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DOCUMENT

ExoMars 2022 Mission
Brief description of the rover and surface platform

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Issue **1**
Revision **0**
Date of Issue **30 November 2020**

European Space Agency
Agence spatiale européenne

CHANGE LOG

Reason for change	Issue	Revision	Date
Original issue	1	0	30 Nov 2020

CHANGE RECORD

Issue 1	Revision 0		
Reason for change	Date	Pages	Paragraph(s)

Table of contents:

1 Introduction

This document presents a general description of the ExoMars 2022 mission; of its two major elements, the *Rosalind Franklin* rover and the *Kazachock* surface platform; and of their corresponding instruments and scientific investigations.

Additional information is available on the ESA exploration web site http://exploration.esa.int/mars/, on the IKI ExoMars web site http://exomars.cosmos.ru, and on a number of scientific publications referenced herein.

2 ExoMars Programme

The ExoMars programme is an international collaboration undertaken by ESA and Roscosmos—with NASA contributions—to develop and launch two missions.

The first ExoMars mission was launched on 14 March 2016 and arrived at the red planet on 19 October 2016. ExoMars 2016 included two elements: 1) the Trace Gas Orbiter (TGO), to study subsurface water and atmospheric trace gases with the goal to acquire information on possible on-going biological or hydrothermal processes; and 2) Schiaparelli, a European Entry, Descent, and Landing (EDL) demonstrator equipped to perform measurements during descent and on the martian surface. Schiaparelli was able to transmit much valuable information during EDL, but unfortunately the last phase of the sequence did not work and the lander crashed on the surface. After performing a series of atmospheric aerobraking passes lasting approximately one year, TGO reached its science orbit in early 2018 and is performing its science mission. TGO also provides data communication services for surface landers and rovers.

The second ExoMars mission will deliver two science elements to the martian surface (see Fig. 1): (1) *Kazachock*, a surface platform (SP) instrumented to perform environmental and geophysics measurements; and (2) *Rosalind Franklin,* a rover tasked with conducting a search for signs of life.

Fig. 1: Artist depiction of rover and surface platform. Credit: ESA/Mlabspace.

3 Launch, Cruise, and Landing

A Proton-M/Breeze-M will launch from Baikonur (KZH) and place the mission on a direct escape trajectory to Mars. The departure window for this flight opportunity opens on 21 September and extends until 1 October 2022 (12 days). All launch instances in this period result in the same arrival, with a touchdown on 10 June 2023 at 15:32 (UTC).

The spacecraft composite (SC) consists of a carrier module (CM) and a descent module (DM).

The CM must 1) execute all manoeuvres during the interplanetary transfer and 2) release the DM —in such way that it can reach the correct atmospheric entry interface point (EIP) with the appropriate entry flight path angle (FPA)— for landing at the required location in Oxia Planum, Mars. The CM will separate from the DM at 5,800 km altitude and will burn in the martian atmosphere.

The DM will coast for 30 minutes and reach the EIP at 120 km altitude traveling at 20,000 km/h. EDL will take six minutes (see Fig. 2). The DM will decelerate by atmospheric frictional drag, relying on the capsule's aerodynamic shape and heat shield, for approximately three minutes. A guidance navigation and control (GNC) algorithm will trigger the opening of the first, 16-m-diameter, supersonic parachute in the altitude range 8–10 km (speed Mach 2.0, ~1,700 km/h). A second, 35-m-diameter subsonic parachute will be deployed 20 s later, at an altitude of 4–6 km (speed Mach 0.6, ~540 km/h). 10 s later, at 3–5 km altitude (speed 230 km/h), the DM will let go of the front shield, deploy its legs, and perform a de-spin manoeuvre using its low-thrust engines. The DM will then turn on the radar altimeter (RDA). At 2 km altitude it will start to monitor the distance to ground and the vertical/horizontal velocity vector to perform terrain relative navigation. Approximately 1 km above the surface (speed 130 km/h), the lander will detach from back shell and parachute and go into free fall for about 1 s—this is done to increase the vertical separation with respect to rear jacket and parachute. The lander will then perform a sideways, collision-avoidance manoeuvre using its main engines (10 s duration). It will then carry out intensive braking during 7 s—the last 500 m—to touch down at a speed ≤ 7 km/h.

