National Aeronautics and
Space Administration

NASA's
Game Changing Technology
Industry Day
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Hypersonic Inflatable Aerodynamic Decelerator (HIAD) Technology

Presented by
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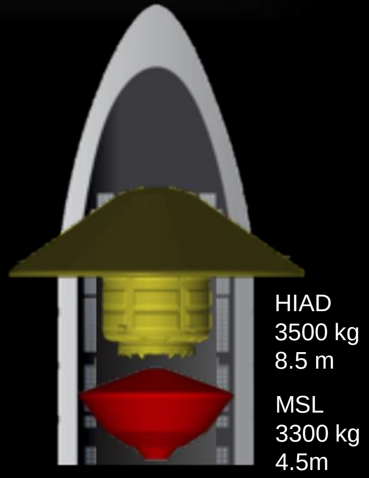
TECHNOLOGY DRIVES EXPLORATION

HIAD Technology

- ***A Hypersonic Inflatable Aerodynamic Decelerator (HIAD)*** is a deployable aeroshell consisting of an Inflatable Structure (IS) that maintains shape during atmospheric flight, and a Flexible Thermal Protection System (F-TPS) employed to protect the entry vehicle through hypersonic atmospheric entry.

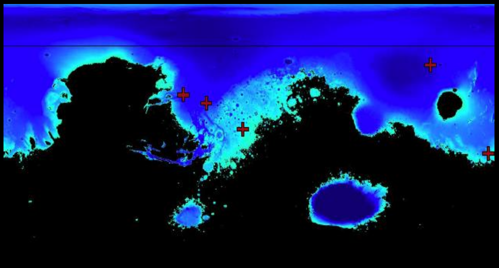
- Aeroshell size is currently confined by launch vehicle shroud diameter. HIAD removes that constraint. Maximum entry mass at Mars (and other destinations with atmospheres) is limited by aeroshell size.



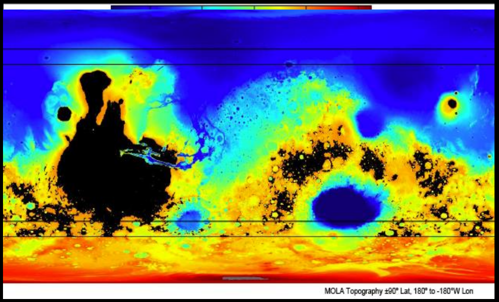
Why a HIAD?

- At Mars, increased capability needed for higher mass and/or higher altitude, eventual human missions.
- Inflatable technologies allow larger aeroshell to be stowed inside launch shroud.
  - ✓ Deployment of IS occurs prior to atmospheric entry.
  - ✓ F-TPS protects IS and payload from atmospheric entry environments.

Rigid EDL technology limited to low mass; to blue areas only



HIAD enables high mass access to southern highlands



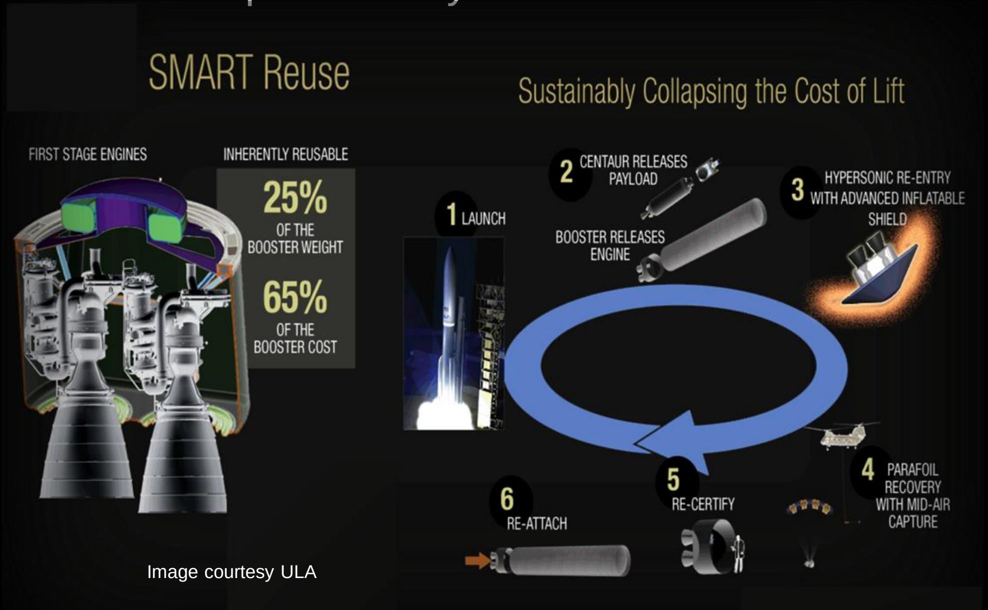
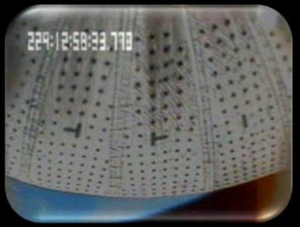
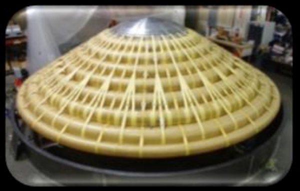


