GENERATION OF TOPOGRAPHIC AND THEMATIC PLANETARY MAPS USING THE SOFTWARE SYSTEM "PIMAP". S. Gehrke[1], M. Wählisch[2], H. Lehmann[1], J. Albertz[1], G. Neukum[3] and the HRSC Co-Investigator Team, [1]Technische Universität Berlin, Germany (stephan@fpk.tu-berlin.de), [2]German Aerospace Center, Berlin, Germany, [3]Freie Universität Berlin, Germany.

Introduction: The "Planetary Image Mapper" (PIMap) is a cartographic software package for the generation of topographic image maps and also thematic maps. Such products are usually based on orthoimages and supplemented with topographic data, i.e. contour lines and named surface features, and/or thematic information. The entire topographic content, grids, frame lines, map titles and sheet designation as well as typical marginal elements can be automatically generated "all in one" with the PIMap software system.

Basically, the software was designed for the operational production of the Topographic Image Map Mars 1:200,000, the standard map series of the Mars Express mission [1,3]. However, due to its flexibility regarding reference body definitions, projections, scales, and layout specifications, PIMap is broadly applicable in planetary cartography. It is not only used for Mars at TU Berlin and in the HRSC on Mars Express team but, moreover, it has been implemented at DLR to map Saturnian satellites as part of the Cassini mission.

Software Features: PIMap has been developed at TU Berlin in ANSI C++; it is executable under both Microsoft Windows and Linux environments [5]. The software is controlled by solely one initialization file in ASCII format, which contains all parameters (keyword equals value) to define map properties, contents, and layout. Depending on the particular task, further input is required. The following data can be processed:

- Initialization file (mandatory!)
- Orthoimage mosaic
- Digital Terrain Model (DTM)
- Topographic names and landing sites
- Map series definitions

Based on this input, PIMap automatically generates all raster and vector data of the digital map, which is a PDF file. Using this output format ensures the possibility to edit each graphical element if desired. This is of special importance for interactive finishing with commercial standard software (Corel Draw, Freehand, Adobe Illustrator), amongst other things with regard to the final placement of topographic feature lettering.

PIMap handles arbitrary spherical and ellipsoidal reference bodies; ellipsoidal input coordinates can consist either of planetocentric or planetographic latitudes in combination with east or west positive longitudes. Azimuthal, conical, cylindrical, Transverse Mercator, and sinusoidal standard projections as well as modified forms used in planetary mapping – spherical formulae with ellipsoidal latitudes [cf. 1] – are supported.

Automatic Generation of Map Contents: In the following it is described, how the elements of a planetary map sheet can be created with PIMap. Figure 1 shows a section of a standard sheet of the Topographic Image Map Mars 1:200,000. Except for the lettering placement, the direct software output is displayed.

Map Surface and Grid Systems. In general, any map sheet coinciding with latitude and longitude lines – the exclusive case in planetary cartography [7,12] – is producible with PIMap by free definition of its center point, dimensions, and scale. The possibility to generate an arbitrary number of grids not only allows to show different ellipsoidal latitude and longitude systems but also to detail one and the same system. This is common praxis [1,2,12] and can be achieved in PIMap by defining one grid represented by full lines and a second of the same coordinate system but with denser tickmarks [cf. 5]. Similarly, labeling can be controlled.

Image Data. The (color ortho-)image basis of a planetary map is a result of photogrammetric processing including mosaicking and final pan-sharpening [e.g. 3]. Such images have to be provided either in VICAR [8] or in common image formats (TIFF, JPEG, etc.), for the latter case necessarily in combination with a separate VICAR-Label (ASCII file). The image integration into the mapped surface includes the adaption of map projection and scale. Thus, any image data can be directly processed by PIMap – provided the desired region is covered in appropriate resolution.

Contour Lines are derived from a DTM [3,11] in VICAR format. While it is spatially adapted to the map sheet (similar to the orthoimage), the height reference is implicitly defined through the input data. If required, heights must be transformed before running PIMap. For the derivation of contour lines, different equidistance levels can be defined to distinguish index and auxiliary contours. If desired, contour values are placed automatically and, furthermore, short unlabeled depression contours can be marked by arrow ticks [5].

It should be stated, that the appearance of contour lines directly depends on DTM quality (i.e. PIMap allows mean filtering). However, possible inaccuracies have to be edited afterwards; alternatively the concerning contours could be deleted.

