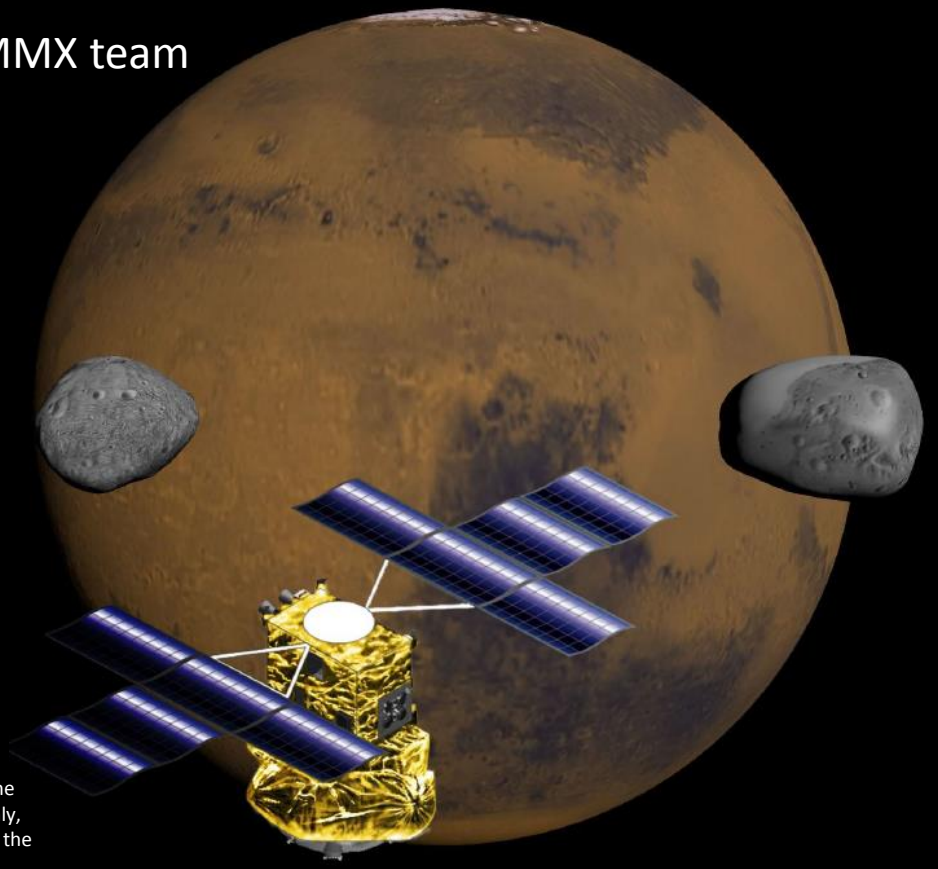
Japanese mission of the two moons of Mars with sample return from Phobos

Hirdy Miyamoto (Univ Tokyo) on behalf of MMX team



JAXA's activity and Japanese perspective

Science community of Japan is interested in understanding the birth and evolution of habitable environment in the solar system.

topics	JAXA missions	NASA/ESA missions
• Early evolution of the solar system • Interactions of mineral-water-organic matter • Distributions and transportations of materials forming planet/life • Surface evolution	Hayabusa (S asteroid) Hayabusa-2(C asteroid) Kaguya (Moon) MMX Mars Moon eXploration	(OSIRIS-Rex Rosetta, DAWN, New horizon,) (BeppiColombo) (LRO, MRO, MER, Mars Odyssey Mars Express, ExoMars, MSR, Insight, Mars 2020
• Atmospheric evolution	Akatsuki (Venus)	(ExoMars, TGO, Maven, JUNO)

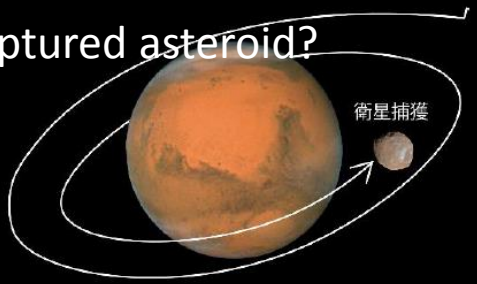
In this line, we are interested in Phobos and Demos because

- They would hold keys for the sources and the delivery process of water and/or building blocks of planets into inner planets.
- Understanding the initial condition of Mars-moon system should provide important inputs to the early evolutional history of terrestrial planets.

