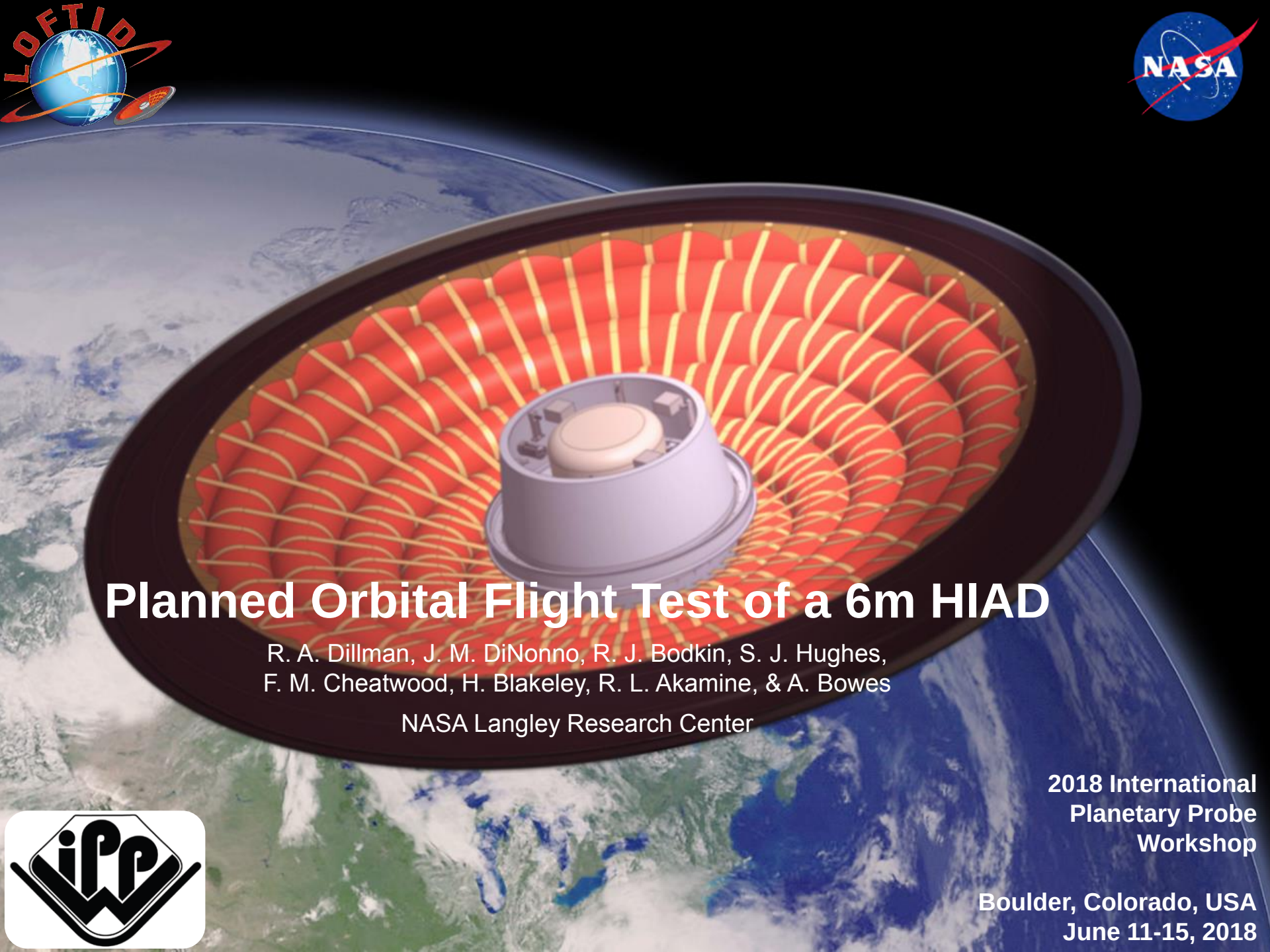

Planned Orbital Flight Test of a 6m HIAD

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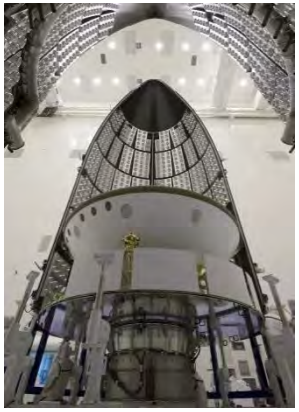
NASA Langley Research Center

