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A VERSATILE BIOCUBESAT PLATFORM FOR FUTURE SPACE SYSTEMS: DEVELOPMENT OF A SECOND-GENERATION BAMMSAT PAYLOAD ON A STRATOSPHERIC BALLOON TECHNOLOGY AND OPERATION DEMONSTRATION FLIGHT

Abstract

The space industry is at an inflexion point for a full-scale microgravity research programme. Microgravity can be leveraged in new value creation, either in data or products associated with biological applications. Microgravity can favourably impact drug development, as Merck Co. (USA) shows in a recent example. Merck leveraged microgravity in its Keytruda® cancer drug RD, which recorded $14.38B in revenue in 2020 after spending $9.87B in RD. The microgravity environment is now primed for RD in vaccine development, disease modelling, biofabrication, stem-cell and stem-cell-derived products. Additionally, national space agencies have announced planned long-duration crewed missions beyond Low Earth Orbit. However, there is a knowledge gap regarding the impact of the space environment on humans, microbiome and associated Earth biology needed to support human activities in space. A versatile bioCubeSat platform could increase life science research and development spaceflight access to support these activities.

BAMMsat stands for Bioscience, Astrobiology, Medical, Material science on CubeSats. The versatile platform builds upon the typical functional requirements such as i) the need to house multiple samples, ii) maintaining viable samples in an appropriate environment, iii) the need to perturb the samples and (iv) the need to monitor the samples. It leverages the CubeSat concept to lower development costs, launch costs, increase space access, and shorter lead times. It replicates conventional laboratory functionalities and repackages them into a miniaturised and autonomous system. The concept uses microfluidics to house and maintain samples in a controlled liquid environment and perturb the sample with reagents in spaceflight. Changes are monitored via chemical sensors (O2, CO2, pH), fluorescence microscopy, and visible spectrometry. This generic platform can be flown as a free-flying CubeSat or hosted as a payload on a larger spacecraft for application in LEO and beyond LEO.

This paper aims to report the development and flight of the 3U BAMMsat 2nd generation bioCubeSat,

which flew on the large stratospheric balloon platform in Oct 2021. The mission named BAMMsat-on-BEXUS launched under the REXUS/BEXUS programme. The mission aimed to perform a technology and operation demonstration of the BAMMsat bioCubeSat payload in an extreme environment using C. elegans as the biological samples. The stratosphere can be used as an analog of a relevant spaceflight physical environment such as reduced pressure (near-vacuum; 11 mbar), and temperature (-50C). The BEXUS flight campaign could also be used as an analog of pre-flight, flight and post-flight operation similar to an orbital launch campaign.