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

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Motivation

Earth is facing increased challenges due to a 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.

We published a paper with IEEE Aerospace focusing on a Lunar Ark design (Figure 1). It is vital that we test our cryo-systems in orbit.

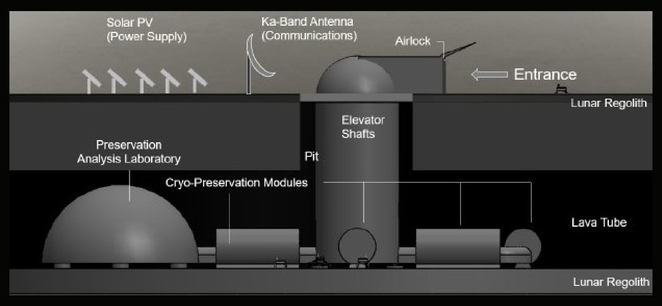


Figure 1: Lunar Ark concept model

Mission Requirements

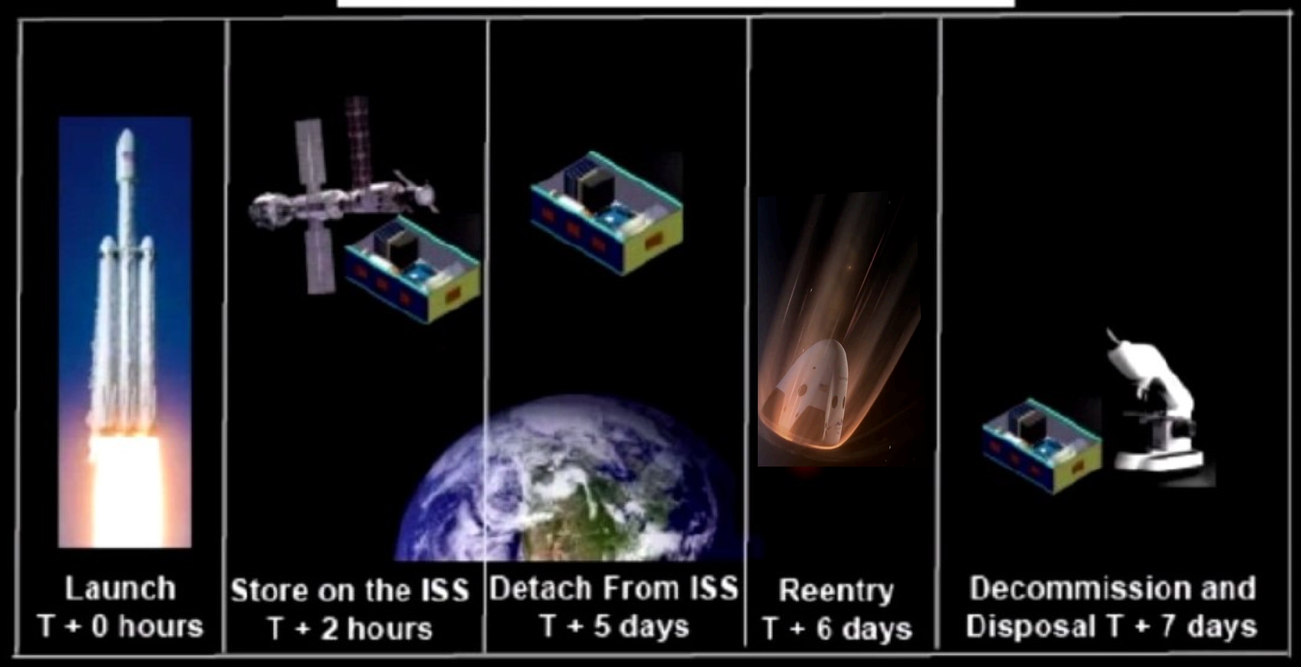
There will be two 20-F cryobags each storing 500 samples of one animal species on board the CubeSat. This number was decided upon bassed on the ecological 50/500 rule stating that in order for a population to remain viable, short term 50 individuals are needed to prevent from inbreeding and long term 500 individuals are needed to prevent from genetic drift (Jamieson and Allendorf, 2021).

Svalbard Global Seed Vault stores containers of approximately 300-500 seed samples (Asdal, 2021)(Figure 2).

