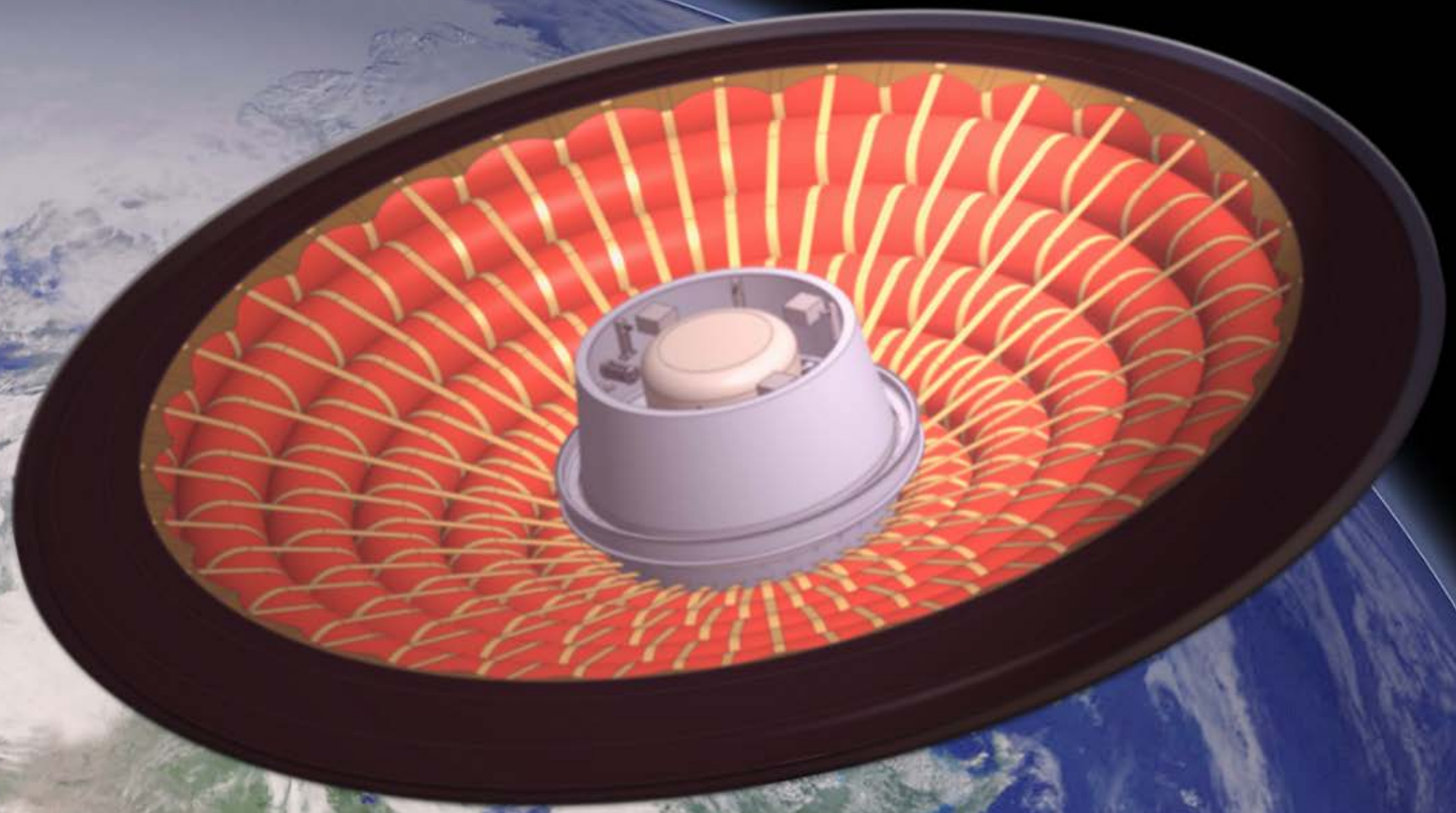


The HIAD Orbital Flight Demonstration Instrumentation Suite

National Aeronautics and
Space Administration



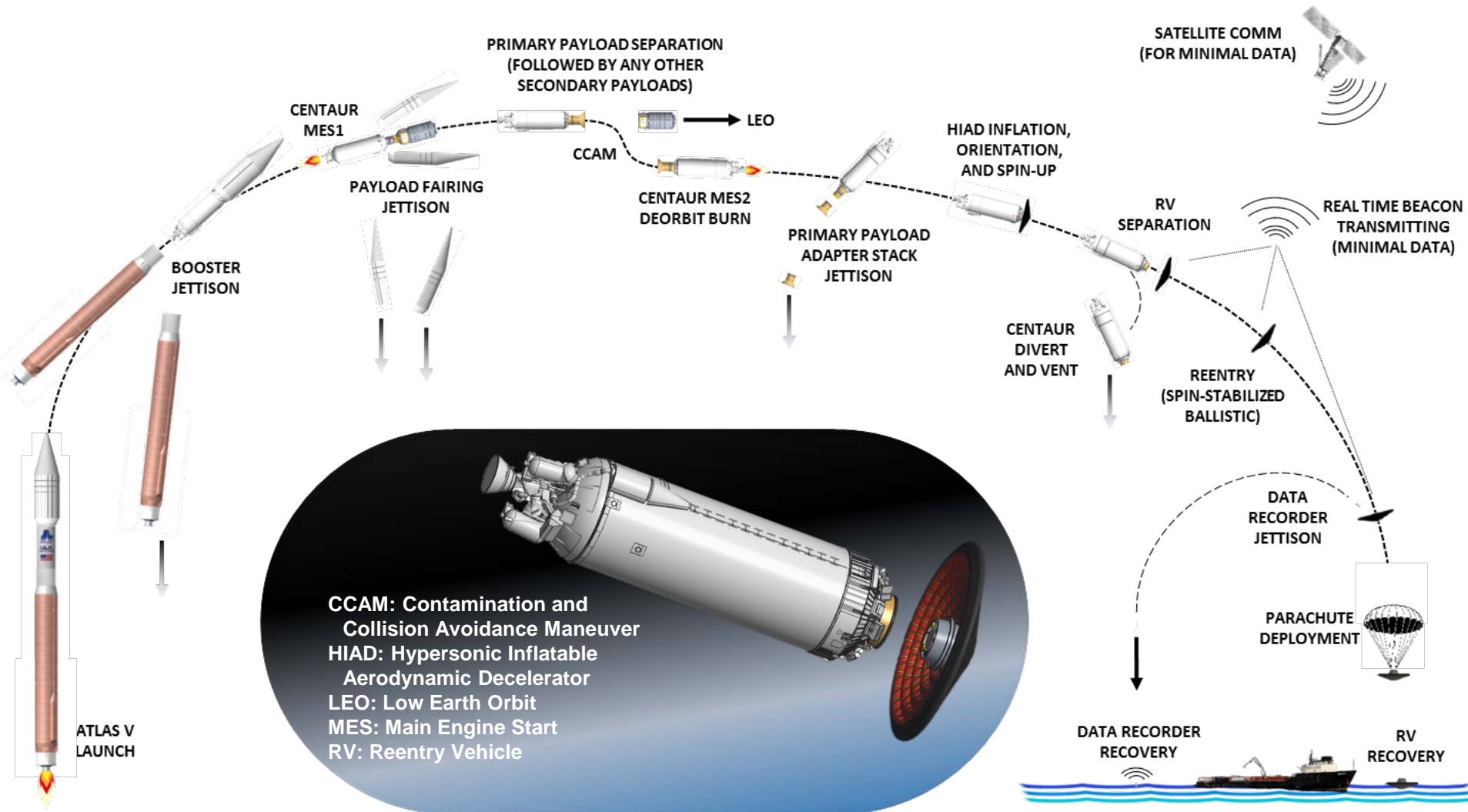
NASA ARC - **Greg Swanson (AMA Inc.)**, Brandon Smith
NASA LaRC –Robert Akamine, R.J. Bodkin, Neil Cheatwood, Stephen Hughes
NASA MSFC - Darrell Gaddy
NASA AFRC – Allen Parker



