On the demonstrated experiment using LEX signal from Quasi-Zenith Satellite in Hokuriku District

Soichiro Shiraishi and Masaaki Shikada

Dept. of Environment and Civil Engineering, Kanazawa Institute of Technology,

7-1 Ohgigaoka, Nonoichi City, Ishikawa, Japan, 921-8501

Tel:+81 76-248-9246; Fax. +81 76-294-6713

E-mail: shiraishi@venus.kanazawa-it.ac.jp

KEY WORDS: GPS, GNSS, QZSS, GIS

Abstract: Survey using GPS has been spreading in the world including Japan. Validity of GNSS(Global Navigation Satellite System) is increasing and it became indispensable to a life. However, there are many places which cannot obtain position information by GPS only and those places are a valley of a building, forest of mountain area and its similar place. Therefore, accuracy of absolute position by GNSS(GPS,QZSS,GLONAS,etc.) will hope more highly for ubiquitous society in the near future. Japanese government launched QZS (Quasi-Zenith Satellite) which is the first satellite of QZSS (Quasi-Zenith Satellite System) for the purpose to improve of GPS weak point. QZS is designed to pass along a special orbit, and is to stay over Japan for 8 hours, and QZS can keep the high zenith angle. Moreover, it is possible to obtain location information of high accuracy by LEX signal transmitted from QZS. LEX signal is expected to collect high accuracy position data, however, launched satellite is only one by 2012, and just a 8 hours stay in the orbit of Japanese sky. The purpose of the research is to conduct the demonstrated experiment which uses the LEX signal from QZS in Hokuriku area in Japan, and to analyze the characteristic as compared with VRS-GPS (Virtual Reference Station-GPS). Experiment results showed that the positioning which uses a LEX signal has high accuracy equivalent to VRS-GPS. Moreover, even if vehicles run at 80 km/h, it became clear that positioning has a high accuracy equivalent to VRS-GPS. On the other hand, it became clear that there are some problems in the LEX signal from a QZSS. In this paper we reported demonstrated experiments of QZSS in HOKURIKU area, and comparison of accuracy for absolute positioning by using GPS control station.

1. INTRODUCTION

Basic improvement on the advancement of utilizing geospatial information (NSDI of Japan) is constructed on May 30, 2007 and advanced practical use of geospatial information became a important issue. Basic plan of advancement of utilizing geospatial information basis NSDI on 2008 revised new basic plan in 2012 was carried out. Japanese government and local governments will use more high positioning service from the satellites and need to make advancement convenience. Geospatial information has to get more accurately, quickly and those area's map has to revise real time. In the research, we used GNSS(Global Navigation Satellite Systems) to get position information. Many of Japanese peoples and public office are using GPS satellite. Using GPS can get right positioning information under open sky, but in the canopy area, multipath and cycle slip affect a high positioning. In order to reduce above issues, QZS(Quasi-Zenith satellites) was launched on September 11, 2010. QZSS was

designed to always exist over Japan. It will increase satellite positioning time at the zenith and they also send signal with equivalent GPS from QZSS satellite, which can use for demonstration experiment all over the Japan. In this paper, we reported demonstrated experience in HOKURIKU area, and comparison of accuracy for absolute positioning by using VRS-GPS and QZSS.

2. Quasi-Zenith satellites system (QZSS)[1][2]

2.1 Quasi-Zenith satellites (QZS)

QZS(Quasi-Zenith Satellite) is the first satellite for QZSS(Quasi-Zenith Satellite System), which was launched by Japanese government. QZSS has special orbit from Japan to Oceania which is similar to 8 character. Cabinet of Japan already decided three QZS satellites will launch in next decade. After all satellites are on the special orbit, Japanese people will be able to get accurate position of all time and all days and QZSS will become the 4th infrastructure of Japan.

2.2 Supplement and addition of GPS signal

QZSS has two main missions. One is additional effect of GPS, which is broadcasting to high accuracy special signal from QZSS. Another is addition of GPS satellite, which is broadcasting a signal equivalent to GPS from QZSS. Since a QZS satellite broadcast the same signal as a GPS satellite system, which will increase for one satellite. In the neighborhoods, such as a building and forest, GPS signal becomes unstable. The additional effect and addition of GPS satellite by QZSS could reduce such a place and conditions. To make maximum influence of QZSS, it is necessary to increase the number of satellites. The Japanese government has a plan to make the number of satellites increase to 7 in next decade. Using special signal from QZS satellite, user can well know the person's position at real time. Special signal of QZSS has two types. One is L1-SAIF and another is LEX signal. L1-SAIF signal has sub-meter accuracy and LEX signal has centimeter accuracy. In this paper, we did demonstrated experiment using LEX signal.

