IMAGING GOALS AND CAPABILITIES OF THE HRSC CAMERA EXPERIMENT ONBOARD MARS EXPRESS. G. Neukum[1], R. Jaumann[2], H. Hoffmann[2], T. Behnke[2], R. Pischel[2], T. Roatsch[2], G. Arnold[2], E. Hauber[2], J. Oberst[2] and the HRSC Co-Investigator Team, [1+2]DLR Berlin-Adlershof, Inst. Space Sensor Technology and Planetary Exploration, Rutherfordstrasse 2, D-12849 Berlin, Germany, e-mail[1]: gerhard.neukum@dlr.de

Introduction: With its first deep space mission Mars Express to a planet, which will be launched in 2003, Europe has also taken up the challenge to make a major contribution to imaging Mars in reply to the urgent need to complete the Mars reconnaissance at medium and high spatial as well as vertical scales. Europe now has the chance not only to fill the image data gap caused by the recent loss of MCO but to make a major contribution in creating the image and cartographic data base for the future Mars exploration program with the High Resolution Stereo Camera (HRSC) experiment onboard the Mars Express mission.

HRSC Science Goals: Primary questions to be answered by future Mars science investigations are: (1) Is there evidence for ancient or present life on Mars? (2) What was the climate and the role of water throughout the Martian history? (3) What are potential resources on Mars? (4) What are the characteristics of past, present and future landing sites? Most of the diagnostic surface features whose recognition could answer these questions are at or below the spatial detection limit of previous and current camera instruments. This has led to formulate the imaging goals to be met by the Mars Express camera instrument as

- Characterization of the surface structure and morphology at high spatial resolution of up to 10 m/pixel.
- Characterization of the surface topography at high spatial and vertical resolution.
- Characterization of morphological details at super-resolution of up to 2m/pixel.
- Terrain compositional classification at high spatial resolution by means of color imaging.
- Refinement of the geodetic control network and the Martian cartographic base.
- Characterization of atmospheric phenomena at high resolution.
- Characterization of the physical properties of the surface through multi-phase angle measurements.

The HRSC experiment onboard the European Mars Express mission finally has the ambitious goal to cover more than 50% of the surface at 20 m/pixel, more than 70% at 30 m/pixel and about 100% at 100 m/pixel during the nominal mission of 1 Martian year. Thus, the HRSC data will close the gap in the high- and medium-resolution reconnaissance imagery and provide the link between the small-sized images at very high resolution of the MOC instrument and the medium- to low-resolution data of former missions. Moreover, the HRSC instrument is equipped with an additional bore-sighted super-resolution channel. This will serve as the sharpening eye by providing image strips nested in the wider swath of the HRSC stereo scanner and will allow to observe at least 1% of the Martian surface at a spatial resolution of up to 2 m/pixel.

The imaging goals were formulated by the international HRSC science team comprising 38 Co-Investigators from 27 institutions and 9 countries.

Instrument Description: In order to fulfill these goals, the HRSC experiment comprises three subunits with the HRSC stereo scanner, the Super-Resolution Channel SRC and a digital unit. The entire experiment has a total mass of 20.4 kg.

The HRSC Stereo Scanner. The HRSC stereo scanner is a pushbroom device with 9 CCD line detectors mounted in parallel. The technical design is defined by

- Single-optics conception
- CCD line arrays with 5272 pixels each
- Nine detectors for simultaneous stereoscopic and color imaging, and for multi-phase angle measurements
- CCDs and sensor electronics implemented in high-rel hybrid, low-noise and low-power technology
- Implementation of the CCD-control unit in ASICs
- High operational flexibility
- Compact and modular light-weight design
- Real-time data compression of up to 72 Mbit/s

The unique feature of the HRSC stereo scanner is the ability to obtain nearly simultaneously imaging data of a specific site at high resolution, with along-track triple stereo, with four colors, and at five different viewing geometries, thus avoiding any time-dependent variations of the observing conditions (e.g. illumination, atmospheric properties, variable features). The spatial resolution from the periapsis altitude of the elliptical orbit of 250 km will be 10 m/pixel with an image swath of 52 km. The triple stereo images permit robust stereo reconstruction yielding Digital Terrain Models at a vertical resolu-

tion similar to the pixel resolution. The four color images (with wavelength centers at 440 nm, 530 nm, 750 nm, and 970 nm) enable terrain classification and provide information on compositional variations. The multiphase imagery allows to address the scattering properties of the surface and atmosphere by means of photometric modeling and supports the photogrammetric evaluation by providing a second stereo triplet, in essence quintuple stereo. The HRSC is operated in individual imaging sequences. A typical imaging sequence will consist of nine image swaths essentially coinciding on ground. The high flexibility in instrument operations (e.g. pixel summation, compression ratio, windowing, integration time) allows to optimize the data acquisition with respect to the scientific goals, the available spacecraft resources and orbital constraints. Originally, the HRSC instrument was developed for the Russian Mars 96 mission [1]. Two fully tested and calibrated flight models were available for this mission. After loss of the Russian Mars 96 mission one flight model remained for further use. The HRSC stereo scanner and the ground data system were extensively tested during outdoor tests and airborne experiments demonstrating the resolving power and the radiometric quality of the instrument as well as the reliability of the fully operational software (Fig. 1).