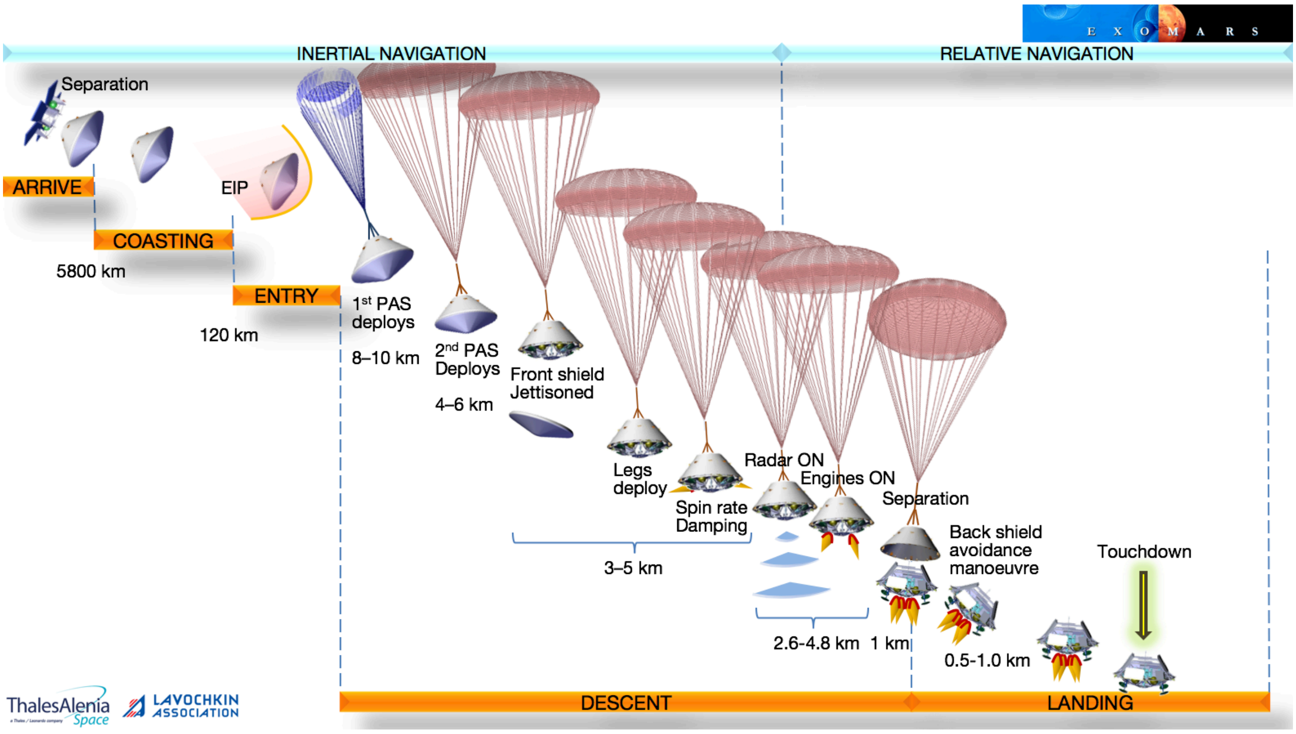


Fig. 2: Main stages of ExoMars 2020 EDL sequence. Credit: ESA/TAS-I/LAV.

Throughout the entire EDL sequence, the DM will transmit telemetry to NASA's Mars Reconnaissance Orbiter (MRO). After touchdown, the SP will deploy its descent ramps, solar panels, and communications antenna. The rover will then open its solar panels. TGO will perform the first telecommunications overflight shortly after landing to ascertain the status of the mission on the surface and recover data and images.

