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Long Term Science Planning for the ExoMars Trace Gas Orbiter

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Abstract

In preparation for the science planning of the ExoMars Trace Gas Orbiter mission, the Science Operations Centre performs an analysis of geometric conditions and the resulting observation opportunities and constraints.

1. Introduction

ExoMars is a joint programme of the European Space Agency (ESA) and the Russian space agency Roscosmos. The ExoMars Trace Gas Orbiter (TGO) spacecraft was launched on 14 March 2016 and entered Mars orbit on 19 October 2016. In the current aerobraking phase the orbital period will be reduced to approximately 2 hours before ultimately achieving a quasi-circular orbit at a distance of ~400km from the surface. The primary science phase of the mission is planned to start in April 2018.

The scientific payload of the TGO spacecraft comprises the following 4 instruments:

- The Atmospheric Chemistry Suite (ACS), [1].
- The Colour and Stereo Surface Imaging System (CaSSIS), [4].
- The Fine Resolution Epithermal Neutron Detector (FREND), [2].
- The Nadir and Occultation for MArs Discovery (NOMAD) instrument [3], [5].

2. Long Term Planning

In preparation for the primary science phase of the mission, the Science Operations Centre (SOC) based at the European Space Astronomy Centre (ESAC) is currently preparing the Long Term Planning (LTP) of science operations. In this process the SOC devises a feasible science observation strategy based on the mission's science priorities and the instrument team requests. In this contribution we show a few examples of the studies carried out for this purpose.

2.1 Data Volume

On long time scales in the order of one year, the mission profile is mainly conditioned by the variability of the available data volume resources. Based on the bitrate evolution shown in Figure 1, conservative estimates for the available data volume range between ~20 Mbit/day at minimum Mars-Earth distance and ~1 Mbit/day close to solar conjunction.

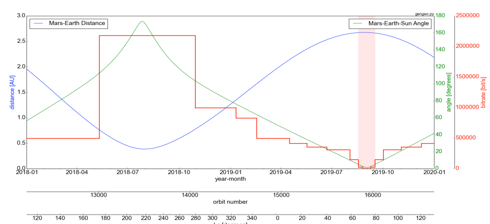

Figure 1: Evolution of the Mars-Earth distance (blue) and Mars-Earth-Sun angle (green) during the years 2018 and 2019. The red line indicates the bitrate for telemetry data downlink.

2.2 Occultation Opportunities and Timelines

On time scales in the order of weeks, the variation of the orientation of the spacecraft orbital plane with respect to the direction of the Sun is decisive for the occurrence and characteristics of solar occultations. These are the most important measurements for the detection and quantification of trace gases in the atmosphere of Mars and are therefore essential for achieving the mission's science objectives.

Figure 2 depicts the typical temporal evolution of the β-angle, which is commonly used to describe the orientation of the orbital plane. Finally, Figure 3 illustrates occultation event and pointing timelines within one orbit as well as their evolution with time over a period of six months.

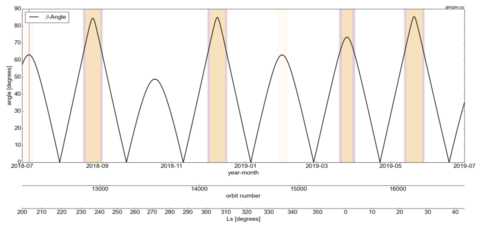

Figure 2: Evolution of the β-angle during a period of one year. The purple shaded periods are intervals with β between 63° and 68° roughly corresponding to the occurrence of "grazing occultations", and the yellowish colour indicates periods with β larger than 68° without occultations.

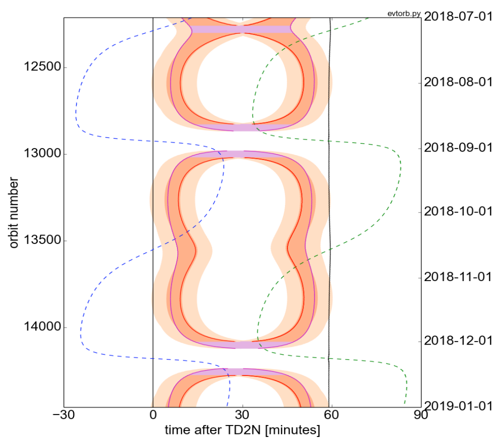

Figure 3: Event and occultation pointing timeline. Event times are depicted relative to the terminator crossing from day to night (TD2N). Black lines: terminator crossing. Red line: Sun at Mars limb. Purple line: Sun at 250km limb height. Dashed blue line: ascending node. Dashed green line: descending node. The red and purple shaded areas, respectively, correspond to the pointing block intervals for normal and grazing solar occultations. The light-red shaded areas indicate the required time for spacecraft slew blocks.

References

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