Signing Ceremony for the Implementation Arrangement with CNES on Cooperative Activities in MMX (Martian Moons eXploration)

Martian Moons eXploration (MMX)

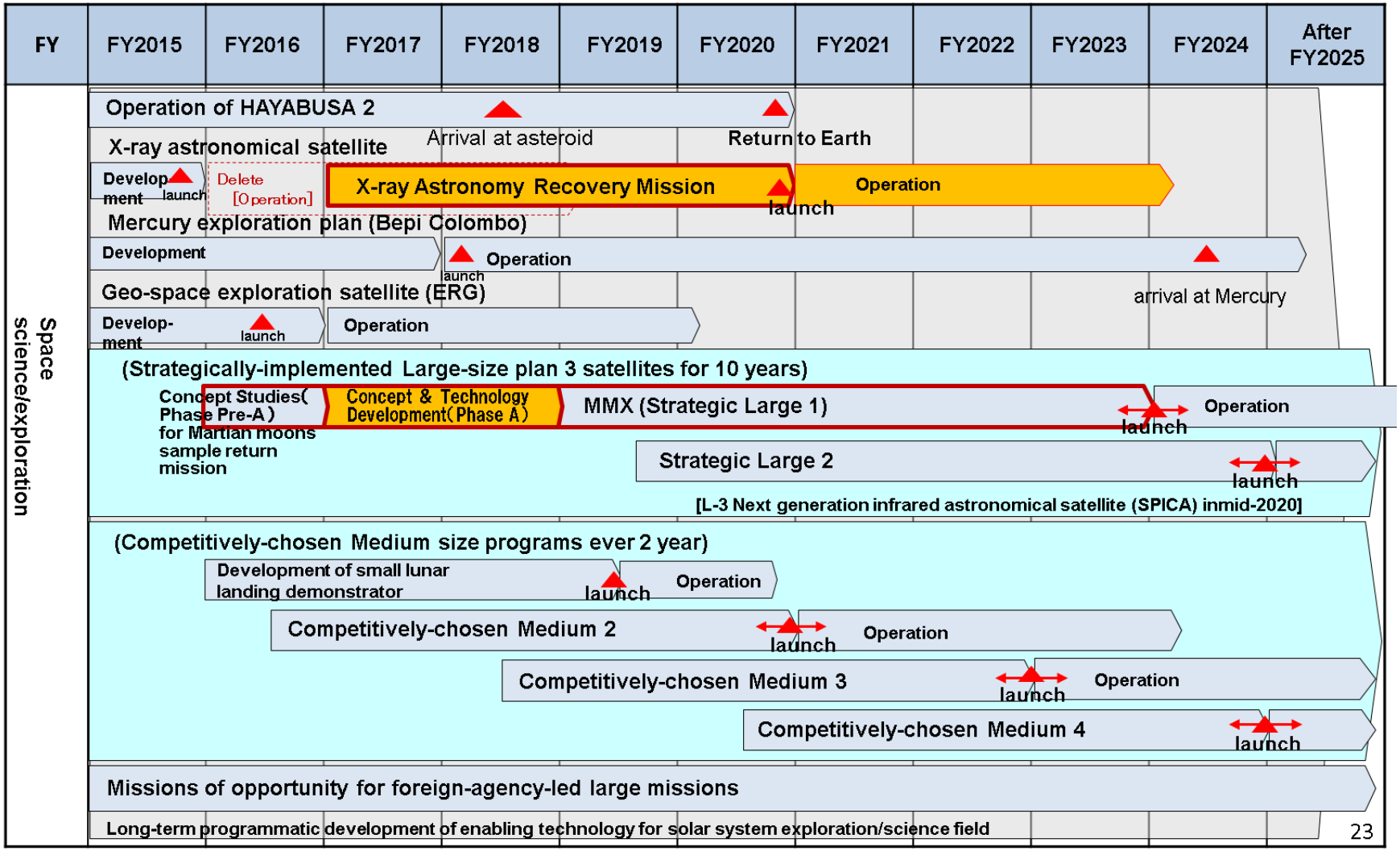
Mission Overview

April 10, 2017 JAXA Tokyo Office

http://mmx.isas.jaxa.jp

MMX in Space Science/Exploration Roadmap

Martian Moons eXploration (MMX) is the mission study that would lead to the ISAS strategic M class mission #1, targeting at a launch in JFY2024.



Mission Goal and Objectives

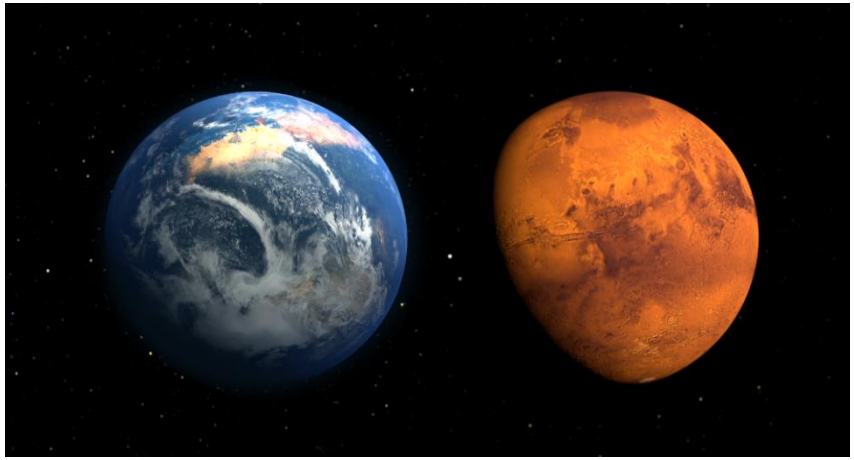
Mars Missions and their Objectives

Missions to Mars are driven by interest in “what its surface environment used to be”. Their key questions (among many) are,

