The Mars Microphone onboard Supercam for the Mars 2020 rover

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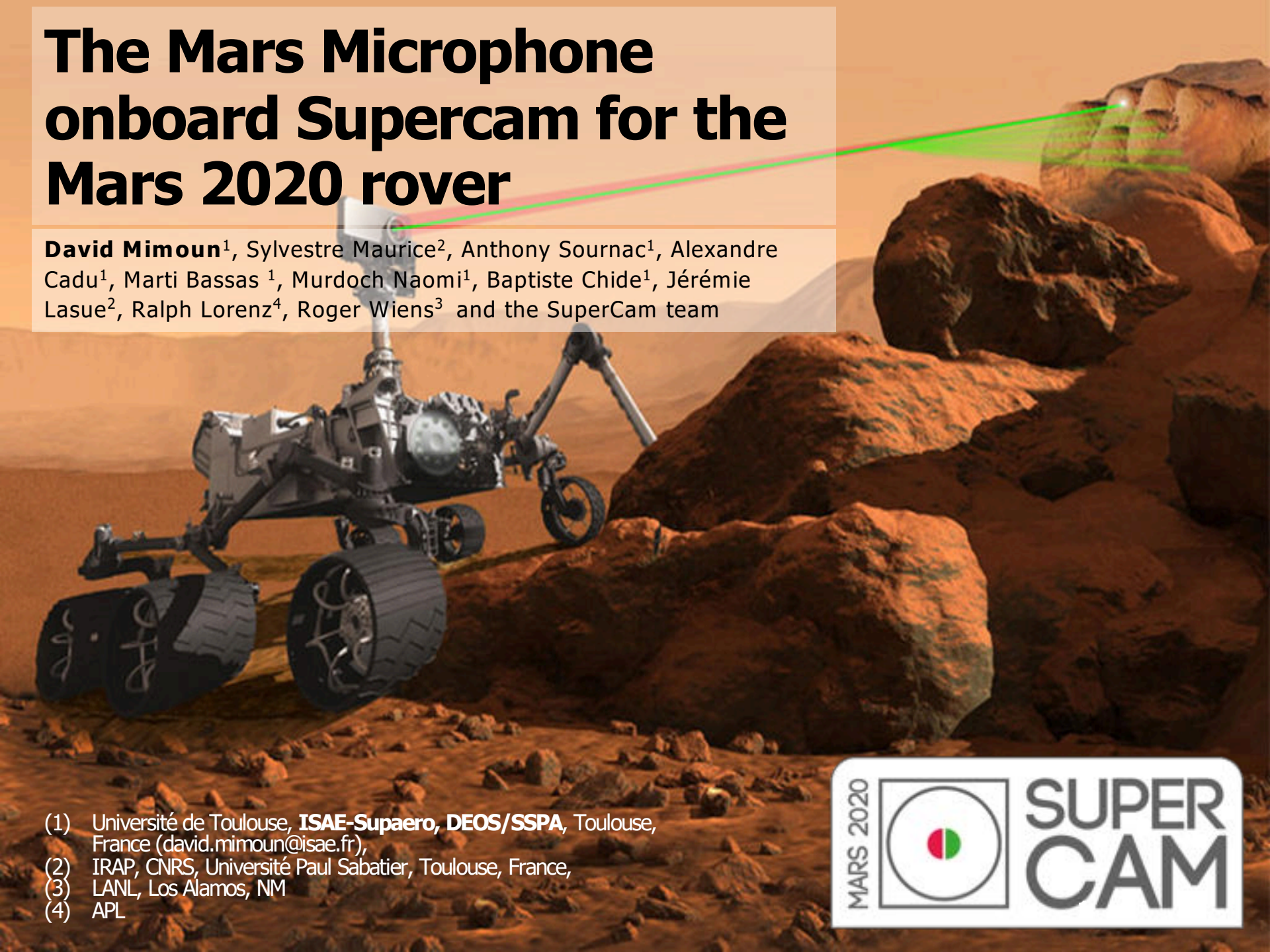
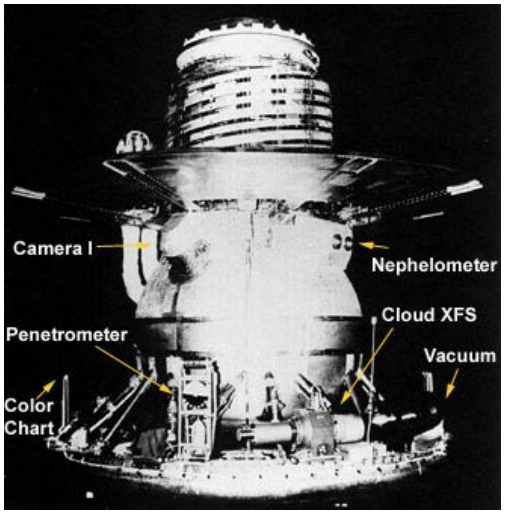
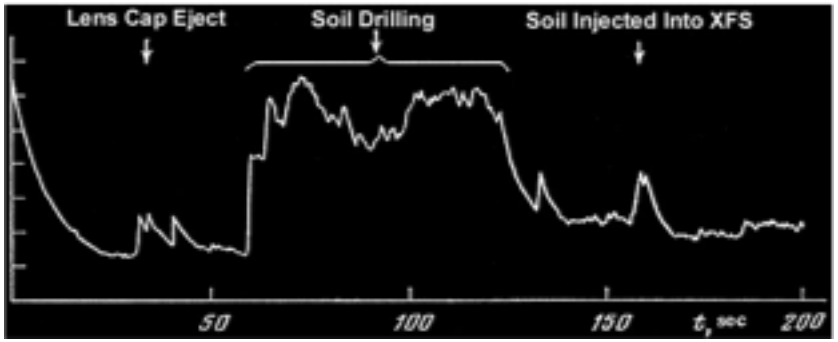
(4) APL



A Short History of Planetary Microphones (1/3)

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





(http://mentallandscape.com/V_Venera11.htm)

