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CUBESAT 3U-PAYLOAD FOR IN-SITU RESOURCE UTILISATION DEMONSTRATION AT C-TYPE NEAR EARTH ASTEROIDS

Abstract

The idea of $In-Situ$ Resource Utilisation (ISRU) has been around since the 1960's and comprises the utilisation of space resources to produce beneficial materials outside the Earth's gravity well, e.g. propellants, life support consumables, and construction materials. ISRU appears repeatedly in recent national and international roadmaps for long duration deep space human exploration as well as in future space economies and parallels a rapid expansion of current ISRU research and development. As an example, the first $in-situ$ demonstration of ISRU is planned – specifically the Mars OXgyen $In-Situ$ Resource Utilisation Experiment (MOXIE) is included in the NASA Mars 2020 rover payload and designed to demonstrate the production of dioxygen from Martian atmospheric carbon dioxide.

Elsewhere in the planetary exploration community, CubeSat hosted payloads are seen as an increasingly cost effective and technologically and scientifically capable approach for planetary exploration. Furthermore, Near Earth Asteroids (NEAs) are seen as important locations for ISRU. Therefore Cranfield University's Space Group has instigated a program of research to develop various aspects of CubeSat-based exploration of NEAs and in particular CubeSat compatible payloads capable of performing cost effective early stage in situ demonstrations of key steps for various types of ISRU. Such demonstrations would be proof-of-concept and de-risking exercises that would enable future pilot scale and eventually full-scaled implementations.

This presentation will focus on a systems design for a 3U payload to demonstration at a C-type NEA the low temperature extraction of water and the subsequent electrolysis of this to dioxygen and dihydrogen. The system has the following features: sample acquisition via counter rotating brushes, extraction of volatile components via ovens with electrical resistive heating, trapping of condensable volatiles – primarily water, electrolysis of the trapped water into dioxygen and dihydrogen gas, and analysis of volatiles at various stages of the process with a miniaturise ion-trap mass-spectrometer. The baseline design allows for the collection and processing of 4 discrete samples using a carousel with 4 single use ovens. Each oven has a nominal internal volume of 7m^3. Additionally the input assumptions concerning regolith properties, modelling studies and the development and implementation of a number of laboratory breadboards of various sub-systems will be presented.

The design is intend to be compatible with use as part of a free-flying interplanetary 6U CubeSat, a 6U CubeSat hosted by and released by a larger parent spacecraft local to a NEA, or permanently hosted on a larger NEA surface rendezvous spacecraft.