- *What is the history of the Mars surface environment?*
- *How did the atmospheric loss happen?*
- *What was driving the climate change?*

Curiosity found evidence of water

Credit: NASA, JPL-Caltech, MSSS, MAHLI

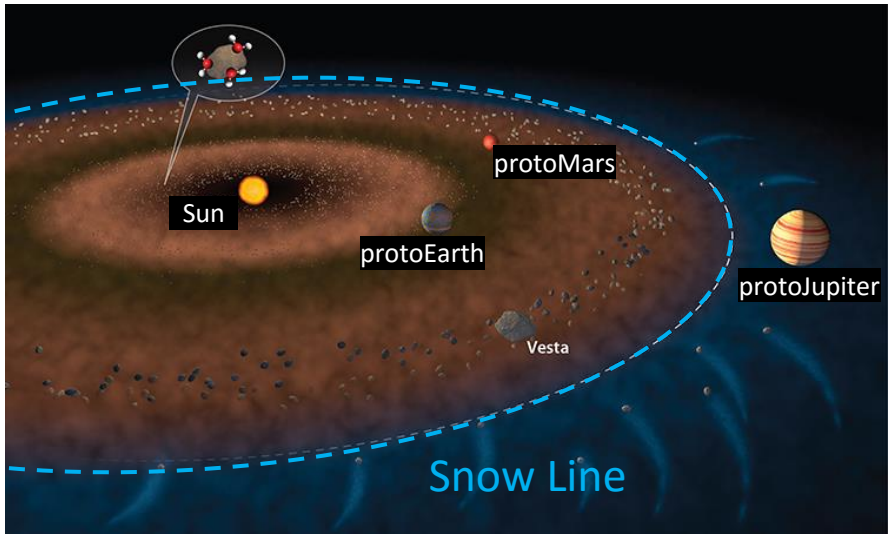


Old habitable Mars and current Mars

Credit: NASA's Goddard Space Flight Center

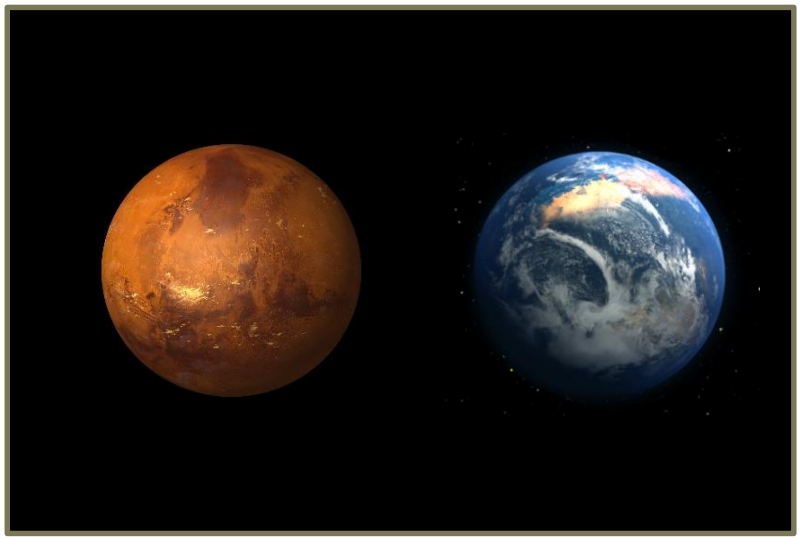
Why Water was on Mars ?

Realizing that rocky planets must have been born dry leads to the key question of different type.



Solar System in early age

Illustration by Jack Cook, Woods Hole Oceanographic Institution



ProtoMars and old habitable Mars

Credit(right): NASA's Goddard Space Flight Center

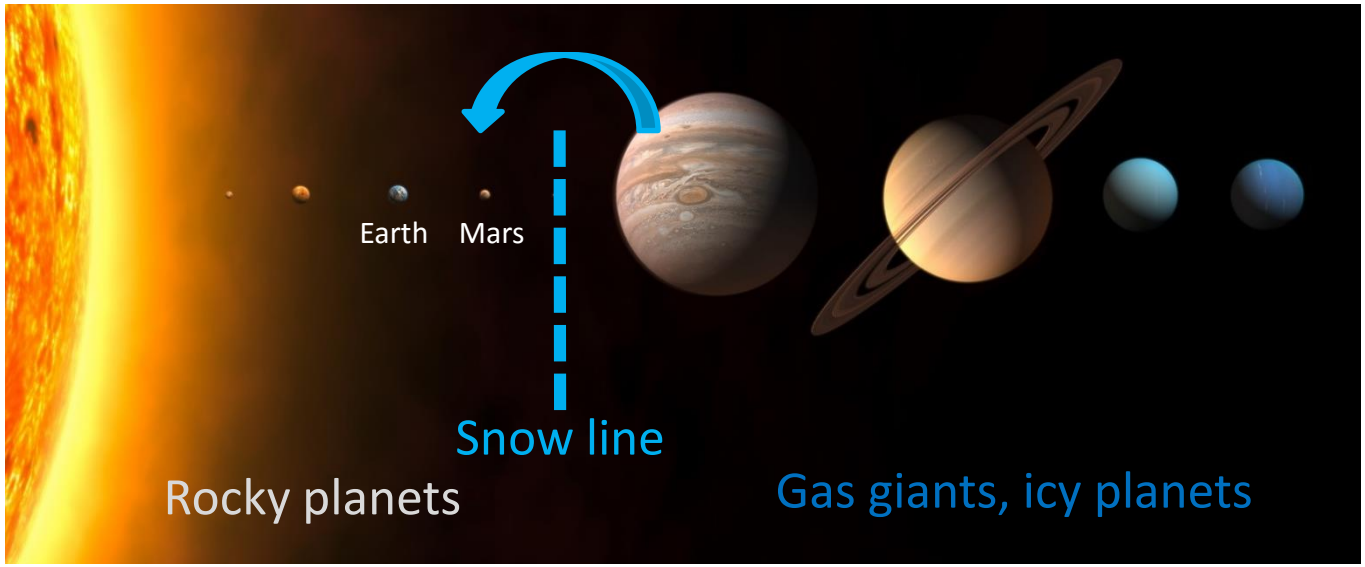
How was water delivered to Mars?

