esa EXOMARS

The ExoMars Program

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The ExoMars Program

Implementing the EXM objectives by remaining compliant with budget restrictions and by maintaining or even increasing the scientific objectives as well as the technical and programmatic reliability

Reasons for changing of the ExoMars mission scenario

The collaborative scenario in 2016 included provision by NASA of an AtlasV 551 launcher, a satellite capable of injecting into Mars orbit the ESA DMC and carrying a scientific payload to search for methane and other trace gases, as well as full TLC capabilities

Programmatic and technical requirements for ESA consists in demonstrating capability to land, rover and drill

Due to financial, technical and risk management considerations NASA came to the conclusion that they would not be able to maintain their commitments to the above scenario on the envisaged timescale

In order to safeguard the ExoMars mission and to maintain collaboration with NASA the following scenario has been recently agreed between ESA and NASA And it is expecting final endorsement by the ESA member states (foreseen by end of September 09)

- **2016 mission consisting of an Orbiter fully capable of satisfying science and TLC requirements and launched by NASA (jointly selected payload for trace gases detectionand sources localization;**

- **2018 mission fulfilling the EXM goals through a joint mission with NASA that will launch and land ESA EXM and another NASA smaller rover**

This is the so called Plymouth scenario agreed by ESA and NASA in the Plymouth bilateral meeting

The full scenario

It requires additional budget by the member states

Basic element as in Plymouth scenario with add on of EDLS technology demonstration in 2016

ESA EDLS back up for 2018

Re-use of ESA EDLS in 2020 mission (partly shaped up by above technology availability)

EXOMARS

Assessment of EDL Demonstrator on 2016 Orbiter Mission

Top Level Requirements

- **Demonstrate safe Entry, Descent and Landing on Mars**
- **Provide measurements during EDL:**
  - Atmospheric Measurements for science and EDL reconstruction
  - Heat-shield instrumentation
- **Robust Development Schedule**
  - Q4 2010 : Lander PDR -All technologies at TRL 5
  - Q1 2011 : Phase C start
  - mid 2014 : Lander FM delivery for system level testing
- **Minimal impact on orbiter and launcher for 2016 mission**
  - Minimize Lander Mass
  - Minimize lander lifetime: limited to few sols to relay EDL data, atmospheric measurements and images
  - Minimize Orbiter Relay Requirements (very limited mission duration)
  - No RHU to avoid impact on launch approval costs
- **Maximise ExoMars heritage**

Mission Constraints and Possible Scenarios

- 2016 Mission Scenario:
  - Jan 2016 launch (Atlas V 411) arriving at Mars in Oct 2016 (Ls ~250 deg)
  - Aerobraking preferred to maximize orbiter mass
- 2 Lander Release options considered:
  - 1) Release from hyperbolic orbit
    - ☒ Arrival during de Global Dust Storm Season
    - ☑ Lowest mass option: Mars insertion without lander mass
  - 2) Release from Mars orbit
    - ☑ Avoidance of Global Dust Storm Season
    - ☒ Nominal waiting time would be ~6 months until Ls 340 deg (end April 2017) delaying arrival into the science orbit, impacting science duration before 2018 data relay capability is needed
- Safe Landing Site:
  - The Meridiani site has been shown by previous missions to be almost flat and without too many rocks; it is being certified in the frame of the EXM landing site selection process

