Terrestrial HIAD Orbital Reentry (THOR) Flight Test Opportunity

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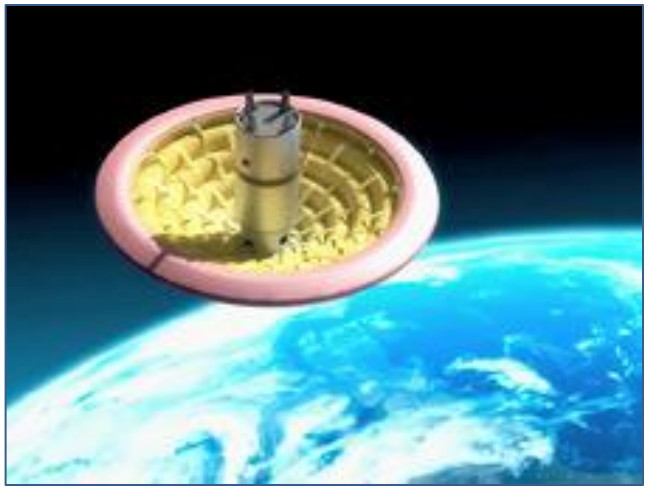
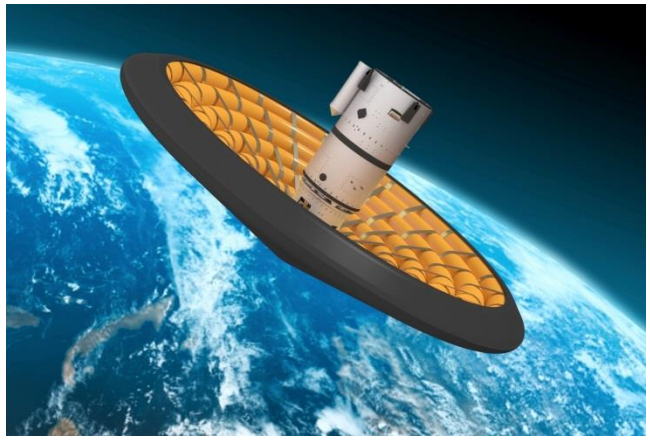
What is a HIAD?

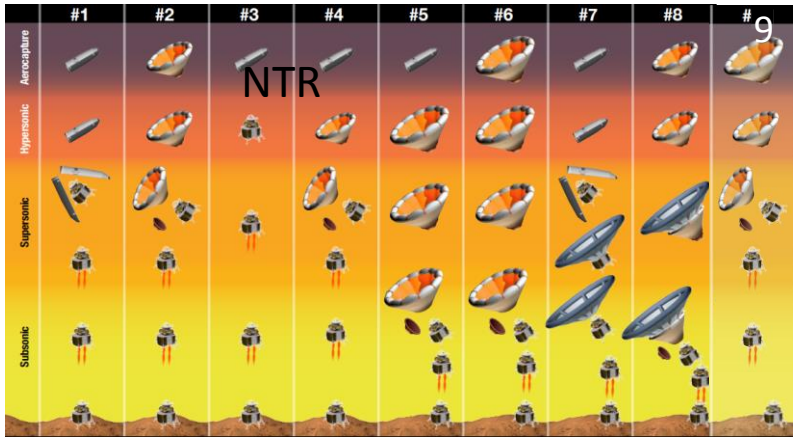
- A Hypersonic Inflatable Aerodynamic Decelerator (HIAD) is a deployable aeroshell consisting of an Inflatable Structure (IS) and a Flexible Thermal Protection System (F-TPS) employed to protect an entry vehicle through hypersonic atmospheric entry





