Demonstrating the Feasibility of Cryopreservation in Space and Planetary Environments Using CubeSat Storage Units

Claire Pedersen[2], Alvaro Diaz-Flores[1], and Jekan Thangavelautham[1,2]

[1]Space and Terrestrial Robotic Exploration (SpaceTREx) Laboratory

[2]Asteroid Science, Technology and Exploration Research Organized by Inclusive eDucation Systems (ASTEROIDS) Laboratory

The University of Arizona

Earth is facing increased challenges due to rapidly expanding human civilization. The rate of extinction and endangerment of Earth's biodiversity is on the rise. We backup our valuable data, we have financial reserves in case of a future crisis, yet we don't have a backup of Earth's rich biodiversity.

In the past few decades, technology surrounding cryogenics has evolved rapidly as can be seen with the Svalbard Global Seed Vault. We propose the concept of a Lunar Ark within lunar lava tubes that would house cryopreserved samples of seeds, spores, and stem cells until further needed. We chose lunar lava tubes because they have been pristine for 3-4 billion years and are insulated from earthly cataclysms. The moon is only four to five days of travel from Earth making it a short trip if one was necessary. This ark would hold 500 samples of each stored species; a number that was decided upon based on the 50/ 500 rule in ecology. This rule states that for a population to remain viable, short term there need to be 50 members present to prevent from inbreeding and long term there need to be 500 members to prevent from genetic drift. These 50-500 samples would be cryopreserved and held in modular cryostorage units and need to hold up on the 4-5 day rocket journey from Earth to the Moon. Cryopreservation is expected to keep the samples without degradation for decades if not centuries. These cryopreservation systems also have applications to interstellar travel where the long voyage times would require human passengers to be in cryopreservation.

It is critical for us to test our cryostorage unit concept. To start we would like to test out some of the fundamental technologies that will be needed for the Lunar Ark while in space. We propose an on-orbit 3U CubeSat system converted into a cryostorage unit that will need to operate for 5 days in-orbit and demonstrate cryopreservation during transport. A critical technology needed

for these cryo-units is a cryocooler. We are looking into the CryoTel MT, CryoTel GT, and CryoTel CT cryocoolers for this mission and will be performing a trade study in order to determine which is best suited for our mission. All three cryocoolers operate via the Stirling cycle with a compressor efficiency of around 80%. The CubeSat would store 500 samples of a single species for a single week on the ISS before returning to Earth to determine if our samples survived. We will be sending two 250 mL 62-F cryobags; two separate bags are being sent should something go wrong with one bag. The results of this trial would give us a better understanding of the next steps of our ark, as well as our next steps. If the samples return to Earth alive, that will give us the go ahead to continue on with that path while taking lunar conditions into account.