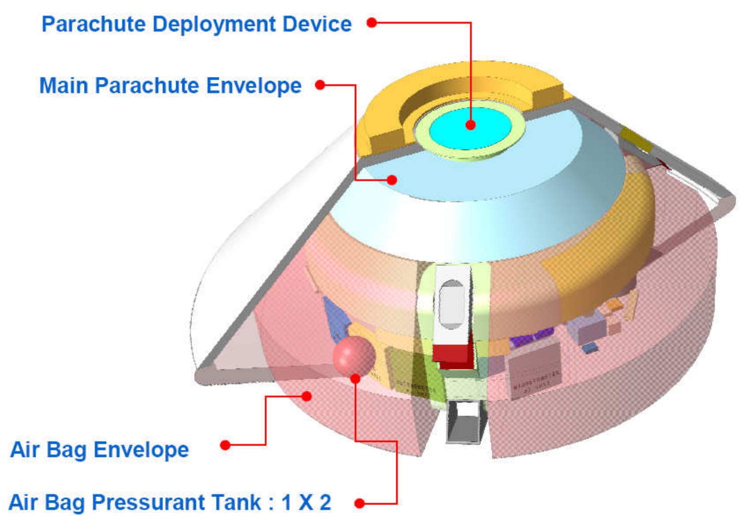
EDL Demonstration Options

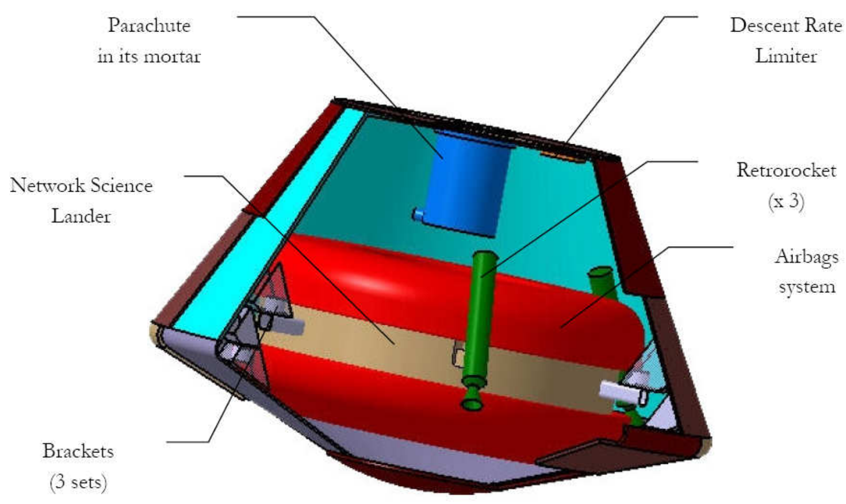
	EXM	2016 EDL Demonstrator	
Heat Shield	**Norcoat-Liege** **70 degree cone**	**Norcoat-Liege** **Scaled from EXM aerodynamic shape**	
Parachute	**2-stage**	**1-stage**	**2-stage**
Propulsive Braking	**Liquid Throttleable (x4)** **(Aerojet engines)**	**Solid Rockets (x3)**	**None**
GNC	**IMUs (x2)** **Radar Doppler (x2)**	**IMUs (x2)** **Radar Altimeter (x2)**	
Landing System	**Vented ABS or Crushable**	**Non-vented ABS or crushable**	

- **The Entry and Descent technology re-uses ExoMars technology developments and is directly applicable to an ExoMars type mission and potentially to a 2020 Mission constituted of a Network of small landers**

Conclusions

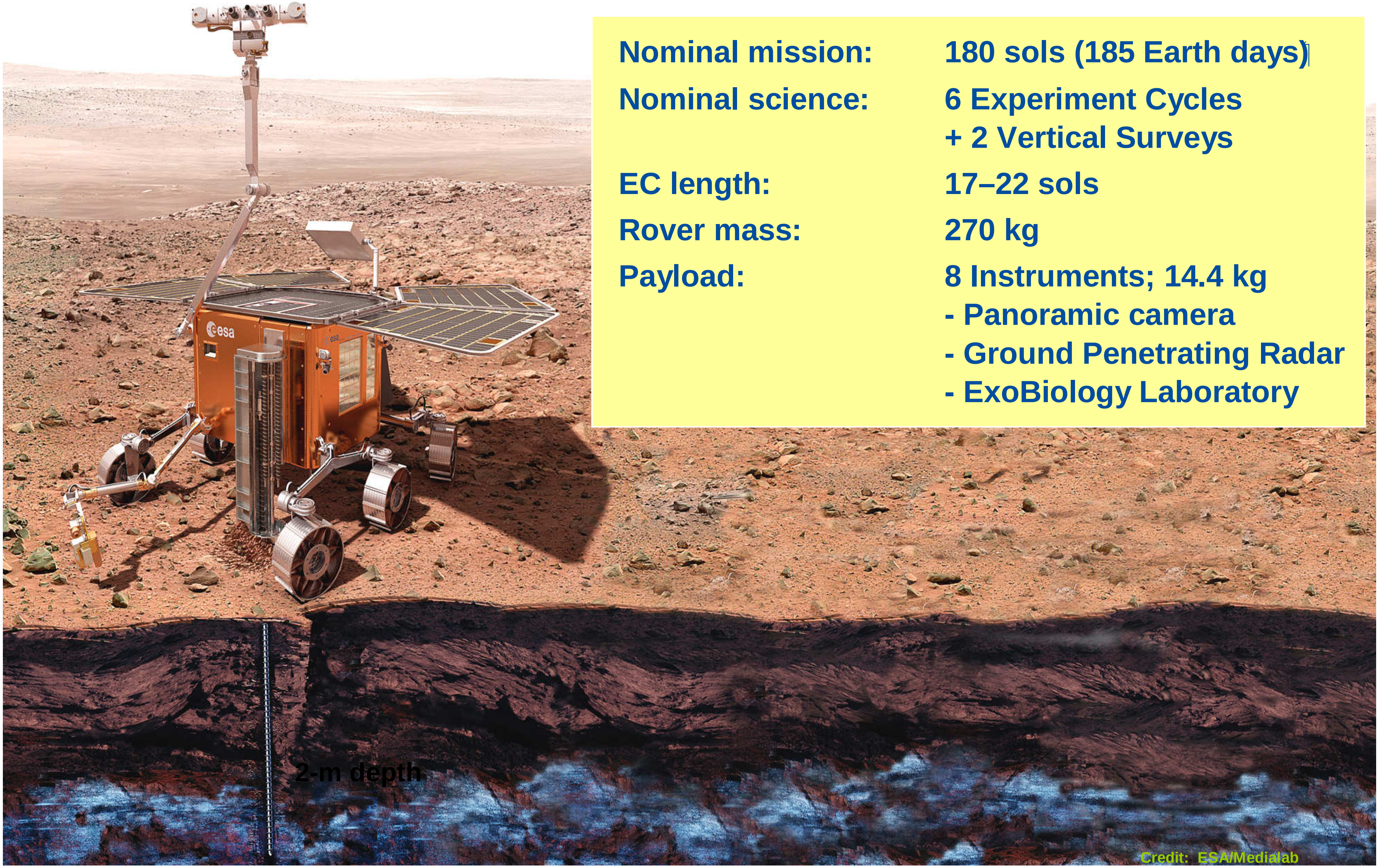
- A small 2016 EDL demonstrator (goal < 200 kg) can demonstrate safe Entry, Descent and Landing on Mars
- Minimal impact on overall mission scenario if released from hyperbolic orbit, but would require landing during the dust storm season
- Development schedule remains critical and overall approach is being consolidated





