Current plan of the MELOS, a proposed Japanese Mars mission

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on behalf of MELOS working group

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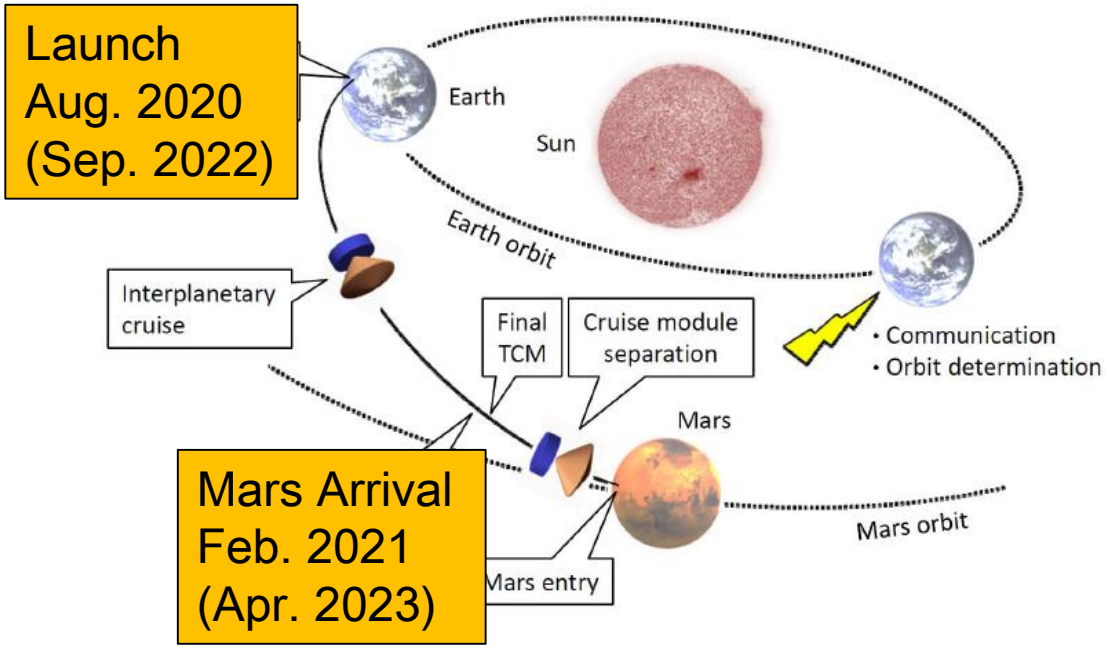
Background of the Japanese Mars program

JAXA's missions to solar system bodies

- NOZOMI Mars Mission (1998) (did not arrive at Mars)
- Hayabusa asteroid mission (2003)
- Kaguya lunar mission (2007)
- Akatsuki Venus mission (2011)
  Venus orbit insertion delayed until 2015
- Hayabusa 2 asteroid mission (2014)
  Successfully launched

- MELOS working group@JAXA from 2008
  MELOS used to stand for "Mars Explorations with Landers and Orbiters"
  Lander(s) and orbiters (meteorology and atmospheric escape)
- MELOS is now down-scaled to be an EDL (+Rover) mission for an engineering demonstration
- MELOS (Mars Exploration of Life-Organism Search) is one of 4 proposals for Announcement of Opportunity for medium-class missions, Feb. 2015, JAXA

Proposed mission outline of MELOS



Primary objective:

Engineering demonstration (Pin-point landing, long-range roving)

Science objectives

Current status/activity on Mars

- Meteorology
- Geology
- Biology

Proposed landing scenario of MELOS

Cruise module separation & entry

Guided flight

Parachute deployment

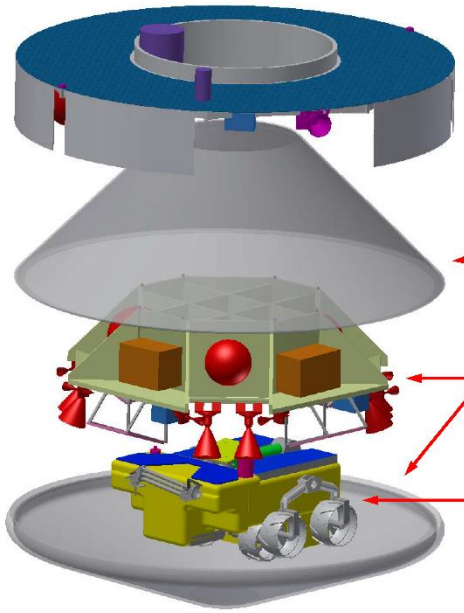
Skycrane

Powered descent

Landing accuracy
20 x 14 km

Rover touchdown

Entry-Descent-Landing (EDL) module
909kg (wet), 803kg (dry)



