EPSC Abstracts
Vol. 11, EPSC2017-473, 2017
European Planetary Science Congress 2017

High Resolution Stereo Camera (HRSC): A Geomorphological Approach

R. Jaumann (1, 2), D. Tirsch (1), S. Adeli (1), E. Hauber (1), H. Hoffmann (1), T. Roatsch (1), K. Gwinner (1), F. Preusker (1), S. Elgner (1), E. Kersten (1) and The HRSC Science Team.
(1) DLR, Inst. of Planetary Research, Berlin, Germany, Ralf.Jaumann@dlr.de. (2) Freie Universität Berlin, Inst. of Geosciences, Berlin, Germany.

The HRSC Experiment: Imagery is the major source for our current understanding of the geologic evolution of Mars in qualitative and quantitative terms. Imaging is required to enhance our knowledge of Mars with respect to geological processes occurring on local, regional and global scales and is an essential prerequisite for detailed surface exploration. The High Resolution Stereo Camera (HRSC) of ESA's Mars Express Mission is designed to simultaneously map the morphology, topography, structure and geologic context of the surface of Mars as well as atmospheric phenomena [1]. The HRSC directly addresses two of the main scientific goals of the Mars Express mission: [1] High-resolution three-dimensional photogeologic surface exploration and [2] the investigation of surface-atmosphere interactions over time; and significantly supports: [3] the study of atmospheric phenomena by multi-angle coverage and limb sounding as well as [4] multispectral mapping by providing high-resolution three-dimensional color context information. In addition, the stereoscopic imagery will especially characterize landing sites and their geologic context [1]. The HRSC surface resolution and the digital terrain models bridge the gap in scales between highest ground resolution images (e.g., HiRISE) and global coverage observations (e.g., Viking). This is also the case with respect to DTMs (e.g., MOLA and local high-resolution DTMs). HRSC is also used as cartographic basis to correlate between panchromatic and multispectral stereo data. The unique multi-angle imaging technique of the HRSC supports its stereo capability by providing 3 to 5 stereo observations from each mapping orbit, making the photogrammetric processing very robust [1,3,4]. The capabilities for three dimensional orbital by HRSC making this camera unique in the international Mars exploration effort.

Imaging Capabilities: The HRSC is a multi-sensor push broom instrument comprising 9 CCD line sensors mounted in parallel for simultaneous high resolution stereo, multicolor and

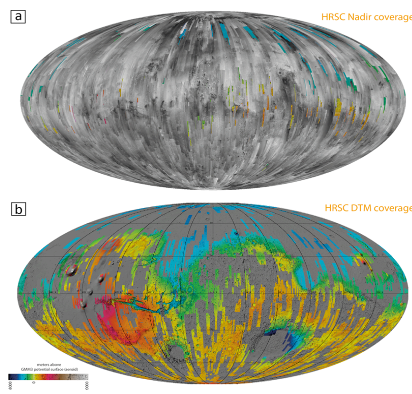

Fig. 1: HRSC coverage maps. (a) Global HRSC nadir mosaic (grey) draped onto color-coded MOLA topography. (b) Global color-coded HRSC DTM mosaic draped onto MOLA shaded relief map in grey.

multi-phase imaging by delivering 9 superimposed image swaths [1,2]. Its design permits stereo imaging with triple to quintuple panchromatic along-track stereo including a nadir-directed, forward- and aft-looking (+/-18.9°), and 2 inner (+/-12.8°) stereo line sensors. Their spectral range covers 675±90 nm. The along-track acquisition of stereo imagery reduces the influence of changes in atmospheric and illumination conditions, which so far have caused problems in the photogrammetric analysis of stereo images acquired at different observation times. The triple to quintuple stereo images permit robust stereo reconstruction, yielding Digital Terrain Models (DTMs) at a 3D accuracy better than the pixel resolution of the images.

The 5 panchromatic images are also used for multi-phase imaging allowing the determination of photometric surface characteristics. Multispectral imaging is realized by four line sensors in the blue, green, red and near infrared color ranges (440±45 nm, 530±45 nm, 750±20 nm, 970±45 nm). All nine lines sensors have a cross track field of view of ± 6°. They are mounted behind a single optics. High-level image processing results in radiometrically corrected and orthorectified nadir and color images as well as high

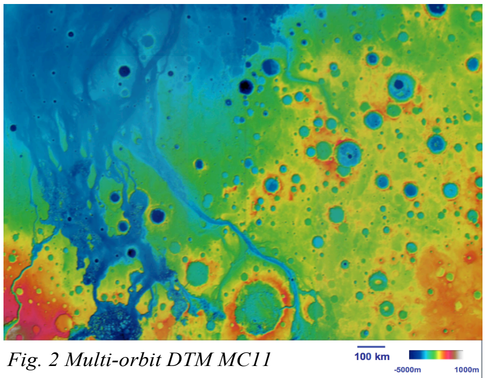

Fig. 2 Multi-orbit DTM MC11

precision DTMs (level 4), all of which are available via multiple platforms (see below). In addition, rectified images using the MOLA DTM as basis for orthorectification are produced. The individual images can be mosaicked to orthoimages of regional extent, 3D points derived from individual images are integrated into multi-orbit DTMs, and these data products can be turned into 3D-perspective views [4].

