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FEASIBLE MISSION DESIGN OF A MARTIAN AIRSHIP AND VERIFICATION WITH A TRAJECTORY CONTROL SIMULATION

Abstract

Increasing interest in Mars would benefit from a new approach that bridges the gap between local rover measurements and global orbit observations. This study proposes an airship to serve as a platform for hosting scientific instruments, thus adding the advantage of capturing vertical features of Martian terrain and benefiting science. The most critical challenge for an airship design is the thin atmosphere, which results in a large balloon size. This paper, building on previous studies conducted at EPFL, addresses this issue and presents a refined design of a Martian airship mission. The focus is placed on the operations and design of the airship as well as a comparison of entry, deployment and landing methods.

For the selection of the operational zone, the impact crater Hellas Planitia and Valles Marineris are analyzed using the Mars Climate Database. A thorough comparison leads to Hellas Planitia being selected, due to its favorable atmospheric conditions in terms of density and solar radiative flux. Within Hellas Planitia, a Design Reference Mission is defined and a trajectory control algorithm is developed to follow it, taking into account the winds on Mars.

The paper continues with a comprehensive study on the design of the airship including the envelope and the gondola. The envelope, with a radius of 19m, enables the airship to lift a 500 kg mass up to 3000 m from the ground. An inner balloon filled with ambient CO_2 air, located inside the envelope, controls the airship's altitude by pressurizing the hydrogen lifting gas. The gondola hosts all the mission-critical subsystems as well as a scientific payload that analyzes the geological composition of the crater walls. To design the envelope and gondola, a systems engineering approach is followed, involving definition of requirements, system architecture, and subsystem trade-offs. Based on this, a preliminary design with mass, power, and data budgets is established. Special attention is given to the design of the solar panel structure, crucial for harnessing energy in the challenging Martian environment.

Furthermore, this paper explores two solutions for Entry, Deployment, and Landing applicable to a Martian airship: space-based-deployment and ground-based-deployment. To perform a trade-off, comparison criteria are defined. They are subsequently evaluated, by undertaking preliminary sizing for both solutions. Ground deployment emerged to be the most suitable solution, of which a first design concept is presented in this paper.