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ExoMars 2018 Surface Platform Experiment Proposal Information Package

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Change Log

Date	Ver	Description	Signature
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28.03.2014	0/2	ExoMars overview added and minor corrections	D.Rodionov
17.12.2014	0/3	Scope corrections	D.Rodionov
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31.03.2015	1/0	Clean version for release	D.Rodionov

1. DOCUMENT SCOPE

The Experiment Proposal Information Package (E-PIP) defines technical, managerial and programmatic data relevant in the context of the Announcement of Opportunity (AO) for European payload elements on the Surface Platform (SP) of the ExoMars 2018 mission.

The ExoMars 2018 mission is a joint mission between ESA and Roscosmos. The SP science payload development is the responsibility of Roscosmos, with the exception of the contributions selected through this call.

Roscosmos has named the Space Research Institute of Russian Academy of Sciences (IKI) to be the leading entity for the development of the SP scientific payload, with the exception of the contributions selected through this call. IKI will manage the development of the SP payload according to Russian standards.

Since the Descent Module (DM) development is in progress, all technical and schedule information can be changed during later project stages.

2. DOCUMENT STRUCTURE

Chapter 3 provides essential information about the ExoMars 2018 Surface Platform, it's mission, and about all issues related to the potential instrument payload.

Chapter 4 includes relevant information having a direct impact on the technical accommodation of the proposed instruments on the ExoMars 2018 Surface Platform.

Chapter 5 deals with management issues.

3. EXOMARS 2018 MISSION

The ExoMars 2018 mission will deliver the ExoMars Rover and a Surface Platform (SP) to the surface of Mars. The rover will search for signs of life, past and present. It will have the capability to drill to depths of 2 m to collect and analyse samples that have been shielded from the harsh conditions prevailing on the surface, where radiation and oxidants can destroy organic materials. The SP will be equipped with instruments to study the Martian environment.

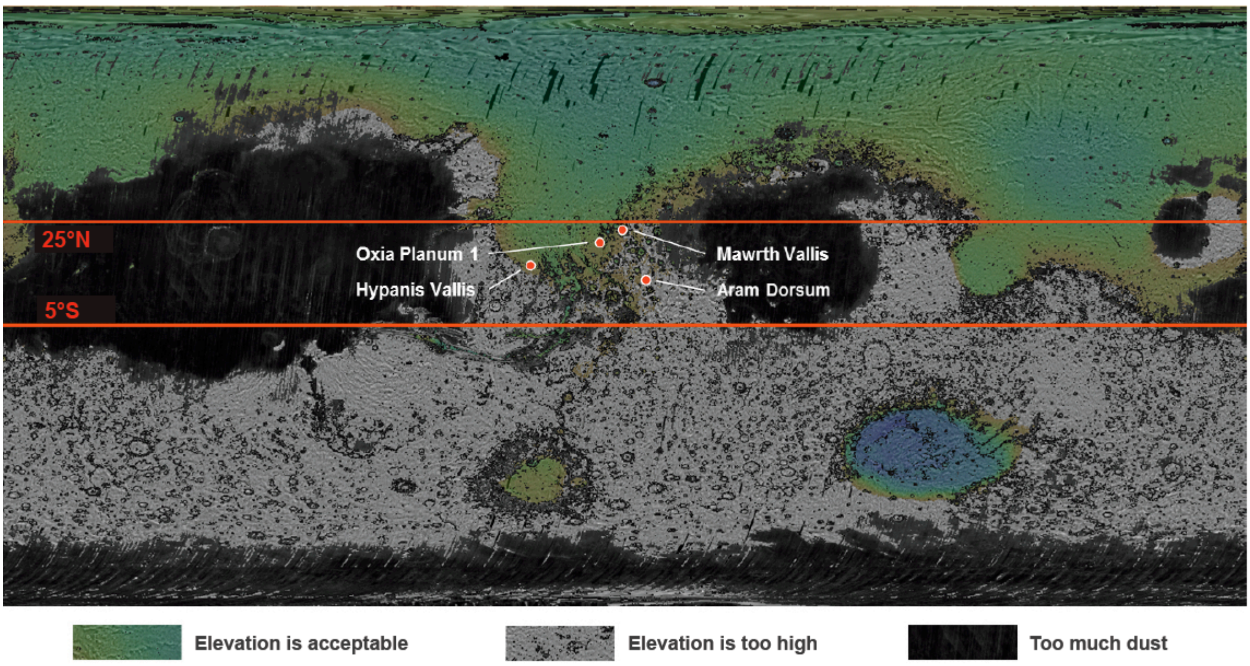
The ExoMars rover will carry a comprehensive suite of instruments dedicated to exobiology and geology research named after Louis Pasteur. The rover will be able to travel several kilometres searching for traces of past and present signs of life. It will do this by collecting and analysing samples from within rocky outcrops, and from the subsurface—down to 2-m depth. The very powerful combination of mobility with the ability to access locations where organic molecules can be well preserved is unique to this mission.