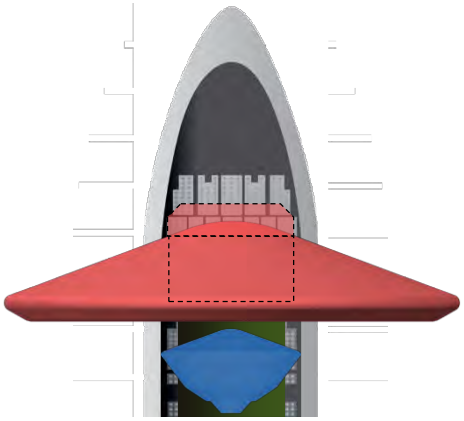
2018 International
Planetary Probe
Workshop

Boulder, Colorado, USA
June 11-15, 2018

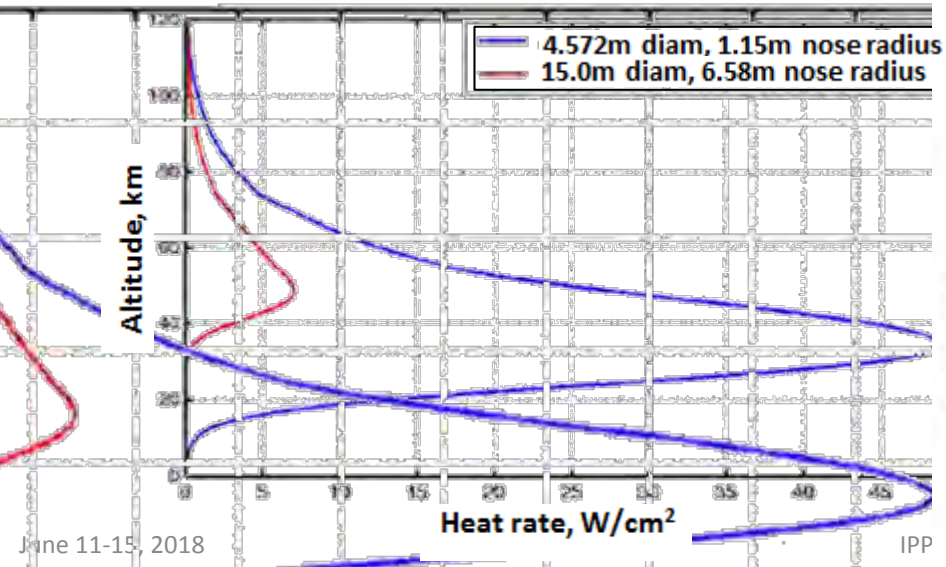
Why Inflatables?

