LARGE-SCALE TOPOGRAPHIC MAPS OF IANI CHAOS, MARS

S. Gehrke a, H. Lehmann a, R. Köhring a, M. Wählisch b, F. Scholten b, J. Albertz a, G. Neukum c, and the HRSC Co-Investigator Team

a Technische Universität Berlin, Geodesy and Geoinformation Science, Germany – {stephan | hartmut | robert | albertz}@fpk.tu-berlin.de
b German Aerospace Center (DLR), Institute of Planetary Research, Berlin, Germany – {marita.waehlisch | frank.scholten}@dlr.de
c Freie Universität Berlin, Institute of Geosciences, Germany

KEY WORDS: Photogrammetry, Remote Sensing, Cartography, Extra-terrestrial, Planetary

ABSTRACT:

The High Resolution Stereo Camera (HSRC) on board of the Mars Express orbiter is covering the Martian surface in color and 3D. Therefore, this camera experiment provides excellent data sets for photogrammetry and large-scale cartography. The standard map series of the Mars Express mission is the Topographic Image Map Mars 1:200,000. All of its sheets are based on HRSC orthoimage mosaics and HRSC Digital Terrain Models. Furthermore, they feature Martian nomenclature, grid systems, individual sheet designations and the respective legendary entries. Altogether, Mars is covered by 10,372 sheets, 10,324 of them in Sinusoidal Equal-area Projection, supplemented by 48 polar sheets in Lambert Azimuthal Equal-area Projection. The series layout scheme is flexible to the generation of special target maps; each sheet can be subdivided into quarters and sixteenths for mapping in scales 1:100,000 and 1:50,000, respectively.

For the illustration of both the quality of Mars Express HRSC imagery and the cartographic concept, two regular map sheets of the Iani Chaos region and several subdivisions in larger scales have been produced at the Technische Universität Berlin in cooperation with the German Aerospace Center (DLR). Iani Chaos is of special geological interest, since it likely has been formed by flowing water. This area has been observed by HRSC with the best possible ground resolution of approximately 12 m/pixel and, therefore, is well suited for mapping in large scales up to 1:50,000. The map generation itself is an automated process using the cartographic software package Planetary Image Mapper (PIMap) that is presented in a companion paper (Gehrke et al., 2006).

KURZFASSUNG:


Um sowohl die Qualität der Mars Express HRSC-Daten als auch das kartographische Konzept zu illustrieren, wurden zwei Regelblätter der Iani Chaos Region und einige Teilblätter in größeren Maßstäben an der Technischen Universität Berlin in Zusammenarbeit mit dem Deutschen Zentrum für Luft- und Raumfahrt (DLR) hergestellt. Iani Chaos ist von besonderem geologischen Interesse, da es wahrscheinlich durch fließendes Wasser geformt wurde. Dieses Gebiet wurde durch die HRSC in der bestmöglichen Bodenauflösung von etwa 12 m/Pixel aufgenommen und ist daher für die Kartierung in Maßstäben bis 1:50 000 gut geeignet. Die Kartengenerierung selbst ist ein automatisierter Prozess unter Verwendung des kartographischen Software-Pakets Planetary Image Mapper (PIMap), das in einem eigenen Beitrag präsentiert wird (Gehrke et al., 2006).

1. INTRODUCTION

During the past two years, the High Resolution Stereo Camera (HRSC) experiment on board of the European Mars Express orbiter has covered more than half of the Martian surface and approximately 27% of it in resolutions better than 20 m/pixel. The HRSC camera instrument is well suited for the special demands of stereophotogrammetry and cartography as well. Thus, color orthoimages, Digital Terrain Models (DTM), and – based on these two data sets – high quality topographic and thematic map products are generated, mainly in standard scale 1:200,000.

