Improving EDL Capabilities Through the Development and Qualification of a New Class of Supersonic Decelerators. I. G. Clark[1], [1]Jet Propsulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr. M/S 321, Pasadena, CA 91109, ian.g.clark@jpl.nasa.gov.

Introduction: Since the 1970's a number of advances have been made in the area of entry and landing technologies. New, lighter and more capable thermal protection systems have been developed and for the first time at Mars an entry vehicle will be using active hypersonic guidance to improve landing accuracy. Landing technologies have evolved to include inflatable airbags and a skycrane terminal descent system. However, the technologies associated with descent, namely supersonic parachutes, remain as they were after the Mars Viking Program. NASA, through the Space Technology Program, has begun the Low-Density Supersonic Decelerator project (LDSD) to mature the next generation of decelerator technologies. These include several types of supersonic inflatable aerodynamic decelerators (SIADs) and a new type of supersonic parachute.

Decelerator Technologies: Prior to the downselection to the disk-gap-band (DGB) parachute, the Viking program had originally considered a number of other supersonic decelerators including ringsail parachutes, trailing ballutes, and attached isotensoid decelerators. The LDSD project has focused on three separate technologies to mature to TRL 6. These include a 6-m attached torus SIAD (Figure 1), a ~4-m trailing ballute, and a large, 33.5-m diameter ringsail parachute. In addition, LDSD will mature to TRL 5 an 8-m diameter attached isotensoid SIAD (Figure 1).

Figure 1. 6-m Attached Torus SIAD (left) and 8-m Attached Isotensoid SIAD (right).

Testing of the two SIAD configurations will qualify them for environments as high as Mach 4 and dynamic pressures as high as 2200 Pa. The trailing ballute will be qualified to Mach numbers up to 3 and the parachute is targeted for deployment around Mach 2+.

Improved Capabilities: Though Viking's choice of the DGB parachute would in part be based on an improved understanding of the Mars atmosphere and relaxed mission requirements, the original impetus to look beyond parachutes is still valid. That is, to decelerate at higher altitudes and earlier in the trajectory, for the purpose of providing improvements in landed altitude, mass, and accuracy. The specifc improvements provided by the suite of LDSD technologies may be interchanged in a number of ways. For example, assuming an Atlas V-551 launch vehicle, a 33.5-m ringsail parachute can provide:

• A -1 km landed elevation, 10 km delivery accuracy at parachute deploy, and a landed mass of 1.7t.

The combination of a 6-m attached torus and 33.5-m ringsail parachute can provide:

• For an MSL class rover and descent system, access to landed elevations of +2 km MOLA and 3 km delivery accuracy at parachute deploy.

• A +1 km MOLA landed elevation, <3 km delivery accuracy, and a landed mass of 2t.

For larger launch vehicles in the Delta IV-H class, the combination of an 8-m attached isotensoid and 33.5-m parachute would allow for landings of payloads up to 2.7t at altitudes as high as +1 km MOLA and with delivery accuracies of less than 3 km.

Though targeted at missions with entry masses greater than that of the Mars Science Laboratory, the benefits provided by the advanced technologies are not limited to large spacecraft. Notably, increases in altitude and timeline are possible with smaller entry vehicles incorporating SIADs and decreases in terminal propulsion requirements are possible with the more efficient ringsail parachute.

New Qualification Techniques: To mature these new decelerators, LDSD is developing several new testing capabilities. Flexible decelerators typically do not scale particularly well and a need exists to test them at full or nearly-full scale. Thus, each decelerator will be tested at full-scale at relevant supersonic conditions in an atmospheric density similar to that at Mars. In addition to this high altitude test series, a set of ground based qualification tests will be conducted. The size of the decelerators and the aerodynamic loading environments which they will be used in precludes the possibility of wind tunnel testing. Thus, to structurally qualify the devices, a new test technique utilizing rocket sleds has been developed. Though only subsonic, the high-denisty near sea level will allow the rocket sleds to subject full-scale test articles to aerodynamic loading that is very similar to that expected during flight. This test technique is even being extended to provide an economical means of qualifying large parachutes to aerodynamic loads in excess of 100,000 lbs.