EPSC Abstracts
Vol. 10, EPSC2015-672, 2015
European Planetary Science Congress 2015

The first Quadrangle of the Mars Express HRSC Multi-Orbit Data Products (MC-11-E)

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Abstract

Panchromatic stereo and color images of the High Resolution Stereo Camera (HRSC) have been used for production of digital terrain models (DTMs) and orthoimages for the surface of Mars from single orbits since several years. We report on the characteristics of a new HRSC data product, HRSC image mosaics and multi-orbit DTMs, related methodology aspects, and the completion of the first regional product dataset.

1. Introduction

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. The sub-pixel accuracy of derived 3D points allows producing DTMs with grid sizes of up to 50 m and a height accuracy on the order of one pixel on the ground and better [3,4].

After more than 10 years of operation, HRSC has covered about 70% of the surface by panchromatic images at 10-20 m/pixel, and about 98% at better than 100 m/pixel. As the areas with continuous coverage by stereo data are increasingly abundant, the HRSC team has recently started a coordinated effort for the mapping of Mars by multi-orbit DTMs and image mosaics, using the complete HRSC mission data record. Such seamless, precisely co-registered data products are thought to provide valuable geodetic reference data and geological context to a variety of other datasets, bridging also between global MOLA altimetry and topography data derived from other stereo imaging instruments.

2. Methodology

Derivation of multi-orbit data products [5] is based on the same set of procedures for image rectification, matching, strip-adjustment, and calculation of 3D points applied also for the production of single-strip HRSC DTMs and orthoimages [4]. In addition, bundle block adjustment [6,7,8] and a technique for joint interpolation of multi-scale 3D point sets [9] are used. Orthoimages are photometrically corrected (Lambert model) and normalized to an external brightness standard (Thermal Emission Spectrometer albedo) prior to mosaicking [10,11]. The table below lists main characteristics of the new data product.

Table 1: Product specifications for HRSC single-strip Level-4 products and multi-orbit data products

	Single-strip DTM	*Single strip orthoimage*	*Multi-orbit DTMs*	*Orthoimage mosaics*
Production Status	40% completed	40% completed	First prototype completed (MC-11E)	First prototype completed (MC-11E)
Product Subtypes	Spheroid DTM Areoid DTM	Panchromatic (Nadir), Red, Green, Blue and Near-Infrared Channel Orthoimages	Spheroid DTM Areoid DTM	Panchromatic nadir mosaic Pan-sharpened color mosaic
Data Format	16 bit, numeric height resolution 1 m	8 bit	16 bit, numeric height resolution 1 m	16 bit
Spatial Resolution	50 / 75 / 100 m … depending on quality of image and orientation data	12.5 / 25 / 50 m … depending on ground resolution	50-100 m	depending on subtype 12.5 m (pan) max 50 m (col)
Reference Bodies for Height	Spheroid r = 3396 km and GMM3-derived equipotential surface (Areoid DTM)	n/a	Spheroid r=3396 km and GMM3-derived equipotential surface (Areoid DTM)	n/a
Reference Body for Map Projection	Spheroid r = 3396 km	Spheroid r = 3396 km	Spheroid r = 3396 km	Spheroid r = 3396 km
Map Projection	Sinusoidal (±85° latitude) Polar-Stereographic (polar areas)	Sinusoidal (±85° latitude) Polar-Stereographic (polar areas)	Equidistant Cylindrical (±57° latitude) Polar Stereographic (polar areas)	Equidistant Cylindrical (±57° latitude) Polar Stereographic (polar areas)

3. Results for quadrangle MC-11-E

The new mapping program adopts the MC-30 global mapping scheme which subdivides Mars into 30 quadrangles. For the HRSC mapping products, each quadrangle is subdivided in two to limit data volumes. MC-11 East is located at the equator and covers an E-W extension of about 1330 km (at the equator) and a N-S extension of about 1780 km. The area includes parts of Arabia Terra, Meridiani Planum and Chryse Planitia and the data products are based on 89 individual HRSC image strips. Comparison with MOLA data and analysis of residual offsets between individual HRSC strips shows that the multi-orbit data product provides the same 3D point precision and the same accuracy of co-registration with MOLA heights as the HRSC single-orbit data products, while, in addition, pixel-scale co-registration accuracy between individual HRSC image strips is achieved using bundle block adjustment, as required for producing image mosaics at the full nadir image resolution [5].

