Deep Space Petri-Pod, a new platform for astrobiology experiments beyond the van Allen belts

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Abstract:

Survival of humanity is likely dependent on our ability to leave Earth and colonise other planetary bodies. To promote this, a common goal of the World's Space Agencies is manned exploration of deep space and of planets such as Mars. However, the deep space environment presents several environmental stressors that prove deleterious to human health, for example high cosmic radiation doses and prolonged microgravity. The consequences of human exposure to such stressors in Low Earth Orbit is well documented and do not appear to subside with up to ~180 d spaceflight examined to date. As such, a major obstacle preventing long duration missions into deep space is exponential decline in multiple physiological systems that would ultimately pose a serious risk to astronaut health. There is therefore a need to understand how life responds to the challenges associated with life in space and, importantly, develop effective countermeasures. Due to the inherent risk associated with human space exploration, utilising model organisms to understand the biological effects of deep space represents an essential first step towards manned missions. However, hardware and associated life support systems for life science experiments in deep space currently do not exist.

We have therefore developed the 'Deep Space Petri-Pod' (figure 1): a small (~100 x 75 mm) multi-user platform designed to accommodate a variety of biological samples, including microorganisms and *C. elegans* as an established *in vivo* model organism of human health and disease. A flex-rigid polyimide printed circuit board is used as a substrate to the 'Pods' and top flange, enabling the integration of embedded heaters (individual Pod temp control) and micro sensors inside the Petri-Pod (a paraylene coating protects the sensors from wet chemistry). Photodiodes with LEDs also enable optical density measurements. Future models could include sensor technologies such as RadFET for radiation monitoring and integration with NanoPore technology for real-time RNA sequencing. Additionally, created with common interface capabilities, DSPP can be incorporated into future missions beyond the van Allen belts, for example Phobos Sample Return, CubeSat and mission to the Moon and asteroids. DSPP therefore represents a novel opportunity for establishing how life responds to the unique deep space environment for promoting targeted therapeutic development prior to sending humans on such high-risk missions. Additionally, DSPP provides a new future platform for conducting astrobiology experiments beyond the van Allen belts fully in keeping with the European Science Foundations' recommendations following the most recent review of ESA science activities.

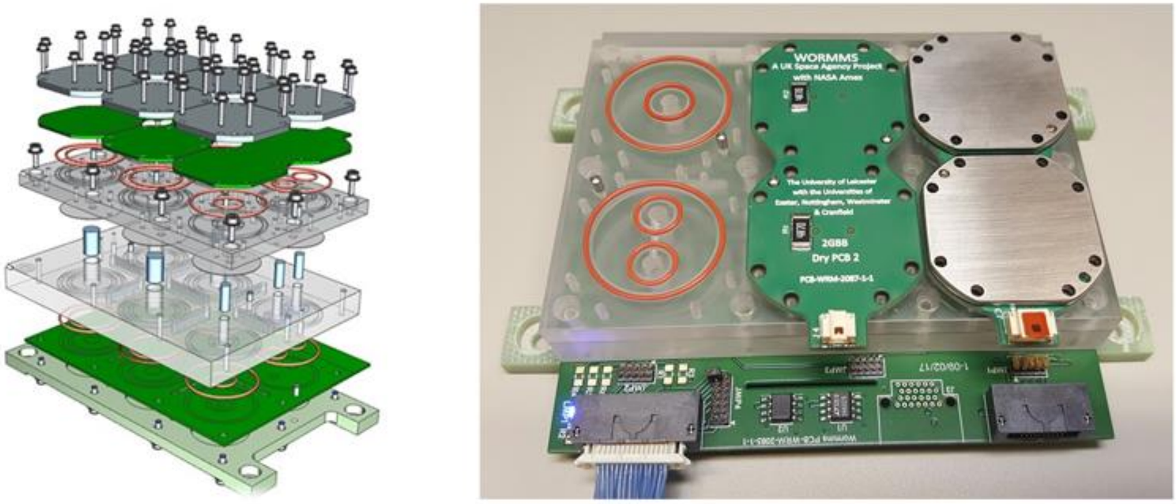

Figure 1. (A) Expanded computer-aided design illustration of the 'Deep Space Petri-Pod' (DSPP) design layers. (B) Photgraph of the DSPP breadboard prototype, including electronic circuit board control system.

Short Summary

The deep space environment poses several health risks that must be understood and countered prior to sending humans on missions to other planets. We have therefore developed the 'Deep Space Petri-Pod' as a multi-user platform for conducting astrobiology experiments beyond the van Allen belts.