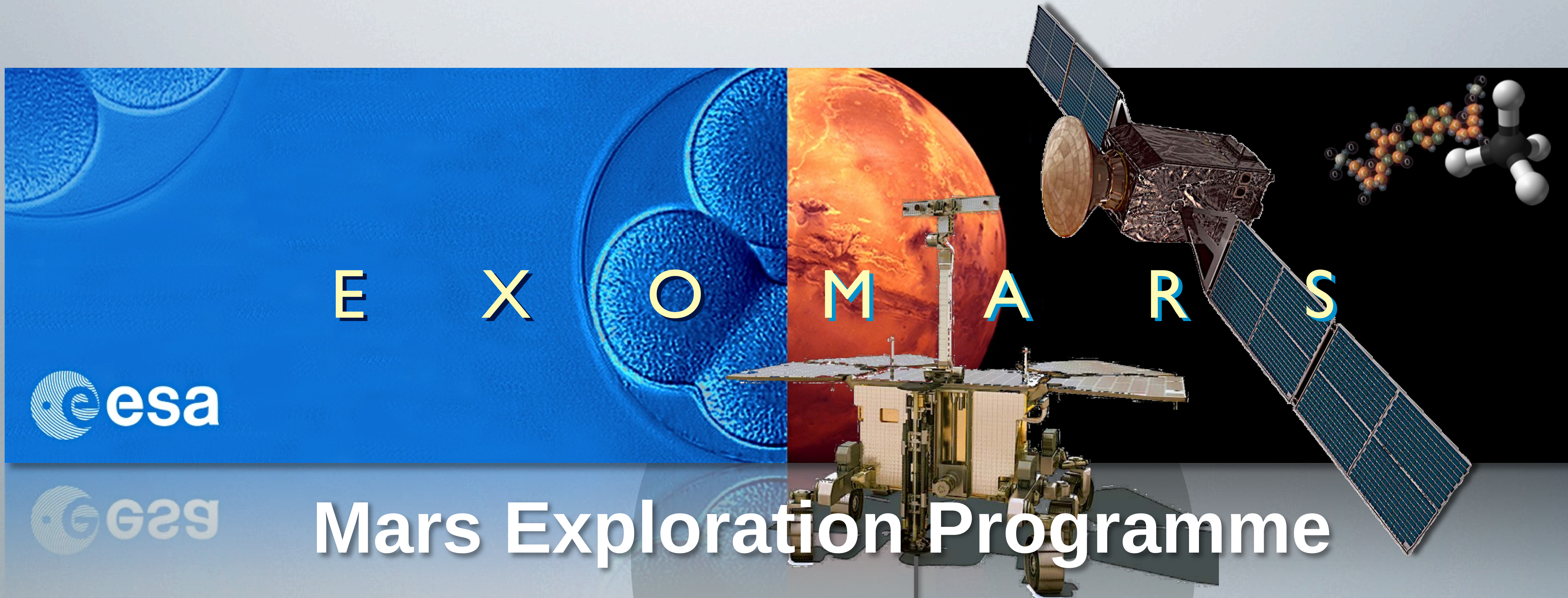
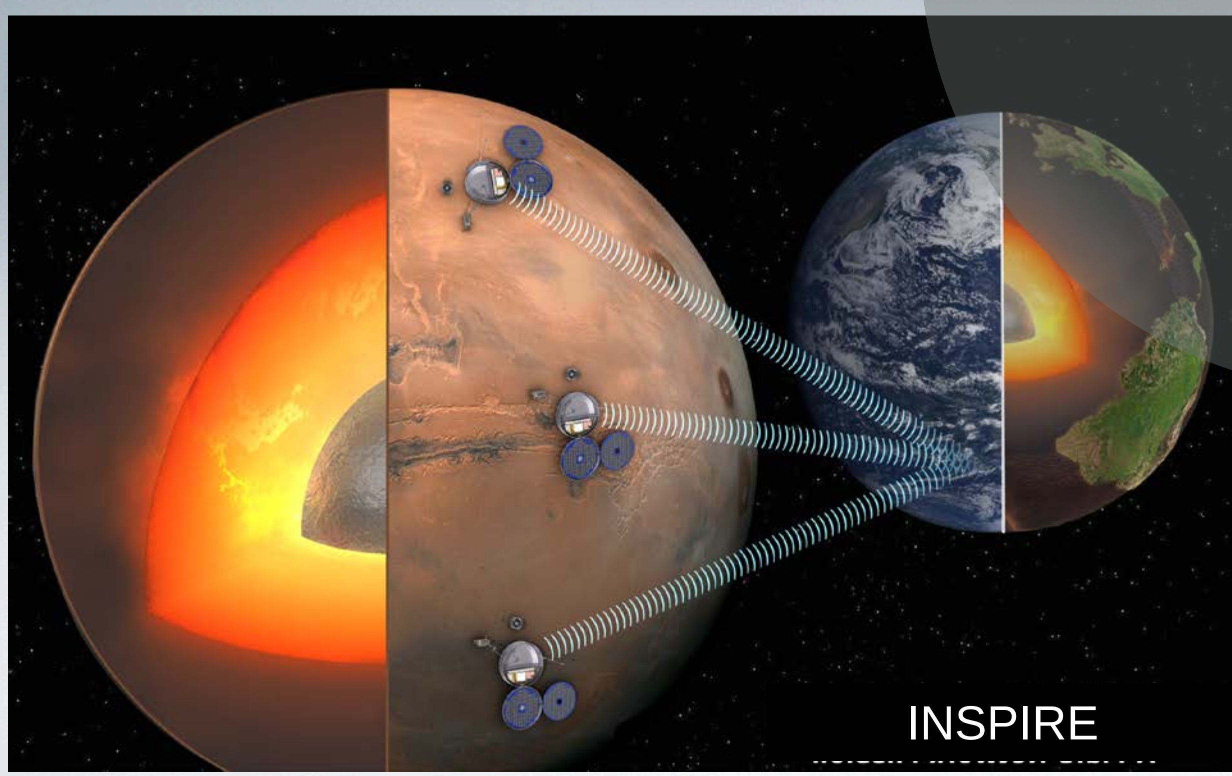
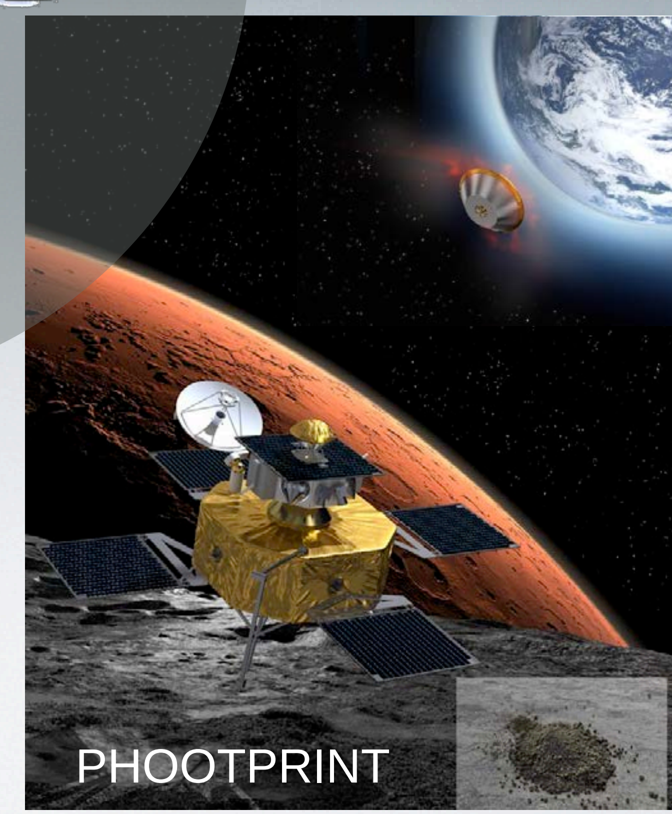


Mars Exploration Programme





J. L. Vago, M. Coradini, ExoMars, and EREP Teams

Concepts and Approaches for Mars Exploration
12 June 2012, LPI, Houston TX (USA)

Mars Exploration at ESA

ExoMars

- ExoMars: Constitutes the core of ESA's Mars Exploration Programme.
- ExoMars: An international collaboration between ESA and Roscosmos, with NASA contributions.
- ExoMars: Two missions — in the 2016 and 2018 opportunities.

European Robotic Exploration Programme (EREP)

- ESA is preparing its post-ExoMars missions through the EREP programme.
- ESA is open to international participation in EREP missions.
- The target is to achieve collaboration either through 80/20 or 20/80 % schemes.