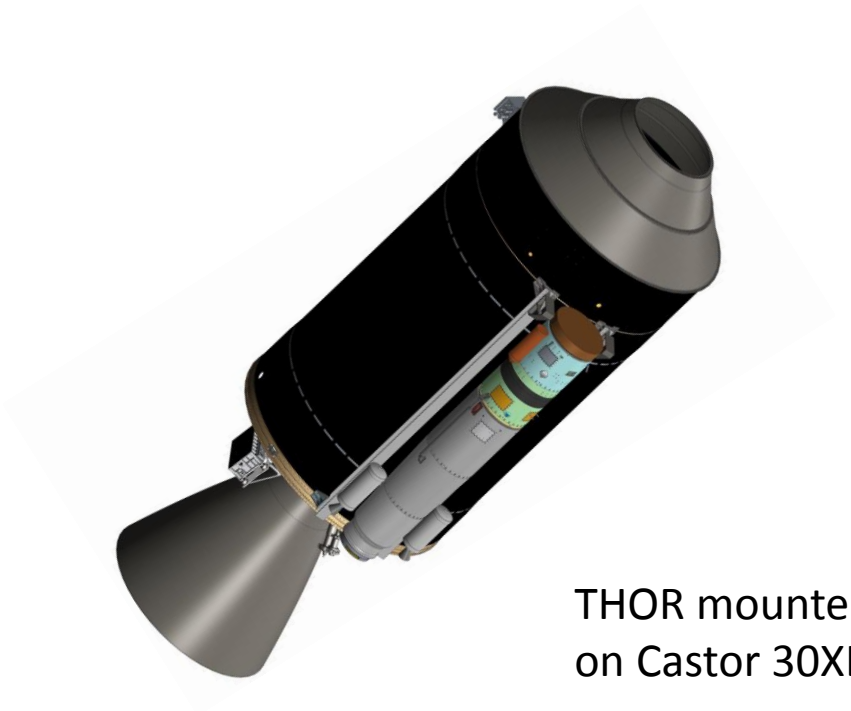
Why a HIAD?

- Multiple studies have been conducted that indicate a HIAD is an enabling or enhancing technology for the delivery of payloads to planetary bodies with a sensible atmosphere.
- Entry Descent and Landing System Architecture (EDL-SA) study concluded the technology was leading hypersonic candidate for landing payload of the scale required for human Mars exploration
- HIAD Project mission analysis studies showed HIAD viability for low Earth Orbit payload return, robotic exploration mission for Mars, launch vehicle asset recovery, and with increased Gen2 capability possibly lunar return
- The new Human Architecture Technology (HAT) study is improving the fidelity of the EDL-SA to bore down into the simulations to determine if the technology recommendations are still valid. HIAD is leading candidate for hypersonic phase.



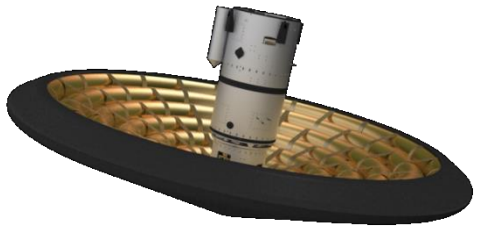
THOR opportunity

- THOR is a proposed low-cost flight experiment of the 2nd Generation HIAD material set. It would utilize duplicate entry vehicle hardware built as risk mitigation for the IRVE-3 flight test. THOR would be a secondary payload on the Antares launch vehicle

