4th IAA Planetary Defense Conference – PDC 2015
13-17 April 2015, Frascati, Roma, Italy

IAA-PDC-15-04-08
Relevance of PHILAE and MASCOT In-Situ Investigations for Planetary Defense

Stephan Ulamec[1,2], Jens Biele[1,3], Jan Thimo Grundmann[5], Jeffrey Hendrikse[6], Christian Krause[1,4]

[1] *DLR Space Operations and Astronaut Training – MUSC,51147 Köln, Germany,*
[2] *+49-(0)2203-601-4567,*
[3] *+49-2203-601-4563,*
[4] *+49-(0)2203-601-3048,*
[5] *DLR Institute of Space Systems, Robert-Hooke-Strasse 7, 28359 Bremen, +49-(0)421-24420-1107,*

[6] *EADS Astrium, Friedrichshafen, Germany,*

Keywords: *small solar system body in-situ characterization, planetary defense, PHILAE, MASCOT, AIDA*

Extended Abstract

On November 12th, 2014, Philae successfully achieved the first ever landing on the surface of a comet, as part of the Rosetta mission launched in 2004 towards comet 67P/Churyumov-Gerasimenko. This event was preceded during summer of 2014 by an intense phase of remote investigation of the comet nucleus also allowing landing site selection [1]. Philae has a mass of about 98 kg including 26.7 kg of scientific payload. Separated from the Rosetta main spacecraft at an altitude of 22.5 km, it descended, as expected, to the surface in 7 hours.
Unfortunately, since a cold gas system, intended to hold down the lander could not be activated, and the anchoring harpoons did not work, Philae bounced off again and only came to rest, about two hours later after two more ground contacts [2,3].

Nevertheless, it was able to successfully execute a scientific sequence of about 64 hours (after separation) where all instruments could be operated at least once. A wealth of scientific data were returned. Placed at a final landing spot with very poor illumination, long term science, based on the output of a solar generator, could not start immediately after the first days of operation. It is expected that contact between Rosetta and Philae can be re-established at smaller heliocentric distances, probably in the May/June 2015 timeframe [3]. Perihelion of 67P is reached in August 2015.

MASCOT, the small asteroid lander launched on December 3rd, 2014, aboard the Japanese Hayabusa-2 asteroid sample-return mission, evolved in a series of Concurrent Engineering Facility sessions at DLR Bremen from a Philae-like design towards the "shoebox-sized" 10 kg spacecraft which has finally been implemented [4]. Like Philae, it is also integrated aboard its mothership at science instrument level. Developed two decades after Philae and being an order of magnitude smaller, MASCOT has no deployable landing gear or active anchoring devices, but it has a fully contained internal uprighting and re-location device instead. This will allow in-situ investigation of different sites on the asteroid surface. MASCOT supports four scientific instruments: a camera, an IR imaging spectrometer, a radiometer and a magnetometer [5].

Both landers' science instruments are designed to operate in conjunction with those aboard their motherships in orbit. They also require the respective motherships as relay for both, scientific data, and housekeeping.
The overall understanding of the nature of a small body does benefit from the combined investigations of both, in-situ and global remote measurements. The recent operational experiences and first evaluation of the scientific data provided by Philae and Rosetta allow a comparison of the results of remote and in-situ investigations, also leading towards an improved understanding of the benefits of surface elements for planetary defense applications.

Results from the simultaneous operation of Philae and Rosetta also provide a basis for optimized planning for MASCOT surface operations and the coordination of its science instrument activities with the orbiter, Hayabusa-2. Combined, these will support and improve the development of the joint NASA / ESA mission AIDA to binary near-Earth asteroid (65803) Didymos [6,7].
MASCOT is a design that allows adaptation to modified payload. For AIDA/AIM it is foreseen to carry a bistatic radar, together with a camera and accelerometers [8].

The immediate relevance of both Philae and MASCOT for planetary defense lay mainly in the data obtained (or to be obtained) on the physical properties of small bodies. The bouncings of Philae (although not foreseen) give hints on surface strength and behavior of low velocity impact. Similar results are expected from MASCOT for an asteroid

surface. High resolution imaging from cameras at a lander show the fine structure of surface material and allow to clearly distinguish between fine or coarse regolith, rubble ore rather monolithic structures. The radar instrument aboard Philae (CONSERT), as also envisioned in slightly modified design for AIDA/AIM gives unique information on the internal structure of small bodies.

Acknowledgements

The authors would like to thank the teams of Rosetta, Philae, Hayabusa 2 and MASCOT to make these missions possible.
Rosetta is an ESA mission with contributions from its member states and NASA. Rosetta's Philae lander is provided by a consortium led by DLR, MPS, CNES and ASI.
Hayabusa 2 is a mission by the Japanese Aerospace Exploration Agency. The lander MASCOT is provided by a consortium by DLR and CNES.

References

[1] S. Ulamec, *et al*., Rosetta Lander – Philae: landing preparations, *Acta Astron*., Vol. 107, pp. 79-86, 2015

[2] J. Biele *et al*. The landing(s) of Philae and Inferences on Comet Surface Mechanical Properties, submitted to Science, 2015

[3] S. Ulamec, *et al*., Philae – First Landing on a Comet, 46th Lunar and Planetary Science Conference, abstract# 1121, Houston, 2015

[4] J.T. Grundmann, *et al*., Mobile Asteroid Surface Scout (MASCOT) – Design, Development and Delivery of a Small Asteroid Lander aboard Hayabusa-2, IAA-PDC15-P-64, this conference

[5] S. Ulamec, *et al*. ; Landing on Small Bodies: From the Rosetta Lander to MASCOT and beyond; *Acta Astron*, Vol. 93, pp. 460-466, 2014

[6] P. Michel *et al*. Asteroid Impact and Deflection Assessment (AIDA) Mission: Science Return and Mitigation Relevance, IAA-PDC-15-04-01, this conference

[7] C. Lange, *et al*., Technology and knowledge reuse concepts to enable responsive NEO characterization missions based on the MASCOT lander, IAA-PDC15-P-65, this conference

[8] A. Herique *et al*. A Direct Observation of Asteroids Structure from Deep Interior to Regolith: Why and How? IAA-PDC15-04-06, this conference

[9] J.T. Grundmann, *et al*., Small Spacecraft in Planetary Defense Related Applications – Capabilities, Constraints, Challenges, 2015 IEEE Aerospace Conference, 2.1211 (accepted)