Structural Testing of a 6m Hypersonic Inflatable Aerodynamic Decelerator System

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NASA is developing low ballistic coefficient technologies to support the Nation's long-term goal of landing humans on Mars. Current entry, decent, and landing technologies are not practical for this class of payloads due to geometric constraints dictated by current and future launch vehicle fairing limitations. Hypersonic Inflatable Aerodynamic Decelerators (HIADs) are being developed to circumvent this limitation and are now considered a leading technology to enable landing of heavy payloads on Mars.

At the beginning of 2014, a 6m diameter HIAD inflatable structure with an integrated flexible thermal protection system (TPS) was subjected to a static load test series to verify its structural performance under flight-relevant loads. The inflatable structure was constructed into a 60 degree sphere-cone configuration using nine inflatable torus segments composed of fiber-reinforced thin films. The inflatable tori were joined together using adhesives and high-strength textile woven structural straps. These straps help distribute the load throughout the inflatable structure. The 6m flexible TPS was constructed using multiple layers of high performance materials that are designed to protect the inflatable structure from heat loads that would be seen in flight during atmospheric entry. A custom test fixture was constructed to perform the static load test series. The fixture consisted of a round structural tub with enough height and width to allow for displacement of the HIAD test article as loads were applied. The bottom of the tub rim had an airtight seal with the floor. The rigid centerbody of the HIAD was mounted to a pedestal in the center of the structural tub. Using an impermeable membrane draped over the HIAD test artcle, an airtight seal was created with the top rim of the static load tub. This seal allowed partial vacuum to be pulled beneath the HIAD resulting in a uniform static pressure load applied to the outer surface. Using this technique, the test article was subjected to loads of up to 50,000lbs. During the test series an extensive amount of instrumentation was used to provide a rich data set, including deflected shape, structural strap loads, torus cord loads, inflation pressures, and applied static load.

In this paper the 2014 6m HIAD static load test series will be discussed in detail, including the design of the 6m HIAD test article, the test setup, and test execution. Analysis results will be described supporting the conclusions that were drawn from the test series.