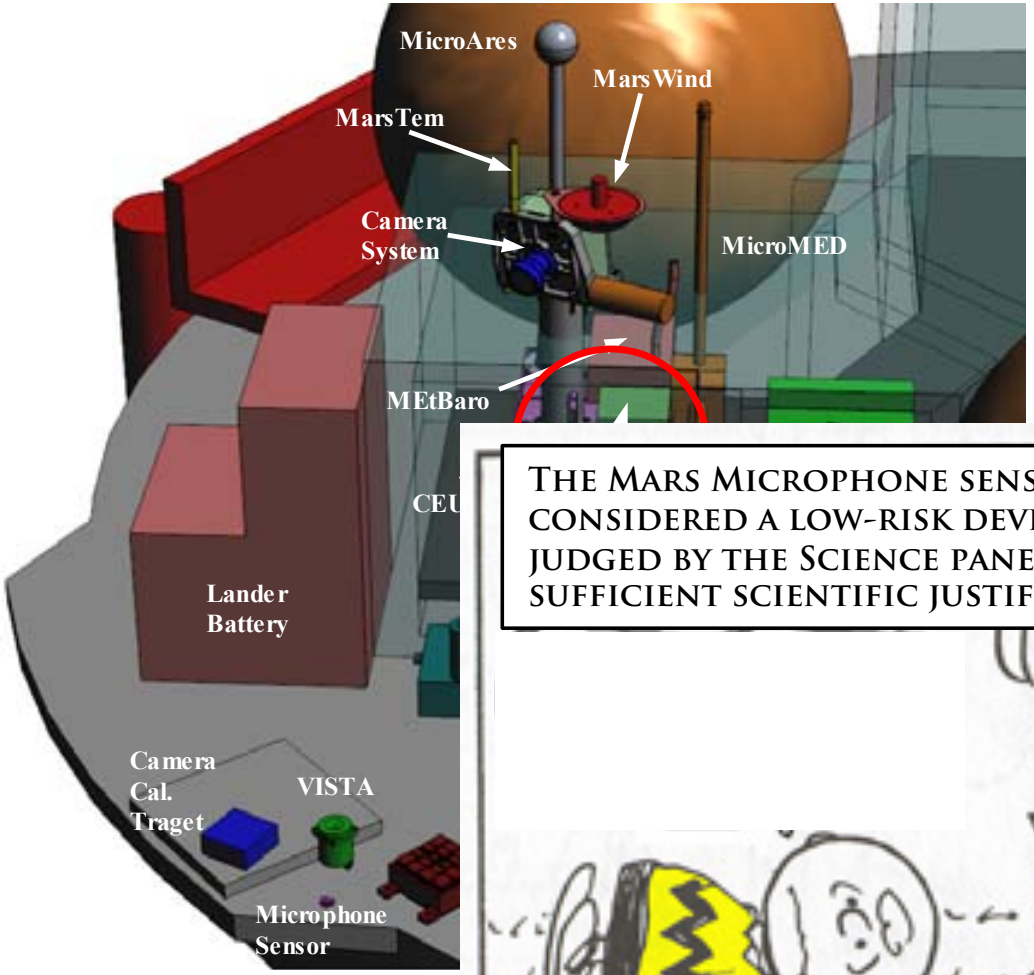
- First Planetary microphone on Huygens
  - Successfully retrieved the descent sounds

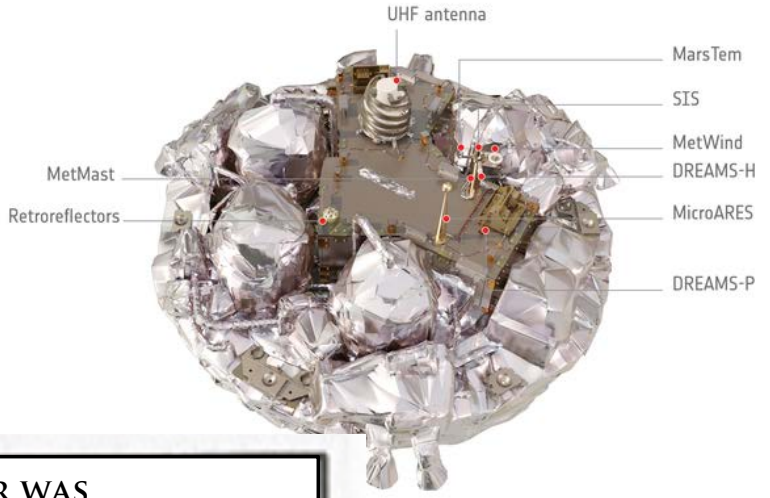
A Short History of Planetary Microphones (2/3)

- 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

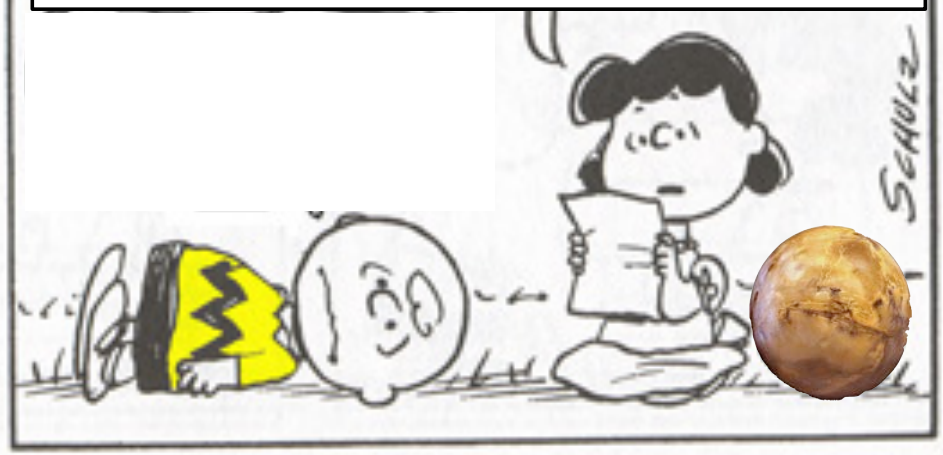
- Third opportunity with Phoenix : sound coupled with Mardi imager (Not used)

