Ground-Based Preparatory Activities (11)
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LUNAR PNT SYSTEM CONCEPT AND SIMULATION RESULTS

Abstract

The revived interest of many countries and the growing number of ongoing and scheduled missions to the Moon increase the significance of supporting navigation systems development. Numbers of publications are based on multi-GNSS signals reception from the opposite side of the Earth using high-gain antennas and lunar augmentation constellations. While the accuracy of such systems could be sufficient, the PNT service dependency on circumterestrial navigation sources prevents the use of advanced navigation technologies honed in circumlunar space for further Mars and other celestial bodies missions, which is one of the major goals of lunar exploration. Moreover, orbit determination and time synchronization (ODTS) methods description and estimations are usually skipped in the studies of lunar augmentations.

Alternative concept of Lunar Navigation Satellite System (LNSS) is proposed based on Earth-dependency reduction principal and onboard ODTS. The advantage of the proposed approach is that LNSS-like systems could be adapted for other celestial bodies taking into account such aspects as e.g. their shape, dynamics, perturbations as well as exploration priority regions.

The baseline LNSS constellation of three circular orbits with three satellites each has been chosen as the results of multi-criteria analysis of orbital stability and geometry. The station keeping requires less than 15 m/s for 10 years without significant changes in navigation performance in prioritized Polar Regions.

The full cycle of LNSS operation from ODTS and signal generation to its reception, processing and obtaining navigation solution has been simulated to obtain positioning accuracy for different types of users. Positioning accuracy of space users in approach/departure phases, in near-lunar orbits as well as static users on a lunar surface confirmed on a level of a few tens of meters. The same accuracy is achievable

by dynamic users on a lunar surface during route stops, or also in motion in case of LNSS constellation expansion, or deployment of ground-based augmentation beacons in on-site exploration zones.