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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 update the global digital terrain model (DTM) of Phobos and to study the proposed new landing site area of the Russian Phobos-Grunt mission [1]. The current version of the DTM has a lateral resolution of 100 m per pixel and a ray intersection accuracy of ±15 m. Images covering the Phobos Grunt landing site were registered to the control point network to establish coordinate control for the landing site area [7]. A map 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.

2. Results

The HRSC successfully imaged Phobos during three close flybys (orbits 7915, 7926, and 7937) with the nadir, stereo and photometric channels. Images from each of these, taken under identical illumination conditions, are 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 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, 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.

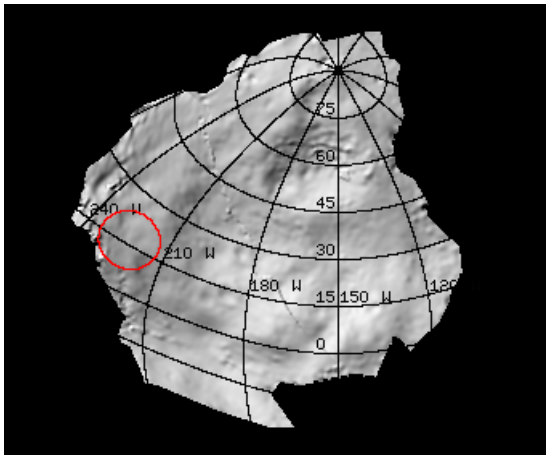

Figure 1: Shaded DTM computed at a lateral resolution of 100 m per pixel. Relative height accuracies are better than 20 m. The proposed landing site area for the PhSRM [1] is marked.

Images obtained during the recent flybys were used to significantly refine the existing DTM. 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.

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.

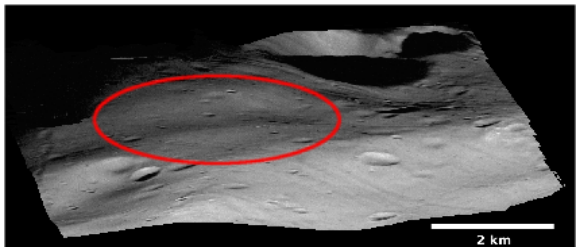

Figure 2: Perspective view for portions of the derived DTM. The proposed landing site area for the Phobos-Grunt lander [1] is marked.

4. Outlook

While the derived DTM represents geometric heights, studies are currently under way to also compute dynamic height for Phobos from gravity, centrifuge, and tidal forces. With new image data from Mars Express scheduled to arrive, we expect further improvements to our DTM to be presented at the time of the conference. An update of the global digital image mosaic and atlas [6] will also be prepared.

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