Mars2020 Entry, Descent, and Landing Instrumentation (MEDLI2): Science Objectives and Instrument Requirements

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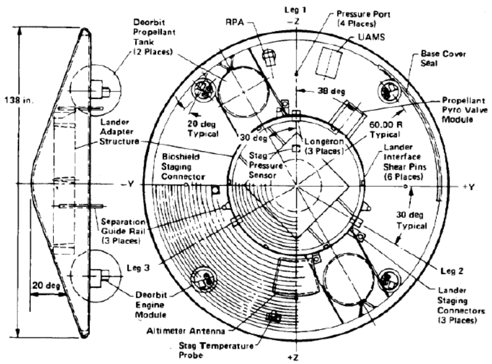
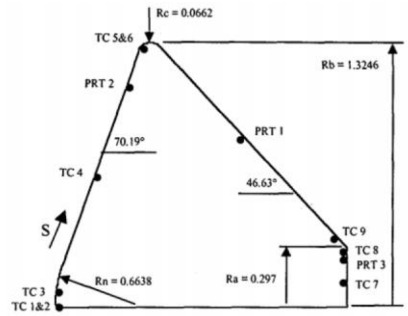
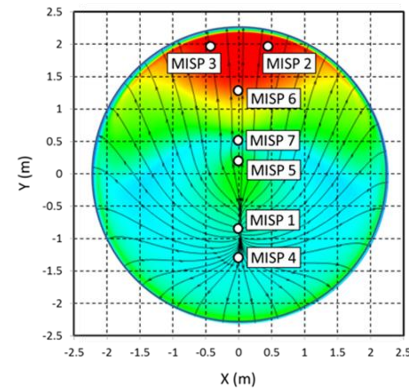
Mars Entry Instrumentation



