Enveloping Aerodynamic Decelerator Entry, Descent and Landing Technology

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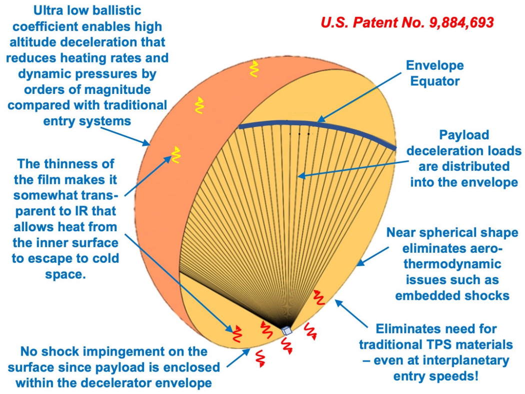
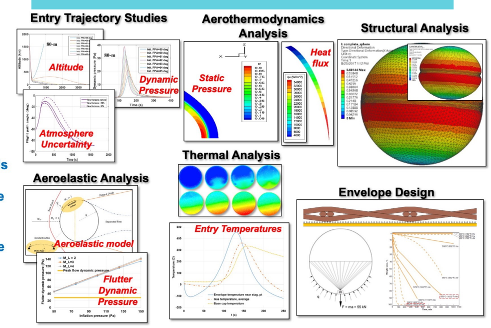
ABSTRACT

We discuss a new, patented technology for entry, descent and landing (EDL) called an Enveloping Aerodynamic Decelerator (EAD). We discuss the EAD innovation, technical feasibility, its system and thermal design, and mission applications. EAD can enable high-altitude orbit entry with extremely low entry heating and can be used for entry at Earth and at several other planetary bodies that have atmospheres. In addition, EAD offers more payload mass, requires less volume, and provides more flexible packing on launch vehicles than other entry technologies.

EAD INNOVATION



TECHNICAL FEASIBILITY



Technical feasibility demonstrated by trajectory, aerothermodynamic CFD, aeroelastic, thermal, and structural FEA analyses & design studies.

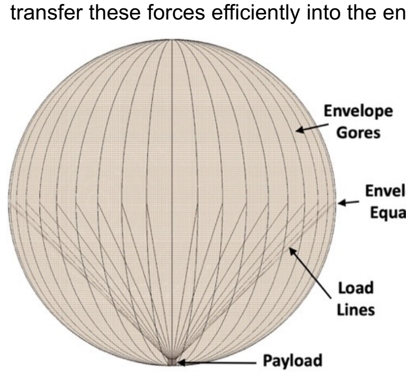
ENVELOPING AERODYNAMIC DECELERATOR (EAD)

Considering the past and current reentry system research and development, it would be useful to have a lightweight decelerator design option that decreases the heating issues and other drawbacks of previous entry system designs.

Elements. The technology consists of a:

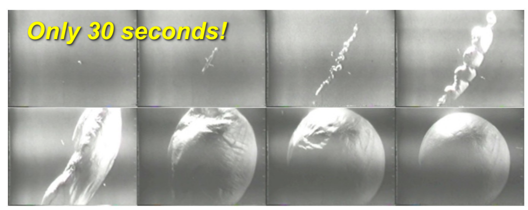
- Relatively large, inflated, ultra-thin, near-spherical envelope;
- Approach to envelope storage and deployment;
- Envelope inflatant and inflation process;
- Scheme of uniformly transmitting the payload g-loads at entry into the envelope;
- Means of separating the payload from the envelope after entry, if that is desired.

Envelope. For small earth reentry payloads, the envelope can be made of thin polyimide films. For medium-sized payloads with higher entry g-loads, the polyimide films can be combined with a high-strength scrims. For large payloads and high g-loads, load lines can be placed between the payload and the envelope equator in order to transfer these forces efficiently into the envelope.



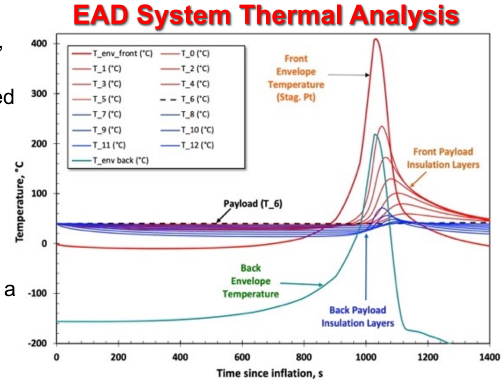
Packing, Deployment and Inflation. Packing, deployment and inflation of any space inflatable structure can be a challenge, but the lessons learned in the NASA Echo Balloon Satellite Project point to solutions. There are several options for inflating the envelope including gas stored in high-pressure tanks; subliming solids; or vaporizing liquids. For the NASA Echo balloons, subliming solids inflated the envelope in only 30 seconds using just the heat of vaporization of the solid!

Eight frames from the 41 m dia. Echo II balloon deployment & inflation video



Thermal Design. The EAD has a unique thermal design that does not require much, if any, thermal protection. Since the envelope is so thin, entry heating is radiated away from both sides of the envelope to keep it cool eliminating the need for traditional TPS. This enables the use of commercially available films such as polyimides. The chart to the right are the results of a simple thermal model showing the temperatures vs. time since inflation of a 3.2 m diameter Earth reentry system. The initial orbit is 200 km circular, and entry occurs only 15 minutes later at 100 km altitude. Total entry mass is 680 g, payload mass is 300 g, and peak heating rate is less than 2 W/cm². The payload is protected by felt and foam layers. In this thermal model the payload temperature increased by only 2°C from its initial temperature of 40°C.

EAD System Thermal Analysis



ACKNOWLEDGEMENT

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MISSION APPLICATIONS

Since the technology is very scalable, there are several mission applications that are being considered from Earth reentry of CubeSat-sized payloads to space station crew rescue systems (see the table). EAD systems are being studied for a Pluto lander mission deployed from a 14 km/s hyperbolic interplanetary trajectory and a small Triton lander deployed from a Neptune orbiter. In addition, an EAD could deploy a Venus balloon by re-inflating the EAD as it descends into the atmosphere.

Mission / Entry State	Entry Mass, kg	EAD Dia., m	Entry Speed, km/s	Stag. Pt. Heat., W/cm²	Peak g-load, gees	Payload Mass, kg
Earth CubeSat Sample Return	0.7	3.2	7.3	1.8	8.9	0.3
Space Station Crew Rescue	350	30.0	7.7	1.9	8.6	200
Venus Direct Entry (DE) Balloon	42	20.0	10.7	3.7	26.7	15
Mars Insight DE Lander	386	19.5	5.5	3.0	15.7	360
Titan Lander from Cassini-like Orbit	108	11.1	6.0	2.9	13.3	100

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