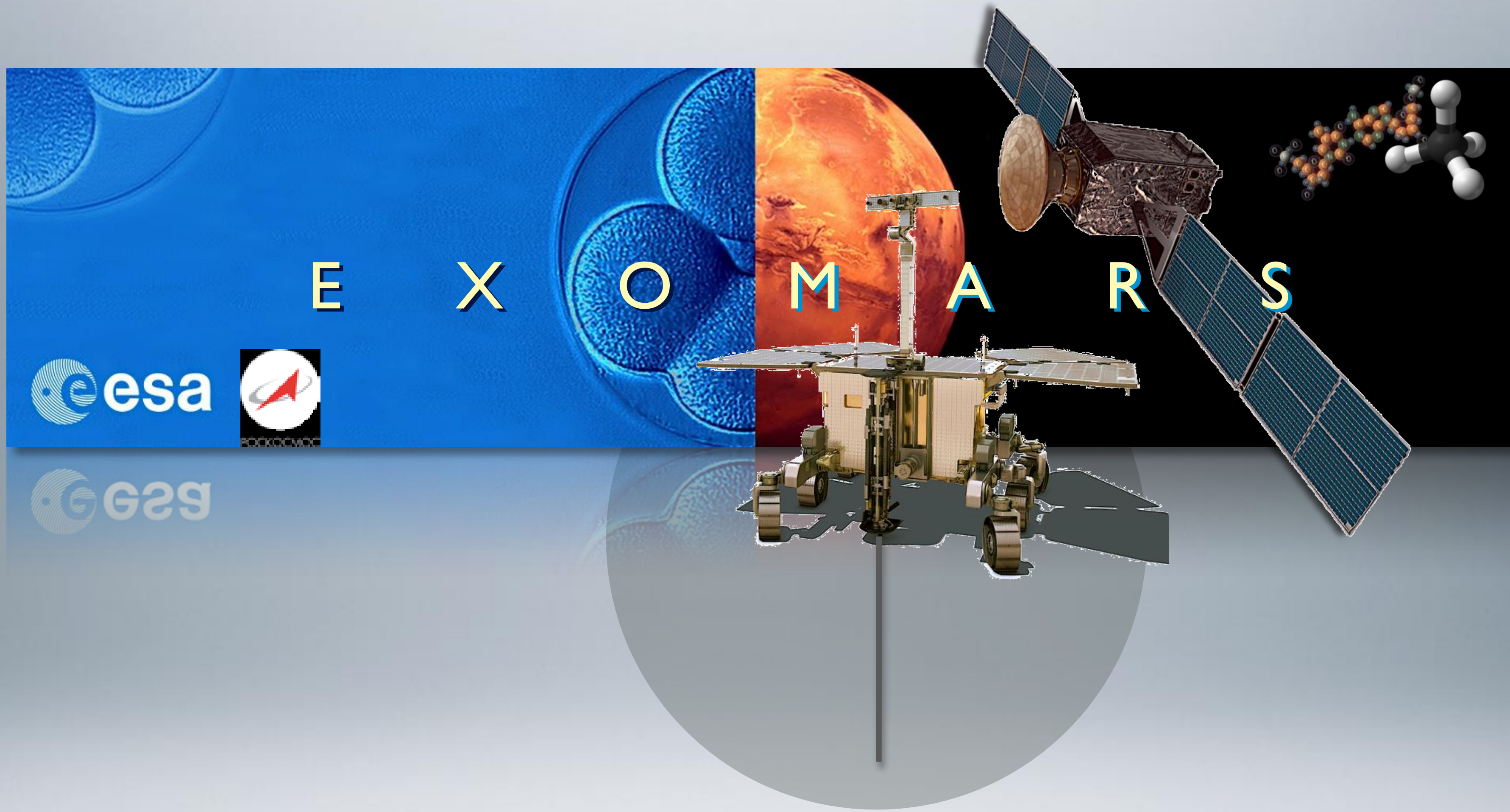


The ExoMars Programme

PHOOTPRINT

Scientific context

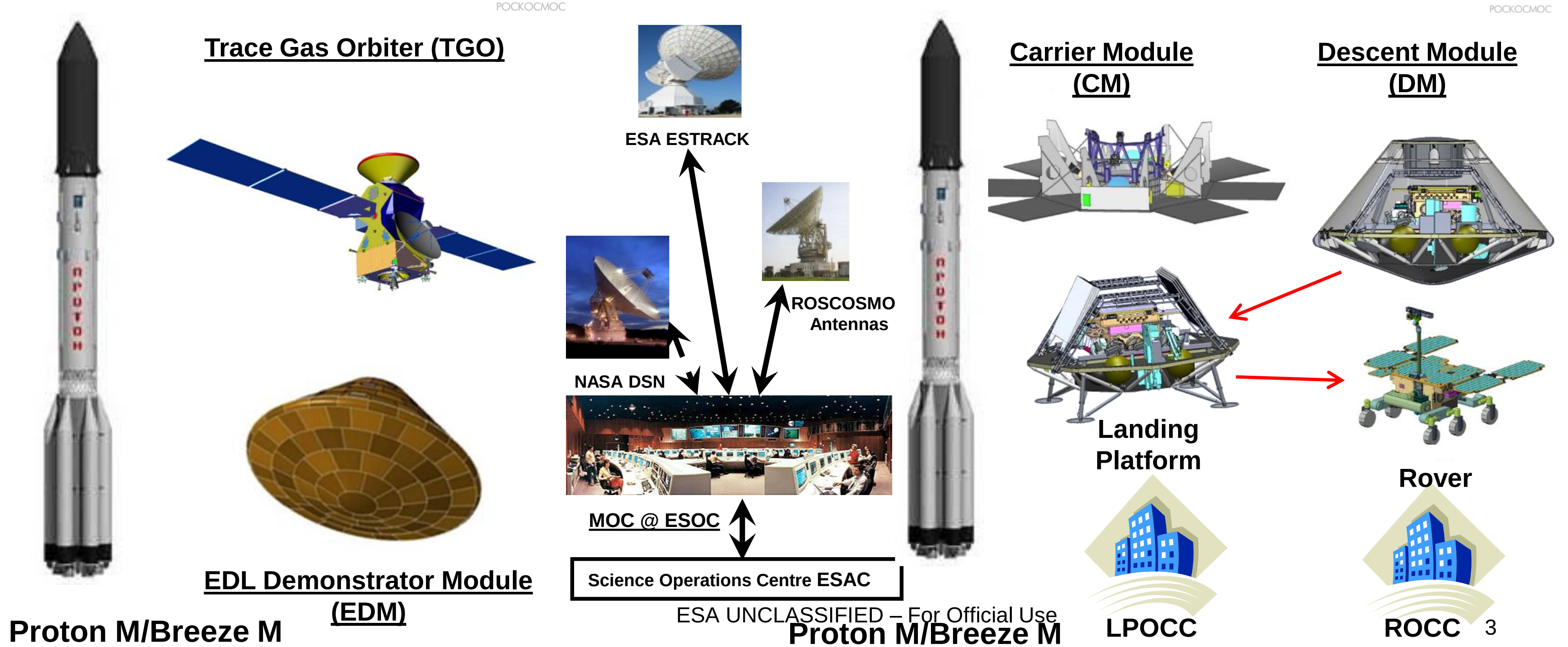
- A primitive Mars likely had an early evolution similar to that of Earth
- But without subsequent alterations due to tectonics or climate effects

If life emerged on early Mars, even if it disappeared, there may still be traces of past life and even of a prebiotic environment, much easier to find than in the case of Earth