LOFTID Mission



LeO Flight Test of an Inflatable Decelerator (LOFTID)





Measurement Objectives



LOFTID is a demonstration flight project that will be used to validate thermal and structural models, and mature understanding of the HIAD technology

IRVE-3 Flight Tested the Gen-1 Inflatable Structure, and Gen-1 F-TPS

- Gen-1 Inflatable Structure Capability: 250° C
- Gen-1 F-TPS Capability: 35 W/cm²

LOFTID will Flight Test the Gen-2 Inflatable Structure and Gen-2 F-TPS

- Gen-2 Inflatable Structure Capability: 400° C
- Gen-2 F-TPS Capability: 80 W/cm²

Unique Instrumentation Challenges

- Embedding Sensors in a Flexible System
- Measurement Location Knowledge
- Aeroshell Do No Harm

Key Performance Measurements

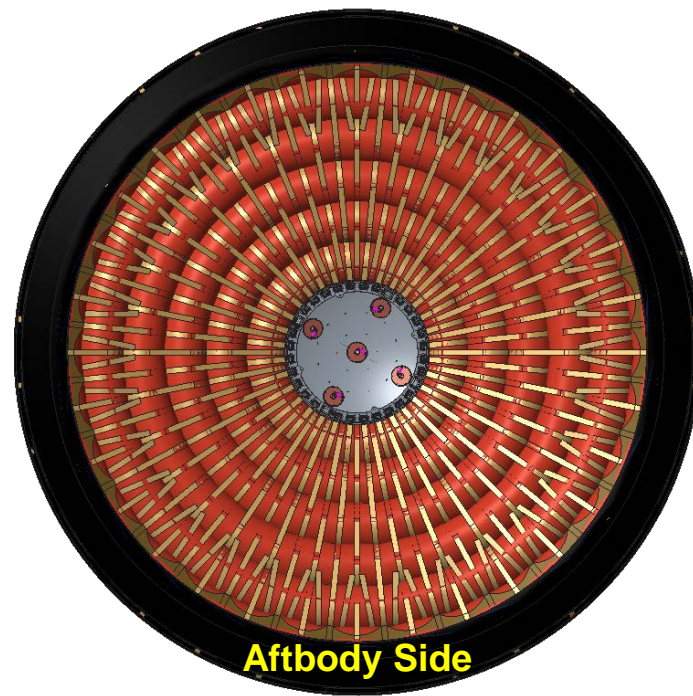
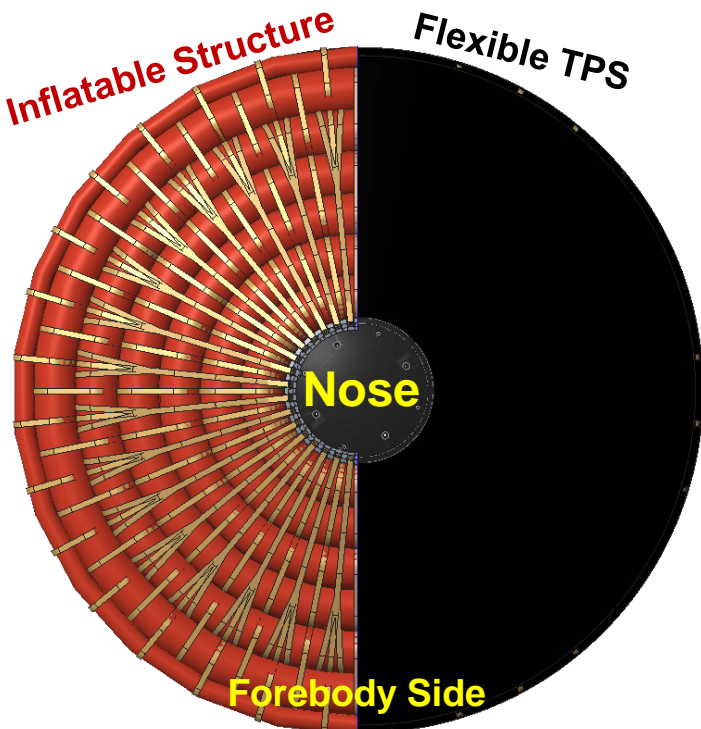
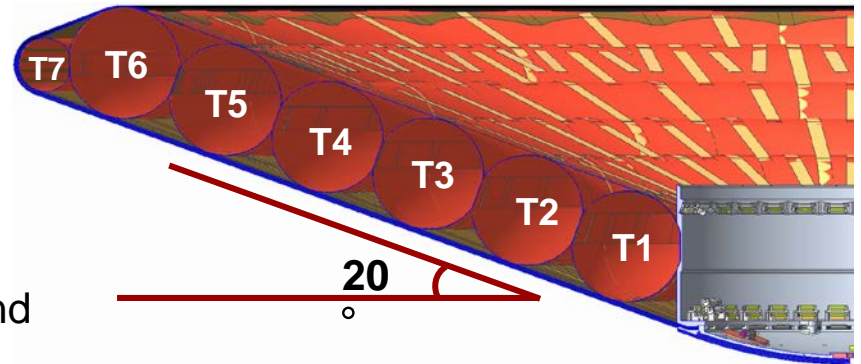
- Aerothermal Response (Temp, Heat Flux)
- Structural Response (Loads, Deflection)



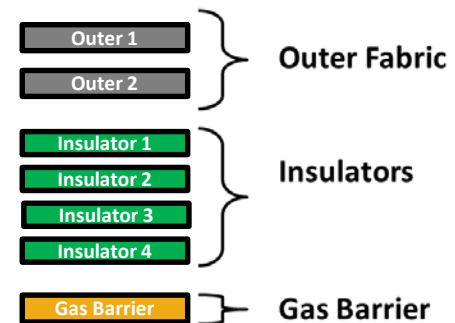
	IRVE-3	LOFTID	LEO Return	ISS Down Mass	ULA Engine Recovery	Humans to Mars
Diameter (m)	3	6	<6	8-12	12	18.8
Forebody Geometry (deg)	60	70	60-70	60-70	60-70	70
Entry Mass (kg)	330	1700	<1500	<5000	12000	56000
Entry Velocity (km/s)	2.7	7.1	7-7.5	7-7.5	4-6.5	6.2
Peak Heat Rate (W/cm ²)	15	60	<50	30-40	<30	40

6m HIAD Aeroshell

- Stacked torus inflatable structure
- Flexible TPS (F-TPS)
- 70-deg half-angle sphere-cone
- 6 structural tori, 1 shoulder torus
- Tori are formed by structural cords and bound together by high strength straps
- 4 (x32) centerbody attachment points