Mission objectives of MMX (Mars Moon eXploration) (1/3)

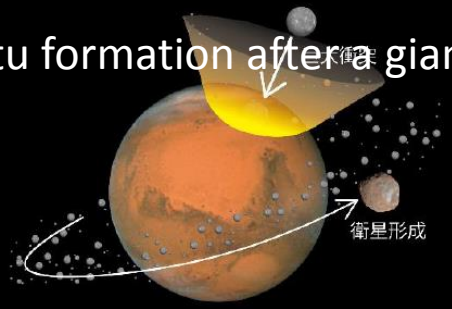
- Clarify whether if the moons are captured or formed in situ after a giant impact

Captured asteroid?



D/C-type asteroid-like spectra
Low density

In situ formation after a giant impact



Very low inclination and eccentricity

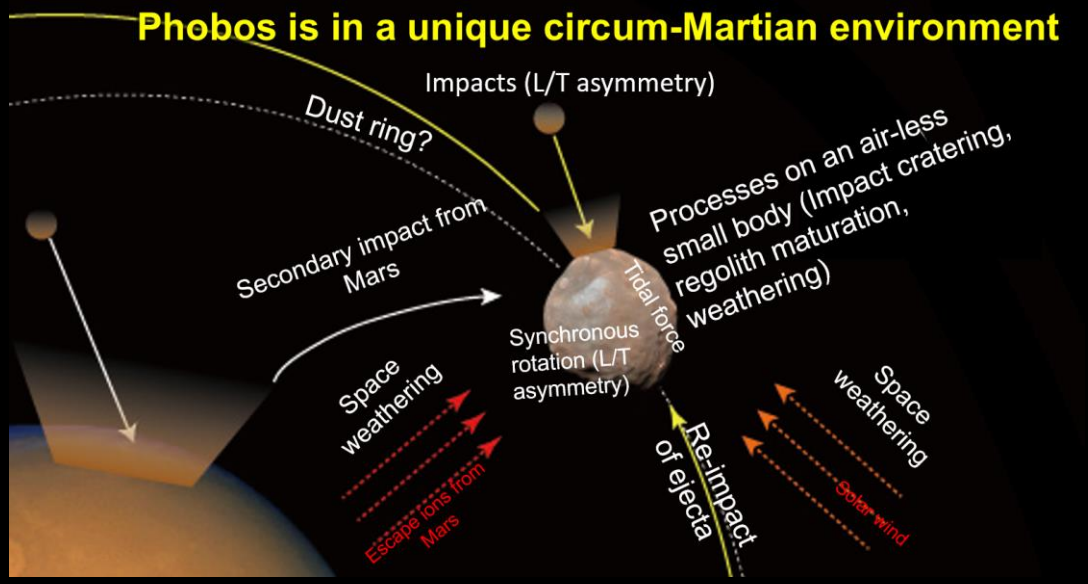
- If captured, how materials forming Mars had been transported in the early history of the solar system?
- If formed in-situ, what is the nature of a giant impact to a terrestrial planet and its impact on the early evolution of mars?
- Does Deimos share its origin to Phobos?

This will improve our understanding of material distributions and transports at the edge of the inner part of the early solar system as well as of planetary formations.

Mission objectives of MMX (Mars Moon eXploration) (2/3)

➢Understand processes in circum-Martian environment

- How the evolutions of the moons are different from asteroids?
- How is the nature of circum-Martian environment in the view of Mars surface and atmospheric evolution?



