THE MARS MICROPHONE 2016 EXPERIMENT : A UNIQUE E/PO OPPORTUNITY

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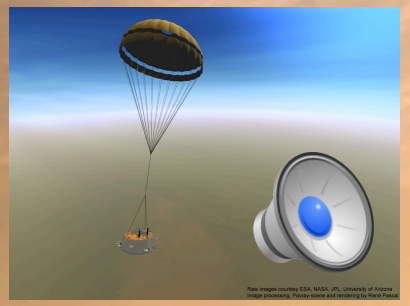
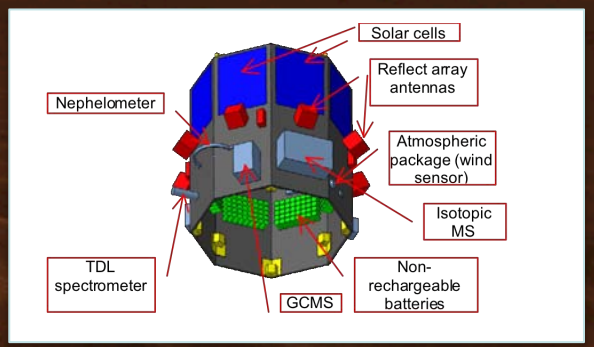
[(3)]See http//bit.ly/MM2016 for full team description

A Short History of Planetary Microphones



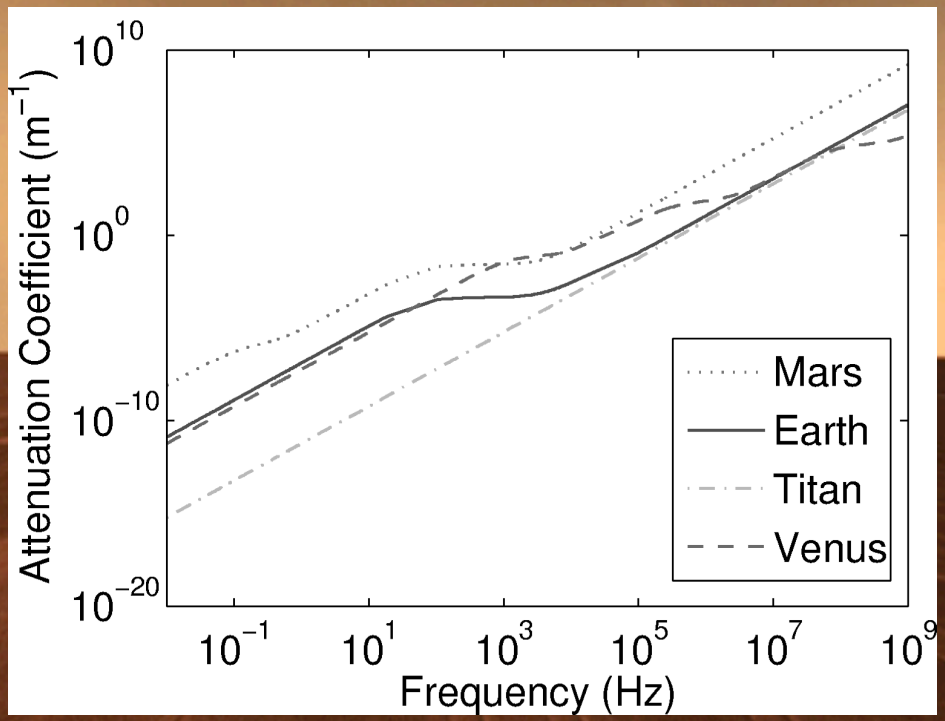
- First Planetary microphone on Huygens
  - Successfully retrieved the descent sounds
- Second opportunity on Mars Polar Lander
  - MM Development up to FM by Greg Delory (UC Berkeley)
  - Support by the Planetary Society
  - Failed landing of MPL

- Third opportunity with Phoenix : sound coupled with Mardi imager (Not used)
- Opportunity on NetLander
  - Stereo – Implementation on PanCam.
  - Development stopped with NetLander
- European Venus Explorer



Can you hear something on Mars ?

