National Aeronautics and Space Administration

# Entry, Descent, and Landing Panel
# Humans to Mars Summit 2020

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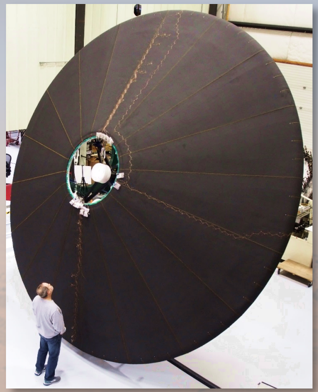
# Entry: Inflatable Aeroshell

## Hypersonic Inflatable Aerodynamic Decelerator (HIAD)

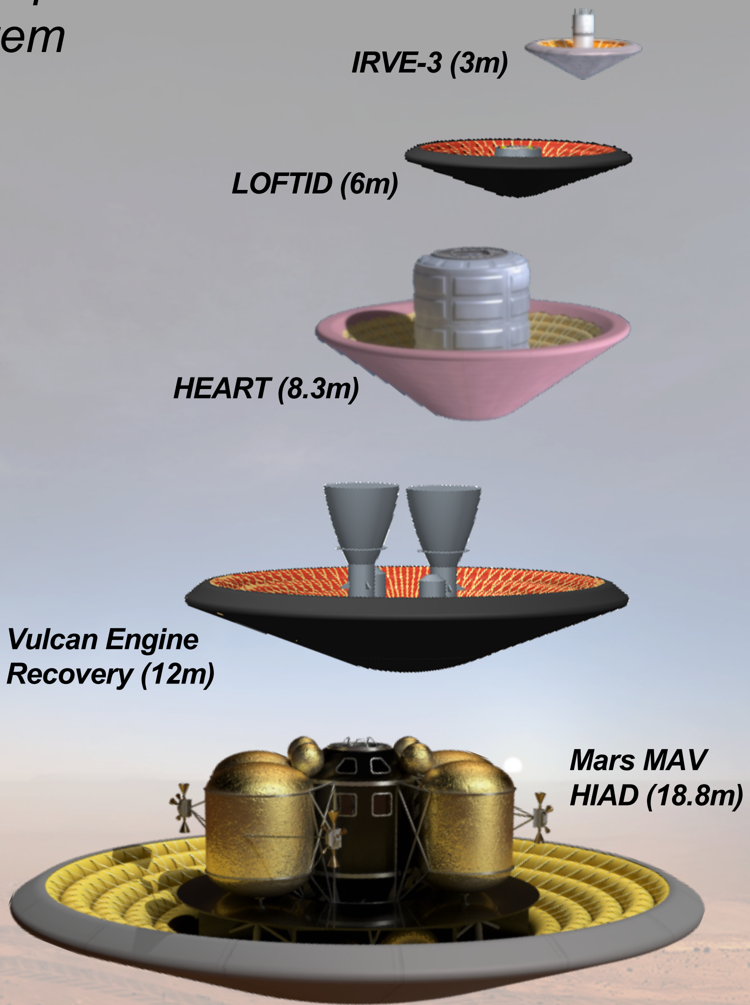
*A deployable aeroshell consisting of an Inflatable Structure that maintains shape during atmospheric flight and flexible and a Flexible Thermal Protection System that protects the entry vehicle through hypersonic entry*

- **Inflatable decelerator technology:**
  - **Deploys a large aeroshell before atmospheric interface**
  - **Enables landing more payload mass and/or at higher altitudes**
  - **Reduces peak heat flux by decelerating more in less dense upper reaches of the atmosphere**
  - **Allows payloads to use full diameter of the launch vehicle fairing**



LOFTID Engineering Development Unit

***Relative Scales of HIAD Missions***



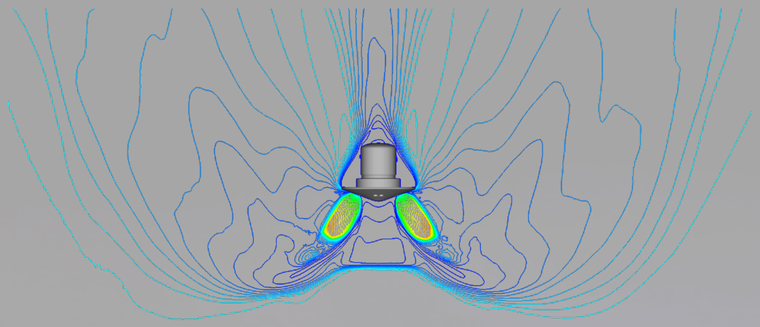
# LOFTID Technology Demonstration Mission