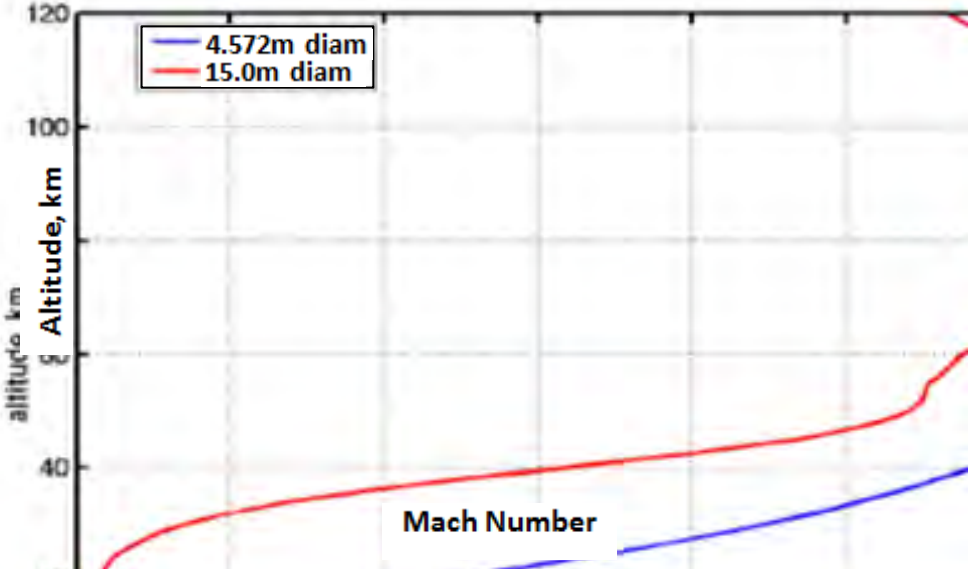
- **Entry mass at Mars, and other destinations with atmospheres, is limited by entry capsule drag**
- **Hypersonic Inflatable Aerodynamic Decelerator (HIAD) approach:**
  - Stows aeroshell in compact volume for launch
  - Deploys aeroshell to larger diameter before atmospheric interface
  - Allows payload to use the full cylinder of launch fairing (HIAD can stow forward of payload)
  - Delivers more payload mass and/or to higher altitudes
  - Reduces peak heat flux by decelerating earlier, in less dense upper reaches of the atmosphere





Example Mars entry at 6km/s,





HIAD Development

2004 ✓ **Ground Test**: Project to Advance Inflatable Decelerators for Atmospheric Entry (PAI-DAE): Soft goods materials R&D

✓ **Flight Test**: Inflatable Reentry Vehicle Experiment (IRVE), 2007: Launch vehicle anomaly – no experiment

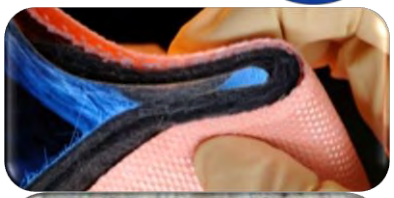
✓ **Flight Test**: IRVE-II, 2009: IRVE "build-to-print" re-flight of 3m HIAD, fully successful; demonstrated in-flight inflation, ability to maintain pressure, and aerodynamic stability (hypersonic through subsonic flight)

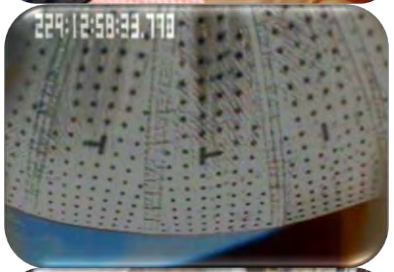
✓ **Ground Test**: HIAD Project: Improved structural and thermal system performance (Gen-1 & Gen-2); extensive work on entire aeroshell

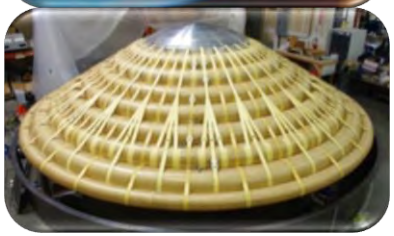
✓ **Flight Test**: IRVE-3, 2012: Improved (Gen-2) 3m diam structure & F-TPS, higher energy reentry (20G's, 15W/cm^2), first HIAD controlled lift entry, L/D moved 0.2 to -0.2 by CG offset

2017 ✓ **Ground Test**: HIAD-2 Project: Improving on Gen-2 F-TPS, evaluating advanced structures, packing of 6m HIAD, and manufacturability at scales >10m

2018-2020 ❑ **Next flight test**: Scaling up flight vehicle to 6m diameter, with higher energy orbital trajectory. This presentation will give an overview of the updated flight test plans.

