EUROPE GOES TO MARS AND VENUS – THE MARS AND VENUS EXPRESS MISSIONS

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The European Space Agency has undertaken an ambitious planetary exploration programme aiming at Mars, the Moon, Titan, comet Wirtanen and Mercury, with a series of missions arriving at their destination in the coming years (Mars Express in 2003, Smart-1 in 2004, Huygens in 2005, Rosetta in 2011 and BepiColombo in 2014, respectively). Realising there was a substantial gap in the return of scientific data and a timely financial envelope available in the programme, a new mission to Venus has recently been approved by ESA's Advisory Bodies that would re-use both the Mars Express bus and many of its instruments, hence its name of Venus Express. The *Mars Express* mission includes an orbiter spacecraft and a small lander module named Beagle-2 in remembrance of Darwin's ship Beagle. The orbiter instruments will focus on the surface, subsurface and atmosphere of Mars, recovering some of the lost scientific objectives of the Russian *Mars-96* mission, while the lander will concentrate on the detection of life. The *Venus Express* mission comprises an orbiter to study the various layers of the atmosphere in great detail and also the surface and space environment of the planet.

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 mass of the orbiter scientific payload is of about 110 kg and 65 kg total for the lander (at launch) to fulfil the mission scenario. 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.

A Russian Soyuz-Fregat rocket will launch a total of 1200 kg from Baikonur into Mars transfer orbit in May-June 2003. The Mars Express orbiter is 3-axis stabilized and will be placed in an elliptical martian orbit (250 × 10142 km) of 86.35° inclination and 6.75 hours period, after a six-month cruise. The 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 to complete global coverage. The Beagle-2 lander lifetime will be of up to 6 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. The ground segment includes the ESA station at Perth, Australia, and the mission operations centre at ESOC. The *Mars Express* Prime Contractor is Astrium in Toulouse, France, and a large number of European companies are involved as subcontractors.

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. 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. For more details on the *Mars Express* mission and its Beagle –2 lander:

http://sci.esa.int/marsexpress/ and **http://www.beagle2.com/**

The specific scientific objectives of the *Venus Express* mission are the study of the space plasma environment and its interaction with the solar wind, the nature and mechanisms of the general atmospheric circulation and the greenhouse effect, the physics and chemistry of the cloud layer, the composition and chemistry of the lower atmosphere and its interaction with the surface, the surface IR topography and the subsurface sounding of the venusian crust down to a few kilometres.

The scientific payload on the *Venus Express* orbiter includes a Planetary Fourier Spectrometer (PFS), a Subsurface-Sounding Radar Altimeter (VENSIS), an Energetic Neutral Atoms Analyser (ASPERA), an UV and IR Atmospheric Spectrometer (SPICAV), a Radio Science Experiment (VeRA), all derived from *Mars Express* instruments, and a VNIR-SWIR spectro-imager inherited from the Rosetta mission (VIRTIS), a new UV-VIS global atmospheric imager (VMC) and a magnetometer (MAG) to study the complex space environment of Venus in detail (see **Table**).

The mass of the orbiter scientific payload is of about 104 kg, in compliance with the approved mission scenario. The spacecraft will be launched by a Soyuz-Fregat rocket in November 2005 and placed in a highly elliptical venusian orbit (250 × 65000 km) of quasi-polar inclination and 24 hours period, after a 150 day cruise. The nominal mission lifetime is two venusian years (2 × 224 days) after orbit insertion. Due to Venus low J2 gravity harmonic, the pericentre will be locked over a 60-70° N latitude band (comprising Ishtar Terra). The *Venus Express* Prime Contractor will be the same as for *Mars Express* (Astrium-Toulouse, France) for cost and efficiency reasons.

International collaboration will also be a feature of this mission as the Japanese *Planet-C* mission to Venus will be launched in 2007 and both missions will complement each other in terms of orbits and scientific investigations; *Planet-C* focusing on the study of the upper atmosphere of Venus as well as the interaction of the solar wind with the ionosphere from a highly elliptic equatorial orbit.

While the study of Mercury and the Moon will help in understanding the early history of the Solar System, Venus and the Earth will give us clues on its recent history while Mars is an intermediate case. However, synergies in the exploration of all terrestrial bodies are essential to establish a complete scenario of the evolution of the Solar System and in particular to understand the state of our own planet.

Table: MARS EXPRESS AND VENUS EXPRESS SCIENTIFIC PAYLOAD

MARS EXPRESS PAYLOAD		**VENUS EXPRESS PAYLOAD**	
Acronyms	**Instruments**	**Acronyms**	**Modifications**
Orbiter			
HRSC	Super/High-Resolution Stereo Colour Imager	No equivalent	
OMEGA	IR Mineralogical Mapping Spectrometer		
PFS	Planetary Fourier Spectrometer	PFS	Identical instrument
MARSIS	Subsurface-Sounding Radar/Altimeter	VENSIS	Different frequencies
ASPERA	Energetic Neutral Atoms Analyzer	ASPERA	Identical instrument
SPICAM	UV and IR Atmospheric Spectrometer	SPICAV	Improved IR channel
MaRS	Radio Science Experiment	VeRA	Addition of USO
No equivalent		VIRTIS	VNIR-SWIR spectral imager (from Rosetta)
		VMC	UV-VIS global imager (new)
		MAG	Magnetometer (new)
Lander			
BEAGLE-2	Suite of imaging instruments, organic and inorganic chemical analysis, robotic sampling devices and meteorological sensors	No equivalent	

For more details on the *Venus Express* mission: **http://sci.esa.int/venusexpress/**