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CONCEPTUAL DESIGN OF A LUNAR GNSS CONSTELLATION BASED ON CUBESAT TECHNOLOGY

Abstract

According to The Global Exploration Roadmap, the next milestone in space exploration is envisaged upon the long-term presence of humans in the vicinity and on the surface of the Moon, also in preparation of future Mars colonization. In detail, the main relevant goal is the design of a permanent lunar base and, in parallel, of a Lunar Orbital Platform aimed to scientific and technological development, along with the exploitation of the in-situ resources. In order to increase safety and effectiveness of future external activities on the lunar surface, a reliable and fast delivery navigation system represents a great advantage to set an effective bridge towards next space exploration.
As a consequence, this significant potentiality leads to the need of deploying satellites in lunar orbit to enable a navigation service ensuring a complete global coverage of the lunar surface. Considering the technology evolution towards hardware miniaturization and the need to keep costs under control, this paper presents a preliminary design of innovative lunar Global Navigation Satellite System (GNSS) based on a constellation of CubeSats, drawing guidelines to support the follow-up investigations. The exploitation of Multi-Attribute Utility Theory (MAUT) has guaranteed an effective and value oriented design of the space segment. Therefore, this activity is carried out by assessing a set of specified mission attributes and aggregating utility functions while estimating mission costs, increasing design quality whereas reducing design iterations compared with traditional design methodologies. Moreover, a rapid exploration of the tradespace Pareto front allows the selection of the optimal mission architecture.
The results have definitely proven that the selected mission concept is suited in supporting operations on the lunar surface, lowering launch costs and improving flexibility of the space segment. A 100% coverage of the Shackleton crater and the lunar south pole, the most interesting site to establish the future lunar outpost, has been guaranteed. In addition, particular attention has been reserved to the technological roadmap required to push the technology readiness level (TRL) towards to a more reliable architecture.
Eventually, the design process has been integrated into a concurrent design environment to validate and further optimize the final architecture including also manufacturing and programmatics issues. The outcomes highlight great benefits in terms of supporting future lunar manned mission and related innovative scientific and economic scenarios, coherently with the foreseen exploration roadmap.