EPSC Abstracts
Vol. 7 EPSC2012-780-1 2012
European Planetary Science Congress 2012


# Improvement of orbits of Mars Express, Voyager 2 and Mariner 9: application of a new arc-splitting method

M. Kudryashova (1), P. Rosenblatt (1), V. Lainey (2), S. Le Maistre (1) and J.C. Marty (3)
(1) Royal Observatory of Belgium (ROB), Brussels, Belgium (mariak@oma.be), (2) IMCCE-Observatoire de Paris, Paris, France, (3) CNES/GRGS, Toulouse, France

## Abstract

In this work we describe a new method of splitting radioscience observations for data-arcs, optimized with respect to the length of data-arc, position of photographic observation inside of it as well as some additional information (like occurrence of maneuvers and pericenter passages when such information is available). Application of this method to the observations of Mars Express (MEX), Voyager 2 and Mariner 9 allow us to produce approximately two times better orbits than in case of usual way of splitting data into arcs (regardless the additional information mentioned above). These new orbits make it possible to use all astrometric observations of Phobos for further recalculation of Phobos ephemerides.

## 1. Introduction

Phobos and Deimos ephemerides have been recently improved, using precise dynamical modeling of their motion and astrometric observations of their positions from images taken by both Earth-based telescopes and cameras onboard spacecraft. In order to compute moon ephemerides from the spacecraft images, the spacecraft position on its orbit has to be known as precisely as possible.
We have elaborated data-arc splitting method, consisting of computing precise orbit of spacecraft using suitable data-arcs encompassing each astrometric observations (as well as additional information when available) instead of successive data-arcs disregarding the occurrence of these observations as usually done for spacecraft navigation orbits.
Here we apply this method for several space-missions, namely MEX, Voyager 2 and Mariner 9, in order to produce better orbits for these spacecraft.

## 2. Arc-splitting method

A software for automatic splitting of radioscience observations into suitable time intervals has been developed. The software performs the following operations: 1) for a selected duration of data-arc its beginning is set up in such a way that the epoch of Phobos image would appear in different places inside this arc. It is attained by shifting the beginning of time interval with respect to the epoch of Phobos images "sliding window". 2) Then, the beginning and end points of each data-arc are adjusted in such a way that before the first and after the last maneuvers in data-arc there would be continuous tracks (under "continuous track" we understand here observations performed by the same station with constant time resolution (i.e. without time gaps)). In such a way we always have a set of overlapping data-arcs for each single astrometric observation.
The method has been tested on the MEX observations performed between May, 2004 and Apr., 2005 for 3 different arc lengths: T=2 days, 4 days and 8 days. Altogether, 140 orbits have been computed: since photographic observations we used were performed in sets of 2-4 observations separated by few seconds (see Oberst et al for details), each set falls in the same data-arc. Thus, we have 10 sets of astrometric observations and for each of them 14 testing orbits have been determined. These orbits have been checked for rms values of overlap differences. Although, to assess the improvements attained due to the application of this method astrometric residuals have been calculated for all computed data-arcs.

## 3. Summary and Conclusions

Arc-splitting method optimized with respect to the length of data-arc, position of photographic observation inside it as well as positions of

maneuvers and pericenter passages was realized and tested on the MEX data.
Orbits calculated from radioscience data splitted in such a way show good overlap (approximately 80% of arcs have rms of orbit overlap less than 25 m for along-track direction; less than 10 m in normal direction and less than 2.5 m in case of radial direction) which is approximately two times better then in previous study by Rosenblatt et al.,2008.
All the astrometric data can be re-processed using this method (even those for which we got only slightly improved MEX orbits). For example, in previous study [2] the 2005 data were removed since data-arcs encompassing these 2005 astrometric data was of poor-quality (probably because of not appropriate choice of the starting and ending dates w.r.t. attitude control maneuvers (Wheel off Loading of intertial wheels) and pericenter coverage).
We process with this method radioscience observations of Viking 2 and Mariner 9 and expect that navigation orbits of these missions will be improved essentially.

## Acknowledgements

This work is a part of the European Satellite Partnership Computing Ephemerides (ESPaCE), funded by the European FP7-project, aiming at strengthening the collaborative activities in the domain of the development of ephemerides and reference systems for natural satellites and spacecraft.

## References

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