Airborne Release and Recapture of UAV from Martian Balloons

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Motivation

Small fixed-wing aircraft hold great potential for analyzing new regions of Mars, allowing a dive into topographical compexities of the planet. Rugged areas of Mars are better suited for aircraft reconaissance, rather than rovers. We take inspiration from uncrewed aerial vehicles on Earth, a growing field where technology has been useful for reconaissance. Furthermore, flight on Mars has been proven to be possible by the Ingenuity Helicopter, a preview of the potential benefits of UAV's on Mars.

Figure : NASA Ingenuity Helicopter

Concept of Operations

Small fixed-wing aircraft are proven to be able to fly with low energy consumption, as is apparent from extensive studies on the flight of gliders. The exploitation of wind allows for these aircraft to fly for considerable distances and durations while using minimal power. The same has been shown to be possible in other planets' atmospheres. While this capability presents great potential for further planetary exploration, it relies on specific wind conditions suitable for flight. Since such conditions do not always exist, we are researching the possibility of docking these vehicles when unsuitable weather is imminent and relaunching them when conditions are again suitable for flight. Assuming a stationary balloon-borne platform as a home base for the fixed-wing aircraft, we present two potential solutions to docking and relaunching: Perching, and the Brodie landing system.

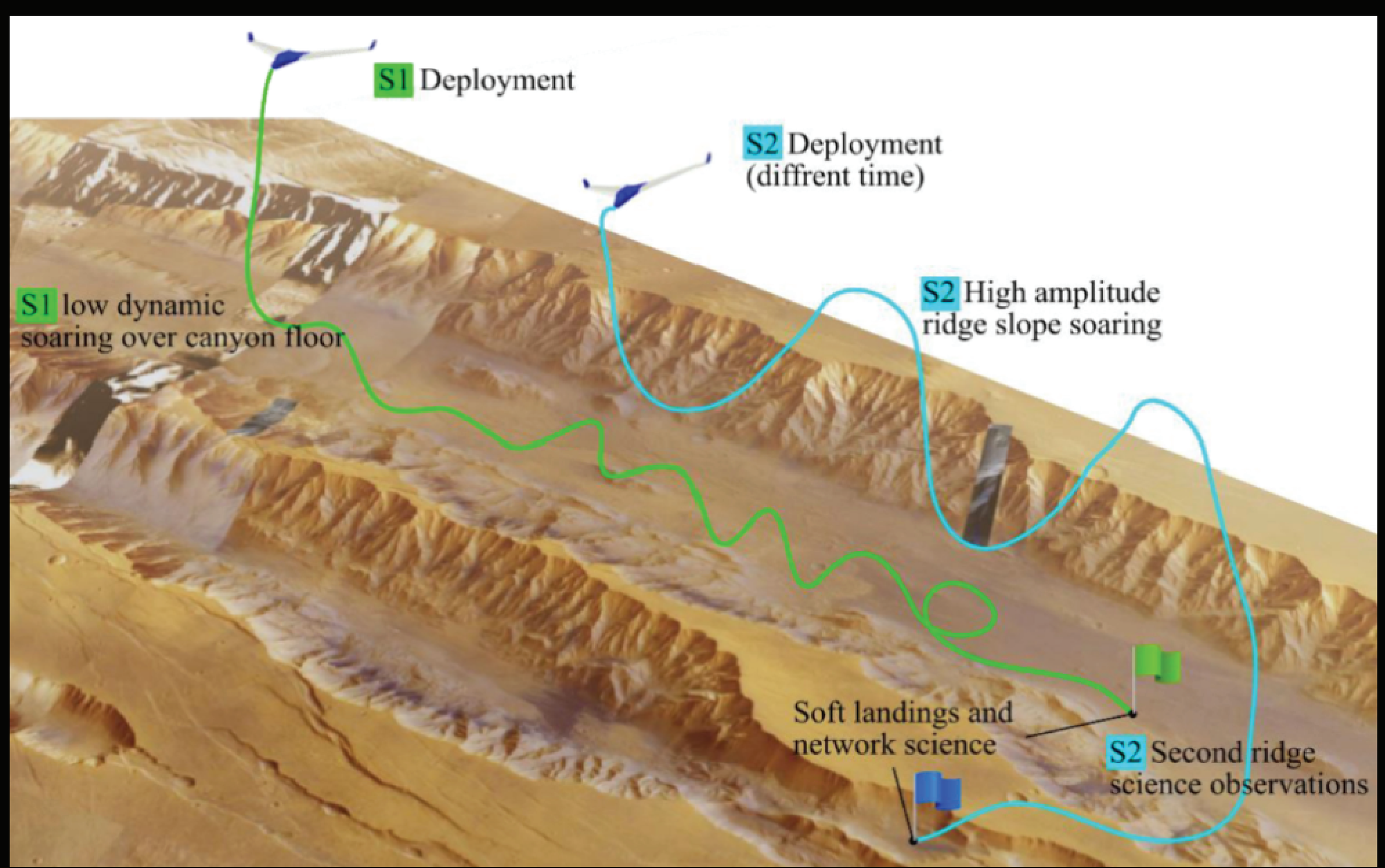


Figure : Two-sailplane mission concept for exploring Valles Marineris. A docking system would allow multiple reflights of each sailplane.

Perching

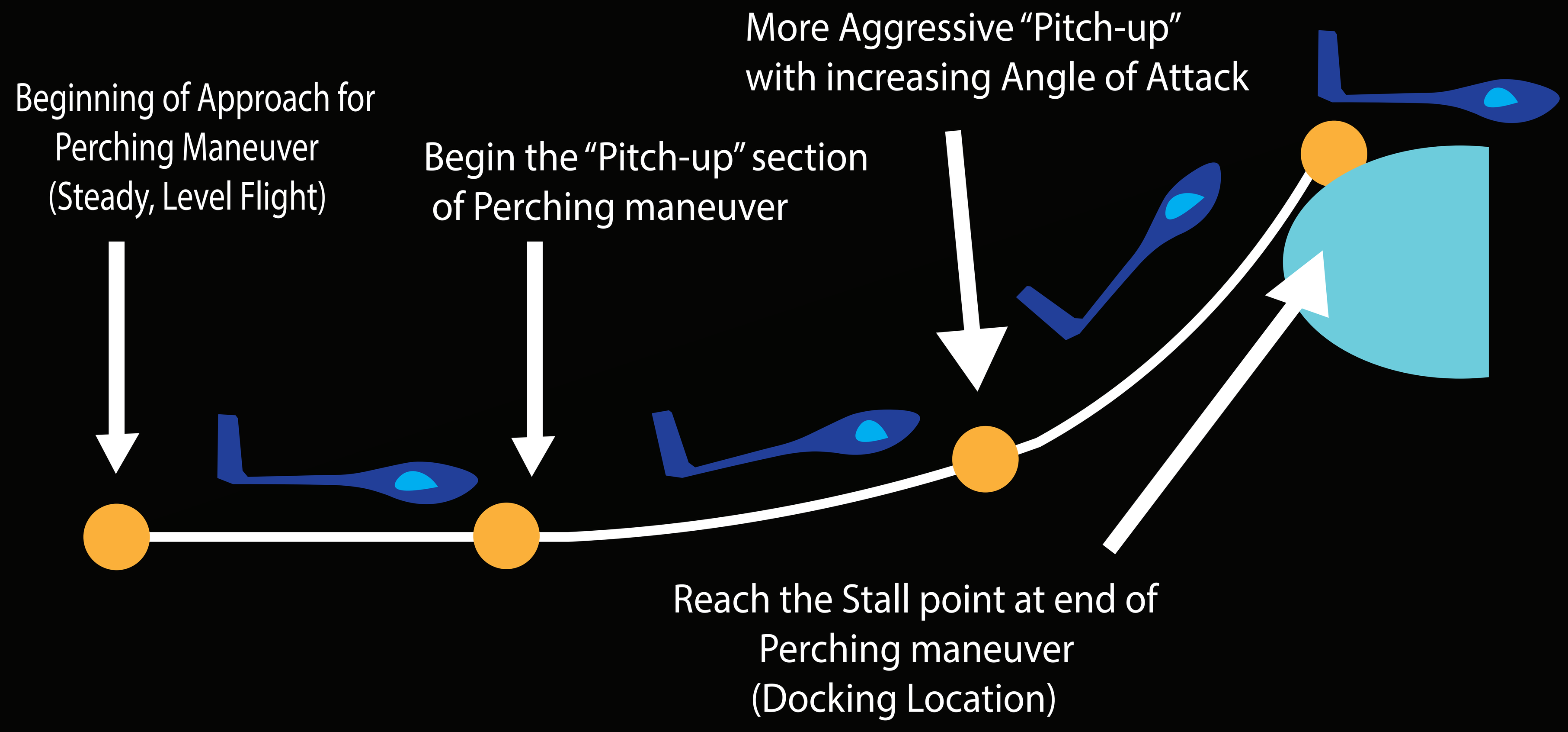
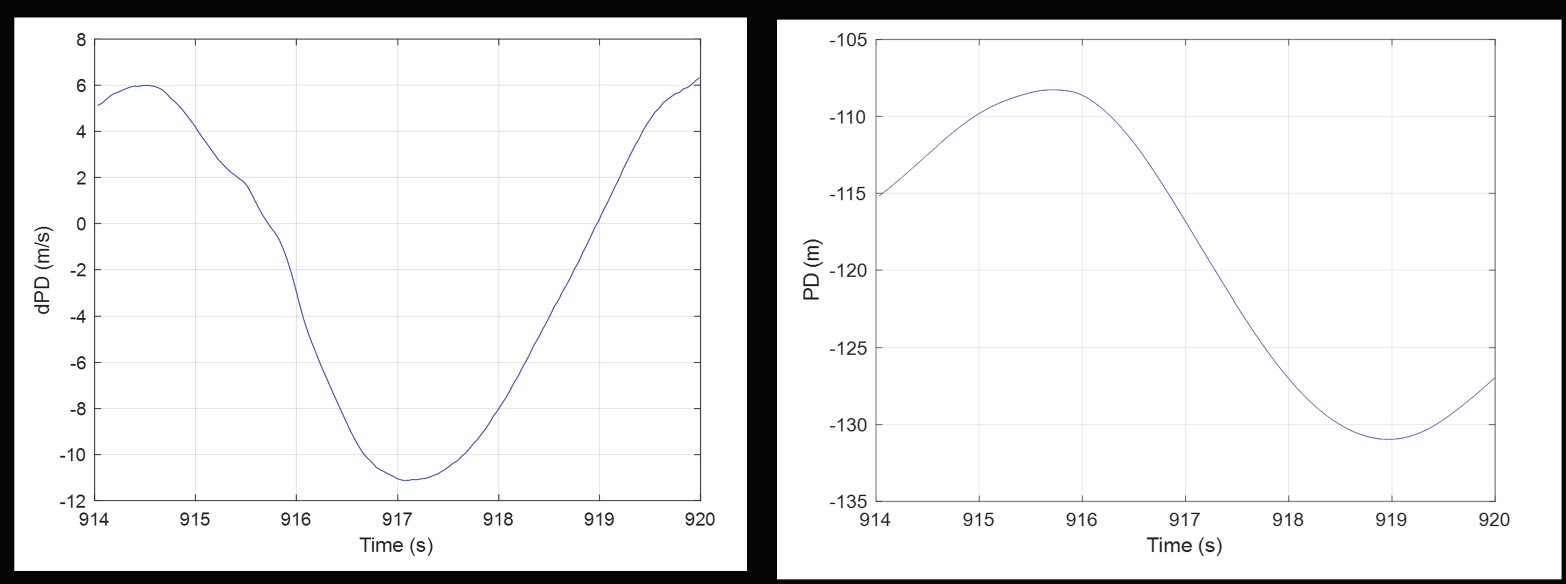