As a part of the big question:

How was water delivered to rocky planets and enabled the habitability of the solar system?

Transport across the Snow Line

- Delivery of water, volatiles, organic compounds etc. from outside the snow line entitles the rocky planet region to be habitable.
- Small bodies play the role of delivery capsules.
- Then, dynamics of small bodies around the snow line in the early solar system is the issue that needs to be understood.



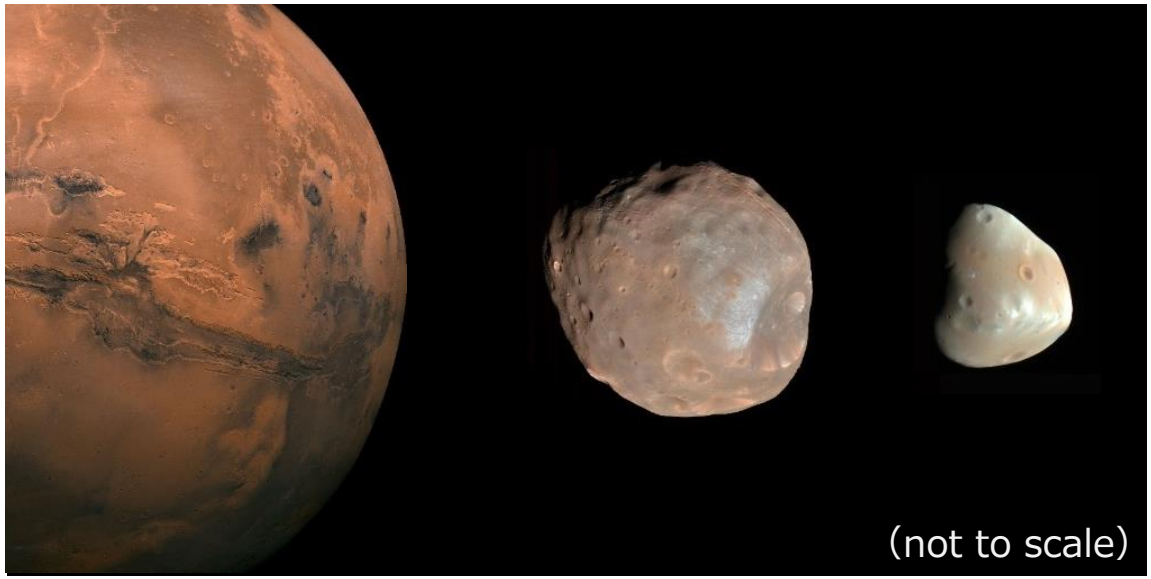
Credit: The International Astronomical Union/Martin Kornmesser

Which, among the seven objects in the inner-solar system, should we explorer to address this key question?!

Martian Moons : Minor Bodies around Mars

Mars was at the gateway position of the rocky planet region to witness the process.

Martian Moons, Phobos (diameter: 23km) and Deimos (diameter: 12km), would be categorized as asteroids if they were not Martian moons.



Credit:
NASA/JPL-Caltech
University of Arizona

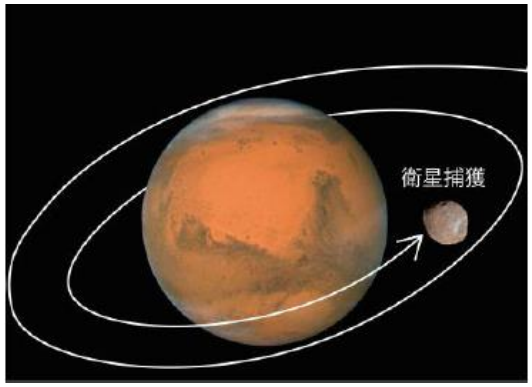
Martian Moons : Phobos and Deimos

Martian moons would have been delivery capsules of water in the early solar system.

Origin of Martian Moons

Origin of Martian Moons are not known. There are two leading hypotheses: captured primordial asteroid or giant impact.

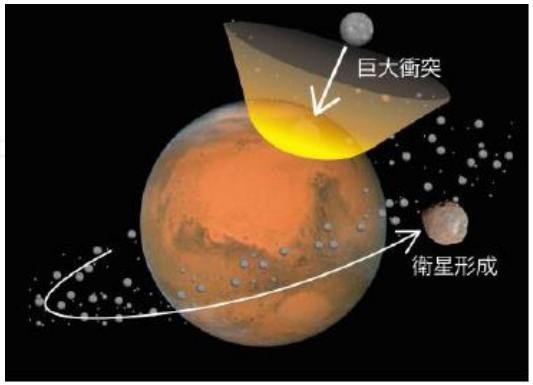
Captured Primordial Asteroid



Credit:
ELSI, Tokyo Inst. of Tech.
Hiroyuki Kurokawa

Sample analysis will characterize a capsule that was on its way to deliver water and organic compounds to the inner-solar system.

