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AUTOMATION OF BIOLOGICAL EXPERIMENTS IN A MINIATURIZED SATELLITE

Abstract

As humanity prepares to reach further in space, progress in the field of botany is needed to provide our space voyagers with the means to grow their own food. CubeSats provide a low-cost platform for perfecting and understanding the way plants grow in space. In this paper, we discuss the process of automating a biological experiment taking place in an incubator designed by Polytechnique Montreal's technical society PolyOrbite in the context of the Canadian CubeSat Project organized by the Canadian Space Agency. The experiment called "Space-Bean" is one of the two payloads that will be accommodated in a 2U CubeSat being also designed by PolyOrbite. The CubeSat accommodate a second payload, a self-reprogramming on-board computer, and is scheduled to be deployed from the ISS in 2021. Space-Bean will be contained in a 95x95x70 mm pressurized incubator weighing 700g and equipped with a camera. SpaceBean will grow *Medicago truncatula*, a leguminous plant considered to be a model-organism for plant biology. Leguminous plants are essential for human nutrition and, in this category, a growth model for space is still missing as of today.

Once in orbit, the experiment will begin by setting the temperature inside the incubator to 4°C for 2 days to rise the dormancy of encapsulated seeds. Afterwards, the temperature will rise to 26°C and the first watering will start with a nutrient solution at pH 5.5 to dissolve the degradable material encapsulating the seeds. The key to this experiment is to provide the incubator with a way to autonomously ensure the growth of the plant. This will be accomplished by adding microporous materials (monoliths) into the artificial soil to improve the diffusion of water and nutrients. Capillarity forces will help the nutrients make its way to the roots. Plants growing will be monitored with pressure, humidity and temperature sensors. The self-adaptive computer will also make adjustments according to the data retrieved by the sensors. Prior to this experiment, the germination of seeds of *Arabidopsis thaliana* have been demonstrated in an 94x94x40 mm incubator. This study will be focused on the main life sequence of the plant and the life support system.

The goal of this technology is to prove that the advancement of basic space biology does not require human supervision nor expensive, complex space laboratories like the ISS. Space-Bean will represent a cheaper alternative for students and researchers all over the world to develop biology experiments in space.