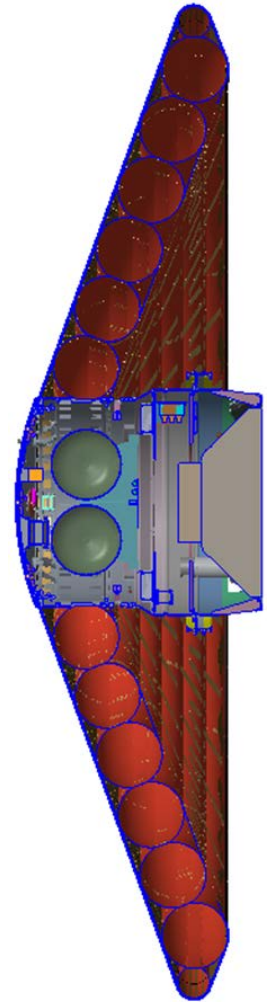


Flexible TPS Design

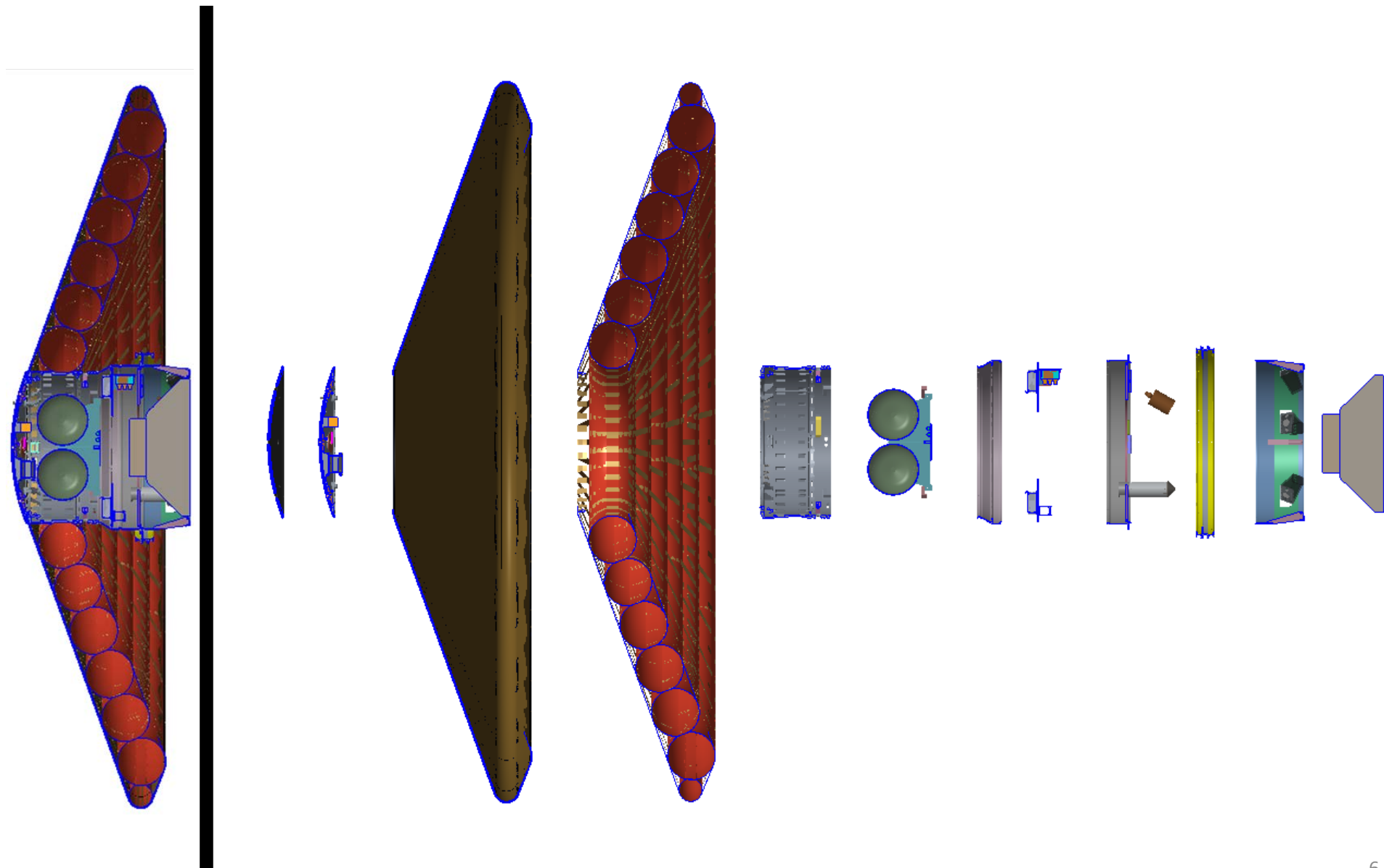




RV Instrumentation Overview

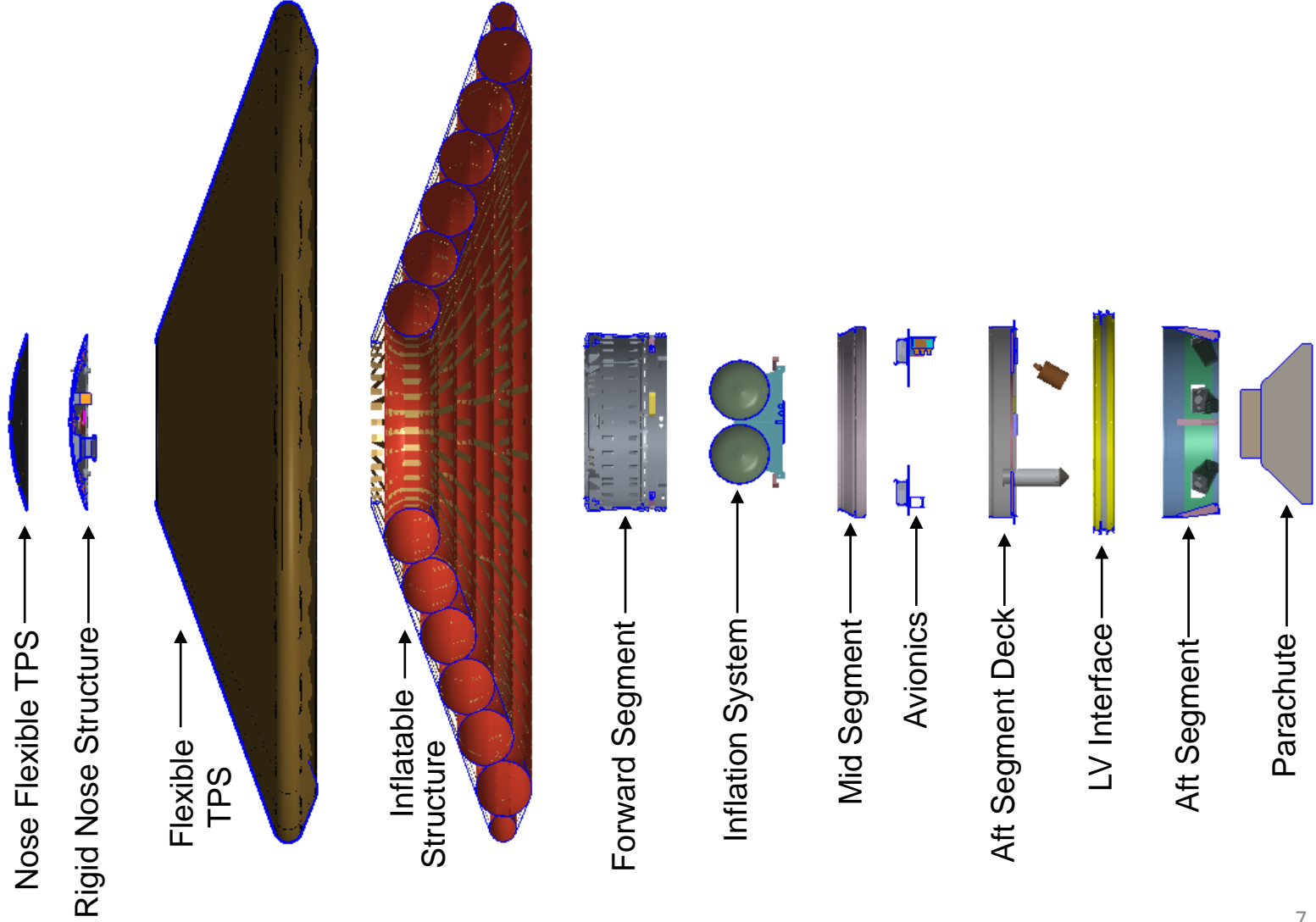
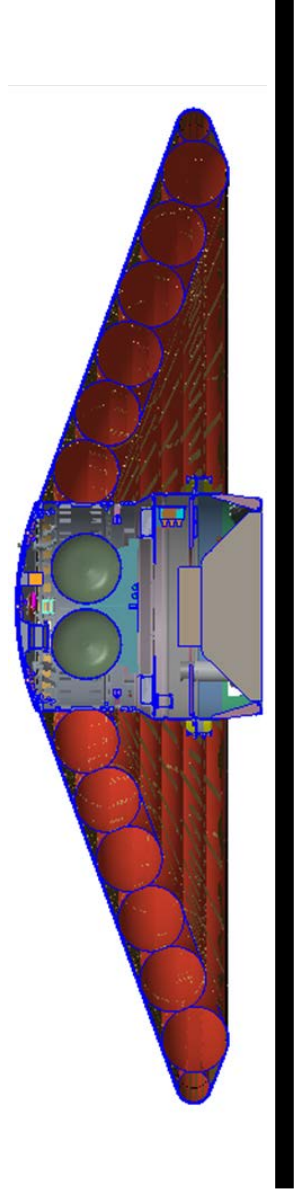


