宇宙航空研究開発機構
Japan Aerospace Exploration Agency

MELOS: Japan's Mars Exploration Plan

Mars
Exploration with
Lander-
Orbiter
Synergy

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“Landing Sites” Workshop (20 Jan 2011 @ ESTEC)

JAXA 宇宙航空研究開発機構
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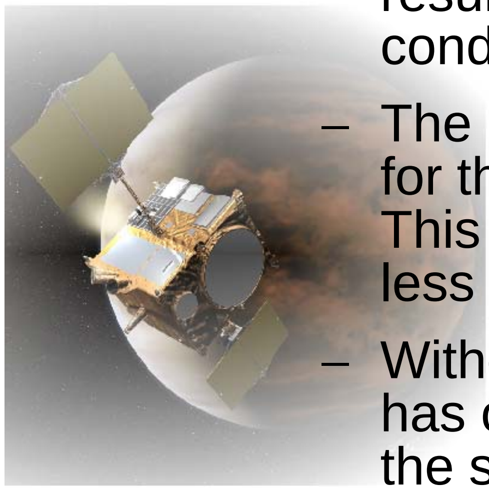
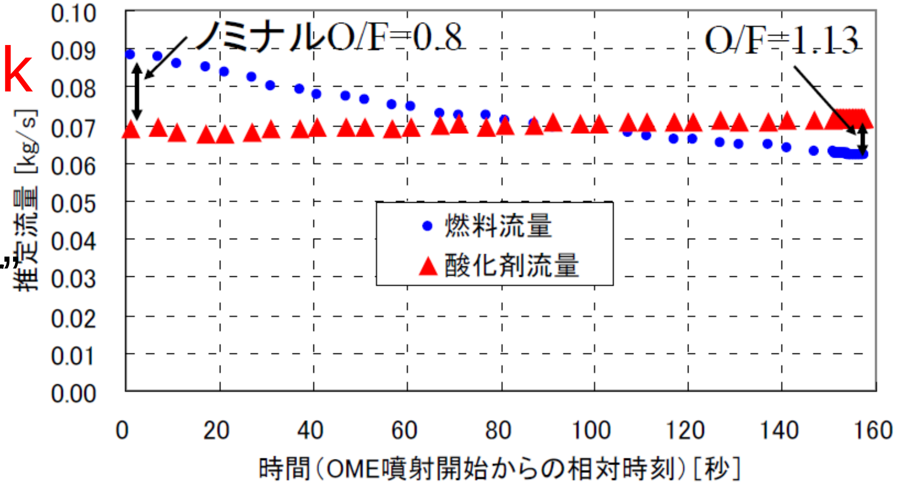
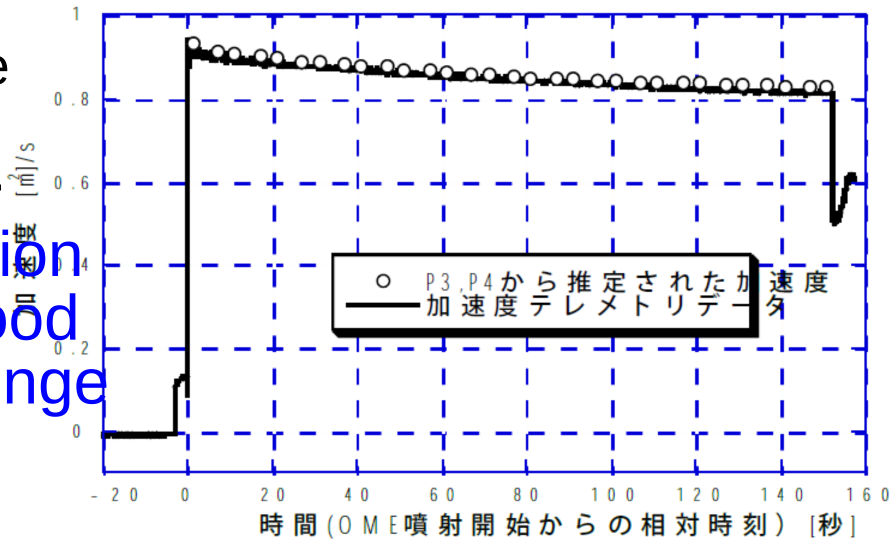
What's happend to "Akatsuki" Venus Mission

- VOI attempted on 7 Dec 2010 but failed...
  - Likely cause is "clogged" check valve in the fuel line (CV-F)
    - It prevented smooth flow of fuel, resulting in "*less fuel than oxidizer*" condition (O/F > 1).
    - The excess fuel acts as "*coolant*" for the thruster throat & nozzle. This does *not* work if the fuel is less than the oxidizer.
    - Without enough cooling, a damage has occured to the thruster, and the spacecraft went to "Safe Hold".
  - The spacecraft (including mission instruments) seems to be in good condition, and we will re-challenge VOI 6 years later.