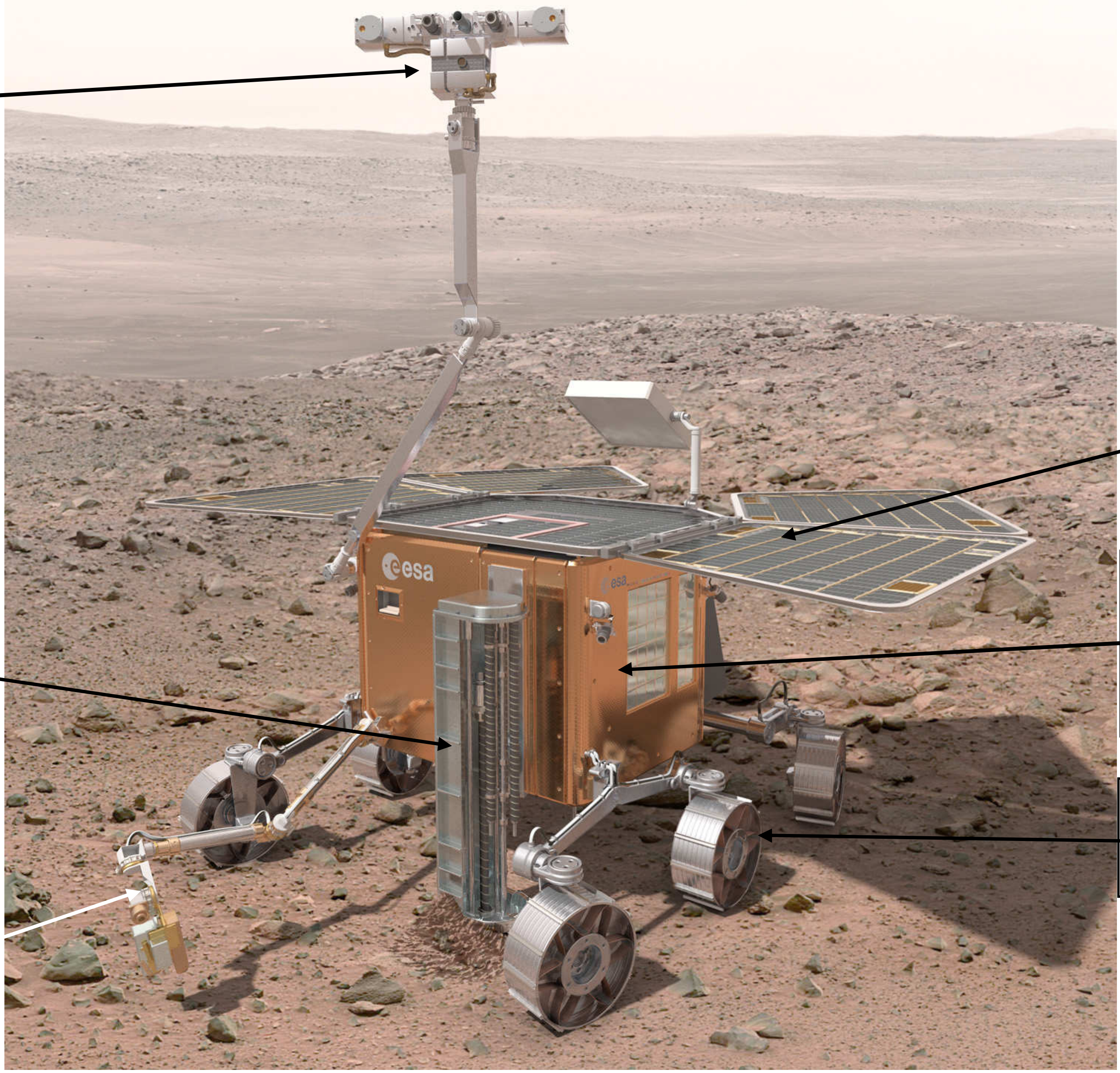
Mobility and Access to Sub-surface

Nominal mission:	**180 sols (185 Earth days)**
Nominal science:	**6 Experiment Cycles** **+ 2 Vertical Surveys**
EC length:	**17–22 sols**
Rover mass:	**270 kg**
Payload:	**8 Instruments; 14.4 kg** **- Panoramic camera** **- Ground Penetrating Radar** **- ExoBiology Laboratory**



