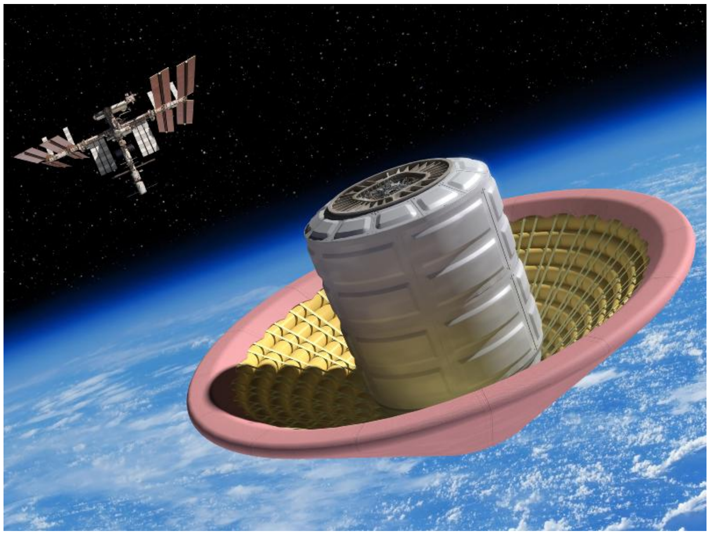
The Hypersonic Inflatable Aerodynamic Decelerator



The Hypersonic Inflatable Aerodynamic Decelerator (HIAD) is a conical heat shield that can be deployed and inflated to safely reduce the speed of a payload returning to a planetary surface. The amount of 'aero breaking' it can provide depends on its surface area. Because of their light-weight design and breaking efficiency, HIAD can be made large enough to place payloads up to 40 tons on the Martian surface.

Recall that the volume of a cone is given by $V = 1/3\ \pi\ R^2\ h$ where R is the base radius and h is the vertical height (not the slant height, s, along the side of the cone!).

Problem 1 – A successful test of this HIAD supersonic aero-breaking concept called IRVE-3 was conducted in July 2012 with a model measuring 3 meters in diameter and a height of 1 meter. What was its volume in cubic meters?

Problem 2 – A larger version of the HIAD design may eventually be used to bring payloads to the surface of Mars. If the diameter of the Mars-HIAD system is 23 meters, and the height of the conical system is in proportion to the IRVE-3 system, what is the volume of the Mars-HIAD system in cubic meters?

Problem 3 – The surface area of a cone is given by $A = \pi\ r\ s$, where r is the radius of the base, and s is the slant height of the cone given by $s = (r^2 + h^2)^{1/2}$. How much larger is the surface area of the Mars-HIAD design than the IRVE-3 system that was tested?

Answer Key

Problem 1 – A test of this HIAD concept, called IRVE-3 was conducted in July 2012 with a model measuring 3 meters in diameter and a height of 1 meter. What was its volume in cubic meters?

Answer: $V = 1/3\ \pi\ (1.5m)^2 \times 1.0m = 2.4\ meter^3$

Problem 2 – A larger version of the HIAD design may eventually be used to bring payloads to the surface of Mars. If the diameter of the Mars-HIAD system is 24 meters, and the height of the conical system is in proportion to the IRVE-3 system, what is the volume of the Mars-HIAD system in cubic meters?

Answer: the height of the Mars HIAD system is 1/3 x 24 = 8 meters.
$V = 1/3\ \pi\ (24/2m)^2 \times 8.0m = 1200\ meter^3$

Problem 3 – The surface area of a cone is given by $A = \pi\ r\ s$, where r is the radius of the base, and s is the slant height of the cone given by $s = (r^2 + h^2)^{1/2}$. How much larger is the surface area of the Mars-HIAD design than the IRVE-3 system that was tested?

Answer: IRVE-3: $s = (1.5^2 + 1.0^2)^{1/2} = 1.8$meters,
then $A = (3.141)(1.5m)(1.8m) = 8.5\ meter^2$

Mars-HIAD: $s = (12^2+8^2)^{1/2} = 14.4$ meters
Then $A = (3.141)(8.0m)(14.4m) = 360\ meters^2$

So the Mars-HIAD system has 360/8.5 = 42 times the surface area of the test model.

Note: Because the amount of breaking that a payload gets depends on the surface area of the system, the larger Mars system can carry more mass to the martian surface.