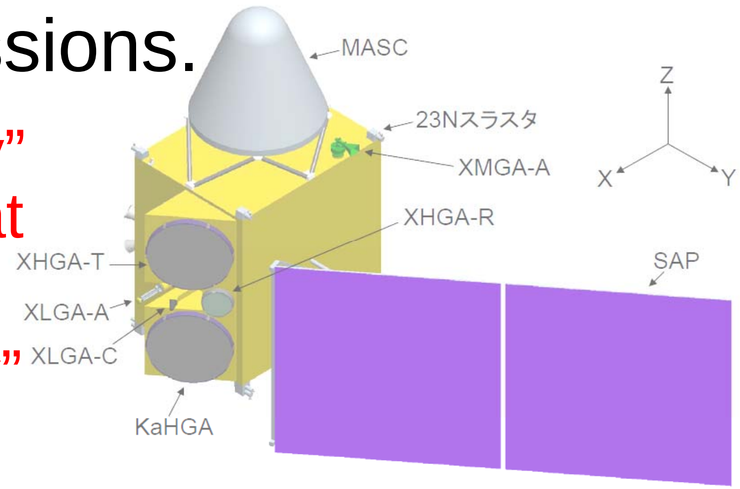






Our Hope to "Mars" Missions

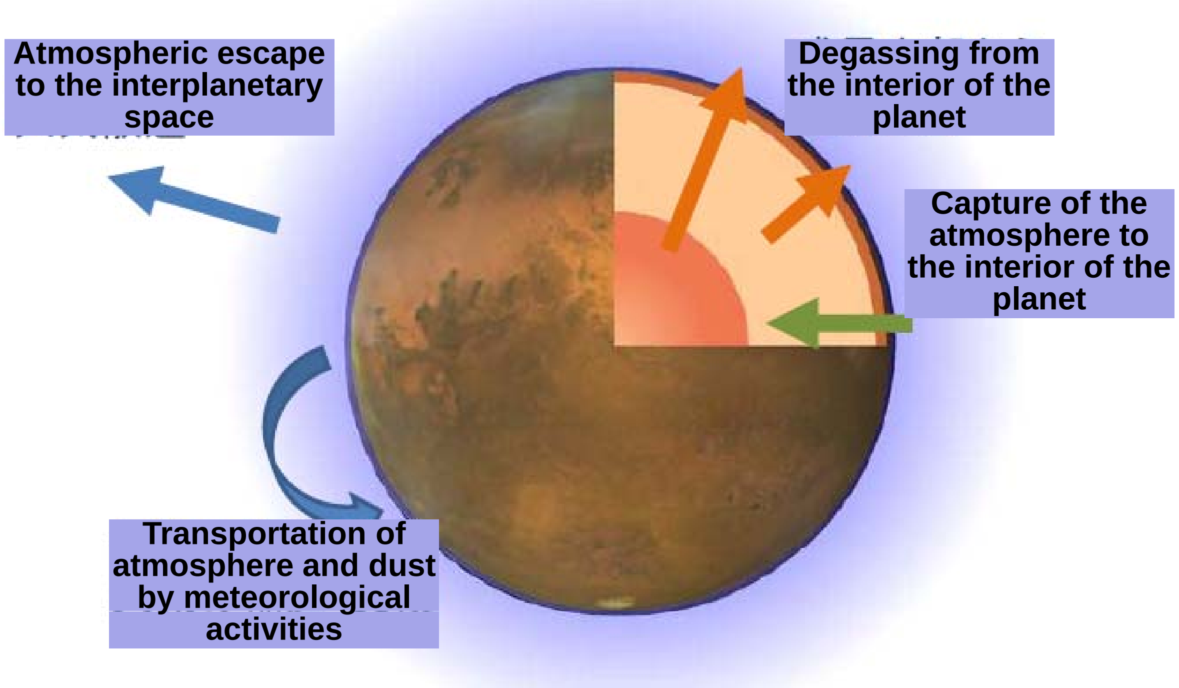
- We'd better plan "step by step" missions.
  - MELOS-1 will be an "orbiter primary" mission with an EDL experiment that is a precursor of MELOS-2 lander.
  - MELOS-2 will be an "lander primary" mission.



