Phobos DTM and Coordinate Refinement for Phobos-Grunt Mission Support

K. Willner [1], J. Oberst [1,2], F. Scholten [2], M. Wählisch [2], T. Roatsch [2], H. Hoffmann [2], K.-D. Matz [2]

[1] Technische Universität Berlin, Department of Geodesy and Geoinformation Science, Berlin, Germany
[2] German Aerospace Center (DLR), Institute of Planetary Research, Berlin-Adlershof , Germany

Abstract

Images obtained by the High Resolution Stereo Camera (HRSC) during the Phobos flybys in March 2010 were used to study the proposed new landing site area of the Russian Phobos Sample Return Mission (PhSRM), 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 [8]. 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.

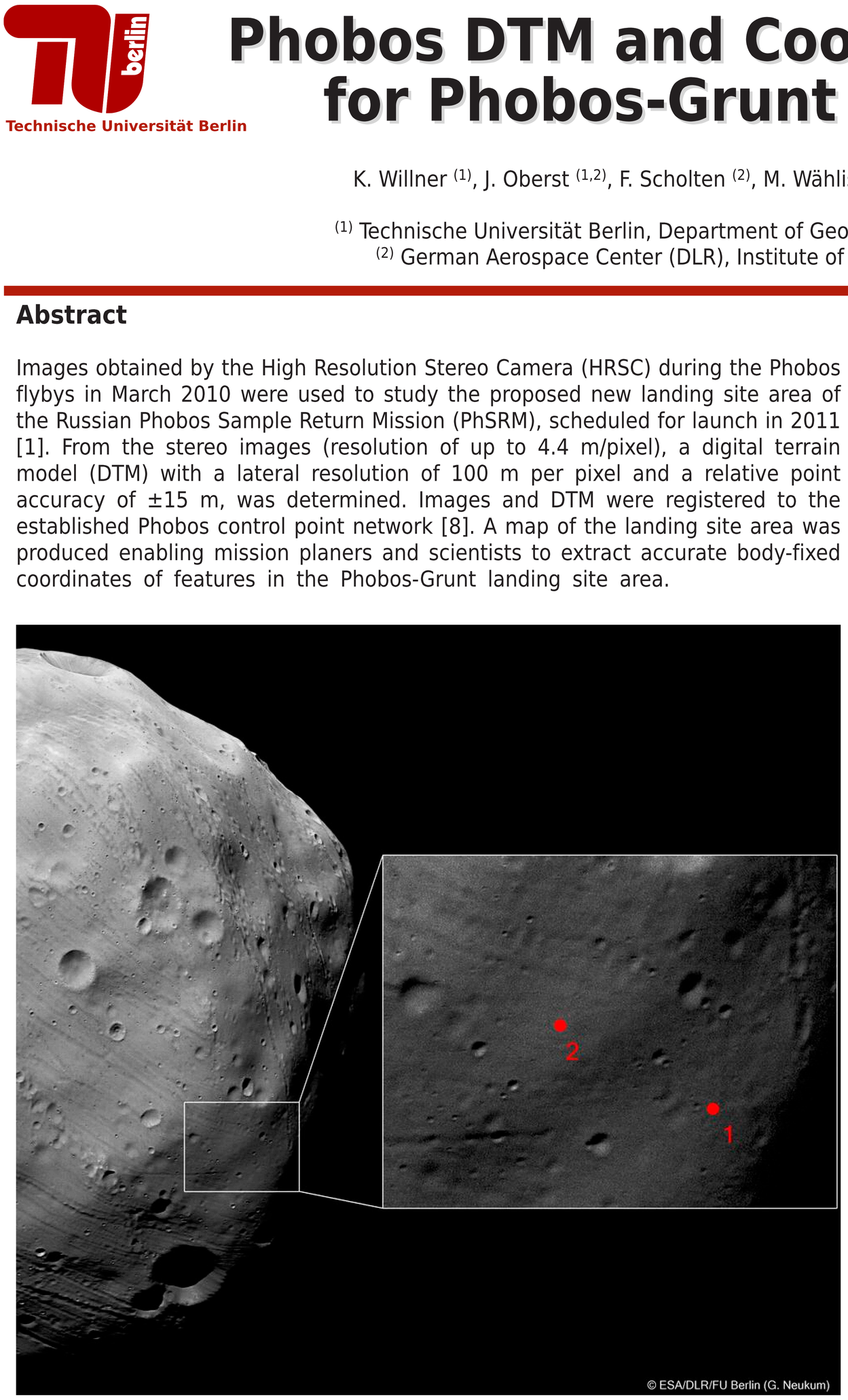

Fig. 1:
Image obtained during orbit 7915 in March 2010. The best ground resolution is at 4.4 m/pixel. The blow up displays the anticipated landing sites for the Phobos-Grunt sample return mission as proposed by [1].

