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DEVELOPMENT OF SUPERSONIC DESCENT VEHICLE RECONFIGURATION RAPID ANALYSIS METHODOLOGY FOR APPLICATION TO HUMAN-CLASS MARS ENTRY, DESCENT, AND LANDING

Abstract

Every mission that has successfully landed a payload on Mars has utilized heritage deceleration technologies from the 1960's and 1970's Viking era. Utilizing only Viking heritage deceleration technologies presently available, it is estimated that a 1.1 mT payload landed at 0 km elevation represents the upper limit of current Entry, Descent, and Landing (EDL) capabilities. The succession from the current state of the art along NASA's goal of extending and sustaining human presence in our solar system will require landing human class payloads (>20 mT) on Mars with landed accuracies on the order of meters. Supersonic Retropropulsion (SRP) is one promising candidate supersonic deceleration technology to enable higher mass Mars missions.

To enable the use of SRP, an entry vehicle will likely need to perform a supersonic vehicle reconfiguration during descent to the Martian surface to expose SRP rocket nozzles into the oncoming atmospheric flow. The change between the hypersonic entry vehicle configuration and the SRP-ready vehicle configuration will require the supersonic ejection of the vehicle aeroshell. Once ejected, the discarded aeroshell becomes solid-mass debris traveling in the same direction as the primary vehicle. This debris poses potential catastrophic recontact risks to the primary descent vehicle. Mitigating these debris recontact risks is a significant hurtle to the development of SRP as a mission-ready technology.

Supersonic descent vehicle reconfigurations have never been performed and there exists no published research in this field. This paper presents current efforts to develop the first supersonic descent vehicle reconfiguration rapid analysis methodology. An overview is presented of a high-level, rapid analysis methodology that provides mission designers the capability to assess the initial feasibility of numerous candidate descent vehicle reconfiguration architectures during trade-study-level investigations. In short, the methodology characterizes far-field recontact risks for each piece of debris, determines an accumulated debris field, and then constrains debris ejection paths along prescribed trajectories to offset the primary vehicle propulsive descent trajectory and the accumulated debris field. The prescribed ejection paths are determined using optimization to minimize ejection subsystem performance requirements. This paper presents efforts to generate and model isolated aerodynamics data for ejected debris and characterize far-field debris field envelopes. Aerodynamic data models are developed using response surface methods. The presented efforts are performed in-line with a larger activity encompassing the development and validation of the overall supersonic descent vehicle reconfiguration rapid analysis methodology.