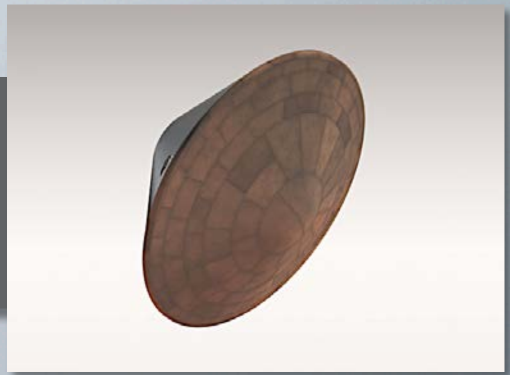
Credit: MEX/HRSC

2016 Mission Objectives

2016

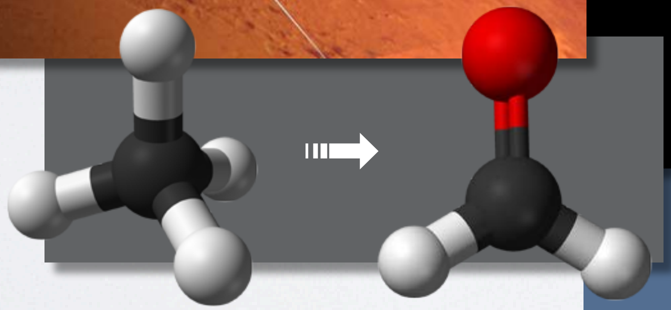
TECHNOLOGY OBJECTIVE

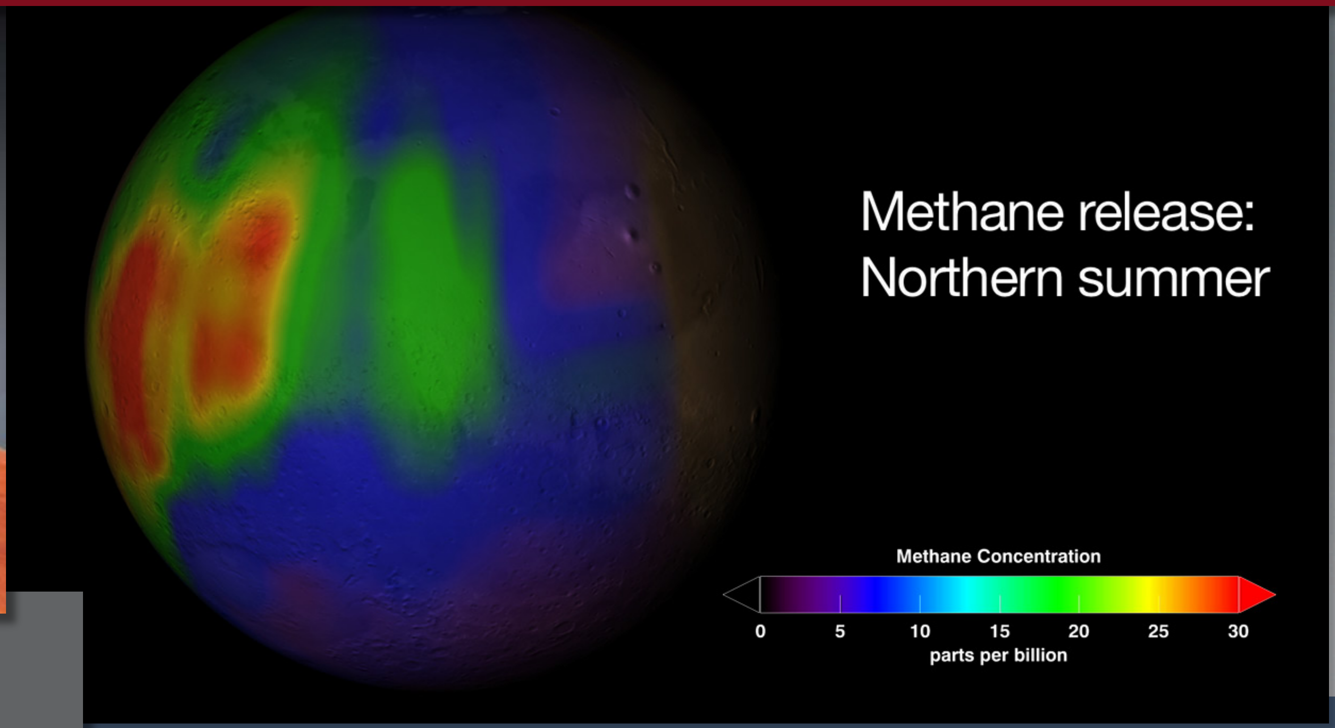
- Entry, Descent, and Landing (EDL) of a payload on the surface of Mars.



SCIENTIFIC OBJECTIVE

- To study Martian atmospheric trace gases and their sources.
- To conduct surface environment measurements.

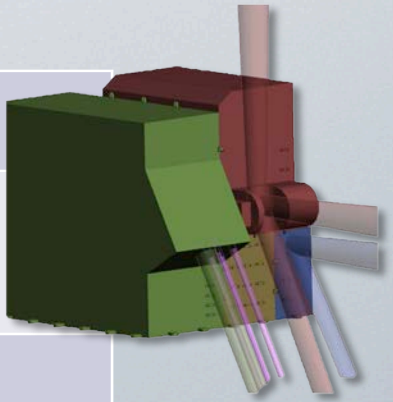


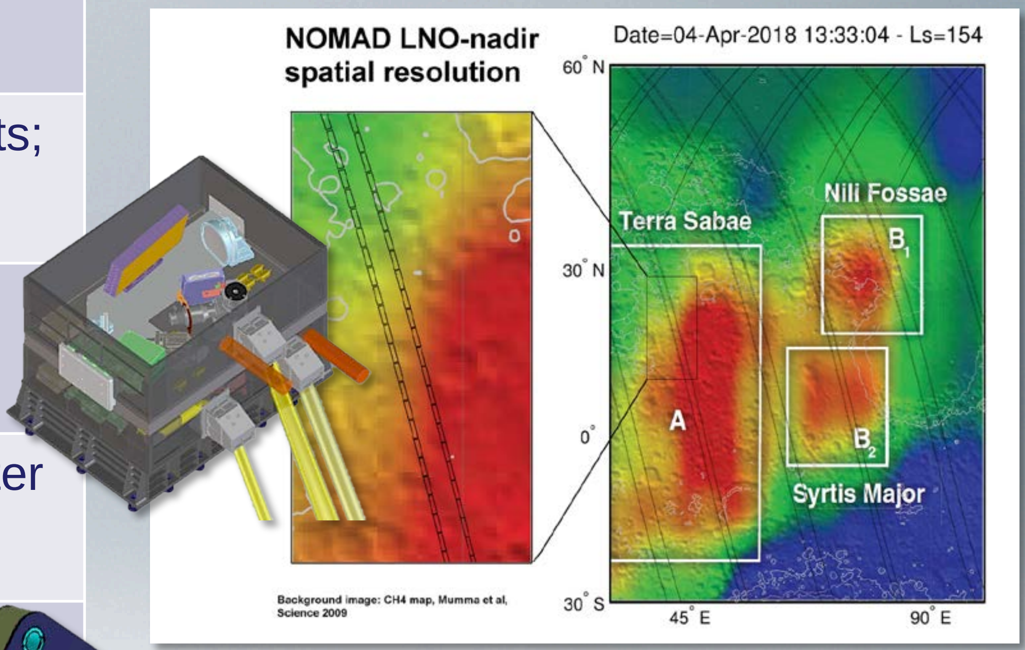


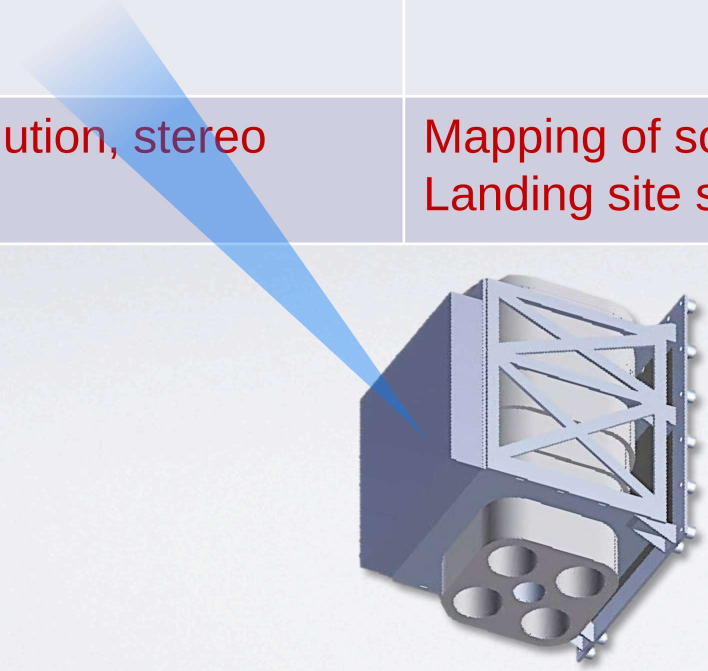
- Provide data relay services for landed missions until 2022.

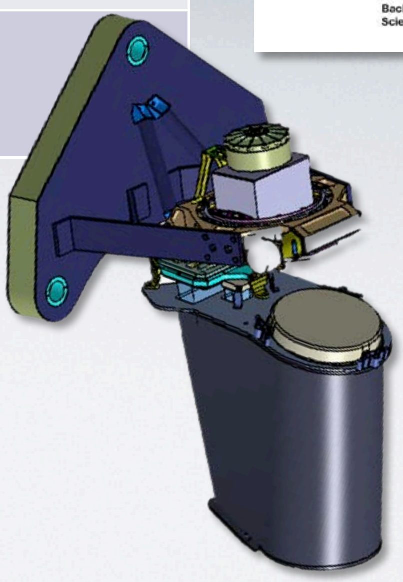
Trace Gas Orbiter

Instrument		Science
ACS-NIR	Echelle-AOTF spectrometer (nadir + limb + occultation)	Water, photochemistry
ACS-MIR	Echelle spectrometer (occultation)	Methane and minor constituents
ACS-TIR	Fourier spectrometer (nadir + occultation)	Aerosols; Minor constituents; Atmospheric structure
NOMAD	Echelle spectrometer (nadir + occultation)	Trace gas inventory; Mapping of sources/sinks
FREND	Collimated neutron detector	Mapping of subsurface water
CASSIS	High-resolution, stereo camera	Mapping of sources; Landing site selection