RV Instrumentation Overview



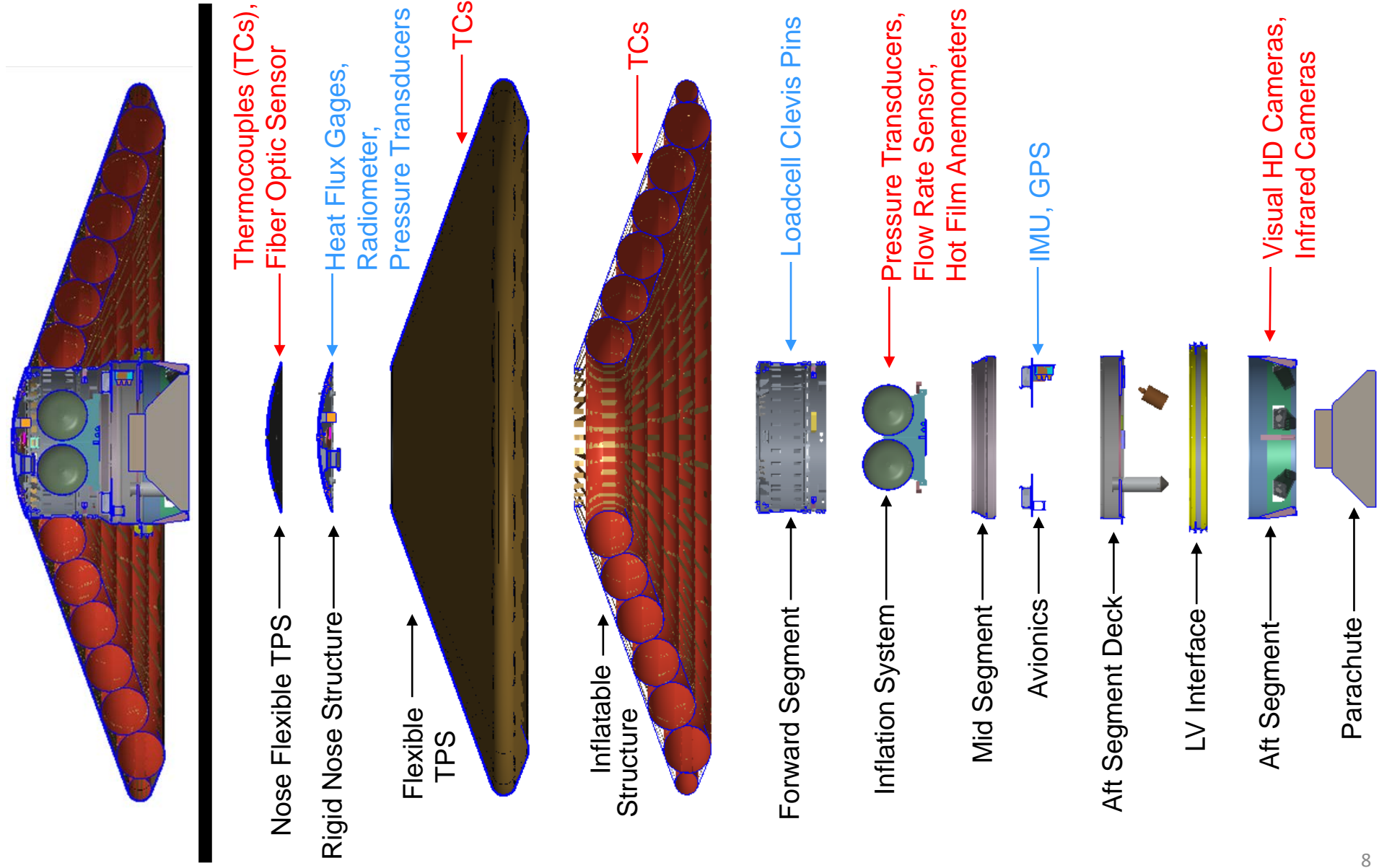


RV Instrumentation Overview



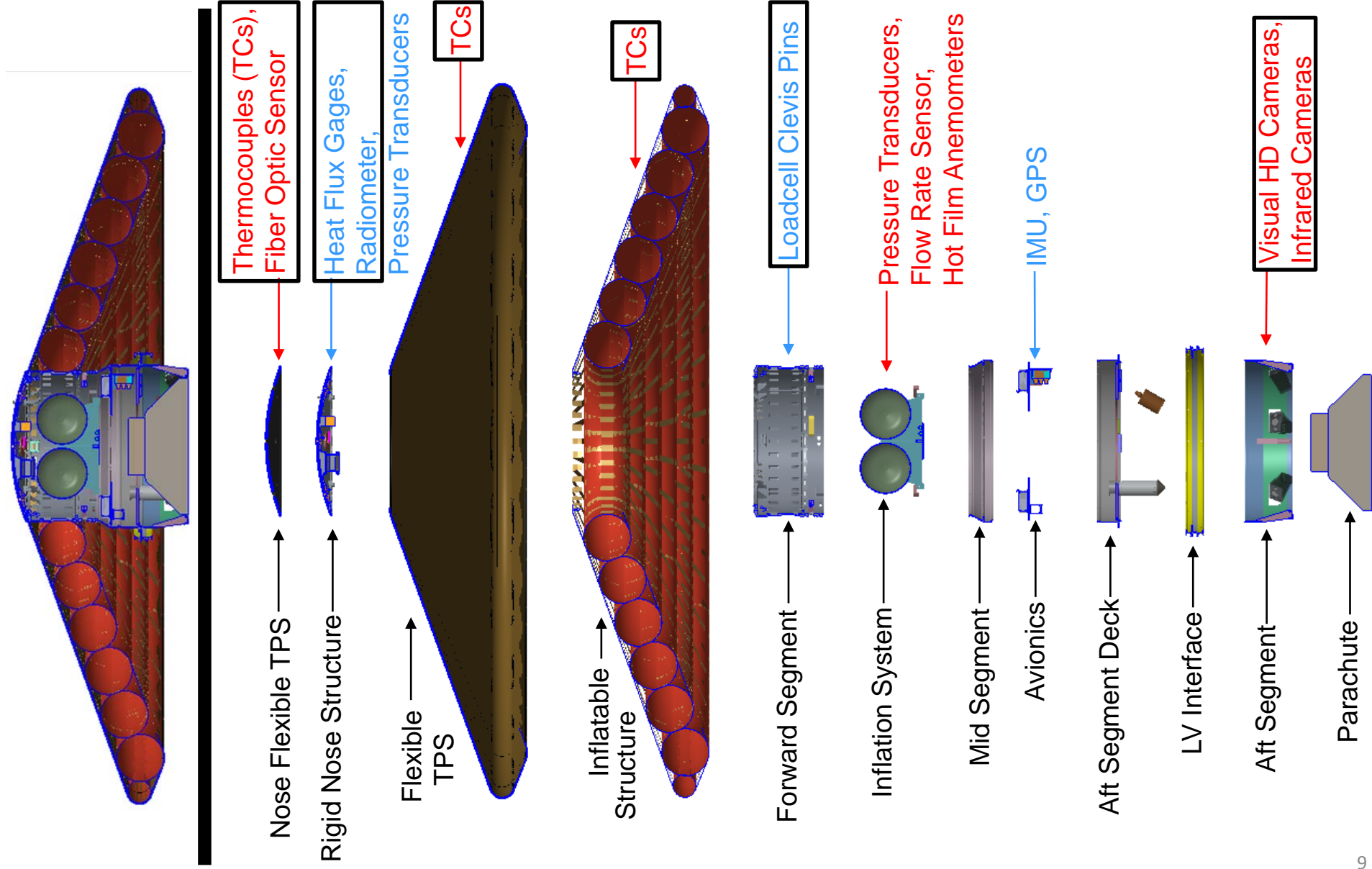


RV Instrumentation Overview





RV Instrumentation Overview

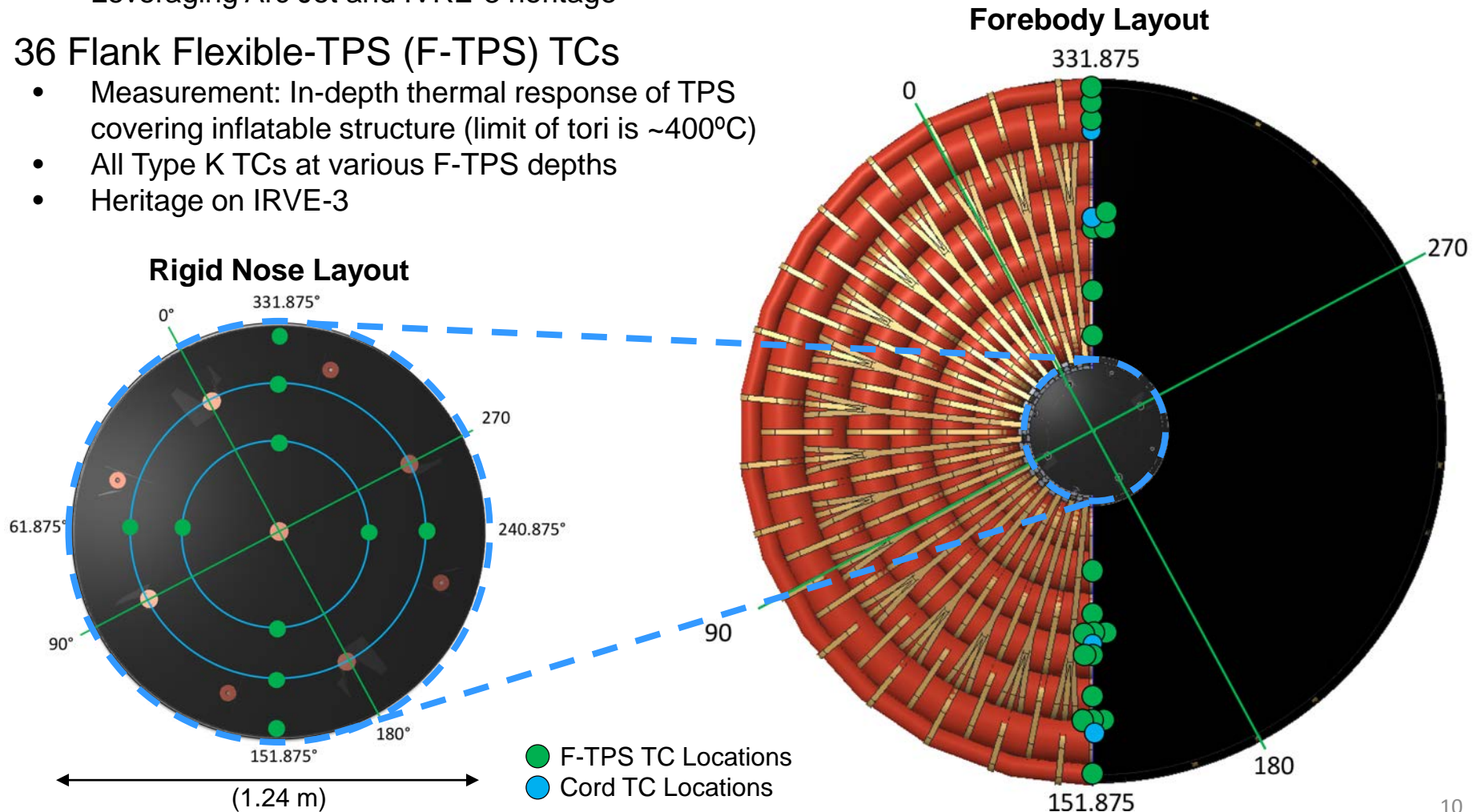




Forebody Thermocouples

- 22 Nose Thermocouples (TCs)
 - Measurement: In-depth thermal response at location of peak heating
 - 10 Type R TCs, 12 Type K TCs
 - Leveraging Arc Jet and IVRE-3 heritage
- 36 Flank Flexible-TPS (F-TPS) TCs
 - Measurement: In-depth thermal response of TPS covering inflatable structure (limit of tori is $\sim 400^{\circ}\text{C}$)
 - All Type K TCs at various F-TPS depths
 - Heritage on IRVE-3

(spin stabilized at 2-4 rpm)