Launch	Arrival	Mass to Mars Orbit (H-IIA202)	Mass to Mars Orbit (H-IIA204)
Jan 2019	Feb 2022	1.4t	2.4t
Jul 2020	Feb 2021	1.2t	2.1t
Nov 2021	Jan 2024	1.3t	2.2t
Sep 2022	Aug 2023	1.1t	2.0t

Science Target of MELOS

- Understanding the Martian System
  - Interior + surface + atmosphere + surrounding space
    - To understand the evolution and to answer the fundamental question “Why (and how) is Mars different from the Earth?”, missions designed to study inter-relations between these are needed.
    - Both “orbiting” science and “landing” science are important.



Keyword:
Why is Mars “red”?

Orbiter (A): Meteorology
Orbiter (B): Aeronomy
for MELOS-1

Lander (A): Surface
Lander (B): Biology
Lander (C): Interior
Lander (D): Sample Return
for MELOS-1 EDL and
for MELOS-2

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Orbiter (A): Martian Meteorology

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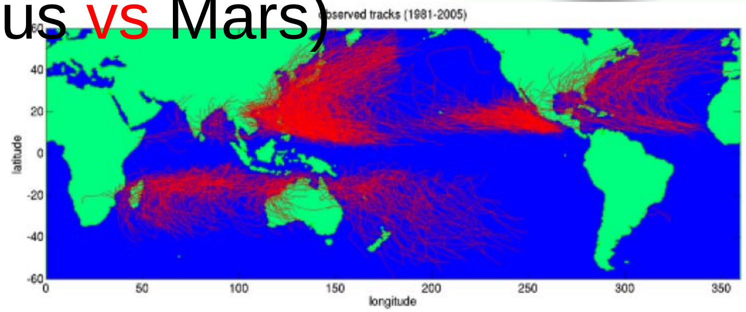
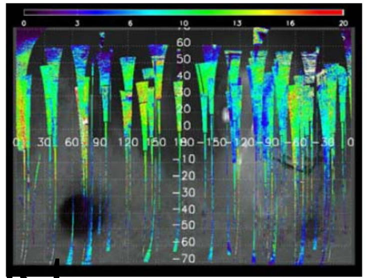
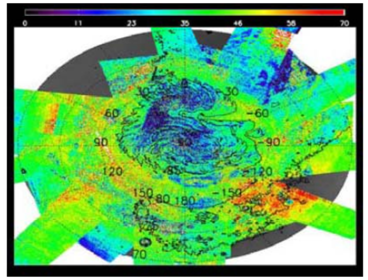
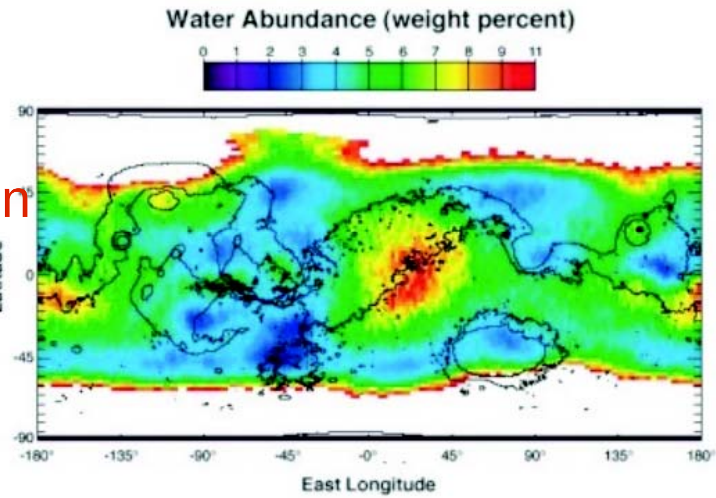
- Comparative Meteorology (Earth vs Venus vs Mars)
  - Similarity: rotation period, tilt of the pole
    - Tenuous CO_2 atmosphere vs suspended dust (heat source)
    - Large seasonal variation (eccentricity) vs relatively small thermal inertia
    - Episodic "global" dust storm
    - Underground water (ice) reservoir







- Transportation/Relocation of Water & Dust
  - Never been studied in detail
    - Limitation of "local-time fixed" orbit
    - Need to characterize "global" transportation
    - Especially in the lower-most atmosphere
    - 3-D structure of temperature, composition, isotopic ratio, etc.

