ARCHIVAL STEREO DATA PRODUCTS OF THE HRSC EXPERIMENT ONBOARD MARS EXPRESS.

K. Gwinner[1], T. Roatsch[1], K.-D. Matz[1], F. Scholten[1], S. Elgner[1], F. Preusker[1], J. Oberst[1], R. Jaumann[1], D. Heather[2], and G. Neukum[3]. [1]DLR Institute of Planetary Research, Berlin, Germany (Klaus.Gwinner@dlr.de), [2]ESTEC, Noordwijk, Netherlands, [3]Freie Universität Berlin, Germany.

Introduction: The High Resolution Stereo Camera (HRSC) [1,2] onboard the European Mission Mars Express is the first photogrammetric stereo sensor system employed for planetary remote sensing. We present the general specifications of HRSC high-level photogrammetric data products for Mars (digital elevation models and orthoimages) together with a short overview of the procedures developed and applied for their derivation.

These data products are now made available to the public through the archives at the Planetary Science Archive (PSA, http://www.rssd.esa.int/PSA) at ESA and the Planetary Data System (PDS, http://pds-geosciences.wustl.edu/missions/mars_express/) at NASA. A joint website of Freie Universitaet Berlin and the German Aerospace Center (DLR) provides the ability of on-line vizualisation of these data products (http://hrscview.fu-berlin.de/, [3]). The products derived from the data of the first 6 months of the mission were delivered by the end of 2007 and are made available from both archives after their validation. Further data products will be delivered periodically to both archives. Up to now, only radiometrically corrected images were available from PSA and PDS, as well as map-projected images rectified without the use of DTMs derived from HRSC stereo data.

Data Product Specifications: The data products of the systematic HRSC Level-4 processing (Table 1) are 8 Bit orthoimages for the Nadir channel and the 4 color channels and 16 Bit DTMs (1 m numeric height resolution), both in VICAR format. The products are also formatted according to Planetary Data System (PDS) specifications. The map scales of the orthoimages adhere to standard resolutions (12.5, 25, 50… m/pixel), depending on the ground resolution of the respective image. For the specification of the DTM spatial resolution, the quality of image and orientation data is also decisive. Usually, a grid spacing of about 2 times the mean stereo resolution is used (up to 50 m). 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 the MOLA team [4]. In addition to the spheroid DTM, an areoid DTM is produced. Again in agreement with the datum used by the MOLA team, the areoid represents heights above an equipotential surface described by potential model GMM3 (PDS dataset MGS-M-MOLA-5-MEGDR-L3-V1.0). The map projection is Sinusoidal for latitudes between ±85° and Polar-Stereographic for polar areas.

Product Generation: DTM generation [5] 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 process of DTM generation is based on adjusted orbit and pointing data [7,8] and has been validated in detail as reported in [5] and [6]. Based on the high-resolution DTM, the quality of co-registration with the MOLA DTM is evaluated, and final improvements to the exterior orientation data are derived.

The DTM and the adjusted orientation data are finally applied for ortho-image production [9]. The only additional pre-processing step for ortho-images consists of a histogram-based linear contrast stretch, which does not affect the linear metrics of the radiometric image calibration, and which is applied independently for each image channel. Similarly, the Level-3 images (orthorectification of complete HRSC images based on MOLA) available via PDS and PSA are successively re-calculated using the new orientation data and product specifications.

Table 1. Overview of the main HRSC high-level data product specifications.

	DTM	Orthoimage
Product Subtypes	Spheroid DTM Areoid DTM	Panchromatic (Nadir), Red, Green, Blue and Near-Infrared Channel Orthoimages
Spatial Resolution	variable, up to 50m	12.5m / 25m / 50m … depending on Ground Resolution
Reference Bodies for Height	Spheroid r=3396km and GMM3-derived Equipotential Surface (Areoid DTM)	n/a
Ref. Body for Map Projection	Spheroid r=3396km	
Map Projection	Sinusoidal (±85° latitude) Polar-Stereographic (polar areas)	

Results for the First 6 Months of the Mission and Current Processing Status: About 85 percent of all HRSC stereo datasets acquired during the first 6 months of the mission have allowed for producing high-level data products. Quality assessment based on internal quality parameters and comparison to external terrain data confirms the results of our earlier investigations based on a smaller number of test datasets [5]. A typical 3D point accuracy of about 10 m – 15 m is achieved (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. In a few cases, a grid spacing of >125m is adopted. Height differences with respect to MOLA topography data (Fig. 1) show near-zero offsets on average, testifying to the accurate co-registration of both datasets. However, local height deviations between the two datasets can be considerable (more than ±100m; typical standard deviations for entire DTMs: >20m). They reflect the measurement uncertainties on both sides, but also differences in the representation of topographic detail (resulting e.g. from the difference in spatial resolution and coverage) and underline the complementarity of the two approaches.

