Deep Space Petri-Pod:

Understanding life beyond the Van Allen belts

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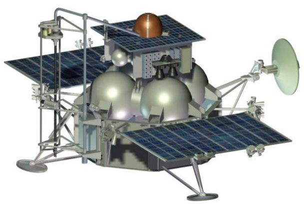
The need to study life in deep space

- Ultimate survival of humankind likely dependent on ability to colonise other planets
- Worlds’ Space Agency’s (and commercial space company's) common goal of Mars habitation/ deep space exploration
- However, major obstacles to achieving these aims include:
  - Prolonged µg/ increased cosmic radiation exposure
  - Exponential negative health consequences
  - Serious risk to human health/ mission performance
- However, it is not safe to do this in humans first, thus need initial demonstrations of viability of life and life support technology in model systems

Deep Space Petri-Pod

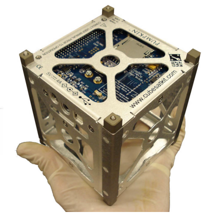
- **<u>Aim:</u>** establish a multi-user, common interface platform for deep space life science experiments, e.g.

Integrate with multiple launch vehicles



Phobos Sample Return

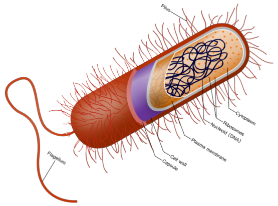
SPACEX



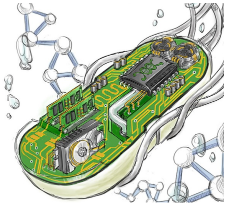
CubeSat

Accommodate multiple experimental systems

In vivo



Microbiology

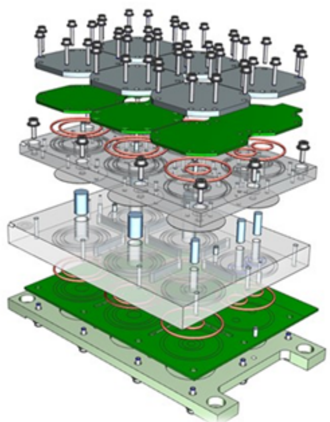


Synthetic biology

- Other key considerations:
  - Small (up-mass)
  - Permits environmental monitoring
  - Sample termination (planetary protection)
  - In-flight sample analysis (remove need for sample return)

NSTP-2 funding:
~£75,000

DSPP prototype



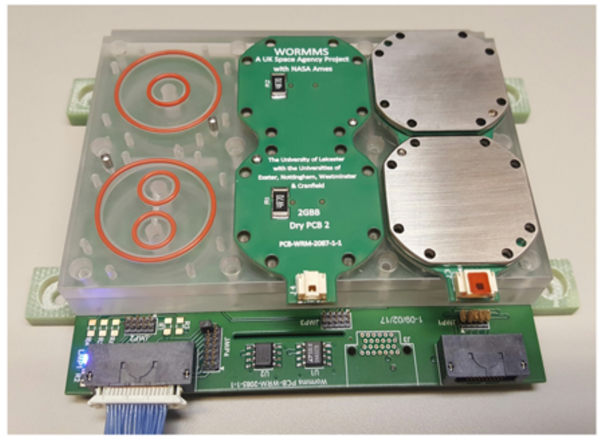
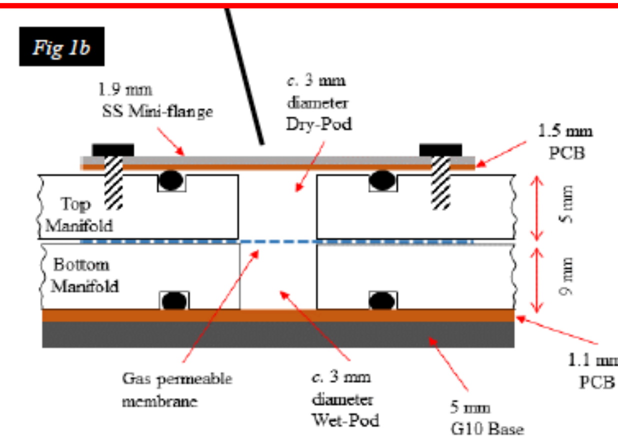
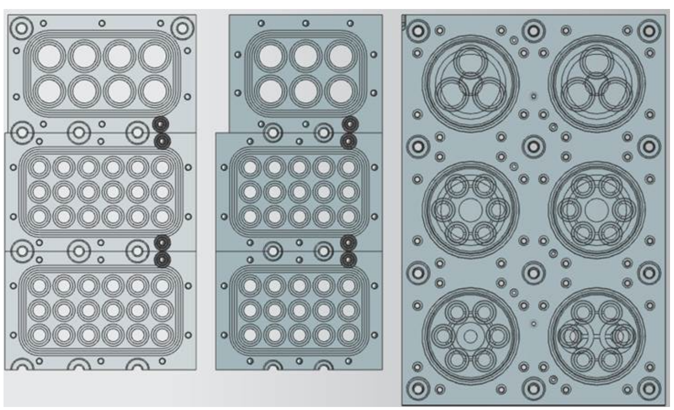


