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MADOCA(Multi-GNSS Advanced Demonstration Tool for Orbit and Clock Analysis) development status for Multi-GNSS Era

KOGURE, Satoshi[1*]

[1]Satellite Navigation Office, Space Applications Mission Directorate I, JAXA

For past two decades, U.S. Global Positioning System (GPS) has been almost sole reliable operational system for space based Position, Navigation and Timing. Recently, other countries, Russia, China, EU, India and Japan, are competing in the efforts to establish their own Global Navigation Satellite System (GNSS) or Regional one in order to seek secure and effective social infrastructure, and economical growth.

In present, two GNSS, U.S. GPS and Russian Glonass, are operated and China is pushing their national program strongly, BeiDou has started regional service with 14 satellites in Asia pacific region since December 2012. European Galileo is progressing to launch its initial service in 2015-16, though their latest two Full Operational Capability (FOC) satellites could not reach planned orbit slots due to the upper stage failure of launch vehicle, unfortunately. India has just started their regional satellite navigation system, IRNSS, three satellites has being launched already. As for Japanese QZSS, adding QZS-1 orbiting since 2010 to three additional satellites, Japan will provide GPS interoperable signal for Eastern Asia and Oceania region as well as augmentation service for Japan in 2018.

Forecasting the situation in 2020, more than 120 navigation satellites will orbiting around the Earth and more than 30 satellites are to be available to use even in town in this coming multi-GNSS era. The utilization of multiple GNSS constellation is expected to resolve one of the drawbacks of satellite navigation which is difficult to use in dense urban area. Especially, carrier phase positioning in urban canyon is still big challenge, since surrounding building can easily block satellite signals, cycle slip and signal loss occur frequently. However, multi-GNSS signals can facilitate to get positioning solution even in the such severe condition. In addition, use of multiple system contributes to more dense atmospheric delay measurement such like Slant Tropospheric Delay (STD) which is useful to monitor the distribution of precipitable water rather than conventional ZTD estimation with only GPS observation.

Toward the future multiple GNSS environment, Multi-GNSS Advanced Demonstration Tool for Orbit and Clock Analysis (MADOCA) has been developed by Japan Aerospace Exploration Agency (JAXA) which supports all usable GNSS constellations. The current version of MADOCA can estimate precise orbit and clock offset for GPS, GLONASS, Galileo and QZSS. The final product for GPS and GLONASS generated by post processing analysis with more than 80 observation at Multi-GNSS Monitoring Network (MGM-Net) and IGS sites is comparable to IGS final product within a couple of centimeters. Supporting BeiDou will come in near future update in 2015. In parallel with MADOCA development, the development of its applications on Precise Point Positioning (PPP), which we call ”MADOCA-PPP” are being conducted. The first satellite of QZSS, Michibiki, has an experimental signal (LEX) which can transmit 2000 bps data stream on 1278.75 MHz with BPSK(5) radio signal. JAXA is routinely generating error correction message for MADOCA-PPP, broadcasting it via LEX signal and evaluating its performance. Current performance of MADOCA-PPP is sub-decimeter accuracy (RMS) for both horizontal and vertical direction in real time processing.

The latest status of the MADOCA and MADOCA-PPP development is described with performance test results. In addition, current technical challenges are introduced and how to resolve them are also discussed in the presentation.

Keywords: Multi-GNSS, Precise Orbit and Clock estimation, Quasi-Zenith Satellite System, MADOCA, PPP/PPP-AR