EXOMARS ROCC
Rover Operation Control Centre

THE EXOMARS PROGRAM

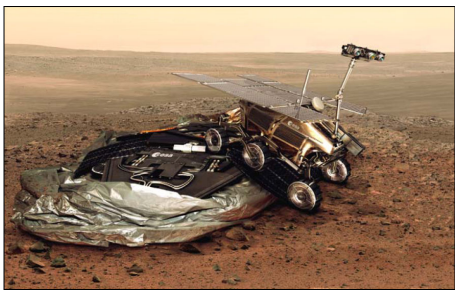
EXOMARS is the first mission of the ESA Aurora exploration program. It will demonstrate flight and in-situ qualification of the key exploration technologies to support European ambitions for future robotic and human exploration missions. **In this scenario ALTEC is responsible for the Rover ground control and relevant technological and scientific operations. This contest ALTEC develop, qualifies, validates and operates the Rover Operations Control Center (ROCC)**

Technological Objectives

- *Entry, Descent and Landing (EDL) of a large payload on the surface of Mars;*
- *Surface mobility via a Rover having several kilometres of mobility range;*
- *Access to sub-surface via a Drill to acquire samples down to 2 metres;*
- *Automatic sample preparation and distribution for analyses of scientific experiments.*

Scientific Objectives

- *To search for signs of past and present life on Mars;*
- *To characterize the water/geochemical environment as a function of depth in the shallow subsurface;*
- *To study the surface environment and identify hazards to future human missions;*
- *To investigate the planet's subsurface and deep interior to better understand the evolution and habitability of Mars.*

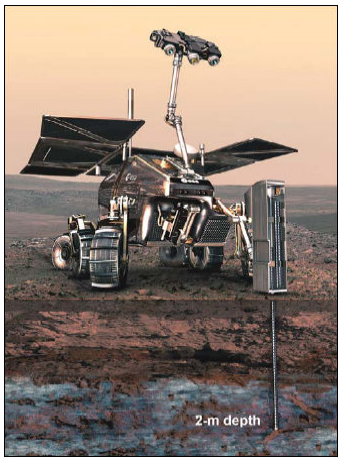


Descent Module and Rover
(Credit: ESA)

THE EXOMARS SYSTEM

Thales Alenia Space Italy - Turin is the Prime Contractor of the European consortium for the design and development of the EXOMARS System. The System is composed by the following major elements:

1. The Carrier Module;
2. The Descent Module;
3. The Rover including the payloads and related instruments.



Rover e drill
(Credit: ESA)

THE MISSION

The spacecraft composite, consisting of the Carrier Module, the Descent Module and the Rover, will be launched by an Arian 5 from Kourou (CSG) in Guyana in late 2013. After a cruise phase of the order of 10 months the Spacecraft Composite will enter orbit around mars where it will stay until the Global Dust Storm season has subsided.

The Descent Module will down on the Mars surface using parachutes and heat shields; control rockets will stabilize the lander for the final fall cushioned by vented air bags.

The first part of the mission (launch, cruise, and landing on Mars surface of the Descent Module) will be controlled by the Mission Operation Centre at the European Space Operation Centre (ESA-ESOC); once on the Mars surface, the Rover mission will be controlled by the **Rover Operation Control Centre (ROCC).**

ROCC RESPONSIBILITIES

ALTEC, as mentioned before, is in charge of the development of the Rover Operations Control Centre (ROCC). The ROCC will include communication infrastructures, operation software tools and related hardware and operations support systems.

ALTEC is also responsible to study, realize and validate the Mars terrain simulator used to develop and verify the potentially critical operational procedure utilizing a suitable Rover ground replica.

The ROCC, located at ALTEC Premises in Turin (Italy), will be responsible for:

- Supporting the ESOC/MOC during the Interplanetary Cruise Operations Phase and Mars Orbit Phase for the periodic checkouts of the Rover. The ROCC is requested to remotely assess the transmitted data provided by ESOC/MOC. Possible corrective actions will be managed by the ESOC/MOC based on the input provided by ROCC.
- Supporting the initial Surface Operations Phase, from the Rover activation until the Rover egress completion and basic functional check-out.
- Performing full Rover (including science operations) commanding and controlling along the Surface Operations Phase. Rover Module activity planning, command sequencing and commands validation will take place every sol between telemetry downlink to Earth and the next up-link opportunity of telecommand (TCs) to the Rover.

  Therefore, ROCC operation process will be designed and sized to allow a day-to-day commanding of the Rover Module, to increase the return of the mission and to maximize the usage of the Rover Module during its nominal mission lifetime
- Data dissemination to the scientific team for mission operation support.
- Post mission data product transfer to ESAC, not required to be performed in line with the Rover mission progress, but as per a different time schedule not impacting the Rover mission operation execution.
- Support engineering and science troubleshooting of the Rover vehicle and payloads;
- support On-Board Software management and uplink of new SW versions;
- Simulate the Mars terrain for advanced verification of special command sequence and operations.

