Introduction: The High Resolution Stereo Camera (HRSC) on Mars Express simultaneously obtains color and stereo imagery of our neighbouring planet. This unique data set is the basis for systematic derivation of color orthoimages and Digital Terrain Models (DTM) and thus for topographic mapping [1,2]. The cartographic standard product for Mars Express is the Topographic Image Map Mars 1:200,000 series, which covers Mars in 10,372 individual sheets in equal-area projections: Sinusoidal projection for latitudes between 85° north and south and Lambert Azimuthal projection around the poles [2,3]. While several standard sheets, special target maps, and related high-quality products are available in mid-latitudes [2-6], the series’ layout in the polar regions has been illustrated only by “preliminary” examples that, e.g., show no contour lines [5].

Recently, two adjacent standard sheets have been produced in Boreales Chasma on either side of the 85° parallel, which is the transition of the two map projections (see figure). The topographic maps combine high-resolution HRSC orthoimages with contour lines from Mars Orbiter Laser Altimeter (MOLA). Map generation was carried out in cooperation of Technische Universität Berlin and German Aerospace Center (DLR).

Map Generation: So far, the sheets of the Topographic Image Map Mars 1:200,000 are derived from HRSC data, which have been registered to MOLA reference. Then HRSC DTMs feature both global accuracy and, in general, better spatial resolution than MOLA [7]. This superiority relaxes in the in the polar regions: On one hand, MOLA track distances narrow and resolution increases with higher latitudes (see below). On the other hand, height derivation from HRSC imagery, i.e. image matching, suffers from the lack of texture in the polar ice; gaps and outliers occur. In such areas, MOLA altimetry is more reliable than the HRSC DTM.

HRSC Imagery: Both map sheets are completely covered by Mars Express orbit 1154 in resolutions of 50 m/pixel in nadir and 200 m/pixel for the color channels. Since HRSC rectification to MOLA — by combined bundle adjustment [8] — is not available for polar orbits so far, we used orthoimagery from DLR standard processing [1,9], which is based on reconstructed orbit geometry with an accuracy of several 100 m [1,8]. As a consequence, an offset between HRSC data and the MOLA reference occurs — primarily in Mars Express’ flight direction —, which we determined from the best overall fit of HRSC orthoimage and MOLA contour lines in the mapped area. Hence, HRSC data needed to be shifted by 898 m in orbit direction (towards south) and 144 m across (towards east). This offset, 910 m in total, is in the range of position and pointing errors of the reconstructed Mars Express orbit. Note that orthoimage generation, i.e. co-registration of color channels, is based on the 200 m HRSC DTM, which generally suffices for this purpose [1]. Misregistrations – due to the discussed DTM inaccuracies – are almost invisible in the concerning icy areas, as they are are radiometrically smooth. To yield appropriate resolution for mapping in scale 1:200,000, the color orthoimage has been pan-sharpened using the nadir channel.

The MOLA DTM for the North Polar Region. Since MOLA point density generally increases with higher latitudes — it should be remarked that, due to orbit inclination, coverage beyond 87° (outside of the mapped region) is rather coarse —, a DTM with 200 m/post has been collected at DLR. Initially, this has been based on 771 MOLA PEDR files or 64,875,630 shots north of 70°. But it contained errors, which have been visually identified by comparing a map of individual shots with the gridded DTM. Thus, a new DTM has been computed by omitting 1,703,604 shots. Finally, few remaining artifacts have been eliminated by median filtering.

Map Compilation was carried out using the Planetary Image Mapper (PIMap) software, which has been especially developed for this purpose at Technische Universität Berlin [5]. PIMap supports map generation by automatic orthoimage adaptation (HRSC), contour line derivation (MOLA) as well as compilation of topographic names, graticules, and marginal elements.

Final Map Products: The sheets “M 200k 84.00N/315.00E OMKT” (Sinusoidal projection) and “M 200k 86.00N/326.00E OMKT” (Lambert Azimuthal projection) of the Topographic Image Map Mars 1:200,000 cover 2° by 18° and 2° by 24°, respectively (see figure). The depicted Chasma Boreale almost divides the ice cap and reveals (in Martian summer) layered structures of water ice and dust [10]. Contour lines nicely fit with these layers and, moreover, give a good impression of the topography of the almost textureless ice cap.

Conclusion: With the standard sheets of Chasma Boreale, the first large-scale maps in the polar regions of Mars are presented. These products take advantage of both HRSC color orthoimagery as well as dense and precise MOLA topography in high latitudes.

Map sheets “M 200k 84.00N/315.00E OMKT” in Sinusoidal projection and “M 200k 86.00N/326.00E OMKT” in Lambert Azimuthal projection. The index map (lower left image) was combined from both sheets and illustrates their relative location, with map surfaces marked in yellow, and neighboring sheets of the Topographic Image Map Mars 1:200,000 series in their projections. The subsection of the northern sheet (upper right image) is shown in scale 1:400,000, which is half of the original size.