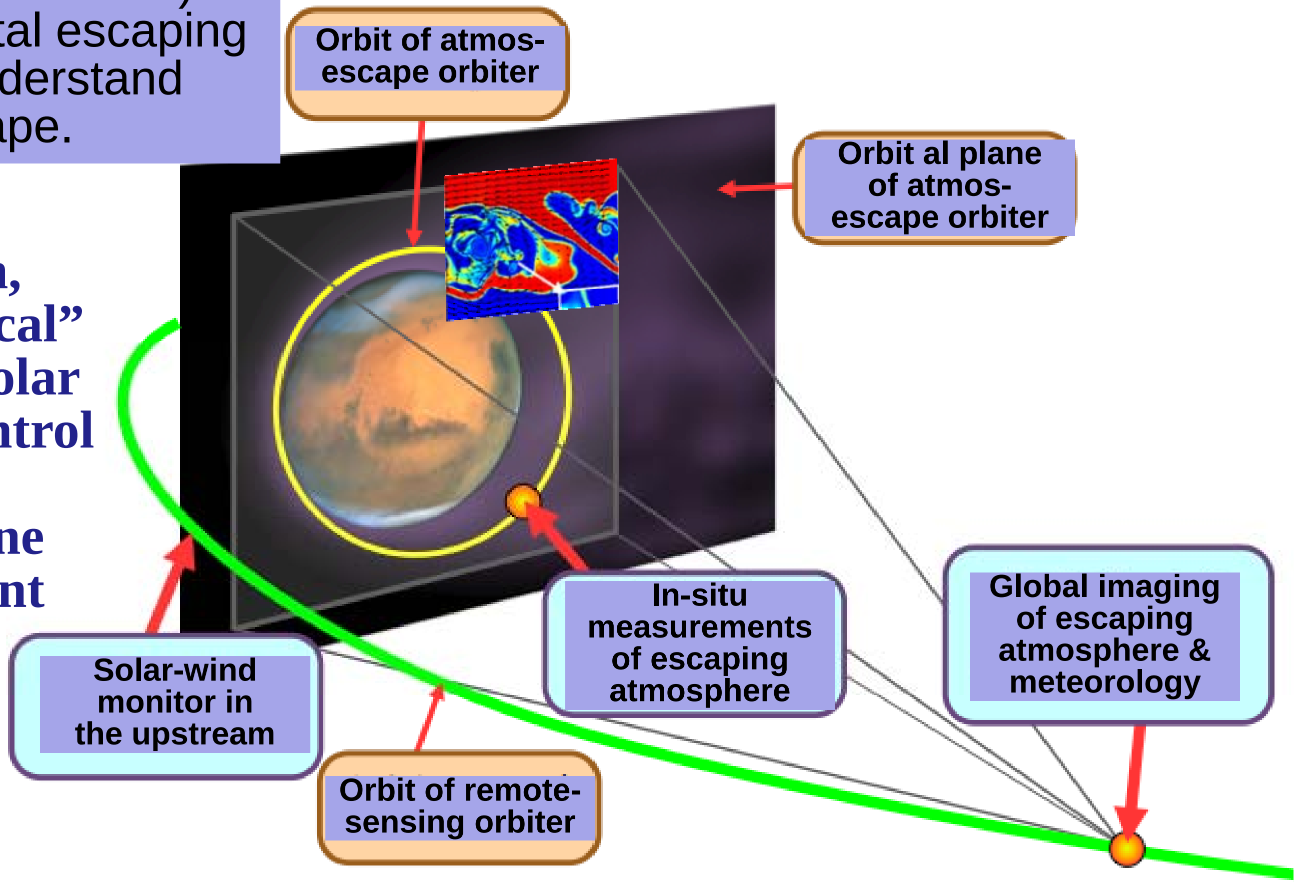


Orbiter (B): Escaping Atmosphere

Resolve composition (C, N, O, and others) in escaping atmosphre. Estimate total escaping flux of the water and CO2 and understand how solar activity affects the escape.

With "two-orbiter" configuration,
- ◆ **Simultaneous "global" and "local" measurements (including the solar wind parametes that would control the escape), and**
- ◆ **Parameter analyses to determine escape rates and most significant physical processes**