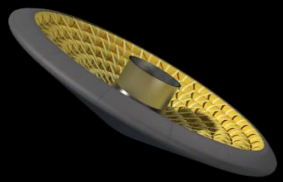
Image courtesy ULA

HIAD Technology Development

- Systematic and stepwise technology advancement
  - ✓ **Ground Test**: Project to Advance Inflatable Decelerators for Atmospheric Entry (PAI-DAE) – Softgoods technology breakthrough
  - ✓ **Flight Test**: Inflatable Reentry Vehicle Experiment (IRVE), 2007: LV anomaly – no experiment
  - ✓ **Flight Test**: IRVE-II, 2009 – IRVE “build-to-print” re-flight; first successful HIAD flight
  - ✓ **Ground Test**: HIAD Project improving structural and thermal system performance (Gen-1 & Gen-2) – Extensive work on entire aeroshell assembly
  - ✓ **Flight Test**: IRVE-3, 2012 – Improved (Gen-1) 3m IS & F-TPS, higher energy reentry; first controlled lift entry

- Next Steps
  - ✓ **Ground Effort**: *Gen-3 F-TPS, advanced structures, packing, manufacturability at scale >10m, controllability, and demonstrated staging to secondary (cascade) decelerator.*
  - ✓ **Flight Test Possibilities**: *United Launch Alliance (ULA) flight test and/or booster recovery application (at scale and environments relevant to Mars Human EDL Pathfinder)*.



IRVE-3 Flight Test

Ground-Based Development Activities

Inflatable Structure

Manufacturing

- Define large-scale fabrication methods
- Optimize packed volume and density requirements
- Establish manufacturing processes and quality control standards

Torus Stacking and Alignment

Testing

- Quantify aerodynamic structural response
- Verify load reaction and structural integrity
- Establish structural performance limits

Torus Compression/ Torsion Tests

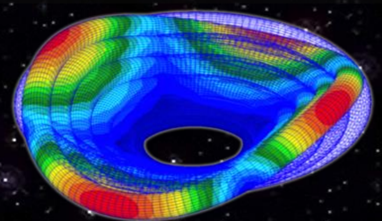
Performance

- Qualify structural materials performance capability
- Establish handling and stowage requirement
- Define design methods and safety margins

Static Loading

Modeling

- Validate non-linear structural modeling capability
- Establish structural design procedures and standards
- Define system weight, stiffness, and strength options



Dynamic Response

Flexible TPS

Manufacturing

- Establish large-scale fabrication methods
- Define manufacturing processes and quality control standards
- Determine handling and stowage requirements

Fabrication

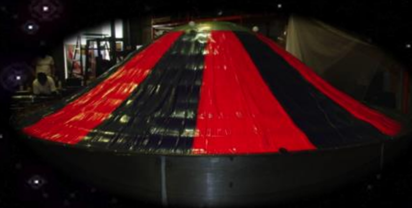
Testing

- Characterize mechanical and thermal physical properties
- Define mission-cycle performance capability
- Establish F-TPS material performance limits

