
# ExoMars Mission Overview and Status

**SSWG Meeting**
**20-21 April 2006**
**ESA - HQ**

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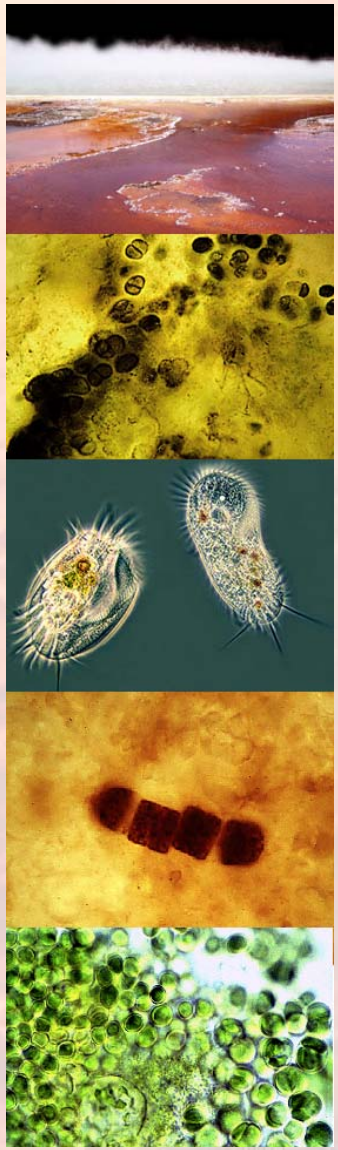
# Mission Objectives

First European led Exploration Mission to be launched in 2011, combining enabling technology development with major scientific investigations



## ❑ Main technology objectives

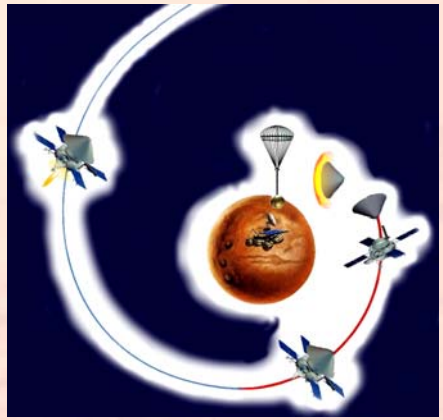
- Safe Entry, Descent and Landing of a large size payload (EDLS)
- Surface mobility (Rover) and access to the subsurface (Drill)
- Forward Planetary Protection

## ❑ Main scientific objectives

- Search for traces of past and present life
- Characterise Martian geochemistry and water distribution
- Improve the knowledge on Martian's environment and geophysics
- Identify surface hazards to future human missions

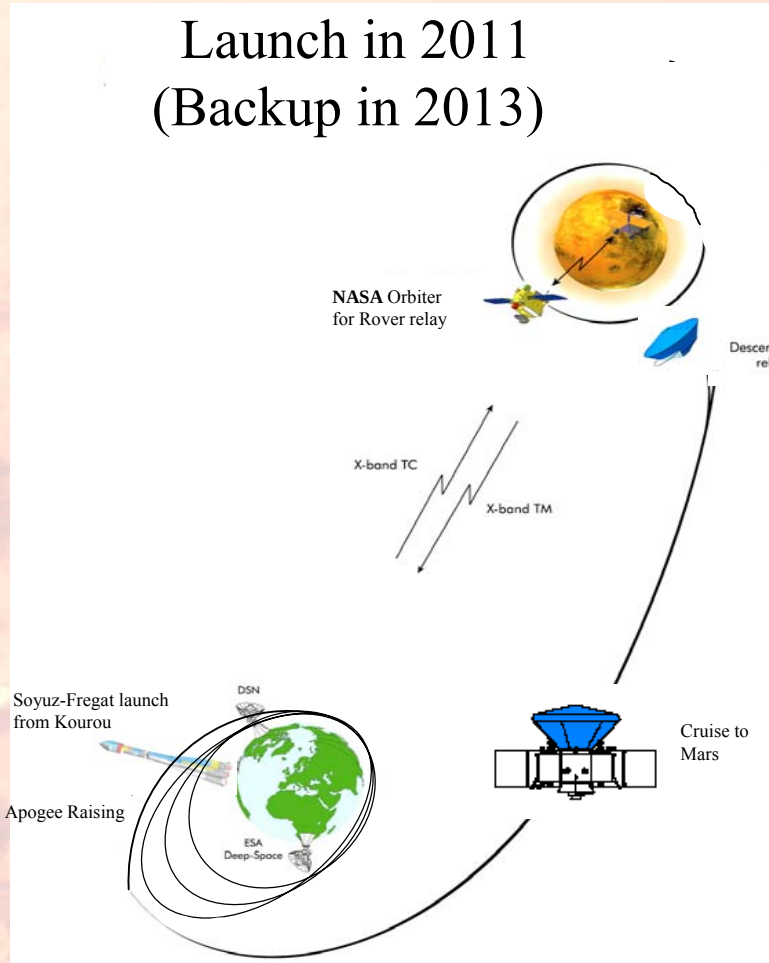
# Baseline Mission-System Architecture Approved at C-Min Dec 2005

