Europlanet TA Scientific Report

PROJECT LEADER Andrés Russu Berlanga

Project number: YY-EPN-XXX
Name: Exomars Dust Sensor 22 Characterization
Home Institution: Carlos III University of Madrid
TA Facility visited: Aarhus University Planetary Environmental Facility

Project Title:

Scientific Report Summary.
(plain text, no figures, maximum 250 words, to be included in database and published)

The Dust Sensor (DS'22) is designed to measure the parameters that determine in situ the size distribution of suspended dust on the surface of Mars. The sensor module is composed of an IR source and two IR detectors based on Lead Sulphide (PbS) and Lead Selenide (PbSe) active elements. These materials are defined by the integration of two spectral filters, band 1 operates in the range 1-3 µm (PbS), and Band 2 operates in the range 3-5 µm (PbSe). The Dust Sensor is part of the Radiation and Dust Monitor (RDM), one of the atmospheric devices of the METEO instrument that will be launched on the Exomars'22 mission led by ESA,

The use of the DENMARK - AU Planetary Environmental Facility is a unique opportunity to obtain experimental measurements in a reproduced condition found at the surface of Mars. The tests campaign has been developed for wind speeds of 2, 7, and 13 m/s; DS'22 has been tested in a temperature range between 5 and -55 °C, and three different positions in relation to the wind direction have been tested. The test campaign has approximately 100 independent campaigns where 5 different types of dust have been used, with various particle distributions.

Thanks to all this information, it has been done a characterization of DS'22 and will help to determine the dust distributions that will be observed during the mission.

Full Scientific Report on the outcome of your TNA visit

We encourage you to add figures to your report, which should be approx. 1 page of text plus figures.

The Dust Sensor (DS) is a system designed to measure the parameters that determine in situ the size distribution of suspended dust on the surface of Mars. The sensor module is composed of an IR source and two IR detectors. The source is a thermosensitive membrane that can reach up to 740°C radiating in a broad IR spectral region. Each detector is based on Lead Sulphide (PbS) and Lead Selenide (PbSe) active elements where two spectral bands are defined by the integration of two spectral filters. Band 1 operates in the range 1-3 µm (PbS), and Band 2 operates in the range 3-5 µm (PbSe). The two detectors are located respectively in a near-forward scattering direction and near-backward scattering direction (referred to IR source location).
The conditioning of the detected signals is performed by an analog circuit, and then the signals are processed by a digital Lock-In amplifier. The Lock-In circuit obtains the peak value of the IR detected signals, which correlates with the presence of dust particles (A elevated presence of dust particles cause a higher peak value). With this system, it is possible to use the amplitude of IR signals from the different Dust Sensor IR detectors to estimate the presence and size of Dust Particles in the iteration volume.

The Dust Sensor is part of the Radiation and Dust Monitor (RDM), one of the atmospheric devices of the METEO instrument that will be launched on the Exomars'22 mission. A Ground Scientific Model that reproduces the design of the optical head of the Flight Model has been fabricated for testing. This system is designed to have the same functionality as the flight model, but it has been designed with commercial parts, thus reducing the manufacturing cost. Therefore, it is less robust to the environment than the flight model, but it allows greater parameterization and configurability to develop test campaigns.

The use of the DENMARK - AU Planetary Environmental Facility is a unique opportunity to obtain experimental measurements in a reproduced condition found at the surface of Mars. In these facilities is located the wind tunnel that will be used in this set of tests, which has dimensions of 8 m long by 2.5 m wide. Inside the chamber, the temperature can be controlled by nitrogen, reaching up to -170°C, it is possible to establish the pressure corresponding to the Martian vacuum (approximately 8 mbar) and to generate a CO_2 atmosphere together with a dust cloud of a certain concentration to simulate the climatic conditions of Mars. All these features make this facility one of the best laboratories for the analysis of Martian instruments worldwide.

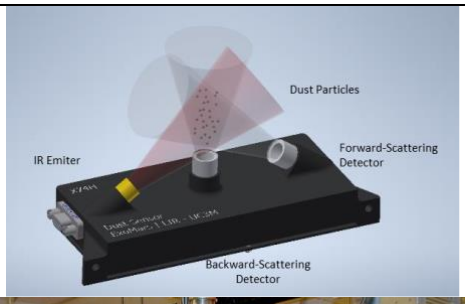
The main objectives during the development of the test campaign can be summarized as follows:

- Characterization of the system from the measurement of the parameters that determine the size distribution function of the suspended dust in a Martian-like environment.
- Capabilities of the instrument to reproduce different and controlled dust and thermal scenarios in low pressure.
- Evaluation of our capabilities to reproduce the experimental conditions in a software tool that reproduces the behaviour of the sensor.

