THE MARS EXPRESS MISSION AND ITS BEAGLE-2 LANDER

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The European Space Agency and the scientific community have performed concept and feasibility studies for more than ten years on potential future European missions to the red planet (*Marsnet, Intermarsnet)*, focusing on a network of surface stations complemented by an orbiter, a concept which is being implemented by the CNES-led *Netlander* mission to be launched in 2005. Before that, however, the ESA *Mars Express* mission includes an orbiter spacecraft and a small lander module named Beagle-2 in remembrance of Darwin's ship Beagle. The mission, to be launched in 2003 by a Russian Soyuz rocket, will recover some of the lost scientific objectives of both the Russian *Mars-96* mission and the ESA *Intermarsnet* study, following the recommendations of the International Mars Exploration Working Group (IMEWG) after the failure of *Mars-96*, and also the endorsement of ESA's Advisory Bodies that *Mars Express* be included in the Science Programme of the Agency.

The specific scientific objectives of the *Mars Express* orbiter are: global high-resolution imaging with 10 m resolution and imaging of selected areas at 2 m/pixel, global IR mineralogical mapping, global atmospheric circulation study and mapping of the atmospheric composition, sounding of the subsurface structure down to the permafrost, study of the interaction of the atmosphere with the surface and with the interplanetary medium as well as radio science. The goals of the Beagle-2 lander are: geology, geochemistry, meteorology and exobiology of the landing site.

The scientific payload on the *Mars Express* orbiter includes a Super/High-Resolution Stereo Colour Imager (HRSC), an IR Mineralogical Mapping Spectrometer (OMEGA), a Planetary Fourier Spectrometer (PFS), a Subsurface-Sounding Radar Altimeter (MARSIS), an Energetic Neutral Atoms Analyser (ASPERA), an UV and IR Atmospheric Spectrometer (SPICAM) and a Radio Science Experiment (MaRS). The Beagle-2 lander includes a suite of imaging instruments, organic and inorganic chemical analysis, robotic sampling devices and meteorological sensors (see **Table**).

The Mars Express mission will address the issue of astrobiology on Mars both directly and indirectly. The majority of instruments on the orbiter will look for indications of favourable conditions to the existence of life, either at present or during the planet's past, and in particular for traces of liquid, solid or gaseous water. Therefore, the HRSC camera will take pictures of ancient riverbeds, the OMEGA spectrometer will look for minerals with OH^- radicals formed in the presence of water, the MARSIS radar will look for subsurface ice and liquid water, the PFS and SPICAM spectrometers will analyse water vapour in the atmosphere, and finally ASPERA and MaRS will study neutral atom escape from the atmosphere, in particular O_2 coming from water and carbonates. The instruments on Beagle-2 will also look for the presence of water in the soil, rocks and the atmosphere, but will also try to find traces of life with direct measurements, such as presence of methane (CH_4) indicative of extanct life and a larger amount of the light C^{12} isotope compared to the heavier C^{13}, which would even indicate the existence of extinct life. Since NASA's Viking mission in 1976, it is the first time that the exhaustive search for life is so central to a space mission to Mars.

Current design estimates allow for an orbiter scientific payload of about 110 kg and 65 kg total lander mass (at launch) compatible with the approved mission scenario. The Beagle-2 lander was selected due to its innovative scientific goals and challenging payload. Beagle-2 will deploy a sophisticated robotic-sampling arm, which could manipulate different types of tools and retrieve samples to be analyzed by the geochemical instruments mounted on the lander platform. One of the tools to be deployed by the arm is a 'mole' capable of subsurface sampling to reach soil unaffected by solar-UV radiation, another is a corer/grinder to reach the rock under the weathering varnish.

A Soyuz-Fregat launcher will inject a total of about 1200 kg into Mars transfer orbit in early June 2003, which is the most favorable launch opportunity to Mars in terms of mass in the foreseeable future. The Mars Express orbiter is 3-axis stabilized and will be placed in an elliptical martian orbit (250 × 10142 km) of 86.35 degrees inclination and 6.75 hours period, which has been optimized for communications with Beagle-2, the *Netlanders*, as well as NASA landers or rovers to be launched both in 2003 and 2005. The Beagle-2 lander module will be independently targeted from separate arriving hyperbolic trajectory, enter and descend through the martian atmosphere in about 5 min, and land with an impact velocity <40 m/sec and an error landing ellipse of 100 × 20 km. A preliminary Beagle-2 landing site has been selected in the Isidis Planitia area (10.6° N, 270° W). The nominal mission lifetime of one martian year (687 days) for the orbiter investigations will be extended by another martian year for lander relay communications and to complete global coverage. The Beagle-2 lander lifetime will be of a few months.

ESA provides the launcher, the orbiter and the operations, while the Beagle-2 lander is delivered by an UK-led consortium of space organizations. The orbiter instruments are provided by scientific institutions through their own funding. In addition to relaying the data from the Beagle-2 lander to Earth, Mars Express will also service landers and rovers from other agencies during its nominal/extended lifetime. The ground segment includes the ESA station at Perth, Australia, and the mission operations centre at ESOC. The *Mars Express* mission is now in Phase-C/D, with Astrium (formerly Matra Marconi Space) in Toulouse, France, as its Prime Contractor and involving a large number of European companies.

International collaboration, either through the participation in instrument hardware or through scientific data analysis is very much valued to diversify the scope and enhance the scientific return of the mission, such as NASA's major contribution to the subsurface-sounding radar, and the use of its DSN for increased science data downloading and critical manoeuvres. Also, arriving at Mars at the very end of 2003, *Mars Express* will be followed by the Japanese *Nozomi* spacecraft a few days later. Both missions are highly complementary in terms of orbits and scientific investigations; *Nozomi* focusing on the study of the upper atmosphere of Mars as well as the interaction of the solar wind with the ionosphere from a highly elliptic equatorial orbit. Close cooperation, including scientific data exchange and analysis, is foreseen by the *Nozomi* and *Mars Express* teams within a joint ESA-ISAS programme of Mars exploration.

For more details on the *Mars Express* mission and its Beagle –2 lander:
http://sci.esa.int/marsexpress/ and **http://www.beagle2.com/**

Table: MARS EXPRESS SCIENTIFIC PAYLOAD			
Acronyms	**Instruments**	**Principal Investigators**	**Countries**
Orbiter			
HRSC	Super/High-Resolution Stereo Colour Imager	G. Neukum	D, F, RU, US, FI, I, UK
OMEGA	IR Mineralogical Mapping Spectrometer	J.P. Bibring	F, I, RU
PFS	Atmospheric Fourier Spectrometer	V. Formisano	I, RU, PL, D, F, E, US
MARSIS	Subsurface-Sounding Radar/Altimeter	G. Picardi & J. Plaut	I, US, D, CH, UK,DK
ASPERA	Energetic Neutral Atoms Analyzer	R. Lundin & S. Barabash	S, D, UK, F, FI, I, US, RU
SPICAM	UV and IR Atmospheric Spectrometer	J.L. Bertaux	F, B, RU, US
MaRS	Radio Science Experiment	M. Paetzold	D, F, US, A
Lander			
BEAGLE-2	Suite of imaging instruments, organic and inorganic chemical analysis, robotic sampling devices and meteo sensors	C. Pillinger & M. Sims	UK, D, F, HK, CH