Interplanetary Cruise Module

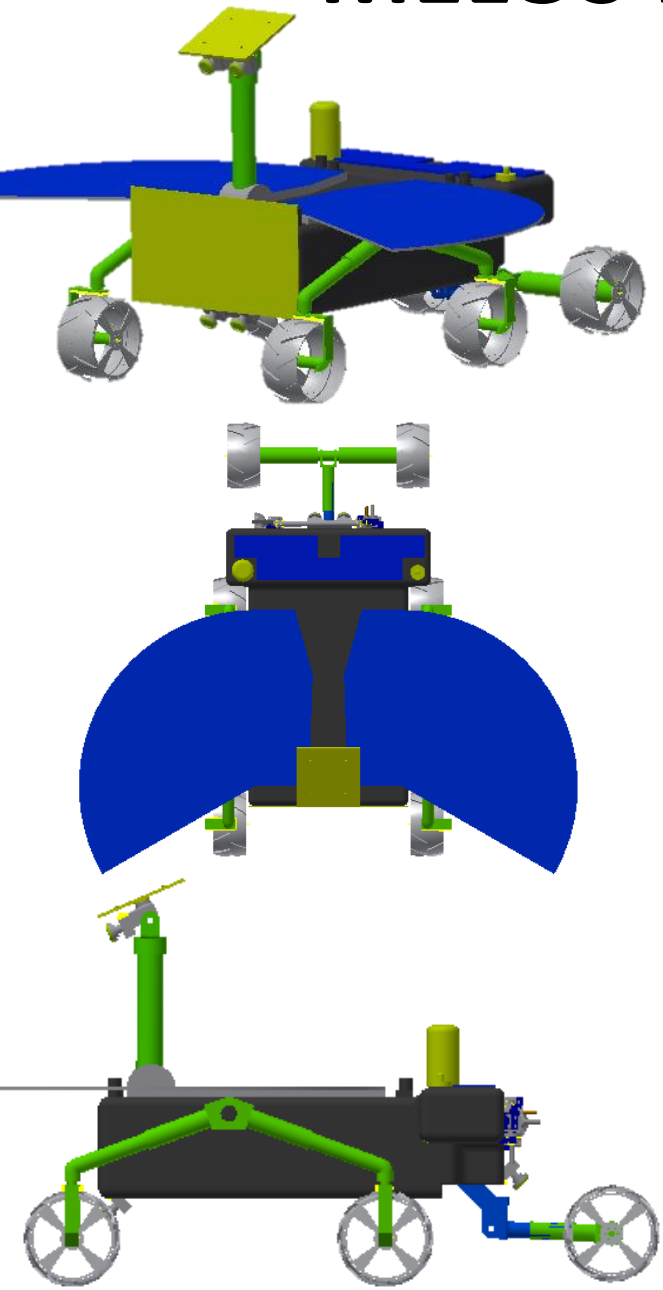
Atmospheric Entry Module

Aeroshell Module

Landing Module

Rover

MELOS Rover (smaller than MER)



Engineering primary objectives

Rough-terrain traversability

- Design & development of the mobility system: i.e. wheel size, suspension mechanism, traction control.
- Terramechanics, slip compensation, mobility-hazard detection

Autonomous Mobility

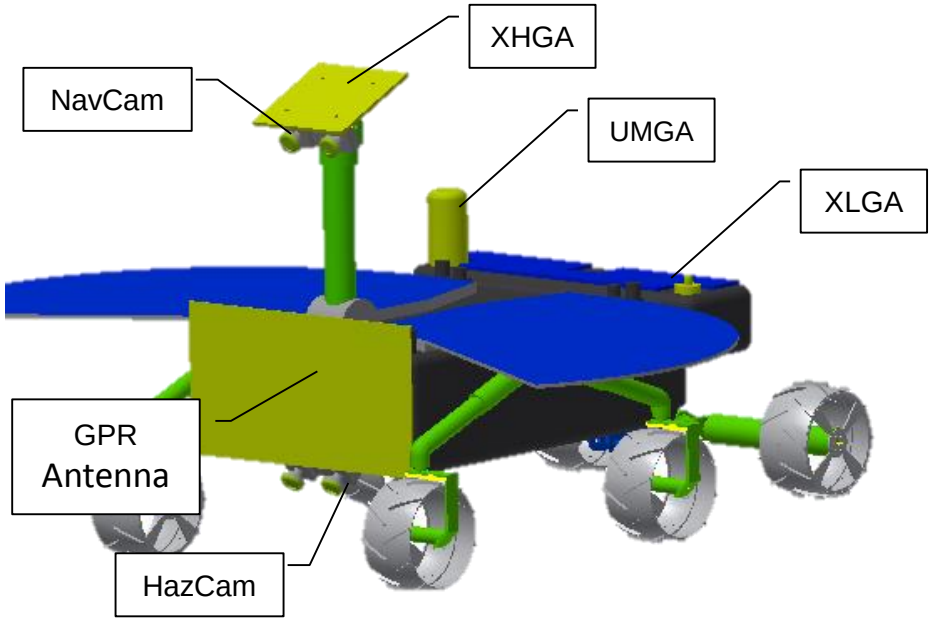
- High degree of autonomous mobility that enables an efficient exploration mission under a limited resource for the communication.
- Terrain mapping, path/motion planning, navigation and control

