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SPACE SYSTEMS SYMPOSIUM (D1)
Innovative and Visionary Space Systems Concepts (1)

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UNMANNED BIOMEDICAL SPACE STATION CONCEPT

Abstract

The diverse effects of microgravity on cell biology are gradually becoming understood. Biological research has been conducted on-orbit over the past five decades, though, in contrast to standard gravity and hyper-gravity (G>1), microgravity still requires an extensive amount of investigation into its effects on cell biology before it can be wide-scale beneficial to the applied biological sciences. Most biomedical experiments conducted under microgravity to date have not been repeated and so are typically N of 1 by nature.

The Unmanned Biomedical Space Station (UBSS) is an innovative robotic platform that seeks to perform high volume, high duty-cycle, complex investigations into effects of microgravity on cell biology and is specifically suited for conducting medical research on infectious and non-infectious diseases. It is unique in that it fully recreates ground-based medical laboratories and their complex processes on-orbit, without astronauts in the loop.

The two primary means for conducting microgravity experiments today are the International Space Station (ISS), or spacecraft and satellite missions. The ISS tends to have the limitation where Astronaut time is severely restricted and biomedical experiments are allocated little if any time at all. Stowage limitations also prevent large-volume biomedical experimentation. Spacecraft and satellite missions such as Bion-M, Foton, GeneSat, PharmaSat are capable of only performing very basic, short term (days to months) biomedical experimentation. They do not have access to specialised instruments for performing complex analysis on-orbit, thus would require re-entry of samples for ground-based analysis. The UBSS is a platform stationed permanently in Low Earth Orbit (LEO). It is equipped with a suite of medical instrumentation such as X-Ray Crystallography, flow cytometry, qPCR for conducting analysis on-orbit. Laboratory processes are automated using various robotic manipulators that handle and process large volumes of biological specimens. Specimens stowed on-board undergo short or long-term incubation, otherwise are cryogenically stored. Microsatellites rendez-vous and dock with the UBSS to resupply or deliver new biological samples.

In this study, a technical feasibility analysis, preliminary design and legal considerations will be derived for both the UBSS and microsatellite resupply vehicles. Results will be presented on the performance of the UBSS concept in terms of throughput and range of biological specimens capable of being processed, and duty-cycle. Design problems and solutions for the automation of laboratory processes, and support mechanisms for live and fixed specimens (for example, waste removal and supply replenishment for long-term incubation) will be outlined.