A Short History of Planetary Microphones (3/3)

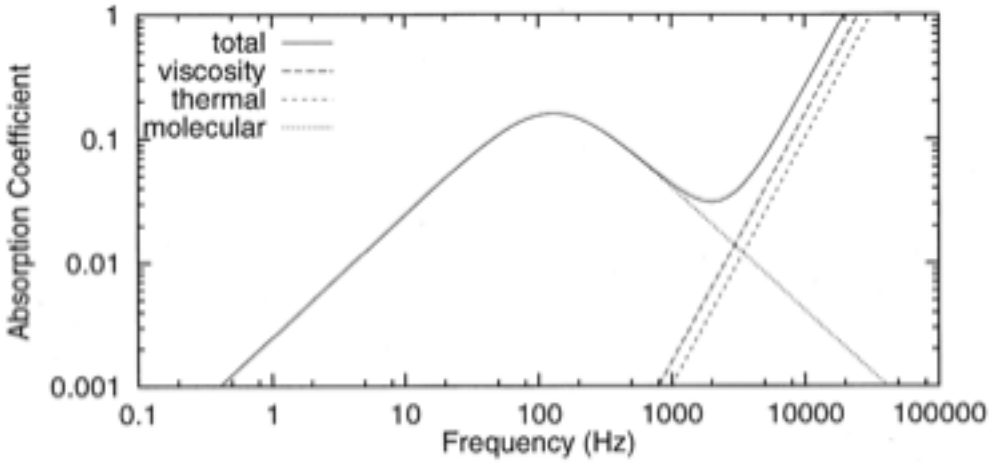




THE MARS MICROPHONE SENSOR WAS CONSIDERED A LOW-RISK DEVELOPMENT, BUT WAS JUDGED BY THE SCIENCE PANEL TO LACK SUFFICIENT SCIENTIFIC JUSTIFICATION

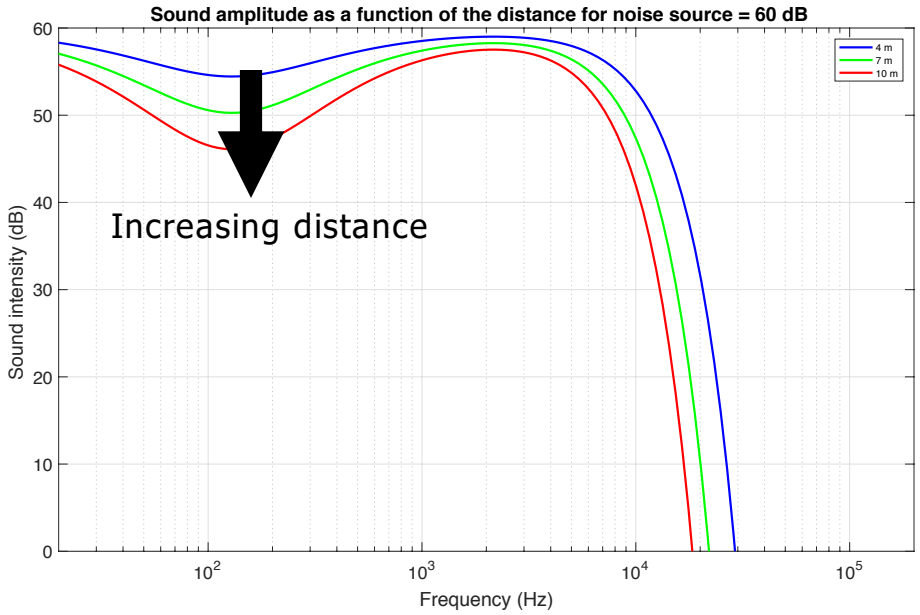


Acoustics on Mars is complicated



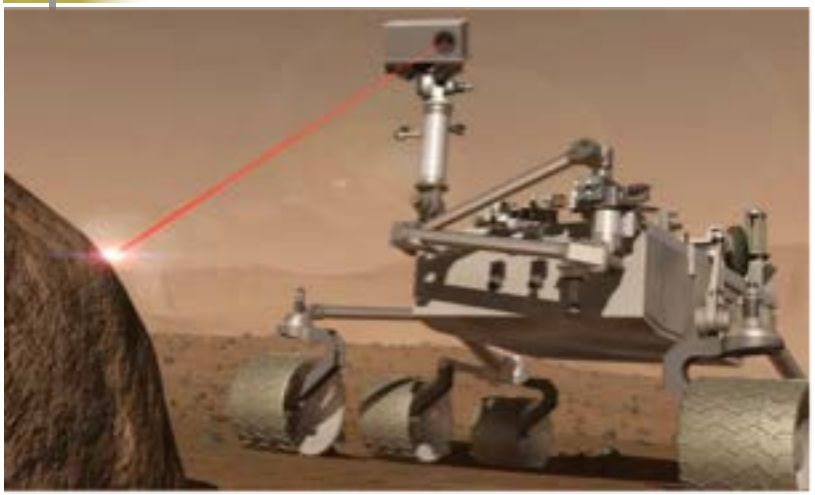
Very strong absorption
Williams (2001)