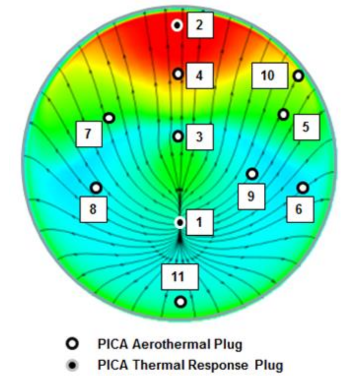
Viking 1976



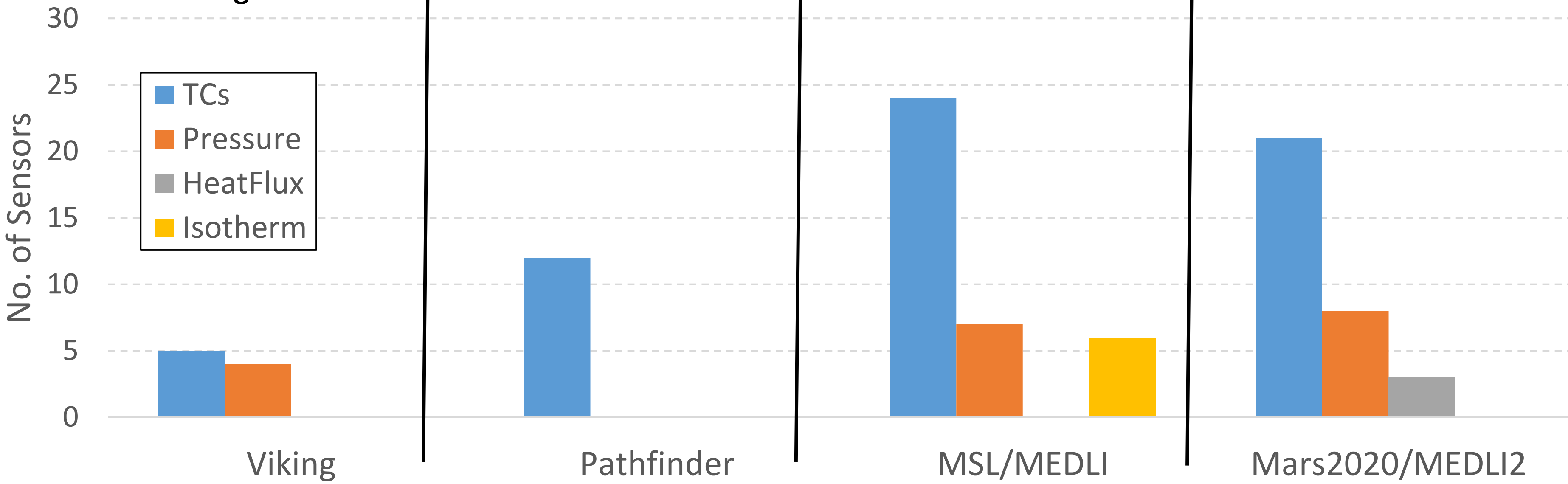
Pathfinder 1997



MSL/MEDLI 2012



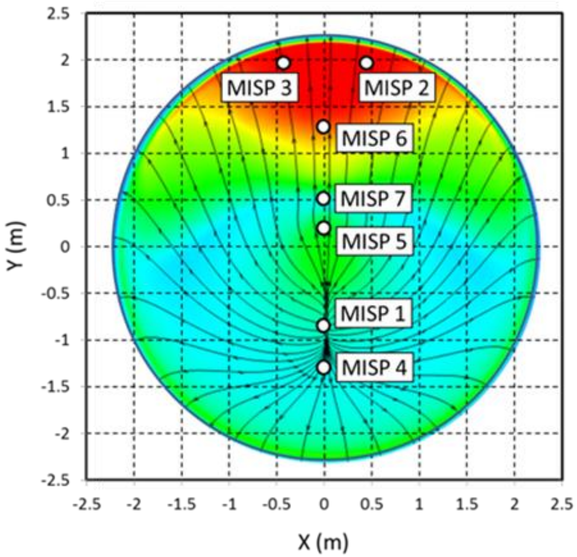
Mars2020/MEDLI2 2020

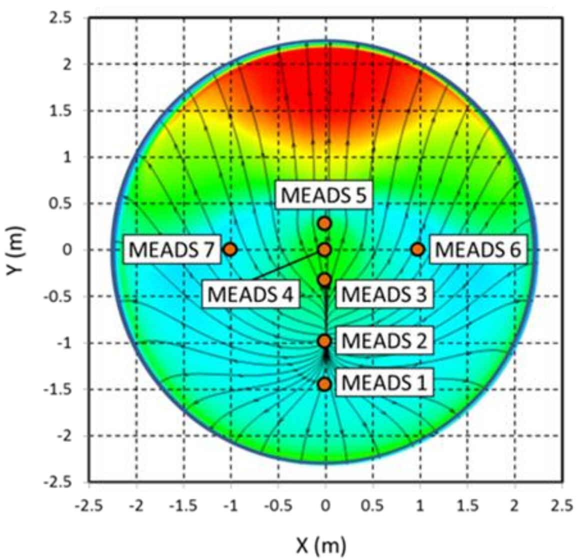


MEDLI2 maintains the same sensor count as MEDLI, but targets different aspects of EDL at a higher data sampling rate

Impact of MEDLI

- **Improved system performance** using flight data to substantiate reduction in TPS design margins → lower mass or additional capability
- **Reduced risk** by validating vehicle aerodynamics, TPS performance and entry environment
- **Reconstructed aerodynamics** for wind relative attitude and force coefficients
- **Reconstructed as-flown atmospheric density**
- **Flight qualified sensors** for pressure and temperature measurements

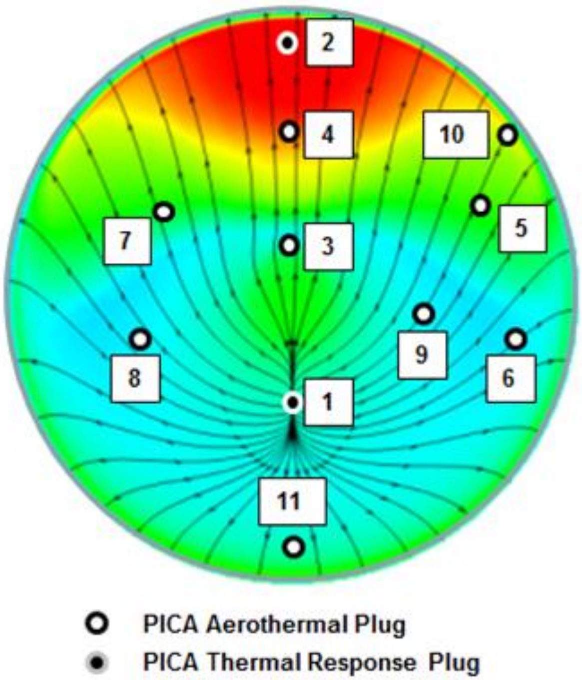


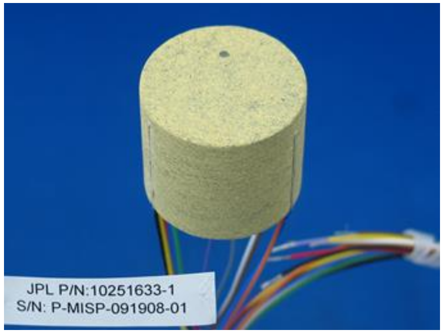


MEDLI2 Objectives

- **Backshell Aerothermal Environment**
  - Large uncertainty applied in backshell TPS design
  - Radiative heating predicted to be a contributor
  - Wind tunnel testing and CFD simulations have lower fidelity
- **Supersonic Aerodynamics**
  - Larger uncertainty in supersonic aerodynamics than hypersonic phase (3% vs. 10%)
  - IMU-only based reconstruction does not account for contribution of winds
  - Afterbody pressure contribution to drag based on Viking era pressure model
- **Turbulent Heating Footprint on Forebody**
  - No predictive tool for onset and coverage of turbulent heating
  - Uncertain mechanisms of transition to turbulence
- **Atmospheric Density Reconstruction**
  - For atmosphere reconstruction and evaluation of EDL system performance