The launch is planned on May 2018 from Baikonur.

After the rover egress the SP will serve as long-lived stationary platform to study surface environment with suite of scientific instruments.

3.1. Candidate landing Sites

At the moment a dedicated working group is studying four potential landing sites (see Figure).



The four candidate sites lie around the Chryse basin. They all possess a record of ancient sediment deposition and alteration acting over large scales (spatial and temporal), requiring a lot of water:

- Mawrth Vallis and Oxia Planum are in extensive, finely layered phyllosilicate-rich areas.
- Aram Dorsum and Hypanis Vallis are in alluvial settings: A sinuous river (Aram) and delta/fan (Hypanis) deposits.

The Mawrth and Oxia clays date from the very early, habitable epoch of Mars. These deposits are well distributed in the landing ellipses and therefore accessible. The Aram Dorsum flood plains —comparable to those on the Nile river— are also ancient. The Hypanis Vallis deltaic deposits are more recent (early Hesperian).

3.2. The ExoMars Rover

The ExoMars rover will have a nominal lifetime of 220 sols (approximately 6 months). During this period, it will ensure a regional mobility of several kilometres, relying on solar array electrical power. The Pasteur model payload contains:

Instrument	Scientific rationale
Panoramic Instruments:	**To characterise the Rover's geological context, both on the surface and on the subsurface. Typical scales span from panoramic to 10 metres, with a resolution in the order of 1 cm for close targets.**
Panoramic Camera System	PanCam: Two wide-angle stereo cameras and one high-resolution camera; to characterise the Rover's environment and its geology. Also very important for target selection.
Infrared (IR) Spectrometer	ISEM: For bulk mineralogy characterisation, remote identification of water-related minerals, and for aiding PanCam with target selection.
Ground Penetrating Radar (GPR)	WISDOM: To establish subsurface stratigraphy down to 3-m depth, and to help plan the drilling strategy.
Neutron Spectrometer	ADRON: To determine the level of subsurface hydration, and the possible presence of ice.
Contact Instruments:	**To investigate outcrops, surface rocks, and soils. Among the scientific interests at this scale are: macroscopic textures, structure and layering. This information will be fundamental to understand the local depositional environment and to search for morphological biosignatures on rocks.**
Close-Up Imager	CLUPI: To visually study rock targets at close range (50 cm) with sub-mm resolution. This instrument will also investigate the fines produced during drilling operations, and image samples collected by the drill. The close-up imager has variable focusing and can obtain high-resolution images at longer distances.
IR spectrometer in drill	Ma_MISS: For conducting mineralogical studies in the drill borehole's walls.
Support Subsystems:	**These essential devices are devoted to the acquisition and preparation of samples for detail investigations in the analytical laboratory. The mission's ability to break new scientific ground, particularly for "signs of life" investigations, depends on these two subsystems.**
Subsurface Drill	Capable of obtaining samples from 0 to 2-m depth, where organic molecules can be well preserved from radiation and oxidation damage. It also integrates temperature sensors and an infrared spectrometer.
Sample Preparation and Distribution System (SPDS)	Receives a sample from the drill system, prepares it for scientific analysis, and presents it to all analytical laboratory instruments. A very important function is to produce particulate material while preserving the organic and water content fractions.
Analytical Laboratory:	**To conduct a detailed analysis of each collected sample. Following crushing of the sample, the first step is a visual and spectroscopic investigation. Thereafter follows a first search for organic molecules. In case interesting results are found, the instruments are able to perform more detailed analyses.**

