EPSC Abstracts
Vol. 6, EPSC-DPS2011-1868-1, 2011
EPSC-DPS Joint Meeting 2011

Objectives and Model Payload Definition for NEO Human Mission Studies

A. Galvez (1), I. Carnelli (1), J. Carpenter (2)
(1) General Studies Programme (D/PPC), European Space Agency, Paris, France (andres.galvez@esa.int)
(2) Future Exploration Missions (D/HSO), European Space Agency, Noordwijk, The Netherlands

Abstract

ESA has supported studies on NEO threat assessment systems and deflection concepts in the context of the General Studies Programme and in close cooperation with the directorates of Technical and Quality Management and of the Scientific Programme. This work has made it possible to identify a project for Europe to make a significant - yet realistic - contribution to the international efforts in this field: the Don Quijote NEO technology demonstration mission. This paper describes what such a small mission can do to prepare future human exploration and what is the in-situ data that can be obtained through such a project.

1. Introduction

The Don Quijote mission consists of two elements, a SMART-1-class asteroid orbiter (called Sancho), and a modified upper stage serving as asteroid impactor (dubbed Hidalgo). The "Sancho" orbiter would rendezvous with a small 300m Near Earth Asteroid and study it before the arrival of the "Hidalgo" impactor, which would hit it with high relative speed. The Sancho Orbiter would then observe the impact, its effects, and in particular the resulting deflection in the asteroid's trajectory.

This mission would address different user communities: a) technical (e.g. on-board autonomy, precise orbit determination, close proximity operations), b) human spaceflight (understanding of interplanetary environmental hazards for humans) and, c) small body science experts (science and impact mitigation). The Don Quijote mission concept has a modular architecture (two separate small spacecraft and the possibility of an independent asteroid "surface package") that would facilitate its implementation in the context of a cooperative project. The mission scenario could also interest third parties not directly involved in the development e.g. for the analysis and sampling of the material in the resulting impact crater. The Sancho orbiter studies would provide in addition a suitable frame for the assessment of payload options aimed at obtaining the necessary understanding of the interplanetary medium as well as the plasma and dust environment close to the surface of airless planetary bodies that are of primary importance for the preparation of future human exploration.

In this frame, among the high-priority objectives of potential payload options are those linked to crew health. These include the need for a thorough understanding of the radiation effects on human physiology for which knowledge on the dose, particle spectra, DNA repair pathway responses are of primordial importance, but also the dust toxicity in terms of the chemical reactivity, its size distribution, mineralogy and physical properties.

Instrumentation could also provide a good understanding on resources present in the regolith or in the subsurface layers that are of potential use for future human activities. Here mineralogical information as well as parameters allowing for correct modelling of the body's physical properties are primordial. These include for example the regolith potential to electrostatically charge and levitate, adhesive or abrasive properties, interaction with crewed vehicles such as airlocks and mechanical joints.

Finally, the above-mentioned data would be of benefit for the characterization and selection of future landing sites for which knowledge on the topography, mechanical properties, and dust environment are fundamental selection parameters.

By prioritising these objectives, a number of model payloads suitable for the preparation of a NEO human exploration mission and that are suitable for such a small-class Sancho-type spacecraft can be identified (figure 1). A high-level description is provided in the sections hereafter.

	Medium Priority: Medium; High Priority: High	Health	Habitation	Resources	Human Activities	Public Outreach	Mobility
Cameras	Stereo panoramic imager		High		Medium	High	
	Arm Camera		High	Medium	High	High	Medium
Radiation and effects package	Experiment in human radiation biology	High	Medium				
	Radiation monitor	High	Medium				
Dust plasma waves and fields package	Dust charge and trajectory sensor	High	High		High		
	Langmuir probes and booms	High	High		High		
	Radio antenna		High		High		
Dust chemistry and microscopy package	Optical Microscope	High		High			
	Atomic Force Microscope	High		High			
	Raman (LIBS?)	High		Medium	Medium		
Dust toxicity	Dust chemical reactivity experiment	High					
Volatiles	Volatiles analysis package			High			
Payloads	X-ray spectrometer / Raman Optical Head	High		Medium	Medium		
CIK	MPE						

Figure 1: Model payload prioritization

2. Examination of radiation effects

Uncertainties about the effects of space radiation on human physiology arise primarily because of an inability to create analogous radiation environments on Earth in which to perform appropriate testing. Rather the current approach to testing is to use experimental models to estimate the relative effectiveness of the radiation in question and γ-rays. Observations show however that the results of this approach are highly complex and vary as a function of biological endpoint, cell or animal model, dose, dose rate and type of radiation. The instrument concept would use cell cultures to characterize radiation response, in parallel with measurements of incident heavy charged particles.

3. Dust analysis package

Regolith is both a hazard for human exploration and a potential asset. While potentially toxic to humans and hazardous to surface infrastructure dust also contains potential resources which, if extracted, may be key to the sustainability of future exploration. The microscopic dust properties are integral to understanding all of these factors and a suite of instruments operating in synergy can provide information required. Possible techniques that could be applied include (but are not limited to):

- Atomic force microscopy (heritage e.g. Phoenix, Rosetta), providing micrometre to nanometre scale microscopy;
- Optical microscopy (heritage e.g. Phoenix, Beagle 2), providing millimetre, micrometre microscopy;
- Raman spectroscopy (heritage e.g. Exomars, MSL), providing chemical/mineralogical (and perhaps elemental) composition data.

4. Dust environment and plasma package

Dust has been identified as the primary potential hazard for operations on airless planetary. The dust properties are however very poorly understood. Particular uncertainty surrounds the charging, levitation and transport of dust particles in the integrated dusty plasma of the NEO environment. The package could determine the properties of levitated dust, the plasma environment, the local electric fields, and resultant effects in the radio regime. A suite of instruments could be the following:

- Langmuir probes to measure plasma properties and electric fields;
- Dust charge and trajectory sensor to directly observe the motion and dust;
- Radio antenna to observe plasma, impacts dust effects and other events in the radio domain.

5. Volatiles resource analysis

In planning for future human exploration activities it is important to understand and characterise the potential availability and distribution of volatiles in the regolith, as they may constitute a potential source of raw materials. A dedicated instrument package would be required to extract the volatile molecules from the regolith and analyse them in order to determine the species present and their relative abundance. The primary mechanism for performing such an analysis is expected to be mass spectroscopy, although additional complimentary measurements may be considered. Samples would have to be representative of the various conditions that exist within reach of a surface element but contamination must also be accounted for and removed.

6. Summary and Conclusions

The paper describes the potential of a small/mini-class interplanetary spacecraft to embark payloads suitable for the preparation of NEO human exploration. These include in particular packages primordial for the improvement of crew health, understanding of potential in-situ resources and characterization and selection of future landing sites.