Search for Life on Mars
2020 Mission Objectives

**TECHNOLOGY OBJECTIVES**

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

**SCIENTIFIC OBJECTIVES**

› To search for signs of past and present life on Mars;
› To investigate the water/subsurface environment as a function of depth.

› To characterise the surface environment.

› Throttleable braking engines for planetary landing.
› Russian deep-space communications stations working in combination with ESA’s ESTRACK.
Launch

Launch date: 24 Jul – 13 Aug 2020
Mars Arrival: 19 Mar 2021
Landing Site: TBD, ~2 km MOLA
Ellipse: 120 km x 20 km
Carrier and Descent Module
Entry, Descent, and Landing
Surface Platform

HABIT
Habitability studies

LaRa
Coherent transponder
Radio science for internal structure investigations

MTK
Meteorological suite
T, P, wind, humidity, optical opacity

TSPP-EM
Multi camera system
Color surface panoramas
Atmospheric dynamics

BIP
Science interface computer
Commands instruments Collects data

MGAK
GCMS
Atmospheric Analysis

MAIGRET
Magnetometer
Magnetic field measurements

RAT-M
Microwave radiometer
Surface and atmospheric T monitoring

ADRON-EM
Neutron detector
Subsurface water content Radiation dosimetry

FAST
IR Fourier spectrometer
Trace gases T and aerosol monitoring

F
Dust properties and E field monitoring

PK
Surface and atmospheric T monitoring

RAT-M
Subsurface water content Radiation dosimetry

GS
Atmospheric chemical and isotopic composition

M-DLS
Diode laser spectrometer

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**Mobility + Subsurface Access**

- **Nominal mission:** 218 sols
- **Nominal science:** 6 Experiment Cycles + 2 Vertical Surveys
- **EC length:** 16–20 sols
- **Rover mass:** 300-kg class
- **Mobility range:** Several km

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**Drilling to Reach Sampling Depth**

1. **Central Piston in Upper Position**
2. **Core Cutting** (closing shutter)
3. **Core Forming**
4. **Drill Uplift**
5. **Sample Discharge**

**Layers:**
- **2-m depth**
- **UV light**
- **Oxidants**
- **Ionising Radiation**

Credit: ESA/Medialab

Credit: Argyre, MEX/HRSC
Site Characterisation

**AT PANORAMIC SCALE:** To establish the geological context

Two Wide Angle Cameras (WAC): Colour, stereo, 35° FOV;
One High-Resolution Camera (HRC): Colour, 5° FOV
One IR spectrometer (ISEM): 1° FOV.

**AT DEPTH:** To study the stratigraphy for drilling

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

Heggy et al. 2007
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
Close-Up Imager

Front imaging of outcrops, rocks, soils

Image collected samples

Side imaging

Image drilling area

Credit: Space Exploration Institute
OBTAIN SAMPLES FOR ANALYSIS: From 0 down to 2-m depth

Subsurface drill includes a miniaturised IR spectrometer for borehole investigations.
Sample Delivery

DRILL discharges sample into Core Sample Transport Mechanism (CSTM). PanCam HRC and CLUPI image the sample. Sample is delivered to Analytical Laboratory Drawer (ALD) — 15 min.
Ultra Clean Zone (UCZ)
Analytical Laboratory Drawer

Ultra Clean Zone (UCZ)
Analytical Laboratory Drawer

- Core Sample Transfer Mechanism (CSTM)
- Blank Dispenser
- Crushing Station (CS)
- Dosing Stations (DS)
- Flattening Device
- Alternative Transport Container (AC)
- Carrousel with MOMA ovens and Refillable Container (RC)
Analytical Laboratory Drawer
Rock Crushing Station
Powder Sample Dosing
Use mineralogical + image information from μΩ to identify targets for Raman and MOMA-LDMS.

