Paper ID: 43707
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IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Interactive Presentations - IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (IP)

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NAVIGATION PERFORMANCE ANALYSIS FOR LUNAR PROBE BASED ON SVLBI DEVELOPED BY NAVIGATION CONSTELLATION

Abstract

With the expansion of the spacecraft flight range, especially the development of deep space exploration missions, traditional ground-based measurement instrument are facing with many challenges. Researchers began to turn their attention to the space measurement system. Therefore, space very long baseline interferometry system (SVLBI) has been proposed and validated. The global Navigation Satellite System (GNSS) possessed high accurate orbit and time-frequency, thus can form baselines over a long span and large airspace. Therefore, constructing SVLBI by GNSS a novle attempt for deep space exploration, which is also a new attempt to expand GNSS applications. However, comparing to the ground-based VLBI, the high dynamic time-varying baseline brings many new problems in the new GNSS-SVLBI. System construction and performance optimization rely on a comprehensive understanding of its characteristics. In this paper, navigation performance for lunar probe by GNSS-VLBI is studied. The observation equation is established firstly based on the measurement of space VLBI and the orbit of GNSS. Then, the calculation of theoretical time delay for the system when observing lunar probe is given, and the systematic error composition and influence are discussed in detail. Furthermore, based on measurement geometry of GNSS-VLBI and the theory of error propagation, the coverage and accuracy for lunar probe navigation are developed. Finally, theoretical analysis and numerical examples validated the superiority of the new system over the traditional ground-based VLBI. A lunar probe with an altitude of 300km was selected for simulation, which is observed by GNSS-VLBI and ground-based VLBI respectively. The GNSS-VLBI is constructed by BeiDou navigation system with satellite No.01 to No.14. The ground-based VLBI station refers to Chinese VLBI network(CVN) in Beijing, Shanghai, Kunming and Urumqi. The results show that baselines of BeiDou have more than 30% visible time than those by ground-based systems. Meanwhile, the MEO satellites provide good complementarity to the GEO satellites. It also can be seen that different space baselines have advantages and disadvantages in different flight stage. But the navigation accuracy is significantly better than the ground-based VLBI up to 1 to 2 orders of magnitude. Especially, the fast orbit changes of the MEO satellite can improve the system coverage and the long baseline of GEO can improve the observation accuracy. The proposed method here can be applied to the baseline optimization of space VLBI, as well as be helpful for demonstrating the feasibility of constructing space VLBI by GNSS.