Giant Impact



Sample analysis will reveal that the samples are mixture of Mars materials and impactor materials: Mars sample return realized! We do learn about dynamics of the small body (the impactor), too.

Martian Moons eXploration (MMX) will reveal the origin of Martian moons from the analysis of returned samples.

Mission Objectives

Realizing that rocky planets must have been born dry leads to the key question *"How was water delivered to Mars?"*

Delivery of water, volatiles, organic compounds etc. from outside the snow line entitled the rocky planet region to be habitable.
Small bodies played the role of delivery capsules.
Mars was at the gateway position of the rocky planet region. Phobos and Deimos are the minor bodies around Mars.
Martian moons would have been delivery capsules of water in the solar system.

Martian Moons eXploration (MMX) Mission Objectives

To reveal the origin of the Martian moons, and then to make a progress in our understanding of planetary system formation and of primordial material transport around the border between the inner- and the outer-part of the early solar system.

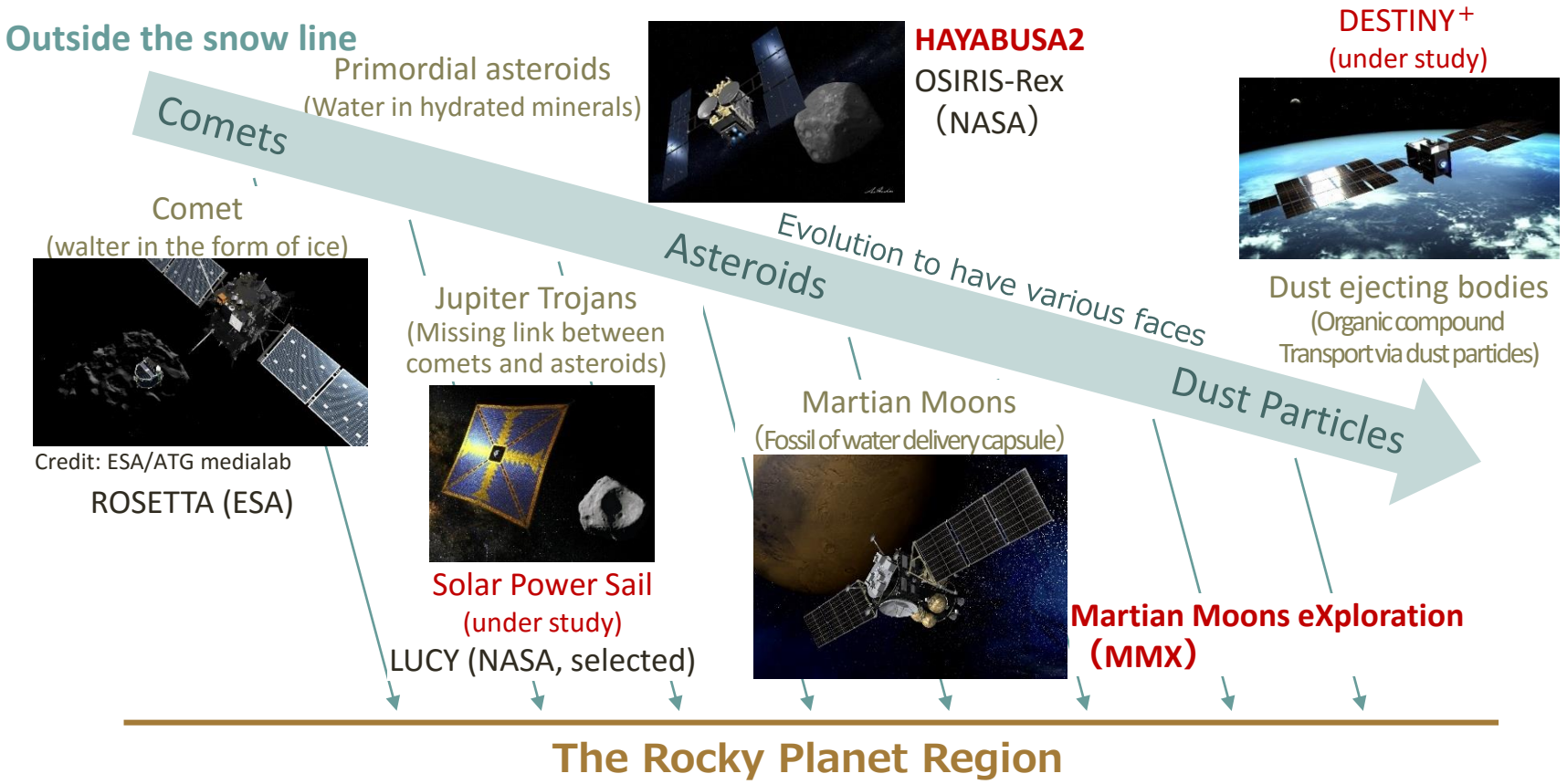
Sub-Objectives

To understand processes in circum-Martian environment and Mars atmosphere, and then to improve our views of evolutions of Martian moons as well as Mars surface environmental transition.

ISAS Minor Body Exploration Strategy

Small bodies born outside the snow line. Initially comet-like, evolved in time to show various faces. Water and organic compound delivery by these enabled the habitability of our planet. When, who and how?

ISAS addresses this question by a series of small body missions.



Previous Martian Moons Exploration

Martian moons has been explored since the beginning of Mars exploration, but they were secondary in the missions with limited fly-by observation. Neither mission aimed at Martian moons failed.