Sound amplitude vs. distance on Mars

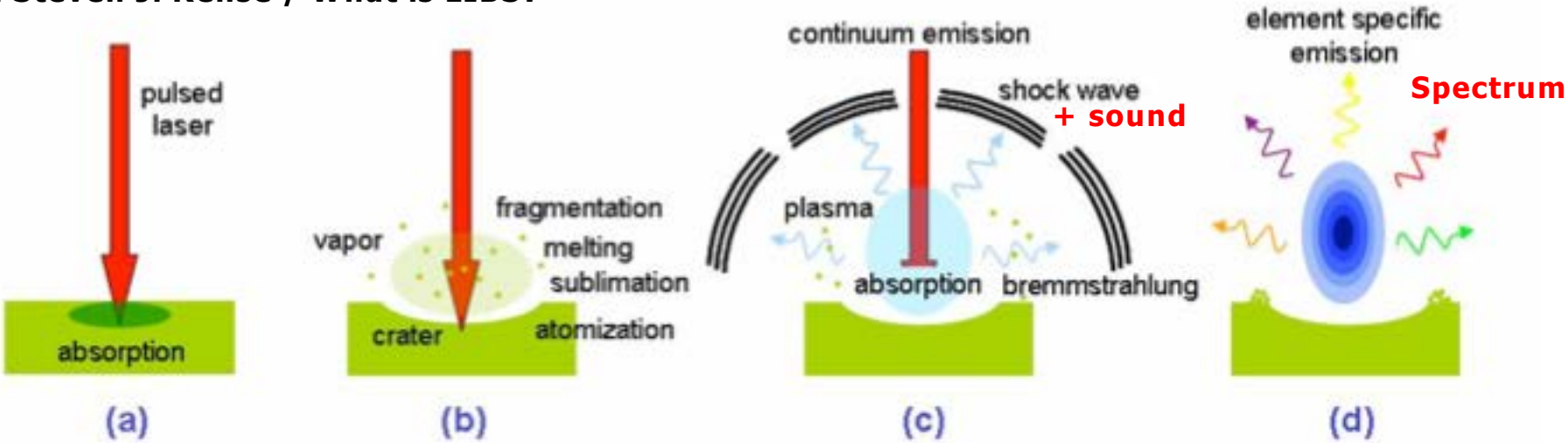


Microphone science goals have to be crystal clear

SuperCam on Mars 2020

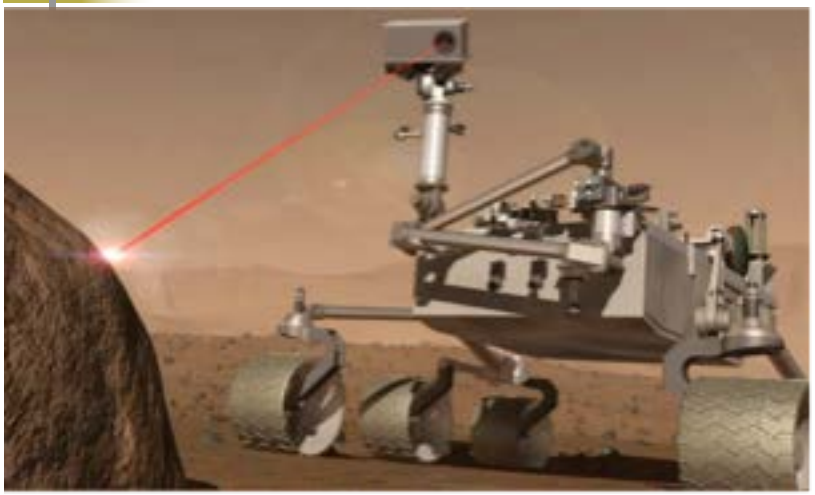


Dr. Steven J. Rehse / What is LIBS?



Schematic of the laser-induced breakdown process.

