Preliminary analysis of possible coordinated observations between Mars Express and ExoMars 2016 Trace Gas Orbiter

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Abstract

In this contribution we focus on the science opportunity analysis between the Mars Express (MEX) and the ExoMars 2016 Trace Gas Orbiter (TGO) missions and the observations that can be combined to improve the scientific outcome of both missions. In particular we will describe the long term analysis of geometrical conditions that allow for coordinated science observations for solar occultation and nadir pointing. We will provide details on the calculations and results for simultaneous and quasi-simultaneous opportunities, taking into account the observation requirements of the instruments and the operational requirements for feasibility checks.

1. Introduction

1.1 Mars Express and ExoMars 2016 Trace Gas Orbiter

The Mars Express mission is still fully operational and has been providing great amounts of data since its arrival at Mars in Christmas 2003, covering a wide range of science objectives from the surface and sub-surface geology, atmosphere dynamics and composition, up to the interaction with the magnetosphere and the characterization of the Martian system including Phobos and Deimos.

The ExoMars 2016 Trace Gas Orbiter mission arrived successfully at Mars in October 2016 and after the first calibration observations in the initial capture orbit, started a long aerobraking phase of more than 12 months, aiming to reach the final nominal orbit and start its operational science phase in April 2018, where the first science operations are taking place following the scientific goals of the mission: atmospheric trace gases, climatology, surface geology and subsurface ice detection.

1.2 MEX and TGO Seasonal Evolution

Mars Express orbit has a high eccentricity that provides a very wide range of distances, allowing for the observation of the planet with very different resolutions and observing conditions. However the long term evolution of the orbit precession causes very stable and slow changing seasons, with very slow variations of the latitude and illumination at pericenter where we can identify long observation campaigns (3~6 months).

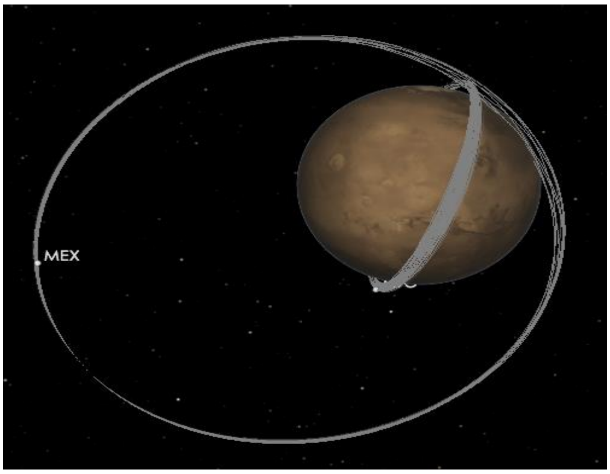

Figure 1: 3D Simulation of MEX-TGO crossing points at different distances.

On the other hand, the ExoMars TGO evolution is very dynamic and has short observing seasons that vary regularly on a weekly basis, based on the orbital node regression. That allows for a full surface and local time coverage on a monthly basis, except for the polar regions that the spacecraft is not able to reach.

The main advantage of ExoMars TGO is the capability to perform continuous science observations, basically pointing Nadir by default and doing solar occultation measurements everywhere possible, although it does not have much flexibility. On the other hand Mars Express does not observe continuously, but has much more flexibility to perform observations as needed.

2. Combined Science Opportunities

2.1 Sun Occultations

We have performed an analysis of all the occultation opportunities MEX-Mars-Sun and TGO-Mars-Sun both for the in-gress and e-gress points (that is dusk and dawn). Though we may not always have observations of the exact same spot in time, we can identify many quasi-simultaneous occultations that can be observed in the same region of the planet within a few minutes difference.

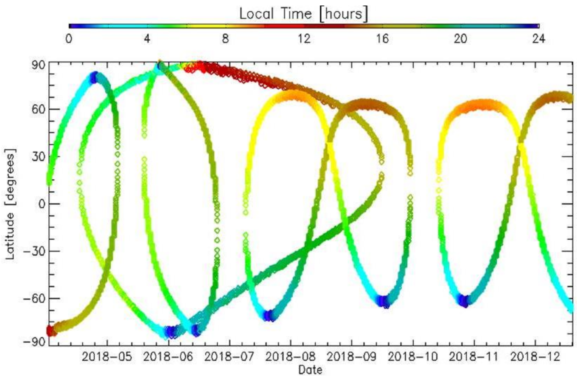

Figure 2: Latitude and local time of both TGO and MEX solar occultations in 2018.

2.1 Nadir observations

Both the Mars Express and Trace Gas Orbiter mission are also observing in Nadir geometry, for which we have performed another analysis of the crossing points where the orbits overlap, and we can easily see that there are always two points per orbit, although the distances may be very different due to the eccentricity of the MEX orbit.

The actual crossing points of both spacecrafts occur regularly and follow the general trend of the orbits, but the crossing points are more sparse whenever the MEX spacecraft is at pericenter. That is simply because the spacecraft is faster and therefore there are less chances of coinciding with TGO. On the other hand, when MEX is at the apocenter, it moves much slower and therefore there are many more crossing points.

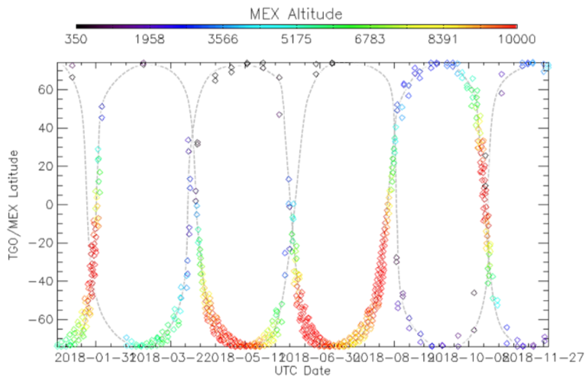

Figure 3: MEX-TGO nadir crossing points (angle <5deg). Note two crossing points per orbit, more often when MEX is at apocenter.

3. Conclusions

We have calculated the potential science opportunities for combined observations between Mars Express and Trace Gas Orbiter, both for sun occultations and nadir observations, and we have identified that interesting opportunities occur regularly on a weekly basis.

These opportunities are used as high priority input for both Mars Express and ExoMars TGO science planning cycles.

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References

[1] Cardesin Moinelo, A. et al: ExoMars 2016 Trace Gas Orbiter and Mars Express Coordinated Science Operations Planning, SpaceOps Conference proceedings 2018.