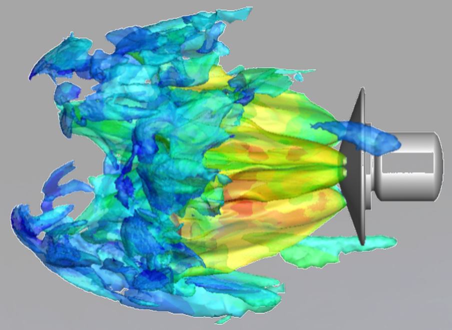
- **L**ow-Earth **O**rbit **F**light **T**est of an **I**nflatable **D**ecelerator (LOFTID)
- Orbital entry (7-11 km/s) flight test of HIAD technology to mature inflatable aeroshell for NASA heavy down-mass missions and commercial applications
- 6m diameter HIAD
- March 2022 launch from Vandenberg AFB

# Descent: Retropropulsion

## Supersonic Retropropulsion (SRP)

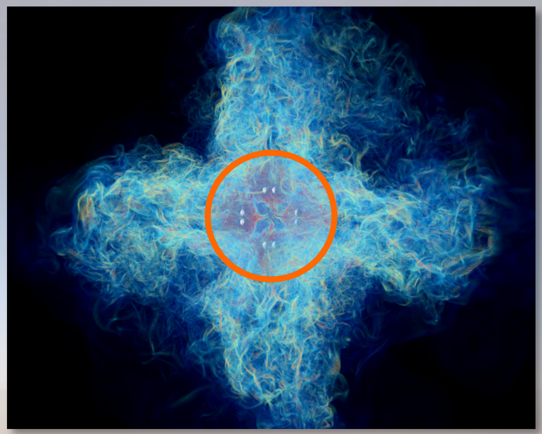
*Use of rocket propulsion for the primary purpose of decelerating the vehicle in atmospheric flight, beginning at supersonic speeds*



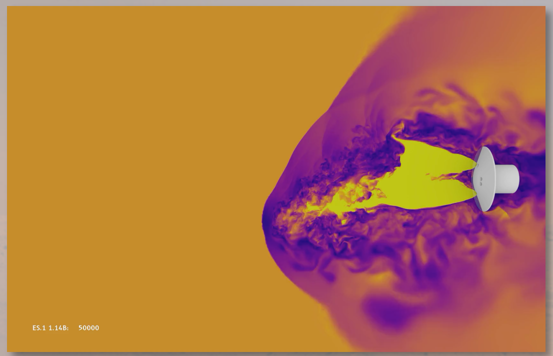


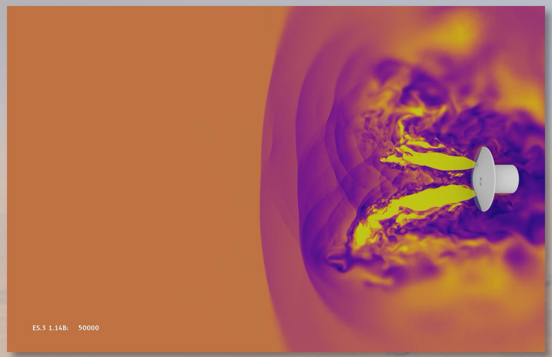
Complex retropropulsion exhaust plumes

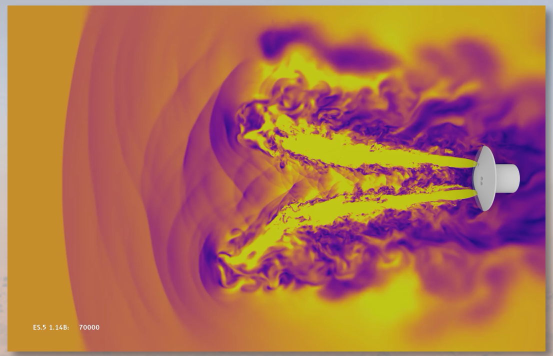
- **Powered descent technology:**
  - **Replaces supersonic parachutes in heritage EDL systems**
  - **Enables landing more payload mass**
  - **Provides additional control authority during descent and landing**
  - **Potential for significant aerodynamic effects on vehicle and impacts to sensor performance**