4. Summary and Outlook

The completion of the first HRSC MC-30 half-tile demonstrates that multi-orbit DTMs with grid spacing of 50 m are feasible for large surface areas in spite of the existing variation of ground pixel size based on bundle block adjustment and joint interpolation of multi-scale 3D points. Likewise, after a photometric normalization and by using an external albedo map as a brightness standard, it is possible to produce visually homogeneous image mosaics although the images (due to orbit constraints) are frequently acquired under very different illumination and atmospheric conditions. Acquisition of additional data for further improving data coverage is one of the priorities for the remaining phases of the mission.

Acknowledgements

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. We acknowledge the funding support of DLR and co-funding by the European Union's Seventh Framework Program (FP7/2007-2013) under Grant agreement n° 607177 and n° 607379. The HRSC Global Topography and Mosaic Generation Task Group is supported by members of the HRSC Science Team from DLR, Institute of Planetary Research, Freie Universität Berlin, Leibniz Universität Hannover, George Mason University, Fairfax, VA, U.S. Geological Survey, Flagstaff, AZ, and MSSL, University College London.

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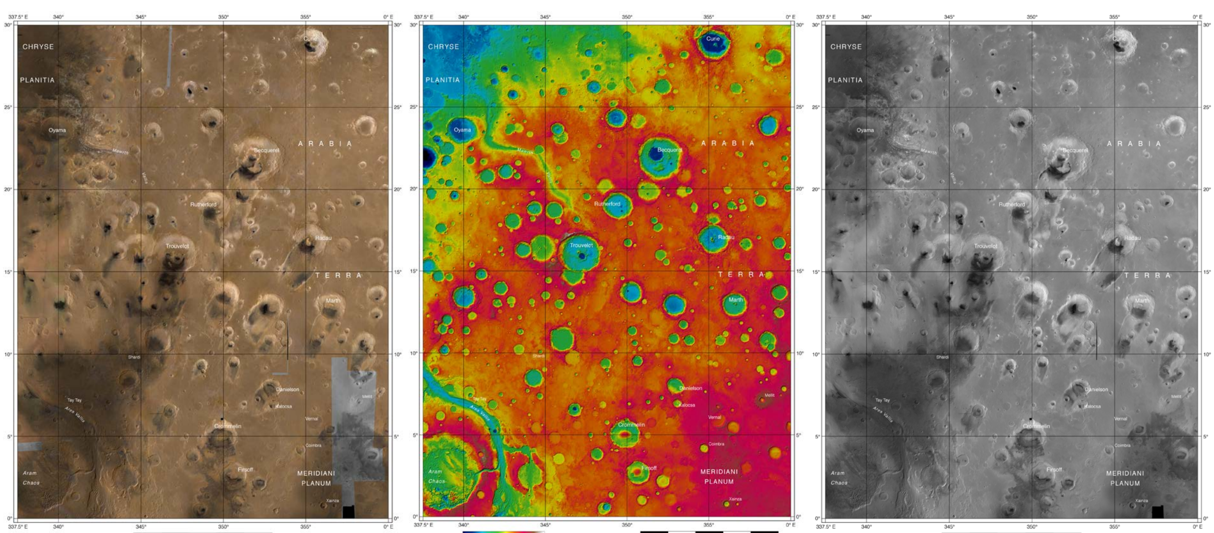

Figure 1: HRSC color mosaic, color-coded relief map, and nadir mosaic for MC-11 (East). E-W width about 1330 km (at the equator), N-S about 1780 km, resolution 12.5 m (panchromatic mosaic) and 50 m (DTM, color mosaic).