National Aeronautics and Space Administration

NASA**facts**

Space Technology

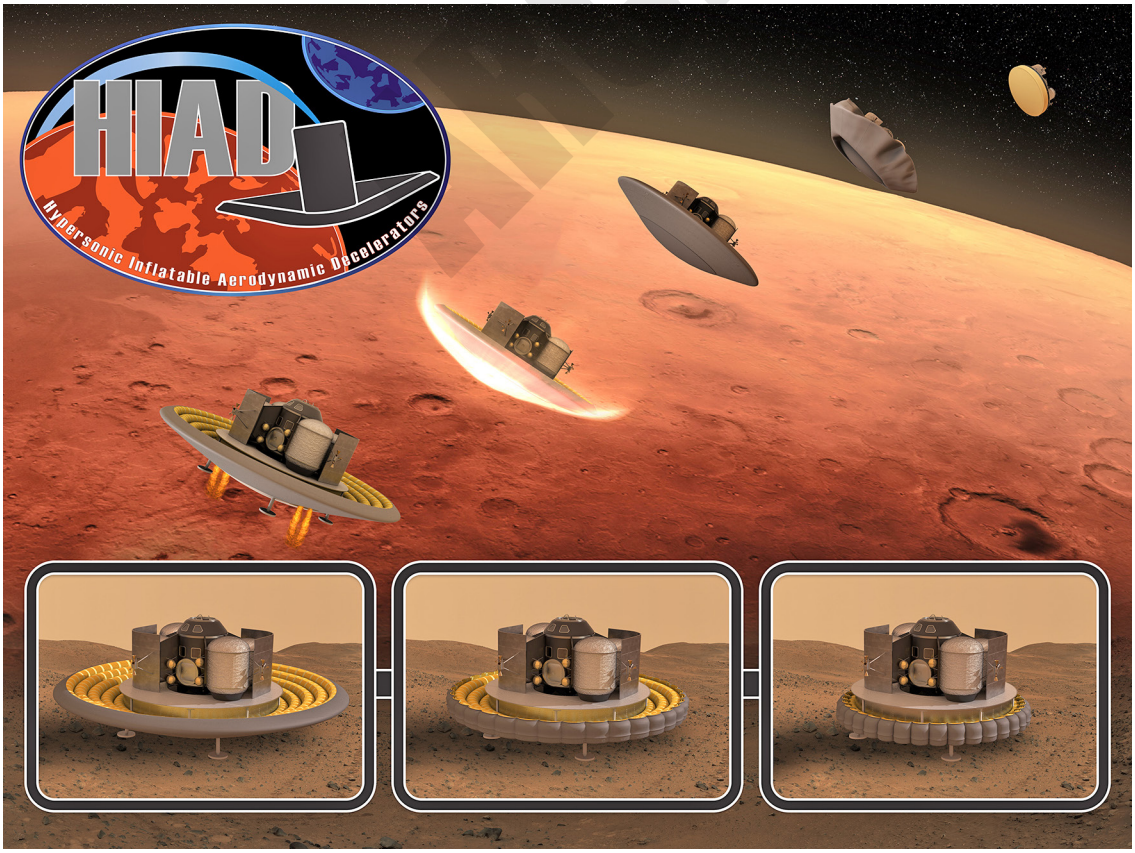
Game Changing Development

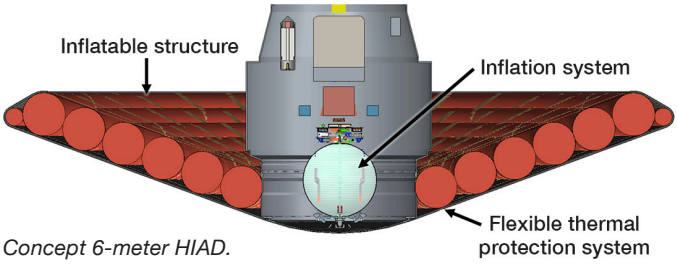
Hypersonic Inflatable Aerodynamic Decelerator 2 (HIAD 2) Ground Demonstration

The Hypersonic Inflatable Aerodynamic Decelerator (HIAD) project is developing and demonstrating an enabling technology that will accommodate the atmospheric entry of heavy payloads to planetary bodies such as Mars. For destinations with a sensible atmosphere, aerodynamics (specifically atmospheric drag) provides the most mass-effective way to decelerate a payload to a soft landing. Larger aerodynamic decelerators, or aeroshells, provide more drag force, and therefore allow larger masses to be delivered to higher elevations. HIAD overcomes size and weight limitations of current rigid systems by utilizing inflatable soft-goods materials that can be packed into a small volume and deployed to form a large heat shield before atmospheric entry.