The HRSC Super-Resolution Channel SRC. The SRC is a framing device and uses an interline CCDdetector to cope with the very short exposure times. The 1 m focal length telescope provides a spatial resolution of 2.2 m/pixel at an altitude of 250 km. The channel is operated in parallel with the HRSC stereo scanner yielding nested-in super-resolution images in order to avoid any location problems and to obtain the contextual information. Both single spot observations and overlapping image strips can be acquired. The SRC is based on an ongoing instrument development for the Rosetta Lander and is mounted on the Mars Express spacecraft below the HRSC stereo scanner in a common honeycomb structure in order to minimize interfaces with the spacecraft. The design is characterized by

- CCD area array interline detector with 1024 x 1032 pixels.
- Highly miniaturized and low-power detector and control electronics.
- Compact 3D multi-chip module technology using thinfilm multilayer metallization, dycostrate, plasma-etching and chip-on-wire technology.
- Selectable dynamic range of 8 and 14 bit per pixel.
- Internal data buffer.
- Light-weight Maksutov-Cassegrain telescope with a focal length of 1 m and an f-number of 9.

The HRSC Digital Unit. The digital unit serves both the HRSC stereo scanner and the SRC. It is based on the digital unit developed for the Mars 96 HRSC experiment [1] and is modified as required for the interfaces with the Mars Express spacecraft. The imaging data both from the HRSC stereo scanner and the SRC will be compressed online by DCT-based compression hardware with a selectable compression factor of 2 to 20.

References:

[1] Neukum G. et al. (1996) *Act. Astron, 38,* 713-720.

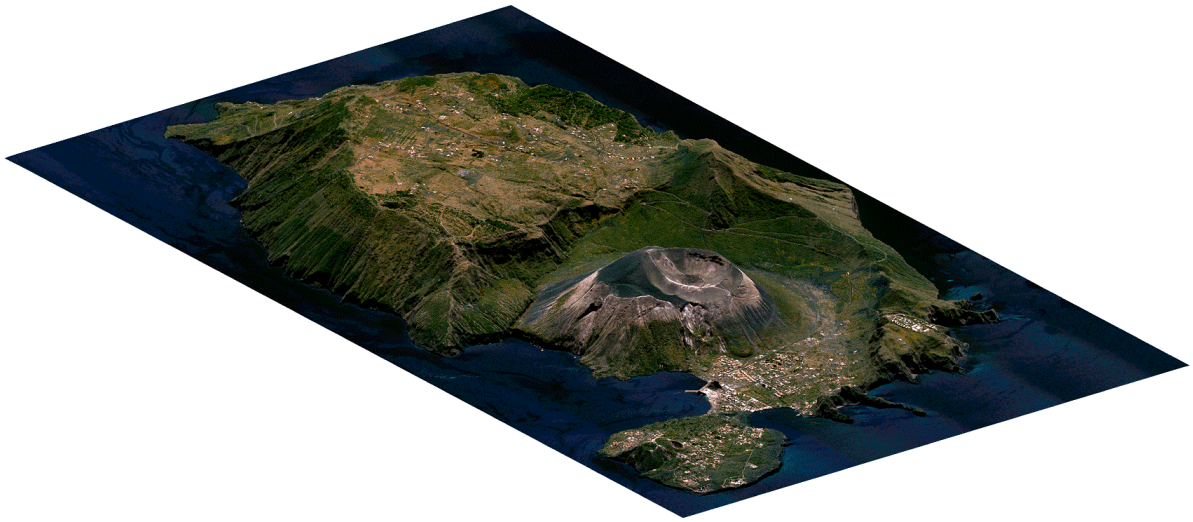

Fig 1. Perspective view of the Vulcano Island, Italy, derived from HRSC stereo and color imagery which was obtained during the HRSC flight campaign (May 1997) at an altitude of 5000 m with a spatial resolution of 20 cm/pixel for the nadir and 40 cm/pixel for the stereo lines.