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ON A LOW INVESTMENT AND STEP-BY-STEP CONSTRUCTION OF A NAVIGATION AND TRAFFIC CONTROL SYSTEM AROUND THE MOON

Abstract

Numerous studies have been conducted to explore positioning in cis-lunar space using the global navigation satellites system (GNSS) signal through the side lobes of GNSS satellites. The main challenge arises from the short baseline length that the GNSS constitutes. And the geometric dilution of precision (GDOP) increases significantly. The clock synchronization requires the positioning to be established simultaneously. When relying on classical radio transponders, it may not work quickly and leaves a significant amount of tasks on the operations, especially in navigation, making it an unfeasible choice. The new asynchronous one-way ranging (AOWR) scheme introduced here functions through a pair of entities, such as the ground station and the spacecraft. The timing is obtained simultaneously with the measurement of distance. In cis-lunar space, one solution is to replace clock synchronization provided by the AOWR scheme instead of relying on GNSS. It is a combination of AOWR and GNSS, which results in positioning based on a smaller number of measurements. It improves the DOP by reducing the number of estimates. Here, the master clock can be installed aboard the lunar gateway station. It provides useful positioning for spacecraft flying from Earth to the moon. Fundamentally, the key challenge in lunar exploration is not providing positioning services for mobile rovers, but ensuring fast and accurate navigation for transportation vehicles as they approach the designated landing area. There are not a huge number of users on the moon's surface who expect a positioning service with only receiving capability. The digital elevation map (DEM) of the moon is available, and terrain-based optical navigation is sufficient for meeting the positioning requirements of the rovers, as there are no weather issues on the surface. So, even with scattered landers whose position is identified after the landing, with the AOWR scheme, they constitute the surface-based navigation network servicing real time positioning to the transporters approaching to the landing area such as southern polar area. To synchronize the clocks on scattered landers, the master clock onboard the lunar gateway will operate in a similar manner. From this point of view, the lunar gateway is conceived to play a traffic control role. The network will further expand by increasing the number of orbiters positioned via the method, aiming to establish global coverage. The paper presents a step-by-step approach to constructing the navigation system around the moon.