ASTROBIOLOGY AND EXPOSURE EXPERIMENTS FROM THE LUNAR SURFACE. D. E. Wills[1,2] and B. Foing[2], [1]H. H. Wills Physics Laboratory, Tyndall Avenue, Bristol BS8 1TL [2]ESA/ESTEC, SRE-S, Postbus 229, 2200AG Noordwijk, Netherlands. dwills@rssd.esa.int, bernard.foing@esa.int

Introduction: In recent years, much experimentation has been directed at assessing how prebiotic organic molecules and micro-organisms are able to survive in the space environment. Such investigations serve to provide us with insight into the origin, propagation and evolution of life and its building blocks within the Solar system, all of which are central issues in the field of astrobiology. In these investigations, samples of organic compounds or dormant forms of life are exposed to the space environment for various lengths of time. The effects are subsequently assessed in the laboratory. Experiments of this type have flown in Low Earth Orbits (LEO's) on the ESA facilities BIOPAN and STONE on the Russian Foton spacecraft, and EXPOSE on the ISS [1]. In LEO exposure experiments the impact of the space vacuum, solar UV radiation, extreme temperature, microgravity, and a certain degree of ionizing cosmic radiation can be studied. However, the crucial next step is to conduct studies outside of the protective shield of our Earth's magnetosphere, such that the full flux of cosmic radiation in the interplanetary medium can be included in the investigations. Until this is done, no complete picture of the effect of the interplanetary space environment on organics and micro-organisms can be achieved. The lunar surface opens new opportunities for investigations outside of the magnetosphere and is thus an appropriate environment for the next generation of exposure experiments.

We propose exposure experiments that can be conducted from the lunar surface. The results of these experiments may be used in conjunction with those obtained from LEO exposure experiments so as to assess the survivability of life across two interplanetary environments. Exposure experiments of this type are precursors for investigations on the Martian surface, a necessary preliminary step for future human missions to Mars.

Proposed Experimental Arrangement: A simple experimental set-up mimics the experiment hardware of EXPOSE on the ISS. Samples of organic compounds or micro-organisms are accommodated in multiple vented or sealed cells situated in sample carriers. These carriers are secured into larger trays, and the trays are exposed on the lunar surface for varying lengths of time. Sensor equipment to monitor the environment to which the samples are exposed includes radiometers, UV sensors, temperature and pressure sensors as well as radiation dosimeters [2]. At the conclusion of the experiment, the organics samples are analysed by way of UV/Vis and Infrared spectroscopy. Survival of micro-organisms is assessed using CFU techniques or Live/Dead Staining.

Further Astrobiological Investigations from the Lunar Surface: The Moon provides an excellent non-biological testing ground for research into spacecraft contamination. Knowledge about the types of micro-organisms that are able to withstand current spacecraft sterilisation techniques and how they interact with a planetary environment is crucial for assessing planetary protection constraints.

The fifth and sixth goals of NASA's Astrobiology roadmap are to 'Understand the evolutionary mechanisms and environmental limits of life', and to 'Understand the principles that will shape the future of life, both on Earth and beyond [3]. Aside from simple exposure experiments, fulfilment of these goals calls for investigations into the evolution and adaptation capacities of micro-organisms in the interplanetary environment, for it is only in the context of multiple generations that the long term effects of life in extreme environments will start to emerge. The Moon is at present the only possible location for long-term biological studies under interplanetary space conditions [4]. From the lunar surface, adaptations of microbial communities by genetic mutations and natural selection can be investigated.

References: [1] Horneck G. Baglioni P. Sabbatini M. (2007) Astrobiology Experiments in Low Earth Orbit, Complete Course in Astrobiology, 273-319. [2] Horneck et al. (1998) Biological Experiments on the Expose Facility of the International Space Station, Proceedings of the 2nd European Symposium on the Utilization of the International Space Station, 459-468. [3] Des Marais D. J. Nuth III J. A. et al. (2008) NASA Astrobiology Roadmap, 1-19. [4] Santos O. (2007) Astrobiology on the Moon, NASA Advisory Council Workshop on Science Associated with the Lunar Exploration Architecture.