Looking at the heatshield (orange) with engines firing





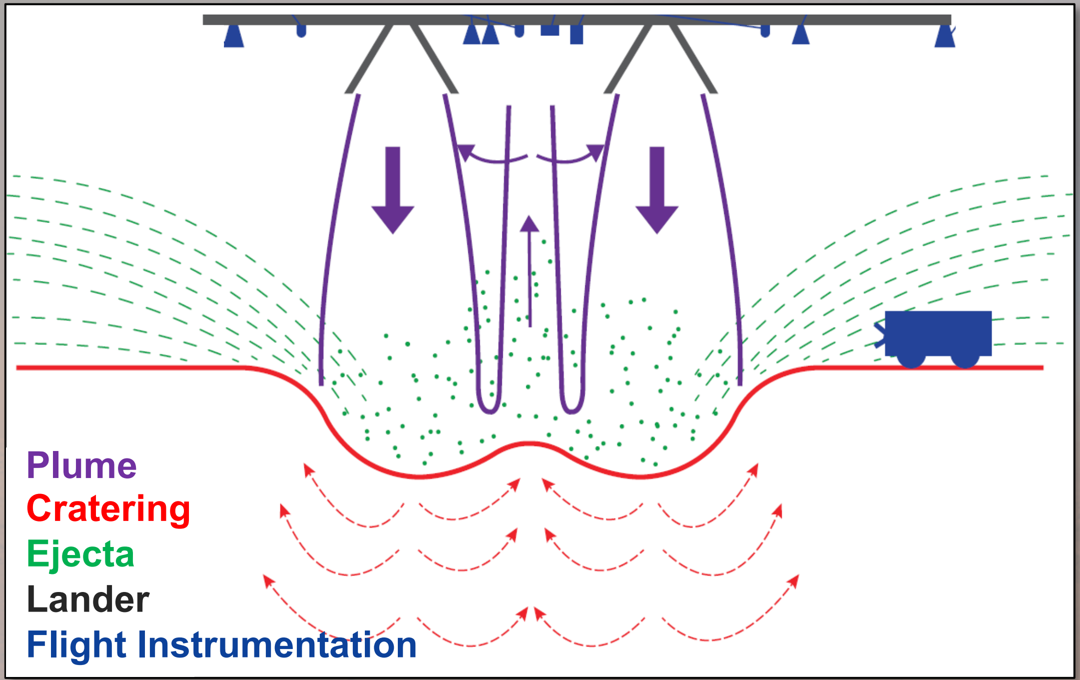


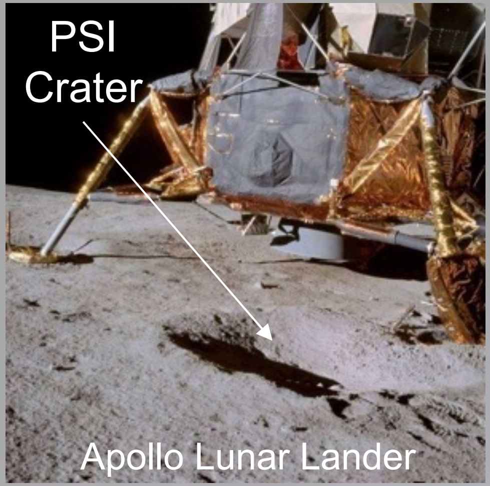
Vehicle decelerates towards the surface of Mars