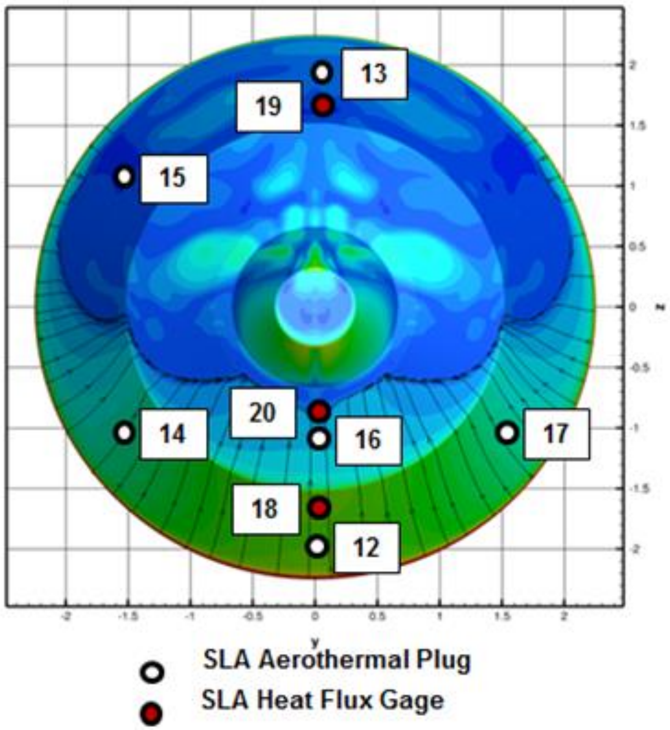
MEDLI2 Forebody Thermal Instrumentation

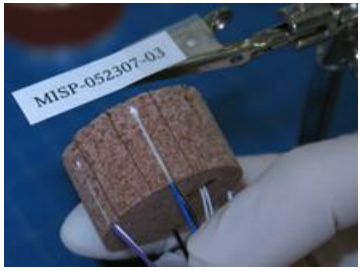




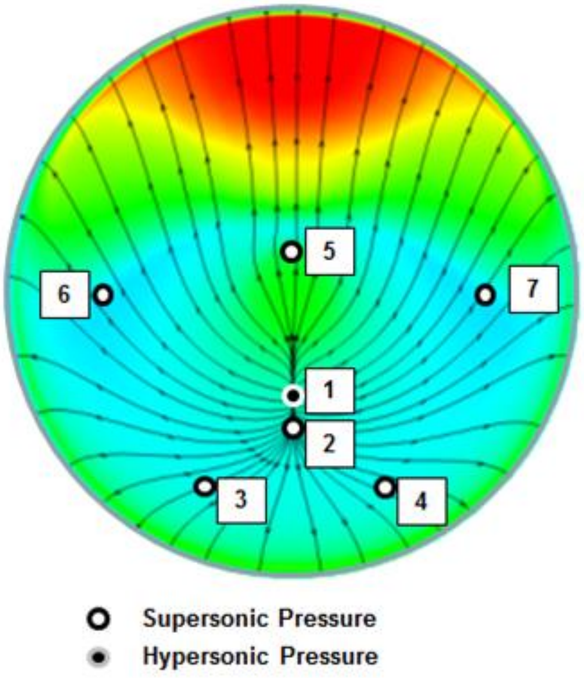
- **Science objectives**: Measure baseline heating, transition to turbulence, turbulent heating footprint, heating augmentation due to fencing at tile gaps
- Forebody thermal instrumentation includes **11 PICA plugs** with embedded thermocouples
  - Two plugs (1-2) with three thermocouples each to measure in-depth thermal response
  - Nine plugs (3-11) with one thermocouple for aerothermal reconstruction
- A combination of Type-S and Type-K TCs
  - Range: -100 to 1800 C
  - Data Rate: 2-8 Hz
- **Post-flight reconstruction target**:
  - Heat flux: ±15 W/cm2
  - Transition to turbulence: 1 sec