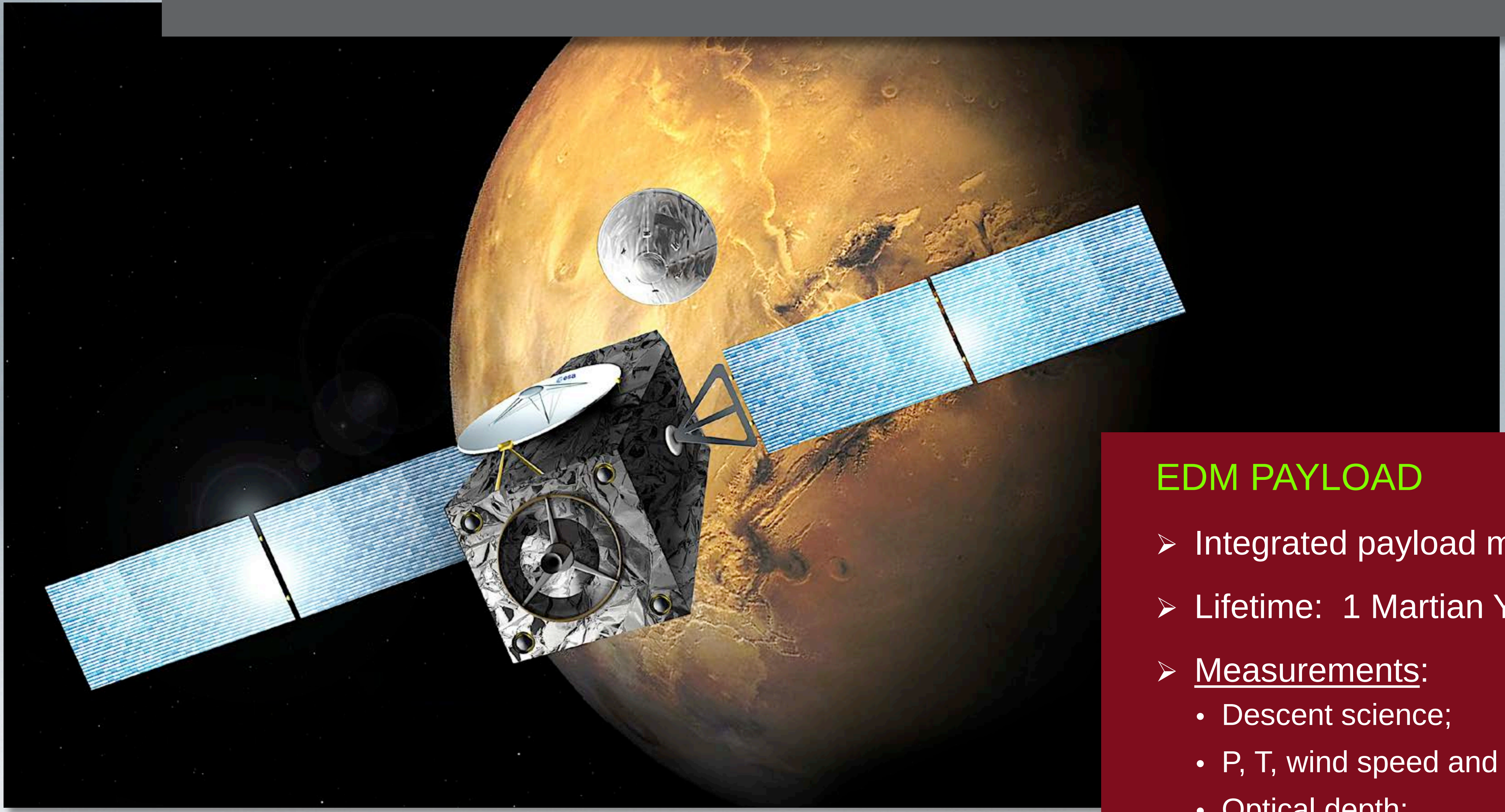




EDL Demonstrator Module

EDM

- A technology demonstrator for landing payloads on Mars;
- A useful platform to conduct environmental measurements, particularly during the dust storm season.



EDM PAYLOAD

- Integrated payload mass: 5 kg;
- Lifetime: 1 Martian Year;
- Measurements:
  - Descent science;
  - P, T, wind speed and direction;
  - Optical depth;
  - Atmospheric charging;
  - Subsurface water content;
  - Descent and surface cameras.

2018 Mission Objectives

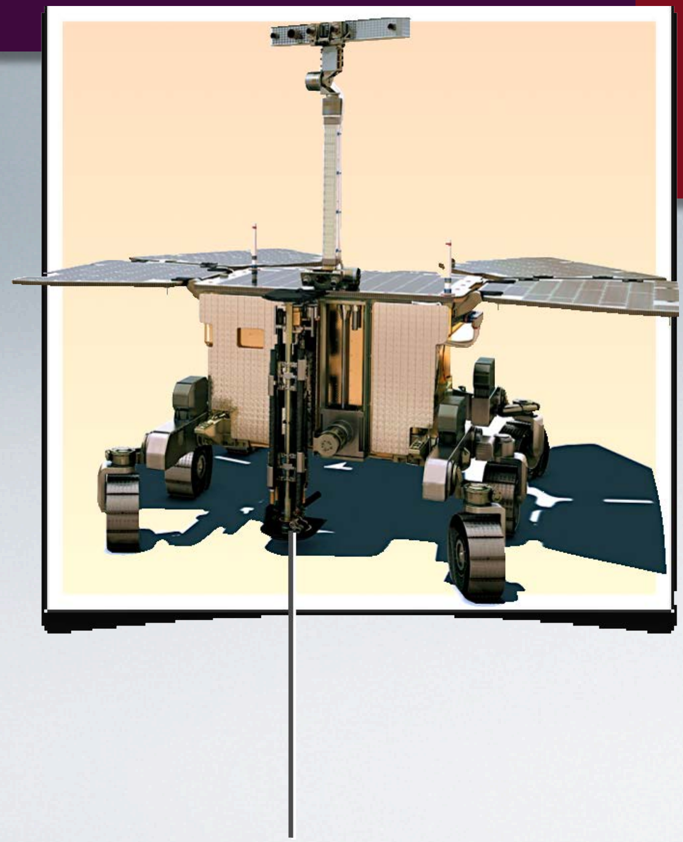
TECHNOLOGY OBJECTIVES

- Surface mobility with a rover (having several kilometres range);
- Access to the subsurface to acquire samples (with a drill, down to 2-m depth);
- Sample acquisition, preparation, distribution, and analysis.

2018

SCIENTIFIC OBJECTIVES

- To search for signs of past and present life on Mars;
- To characterise the water/subsurface environment as a function of depth in the shallow subsurface.

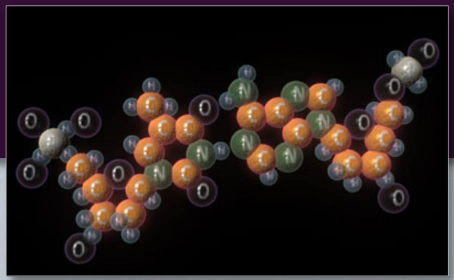


- To characterise the surface and subsurface environment.

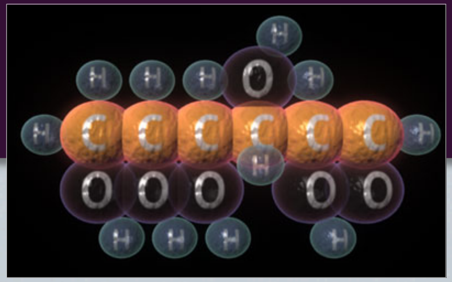
What to Search For

- **PRESENT LIFE:** Biological markers, such as:

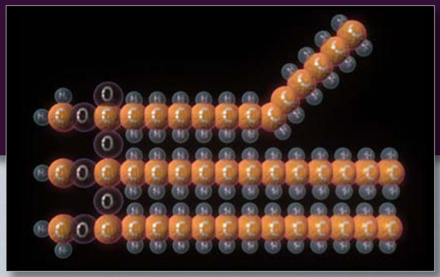
Amino acids



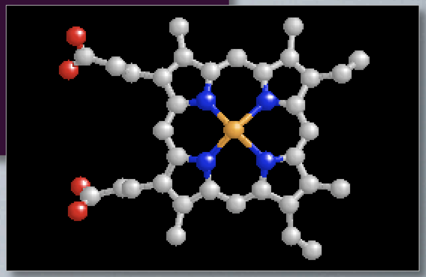
Nucleobases



Sugars



Phospholipids

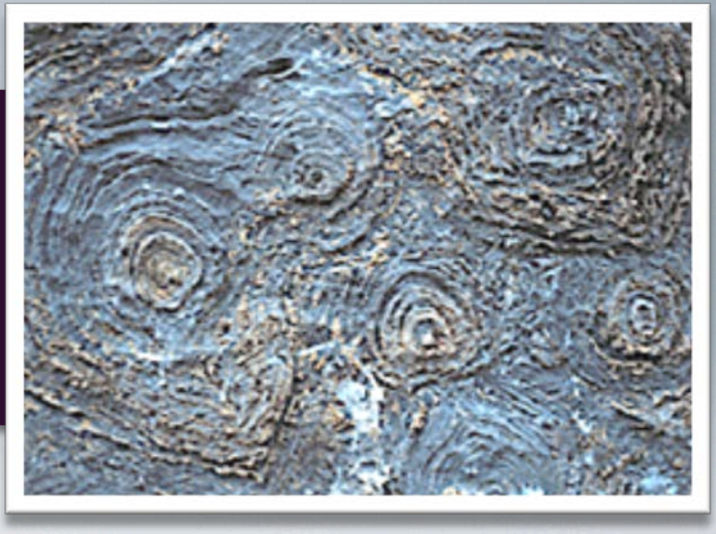


Pigments

...

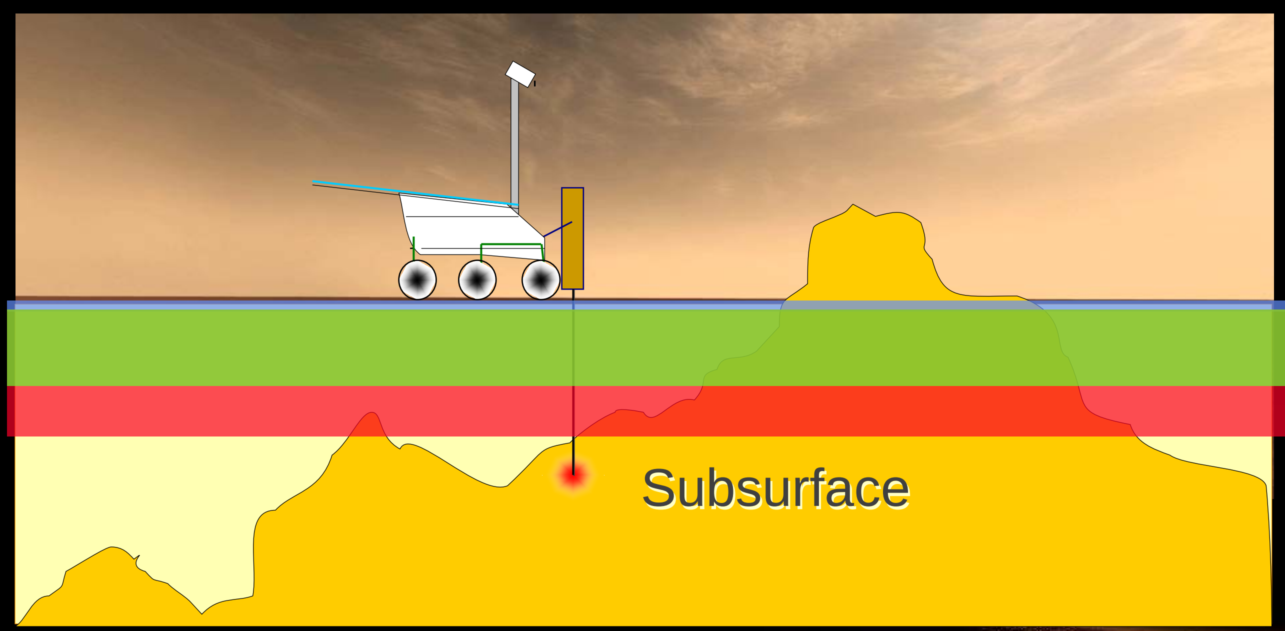
- **PAST LIFE:** Organic residues of biological origin;
  (chemical, chiral, spectroscopic, and isotopic info)

  Images of fossil organisms and their structure;
  (morphological evidence)



- **DELIVERED ORGANICS:** by meteoritic and cometary infall.