ExoMars Programme

- ***Two missions launched in 2016 and 2018, respectively***
  - The 2016 flight segment consists of a **Trace Gas Orbiter (TGO)** and an **EDL Demonstrator Module (EDM) - Schiaparelli**
  - The 2018 flight segment consists of a **Carrier Module (CM)** and a **Descent Module (DM)** with a **Rover** and a stationary **Landing Platform**

2016 Mission — And — 2018 Mission



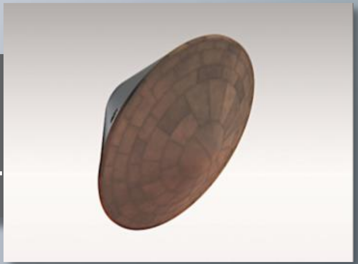
2016 Mission Objectives

EXOMARS

2016

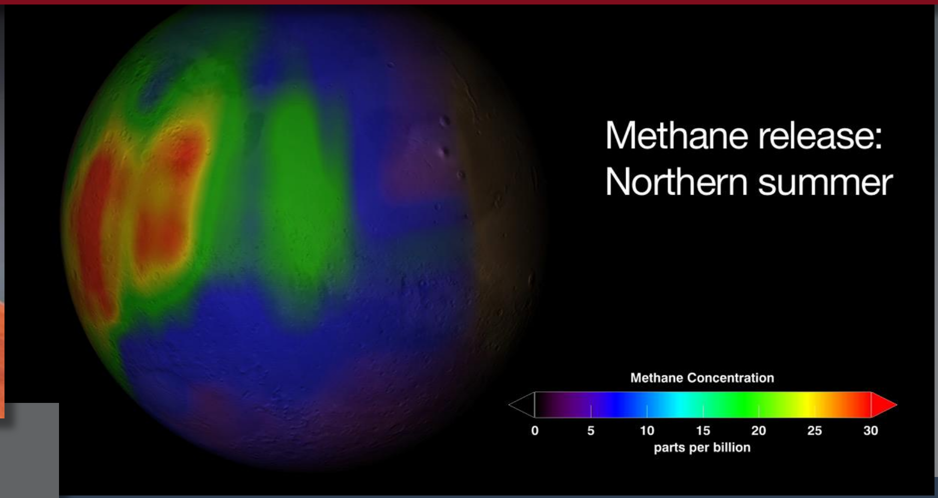
TECHNOLOGY OBJECTIVE

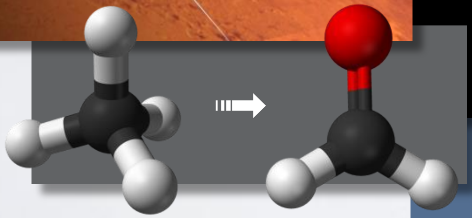
- Entry, Descent, and Landing (EDL) of a payload on the surface of Mars.



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.

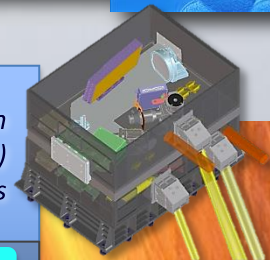
Trace Gas Orbiter

NOMAD

High-resolution occultation and nadir spectrometers

Atmospheric composition (CH_4, O_3, trace species, isotopes) dust, clouds, P&T profiles

UVIS (0.20 – 0.65 μm) λ/Δλ ~250	SO	Limb	Nadir
IR (2.3 – 3.8 μm) λ/Δλ ~10,000	SO	Limb	Nadir
IR (2.3 – 4.3 μm) λ/Δλ ~20,000	SO		



CaSSIS

High-resolution, stereo camera

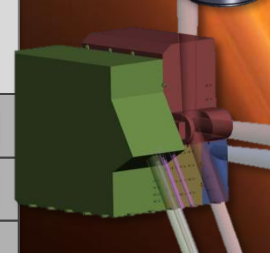
Mapping of sources
Landing site selection

ACS

Suite of 3 high-resolution spectrometers

Atmospheric chemistry, aerosols, surface T, structure

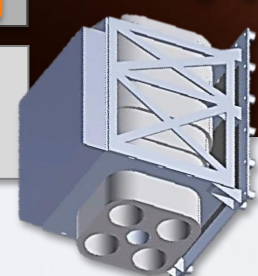
Near IR (0.7 – 1.7 μm) λ/Δλ ~20,000	SO	Limb	Nadir
IR (Fourier, 2 – 25 μm) λ/Δλ ~4000 (SO)/500 (N)	SO		Nadir
Mid IR (2.2 – 4.5 μm) λ/Δλ ~50,000	SO		