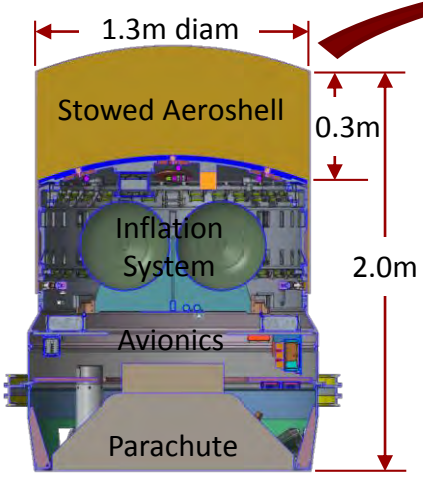






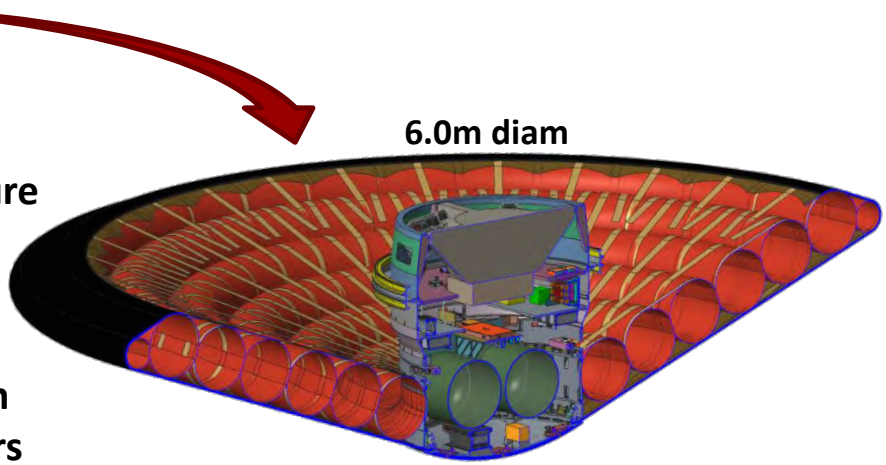
Next Flight Test: Reentry from Orbit

- Will demonstrate HIAD technology at scale and entry conditions relevant to Earth return and Mars mission infusion opportunities, for NASA heavy down-mass missions and commercial applications
- This mission has appeared before at IPPW
  - In 2016, as HULA, a proposed HIAD flight test with United Launch Alliance (ULA); interested in using HIADs for first stage engine recovery
  - In 2017, as HIAD-TDM, under NASA's Space Technology Mission Directorate (STMD), Technology Demonstration Missions (TDM)
- Funded by TDM as "LeO Flight Test of an Inflatable Decelerator" (LOFTID)
- Started 10/1/17 on a 39-month schedule, planning launch in late 2020 as a secondary payload on an Atlas V; not assigned to a specific launch manifest

