

ProsPA

Lunar Polar Prospecting: Processing and Analysis

ES: Executive Summary

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| Written by: | Simeon Barber | | 21 April 2017 |
| Approved by: | Ian Wright | | |
| Authorized by: | Simeon Barber | <i>SBarber</i> | 21 April 2017 |

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Executive Summary

A package is foreseen which will assess the resource utilisation potential of the lunar surface by drilling, extracting and chemically processing samples of lunar regolith before performing chemical and isotopic analysis on the derived products. In doing so the package can also address questions of fundamental scientific interest. The first platform targeted for such a package is the Russian Luna-27 (Luna-Resurs) mission. The sample processing and analysis functions of the package build on the work performed during the Lunar Volatile Resource Analysis Package study (L-VRAP: contract 4000103345/11/NL/AF), which defined a miniaturised chemical laboratory, defined to quantify the resource potential of volatiles in the lunar regolith.

The objectives of the present study were to further develop a concept for a sample processing and analysis package in support of resource prospecting on the Moon, with an emphasis on the polar regions. Specifically the activity aimed to provide a concept of sufficient fidelity and maturity as to allow the process of development to flight to begin circa first quarter 2014, for flight in 2019. All elements of the package, from system level down to component level, were to be defined so as to demonstrate compliance with the system requirements and to provide details on internal and external interfaces.

The resulting instrument package concept is shown in Figure 1 and comprises two units:

- a miniature chemical laboratory housing various analytical equipment including two mass spectrometers, gas control valves, chemical reactors, pressure sensors and gas control valves, with a Local Electronics System for ProsPA control; and
- a Solids Inlet System comprising a sample inlet funnel which allows admittance of a sample from the PROSEED drill into a sample vessel or “oven”, which is then sealed and heated to release volatiles which are passed to the chemical laboratory for analysis.

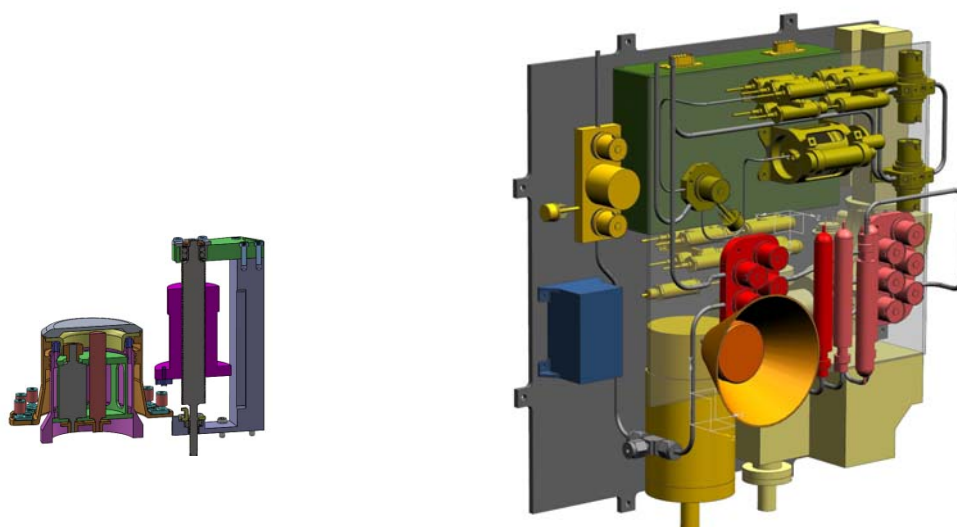


Figure 1 ProsPA concept comprises a Solids Inlet System (left) and chemical laboratory (right)

The SIS is required to:

- Operate in a cold environment (down to order -180°C)
- Interface to the PROSEED drill
- Accept samples of TBD size (options include “small” ca. 35 mm^3 and “large” ca. 2000 mm^3 and are dependent upon eventual configuration of the PROSEED drill)
- Make a gas-tight seal to the sample oven ($10^{-6}\text{ mbar.l.s}^{-1}$ or $10^{-7}\text{ mbar.l.s}^{-1}$)
- Heat the sample to 1200°C (goal 1600°C)

The Chemical Laboratory Unit is required to:

- Control its own and the SIS systems and communicate with the lander
- Analyse samples with a wide range of concentrations of volatiles (ppm to % levels)
- Identify volatiles released in the SIS up to $m/z \sim 150-200$
- Quantify volatiles released to a few % accuracy
- Determine yields of volatiles (requiring estimation of input sample size)
- Isotopically characterise released volatiles at \sim per mil level

The functional performance is summarised in Figure 2.

