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Scope of this presentation is a walk through the **Alcatel Alenia Space Italia** lead projects within ESA “Aurora” program dealing with the MARS exploration.

Making reference to the activities to be performed in these contests some of the enabling technologies could be adopted entirely or partially to the moon exploration programs.

To reach the end objective “The presence of humans on Mars”, three main paths should be followed:

- *Mars robotic missions*
- *Missions on the Moon*
- *Development of some enabling technologies working in Earth Orbit*

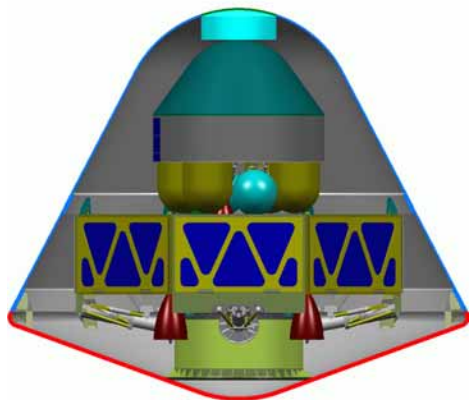
Main differences when approaching Mars and Moon missions:

- Martian gravity level is greater (nearly twice) than the lunar one which has implication on landing and mobility technologies
- Mars has an atmosphere which implies differences in Entry, descent and landing operations (typically based on heatshields, parachutes and airbags)
- Soil temperature variations are different due to presence of atmosphere and distance to the Sun
- Approach to planetary protection is significantly different. For Mars exploration is a key requirement
- Communication latency requires extensive autonomy capabilities

Alcatel Alenia Space - Italia is Prime Contractor for:



Exomars : currently in Phase B1, Phase B2/CD expected to start in the second half of 2007. Launch date 2011, back up 2013.



Mars Sample Return: currently in Phase A2. precursor missions launch 2016.

ExoMars program & enabling technologies for Moon exploration

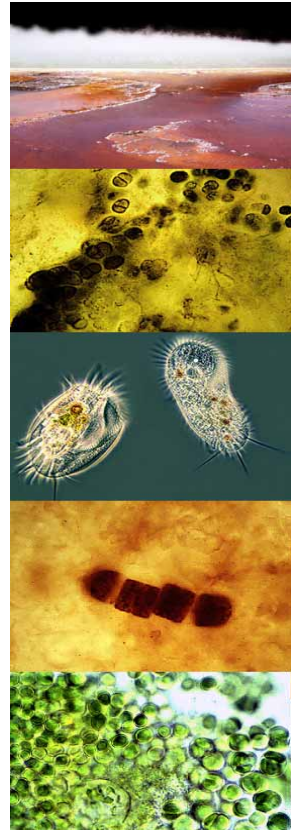
First European led Exploration Mission, combining development of exploration enabling technology with major scientific investigations

