ENVIRONMENTAL MONITORING INSTRUMENT FOR MARS EXPLORATION. J. Gómez-Elvira[1] and REMS team, [1]Centro de Astrobiología (CSIC-INTA) (gomezej@inta.es, Ctra. Ajalvir km. 4 28850 Torrejón de Ardoz -Madrid-Spain,)

Introduction. The Mars Science Laboratory (MSL) payload is composed of a set of instruments including an environmental monitoring station, REMS (Rover Environmental Monitoring Station), which is a contribution of Spain. The CAB is leading the development of the instrument. The instrument is composed of different sensors which have the aim of recording pressure, humidity, air and ground temperature, UV radiation and wind speed and direction.

NASA has included environmental sensors on most Mars surface exploration missions. The Viking Landers measured pressure, wind speed and direction, and air temperature with a small boom [1]. Mars Pathfinder had the Atmospheric Structure Instrument on its lander and recorded pressure, air temperature and wind direction [2]. However, this is the first time that a exploration rover is equipped with an environmental station, which provides a big design challenge due to the fact that sensors need to measure an environment that in many cases is perturbed by the rover itself.

Science objectives. REMS scientific objectives are included in two of the MSL objectives: to characterize the Martian climate and to study Mars habitability. If we understand habitability as a concept derived from local habitat, the knowledge of environmental conditions play a key role.

REMS will record atmospheric data at surface level at different locations during the MSL mission. These local measurements are the combinations of many effects and many scales. Global atmospheric phenomena like Hadley cells or fronts are perturbed by large-scale orographic conditions and at the end are modified again by local orography and geology. Global circulation models and mesoscale models are the tools that the community has to simulate all those effects [3][4], which means that REMS records will be used to verify the prediction capabilities of actual models, and to understand some key aspects of Mars climatology like the Martian global water cycle..

UV radiation levels have neverbeen recorded directly at surface level. This knowledge could help to evaluate more precisely its biological damage for future manned missions as well as two more important aspects: the UV radiation contribution to the geochemical processes which run at the Mars surface[5] and, by comparison with satellite records, the study of the Mars atmospheric radiation absorption [6]

To evaluate the habitability of a location it is necessary to analyze many factors together, including temperature, water conditions, minerals and morphology, radiations levels and type of microorganisms [7][8]. REMS will play an important role in this area because it will record much of the relevant data andin collaboration with data from other MSL instruments could give a good idea of the subsurface conditions for life development.

Instrument Description. Due to MSL design restrictions, REMS is composed of four modules: two booms, UV sensor and instrument electronic and pressure sensor.

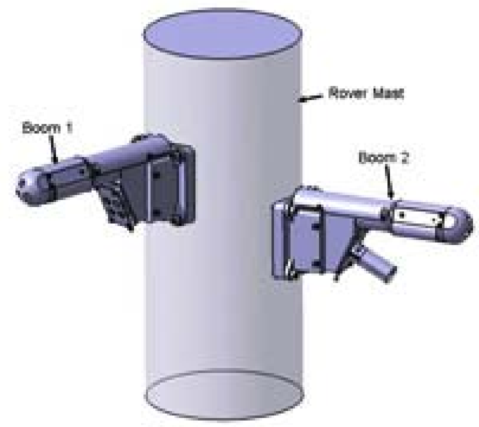

Figure 1. This figure shows a sketch of the booms location on the rover mast. Boom lengths are constrained by the rover design. The rover mast will perturb the wind stream and in order to have useful data for most wind directions, two booms have been implemented.

Wind sensors will record wind speed and determines its 3D direction. These sensors are composed of three 2D wind transducers on each boom, each one based on the hot film anemometry concept. Based on calibration tests, data from hot film will be translated to local wind speed and direction. Nevertheless, those data will not be enough to know actual wind information because, as mentioned above, the wind sensor will record data perturbed by the rover mast and by the rover body, which means that some correction factors will be applied based on rover mast and boom tests and aerodynamic simulations.

Ground temperature will be recorded with three thermopiles place on the Boom 1 (see Figure 1) which look forward of the rover. The bandwidth of each thermopiles is: 8-14, 15, 16-20 microns. These bands were selected to avoid as much as possible the CO_2 absorption and to maintain performance in the temperature range 100 to 373 K with an accuracy of 5 K.

Air temperature will be recorded in both booms with a PT1000-type sensor placed in a small rod with enough length to be outside the mast and boom thermal boundary layers. Its measurement range goes from 150 to 300 K with an accuracy of 5 K.

Boom 2 houses the humidity sensor which is located inside a protective cylinder. That sensor is developed by FMI and based on a Vaisala transducer, and will measure with an accuracy of 10% in the 2003 – 323 K range.

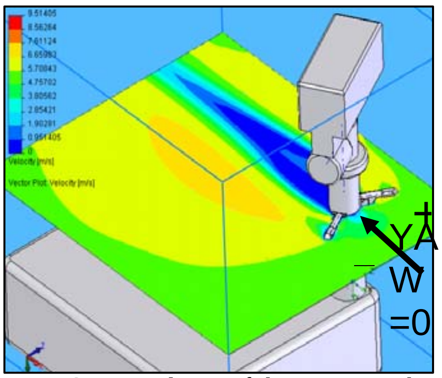

Figure 2. CFD simulation of the interaction between a wind flow and the rover mast, different colors show wind speed perturbation and how boom measurement could be modified.

Two of the main constraints on the REMS instrument design are the need of the booms to survive and operate in a broad range of temperatures and a mass restriction of 1.3 kg for all the instrument. Both conditions have required the development of an ASIC for data conditioning which should survive to -130ºC to 70ºC temperature ranges and minimize power consumption for operation.

The UV sensor will be located on the rover deck and is composed of six photodiodes in the following ranges: 335-395 nm (UVA), 280-325 nm (UVB), 220-275 nm (UVC), 210-380 nm (total dose), 245-290 nm and 310-335 nm (these two bands have been selected to ease comparison with MRO data and correspond to ozone absorption bands [9]), with an accuracy better than 5% of the full range. The sensor will be place on the rover deck without any dust protection. To mitigate dust degradation, a magnet has been placed around each photodiode with the aim to increase as much as possible their operation time. Nevertheless, to evaluate dust deposition degradation, images of the sensor will be recorded periodically.Comparison of these images with laboratory measurement will permitevaluation of the level of dust absorption.

The Pressure sensor is developed by FMI and based on a Vaisala transducer. This sensorwill be located inside the rover body and connected with the atmosphere by a small opening with a protection to avoid dust deposition. Its measurement range goes from 1 to 1150 Pa with and accuracy (end-of-life) of 20 Pa. As this component will be in contact with the atmosphere and in order to avoid any contamination of the Mars environment a HEPA filter will be placed on the opening.

Operation. Regularity is the main driver for REMS operation. Each hour, every day, REMS will record 5 minutes of data at1 data/sec rate for all sensors. This strategy will be implemented based on a high degree of autonomy in the REMS operation, which means that the instrument will wake up itself each hour and after recording and storing data will go to sleep independently of rover operation. REMS will record data during both rover operation and non-operation period, during day and night.

REMS operation is designed assuming three hours of operation each day, based on data volumes. In addition to the regular recording periods it is possible to increase some of the regular periods or to define new ones, in order to capture specific times with special scientific interest.

Another option that has been studied is to implement in the REMS software an algorithm to lengthen some of the regular observations when an atmospheric event is detected.

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