E X O M A R S

Rover External Configuration



Mast, 1.7 m height:
- **Navigation stereo**
- **Panoramic stereo**
- **High res. imager**

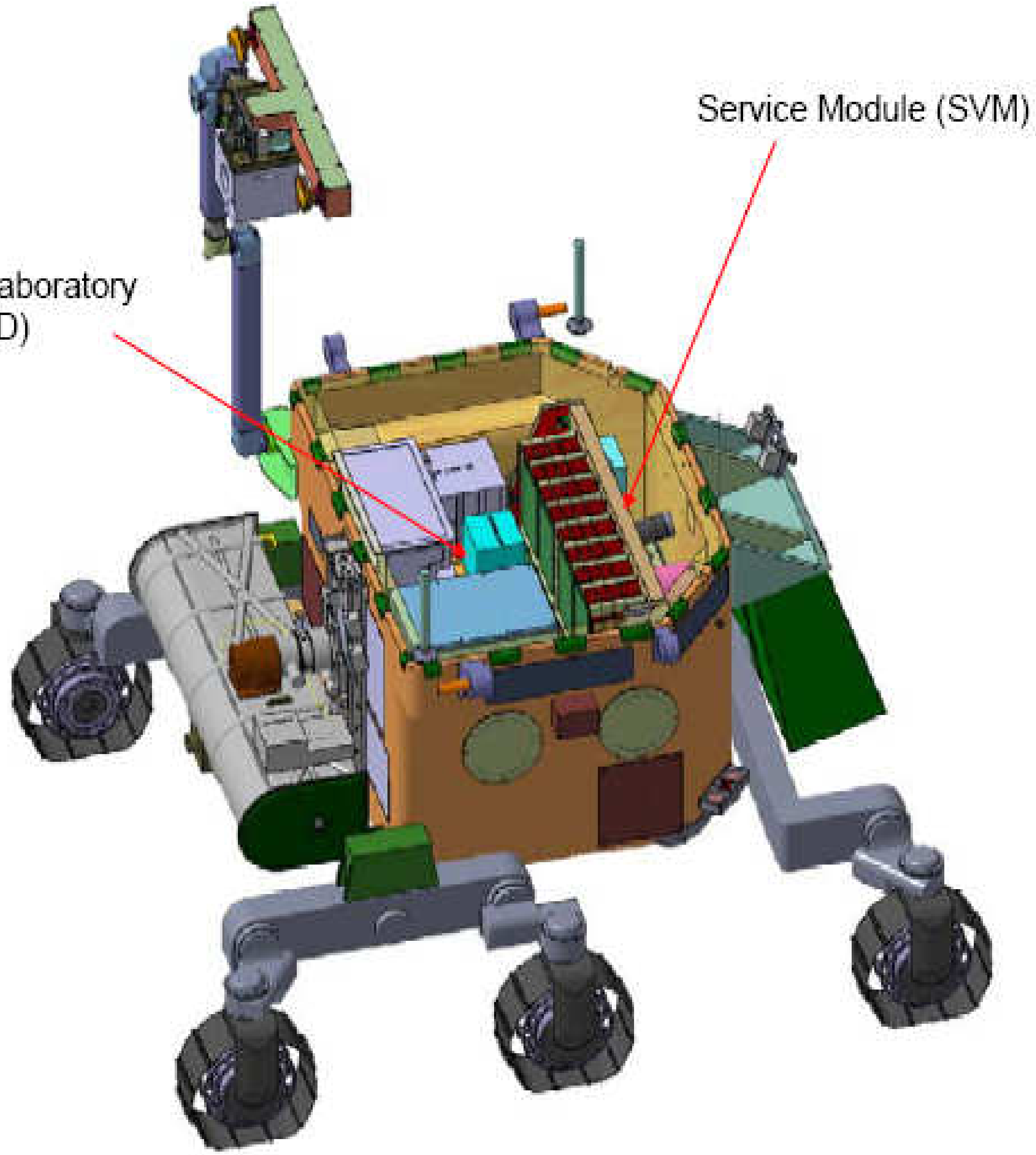
Drill:
- **Deployment joints**
- **Main drill tool**
- **3 extension rods**
- **Back-up drill tool**
- **Ma_Miss Instr.**