❑ 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

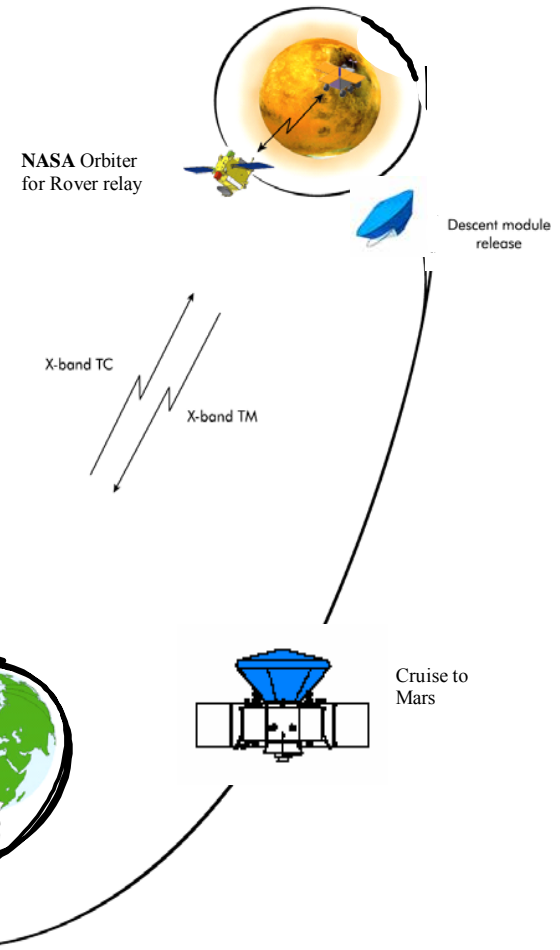
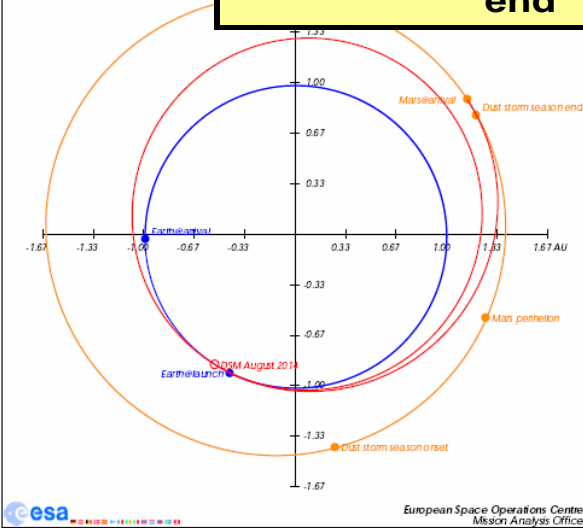
❑ Main scientific objectives

- 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



	2011 Launch	2013 Launch
Launch Window Start	29/05/2011	16/05/2013
Launch Window end	18/06/2011	05/06/2013
Deep Space Manoeuvre	Oct 2012	Aug 2014
Mars Arrival	09/06/2013	21/03/2015
Mars Landing	09/06/2013	21/03/2015
Nominal Surface operations end	10/12/2013	29/09/2015
Extended Surface operations end	10/06/2014	29/03/2016

ESA Mars transfer via Soyuz-Fregat
Launches: May 2011
Mars arrival: March 2015



Spacecraft Composite

Carrier Module (CM) plus Descent Module (DM) including Rover.
Data relay function to be provided by NASA via MRO

Launch

May-June 2011, from Kourou on Soyuz ST 2-1b/Fregat
Mission and spacecraft design shall be compatible with 2013 launch

Arrival

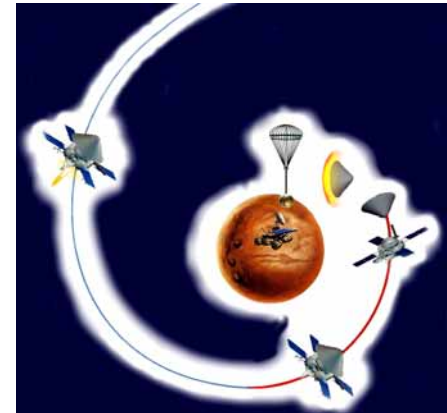
June 2013 (to arrive, via delayed trajectory, after the dust storm season)

Landing

Direct entry from hyperbolic trajectory

Landing Range

Latitudes between 15° S and 45° N, all longitudes - Altitude \leq 0 km, relative to the MOLA zero level



Science

Rover with Pasteur Payload



Mass \leq 180 kg, includes:
Drill System / SPDS and
Instruments (12.5 kg)

