On the reception situation of satellite signals from GNSS in the mountains
~ Hakusan Shirakawago White Road as an example ~

Takashi Kanai*, Masaaki Shikada*[1] and Kentaro Ueshima*[2]
Kanazawa Institute of Technology 7-1 Ogigaoka, Nonoichi City, Ishikawa, Japan.
E-mail*: b1247013@planet.kanazawa-it.ac.jp
E-mail*[1]: shikada@neptune.kanazawa-it.ac.jp
E-mail*[2]: b1363854@planet.kanazawa-it.ac.jp

KEY WORDS: GNSS, GPS, QZSS Cadastral, Accuracy

ABSTRACT
The positioning technology based on GNSS has been utilizing in various places, from the familiar scene of life such as application of smartphone to civil engineering work, agricultural technology, cadaster examination. In addition, the satellite positioning system by the quasi-zenith satellite (QZS) in Japan is planned to launch three satellite in FY2019, and the operation is started with a total of four aircraft systems. From FY 2023, the QZS will be equipped with seven satellite systems and it will be possible to receive signals from multiple QZS at elevated elevation all the time. In this study, Leica GPS 1200 + (Leica geosystems), JAVAD ALPHA G 3 T (JAVAD), SOKKIA GIR 1600 (TOPCON) were used in a mountainous area named Hakusan Shirakawago White Road with a height difference is about 800 m. We conducted also positioning experiment using GNSS Logger and considered the receiving condition of satellite signals in the mountainous region. In the experiment, each receiver was attached at the top of roof the vehicle, and data of every one second data was received and analyzed. Furthermore, it was compared with the center of the road distributed by Geographical Survey Map where accuracy is guaranteed as public data relatively.

INTRODUCTION
The positioning technology by GNSS is utilized in various places and it is also used in cadastral survey, however, cadastral research has not been progressing yet. The reason is that GNSS positioning cannot be used simply in mountainous areas. At the present, three satellites were launched in Japan named QZSS (Quasi-Zenith Satellite System), a satellite positioning system based on the Quasi-Zenith Satellite in Japan, and total of four satellite systems will be completed at the end of year. By the 2023, QZSS will have seven satellites and it will be possible to receive signals from multiple quasi-zenith satellites at elevated elevation all the time. In this study, we investigated the change of environment of the positioning using Leica GPS 1200 + (Leica geosystems), JAVAD ALPHA G 3 T (JAVAD), SOKKIA GIR 1600 (TOPCON), GNSS logger, and on the reception situation of the satellite signal in the mountainous regions were checked by the Geographical Survey Map which accuracy guaranteed as public data.

JAPANESE QZS
Three quasi-zenith satellites in Japan have successfully launched, and another one will be launched at the end of year. Since QZS has a special orbit, it is possible to stay at the zenith of Japan for a long time.
QZS has 2 functions, which are GNSS augmentation and GNSS complementary. The augmentation of GNSS which

transmitting a high accuracy corrections signal from QZS can be able to collect high accuracy positioning. Complementary of GNSS helps improve the geometry of the satellite.

In addition to two characteristics, QZSS can increase receiving time around the zenith. Signals sent from high elevation angle will increase the receivable number of satellites, and improve a satellite constellation. QZS has been designed to support the performance of GNSS use by Japan. It has the compatible signals of L1C, L2C and L5 to the future GNSS. [1]

In addition, around 2023, there will be 7 satellite systems and it will be possible to receive signals at high elevation all the time. If signals can be received at high elevation angles, highly accurate positioning is possible even in mountainous areas and urban areas where high precision positioning was difficult by crowding trees and buildings.

In this way, the change of the satellite positioning environment in Japan is a remarkable situation now.

OUTLINE OF EXPERIMENT

We conducted experiments mainly on the mountainous area called Hakusan Shirakawago White Road by using four GNSS receivers of Leica GPS 1200 + (Leica geosystems), JAVAD ALPHA G 3 T (JAVAD), SOKKIA GIR 1600 (TOPCON), and GNSS logger.

Table 1 shows the specifications of the GNSS receiver used in the experiment.

Table1 GNSS receiver specifications

Receiver type	Accuracy	Satellite
Leica-GPS1200+	Horizontal 10mm+1ppm （Kinematic） Vertical 20mm+1ppm （Kinematic） Horizontal 5mm+0.5ppm （Static） Vertical 10mm+0.5ppm （Static）	GPS、GLONASS、Galileo、Compass
JAVAD-ALPHA-G3T	Single Within "2m DGPS Within "0.5m (Real time) Within "0.25m （ Post processing） Static Horizontal 0.3cm+0.5ppm Vertical 0.5cm+0.5ppm	GPS、GLONASS、Galileo、QZS
SOKKIA-GIR1600	DGPS Within "1m（2DRMS） Post processing DGPS Within "30cm（20min） Post processing DGPS 15mm+1.0ppm（30min）	GPS
GNSS Logger	Single 2.5m	GPS

The experiment was conducted 5 times in total during the period from August 3, 2016 to November 2.

