END TO END MISSION PERFORMANCES OF EXOMARS 2016 EDM

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The EXOMARS programme foresees two missions: the first, to be launched in 2016, consisting of an Orbiter plus an Entry, Descent and Landing Demonstrator (EDM) and the second, with a launch date in 2018, consisting of two rovers. Both missions will be carried out in cooperation with NASA. This scenario is the result of a 4 year evolution during the Phase B of the Exomars programme.

The objective of this paper is to present the Mission Performances (dispersion analysis) of the Exomars 2016 Mission from launch to splashdown for the Baseline presented at the System PDR with focus on the EDM element.

The present 2016 mission baseline is based on launch with Atlas V (421) in 2016 of a spacecraft Composite bearing a Orbiter Module and the EDM which is directed towards Mars through a direct type T2 transfer orbit, which includes a Deep Space Manoeuvre (DSM). The EDM is released from the arrival hyperbola 3 days before reaching Mars atmosphere. The EDM performs a ballistic entry and deploys a single stage Disk-gap-band parachute at Mach 1.95. After 40 s the frontshield is jettisoned and the rest of the EDM continues descent while radar is activated. The backshell is separated and the lander performs a powered landing with a g-turn manoeuvre to cancel the vertical velocity at 2 m above ground, where the retrorockets are switched off and the surface platform lands using its crushable structure on the Meridiani region.

One of the objectives of the Mission Design and Analysis activity has been the consideration of a continuous end to end profile from launcher injection to touchdown in order to couple the arrival with the EDL phases since the first steps of the mission design. This coupling is relevant in several areas; among others: arrival epoch and local time with Mars environment, arrival hyperbola with reachability of landing latitudes, entry orientation (pro/retrograde) with aerothermodynamics and parachute deployment conditions, mapping of Navigation uncertainties and manoeuvres dispersions into landing accuracy and Entry Corridor size…

This end-to-end philosophy has been applied in all of the mission design steps and in particular in the Mission performances evaluation. A single continuous mission timeline and trajectory from launcher separation to touchdown has been built as reference for the assessment. This evaluation of the performances has been carried out through high fidelity simulation of the mission phases and events. Different levels of simulations have been planned and executed depending on the performances to be assessed. All of them are based on large Monte Carlo campaigns where initial states, atmosphere, mechanisms and vehicle characteristics are perturbed using high fidelity models for the environment and suitable performance models for the different elements and functions (separation mechanism, GNC…).

First, the 3 DoF Monte Carlo campaign provides the overall mission performances with end-2-end simulations from the DSM to the touchdown where the compliance of the entry constraints (heat flux, load factor..), descent constraints (verticalisation, terminal velocities, inflation loads…) and landing constraints (impact velocity, consumed fuel…) are assessed in a multiphase process. This is the reference Mission Performance simulation which is complemented and tuned with more detailed performance assessments. Thus, 6 DoF simulations from the EDM separation down to the parachute triggering are carried out to assess the vehicle attitude dynamics and coupling with trajectory performances. Multibody simulations of the EDM under the parachute as a continuation of the perturbed 6DoF entry trajectories are executed for a detailed assessment of the dynamics under parachutes and the impact of the frontshield jettison on the EDM dynamics.

The paper will present a summary of the mission design status, the selection of the reference Exomars Mission timeline and the results and discussion of the different campaigns (3DoF, 6DoF, Multibody) against the Mission and System Requirements. These results constitute the reference Mission performances for the Exomars Mission. A comparison of these performances with the Entry Corridor predictions will be presented and discussed.

The s/w environment used for this assessment is the Endoatmospheric Simulator (EndoSim) of the Planetary Entry Toolbox and the Parachute System Design and Analysis Tool (PASDA), which represent the reference and validation sources for the official Exomars simulator.