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TRANSFORMING EDEN ISS INTO EDEN LUNA – HOW DLR'S PLANT CULTIVATION SYSTEM FOR FUTURE DEEP SPACE EXPLORATION MISSIONS IS BEING PREPARED FOR ITS NEXT TEST CAMPAIGN

Abstract

Deep space habitats will rely on a dependable supply of consumables like food and oxygen to sustain human life on the Moon and beyond. To address this need, frequent resupply from Earth – while being a reasonable choice for short-duration missions – is not sustainable when trying to establish a permanently crewed lunar outpost. Instead, a closed-loop bio-regenerative life-support system (BLSS) will be needed to produce fresh food and oxygen on-site, while eliminating carbon dioxide and other unwanted waste products. Thus, BLSS technologies have to be developed and tested in a space-analog environment. To this end, DLR has founded the Planetary Infrastructures research group. The group has worked on BLSS for more than 10 years, during which time it has designed, built and operated a greenhouse system called EDEN (Evolution Design of Environmentally-closed Nutrition-Sources) ISS. EDEN ISS was field-tested at the German Neumayer-Station III, located in Antarctica. The purpose of this test facility was to enable research on plant cultivation for human space exploration missions in a multidisciplinary fashion. Objects of investigation ranged from plant health monitoring and microbiology to human factors, but also included food quality and safety as well as system validation. After 5 years in Antarctica and more than 1 ton of biomass produced, the greenhouse was shipped back to Germany, bringing the project to a successful end in 2023. The follow-on project, EDEN LUNA, is currently under development. Its goal is to prepare the plant cultivation system for a second test campaign at the LUNA analog facility in Cologne, where it is used for astronaut training purposes. To this end, the greenhouse is being refurbished and outfitted with upgraded Controlled Environmental Agriculture (CEA) subsystems, while also introducing new payloads like a robotic arm for automated plant health monitoring and handling, a biofilter for nutrient recovery from urine, and AI-based risk mitigation. This paper summarizes the main findings and lessons learned from EDEN ISS, while giving a status report on the development of the EDEN LUNA project. Presenting a system overview, we showcase the most significant advances in BLSS technology at DLR.