Solar Panels
- **1 fixed, 4 deploy.**
- **Tilt: sunrise/set**

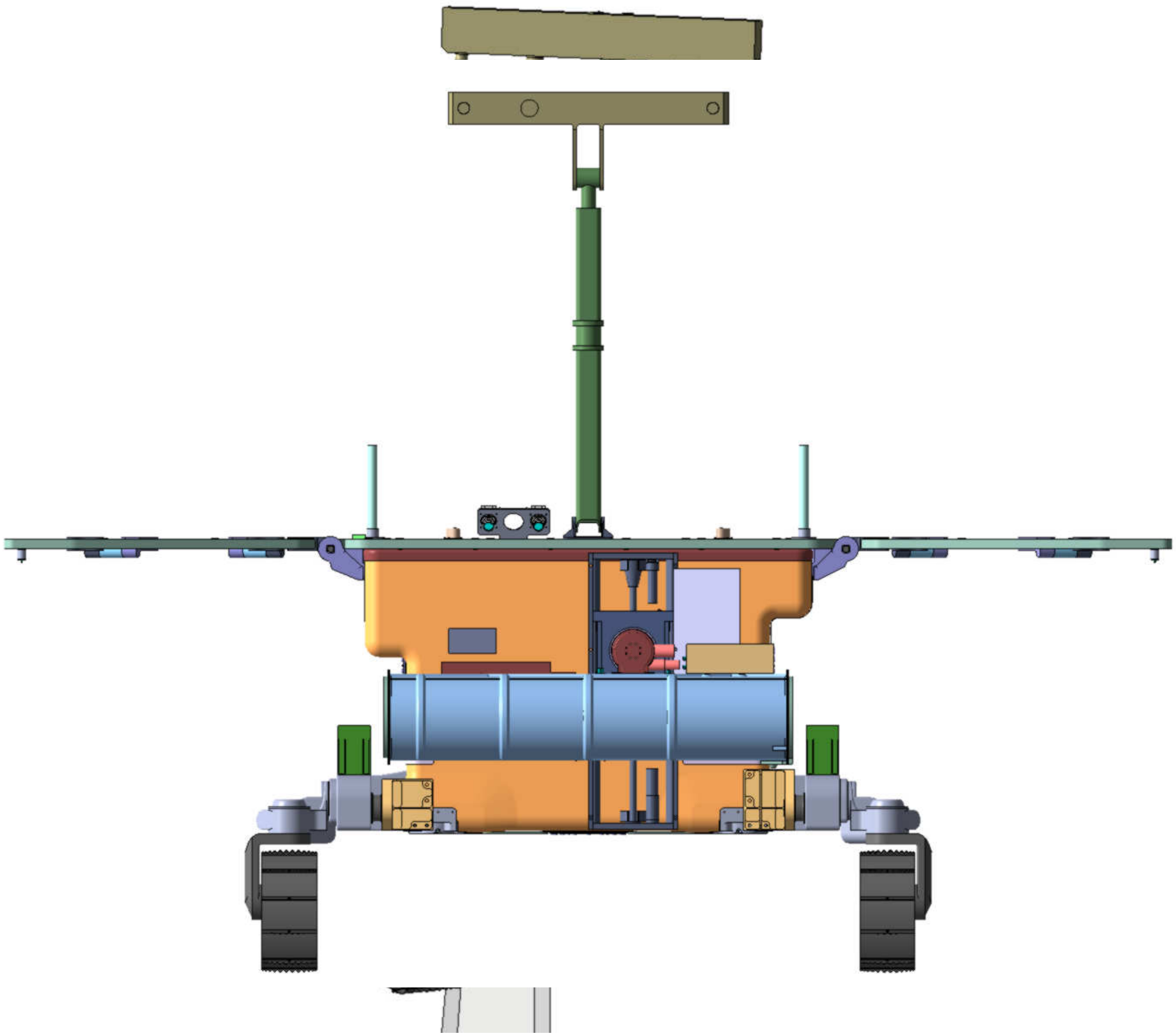
Main body:
- **Structure frame**
- **Thermal insul.**
- **Radiator area**
- **Harness ducts**

