Mars and Moon Landing: Systems for Landing Impact Attenuation and Dynamic Stability

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ABSTRACT

The critical moment of touchdown, in the final phase of a planetary landing, can be considered as one of the major drivers of the design configuration for planetary landers.

Studies are currently being carried out by the European Space Agency in order to develop reliable, light weight and cheap solutions for a successful landing. Some of these solutions have been selected and are presently taken into consideration for implementation in projects such as Exomars and the European Lunar Lander. The driving requirements in both cases are: the minimization of the mass, the maximization of the impact shock alleviation capabilities and the dynamic stability at touchdown.

For the 2016 Exomars mission, the platform that will land on the Mars surface is foreseen to be equipped with a layer of crushable aluminium honeycomb. Simulation outputs show that the selected honeycomb material properties are well suited to the energy absorption requirements for limiting the responses at equipment interfaces. A consistent set of simulations, complemented by sample testing for material characterization, has shown that this is a viable solution to mitigate the effects of the last few meters per second of residual velocity at touchdown. The simulations results show that the selected honeycomb materials adequately meet the energy absorbing requirements needed for the limitation of the response at equipment interfaces. Several landing scenarios have been simulated, taking into consideration the most likely combinations of boundary conditions for the platform in terms of attitude, slope and nature of the terrain at the landing site. At this design stage, the choice of crushable honeycomb as a fully passive shock attenuation system seems to be a very effective and promising solution. The major findings are highlighted in this paper.

The first European Lunar Lander, to be launched in 2018, has as primary objective the demonstration of Europe's ability to autonomously deliver a payload safely and accurately to the Moon's surface, near the lunar South Pole.

A landing technology, capable of guaranteeing a soft and stable touchdown, is one of the key points of the mission. Given the reduced stabilizing effects of the Moon’s gravity, the inertial properties and the required ground clearance of the nozzles toward the ground, a legged landing gear was assessed to be the most effective solution.

Moreover, the limitation of the CoG acceleration to 10g at touchdown requires a system with effective energy absorption capabilities. This is achieved by a combination of crushable honeycomb and load limiters. The kinematic properties of different solutions, such as inverted tripod or cantilever leg, have also been investigated analytically by means of multibody simulations, and experimentally by using dedicated breadboards. Several landing scenarios and boundary conditions have been considered in the frame of the Lunar Lander project and parallel studies. The most important findings are presented in this paper.