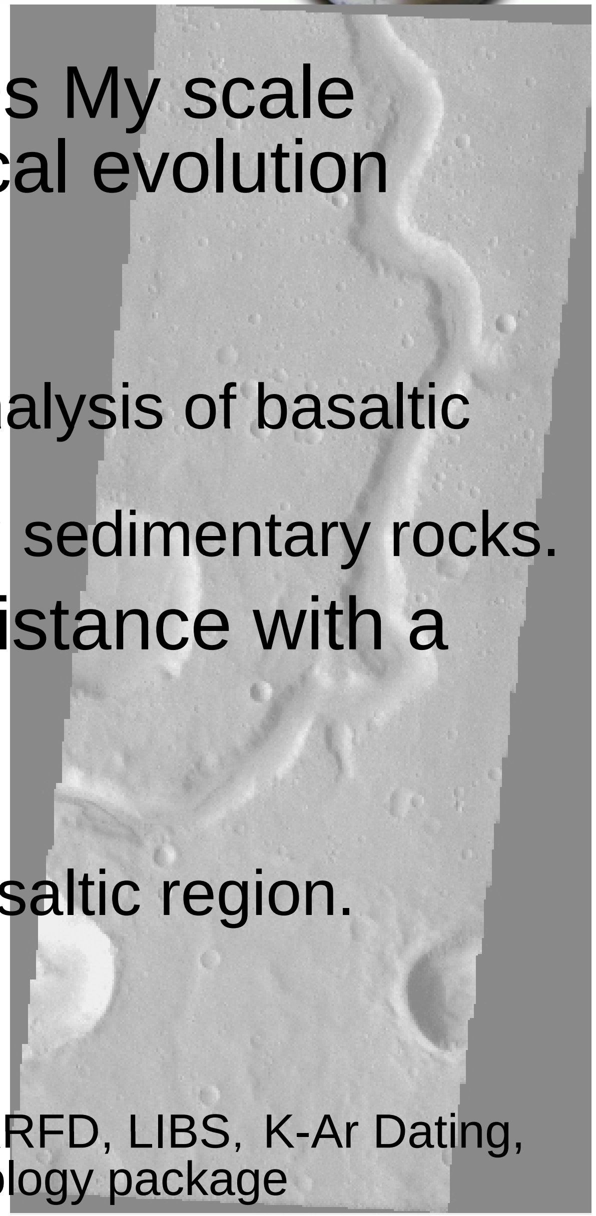
will be possible.

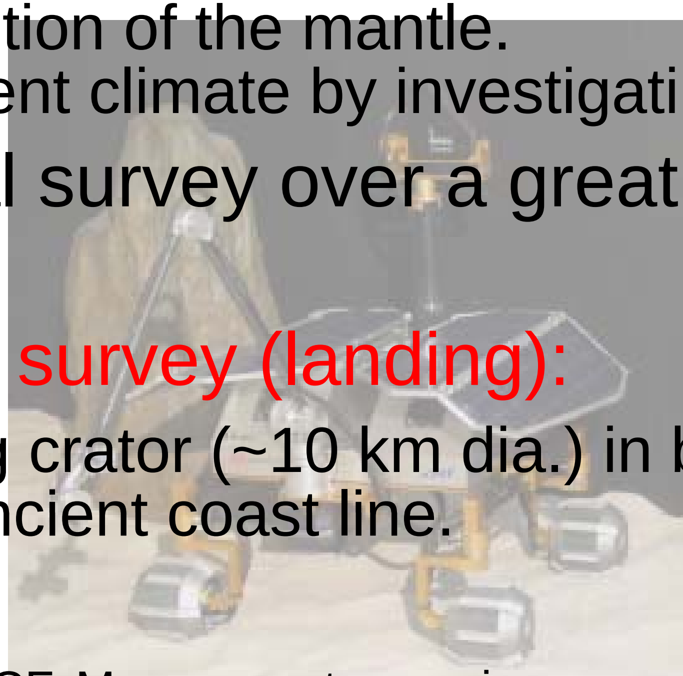


Proposed Payload

"Escaping Atmosphere" Orbiter:	Ion analyzers (mass, energy, velocity), Neutral-gas mass analyser, Langmure probe, Magnetometer, Electric-field & Plasma-wave package, Potential control
"Remote Sensing" Orbiter:	Global imager for "escaping atmosphere", UV absorption cell, Solar-wind monitor, Solar-radiation monitor