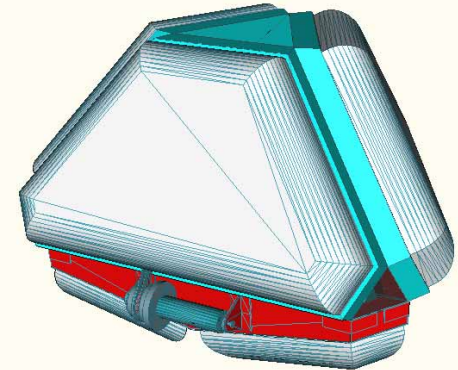
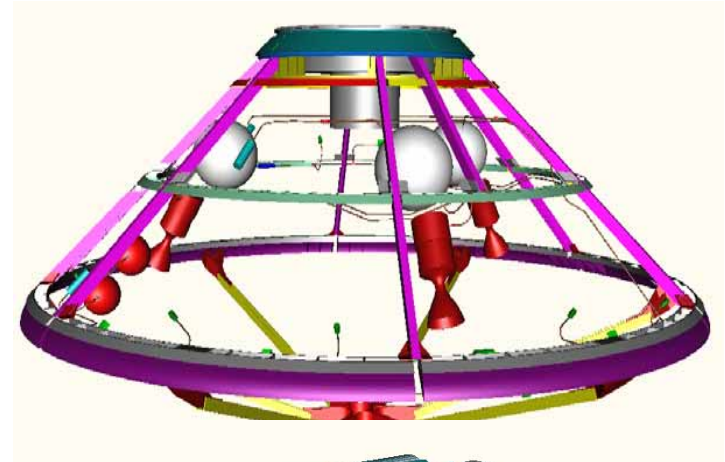
Geophysics/meteorology and
Environment Package (GEP)

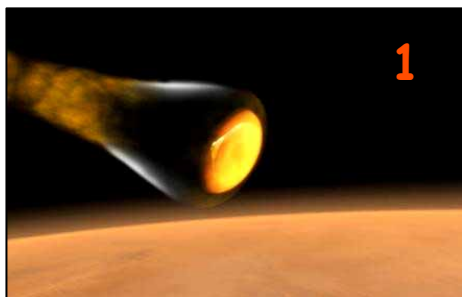


Mass \leq 20 kg; includes:
Instruments (4-5 kg TBC)
Lifetime \geq 6 years

	Mass [kg]	Note
Composite Dry	1519	Including 20% system Margin
Carrier Dry	490	Pasteur + GEP
Descend Module	1030	
Rover Module	179	
Payloads	12.5 + 20	
ΔV	1917	m/s
Total propellant Mass	1379	Bipropellant system
Total S/C composite Wet	2898	
TOTAL AT LAUNCH	2988	

- ❑ The DM will perform the Coasting and EDL (onto Mars surface) of two elements: the high-mobility Rover, which carries the Pasteur Payload, and the GEP -
 - ❑ Mass = 1006 kg
 - ❑ Energy ~700 Wh for EDL
 - ❑ X-band tones to Earth and UHF link with MRO during coasting and EDL
- ❑ The DM can be split in two differentiated parts:
 - the system which allows the safe landing, i.e., the Entry Descent and Landing System (EDLS)
 - the landing platform (which includes the Rover).





1

Entry

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



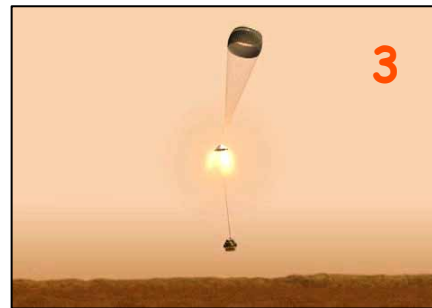
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Parachute Descent

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 $\sim 10-15$ m/s.



3

Landing

Landing with airbags
Velocity Range: start $\sim 10-15$ m/s end 0 m/s.



