REGOLITH SCIENCE WITH THE CAMERAS ON THE MMX ROVER

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Introduction: The JAXA Martian Moons Exploration (MMX) mission [1] has a primary objective to study the formation and origins of Phobos and Deimos. The MMX spacecraft will also deploy a CNES/DLR rover to the surface of Phobos [2,3]. This rover will be the first of its kind to attempt wheeled-locomotion on a low-gravity surface. As such, this rover provides a unique opportunity to study not only the surface properties of Phobos, but also regolith dynamics on small-bodies. This information is valuable for understanding the surface processes and geological history of Phobos in addition to being of high importance to the landing (and sampling) operations of the main MMX spacecraft [1].

The MMX rover cameras: The rover includes two colour NavCams and two panchromatic WheelCams [2,3]. The cameras will be used for navigation, locomotion, and science. The NavCams are a stereo pair looking in the driving direction, the WheelCams are placed on the underside of the rover, each aimed at a different rover wheel. For the NavCams, the spatial resolution is about ~ 1 mm per pixel at a distance of 1 m. The WheelCams have a pixel resolution of approximately 100 µm at the centre of the image (at a distance of ~35 cm). The WheelCams are also equipped with LEDs to illuminate the scene and to allow for multispectral imaging.

Local geomorphology and regolith properties: By imaging the landscape, the NavCams will allow the local geomorphology of the terrain to be constrained as well as the level of heterogeneity of the regolith in terms of composition, space weathering alteration and texture (size frequency distribution of boulders). The images from both cameras will be used to characterize the general grain properties of the regolith (size distribution, morphological parameters [4,5]) within the limits of the camera resolution.

Rover wheel – regolith interactions: The WheelCam images will be used to determine the depth of the wheel sinkage, which is closely linked to the load bearing strength and friction angle of the regolith [6], and they will measure the traction and slippage of the wheel that provides shearing characteristics of the regolith [7,8]. Observations of the rover tracks, talus and tailings behind the wheels can provide additional constraints on the physical properties of the regolith.

Preparing for the WheelCam analyses: We have developed the MMX WheelCam testbed (Fig. 1, [9]) that recreates the scene that the WheelCams will observe during the mission. The testbed is instrumented with multiple sensors allowing measurements to be made of the sinkage and slippage of the wheel. The main objective of the testbed is to develop the image processing tools for the WheelCams.

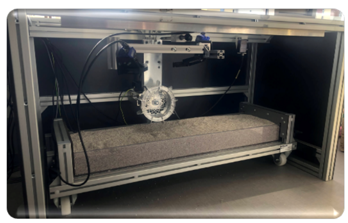

Figure 1. The MMX WheelCam testbed at ISAE-SUPAERO [9]. The testbed includes a flight representative MMX rover wheel, WheelCam camera baffles, LEDs and blackout panels.

We also perform Discrete Element Method simulations [10] in order to understand the influence of the low gravity environment on sinking and driving behaviour (Fig. 2; [11,12]). This is essential to ensure an accurate determination of the regolith properties from the wheel – surface interactions.

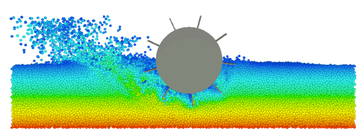

Figure 2. Snapshot from a rolling simulation where gravity is 0.006 m/s2 and the rotational velocity is 0.65 rad/s [11,12].

Conclusions: This presentation will discuss how the rover cameras are expected to achieve the regolith science objectives of the MMX rover.

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References: [1] Kuramoto, K. et al. EPS (2022), [2] Michel et al., EPS (2022), [3] Ulamec, S. et al., ACM (2023), [4] Robin, C. et al., ACM (2023), [5] Duchêne, A. et al., ACM (2023), [6] Sullivan et al., JGR-Planets (2011), [7] Maimone, M. et al. J. Field Robotics (2007) [8] Reina, G. et al. IEEE/ASME Trans. On Mechatronics (2006), [9] Passoni, L. et al., LPSC (2021) [10] Sunday, C. et al., MNRAS (2020), [11] Sunday, C., et al. EPSC (2022), [12] Sunday, C. PhD Thesis, ISAE-SUPAERO (2022).