

Topographic mapping of the Mars MC quadrangles using HRSC data

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Keywords: Topographic maps, planetary cartography, map series, atlas

The High Resolution Stereo Camera (HRSC) of ESA's Mars Express mission [1, 2] is designed to map and investigate the topography of Mars and its satellites. As a push broom scanning instrument with nine CCD line detectors mounted in parallel, its unique feature is the ability to obtain along-track stereo images and four colors during a single orbital pass (Fig. 1). Thus, panchromatic stereo and color images from single orbits of the HRSC have been used to produce digital terrain models (DTMs) and orthoimages of the Martian surface since 2004. The HRSC is still running nominally and delivering new image strips to fill remaining gaps that lead to a contiguous coverage of the surface at high resolution stereo. The very high degree of nadir image coverage (up to 96%) of the Mars surface is an outstanding characteristic of the Mars Express mission, which no other mission has been achieved so far. The sub-pixel accuracy of derived 3D points results in DTMs with grid sizes of up to 50 m and height accuracy on the order of one pixel on the ground and better [3].

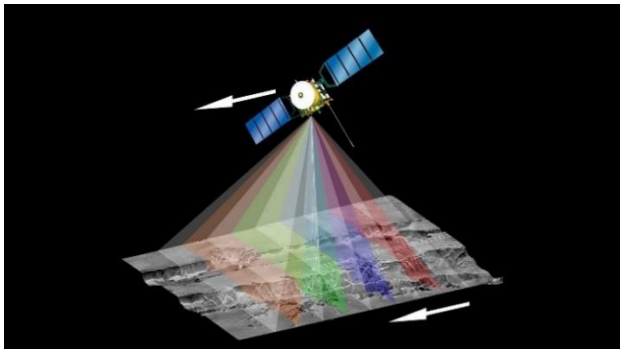


Figure 1. HRSC imaging scheme showing the nine sensors

Since 2010 new HRSC multi-orbit data products have been generated, which have been developed into a global mapping program organized into MC-30 half-tiles, since 2014 [4,5]. Based on continuous coverage of an area, regional DTMs and orthomosaics can be produced by combining image data from multiple orbits using specifically adapted techniques for block-adjustment, DTM interpolation and image equalization [6]. The resulting DTMs and color orthomosaics are the baseline for a controlled topographic map series of Mars at a scale of 1:700,000. The extents of the regional products follow the MC-30 (Mars Chart) global mapping scheme of Greeley and Batson (Fig. 2) [7], which subdivides Mars into 30

quadrangles. Ronald Greeley and Raymond Batson were pioneers in planetary cartography and set fundamental standards for e.g., map formats and projections for planetary bodies. For the generation of the DTMs and color mosaics, the MC-30 quadrangles are further divided into East (E) and West (W). In parallel to the completion of the first half-tile DTM and color mosaic (MC-11-E) we developed a concept for a topographic map series of Mars [8,9]. To limit data volumes and map sizes, each quadrangle is subdivided into eight tiles (i.e. each half-tile into four tiles, Fig. 3). The map scale of 1:700,000 is a compromise between the high DTM and orthomosaic resolution of 50 m/pxl and an acceptable hardcopy format of about 1 m in width to 2 m in height. This results in a printing scale of 14 pxl/mm. MC-11 was selected to be produced first because it contained the four final landing site candidates of ESA's ExoMars mission, including Mawrth Vallis and the finally selected site for the Rosalind Franklin rover (launch in 2022), Oxia Planum.

Geographically, the region is located on the northern hemisphere within Acidalia Planitia and Arabia Terra. After MC-11, the Global Topography and Mosaics Task Group (GTMTG) of the HRSC Science Team focussed on MC-13, which

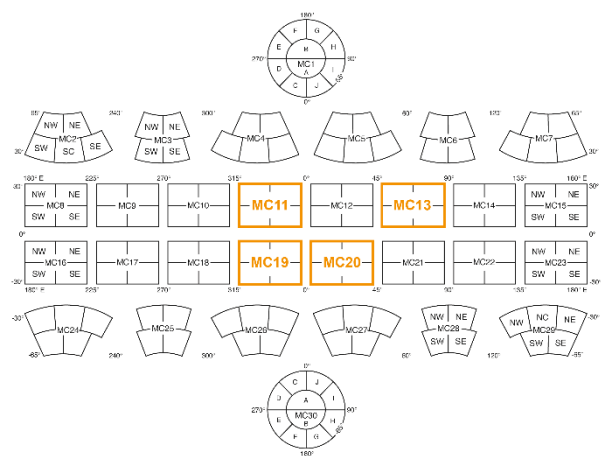


Figure 2. MC-30 scheme tiling Mars into 30 quadrangles

MC-11

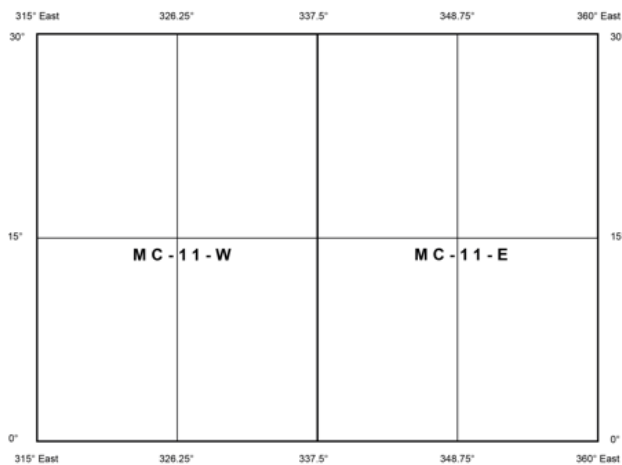


Figure 1. Tiling scheme of the topographic maps

to small, regions (planitia, planum, terra), valleys (vallis), linear features (chasma, fossa, rupes), mountains (mons, tholus), and craters. Also typical for Mars are chaotic terrains (chaos). Besides a text with explanations on the maps and the data we used side maps with a) the footprints of the HRSC image stripes and b) a color-coded and shaded DTM of the shown map tile.

All maps are available for the public at the HRSC team website (<http://hrscteam.dlr.de/HMC30/index.html>).

We thank the HRSC Experiment team at DLR, Institute of Planetary Research, Berlin, and at Freie Universität Berlin, the HRSC Science Team, as well as the Mars Express Project teams at ESTEC, ESOC, and ESAC for their successful planning and acquisition of data as well as for making processed data available to the HRSC team.

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is also located on the northern hemisphere and covering parts of Arabia Terra. Further, the quadrangle hosts the landing site of the Perseverance rover from NASA's Mars 2020 mission (arrival in 2021), Jezero crater. Scientists found an ancient river delta near the crater rim that most likely was formed in an ancient crater lake – a highly promising place for the search for life. The next HRSC MC quadrangles will also be equatorial ones (i.e. 19 and 20).

The topographic maps of our series are dominated by the almost format-filling HRSC orthomosaic. Where available, color orthoimages are used, showing Mars-typical reddish-brown colors. The color comes from a combination of the HRSC color channels following a color standard by processing of the mosaic on ground, but is no true color. The cartographic context is given by a geographic coordinate grid with East longitudes from 0° to 360° and contour lines that depict the topography of the region. The top layer shows the names of the regions, craters and other landforms that have been named so far. On Mars we mostly have, from large