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A WIDE-ANGLE CAMERA FOR THE MOBILE ASTEROID SURFACE SCOUT (MASCOT) ON HAYABUSA-2

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1. Introduction

JAXA's Hayabusa-2 mission, an asteroid sample return mission, is scheduled for launch in December 2014, for a rendezvous with the C-type asteroid 1999 JU3 in 2018. MASCOT, the Mobile Asteroid Surface Scout [1], is a small lander, designed to deliver ground truth for the orbiter remote measurements, support the selection of sampling sites, and provide context for the returned samples.

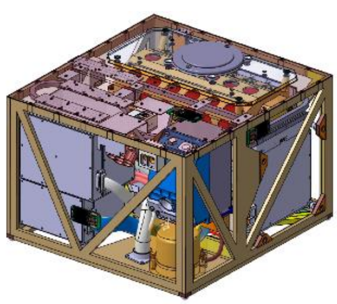

Figure 1: MASCOT lander, with the camera (in blue) mounted inside.

MASCOT's main objective is to investigate the landing site's geomorphology, the internal structure, texture and composition of the regolith (dust, soil and rocks), and the thermal, mechanical, and magnetic properties of the surface. MASCOT comprises a payload of four scientific instruments: camera, radiometer, magnetometer and hyper-spectral microscope. The camera (MASCOT CAM) was designed and built by DLR's Institute of Planetary Research, together with Airbus DS Germany.

2. Science Objectives

The Hayabusa-2 mission will perform the first in-situ examination of a C-type asteroid. 1999 JU3 is expected to be a rubble-pile, with a size slightly larger than Itokawa. The MASCOT camera will provide in-situ context for the orbiter remote sensing observations, for measurements by the other lander instruments (radiometer, spectrometer), and for the orbiter sampling experiment. Imaging during the descent and on the surface will allow a characterization of the geological context, mineralogy and physical properties of the landing site (e.g. rock and regolith particle size distributions). During the day, clear filter images will be acquired. During the night, illumination of the dark surface by means of four LED arrays in four spectral bands will permit colour imaging. This may allow identifying minerals, organics, and, possibly, ices. The acquisition of image series at different sun angles over the course of a day will allow characterizing time-dependent surface processes and the photometric properties of the regolith. Combined Hayabusa-2 and MASCOT visual and spectral observations will cover a wide range of observational scales. MASCOT will serve as a strong tie point between Hayabusa-2's remote sensing science (10^{3} - 10^{-3}m) and sample science (10^{-3} -10^{-6} m). [3,4]

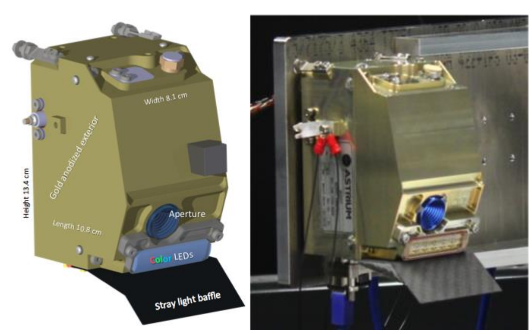

Figure 2: Engineering drawing and photo of the MASCOT camera flight model

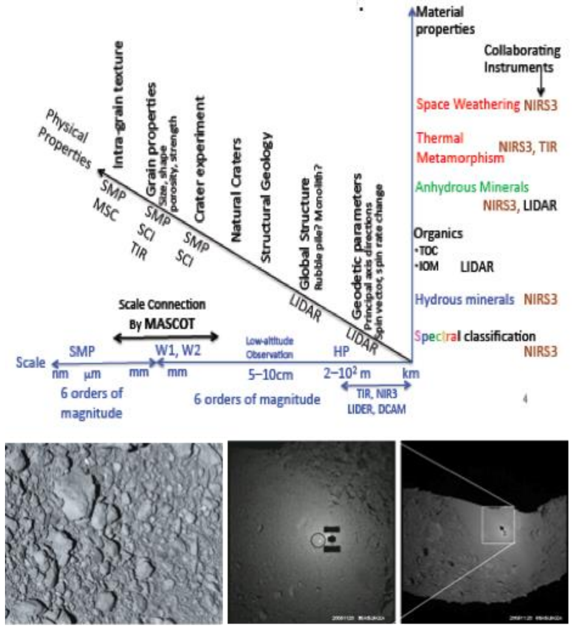

Figure 3: Hayabusa 2 / MASCOT combined measurement scales.

3. Instrument Description

The MASCOT camera is designed to cover a large part of the surface in front of MASCOT. It is mounted inside the lander slightly tilted, such that the centre of its 55° square field-of-view is aimed at the surface at an angle of 22°, so that both the surface close to the lander and the horizon are in the FOV, when the lander rests on an even surface. The camera is designed according to the Scheimpflug principle, which ensures that the entire scene along the camera's depth of field (150mm to infinity) is in focus. The camera is equipped with a 1024x1024 pixel CMOS sensor sensitive in the 400-1000 nm wavelength range, peaking at 600-700 nm. Together with the f-16 optics, this yields a nominal ground resolution of 150 micron/px at 150 mm distance (diffraction limited). An LED array, equipped with 4x36 LEDs of different colours (centered at B: 470nm, G: 530nm, R: 624nm, IR: 805nm), is available to illuminate the surface at night for colour imaging. To fit in the limited payload mass allocation for MASCOT, the camera optical head including illumination unit and electronics is designed as a highly compact camera with a low mass of 403g. The power consumption is less than 6.4W (during multiband night-time imaging).

3. Performance and Calibration

Geometrical calibration was done at Airbus DS. Contrast, geometric distortion, thermal focus stability, as well as in- and out-of-field straylight were measured and confirmed to be within the design limits. Radiometric calibration at DLR Berlin included an absolute radiometric calibration, flat field and linearity characterization, a characterization of the camera spectral sensitivity, a spectral characterization of the LEDs, as well as a characterization of the LED illumination spatial distribution. Detailed results will be presented.

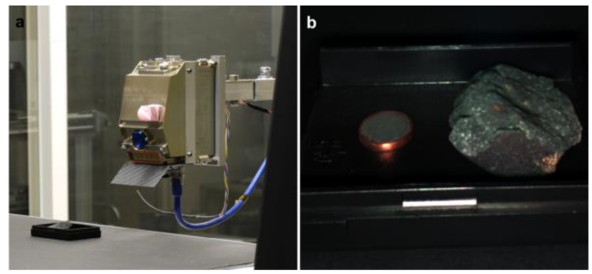

Figure 4: Colour imaging of a powder-pressed pellet and a slab of the Murchison meteorite.

Colour imaging of samples of the Murchison meteorite was conducted as part of a cross-calibration campaign with the Hayabusa-2 ONC camera. Figure 4a shows the experimental setup with the MASCOT camera. In front of the camera is a tableau with a powder-pressed pellet and a slab of the meteorite. Figure 4b shows the acquired image, a combination of images in three spectral bands (R,G,B), corrected for dark current.

References

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