| | | |
|---|---|---|
| Spacecraft Composite: | Carrier Module (CM) plus Descent Module (DM) - including Rover<br>Data relay function to be provided by NASA via MRO | |
| Launch: | May-June 2011, from Kourou on Soyuz ST 2-1b/Fregat<br>Mission and spacecraft design shall be compatible with 2013 launch | |
| Arrival: | June 2013 (to arrive, via delayed trajectory, after the dust storm season) | |
| Landing: | Direct entry from hyperbolic trajectory | |
| Landing Range: | Latitudes between 15º S and 45º N, all longitudes<br>Altitude $\leq$ 0 km, relative to the MOLA zero level | |
| Science: | Rover with Pasteur Payload | Mass 120 - 180 kg, includes:<br>Drill System / SPDS and Instruments (8 kg)<br>Lifetime $\geq$ 180 sols |
| | Geophysics/meteorology and Environment Package (GEP) | Mass $\leq$ 20 kg; includes:<br>Instruments (4-5 kg TBC)<br>Lifetime $\geq$ 6 years |
| G.S. and Mission Ops: | Approach for spacecraft composite similar to that employed for Scientific Satellite Missions | Mission Operation Centre @ ESOC |
| | Rover Operation on Mars surface in combination with Rover test bed and Mars terrain simulator | Rover (and Pasteur) Operation Centre @ Altec (Turin) |

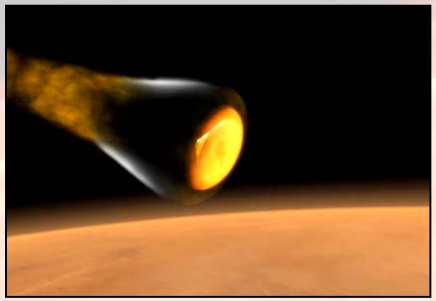


# Mission Strategy

- Soyuz ST 2-1b/Fregat will insert the Spacecraft Composite into a sub-GTO orbit (~30000 km)
- After separation from the launcher, the CM will take the Spacecraft Composite into an escape trajectory by means of a series of apogee raising manoeuvres
- A Mid-Course Manoeuvre will be required to avoid arrival at Mars during the Global Dust Storm season
- Once arrived in Mars proximity, after almost 2 years of Cruise phase, the DM will be released from the hyperbolic approach trajectory, hence initiating the Coasting and Entry, Descent and Landing (EDL) phases