Stagnation

Performance

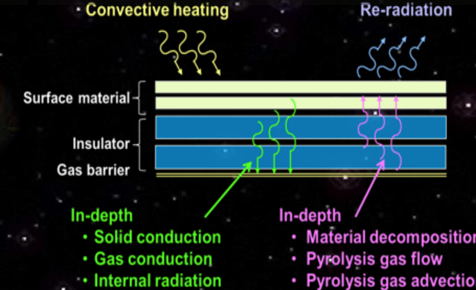
- Extend F-TPS materials performance capability
- Qualify thermal and aero-elastic response
- Define system integration metrics and requirements



Structural Contribution

Modeling

- Validate a multi-physics thermal response model
- Establish design requirements and safety margins
- Verify integrated system load response



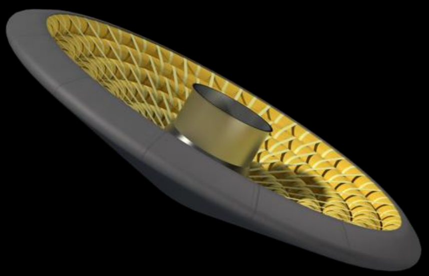
Multi-Physics Model

Latest IS Advancements

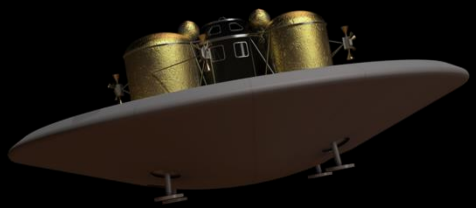
HIAD is physically scaling up

- Successfully manufactured 24” minor diameter tori (inner 2 tori for notional 12m HIAD).
- Successfully hydrostatically pressure tested large scale toroid to 30psi, utilizing less-than-ideal (but readily available) materials given budget constraints.

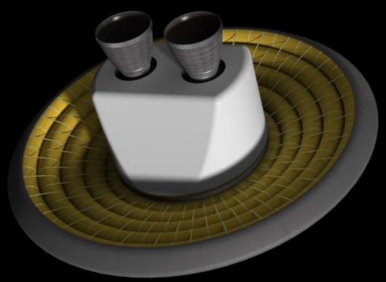
Potential HIAD Mission Infusion



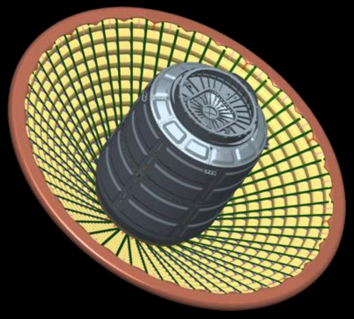
- Robotic missions to any destination with an atmosphere (including sample return to Earth)



- High mass delivery to high altitudes at Mars (including humans to Mars)



- Lower cost access to space through launch vehicle asset recovery (for example, ULA's booster module)