VIS+IR Imaging Spectrometer	MicrOmega: Will examine the crushed sample material to characterise structure and composition at grain-size level. These measurements will also be used to help point the laser-based instruments, Raman and MOMA.
Raman Laser Spectrometer	RLS: To determine the geochemistry/organic content of minerals in the crushed sample material.
LDMS + Der-TV GCMS	MOMA: This is the rover's largest instrument. Its goal is to conduct a broad-range, very-high sensitivity search for organic molecules in the collected sample. It incudes two different ways for extracting organics: 1) Laser Desorption (LD); and 2) Thermal Volatilisation (TV), with or without derivatisation (Der) agents, followed by separation using 4 Gas Chromatograph (GC) columns. The identification of the evolved organic molecules is performed with an ion trap Mass Spectrometer (MS).

3.3. Descent Module and Surface Platform

The ExoMars Descent Module (DM) is the part of the spacecraft composite that enters the atmosphere to achieve a controlled descent and landing. The Carrier Module (CM) will take the DM to Mars and deliver it at a very precise angle. A thermal shield at the bottom of the capsule will be used to decelerate to roughly twice the speed of sound. Thereafter, the parachute system will take over. The last stage will involve the use of throttled liquid engines. A multi-beam radar will measure the distance to ground and the horizontal speed over the terrain. The DM's computer will receive this information and combine it with its knowledge of the DM's attitude to decide how to exercise the engines and achieve a controlled landing.

After the landing, the rover, which sits on top of the landing platform, must then unfold its solar panels, camera mast, and wheels. The landing platform will deploy several ramps that the rover can use to egress onto the Martian surface. Once the rover is on its way, it is planned to conduct experiments from the remaining SP.

3.3.1. Contact Persons for Russian SP Instruments

The following European contributions to Russian-led instruments are envisaged:

Instrument	European Contribution	Instrument PI and contacts
METEO	- Humidity sensor - Pressure sensor - Optical depth sensor - Solar irradiance sensor - Magnetometer - Dust sensor	A. Lipatov (PI) slip@iki.rssi.ru
FAST	- Interferometer unit	A. Shakun (PI) avshakun@iki.rssi.ru A. Grigoriev

		avgrirn@gmail.com
M-DLS	- Spectroscopic support, procurement and characterisation of diode lasers, principal optical, vacuum, electronic parts and modules, laboratory M-DLS prototype characterisation, development of the inversion algorithms	I.Vinogradov (PI) imant@iki.rssi.ru
Dust Suite	- Aerosol particle counter - Electric field sensor	G. Dolnikov (PI) ggd@iki.rssi.ru A. Zakharov zakharov@iki.rssi.ru
MGAP	- Mass spectrometer	M. Gerasimov (PI) mgerasim@mx.iki.rssi.ru
MAIGRET	- Wave analyser module	A. Skalsky skalsky@iki.rssi.ru

3.3.2. DM Overview

MISSION PURPOSE: Mars Rover delivery: 345 kg and SP Science payload delivery: 45 kg

LANDING SITE: latitude 5 ˚ S ... 25˚N, landing site elevation H ≤ –2 km

LANDING PARAMETERS: axial g-load nx ≤ 18, lateral g-load nlat ≤ 8

KEY LOGICAL REQUIREMENTS:

- Type of the Mars atmosphere motion path – ballistic
- Landing – without selection of place
- Transmission of scientific and command-program data through ExoMars-2016 TGO
- Time of separation - ~30 min before the entry into the Mars atmosphere
- H_{entry} = 120 km above the areoid surface
- DM stabilization – by spinning-up
- ΔVsep. = 0.6 m/s ÷ 0,8 m/s

LAUNCH VEHICLE: Proton-M → FS Ø 3.8m (Briz-M)

ACTIVE LIFE: Surface Platform – 1 Earth year, Mars Rover 218 sols

DM Mass budget:

Element Name	**Mass, kg**
DM structure	353.39
Parachute System	178.8
Surface platform (SP)	827.90
Incl. Scientific Payload	*45.00*
MarsRover	345.00
Balance Weight	10.00
Fuel	151.70
Total	1866.80
Margin	132.51
Total with margin	1999.30