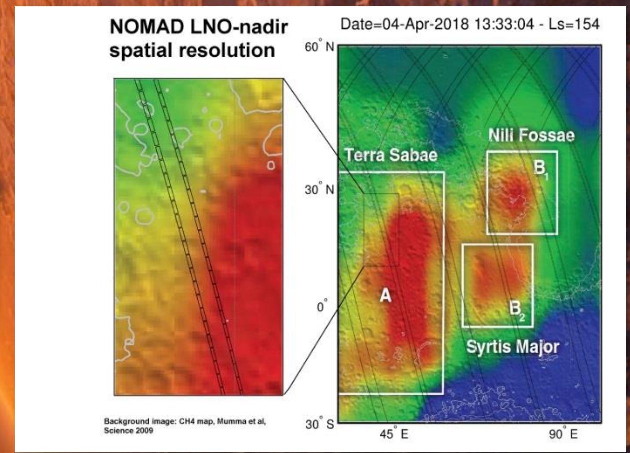


FREND

Collimated neutron detector

Mapping of subsurface water
And hydrated minerals

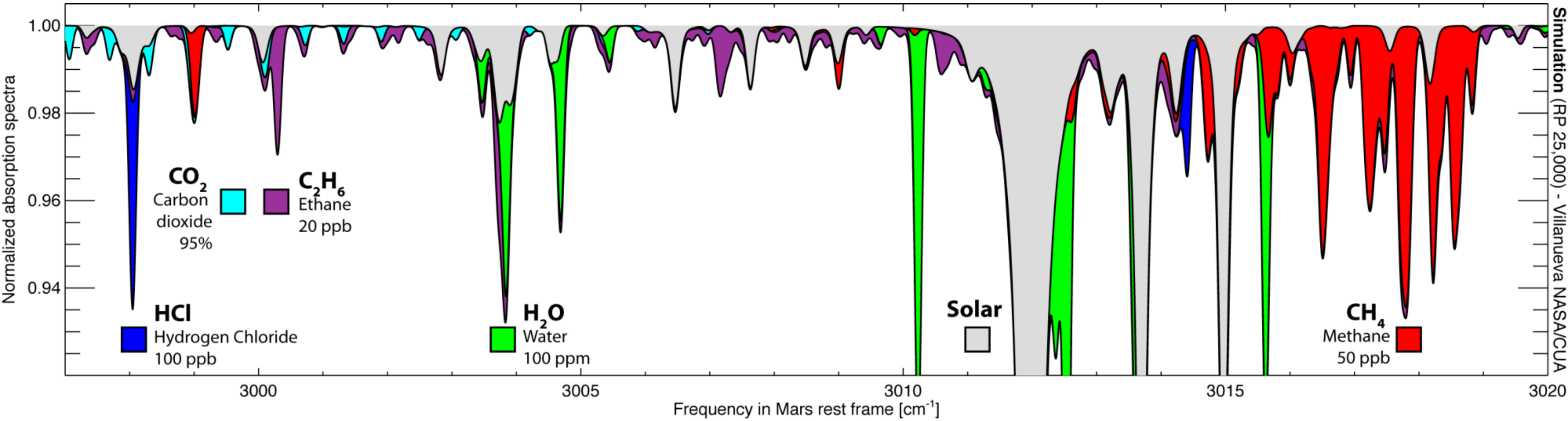




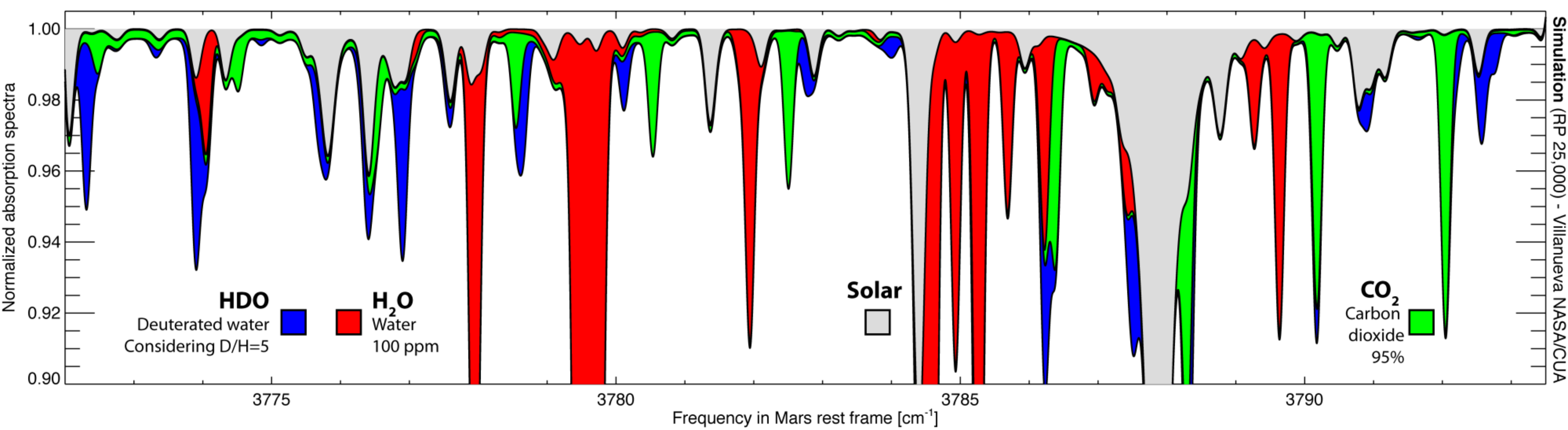
Credit: Kees Veenenbos

Trace species visible in the IR

"Hydrocarbons window" (CH_4, C_2H_6, CH_3OH, C_2H_4, etc.)



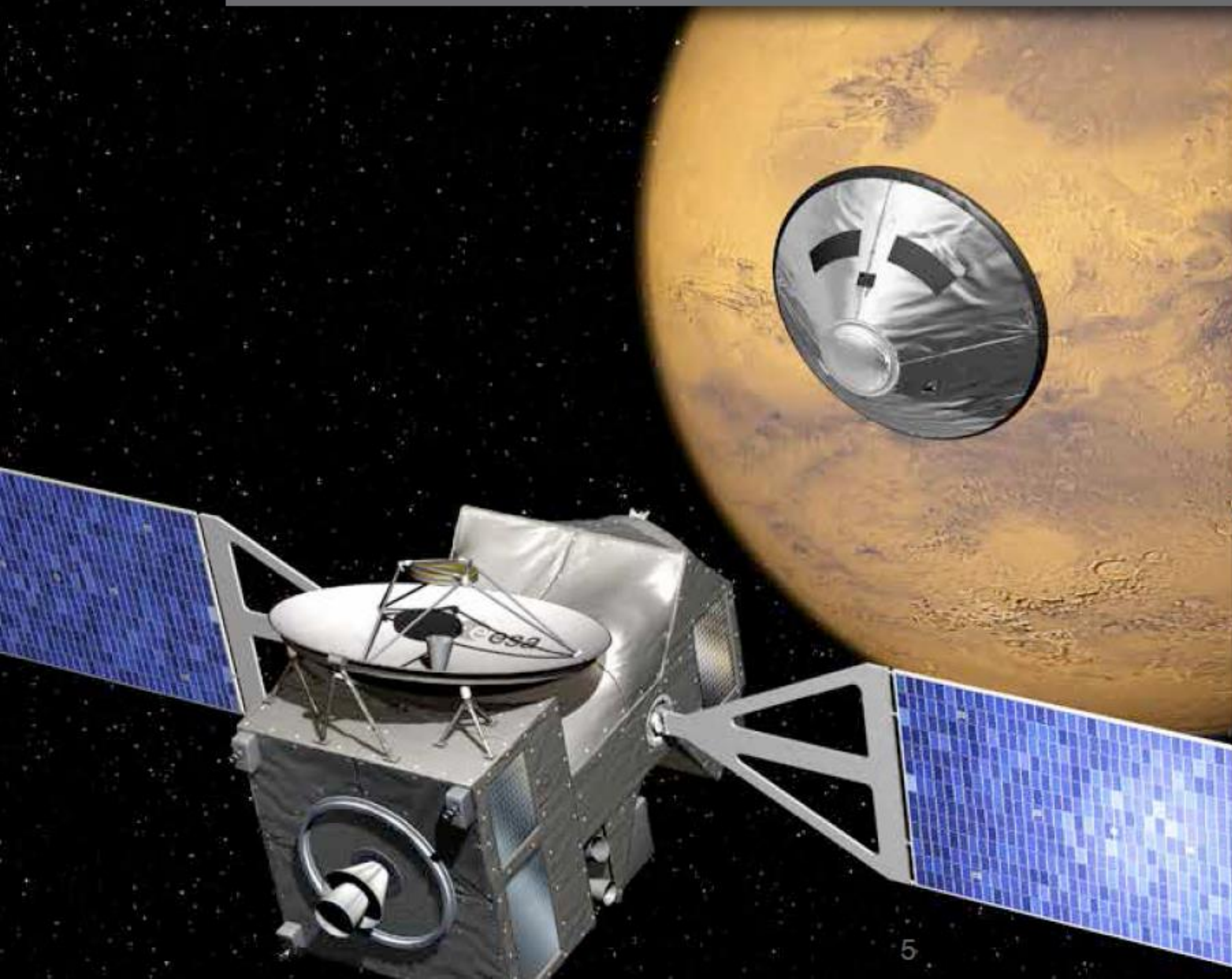
"Water D/H window"



EDL Demonstrator Module

EDM

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



EDM PAYLOAD

- Integrated mass: 5 kg;
- Surface lifetime: 4–8 sols;
- Measurements:
  - Descent science;
  - P, T, wind speed and direction;
  - Optical depth;
  - Atmospheric charging;
  - Descent camera.