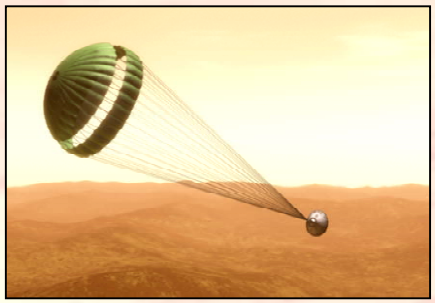


# Entry, Descent and Landing Strategy



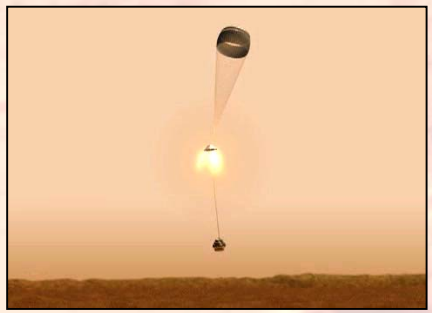
## Entry

**Energy dissipation via aerodynamic drag;**
**Velocity Range: start ~5.4 km/s end ~430 m/s.**



## Parachute Descent

**Energy dissipation via aerodynamic drag;**
**Velocity Range: start ~430 m/s end ~85 m/s.**



## Retrorockets

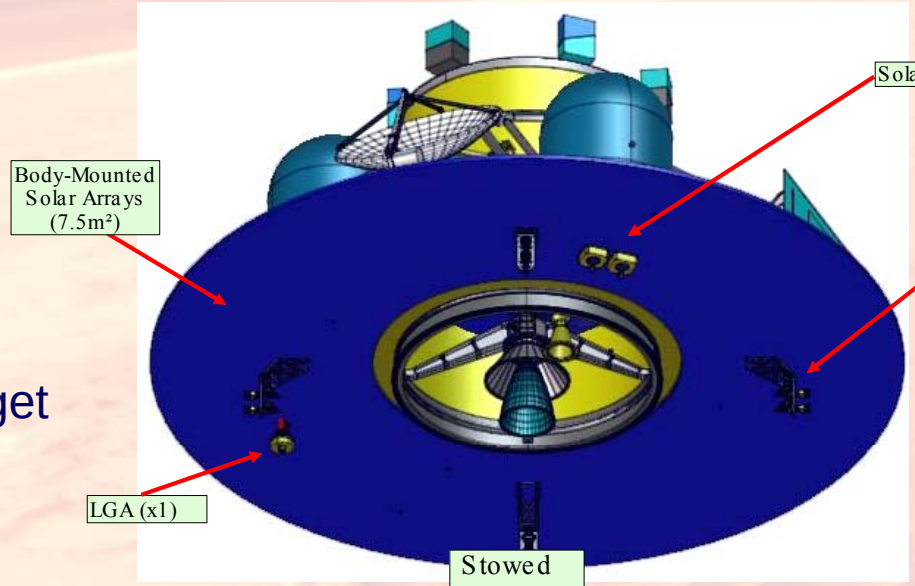
**Energy dissipation via propulsive impulse;**
**Velocity Range: start ~85 m/s end ~10-15 m/s.**

## Landing

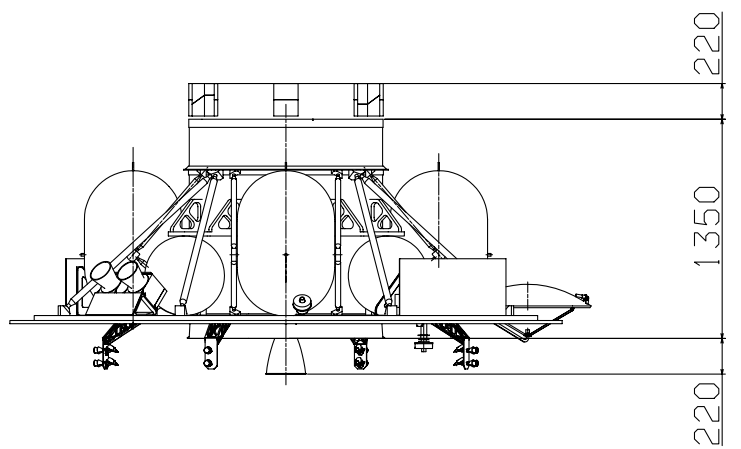
**Landing with airbags**
**Velocity Range: start ~10–15 m/s end 0 m/s.**

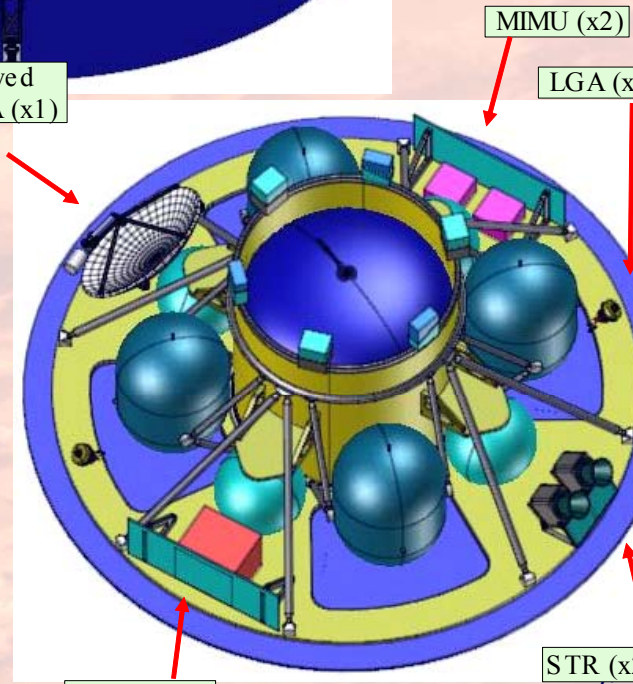
# Carrier Module Description

- The CM will provide controlled attitude and orbit correction capabilities needed to complement the Soyuz launch, perform the LEOP and Cruise manoeuvres and accurately target the DM entry into the Martian atmosphere