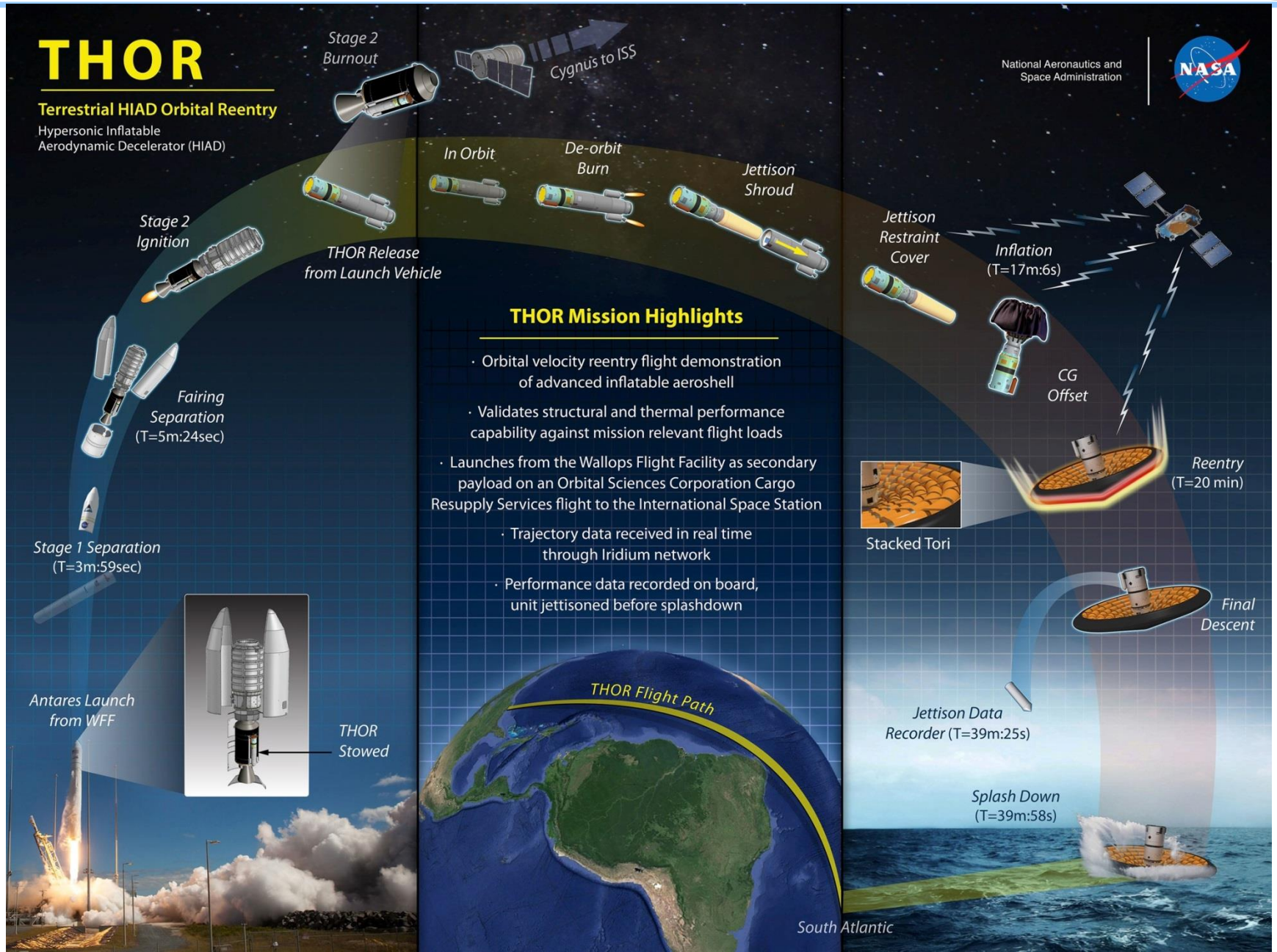


THOR mounted on Castor 30XL

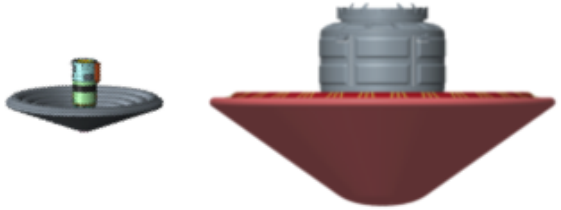
THOR 3.7m 2nd gen aeroshell deployed for entry



THOR Concept of Operations



Relative Mission Comparison

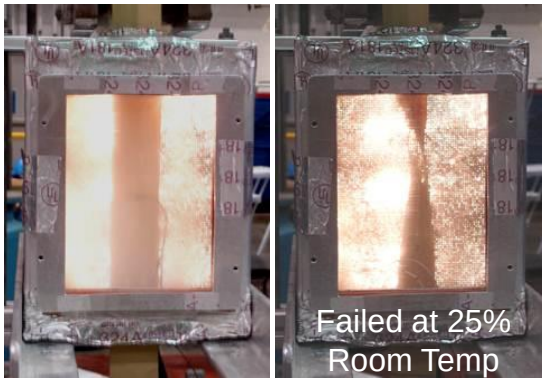


Capability	THOR	ISS Downmass	Mars 2024	EDLSA
HIAD Diameter (m)	3.7	9	12	23
Entry Mass (MT)	0.35	4.5	6.5	84
Peak Heat Rate (Relative to 2024 opportunity)	1.2	1.2	1.0	2.2
Total Heat Load (Relative to 2024 opportunity)	1.8	1.4	1.0	2.2