Fig. Descent profile

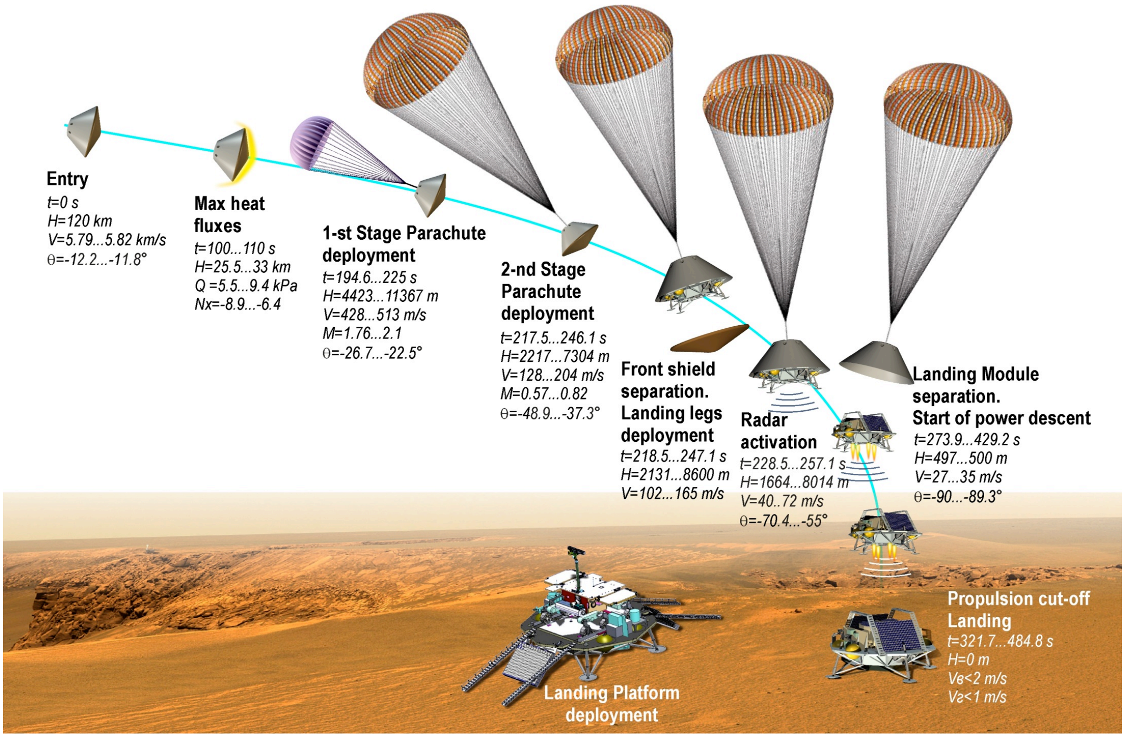


Fig. DM with folded solar panels

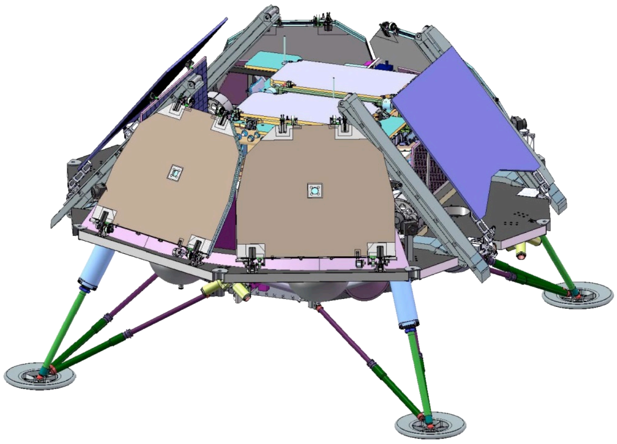


Fig. DM with unfolded solar panels (side view)