SuperCam on Mars 2020



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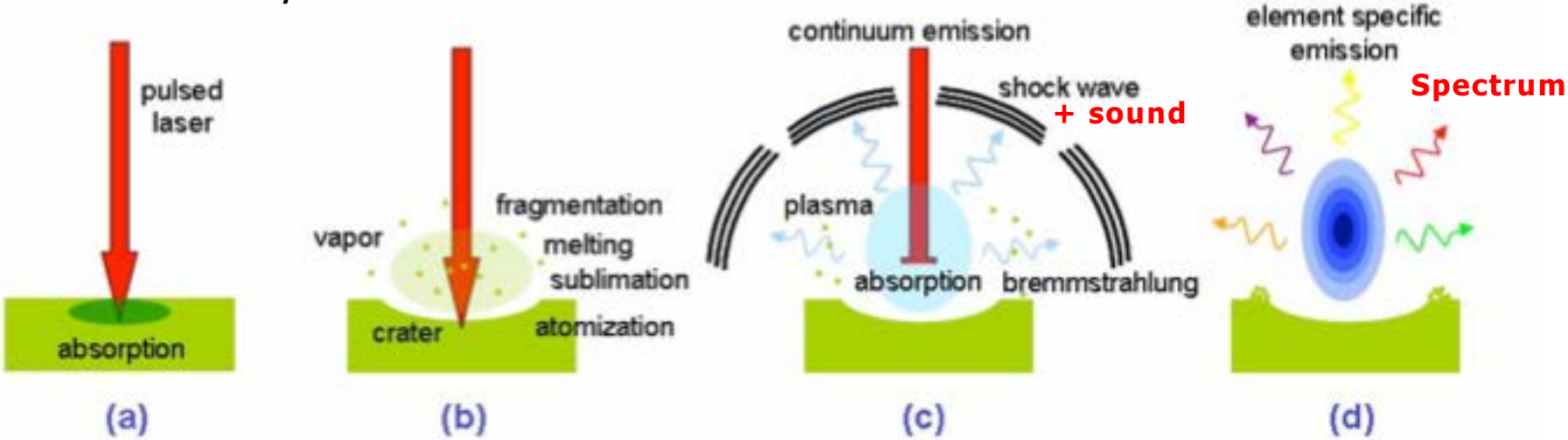
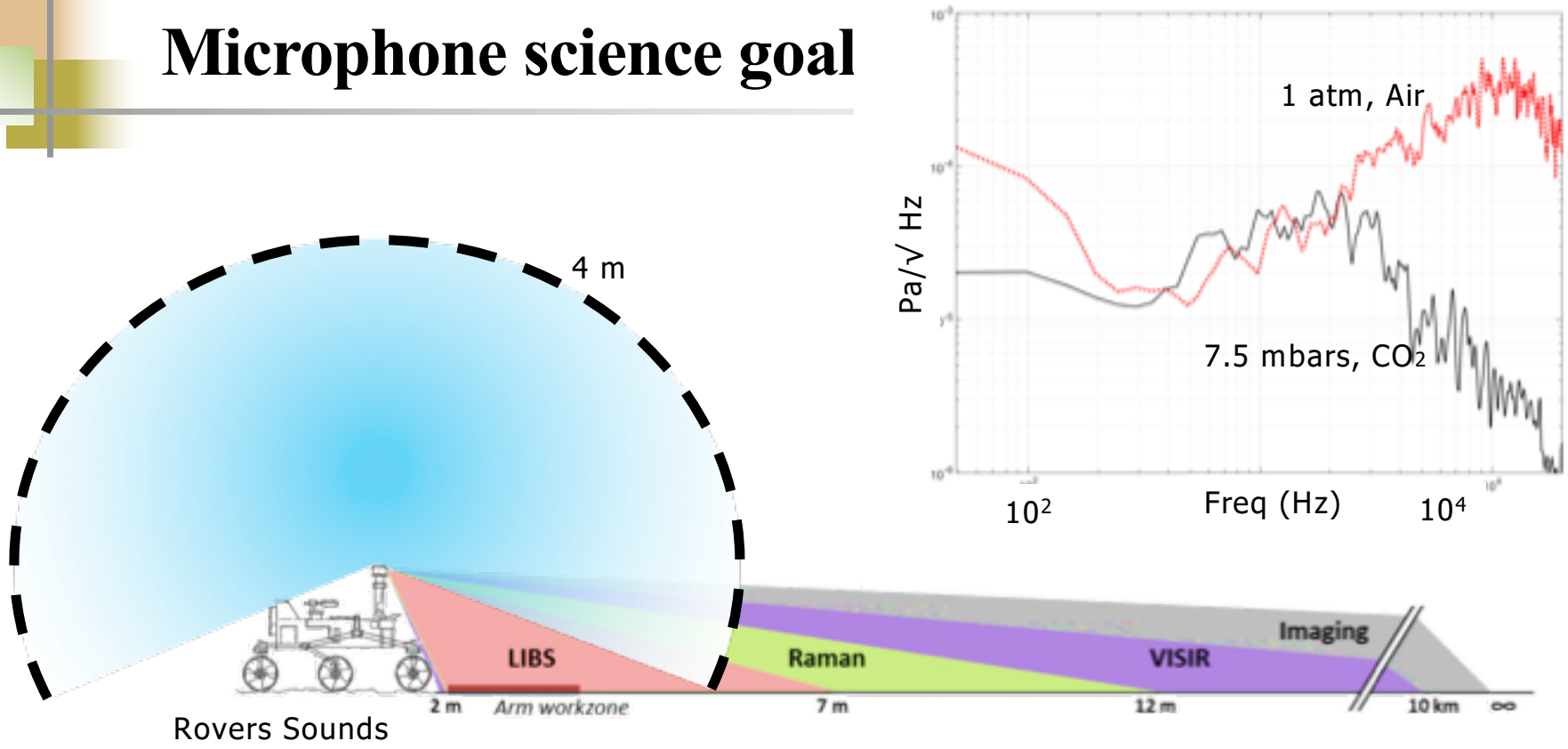


Schematic of the laser-induced breakdown process.

Microphone science goal

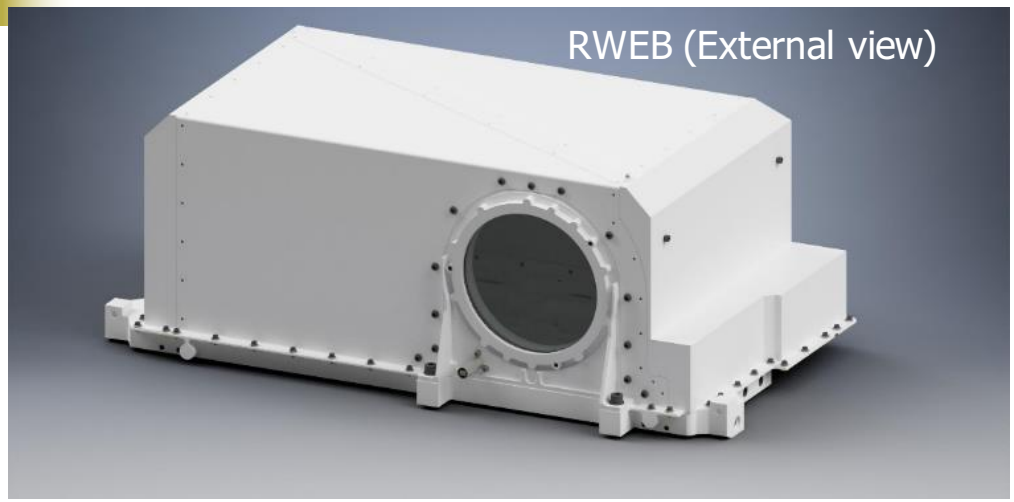


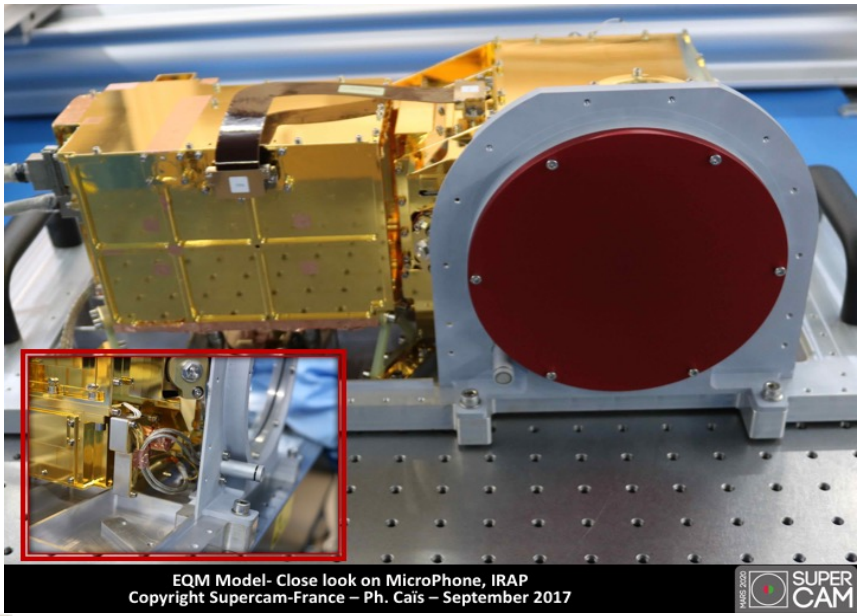
Microphone will record LIBS impacts up to 4 meters

