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The Multi-GNSS Issue and Military Application

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ABSTRACT : *One of the hot issues on GNSS might be that China declared to broadcast the signal of the new Global Navigation Satellite System called Beidou-Compass in December 2011. The multi-GNSS systems with the existing GPS and GLONASS consist of more than 100 GNSS satellites and transmit their signals in near future. Many benefits are expected in accuracy, availability, integrity and increasing anti-jam performance. In this presentation, we have mainly investigated the latest issue for multi- GNSS and discussed spectrum analysis as well as the accuracy improvement issue. The use of the modern weapon system based on satellite navigation information was also briefly investigated in warfare.*

KEY WORDS : GNSS,Compass, modern weapon, warfare

1. Introduction

In recent, one of the hot issues on GNSS(Global Navigation Satellite System)might be that China declared to broadcast the signal of the new Global Navigation Satellite System called Beidou in December 2011. China also has conducted for the whole constellation over the earth by three steps. Therefore, the future multi-GNSS systems with the existing GPS and GLONASS consist of more than 100 GNSS satellites and transmit their signals in near future. One may expect that the new developing system is able to contribute to not only extend the user's choice of satellite navigation system but also enhance navigation quality parameters. And then the global service will be available for civil and military in various areas.

In fact there has been security and military concerns in view of the western countries and US since China started to develop its own global navigation system in early 2000 because informations obtained by GNSS plays a key role to control the modern weapon system. The issues on characteristics of multi-GNSS including the recent Beidou- Compass have been investigated by several researchers[1,2]. However, none of these has not focused on the modern weapon systems. In this presentation, the latest circumstance and the acciracy improvement based on multi- GNSS are investigated. We briefly discussed how multi- GNSS can impact to the modern weapon system or the future warfare.

2. Investigation on Multi-GNSS Development

GNSS is generally called the satellite navigation system which has the global coverage in signal service. It provides 3-D position, velocity and time which are available in precise, realtime and continuous manner. Today there are several GNSSs such as the globally operational GPS, GLONASS, Compass transmitting satellite navigation signals and Galileo under developing. In addition, France, Japan and India are also developing their regional satellite navigation systems. The latest issues on major GNSSs are investigated as below.

China officially announced that Compass has been offered navigation data, position, and timing in December 2011. Currently, 10 satellites of the system are transmitting signals and covering from Australia in the south to Russian in the north. Additional six satellites would be launched in orbit by end of 2012, and then its coverage referred to Fig.1 also seems to extend to most part of Asia. Futhermore, it is known that the total of 35 satellites will offer global coverage by 2020[2,3,4]. The development of Compass has been

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developing in three steps as follows;

***Step 1**: 2000 – 2003: experimental BeiDou navigation system consisting of 3 satellites*

***Step 2**: by 2012: regional BeiDou navigation system covering China and neighboring regions*

***Step 3**: by 2020: global BeiDou navigation system*

The system will be a constellation of 35 satellites(5GEO(geostationary orbit)+ 30MEO(medium Earth orbit) satellites. The opened free system will have accuracy of 10m , 50 ns timing, and 0.2 m/s. The limited service will be more accurate than the free service.

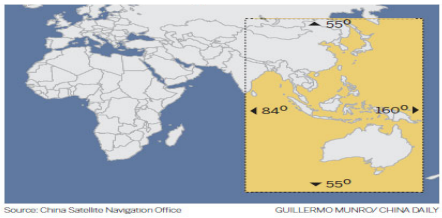

Fig 1. The Current Compass Coverage Declared by China

The two Galileo satellites for IOV(In-Orbit Validation) will be launched in October, 2012. These satellites will be working with the first two Galileo satellites launched last year. The launching is the significant step because it is the last step for the IOV phase to go forward FOC(Full Operational Capability) and can provide positioning based on Galileo satellites. The initial operational capability of the system is expected in 2014. Full completion of the 30 satellites Galileo system (27 operational + 3 active spares) is expected by 2019. The system will provide 1m positioning accuracy and a global Search and Rescue (SAR) function[5,6].