3. Demonstrated experiment in HOKURIKU

In the Figure1, left side shows LEX signal receiver and right side shows signal receiving antenna of GPS and QZSS on roof of vehicle.

Figure 1: LEX signal receiver and LEX antenna and Vehicle

The height of the antenna set up on high position is in order to avoid the multipass and cycle slip from vehicle's roof. Wind and vibration of the vehicle to an antenna was negligible. First experiment did March 5th to 9th,

2012 and second experiment did April 23 to 27, 2012. On the first and second experiment, we used same equipment and same vehicle, therefore we considered first and second experiment is same condition.

4. RESULT

In this research we used FIX and FLOAT flag of LEX signal data from surveying results. FIX and FLOAT flag was output automatically by LEX signal receiver's log. VRS-GPS was used to confirm the accuracy of LEX signal. In this paper, using LEX surveying results express "FIX" or "FLOAT" and VRS-GPS surveying results express "VRS". The LEX signal receiver has two types output mode. One is 1Hz synchronous mode and another is synchronous 5Hz mode. Control point surveying and movement surveying used 1Hz and 5Hz respectively.

4.1 RESULT OF FIXATION

On the first experiment, fixed surveying using LEX and VRS-GPS conducted around the Kanazawa City area and campus of Kanazawa Institute of Technology. Purpose of the experiments is to get high accuracy data in short time (less than 5 min).

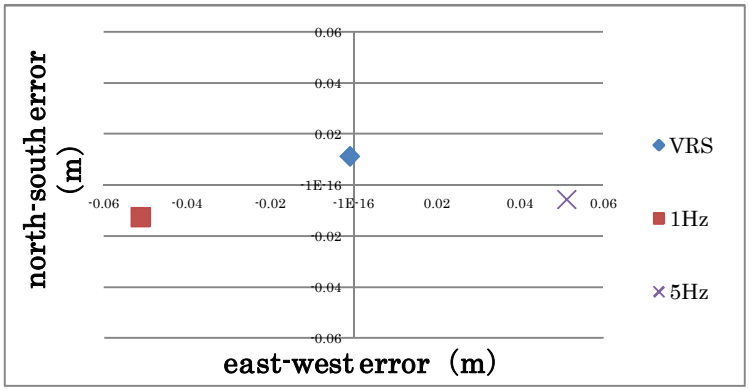
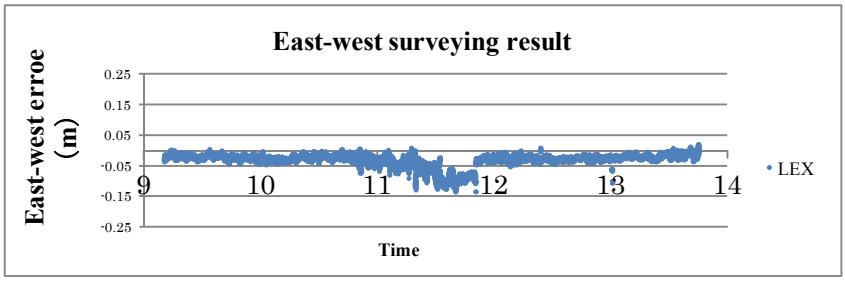


Figure2: Fixation surveying result

Origin of Figure2 shows control point which was measured by VRS-GPS for two hour. On the other hand, VRS solution is 5 minute surveying. LEX and VRS result has a same accuracy at 5 minutes respectively. Max error of east-west direction is ±5 cm.

The second experiment is long time surveying from 9:00 to14:00. Purpose of experiment was to check effect by number of satellite and QZSS's orbit in long time. Experiment area is open southern sky area.