By November 2007, stereo analysis for 317 data sets has been finished, of which 260 yielded high-quality DTMs (and consequently, Level-4 ortho-images). They cover a surface of 16.8 Mio km^2. In more than 2/3 of the unsuccessful datasets, the obstacle to deriving a high-level product was insufficient surface visibility (due to cloud coverage and strong atmospheric haze causing contrast reduction).

Outlook: The derivation of the data products of the nominal mission and first mission extension is expected to be finalized after 3 years, i.e. in early 2010. This includes MEX orbits until October 2007, which cover 105 Mio km^2 or about 72 percent of the surface of Mars by stereo datasets. We plan to have seven further data releases, each encompassing the stereo data acquired within 6 months of the mission (i.e. orbits until #1224, #1863, #2529, #3160, #3795, #4479, #4917). We are also pursuing the generation of mosaicked data products (see e.g. [2] and [10] for previous results), as far as sufficient coverage by high-quality DTM for the respective areas has been achieved. As discussed before, the net coverage by high-level data products is expected to fall short of the total coverage by image data to some degree. The goal of global coverage by HRSC high-level data products, which could still be achieved, critically depends on the further progression of the mission, and in particular on the approval of the 3rd mission extension.

References: [1] Neukum, G., et al. (2004) *ESA SP-1240*, 17-35. [2] Jaumann, R., et al. (2007), *PSS 55,* 928-952. [3] Michael, G., et al. (2008), 39th LPSC (this conference). [4] Smith, D.E., et al. (2001)., *JGR 106(E10),* 23689-23722. [5] Gwinner, K., et al. (2008), *PERS*, *subm*. [6] Heipke, C., et al. (2007), *PSS* 55, 2173-2191. [7] Spiegel, M., et al. (2006), *IntArchPhRS (36)4*. [8] Spiegel, M. (2007), *IntArchPhRS 35(3)*/ W49B, 161-166. [9] Scholten, F., et al. (2005), *PERS* 71(10), 1143-1152. [10] Dumke, A., et al. (2008), 39th LPSC (this conference).

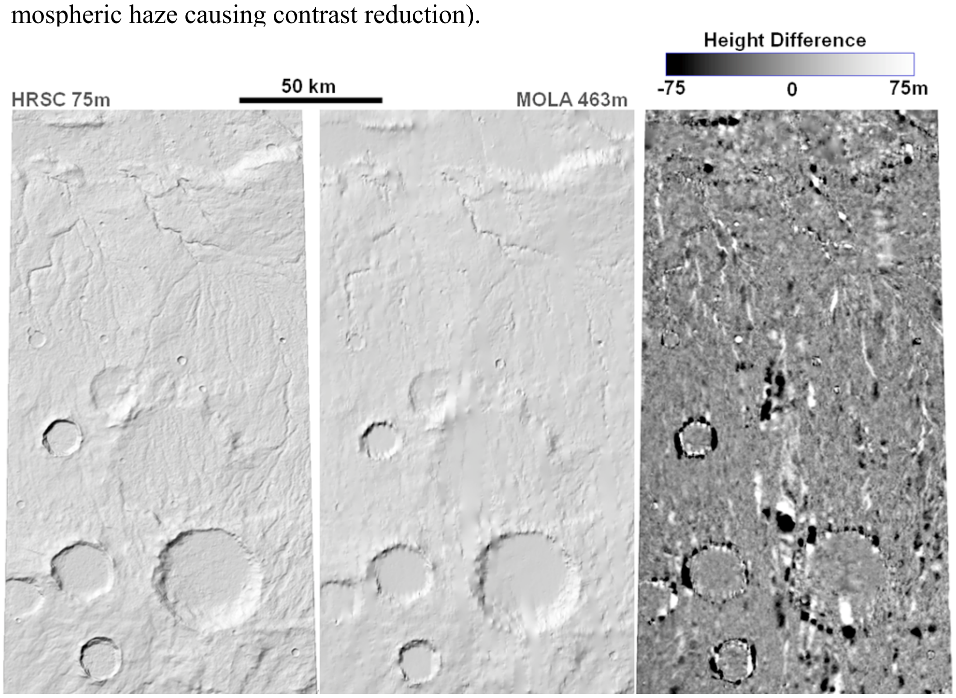

Figure 1. Shaded views of HRSC DTM (left) and MOLA DTM (center), and height difference map of both datasets for a sub-area in Thaumasia Fossae (268°E 42°S).