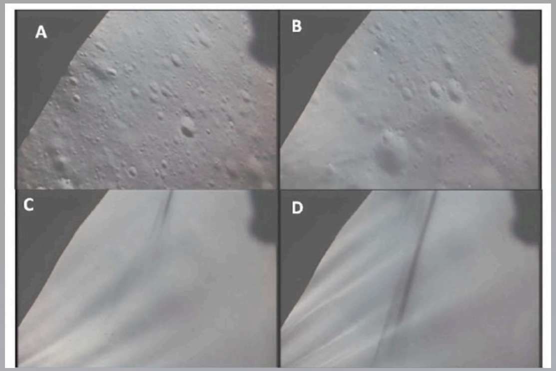
## Rocket Plume-Surface Interaction (PSI)

*The lander environment due to the impingement of hot rocket exhaust on the regolith of planetary bodies*

- **Plume effects can lead to vehicle instability before touchdown and localized heating on the lander**
- **Cratering can lead to vehicle instability and tilt**
- **Ejecta can obscure sensors and damage hardware and surface assets**

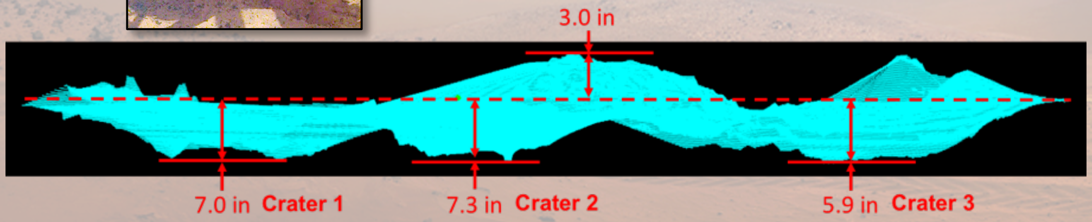


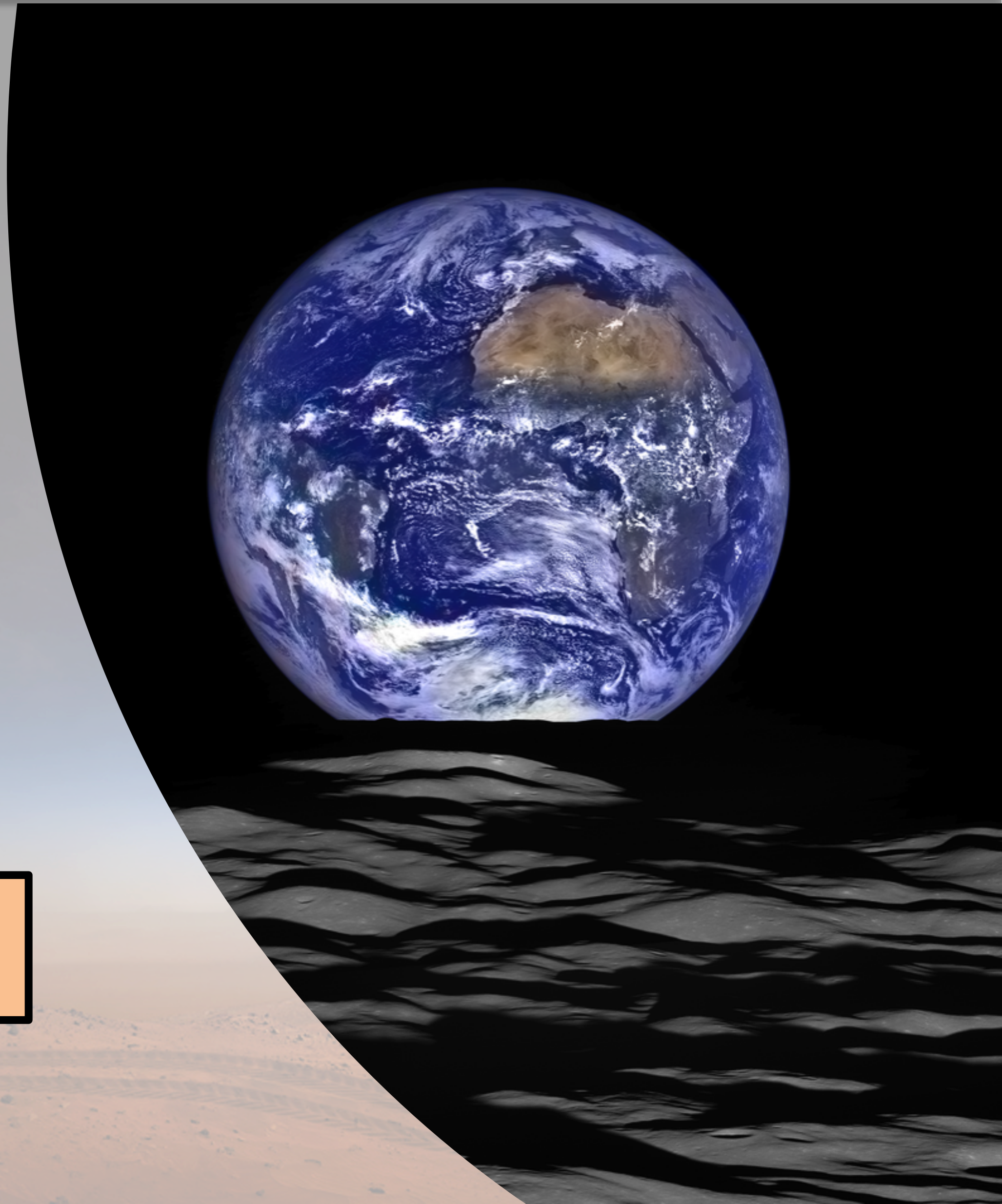

Apollo 15 LEM camera views


*InSight average crater diameter: 20 inches wide, 7 inches deep*



# Moon to Mars

- Coming years will see an uptick in lunar landing attempts, all of which will use powered descent
- Commercial lunar landers are a key component of technology demonstration
- Points of departure for:
  - Long-term cryogenic storage
