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Temporal Areographic Patterns of Phobos Eclipses on Mars for the Metnet Precursor Mission

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MetNet is a new type of atmospheric science mission to Mars. This project is being fulfilled in collaboration between the Finnish Meteorological Institute, the Russian Space Research Institute, the Russian Lavoschkin Association and the Spanish National Institute for Aerospace Technology. The MetNet Precursor (MMPM) is planned to be launched as a secondary part of the Russian mission Phobos–Grunt.

Solar eclipses of Phobos could be used as complementary information for the localization of the MetNet landing site on Mars, as well as to study atmospheric properties using shadow density measurement in different spectral intervals. In order to detect solar eclipses by Phobos we will use the data provided by a Solar Irradiance Sensor device (MetSis, http://metnet.fmi.fi) which is part of the scientific payload. To observe these eclipses, an a priori model is necessary for the establishment of an observational strategy which maximizes the possibility to obtain these data.

Spatial and temporal patterns of solar eclipses by Phobos on Mars are very different than those associated with solar eclipses on Earth. We present the developed algorithm to predict the location, size and dimensions of Phobos penumbral footprint on the surface of Mars for a given time, using precise Phobos and Mars areocentric ephemeris. The results have been validated using the first direct imaging observations of eclipses from the surface of another planet corresponding to the solar eclipses of Phobos observed by Martian Exploration Rovers Spirit and Opportunity.

From the derived annual cycle of the latitude and the diurnal cycle of the longitudinal shadow motion patterns we have establish the observational strategy for MetSis. Dealing with the strategy, the inferred main features are: the latitude of the landing site determines the days to observe, whereas the longitude determine the time of the day of the initial and final contacts. Shadow stripes of about 167º in longitude occur every 7h.6574. Phobos eclipses take about 55 minutes to cover the whole stripe. The shadow shape depart from nearly circular to an elliptical shape, with major axis ranging from 62.5 km up to 700 km along the shadow track and minor axis from 56.5 km up to 57.6 km. The rapidly growth simultaneously occurs to the shadow speed rise, so shadow passages duration for a fixed point on the surface of Mars remain of the same order, about 30-50 seconds.

As one of the MMPM main goals is to demonstrate the landing concept, the mission is aiming at an equatorial descent insertion with high enough atmospheric pressure to support the aerobraking unit in order to maximize the success possibilities for landing.
This envisaged descent limits the possible latitude range to be close to the equator, being estimated within a latitude band of 5 deg. We present the observational strategy for observing eclipses in this latitude band.

If a longitude band for the landing site is constrained before the separation of MMPM from the Phobos-Grunt, the modification of the primary strategy will be considered. Cloud infrastructure will enable us to face with this punctual volume of computations in a fast and efficient way.