Satellite Autonomous Navigation for Korea Regional Navigation Satellite System with No Ground Links

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This study presents satellite autonomous navigation for Korea Regional Navigation Satellite System (KRNSS). KRNSS is now at preliminary research stage for the purpose of providing regional navigation service to East Asia. Its candidate constellation consists of four elliptically-inclined-geosynchronous-orbit (EIGSO) and three geosynchronous-orbit (GEO) satellites such that at least four navigation satellites are always visible above Korea peninsula.
While observation and ephemeris upload from ground segments are available in usual mission period, there can be potential vulnerability of loss of ground links. If satellites' orbit ephemeris update from ground segment are unavailable for relatively long period, the orbital accuracy of the satellite decreases gradually, and the navigation system would ultimately break down. The satellite autonomous navigation is developed to overcome this abnormal situation. It enables satellites to self-determine its orbit and maintain their ephemeris in high accuracy without any ground communications. GPS has so far demonstrated its own autonomous navigation system (AutoNav) with GPS II-R, GPS II-F, and GPS III. In doing so, an inter-satellite ranging (ISR) technique was introduced to cover the period with no ground-based observations. AutoNav allows satellites to perform its mission for at least 180 days without ground contacts [1].
We first discuss the obtainability of ISR measurements for KRNSS. ISR data cannot be obtained if an observer satellite is hidden from a target satellite by the Earth or its atmosphere. We analyze these unobservable periods by simulation, in which the ISR measurements assume Gaussian random noise that describes potential error occurred by ISR hardware and delay.
Then, the performance of autonomous navigation by using ISR measurements is assessed. We follow the sequence of GPS AutoNav that estimates the orbit of each satellite with obtained ISR measurements. The associated results are shared by inter-satellite crosslinks. The extended Kalman filter algorithm is used to determine the satellite orbit. We analyze the effect of the ISR measurement precision on the autonomous navigation accuracy depending on the magnitude of noise.
According to our preliminary results, the autonomous navigation of KRNSS may highly increase mission lifetime in scenario with no ground communication, while its orbit diverges instantly when it is propagated without any autonomous navigation update under no ground links. These simulation results also indicate that they are applicable to the development of regional navigation satellite system as an indicator of determining the navigation accuracy and ISR hardware requirements.

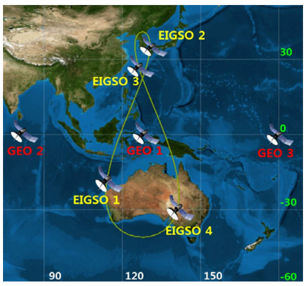

Fig. 1. Ground Tracks of the KRNSS

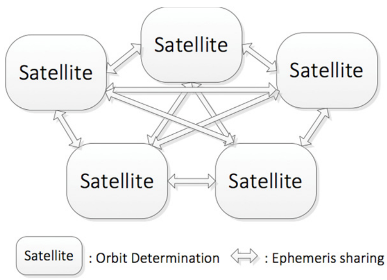

Fig. 2. Satellite Autonomous Navigation Diagram

References
[1] J. A. Rajan, Highlights of GPS II-R Autonomus Navigation, *Proceedings of the 58th Annual Meeting of the Institute of Navigation and CIGTF 21st Guidance Test Symposium*, 2002, pp. 354-363.