Figure 1 shows the setting condition of the antenna, and measuring was performed on the Hakusan Shirakawago White Road. The data reception interval of the GNSS receiver was 1 second.

Fig.1 Receiver setting condition

RESULTS OF EXPERIMENT

Data analysis was performed using each different analysis methods for receiver. Leica GPS 1200 + used dedicated software Leica Geo Office. JAVAD ALPHA G3T used dedicated software JAVAD-Net View and JPS 2 RIN. SOKKIA GIR 1600 (TOPCON) and GNSS logger used the output NMEA data. Also, RTKLIB ver.2.4.2 was used to unify the elevation mask.

Experiment area extracted 500 m of the representative part of each region and extracted errors with the center of the road at 50 m intervals.

Figures 2 and 3 show the data of each GNSS receiver overlaid to seamless aerial photograph of the Geographical Survey Map. The lines perpendicular to the road in the Figure represent 50 m intervals.

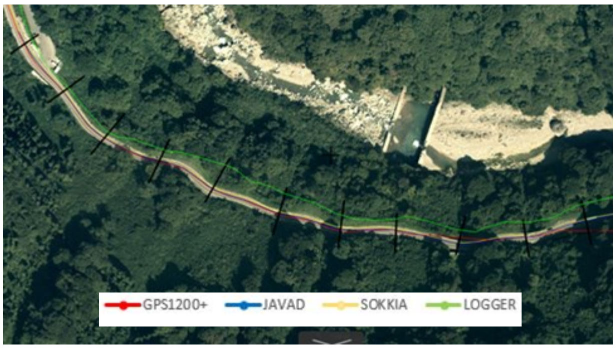

Fig.2 Received data in the mountainous areas

Fig.3 Received data in the urban area

Figure 4 and 5 shows the distance from road center every 50m.

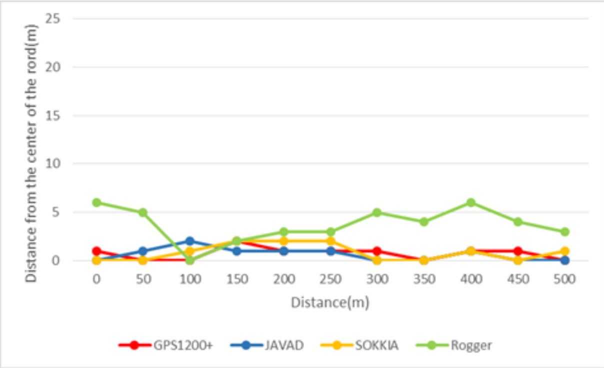

Fig.4 Distance from road center in the mountainous region

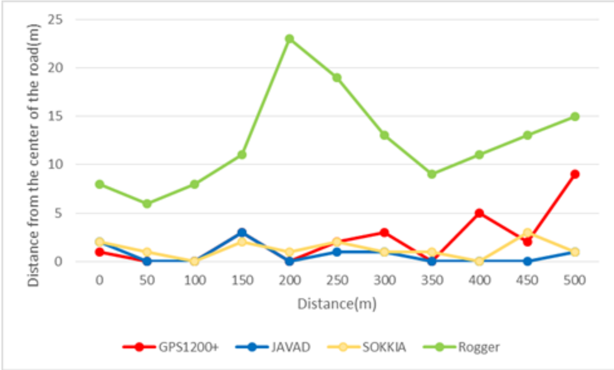

Fig.5 Distance from road center in the urban area

From this result, both the mean and the standard deviation of the distance from the center of the road exceeded the value of the urban area than that of mountainous area. Between Leica GPS 1200 + and GNSS logger data were more than three times of urban areas. Leica GPS 1200 + may be influenced by the tunnel immediately after 500 m of the mountainous region representative part, as the results, it was thought that Leica GPS 1200 + was greatly displaced at 500 m point. The specifications that GNSS logger was low caused this result.

CONCLUSIONS

In the experiment, we did experiments of GNSS positioning in the mountainous region where the signal environment changes complexity. To use various price GNSS receivers from 5000 yen to about 3 million yen is the most remarkable research point. In recent years, small, inexpensive and highly accurate positioning device has become possible. It is necessary the cadastral survey of the mountainous area has high precision and to be cheap. Our research around the mountainous area for cadastral survey will be able to suggest the process to receive GNSS in the near future.

ACKNOWLEDGEMENT

The authors would like to thank to Shigeru Matsuoka of SPAC (Satellite Positioning Research and Application Center) which you lent us the JAVAD TR_G3T ALPHA, and also thanks to Toshiyuki Yamashita and Noriyuki Hukumitsu of Kanazawa Institute of Technology, and Toshihiro Nashii Hakusan city hall, which gave us the cooperation of our experiment.

REFERENCES

[1] M.Shikada and N.Sekiguchi, Evaluation of the high accuracy positioning by quasi-zenith satellite, Japan Society of Photogrammetry and Remote sensing Journal

[2]M.Shikada and S.Shiraishi, Evaluation of positioning characteristics using the LEX signal of the quasi-zenith satellite, Japan Society of Photogrammetry and Remote sensing Journal