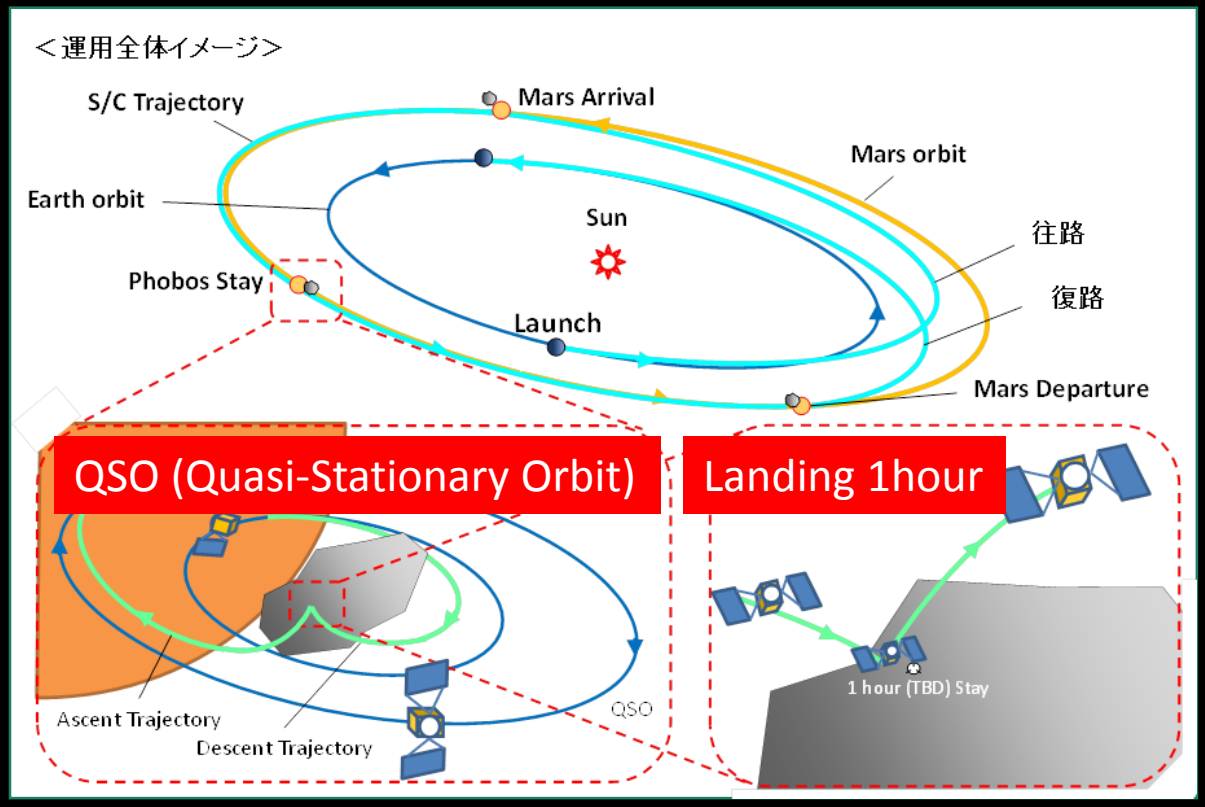
➢Mars atmospheric observation

- How are the temporal and global distributions of dust storms, ice clouds, and water vapor of Mars?

These will lead to improve our views of evolutions of the moons and the environmental transition of Mars surface

Mission objectives of MMX (Mars Moon eXploration) (3/3)

- Exploit astronautics and exploration capabilities, such as
  - Round trip to Martian system (Astronautics)
  - Sophisticated sample retrieval technologies (Robotics)
  - High rate of data transmission (Communication)



Important for our future deep space missions

Tentative design of the MMX mission

Timeline

Launch	Aug, 2022
Mars Arrival	July, 2023
Mars Departure	May, 2026
Earth Arrival	April, 2027

Spacecraft

Launch Mass : 3000kg

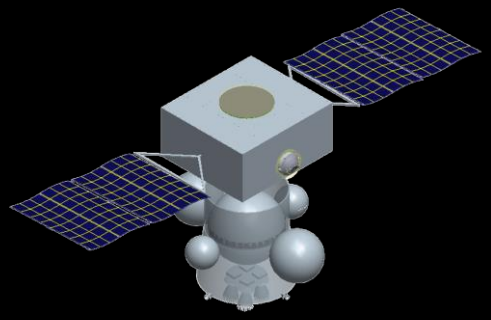
Three stages system.