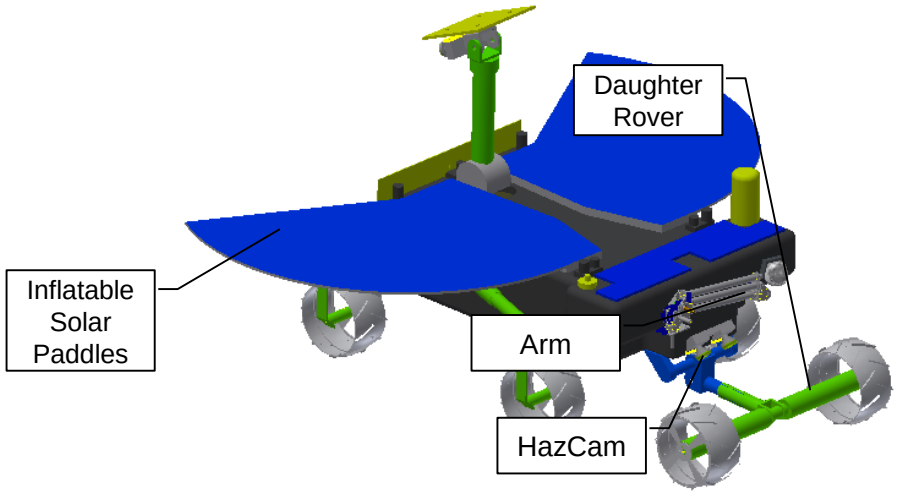
Self-sustained System

- Power management and thermal control systems w/o radioisotope technology.
- Solar cells design for the Martian spectra, high energy-density batteries

MELOS Rover (smaller than MER)

150kg in mass with 15kg science payload





Power management

- SAP: 1.50 m^2
- Battery capacity : 720 Wh

Thermal control

- Passive thermal design
- Survival heaters and insulations for the Mars nighttime

Mobility

- Cruise velocity: <0.075 m/s
- Daily travel distance: ~ 500 m
- Slopes : up to 15 degrees

Communication

- Primary: X-band comms to the Earth
- Secondary: UHF via a relay satellite

Nominal mission period 68 days
Extended mission > 1 Mars year
(overall travel distance >50km)

Instruments for Meteorological Study

Primary objectives

- Basic meteorological observations
  (Temperature, wind velocity and direction, pressure, short/long wave radiation)
- Dust devil and dust entrainment
  (pressure drop, wind velocity and direction, dust particle, opacity)

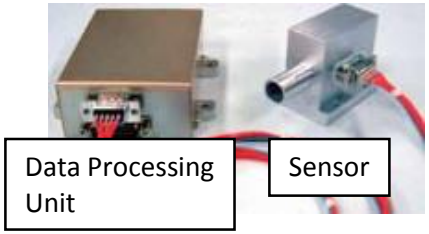
Sensors	Resolution
Temperature	0.1K
Wind Velocity	0.1m/s
Pressure	0.1Pa
Surface Temp.	0.1K
Wind Direction	5deg

Thermometer, Anemometer: Thermistor

Size:ϕ10 Weight:10g × 4

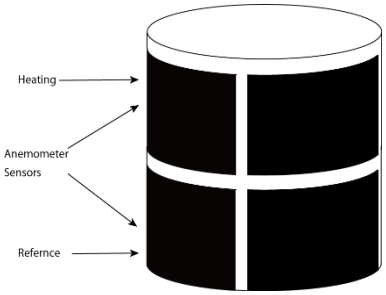
Barometer

Impedance of crystal oscillator
Size:70x25x60, 30x20x10mm
Weight: 300g + 100g



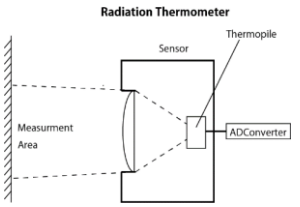
Anemometer:

Hot-film Anemometer
Size:ϕ20x20 mm
Weight: 20g



Radiation Thermometer:

Surface Temperature
Size: 40x50x30 mm
Weight: 100g



Instruments for Geological Observation

Primary objectives

- Description of the landing site
- Geology of the landing site
  origin and formation of RSL,
  Interior Layered Deposits (ILDs),
  canyon wall of Valles Marineris
- Subsurface structure of regolith

Multi-band Stereo Cameras

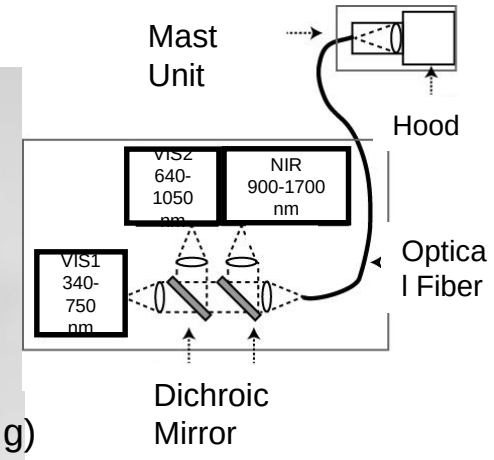
Stereo MastCam NavCam camera

5M pixels in 1/4“,
1mm resolution at 2m distance,
5colors, 400-980nm

VIS-NIR Spectrometer (optional)