  - Engine performance
  - GNC with retropropulsion
  - Plume-surface interaction
  - Sensors and onboard instrumentation



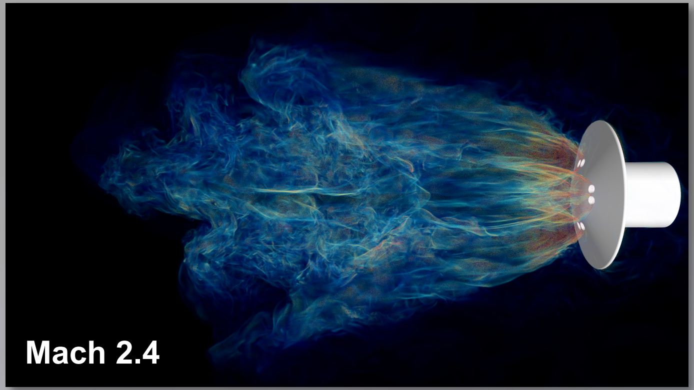
**All phases of EDL at Mars are critically impacted by the presence of an atmosphere**

# Summary

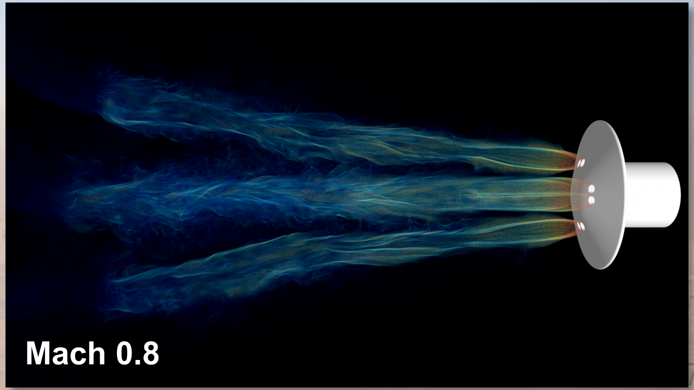
- Human-scale EDL at Mars requires new technology for all phases of flight, including:
  - Hypersonic Inflatable Aerodynamic Decelerator (HIAD)
  - Retropropulsion for descent and landing
  - Precision landing and hazard avoidance
  - New Guidance, Navigation, and Control (GN&C) approaches

- EDL is challenged by constraints from the larger human exploration architecture

- Ground testing, computational analysis, terrestrial flight testing, robotic Mars science missions, and Lunar exploration all bring us closer to boot prints on Mars







# See you on Mars!