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A MOBILE ASTEROID SURFACE SCOUT (MASCOT) for the HAYABUSA 2 MISSION to Ryugu

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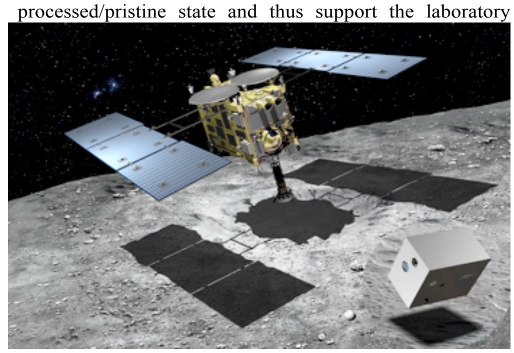
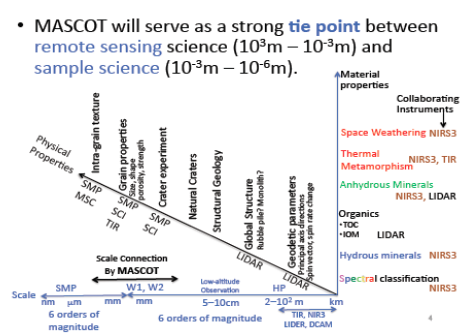
Introduction: MASCOT is part of JAXA's Hayabusa 2 asteroid sample return mission that has been launched to asteroid (162173) Ryugu (1,2,3) on Dec 3rd, 2014. It is scheduled to arrive at Ryugu in 2018, and return samples to Earth in 2020. The German Aerospace Center (DLR) developed the lander MASCOT with contributions from CNES (France) (2,3). Ryugu has been classified as a Cg-type (4), believed to be a primitive, volatile-rich remnant from the early solar system. Its visible geometric albedo is 0.07±0.01, its diameter 0.87±0.03 km (5). The thermal inertia indicates thick dust with a cm-sized, gravel-dominated surface layer (5,6). Ryugu shows a retrograde rotation with a period of 7.63±0.01h. Spectral observations indicate iron-bearing phyllosilicates (1) on parts of the surface, suggesting compositional heterogeneity. MASCOT will enable to in-situ map the asteroid's geomorphology, the intimate structure, texture and composition of the regolith (dust, soil and rocks), and its thermal, mechanical, and magnetic properties in order to provide ground truth for the orbiter remote measurements, support the selection of sampling sites, and provide context information for the returned samples (2,3). MASCOT comprises a payload of four scientific instruments: a camera, a radiometer, a magnetometer and a hyperspectral microscope (2,3,7,8). Characterizing the properties of asteroid regolith in-situ will deliver important ground truth for further understanding telescopic and orbital observations as well as samples of asteroids. MASCOT will descend and land on the asteroid and will change its position by hopping (3). This enables measurements during descent, at the touch-down positions, and during hopping. The first order scientific objectives for MASCOT are to investigate at least at one position: the geological context of the surface by descent imaging and far field in-situ imaging; the global magnetization by magnetic field measurements during descent and any local magnetization at the landing positions; the mineralogical composition and physical properties of the surface and near-surface material including minerals, organics and the detection of possible, near–surface ices; the surface thermal environment by measuring the asteroids surface temperature over the entire expected temperature range for a full day-night cycle; the regolith thermophysical properties by determining the surface emissivity and surface thermal inertia; the local morphology and in-situ structure and texture of the regolith including the rock size distribution and small-scale particle size distribution; the context of the observations performed by both, the instruments onboard the main spacecraft and the in situ measurements performed by MASCOT ('cooperative observations'). Provide documentation and context of the samples and correlate the local context of the in situ analysis with the remotely sensed global data; the body constitution on local and/or global scales and constrain surface and possibly sub-surface physical properties; the context of the sample collected and returned by the main spacecraft by qualifying its generic value and processed/pristine state and thus support the laboratory



Artist's conception of HY-2 during sampling, also showing MASCOT landed on the surface. CREDIT:JAXA/Akihiro Ikeshita.



analyses by indicating potential alteration during sampling, cruise, atmospheric entry and impact phases.