esa

Launch

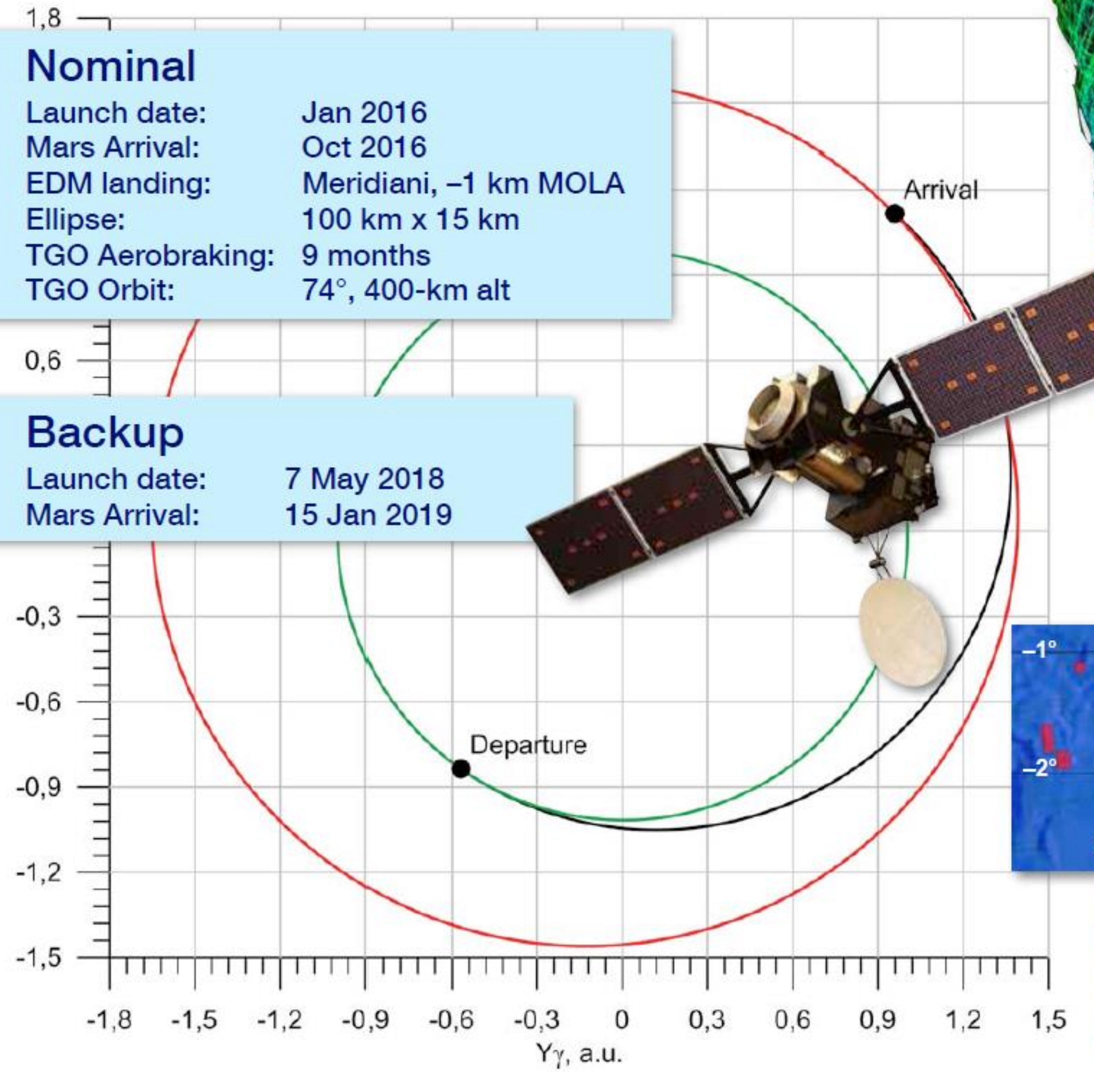
E X O M A R S

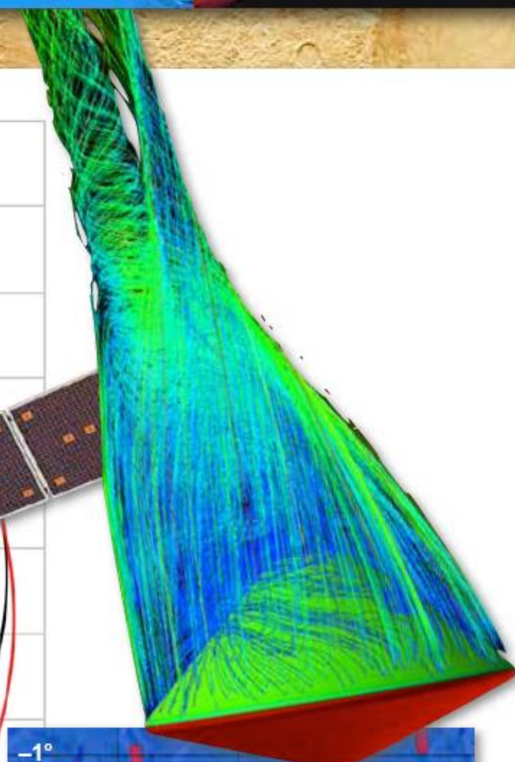
Nominal

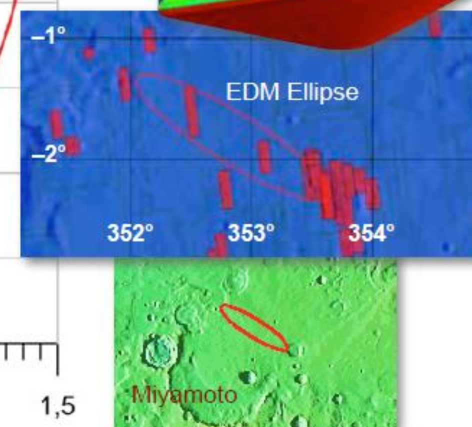
Launch date:	Jan 2016
Mars Arrival:	Oct 2016
EDM landing:	Meridiani, –1 km MOLA
Ellipse:	100 km x 15 km
TGO Aerobraking:	9 months
TGO Orbit:	74°, 400-km alt

Backup

Launch date:	7 May 2018
Mars Arrival:	15 Jan 2019







Credit: MEX/HRSC

2018 Mission Objectives

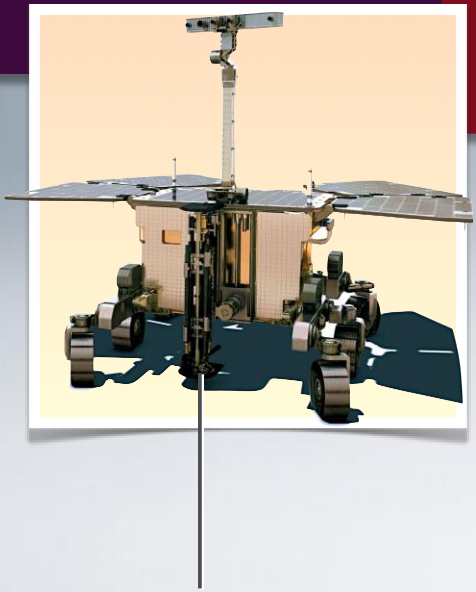
TECHNOLOGY OBJECTIVES

- 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.

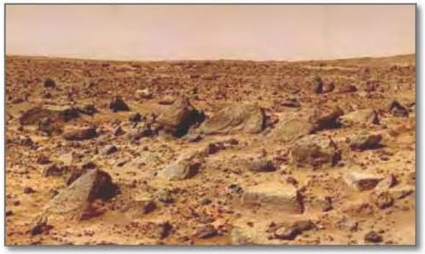


- To study the surface and subsurface environment.

