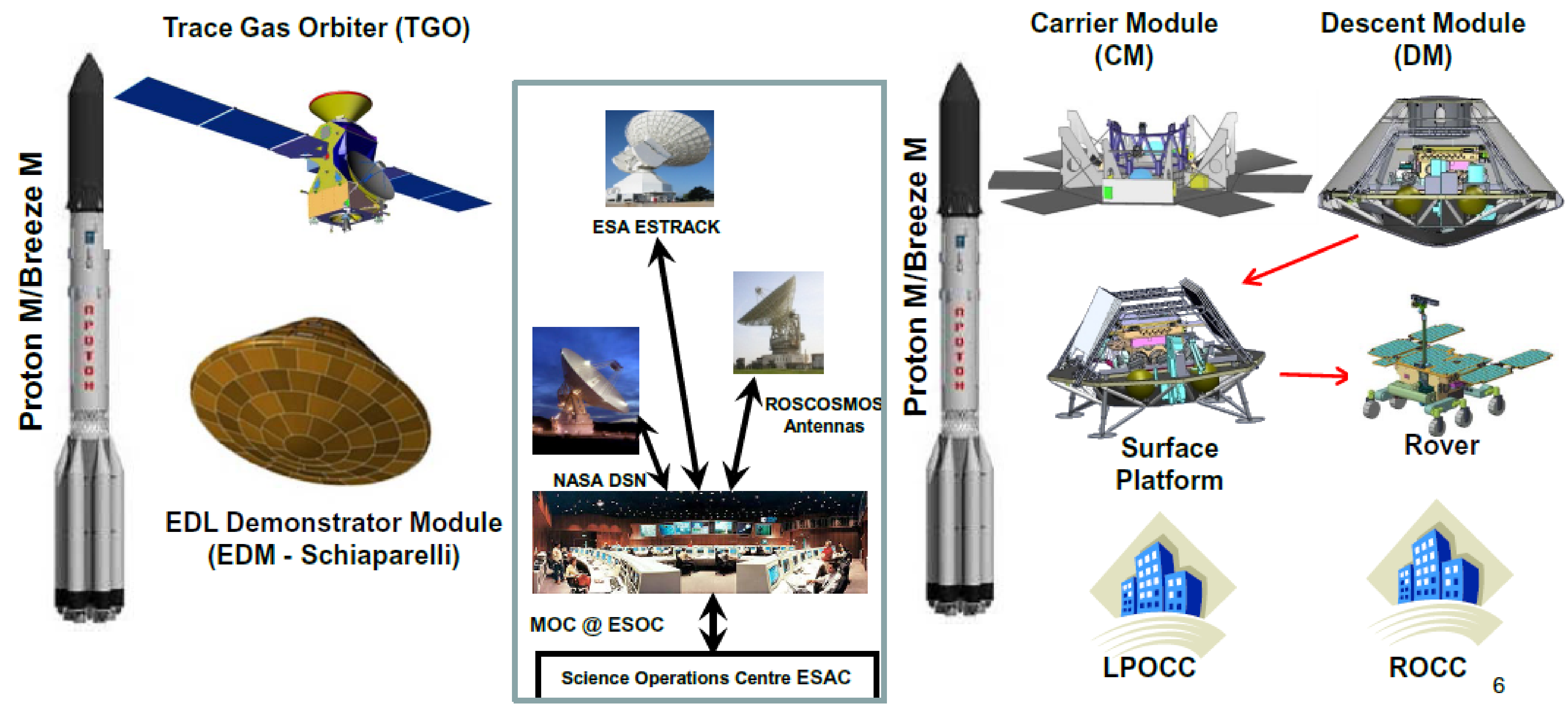
ExoMars 2016 and 2018 programme
a very brief description
(and LMD’s implication therein)

