# MMX

## Martian Moons eXploration

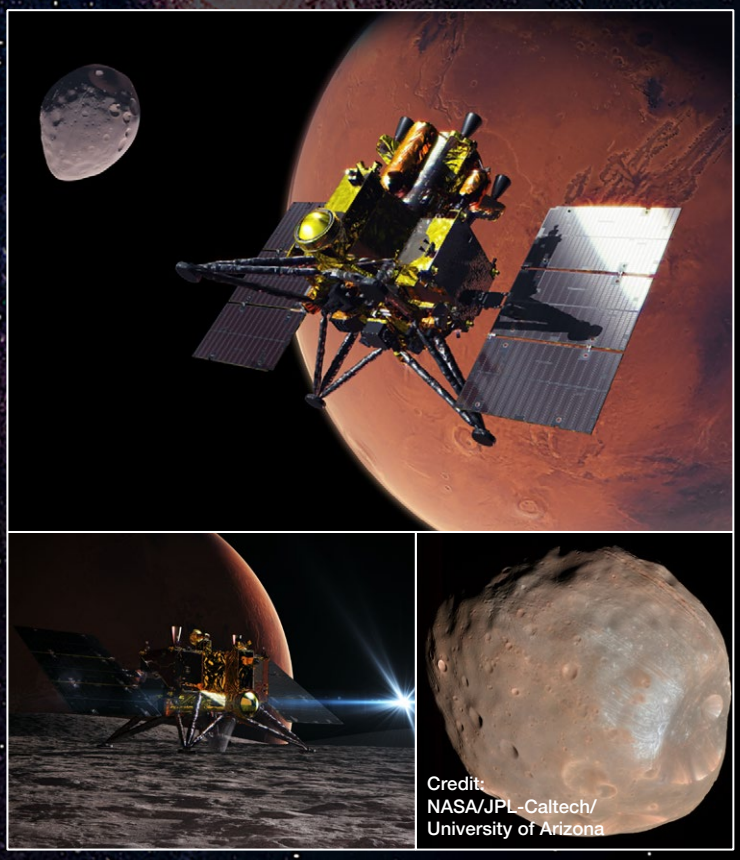
Japan Aerospace Exploration Agency

# Martian Moons eXploration (MMX)

The Martian Moons eXploration (MMX) mission will be the world's first mission to return samples from the Martian sphere (the Martian moon, Phobos) by utilizing technology developed through the Hayabusa2 sample return mission.

MMX will analyze hydrous minerals, water, and organic matter contained in the soil of the Martian moon to clarify the existence of water and organic matter in the Martian sphere, the origin of the two Martian moons, and the evolution process of the Martian sphere system (Mars, Phobos, and Deimos). MMX will also help elucidate the migration process of organic matter and water in the primitive Solar System and their supply to celestial bodies.

In addition, the mission will carry out the world's first detailed observation of Phobos' surface topography, ground information and surrounding environment, and investigate the moon's potential use as a base for future crewed Mars exploration.




Upper : CG Image of MMX

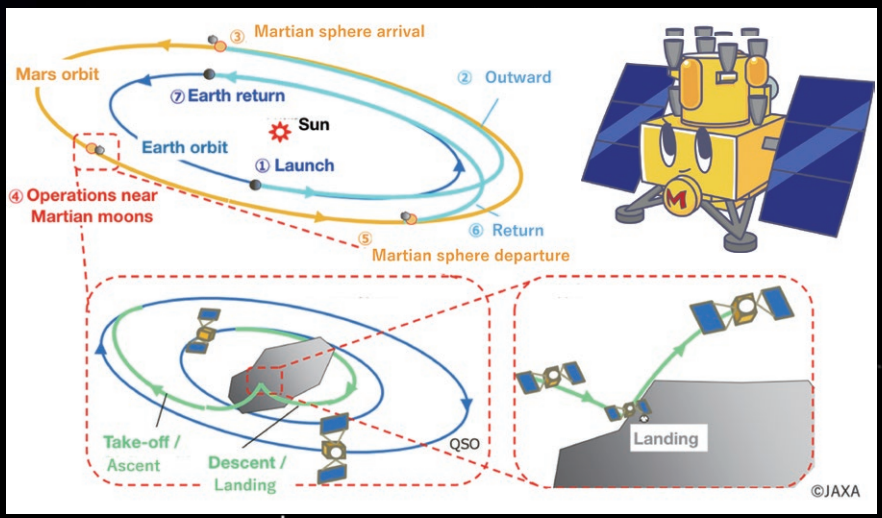
Lower left : Collection of sample by sampling equipment  Lower right : Phobos image taken by NASA MRO