Science Exploration Scenario

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**

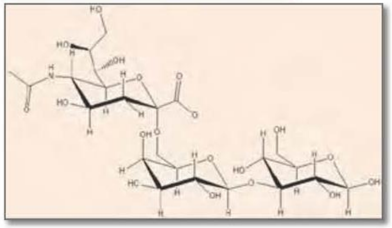


Collect a subsurface (or surface) sample

Study sample:

- Survey analysis
- Detailed analysis

Analytical Laboratory

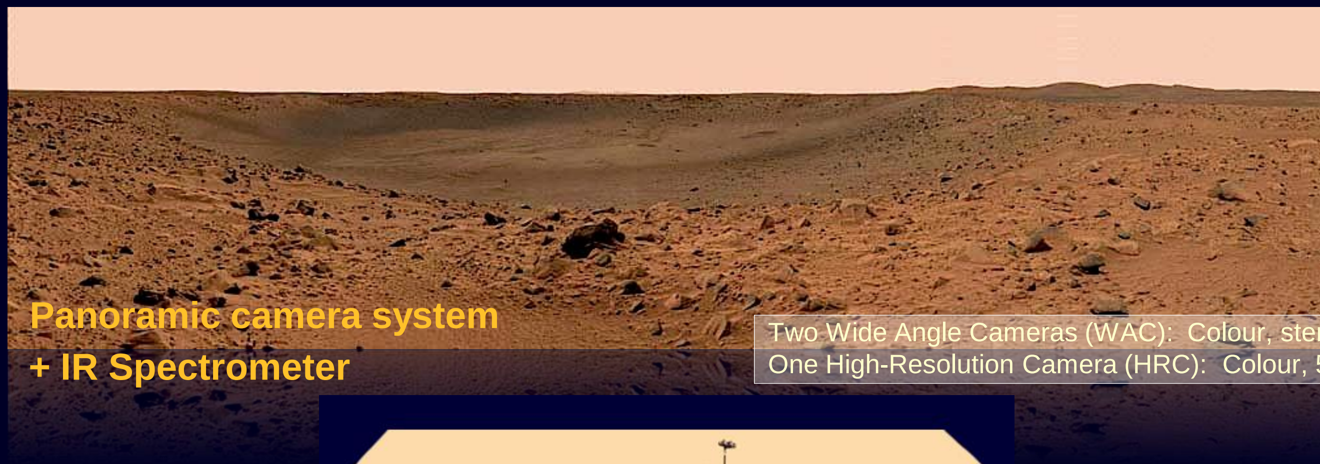


Scale

Site Characterisation

E X O M A R S

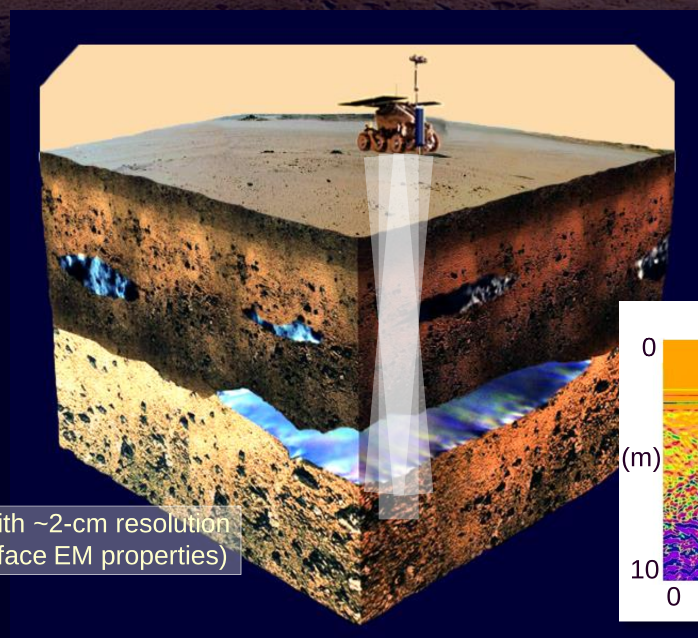
AT PANORAMIC SCALE: To establish the geological context



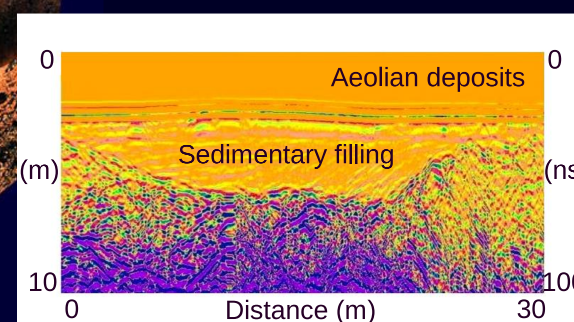
Panoramic camera system
+ IR Spectrometer

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

Ground-Penetrating Radar
+ Neutron Spectrometer

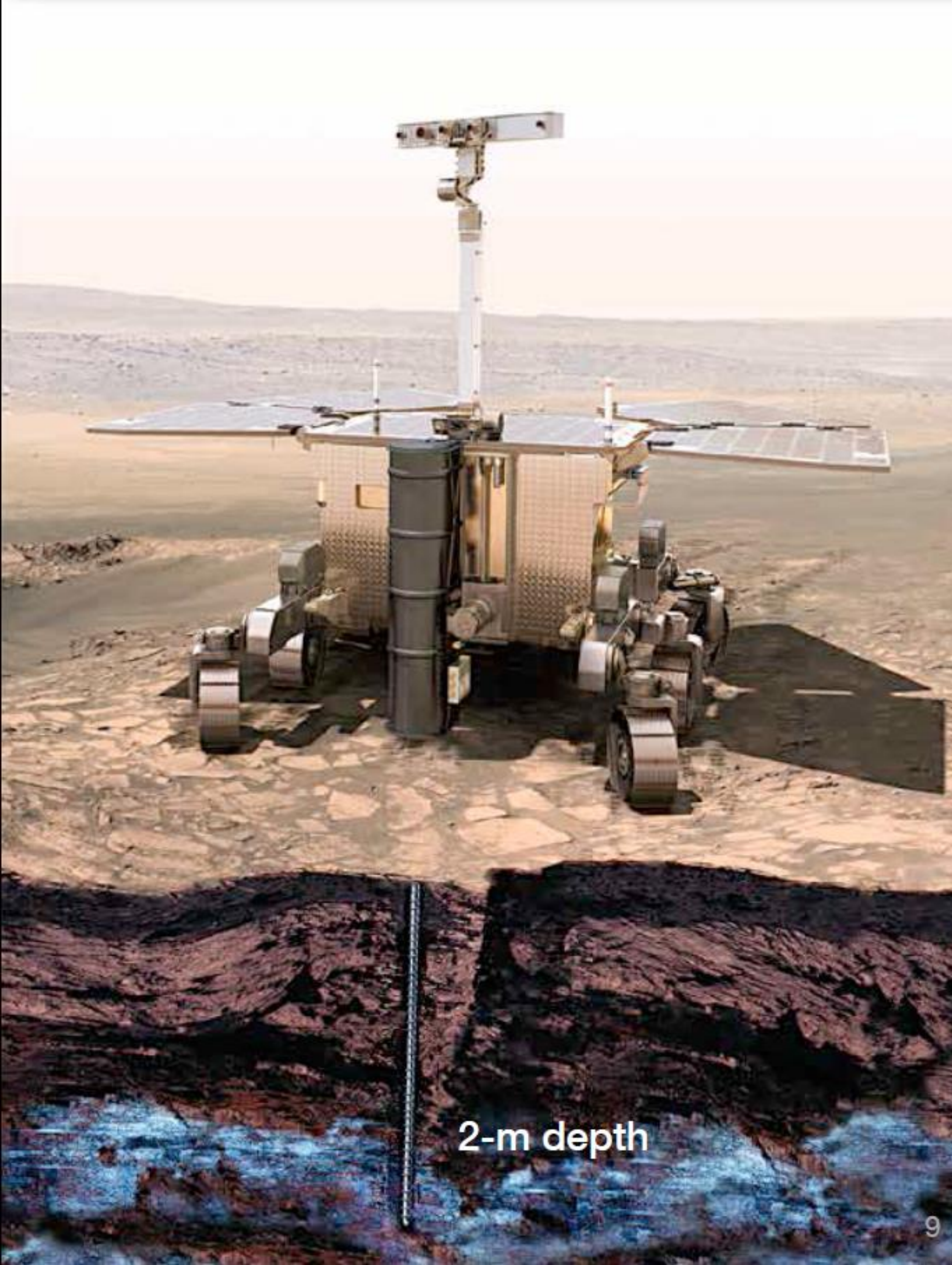


~3-m penetration, with ~2-cm resolution
(depends on subsurface EM properties)