Measurement scenario: MASCOT enables measurements during descent, at the landing and up to two hopping positions, and during hopping. The first order scientific objectives for MASCOT is to investigate at least at one position: (1) the geological context of the surface by descent imaging and far field imaging in-situ; (2) the global magnetization by magnetic field measurements during descent and any local magnetization at the landing positions; (3) the mineralogical composition and physical properties of the surface and near-surface material including minerals, organics and detection of possible, near–surface ices; (4) the surface thermal environment by measuring the asteroids surface temperature over the entire expected temperature range for a full day-night cycle; (5) the regolith thermophysical properties by determining the surface emissivity and surface thermal inertia; (6) the local morphology and in-situ structure and texture of the regolith including the rock size distribution and small-scale particle size distribution; (7) the context of the observations performed by the instruments onboard the main spacecraft and the in situ measurements performed by MASCOT ('cooperative observations') and provide documentation and context of the samples and correlate the local context of the in situ analysis into the remotely sensed global context; (8) the body constitution on local and/or global scales and constrain surface and possibly sub-surface physical properties; (9) the context of the sample collected and returned by the main spacecraft by qualifying its generic value and processed/pristine state and thus support the laboratory analysis by indicating potential alteration during cruise, atmospheric entry and impact phases. In addition to the main science objectives further science measurement can be performed by the lander's engineering sensors that are supposed to monitor the housekeeping and/or provide the right measuring orientation/position of MASCOT and by the scientific payload based on their given favourable observing conditions within the lander's nominal operation mode ('opportunity science').

Instruments: The camera (2) will provide ground truth for the orbital measurements of the Hayabusa-2 orbiter instruments and the in-situ MASCOT sensor suite and to provide context of the undisturbed sampling sites. This is achieved by contributing to the determination of the structural, textural and compositional characteristics of the surface layer on scale lengths ranging from tens of meters to a fraction of a millimeter, by means of multi-color imaging of the asteroid's surface.

The camera will operate both as descent and in-situ imager (both during day and night phases). Imaging will start shortly after the separation from the Hayabusa-2 mother S/C and images will be acquired until touchdown. The images will close the resolution gap between orbital and in situ imaging and allow for determining the landing site within the orbiter camera dataset. After touchdown, the camera will acquire wide angle images of the asteroid's surface. Multispectral imaging during dark phases is achieved through an illumination device consisting of four arrays of monochromatic light emitting diodes working in 4 spectral bands that allow classifying and mapping compositional heterogeneity of the asteroid's surface by the means of color ratios Image series at different sun angles over the course of a day will also contribute to the physical characterization of the asteroid surface properties by photometric analysis. The radiometer is a multispectral instrument which will measure the radiative flux emitted from the asteroid's surface using thermopile sensors. Six individual filters will be employed to measure the flux in the wavelength bands between 5.5-7, 8-9.5, 9.5-11.5, 13.5-15.5, 8-14, and 5-100 µm in order to determine the asteroid's thermal inertia and to support mineralogical characterization. The magnetometer will measure the global magnetic field during descent and hopping phases either indicating a global magnetization of the asteroid or induction effects due to time-varying external magnetic fields. Furthermore, magnetic field vectors at the individual landing and hopping locations will be determined in order to characterize the magnetic properties of surface materials that will allow understanding the magnetic evolution of asteroidal bodies. The hyperspectral microscope will surface samples a few mm2 in size, with a resolution of 20 µm, as to their structure and composition. On each pixel, the spectrum is acquired from 0.9 to 3.5 µm, in more than 300 contiguous spectral channels. The spectral range and resolution have been chosen so as to enable to retrieve the composition of the major and minor constituents present in each image element: most minerals, both pristine and altered, have diagnostic signatures in this domain, as well as most frosts and ices, and noticeably, organics. Thus a microscopic determination of the asteroidal surface composition is provided down to its grain scale, offering key clues to decipher its origin and evolution. The external window of the hyperspectral microscope is in direct contact with surface material. An illumination system, based on an acousto-optic tunable filter, provides a monochromatic enlightening of the sample through the window, and an image is acquired on a 2D infrared cooled detector.

References: (1) Vilas, F., Astro. J. 1101-1105, 2008; (2) Jaumann, R., et al., SSR, DOI 10.1007/s11214-016-0263-2, 2016; (3) Ho, T.-M. et al., SSR, DOI 10.1007/s11214-016-0251-6. (4) Bus, S.J., Binzel, R.P. Icarus 158, 2002; (5) Hasegawa, T.G., et al., Astron. Soc. Japan 60, 2008; (6) T.G. Müller, T.G., et al., doi 10.1051/0004-6361/201015599, 2011. (7) Herčík, D., et al. Space Sci Rev (2016). doi:10.1007/s11214-016-0236-5. (8) Grott, M., et al. Space Sci Rev (2016). doi:10.1007/s11214-016-0272-1.