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RADIATION SHIELDING FOR LONG-TERM LUNAR SETTLEMENTS WITH REGOLITH AND OTHER ISRU OPTIONS

Abstract

With numerous organizations increasing their scientific interests in the Moon, and NASA's Artemis Missions set to establish a permanent lunar base, a critical concern remains: how do we ensure the long-term survivability of humans in the hostile lunar radiation environment? The Moon lacks both an atmosphere and a magnetic field, exposing the surface of the Moon to a bombardment of Galactic Cosmic Rays and Solar Energetic Particles. Without effective radiation shielding, prolonged exposure can lead to increases in cancer, radiation sickness, and other physiological effects. Comparing the proposed NASA total career exposure limit of 600mSv to the exposure experienced from the Apollo missions emphasizes the need for a robust shielding infrastructure. At the rate Apollo 14 astronauts were exposed, astronauts on a lunar base with the same amount of shielding would have under 100 days before reaching their career radiation exposure limits. Yet, transporting radiation shielding material from Earth to the Moon is technically challenging and economically prohibitive. To avoid these challenges, the utilization of in-situ resources for radiation shielding is paramount. This paper examines the effectiveness, cost, and feasibility of utilizing lunar regolith for shielding purposes. A radiation analysis is presented using the OLTARIS program and the Badhwar-O'Neil (BON) BON2020 model with an examination of the varying ISRU shielding construction options based on geological location. Our results show that for a habitat constructed from only regolith, the total radiation dose increases with regolith depth up to approximately 1 meter due to the presence of secondary radiation. The paper concludes that at least 2m of regolith shielding is required, corresponding to an exposure of about 150mSv per 180-day mission. Increasing this thickness to 3m results in approximately 100mSv of exposure. It should be noted that this value does not include any other type of shielding material, and no excursions outside of the habitat, both of which would affect the exposure rate. The preliminary cost estimates forecast this to be a cost competitive avenue. Lunar settlement costs are largely dependent on launch mass, which can be reduced with these solutions. Three settlement options are studied, with cost estimates weighed against radiation protection, structural integrity, and construction feasibility. Estimates show a cost decrease of
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