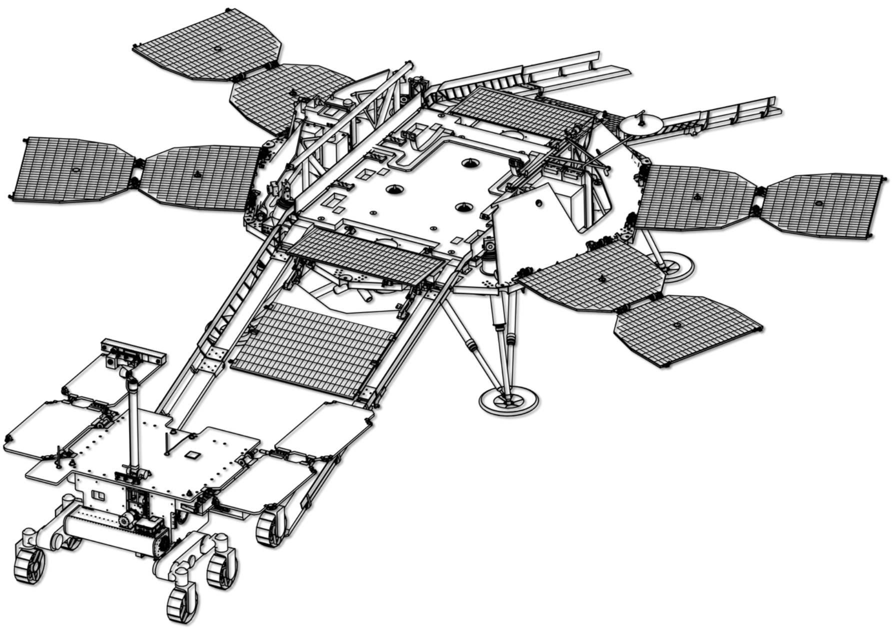
4 Surface Mission

The SP will conduct environment and geophysics investigations for a nominal period of one martian year. The large majority of the meteorological SP measurements will be periodic in nature, *e.g.* sample temperature and humidity at regular intervals throughout the day and seasons. Other measurements will be decided on the basis of opportunity and resources. SP investigations can be programmed several sols in advance.

The nominal duration of the rover search-for-signs-of-life mission is 218 sols. In contrast to the SP, rover operations require twice-daily interactions with ground control. This is because precise knowledge of yesterday's results (*e.g.,* rover final drive position) is needed to plan today's activities (*e.g.,* obtaining a sample for analysis). Typically, the rover will be instructed using a morning satellite overflight and report back on an evening telecommunications pass.

After landing, once the SP and rover status has been stabilised, the next important stage will be the descent of Rosalind Franklin onto the martian surface. We have budgeted 10 sols for this. The rover will remain in the vicinity of the SP for a few weeks. The rover and SP can image each other, assist with commissioning activities, and conduct proximity science measurements.

Once this proximity phase will have finished, the rover will drive off. Each surface element will then begin its individual mission.



5 The Surface Platform

Kazachock has thirteen instruments. Some include elements contributed by one or more institutes (see Table 1).

Table 1: ExoMars 2022 Surface Platform instruments

Instrument	Description
METEO M	Meteorological package PI: A. Lipatov (IKI, Russia)
METEO-P, METEO-H (part of METEO)	Pressure and humidity sensors PI: A.-M. Harri (Finnish Meteorological Institute, Finland)
RDM (part of METEO)	Radiation and dust sensors PI: I. Arruego (INTA, Spain)
AMR (part of METEO)	Anisotropic magneto-resistance sensor to measure magnetic fields Principal Investigator: M. Diaz Michelena (INTA, Spain)
MAIGRET	Magnetometer PI: A. Skalsky (IKI, Russia)
WAM (part of MAIGRET)	Wave analyser module PI: O. Santolik (Institute of Atmospheric Physics, Czech Republic)
TSPP	Set of cameras to characterise the landing site environment PI: I. Polyanskiy (IKI, Russia)
BIP	Instrument interface and memory unit PI: K. Anufreychik (IKI, Russia)
FAST	IR Fourier spectrometer to study the atmosphere PI: O. Korablev (IKI, Russia)
ADRON-EM	Active neutron spectrometer and dosimeter (can work in tandem with rover neutron detector) PI: I. Mitrofanov (IKI, Russia)
M-DLS	Multi-channel Diode-Laser Spectrometer for atmospheric investigations PI: I. Vinogradov (IKI, Russia)
PAT-M	Radio thermometer for soil temperatures (down to 1-m depth) PI: D. Skulachev (IKI, Russia)
Dust Suite	Dust particle size, impact, and atmospheric charging instrument suite PI: A. Zakharov (IKI, Russia)

SEM	Seismometer PI: A. Manukin (IKI, Russia)
MGAP	Gas chromatography-mass spectrometry for atmospheric analysis PI: M. Gerasimov (IKI, Russia)
LaRa	Lander radio-science experiment PI: V. Dehant (Royal Observatory Belgium)
HABIT	Habitability, brine irradiation and temperature package PI: F. J. Martin-Torres (Luleå University of Technology, Sweden)

Abbreviations: PI, principal investigator.