- Wet mass 2025 kg (≅ 500 kg dry)
- Average power 600 W
- X-band link to Ear

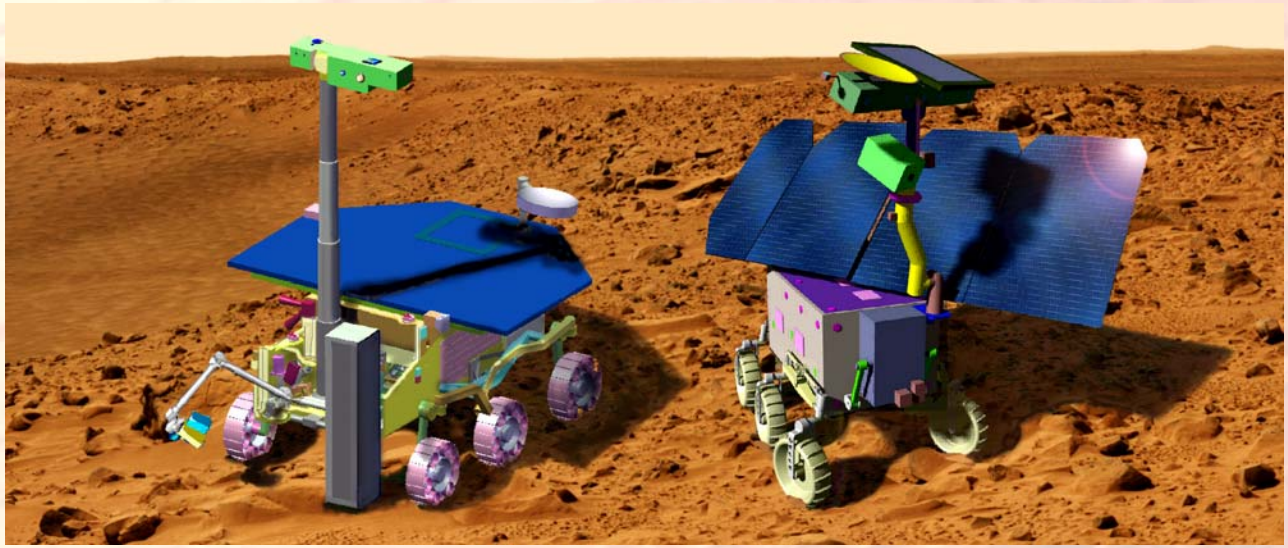


# Rover Module Description

- The Rover will ensure regional mobility (several km) to the Pasteur Payload
- The Rover includes a drill-based sample acquisition and distribution tool which will allow access to surface and sub-surface (down to a depth of 2 m)
- Two Thermal Control solutions still under trade-off: with and without RHU's