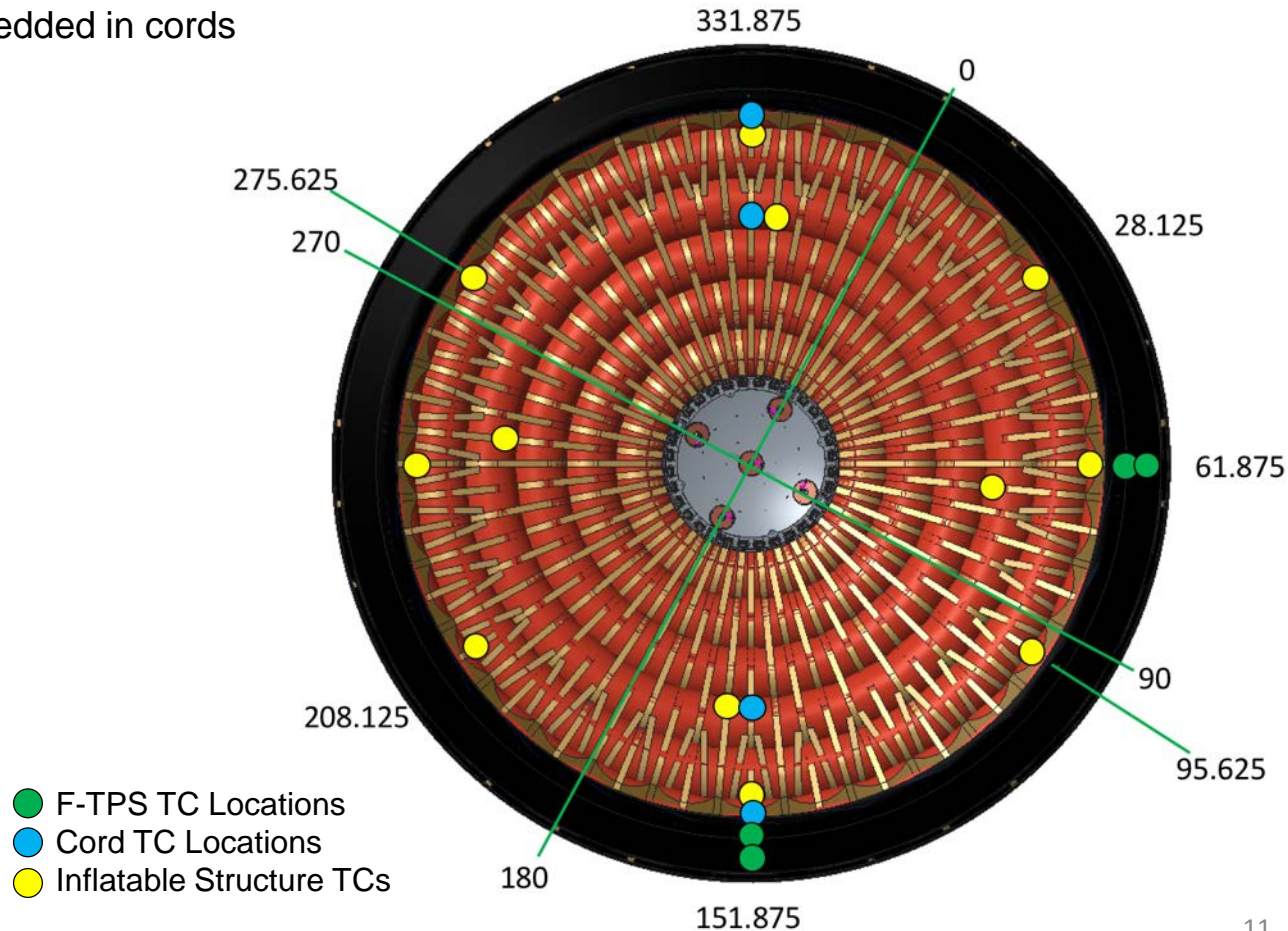


- 24 Inflatable Structure TCs
 - Measurement: Temperature of key structural elements in the inflatable structure and IR camera anchoring
 - All Type K TCs
 - Placed on straps, embedded in cords

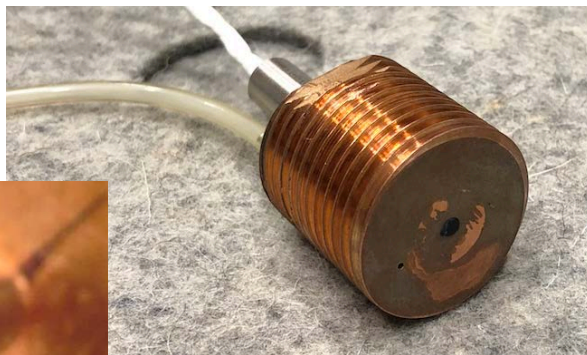
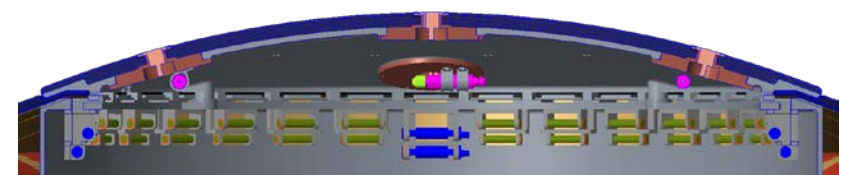
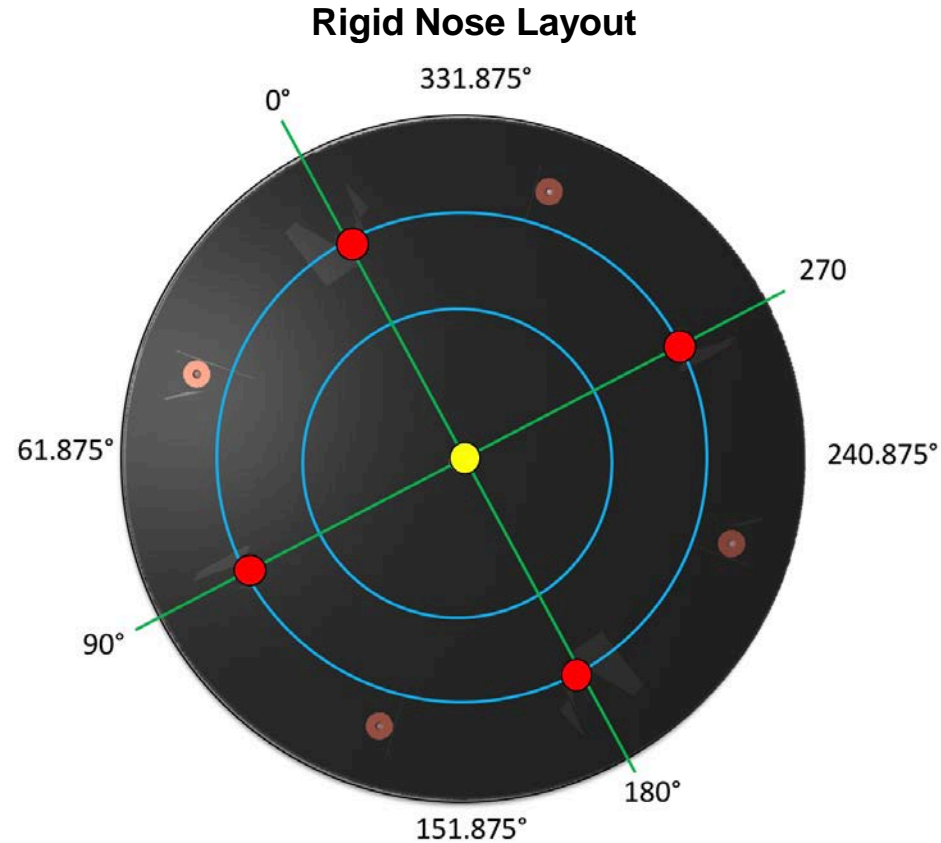
TC Embedded in Structural Cord



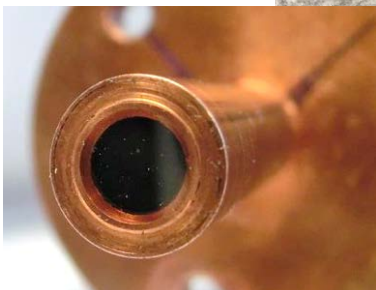
Aftbody Layout



- 4 Total Heat Flux Sensors ●
 - Measurement: Measure heat rate and total heat load
 - Heritage design from IRVE 3
 - Schmidt-Boelter Gage
 - Pressure Port
- 1 Radiometer ●
 - Measurement: Radiative component of the total heat flux
 - New to HIAD, but has been qualified and will fly as part of MEDLI2
 - Schmidt-Boelter Gage, Sapphire Window
 - Pressure Port



