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AUGMENTATION OF GNSS FOR CISLUNAR NAVIGATION EXPLOITING EARTH-MOON LIBRATION POINTS

Abstract

The renovated interest towards Moon exploration has led to an increase of technological activities aiming at providing services in a new scenario, in which Institutions and companies expand their sphere of interest in the Earth-Moon System. One of the fundamental space assets used on Earth is GNSS, and it is gaining considerable attention related to orbital activities around Earth, as long as receivers are operational spacecraft subsystem since decades, used to increment Orbit Determination capabilities to perform mission tasks with improved accuracy, contributing to time synchronisation and optimal telecommunication and control. Generally, an Earth-focused GNSS is not optimised for space applications, which is the case for several of the maiden versions of present Systems. But the use of GNSS in the Space Service Volume, i.e. up to Geosynchronous Orbit heights, has received particular attention in recent years, despite the limitations that are a direct consequence of system nature and that become heavier the farther from Earth. New mission concepts are becoming a reality (e.g. in-orbit servicing) and the space traffic around Earth is becoming increasingly populated by active spacecraft, with a parallel effort of minimising non-operational spacecraft and in general non-cooperative bodies (e.g. space debris). As long as the trend affects all the orbital regimes, the need for an augmentation of GNSS capabilities in space is more evident for the higher layers. As long as the number of spacecraft rises, including manned missions, spaceborne autonomy also in terms of navigation helps relieving the effort of ground segments. In transfer orbits from Earth to the Moon, and more generally in the Cislunar Service Volume, i.e. up to Lunar orbit, navigation subsystems based on the fusion of several sensors that include GNSS receivers are under study and development. Nevertheless, the use of a single GNSS constellation as a stand-alone Position-Velocity-Time provider is hampered fundamentally by scarcer availability and continuity of Signal In Space, by unfavourable geometric distribution of the sources that worsens Dilution Of Precision, and by navigation signal power thresholds. The present paper aims at analysing the concept of a GNSS Augmentation System for trajectories in the Cislunar Service Volume, that takes advantage of Earth-Moon libration points (in particular L4 and L5) in order to address the limitations of present Earth-focused GNSS constellations that are not able to provide sufficient Dilution of Precision, Availability and Continuity performances for future autonomous spacecraft navigation and improved ground mission support tasks relying on GNSS.