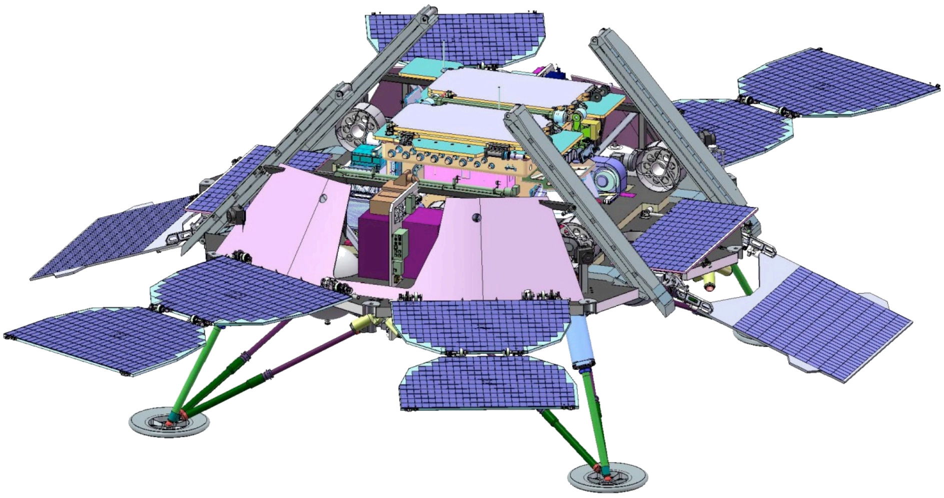
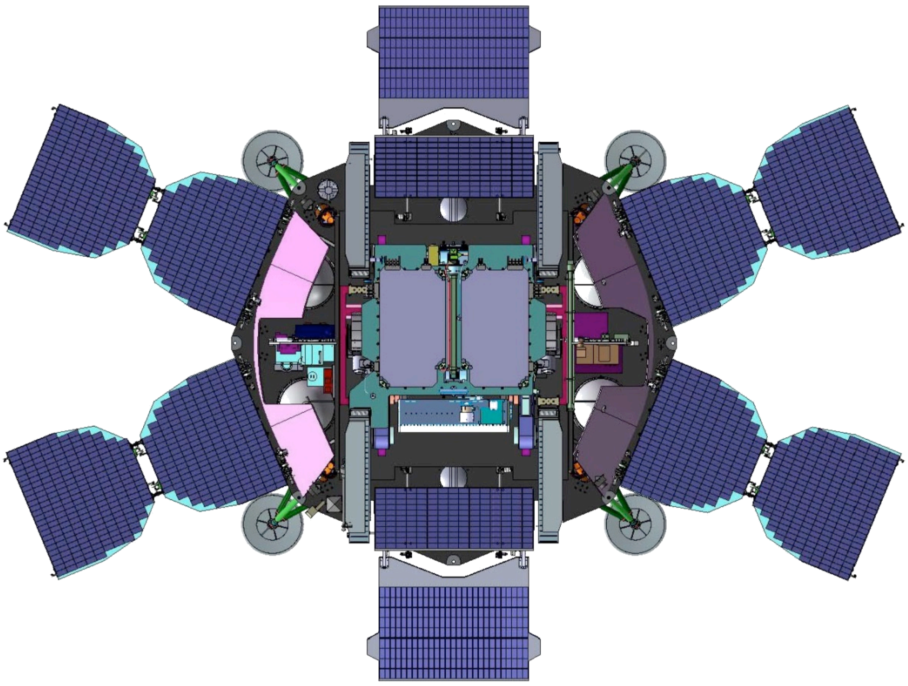


Fig. DM with unfolded solar panels (view from the top)



4. CONSTRAINTS IMPOSED BY MISSION DESIGN

4.1. Mass

The total maximum mass allocated for the entire science payload of the Surface Platform is 45 kg including maturity margins and harness between instruments and the BIP (Payload Interface Block) Interface and Memory Unit. Within this 45 kg, a maximum of 3.5 kg (including 20% margin) is available for the proposed European-led instrument(s) (or integrated suite of sensors).

The instrument target masses shall comprise all hardware belonging to the instruments, including:

- control electronics
- thermal hardware (e.g.: radiators, coolers, heaters, blankets/ MLI, thermostats)
- internal harness
- electrical, mechanical and thermal interface hardware, as needed for the accommodation.

