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

Deepak Bose,¹ Todd White,² Mark Schoenenberger,³ Chris Karlgaard,³ and Henry Wright³

¹NASA Ames Research Center, Moffett Field, CA
²ERC, Inc. Moffett Field, CA
³NASA Langley Research Center, Hampton, VA
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/cm² at 8 Hz
  - Direct heat flux measurement: ±1 W/cm² at 16 Hz
**MEDLI2 Forebody Pressure Measurement**

- **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

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.