Data supplied by NSSDC

Image taken in 1978
from Viking-1 orbiter (NASA).

The Phobos-Grunt mission (Russia) was launched in 2011, but failed to escape the Earth due to a failure immediately after the launch. At the moment, there are no prospects of realization of Martian Moons exploration mission in other countries.

Mission Objectives (from engineering side)

A major role of the space technology divisions is to provide engineering realization to this planetary science mission. Besides, we set our own mission objectives from the engineering side in line with our mission goals to realize “further and more flexible” space exploration.

Objective : To exploit astronautics and exploration capability for our future deep space missions in the following areas.

Round trip to Martian system (Astronautics)
Large energy (Δv around 5km/s) is required for a round trip to a Martian moon.

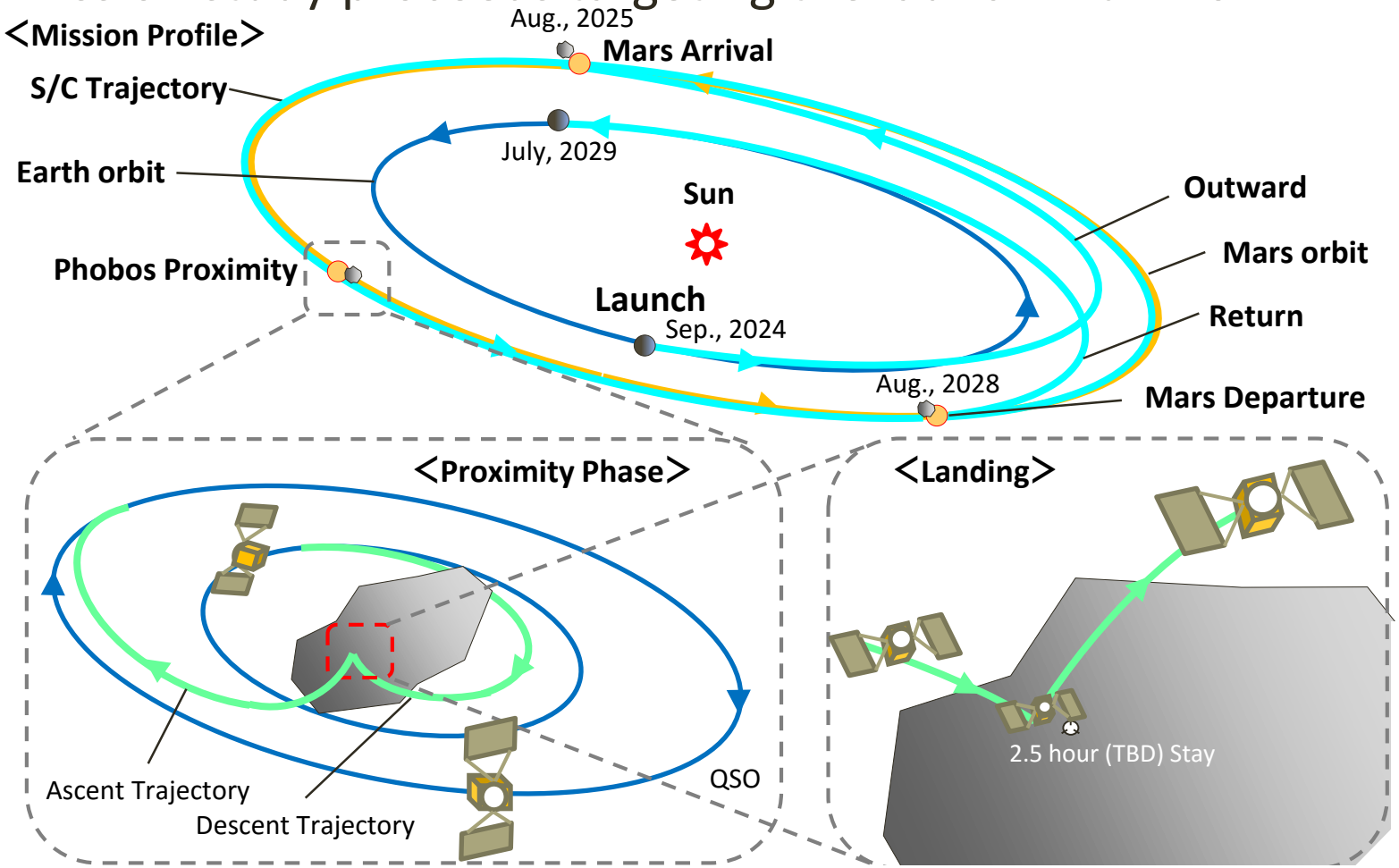
Sophisticated sample retrieval technologies (Robotics)
Higher performance (than in case of Hayabusa2) is required for sample retrieval.

High rate mission data transmission (Communication)
Performance equivalent to European and U.S. deep space missions is envisioned.