4.2. Thermal conditions

Instruments should be compatible with following thermal conditions:
T(operational): –20 °C … +40 °C
T(storage): –50 °C … +40 °C
For elements outside of thermo controlled area: –100 °C to +30 °C

4.3. Power

Power to the instruments will be provided from the SP stabilized power distribution system. The Voltage is 28 ± 0.3 V (in stabilized conditions) and 28 ± 3 V (in transitional process up to 50 ms).

Total power consumption of whole payload should not exceed 75 W during daytime (10 hour period) and 25 W during night.

4.4. Mechanical

For design loads the following quasi-static accelerations should be taken. Maximum quasi-static accelerations are determined by the conditions of DM descent in the Mars atmosphere and landing onto its surface.

Operation	a_x, g	a_{lat}, g	duration, s
Atmosphere deceleration	10.0	± 1.0	static
Parachute deployment	10.0	± 2.5	0.05 – 0.20
Landing max a_x case max a_{lat} case	 10.2 5.4	 0 9	0.03 – 0.10
$g = 9{,}8\ m/s^2$			

Instruments should not have resonant frequencies below 40 Hz.

4.5. Shocks

The payload is subjected to shock influence during launch:

Frequency, Hz	30-50	50-100	100-200	200-500	500-1000	1000-2000	2000-5000
Acceleration, g	3-5	5-15	15-40	40-175	175-500	500	500

The payload is subjected to shock influence during separation procedures:

Frequency, Hz	30-50	50-100	100-200	200-500	500-1000	1000-2000	2000-5000
Acceleration, g	15-40	40-160	160-200	200-1000	1000	1000	1000

Shock spectra are for a Q factor of 10.

4.6. Payload accommodation

The scientific payload is accommodated on thermo-controlled panels on one side of the DM.

4.7. Data interface

Data exchange interface between payload instruments and BIP (Payload Interface Block): LVDS (RS-485 is also available).

Depending on particular instrument data volume requirements it is possible to use either high-speed (up to 4 Mbits/s) interface or low-speed (38400 bits/s) interface.

4.8. Instrument volume and geometry

It is not yet known precisely how much volume can be made available to each individual instrument. This will be analysed on the basis of the proposals that are received. Instruments with a simple geometry that do not require deployment of appendages or need a special field of view will have a higher chance of being accommodated successfully.

4.9. Planetary Protection

For Payload FM units (COSPAR classification IVa) the density of internal and external surface contamination should not exceed 300 bacterial spores per square meter.

5. PAYLOAD AND INSTRUMENT MANAGEMENT

The ExoMars 2018 mission is a joint mission between ESA and Roscosmos.

The SP science payload development is the responsibility of Roscosmos, with the exception of the contributions selected through this call. Roscosmos named Space Research Institute of Russian Academy of Sciences (IKI) as a leading entity in development of SP scientific payload, with the exception of the contributions selected through this call. IKI will manage the development of SP payload according to Russian standards.

The IKI Payload Manager(s) will monitor the programmatic and technical progress of the design, development, and verification of instruments.

In case of European contributions to Russian-led instruments, the instrument PI on the Russian side is the point of contact for all information exchange regarding the particular contribution.

In case of European-led instrument(s), IKI will appoint an instrument manager to be the point of contact for all information exchange with the Principal Investigator (PI) regarding the instrument.

IKI will manage the documentation according to Russian standards. IKI will provide support in preparing the documentation according to Russian standards based on instrument's inputs.

5.1. Hardware deliveries

The instrument hardware deliverables consist of following models for European-led instrument(s):

- Structural Model (SM)
- Thermal Model (TM)
- Instrument Electrical Interface Simulator (EIS).
- Flight Model (FM).
- Flight Spare Model (FSM) (if required).

The instrument hardware model deliveries must be accompanied by all ground support equipment (GSE) needed for stand-alone integration system test and launch operations.

Model requirements are according to Russian standards for space scientific equipment.

IKI may support (if necessary) manufacturing of ST and TM models in Russia based on instrument's input to speed up the delivery process.

5.2. Deliveries schedule

SM and TM – December 2015 (TBC).

The proposal must contain the detailed description and drawings necessary to manufacture the instrument's SM and TM models. In case SM and/or TM of the proposed instrument will not be available in time for delivery, IKI might produce them.

EIS – June 2016 (TBC).

FM – May 2017 (TBC).