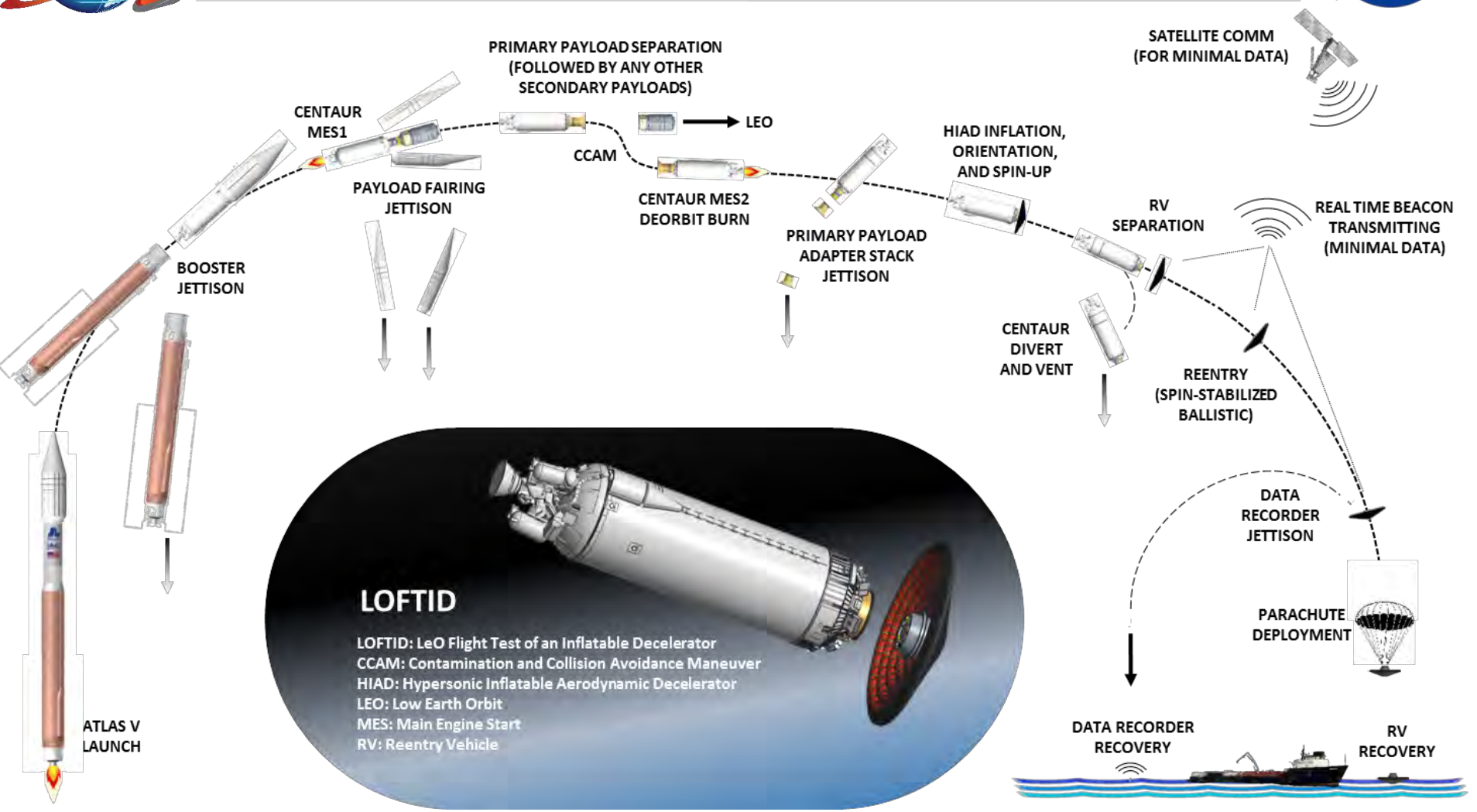


Mass Breakdown

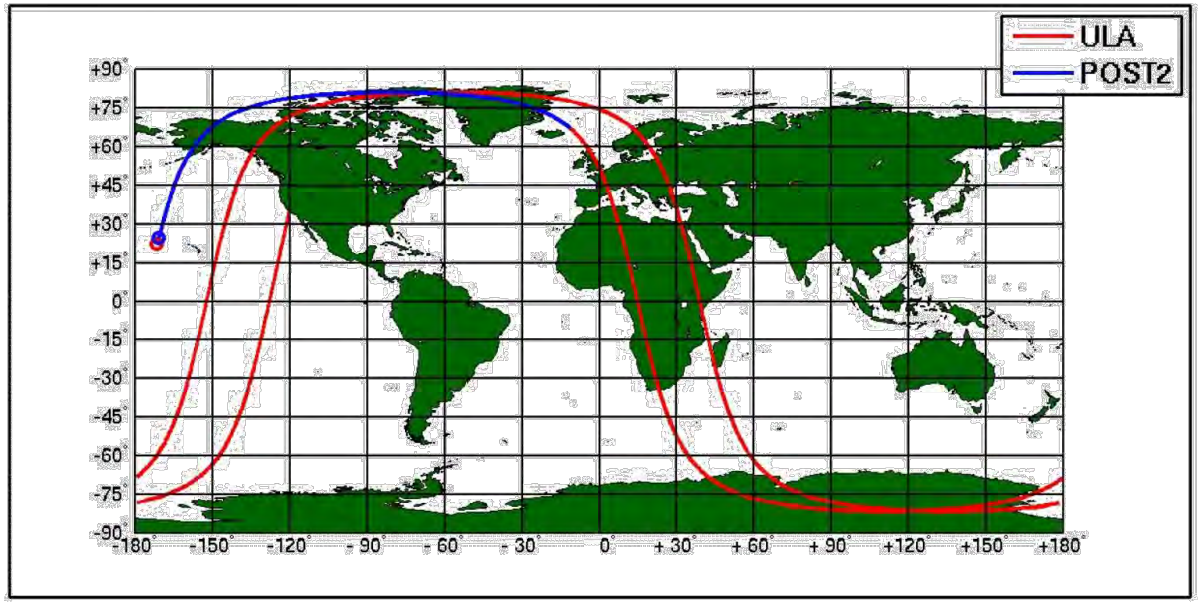
62 kg (136 lb) inflatable structure
106 kg (233 lb) FTPS & sensors
140 kg (310 lb) inflation system
462 kg (1020 lb) centerbody
130 kg (290 lb) parachute system
290 kg (640 lb) avionics & sensors
1190 kg (2630 lb) total