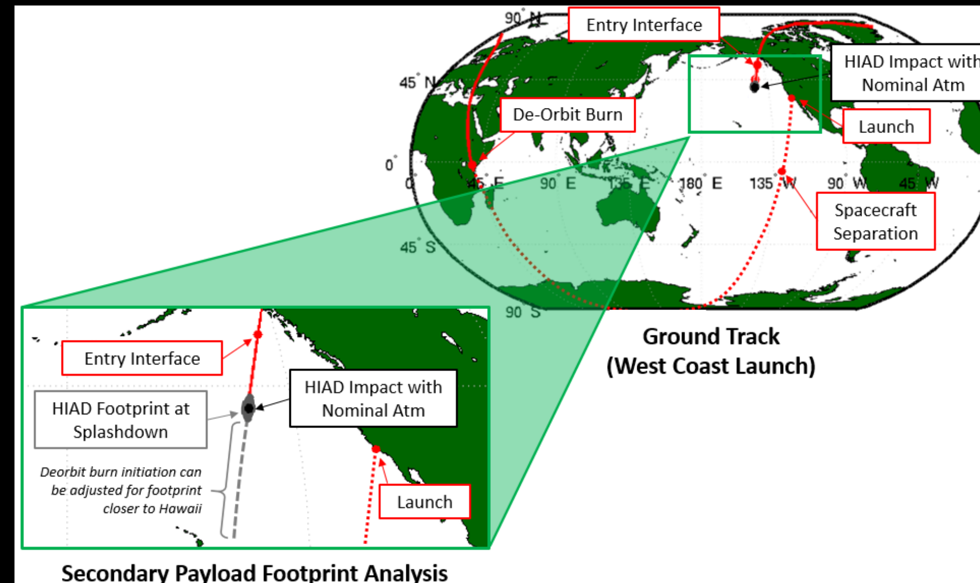


- ISS down mass (without Shuttle, the U.S. has no large-scale down mass capability)

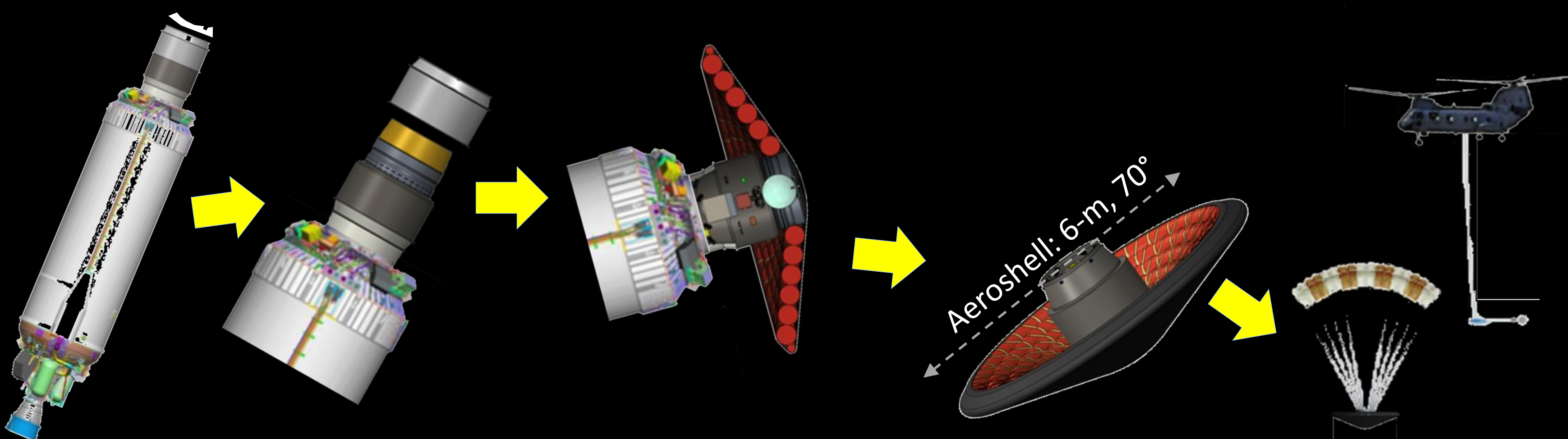
Proposed Partnership: HIAD on ULA (HULA) Flight Demo

Pursue Secondary Payload large scale flight demonstration to give NASA/ULA confidence in HIAD readiness.

- Mars relevant heating environment for HIAD technology at larger scale than THOR would have provided (reduces uncertainty).
- 5-6m scale is ~½ scale for both ULA booster recovery and proposed Mars EDL Pathfinder (both in 2024-2026 timeframe).
- Ballistic reentry; pointing, deorbit, and spin-up provided by ULA (simplifies reentry vehicle design and development effort).



Secondary Payload Footprint Analysis



Reentry Vehicle Stowed Config. → Separated Adapter → Deploy Aeroshell and Spin up for Entry → Reentry Vehicle → Mid-Air Recovery (MAR) Experiment End

Contact Information

For more information about this technology or to discuss potential collaboration efforts:

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