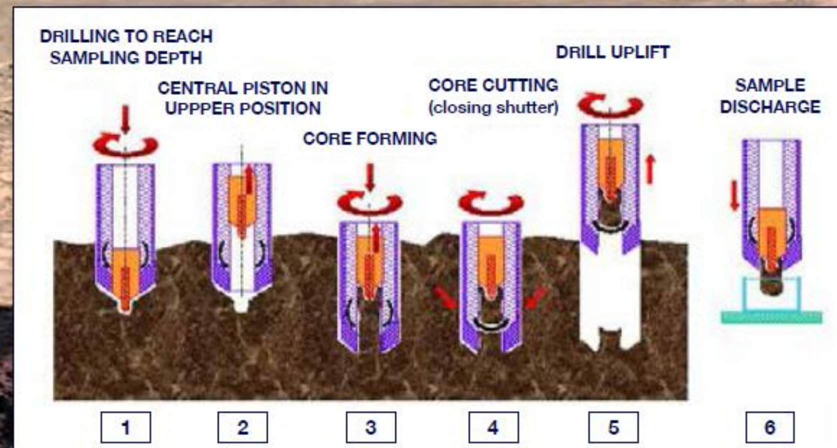


Heggy et al. 2007

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

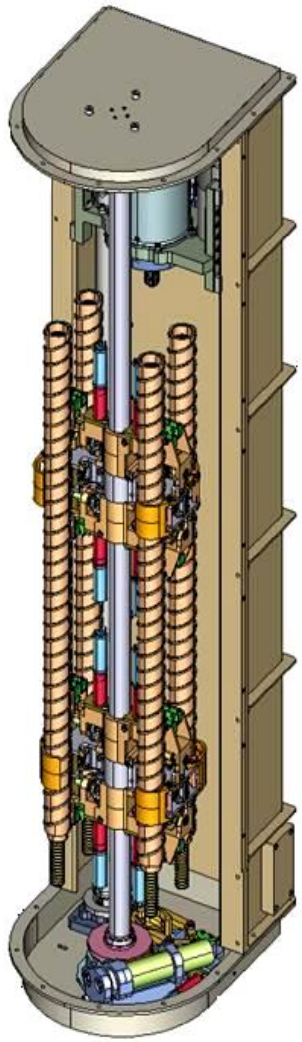


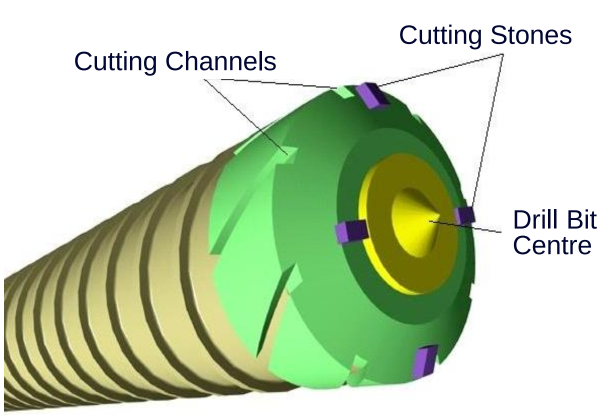
Credit: ESA/Medialab

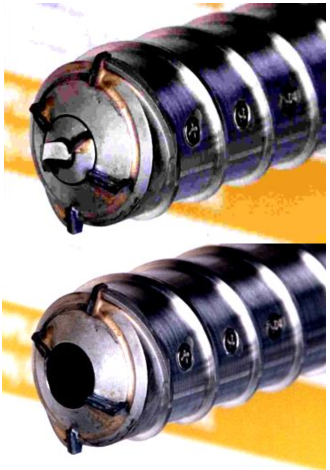
Subsurface Drill

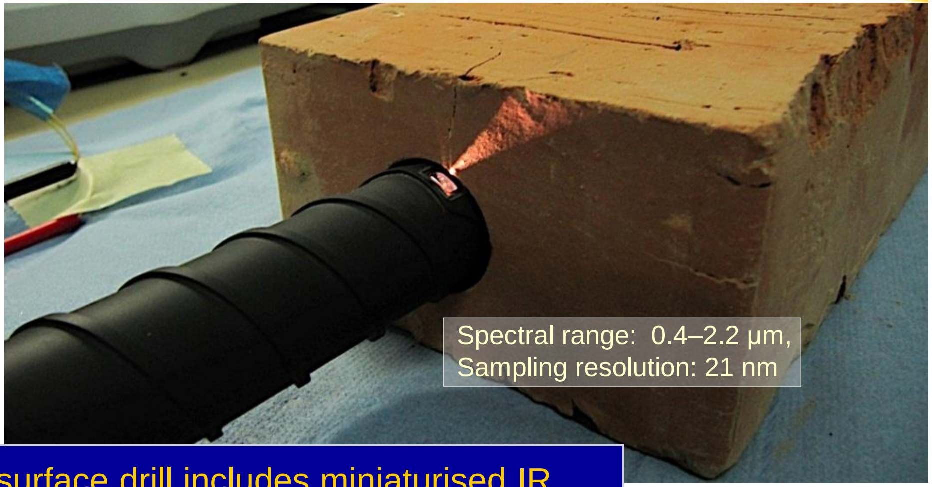
E X O M A R S

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



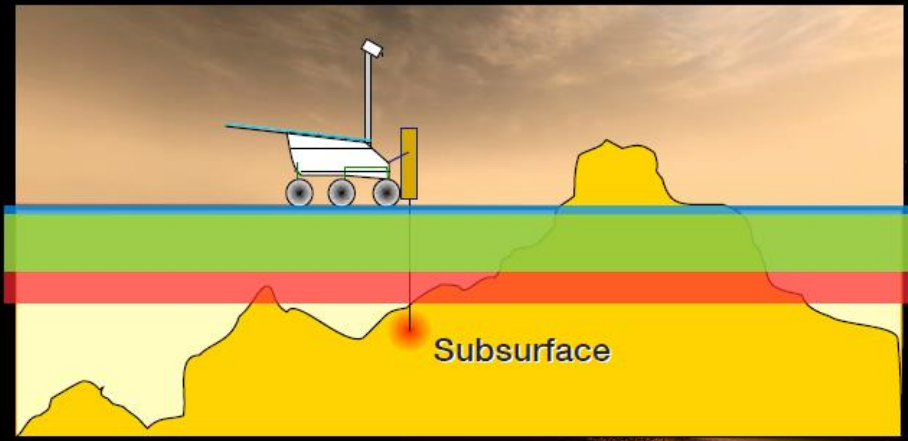






Subsurface drill includes miniaturised IR spectrometer for borehole investigations.

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 analyse them.