## ■ MMX Facts

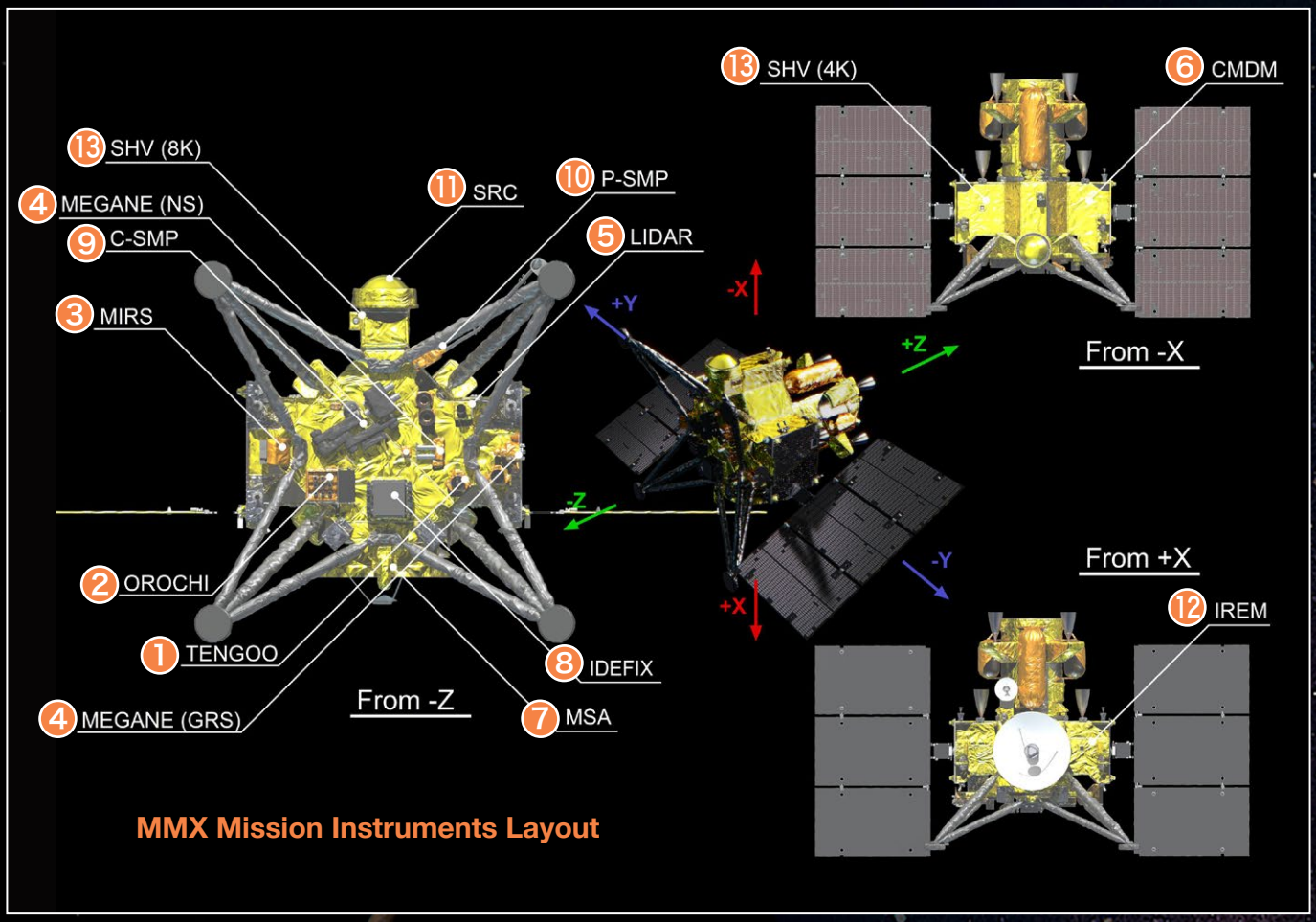
| Item | Performance/Features |
|---|---|
| Configuration | Three-module configuration (Propulsion / Exploration /Return) |
| Launcher | H3-24L |
| Launch Year | 2026 |
| Mission Duration | 5 years |
| Launch Mass | 4,200kg |
| Propellant Mass | Propulsion Mod. : 1,750kg<br>Return Mod. : 1,100kg |
| Communication | X-band 32kbps/Ka-band 128kbps<br>(When distance btw Earth-Mars=2.7au) |
| Electric Power | High-efficiency thin-film solar cells |
| Landing Navigation | Image-based navigation<br>SLIM-derived technology |