6 The Rover

It is probable that chemical biosignatures that would quickly degrade on Earth may last much, much longer on Mars if trapped sufficiently deep in the cold subsurface. To improve the likelihood of collecting and analysing well-preserved samples, the ExoMars *Rosalind Franklin* rover includes a 2-m drill and a powerful set of nine instruments known as the *Pasteur* payload (see Table 2).

Table 2: ExoMars 2022 Rover instruments

Instrument	Description
PanCam	Panoramic camera system PI: A. J. Coates (MSSL, United Kingdom) Co-PI (high-resolution camera): N. Schmitz (DLR Berlin, Germany) Co-PI (Wide-angle cameras): J. L. Josset (Inst. for Space Exploration, Switzerland)
ISEM	Infrared spectrometer on mast PI: O. Korablev (IKI, Russia)
WISDOM	Ground penetrating radar for subsurface stratigraphy and drilling operations PI: V. Ciarletti (LATMOS, France) Co-PI: S.-E. Hamran (FFI, Norway) Co-PI: Dirk Plettemeier (TU-Dresden, Germany)
ADRON	Neutron detector for characterising subsurface hydration PI: I. Mitrofanov (IKI, Russia)
CLUPI	Close-up imager for rock and soil investigations PI: J. L. Josset (Inst. for Space Exploration, Switzerland) Co-PI: F. Westall (Centre de Byophisique Moléculaire, France) Co-PI: B. Hofmann (Natural History Museum Bern, Switzerland)

Ma_MISS	Infrared spectrometer in drill for subsurface mineralogy PI: M. C. De Sanctis (INAF-IASF, Italy) Co-PI: F. Altieri (INAF-IASF, Italy)
MicrOmega	A visible plus infrared spectrometer in the analytical laboratory, for mineralogy studies of collected sample material PI: J.-P. Bibring (Institut d'Astrophysique Spatial, France)
RLS	Raman spectrometer in the analytical laboratory, to study mineralogical composition and identify organic pigments PI: F. Rull (Universidad de Valladolid, Spain) Co-PI: S. Maurice (LAOMP, France)
MOMA	Combined, laser desorption-mass spectrometer and gas chromatographer-mass spectrometer for studying organic molecules, seeking those having potential biological significance PI: F. Goesmann (Max-Plack Inst for Solar System Research, Germany) Co-PI: F. Raulin (Université Paris 12 and 7, France) Co-PI: W. Brinckerhoff (NASA Goddard Space Flight Center, United States)

The rover mission and instruments are described in the following open access publications:

Mission: (Vago *et al.*, 2017)
PanCam: (Coates *et al.*, 2017)
ISEM: (Korablev *et al.*, 2017)
WISDOM: (Ciarletti *et al.*, 2017)
ADRON: (Mitrofanov *et al.*, 2017)
CLUPI: (Josset *et al.*, 2017)
Ma_MISS: (De Sanctis *et al.*, 2017)
MicrOmega: (Bibring *et al.*, 2017)
RLS: (Rull *et al.*, 2017)
MOMA: (Goesmann *et al.*, 2017)

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Ciarletti, V. *et al.* (2017) 'The WISDOM Radar: Unveiling the Subsurface Beneath the ExoMars Rover and Identifying the Best Locations for Drilling', *Astrobiology*, 17(6–7), pp. 565–584. doi: 10.1089/ast.2016.1532.

Coates, A. J. *et al.* (2017) 'The PanCam Instrument for the ExoMars Rover', *Astrobiology*, 17(6–7), pp. 511–541. doi: 10.1089/ast.2016.1548.

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De Sanctis, M. C. *et al.* (2017) 'Ma_MISS on ExoMars: Mineralogical Characterization of the Martian Subsurface', *Astrobiology*, 17(6–7), pp. 612–620. doi: 10.1089/ast.2016.1541.

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