Locomotion SS:
- **6 wheels, 21 DoF**
- **Flexible wheels**

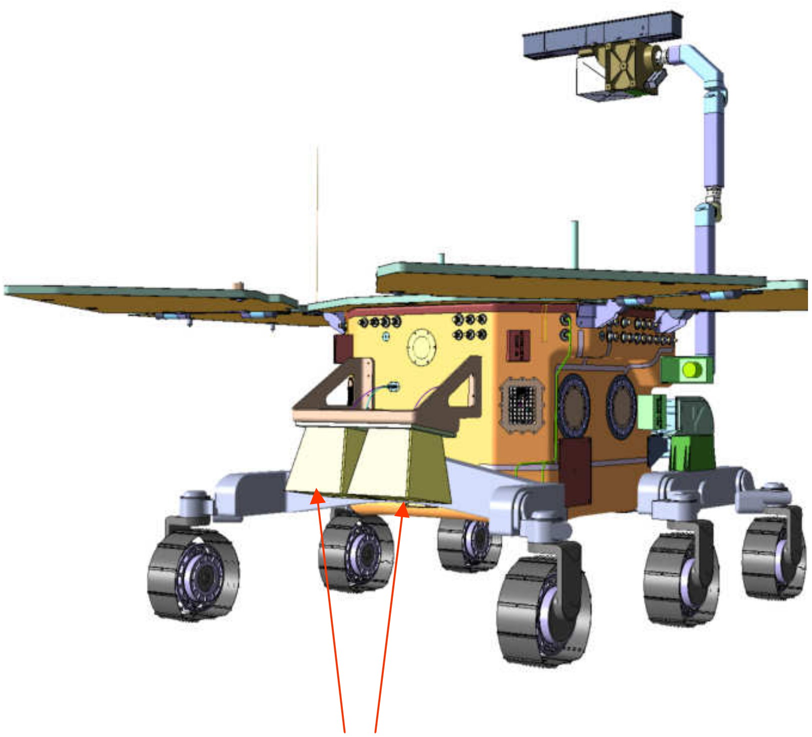
Rover Internal Configuration



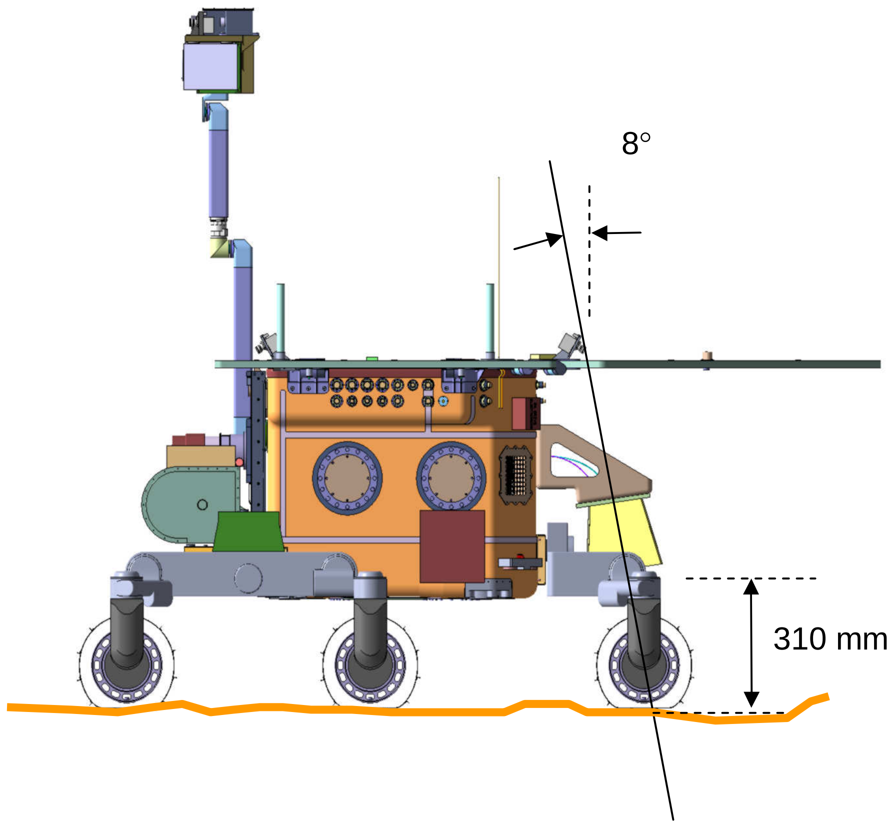
Deployable Mast with PanCam & NavCam (~1.6 m height)