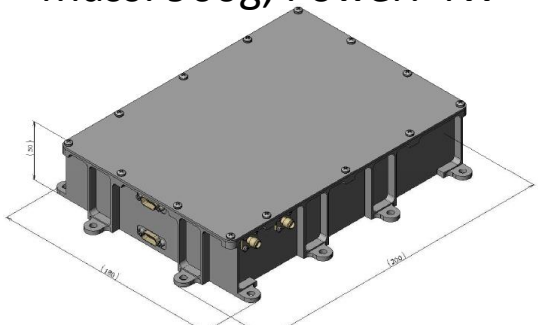
Spectral Resolution: ~10−20 nm
Size 100 × 100 × 100 mm
Mass 1 kg
Power < 3 W
Data ~1kB

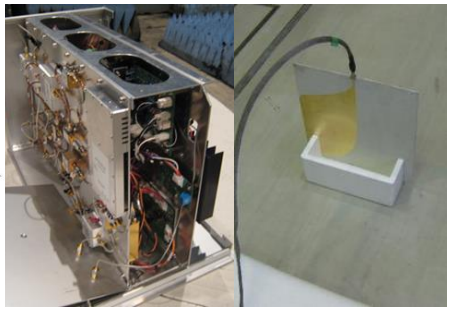
NIR (270 g)



Ground Penetrating Radar(GPR)

FMCW radar (300-900MHz), Vivaldy-type antenna (350 x 350 x 3mm)
Detection range: 10-50m Range resolution: 30cm
Mass: 900g, Power: 4W

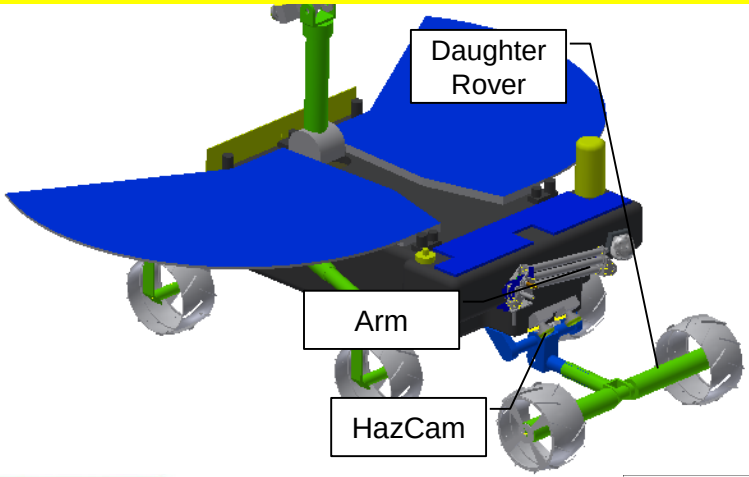


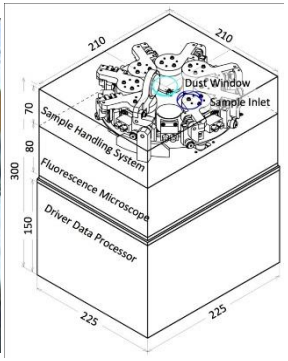


Instruments for Biosignature Identification

Primary objectives

- Identifications of biosignatures
  Current life (from Mars or Earth)
- Observations of dust particles





Daughter rover (optional): May be deployed and carry sample from top of a steep slope

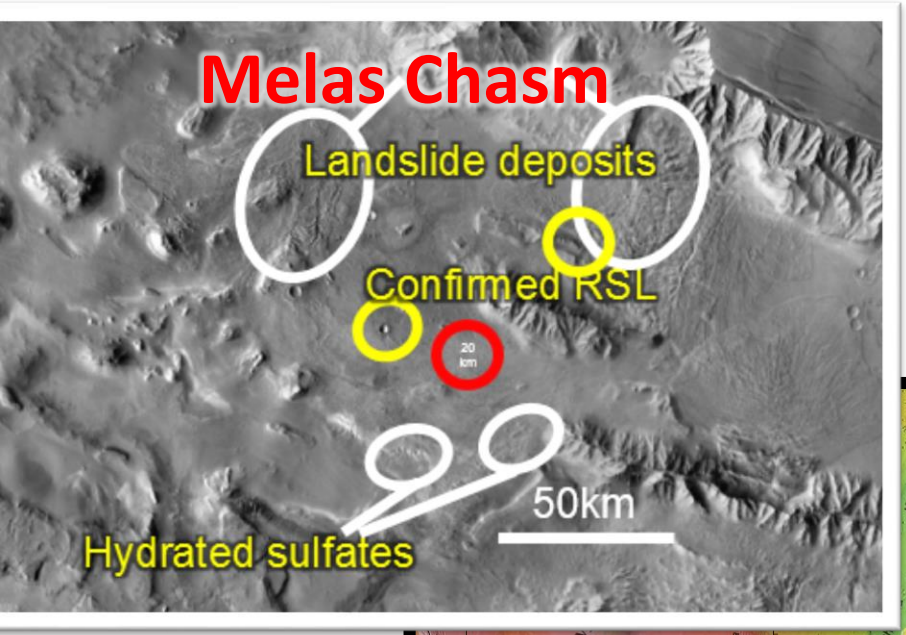
Arm: Scoop soil sample from a few centimeters below the surface