Lander (A): Surface Environment



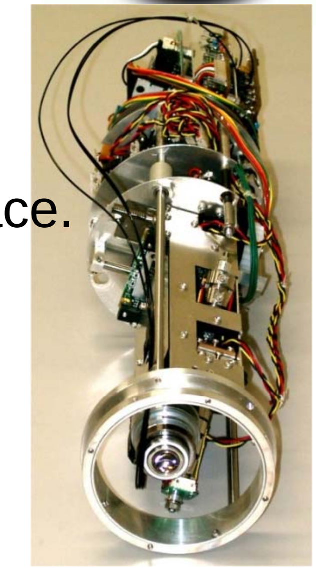


Mars Exploration with Lander-Orbiter Synergy

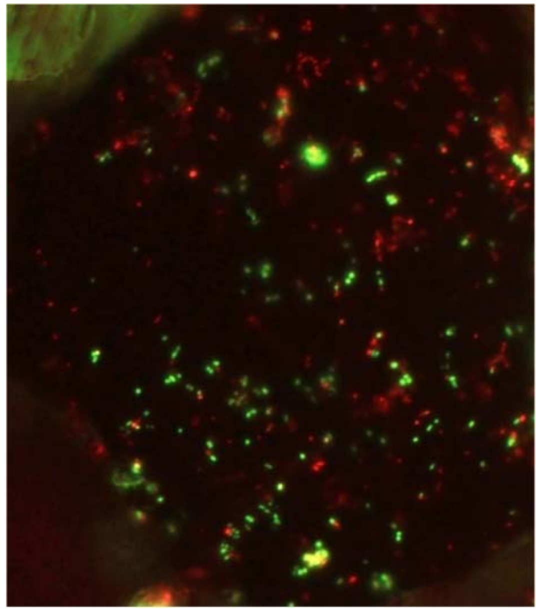
- Goal: Understand climate changes of 100s My scale and chemical coupling with thermochemical evolution of the solid planet.
- Objectives:
  (a) Discover initial melt through composition analysis of basaltic flow to infer composition of the mantle.
  (b) Understand ancient climate by investigating sedimentary rocks.
- Method: Geological survey over a great distance with a well-equiped rover.
- Candidate sites for survey (landing):
  (a) Ejecta of a young crator (~10 km dia.) in basaltic region.
  (b) Nili Fossae, or ancient coast line.
- Model Payload:
  3-D camera with variable LCF, Macro spectroscopic camera, XRFD, LIBS, K-Ar Dating, Magnetometer, Radar sensing, Electro-magnetic field, Meteorology package

Lander (B): Astrobiology

- Most likey place for Martian life?
  - Surface soil near the methane vent
    - Terrestial life may survive at a few cm below Martian surface.
    - Martian environment ~4 Gy ago similar to Earth.
    - The birth of life can be in very short time.
    - Martian methane detected recently.
    - Bacteria that utilize methane & iron oxide discovered.



- Method?
  - With fluorochrome and a microscope
    - Dye protein, membrane, catalyst, etc.
    - Target sensitivity: 10 cells / 1 g of soil. (compared to 10^4 cells / 1 g in Earth desert)
    - Conclude "no life on Mars" if no detection.
    - Possibly detect organic materials related to chemical evolution before life.



Antarctic soil after dying

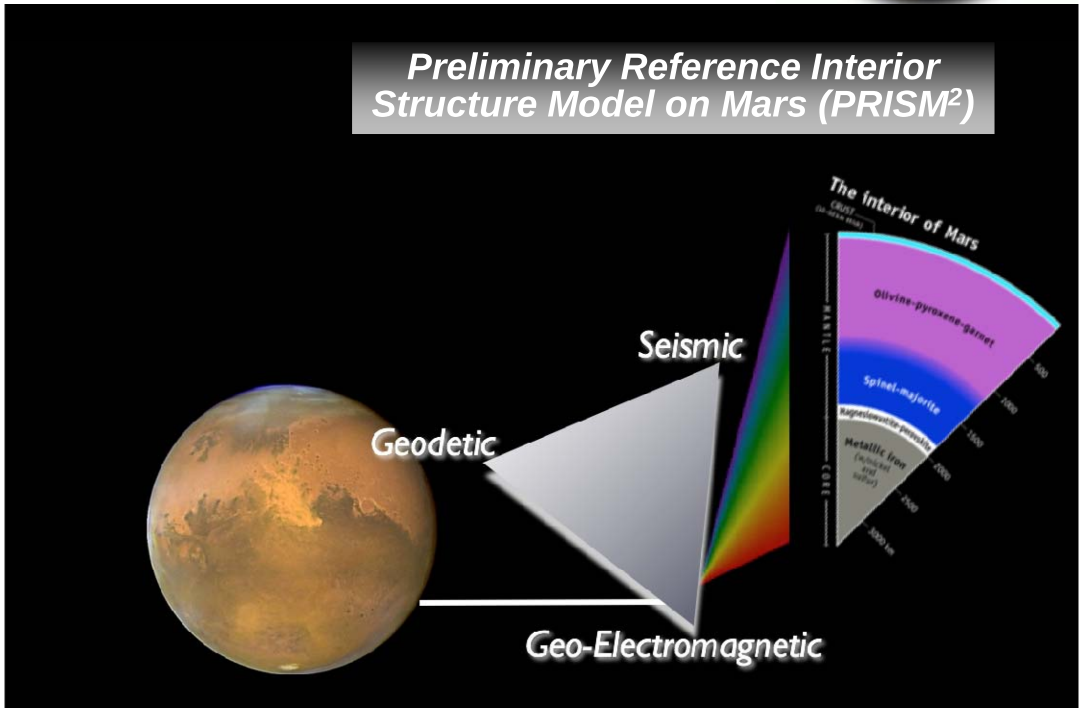
Lander (C): Interior Structure

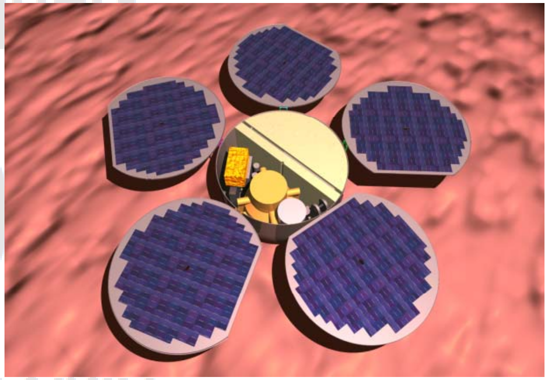
Mars Exploration with Lander-Orbiter Synergy