Where to Search



Penetration of organic destructive agents

UV Radiation	~ 1 mm
Oxidants	~ 1 m
Ionising Radiation	~ 1.5 m

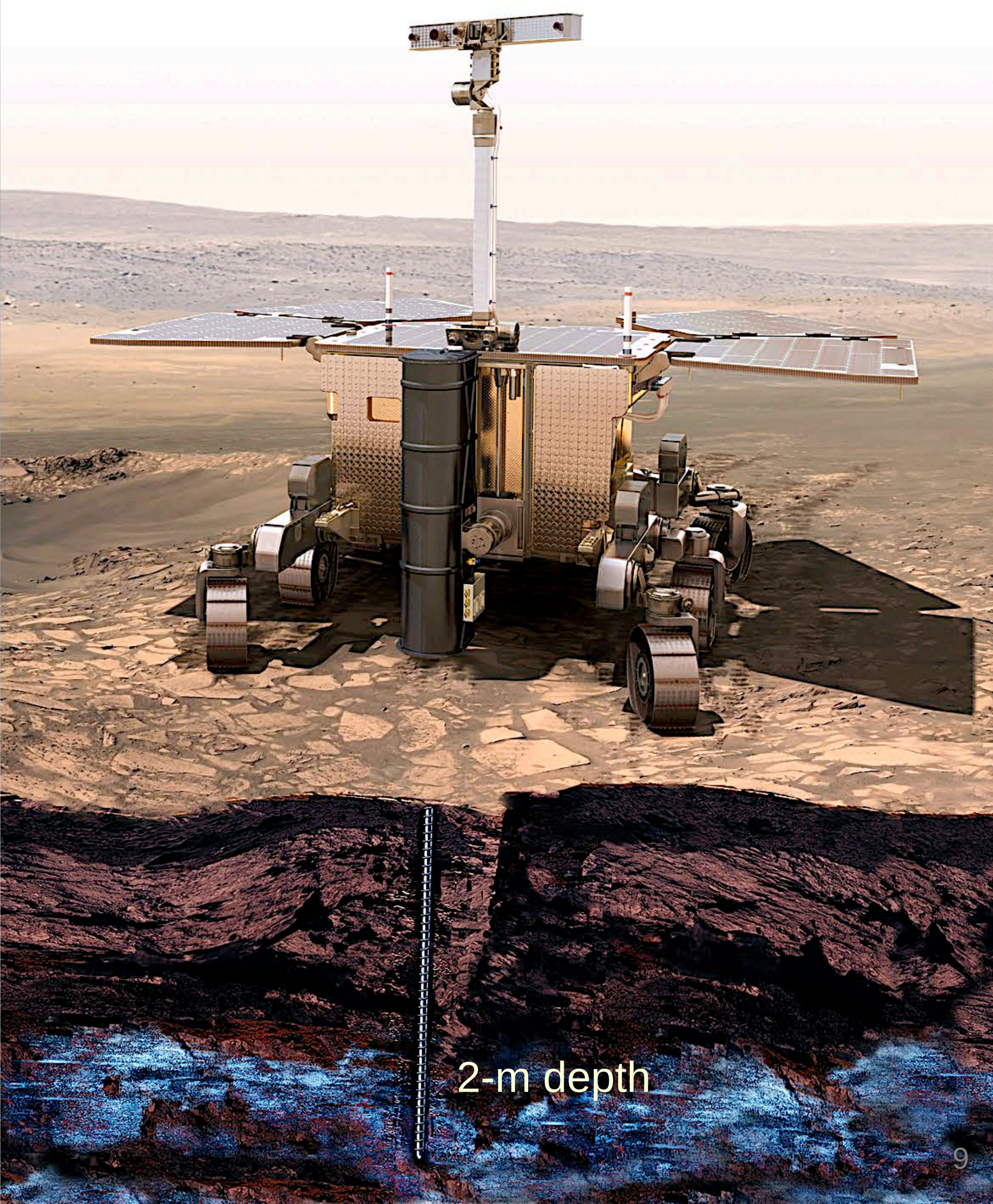
ExoMars exobiology strategy:

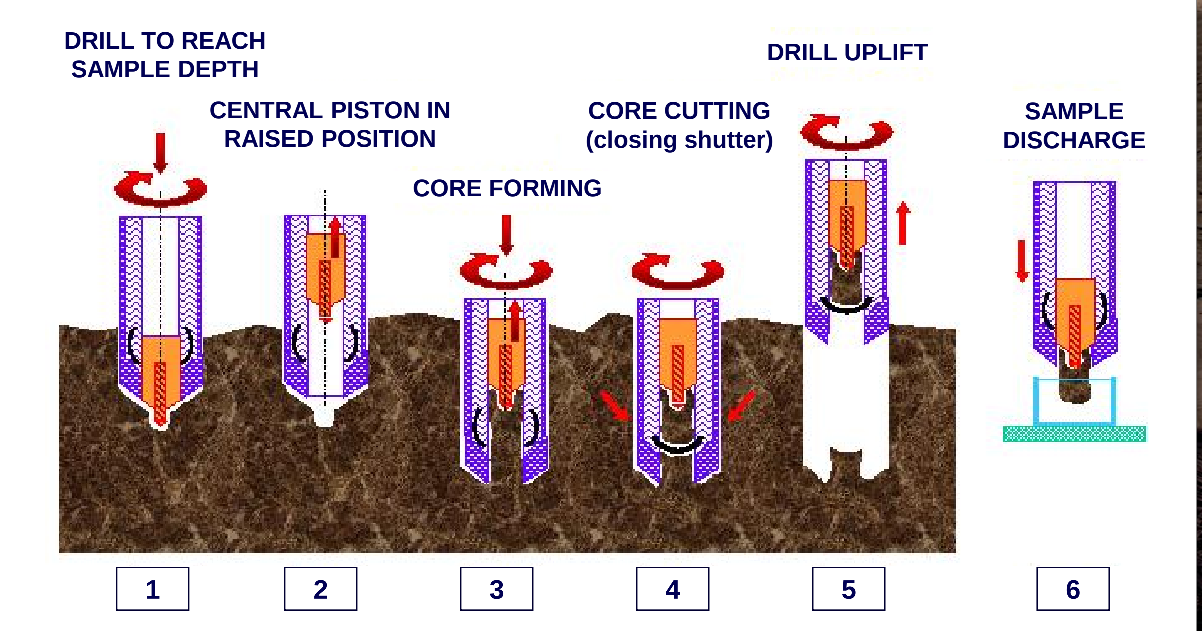
Identify and study the appropriate type of outcrop;

Collect samples below the degradation horizon and analyze them.

Mobility + Subsurface Access

Nominal mission:	220 sols
Nominal science:	6 Experiment Cycles + 2 Vertical Surveys
EC length:	16–20 sols
Rover mass:	300-kg class
Mobility range:	Several km





Credit: ESA/Medialab

Science Exploration Scenario

E X O M A R S

Determine the rover's geological context:

- Survey site at large scales — **Panoramic Instruments**
- Examine surface outcrops and soils at sub-mm scales — **Close-Up Instruments**

↓

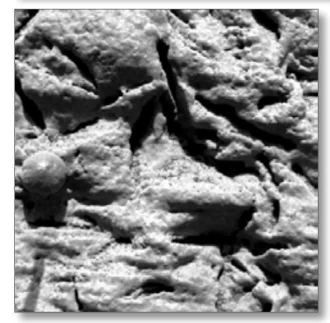
Collect a subsurface (or surface) sample

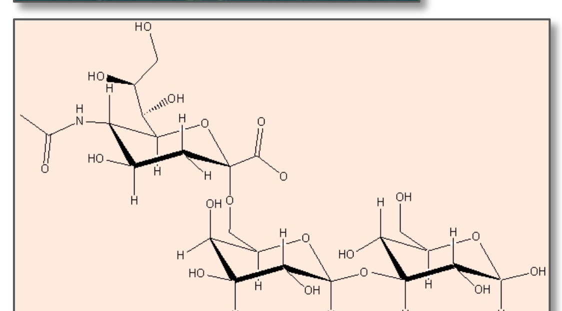
↓

Study sample:

