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Small Bodies Missions and Technologies (Part 2) (4B)

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ANALYSIS AND DESIGN OF A PROPULSION MODULE FOR SMALL BODY NANOLANDER AND SURFACE SCIENCE PACKAGES BASED ON THE MASCOT LANDER CONCEPT

Abstract

Carry-on surface science packages or nanolanders have recently gained interest in small body exploration due to their capability of adding scientific value to a larger mission while at simultaneously reducing the burden to the carrier spacecraft itself. However, the latest successful demonstrations of such capabilities, the Minerva and MASCOT landers on Hayabusa2, had constrained capabilities in terms of delta-v applicable in order to realize a successful mission. In general, the Separation, Descent and Landing (SDL) phase of a SB nanolander missionn is complex and depends on a multitude of constraints. The main requirement of this mission phase is the safe landing, which consists of actually reaching the surface and dedicated landing spot, staying on the surface (not bouncing back) and surviving the landing impact. It is also wished that this phase is finished in an acceptable timeframe and with limited resources. Regarind survivability of the impact shock, smaller bodies are very benign targets. However, depending on the initial impact velocity, passive bouncing would take a long time due to the microgravity. For medium-sized bodies the landing velocity must be reduced to a survivable limit in order not to damage the system at impact. For the case of HY2, the spacecraft was maintaining a hovering altitude of 20km above the asteroid surface during its nominal mission. Only for dedicated operations such as the release of its landing elements, the spacecraft underwent a surface-near hovering to deploy the same, allowing them to reach the surface safely after a ballistic flight. Such a manoeuvre requires a lot of resources from the main spacecraft and a complex navigation and operation scheme. It is thus advisable to increase the capabilities of a nanolander with an active landing system realized by propulsive means. This paper is dedicated to discussing the different aspects of such an endeavor. At first we will discuss the range of possible use cases and concepts for propulsive landing based on a review of mission scenarios. The main peculiarities are the miniaturization of the propulsion system, its integration with the system design and its demand in terms of resources. In addition, we will discuss the current developmental status of available propulsion solutions and analyze their maturity and performance capabilities within the nanolander context. Finally, this paper will present a low risk propulsion module design based on cold gas propulsion systems, which benefit from their simplicity in design and use and their low cost.