Introduction

The European Mars Express spacecraft is currently the only spacecraft orbiting Mars to carry out Phobos flybys on a regular basis. The HRSC successfully imaged Phobos during three very close passes (orbits 7915, 7926, and 7937) with the nadir, stereo and photometric channels. Image resolutions were between 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 proposed landing site for the PhSRM. The previously available digital terrain model for Phobos [7] was derived from low resolution Viking Orbiter images only and was interpolated over large parts.

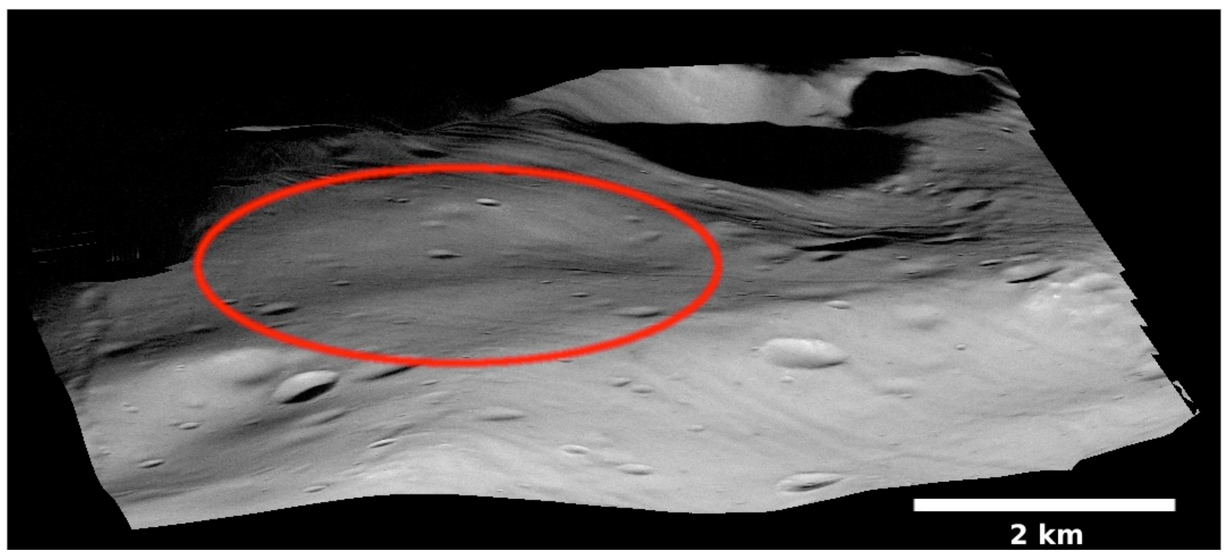

Fig. 2:
Perspective view of the landing site area based on a 100 m DTM grid. The area appears to be rather smooth with only small slopes.

