IDEFIX, THE MMX ROVER – IN-SITU SCIENCE ON PHOBOS. S. Ulamec[1], P. Michel[2], M. Grott[3], S. Schröder[3], H.-W. Hübers[3], Y. Cho[4], O. Prieto-Ballesteros[5], N. Murdoch[6], P. Vernazza[7], J. Biele[1], S. Tardivel[8], H. Miyamoto[4], [1]German Aerospace Center (DLR), 51147 Cologne, Germany, stephan.ulamec@dlr.de, [2]Université Côte d'Azur, Obs. Côte d'Azur, CNRS, Lab. Lagrange, 06304 Nice, France, [3]German Aerospace Center (DLR), 12489 Berlin, Germany, [4]University of Tokyo, 113-0033 Tokyo, Japan, [5]Centro de Astrobiología CSIC-INTA, Torrejón de Ardoz, Spain, [6]Inst. Supérieur de l'Aéronautique et de l'Espace (ISAE-SUPAERO), 31055 Toulouse, France, [7]Laboratoire d'Astrophysique de Marseille (LAM), 13388 Marseille, France, [8]Centre National d'Etudes Spatiales (CNES), 31401 Toulouse, France.

Introduction: IDEFIX is a small rover, contributed by the Centre National d'Etudes Spatiales (CNES) and the German Aerospace Center (DLR) to JAXA´s Martian Moons eXploration (MMX) mission which will investigate the Martian moons Phobos and Deimos [1,2]. IDEFIX will be delivered to the surface of Phobos to perform in-situ science but also to serve as a scout, gathering data to prepare the landing of the main spacecraft. The MMX Rover will deliver information on the regolith properties by high resolution imaging (NavCams and WheelCams), measurement of the spectral properties in the thermal infrared as well as the thermophysical properties using a radiometer (miniRAD) and Raman spectroscopy (RAX) [3,4].

Scientific Objectives and Instruments: The scientific objectives of the MMX rover complement and support the overall MMX mission, as is described in Refs. [2,4]. They complement the science which can be performed remotely with the instruments on board the main MMX spacecraft or the returned samples. In addition to its science objectives, the rover will also serve as a technological demonstrator for roving in a low gravity environment.

Onboard IDEFIX there are four PI-led instruments:

a) The Navigation Cameras (NavCam) looking into the driving direction to be used for navigating but also for imaging the landscape with high resolution (1 mm at 1 m distance). As the detector of the NavCams is coated with pixel sized color filters, color information will be available. Illumination with white LED´s will allow imaging at night [3].

b) Two WheelCams (WheelCam) will image the contact points of the rover wheels with the surface. Analyzing, e.g., the depth and structure of the tracks allows information to be gained on the physical properties of the regolith. Illumination with LED's will allow imaging in the shadow below the rover D´s) and also colored imaging (three colored LED´s).

c) A Raman spectrometer (RAX), spectroscopically analyzing a spot underneath the rover will identify the mineralogy on Phobos' surface and provide information on the grain heterogeneity [5].

d) A radiometer (miniRAD) will measure surface brightness temperature during day-night cycles in six thermal infrared wavelength bands, allowing a determination of the surface thermo-physical properties as well as the surface emissivity [6].

IDEFIX System Overview: The rover with an allocated mass of 29,1 kg, (including units that will stay on the main spacecraft as well as its scientific payload) is based on a carbon fibers structure, a locomotion system with four individually controlled wheels and a power system with a solar generator and re-chargeable batteries. During cruise it will be attached to the main MMX spacecraft and later, during an MMX landing rehearsal, IDEFIX will released to the surface of Phobos from an altitude of about 40 m. After coming to rest on the surface it will upright autonomously, deploy its solar generator and get ready for commissioning, driving and science operations.

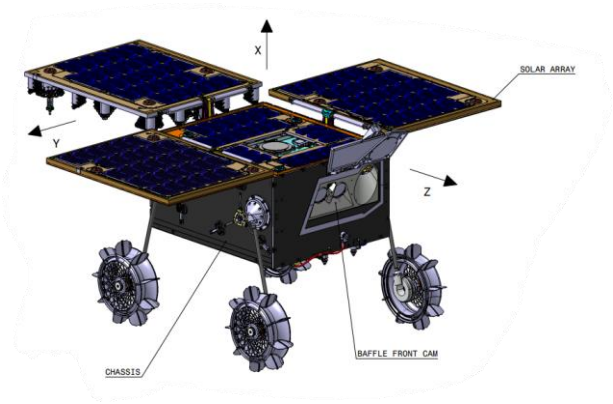

Figure 1: IDEFIX in on-surface configuration (image: CNES)

Figure 1 shows a CAD model of the rover with fully deployed locomotion system and solar generator. Figure 2 shows the flight model of IDEFIX shortly before delivery to JAXA.

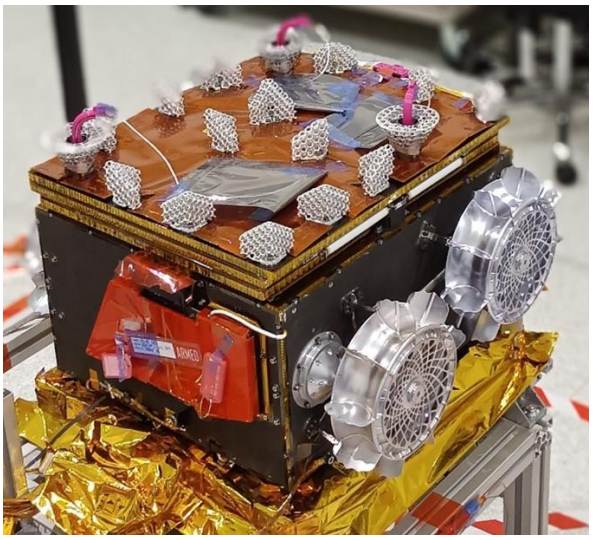

Figure 2 Rover Flight model in cruise configuration (image: CNES)

Mission Status: The qualified IDEFIX Rover has been delivered from Europe to Japan in early 2024. It will be integrated into the main spacecraft and will undergo further tests on spacecraft level. The current MMX schedule has a launch date in JFY 2026, followed by Martian orbit insertion in JFY 2027 and the spacecraft will return to Earth in JFY 2031. Rover delivery to the surface of Phobos is currently planned for the end of 2028. The estimated life-time on Phobos is at least 100 (Earth-) days. There are two dedicated Rover control centers, one at CNES in Toulouse, the other at DLR in Cologne. All telemetry and commands will be relayed via the MMX main spacecraft.

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References: [1] Y. Kawakatsu, *et al*. (2023) *Acta Astron*. 202, 715–728. [2] K. Kuramoto, *et al*. (2022) *EPS* 74 (12). [3] S. Ulamec, P. Michel, *et al*. (2023) *Acta Astron*. 210, 95-101. [4] P. Michel, S. Ulamec, *et al.* (2022) *EPS* 74 (2). [5] Y. Cho, *et al.* (2021) *EPS* 73 (232). [6] M. Grott, *et al*. (2022) *LPS LIII* Abstract #1199.