Figure : General Diagram for Perching Waypoints

The perching method uses aerodynamic forces as an aid for landing the small-winged aircraft at a specific point. Using an intense pitch-up maneuver and dynamic stall, the fixed wing aircraft can dock to its home base.

Figure : UAV Flight plot from Testing



Figures : Graphs of Vertical Velocity and Altitude during Perching Maneuver

We have conducted several flight tests with the sailplane performing the perching maneuver at various approach speeds and levels of aggressiveness in the "pitch up" section. With this flight data, we are currently working on its full dynamic modeling. It is our goal to linearize these results to prove it is viable for Mars' conditions.

Brodie System

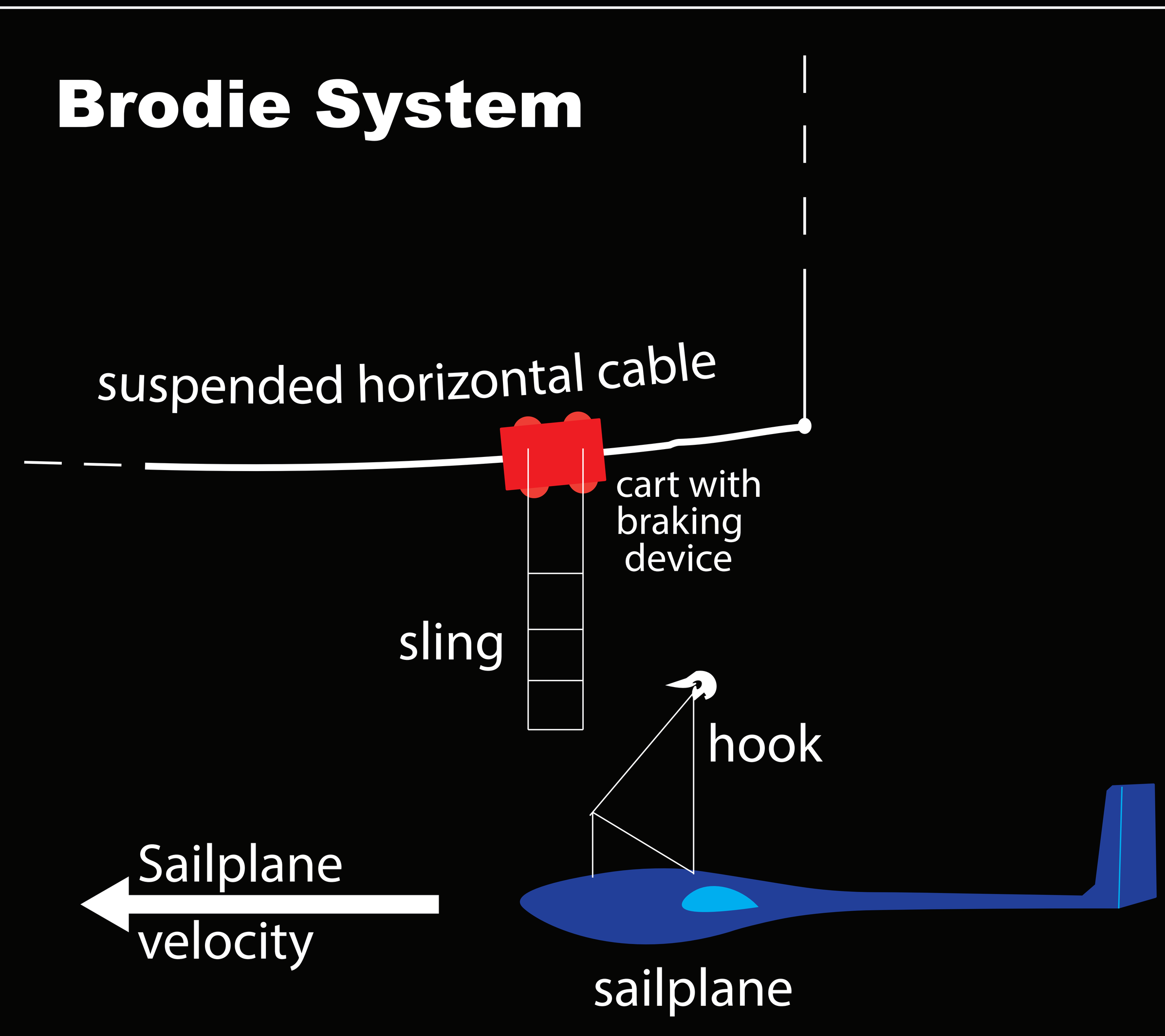
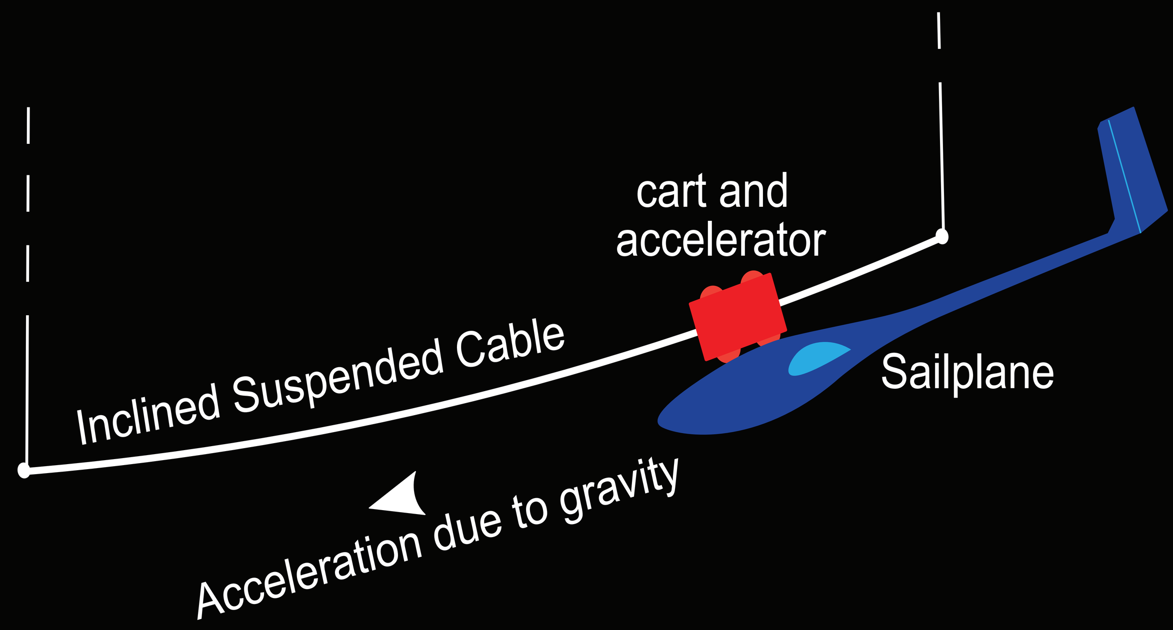


