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PRELIMINARY DESIGN OF A NOVEL INFLATABLE HABITAT FOR HUMAN MISSIONS TO MARS

Abstract

Space habitats currently adopted for prolonged manned missions are made from aluminium alloy or stainless steel; due to their weights and large volumes required to accommodate the astronauts, it is impossible to use this kind of structures for a mission aiming to reach Mars. The challenge is to design light and initially stowed structures that both make the best use of the reduced transport capacity of the available launchers and ensure safety and reliability levels comparable to those of classical solutions. For this reason, space inflatable structures have gained interest in recent years: initially folded in stowed configuration to fit in the space dedicated to the payload inside a launcher, they can be subsequently deployed and inflated to reach the required volume. In addition, these structures are much lighter than traditional ones and would significantly reduce the costs of the related missions, as the number of launches required to build a structure of the same size using traditional technologies would be much higher.

However, inflatable habitats are currently unable to withstand damages after, for example, impacts with micrometeoroids and space debris, and they would depressurise and collapse if punctured, with catastrophic consequences for devices and astronauts in case of crewed missions. The here presented study describes the design of a self-healing inflatable habitat in the context of a preliminary mission analysis related to a Mars exploration scenario.

The presented structure, initially folded and stowed in a small volume, is capable of subsequently opening thanks to a network of inflatable beams rigidised by soliciting their material beyond its yielding point. These beams have a circular section and are folded using an origami technique known as Miura-Ori. A layer of self-healing material is also inserted in the lamination sequence of the protective membrane of the structure, to ensure autonomous and rapid damage recovery.

In the preliminary manned mission analysis, the launch windows for each interplanetary transfer were identified, including the re-entry phase, and the optimal trade-off between the transfer time and the related costs was found using the patched-conics method. Then, the Martian environment was studied to determine specific radiation shielding and internal temperature range requirements that the structure must follow to be usable as a habitat. Finally, in situ resources utilisation methods were analysed to produce resources that are essential for the astronauts' survival in the habitat, such as water and oxygen.