The Lunar Volatile Resources Analysis Package

Conference or Workshop Item

The Lunar Volatile Resources Analysis Package. A. D. Morse[1], S. J. Barber[1], K. R. Dewar[1], J. M. Pillinger[1], S. Sheridan[1], I. P. Wright[1], E. K. Gibson[2], J. A. Merrifield[3], C. J. Howe[4], L. J. Waugh[5] and C. T. Pillinger[1], [1]Planetary & Space Sciences, The Open University, Walton Hall, Milton Keynes. MK7 6AA UK. (a.d.morse@open.ac.uk), [2]Astromaterials Research Office, NASA Johnson Space Center, Houston, TX 77058, USA, [3]Fluid Gravity Engineering, 1 West Street, Emsworth, PO10 7DX, UK, [4]RAL Space, Didcot, Oxfordshire, OX11 0QX, UK, [5]EADS Astrium Ltd., Gunnels Wood Rd., Stevenage SG1 2AS, UK.

Introduction: The presence and abundance of lunar volatiles is an important consideration for ISRU (In Situ Resource Utilisation) since this is likely to be a part of a strategy for supporting long term human exploration of the moon. The Lunar Volatile Resources Analysis Package (L-VRAP) is part of the provisional payload for the ESA European Lander [1] and aims to measure the abundance and chemical/isotopic composition of volatiles from regolith samples and the lunar exosphere.

L-VRAP Concept: The Package concept is based on instruments flown for other lander missions (e.g. GAP[2], TEGA[3], and Ptolemy[4]). Regolith samples are loaded into one of 24 ovens on a carousel whereupon the volatiles are extracted by either pyrolysis or combustion to temperatures of least 800°C. The abundance and chemical composition is determined by an ion trap mass spectrometer. The volatiles are then chemically processed to be suitable for isotopic analysis by a magnetic sector mass spectrometer. L-VRAP also contains reference gases of known chemical and isotopic composition to enable precise isotopic measurements. The CAD layout is shown in figures 1 and 2.

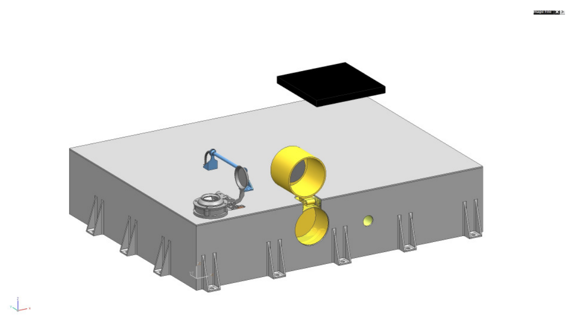

Figure 1. L-VRAP CAD model showing enclosure. Enclosure dimensions 460 mm × 350 mm, ht 97 mm

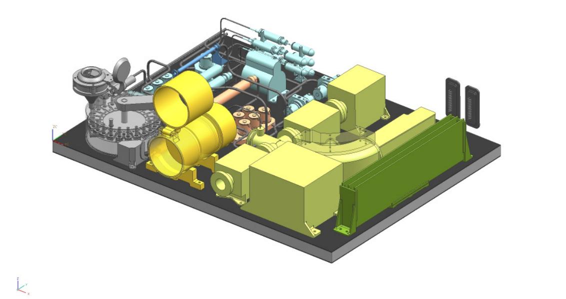

Figure 2 CAD model if the internal layout of L-VRAP. Subsystem details are listed opposite.

Solid Sample Inlet.
24 resistively heated ovens mounted on carousel
Sample size 50-100mg
Imager to estimate sample volume
Tapping station to seal sample

Chemical Processing System.
Valves and manifolds to control gases
Reagents and reactors to process volatiles
Reference gases H, C, N, O & noble gases
Reference gas mixture for ion trap MS

Ion Trap Mass Spectrometer.
Ring electrode r_0 = 8mm, 1MHz RF
Mass range 10 – 150 amu
Unit mass resolution
Electron multiplier detector
Frequency 1 mass spectrum/second

Magnetic Sector Mass Spectrometer.
6cm radius 90° magnetic sector
Mass range 2 – 150 amu
Mass resolution $M/\Delta M = 65$
Triple Faraday cup detectors for C, N, O isotopes
Double Faraday cup detector for D/H isotopes
Electron multiplier detector for noble gases
Isotopic precision ±0.1‰ µmol samples, ±1‰ nmol samples.

Sample collection: The Lunar Lander includes a robotic arm capable of scooping samples from up to 3.5m from the lander centre and to a nominal depth of 10cm. A timeline has been developed to analyse volatiles at various depths and locations as well as their variation over time and changing illumination conditions. The possible inclusion of a mobile payload element with a mole would allow a much larger range of samples to be acquired.

Exosphere samples: In addition to analysing volatiles released from regolith samples, L-VRAP can directly analyse the tenuous lunar exosphere by opening the mass spectrometers to the lunar environment. The ion trap MS can rapidly monitor the full mass range to detect transient events (e.g. during changes of illumination) whereas the magnetic sector MS has greater sensitivity can detect the less abundant volatiles. The housing for the Ion Trap MS also includes a material which passively traps the exosphere. Hence the exosphere can be collected over a long time scale during darkness.

Contamination: An important consideration for this study is the effects of contamination from the Lander. The landing sequence will use about 1000 kg of propellant, with a large fraction directed onto the landing site. Initial modeling indicates that uncontaminated samples will be accessible by the robotic arm at depths of several centimeters. Knowledge of the contamination composition and distribution will allow the identification of surface volatiles, either by subtracting the contamination or by identifying protected areas such as surface shielded by small rocks.

References: [1] Carpenter J. D. et al. (2012) *LPSC XLIII*, Abstract#1990. [2] Hoffmann J. H. et al. (2008) *J.Am.Soc.Mass Spectrom.* 19, 1377-1383. [3] Stewart et al. (2003) *J. Geophys Res*. Abstracts 5, 09489. [4] Morse A. D. et al. (2009) *In: Rosetta: ESA's mission to the origin of the solar system, 19.6,* 669–686.