EPSC Abstracts
Vol. 11, EPSC2017-239-1, 2017
European Planetary Science Congress 2017

Microphone characterisation for the Mars 2020 rover

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Abstract

We have used the Aarhus planetary simulator facility to test the Mars 2020 rover microphones in a fully representative environment. Wind characterisation experiments were performed in addition to the first ever tests of a LIBS acoustic measurement in a Martian environment at long range.

1. Introduction

The SuperCam instrument suite onboard the Mars 2020 rover will include the Mars Microphone (provided by ISAE-SUPAERO in France) to support the Laser Induced Breakdown Spectroscopy (LIBS) investigation of soils and rocks on Mars [1,2]. The primary purpose of the LIBS instrument is to investigate at remote distances the elemental composition of Martian rocks, thanks to a pulsed laser and the spectroscopic analysis of the plasma that is created when the laser beam is focused to achieve >1 GW/cm2 irradiance. The LIBS plasma bubble expands in a few hundreds of ns, and therefore generates a pressure shock wave. The overall intensity of the resulting acoustic wave is proportional to the laser irradiance and to the mass of ablated materials [3,4] thus revealing some unique physical properties of the targets probed with LIBS such as the target hardness and other mechanical properties that are otherwise unknown at remote distances [5].

In order to satisfy the SuperCam requirements, the Mars Microphone must be able to record audio signals from 100 Hz to 10 kHz on the surface of Mars, with a sensitivity sufficient to monitor a LIBS impact at distances up to 4 m. In addition to supporting the LIBS investigation, the Mars Microphone will also contribute to basic atmospheric science studies such as studying the Martian wind properties, convective vortices and dust devils [e.g., 6]. To meet these requirement, a condenser microphone has been selected and the amplification gains and dynamics of the instrument have been carefully chosen. Therefore, realistic testing in Mars conditions is essential given the strong acoustic attenuation at high frequencies due to the low surface pressure and the difference of acoustic impedance with respect to Earth [7].

2. Aarhus Wind Tunnel Tests

The tests were performed using the Aarhus Wind Tunnel Simulator II (AWTSII) [8] in Denmark over the course of three days in January 2017. AWTSII is a climatic chamber housing a recirculating wind tunnel. The cylindrical chamber has a 2.1 m inner diameter, and is 10 m in length. The tests were performed at 6 mbar of CO_2, achieved by evacuating the chamber and then repressurizing with CO_2. The facility is fitted with a suite of environment sensors (temperature, pressure, humidity, …) in addition to an in-situ webcam.

The first set of tests focussed on the wind speed characterisation to evaluate a possible aeroacoustic saturation of the microphone. Wind speeds of 2-10 m/s were generated. There were five microphones inside the chamber: two Mars Microphone Engineering Models (EMs) without front end electronics (FEE), two Mars Microphone EMs with FEE, and a ½ inch reference microphone. One of the Mars Microphones was attached to the Structural and Thermal Model (STM) of the SuperCam thermal enclosure. See Fig. 1.

The second set of tests focused on performing the first ever tests of a LIBS acoustic measurement in a Martian environment at long range. A portable LIBS was used outside the chamber and was fired through a 8 mm thick chamber window onto a small aluminium target. Table 1 gives the characteristics of both the portable LIBS and the SuperCam LIBS. For these tests the 5 microphones were all orientated towards the LIBS target with two different source-microphone distances: 1.2 m and 4 m.

Table 1. Comparison of the characteristics of the portable LIBS used in these experiments and the SuperCam LIBS

	PORTABLE LIBS	**SUPERCAM LIBS**
Laser wavelength	1064 nm	1064 nm
Pulse duration	5 ns	4 ns
Laser energy	40 mJ	24 mJ
Spot diameter at target	400-500 µm	300-600 µm
Incident angle of laser onto target (from normal)	~80°	0° (calibration targets); 45° (typical rock targets)

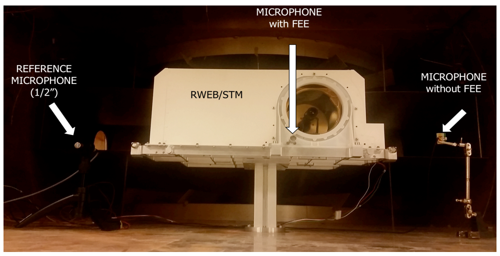

Figure 1. Test configuration for the wind characterization tests. At one end of the tunnel there was a Mars Microphone EM with FEE attached to the SuperCam thermal enclosure STM (RWEB/STM in figure), a Mars Microphone EM without FEE, and a reference microphone. At the other end of the tunnel there was a Mars Microphone EM with FEE and a Mars Microphone EM without FEE (not shown here).

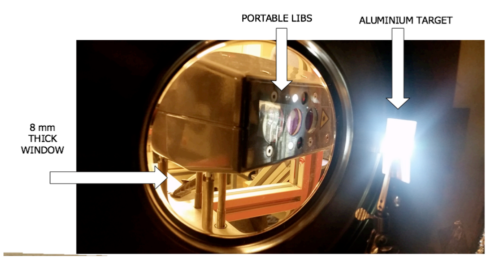

Figure 2. The LIBS experiment configuration.

3. Results and Conclusions

We have used the Aarhus Mars chamber to test the Mars Microphone in a fully representative environment before flight. The tests performed were successful, with no saturation of the instrument under Martian wind and a recording of the LIBS signal at 4 meters with a signal-to-noise ratio consistent with the requirements. The wind characterization tests demonstrated that the microphone signal RMS varies with the square of the wind velocity, indicating that the Mars Microphone may be used for wind speed determination. However, further experiments are required to understand the influence of the incident wind direction. The large size of the chamber also ensured that we could perform the acoustic measurements at the required distance of 4 m from the LIBS target (Fig 3). Now that the feasibility of the measurement has been demonstrated, further testing will be performed to provide a detailed characterization of the LIBS acoustic emission from various rock samples in the Martian environment.

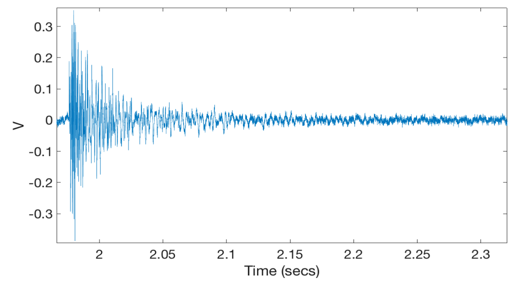

Figure 3. LIBS acoustic signal recorded by the EM of the Mars Microphone in 6 mbar, CO2 at 4 m from the source.

Acknowledgements

We gratefully acknowledge funding from the French space agency (CNES) and from ISAE-SUPAERO.

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