AN ACCURACY PERFOMANCE OF THE MULTIPLE GNSS CONSTELLATION

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1. INTRODUCTION

The first Japanese satellite positioning system "QZSS (Quasi Zenith Satellite System)" has been operated since the first satellite QZS-1 was launched in September 2010. Until now, in the field of satellite positioning, GPS (Global Positioning System) had been mainly used for long time. Additionally, recently, the Russian "GLONASS", the EU "GALILEO", and the Chinese "COMPASS" has been operated stably. And the GNSS (Global Navigation Satellite Systems) is known as a generic term of the new global satellite positioning systems, which are the multiple constellations (GPS, GLONASS, GALILEO, COMPASS, QZSS and so on). However, the positional accuracy performance of the multiple GNSS constellation including QZSS have not been fully examined yet because the QZSS has been just operated for about two years.

This study shows the evaluation of an positional accuracy performance of the multiple GNSS constellation through the acquisition of the signals of the GPS, the GLONASS, and the QZSS on the study sites. Especially, it is focused on the positional accuracy by the use of the QZSS.

2. METHODOLOGY

The study sites were located in Yakusa Campus of Aichi Institute of Technology, Toyota city. The signals of the GPS, the GLONASS, and the QZSS were received under various surrounding environments including open sky and urban canyon at 15 seconds intervals over a period of 24 hours (5760 records total). The positioning accuracies of the GNSS constellation were evaluated by the standard deviation errors through stand alone positioning method using RTKLIB. The numbers of GNSS constellation and the dilution of precision (DOP) were calculated during the observation period. The DOP indicates the effect of receiver-satellite geometry on the accuracy of point positioning (Leick, 2004). And the relationships among the positioning accuracies, the numbers of GNSS constellation, and the DOP were examined.

3. RESULTS

Table 1 shows the standard deviation of horizontal positioning by the multiple GNSS constellations. Basically, in the constellations including the GPS, the results showed high precision positioning. In the GPS and the QZSS constellation, the standard deviation was less than 0.900 m. That is to say that the GPS and the QZSS constellation was the highest performance on the precise positioning. Though the standard deviation of the GLONASS and QZSS constellation was much larger than the other, the standard deviation of the constellation with more than 6 vehicles was less than about 4.000m. Fig.1 shows the relationship among the standard deviation (top), the number of satellites (middle), and the HDOP (horizontal DOP) (bottom) in the GPS, the GLONASS, and the QZSS constellation. Basically, the changes in the value of the standard deviation corresponded reasonably well with the changes in the value of the HDOP. Also, it could be seen that the changes in the number of the GPS satellites have some effect on the positional accuracy. Table2 shows the availability of the GPS and the QZSS at the various locations, where the open sky ratio are different, during the observation period. The high availability of both only the GPS and the constellation of the GPS and the QZSS was indicated in the locations with the open sky ratio of more than 25 %. There was not much differences in the availability between only the GPS and the constellation of the GPS and the QZSS. Table3 shows the standard deviation of horizontal positioning at the various locations. The high positional precision (STD≦about 1m) was resulted in the locations with the open sky ratio of more than 75 %. And the standard deviation of less than about 3m were resulted in the locations with the open sky ratio of more than 25%. However, it can be seen that the satellite positioning at the locations with the ratio of less than 25 % has low positional accuracy due to multipath, which is the reception of reflected or diffracted replicas of the desired signal. That is to say that since the path traveled by a reflection is always longer than the direct path, multipath arrivals are delayed relative to the direct path (Kaplan and Hegarty, 2006). Fig.2 shows the correlation between the HDOP and the standard deviation in the constellation of the GPS and the QZSS observed at the location with the open sky ratio of more than 75 %. As the result, the HDOP showed the strong correlation with the standard deviation in the constellation. That is to say that the user/satellite geometry have a stronger effect on the positional accuracy.

4. CONCLUSIONS

The analysis results showed the high positioning performance through the constellation of positioning satellites including the QZSS. Also, it showed the effects of the composition of GNSS satellites and user/satellite geometry (DOP) on the positioning accuracy. Future research will be tried to examine the improvement of the calculation method of GLONASS positioning.