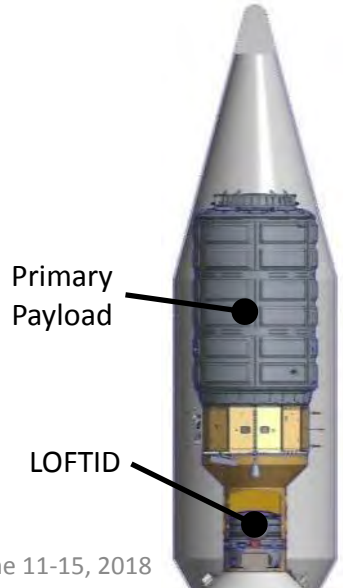


LOFTID Con-Ops



Ground Track, & Separation Detail



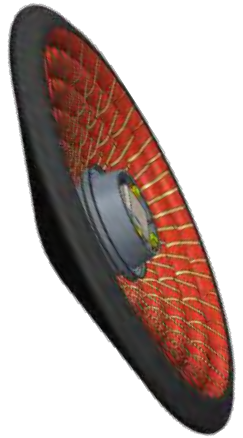


Primary Payload Released

Payload Adapter Jettisoned

LOFTID Aeroshell Inflated

LOFTID Reentry Vehicle Released



Flight Test Description

- Ballistic coefficient of 25 kg/m2 (6m diam, ~1200 kg)
- 12G entry, peak flux on nose of 35-50 W/cm^2
- 6m inflatable structure ground test unit previously tested to higher loads (50,000 lbs pressure load, ~19G's), and at AoA in 80x40 National Full-scale Aerodynamics Complex (NFAC) at NASA Ames
- F-TPS coupons arc-jet tested to ~2x LOFTID's peak flux

LOFTID flight will:

- Expose full vehicle to time-varying flight environment, with in-flight deployment and flight inflation system
- Apply thermal & structural load to full vehicle during same test
- Provide aerothermal response data for flight heat pulse, with long enough duration to allow in-depth performance evaluation of F-TPS
- Measure aft-side aerothermal response

Project Team

- **NASA Langley: Design and analysis of reentry vehicle, trajectory, inflation system, & most of avionics; assembly, integration, & testing**
  - **Airborne Systems: Inflatable structure**
  - **Jackson Bond Enterprises: Flexible TPS**
- **ULA: Integration to launch vehicle; recovery parachute & recovery ship**
- **NASA Marshall: Data acquisition system, cameras**
- **NASA Ames: Aeroshell fabrication oversight, flight sensors**
- **NASA Kennedy / Launch Services Program: Fiber Optic Sensor System (FOSS)**