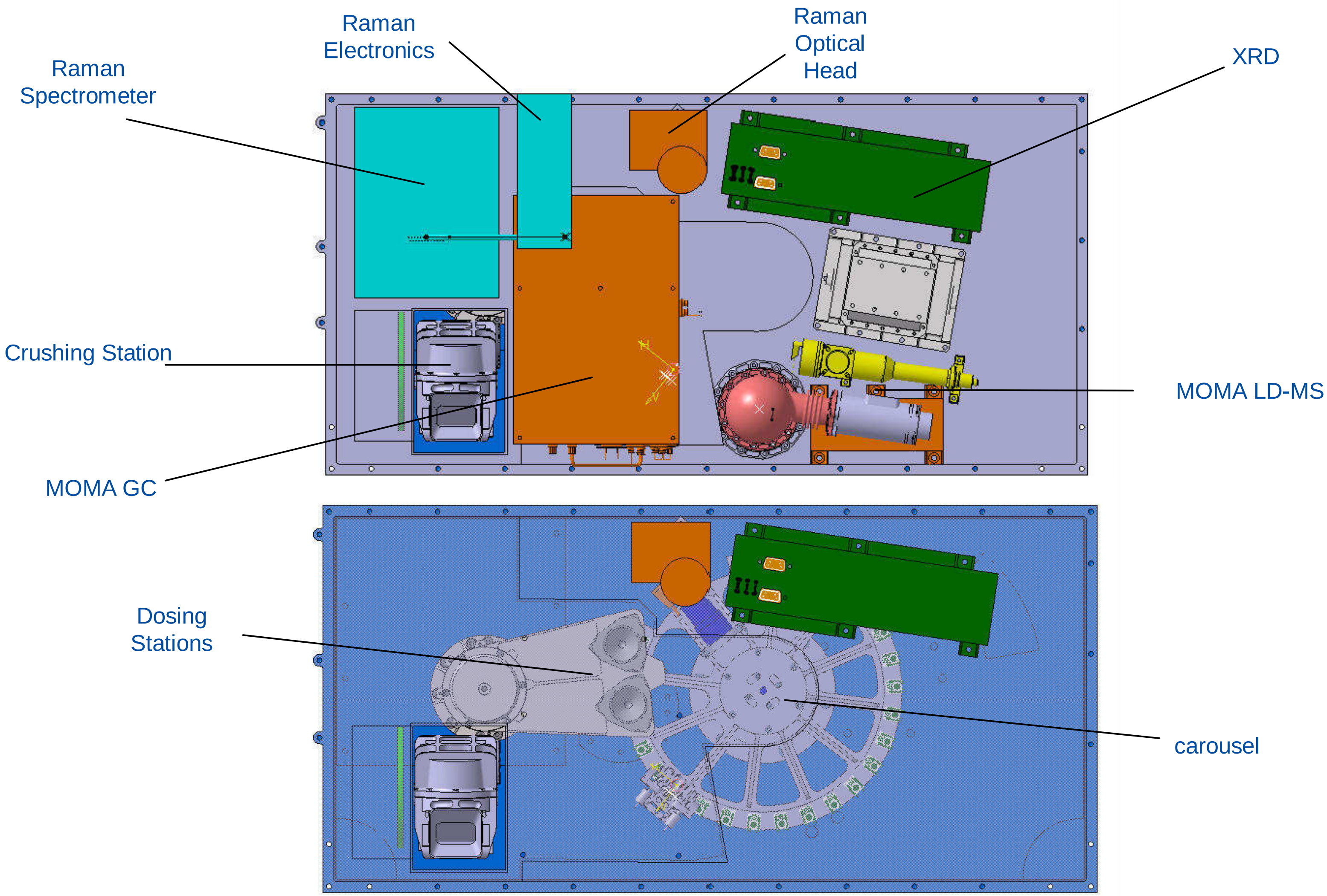
WISDOM Accommodation



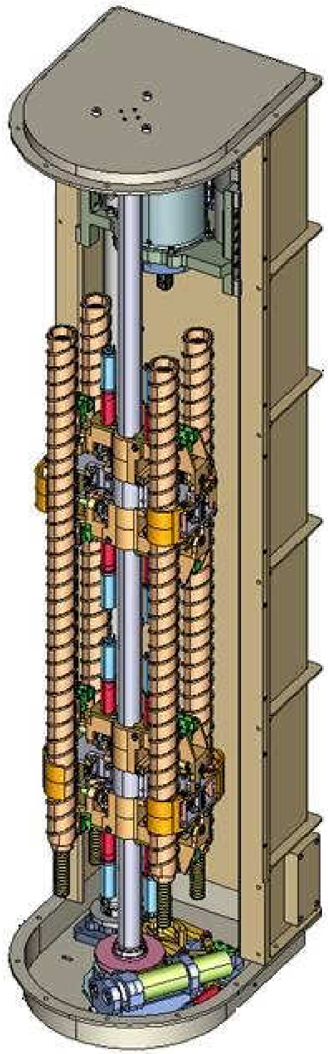
WISDOM GPR Horns (2)

