Martian Moons eXploration (MMX)

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Martian Moon eXploration (MMX) is the 3rd Japanese sample return mission followed by Hayabusa [1] and Hayabusa-2 [2]. The MMX spacecraft is scheduled to be launched in 2024, orbit both Phobos and Deimos (multi-flyby), and retrieve and return >10 g of Phobos regolith back to Earth in 2029 [3]. The origins of Phobos and Deimos are still a matter of significant debate: capture of asteroids versus in-situ formation by a giant impact on Mars. In either case, MMX will definitely provide clues about their origins and offer an opportunity to directly explore the satellite building blocks or juvenile crust/mantle components of Mars. MMX will also aim to understand physical processes in the circumplanetary environment of Mars. The new knowledge of Phobos/Deimos and Mars will be further leveraged to constrain the initial condition of the Mars-moon system and to gain vital insights regarding the sources and delivery process of water (and organics) into the inner rocky planets.

We select seven nominal science payloads for the remote sensing observations: 1) wide-angle multi-band camera (OROCHI), 2) telescope camera (TENGOO), 3) near-infrared spectrometer (MacrOmega), 4) gamma-ray and neutron spectrometer (MEGANE), 5) light detection and ranging (LIDAR), 6) circum-Martian dust monitor (CMDM), and 7) mass spectrum analyzer (MSA) (Table 1). The spacecraft also carries a sampler system equipped with a robotic manipulator and corers, which enables the acquisition of Phobos regolith >2 cm beneath the surface.

The spacecraft consists of propulsion, exploration, and return modules (total launch mass = ~3,500 kg). The chemical propulsion system is utilized for Mars orbit injection and escape maneuver. The outward interplanetary flights take ~1 year by the most efficient Hohmann-like transfer. The spacecraft stays at circum-Mars orbits ~3 years for exploration followed by the ~1 year homeward interplanetary flight to Earth. The Phobos exploration includes multiple landing/sampling operations; each takes ~2.5 hours. The spacecraft employs ballistic descent to reach the space right above a landing site before the final free-fall descent without a thruster jet to prevent whirling wind from blowing regolith particles.

Table 1. Nominal science payload

Payload	**Measurements**
Wide-angle multiband camera (OROCHI)	• Global mapping of hydrated minerals, organics, and the spectral heterogeneity of the Martian moons
Telescopic camera (TENGOO)	• Determine the global topography and surface structure of the Martian moons • Characterize the topography around the sampling sites
Gamma-ray, neutron spectrometer (MEGANE)	• Determine the bulk elemental abundance and compositional variability of Phobos
Near-infrared spectrometer (MacrOmega)	• Global mapping of minerals, molecular H_2O and organics of the Martian moons • Characterize the material distribution around the sampling sites • Monitor the transport of H_2O vapor, H_2O/CO_2clouds, and dust in the Mars atmosphere
Light detection and ranging (LIDAR)	• Determine the Phobos shape and topography
Circum-martian dust monitor (CMDM)	• Detect and monitor: 1) the circum-martian dust ring; 2) interplanetary dust; 3) Interstellar dust
Mass spectrum analyser (MSA)	• Determine the mass and energy of ions from Phobos, Mars and Sun

References

[1] Fujiwara, A. et al.2006, Science 312: 1330-1334. [2] Tsuda, Y. et al. 2013. Acta Astronautica 9: 356-362. [3] Usui, T. et al. 2018, Abstract# B4.2-0007-18, 42nd COSPAR.