Improvements for 2nd Gen IS

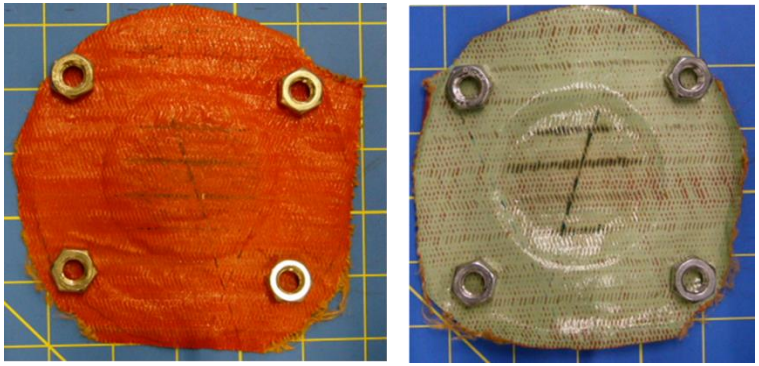
- Use temperature increase to in excess of 400C
- Significant weight reduction (~40% assembly mass reduction)
- Significant improvement in manufacturing consistency

2nd Gen IS materials capabilities

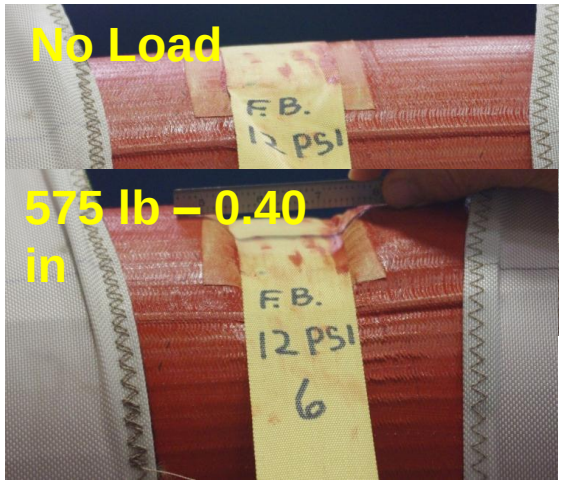


Zylon at 500 degree C

IS Gas Barrier
Fixture In Oven



Prototype T5 maintains pressure at 425C



Strap Indentation Testing

Packed Zylon T5 torus

T5 and T1 liners post testing

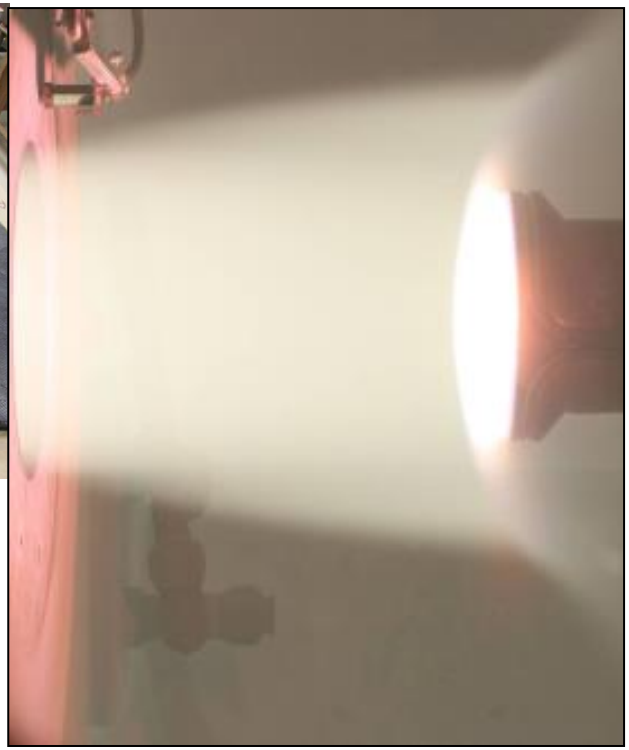
2nd Generation TPS materials and Testing

- Silicon Carbide cloth maintains integrity over 100W/cm2
- Carbon felt/Pyrogel insulators assemblies capable of maintaining 400C bondline temperatures for heat loads in excess of 14kJ/cm2 (with thickness and areal weight improvement over Gen1 system)
- Representative TPS assembly withstands repeated packing and deployment then performs in LCAT arcjet testing

