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A FEASIBILITY STUDY OF AN AUTONOMOUS UAV FOR MARS EXPLORATION FOR THE ESA MARS SAMPLE RETURN MISSION

Abstract

The first few kilometres of the Martian atmosphere above the surface are particularly challenging to observe from Mars orbiting spacecraft, due to enhanced extinction. Orbiters have measured methane levels on Mars almost 1/200th the level that rovers have found on the surface. This discrepancy significantly constrains the mechanisms to corroborate the measurements and highlights the need for detailed global exploration of the lower Martian atmosphere.

An autonomous Mars powered aerobot (airship) could enable global in situ measurements of trace gases, locating potential trace gas sources and sinks, and potentially corroborating surface and orbital observations. Moreover, a Mars airship would enable dedicated study of the Martian planetary boundary layer (PBL) and enable surveying of future robotic and human exploration landing sites. An airship has a fail-safe condition; if propulsion fails, it continues to fly. This enables a Martian airship to remain motionless, over a target region of interest, unless local wind conditions exceed its forward speed capacity. An airship could hover over a selected site (including interesting sites that would be deemed too dangerous for a surface rover to explore), winch down a surface instrument package, acquire samples and winch the instruments and samples back up. These attributes combined strengthen the case for autonomous airships operating in the first few kilometres above the Martian surface and could significantly enhance the scientific return from the ESA Mars Sample Return (MSR) mission.

To understand super-pressure balloons the radiation fluxes in the Martian atmosphere should be known and carefully evaluated. We evaluated the optimum radiation and atmospheric conditions for such an airship operating in the lower Martian atmosphere, utilising the Mars Climate Database. The primary goal of this project was to optimise the mass efficiency parameter, i.e. the ratio of payload mass (Mp) to the total floating mass (M), which includes the mass of the payload (Mp), balloon/airship envelope (Mb) and buoyant gas (Mg). This involved exploring a range of expected Martian atmospheric pressures (Pa) and temperatures (Ta) and feasible Mp, Mb and Mg. This project also includes an evaluation of the instrument payload, new light-weight strong materials and fabrication techniques that could be used for a Mars airship envelope to further increase the mass efficiency parameter. It is the hopes of the authors that the work presented will raise awareness to the many benefits that aerobot exploration has for the exploration of Mars while also showing clear advancement of this technology.