Coverage: After 13 years of orbiting the planet, HRSC has covered more than 90% of the surface with image resolutions up to 10 m/pixel. By the time of writing, the HRSC has taken more than 39.400 image sequences acquired during 4990 orbits of image acquisition flew a total of 16.882 orbits. High precision digital elevation models of up to 50 m grid spacing, generated from all suitable datasets of stereo coverage, currently cover about 50 % of the surface.

Scientific Achievements: HRSC continues yielding numerous scientific results in a variety of geological topics [e.g.5,6,7,8]. Parts of the accomplishments of the last years are collected in the Earth and Planetary Science Letters special issue "Mars Express after 6 Years in Orbit" of 2010 [e.g., 9, 10]. Recent results on the Martian Moons based on HRSC data are summarized in the 2014 PSS special issue on Phobos and Deimos [e.g.11,12,13]. The geomorphological analysis of surface features, observed by the HRSC indicate major surface modifications by endogenic and exogenic processes on all scales. Endogenic landforms (e.g., tectonic rifts, small basaltic shield volcanoes) were found to be very similar to their equivalents on Earth, suggesting that no unique processes are required to explain their formation. Volcanism may have been active up to the very recent past or even to the present, putting important constraints on thermal evolution models [13]. The analysis of diverse landforms produced by aqueous processes revealed that surface water activity was likely episodic, but ranged in age from very ancient to very recent [13]. Particularly important is prominent glaciation and periglacial features at several latitudes, including mountain glaciers [13]. The identification of aqueous alteration minerals and their geological context has enabled a better understanding of paleoenvironmental conditions and pedogenetic processes [13]. Dark dunes contain volcanic material and are evidence for the significantly dynamic surface environment, characterized by widespread erosion, transport, and redeposition [13]. Since basically all geologic interpretations of extraterrestrial features require profound knowledge of the Earth as key reference, studies of terrestrial analogues are mandatory in planetary geology. Field work in Antarctica, Svalbard and Iceland [13] provided a basis for the analysis of periglacial and volcanic processes, respectively.

Data download platforms:
http://www.rssd.esa.int/index.php?project=PSA
http://ode.rsl.wustl.edu/mars/
http://europlanet.dlr.de/mex/
http://maps.planet.fu-berlin.de
http://muted.wwu.de/
http://www.i-mars.eu/
https://jmars.mars.asu.edu/
http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10333/

The HRSC Team: PI: R. Jaumann. Co-Is: V. Ansan, T. Basilevsky, G. Bellucci, J.-P. Bibring, M.G. Chapman, M.H. Carr, T.C. Duxbury, H. Foing, F. Fueten, S. van Gasselt, K. Gwinner, E. Hauber, J.W. Head, W.K. Hartmann, C. Heipke, H. Hiesinger, H. Hoffmann, A. Inada, W.-H. Ip, B. Ivanov, J. Jansa, H.U. Keller, R. Kirk, M. Kleinhans, P. Kronberg, R. Kuzmin, Y. Langevin, L. Le Deit, N. Mangold, W. Markiewicz, P. Masson, T.B. McCord, G.G. Michael, J.-P. Muller, J.B. Murray, J. Oberst, G. Neukum, G.G. Ori, M. Pätzold, P. Pinet, R. Pischel, T. Platz, M. Pondrelli, F. Poulet, J. Raitala, D. Reiss, A.P. Rossi, G. Schwarz, T. Spohn, S.W. Squyres, D. Tirsch, D. Williams, K. Willner.

References: [1] Jaumann R. et al. (2007) PSS, 55, 928-952. [2] Neukum G. et al. (2004), ESA Sp. Pub., SP-1240, 1-19. [3] Gwinner K. et al. (2009), PE&RS, 75(9), 1127-1142. [4] Gwinner, K. et al. (2016), PSS 126, 93-138. [5] Ansan V. & Mangold N. (2013) JGR, 118(9), 1873-1894. [6] Le Deit L. et al. (2013) JGR, 118, 1-35. [7] Hartmann W. et al. (2014) Icarus, 228, 96-120. [8] Fueten F. et al. (2014) JGR, 119, 331-354. [9] Gwinner K. et al. (2010), EPSL, 294(3-4), 506-519. [10] Jaumann R. et al. (2010), EPSL 294(3-4), 272-290. [11] Wählisch M. et al. (2014), PSS, in press, doi: 10.1016/j.pss.2013.05.012. [12] Willner K. et al. (2014), PSS, in press, doi: 10.1016/j.pss.2013.12.006. [13] Jaumann R. et al. (2015), PSS 112, 53-97.