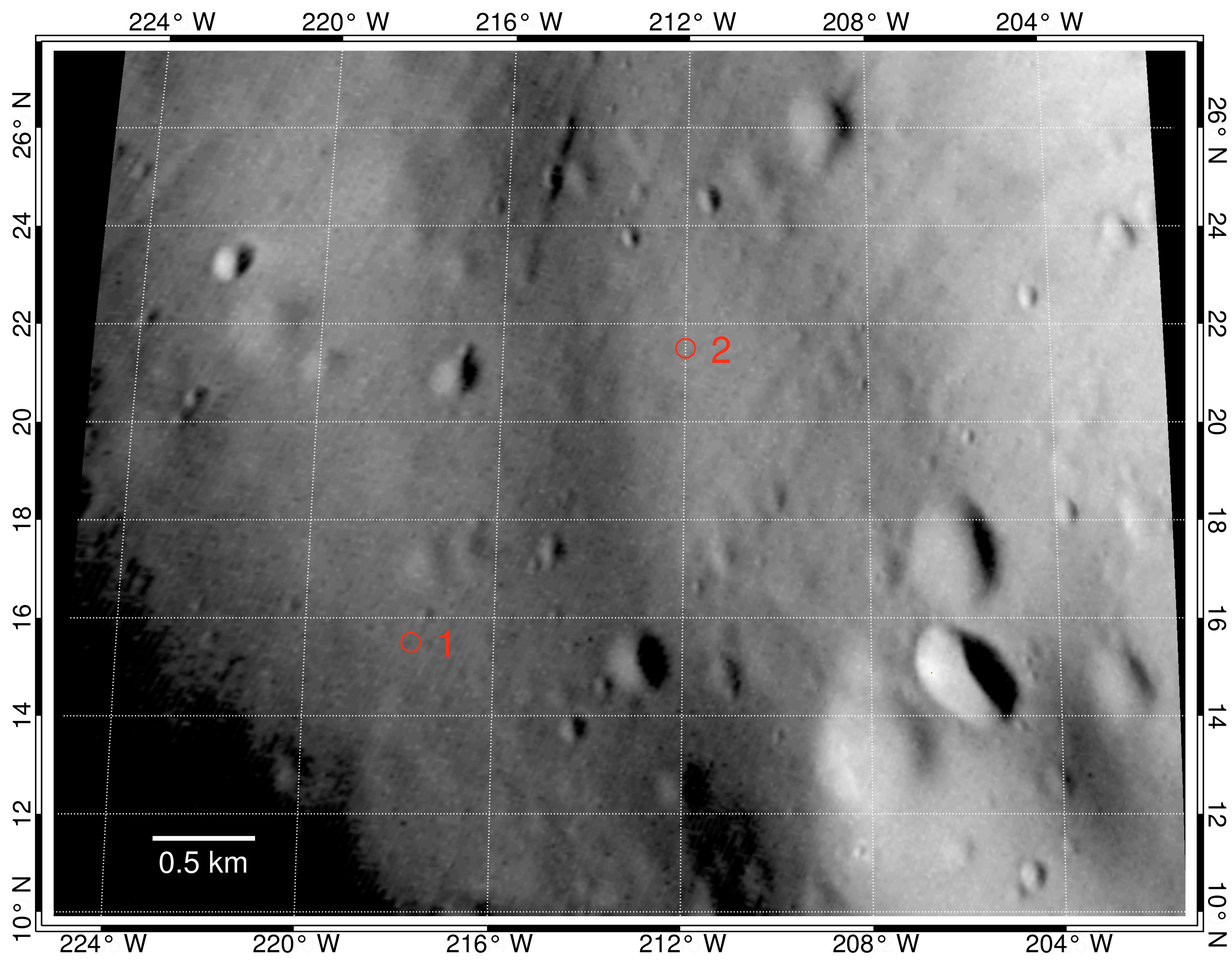

Fig. 3:
Map of the proposed landing site area in a Sinusoidal map projection. The two possible landing sites are marked.

Data processing

Prior to the matching process orientation parameters of the camera were adjusted [6] and tied to the control point network [8]. This adjustment included data of 20 flybys to tie all data suitable for a DTM generation to the same reference. An apriori ortho-rectification of the image data onto a shape model derived from spherical harmonic functions was performed to minimize parallaxes between them, thus reducing search areas for the automated matching process [2].

Table 1:
Estimated coordinates for the proposed landing sites [1] based on image data obtained during MEX orbit 7915 orthorectified onto the new DTM. The coordinate reference is the frame defined by the control network published in [7].

Landing Site	Longitude	Latitude
1	217.7° W +/- 0.1°	15.5° N +/- 0.1°
2	212.0° W +/- 0.1°	21.5° N +/- 0.1°

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. The ortho-rectified images of the MEX orbit 7915 were used to determine accurate body fixed coordinates of Phobos-Grunt landing sites (Fig. 3 & Table 1). 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. The geometry suggests for both proposed landing sites a smooth area without steep slopes. Variations of the dynamic heights in this area also appear to be of small magnitudes [5].

References

[1] Basilevsky, A. T. & Shingareva, T. V. (2010), 'The selection and characterization of the Phobos-Soil landing sites', SoSyR, 2010, 44, 38-43.
[2] Gwinner, K. et. al (2009), 'Derivation and Validation of High-Resolution Digital Terrain Models from Mars Express HRSC-Data', PE&RS 75(9), 1127-1142.
[3] Jaumann, R. et al (2007), 'The high-resolution stereo camera (HRSC) experiment on Mars Express: Instrument aspects and experiment conduct from interplanetary cruise through the nominal mission', PSS, 55, 928-952.
[4] Oberst, J. et. al (2008), 'The imaging performance of the SRC on Mars Express', PSS, 56, 473-491.
[5] Shi, X. et. al (2010), 'Working Models for the Gravity Field of Phobos', EPSC, this meeting
[6] Spiegel, M. (2007), 'Kombinierte Ausgleichung der Mars Express HRSC Zeilenbilddaten und des Mars Global Surveyor MOLA DGM', PhD thesis, Technische Universität München, Fakultät für Bauingenieur- und Vermessungswesen.
[7] Wählisch, M.; Willner, K.; Oberst, J.; Matz, K.-D.; Scholten, F.; Roatsch, T.; Hoffmann, H.; Semm, S. & Neukum, G. (2010), 'A new topographic image atlas of Phobos', EPSL, 2010, 294, 547-553.
[8] Willner, K.; Oberst, J.; Hussmann, H.; Giese, B.; Hoffmann, H.; Matz, K.-D.; Roatsch, T. & Duxbury, T. (2010), 'Phobos control point network, rotation, and shape', EPSL, 294, 541-546.