Return module: 1050kg

Exploration module: 150kg

Propulsion module: 1800kg

Mission Duration : 5 years



These are for the case of using only a chemical propulsion system.
Combination with an electric propulsion system is also discussed

In situ observation of MMX (TBD)

MMX spacecraft will be in the Quasi-Stationary Orbit for 34 months.
We may perform:

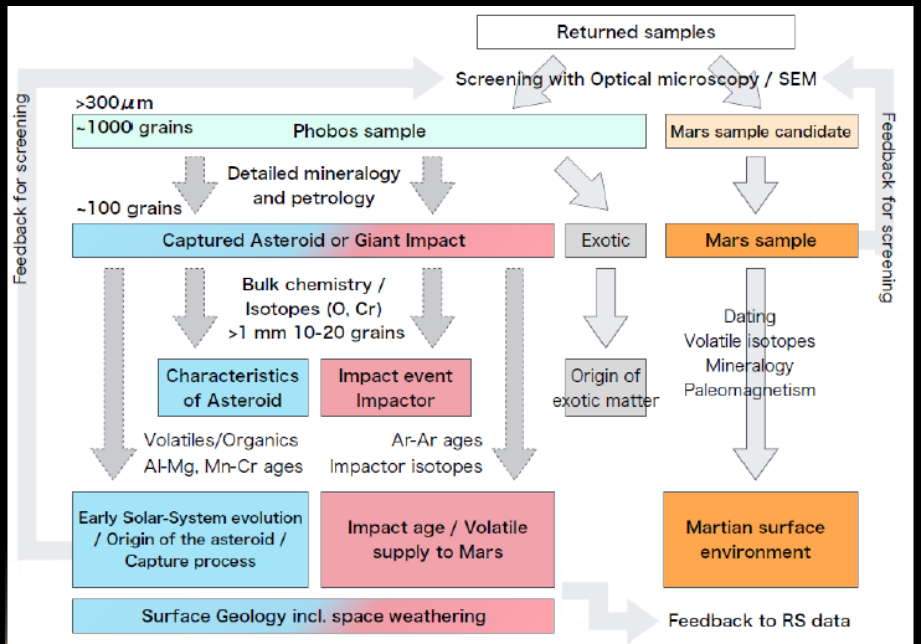
- Mineralogical mapping especially for hydrous minerals (globally for Phobos, partially for Deimos)
- Imaging for geological study, including craters, boulders, grooves, and regolith (globally for Phobos, partially for Deimos)
- Close-up observations of Phobos for landing-site selections and descriptions
- Observations of Phobos for understanding the internal structures especially for the presence of ice (in terms of iron flux and gravity/density measurements)
- Mars atmospheric observations by taking the advantage of the QSO

Instruments positively discussed include:

- Visible color imager
- Near-infrared spectrometer (2-3.8μm)
- Gamma-ray and Neutron spectrometer (Si, Fe, Ca)
- Gravity measurement
- Gradiometer
- Ion flux measurement
- Radar sounder
- Lander onboard instruments
- Small rover(s)

Decent/sampling on Phobos and sample analyses on Earth

- During the observational phase of Phobos, mineralogical/morphological mappings will be completed to determine two sampling sites
- At least 10g (> 1000 grains) of samples are expected to be collected
- Sampling instrument is still under discussion, but we will try to acquire samples from at least deeper than 2cm from the surface
- Sampling site will be fully studied by optical instruments during the decent phase
- Samples will be analyzed at high precision. We consider petrology, mineralogy, bulk chemistry, and isotopic compositions (especially O and Cr) can constrain origins of the samples



Summary

- JAXA's 3rd sample-return mission will go to Phobos
- The mission (MMX, Mars Moon eXploration) will observe Phobos, Deimos, and Mars and return samples from Phobos
- Objectives of the MMX mission include:
  - Clarify whether if the moons are captured or results of a giant impact
  - Understand the processes/evolutions of bodies in circum-Martian environment
  - Exploit astronautics and exploration capability for Japanese future missions
- The shape of the mission will be frozen in one year from now
- The mission study, including interaction with international science community, will continue to be fully boosted towards to the launch in 2022