OPERATIONAL APPROACH FOR THE EXOMARS AEROBRAKING

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ABSTRACT

ExoMars is the future ESA Martian exploration programme with two missions to be launched in 2016 and in 2018. The 2016 mission consists of a composite spacecraft integrated by an orbiter and a lander. The lander is separated from the orbiter during the last phase of the approach to Mars and performs entry descend and landing (EDL) on Mars. After separation, the orbiter trajectory is deflected, and the orbiter performs a Mars orbit insertion (MOI). The MOI sequence of maneuvers brings the orbiter to a 1-sol orbit. From there, the orbiter is brought to its final relay and science orbit using aerobraking techniques.

The aerobraking consists in using the drag of the upper layers of the atmosphere to decrease the spacecraft velocity and reach a target orbit. It is the first time that an ESA mission includes nominally aerobraking as a main sequence to achieve its target orbit. In the case of ExoMars, the aerobraking will circularize the initial high elliptical orbit, after the Mars insertion, to a circular operational orbit. The whole duration of the aerobraking will take several months. Aerobraking involves risk, because the spacecraft is operated close to the acceptable limits in thermal loads. Therefore a robust operational strategy has to be defined.

The aerobraking includes three phases:

- Walk-in phase: It is composed by a group of pericenter lowering maneuvers (PLM) to gradually decrease the pericenter, until an aerobraking altitude is reached. During this phase, no previous knowledge of the atmosphere will be available. Each PLM needs to be optimized independently after obtaining atmosphere data at the pericenter height achieved in the previous maneuver.

- Nominal aerobraking: This is the main part of the aerobraking. Normally several pericenter control maneuvers (PCM), covering a period of several days, will be optimized as a block. The optimization will target to obtain the maximum performance of the aerobraking compatible with the spacecraft integrity.

- Walk-out phase: The last phase of the aerobraking includes several pericenter raising maneuvers (PRM). They will gradually decrease the aerobraking effect until the final target apocenter is reached. This phase is characterized by a large numbers of aerobraking passes and each of them with a high duration. To ensure the safety of the spacecraft short

turn-around time for operations is considered, with an optimization of one maneuver each time.

The following constraints are applicable to the aerobraking:

- Aerodynamic constraints:
  - Maximum Dynamic pressure: $D_{pr} = 1/2 \rho v^2$
  - Maximum free stream Heat Flux: $\dot{q}_{fs} = 1/2 \rho v^3$
  - Maximum free stream Heat load: $q_{fs} = \int Hfl \cdot dt$

  Where "υ" is the spacecraft aerodynamic velocity and "ρ" the air density

- Survivability of the spacecraft (from mission requirements):
  The missions design shall guarantee at least 48h of orbit life time before the apoares decay at all time during the aerobraking phase.
    - The orbit lifetime is defined as the time necessary for the apoares to decay to an altitude of 350 km using a nominal atmospheric model.

- Solar Conjunction (from mission requirements)
  The mission design shall allow for the acquisition, via aerobraking, of the final orbit specified 1.5 months before the Solar Conjunction (i.e. 1 month before the SES is 5 deg).
    - Considering the starting date of the aerobraking: 04-11-2016
    - The aerobraking shall finish one month before SES < 5 deg, 11-07-2017

In this paper, the ESOC proposed operational strategy for ExoMars aerobraking is presented. Drivers of the strategy are first safety and second total duration of the phase.

The paper shows results of simulations of the aerobraking phase. For these simulations a "real world" atmosphere scenario is implemented, based on EMCD v4.3, European Mars climate database. The optimization of the maneuvers and pericentre corridor is performed without a-priori knowledge of the "real world" atmosphere. Those simulations are based on a model for drag forces derived only from measurements provided by on-board sensors. Therefore, deviations between predicted drag forces and "real world" result in discrepancies between the predicted and "real" trajectory. These differences are evaluated and the overall robustness of the proposed aerobraking strategy is assessed