefore, the GPS positioning area is restricted. In order to expand of positioning area and raise positioning accuracy, the MICHIBIKI satellite was launched in September, 2010. The MICHIBIKI satellite passed near the zenith in Japan and transmits the almost same signal as GPS. Moreover, MICHIBIKI satellite transmits L1-SAIF as a reinforcement signal derived from electronic reference point that is operated by GSI, Japan, to raise positioning accuracy. L1-SAIF signal is so called the sub-meter class and the expected accuracy is less than 1 m.
The purpose of this research is to verify the positioning accuracy by an L1-SAIF signal. In order to verify it, GPS and L1-SAIF positioning data observed in same time and position were compared. The positioning data observed twice of the morning and an afternoon a day.
As the result, for example, GPS accuracy is 3.1674284m in latitude and 3.9034698m in longitude, and L1-SAIF accuracy is 1.68477m and 1.79976m respectively. This result indicates L1-SAIF provides high accuracy than GPS. But others result showed, GPS accuracy is 1.56595m in latitude and 1.257894m in longitude and L1-SAIF accuracy is 4.027356m and 0.916591m respectively.
Conclusion are; (1) L1-SAIF signal were obtain sub-meter accuracy. (2) Almost L1-SAIF signal were obtained high accuracy better than GPS. (3) In worst case, L1-SAIF signal were obtained worse accuracy than GPS. The reason is assumed the influence of the East Japan tremendous earthquake. As the electronic reference points were moved by the earthquake, the reinforcement value derived from the electronic reference points might be incorrect.

1. Introduction

GPS signals are interrupted by a building in urban area and a mountain slope. Therefore, the GPS positioning is not available in all places. In order to expand of GPS positioning area and raise positioning accuracy, the MICHIBIKI satellite was launched in September 2010. The MICHIBIKI satellite passed near the zenith in Japan and transmitted the almost same signal as GPS. Therefore, it is expected expansion of the use possible area and the increase in utility time. Moreover, MICHIBIKI satellite can correct the error caused by ionosphere delay and water vapor though cooperate with ground stations. It is also expected to improve the positioning accuracy. It is necessary to prove that MICHIBIKI satellite can be positioning in the accuracy according to the design, carry out evaluation accuracy after carry out an experiment in this research.

2. The feature of the MICHIBIKI satellite

There are two kinds of signals of the MICHIBIKI satellite, a LEX signal and an L1-SAIF signal. LEX signal is called centimeter class that is expected in the positioning ability of centimeters of accuracy. L1-SAIF signal is called sub-mater class that is expected in the positioning ability of one meters of accuracy. The MICHIBIKI satellite has some features in raising accuracy. To receive the satellite signal easily, which is designed to pass the zenith parts of the Japan while draw the figure eight of orbit. So it is called Quasi-Zenith Satellite. Moreover, in order to improve the positioning accuracy of GPS, it has the performance of a complement and reinforcement.

2.1 The role of a complement

To MICHIBIKI satellite sends the signal almost the same as GPS signal, which enables MICHIBIKI satellite to be used as GPS satellite. Thereby, a positioning possible hour rate will be expected 99.8% from about 90%. Satellite covers the country without interruption to shield, which can increase available time and can be positioning highly accurate. However, time to stay over Japan is restricted within 8 hours. Quasi-Zenith Satellite of least two aircraft is required for 24 hour operation. The complement improves of observation area. But it is not expected to improvement in accuracy.

2.2 The role of reinforcement

Reinforcement has worked to improve the error caused by the influence of the ionosphere and troposphere called to propagation of errors receives location information from the positioning satellites. This structure corrects the error produced in the ionosphere or the troposphere, When a ground station transmits the information on the electronic reference point where known as the true position is carried out to a satellite. The reinforcement can expect the high accuracy of less than 1 meter called the sub-meter class.

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. Experiment Method

4.1 Development of MICHIBIKI signal receiving System

The system used by this research is developed by the following.
・PDA HP iPAQ112 (Windows Mobile6)
・Receiving antenna (β-II version) SPAC offer
・Soft 1. Development environment　Visual Studio2008 Professional Edition
　　2. Development program　A sample program provided by AISAN Technology is repaired.
　　3. Offer Tool　QZSProveTool (β)

Fig.1　The screen image of an experiment system

4.2 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 carried out accuracy evaluation. Time divided into 2 times at from 10:00 a.m. to 11:00a.m.and 2:00 p.m. to 3:00p.m.and measured change of the positioning by time. A measurement point is a reference point (59033.3235m in latitude, 48299.2964m in longitude) in the university.