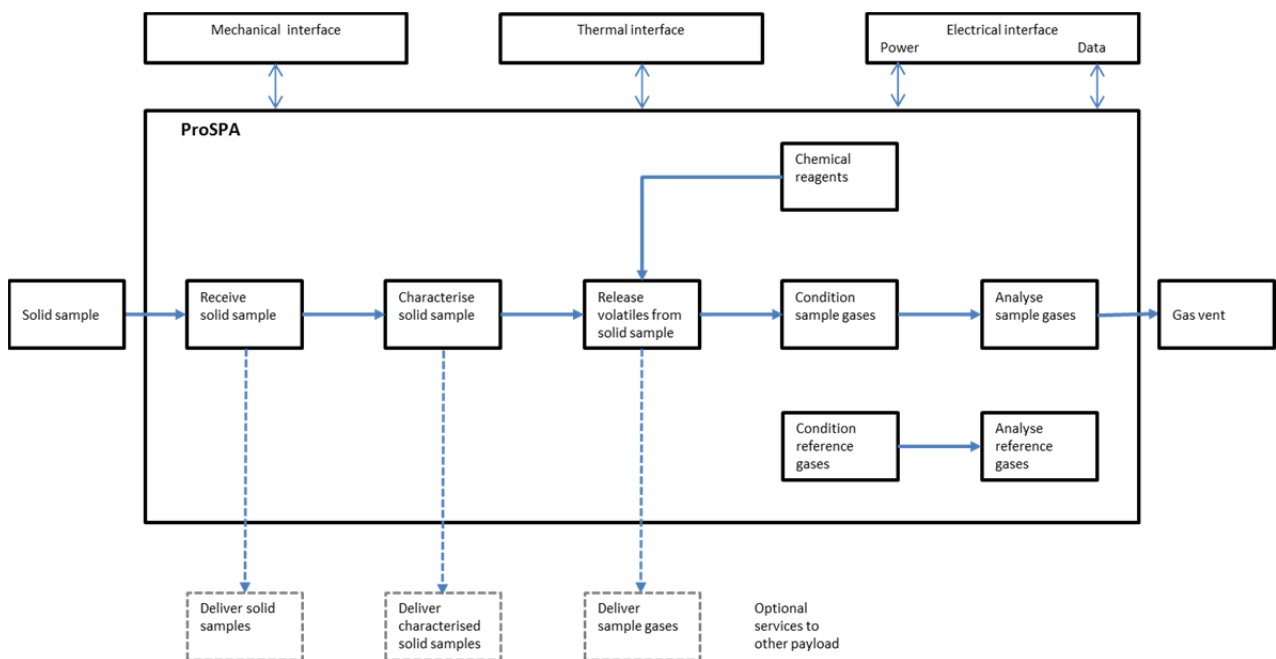


Figure 2 ProsPA Functional overview

The detailed system diagram is shown in Figure 3

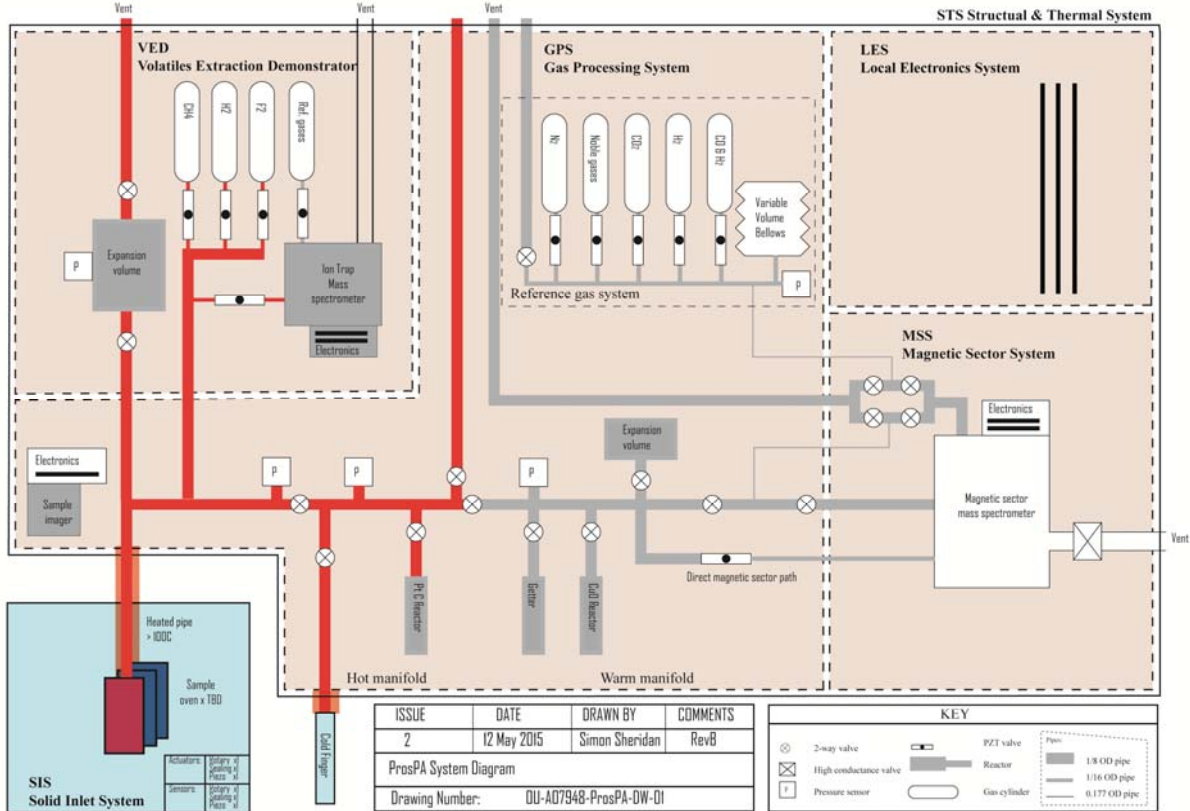


Figure 3 Revised ProsPA concept schematic diagram

The operational concept is as follows. Prior to sample acquisition, ovens may be heated to degas any contamination (TBC – note this may place an additional requirement on the SIS to be able to heat ovens before they are fully sealed). The ovens are then cooled in readiness for receipt of samples. Solid samples are delivered to SIS by the drill. During or after transfer, the SamCam will take images of the samples in order to enable an estimation of sample size (by post-facto analysis of the images on ground).

Following sample admittance, the oven is sealed and sample heating can begin in one of three general modes, as outlined in Figure 4.