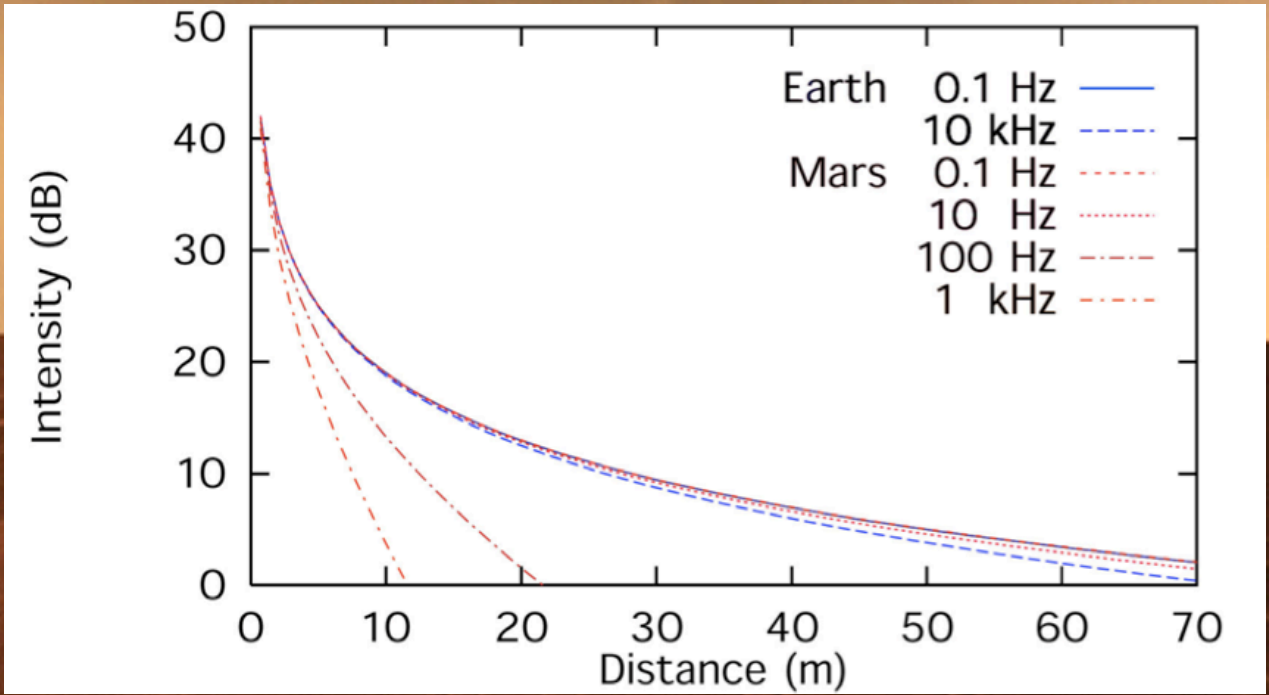
- Sound behaviour at the Martian surface is surface is expected to be very similar to the Earth stratosphere, with an average atmospheric pressure between 6 and 8 mbar and a mean temperature about 240 K



Adapted from Petculescu & Lueptow (2007)

Sounds on Mars ?

- Sound behaviour at the Martian surface is surface is expected to be very similar to the Earth stratosphere, with an average atmospheric pressure between 6 and 8 mbar and a mean temperature about 240 K



Attenuation of sound on Mars and Earth for spherically spreading sound wave.

Infrasounds propagate well on both Mars and Earth

Sounds that can be recorded

- Sounds likely to be heard on Mars
  - Aeolian tones (Curle, N., 1955)

$$f_{aeolian} = 0.2\frac{U_{Wind}}{D_{Lander}} \quad [E1]$$

Wind speed

Lander Diameter

  - Intensity of the sound

Atmosphere density

$$I(r) = \rho_0 \frac{U^6 D^2}{c^3 r^2} \quad [E2]$$

Sound speed

Distance to the source

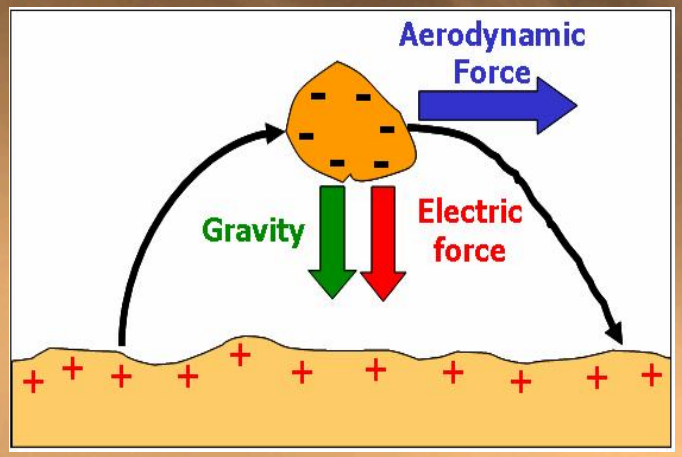
  - Calibration in a Martian wind tunnel proposed to secure amplification loop.