Mission Profile
Spacecraft Overview

Mission Profile

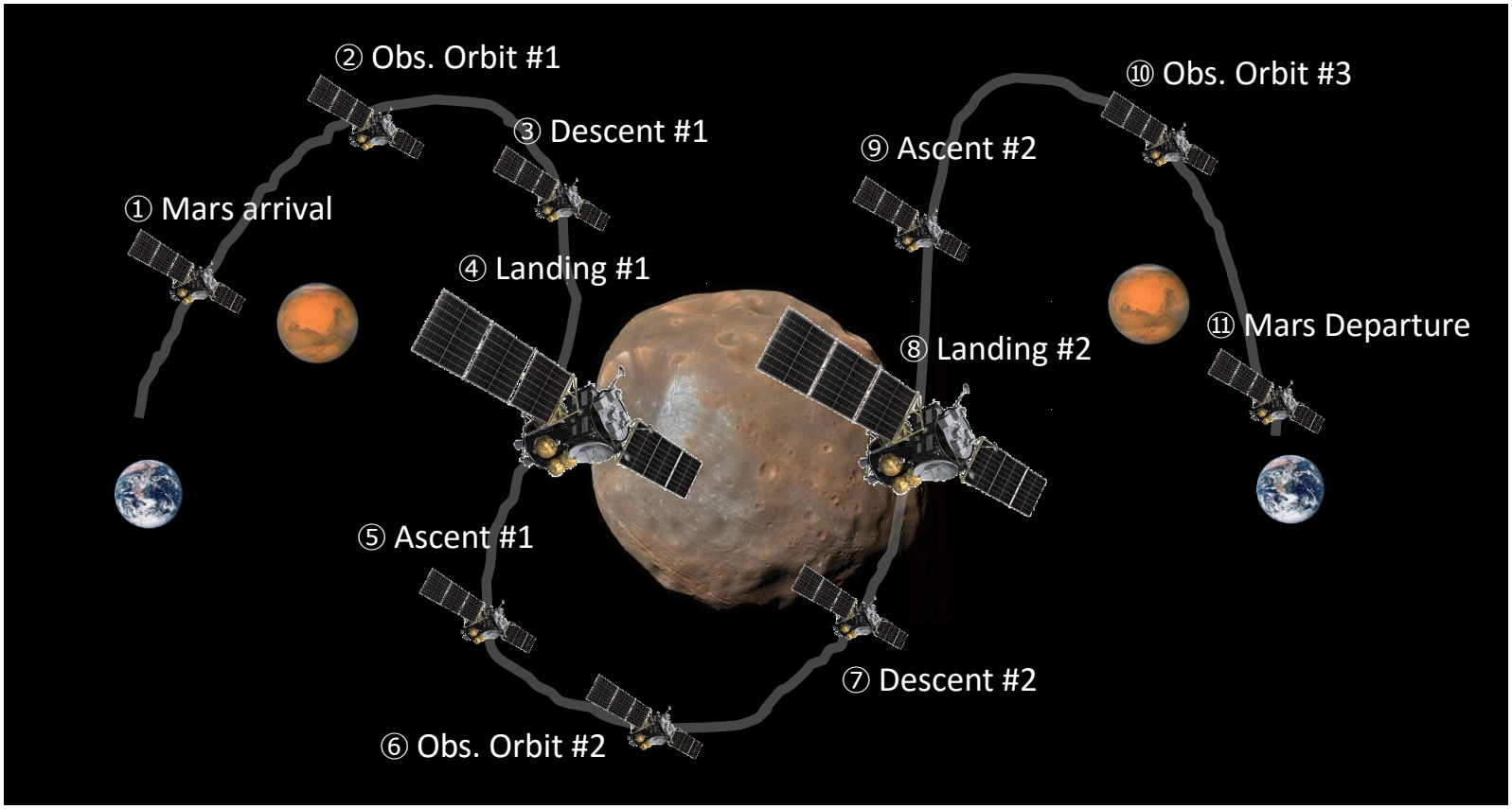
Interplanetary flight takes about 1 year for outward/homeward.
Trade-off study on the mission profile and spacecraft system results in 5 years trip by use of chemical propulsion system.
The mission study proceeds targeting the launch in JFY2024.



(written above is an example, and could change in the future)

Proximity Operation around Martian Moon

Remote sensing, landing and sample retrieval from a far distant small body is one of the most challenging operation in space missions. In spite of our experience and heritage in this area, modification of the sequence and procedure to cope with the new environment and higher mission requirements is a challenging task.

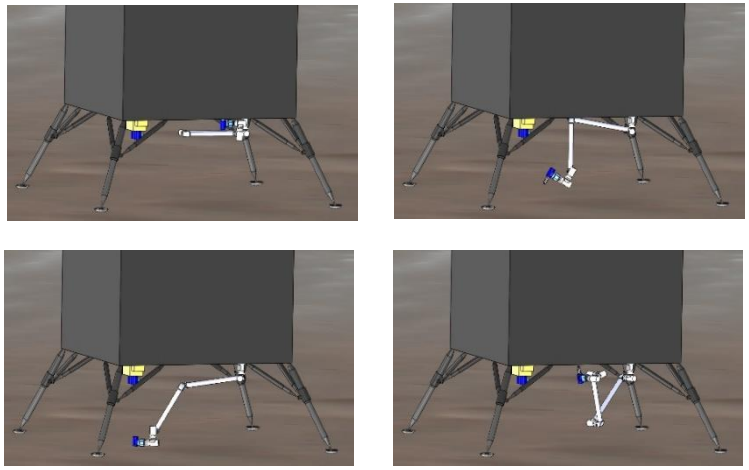


(written above is an example, and could change in the future)

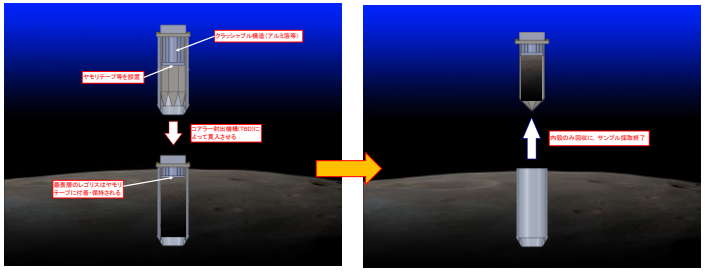
Mission Instruments

Sophisticated sampling system and a sample return capsule are necessary to meet with high level sample retrieval requirements. Scientific instruments for remote sensing and in-situ observation are needed as well for sampling site selection and sampling site information.

