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A PROPOSED FRAMEWORK FOR EVALUATION OF UNMANNED AERIAL PLATFORMS FOR MARS EXPLORATION

Abstract

Unmanned Aerial Vehicles (UAVs) have become fundamental assets for many activities on Earth. Thanks to the recent developments in hardware miniaturisation, battery optimisation and reliability of flight control and artificial intelligence algorithms, UAVs are used in several applications where flying platforms can provide a clear advantage on land and marine assets. They can also decrease the risk, performing tasks which are potentially dangerous for humans. The most recent application of aerial drones is planetary exploration: space Agencies like NASA and ESA already implemented the use of UAVs in their most recent exploration class missions. Missions range from demonstrators, such as Ingenuity, a small flying drone mounted on the Mars Perseverance rover, to fully functional spacecraft like the Titan exploration drone Dragonfly. The interest in these platforms for space applications is rising exponentially, and it will probably lead to the development of a new generation of autonomous and semi-autonomous exploration systems, adaptable both to precursory and human-rated missions.

This paper proposes a methodology for the preliminary design of martian UAV missions, providing a performance evaluation roadmap tool. First, a review of proposed martian flying missions is presented, as well as available martian environmental data from past missions. Secondly, a classification of aerial systems for planetary exploration missions is discussed, focusing on available technologies (types of propulsion, flight configuration, power management) and potential operational scenarios. Concurrently, a set of performance metrics is defined and evaluated. These metrics are then employed to rank aerial system configurations and technologies with respect to mission objectives and constraints, in search for an optimal match. Radar diagrams are created to provide a visual tool to evaluate the candidate solutions. To better define the operational scenarios, a martian environment toolbox is conceived: depending on data such as location and flight altitude, it returns available data on temperature, density, etc;, using both interpolated experimental data and analytical models. Through this preliminary tool, flying conditions can be estimated, and the proposed architectures can be tested. A user-friendly interface allows the user to select a main mission objective and operational scenario, and the software then provides a ranking of the most suitable aircraft configurations with respect to the selected figures of merit.