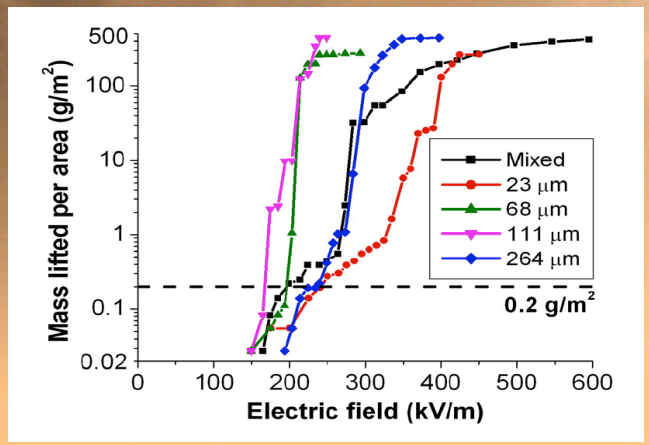
Sounds that can be recorded

- Saltation Noise : counting of particle impacts : constraints on dust flux

Sounds that can be recorded

- Saltation Noise : counting of particle impacts : constraints on dust flux

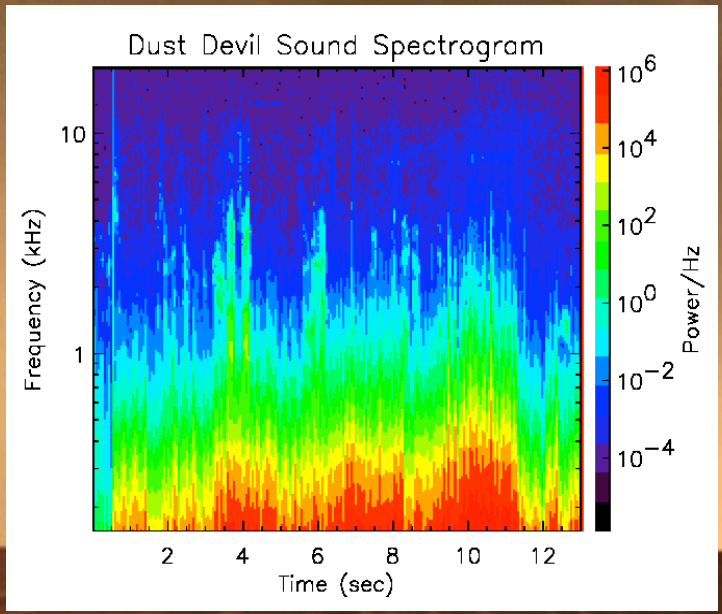




Berthelier, 2000

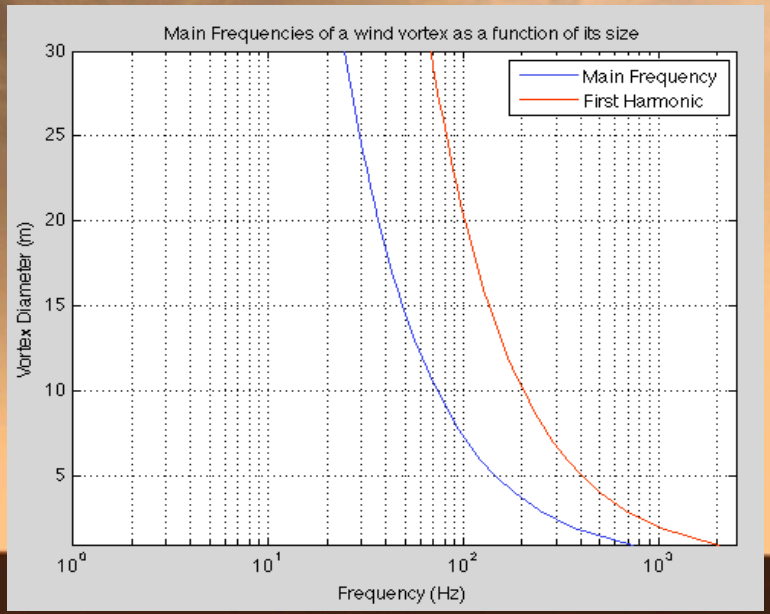
Sounds that *could* be recorded

- Signals likely to be recorded: wind vortex associated noises



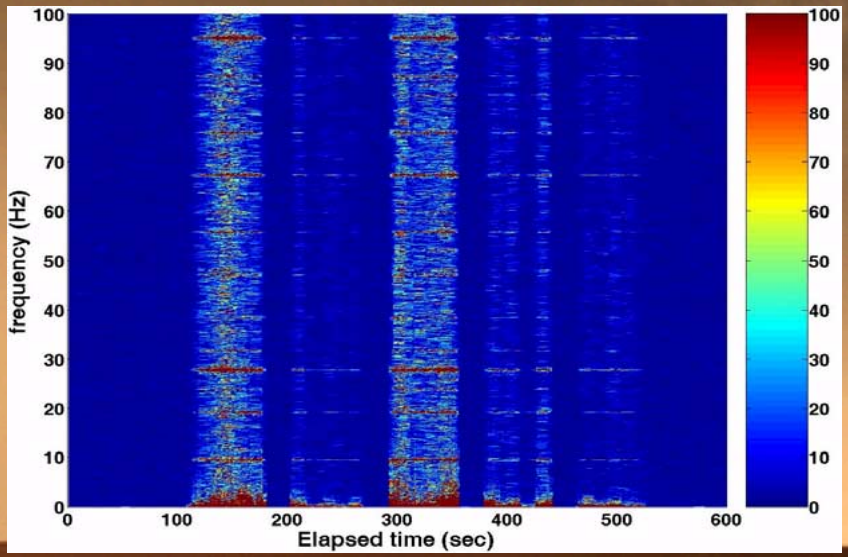
Sounds spectrogram of a terrestrial dust devil obtained with a pair of stereo binaural microphones during field tests.