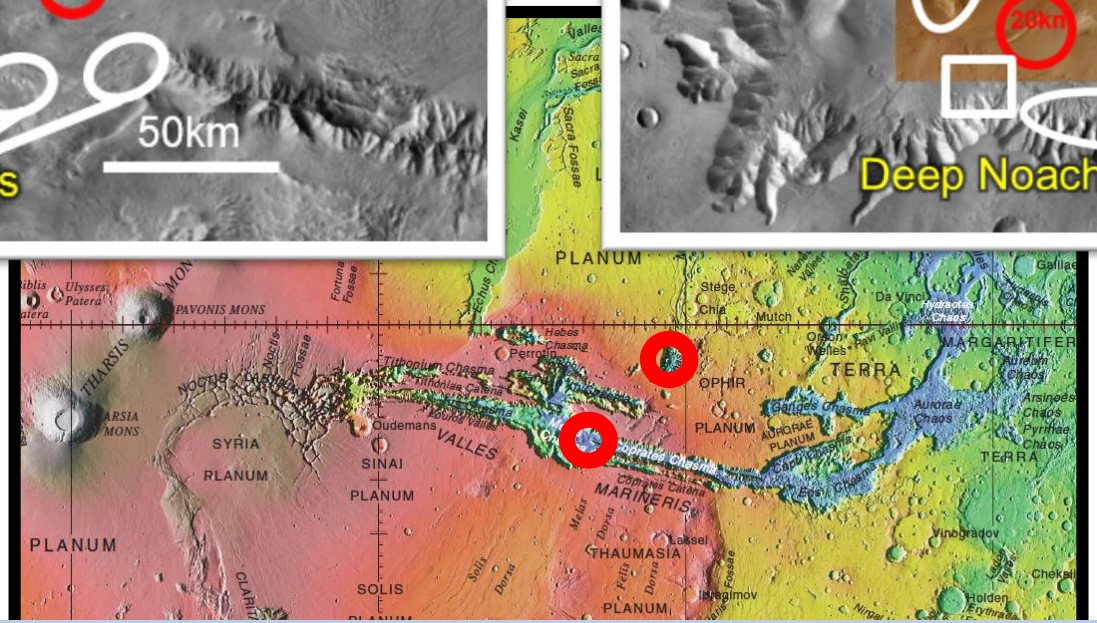
LDM (Life Detection Microscope):

Analyze the sample with fluorescence microscope.

- $1cm^3$ of sample dyed with pigments
- Stained "cells" observed by fluorescence microscope
- Very high sensitivity; $10^4 cells/cm^3$
- 1 μm/pixel resolution images of regolith and dust particles

Candidates of the landingsite





Regions with current activities and water-related features are preferred for life detection, but, landing site should be away from special regions.

Proposed landingsites include Valles Marineris (Melas, Juvantae Chasma) near the confirmed Recurring Slope Linea and Marte Vales near dark patches.

Planetary Protection Plan at JAXA

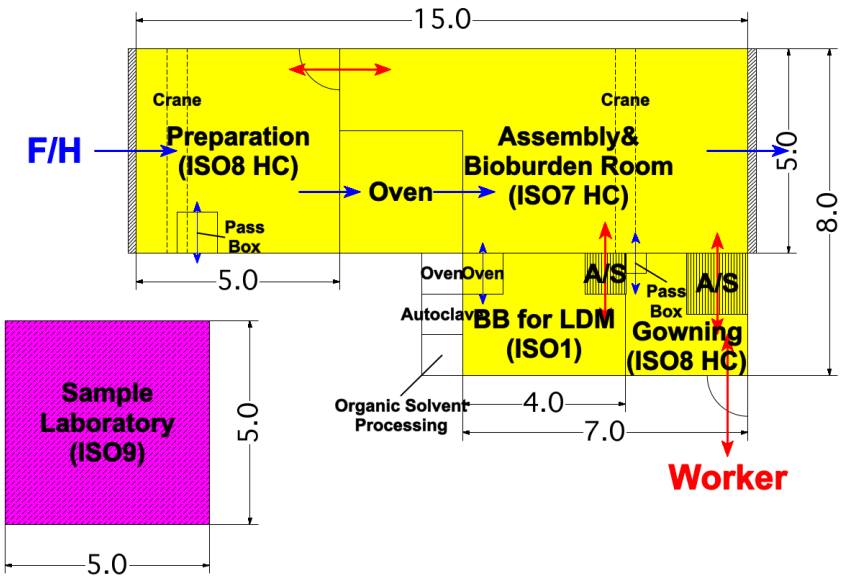
MELOS mission can be classified as Category IV(c).

