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Title

Design and deployment methods for a Martian exploration airship

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Abstract

Currently, there are mainly two ways to explore Mars: from orbit using satellites and from ground level using rovers eventually assisted by helicopters. There is a gap to explore between these two methods and there are still interesting but unreachable areas of the Martian surface such as craters or cliffs. An exploration airship can overcome this problem and observe the steepest walls with a camera, a spectrometer or a hyperspectral camera. It allows vertical and horizontal displacements and it can cover long distances with a large energetic autonomy to collect data. The possibility of using such a balloon to explore the slopes of Valles Marineris was assessed in a preliminary feasibility study [1] presented at GLEX 2021. Follow-up work [2] was presented at IAC 2022. The low density of the cold Martian atmosphere is a considerable challenge for the design of a lighter-than-air vehicle and hydrogen is the most suitable gas for this application. The mean diameter of the airship would be 45m and it allows to lift a payload of 500 kg. The deployment of such a balloon is a big challenge. In this feasibility study, multiple methods for the unfolding and inflation phase have been assessed. Deployment from the Martian ground is the privileged option, but there are serious issues with the inflation phase. The main concern is how to guarantee a safe unfolding of the envelope in the hostile Martian environment. Therefore, additional mechanisms or equipment are needed to ensure the deployment from the ground. Alternatively, deployment and inflation from space are also considered. The goal is to inflate the balloon under fewer constraints and to use its large surface to reduce the heat flux generated by the atmospheric entry. The dynamic pressure does not generate important mechanical stresses on the envelope. Nevertheless, the maximal temperature created by the heat on the surface of the airship is an issue for the structure and especially for the Mylar layer which has a low thermal tolerance. Thus, a thermal shield layer is required. The choice of materials and the structure of the envelope are decisive in the continuation of the feasibility study. Indeed, knowing that the mass and the size of the balloon have a great influence on the general system such as propulsion or solar panels, it is essential to have a proper design of the envelope's structure. Two solutions are presented consisting of two layers, the first one allowing the containment of hydrogen and the second one resisting the mechanical stresses exerted on the envelope. The other item related to the design of the envelope that was addressed in this study bears on the system of attachment to the gondola. After having explored various possibilities, it was concluded that the best solution is a skirt similar to the system used for hot-air balloons.

References

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