Delory, 2010

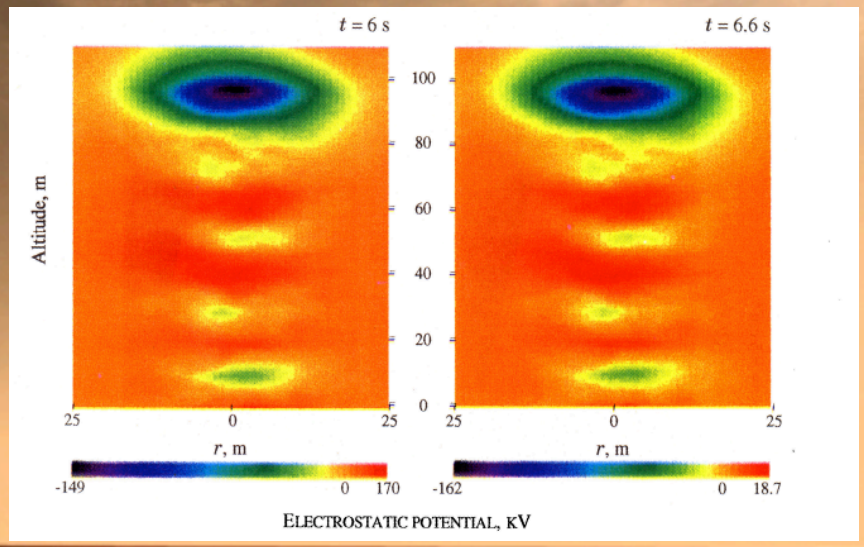


Main frequency of a wind vortex as a function of its size

Sounds that *could* be recorded

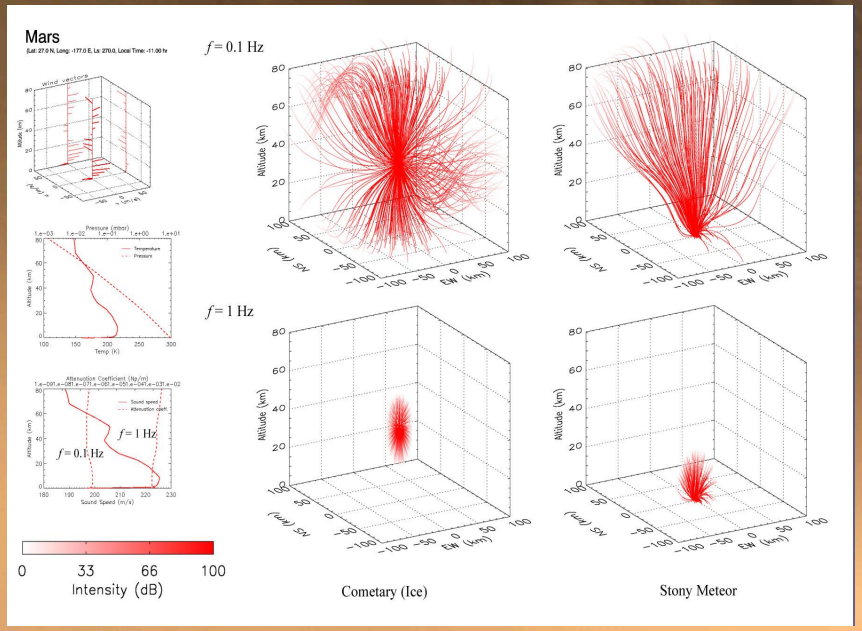


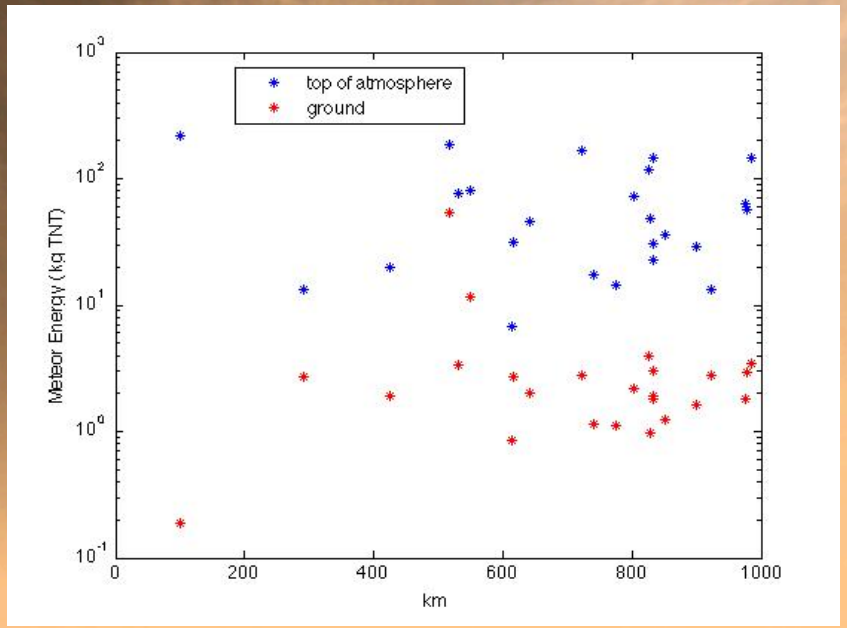
Emission of non-thermal microwave radiation by a Martian dust storm (Ruf C. et al (2009))