(Depth)

Heat flow

Electromagnetic (>2 stations)





Possible collaboration with ESA's network mission

Rotation
(better to have multiple stations)
(precession, nutation)
Z Term of Mars

Mars-quake
(better achievement with multiple stations)
(quakes, free oscillations)

(Information)

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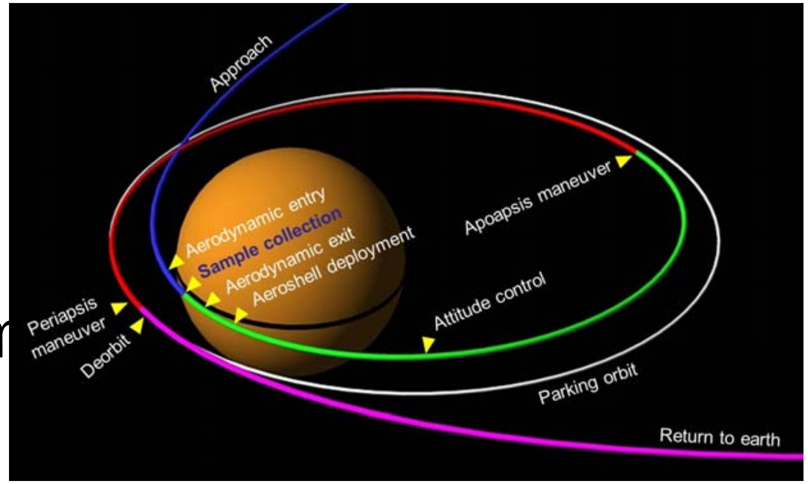
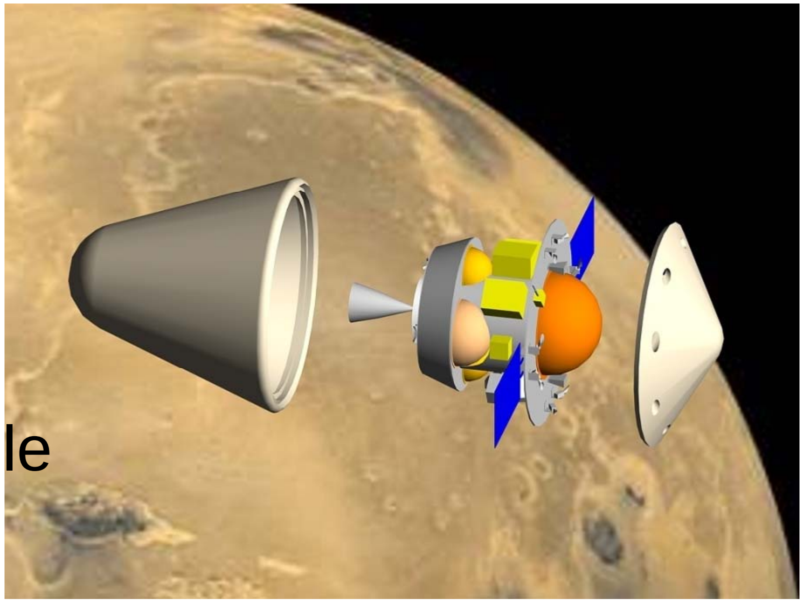
Lander (D): No-Landing Sampel Return (MASC)

Mars Exploration with Lander-Orbiter Synergy

Capture and return the dust & atmospheric samples by performing aero-flyby.

- "Global average" information from such sample is significant to:
  - Orbiter sciences (meteorology, atmospheric escape),
  - Biological study
- Benefit from state-of-the-art analyses in the laboratory
  - High-sensitivity & high-precision analyses that would not be possible with *in-situ* equipment