To illustrate both the quality of HRSC images and DTMs as well as the sophisticated cartographic concept and the flexibility of the Topographic Image Map Mars 1:200,000 series, a pair of adjacent regular map sheets of the Martian Iani Chaos region as well as some of their subdivisions in scales of 1:100,000 and 1:50,000 have been generated.
2. THE CARTOGRAPHIC CONCEPT

The Topographic Image Map Mars 1:200,000 is defined as the standard map series of the Mars Express mission. It has originally been designed for the failed Mars96 mission (Lehmann et al., 1997) and further developed and/or adapted for Mars Express cartography. The basic cartographic concepts, sheet layout as well as reference and coordinate systems of the series have been presented in earlier publications – see e.g. Gehrke et al. (2003) and Albertz et al. (2004). An example of the standard series is shown in Fig. 1.

In general, all map sheets are based on HRSC orthoimages, supplemented by contour lines derived from HRSC DTMs, topographic names, grids, and marginal information. The compilation of such a map is an automated process using the cartographic software package Planetary Image Mapper (PIMap), which has been developed at Technische Universität Berlin (Gehrke et al., 2005; Gehrke et al., 2006). However, few interactive finalizations, e.g. with regard to the final label placement, are necessary.

The planet Mars is covered by 10,372 individual sheets in equal-area map projections, i.e. 10,324 of them within the ±85° latitude zone in Sinusoidal Projection and 48 around the poles in Lambert Azimuthal Equal-area Projection. While each of the quadrangles spans 2° in latitude, longitudinal extents increase from 2° near the equator up to 360° towards the poles in order to keep the mapped area approximately constant. The Martian reference body is the IAU 2000 Ellipsoid with an equatorial axis of 3396.19 km and a polar axis of 3376.20 km. Both Martian coordinate systems – i.e. the standard consisting of eastern longitudes and planetocentric latitudes as well as the formerly used system of western longitudes and planetographic latitudes – are shown within the map sheets. Zero longitude (Airy-0) is determined by an angle W 0 of 176.630° with respect to the inertial coordinate system. An areoid, i.e. the Martian geoid, is defined as the reference surface for heights (Seidelmann, 2002).

The sheets of the Topographic Image Map Mars 1:200,000 standard series can be subdivided into quarters and sixteenths for systematic mapping in larger scales 1:100,000 and 1:50,000, respectively. In principle, the cartographic concept perfectly meets all requirements for mapping features or regions of interest as well as particular HRSC orbits that don’t fit with the standard sheet line system.

![Image of regular sheet of the Topographic Image Map Mars 1:200,000 standard series – “M 200k 2.00S/343.00E OMKT, Iani Chaos Region” (downscaled).](image-url)
3. TOPOGRAPHIC MAPS OF IANI CHAOS

3.1 The Iani Chaos Region

Iani Chaos is a large depression with dimensions of 330 km in length and 430 km in width, located at 2.8° south and 342.5° east (USGS 2006a). Individual blocks of rock and hills form a disrupted, knobby pattern in an apparently “chaotic” distribution. Terraces and “islands” are likely remnants of the pre-existing surface, which collapsed after cavities had formed beneath it – ice in these cavities might have been melted by volcanic heat and flown into Ares Vallis towards the northern lowlands (FU Berlin, 2005). Due to the hints of water having formed it, such a landscape is of special geological interest and also well suited to present the design and the potential of the map series.

The Iani Chaos region was covered within the Mars Express orbits 912, 923, and 934 (Fig. 2). These three orbits provide best possible ground resolutions within the respective region, in particular between 11.9 m/pixel and 12.5 m/pixel for the HRSC nadir channel images. The color channels have been obtained in 4x4 macropixel format mode resulting in approximately 50 m/pixel.

3.2 Data Processing and Map Generation

The photogrammetric processing of HRSC data – amongst other things including pan-sharpening of the color channels and mosaicking of the three orbits – was carried out at the German Aerospace Center (DLR); details of such a processing chain are described by Scholten et al. (2005). The resulting orthoimage mosaic and the HRSC DTM of the Iani Chaos region feature spatial resolutions of 12.5 and 50 m, respectively.