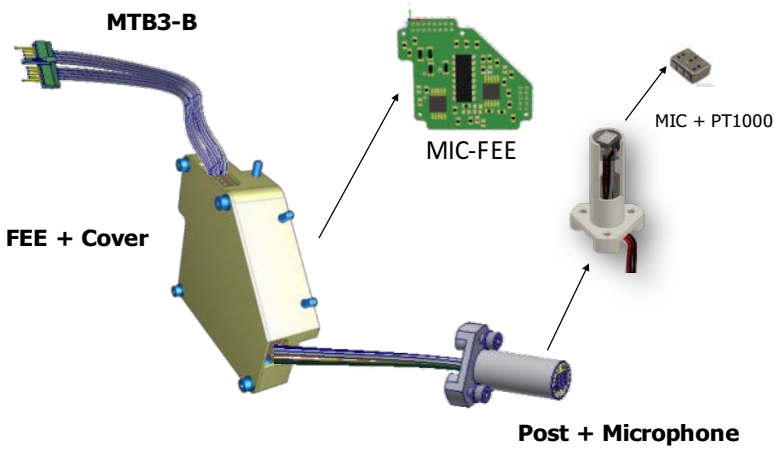
The science objectives of the Mars Microphone are:

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.

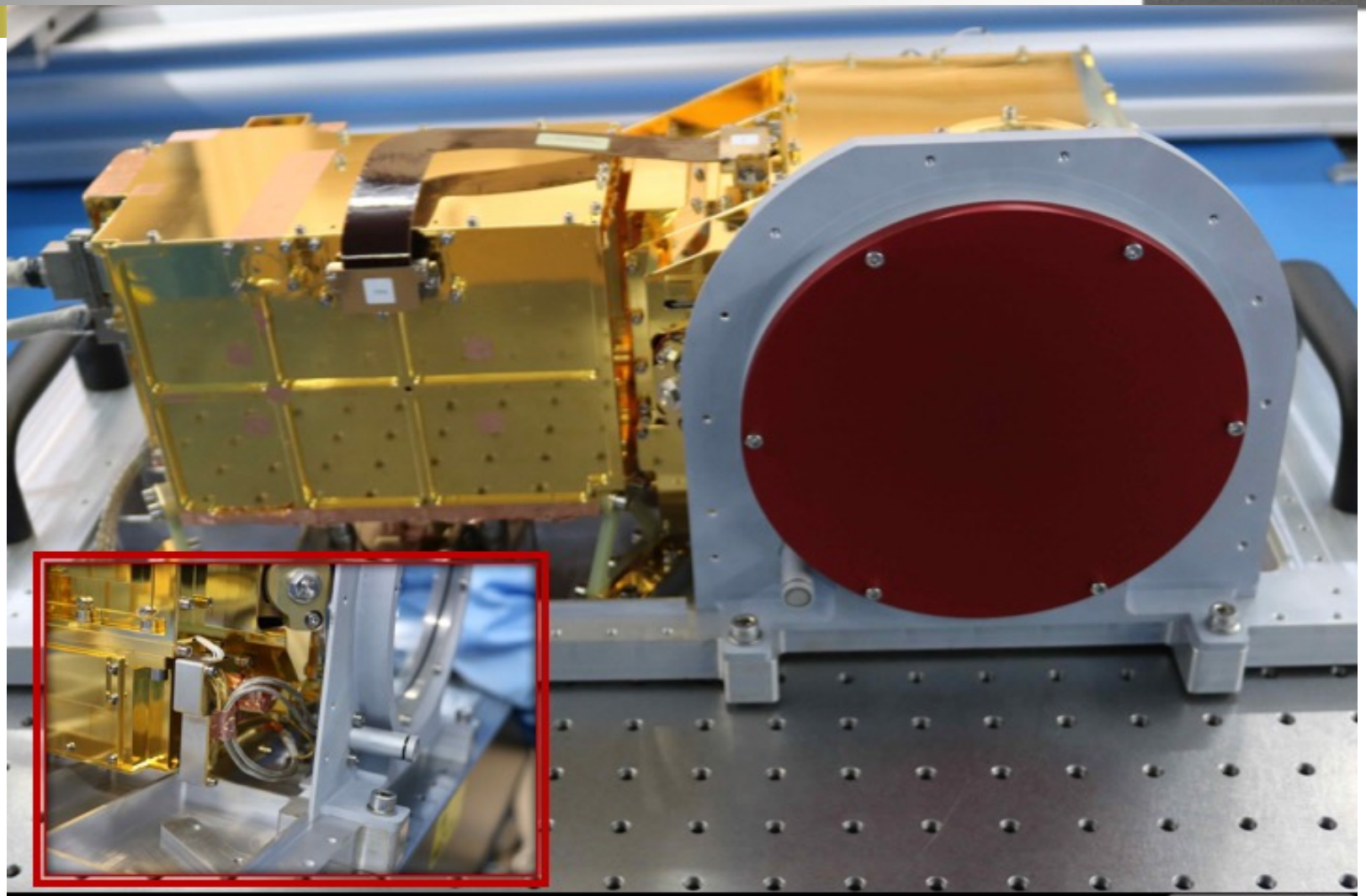
Microphone accommodation







SuperCam EQM Model



EQM Model- Close look on MicroPhone, IRAP
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What can we learn from LIBS acoustics?