Fig.2 Experiment scenery　　Fig.3　Sky view at test site (Open Sky)

5. Positioning Result

5.1 Positioning Result of Morning of March 31, 2011

The measurement data on March 31 is shown below. A horizontal axis is latitude and a vertical axis is longitude.

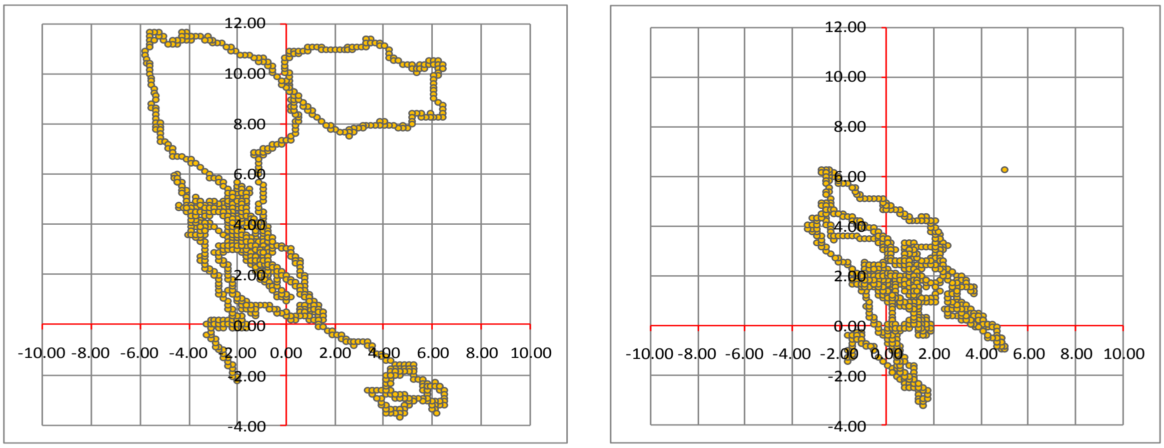


Fig.4　Measurement data of March 31 mornings　(Left)GPS (Right)L1-SAIF

Table1 Comparison of GPS and L1-SAIF

31 March　10:00～11:00				
	GPS		L1-SAIF	
	x	y	x	y
Average	2.62184	3.09542	1.29385	1.39302
Standard deviation	3.16743	3.90347	1.68477	1.79976
The maximum error	6.51338	11.65401	5.02138	6.29046

5.2 Positioning Result of Afternoon of March 31, 2011

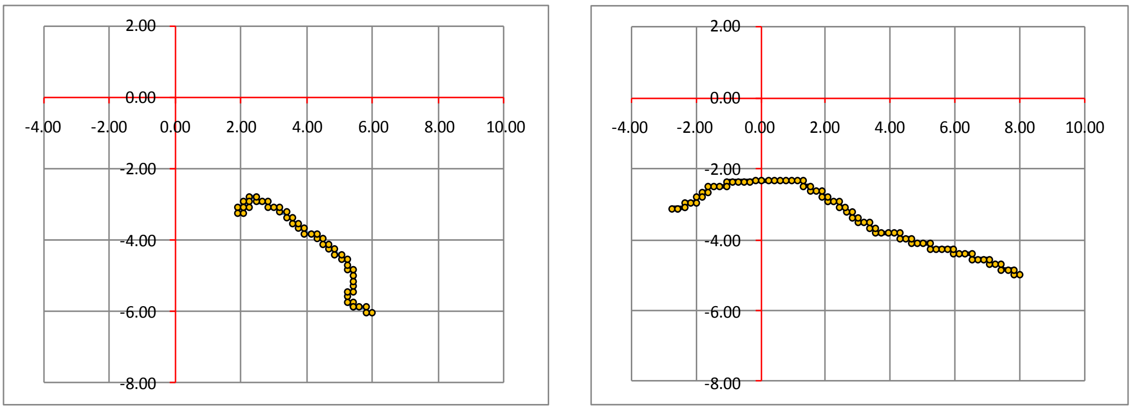


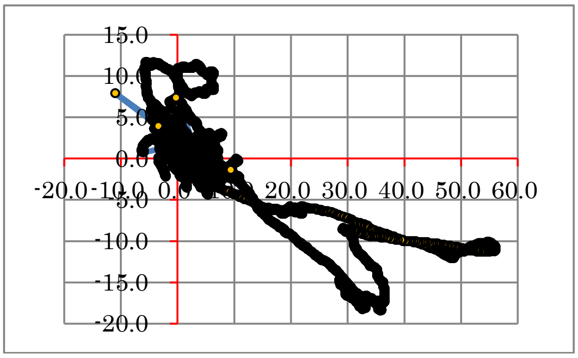
Fig.5　Measurement data of March 31 afternoon　(Left)GPS (Right)L1-SAIF

