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Handling Planetary Ices

HPI EXECUTIVE SUMMARY

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1 INTRODUCTION

The document presented hereafter is the Final Report of the Handling Planetary ices activity.

The package is composed of the following parts:

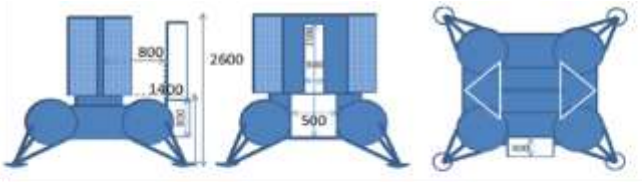
- Executive Summary: a summary of the whole work performed;
- TN1 (Document number HPI-REQ-SES-001 rev. A) : Identification of the requirements associated to ice sampling mission on Moon surface environment for both Scenarios;
- TN2.1 (Document number HPI-TN2.1 rev. A) : Sampling chain design definition and justification for Scenario 1;
- TN2.2 (Document number HPI-TN2.2 rev. A) : Sampling chain design definition and justification for Scenario 2;
- TN3 (Document number HPI-TN3 rev. -) : Sampling and handling Subsystem interfaces definition for both Scenarios;

2 EXECUTIVE SUMMARY

The summary of the Handling Planetary Ices work performed is reported in this chapter.

The main scope of this activity is to carry out preparatory analysis in order to lay the groundwork for the ESA's future activities. In view of this, a sampling/handling/analysing chain must be designed and all the critical aspects should be underlined in view of future missions.

The following two scenarios are considered in this analysis (lander envelope available is reported):



SCENARIO 1
In-situ Analysis

Mission consists of a single static platform

Samples shall be analysed by an in-situ suite of instruments

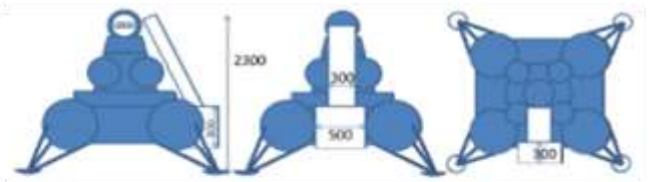
Surface operations shall take place during day/illuminated periods only (2 weeks duration)

During darkness (2 weeks) all equipment must be placed into survival mode

Total duration of the mission is 1 year

Total mass available for the sampling chain is 30kg

The sampling/handling/analysing chain shall be compatible with the configuration in the above figure



SCENARIO 2
Sample Return

Mission consists of a single static lander with sampling and return capability

Surface operations carried out in darkness

Samples may be pre-screened in-situ before loading into return container

Surface mission operations within 2 weeks

Surrounding lunar surface is at 40K

Total mass available in the return capsule is 10kg

Return phase duration (from lunar lift-off to return on Earth) is 14 days

The internal temperature of the sample return capsule can reach a max of 350K after landing

The sample container shall be retrieved from the sample return capsule after a maximum of 12 hours after landing

The total volume available to accommodate the sample preservation container is that associated with a sphere of diameter 250mm

The sampling/handling chain shall be compatible with the configuration in the above figure

A brief summary of each Technical Note is reported in the following sub-chapters.

2.1 TN1 summary

This document TN1 Sampling Requirements deals with the following aspects:

- Introduction to the current knowledge of lunar volatiles and open science questions
- Derivation and definition of science requirements for icy samples justified with respect to the specific chemistry and physical properties to be investigated through analysis of these samples.
- Sampling environment specification e.g. regolith / sample temperatures, mechanical properties etc., including the physical state of the samples prior to extraction e.g. temperature, mechanical strength, porosity
- Consideration of Samples, Sampling and Sample Alteration
- Definition of Sampling Reference Cases
- Sampling chain requirements, in both reference scenarios, including:
    - Sample properties
    - Locations and depths from which samples shall be extracted
    - The required physical state of the samples at the point of analysis
    - The quantities of sample required for analysis or return
    - The number of samples
    - Dosing of samples to allow comparison between measurements made by different techniques
    - Operational constraints, taking into account constraints driven by temperature and time
    - Measurements to be made prior to or during the sampling and sample handling process
- Recommended sample analysis payload for the two scenarios (in situ and sample return):
    - Definition of a nominal sample analysis payload (consisting of no more than three instruments) to support the later definition of the interfaces for delivery in the in situ scenario.
    - Definition of a minimum set of sample pre-screening instruments (defined with reference to the derived science requirements) to support the sample return scenario.
- Uncertainties in assumptions made in the derivation of requirements and sampling environment specification
- Input to development plan, as far as the soil simulant definition is concerned
- Consideration of environmental conditions and operative constraints

2.2 TN2.1 summary

The TN2.1 provides a conceptual design of the Sampling Chain for what concerns the Scenario 1, envisaging an In-Situ mission on Lunar surface. The following aspects are covered:

- Definition of the reference mission scenario
    - Brief recap of the sample definition and high-level Interfaces definition
    - Identification of the Instruments Suite for the scenario under study
    - Identification of the environment and of the mission phases
    - Brief discussion on the environmental impacts on the collected samples after sample collection
- Conceptual design of the End-To-End Sample Chain system and of its main components
    - System description (sub-systems identification)
    - Generation of the Function Tree and of the Product Tree
    - Identification of the High-level Operational sequence
    - Thermal analysis
    - Design of the Sample Acquisition System (SAS)
    - Design of the Local Handling and Analysis System (LHAS)
    - Identification of the Local Electronics main tasks
- Identification of the critical aspects related to each subsystem
- Generation of technical requirements in view of the proposed design
- Generation of the main engineering budget in view of the proposed design

2.3 TN2.2 summary

The TN2.2 provides a conceptual design of the Sampling Chain for what concerns the Scenario 2, envisaging a sample collection on a permanently shaded crater on the Moon and a sample return on Earth.

This document deals with the following aspects:

- Definition of the reference mission scenario
  - Brief recap of the sample definition
  - Identification of the Instruments Suite for the scenario under study
  - Identification of the environment and of the mission phases
  - Brief discussion on the environmental impacts on the collected samples after sample collection
- Conceptual design of the End-To-End Sample Chain system and of its main components
  - System description (sub-systems identification) and high-level Interfaces definition
  - Generation of the Function Tree and of the Product Tree
  - Identification of the High-level Operational sequence
  - Thermal analysis
  - Design of the Sample Acquisition System (SAS)
  - Design of the Local Handling and Encapsulating System (LHES)
  - Design of the Sample Transportation System (STS) and of the Sample Preservation Container (SPC)
- Identification of the critical aspects related to each subsystem
- Generation of technical requirements in view of the proposed design
- Generation of the main engineering budget in view of the proposed design

2.4 TN3 summary

This document provides a preliminary set of interface requirements toward the host platform (for discussion purposes). Both the mission scenarios are dealt. The following aspects for each Scenario are identified:

- Subsystem characteristics (brief recap from previous Technical Notes)
  - Configuration and accommodation
  - Mass
  - Power
  - Dimensions
- Interfaces definition
  - Structural
  - Mechanical
  - Thermal
  - Electrical lines
  - Data and communications
- Operations and AIV
  - Operations
  - AIV requirements and contamination control
  - Capsule requirements (only for Sample Return scenario)

The interfaces are identified for the following elements of the whole chain:

- Drill
- Relevant Positioner
- Structural plate, if any
- Devices in support to sample release from Drill (i.e. Carousel and Rotating arm)
- Encapsulating Station for the preparation of the sample for final transfer into sample preservation container, only for Sample Return Scenario
- Capping Station and Shunting valve for the distribution of the heated sample to the instruments, only for In-Situ Scenario