ablated mass

distance

$$\Delta p_{max} \approx m_{abl} \cdot 1 / v_{acw} \cdot 1 / r$$

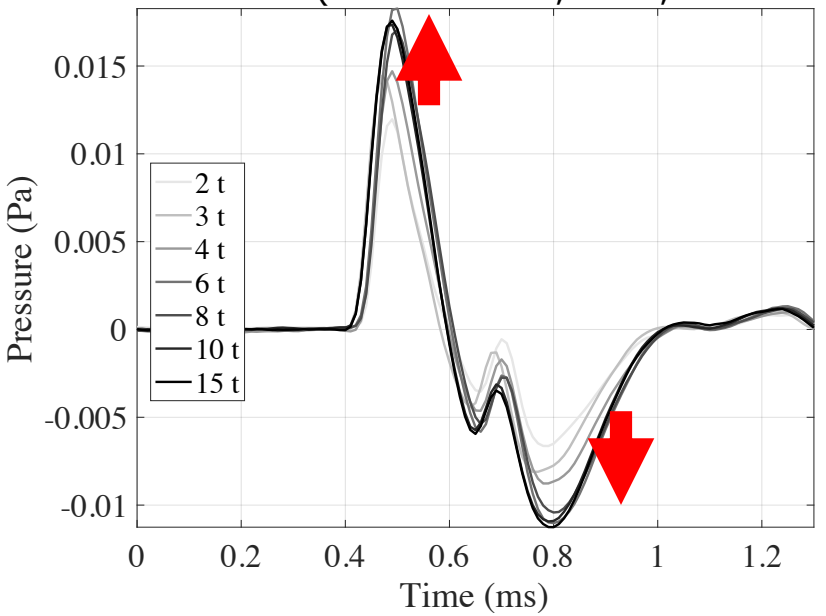
peak-to-peak amplitude of acoustic waveform (pressure gap)

velocity of acoustic wave front

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

The mass ablated is obtained from the acoustic signal amplitude.

(Murdoch et al, 2018, submitted)



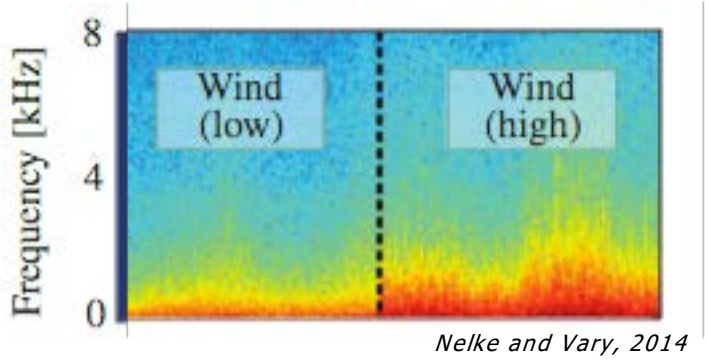
Waveforms of JSC1 targets at different levels of compaction as measured by the microphone at 1.5 m from the targets.

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



Nelke and Vary, 2014

MICROPHONE BANDWIDTH (100 Hz – 10 kHz)

LIBS acoustics (0.5-5 kHz)

Rover activities (1-10 kHz)

Vortices (10 Hz to 1 kHz) *for vortex diameters 1 – 30 m*

Aeroacoustics (1 Hz to 500 Hz) *for wind speeds < 20 m/s, object sizes > 1 cm*

Saltation (5-10 kHz)

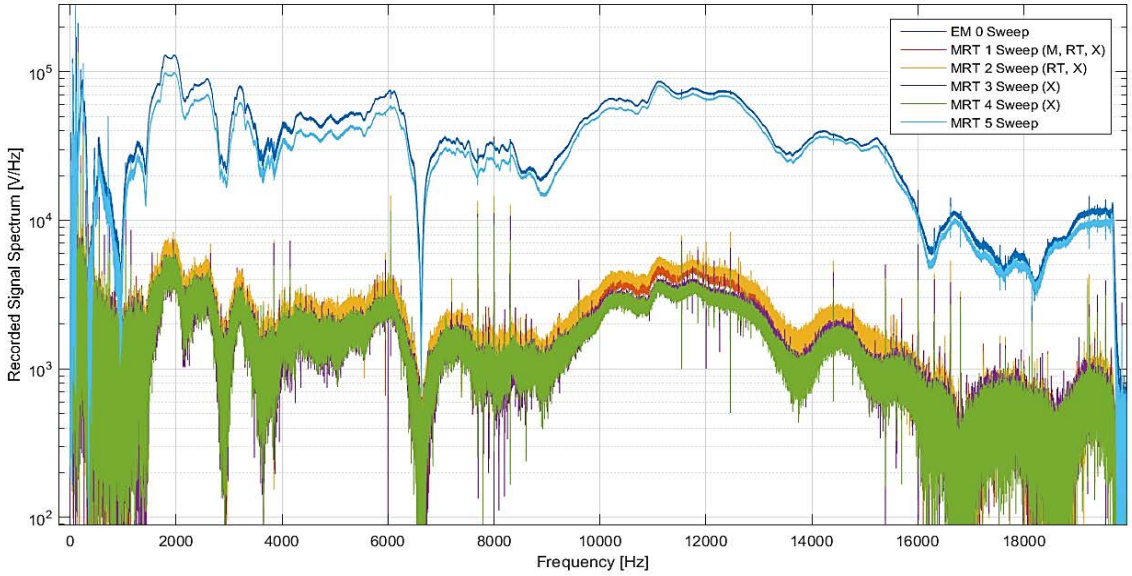
Dynamic pressure (all frequencies) *but drops off rapidly with increasing frequency*

10^0 10^1 10^2 10^3 10^4

FREQUENCY (Hz)