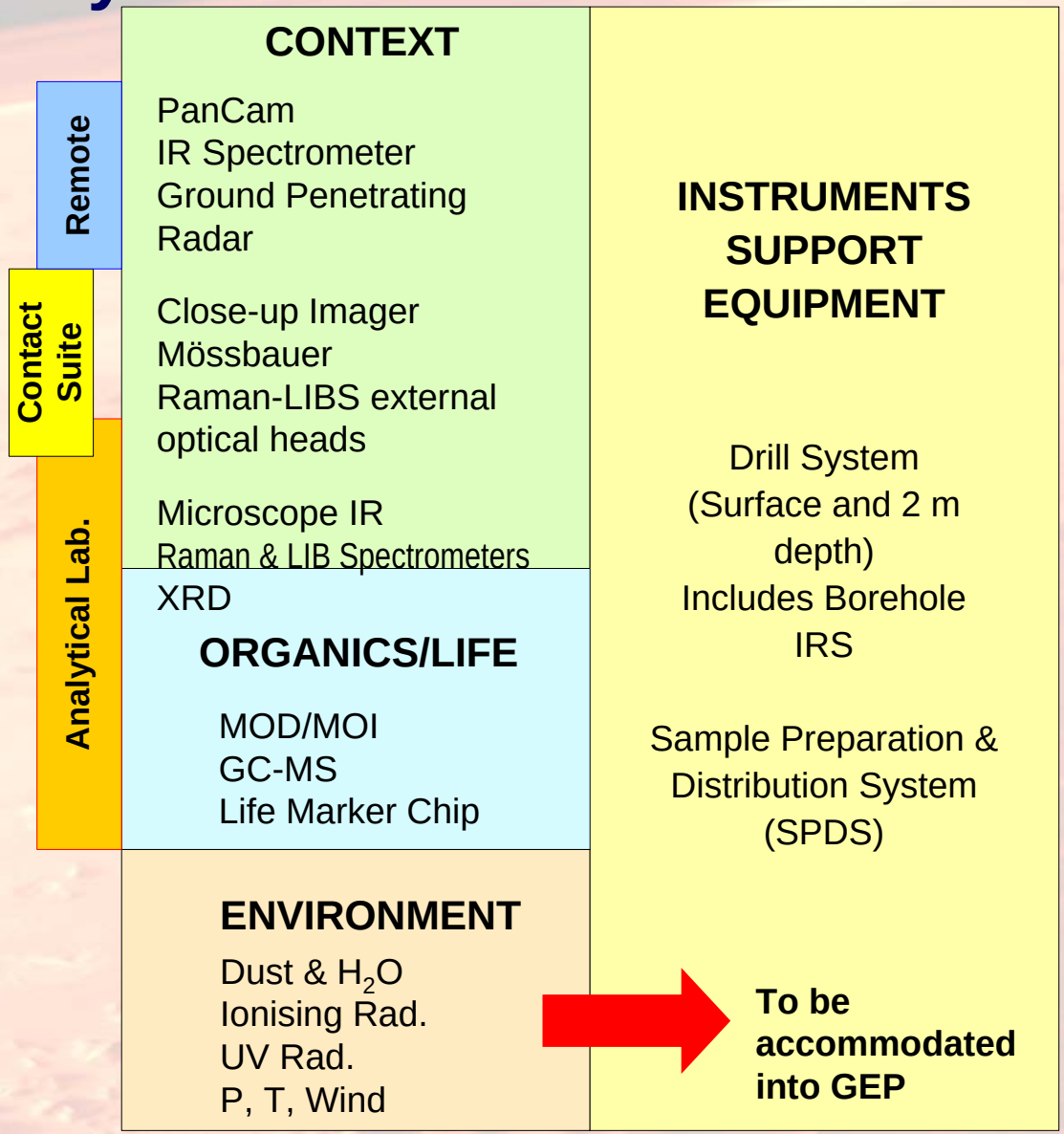
- Mass ~ 165 kg
- Power ~ 280 W (by Solar Array)
- Communication Architecture: X Band for DTE and UHF Band for Proxi-link with MRO



