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Phobos Eclipse Observation Opportunities with the Mars Science Laboratory

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Abstract

Dates for observing Phobos transits for years 2012 to 2014 with the Mars Science Laboratory (MSL) have been characterized. Applications of Phobos eclipse detections used as an alternative procedure to determine the coordinates of the rover as well as to analyze the parameters connecting Earth-Mars reference frames are presented.

1. Introduction

Mars Science Laboratory (MSL) is intended for landing at the northwest of Gale Crater at 4.49 S; 137.42 E. The uncertainties in the Entry-Decent-Land leads to a landing ellipse about 25x20 km.

A first approach to characterize the transit observation opportunities with MSL has been obtained by developing a temporal chronogram of eclipses for years 2012 to 2014 following the procedures described in [8]. Three main observable eclipse seasons in Sept. 2012, Aug. 2013 and Aug. 2014 have been dated. Afterwards, a Monte Carlo approach has been applied, as it was used in [5] for Beagle 2, in order to enable the maximum number of detections for the MSL landing ellipse.

2. Temporal Chronogram

In order to generate a chronogram of the shadow path across de surface of Mars, Phobos shadow motion has been modeled studying the intercepting point of the line through the centers of the Sun and Phobos with the Mars surface. Conditions for Phobos eclipses to occur on Mars are met twice a Martian year, covering a range of latitudes of about $[-70°, 70°]$, lasting few days within the forecasted MSL landing site band (see Figure 1). To provide an observational plan including observations within the whole shadow area, the shadow size has been also modeled projecting Phobos as an ellipsoid [10] on Mars surface. Eclipse observation opportunities are characterized when this shadow area intersects with the landing ellipse. Transits in Sept. 2012, Aug. 2013 and Aug. 2014 are shown in Table 1.

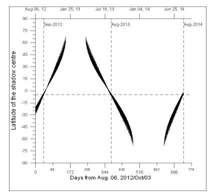

Figure 1: Latitudinal shadow center motion.

Table 1: Phobos eclipse prediction (UT) for the landing site using the temporal chronogram approach.

2012		2013		2014	
Sept. 10	23:09	Aug. 13	21:32	Aug. 03	16:59
Sept. 13	05:15	Aug. 17	02:19	Aug. 04	15:50
Sept. 16	09:56	Aug. 19	08:25	Aug. 07	12:09
Sept. 17	23:19	Aug. 20	07:12	Aug. 08	11:00

3. Monte Carlo Approach

To maximize the detections for the MSL landing ellipse we have studied how a fixed observer would watch these phenomena for a number of landing sites within the landing ellipse. Phobos projection onto the Sun disc plane as seen from a Mars observer has been modeled as an ellipse centered at Phobos center projection. Initial and final contact points of any possible eclipse are then determined when the resulting ellipse intersects the Sun disc. Table 2 summarizes this procedure for the landing ellipse main points.

Table 2: Eclipse initial-final contact times (UT) for the landing site ellipse limits using the Monte Carlo approach.

Season	Date	Center (4°49S, 137°42E)		North (4°32S, 137°42E)		South (4°66S, 137°42E)		East (4°49S, 137°69E)		West (4°49S, 137°20E)	
2012	Sept. 13	05:15:23	05:15:39			05:15:16	05:15:45	05:15:28	05:15:43	05:15:18	05:15:35
	Sept. 16					09:56:45	09:56:50				
	Sept. 17	23:19:25	23:19:48	23:19:25	23:19:50	23:19:25	23:19:43	23:19:25	23:19:48	23:19:25	23:19:48
2013	Aug. 13	21:31:53	21:32:28	21:31:52	21:32:28	21:31:56	21:32:26	21:31:58	21:32:33	21:31:50	21:32:26
	Aug. 17	02:18:55	02:19:07	02:18:47	02:19:14			02:19:08	02:19:17	02:18:48	02:19:01
	Aug. 19	08:25:25	08:25:47			08:25:21	08:25:41	08:25:36	08:25:56	08:25:20	08:25:41
	Aug. 20	07:12:17	07:12:45	07:12:21	07:12:41	07:12:15	07:12:47	07:12:30	07:12:58	07:12:10	07:12:39
2014	Aug. 03	16:59:41	16:59:52			16:59:32	17:00:00	16:59:45	16:59:54	16:59:37	16:59:50
	Aug. 04			15:49:46	15:50:05						
	Aug. 07			12:09:16	12:09:37						
	Aug. 08	11:00:50	11:01:27	11:00:49	11:01:27	11:00:53	11:01:25	11:00:52	11:01:29	11:00:48	11:01:25