Hypersonic spacecraft entering the atmospheres of planets are traveling so fast that they create a high-energy pressure wave. This pressure wave entraps and rapidly compresses atmospheric gases, resulting in drag forces that decelerate the vehicle and intense thermal loads that heat the vehicle.

The HIAD design consists of an inflatable structure that maintains the aeroshell shape against the drag forces, and a protective flexible thermal protection system (F-TPS) that withstands the thermal loading. The term





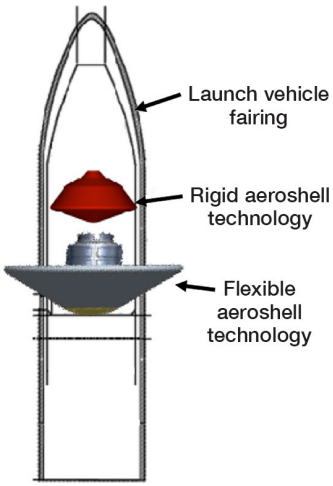
Concept 6-meter HIAD.

"flexible" refers to the F-TPS being foldable, packable, deployable, and tailorable as opposed to being stretchable.

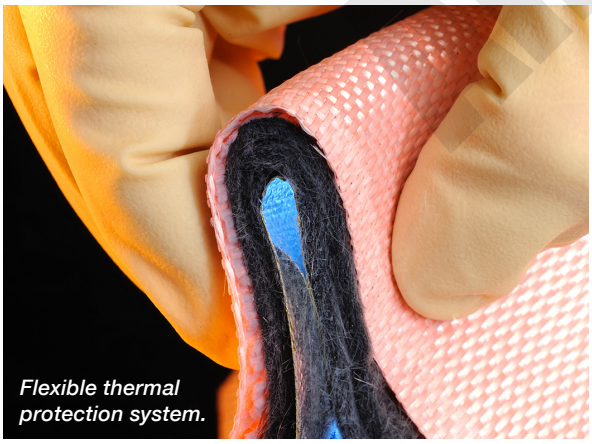
Normally, soft-goods materials would not be considered for the loads and environments a spacecraft would encounter during atmospheric entry. However, the inflatable structure is constructed out of a stack of pressurized concentric tubes, or tori, that are strapped together to form an exceptionally strong blunt cone shaped structure. The tori are constructed from braided synthetic fibers that are 15 times stronger than steel. While the inflatable structure has the capability to withstand temperatures beyond 250 °C, the HIAD relies on the F-TPS to survive entry temperatures.

The F-TPS, which covers the inflatable structure and insulates it from the searing heat of atmospheric entry, can be separated into three functional layers: an exterior ceramic fiber cloth layer that can maintain integrity at surface temperatures in excess of 1600 °C, protecting the underlying insulation from the aerodynamic shear forces; a middle layer of high temperature insulators that inhibit heat transmission; and an interior impermeable gas barrier layer that prevents hot gas from reaching the inflatable structure.

Beyond enabling the entry, descent, and landing of much larger and heavier payloads, HIAD technology has several other benefits over existing rigid technologies. These include lower volume at launch, lower total system weight, and deceleration at higher altitudes than smaller area rigid heat shields. In addition, aeroshell size is scalable to fit missions with different payload mass requirements and launch vehicle fairing limitations. This mission flexibility provides new opportunities for robotic and human exploration missions previously deemed infeasible.



Flexible aeroshell is not limited by launch vehicle fairing size.


Flexible thermal protection system.

Since the beginning of its development in 2003, several ground based advancements and two successful flight tests have provided a team of engineers at NASA Langley Research Center valuable data used to refine the HIAD technology. The Inflatable Reentry Vehicle Experiment-3, or IRVE-3, suborbital launch of a 300-kg reentry vehicle to a height of 460 km on July 23, 2012, was the most recent HIAD test flight. The IRVE-3 flight test successfully demonstrated the ability of a 3-m diameter HIAD to decelerate the vehicle from an entry speed of more than 2700 m/s with drag forces as high as 20 g. The IRVE3 flight also demonstrated the ability to produce lift while maintaining aerodynamic stability through hypersonic, supersonic, transonic, and subsonic flight regimes. Recent manufacturing developments in HIAD have enabled fabrication and ground testing of a 400 °C inflatable structure featuring tori suitable for a 12-m diameter scale.

Through iterative successes, HIAD technology continues to show great promise as a strong candidate for mission infusion, and is paving the way for future human access to Mars by challenging past conceptions of entry, descent and landing technologies.

The Game Changing Development (GCD) Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

For more information about GCD, please visit http://gameon.nasa.gov/

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