Simulation of impact electrification in a 'dust devil' *(Melnik and Parrot, 1998 Zhai et al., 2006, Farrell et al., 2003 & 2006)*

Sounds that *could* be recorded





Simulation of bolide entry acoustic counterpart in the Martian atmosphere [Williams, J.P, 2010] and typical distributions of the largest impacts as a function of distance during 4 weeks (to take into account the statistical dispersion), following realistic statistical modelling. The amount of impacts during one week is one fourth and typically 4-6 at less than 1000kg will have energies equivalent to several tens to a few 100 kg of TNT

Mars Microphone Objectives

- Science floor
  - Involvement of student teams
  - First sounds recorded on Mars

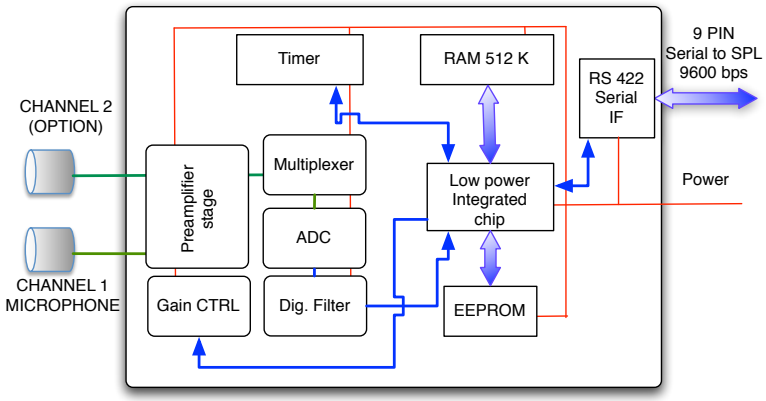
- "Full Science"
  - If stereo implementation
    - Contribution to dust devil science (retrieving of devil direction)
    - Complementary instrument to atmospheric science
  - Dust Storm
    - Recording of thunder ?
  - Evaluation of particle impacts on EDL (depends on accommodation)

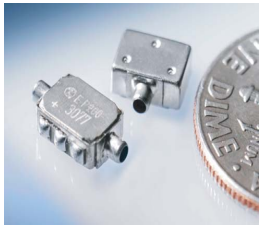
Science Matrix

Science Objectives (Top-Level)	Primary Scientific Measurement Requirements	Instrument Functional Requirements	Mission Functional Requirements
Obj. #1: Retrieve sounds from Mars	Acoustic Environment [20-20000] Hz	Sound recording Compression	Microphone recording operation during 1 to 4 min TBC
Obj. #2: Dust Properties	High Frequency dust impacts on EDL monitoring [20-20000] Hz	Sound recording Compression	Microphone recording operation during 1 to 4 min TBC
Obj. #3: Wind vortex and Dust devils properties	Vortex Wind Spectrum [20-20000] Hz Differential acoustic amplitude and phase	Stereo Sound recording Compression	Microphone recording operation during 1 to 4 min TBC Widest possible MIC location accommodation
Obj. #4: Electrical Activity, Meteoritic impacts	Sound measurement [20-20000] Hz Sound Spectrum	Sound recording Compression Recording triggered by threshold event	Microphone operation during 2 min TBC after a triggered event
Obj. #5: Transient and other EDL noises	Sound measurement [20-20000] Hz	Sound recording Compression	Microphone on during Entry, Descent and Landing

Investigation concept

- Proposed design mainly based on COTS
  - Heritage from previous versions of Mars Microphone
  - Sound recording chip with two channels and built-in compression
  - Qualified COTS for microphone element
  - 50g, 150 mW peak power.
  - Backup TRL 9 (previous H/W)