IRVE3 Heat Flux Gage



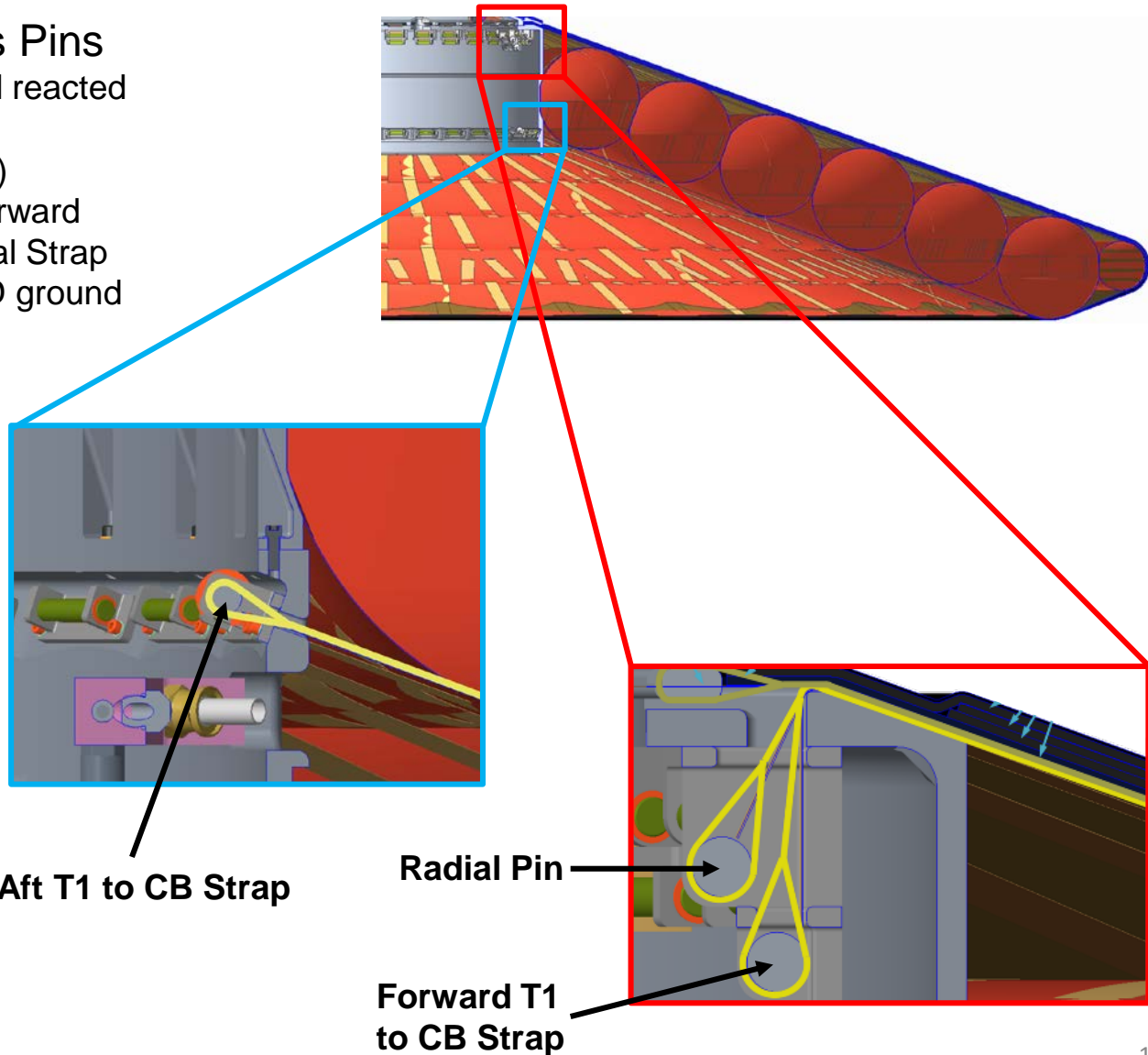
MEDLI2 Radiometer

Cross-Section of Nose

- 12 Strap Loadcell Clevis Pins
 - Measurement: Total load reacted at each cardinal position (0° , 90° , 180° , 270°)
 - 3 at each position: T1 Forward Strap, T1 Aft Strap, Radial Strap
 - Used extensively in HIAD ground testing



Loadcell Clevis Pin



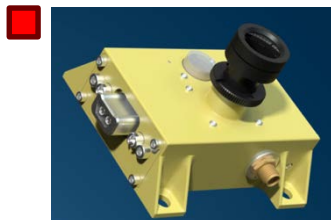
- 6 Visual HD Cameras
 - Aeroshell deflection and observation (360° Coverage)
- 1 Up-Look camera
 - Launch vehicle separation and parachute deployment
- 12 Infrared Cameras
 - Aft-body temperature distribution (360° Coverage)



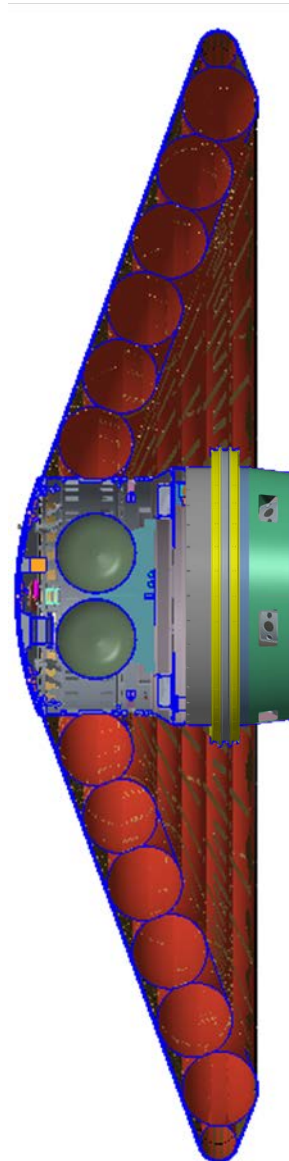
IR Camera



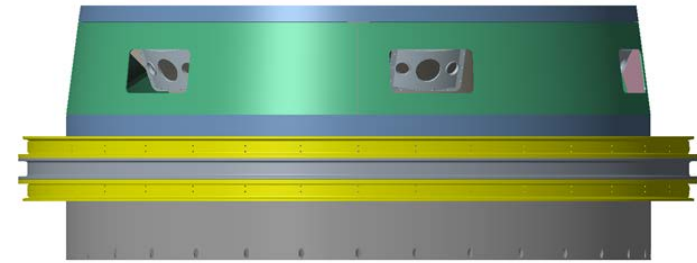
HD Aeroshell Camera



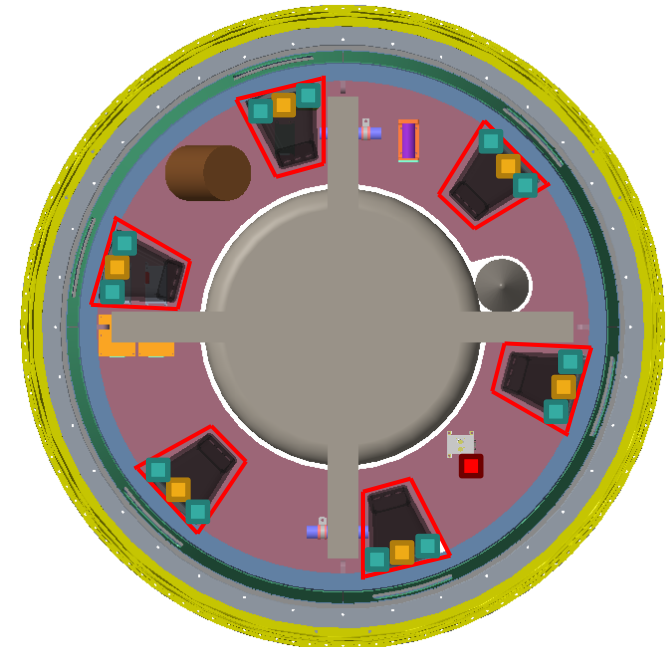
HD Up-Look Camera



Aft Deck Camera Mounting



6 Camera Pod Locations



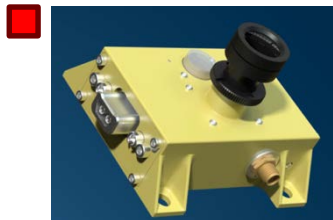
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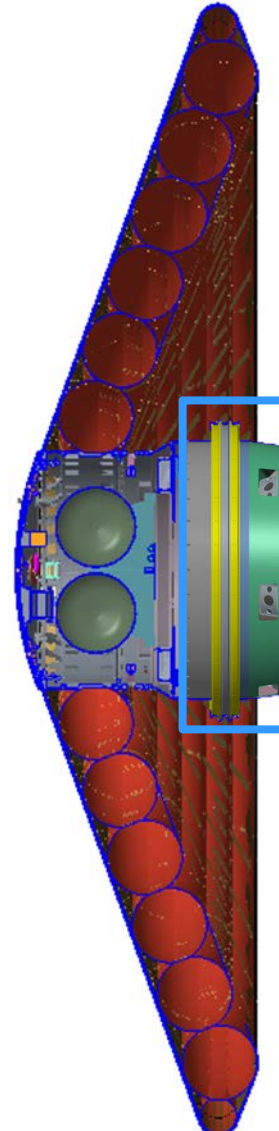
IR Camera



