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RESEARCH ON EFFICIENT LIFE SUPPORT SYSTEMS FOR SPACE HABITATION ACTIVITIES, CONSIDERING BOTH CREWED AND UNCREWED PERIOD

Abstract

This paper presents an efficient material circulation system that takes into account both crewed periods and uncrewed downtime periods in surface exploration of celestial bodies using pressurized rovers with a few crew members, such as lunar exploration missions in the Artemis program. A crewed pressurized rover is currently under joint development by Japan Aerospace Exploration Agency(JAXA) and a private Japanese company, and is expected to stay on the lunar surface for approximately 45 days, including both day and night time, with a four-person crew using two rovers to explore the destination. The challenge in this activity is the difficulty in implementing a high efficient environmental control life support system (ECLSS). In an environment where the weight of supplies that can be carried from Earth is limited, it is difficult from the standpoint of cost and safety to bring along high weight and high power equipment capable of regenerating air and water consumed by the crew. Therefore, the current expectation is that all life-support supplies consumed during the mission will have to be disposable. To address this issue, this paper proposes a new system architecture with "ECLSS station" that slowly regenerates used air and water by operating with low peak current draw during uncrewed periods. In this proposal, the design of the pressurized rover would continue to use disposable life support systems, but would interface with another independent hardware station dedicated to receiving and regenerating consumed water and air. The station would receive cartridges of silver oxide that have absorbed the carbon dioxide emitted during the activity period and a tank containing urine or spent condensed water. During the next crewed stay, the station will replenish the rover with regenerated clean air and water to support life during the activity period. In order to validate the above concept, this paper presents the break-even point analysis between the ECLSS station framework and a framework using a rover with only disposable systems as a result of improved air and water regeneration rates, based on estimation of Equivalent System Masses (ESM). In this paper, as described above, we discuss a new mission architecture to extend the capabilities of the lunar surface mission in the Artemis program using crewed pressurized rovers, and a new technology for a material regeneration system using the ECLSS station for future human space exploration.