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FEASIBILITY ANALYSIS OF THE MID-AIR RELEASE OF MULTICOPTERS IN THE MARTIAN ATMOSPHERE

Abstract

The Martian atmosphere presents a unique obstacle due to its exceptionally low density, posing significant challenges for the deceleration of incoming spacecraft. In this study, we propose a novel approach to Martian atmospheric reentry that focuses on optimizing the limited space within a reentry aeroshell for a mission that relies solely on helicopter technology, foregoing traditional rovers and heavy and large landers. The proposed approach is driven by the need to maximize payload capacity and minimize mission architecture complexity. Previous research has explored mid-air helicopter release techniques in the Martian atmosphere, often using auxiliary jet packs for deceleration. However, such systems take up valuable space within the aeroshell, limiting payload capacity and complicating mission logistics. For the Dragonfly mission, a direct mid-air release was chosen to place a multicopter in Titan's atmosphere. In this case, the dense atmosphere helps both the deceleration of the aeroshell and increases the thrust of the rotors, allowing an effective final deceleration phase. This type of operation will be much more challenging on Mars.

Our proposed solution is to use the internal volume of the aeroshell to accommodate multiple multicopters, using the space occupied by rovers and landers in previous missions. By sequentially releasing these multicopters and using a secondary parachute system for additional deceleration, we aim to investigate the feasibility of this approach for achieving controlled flight and landing on the Martian surface. The use of multiple unmanned aerial systems (UAS) would potentially enable new scientific missions requiring the simultaneous operation of different instruments. The main objectives of this study are to analyze the aerodynamic and propulsion characteristics of multicopters in descending flight and to assess the overall mission feasibility within the constraints of available technology and resources. Through detailed simulations and theoretical analysis, we aim to demonstrate the viability of our proposed approach and identify potential challenges and opportunities for future research and development. In particular, we will analyze the problematic nature of the vortex ring flight regime, which should be avoided in order to limit vibrations that could threaten the structural integrity of the vehicle. Especially, considering the extremely small relative thickness that efficient airfoils require in such a low Reynolds number regime.