Pasteur Payload

E X O M A R S

PanCam
Wide-angle stereo camera pair
High-resolution camera

Geological context
Rover traverse planning
Atmospheric studies

WAC: 35° FOV, HRC: 5° FOV

ISEM
IR spectrometer on mast

Bulk mineralogy of outcrops
Target selection

λ = 1.15 – 3.3 µm, 1° FOV

CLUPI
Close-up imager

Geological deposition environment
Microtexture of rocks
Morphological biomarkers

20-µm resolution at 50-cm distance, focus: 20 cm to ∞

WISDOM
Ground-penetrating radar

Mapping of subsurface stratigraphy

3 – 5-m penetration, 2-cm resolution

FREND
Passive neutron detector

Mapping of subsurface
Water and hydrated minerals

Drill + Ma_MISS
IR borehole spectrometer

In-situ mineralogy information

λ = 0.4 – 2.2 µm

Analytical Laboratory Drawer

MicrOmega
VIS + IR Spectrometer

Mineralogical characterization of crushed sample material
Pointing for other instruments

λ = 0.9 – 3.5 µm, 256 x 256, 20-µm/pixel, 500 steps

RLS
Raman spectrometer

Geochemical composition
Detection of organic pigments

spectral shift range 200–3800 cm^{-1}, resolution ≤ 6 cm^{-1}

MOMA
LDMS + Pyr-Dev GCMS

Broad-range organic molecules at high sensitivity (ppb)
Chirality determination

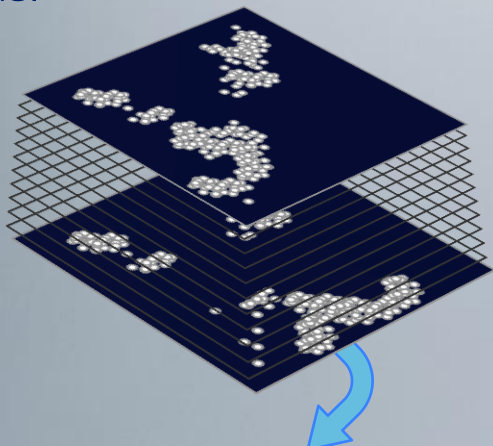
Laser-desorption extraction and mass spectroscopy

Pyrolisis extraction in the presence of derivatisation agents, coupled with chiral gas chromatography, and mass spectroscopy