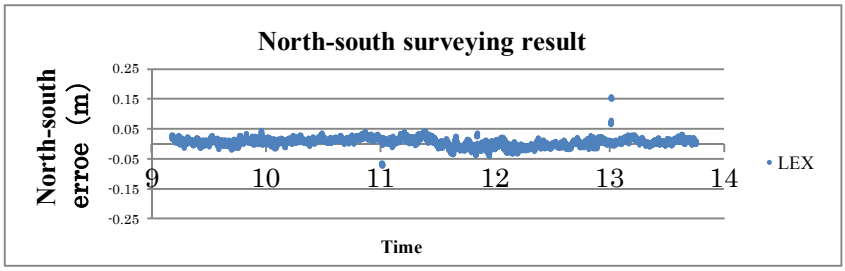


Figure 3: Long time surveying result

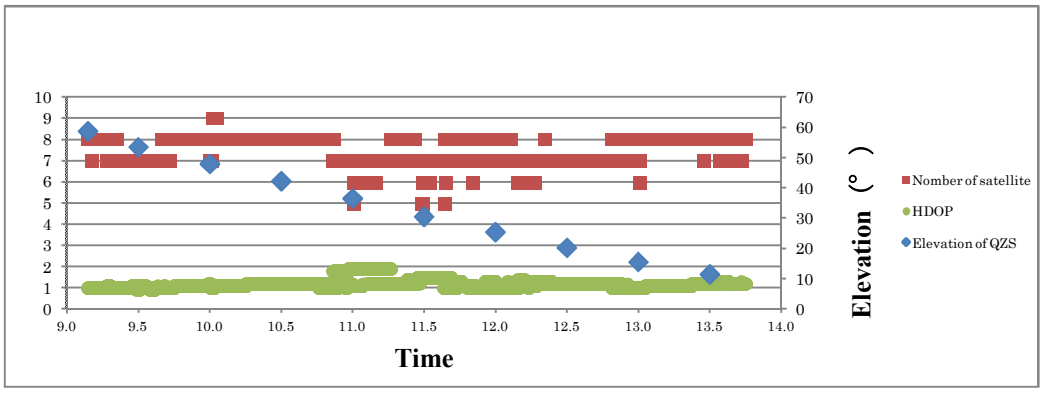


Figure 4: Number of satellite, elevation of QZS and HDOP

Error of VRS-GPS solution, number of GPS satellite, HDOP value and QZS's angle of elevation from LEX's log and QZ-radar was considered. Figure3 shows the result east-west error became big during 11:00 to 12:00. In the Figure 4, number of satellites decreases and HDOP became large. On the other hand, LEX accuracy keep high level after 13:00 which time is back away for Quasi-Zenith for QZS' obit. It is no relationship between QZS's angle of elevation and LEX's accuracy. Using the southern open sky area, LEX receiver could get high accuracy positioning information in long time.

4.2 RESULT OF MOBILE EXPERIMENT

High speed mobile experiment by using HOKURIKU highway were demonstrated around the Kanazawa City area. Around the HOKURIKU highway has mountain and non- mountain area. Such an area is the better place for evaluating the performance of GPS and a LEX signal. On the second experiment, two cameras were attached to the forward and the upper part of vehicle, and the image during experiment was recorded. Figure 5 shows FIX and FLOAT area by LEX signal on the HOKURIKU highway. Back ground map is fundamental geospatial data by Geospatial Information Authority of Japan.

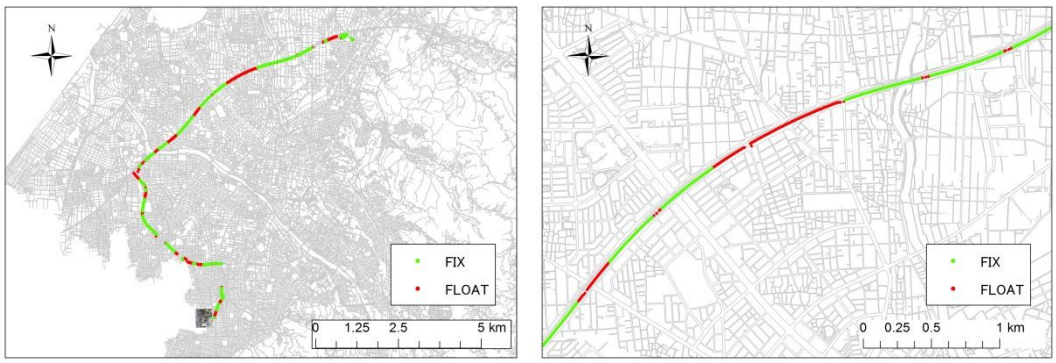


Figure 5: Mobile experiment result (right side figure expanded left side area)

The moving experiments of the highway was conducted toward right top from under left for center of a left side Figure. There are many FLOAT areas on the HOKURIKU highway. Figure 6 shows vehicle's speed on HOKURIKU highway calculated from VRS solution.