Concept with RHUs  Concept without RHUs

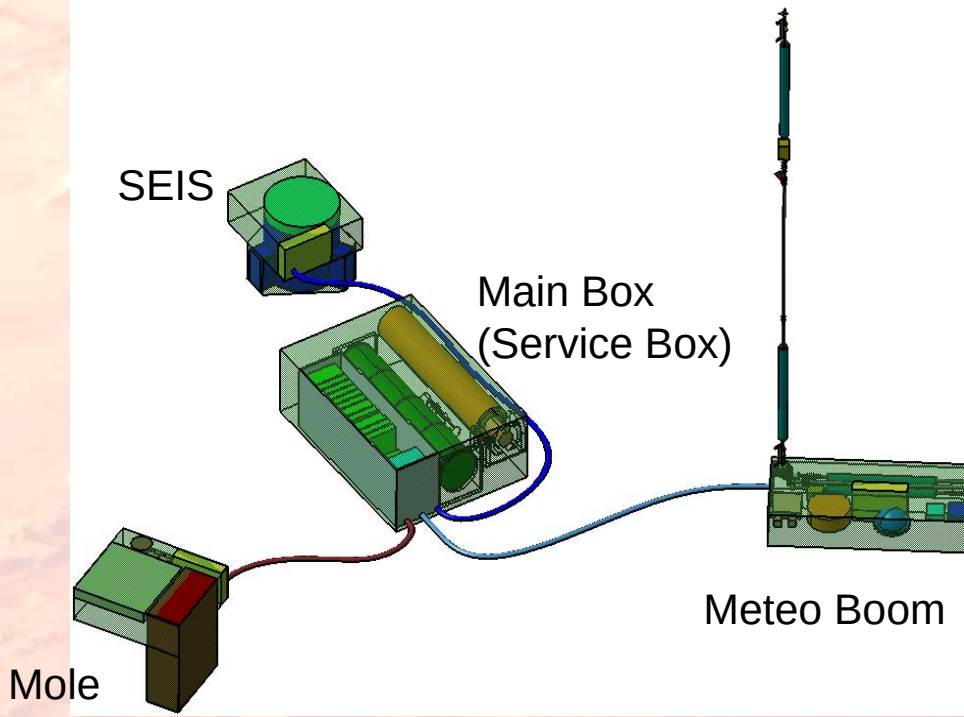
# The Pasteur Payload Instruments

- The current Scientific Instruments mass is 12.5 kg, thus exceeding the 8 kg allocation. If necessary, Instruments from the aside list will have to be de-scoped to comply with the finally available resources
- The instruments development is under the responsibility of relevant National Agencies
- The Drill and SPDS are part of the Rover Module



# The GEP

- The GEP will be carried to Mars by the DM, and will be activated once the Rover egress has taken place
- It  be powered by a small Radioisotope Thermal Generator (RTG) and will become the first element of a proposed international network of autonomous stations devoted to the long-term study of Martian geophysics and ambient conditions
- The GEP will include the following instruments (TBC):
  - Pasteur Payload Environment Instruments:
    - Dust Suite
    - UV Spectrometer
    - Ionising Radiation
    - Meteorological Package
  - Seismometer
  - ATM (set of atmospheric probes)
  - AEP (set of environmental probes)
  - Magnetometer
  - HP3/MOLE



# Mission Operations and Ground Segment

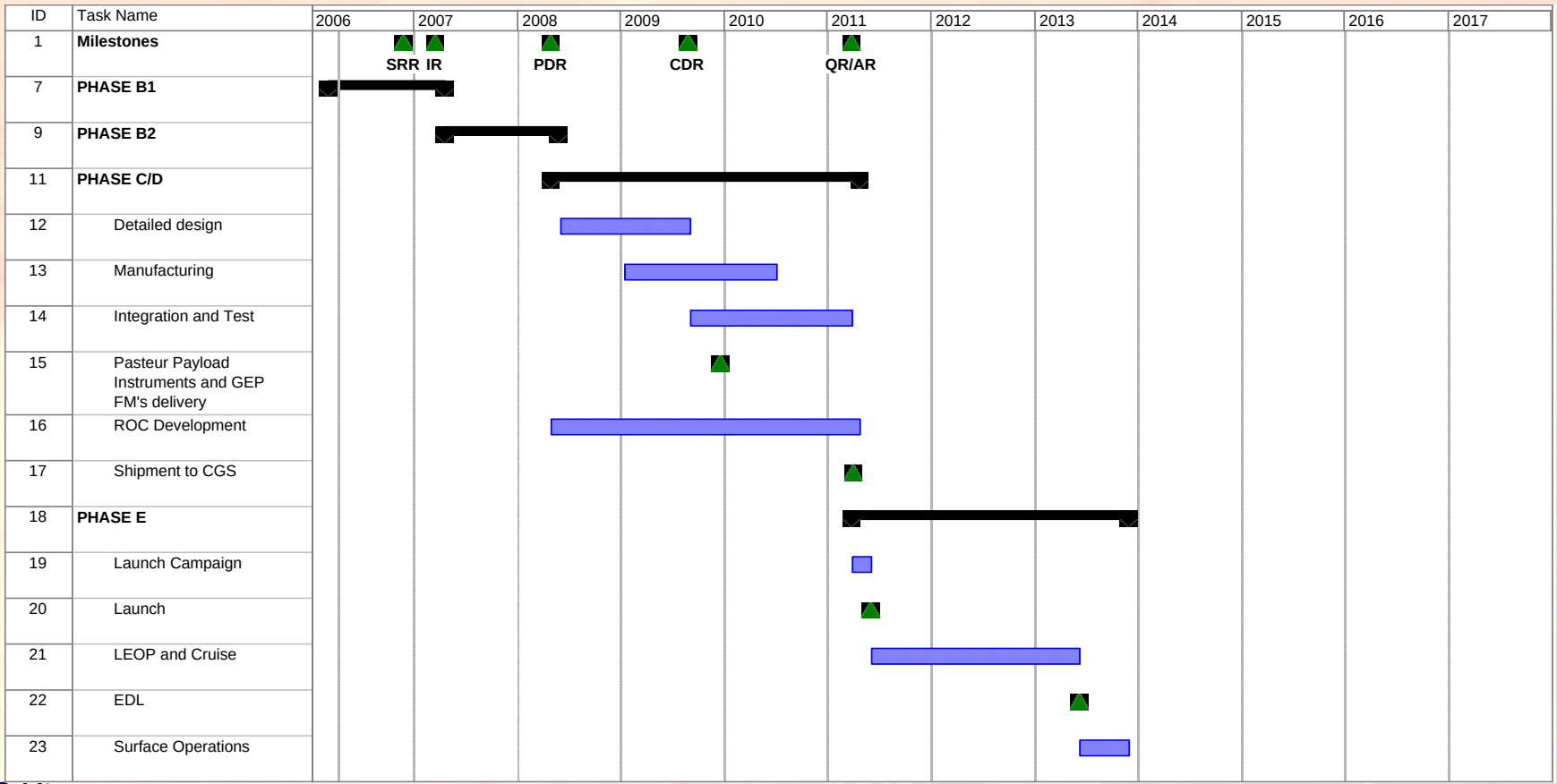
- The spacecraft operations will be similar to those of many other ESA missions, and will be carried out by ESOC
- The operation of the Rover with its scientific payload will require a dedicated Rover Control Centre in combination (locally) with a Rover Test Bed and Mars Terrain Simulation Facility
  - to implement the near-real time handling of telemetry from the Rover and telecommand to the Rover for the execution of the daily surface operations.
  - to test on ground the daily surface operations, to validate the sequence of commands to be uplinked and to prepare and validate relevant procedures for reacting to off-nominal situations
- The conceptual design and the architecture requirements definition for this centre is one of the subjects of the Phase B1 industrial study