Technology Development: Surface Exploration with 100-kg Class Rover

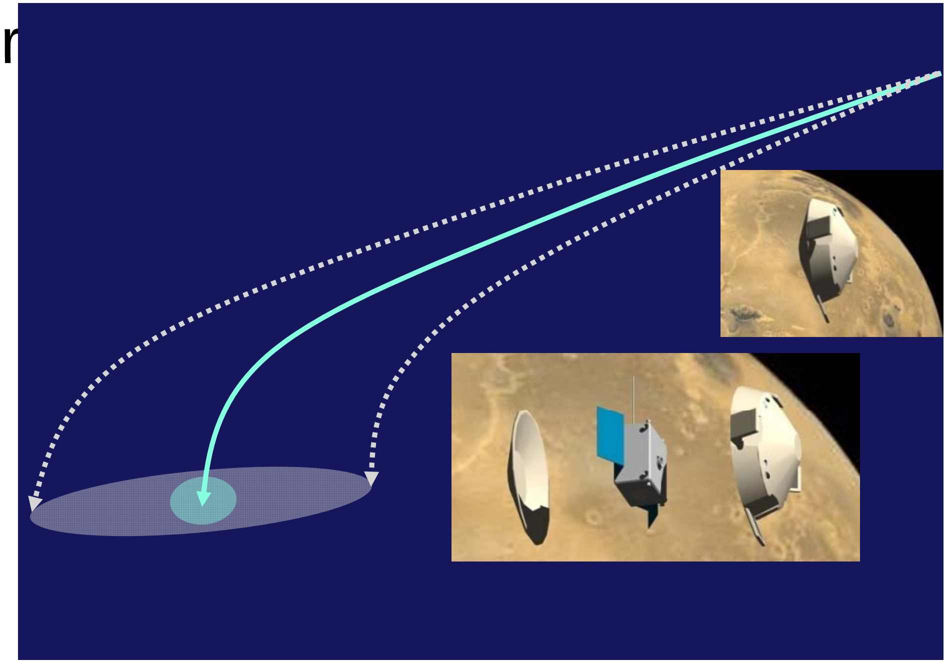
Robotics for geological & biological survey

- Rover (mobility, obstacles, durability against dust)
- Manipulator (function, portability, etc.)

- Under development by a team of people from JAXA and from many universities

Technology Development: Aerodynamic Control

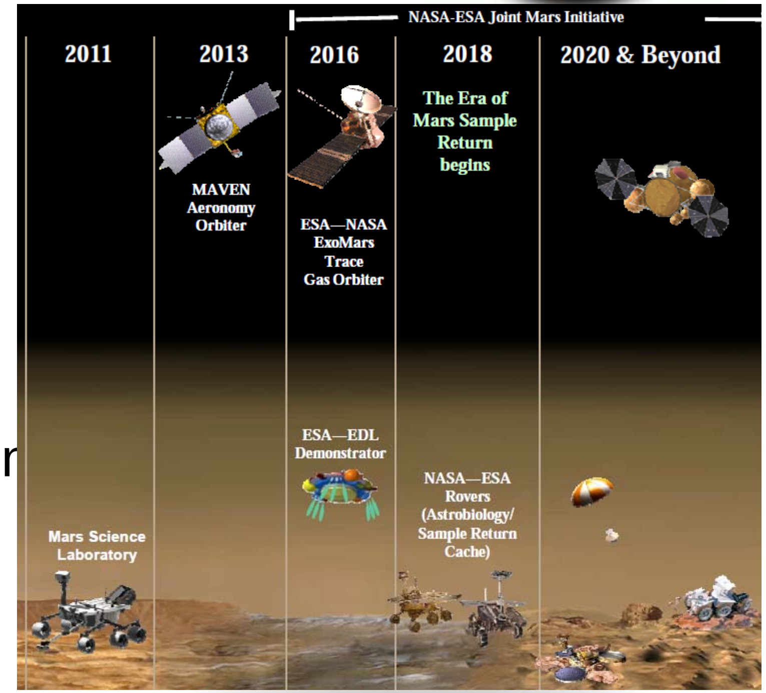
- **Aerobraking**
  - HITEN (Engineering Demonstration Mission): Multiple swingbys between the Moon and the Earth + Aerobraking experiments at the Earth
- **Atmospheric Entry/Landing**
  - HAYABUSA sample-return capsule
  - SELENE-2 Lunar Lander (under development)
- **Aero-assisted Control**
  - Pin-point landing, non-landing sample return (LANDER D)



International Challenges to Mars

Mars Exploration with Lander Orbiter Synergy

- Launches in all possible windows
  - Sample return in late 2020's
    - NASA+ESA2016, 18
    - 2011: Curiosity (MSL) (USA)
    - 2013: MAVEN (USA)
    - 2011: Phobos-Grunt (Russia) + YH-1 (Chir
    - Indian Mars mission (2018?)



- Japan: NOZOMI (launch in 1998)
  - Failure before arrival at Mars
    - Then, we had HAYABUSA, KAGUYA, and AKATUKI
    - 2014: BepiColombo Mercury mission with ESA
    - SPRINT-A/EXCEED (Earth-orbiting EUV telescope)
    - Plans of lunar, asteroidal, planetary missions
    - We challenge Mars, the planet like the Earth, with MELOS!