Imaging VIS + IR spectrometer: 256 x 256 pixels, 20 μm/pixel resolution, 0.95–3.65 μm spectral range, 320 steps

Raman:  Spectral shift range 200–3800 cm\(^{-1}\)
Spectral resolution: 6 cm\(^{-1}\)

LDMS = Laser Desorption Mass Spectrometry
GCMS = Gas Chromatograph Mass Spectrometer
Characterisation of Organic Molecules

Broad identification range (50–1000 Da), including distribution, and chirality. High sensitivity (≤ 1 pmol/mol in TV-CGMS, ≤ 1 pmol/mol/mm² in LDMS). Resolution ≤ 1 Da over 50–500 Da range, ≤ 2 Da thereafter. Ability to perform MS-MS analysis on trapped fragments. LDMS mode appears not to be disturbed by perchlorates.

Credit: Mamers Valles, MEX/HRSC
## ExoMars Biosignature Score

### Morphological biosignatures: Σ points

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multilayer organosedimentary structures (e.g. stromatolites)</td>
<td>20</td>
</tr>
<tr>
<td>Other candidate biomediated textures (e.g. MISS)</td>
<td>10</td>
</tr>
<tr>
<td>Features suggestive of (fossil) microorganisms</td>
<td>20</td>
</tr>
</tbody>
</table>

### Result of first blank chemical check: (prior to beginning sample analysis)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>No organics, clean background</td>
<td>1.0–0.9</td>
</tr>
<tr>
<td><strong>OR</strong> Few, well known spacecraft organics in background</td>
<td>0.8–0.5</td>
</tr>
<tr>
<td><strong>OR</strong> Background heavily compromised by contamination</td>
<td>0.2–0.0</td>
</tr>
</tbody>
</table>

### Chemical biosignatures: Σ points

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</thead>
<tbody>
<tr>
<td>Detection of primary biomolecules or their degradation products</td>
<td>20</td>
</tr>
<tr>
<td>Enantiomeric excess (or other isomer selectivity)</td>
<td>30</td>
</tr>
<tr>
<td>Molecular weight clustering of organic compounds</td>
<td>20</td>
</tr>
<tr>
<td>Evidence of repeating constitutional subunits</td>
<td>20</td>
</tr>
<tr>
<td>Systematic isotopic ordering at molecular (group) level</td>
<td>20</td>
</tr>
<tr>
<td>Bulk isotopic fractionation</td>
<td>10</td>
</tr>
</tbody>
</table>

### Geological context: Σ points

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</tr>
</thead>
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<tr>
<td>Long-lived water or hydrothermal setting (morphology)</td>
<td>15–10</td>
</tr>
<tr>
<td>Long-lived water or hydrothermal setting (mineralogy)</td>
<td>15–10</td>
</tr>
</tbody>
</table>
ExoMars Rover Issue

- *Astrobiology*, June–July 2017
- Introduction paper describing the ExoMars rover science and mission.
- A dedicated paper for each of the nine instruments.
Candidate Landing Sites

Candidate landing sites:
- Oxia Planum
- Mawrth Vallis

- Oxia Planum
  - Elevation: ~10 m
  - Age: ~3.7 Ga

- Mawrth Vallis
  - Elevation: ~50 m
  - Age: ~3.8 Ga

- Aram Dorsum
  - Elevation: ~200 m
  - Age: ~4.0 Ga or more

Oldest terrains to be targeted

Credit: THEMIS/MOLA/Peter Grindrod
Candidate Landing Sites

Beginning of terrestrial planetary accretion: 4.568 Ga

Earliest preserved traces of life (Hadean):
- Earth: 3.5 Ga
- Mars: 3.7 Ga

Earliest heavy bombardment:
- Earth: 4.4 Ga
- Mars: 4.1 Ga

Start of conditions compatible with life:
- Earth: 3.9 Ga
- Mars: 3.5 Ga

Surface conditions become less habitable:
- Earth: 4.1 Ga
- Mars: 4.4 Ga

Candidate Landing Sites:
- Oxia Planum
- Mawrth Vallis

Clays

Credit: Kasei Valles, MEX/NRSC
Rover and Surface Platform
2020: ExoMars Rover and Surface Platform

- Travel back in time 4 billion years to explore the bottom of a Mars ocean.
- Drill deep to penetrate below the organics degradation horizon.
- Look for traces of life beyond Earth.
- Study the surface geology and environment.
- Obtain results that may make MSR and astronaut missions possible.