Paper ID: 58465
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IAF SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 3 (2C)

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PRELIMINARY STUDIES OF THE USE OF REFLECTED SUNLIGHT, AS A SUSTAINABLE SOLUTION FOR ILLUMINATION AND HUMAN COMFORT AT LUNAR OUTPOST

Abstract

After a couple of decades of the only human settlement in outer space - the international space station - is approaching its retirement. The next space exploration frontier is the Moon, then Mars. Various missions were proposing human settlement on Cislunar orbit or on the lunar surface. In such an extreme environment, the habitat - designed with a pure engineering approach - becomes the only space for the astronauts' existence, far away from any support from Earth. Thus, planning the human, long-term lunar exploration experts in related fields seek for solutions answering technological challenges, at the same time responding to the habitability issues, ensuring not only survival but also the psychological and mental health of the inhabitants.

Due to the protection from harmful solar radiation and proximity to the most precious resource on the Moon - frozen water, it is often suggested that good localisations for the establishment of the lunar outpost are permanently dark craters. To maximize the site potential, and improve its habitability quality, we propose the use of reflected natural lighting, for the establishment of sustainable illumination solutions of this - permanently shadowed - outposts. The proposed system - introduced as a part of the lunar outpost infrastructure - uses curved mirrors to reflect light and heat from the rim to the base of the craters, while still not reflecting the high energy harmful sun radiation. It would enable permanent control over the temperatures around the base, which reduces the need of thermal insulation on the outpost, and, at the same time, it would provide the possibility to simulate a twenty-four-hour day-night cycle imitating the human circadian rhythm, enhancing mental and physical health of the inhabitants.

This paper presents an investigation of the various reflective materials, metamaterials, and surface patterns, with a focus on their anti-reflectivity and reflection of high energy solar radiation, and their durability in the harsh vacuum environment, to achieve safe reflectance of sunlight to the lunar colony. The design and degree of the curvature of the mirrors is decided based on iterative experimentation and computer simulations, the most efficient angle is expected to provide the desired temperatures sufficient for the colony and the adequate light and shade balance to simulate the Earth's circadian rhythm.