MEDLI2 Afterbody Thermal Instrumentation



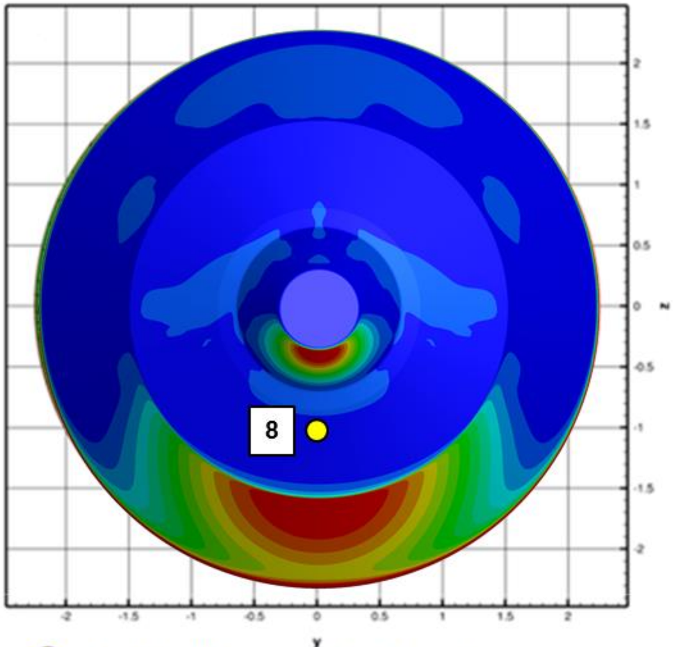


- **Science objectives:** Measure/reconstruct
  - Aeroheating (reconstructed and direct measurement)
  - RCS interaction (if any)
  - Radiative heating (under consideration)
- Afterbody instrumentation includes **6 SLA-561V thermal plugs**
- Each plug will have 1 or 2 Type-K thermocouple for aerothermal reconstruction
  - Range: -100 to 1400 C
  - Data Rate: 2-8 Hz
- **3 Heat flux gages** will also be used for fast-response direct heat flux measurements
  - Range: 0-15 W/cm2
  - Data Rate: 16 Hz
- **Post-flight reconstruction target**:
  - Heat flux reconstruction: ±3 W/cm^2 at 8 Hz
  - Direct heat flux measurement: ±1 W/cm^2 at 16 Hz

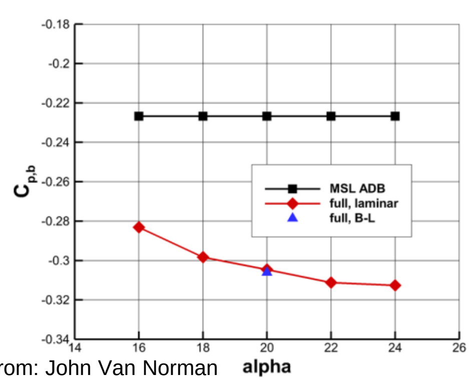


- **Science objectives**: Reconstruct
  - wind relative vehicle attitude (supersonic)
  - axial force coefficient (supersonic)
  - as-flown atmospheric density
- **Six pressure transducers** measure surface pressure in the range relevant for supersonic flight
  - Range: 0-1 psia
  - Data Rate: 8 Hz
- **One pressure transducer** to measure stagnation point pressure during hypersonic flight for reconstruction of atmospheric density
  - Range: 0-5 psia
  - Data Rate: 8 Hz
- The “supersonic” port locations are based on a constrained-optimization process to minimize error in the reconstruction of angles of attack and side-slip
- **Post-flight reconstruction target:**
  - Vehicle attitude: ±0.5 degrees
  - Axial force coefficient: ±2%
  - Atmospheric winds: ±10 m/s, Atmospheric density: ±5%

MEDLI2 Afterbody Pressure Measurement



Backshell Pressure Port Location



From: John Van Norman

- **Science Objectives:**
  - Improve backshell pressure model
  - Estimate backshell contribution to drag
- **One pressure measurement** port in the afterbody
  - Range: 0-0.1 psia
  - Data Rate: 8 Hz
  - Engagement with suitable vendors ongoing based on responses from industry
- The current port location is defined based on available wind tunnel data and CFD analysis
- Further refinement of the location will occur based on the results of on-going ballistics range test
- **Post-flight reconstruction target:**
  - Measure backshell pressure within 4 Pa

Summary

- EDL instrumentation for Mars-2020 mission (called MEDLI2) is being developed with an extended scope beyond MEDLI
- MEDLI2 will emphasize
  - Backshell aerothermal and TPS
  - Supersonic aerodynamics
  - Forebody turbulent heating footprint
  - Atmospheric density
- Instrument requirements and reconstruction targets have been defined
- Vendors for instrumentation being identified for off-the-shelf sensor technologies
- Sensors selection, performance testing/calibration, and “do-no-harm” demonstration will occur in the next 1-2 years