24 GLONASS satellites are currently operating and serving for global coverage since October 2011. The system accuracy, 4.46－7.38 m with 7－8 satellites, is officially opened by Russian System of Differentional Correction and Monitoring. The accuracy is close to GPS. The most attactive improvement is to start to transmit CDMA signals, which has been transmitting in L3, since the first launch of GLONASS-K2 satellite in February 2011. The system is scheduled to have 24 satellites transmitting both the new CDMA and legacy FDMA signals through 2020 and its accuracy is expected to reach to 0.6m by the year. The outstanding improvement of GLONASS will improve the various navigation parameters such as accuracy, compatibility with other GNSSs and interoperability with other GNSSs[7].

There are currently 31 healthy satellites in constellation, which are 10 Block IIA satellites, 12 Block IIR satellites, 7 Block IIR-M satellites and 2 Block IIF satellites. GPS is broadcasting a civil signal at L1, second civil signal L2C designed to meet commercials needs from 7 Block IIR-M satellites(full capability/24 satellites by 2016) and third civil signal L5 designed to meet demanding requirements for transportation safety by 2 Block IIF satellites(full capability/24 satellites by 2018). In addition, the fourth civil signal L1C designed with international partners for interoperability will begin to transmit signal with GPS III in 2014 and will be expected with 24 satellites by 2021. The GPS Modernization effort focuses on improving positioning and timing accuracy, availability, integrity monitoring support capability, and enhancement to the operational control segment. Table 1shows the road map for GPS Modernization status. Specially, GPS III satellites will improve accuracy, availability, and integrity and provide increased anti-jam performance to meet for the future civil and military users[7,8,9]

3. Spectrum Analysis and Enhancement Issue of Multi-GNSS

3.1. Frequency Allocation of Multi- GNSS

All the GNSS frequencies are very similar ones allocating from a little below 1200MHz to around 1600MHz. These frequencies are shared by other GNSSs such as the EU's Galileo, China's Compass, and by Russia's GLONASS. In addition, their signal powers have been known so weak around as low as -160dbW(1×10^{-16}w, in case of a ordinary GPS) in the surface receivers. The GNSS's signal strength can not be dramatically increased even the modernized GNSS and military receivers because of the long distance between navigation satellites and receivers on the earth surface. Therefore the users receivers are easily vulnerable by the unintentional or intentional interference, and resulting in loss of the navigation informations such as positioning, velocity and timing

can lead users to dangerous situations

One of the significant example might be the issue of interference by LightSquared's wireless broadband communications network, which cover across the United States using frequencies near the band used GPS. The interference testing and studies were conducted by many by vrious groups including the DOD,FAA,NASA, GNSS companies, LightSquared. The results were released at the end of June 2011. It has known that there was no practical way to mitigate potential interference at this time, and also tested that a GPS receiver near LightSquared's base station transmitting high-powered could not filter out the level of power. Accordingly it seems that GNSS's receiver, which is affected by the communication systems transmitting close frequencies to satellite navigation systems, can be overloaded by rf signals[9,10,11].

3.2.Perspective on Multi-GNSS Application to Modern Weapon System

GNSS has widely used for weapon positioning, movement, tracking
,rescue and map update since the Gulf war. It has also verified that GNSS providing real time 3-D coordinates, velocity and timing could play a key role in modern warfare. Specially, it also has applied to missile, smart bombs and UAV. It has shown that C4ISR+PGM have rapidly advanced and played a key role in several battle fields.

Fig. 2 The Overview on the Modern Warfare

According to the statistics[12,13], there have been the dramatic use of in modern wars. One can expect that C4ISR+PGM based on multi-GNSS having various advantages will be getting important in future warfare.

4. Conclusion

As mentioned previously, multi-GNSS seems to be completed in near future, and then many benefits are expected in accuracy, availability, and integrity as well as increasing anti-jam performance. In this presentation, we have mainly investigated the latest issue for multi GNSS and discussed spectrum analysis and the accuracy improvement issue. The use of C4ISR+PGM with satellite navigation information was also investigated in modern war. This presentation is a work for going to a complete research under processing. It will be released in near future.

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