Ehouarn Millour for the LMD team

May 14th 2015, Kobe

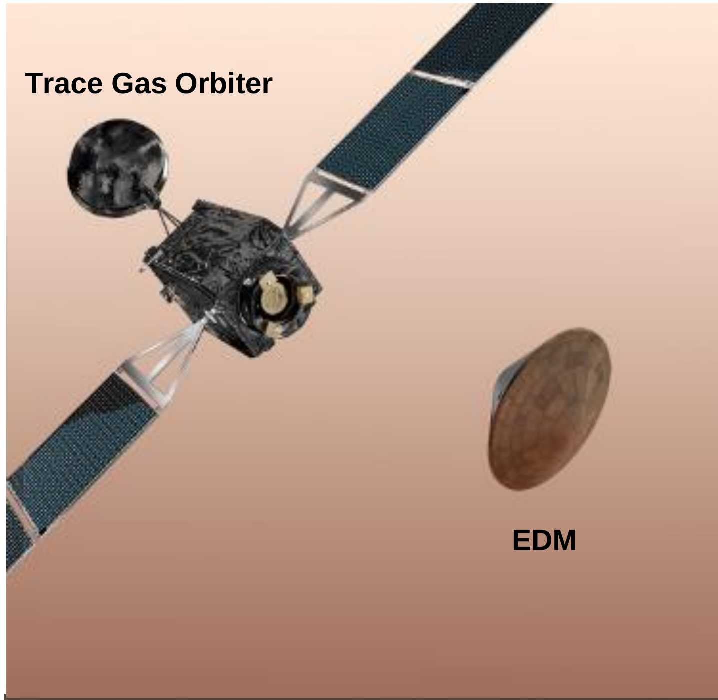
ExoMars Programme in cooperation with Roscosmos: ESA's flagship mission in Robotic Exploration

esa 2016 Mission **And** esa 2018 Mission



ExoMars 2016

- The 2016 mission will carry a 600 kg **Entry and descent Demonstration Module (EDM)** that shall allow Europe to test and demonstrate its capability to land on Mars, and **improve EDL technologies for future missions.**
- For this purpose, it will be equipped with a suite of sensors:
  - Front shield : pressure sensors + 7 thermal plugs
  - Back Shield sun sensors, 3 thermal plugs, Infrared radiometer
  - 2 Inertial measurement units
  - Near surface radar altimeter
  - Downward looking descent camera
- LMD involved (as sub-contractor to TAS-I) in the characterization of the atmosphere for the preparation of EDL




CE

The science of the ExoMars 2016 EDM

The EDM will support two major scientific motivations:

• Improve our knowledge of Mars atmosphere
with in-situ observations (Entry-Descent-Landing phase)
=> **AMELIA** experiment

