CHARACTERIZING DUST ENVIRONMENTS FOR MARS MISSIONS DURING ENTRY, DESCENT, AND LANDING. J. Rabinovitch[1], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109 (jason.rabinovitch@jpl.nasa.gov).

Introduction: Characterizing the dust environment on Mars during entry, descent, and landing (EDL) is a challenging yet critical task for any flight mission that will land on the surface of Mars. This work will discuss two scenarios: 1) dust being transported due to plume surface impingement during powered descent, and 2) potential brownout conditions for a helicopter flying on the surface of Mars.

Plume Surface Interactions during Powered Descent: The subject of plume surface interaction has been the subject of many works in the past, but particularly relevant to the Mars Science Laboratory (MSL) are [1] and [2], where the former attributes some errors in the Terminal Descent Sensor (TDS) to significant amounts of dust and debris being kicked up by the Mars Landing Engines (MLEs), and the latter highlights concerns over Rover paint erosion due to particulate impacts. Photos from the Mars Descent Imager (MARDI) instrument show significant cratering occurring on the Martian surface during descent (Fig.1). While high-fidelity plume surface interaction simulations including particle entrainment under Mars conditions are still beyond state-of-the-art capabilities, the MARDI images can be of great use in order to start validating numerical simulations and models for cratering on Mars during powered descent.

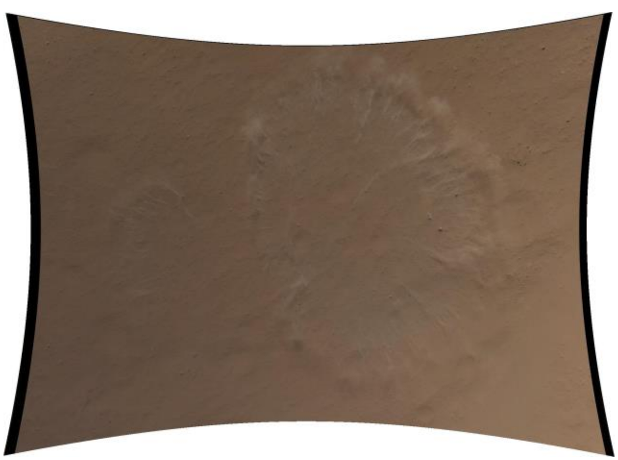

Fig. 1 – Sample MARDI image showing cratering occurring on the surface of Mars during MSL descent.

Helicopter Degraded Visual Environment (Brownout): When a helicopter is hovering over a loose sediment bed, the interaction between the helicopter wake and loose sediment can allow particles to be lifted into air, which in turn can create a visually degraded environment around the helicopter. When this effect is severe, the situation is often referred to as helicopter brownout, and has been a subject of study for numerous works (for example [3]). A lack of visual cues for a pilot during takeoff and landing can result in helicopter crashes, and particles impacting the helicopter can cause damage to the helicopter itself, or cause onboard sensors to malfunction. Recent advances in numerical approaches for modeling helicopter brownout have increased the fidelity of predicting the severity of brownout for a helicopter, but work still needs to be done to reduce errors in even state of the art simulations [4].

For a potential autonomous Mars helicopter, dust erosion, or a possible brownout cloud could damage the helicopter, deposit dust on solar arrays, or interfere with onboard sensors during take-off and landing, where a knowledge of the helicopter's state is critical. For a relatively small counter-rotating coaxial helicopter that could fit as a payload on an MSL-like mission, scaling arguments accounting for Mars saltation velocities [5] have been combined with the methodology outlined [3] along with experiments to predict that only a minimal amount of sediment will be moved by a small Mars helicopter during take-off and landing.

Conclusions: While the accurate numerical modeling of multi-phase flows during Mars EDL remains a challenging problem, much work is still being conducted to attempt to better characterize dust environments during EDL. Continued work in this field is crucial as the expected dust environment for a mission during EDL can have considerable design and operational impacts on the overall mission design.

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