# Project Reviews

- Key milestones for the overall project cycle (B/C/D/E) have been identified in terms of major project reviews:
  - System Requirement Review (SRR), in phase B1
  - System Preliminary Design Review (PDR), concluding the Phase B2
  - System Critical Design Review (CDR)
  - System Qualification Review and Acceptance Review (QR/AR), concluding the Phase C/D
  - Operational Readiness Review (ORR), Flight Readiness Review (FRR) and Launch Readiness Review (LRR), foreseen in Phase E
- Technology readiness and Payload interfaces will be dealt with in the context of the above-mentioned reviews

# Master Schedule

- In the schedule below, it is assumed that the Phase B2 and C/D is authorised for starting by early 2007 and that the transition from the 12 months Phase B2 to the 32 months Phase C/D will be smooth
  - As a unique milestone the Implementation Review will conclude the phase B1 and authorise to proceed to phases B2, C/D and E



# Outcomes of the December 2005 C-Min (1/2)

- At the December 2005 ESA Council al Ministerial Level, the implementation and exploitation phases (B2, C/D and E) of the baseline ExoMars mission were approved and funded

- With reference to the Programme Declaration, two mission options in addition to the baseline scenario shall be studied in Phase B1 to enable Participating States to decide on the final mission scenario. These options are:

1. To add a separate European communications satellite (to be launched separately) to the baseline scenario

2. To implement an Ariane 5 based mission having a Mars Orbiter, acting as a communications (and orbital science) node, enabling a more robust mission design and a relatively large Pasteur Payload to be deployed on the Martian surface

# Outcomes of the December 2005 C-Min (2/2)

- Prior to proceed into Phase B2 and C/D an Implementation Review by the Participating States shall be conducted on the basis of:
  - The results of the SRR, including the two Orbiter options
  - A committing industrial schedule and cost for the development and exploitation of ExoMars
  - An agreement with the Participating States concerning the provision of the selected Pasteur Payload Instruments and the GEP
- In concluding the a. m. Implementation Review the Participating States will take a decision on the development and exploitation phase of ExoMars, addressing:
  - The final payload configuration (and the relevant funding for the development and exploitation of the Pasteur Payload Instruments and the GEP)
  - The launch date for the mission
  - The confirmation that the Project can be implemented within the available financial resources

