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A NOVEL AND SUSTAINABLE APPROACH TO DEVELOPING LUNAR COMMUNICATION ARCHITECTURE FOR HUMAN SETTLEMENTS AND ROBOTIC EXPLORATION

Abstract

After decades of the first moon landing by a human, major space agencies such as NASA, ESA, ROSCOSMOS, JAXA, CSA and, ISRO are planning for sustainable long term stay on the lunar soil. One of the critical challenges of human spaceflight and settlements on Moon is connecting them to Earth for technical and psychological reasons. This paper focuses on the systems engineering approach to develop a conceptual design of a robust communication architecture both in terms of audio and video communication with Earth. To achieve this, it is necessary to have continuous coverage of the lunar village. A SmallSat constellation is proposed to achieve this. The constellation will have continuous data transmission via Inter-Satellite Link (ISL) and transmits data to the lunar gateway in Near-Rectilinear Halo Orbit (NRHO). Further, link budget calculation of the constellation and lunar gateway is presented. The transmission link between the lunar village and the lunar gateway, Inter-Satellite Link (ISL) between SmallSats orbiting the moon, will employ S-band. The space segment of this architecture is powered by Space-Based Solar Power (SBSP). This provides the opportunity to have a continuous link specifically for SmallSats constellation. The direct link of Moon-Earth is operated in V-band which is less occupied and has high enough throughput for video communication. To justify the effectiveness of V-band for this purpose, an extensive trade-off study is presented for different available bands. This architecture also integrates communication with exploration rovers to support robotic explorations of the Moon. Finally, challenges and opportunities are discussed for sustainable settlement on the Moon and further exploration of the interplanetary human settlements. This independent research activity is conducted by graduate students satisfying long term vision of Skoltech Space Center.