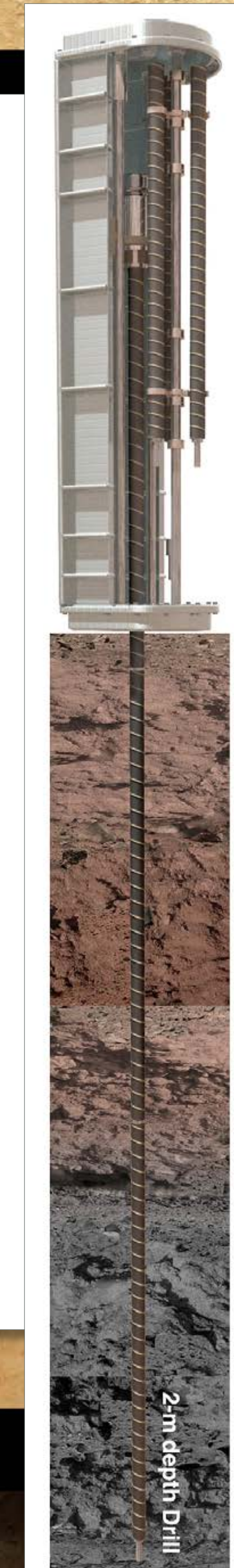
- Survey analysis
- Detailed analysis

Analytical Laboratory



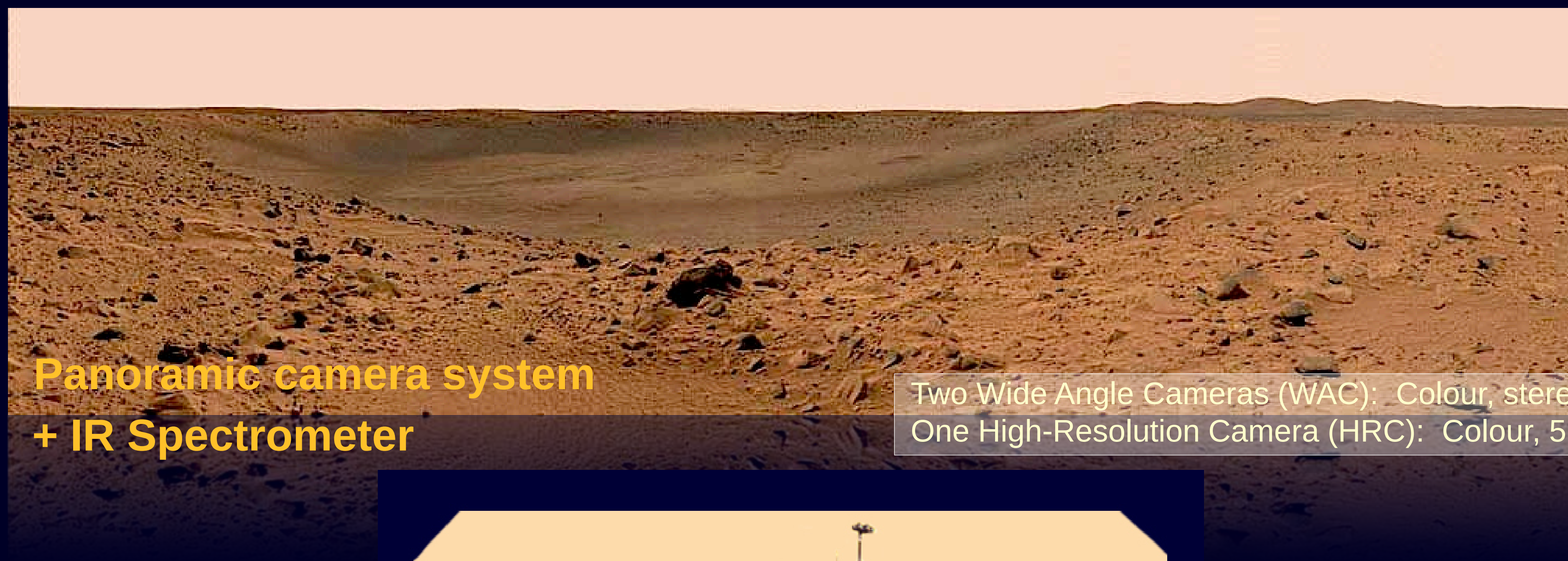


Scale



Site Characterisation

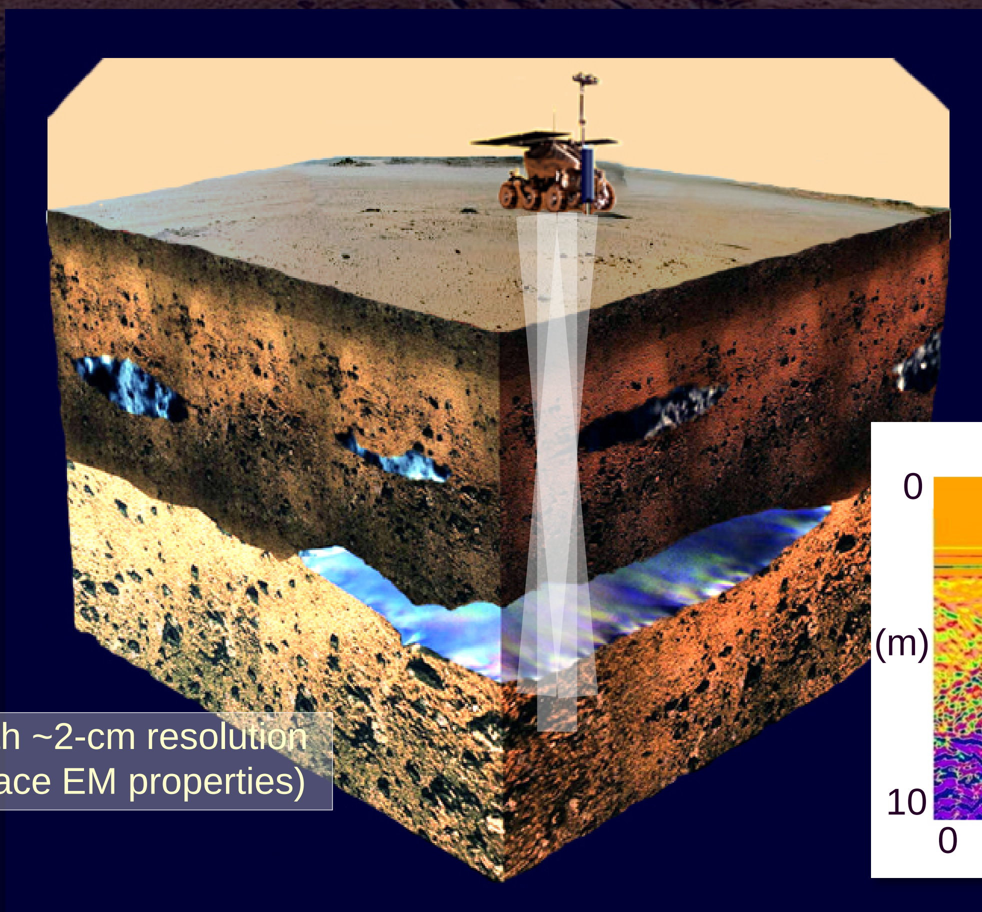
AT PANORAMIC SCALE: To establish the geological context



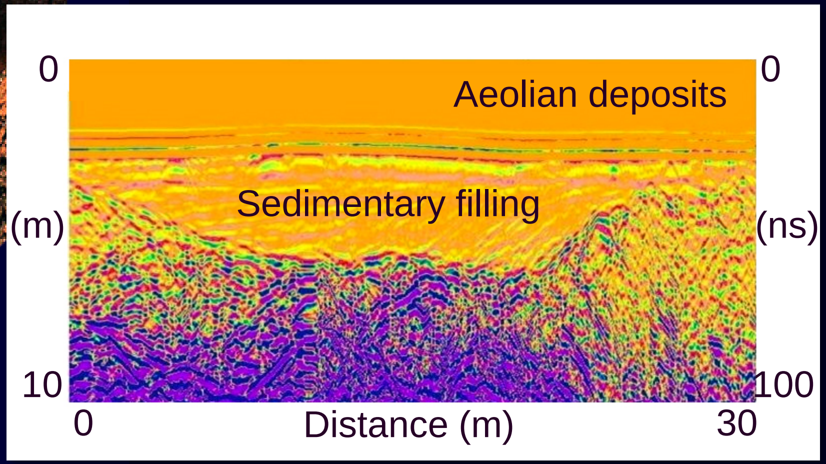
Panoramic camera system
+ IR Spectrometer

Two Wide Angle Cameras (WAC): Colour, stereo, 35° FOV;
One High-Resolution Camera (HRC): Colour, 5° FOV.

Ground-Penetrating Radar
+ Neutron Spectrometer



~3-m penetration, with ~2-cm resolution
(depends on subsurface EM properties)



Heggy et al. 2007

Outcrop Characterisation

AT ROCK SCALE:

To ascertain the past presence of water
For a more detailed morphological examination

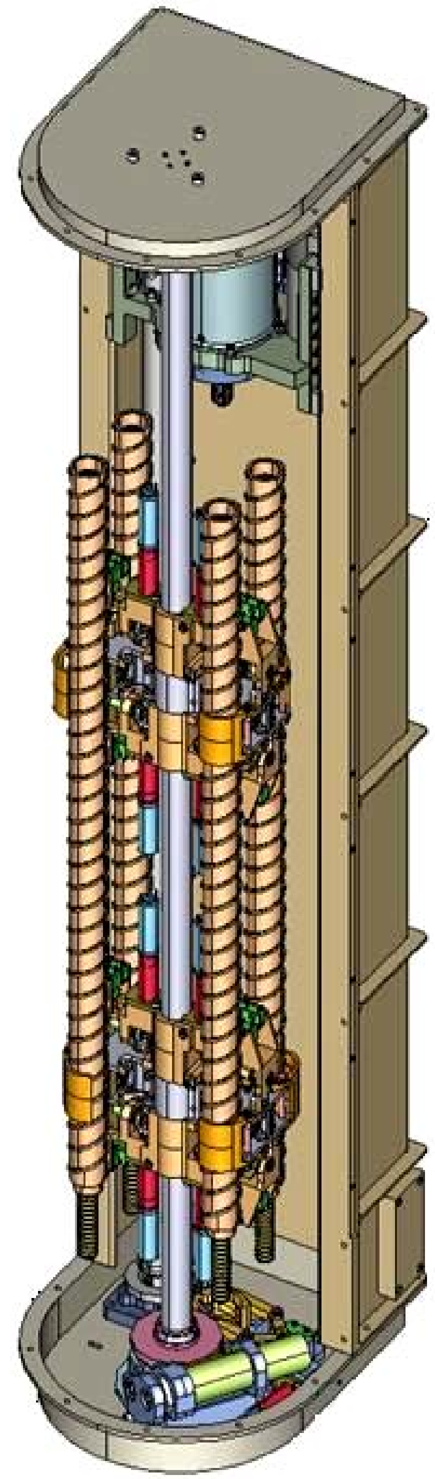
Next step: **ANALYSIS**

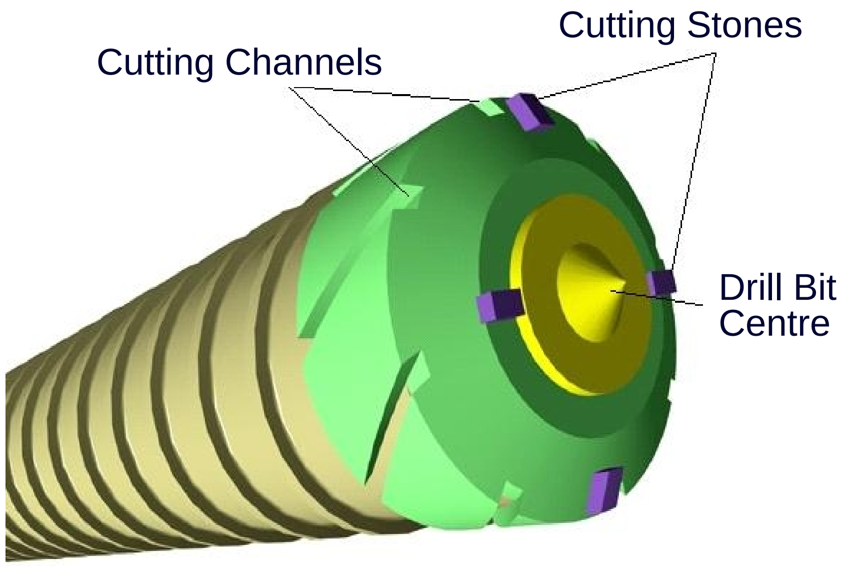
Use the drill to collect a sample
- From an outcrop
- From the subsurface

