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Phobos Control Point Network and Librations

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Abstract

High resolution images of Phobos obtained by the Mars Express (MEX) spacecraft open up possibilities to study the shape and rotational parameters of this Martian moon in more detail. In this respect, we have analyzed images obtained by the SRC (Super Resolution Channel) with results of our studies reported at the meeting.

1. Introduction

We have derived a new control point network for Phobos [2, 4] to study the shape and the librational motion of Phobos, using images obtained by SRC on Mars Express. We have produced a new global Digital Terrain Model (DTM) and orthoimage mosaic of Phobos. In the DTM, we study various parameters relevant to planetary geologists, including surface slopes, surface roughness, as well as tectonic breaklines.

2. Control point network

We have selected 16 Viking Orbiters (VO) images and 165 MEX SRC images to derive a new control point network [2, 4]. The pixel resolution of images varies from 2.6 to 51.1 m/pixel for SRC images (average 24.3 m/pixel) and from 5.6 to 85.3 m/pixel for VO images (average 18.7 m/pixel). A total of 9461 tiepont measurements have been carried out, that were processed by bundle block adjustments for combined SRC and VO data. As a result a catalogue of 3D Cartesian coordinates of 800 ground control points was generated (Fig. 1). The accuracy of control points varies from 4.5 to 54.6 m. RMS errors are presented in Table 1. A catalogue of contours was created to identify the locations of the control points.
Point measurements and bundle block adjustments were carried out by means of PHOTOMOD software [4, 5] which was especially adapted for this study to accommodate global networks of small bodies, such as Phobos.

Table 1: The results of the study compared with a previous study [3].

	This study	Willner, 2010
Images	181	69
Points	800	665
Mesurements	9461	3898
Error X, m	7.87*	21.3**
Error Y, m	6.03	16.2
Error Z, m	6.05	16.7
Error XYZ, m	11.92	

*RMS – root-mean-square error
**σ – object point accuracy

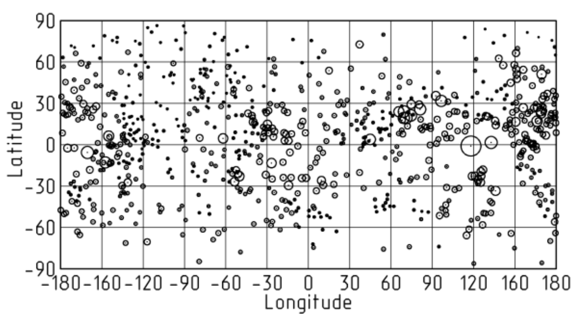

Figure 1: Control points distribution. The sizes of symbols are proportional to the errors in the coordinates.

3. Shape Studies

The control network has been used to compute the radii of a best-fit ellipsoid. The center of the figure was found to be shifted from the origin of the reference frame and is located at x=603.2 m, y=-998.9 m, and z=330.4 m. The radii of an equilibrium ellipsoid were also computed.

Table 2: Shape parameters of Phobos compared with a previous study [3].

Source	Method	a x b x c, km
Willner, 2010	best-fit	13.00 x 11.39 x 9.07
This study	**best-fit**	**13.09 x 11.72 x 9.48**
This study	**equilibrium**	**12.78 x 11.36 x 8.82**

Also, the coefficients of spherical harmonic functions up to the 22nd degree and order were determined, from which moments of inertia coefficients were derived.
From 117 SRC images a global DTM with breaklines has been produced. On the basis of the control points and improved pointing for 117 SRC images, large numbers of surface points were determined using a stereo viewing facility. As a result, we obtained over 108,000 points, it reflecting both the global and local relief of Phobos through the breaklines.

4. Librational Motion

The least-square adjustment of the control point network was computed for a variety of forced libration amplitudes. Unlike more recent observations [3], we studied residuals of the perspective centers, rather than the residuals of the control points. A total of 165 SRC images were used to observe the forced libration. Forced libration amplitude can be predicted from shape and moments of inertia, following:

$$\gamma = \frac{B-A}{C}, \vartheta_A = \frac{2e}{1-\frac{1}{3\gamma}}, \quad (1)$$

where e equals the orbital eccentricity of Phobos and A ≤ B ≤ C are the moments of inertia along the principle axis of inertia.
Libration parameters from shape were compared with observations. Both were found in good agreement with a recent estimation (Table 3) [1, 3].

Table 3: History of libration amplitudes

Source	Method	Value, °
Duxbury, 1991	Observed	0.8 ±0.3
	Modeled	0.9
Seidelmann, 2007	Observed	0.78
Willner, 2010	Observed	1.24±0.15
	Modeled	1.1
This study	**Observed**	**1.09±0.1**
	Modeled	**0.93**

6. Summary and Conclusions

For the control network analysis a larger number of SRC images were used than for the previous study [3] that allowed us to obtain a larger number of control points with higher accuracy of control points (Table 1).

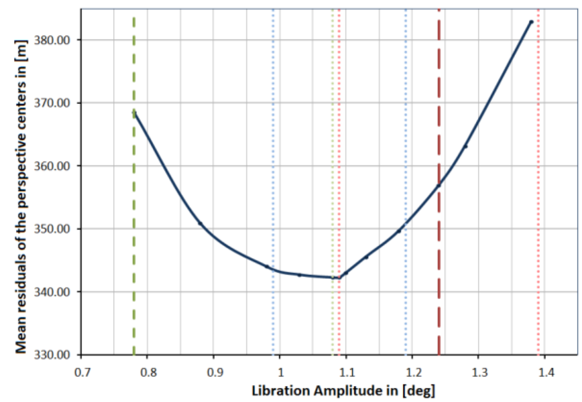

Figure 2: Observed residuals of the SRC perspective centers. The red vertical line indicates observation by (Willner, 2010), the green line – by (Duxbury, 1991).

The forced libration can be used as a basis for a further study of the mass-distribution within Phobos. At present, we are carrying out a detailed comparison of our results with DTMs from previous studies [3]. We also deal with multispectral analysis of Phobos' images, using the new DTM for data co-registrations. In the future, we plan to produce an orthomosaic on a three-axial ellipsoid.

Acknowledgements

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References

[1] Duxbury, T., Wang, M., Herkenhoff, H.: The figure of Phobos: an update from the PHOBOS Mission. Lunar and Planetary Institute Conference, vol. 22, pp. 327, 1991.

[2] Karachevtseva, I. et al.: Global Phobos Geodatabase and GIS Analyses, 43 LPSC, 19-23 March, 2012, The Woodlands, USA.

[3] Willner K.et al.: Phobos control point network, rotation, and shape, Earth and Planetary Science Letters, 294, pp. 541-546, 2010.

[4] Zubarev A. et al.: Problems of remote sensing data processing for modeling of small bodies of the solar system, Actual problems in ERS Journal, IKI RAS, submitted.

[5] http://www.racurs.ru/?lng=en&page=634.