EXOMARS ROCC
Rover Operation Control Centre

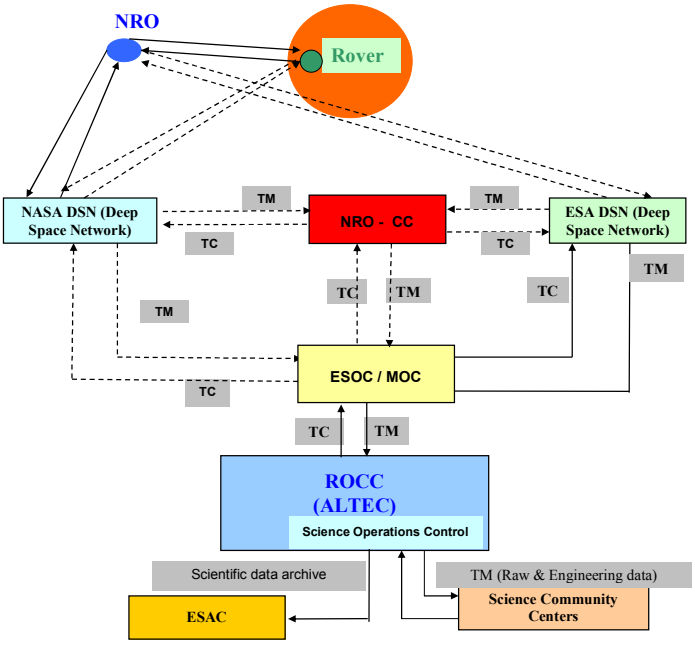
COMMUNICATION SCENARIO

The main communication path between the Rover and the ROCC is:

Rover → NASA Relay Orbiter (NRO) → NRO Control Centre (NRO-CC) → ESOC/MOC → ROCC.

The science data will be also distributed to scientists supporting the mission outside the ROCC and post mission data product will be generated and provided to the European Space Astronomy Centre (ESAC) for long term archiving and dissemination .

The communication opportunities between the rover and the NRO vary to a maximum of two per sol, one during the mars night and the other during the Mars afternoon, but there are sols without any communication opportunity. In this cases the direct communication with the ground station via the Deep Space Network (DSN) is very important.



Communication Scenario

OPERATIONS CONCEPT

The basic concept is based on the capability to command the Rover every sol with a morning uplink pass before the sunrise and considering data downlink completed before the Mars sunset. This provide two reference points in terms of start and end of the ground activities for the next sol planning.
Different level of planning will be made:

- Activity plan providing instruction and command to the Rover;
- Tactical plan: related to the current experiment cycle sequence executed on board consists in the verification of validity of the plan for the next sol and the preparation of the plan for the after sol.
- Strategic plan: long, multi-weeks, planning. It can be considered as the ground process for preparing the next experiment cycle.

Hours (Mars Time)	14	15	16	17	18	19	20	21	22	23	24	1	2	3
Communication Link														
Telemetry down-link (latency)														
Telemetry Processing														
Data Assessment														
Planning														
Comm.preparation/validation														
Telemetry up-link (latency)														

Sequence of the operations activities during a typical Mars sol

THE OPERATIONS TEAMS

All the operations teams will be located at **ROCC.** The center will operates 24/7 hours schedule. Considering that the Mars **sol** (the equivalent of the Earth day) is about 40 minutes longer that the Earth day, the shifts will be adapted to accomplish the mission objectives and reduce the discomfort to the operators due the continuous change of the working shift.

- The **Rover Engineering Team (RET)** will receive and transmit the data and will distribute them to the others teams; it will analyze the rover housekeeping data to verify status and recourses.
- The **Rover Science Team (RST)** will analyze the scientific data and will provide the inputs for the planning to the RIPT.
- The **Rover Integrated Planning Team (RIPT)** will prepare and validate the tactic and strategic plan.
- The **ROCC Ground System Team (RGST)** will manage communication system, the status of the hardware and software tools and of the Mars Terrain Simulator.

THE OPERATIONS TOOLS

Due to the limited time available for the data processing, analysis and the planning preparation, it will be very important to accomplish the mission objectives the availability of effective software tools. Different tools, based on SCOS2000 packet format, will be developed for different uses (telemetry acquisition and processing, rover housekeeping data assessment and planning, science data assessment and planning, rover planning, activity preparation and planning, telecommand uplink, simulator, on-board software maintenance, post-mission science product generation).

Software tool for data analysis

MARS TERRAIN SIMULATOR (MTS)

A Mars Terrain Simulator will be available at ROCC. The MTS will support simulation of off-line nominal and non-nominal Rover surface operations, in particular for rehearsing, simulating and validating critical rover maneuvers providing a reconfigurable Mars like environment. The MTS will be used also during the development phase for software and procedure validation and operation teams training.

Graphic elaboration of the Mars Terrain Simulator