Topographic Names and Landing Sites. Surface features could be lettered automatically in PIMap, rea-

sonably using the all-embracing data set provided by the Gazetteer of Planetary Nomenclature [12]. Based on that, topographic features of different kind and diameter can be distinguished by means of font type and size. Therewith also the omission in the map sheet, as it may be desired for Albedo features, is controllable.

The output map review should especially consider name placements. Corrections, adaptations (e.g. to valley courses) but also cancellations might be necessary.

Marginal Information. A planetary map is usually indicated with the title of the map series, a sheet name derived from a topographic feature, and its individual designation [7], which is shown in Figure 1. In addition, PIMap can generate several legendary entries, in particular the scale bar and explanations of map projection, reference body, and coordinate systems as well as an index map showing the position of a map within the context of its neighboring sheets.

All marginal elements, and self-evidently the map surface too, can be automatically arranged in the sheet in order to achieve the layout of different map series.

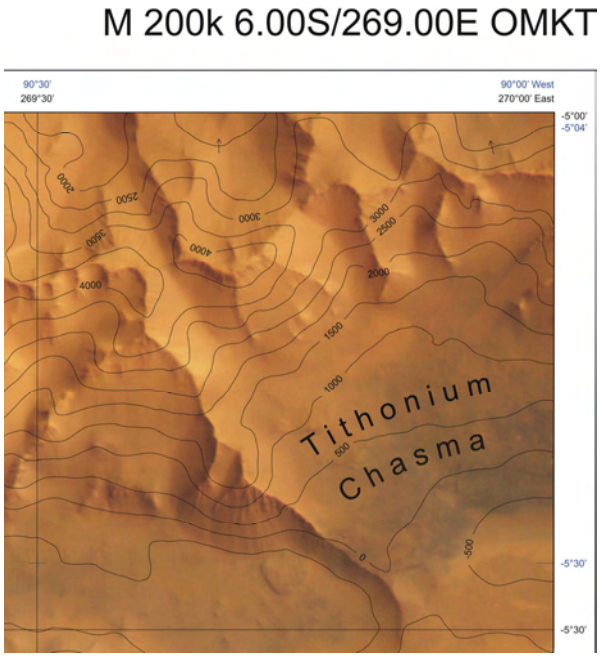

Figure 1: *Subsection of a Topographic Image Map Mars 1:200,000, sheet "M 200k 6.00S/269.00E OMKT".*

Applications: As described in the previous sections, the entire topographic content of a map sheet can be generated automatically with PIMap. However, while only few post processing steps are required to yield high quality topographic maps, the integration of thematic data is an interactive follow-up work.

Topographic Image Maps have already been produced in preparation of the Mars Express mission. Such specimen sheets are based on MOC imagery and MOLA DTM data [4]. Since 2004, along with HRSC image acquisition and processing [3,11], the sheets of the Topographic Image Map Mars 1:200,000 series (Figure 1) as well as special target maps in different scales are generated for selected regions [1,2,3,6].

For Cassini cartography, PIMap is in use at DLR to map the medium-sized icy satellites of the Saturnian system. In particular, map series following the definitions given by *Greyley & Batson* [7] are going to be produced for Mimas, Enceladus, Tethys, Dione, Rhea, Iapetus, and Phoebe on the basis of new Cassini ISS data with Voyager images filling gaps [10].

Thematic Map Products are necessarily assembled on topographic base maps, which are producible with PIMap. Heterogeneous thematic information – linear vector data (boundaries, isolines, faults, etc.), area-related raster or vector data (e.g. geological formations), and signatures – has to be harmoniously merged with this basis. In comparison to the automatic generation of topographic (base-)maps, thematic mapping is a comparatively individual process. Usually, digital topographic image maps are used by experts for their thematic interpretation and mapping purposes – information is interactively derived and integrated. Aiming at high quality map products, final cartographic processing is of special importance [3].

Recently, a geologic map of Mars, showing the Gusev crater with the Spirit rover landing site and its surroundings, has been presented by *Albertz et al.* [2].

Conclusion: The cartographic software package PIMap accomplishes all cartographic processing steps that are required for topographic image maps; it is an operational software system. Compared to common map generation, i.e. the preparation of all components on its own followed by cumbersome merging processes, the new comprehensive approach is a substantial step towards future planetary cartography [cf. 1,2].

Software upgrades will focus on the automatic integration of thematic information, which might be possible to some extent. The processing of images and DTMs in ISIS [12] and PDS [9] formats is envisaged.

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