- **Life detection and access to a special region (i.e. Melas Chasma, Juventae Chasma)**
- **Documentations for project planetary protection requirements are in preparation.**
- **Bioburden controlled environments will be developed in FY2016-2017, consisting of 4 CRs: (1) Gowning (ISO8 HC), (2) Preparation Room (ISO8 HC), (3) Assembly& Bioburden Room (ISO7 HC), and (4) Bioburden Room for Life Detection Module (ISO1).**
- **A pilot model of bioburden laboratory has been developed at JAXA, and a procedure of bioburden assays has been practiced.**

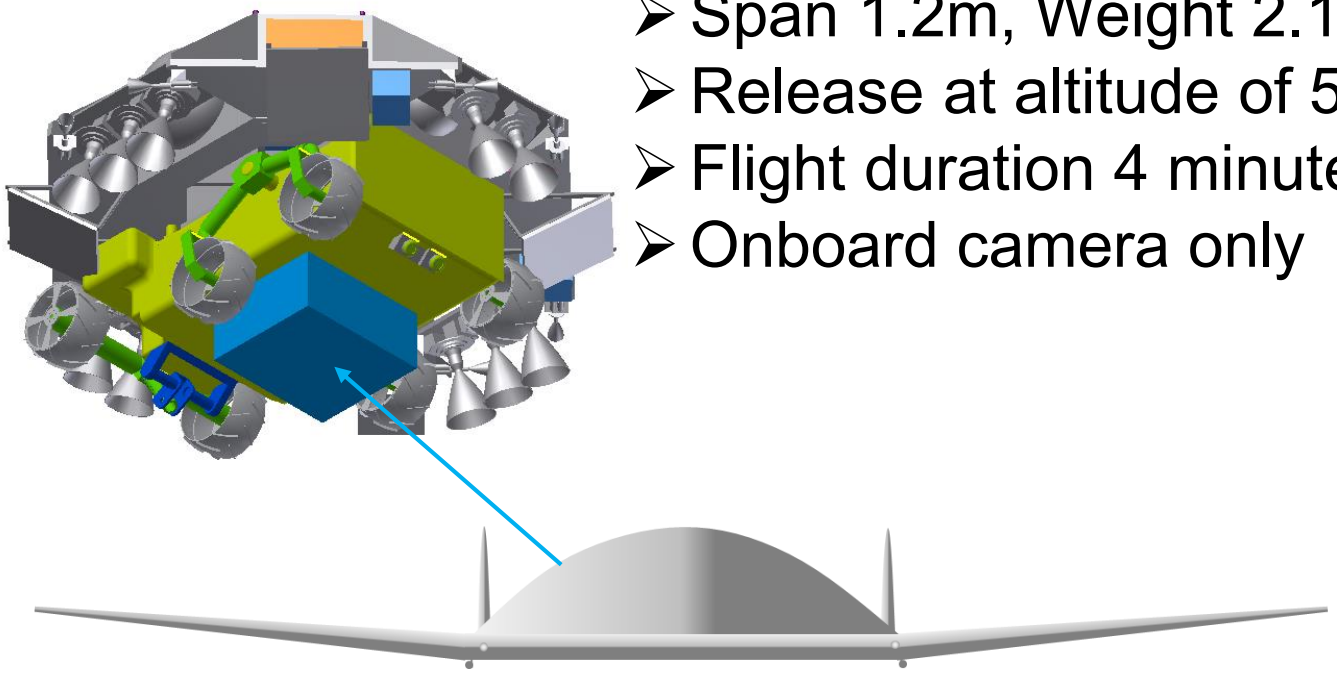
Roadmap for Planetary Protection at JAXA

FY	2014	2015	2016	2017	2018	2019	2020
Requirements Management	Documentation						
			Management and Improvement of Documentations COSPAR Reports				
			Training Engineering Experts				
			Probability Analysis of Impact and Contamination				
Facility	Proposal		Management, Inspection, Improvement				
			Establishment of CRs (ISAS)		Establishment of CRs (at Launching Site)		
				Sterilization and Operation			
Sterilization	Technical Development of Sterilization		Introduction of Sterilization Apparatus		Operation of Sterilization		
		Guideline for Manufacturer			Guiding and Managing Manufacturer		
Bioburden	Pilot Model of Bioburden Lab.		Establishment of Bioburden Lab.		Operation of Laboratory		
					Management of Organic Materials Inventory		

