

# Exploring the Martian canyons by means of atmospheric energy harvesting

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The use of aerial vehicles for planetary exploration of Mars was successfully demonstrated by the Ingenuity helicopter, paving the way for future missions to push past existing limitations to scientific return. Existing spacecrafts often restrict themselves to terrain favorable to available Entry Descent and Landing (EDL) technology. Yet aircrafts can forgo the last step of EDL and deploy to previously unreachable regions of high interest such as canyons and high ridges. For such targets, science can be returned at minimal to no energy cost by gliders utilizing a technique known as soaring. By maneuvering within variable airflow regions energy is harvested from the atmosphere, enabling a purposely designed glider to achieve extreme endurance without the need for propulsion.

Previous research has shown that Mars's near surface planetary boundary layer has substantial and persistent wind flows driven, in part, by the high daily thermal changes. Both are advantageous to soaring with temperature changes leading to ascending airflows highly favorable to static soaring. Wind around ridges cause shear layers, regions of significant vertical changes in horizontal air velocity. On earth such flow structures have been utilized for dynamic soaring, a cyclic flight pattern that harvests energy through repetitive crossing of the shear region, increasing available flight energy over time.

The energetics of dynamic soaring have been studied and showed that such flight is possible on Mars, where numerical modeling found substantial winds in regions such as Valles Marineris. The present work introduces solution flight paths for Mars such as (1) straight line ascending and descending, (2) fixed circular paths inclined to the horizontal, and (3) spiraling ascent and descent along a helical path. Together they form the fundamental flight paths for accumulation of kinetic energy through circular flight, gains of potential energy by means of static soaring, and traveling at no energy cost through wind riding. Numerical solutions are obtained for each technique given a Mars glider and typical Mars conditions. Results show significant amounts of energy gains and support the construction of a proposed comprehensive exploration mission.