4.3.1 Mars Express

Introduction

Mars has been an object of fascination for centuries. It has become possible only recently to visit the planet for detailed scientific exploration, which will reveal the differences between the planets of the solar system and allow their common origin to be understood.

Spacecraft exploration of Mars started in the 1960s. The first global survey was conducted by Mariner-9 in 1971, but the most significant and scientifically rewarding mission was Viking in 1976, consisting of two orbiters and two landers. Most of the existing environmental models of Mars have been derived from Viking data. There is now a new phase of Mars exploration underway: Mars Pathfinder (US), Mars Global Surveyor (US) and the failed Mars-96 (Russia) in 1996, Planet-B (Japan) and Mars Surveyor (US) missions in 1998, 2001 and beyond.

The Mars Express mission, comprising an Orbiter carrying a number of Landers, is the natural next phase of Mars exploration. It satisfies the recommendations of ESA's Space Science Advisory Committee (SSAC) Task Force on Mars Exploration and of the International Mars Exploration Working Group (IMEWG), to recover the scientific objectives of the lost Mars-96 mission and the Intermarsnet study.

Mars Express is planned for launch in June 2003 as the first flexible (F) mission of the new and inventive scenario of ESA's Horizons 2000 long-term Scientific Programme. The mission is dedicated to the orbital and possibly in-situ study of the planet's interior, surface and atmosphere. The mission nominal lifetime is one martian year (687 Earth days).

Mission overview

Owing to an innovative, flexible and fast way of implementing the first of the new F missions of ESA's Scientific Programme, Industry will be asked to bid for a ceiling price contract to design and build a 3-axis stabilised Orbiter capable of supporting a payload of up to 120 kg during a nominal operational period of one martian year (with a possible extension to two martian years). The spacecraft should be compatible with Ariane-5 in dual launch configuration and the Soyuz family of launch vehicles. The Orbiter will also serve as a communications relay for the Lander Modules. The expected launch mass for the June 2003 window is about 1100 kg

Several Lander Modules could be deployed on the martian surface, depending on available resources and on scientific and mission goals. Three possibilities were foreseen in the Announcement of Opportunity:

— A single large Lander Module carrying a drill, and geochemistry and exobiology instruments;
— Up to four smaller Lander Modules forming a network and carrying seismology, meteorology, geology and chemistry instruments, including an Instrument Deployment Device (IDD) on one;
— One larger and two smaller Lander Modules combining the previous two objectives.

The Lander Modules may either be inserted combined with the Orbiter (carrier spacecraft scenario) or separately (free-flyer scenario) into a Mars transfer trajectory. The development of the precise Mars Express mission concept is part of the industrial system studies being carried out in 1998.

The current baseline orbit, which could be reached within the propellant budget limit imposed by the launcher performance, is an orbit with an inclination of 90°, a pericentre altitude of 300 km and an apocentre altitude of 6800 km. The orbital period is 4.88 h. This elliptical orbit could be lowered to improve the communications of the

For further information, see http://www.estec.esa.nl/spdwww/mars/html/index.html

Orbiter with the Lander Modules during the extended mission through the use of aerobraking.

Scientific objectives

In the broad context of planetary science, Mars represents an important transition between the outer volatile-rich, more oxidised regions of the accretion zone of the terrestrial bodies (asteroid belt) and the inner, more refractory and less oxidised regions from which Earth, Venus and Mercury accreted. This special position of Mars and its transitional character is also manifested by its size, the degree of internal activity, the age of its surface features and the density of its atmosphere – properties that are intermediate between those of the large terrestrial planets (Earth, Venus) and the smaller planetary bodies (Mercury, Moon, asteroids).

Although geologically less evolved, Mars is more Earth-like than the other terrestrial planets. Consequently, Mars exploration is crucial for a better understanding of the Earth from the perspective of comparative planetology.

The scientific objectives of the Mars Express mission represent an attempt to fulfil in part the lost scientific goals of the Mars-96 mission, and also the Intermarsnet study, both in terms of orbital and in-situ landing science addressing the interior, subsurface, surface, atmosphere and environment of the planet. The scientific objectives of the mission, as endorsed by the Mars Express Science Definition Team, are summarised as:

Orbiter
- Global high-resolution photogeology (including topography, morphology, paleoclimatology, etc) at 10 m resolution
- Global spatial high-resolution mineralogical mapping of surface at 100 m resolution
- Global atmospheric circulation and high-resolution mapping of atmospheric composition
- Subsurface structure at km-scale down to permafrost
- Surface-atmosphere interactions
- Interaction of atmosphere with interplanetary medium

Lander Modules
- Internal structure and dynamic activity
- Meteorology and climatology
- Landing site geology, mineralogy and geochemistry
- Physical properties of atmosphere and surface layers
- Exobiology (i.e. search for signatures of life)

The Mars Express Orbiter spacecraft represents the core of the mission, being scientifically justified on its own investigations, such as high-resolution imaging and mineralogical mapping of the surface, radar sounding of the subsurface structure down to the permafrost, precise determination of the atmospheric circulation and composition, and study of the interaction of the atmosphere with the interplanetary medium. The Lander Modules are considered to be a very valuable complement to the mission.

The Mars Express Lander Modules may establish the first surface network of scientific stations to study the interior, near-surface, surface and atmosphere, as a precursor to more detailed surface exploration (e.g. sample return). With multiple surface stations, it would be possible to perform seismological and meteorological measurements in order to infer the planet's internal structure, the atmospheric circulation and the weather patterns. Other scientific goals of the Lander Modules will be the morphology and geology of the landing sites, the chemical and mineralogical composition of surface rocks and soils, and other physical properties of the surface materials. Also, exobiology (i.e. signatures of life) is one of the mission's main objectives.

Proposals in response to the Mars Express Announcement of Opportunity for both the Orbiter payload and the Lander Modules, including their scientific instruments, are now being evaluated by the Mars Express Peer Review Committee.

Concluding remarks

Mars Express is an ESA mission for the orbital and in-situ study of the interior, surface and atmosphere of the planet Mars. The Orbiter will be developed, operated and fully funded by ESA, with the exception of the scientific instruments. To complement and enhance the mission's scientific capabilities, the Orbiter could carry a number of Lander Modules provided by consortia under the auspices of the National Space Agencies of ESA member states or international IMEWG partners.

Mars Express represents a unique opportunity for Europe to join the other major space-faring nations in the scientific exploration of the most Earth-like of the planets in our solar system by providing a major contribution at relatively low cost and risk.