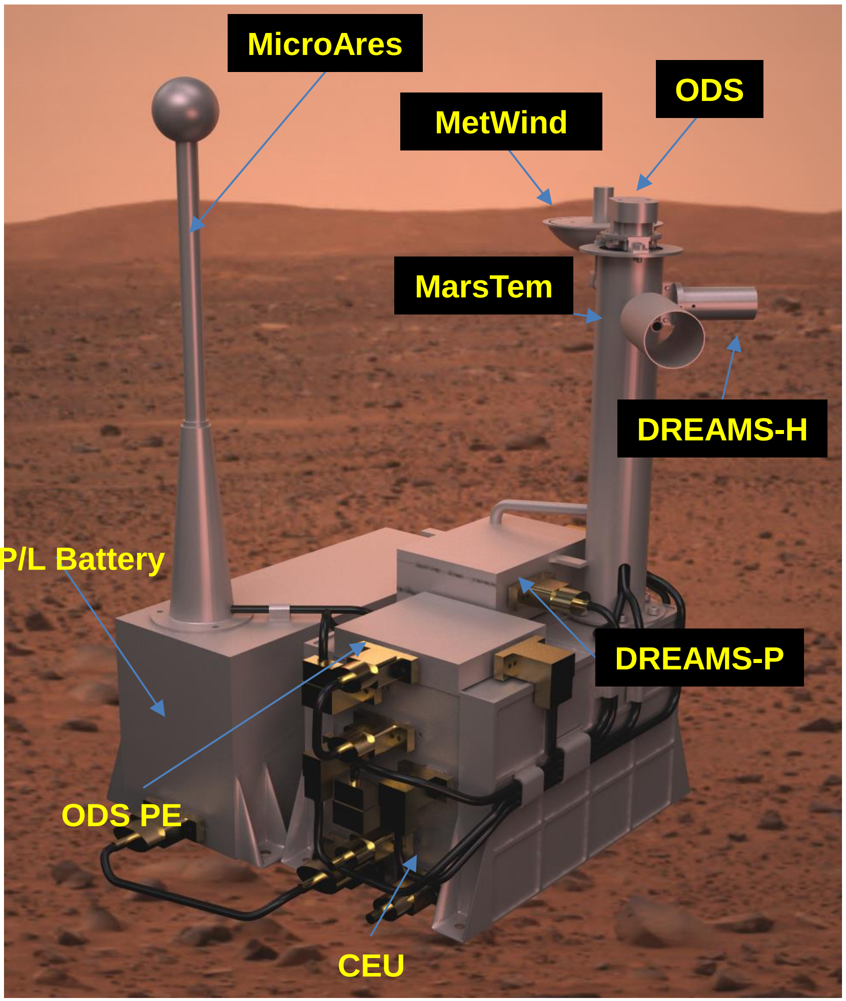
PI: **F. Ferri** (Univ. Padova, It.)
co-PIs: F. Forget (Fr.), S. Lewis (UK), O. Katatekin (Bel.)
+ 20 co-Is + 10 collaborators from 7 countries

• Improve our knowledge of Mars environment
at times of high dust loading (Surface operations)
=> **DREAMS** experiment

PI: **F. Esposito** (INAF, It.)
co-PI: F. Montmessin (Fr.)
+ 6 lead-CoIs + 40 co-Is from 9 countries

EDM Surface Payload (DREAMS)

DREAMS



•**Short lived: will only operate a few days (2-4) on the surface of Mars**

DREAMS is an integrated and autonomous system which will perform:

•First ever investigation of **atmospheric electric phenomena on Mars**

•Characterization of the **diurnal cycle during the dusty season.**

Trace Gas Orbiter
Science instruments

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) $\lambda/\Delta\lambda$ ~ 250	SO, Limb, Nadir
IR (2.3 – 3.8 μm) $\lambda/\Delta\lambda$ ~ 10,000	SO, Limb, Nadir
IR (2.3 – 4.3 μm) $\lambda/\Delta\lambda$ ~ 20,000	SO