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

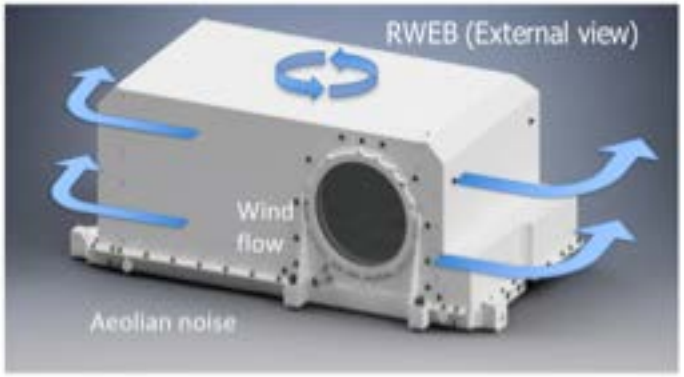


Blue curves (light and dark): no X-ray inspection
Other curves: X-ray inspection

Calibration: End to end

Objectives:

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



Arhus wind tunnel, Denmark

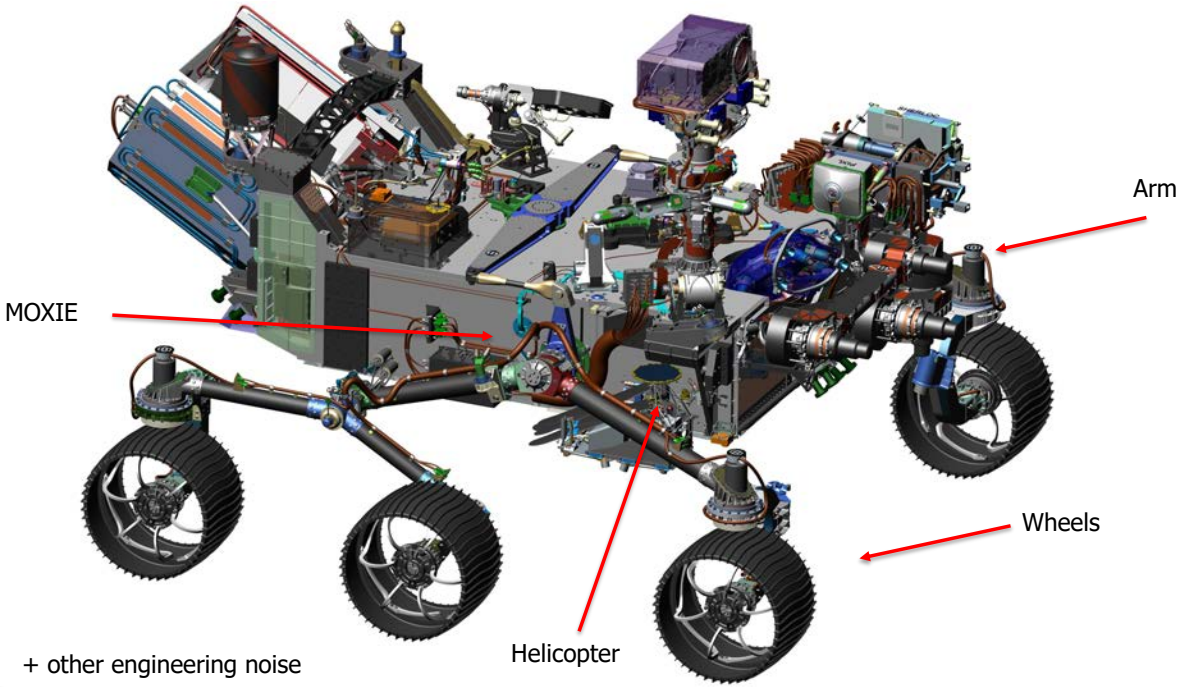
Test details:

- 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

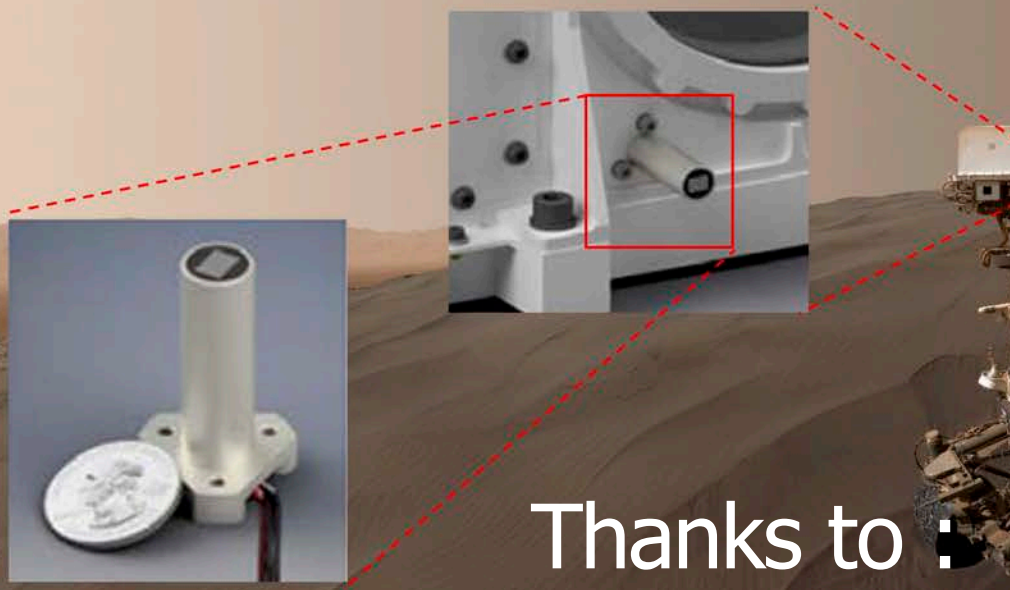
Aarhus end-to-end validation tests

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



Thanks to :
CNES
ISAE-SUPAERO
IRAP
LANL
JPL

Schematics from N. Striebig (OMP/GIS) and background Curiosity selfie at Bagnold dunes