SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Mobile Satellite Communications and Navigation Technology (7)

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THE RESEARCH ON SIGNAL VISIBILITY OF MULTI-GNSS CONSTELLATIONS FOR CHINA'S FUTURE LUNAR MISSIONS

Abstract

With the successful landing of Chang'E 3 (CE3) lander carrying the Yutu rover at the end of 2013, China becomes the third country ever perform the lunar feat. However the dependence on ground-based measurement and control system leads to a high cost of manpower and finance over the 3 months mission period. Beijing Aerospace Control Center (BACC) is trying to find an autonomous and low cost approach to prepare for the future lunar missions. It is believed that using the Global Navigation Satellite System(GNSS) to do the lunar explorer autonomous navigation is a feasible mode. GNSS signals are designed for users on or near the surface of the Earth, which means the transmitting antennas are earth-oriented and the signal power is limited. Hence only the signals from 'the other side' of the Earth can be received from above the constellations. It is widely acknowledged from decades of researches on using GPS to do LEO even HEO satellites autonomous navigation that the primary obstacle is the sparse and weak nature of GPS signals for space users. Fortunately the blooms of new GNSS constellations makes this approach potentially more favorable. Seldom researches have been done to investigate the signal visibility of multi-GNSS constellations for lunar explorers. The concept of visibility contains two ideas: the light-of-sight is not obstructed, and the received signal power is sufficiently high for the receiver

to do acquisition and tracking. This paper analyzes the multi-GNSS signal visibility for a hemispherical GNSS antenna mounted on board operating in a CE3 Earth-Lunar transfer orbit. Firstly, a scenario including CE3 and four GNSS constellations (GPS, GLONASS, Galileo and Beidou) is modeled; The GNSS antenna is assumed to be earth-oriented while flying above the constellations and the opposite orientation while flying below the constellations. Secondly, the variation of the unobstructed satellite number with time with a set of antenna cut-off angles is analyzed and accordingly a relatively optimal cut-off angle can be obtained; The GNSS side-lobe signals are used in particular. Thirdly, the relationship between visible satellites' number and receiver tracking threshold in the case of the relatively optimal cut-off angle is studied ,based on which the most favorable threshold required for navigation is obtained. The numerical results of this paper can be beneficial to the design of space GNSS receivers and new GNSS satellites/signals for the future applications in China's lunar missions.