Table2 Comparison of GPS and L1-SAIF

31 March　13:00～14:00				
	GPS		L1-SAIF	
	x	y	x	y
Average	1.46665	1.18211	1.32446	-3.38328
Standard deviation	1.56595	1.25789	4.02736	0.91659
The maximum error	5.97448	-2.78662	8.00288	-2.3451

Positioning data from the morning of March 31, the result brought that the accuracy of L1-SAIF is higher than the accuracy of GPS. Conducted measurements from March to April, 10:00a.m.to 11:00a.m. MICHIBIKI satellite passes near the zenith of Japanese. So L1-SAIF became highly accurate than GPS. However, L1-SAIF can’t receive accuracy of sub-meter class in these results. Positioning data in the afternoon of March 31 did not have difference in the accuracy between GPS and L1-SAIF.At Figures GPS and L1-SAIF in the morning and afternoon, movements of GPS and L1-SAIF are almost the same. So, the problem of the accuracy is not a problem receiver of the GPS satellite.

5.3 The positioning result of the whole data



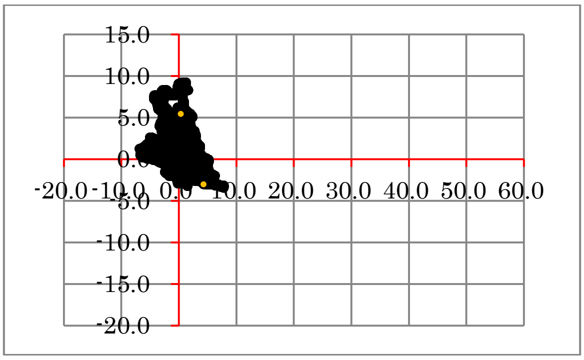


Fig.6 Measurement data of the whole data (Left)GPS (Right)L1-SAIF

Table3 Comparison of GPS and L1-SAIF

Results at Morning time				
	GPS		L1-SAIF	
	x	y	x	y
Average	5.29802	-0.55014	0.27783	1.20462
Standard deviation	10.19444	5.28484	2.38040	2.38702
The maximum error	56.12118	11.65401	7.80958	9.146868

6. Conclusions

Accuracy evaluation of GPS and L1-SAIF were able to be verified in this research. The difference of the accuracy of L1-SAIF by a time zone was seen from the result of this accuracy evaluation. When comparing GPS data and L1-SAIF data, morning data has higher accuracy. While the afternoon data does not show big difference between GPS and L1-SAIF.In addition, the result obtained from GPS is higher in accuracy than L1-SAIF on another day. For L1-SAIF signal send only the compensation data of propagation of errors, position information is obtained from GPS. However, due to PDA had received the L1-SAIF signal, it is thought that accuracy became low by the problem of arrangement of GPS. Considering the DOP value of a measured day, the DOP value in the morning was stabilized and was high. But the afternoon DOP value was unstable and the number of satellites also had fewer afternoons than the morning. Since this experiment used the electronic reference point of the Geographical Survey Institute, it was affected by the influence of an Eastern Japan tremendous earthquake which happened on March 11th 2011.It is not taken the degree of the influence in this experiment. Measurement of a MICHIBIKI satellite will be continued from now on. And it is necessary that the accuracy of the reinforcement signal of a MICHIBIKI satellite become less than 1 meter

7. Future View

At the present stage, the receiving antenna of a MICHIBIKI satellite is using the β-Ⅱ version. This paper is only the rudiment evaluation step of MICHIBIKI satellite. MICHIBIKI receiving antenna(β-version Ⅱ) are manifestation the result in this paper. From now on, a MICHIBIKI receiving antenna (the β-Ⅲ version) will be provided from Satellite Positioning Research And Application center. To β-Ⅲ version is considered multipath, which can expect improvement of accuracy higher than β-Ⅱ version.

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