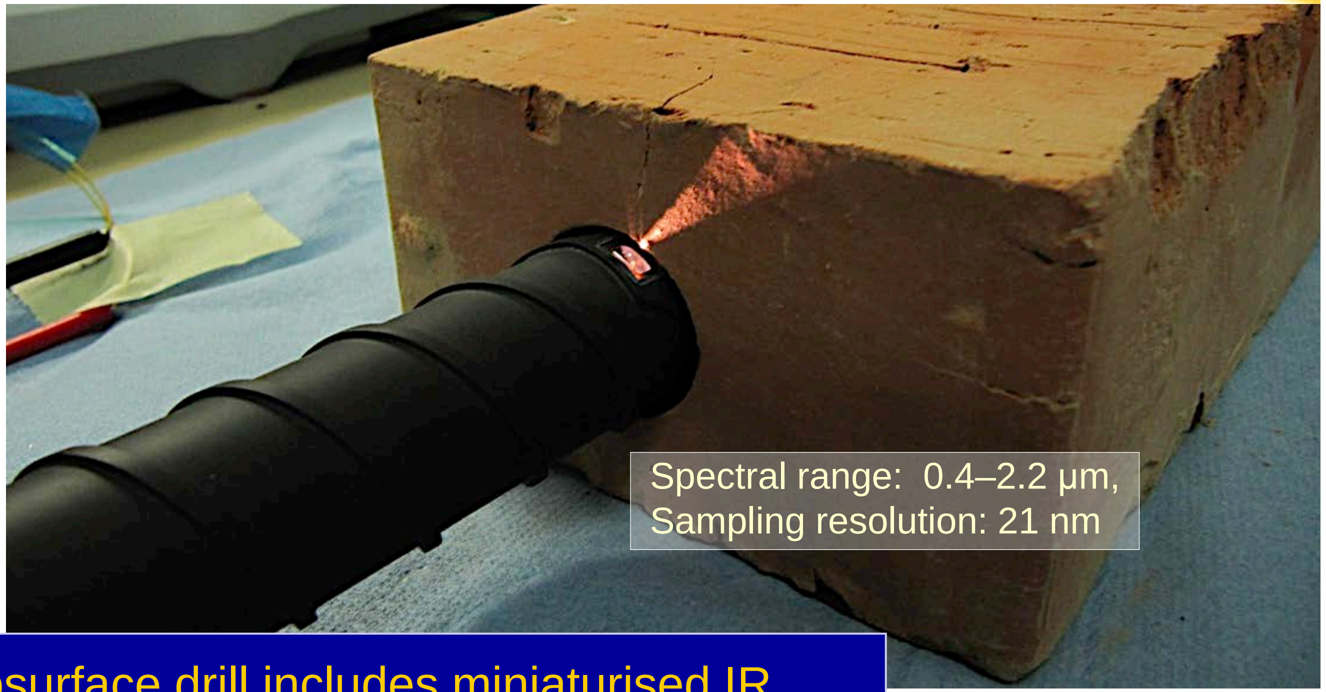
Subsurface Drill

EXOMARS

OBTAIN SAMPLES FOR ANALYSIS: From 0 to 2-m depth

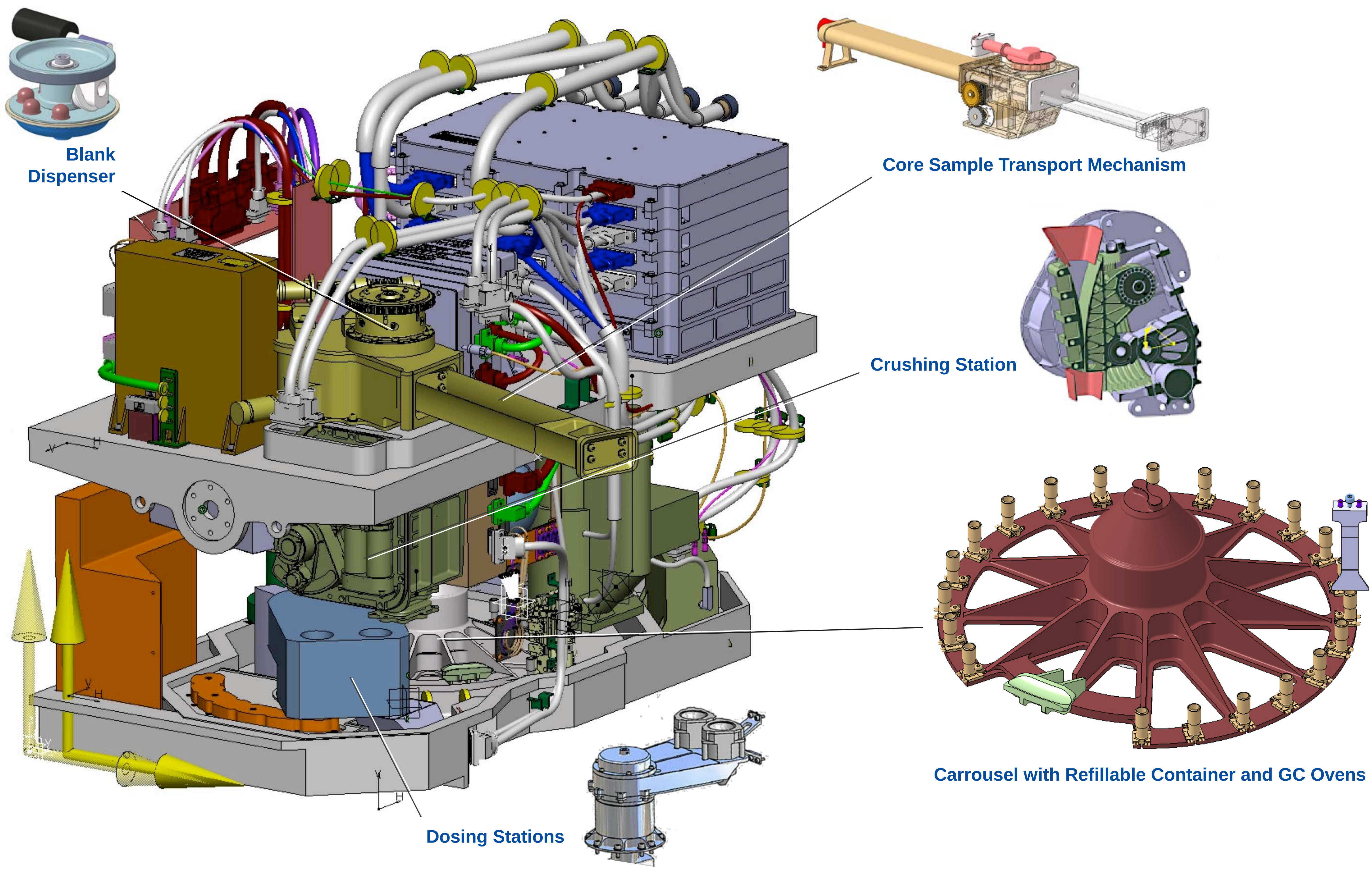






Subsurface drill includes miniaturised IR spectrometer for borehole investigations.

