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SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Upper Stages, Space Transfer, Entry and Landing Systems (3)

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ATMOSPHERIC RE-ENTRY SYSTEMS WITH FLEXIBLE AND INFLATABLE TECHNOLOGIES

Abstract

In this investigation a study of the Entry, Descent and Landing phases with the use of flexible and inflatable technologies has been conducted. The type of capsule chosen to host this technology is the Viking heritage blunt body.

These new structural solutions, called Large Inflatable Entry Decelerators (LIED), were evaluated both for the advantages they offer in terms of weight and performance.

Two separate analyzes have been conducted, each one with a dedicated MATLAB code able to search for an *optimum condition* for the atmospheric entry parameters, as the velocity V and the flight path angle γ. Particular attention was paid to the thermal, structural and human limitations, by imposing respectively a maximum operative temperature for the chosen ablative material for the Thermal Protection System (SLA-561V) and a limit for the load factor n, both for the structural preservation and for the possibility of hosting a human crew.

One analysis focused on an unmanned Earth reentry mission from the International Space Station of a mass of 150 kg: it emerged that, from an atmospheric entry with $V \approx 5.8$ km/s, $\gamma \approx -5$ degree, a single Lifted Hypersonic Inflatable Aerodynamic Decelerator (LHIAD) would be sufficient to cover the supersonic and subsonic deceleration phases, managing to replace multiple distinct deceleration systems used in the past, as the drogue parachutes or other propulsion means, and ensuring a touchdown speed of $V_{land} \approx 10$ m/s.

The second study focused on a future manned mission to Mars, for which it would be required a capsule of at least 40 tons, of which 20 of payload: entering the Martian atmosphere with $V \approx 5.1$ km/s, $\gamma \approx -5$ degree, the results showed that a pair of IADs would be enough to decelerate the capsule in the supersonic and subsonic regime, ensuring a weight saving of 25% compared to what would be obtained by performing the same mission, for example, with the architecture used for the Mars Science Laboratory mission. In particular, an efficient combination was found with a Hypersonic Inflatable Aerodynamic Decelerator (HIAD) of 20 m in diameter, inflated at 3 Mach, supported by a second Supersonic Inflatable Aerodynamic Decelerator (SIAD) of 40 m in diameter, providing a terminal speed of $V_{term} \approx 50$ m/s at +0.3 km MOLA. Even if freedom of choice is left for the technology to be used for the landing, the result is encouraging, given the high mass to be decelerated and the low Martian atmospheric density.