Planetary Protection Facility at JAXA



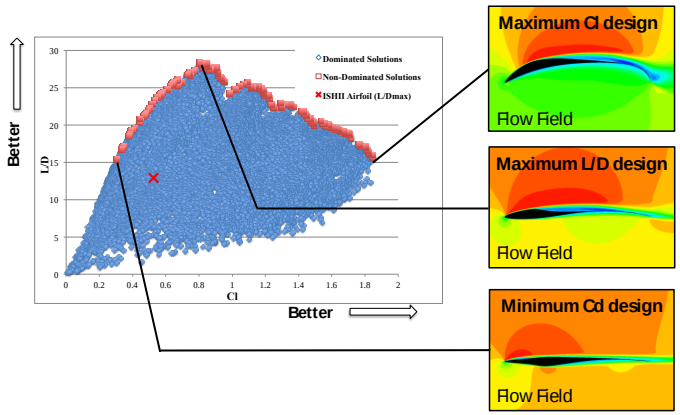
(Optional) Mars Airplane: Flight technology demonstrator



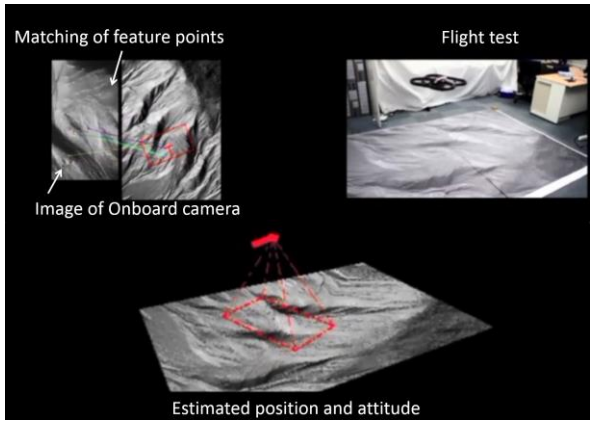
- Span 1.2m, Weight 2.1kg
- Release at altitude of 5 km
- Flight duration 4 minutes, distance 25km
- Onboard camera only

Ultra-light wing structure

Mars Wind Tunnel



Low Reynolds number wing design

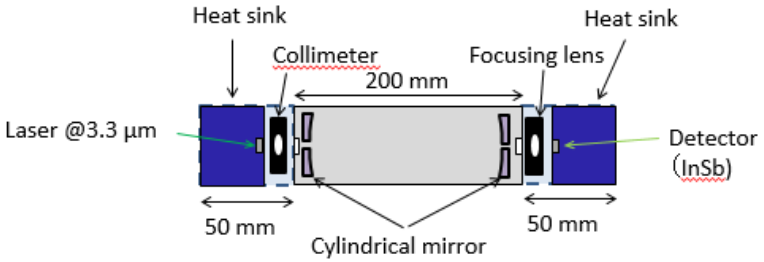


GNC for Mars airplane

Optional Instruments for meteorological study

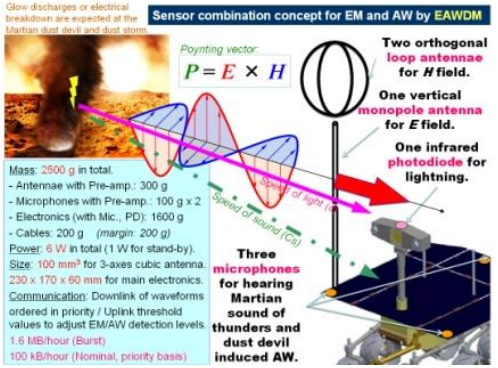
Methane detector

infrared wavelength modulation spectroscopy with a multi-pass absorption Cell. Detection level is a few ppb



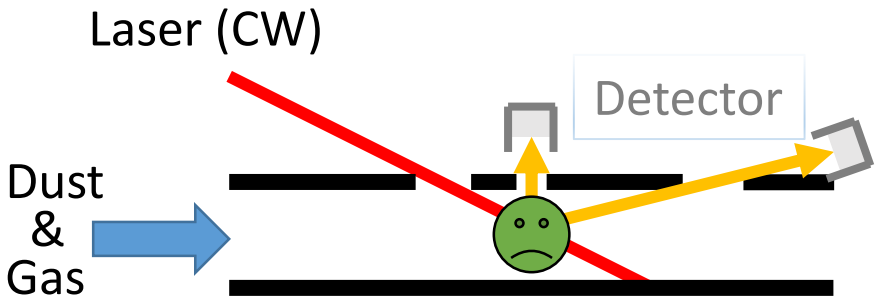
Electromagnetic & Sonic Wave measurement

In order to investigate DC field contribution to "uplift" of dusts



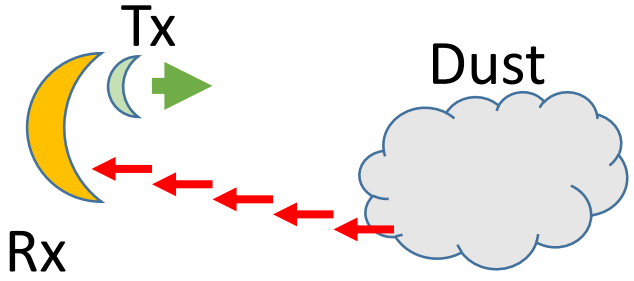
Particle sensor

Monitor the frequency of signal from transiting dust. Weight <200g, sensor size 100x80x30mm