Figure : Simplified diagram of Brodie landing system



The Brodie landing system is a mechanical approach to the challenge of recovering the sailplane. In this system a hook on the aircraft is used to grab onto a braking mechanism that slides along a cable suspended between two points. As in the perching method, a pitch-up maneuver may be used to reduce the velocity of the sailplane before it grabs the braking mechanism.

We are in the process of modeling the physics of the Brodie system to determine what it would take to build a working prototype.

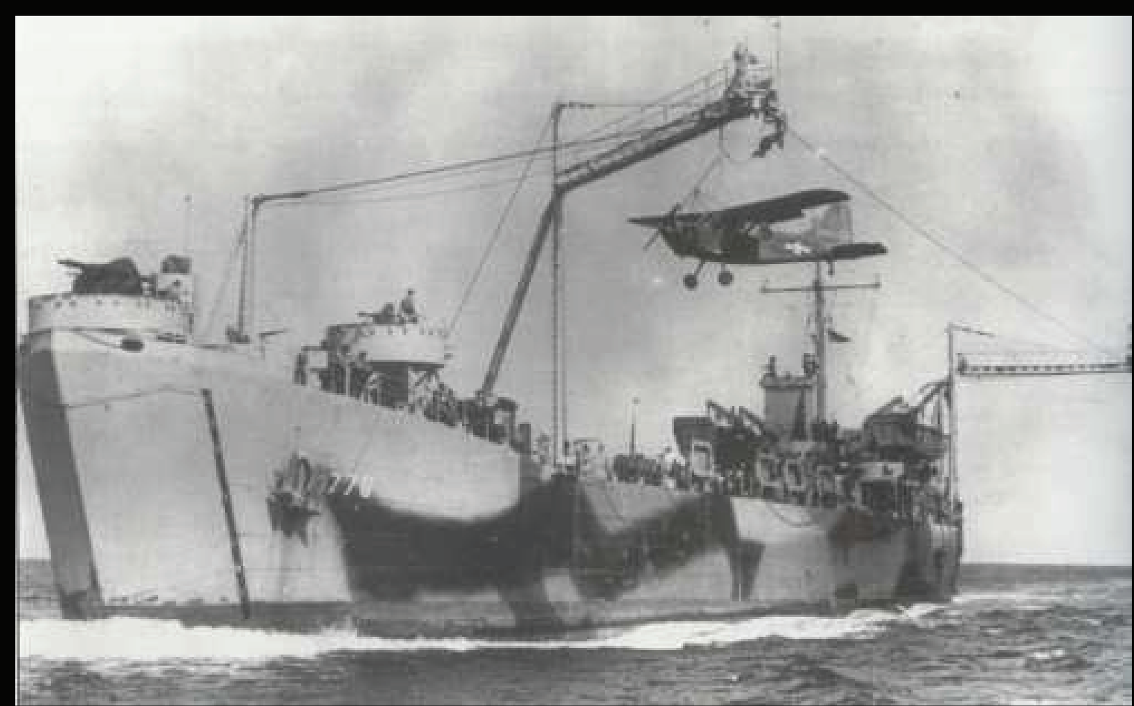


Figure: Brodie System in use during WW2

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