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MARS HARD LANDER: A PARAMETRIC STUDY

Abstract

In this work we carried out a parametric study to outline system engineering constraints for designing small Mars hard-landing vehicles, without parachutes or other more complex descent systems (like airbags, skycranes or powered soft-landings). Historical aspects have been taken into consideration to re-evaluate forgotten, but effective, solutions and strategies used or proposed in the past. By analyzing those missions and studies it has been possible to explore the challenges and limitations in designing Martian landers, and to develop the proposed concept. This parametric study focuses on viable approaches to: 1) reduce the terminal velocity during entry into the Martian atmosphere, 2) use a single solid rocket motor to soften the impact, and 3) assess different strategies to absorb the impact with the ground. The first part of the parametric study, the one that characterize the entry and descent phases, is modeled using a MATLAB algorithm that takes into account physical characteristics of the proposed lander and the Martian atmosphere, with all its seasonal variation. The landing phase is analyzed in the second part of the parametric study, assessing the level of shock at impact that the structure must be able to absorb in order to operate properly on Martian soil. Realistic landing locations are considered accordingly also with current Mars exploration program objectives, in particular the need for scouting possible human landing sites. The last part of this work proposes a possible architecture that satisfies the identified constraints, including the design of a reference mission with trade-offs among components and preliminary budgets (mass, power and link budget), and evaluation of possible applications of this landing concept, after discussions with representatives of the Mars science community.