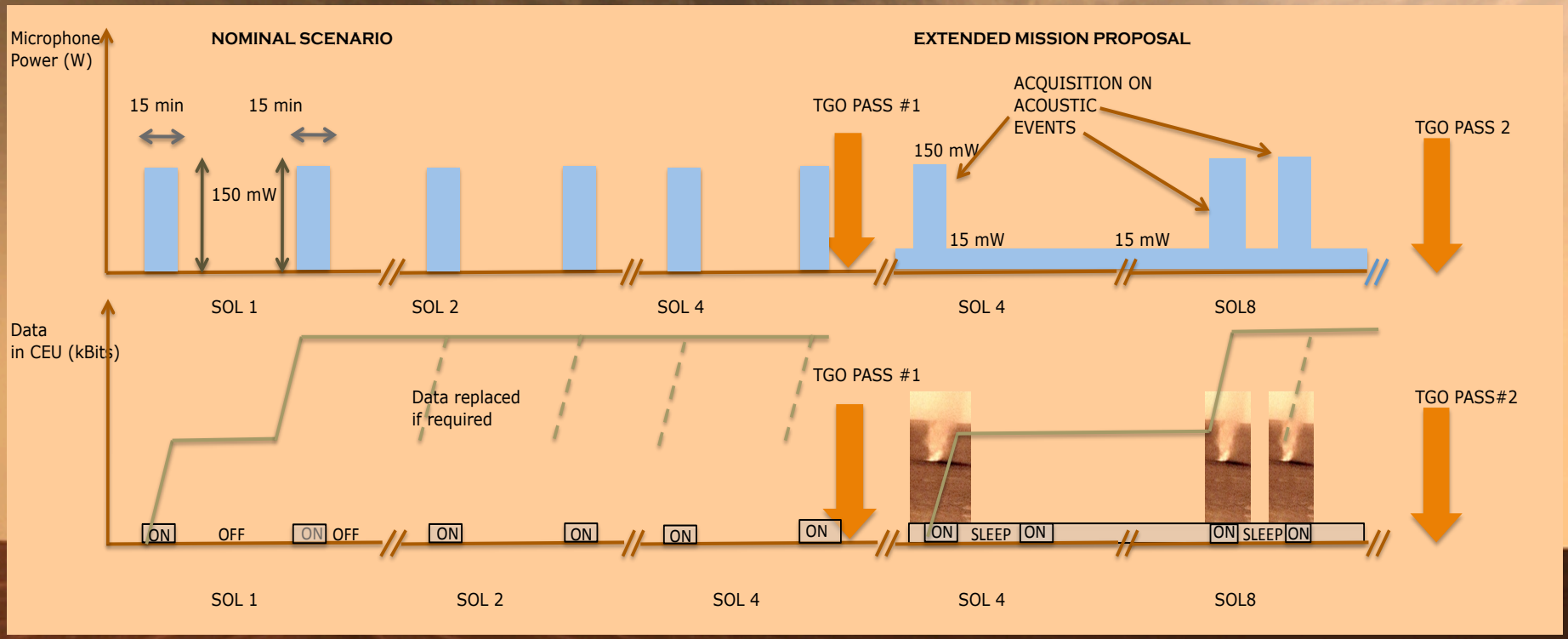




COTS microphone sensor

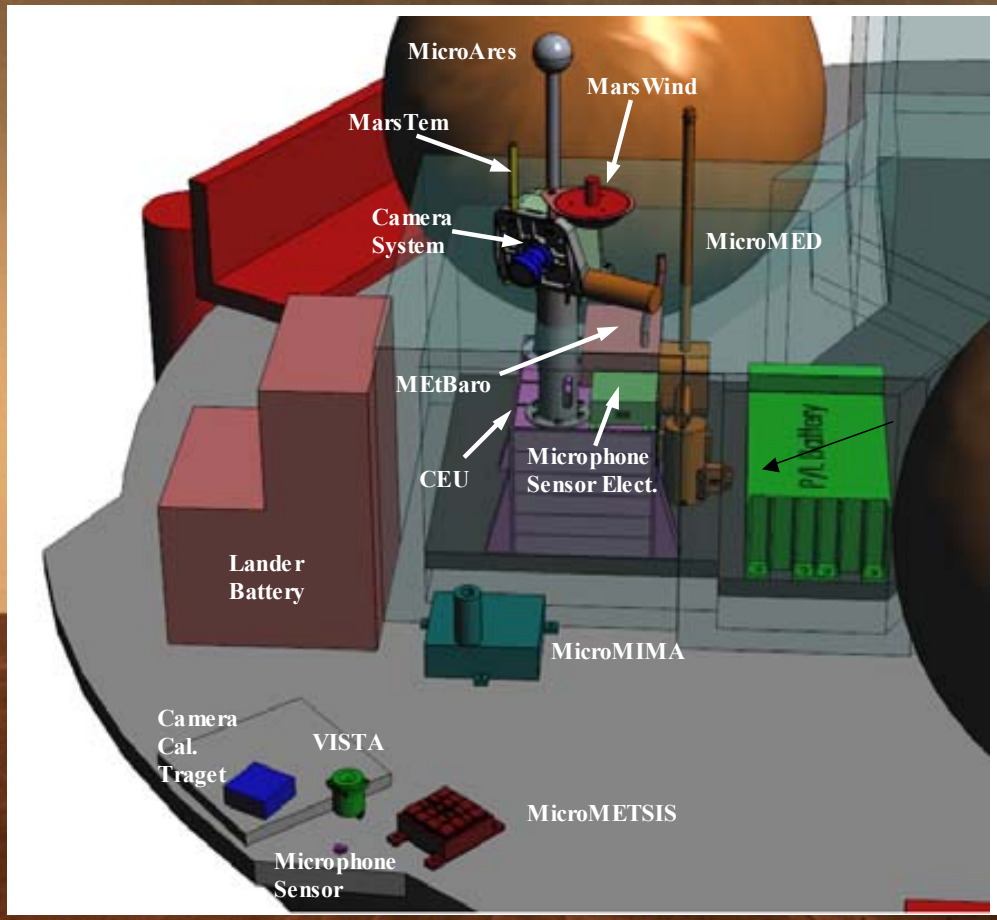
Development board

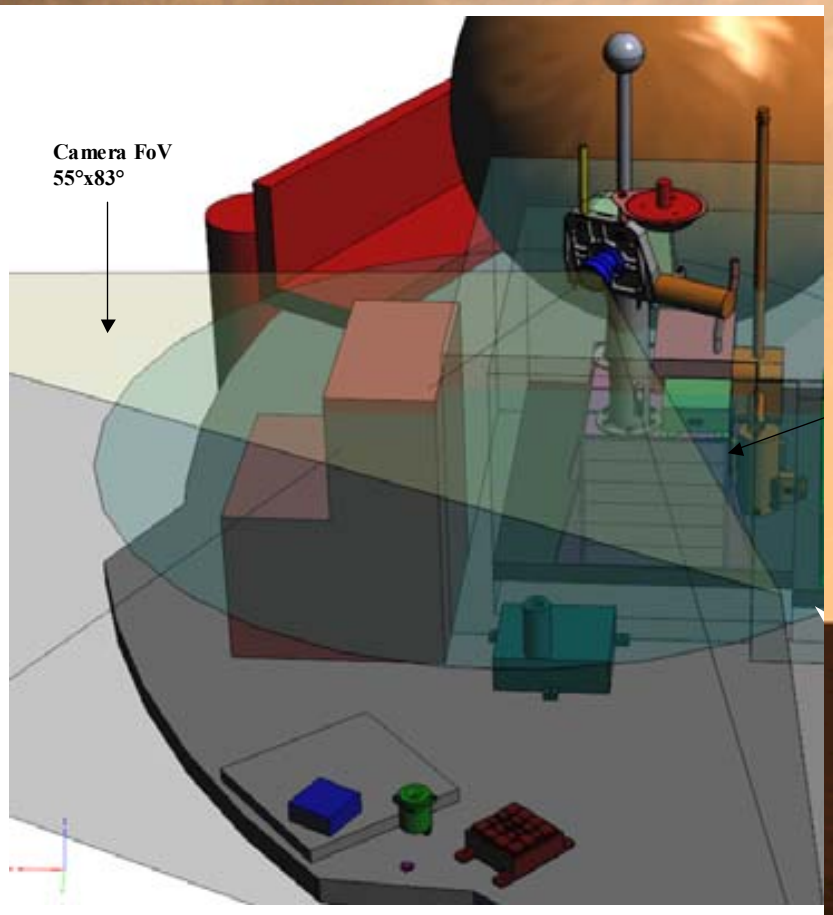
Observing profiles



300 mW.h during 4 days - 2700mW.h for the extended mission

SPL Proposed Accommodation





Organization

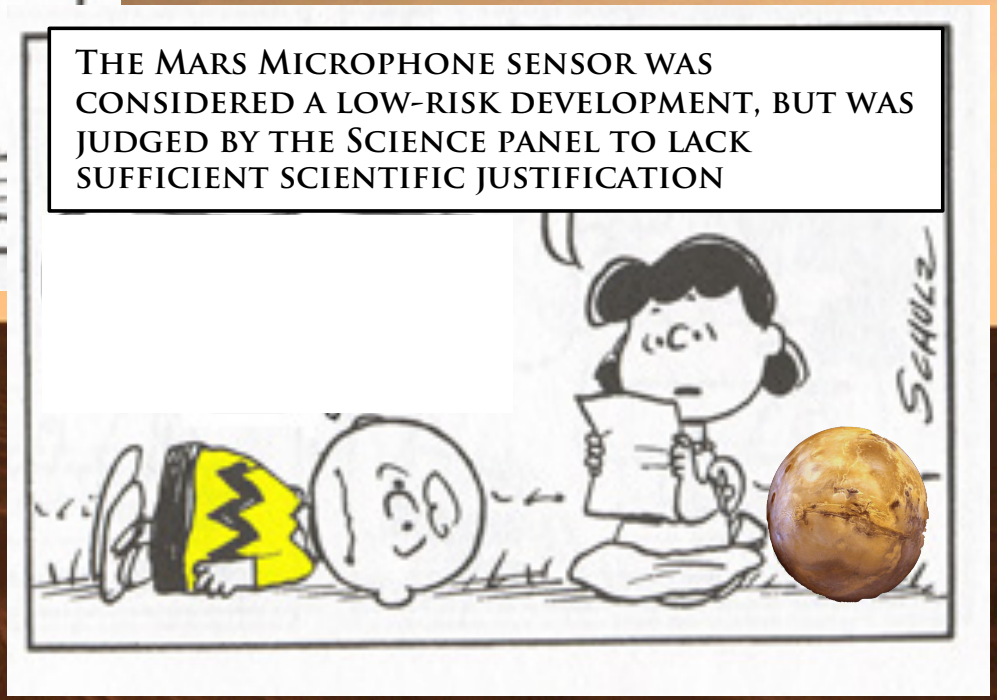
Institution	Name	Funding
Hardware providing institutions	Institut Supérieur de l'Aéronautique et de l'Espace	Manpower
	Space Science Laboratory of Berkeley	Manpower
Funding partners	CNES	Hardware
	The Planetary Society	Microphone Sensor
Co-I Institutions	Co-I institutes	Manpower associated to science contributions
Student Project Partners	Institut Supérieur de l'Aéronautique et de l'Espace Campus Spatial Paris Diderot University of Padova University of Aachen Ecole Polytechnique de Louvain	Manpower and ground testing facilities
Outreach partners	The Planetary Society Europlanet	