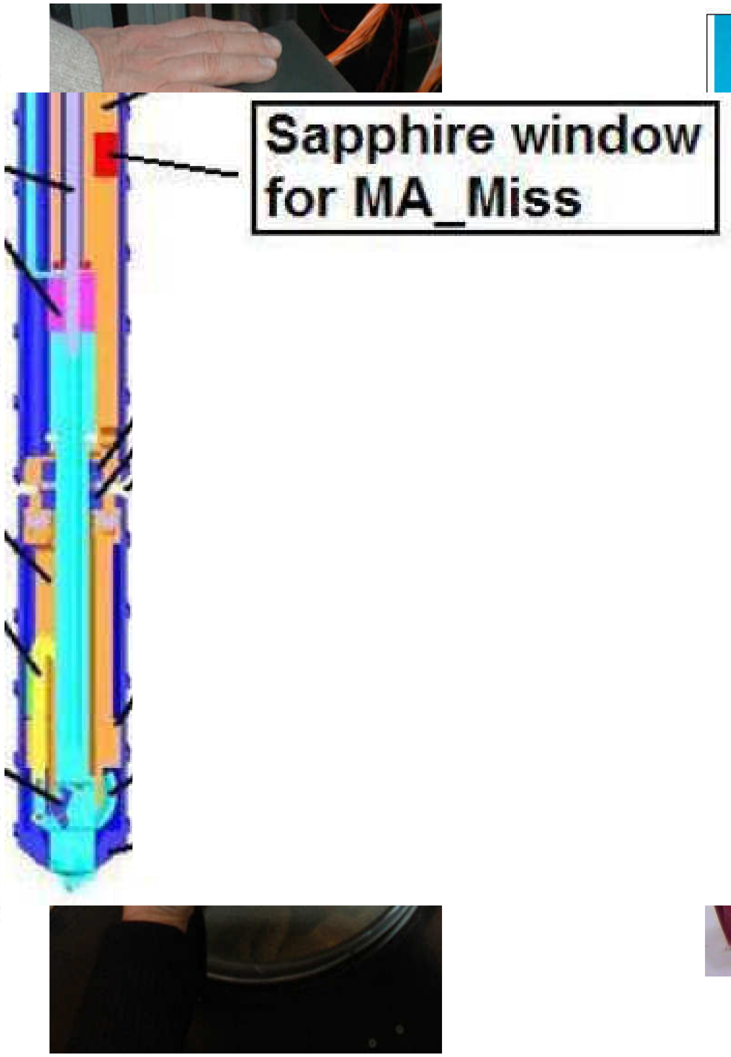


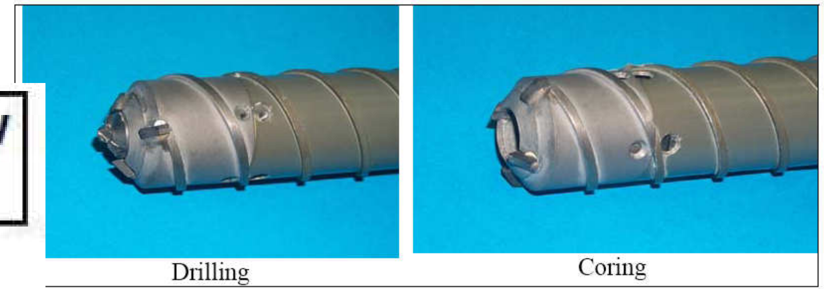
Analytical Laboratory Configuration (2/2)



Drill Configuration







Drill Tool with sample acquisition mechanism

- **Drill box with roto-translational group**
- **Rod magazine & extension rods**

Rover Evolution

❑ The main recent design evolutions are:

- Removal of the Instrument Arm
- HEPA Insulation of the Internal Body Volume
- Optimised Solar Cell Layout and Use of Tilting at Dawn/Dusk
- Reduced Battery with Maintained Performance
- Locomotion Subsystem Refinements
- Deployable Mast Assembly Simplifications (e.g. removal of MIMA)
- Mass Reduction and Design Refinement of the Drill Subsystem
- New Configuration of the Analytical Laboratory
- Mass reduction to reinstate 20% System Mass Margin w/o penalties to the rover system

Mars Robotic Exploration Preparation Programme (MREP)

Programme Objectives

- **ESA Optional Programme subscribed at C-Min(2008)**
- **Objective is to build Mars Exploration programme, in collaboration with NASA, and taking Mars Sample Return (MSR) as long term objectives**
  - **Prepare a series of Mars exploration missions beyond 2016, for enabling implementation decisions by the next C-Min (2011)**
  - **MSR architecture studies (jointly with NASA)**
  - **Long term enabling technology developments, for MSR**

Technology preparation

Two types of technology activities:

- Predevelopment for preparing the 2020 mission: objective is to reach TRL5 prior to implementation decision (Phase B2/C/D)
- Long term enabling technologies: Nuclear power sources, propulsion, sampling, landing and re-entry technologies (for MSR)

- **The first part of the Technology Development Plan (TDP) has been produced and is being implemented (horizon ~ 3 years, includes Nuclear Power Systems & Propulsion)**

- **The second part should be issued by end 2009: 2020 small lander technologies, MSR landing/sampling/re-entry technologies.**

Long term technologies

Nuclear Power Systems

- **Key elements of the plan**
  - ✓ **Radioisotope: selection & production technique,**
  - ✓ **Fuel encapsulation, for RHU and RPS**
  - ✓ **Conversion techniques: Thermoelectric and Stirling engine. Design, with breadboarding in both cases**
- **Schedule: Started in 2009, reach TRL 4 by 2011-2012**

Propulsion

- **High thrust apogee engine (~1.5 kN) for future robotic exploration missions. Improves Mars orbit insertion.**
- **Schedule: start end 2009, reach TRL 4 by 2011-2012**

Example of network Science Probe

- Potential Payloads:
  - Seismometer, mole, magnetometer, panoramic camera, atmospheric instrument suite, optical depth sensor, etc
- Landing site location:
  - +30°N to -15°S, longitudinal spread
- EDL:
  - 70° nosecone aeroshell, 1 or 2 stage parachute, potential retrorockets, unvented airbags
- Surface lifetime: 1 Martian year
  - RHU needed to survive global dust storm season
- Total probe mass: ~135kg
- Planetary Protection Category IVb