CaSSIS

High-resolution camera

Mapping of sources; landing site selection

5 m/px 3-colour imaging and panchromatic stereo

ACS

Suite of 3 high-resolution spectrometers

Atmospheric chemistry, aerosols, surface T, structure

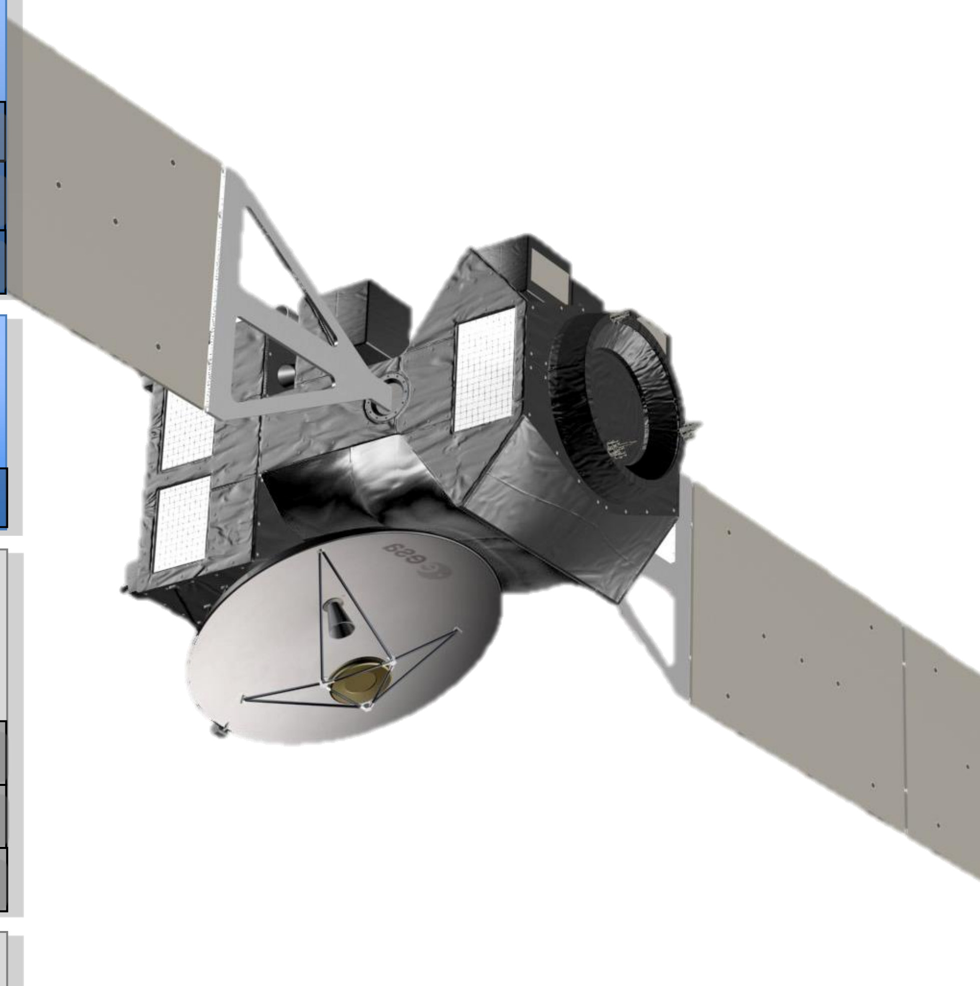
Near IR (0.7 – 1.7 μm) $\lambda/\Delta\lambda$ ~ 20,000	SO, Limb, Nadir
IR (Fourier, 2 – 25 μm) $\lambda/\Delta\lambda$ ~ 4000 (SO)/500 (N)	SO, Nadir
Mid IR (2.2 – 4.5 μm) $\lambda/\Delta\lambda$ ~ 50,000	SO

FREND

Collimated neutron detector

Mapping of subsurface water

All resolving power figures $\lambda/\Delta\lambda$ are calculated at mid-range



Major Scientific Products

- Spatially-resolved inventory of trace gases and key isotopes
  - Monitoring and profiling of CO, H_2O/HDO, organics, aerosols, ... (NOMAD, ACS)
  - Mapping and profiling of isotopologues and O_3 (NOMAD)
  - Monitor meteorology , and back-track trace gas sources

  => Confirm/characterise CH_4 presence on Mars
  - mapping, profiling, image of sources and terrain
- Higher resolution mapping of sub-surface water and hydrated minerals (FREND)
- High resolution, colour and stereo coverage of extended areas (incl. future landing sites), with focus on trace gas sources and dynamic processes (CaSSIS)

