7th IAA Planetary Defense Conference – PDC 2021
26-30 April 2021, Vienna, Austria

IAA-PDC-21-06-YY

PLANETARY DEFENSE GROUND ZERO: MASCOT'S VIEW ON THE ROCKS – AN UPDATE BETWEEN FIRST IMAGES AND SAMPLE RETURN

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Keywords: *asteroid surface properties, planetary defense, MASCOT, (162173) Ryugu, HAYABUSA2*

ABSTRACT

At 01:57:20 UTC on October 3rd, 2018, after 3½ years of cruise aboard the JAXA spacecraft HAYABUSA2 and about 3 months in the vicinity of its target, the MASCOT lander was separated successfully by from an altitude of 41 m. After a free-fall of only ≈5m51s MASCOT made first contact with C-type near-Earth and potentially hazardous asteroid (162173) Ryugu, by hitting a big boulder. MASCOT then bounced for ≈11m3s, in the process already gathering valuable information on mechanical properties of the

surface before it came to rest. It was able to perform science measurements at 3 different locations on the surface of Ryugu and took many images of its spectacular pitch-black landscape. MASCOT's payload suite was designed to investigate the fine-scale structure, multispectral reflectance, thermal characteristics and magnetic properties of the surface. Somewhat unexpectedly, MASCOT encountered very rugged terrain littered with large surface boulders. Observing in-situ, it confirmed the absence of fine particles and dust as already implied by the remote sensing instruments aboard the HAYABUSA2 spacecraft. After some 17^{h} of operations, MASCOT's mission ended with the last communication contact as it followed Ryugu's rotation beyond the horizon as seen from HAYABUSA2. Soon after, its primary battery was depleted. We present a broad overview of the recent scientific results of the MASCOT mission from separation through descent, landing and in-situ investigations on Ryugu until the end of its operation and relate them to the needs of planetary defense interactions with asteroids. We also recall the agile, responsive and sometimes serendipitous creation of MASCOT, the two-year rush of building and delivering it to JAXA's HAYABUSA2 spacecraft in time for launch, and the four years of in-flight operations and on-ground testing to make the most of the brief on-surface mission.

INTRODUCTION

On October 3rd, 2018, the Mobile Asteroid Surface Scout, MASCOT, successfully completed its 17-hours mission on the ~km-sized C-type potentially hazardous asteroid (162173) Ryugu. Investigating the surface and its thermal properties, looking for a magnetic field, and imaging the stark landscapes of this dark rubble pile, it contributed valuable close-up information before the surface sampling by its mothership, HAYABUSA2.

MASCOT SYSTEM

DLR in collaboration with the French space agency, CNES, has developed the Mobile Asteroid Surface Scout, MASCOT, a small asteroid lander which packs four full-scale science instruments and relocation capability into a shoebox-sized 10 kg spacecraft. It carries the near-IR soil microscope, MicrOmega (MMEGA), a high dynamic range black-and-white camera with night-time multicolour LED illumination (MasCAM), a 6-channel thermal IR radiometer (MARA), and a fluxgate magnetometer (MasMAG).

The MASCOT Flight Model (FM) was delivered to JAXA mid-June 2014 and was launched aboard the HAYABUSA2 space probe on December 3rd, 2014, to asteroid (162173) Ryugu. MASCOT is an organically integrated high-density constraints-driven design. The design, integration and testing of MASCOT followed a fast-paced Concurrent Assembly Integration Verification (C-AIV) approach. After preparatory studies, it was completed in 2 years from Preliminary Design Review (PDR) on June 6th, 2012 (the day of the Venus transit) to delivery of the Flight Model (FM) in July 2014 for integration and final joint testing with HAYABUSA2.

Science Instruments aboard MASCOT

MicrOmega is a near-infrared imaging spectrometer/microscope for the study of mineralogy and composition at grain scale. It acquires 3D (x,y,λ) microscopic image-

cubes of an area approximately (3 mm)² in size with a spatial sampling of (25 µm)² in (128² pixel)² images. For each pixel, the spectrum is acquired in contiguous spectral channels covering the range 0.99 to 3.55 µm with spectral sampling better than 40 cm-1 and a signal-to-noise ratio of 100, over the entire spectral range.

MasCAM uses a clear filter 1 Mpixel Si-CMOS sensor with high dynamic range imaging capability covering a (60°)² field of view, pointed slightly down to image an area in front of the lander. Multiple observations during the day are used for detailled studies of the reflection and scattering properties of the surface. During daytime, images are black-and-white. At night, colour images are taken using 4-channel IR-RGB LED illumination.

MARA is a 6-band multispectral thermal infrared radiometer, covering wavelengths from 5 to 100 µm. In addition to a clear filter, the remaining channels are narrow-band filtered and can be adapted to a thermal infrared instrument aboard the orbiter.

MasMAG is a vector compensated three-axis fluxgate magnetometer consisting of a digital electronics board and a sensor head. It has a long heritage from previous space missions. Due to the extreme conditions the design covered in these missions, the sensors can be mounted outside of the temperature controlled compartment.

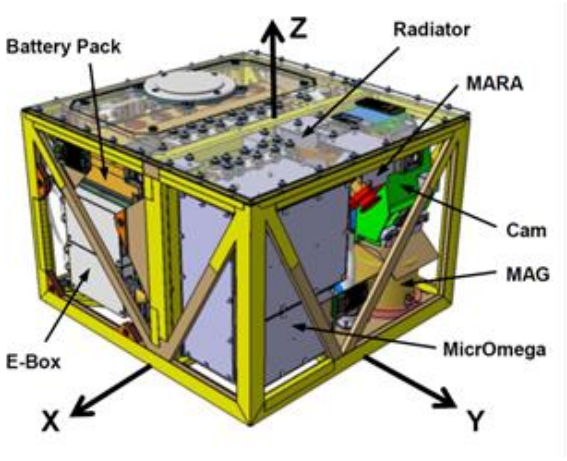

Fig.1 – The MASCOT Landing Module

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