2nd Gen F-TPS materials capabilities

Packed Ageing 2nd Gen F-TPS

2nd Gen F-TPS post-Aging



LCAT Testing 2nd Gen Aged F-TPS

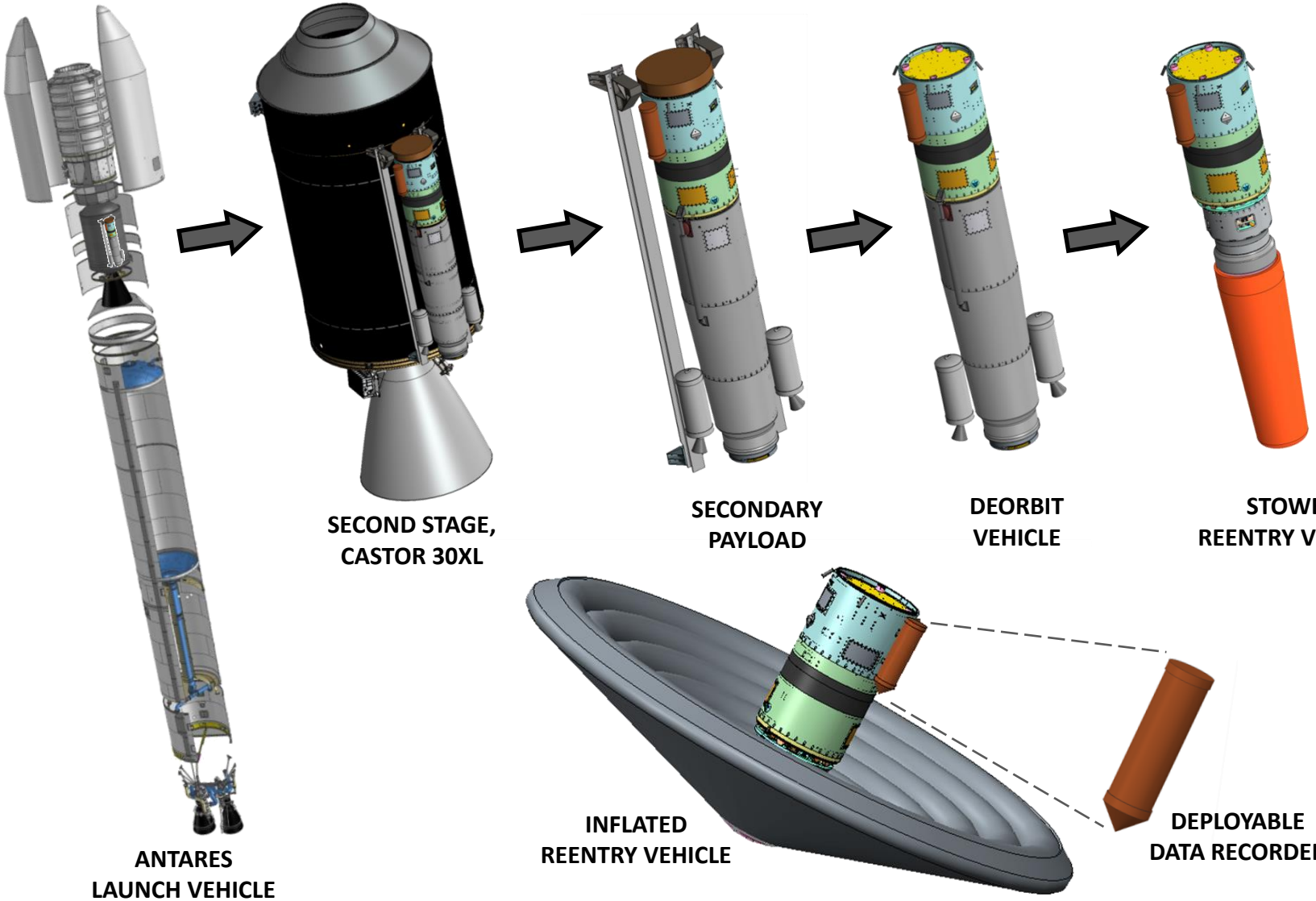
2nd Gen Aged F-TPS Pre and Post LCAT Testing

Conclusion

- The HIAD project has matured a 2nd generation material set to the point that it is mature enough to perform a flight demonstration
- The THOR mission opportunity is a relevant environment for demonstrating that 2nd generation material set