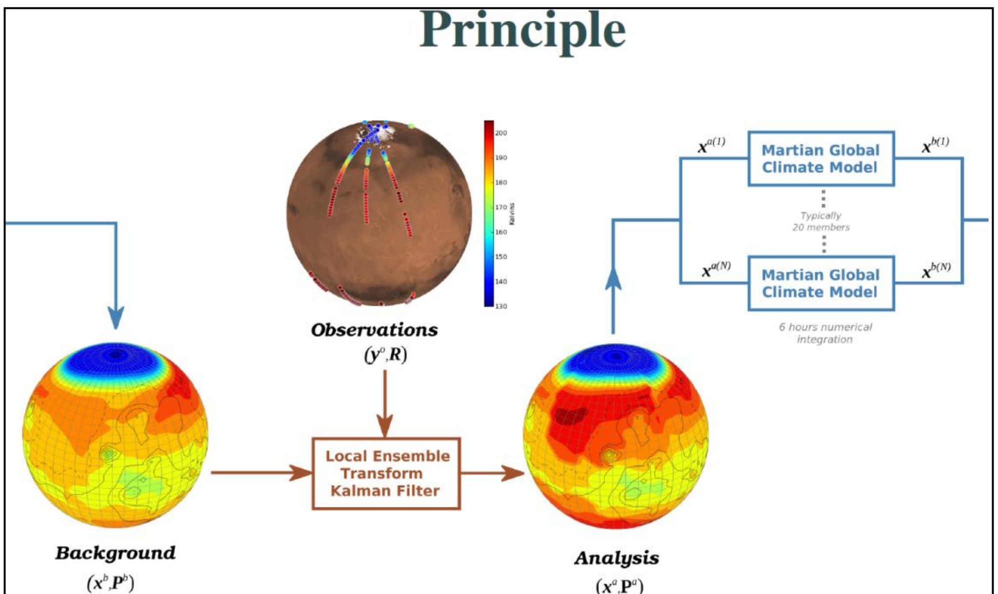
LMD implication in ExoMars Trace Gas Orbiter

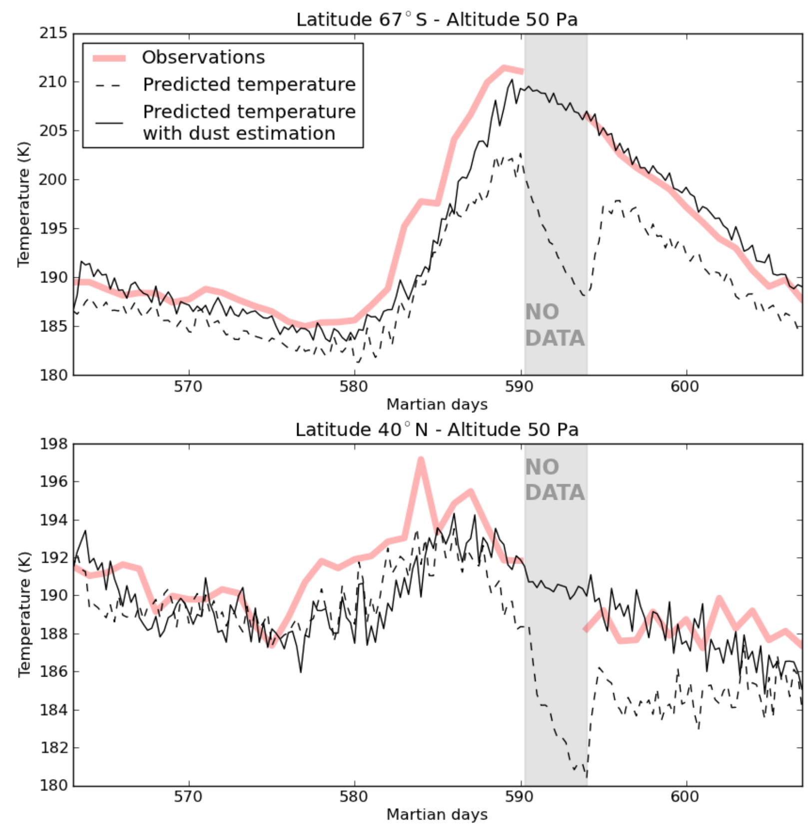
- In performing retrievals using ACS (S. Guerlet).
- In performing data assimilation of ACS in near « real time » conditions to support retrievals for other instruments.