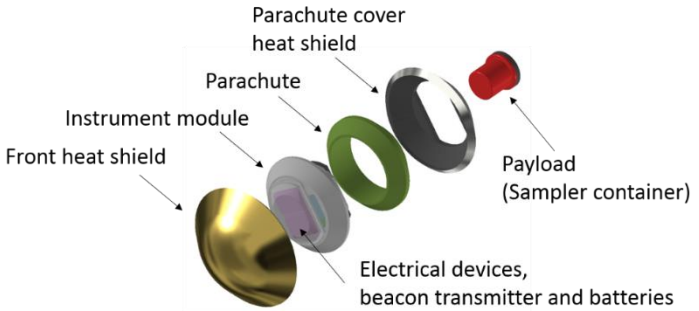
Sampling System with Manipulator



Concept of Corer Mechanism



Sample Return Capsule



Scientific Instruments Candidate

- Visible cameras
- Near-IR spectrometer(*1)
- Gamma-ray/neutron spectrometer(*2)
- LIDAR
- Ion mass spectrometer
- Dust counter

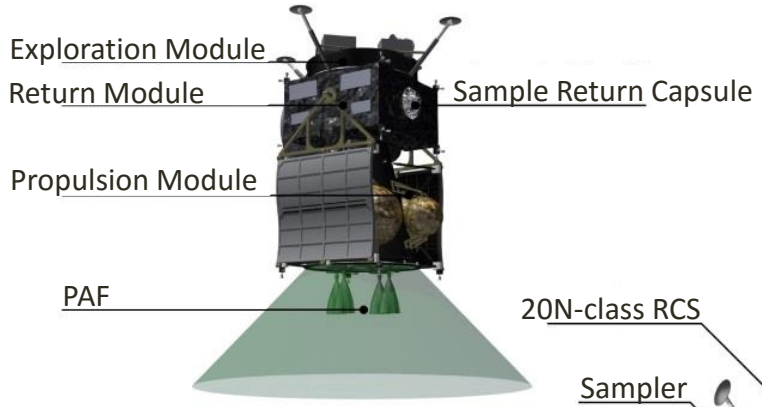
(*1) provided from CNES, (*2) provided from NASA

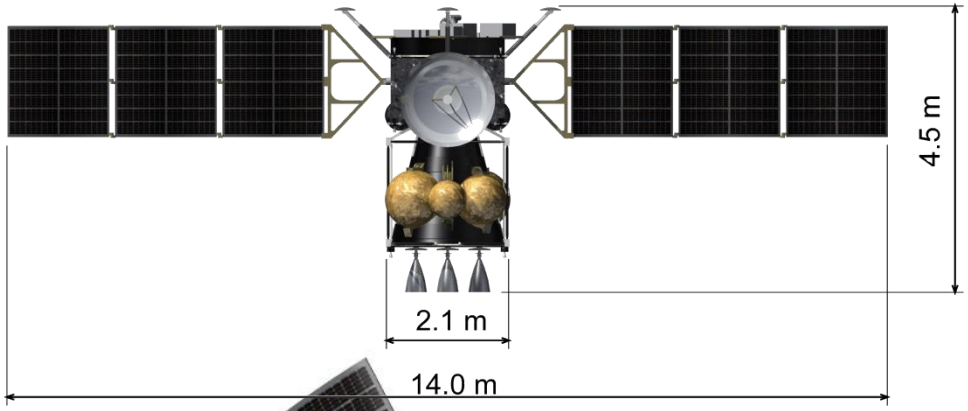
(written above is an example, and could change in the future)

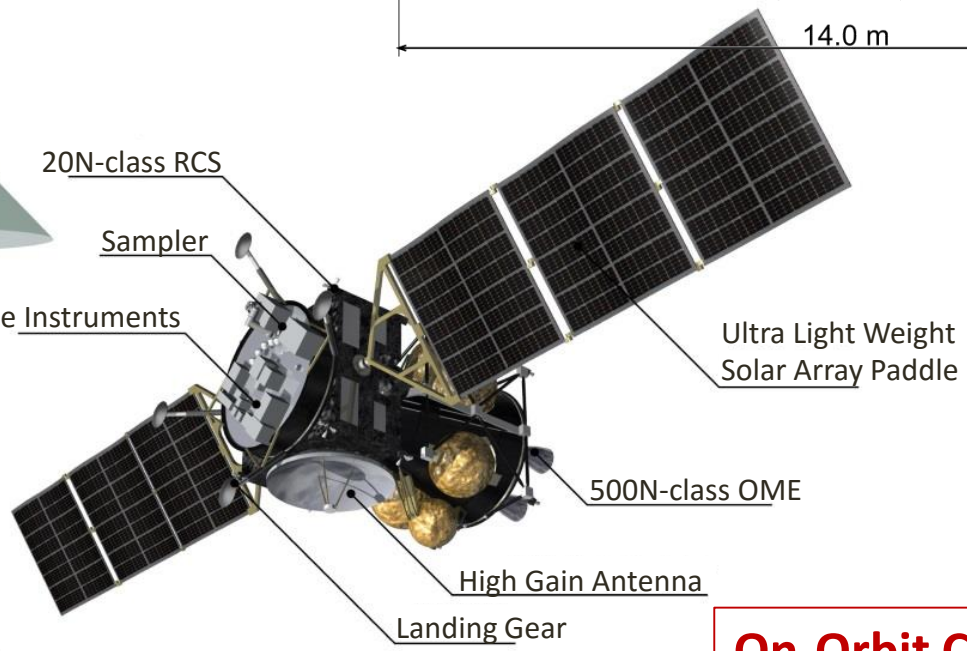
Spacecraft Configuration

Wide range trade-off study has been done in pre-Phase A study, and spacecraft system's configuration and major specification are defined preliminarily.