Analytical Laboratory

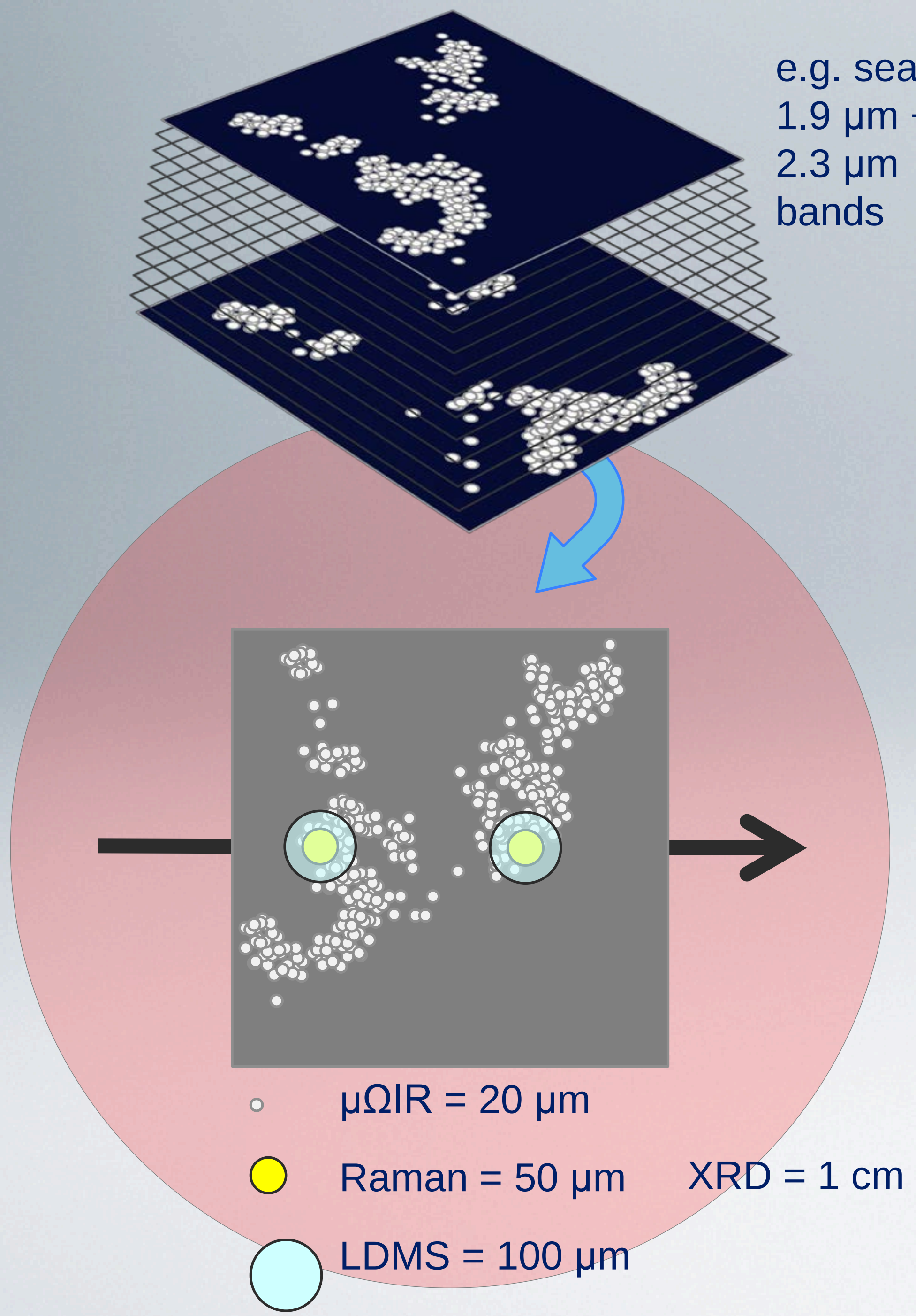


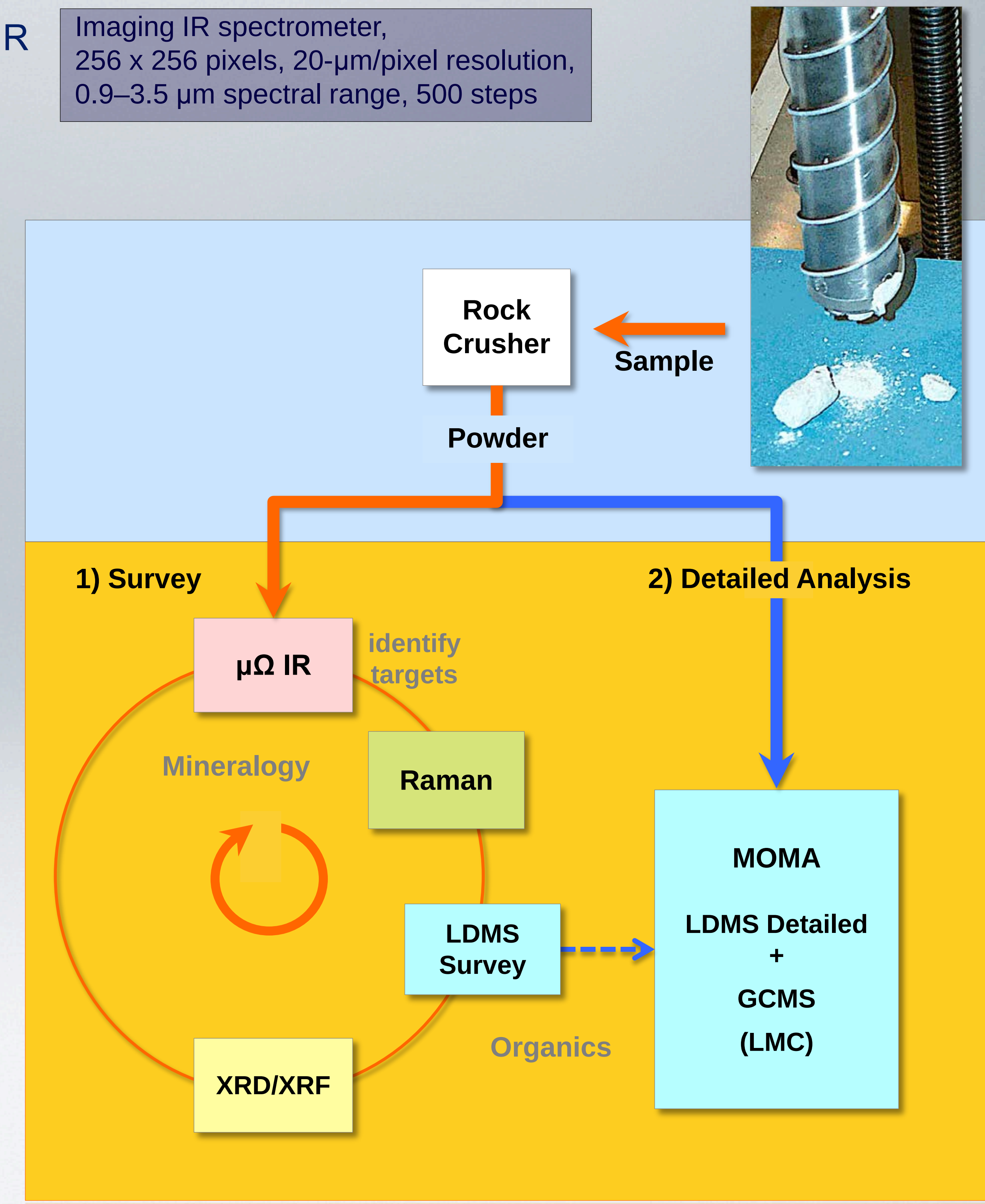
Sample Analysis

E X O M A R S

Use mineralogical + imaging information from µΩIR to identify targets for Raman and MOMA LDMS.

Imaging IR spectrometer,
256 x 256 pixels, 20-µm/pixel resolution,
0.9–3.5 µm spectral range, 500 steps





Raman: spectral shift range 200–3800 cm^{-1}
Spectral resolution ~6 cm^{-1}

LDMS = Laser-Desorption Mass Spectrometry,
GCMS = Gas-Chromatograph Mass Spectrometry

EREP

EREP Objectives

- Build and sustain competence of European robotic exploration through a series of missions to Mars.
- Target a mission for every launch opportunity.
- Develop missions in cooperation, ensuring they are well integrated in the international context.
- Aim for first two missions to be European-led.
- Reinforce the exploration technology programme already started with MREP.
- Maintain Mars Sample Return (MSR) as medium to long-term goal.

Candidate Missions

- Four candidate missions selected in May 2010 and studied:
  1. MSR Orbiter — implementation subject to the successful start of international MSR effort.
  2. Mars moon sample return.
  3. Mars network science mission.
  4. Mars precision lander — possibly as element of international MSR.

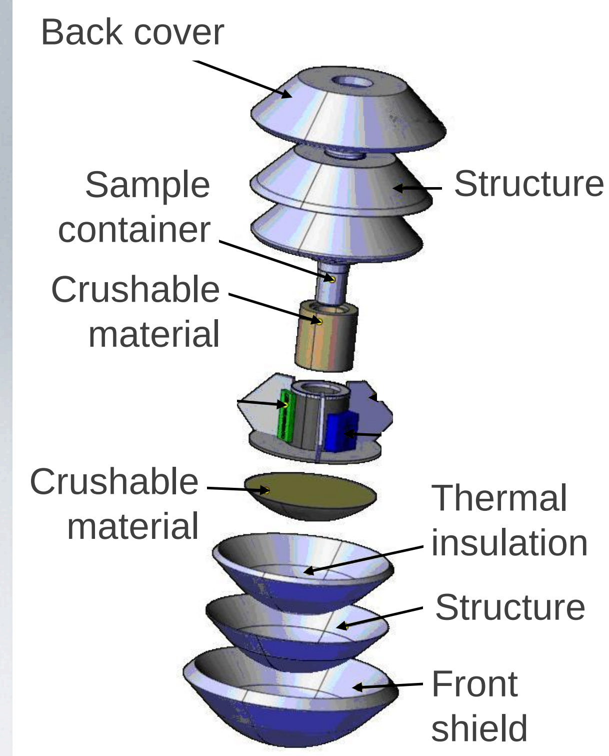
Two Missions Recommended

- For the 2022 and 2024 opportunities (which is first, still TBD):
  1. PHOOTPRINT: Phobos sample return.
  2. INSPIRE: Mars network science mission.

Mission Objectives:

1. To develop European capabilities to return a sample from a solar system body.
2. To prepare critical building block for MSR, including: sampling, sample handling, and Earth reentry technologies.
3. To obtain science information on the formation of the Martian moons and better constrain the evolution of the solar system.

- Lander/Orbiter (1900 kg wet mass):
  - 3-m diameter x 1.8-m height;
  - Two full day/night cycles on Phobos surface;
  - Robotic arm on side panel for sampling (rotating corer) and sample transfer;
  - 3-axis control + dedicated landing GNC sensors;
  - 30-kg instrument suite, 60-Gbit science data return.
- Earth Return Vehicle (400 kg wet mass):
  - Mass-minimised system (195 kg dry mass);
  - 1.6-m diameter x 0.5-m height.
- Earth Return Capsule:
  - 32 kg, reentry at 11.5 km/s fully passive.
- Total launch mass ~5 tons

