THE ESA MARS EXPRESS MISSION: SPECTRAL AND COMPOSITIONAL INVESTIGATIONS. P. D. Martin, Research and Scientific Support Department, European Space Agency, ESTEC, Postbus 299, NL 2200 AG Noordwijk, The Netherlands; patrick.martin@rssd.esa.int.

Introduction: Within the past 40 years, advances in ground-based remote sensing and significant return of spectral and compositional data from the Martian surface have led to a rapidly increasing knowledge of the surface mineralogy of the planet. These results, combined with progress made in the fields of laboratory measurements and simulations, have permitted better-constrained interpretation of the surface materials, hence allowing for improved understanding and comparisons of the various evolution processes, whether these processes are relevant to weathering and alteration or to more climatic-related changes. It is expected from future missions to bring back a substantial amount of additional compositional data. In particular, the ESA Mars Express spacecraft (Fig. 1), due for launch at the beginning of June 2003 and for arrival at Mars at the end of December 2003 [1], will return outstanding, unprecedented stereo images, multi-/hyper-spectral visible/near-infrared data sets, and UV-infrared spectra. These will be acquired and delivered by the HRSC, OMEGA, PFS and SPICAM instruments (Fig.2), with better spatial and/or spectral coverage than previous Mars missions. The purpose of the investigations to be done with the data from those experiments will be to process and analyze such data sets with the broad scientific objectives of:

- providing additional essential information and clarifying the debate about the detection, presence, abundance, and mixing degrees of surface constituents such as oxides, hydrates, silicates, clays, frosts, carbonates, sulfates, and palagonitic-like materials.
- decorrelating the respective contributions of the surface and atmosphere.
- updating the models of evolution of the Martian surface, in relation with the geologic timescales.

The HRSC, OMEGA, PFS, and SPICAM experiments onboard Mars Express: Among the main scientific goals of the Mars Express mission [2], surface investigations using high-resolution imaging and mineralogical detection and mapping will play an essential role in the study of the Martian surface composition and evolution. This is ensured by a comprehensive set of instruments comprised in the Mars Express payload.

The HRSC camera, a pushbroom scanning instrument with 9 CCD line detectors mounted in parallel, has the capability to acquire simultaneously stereo, high resolution, multispectral, and multi-phase angle imagery covering extended contiguous regions on Mars. It will characterize the surface structure and morphology at high spatial resolution (up to 10 m/pixel), and super resolution using its SRC channel (up to 2 m/pixel). During the nominal operational lifetime of the mission (1 Martian year), it is expected that 70% to 90% of global/regional coverage will be achieved at >20m resolutions. High-resolution (10-20m) imaging will cover up to 50% of the surface, and super-resolution imaging will cover about 1% of the surface. Among many other objectives, the camera will also characterize the surface topography at high spatial and vertical resolution, perform terrain compositional classification, and investigate the geologic evolution of the surface and the links with the climate history of the planet.

The OMEGA mapping spectrometer is operating in the visible and near-infrared from 0.5 to 5.2 micrometers with 352 contiguous wavelength channels, allowing for identification of the major classes of minerals. The spectral resolution $\lambda/\Delta\lambda$ is in the range 70 to 200. It is composed of two grating spectrographs, with an imaging capability of 128 contiguous IFOV of 1.2 mrad each and a FOV of 8.8 degrees. OMEGA will provide data of the Martian surface that will be very complementary of the TES and THEMIS data sets onboard MGS and Mars Odyssey, respectively. In orbit around Mars, this experiment will identify and characterize specific mineral and molecular phases of the major geologic and photometric units, map the spatial distribution and abundance of the detected mineral species, achieving global mineralogical mapping at a few kilometers spatial resolution. High-resolution coverage of selected areas of interest will be obtained at a few hundred meters spatial resolution.