During the execution of the tests, it has been tried to obtain sufficient data to characterize the performance of the device with respect to the detection of different dust concentrations and distributions. It should be noted that the use of the data measured by the laser meter (LDA) available at the Aarhus facility makes it possible to correlate the data measured by the Dust Sensor with the actual distribution. The time evolution of the signals could give us information about dust dynamics. For example, if the ratio between signals (which should be constant for the same distribution) suddenly changes, it would mean that we are observing a change in the dust distribution. This, together with the post-processing of the signal and the use of reverse engineering, makes it possible to predict possible dust distributions on the red planet.

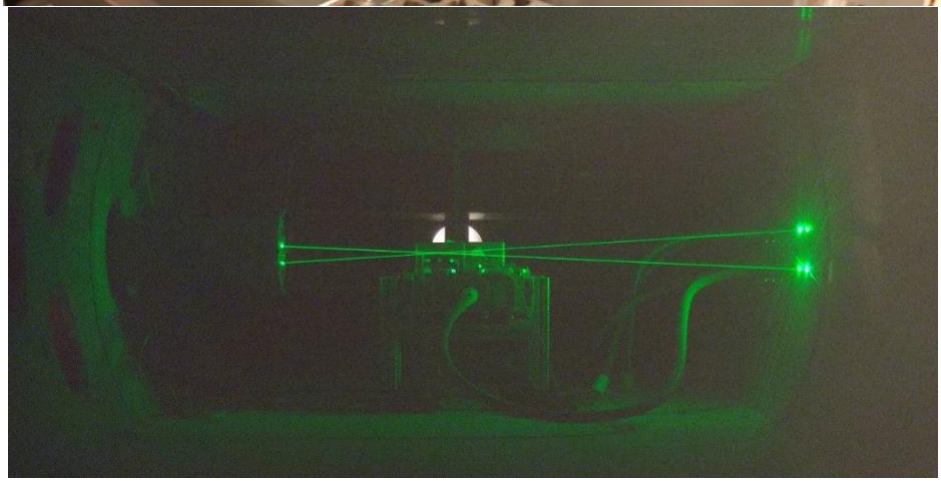
The tests campaign has been developed for wind speeds of 2, 7, and 13 m/s; the device has been tested in a temperature range between 5 and -55 °C, and three different positions of the device concerning the wind direction have been tested. The development of tests varying all these factors independently has made possible approximately 100 data campaigns with information on the detection of dust in different situations. In addition to the physical factors that can be varied with the operation of the camera, it should be noted that 5 different types of dust have been used, with various particle distributions to see the variations in the detection of each one.

Regarding the results obtained, it can be said that the campaign has been successfully developed. There is a great need to post-process the information and match it to all the processing and interpretation systems previously designed; but it can be stipulated that the number of experiments and the configurations tested during the performance of the tests, has been satisfactory.