## ■ Mission Overview

MMX is scheduled to arrive in the vicinity of Mars approximately one year after launch, after which the spacecraft will enter an orbit to fly near the Martian moons. The spacecraft is scheduled to stay in the Martian orbit for about three years, during which it will conduct observations, attempt to land on Phobos twice, and collect samples. After completion of observations and sample collection, the spacecraft will take about one year to return to Earth.



# MMX Mission Instruments




MMX Mission Instruments Layout

## Observations by remote sensing / on the surface of Phobos

**① TENGOO (TElescopic Nadir imager for GeOmOrphology)**
Carries out a detailed observation of the surface structure and the topography around the sampling points on Phobos to obtain information necessary for material distribution and sample collection.

**② OROCHI (Optical RadiOmeter composed of CHromatic Imagers)**
Observes hydrous minerals in the surface layer of Phobos and estimate materials around sampling sites.

**③ MIRS (MMX InfraRed Spectrometer)**
Performs near-infrared spectroscopic observations of the surface layers of Phobos to map the distribution of mineral and molecular species (especially hydrous minerals and organic matter).

**④ MEGANE (Mars-moon Exploration with GAmma rays and NEutrons)**
Measures neutrons and gamma rays emitted from the surface of Phobos to determine its elemental composition.

**⑤ LIDAR (Laser Altimeter)**
Obtains global topographic information of Phobos and create its detailed shape models.

**⑥ CMDM (Circum-Martian Dust Monitor)**
Detects Mars dust rings or determine upper limits for dust abundance to constrain dust re-accumulation events on Mars moon orbits.

**⑦ MSA (Mass Spectrum Analyzer)**
Observes Martian and Martian-moon origin ions and solar wind ions, and select/measure the origin of each.

**⑧ IDEFIX (Rover)**
Lands before the MMX spacecraft, explore the surface of Phobos, and acquire properties of the surface regolith to reduce the risk of landing and sample acquisition operations, as well as acquire calibration data for science observations.

## Sampling and Return

**⑨ C-SMP (Coring Sampler)**
Collects regolith from the surface of Phobos to a depth of 2cm and transfer to the return capsule.

**⑩ P-SMP (Pneumatic Sampler)**
Collects and retain a small amount of regolith from the surface layer of Phobos using a nitrogen gas injection collection mechanism.

**⑪ SRC (Sample Return Capsule)**
Brings back to Earth Phobos samples obtained by the two types of sampling equipment.

## Acquisition of exploration technology

**⑫ IREM (Interplanetary Radiation Environment Monitor)**
Obtains energy spectra of solar energetic particles and establish a method for evaluating radiation exposure doses.