4

Locomotion:

- 6 wheels, RCL chassis

TTC:

- X-band subsystem for DTE:

- 2 redundant transponders
- 2 redundant 15W SSPA
- 1 RFDN
- 1 Small HGA (30cm dish, 24dBi gain)

UHF subsystem for relay with MRO

- Internal redundant Proximity-1 compliant transponder
- 1 LGA (quad helix)
- 1 RFDN

Thermal Control:

- Two options with and without RHUs

Navigation:

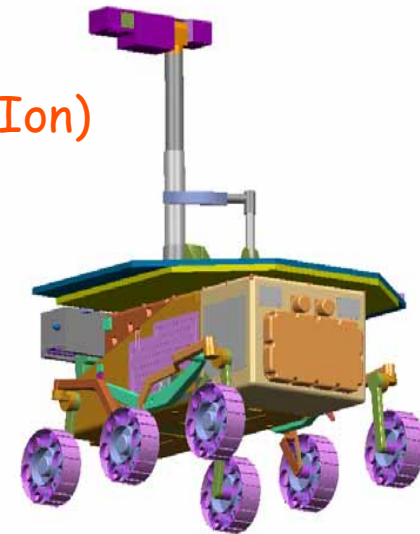
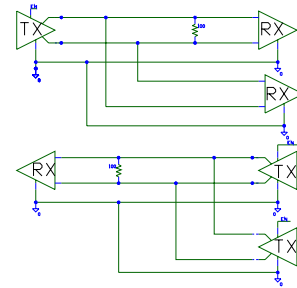
- Camera
- Navigation sensors
- Software

Electrical Power:

- Solar Array
- Battery (Rechargeable, Li-Ion)
- PCDU

Payload Handling:

- Payload management
- Data Compression
- Autonomy



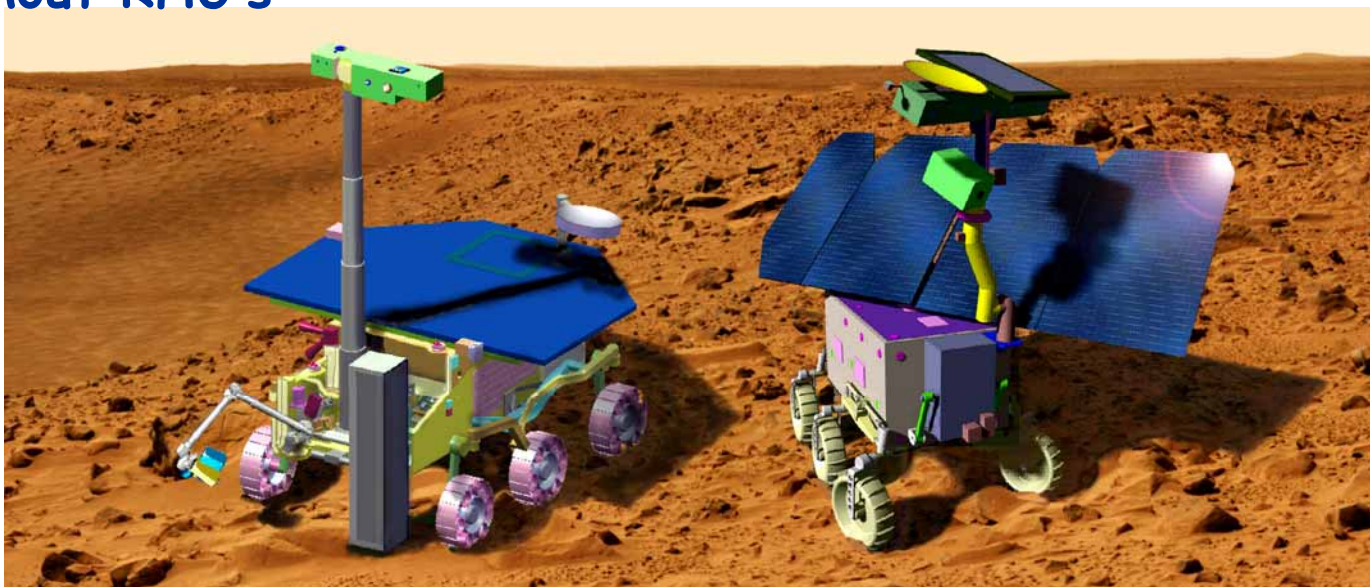
The current concept for the EDLS includes:

- Rigid Front Shield and Back Shell
- Flight instrumentation in the aeroshell
- Parachute Assembly (Single Disk Gap Band)
- Vertical and Horizontal Solid Retrorockets or Combined Vertical-Horizontal Throtttable Liquid Retrorockets
- Airbags Assembly

For the airbag system, parallel developments are foreseen, in Phase B1, for two concepts: one similar to the NASA bouncing airbags; the other utilising vented airbags. Neither currently available in Europe.



- ❑ Mass = 179 kg
- ❑ Power ~ 280 W (by Solar Array)
- ❑ Communication Architecture: X Band for DTE and UHF Band for Proxi-link with MRO
- ❑ Two Thermal Control solutions still under trade-off: with and without RHU's



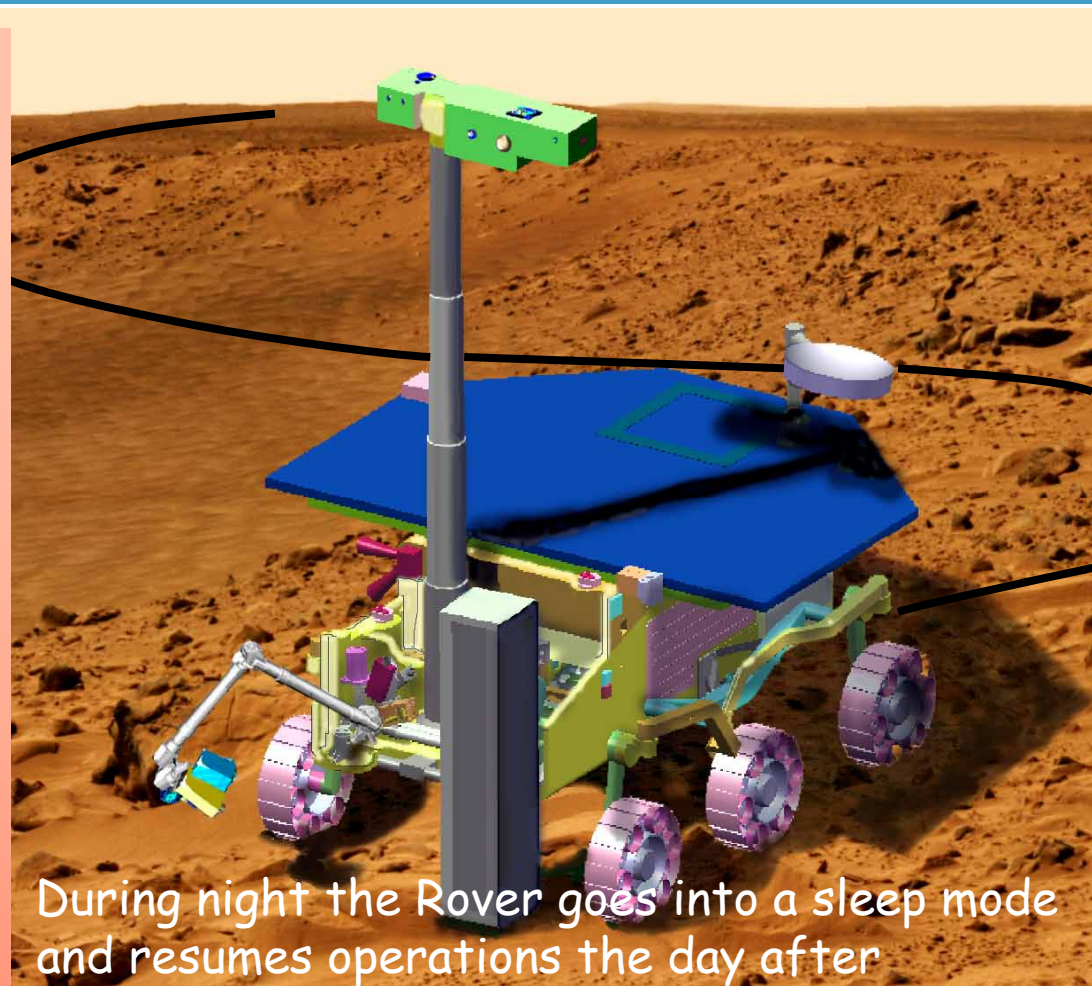
An **Experiment Cycle** consists of:

Identifying the location at which to perform the Measurement Cycle (from Ground Control)

Traveling to the new location (distance about 1 km between locations)

Performing a full Measurement Cycle using all instruments

Transmitting scientific, housekeeping and navigation data to the Relay Orbiter/Earth (Data volume ~ 1Gbit per Experiment Cycle)



- ❑ **Rover mass optimization (material, compacted avionic, miniaturization)**
- ❑ **Sample collection, preparation and preservation (Drill & SPDS technology)**
- ❑ **Rover mobility, navigation and autonomy**
- ❑ **Rover control concept including the Operations Center**
- ❑ **Release from orbit of the landing vehicle**

Mars Sample Return program & enabling technologies for Moon exploration

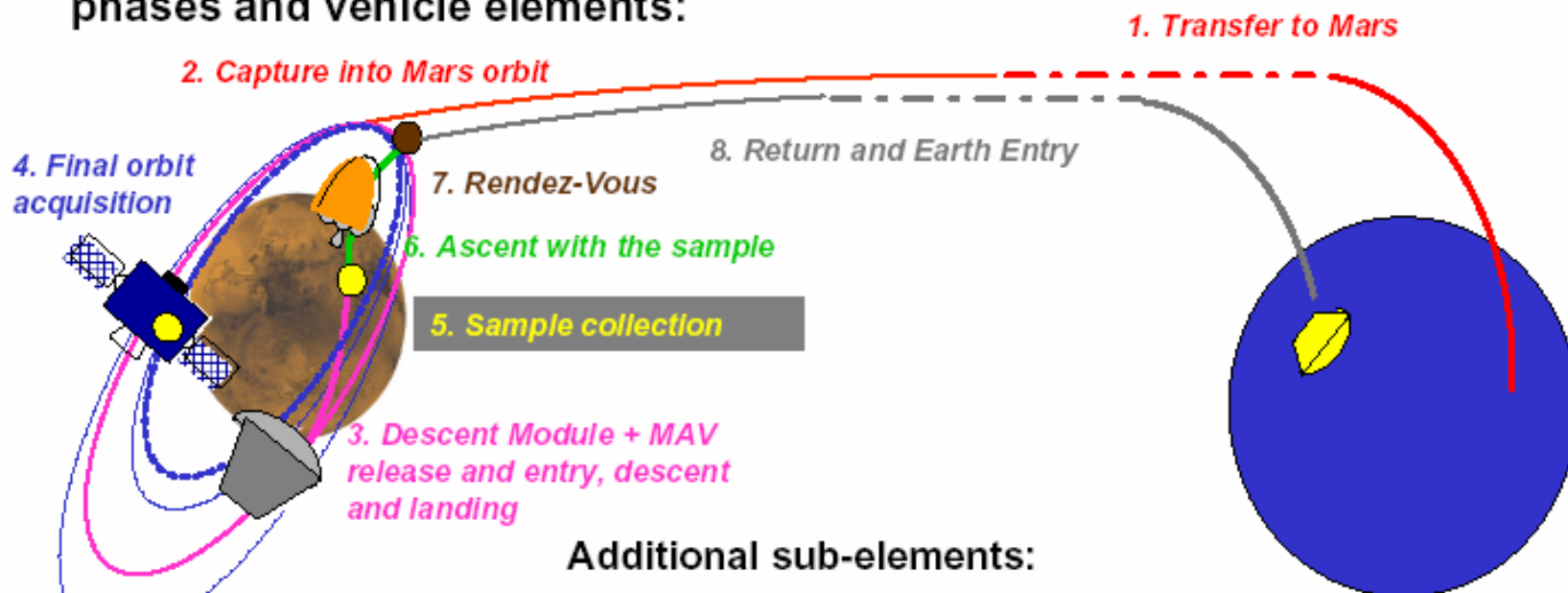
MISSION OBJECTIVE:

- **to get a sample of Martian soil and atmosphere to Earth**

PHASE A2 OBJECTIVES:

- **to review mission requirements**
- **to consolidate mission architecture**
- **to define mission requirements for 2 precursor missions**
- **to define mission/system architecture for 2 precursor miss.**

Whatever the strategy/architecture the mission features several phases and vehicle elements:



Additional sub-elements:

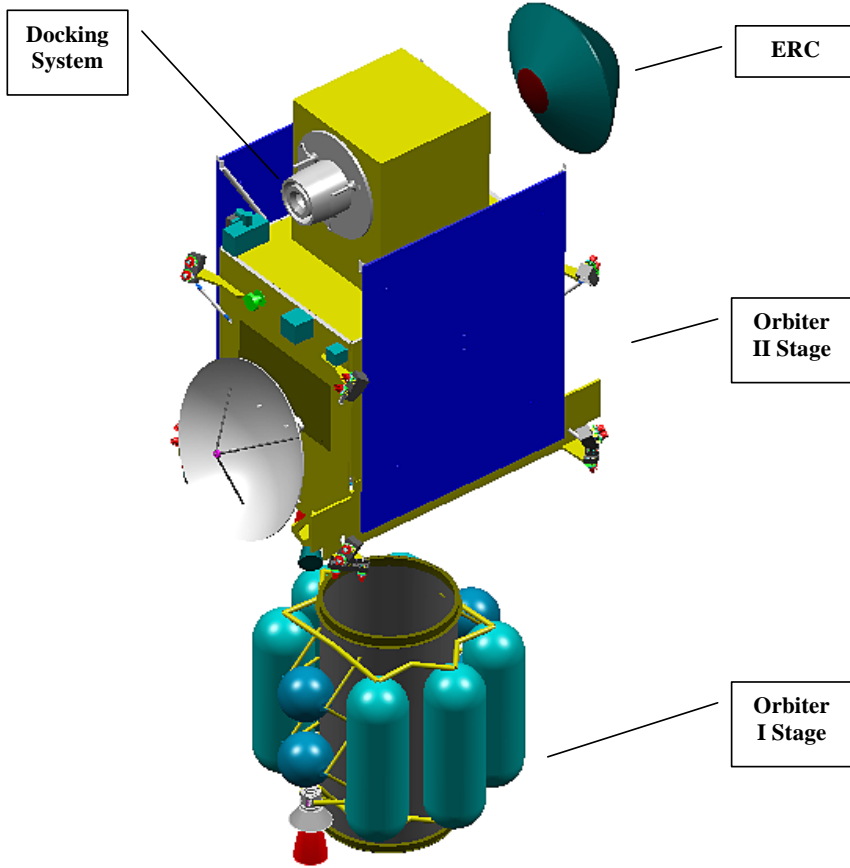
- **Sample container:** a complex system including sub-containers, sealing system, a device (redundant) to check the sealing function
- **Sample container transfer system** from ground to ERC
- **Mars drilling station:** the system that performs the drilling and handling of the sample to its container

- 
- 3 Launch Windows identified: **2018 / 2020 / 2022** (AR-5)
 - Precursor Missions Launch : **2016** (Soyuz)
 - Precursor Mission Approval : **2008**