# Status of Phase B1 Industrial Activities

- Phase B1 industrial activities kicked off with AAS-I (Prime Contractor) on 3-4 October 2005. Soon after, mission-system level work and selection of Subcontractors commenced
- Phase B1 Contract with AAS-I signed in November
- Procurement of System level support analyses/tasks on going:
  - Composite Mission Analyses and DM EDL Analyses kicked off on 17 January
  - DM Aerodynamic/thermal Analyses kicked off on 19 January
  - Planetary Protection Support Tasks ITT issued end November, proposals received end January and now under evaluation
- Spacecraft Composite Requirements Review (SCRR) performed (January – February):
  - RID Close-out completed early April
- Phase B1 Re-direction (to be implemented following the outcomes of Dec 05 C-Min) almost finalised:
  - Subcontractor's selection process for relevant Modules and Subsystems to be soo resumed

# Status of Key Enabling Technologies

- Before the start of Phase B1, a series of R&D activities (Aurora/TRP) related to ExoMars have been performed. The results of these activities are being considered in the context of the Phase B1

- The development of ExoMars key technologies (namely EDLS, Rover and Drill) are part of the Phase B1. In particular, breadboard models of airbags, Rover navigation and locomotion and the Drill and Sample Preparation and Distribution System will be manufactured and tested to achieve TRL 4/TRL 5 (as goal)

- Continuation of key technology development will be part of following project phases consistent with the main ExoMars Mission objective (i.e. flight and in-situ qualification of new enabling technologies such as the Entry, Descent and Landing System, the Rover and the Drill)

# Status of Pasteur Payload Interfaces

- Implementation of Technical Readiness Level (TRL) Upgrade Program for selected Pasteur Instruments (up to TRL 4 / TRL 5 as goal) on-going:
  - XRD (September), IR Spectrometer (November), Dust Instrument Suite (November), UV Spectrometer (December) and GCMS (March) activities kicked off
  - Activities for RAMAN/LIBS and LMC instruments will follow in staggered approach

- Good progress achieved in the definition of Instruments interfaces:
  - Pasteur Payload Instruments Interface WS #1 held on 23-24 January and short term planning agreed together with Phase B1 interface activities planning
  - Instrument Information Packages (IIPs) part A delivered by Instruments Teams and considered in view of IRD preparation. IIPs part B requested and being delivered in staggered approach
  - IRD Issue 1 issued together with ICD template: a series of interface meetings is planned (April – May time frame) to discuss and assess input for ICD consolidation

# Status of GEP Interfaces

- Assessment of GEP configuration and DM/GEP interface definition performed in cooperation with CNES (CNES CIC study - ESA CDF equivalent) during October – November
  - Main outcomes passed as interface data to the industrial Prime Contractor for evaluation and consideration in view of the IRD preparation
  - Preliminary GEP accommodation performed: Relevant results reviewed in the context of SCRR
- GEP Interface WS # 1 held on 14 February and short term planning agreed
- A new accommodation study has been performed by CNES taking into account the interface constraints applicable to the GEP
  - Main study outcomes will be taken into account to consolidate IRD
  - First issue of DM to GEP will be distributed together with ICD Template to GEP by end April

# Status of International Cooperation with NASA (1/2)

- Initial contacts established and discussion held with NASA (at the occasion of the MEPAG Meeting, 2-3 November)
- Letter (received before the Dec 05 C-Min) preliminarily confirming NASA intent to cooperate on the ExoMars mission
- Consolidation activities to secure the NASA provision of the following elements initiated:
  - The provision of the Urey exobiology instrument (MOD+MOI)
  - The provision of Data Relay infrastructure and telecomm service for the ExoMars Rover, e.g. via MRO (2013) or Mars Science Orbiter (2015) as back up
  - The provision of high resolution images of Mars (from MRO data) for the selection of potential landing sites
  - The provision of technical support for mission-system and spacecraft design, operations and project reviews, in particular for the development of DM (e. g. EDLS) and Rover (e. g. Communication System)

# Status of International Cooperation with NASA (2/2)

- The preparation of the ESA – NASA Understanding for the ExoMars Mission Cooperation is being finalised
  - It will be submitted to NASA and once this is agreed and signed the finalisation of the ExoMars dedicated ESA-NASA MoU will be initiated

- Coordination with JPL has been implemented to achieve compliance with ITAR. Two 2 TAA's currently under preparation:
  - one on the provision of support and services for ExoMars S/C design, verification and operational support
  - the other on the Urey instrument data exchange

- The objective is that JPL TAAs are submitted to US State Department by mid April hence approval is obtained in June