=> PhD work of T. Navarro: Using LETKF on Mars Climate Sounder data

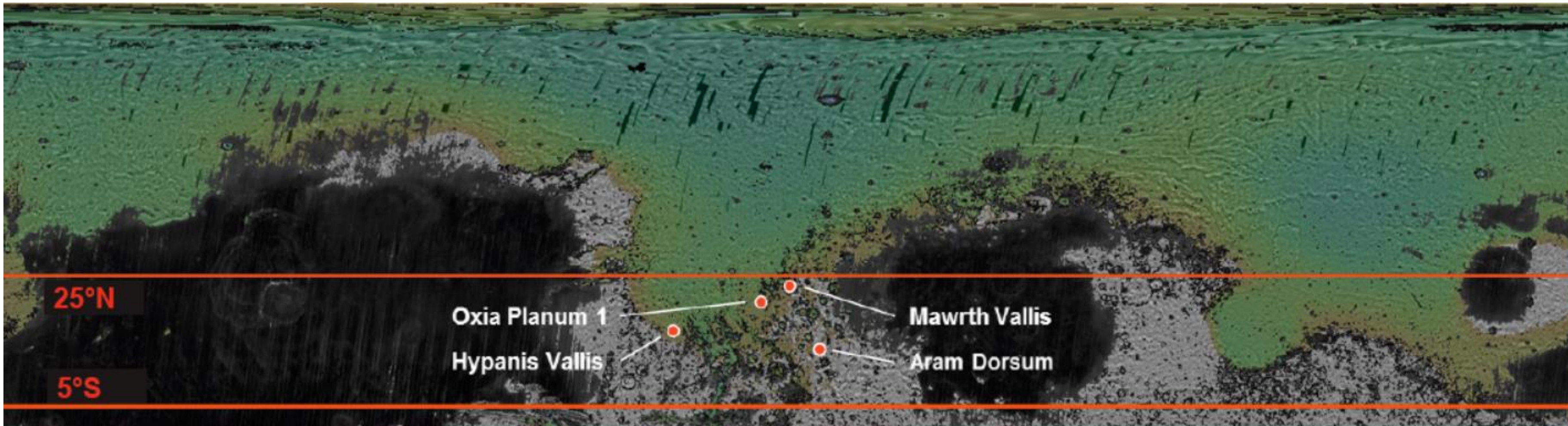
Strategy: Temperature biases are also corrected by adding dust (and/or water vapor) based on dust-cloud-temperature correlations and/or direct aerosol observations.