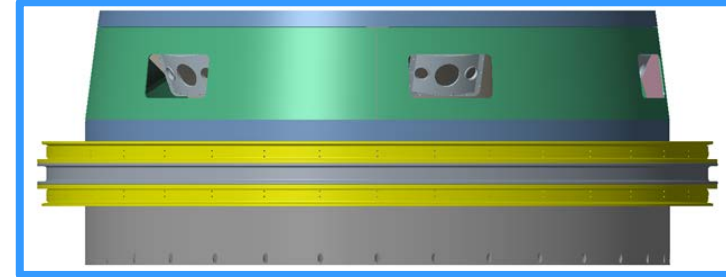
HD Aeroshell Camera



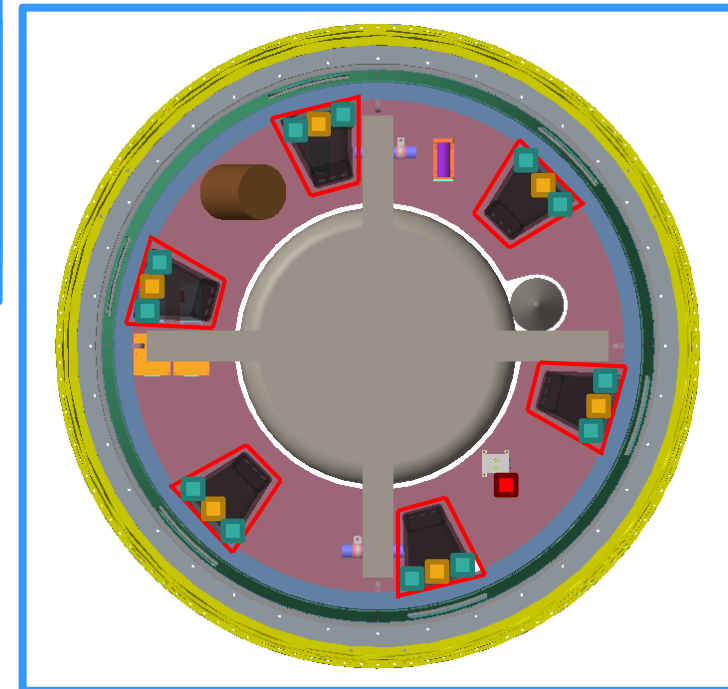
HD Up-Look Camera



Aft Deck Camera Mounting

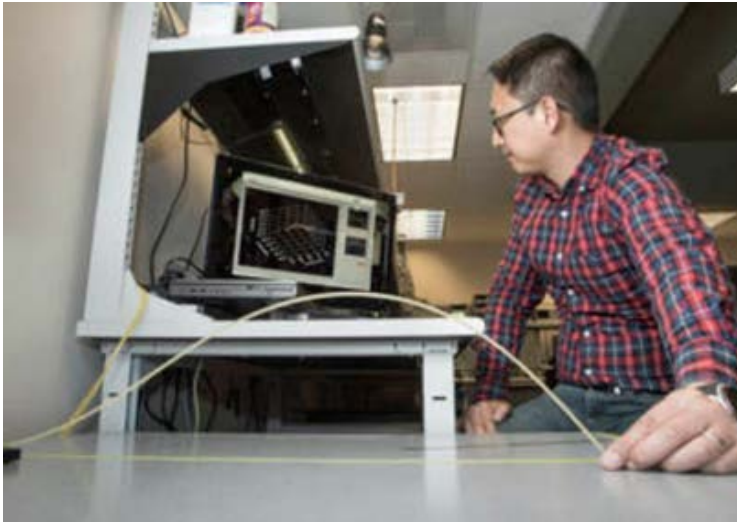


6 Camera Pod Locations

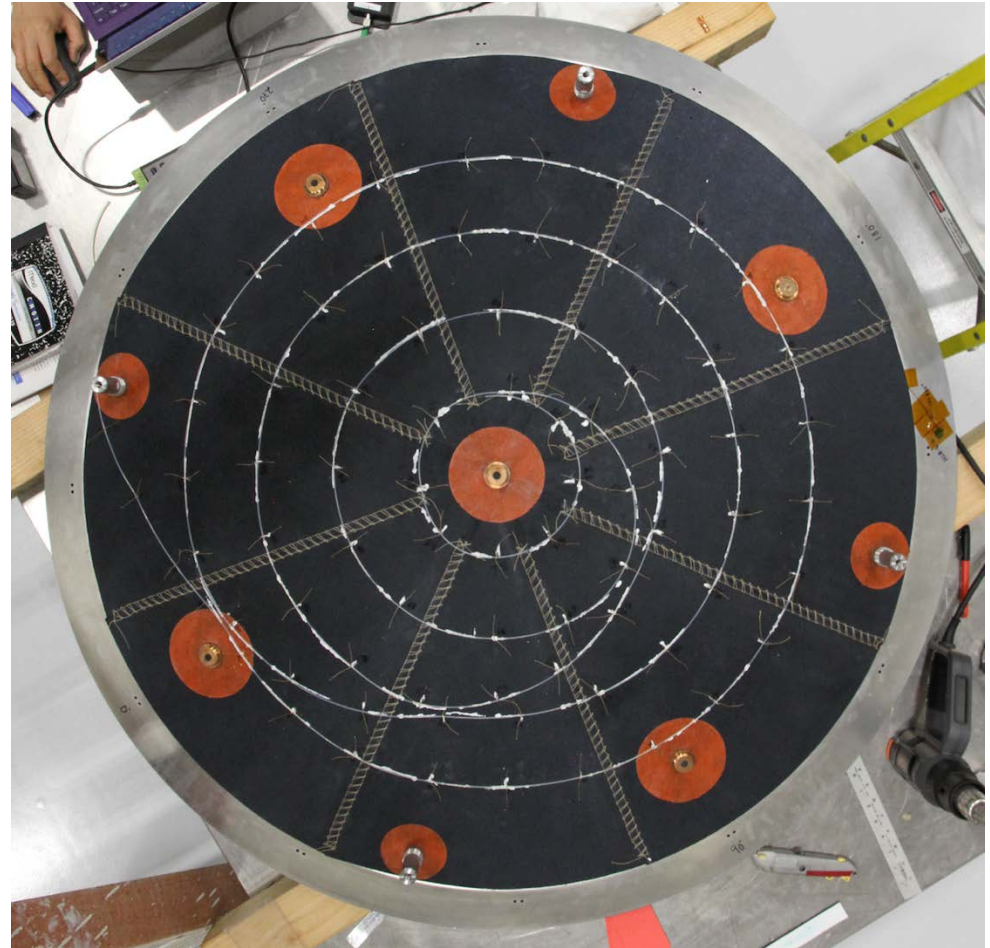


2 Fiber Optic Strain Sensors

- Fibers are strain Isolated so they only sense temperature
- 1 Fiber on the rigid nose
- 1 fiber on centerbody
- Have been flown on test aircraft



Fiber Optic Strain Sensing Fiber in Lab



Fiber Optic Strain Sensing Fiber Integrated on EDU Nose in Semi-Spiral Pattern



Questions?