In order to be cryopreserved, seeds need to be stored at temperatures of -180° C and cells need to be stored at temperatures of -196° C.

Figure 2: Svalbard Global Seed Vault Seed Samples

Concept of Operations



We plan for our CubeSat to launch, heading to the ISS. Here it will dock and use the ISS's power sitting idle for 5 days while the cell samples remain at temperatures of -196° C. On day 5, the CubeSat will we retrieved by a Dragon reentry vehicle and begin its return to Earth. Once it has returned, the cell samples will be analyzed in order to verify if they are still alive and viable.

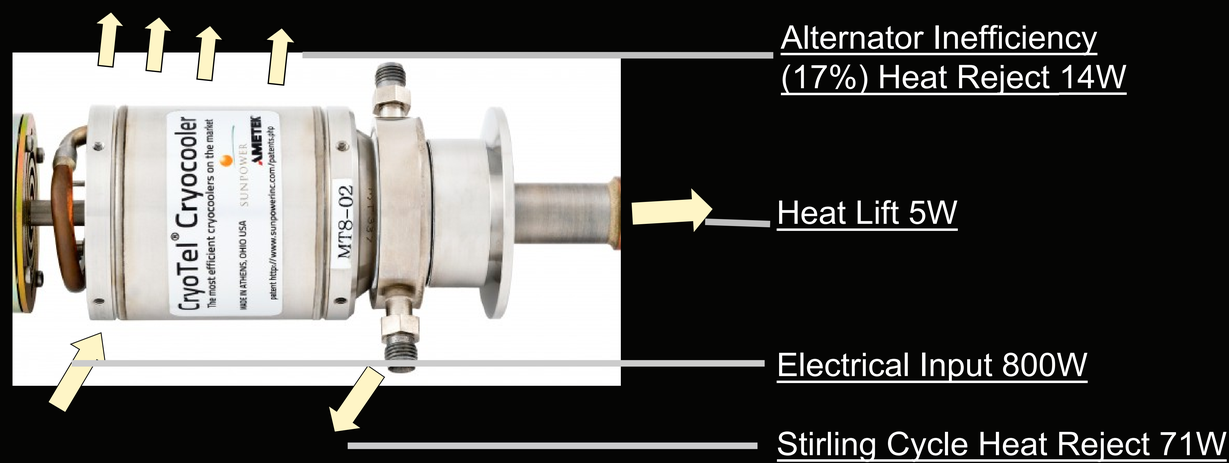


Figure 3: CryoTel MT Cryocooler Energy Flow

The CryoTel MT Cryocooler has a inear temperature variation between the cold tip and the heat rejection system. It works up to cryotemperatures (77K) and has a power lift of 5W while consuming 80W. The effiiency of the cryocooler is ~7%. The heat reject being thrown into the ISS is 75W. (Figure 3)

Figure 5: Stem Cell Cryopreservation

Specifications

These are the specifications for the system of a 6U CubeSat.
Mission: 5-7 Days
Instruments: CryoTel MT Cryocooler
Power: 50W
Battery: TITAN-1
Data Storage: Raspberry Pi

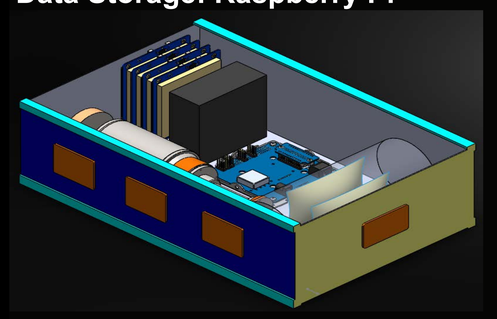


Figure 4: 6U CubeSat

Conclusions

It is critical for us to test the concept of our cryostorage unit. 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 6U CubeSat system converted into a cryostorage unit that will need to operate for 5-7 days in-orbit and demonstrate cryopreservation during transport. The CubeSat would store 1,000 samples of a single species for 5-7 days on the ISS before returning to Earth to determine if our samples survived. We will be sending two 250 mL 20-F cryobags.

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. We predict an early version of the ark to be completed in approximately 30 years. (Figure 5)

References

Asdal, Å., 2021. Discussion on how Svalbard Global Seed Vault runs.

Jamieson, I. and Allendorf, F., 2021. How does the 50/500 rule apply to MVPs?.