The Planetary Fourier Spectrometer (PFS) is an infrared spectrometer with onboard real-time Fast Fourier Transform capability, covering a wavelength range from 1.2 to 45 micrometers, separated in two wavelength channels, short (SW; 1.2-5 µm) and long (LW; 5-45 µm). The spectral resolution is 2 cm^{-1}. The FOV is 2 and 4 degrees for the SW and LW channels, respectively. The obtained spatial resolution will be about 10 to 20 km around pericentre. Although its main objective is the investigation of the Martian atmosphere, with a focus on the global atmospheric circulation and on the mapping of the atmospheric composition, the PFS experiment will also contribute to surface studies. In particular, it will provide spectral data that will inform on the thermal inertia, the mineralogical composition of the surface layer, the nature and composition of the surface condensate and its seasonal variations, and the surface-atmosphere interactions.

SPICAM is a UV-Infrared imaging spectrometer dedicated to the study of the Martian atmosphere circulation and composition. This instrument will also investigate surface-atmosphere interactions. It is composed of a UV channel (118-320 nm) and an IR channel (1.3-4.8 μm). SPICAM measurements will provide enough information for modeling the Martian environment at ground level, allowing for an accurate assessment of the effect of solar UV and oxidation of the surface materials. The investigation of surface-atmosphere chemical interactions using SPICAM will be essential to the development of models and scientific interpretations relevant to the presence and history of water on Mars, in connection with geological evidence. In addition, measurements of the spectral UV albedo of the surface will permit possible discrimination of diagnostic mineral phases, and infrared surface spectra will be produced that could be cross-compared with data acquired by OMEGA and PFS.

Spectral and Compositional Investigations: Variations in the chemical composition, physical properties, and mineralogy of the soils, dust, and rocks are the consequence of various surface processes acting on Mars over geologic timescales, such as weathering and alteration [e.g., 3]. Detailed investigations of the multispectral and hyperspectral data sets to be returned by HRSC and OMEGA, using additional correlation with complementary spectroscopic data from PFS and SPICAM, will be performed to address the following key issues: The quantitative constraint of the physical/chemical composition and mineralogy of rocks and soils; the potential genetic connection between rock coatings and surface/airborne fines; the extent of the control of mixing on the observed composition of soils and rocks; the controlling role of weathering or other alteration processes in the physical modification or the chemical composition of the surface materials; the evolutionary stages of the sedimentary (or other) geologic processes that created and modified rocks and soils. Current (Mars Odyssey 2001, Mars Global Surveyor) data sets returned from Mars constitute the best information to date against which the consistency of the Mars Express data will be tested, past (Mars Pathfinder, HST, Viking) data sets still being used for comparisons. Furthermore, *in situ* data sets acquired at the Beagle-2 landing site in Isidis Planitia (90.75°E, 11.6°N) or at the Mars Exploration Rovers landing sites will be used as additional information on the composition and mineralogy of the local surface, providing independent "ground truth" to the interpretations made at regional scale.

The analyses to be performed using HRSC and OMEGA data will attempt to accurately characterize the full range of spectral, compositional, and mineralogical diversity of the Martian surface, focusing on regional areas selected on the basis of their compositional and/or geologic interest. A comprehensive set of analytical tools and methodologies will be used to validate the Mars Express data, using the latest advances made in the gathering and analysis of spectral data, images and samples. Existing databases produced from experimental spectro-imaging studies or from laboratory analyses will also be used, allowing for improved documentation of the various physical and compositional mixing processes involved at mesoscale in the integrated remote sensing observations made at macroscopic scale. Spectral surface units will be identified as well as their extension, photometric properties will be investigated, and mineralogical maps produced. Mineralogic and compositional data from OMEGA will be correlated with HRSC geomorphologic multispectral maps, leading to a refined classification of soil and dust materials.

Conclusion: OMEGA and HRSC data sets will bring important new information on the roles played by weathering and/or mixing processes that altered the surface materials during both past and present climatic regimes. The interpretation of these analyses will confirm, complement or challenge the latest results from Mars Global Surveyor and/or Mars Odyssey dealing with, e.g., rock composition variations of the volcanic surface materials, the occurrence of aqueous mineralization, or the detection of crystalline hematite in sedimentary rock formations.

References: [1] P. D. Martin and A. F. Chicarro (2002) LPS XXXIII, Abstract # 1495. [2] P. D. Martin et al. (2001) LPS XXXII, Abstract # 1575. [3] Pieters, C.M. and Englert, P.A.J. (1993) Cambridge University Press.

