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Philae (Rosetta Lander): Experiment status after commissioning

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Abstract

Being successfully launched on March 2, 2004, ESA's cornerstone mission "ROSETTA" (originally planned to be launched in January 2003 to comet Wirtanen) is en route. It will also bring the 100 kg Lander "Philae" with a scientific payload of 26.7 kg to the surface of comet 67P/Churyumov-Gerasimenko. After a first scientific sequence in 2014 it will operate for a considerable fraction of the cometary orbit around the sun (between 3 AU and at least 2 AU).

The Lander, after separation, is an autonomous spacecraft powered with solar cells and using the ROSETTA Orbiter as a telemetry relais to Earth. The main scientific objectives are the in situ investigation of the chemical, elemental, isotopic and mineralogical composition of the comet, study of the physical properties of the surface material, analyze the internal structure of the nucleus, observe temporal variations (day/night cycle, approach to sun), study the relationship between the comet and the interplanetary matter and provide ground truth data for the Orbiter instruments. Ten experiments with a number of sub-experiments are foreseen to fulfil these objectives.

Philae is operated (via ESOC) by the Lander Control Centre (LCC) at DLR and the Science Operations and Navigation Centre (SONC) at CNES. In this paper we present the flight status of the scientific instruments as it is known after in-orbit commissioning.

Keywords: Comets; Rosetta; Philae; Lander; Solar system; In situ experiments

1. Introduction and scientific goals of the Philae experiments

1.1. Mission

Rosetta is the third of ESA's cornerstone missions within the science programme "Horizon 2000" (CNES et al., 1995; DLR et al., 1995). Originally planned as a comet nucleus sample return mission (CNSR), it now includes a comet rendezvous (injection into orbit) and the delivery of a surface lander.

After the change of the original mission to comet 47P/Wirtanen (2003) to comet 67P/Curyumov-Gerasimenko, Rosetta has now been launched successfully with an Ariane 5 G+ from Kourou on March 2nd 2004. Apart from a new target comet (and asteroids en route), the flight trajectory had to be reworked completely. Due to the considerably higher mass of 67P, the landing gear of Philae has been reworked (tilt limiter in the cardanic joint to prevent overturning at much higher landing velocities, Ulamec et al., 2006)).

After swing-by manoeuvres at Earth (March 2005, November 2007 and November 2009) and Mars (February 2007), and asteroid flybys at Steins and Lutetia, the target comet, 67P/Churyumov-Gerasimenko shall be reached in 2014.

After a phase of close comet investigation with the Orbiter remote-sensing instruments, including high resolution global mapping of the nucleus, a safe and scientifically relevant landing site will be selected. From the comet orbit the spacecraft will provide detailed information on the properties of the comet nucleus to parameterise the Lander separation and descent sequence. The delivery of the Lander to the surface of the comet is foreseen in November 2014

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at a distance of about 3 Astronomical Units (AU) to the sun.

1.2. Naming of the Lander

The name Philae has been chosen as a parallel to the obelisk which was found on the island of Philae (near Aswan) where an inscription finally allowed the decipherment of the Egyptian hieroglyphs by J.-F. Champollion, based on the text on the stone of Rosetta.

1.3. Scientific objectives

It is the general task of the scientific investigations carried out and operated by the Rosetta Lander to get a first in situ analysis of primitive material from the early solar system, to study the structure of a cometary nucleus, reflecting growth processes in the early solar system and to provide ground truth for Rosetta Orbiter instruments. The scientific objectives of the Lander comprise:

- The determination of the composition of cometary surface matter: bulk elemental abundances, isotopes, minerals, ices, carbonaceous compounds, organics volatiles – in dependence on time and insolation.
- The investigation of the structure, physical, chemical and mineralogical properties of the cometary surface: topography, texture, roughness, mechanical, electrical, optical and thermal properties.
- The investigation of the local depth structure (stratigraphy), and the global internal structure.
- Investigation of plasma environment.

These scientific objectives are in-dependent of the target comet and thus identical as for the original Wirtanen Mission. Table 1 presents an overview on the 10 Lander experiments. More details can be found in Biele et al. (2002a,b) and Bibring et al. (2006).

1.4. Commissioning

Philae commissioning was performed in four blocks of about one week each, in March, April, May and October 2004. The duration of each daily pass (AOS) was between 4 and 8 h. While the focus of the first block lay on subsystem commissioning, all experiments were commissioned in block 2 and again in block 3 (usually in a different configuration and with additional procedures if necessitated by the results of block 2). Final tests have been executed in October 2004, but engineering tests continue.. Since commissioning, the Lander has been operated during four passive checkout phases (PC0: March 2005; PC1: September 2005, PC2: March 2006, PC3: August 2006). Philae has participated in operations during the first Earth swingby (March 4, 2005) and was activated for several maintenance and servicing activities (CDMS check, battery charging, improvement of thermal mathematical model, link tests, software improvements of both subsystems and payload).

2. Instruments – status

2.1. Overview

All 10 instruments, including SD2, have been tested according to plan.

Although most instruments cannot be operated as they will be after release, given their stored configuration, the modes were chosen so as to check the health, functionality and level of performances following launch.

The tests were primarily performed in a sequential mode (instrument per instrument). Some interference tests have also already been conducted.

For all instruments, these tests were essentially successful.

Examples to illustrate the level of accuracy achieved:

- ROMAP measured the 3 axis components of the interplanetary magnetic field.

Table 1
Philae instrument overview

Composition		
Elemental	APXS	Surface
Isotopic	PTOLEMY, COSAC	Samples
Molecular	COSAC, CIVA-M, PTOLEMY	Samples
Mineralogical	ÇIVA-M	Samples
Physical properties		
Thermal	MUPUS, SESAME	Surface, subsurface
Electrical	SESAME, CONSERT	Surface, global
Mechanical	SESAME, SD2, MUPUS, ROLIS	Surface, subsurface
Imaging and large scale structure		
Imagery	ÇIVA, ROLIS	Landing/drilling sites
Magnetic	ROMAP	Local, global
Gas, plasma	ROMAP, SESAME	Local, global
Internal structure	CONSERT	Global
Cometary activity		
All properties	All instruments	