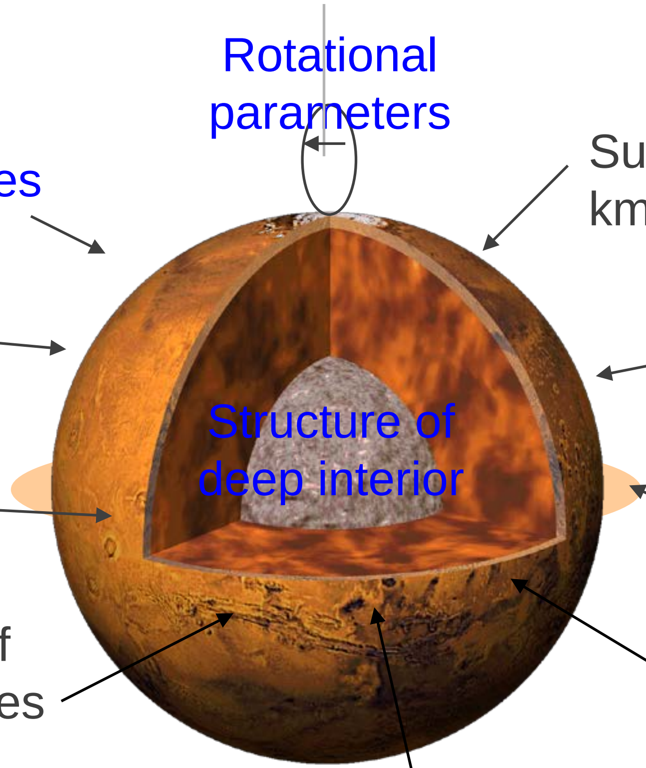


INSPIRE

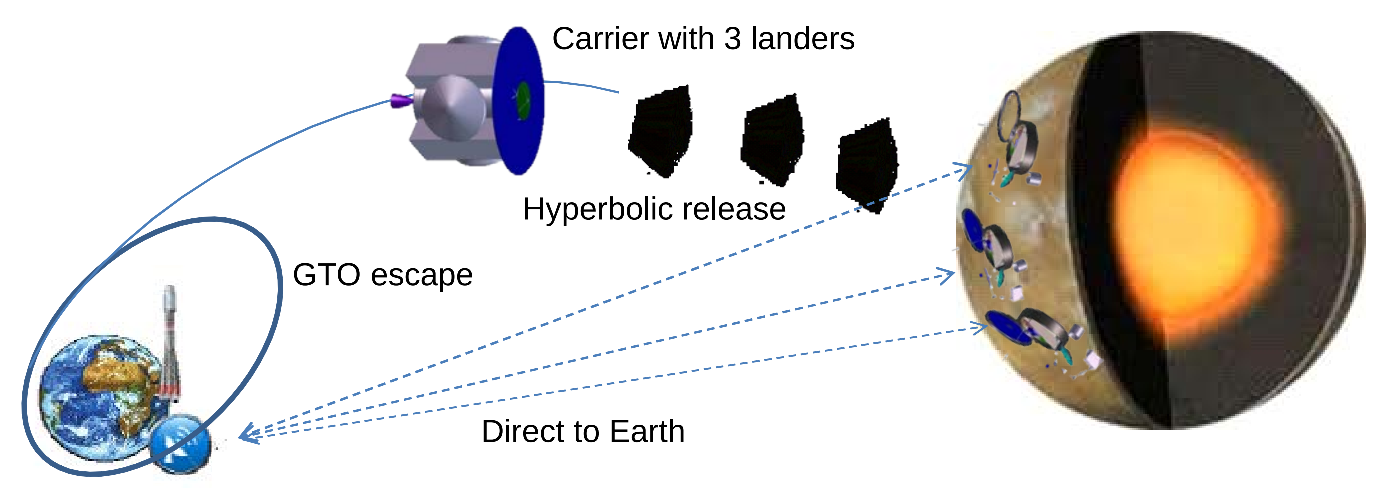
EREP

A network mission can address a broad range of scientific objectives:

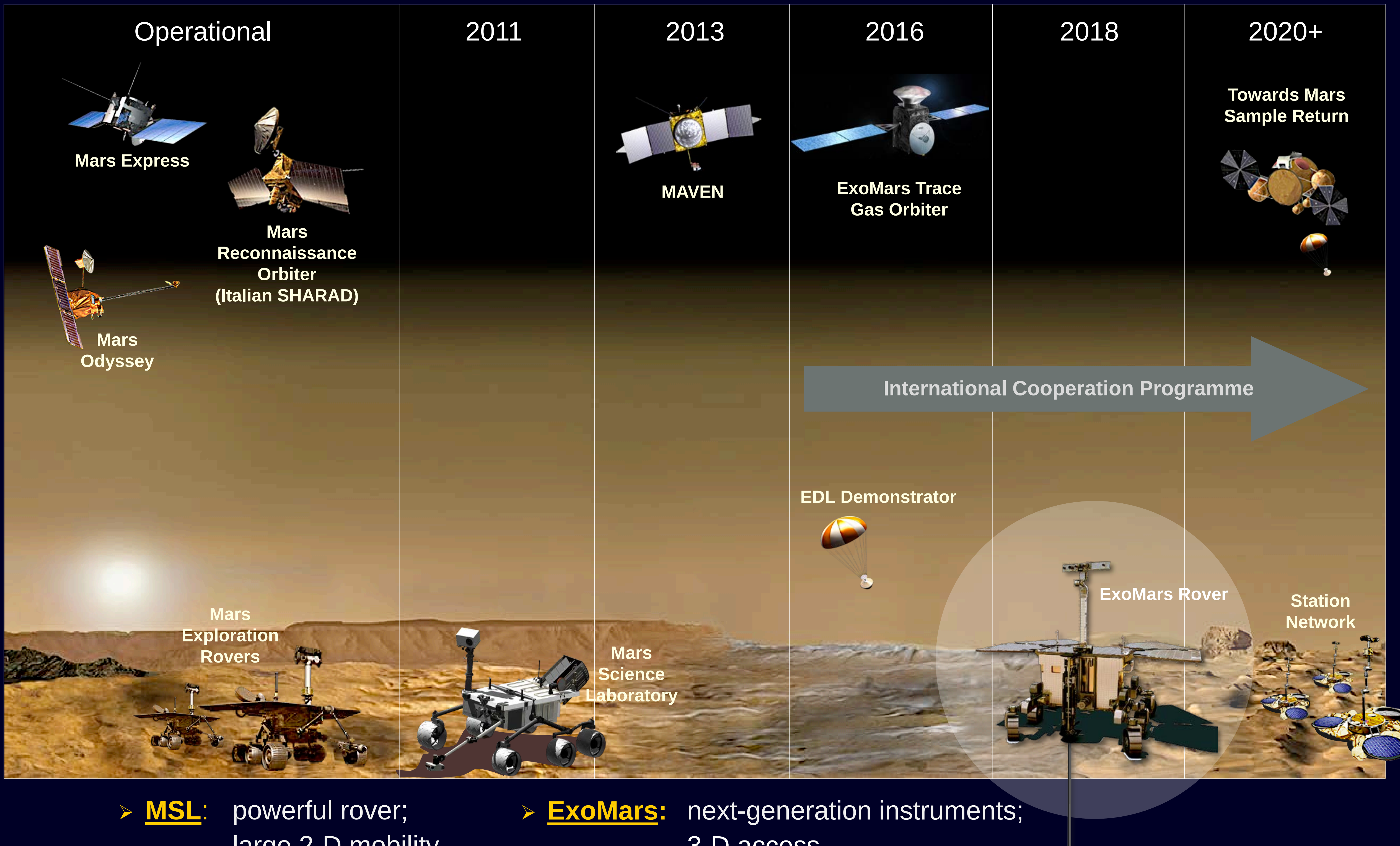
Network science objectives in blue.
In-Situ science goals in black.



- The Network concept has a long heritage, including ESA (Marsnet, Intermarsnet), NASA (MESUR), CNES Netlander, and FMI (MetNet).
- Simultaneous measurements from multiple locations (Network of science probes) enable unique opportunities to address key science issues (e.g. seismology, geodesy, meteorology).
- **Three stations, NO ORBITER NEEDED !**



International Context



- **MSL**: powerful rover; large 2-D mobility.
- **ExoMars**: next-generation instruments; 3-D access.

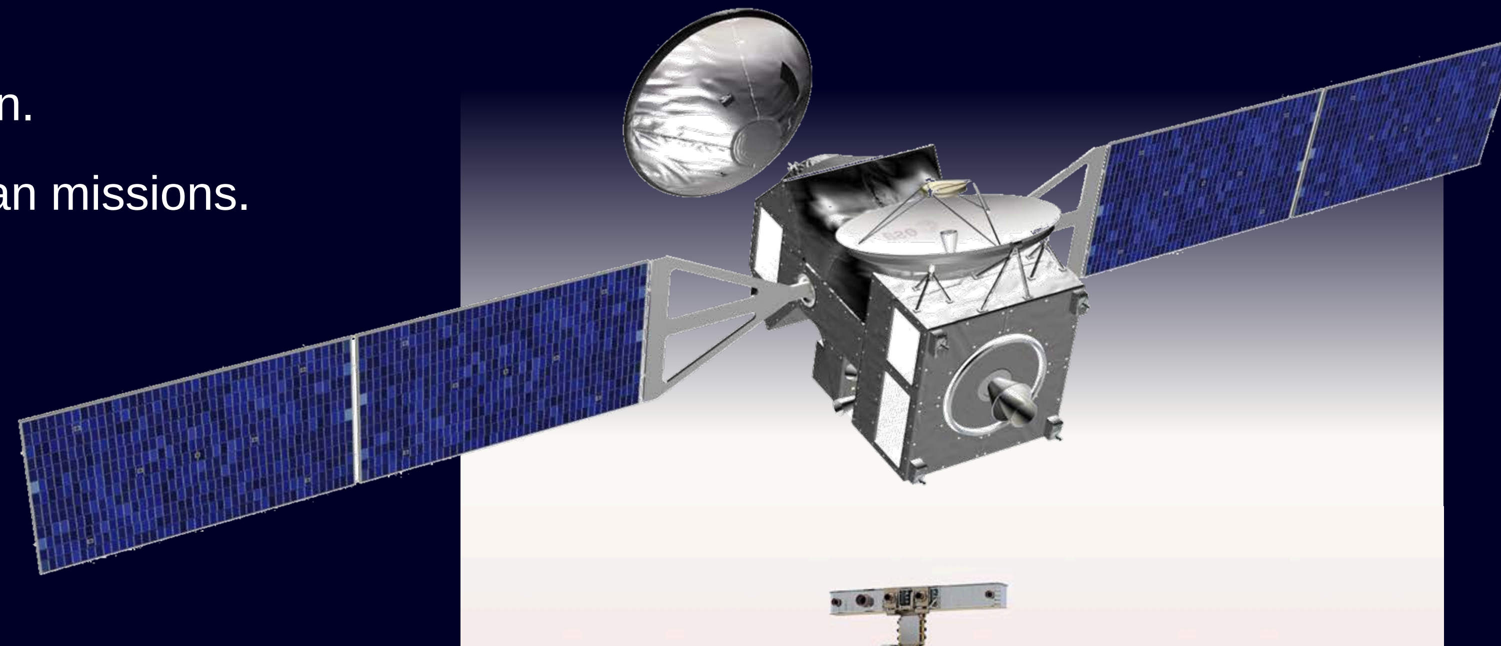
Following on the results of MSL, ExoMars is the logical next step in international Mars surface exploration.

➔ 2016: ExoMars Trace Gas Orbiter

Its science outcome will provide new insights into our understanding of Mars and of key atmospheric processes of potential astrobiological relevance.

An excellent base for international collaboration.

Master landing technologies for future European missions.



➔ 2018: ExoMars Rover

A great exobiology mission.

The first ever to combine mobility with access to the subsurface.

The rover's Pasteur payload contains next-generation instruments.

The rover will study, for the first time:

- Organics and biomarkers for past and present life at depth;
- Vertical characterisation of geochemistry and water.

New sample handling and locomotion technologies.

A step closer to Mars Sample Return.

Conclusions

➔ 2022 and 2024: <u>PHOOTPRINT & INSPIRE</u>

Missions with a strong scientific and technology content:

- Phobos sample return;
- Mars network.

New opportunities for international collaboration.

To be proposed at C-MIN 2012 for pre-development.

To be approved at C-MIN 2015 for implementation and launch.