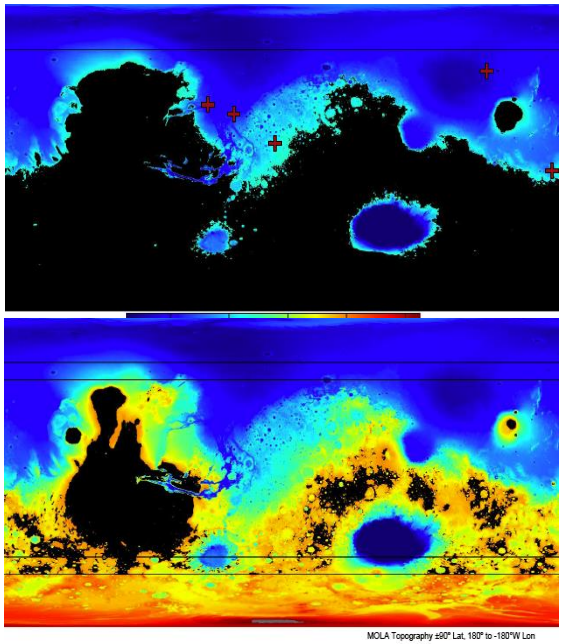
BACKUP

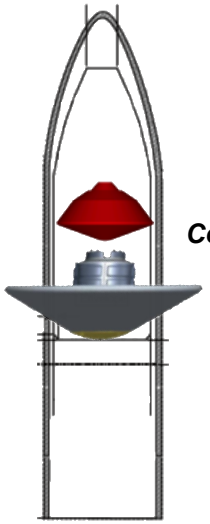
THOR Configurations



Background

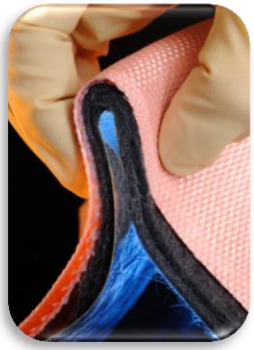
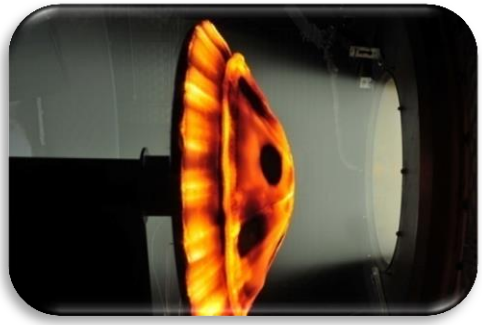
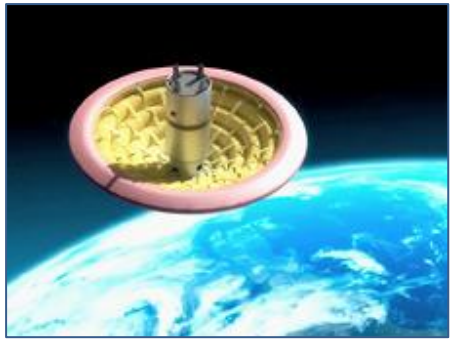
- NASA Langley Research Center has been developing Inflatable Aeroshell technology for over 10 years
- Entry mass at Mars (and other destinations with atmospheres) is limited by size of reentry capsule that will fit inside a launch vehicle shroud
- Increased capability needed for higher mass and/or higher altitude, eventual manned missions, etc.
- Inflatable aeroshell allows larger aeroshell to be stowed inside launch shroud
  - Inflation of Inflatable Structure (IS) occurs prior to atmospheric entry
  - Flexible Thermal Protection System (F-TPS) protects IS and payload from aerothermal environments





Comparable Entry Masses

Hypersonic Inflatable Aerodynamic Decelerator (HIAD) www.nasa.gov/hiad/

HIAD Technology Advancement

- Demonstrated concept, verified performance with sub-orbital Reentry Vehicle (RV) flight experiments (3m RV):
  - Inflatable Reentry Vehicle Experiment (IRVE), 2007:
    - Sounding rocket nose cone did not release
    - No experiment
  - IRVE-II, 2009: IRVE “build-to-print” re-flight; fully successful
  - IRVE-3, 2012: improved IS & TPS, higher energy reentry; fully successful
  - HIAD Project working structural improvements, materials development, and ground testing in parallel with flight tests
    - Performance ground development, testing, and extensive work on entire aeroshell assembly
- Earth orbital reentry flight test is good analog to larger payload to Mars surface (> 1 mT)