Systematic Mapping of Mars with HRSC – Specifications and Examples for DTM and Orthoimage Products From the First Six Months of the Mars Express Mission

K. Gwinner [1), F. Scholten [1), S. Elgner [1), F. Preusker [1), J. Oberst [1), R. Jaumann [1), and G. Neukum [2)

[1) German Aerospace Center, Institute of Planetary Science, Rutherfordstrass 2, 12489 Berlin, Germany
[2) Freie Universität Berlin, Institut for Geological Sciences, Malteserstr. 74-100, 12249 Berlin, Germany

The European Space Agency (ESA) Mission Mars Express was launched in 2003. The onboard High Resolution Stereo Camera (HRSC) [1,2] is the first photogrammetric stereo sensor experiment which was specifically developed for remote sensing in distant planetary environments. While HRSC DTMs and orthoimages in various formats and at different quality levels have been developed and presented previously, we now report on the general specifications and discuss the production of "systematic" HRSC photogrammetric data products (also termed "Level 4" data products), as they are intended for coming delivery to public archives in the near future, i.e., PSA and PDS.

The data products of the systematic HRSC Level-4 processing are 8 Bit orthoimages for the Nadir channel and the 4 color channels and 16 Bit DTMs (1 m numeric height resolution). The data are in the VICAR format and comply with Planetary Data System (PDS) specifications. The map scales of the orthoimages adhere to standard resolutions (12.5, 25, 50... m/pixel), depending on the resolution of the respective image. For the specification of the DTM spatial resolution, in addition the quality of orientation and the quality of the image data are decisive. Usually, a grid spacing of about 2 times the mean stereo resolution (up to 50 m) can be used. Since Level-4 orthoimages are based on the Level-4 DTM, they are available exclusively for areas covered by the latter. The principal geometric reference for both planimetry and height is a sphere of radius r=3396.0 km as defined by MOLA [3]. In addition, heights above the areoid surface are provided. The map projection is Sinusoidal for latitudes between ±85° and Polar-Stereographic for polar areas.

The DTM generation [4] is based on multi-image matching using pyramid-based least-squares correlation after pre-processing by adaptive (variable bandwidth) Gaussian low pass filtering of the stereo images to reduce the effects of image compression. 3D point determination by least- squares forward intersection is followed by DTM grid interpolation (distance-weighted averaging within a local interpolation radius). The overall process involves automatic procedures in combination with standardized quality checks. The DTM generation uses adjusted orbit and pointing data [5].

Once a high-resolution DTM result is available, comparisons are made between the HRSC DTM and the MOLA DTM to check for geometric co-registration, and final improvements to the exterior orientation data are derived. The DTM and the adjusted orientation data are used for ortho-image production [6]. A histogram-based linear contrast stretch is applied, which does not affect the linear metrics of the radiometric image calibration. Similarly, the Level-3 images (ortho-rectification based on MOLA) are successively re- calculated using the new orientation data and product specifications.

About 130 image sequences (or 85 percent) of all HRSC stereo datasets acquired during the first 6 months of the mission have allowed us to produce high-level data products. Product assessment based on internal quality parameters and comparison to external terrain data show that typical 3D point accuracy are about 10 m – 15 m (up to about 5 m for the best datasets). This sub-pixel accuracy with respect to stereo image resolution allows us to derive raster DTMs at a spatial resolution of up to 50 m for large parts of the surface of Mars within a reasonable effort. The height differences with respect to MOLA topography data are near-zero on average, testifying to the accurate co-registration of both datasets. However, local height deviations between the two datasets can be considerable (typically more than ±20m, 1σ, amounting to >100m). They reflect the measurement uncertainties on both experiments, but also differences in the representation of topographic detail (resulting e.g. from the difference in spatial resolution and coverage) and underline that the two approaches are complementary.

References: [1] Neukum, G., et al. (2004) ESA SP-1240, 17-35. [2] Jaumann, R., et al. (2007), PSS,55, 928-952. [3] Smith, D.E., et al. (2001)., JGR, 106(E10), 23689-23722. [4] Gwinner, K., et al. (2007), PERS, subm. [5] Spiegel, M., et al. (2006), IntArchPhRS (36) 4. [6] Scholten, F., et al., PERS 71(10), 1143-1152, 2005.