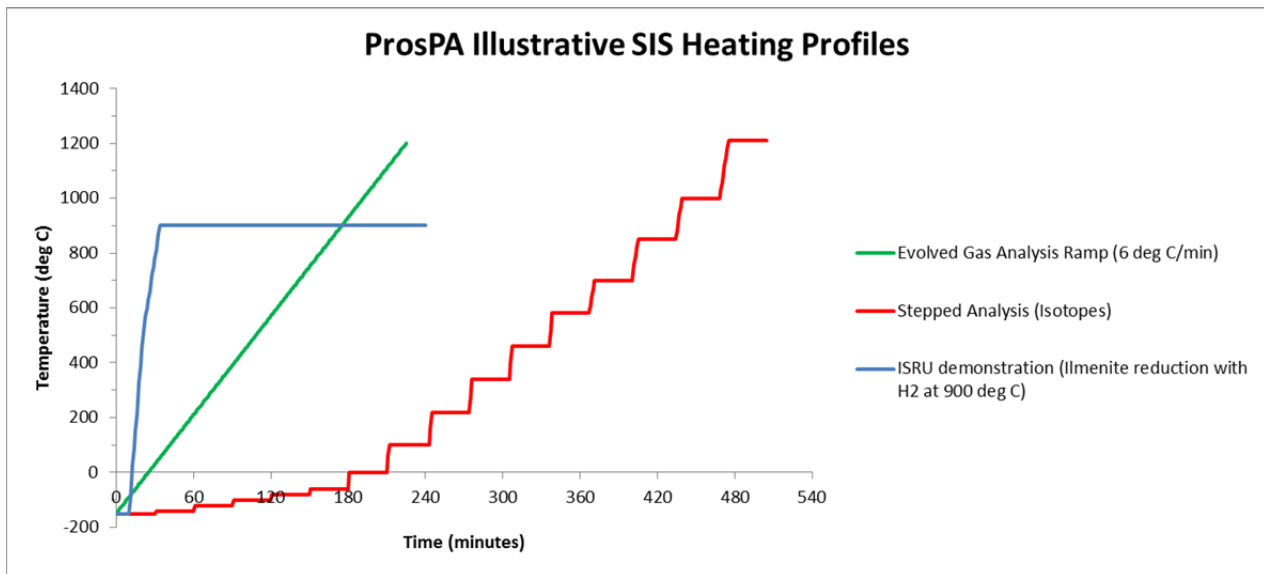


Figure 4 ProsPA Illustrative SIS Heating Profiles.

Following extraction of volatiles by heating of samples within the SIS, the gases are passed to the chemical laboratory for processing and analysis. The analysis functions include two mass spectrometers: an ion trap mass spectrometer for the chemical identification and quantification of the released gases, and a magnetic sector mass spectrometer for the isotopic analysis of the gases.

ProsPA is therefore a flexible laboratory which will be available to scientists to design and perform in situ analyses of lunar samples extracted from locations on the Moon which may be expected to contain significant quantities of volatiles.

Resource Requirements: As currently envisioned ProSPA requires a mass allocation of ~10 kg and power up to 72 W.