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Mission Design for a Retropropulsive Mars Pinpoint Landing

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The execution of precision landing missions applicable for future Mars missions (in particular, Sample Return Missions and Human Missions) is a major technical challenge that will require the adoption of a set of technologies that have not yet been demonstrated in flight.
In the scope of an ongoing ESA activity related to the development of advanced navigation techniques for pinpoint landing on the Moon and at Mars, an effort was directed towards the trajectory definition component of such missions. For the Mars case in particular, it is found that the enhanced control authority permitted by using a retropropulsive phase directly after the reentry phase (e.g. without the use of parachutes) is very likely to improve the ability to land precisely at a pre-defined site. This requires a sequence of design steps not normally associated with the concept of optimization (such as including specific guidance algorithms in the trajectory design loop, both during the entry and the retropropulsive phases), while simultaneously ensuring that there are specific time windows for the ground observations necessary to acquire sufficient knowledge to enable true pinpoint landing (defined as landing well within 100m of a selected site). The present work describes the mission design process which was followed in the scope of the ESA ANPLE activity for the purpose of demonstrating the feasibility of Mars pinpoint landing missions, from interplanetary transfer to touchdown, and considering the specific application to a NASA MER/NASA Phoenix/ESA Exomars EDM-class vehicle and assuming the availability of highly accurate navigation aids (including vision-aided absolute navigation means and the use of orbiting and surface radio beacons).

Summary

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