Launch Configuration







Launch Mass : 3400kg
Three stages system.
Return module: 1350kg
Exploration module: 150kg
Propulsion module: 1900kg
Mission Duration : 5 years

On-Orbit Configuration

(written above is an example, and could change in the future)

Cooperative Activities with CNES

Cooperative Activities with CNES

JAXA and CNES will review the collaborative matters expected to be provided from CNES to MMX in the development research.

Near-IR Spectrometer (MacrOmega)

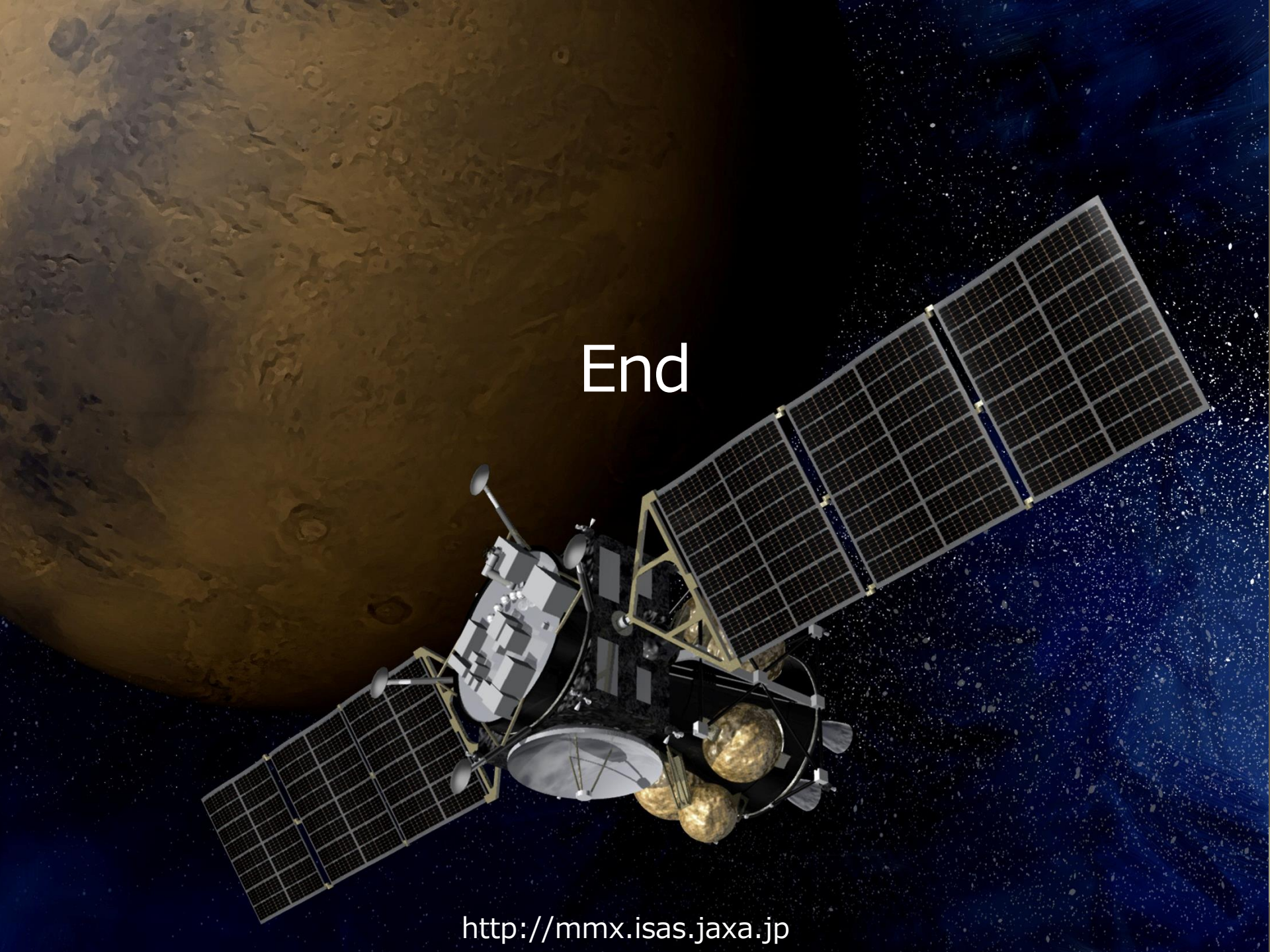
Instrument for sampling site selection and sampling site information. Spectroscopic observation with near-IR up to the 4 μm wavelength, and the main observation targets are water-containing minerals, water-related substances and organic compounds on the Martian Moons' surface.
IAS (Institut d'Astrophysique Spatiale) with support by CNES has developed a near-IR spectrometer "MicrOmega" to be mounted on the European Mars lander "ExoMars".

Flight Dynamics

Flight dynamics of the spacecraft around Martian Moons. Orbital dynamics around a small object orbiting a planet is complicated and is one of the cutting-edge research subjects. CNES was in charge of the landing orbit analysis of the lander Philae mounted on European comet probe Rosetta.

Feasibility of the Small Lander to be Equipped

Consider the possibility of equipping a small lander for local exploration around the landing site, with the primary purpose of observing around the sampling site. CNES is participating in the development of MASCOT mounted on Hayabusa 2.



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