LESSONS LEARNED AND FLIGHT EXPERIENCE FROM PLANETARY PARACHUTE DEVELOPMENT

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ABSTRACT

Recent planetary probe development experiences from the Phoenix Mars Scout and Mars Science Laboratory (MSL) parachute decelerator programs are reviewed. Particular attention is given to lessons learned from the development process and the testing techniques required to structurally qualify the parachute designs for flight. Limitations of these atmospheric tests are discussed and a rationalization for the flight qualification of the design is provided. Potential future parachute designs and the necessity for associated full-scale high speed testing are briefly examined.

Both Phoenix and MSL make use of Viking scaled disk-gap-band parachute designs and scalability issues encountered during the two efforts are discussed. In particular, MSL employs a 21.35 m nominal diameter parachute which will be the largest extraterrestrial parachute ever flown. Full-scale wind tunnel testing of the MSL parachute revealed a band leading edge inversion failure mode that had never previously been observed in any test or flight deployment of a disk-gap-band parachute. The consequences of this new failure mode and its implications for the flight qualification are reviewed in the context of its intended flight regime.

The supersonic characteristics of the Phoenix parachute as measured in flight are compared to available full-scale terrestrial supersonic flight data as well as a Pflanz opening model that is commonly used to estimate supersonic parachute drag. The area oscillations phenomenon associated with Viking disk-gap-band parachutes is discussed in light of MSL's planned Mach 2.2 deployment and the potential consequences of extended supersonic operation required by the MSL entry timeline. This extended exposure to high speed flow necessitated additional testing in order to demonstrate structural margins against the increased parachute dynamics. The effect of the associated area oscillations on the entry body attitude and the potential risk due to excessive wrist-mode excitation are also assessed.