LETKF scheme from University of Maryland Combined to the LMD GCM





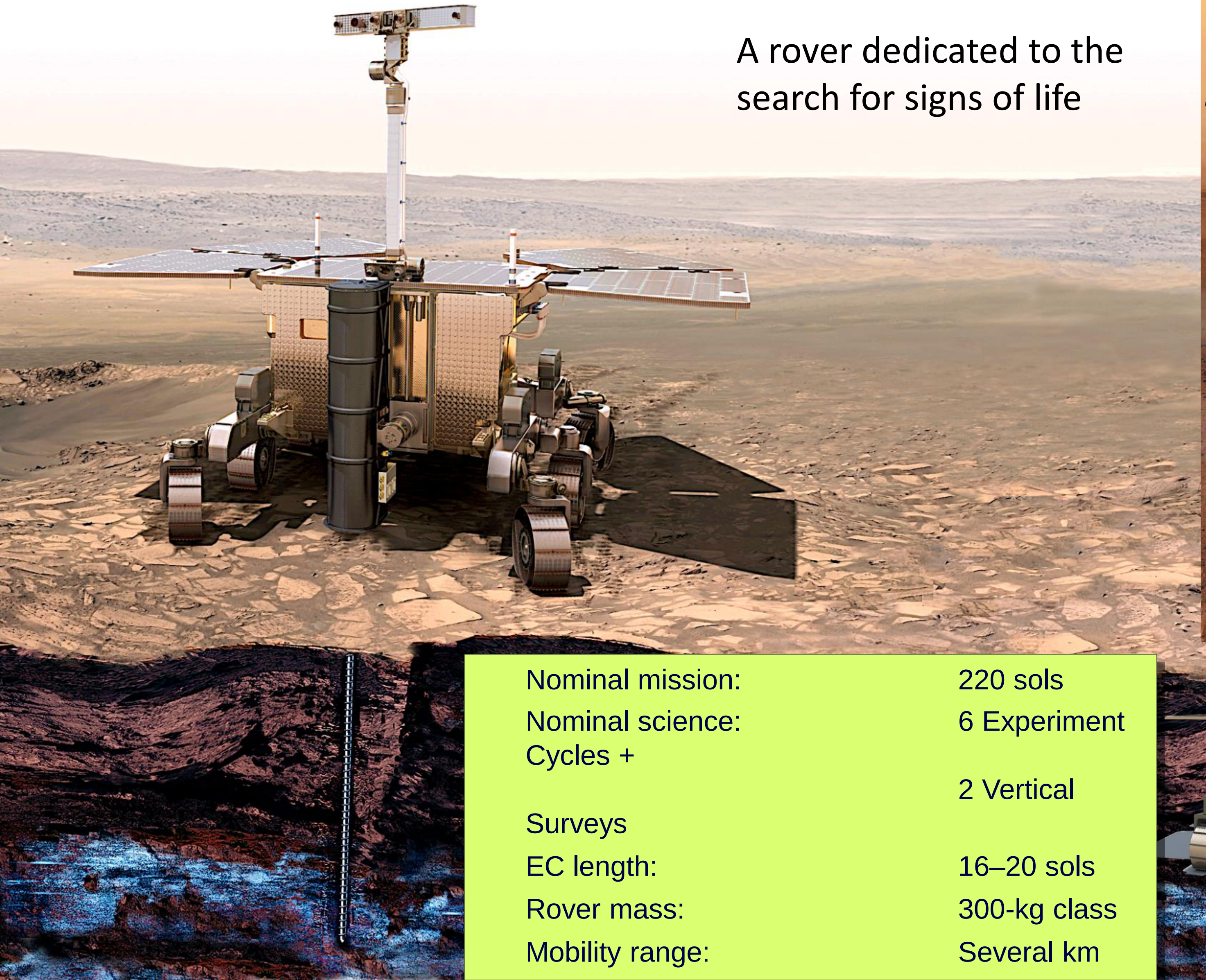
ExoMars 2018 Candidates Landing sites

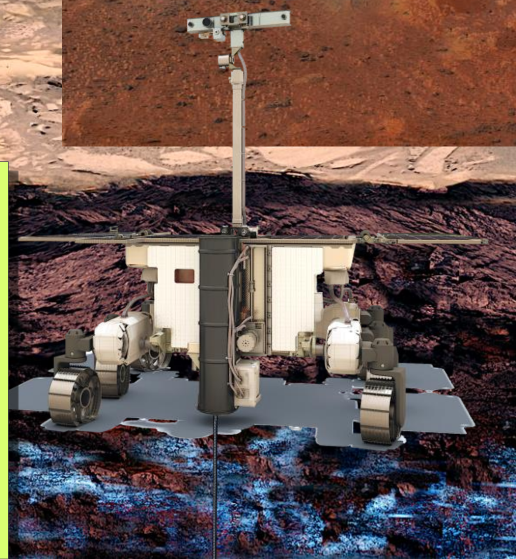


- The four candidate sites lie around the Chryse basin.
- They all possess a record of ancient sediment deposition and alteration acting over large scales (spatial and temporal), requiring a lot of water:
  - Mawrth Vallis and Oxia Planum are in extensive, finely layered phyllosilicate-rich areas.
  - Aram Dorsum and Hypanis Vallis are in alluvial settings: A sinuous river (Aram) and a delta/fan (Hypanis).
- The clays at Mawrth and Oxia, and the Aram Dorsum floodplains, date from the very early, habitable epoch of Mars.
- The Hypanis Vallis deltaic deposits are more recent (early Hesperian).
- F. Forget is a member of the LLSWG (Landing Site Selection Working Group)