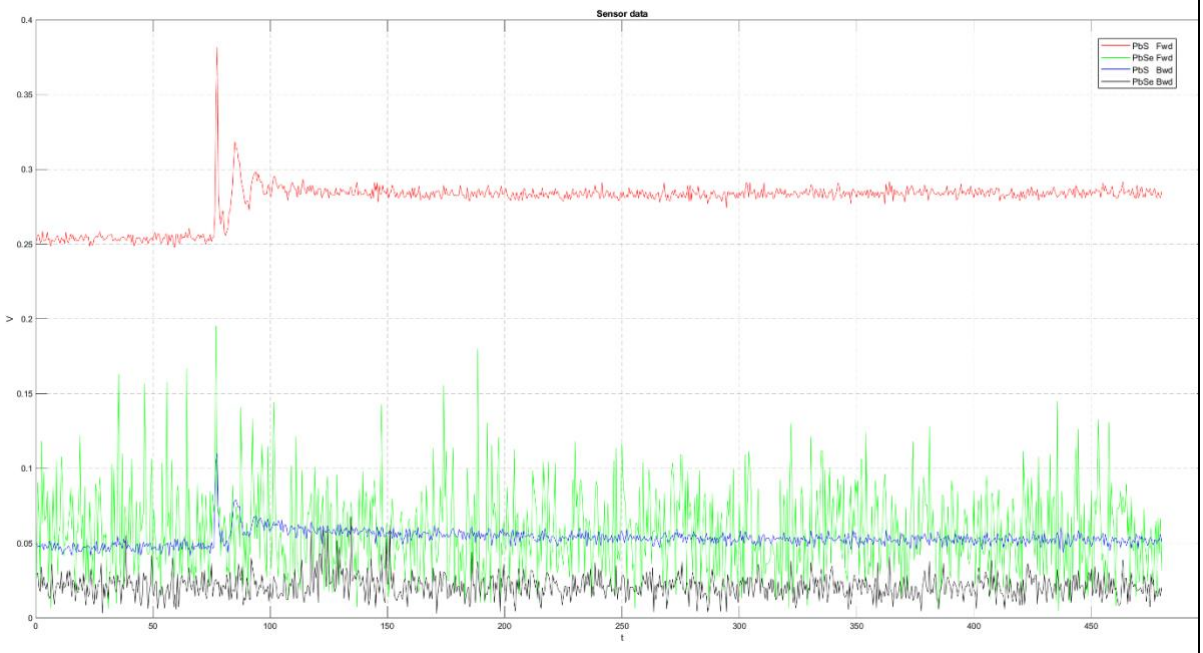

Dust Particles
IR Emiter
Forward-Scattering Detector
Backward-Scattering Detector

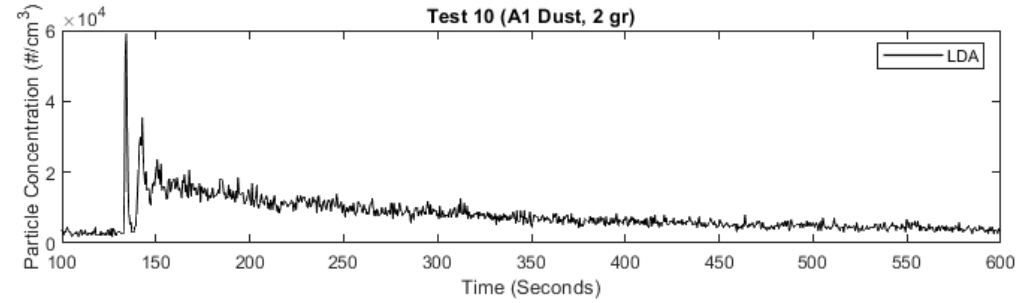

NITROGEN

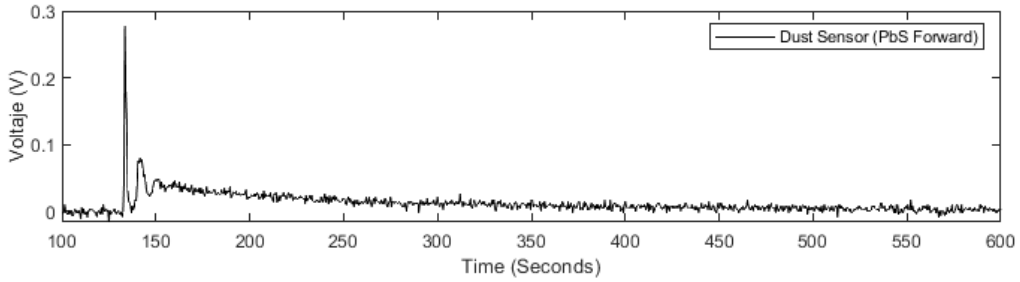

X74H
Dust Sensor
ExoMars | LIR - UC3M




X74H
Dust Sensor
ExoMars | LIR - UC3M


Sensor data
PbS Fwd
PbSe Fwd
PbS Bwd
PbSe Bwd
V
t
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
250
300
350
400
450


Test 10 (A1 Dust, 2 gr)
×10^4
Particle Concentration (#/cm^3)
LDA
Time (Seconds)


Voltaje (V)
Dust Sensor (PbS Forward)
Time (Seconds)


DIRT
RAG

- Give details of any publications arising/planned (include conference abstracts etc)

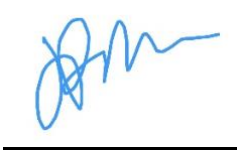
The results of the test campaign and the description of the campaign itself will be added on the publications of the Dust Sensor'22.

- Host confirmation

Please can hosts fill in/check this table confirming the breakdown of time for this TA project:

Dates for travel to accommodation for TA visit (if physical visit by applicant)	Start Date of TA project at facility	Number of lab/field days spent on TA Visit pre-analytical preparation	Number of days in lab/field site for TA Visit	Number of days spent in lab for TA Visit data analysis	End Date of TA project at facility	Dates for travel home (if physical visit by applicant)
Departed: 28-11-21 Arrived: 28-11-21	29-11-21	1	3	1	03-12-21	Departed: 03-12-21 Arrived: 04-12-21

The host is required to approve the report agreeing it is an accurate account of the research performed.

Host Name	
Host Signature	
Date	

- Project Leader confirmation

Do you give permission for the full version of this TA Scientific Report (in addition to the 250 word summary) to be published by Europlanet 2024 RI on its website and/or public reports? YES

Project Leader Name	Andrés Russu Berlanga
Project Leader Signature	
Date	22/12/2021