Figure 1. (A) Expanded computer-aided design illustration of the 'Deep Space Petri-Pod' (DSPP) design layers. (B) Photgraph of the DSPP breadboard proto-type, including electronic circuit board control system.



Cross Section of a Single Bio-Pod

- Dimensions: 100 x 75 mm ('matchbox' sized)
- Comprises a series of 'biopods'
  - Individual culture pods with 'wet' and 'dry' chambers for culture media and O_2 supply
- Separated by gas permeable membrane



DSPP incorporates a range of 'bio-pod' configurations/ sizes

Planetary protection

- Planetary protection is an central aspect of any interplanetary mission
- DSPP therefore incorporates a heated ‘kill switch’

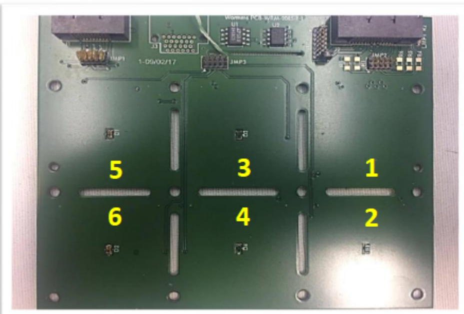


Figure 1. Substrate PCB layout with cluster location identified. Platinum resist thermometers (PRT)” are present in cluster 2, 3 & 6

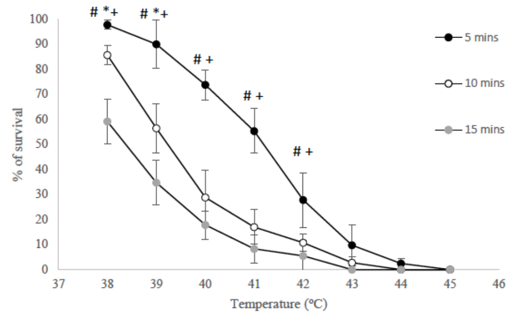


Figure 2. The percentage of survival as compared to the control scored immediately (<60 min) after lethal heat shock administration of temperatures between 38 – 44°C. Data points represent means ± SD. Symbols denote significant differences between time durations, # = 5-10 min, + = 5-15 min, * = 10-15 min.

