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

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SIZE MATTERS - THE SHELL LANDER CONCEPT FOR EXPLORING MEDIUM-SIZE AIRLESS BODIES

Abstract

In recent years, the exploration of small solar system bodies has increased significantly. Apart from remote sensing surveys and fly-bys, especially landing and sample collection missions have dramatically increased our understanding of their physical composition as well as their mechanical properties. Small carry-on landers, like the European Rosetta Lander Philae which successfully landed on the comet 67P/Churyumov–Gerasimenko in November 2014, or the German/French Lander MASCOT on-board the Japanese Hayabusa2 mission scheduled for landing on asteroid 162173 Ryugu in October 2018, have proven to be a valuable asset by avoiding additional complexity of the main satellite and keeping project development times and costs in manageable bounds. Landing on small bodies is particular difficult due to the weak gravitational field and means to secure the lander to the surface have to be taken into account. However, with increasing size and density of the target the gravitational attraction on a lander increases also. Currently, non-propelled landers have been designed to land on very small bodies only, but medium-size class objects between diameters of $10-50\ km$ are of great interest as well. For example, the Martian moons Phobos ($D = 22\ km$) and Deimos ($D = 12.5\ km$) as well as many Jupiter trojan asteroids have mean diameters of more then $10\ km$. Rendezvous missions to those targets considering a detachable lander will have to focus on a dedicated landing support system. Depending on the capabilities of the mother spacecraft and resulting landing strategy, mainly the separation altitude defines the final landing velocity at touchdown. Higher landing velocities introduce high shock loads and can cause damage to lander subsystems and instruments. Reducing the need of an optional retro-propulsion system, other means of absorbing the impact energy have to be taken into careful consideration. Non-propelled landing strategies can be divided into three categories. (i) Landing without a dedicated landing subsystem (MASCOT), (ii) landing with energy absorption to reduce the impact velocity to stay below the target's escape velocity (Philae), and (iii) heavy duty landing with a dedicated protection system to lower internal shock loads. In order to enable the exploration and landing on medium-size airless bodies, this paper outlines the concept of advancing small body landers with a crushable-shell protection system to sustain higher landing velocities in the range of $1-4\ m/s$. Design aspects as well as a possible reference mission are given in addition to results of initial crushable-shell impact tests.