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Geodetic Framework for Martian Satellite Exploration II: Astrometry; Phobos Geodetic Control and Maps

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Introduction

Phobos, the larger of the two Martian moons is currently of great interest to the science community. While there were several Phobos mission proposals in the scope of NASA's discovery program [1-3], ESA and Roscosmos are currently studying the feasibility of a sample return mission [4], the Japanese space Agency plans to launch a sample return mission by 2024 [5], and ESA's M5 call received a mission proposal to explore the Martian moons [6]. Following the successful launch in 2003, ESA's Mars Express Mission (MEX) moves in an orbit, which has close encounters of Phobos on a regular basis, favorable for Phobos observations [7]. Here we report on current activities of Phobos research in the various fields of interest based on image data of the High Resolution Stereo Camera on-board the MEX spacecraft.

1. Astrometric observations

We carry out astrometric observations of Deimos and Phobos to support orbit determination for the two satellites. In the recent past mutual event observations – showing Phobos or Deimos together with yet another body in the stellar sky – were reduced to determine the angular separation between two visible objects, respectively. The spacecraft pointing is not relevant for this kind of observations which eliminates one of the largest error sources of past astrometric observations [8-11]. Observations include Phobos and Deimos, or the relative position of Phobos or Deimos with respect to Jupiter and Saturn,. Observations and data reductions are ongoing. Phobos' and Deimos' secular orbital motion may constrain interior models, in particular the mass distributions within the two satellites [12, 13].

Figure 1: Example of a Phobos-Jupiter mutual event observation by the Super Resolution Channel of the HRSC (Image Credit: ESA/DLR/FU Berlin).

2. Rotation parameters

Deimos and Phobos are tidally locked. In the past, observations of the rotation parameters such as the forced libration amplitude were based on an empirical approach to find a best fit to control point network solutions. We have now implemented a least-squares adjustment algorithm that can directly solve for rotation parameters by computing the bundle block in the inertial reference frame. The forced libration amplitude can be solved for directly when computing coordinates of control points of a global network. The approach also allows us to test the orientation of the pole axis and the precession motion [14].

3. Cartographic products

In 2016 all HRSC Phobos map products have been released to the public through PSA and PDS. This information was now brought together with other GIS mapping products in a catalogue and as a web-map. Both, catalog and maps, are used to support

Mars Express Phobos observation planning, to further exploit the existing data and to support future missions to Phobos in the preparation and planning phase.

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