**A NEW ASTROMETRIC MEASUREMENT TECHNIQUE FOR PHOBOS USING BACKGROUND STARS AND SURFACE CONTROL POINTS.** K. Willner, J. Oberst, K-D. Matz, T. Roatsch, H. Hoffmann, German Aerospace Center (Institute of Planetary Research, Rutherfordstrasse 2, 12489 Berlin, Germany, konrad.willner@dlr.de)

**Introduction:** Phobos, the larger natural satellite of Mars is undergoing a complex orbital evolution. Recent analysis on the basis of HRSC/SRC image data [4] showed discrepancies between orbit models and observations of up to 12 km, a fact which renewed the interest in more detailed astrometric analysis of Phobos data to constrain its orbit [2,3]. We now have carried out new Phobos astrometric measurements in images obtained by the Super Resolution Channel (SRC) on Mars Express (MEX) to verify the accuracy of the new available Phobos orbit models.

We have made several improvements over our previous measurement techniques [4]. Background star images before and /or after the Phobos encounter during 35 orbits were used to identify and remove offsets in the nominal pointing data. Also, we use control point measurements rather than limb fits to determine the position of the Phobos COF/COM (center of figure/mass) in the image. Many more Phobos images from 34 flybys were available compared to what we had in our previous studies.

**Astrometric measurements:** Flyby distances varied between 600 km and 5400 km. Hence, the images show large differences in resolution, and measurement accuracies varied accordingly. Background star observations where compared with star catalog data to determine or verify the nominal pointing direction of the camera with respect to the stellar background.

Control points from the catalog of Duxbury and Callahan [1] – all of them craters – were identified in the images, and their line/sample coordinates were measured in 96 SRC images from the 34 flybys. The catalog coordinates of the control points are known to represent the centers of the craters on the surface of the crater lid as defined in [1]. It was assumed that the craters (mostly under oblique view) appear like ellipses. An ellipse-fit method was used to extract image coordinates of the ellipse centers.

**Analysis:** The observations were reduced by calculating the theoretical image coordinates, $x_t$, $y_t$ , for each control point using the Phobos orbit model and corrected camera pointing. Then, theoretical image coordinates of the surface feature, $x_t$, $y_t$, were transformed to measured image coordinates, $x_m$, $y_m$ using the functional model shown in (eq. 1). The free parameters, rotation $R(\alpha)$, scale s and translation in direction of $x_{trans}$ and $y_{trans}$ were determined using an iterative least-squares analysis involving all identified surface features of one image at a time.

$$\begin{bmatrix} x_m \\ y_m \end{bmatrix} = s\left[R(\alpha)\right]\begin{bmatrix} x_t \\ y_t \end{bmatrix} + \begin{bmatrix} x_{trans} \\ y_{trans} \end{bmatrix}$$

Likewise, the Phobos COM was converted to predicted image space coordinates. The translation parameters from above were used to calculate the correct COF of Phobos. From the correct camera pointing, we then obtained the observed stellar position of Phobos.

**Results:** The process converged rapidly after only 3 to 4 iterations. We are mainly interested in the translation vector, as this vector reveals errors in the orbit models that have been used. These translation vectors showed no significant offset in comparison with the current orbit models in the across track directions (towards the center of the orbit ellipse and out of the orbit plane) of Phobos. However, the along track component of the observed vectors show magnitudes between 1.5 km and 2.6 km with estimated accuracies of ±0.1 km and ±0.5 km, depending on the distance to the target (see table 1). Even though understanding of Phobos' orbit has much improved since our early studies [2, 3], we anticipate that our new results will be the basis for further improvement of the models.

| Orbit model | Along track offsets | Across track offsets |
|---|---|---|
| Lainey [3] | + 1.5 km | ±0.3 km |
| Jacobson [2] | + 2.6km | ±0.5 km |
| HRSC Team | -0.6 km | +1.4 km |

Table 1: Differences between orbit models and our analysis of Phobos observations. Positive numbers show that Phobos is ahead of its predicted position. Note that the HRSC Team orbit model represents an empiric derived model based on the former ephemerides by Jacobson and results of the analysis by Oberst et al. [4].

**References:** [1] Duxbury T. C. and Callahan J. D. (1989). PHOBOS and Deimos control networks. *Icarus*, 77:275-286. [2] Jacobson, pers. communication. [3] Lainey V.et al. (2005). New ephemerides of the Martian moons. EOS Trans AGU, G51A-0802. [4] Oberst J. et al. (2006). Astrometric observations of Phobos and Deimos with the SRC on Mars Express. *A&A*, 447:1145-1151.