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Keywords: GNSS, GPS, QZSS, positional accuracy, DOP

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Table1 The standard deviation of horizontal stand alone positioning differences calculated from the GNSS constellation

CONSTELLATION	STANDARD DEVIATION	
	W-E (m)	S-N (m)
GPS	0.784	1.032
GPS GLONASS	0.791	1.343
GPS QZSS	0.781	0.897
GPS GLONASS QZSS	0.828	1.207
GLONASS	3.550	4.538
GLONASS QZSS	112.622 3.369 (≧6 sats) 300.189(=5sats)	112.057 3.727(≧6 sats) 292.989(=5sats)

Table2 The availability of GPS and GPS+QZSS at the various locations during the observed period, 24hrs.

Open Sky Ratio(%)	GPS	GPS+QZSS
75～100	100%	100%
50～75	100%	100%
25～50	97.4%	97.4%
15～25	59.0%	61.8%

Table3 The positional accuracy of GPS and GPS+QZSS at the various locations during the observed period, 24hrs.

Open Sky Ratio(%)	CONSTELLATION	STANDARD DEVIATION(m)	
		W-E (m)	S-N (m)
75～100	GPS	0.784	1.032
	GPS＋QZSS	0.781	0.897
50～75	GPS	1.658	1.318
	GPS＋QZSS	1.088	1.295
25～50	GPS	2.173	2.707
	GPS＋QZSS	2.109	2.582
15～25	GPS	36428.086	18053.577
	GPS＋QZSS	35581.987	17633.707

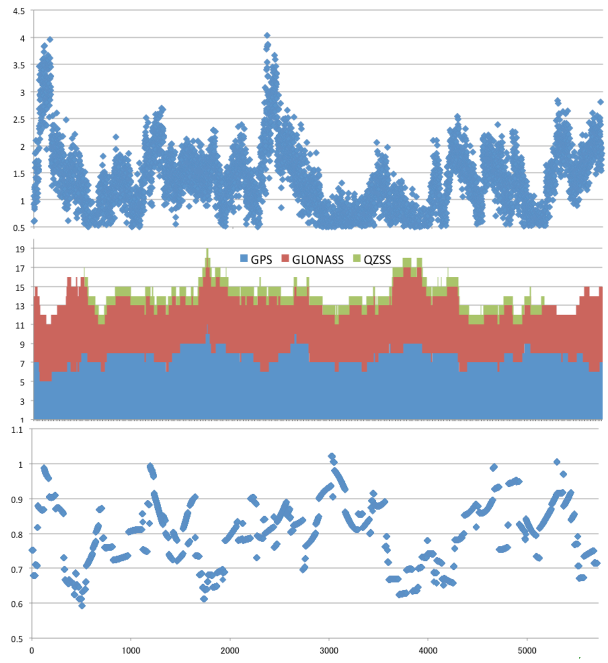

Fig.1 These figures show that the relationships among the horizontal accuracy, the numbers of satellites, and HDOP during the observed period, 24hrs.

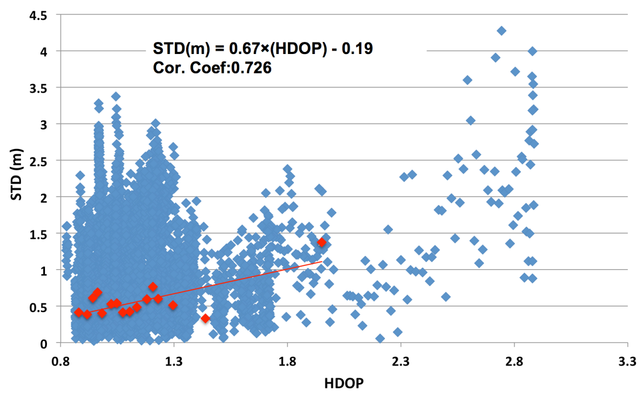

Fig.2 This figures show that the HDOP showed the strong correlation with the standard deviation in the constellation of the GPS and the QZSS.