Status / Future Schedule

FY18												FY19												FY20												
Q1			Q2			Q3			Q4			Q1			Q2			Q3			Q4			Q1			Q2			Q3			Q4			Q1	
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

ATP SRR PDR CDR CST PSR RV to ULA FRR

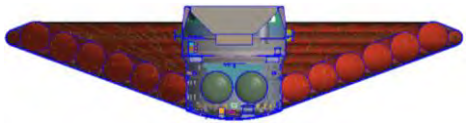
- Authority to Proceed: October 2017
- System Requirements Review: May 10-11, 2018
- Currently fabricating engineering development units of centerbody, inflatable structure, & F-TPS based on ground-tested designs; will load test & hard pack multiple times
- Preliminary Design Review: November 2018
- Critical Design Review: May 2019
- Ground testing ends with Complete System Test – autonomous deployment and inflation of reentry vehicle in LaRC vacuum chamber: January 2020
- RV repacked & ready to ship to launch site: July 2020
- 4 months schedule reserve before start integration to launch vehicle

- LOFTID HIAD will be largest diameter blunt body reentry ever flown

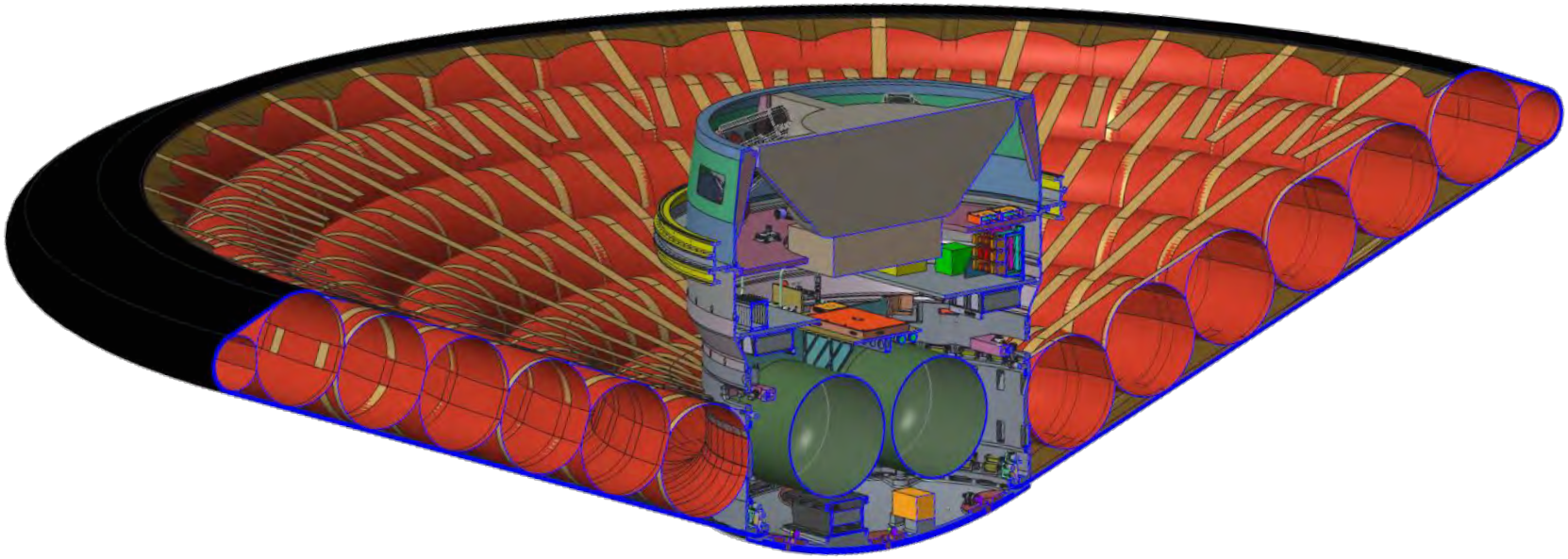
Apollo: 3.9m

Orion: 5.0m

LOFTID: 6.0m



Questions?



Inner Three Tori for a 12m HIAD