Paper ID: 33494
oral
student

IAA/IAF SPACE LIFE SCIENCES SYMPOSIUM (A1)
Interactive Presentations (IP)

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A MINIATURIZED INCUBATOR DESIGN FOR MICROGRAVITY BOTANIC EXPERIMENTS IN CUBESATS

Abstract

As the interest in commercial human space-flight and human space-exploration is gaining momentum, the development of closed-loop life-support systems and their enabling technologies becomes a more and more critical need. Perfecting our understanding of how botany and plant-growing are affected by microgravity environments is essential to develop the ability to produce food in space and plan long-duration human missions. The rationale behind this work is that we would be able to reach these goals faster if space botanic experiments were simpler and cheaper to perform for researchers around the world. In this paper, we describe the design of a miniaturized, autonomous plant incubator that can fit within the narrow size constraints of the 3 units CubeSat standard. This incubator is also one of two payload of the 3U CubeSat being developed at Polytechnique Montreal by PolyOrbite for the third iteration of the Canadian Satellite Design Challenge, an inter-university competition.

The payload named SpaceBean is a technology demonstrator, it measures 94x94x30mm and weighs just about 400 g. It includes pressure, temperature, and humidity sensors, as well as CO_2 and O_2 detectors. The specific scientific experiment that will be carried out in SpaceBean by PolyOrbite is to grow this plant for only three to four weeks, when the surface of its leafs reaches approximatively $1cm^2$, to study its germination and respiration process. All the information about the status of the plant is collected by the incubator and transmitted using the I^2C protocol. The overall design does not exceed a peak power consumption of 2.5W. PolyOrbite's mission aims at positioning SpaceBean in a sun-synchronous orbit at a 700km altitude. It is worth noting that the incubator is artificially lighted and heated according to the preferences of the designer of the botanic experiments. SpaceBean will grow an Arabidopsis Thaliana, a plant native from Europe and Asia from the family of Brassicaceae that has been previously grown in microgravity and for which reference experimental results exist. Moreover, its genome was entirely synthesized in 2008 in the 1001 genome project, making it particularly easy to study only certain traits of interest.

If successful, the most relevant result of this experiment will be the validation of a simple, cheap, and reusable plant incubator that can fit small satellites, allowing "space-biology on a budget" for many more students and researchers.