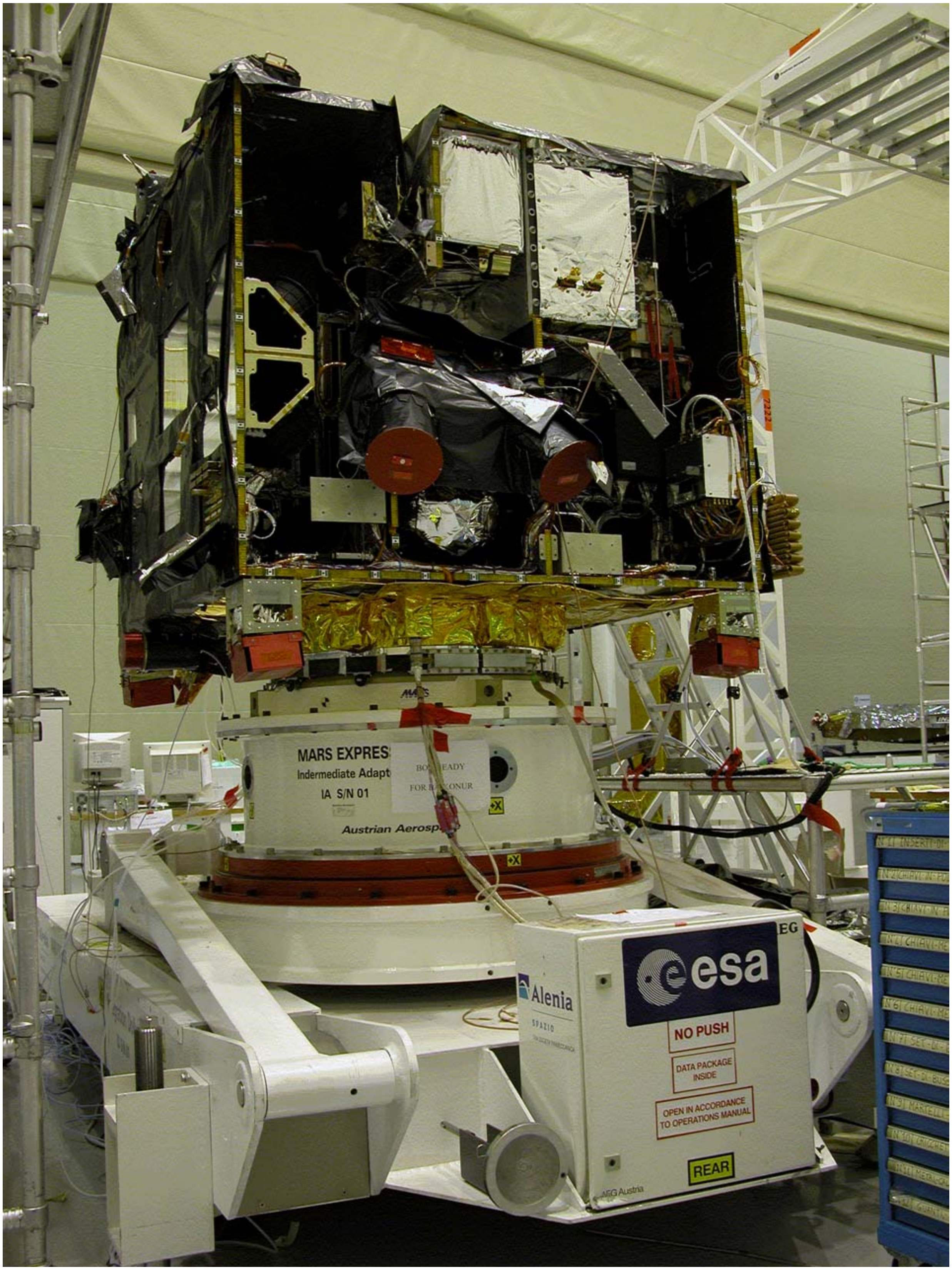

Figure 1: Mars Express spacecraft in integration and testing facility in Astrium-Toulouse, France.