At Technische Universität Berlin, two adjacent standard products within the regular sheet lines of the Topographic Image Map Mars 1:200,000 standard series, “M 200k 0.00N/343.00E OMKT” and “M 200k 2.00S/343.00E OMKT” (see Fig. 1 for the latter map) as well as several subdividing sheets in larger scales, i.e. 1:100,000 and 1:50,000 have been produced – cf. Fig. 3. The general layout, following the cartographic concepts described above, appears very similar for all map sheets. While the maps feature their individual designations, all of them are named “Iani Chaos Region”.

Fig. 2: Iani Chaos and its coverage by Mars Express orbits 912 (eastern part), 923 (middle), and 934 (western part). Background data are based on Viking imagery (USGS, 2006b). The dashed line represents the border of Fig. 3.

Fig. 3: Overview of Topographic Image Maps Mars of the Iani Chaos region generated in scales 1:200,000 (neat lines shown in black), 1:100,000 (blue), and 1:50,000 (yellow), respectively. The standard sheet lines system is indicated by dashed lines.
Each map sheet has been generated automatically using the software PIMap, which is presented in a companion paper by Gehrke et al. (2006). PIMap is very flexible, regarding e.g. map scales, contour line layout, or sheet contents in general.

Compared to exact radiometric analysis of HRSC imagery, map products are viewed by the human eye and visually interpreted. Thus, for its representation within the map sheet, the original orthoimage has been enhanced with regard to contrast and also slightly sharpened utilizing an unsharp mask.

For the map productions in different scales, the equidistances of contour lines have been adapted depending on the individual surface properties in order to present the terrain topography adequately.

### 3.3 Comparison of Map Sheets With Regard to Different Scales

A part of Iani Chaos as taken from three topographic map sheets in three different scales (i.e. “M 200k 2.00S/343.00E OMKT”, “M 100k 2.50S/343.50E OMKT”, and “M 50k 2.25S/343.25E OMKT”) is shown in Fig. 4. The depicted area is characteristic for the Iani Chaos terrain; it features the typical knobs and hills as well as a larger mesa in the north-eastern area.

Within their mapped surfaces, the three sheets differ in image resolution: 12.5 m/pixel in the orthoimage mosaic translate to 406 dpi, 203 dpi, and 102 dpi, respectively. Although few effects of image compression are recognizable in the largest scale (e.g. at shadowed slopes), in general more texture details of the Martian surface become visible.

The chosen equidistance of 250 m is common for most of the sheets of the Topographic Image Map Mars series in standard scale 1:200,000 that have been produced so far. In larger scales, a more subtle representation of the terrain topography is achieved by denser contour lines. Thus, equidistances of 100 m for the 1:100,000 sheets and 50 m for three out of altogether four 1:50,000 sheets have been applied; for the sheet “M 50k 2.25S/343.25E OMKT” an equidistance of 100 m has indicated to be still sufficient, as this area features the highest relief energy.

### 4. CONCLUSION

While the Topographic Image Map Mars 1:200,000 series was already shown to be a useful and guiding standard (Albertz et al., 2004), the presented sheets of the Iani Chaos region of Mars confirm the flexibility of the mapping concept. Scales up to 1:50,000 could be accomplished in combination with high quality HRSC data in best possible resolutions, which are acquired under optimum conditions, particularly high resolution and little atmospheric disturbance, and adeptly processed.

With regard to the contour line appearance that directly depends on DTM quality, further refinements could lead to improvements in parts. At present, a DTM contest takes place within the HRSC on Mars Express Co-Investigator Team. Resulting DTM data will be evaluated numerically and visually, in particular by deriving topographic image maps with contour lines.

### REFERENCES


ACKNOWLEDGEMENT

The research project Software Development and Technical Support for Cartographic Data Processing at the Technische Universität Berlin is funded by the German Bundesministerium für Bildung und Forschung. This project is part of the research program High Resolution Stereo Camera (HRSC) on the Mars Express Orbiter under the guidance of Principal Investigator Prof. Gerhard Neukum, Freie Universität Berlin.