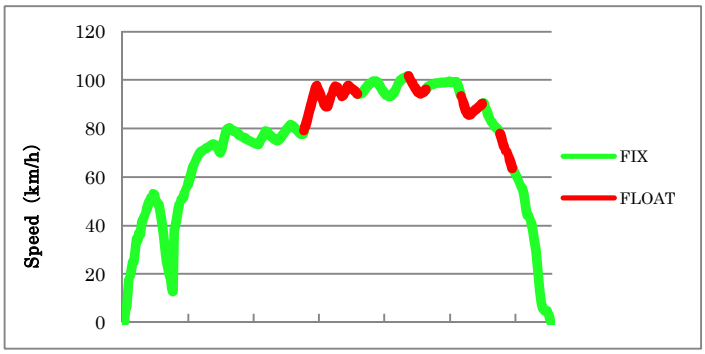


Figure 6: Effect of speed

In this figure, max speed of vehicle is about 100 km/h and FIX rate become low when vehicle's speed exceeds 80 km/h.

On the movement experiment for slow speed, examinee traced near the fundamental geospatial data with GPS and LEX antenna. After the experiments, output data was compared with based map information and LEX and GPS solution on GIS. Figure 7 shows result of slow speed movement experiment. In this figure, FIX and FLOAT solution was completed in north-south direction, however LEX solution did not get in the east-west movement.

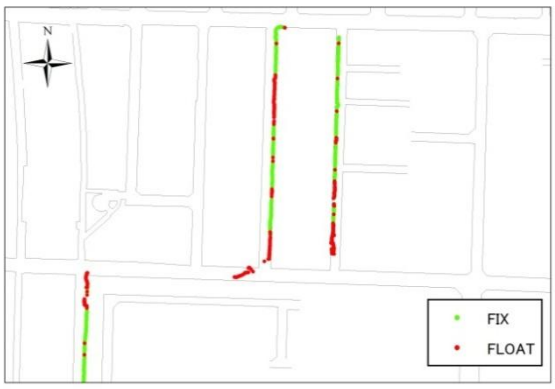


Figure 7: Low speed experiment result

As a result, slow speed movement experiment using LEX signal contributes renewal of fundamental geospatial data in detail and it has more advancement to improve the geographical spatial information.

5. CONCLUSIONS

Time required for a LEX signal to FIX was longer than VRS-GPS. In the experiment which observed time less than 5min, LEX signal was the almost same result as the accuracy of VRS-GPS. Even when an experiment was long time, the number of GPS did not affect the accuracy of the LEX signal. When the orbit of QZS became low, the LEX signal was able to be received in the southern open sky area and at that time, LEX solution had been keeping high accuracy too. On the other hand, in the high speed experiment using LEX signal, surveying accuracy became unstable near 100km/h. Reason of those results was affected by many factors which are satellite position, mobile speed and other measuring condition. The factor which influences the accuracy of a LEX signal was not able to be specified in the experiment including high speed experiment. Moreover, we have to find the factor which has on satellite positioning. For example, there are walking speed movement angle etc. This time supplement signal from QZS could not use because of the problem stem from LEX receiver system. If it will have a chance of next experiment, we want to confirm QZS signal equivalent to a GPS signal be able to increase the accuracy of positioning. When QZS will be four sets, exact position information can be acquired also in the valley of a building, forest of mountain area and its similar place which were not able to be observed by GPS.

REFERENCES

References from Books:

[1] S. Sugimoto and R. Shibasaki,2010 GPS hand book pp.258-273

[2] S. Nishi,2010 All of GNSS pp.335-341

ACKNOWLEDEMENTS

We would like to express my deepest gratitude to Mr.Matuoka and Mr.Miya who provided carefully considered feedback and valuable comments, and thanks to Mr.Kita and Mr.Tanaka whose meticulous comments were an enormous help to me. Finally, a part of this research was done by assistance of Grants for Science Research.