Short range LIDAR (LIght Detection and Ranging)

Observe 100m dividing into 1m bins
ϕ100mm, 900g in total



Summary

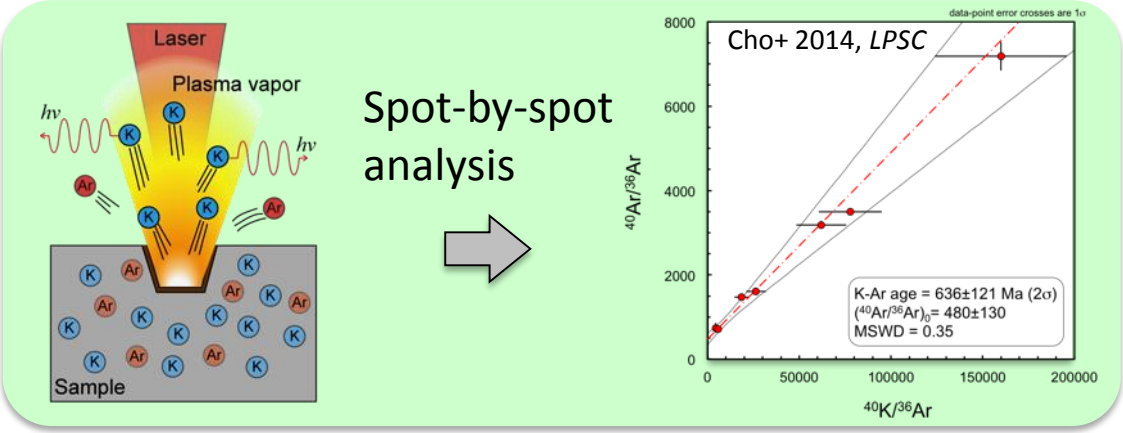
- MELOS mission would be an engineering demonstration mission of EDL with a rover
- Rover would be designed for a long-range travel
- Scientific objectives would include environmental observations, geological study, and detections of current biosignatures
- Our resources are limited, though many scientists/engineers are interested in Mars mission!

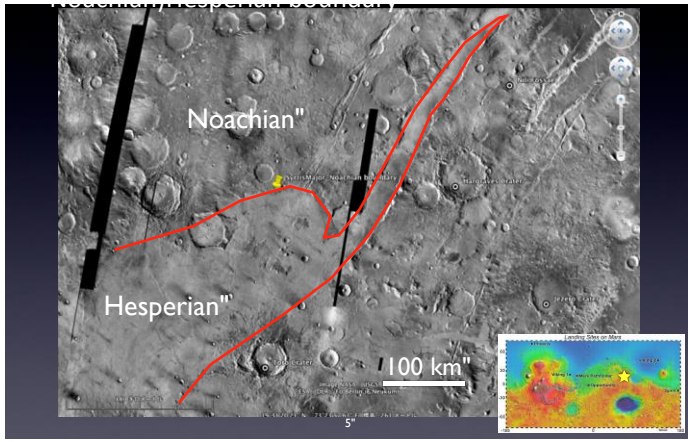
Back-up instrument

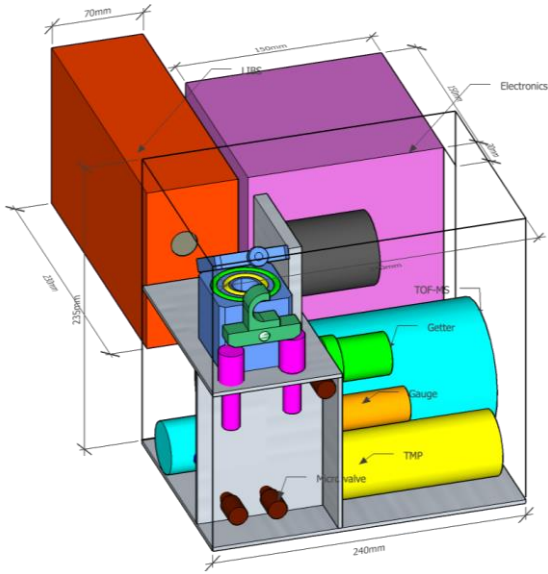
In-situ Geochronology Instrument

CHRONICLE=CHRONological Investigation Conducted by Laser Extraction

- Dating Noachian/Hesperian boundary at Syrtis Major with the **isochron** method
  - LIBS + MS + Imaging = K-Ar isochron
  - 10-15 % error for K-rich (>1 wt%) old (>2 Ga) rocks
  - Compact, light-weight O-ring seal system







- Investigators/Collaborators
  - Japanese investigators: S. Kameda, Y. Cho (Rikkyo U.); S. Sugita, Y.N. Miura (U. Tokyo)
  - International collaborators: B.A. Cohen (MSFC/NASA); W. Blinckerhoff (GSFC/NASA); O. Gasnault, S. Maurice (CNES); F. Rull (IRAP)