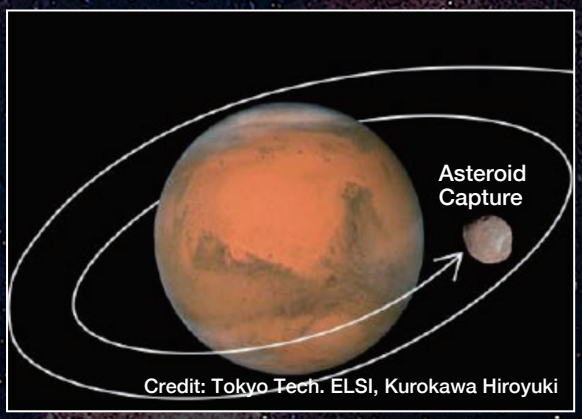
**⑬ SHV (Super Hi-Vision cameras)**
Contributes to the operational improvement and outreach of space exploration through high-definition (8K, 4K) imaging of Phobos and will help visualize the mission.

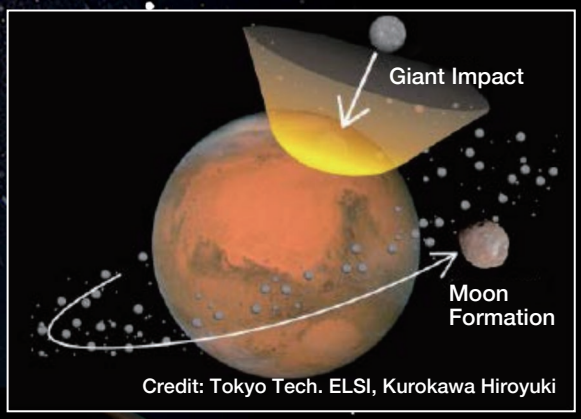
## Instruments provided by:

④ ⑩ National Aeronautics and Space Administration (NASA)
③ National Center for Space Studies (CNES)
⑧ CNES, German Aerospace Center (DLR)
⑬ Japan Broadcasting Corporation (NHK)

# Scientific and Technical Significance of MMX

## ■ Origin of the Martian Moons




### Asteroid Capture Theory

Theory that an originally distant asteroid changed its orbit due to collision with another celestial body, flew to the vicinity of Mars, and was captured by the Martian gravity.

### Giant Impact Theory

Theory that the Martian moons were formed after a major celestial impact with Mars that scattered debris into Mars' orbit and then re-accumulated to form the moons.

MMX aims to settle the theory of the origin of Martian moons by analyzing the returned samples.

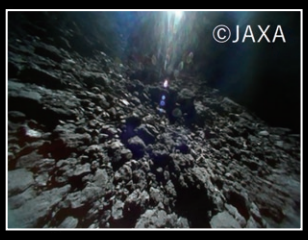
## ■ Expansion and development of asteroid exploration and sample return technologies

Based on the successful Hayabusa and Hayabusa2 missions, MMX will take advantage of Japan's world-leading small celestial body exploration and sample return technologies to challenge sample return from one of the most important unexplored celestial bodies in the Solar System, Phobos.

To date, Japan and the United States are the only countries that have successfully collected and recovered samples from extraterrestrial bodies outside the Earth system.

The Martian moons Phobos and Deimos are small bodies, about 10-20 km in diameter, that have never been directly explored. MMX will land on the surface of Phobos and, during its several-hour stay, collect samples of 10g or more from a depth of 2cm or greater (Hayabusa2 aimed to collect 0.1g) using an advanced sampling device with manipulators and corers.


The Martian moons


Upper: Hayabusa2 touchdown on asteroid (illustration)
Lower left: Asteroid Ryugu
Lower right: Image from Ryugu surface observation by MINERVA-II1

## Web Page

MMX Web page
https://www.mmx.jaxa.jp/en/

MMX "X" Account
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JSEC "X" Account
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