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PHASE-A DESIGN OF A MARS EXPLORATION AERIAL VEHICLE

Abstract

This research work focuses on the preliminary design of a fixed wing Unmanned Aerial Vehicle (UAV), suitable for surface imaging of Mars. A propeller-driven configuration, powered by solar panels and batteries, and equipped with an airfoil in-house optimized for low-Reynolds flow conditions is proposed. A multidisciplinary tool for the preliminary design of a Martian UAV is detailed discussed in the paper. The conceptual design procedure follows the Noth's methodology, which was investigated and proposed for the conceptual design of the Sky-Sailor. In particular, the Noth's design procedure is opportunely reworked to determine design requirements in terms of Reynolds and Mach numbers at cruising conditions of a fixed-wing and as well as the Martian incident solar flux, needed to the UAV operations. Recall that, determining the right Mach and Reynolds flow similarity parameters is of paramount importance to address the aerodynamic performances of the UAV to fly in the low density and adiabatic parameter Mars atmosphere. The design methodology is based on the power and mass balances that occur during level flight. The total mass of the drone is calculated by summing the masses of its components, such as payload and avionics, airframe, batteries, solar panels, and propulsion group. The payload mass is assumed based on mission requirements, while the avionics mass is constant. Then, statistical relations are used to estimate the airframe and propulsion group masses. The mass of the solar panels is calculated based on the gravimetric density and the covered wing area. Meanwhile, the mass of the batteries is assumed to be proportional to the energy required for storage. The energy required to power the drone is calculated by adding the power needed for horizontal flight (minus the efficiency of the electric thruster components), the power needed to operate the on-board avionics, and the scientific payload. The available daily solar energy was estimated by using the values suggested by the Mars Climate Database, depending on the geographical location to be explored and the time of year. In this framework, the design problem is modelled by a third-degree equation. The equation coefficients depend firstly on the two design parameters (as well as other fixed parameters): wing aspect ratio and wingspan. After establishing the mission requirements and selecting the technological parameters, the optimum combination is chosen based on UAV gross mass and range. The objective is to analyse how the optimum design point varies as aerodynamic and design parameters change.