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COMPATIBILITY AND INTEROPERABILITY OF THE ORBITAL CONSTELLATIONS OF GLOBAL NAVIGATION SATELLITE SYSTEMS

Abstract

Nowadays, there are four Global Navigation Satellite Systems (GNSS) have been put in orbit. American GPS consists of 32 satellites, 31 satellites are operational, and one satellite is in maintenance. Russian GLONASS consists of 27 satellites, 24 satellites are operational, one satellite is under check by the satellite prime contractor, one is in flight tests phase, and the other one is the spare satellite. Chinese BeiDou Navigation Satellite System (BDS) completed regional deployment phase on December 27, 2012, which includes 14 satellites. By 2020, 35 BDS satellites will have been sent into space, providing service to users around the globe. European Galileo has launched 18 satellites, and will complete the construction of the whole constellation by 2020, which will include 30 satellites. The Medium earth orbit (MEO) region will be more and crowded, and the safe operation of the four GNSS constellations will be the first priority problem.

This paper will firstly define the concept of constellation compatibility and constellation interoperability. Constellation compatibility means the operational GNSS satellites, the decommissioned GNSS satellites and the spent upper-stages of one navigation system do not interfere with the other. Constellation interoperability means when multiple GNSS systems broadcast open service signals, the observation geometry, the visible satellite number, the service accuracy of end user everywhere, and the availability and reliability under bad visibility shall be improved.

Secondly, the navigation performance of the four GNSS constellations will be analyzed under different elevation angles, separately. The constellation value will also be provided. The combined navigation performance of any two GNSS constellations will be analyzed under different mask angles, and these results will also be compared with each other.

Then, the long-term evolution of the space debris and operational navigation satellites in the MEO region will be performed; the evolution time is 100 years. The collision probability will also be computed.

This paper focuses on the compatibility and interoperability of GNSS constellations. The analysis indicates that the combined navigation performance will be greatly promoted, especially under high elevation angle. The theoretical collision probability of MEO region is about the 10-7 level. Further research will focus on the optimal disposal orbit design for the GNSS space debris.