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Phobos DTM and Coordinate Refinement for Phobos-Grunt Mission Support

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Abstract

Images obtained by the High Resolution Stereo Camera (HRSC) during recent Phobos flybys were used to study the proposed new landing site area of the Russian Phobos-Grunt mission, scheduled for launch in 2011 [1]. From the stereo images (resolution of up to 4.4 m/pixel), a digital terrain model (DTM) with a lateral resolution of 100 m per pixel and a relative point accuracy of ±15 m, was determined. Images and DTM were registered to the established Phobos control point network [7]. A map of the landing site area was produced enabling mission planers and scientists to extract accurate body-fixed coordinates of features in the Phobos Grunt landing site area.

1. Introduction

The European Mars Express spacecraft is moving in a highly elliptical (11,000 km at apo-apsis) orbit that reaches beyond the low equatorial (6000 km above the surface), nearly circular orbit of Phobos [3,4]. Hence, Mars Express is currently the only spacecraft orbiting Mars to carry out Phobos flybys on a regular basis. In March of this year, the orbit of MEX was specifically adjusted to provide a series of Phobos flybys, as close as 110 km. The flybys were intended for radio science investigations and for studies of the prime target area of the Phobos-Grunt Sample Return Mission (PhSRM). Currently a landing site location between 210° to 240° W and 0° to 30° N [1] is discussed. The HRSC successfully imaged Phobos during three passes (orbits 7915, 7926, and 7937) with the nadir, stereo and photometric channels. Images from each of these, taken under identical illumination conditions, are highly suitable for photogrammetric stereo analysis, specifically for the automated matching algorithms [3]. Resolutions ranged from 4.4 m/pixel to 19 m/pixel in the nadir and stereo channels. Further observations during the orbits 7948 and 7959 were dedicated to color imaging at reduced resolution. Images of these flybys cover the area from the North-Western rim of Stickney to approx. 230° West longitude and North Pole to Equator, just covering the proposed landing site for the PhSRM. The previously available global digital terrain model for Phobos [6] has been only weakly controlled in the new observed areas.

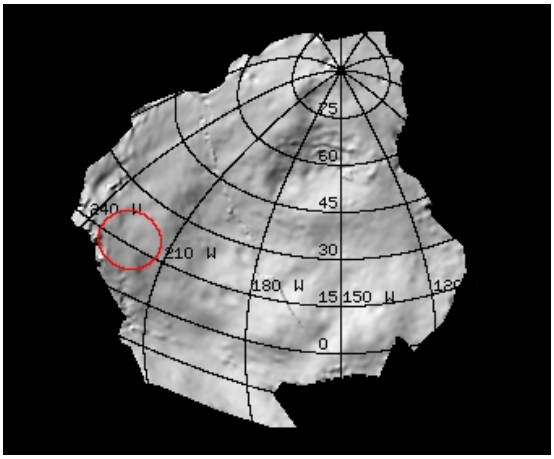

Figure 1: Shaded DTM computed at a lateral resolution of 100 m per pixel. Relative height accuracies are better than 20 m. The proposed landing site area for the PhSRM [1] is marked.

2. Data processing

Images obtained during the orbits 7915, 7926, and 7937 were used to refine the DTM in the described area. In a first step the exterior orientation information of all images of one flyby were adjusted and tied to the control point network [5,7]. Then, to prepare for the automated matching process, images are pre-rectified using a preliminary DTM derived from the global shape model [7] to minimize parallaxes between images. This significantly reduces the search area for conjugate points [2] and the number of

matching outliers. Best matching results were achieved when pre-rectifying the images on the DTM into a stereographic map projection. Inspection of projected images indicates that parallaxes are very small indeed close to the chosen centric latitude and centric longitude of the map projection but increase significantly towards the edge of the visible area. This is an effect of the map projection. To overcome this problem, the matching is carried out in several steps, using different center latitude/longitude pairs to reduce parallaxes in different areas of the image and thus to fully exploit the image information.

3. Results

We derived a DTM with a resolution of 100 m per pixel (Fig 1). The relative height accuracy, representing the remaining uncertainty of the ray intersections, is on average 10 m, but not higher than 20 m. We derived controlled ortho-rectified images of the Phobos-Grunt landing site that can be used to determine accurate body fixed coordinates of surface features. Different representations, such as perspective views (Fig. 2), allow us to judge the overall topography and to study the safety of the proposed Phobos-Grunt landing site area.

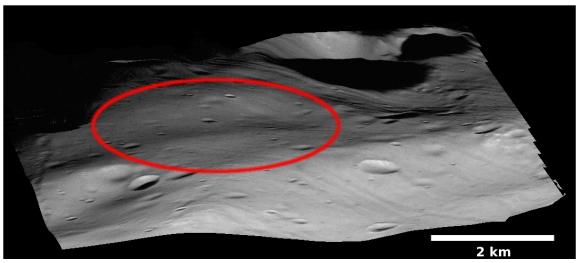

Figure 2: Perspective view for portions of the derived DTM. The proposed landing site area for the Phobos-Grunt lander [1] is marked.

4. Summary and Outlook

Currently, the orientation data for the images is improved separately for each orbit. A combined bundle adjustment of all flyby images suitable for stereo processing is desired to achieve a consistent reference. This adjustment will also include a tie to the existing control network. While the derived DTM represents geometric heights, currently, studies are under way to also compute dynamic height for Phobos from gravity, centrifuge, and tidal forces (Shi et al., this meeting). Based on the improved DTM, an update of the global digital image mosaic and atlas [6] will also be prepared.

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