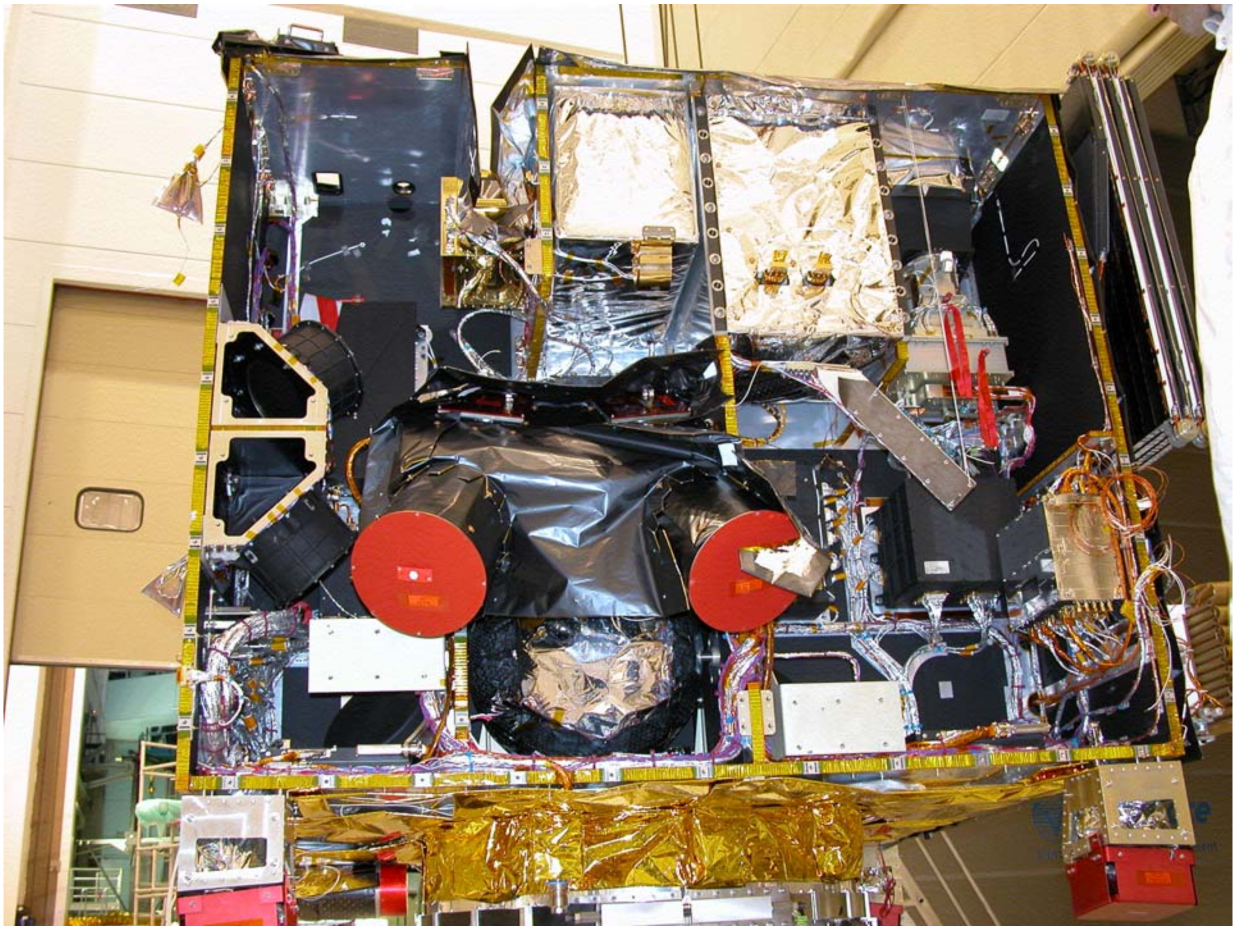

Figure 2: Same as Figure 1, with a view focused on the payload instruments to be involved in spectral and compositional investigations of the Martian surface. From right to left: HRSC, OMEGA, PFS, and SPICAM.