EXOMARS 2018 ROVER AND LANDED PLATFORM

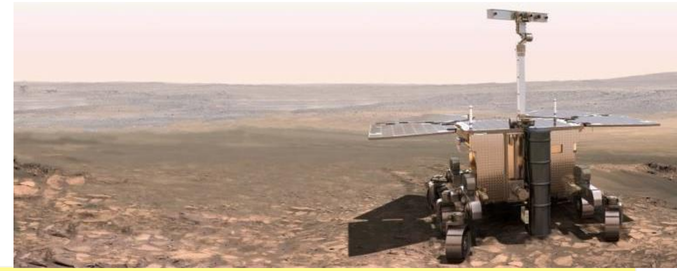
A rover dedicated to the search for signs of life





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

Rover Pasteur Payload



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

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

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

0.4 – 2.2 µm

Analytical Laboratory Drawer

MicrOmega

VIS + IR Spectrometer

Mineralogical characterization of crushed sample material
Pointing for other instruments

0.9 – 3.5 µm, 256 x 256 pixels, 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 molecule detection at high sensitivity (ppb)
Chirality determination

Laser-desorption extraction and mass spectroscopy

Step-heating & Pyrolysis extraction in the presence of derivatisation agents, coupled with chiral gas chromatography and mass spectroscopy

Rover Pasteur Payload

Instrument Name	Description	Countries
PanCam (WAC + HRC)	Panoramic camera system	**UK**, D, CH H/W F, I, A, USA Sci
ISEM	IR spectrometer for bulk mineralogy identification	**RUS**
WISDOM	Shallow ground-penetrating radar for subsurface stratigraphy	**F**, D N, USA, B, I, E, UK
FREND	Passive neutron spectrometer for subsurface water content	**RUS**
CLUPI on drill box	Close-Up Imager	**CH**, F CAN, UK, D, I, B
Ma_MISS included in 2.0-m drill	IR borehole spectrometer	**I** P, PL
MicrOmega	Vis+IR imaging spectrometer	**F** CH, RUS, I, D, UK
RLS	Raman spectrometer	**Sp**, F, UK D, NL, USA
MOMA	LD-MS + Pyr-Der GC-MS for organic molecule characterisation	**D**, F, USA NL, S

ExoMars 2018 Russian Surface platform:

(European contributed payload currently under selection)

Lifetime ~1 Earth year

Instrument	Description	Mass, kg
TSPP	Set of cameras to characterise the landing site environment	3.4
BIP	Instrument interface and memory unit	3.0
METEO	Meteorological package	3.4
FAST	IR Fourier spectrometer to study the atmosphere	3.5
ADRON-EM	Active neutron spectrometer and dosimeter (can work in tandem with the rover neutron detector)	5.6
M-DLS	Multi-channel Diode-Laser Spectrometer for atmospheric investigations	2.6
PAT-M	Radio thermometer for soil temperatures (down to 50-cm depth)	0.6
Dust Suite	Dust particle size, impact, and atmospheric charging instrument suite	1.6
SEM	Seismometer	1.5
MGAP	GC-MS for atmospheric analysis	7.0
MAIGRET	Magnetometer	1.7
To be selected through this call	European-led instrument(s) (or integrated suite of sensors)	3.5
TOTAL		**37.4**

'able 2. *SP Model Payload. The mass figures are best engineering estimates without instrument harness*

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