The Mars Microphone onboard Supercam for the Mars 2020 rover

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The short history of the planetary microphones began probably with Grozo 2 instrument during the Venera 13 and 14 mission.

First Planetary microphone on Huygens
- Successfully retrieved the descent sounds

(http://mentallandscape.com/V_Venera11.htm)
A Short History of Planetary Microphones (2/3)

- Second opportunity on Mars Polar Lander
  - Mars Microphone Development up to FM by Greg Delory (UC Berkeley)
  - Support by the Planetary Society
  - Failed landing of MPL

- Third opportunity with Phoenix: sound coupled with Mardi imager (Not used)
Taking into account both the sensor and the lander requirements, two possible accommodations are studied and shown in Figure 19 and Figure 20. For exact dimensions, details, MICD, and additional views, please refer to Annex #4.

Camera system is the sensor imposing the strongest accommodation constraints. MARIE Camera system:

1. Focus from 500 mm up to infinite
2. FoV: 55°x83° (100° diagonal)
3. Calibration target to be positioned nominally within focus range (>390-400 mm).

After landing, EDM platform may be tilted up to ±40° and centre of the EDM baseplate may lie between 0.25 m and 0.60 m above nominal Martian surface (respectively for a horizontal and a 40° tilted attitude). Considering the above constraints, the following requirements for the camera accommodation have been considered:

a) Calibration target shall stay at a minimum distance of 400 mm;
Acoustics on Mars is complicated

Very strong absorption
Williams (2001)

Sound amplitude vs. distance on Mars

Increasing distance
Microphone science goals have to be crystal clear
SuperCam on Mars 2020

Dr. Steven J. Rehse / What is LIBS?

(a) pulsed laser → absorption
(b) vapor → crater → fragmentation, melting, sublimation, atomization
(c) continuum emission
   - shock wave
   - plasma absorption
   - bremsstrahlung

Schematic of the laser-induced breakdown process.

+ sound

Spectrum
SuperCam on Mars 2020

Dr. Steven J. Rehse / What is LIBS?

Schematic of the laser-induced breakdown process.
The science objectives of the Mars Microphone are:

1) To support the LIBS investigation to obtain unique properties of Mars rocks and soils through their coupling with the LIBS laser.

2) To contribute to basic atmospheric science: wind, convective vortices, dust devils studies at close distance or when interacting with the rover.

3) To monitor various artificial sounds.
Microphone accommodation

RWEB (External view)

MTB3-B

MIC-FEE

FEE + Cover

MIC + PT1000

Post + Microphone

EQM Model: Close look on Microphone, IRAP
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What can we learn from LIBS acoustics?

The intensity of the acoustic signal acquired as the peak-to-peak amplitude of acoustic waveform is proportional to the ablated masses (Chaléard et al., 1997; Grad and Mozina 1993)

The mass ablated is obtained from the acoustic signal amplitude.

Waveforms of JSC1 targets at different levels of compaction as measured by the microphone at 1.5 m from the targets.

The sound peak amplitude increases with the hardness of the material.

The LIBS acoustic signal constraints the material hardness
Bandwidth of acoustic signals on Mars

- Frequency ranges of the different signals to be calibrated

- **Aeroacoustics** (1 Hz to 500 Hz) for wind speeds < 20 m/s, object sizes > 1 cm
- **Vortices** (10 Hz to 1 kHz) for vortex diameters 1 – 30 m
- **Dynamic pressure** (all frequencies) but drops off rapidly with increasing frequency
- **Saltation** (5-10 kHz)
- **LIBS acoustics** (0.5-5 kHz)
- **Rover activities** (1-10 kHz)

MICROPHONE BANDWIDTH (100 Hz – 10 kHz)

Nelke and Vary, 2014
Microphone Radiation issues

- Microphone gain had decreased sharply after X-ray inspections
  - All other operations (Shocks, Serialization, retinning) have no impact on performance
  - All flight/qualification microphones have been exposed to X-ray
    - Need of another lot

Blue curves (light and dark): no X-ray inspection
Other curves: X-ray inspection
Calibration: End to end

Objectives:
- Verify the gains of the instrument in the windy Martian environment
- Ensure microphone is not saturated by Aeolian noise

Test details:
- Use of AWTSII 2010 Martian wind tunnel foreseen (2m x 2m x 0.9m) in Denmark
- LIBS-like sound + MIC operation + Martian atmosphere over a sufficient distance, with wind.
- Target: Spring 2017
Aarhus end-to-end validation tests
To summarize

- There will be a microphone on Mars 2020 (FM delivered in February 2018, Supercam FM this fall)
- You can hear sounds on Mars (even if it’s tough)
- You can do science with it!
The Mars Microphone on SuperCam

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