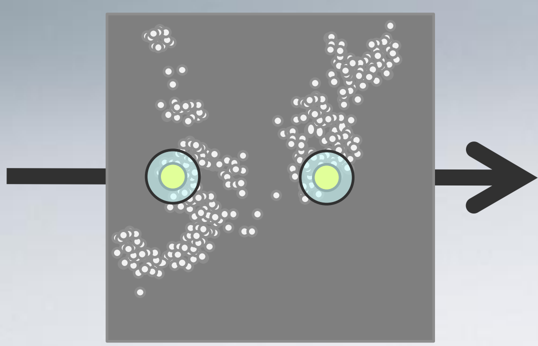
Sample Analysis

EXOMARS

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



e.g. search 1.9 μm + 2.3 μm bands



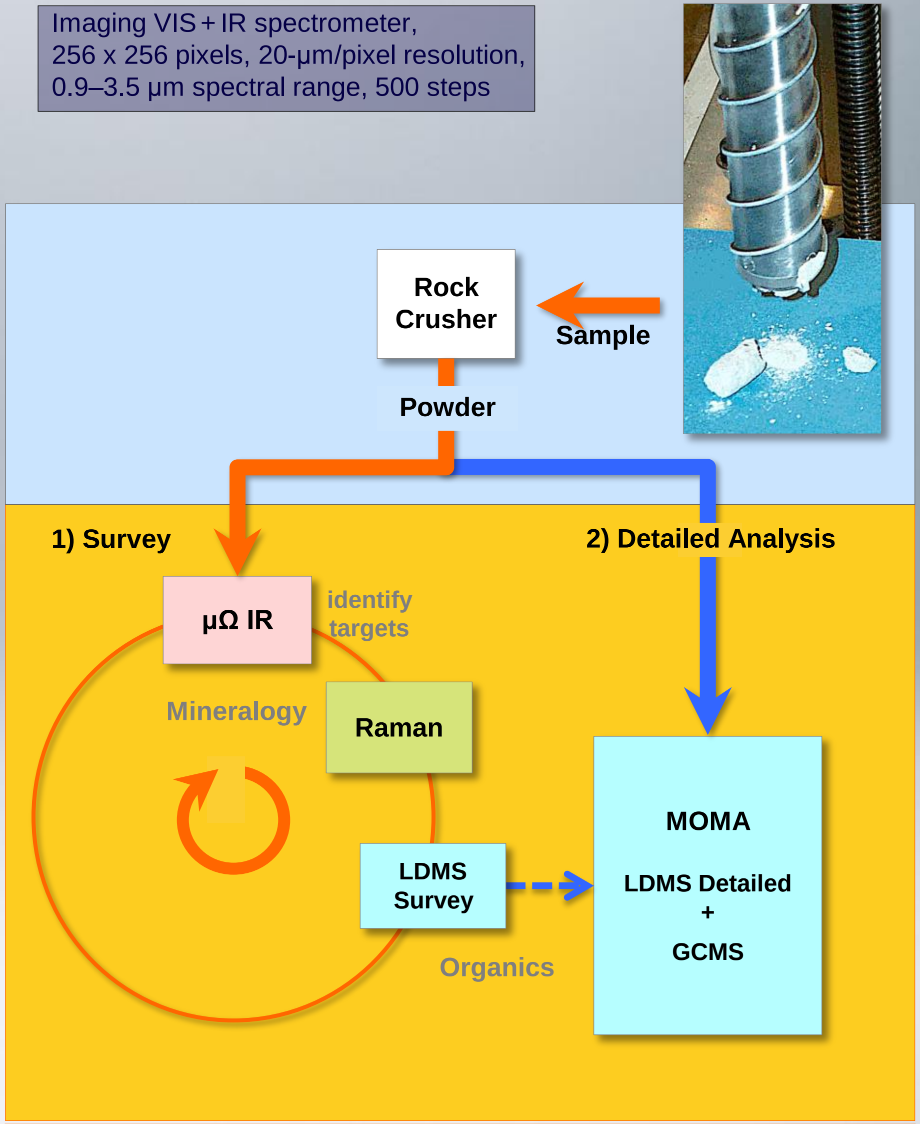
μΩIR = 20 μm

Raman = 50 μm

LDMS = 100 μm

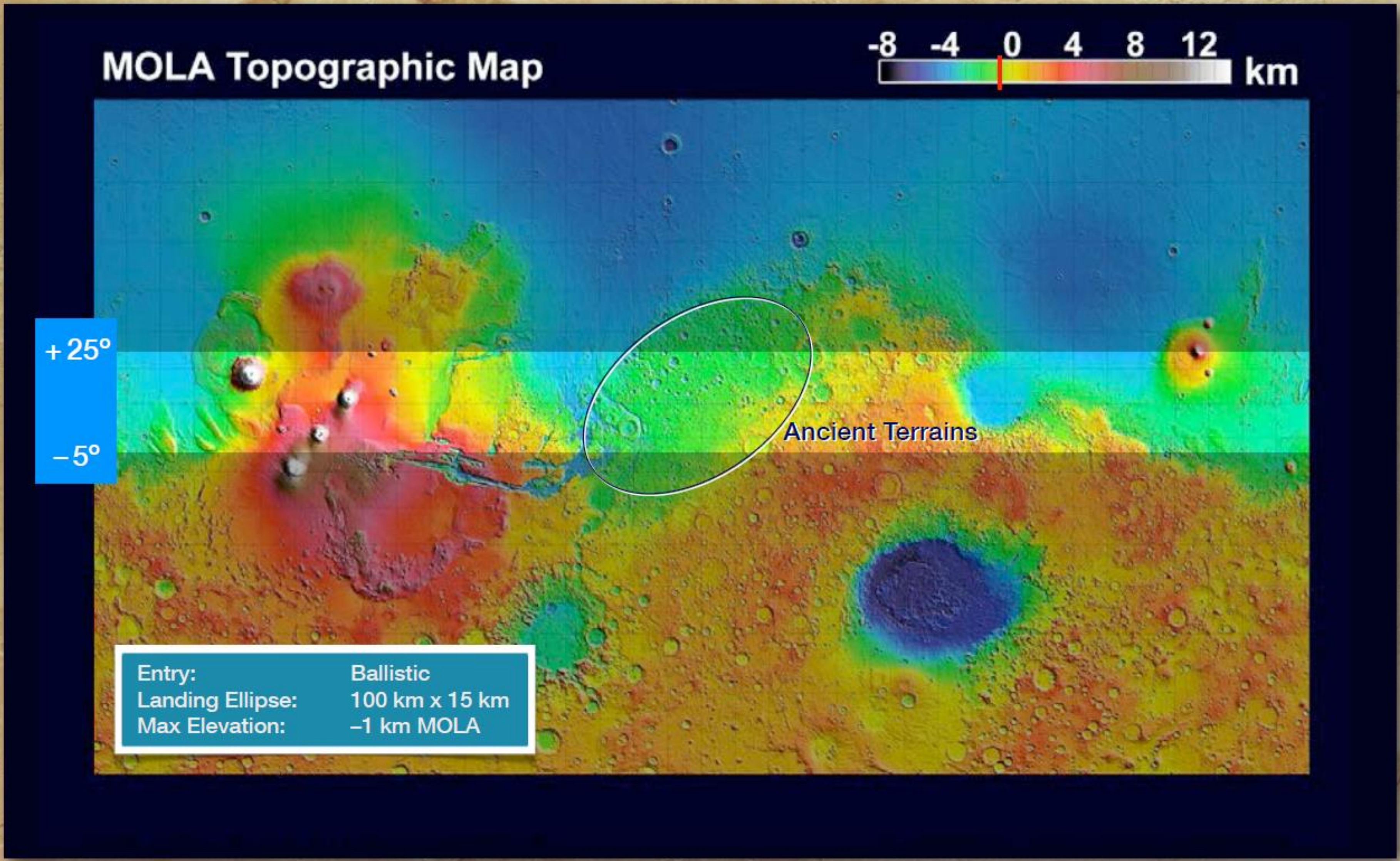
Raman: spectral shift range 200–3800 cm^{-1}
Spectral resolution ~6 cm^{-1}

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



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

Landing Latitudes



Credit: MEX/HRSC

Launch

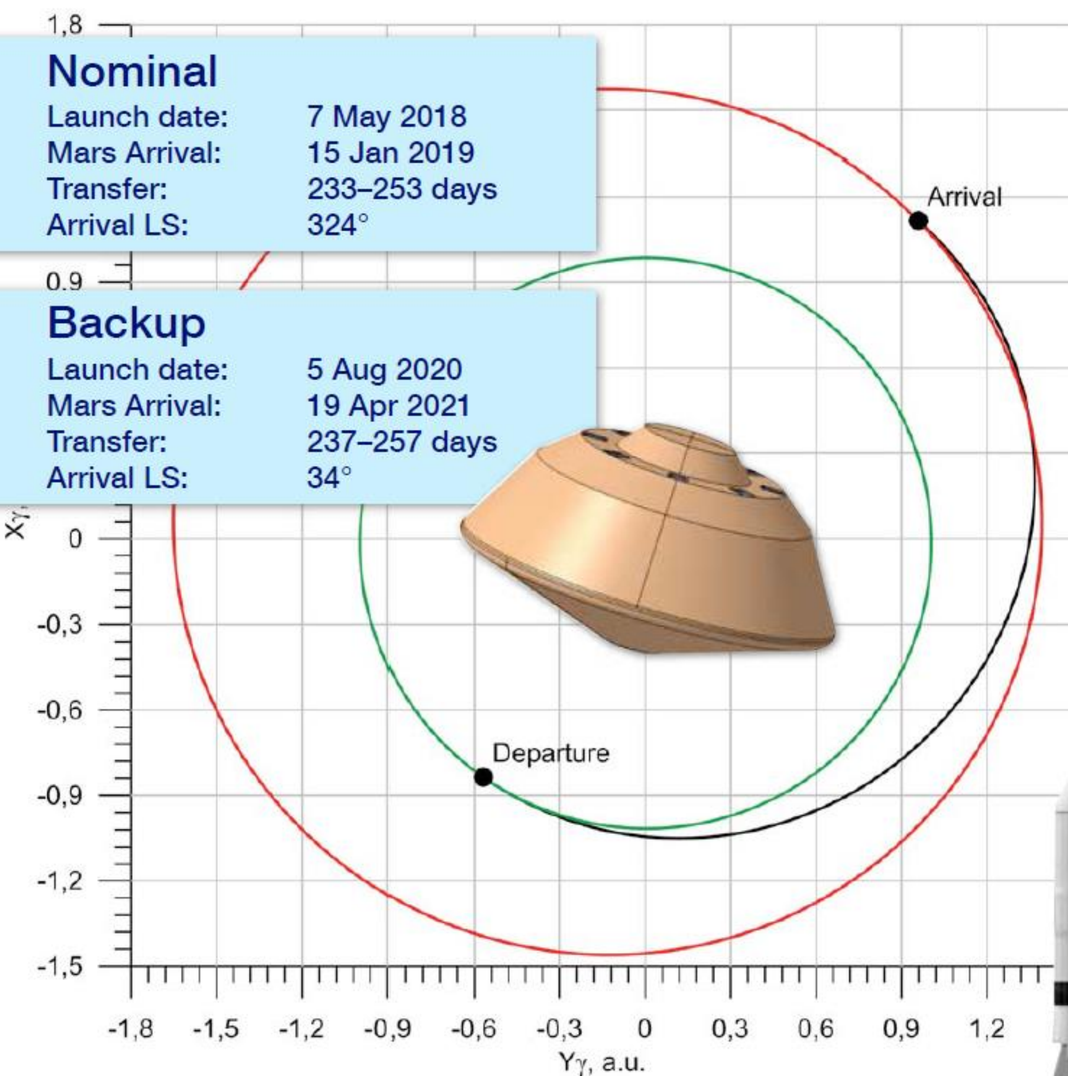
E X O M A R S

Nominal

Launch date:	7 May 2018
Mars Arrival:	15 Jan 2019
Transfer:	233–253 days
Arrival LS:	324°

Backup

Launch date:	5 Aug 2020
Mars Arrival:	19 Apr 2021
Transfer:	237–257 days
Arrival LS:	34°



Credit: MEX/HRSC

Conclusions ExoMars

➔ 2016: ExoMars TGO and EDM

- Science will improve understanding of Mars and of key atmospheric processes with astrobiological relevance
- Master landing technologies for future ESA missions

➔ 2018: ExoMars Rover

- Challenging Exobiology mission
- First to combine mobility and access to sub-surface
- Payload with next generation instruments
- First time study of organics and biomarkers in subsurface
- Big step towards Mars Sample Return mission