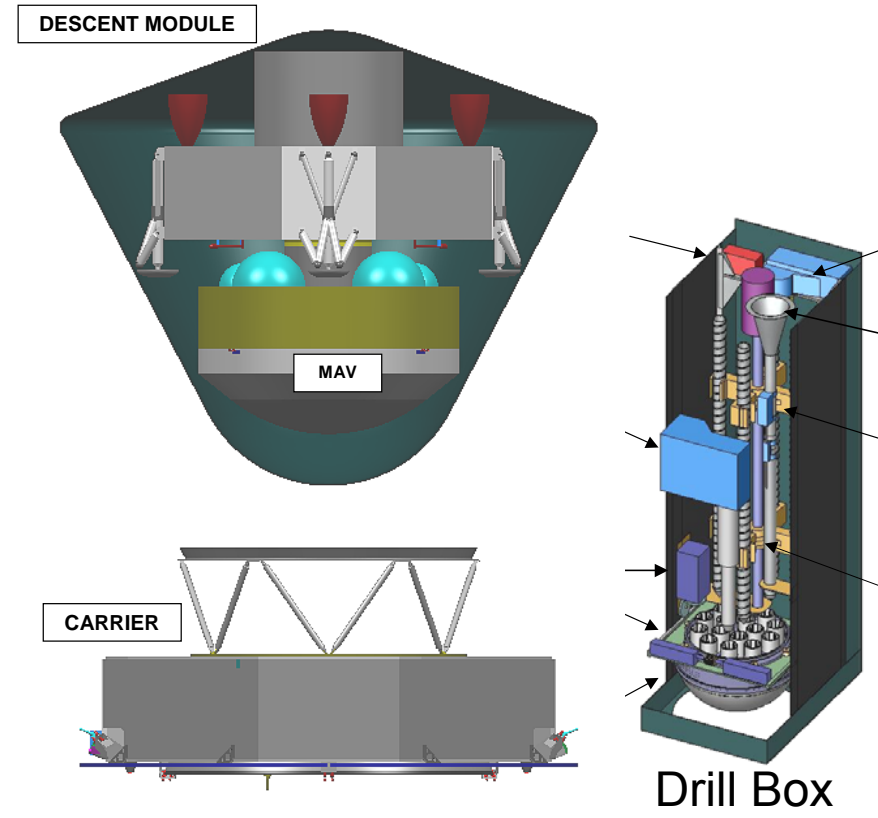
Phase A2: September 2006 – September 2007

Phase A1: October 2003 – September 2004

Launch Composite #1



Launch Composite #2



Entry, Descent and Landing on Mars

- Very high landing mass w.r.t. other missions
- Requirements on landing site accuracy very severe (in the order of 10-km semi-major axis), which means GUIDED Entry instead of Ballistic
- Soft Landing and Soil Recognition capability

RendezVous and Capture or Docking

- Capture: never done before
- Docking: much more complex than capture, but still under trade-off; never done before in autonomous way

Ascent from Mars Surface

- Never done before

RendezVous and Capture or Docking

- Capture: never done before
- Docking: much more complex than capture, but still under trade-off; never done before in autonomous way

Earth Re-entry

- Never done before at the required speed

Candidate Precursor Missions

1. Soft Landing and soil recognition

Too much expensive to be deployed on Moon or Mars. Technologies can be developed by means of Earth-based technology development plan

2. Guided Entry

It could be deployed as secondary P/L of other missions to Mars, with a small capsule having the same ballistic coefficient – Not seen as applicable for moon missions

3. Ascent from Mars Surface

Too much expensive to be deployed on Mars. On Moon it is not significant (no atmosphere).

Candidate Precursor Missions (cont.d)

4. RV & Capture or Docking

- Benefit-to-cost ratio very interesting if performed as a secondary experiment of another mission. **APPLICABLE TO MOON MISSION**

5. Earth Re-entry

- Benefit-to-cost ratio very interesting; Launch cost can be reduced if missile are used (EXPERT-like). **APPLICABLE TO MOON MISSION**