Student Involvement

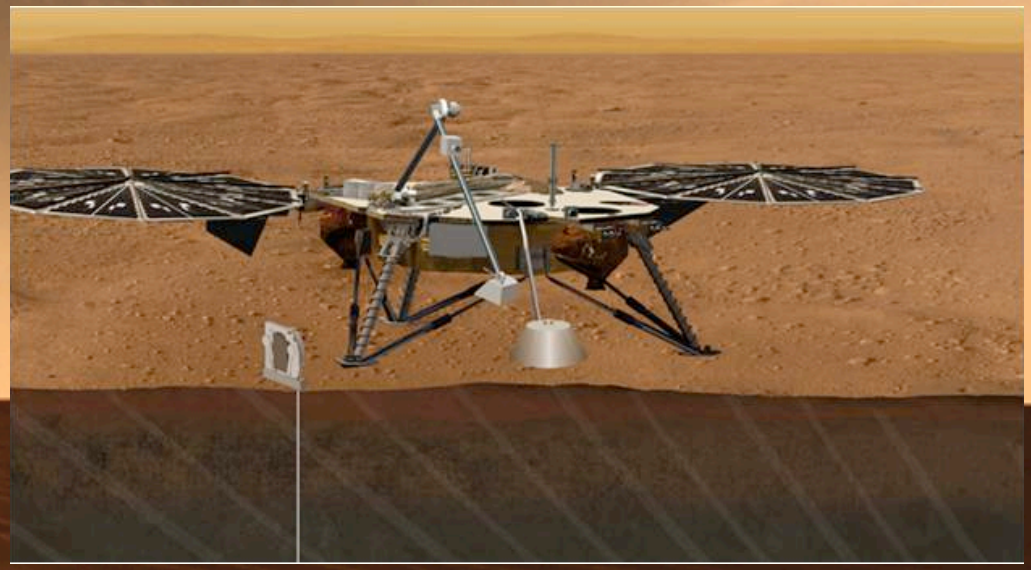
- Consortium led by ISAE, with UC Berkeley and The Planetary Society

Activity	Level of student involvement			Comment
	Design	*Contribution*	*Witness*	
E-box mechanical design	X			Simple mechanical box
Environment test		X		Contribution to test setup and reports
Ground calibration		X		Analysis of acoustic environment in Martian chamber
Operations			X	Twitter, blog
Science Operations		X		Duplication of real data analysis
Data analysis		X		Duplication of data analysis
Outreach	X			Younger kids mentoring

Selection Outcome



A way forward ?



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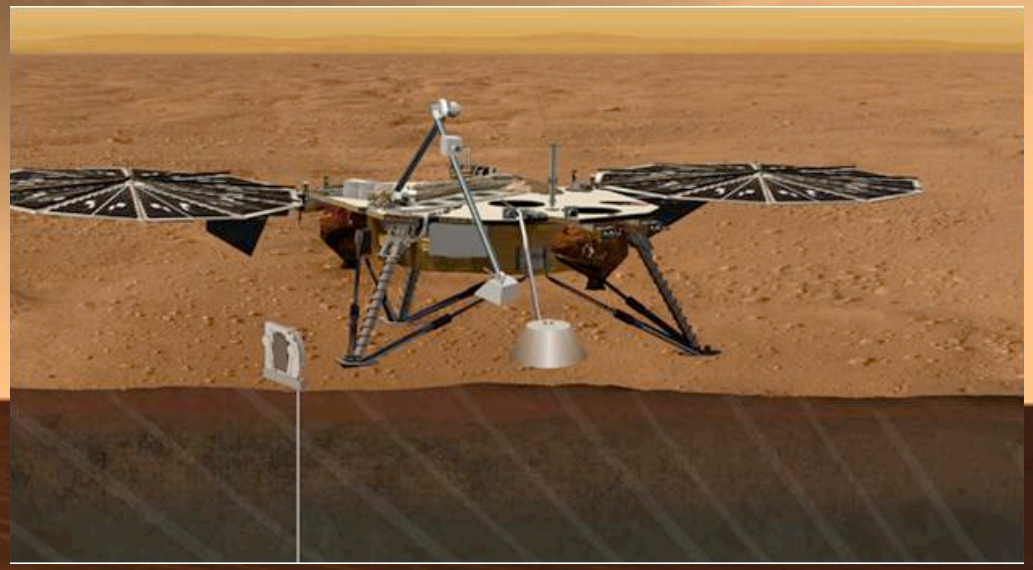

Stay Tuned !