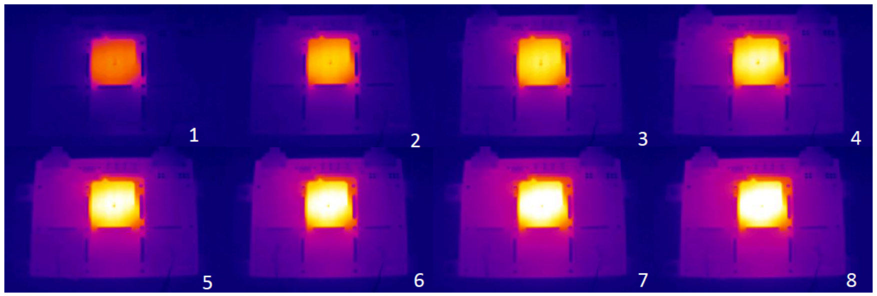
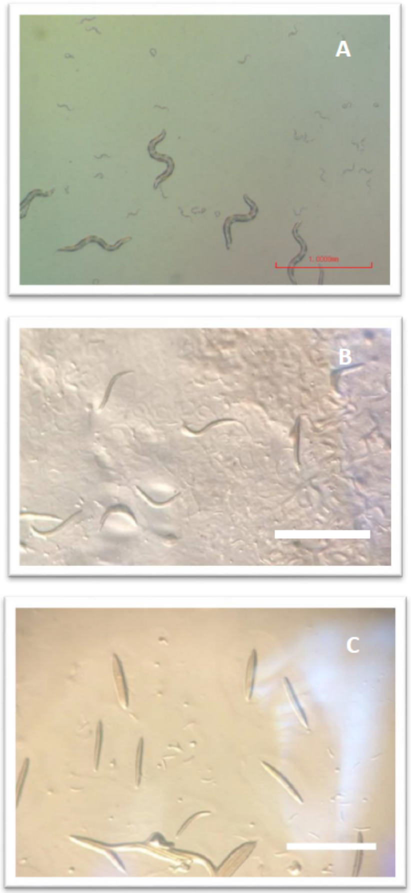


Figure 9. Infrared camera images at minute intervals of the substrate PCB with a constant input of 20V into heater 3. Dark blue <25°C – White >45°C. After 8 minute’s cluster temperatures are as follows: 1=29.8°C, 2=27.9°C, 3=45.8°C, 4=31.2°C, 5=31.5°C, 6=28.5°C.



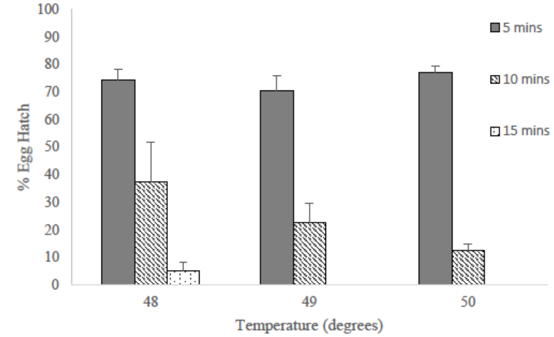
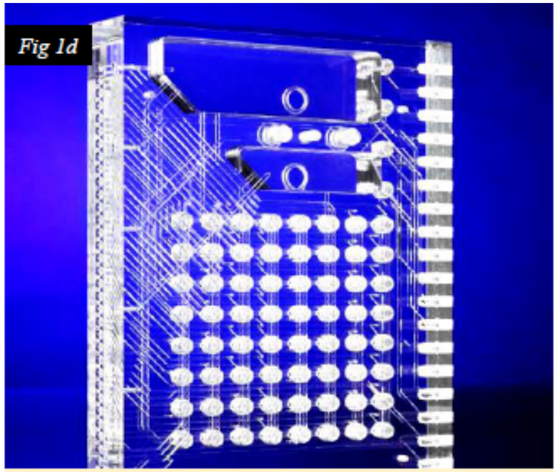


Figure 12. The percentage of eggs hatched compared to the control 24 hours after exposure to lethal heat shock administration of temperatures between 48 – 50°C for various durations. Bars represents means ± SD.

Capacity for future development

- RadFET for radiation monitoring
- NANOPORE for in-flight, real-time RNA sequencing
- Internal 3D μ-fluidics for automated media exhcange



Diffusion Molecular Bonding μ-fluidics Manifold

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UK SPACE AGENCY

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