4. Analysis of Parameters

Initial and final contact times could be used to test the parameters connecting the Mars-Earth reference frames. Figure 2 shows the offsets and mean offsets of the predictions for observed Phobos eclipses by MER [2, 6] and MOLA [3] applying different set of parameters.

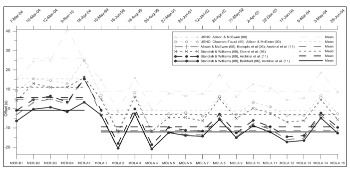

Figure 2: Observed eclipses prediction offsets.

Parameters given in [1], [4] and [9] used in our parameterization model better fit observations with a nearly null offset for MER observation, and parameters given in [7] and [9] better fit MOLA observations.

5. Landing Site Coordinate Determination

Lander position determination corresponds to the inversion of a non continuous, multievaluated and nonlinear function which models the latitudinal and longitudinal Phobos shadow motion across the Mars surface (as can be seen in Figure 3). We present a solution for this problem by assuming that observables are a function of two weakly dependent variables: the date and the time for mid-transit and the duration. We have considered different scenarios for this inverse problem. Results show the efficiency of an algorithm which employs a recursive least squares estimator with a functional model of cyclic coordinates.

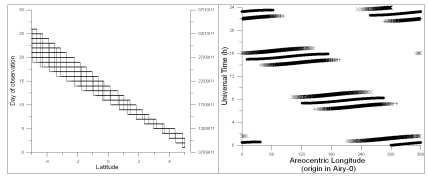

Figure 3: Latitudinal and longitudinal Phobos shadow motion.

Acknowledgements

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References

[1] Archinal, B.A., et al.: Report of the IAUWorking Group on Cartographic Coordinates and Rotational Elements: 2009, Celest Mech Dyn Astr, 109, 2010.

[2] Bell, J.F. et al.: Solar eclipses of Phobos and Deimos observed from the surface of Mars, Nature, 436, 55-57, 2005.

[3] Bills, B., et al.: Improved estimate of tidal dissipation within Mars from MOLA observations of the shadow of Phobos, J Geophys Res, 110, E07004, 2005.

[4] Burkhart, P.D.: MSL Update to Mars Coordinate Frame Definitions, JPL, IOM 343B-2006-004, 2006.

[5] Christou, A.A.: Lander position determination on Mars using Phobos transits: application to beagle 2, Plan Space Sci, 50, 781–788, 2002.

[6] Dean, E., et al.: Phobos transits the Sun, NASA/JPL, http://www.jpl.nasa.gov/video/index.cfm?id=995, 2010.

[7] Oberst, J., et al.: Mars Pathfinder: Cartographic Analysis of the landing site from orbit, IAPRS, 32, 1998.

[8] Romero, P., et al.: Spatial chronogram to detect Phobos eclipses on Mars with the MetNet Precursor Lander, Plan Space Sci, 59, 1542–1550, 2011.

[9] Standish, E. M., Williams, J. G.: Orbital Ephemerides of the Sun, Moon, and Planets, JPL, http://ssd.jpl.nasa.gov/?planet_pos, 2009.

[10] Willner, K. et al.: Phobos control point network, rotation, and shape, Earth Planet. Sci. Lett., 294, 541-546, 2010.