THE DREAMS EXPERIMENT ON THE EXOMARS 2016 MISSION FOR THE STUDY OF MARTIAN ENVIRONMENT DURING THE DUST STORM SEASON

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Introduction:

The ExoMars mission is carried out by European Space Agency (ESA) in cooperation with the Russian federal Space Agency (Roscosmos). It is a two-steps mission. It includes an orbiter, the *Trace Gas Orbiter*, and an Entry Descent and Landing Demonstrator Module (EDM), that will be launched on January 2016, and a descent module and surface platform, plus a rover, to be launched in 2018.

The mission will allow Europe to acquire the technologies necessary for the entry, descent and landing of a payload on the surface of Mars, to move on the Martian surface with a rover, to penetrate into the subsurface and acquire samples, to distribute the collected samples to on-board instruments for analysis. From the scientific point of view, the mission will search signs of extant or extinct life forms, will monitor the trace gases in the atmosphere of Mars and their sources, will study the Martian environment during the dust storm season and will perform the first ever measurement of electric field on Mars. The last two represent the scientific objectives of the DREAMS payload on-board the EDM 2016. DREAMS is a small meteorological station including also an electric field probe. It will land on Mars during the statistical dust storm season. It has been designed to study the effect of dust on Martian environment. A scientific field campaign has been carried out in the Moroccan desert in support to DREAMS experiment science. This campaign was finalized to the study of the response of meteorological and electric field sensors during the period of frequent dust storms. The preliminary results will be shown, where the strong relations between fresh lifted dust and enhancement of the atmospheric electric field is clearly evident.

The DREAMS experiment:

DREAMS (*Dust characterization, Risk assessment and Environment Analyzer on the Martian Surface*) is a meteorological station with the additional capability to perform measurements of the electric field close to the surface of Mars. It is an autonomous system that includes its own power supply and control system. It is constituted by the following subsystems (see Figure 1): MarsTEM (thermometer), DREAMS-P (pressure sensors), DREAMS-H (humidity sensor), MetWind (2-D wind sensor), MicroARES (electric field sensor), SIS (Solar Irradiance Sensor), a CEU (Central Electronic Unit) and a battery. All systems in DREAMS have a solid heritage from other missions and have very high TRL.

The ExoMars 2016 EDM mission is foreseen to land on Mars during the statistical dust storm season. DREAMS will have the unique chance to make scientific measurements able to characterize the Martian environment in this dust loaded scenario. DREAMS will perform:

- Meteorological measurements
  - The measurement of pressure, temperature, wind speed and direction, humidity and dust opacity will supply the needed parameters to characterize the basic state meteorology and its daily variation at the

landing site. Such information will directly be ingested by climate models.

- Characterization of the Martian boundary layer in dusty conditions.

• Hazard monitoring

- DREAMS will provide a comprehensive dataset to help in quantifying hazards for equipments and human crew: velocity of windblown dust, electrostatic charging, existence of discharges, and E.M. noise potentially affecting communications, intensity of UV radiation.

• The first ever investigation of atmospheric electric phenomena at Mars

- A global atmospheric electrical circuit is likely to exist on Mars, between the surface and the ionosphere, with similarities and differences with the Earth's circuit. Atmospheric ionization should be similar to that of the Earth's stratosphere but impact charging through collisions between dust particles moved by the wind and the surface, or between dust particles themselves, is expected to be the dominant charging mechanism. Intense electric fields, possibly capable of producing electrical breakdown, are expected at the time of dust storms and in the vicinity of dust devils.
- Atmospheric electricity is also involved in several processes that have a noticeable impact on the surface and atmosphere. At times of dust storms, electrostatic forces on fine electrically charged dust grains may become larger than aerodynamic forces due to the wind. They are expected to play a significant role in the dynamics (including lifting) of suspended dust particles and their interaction with the surface, thus on the processes that contribute to the erosion and long-term evolution of the surface.
- By energizing the free electrons, the atmospheric electric fields control their interaction with both the surface and the atmospheric gases. They have thus a definite role in the chain of physical and chemical processes that govern the chemical state of surface materials and the production of oxidized constituents in the atmosphere with consequences on the sustainability of proper conditions for life.

DREAMS is an international experiment with hardware contribution from Italy (system, CEU and MarsTEM), Finland (DREAMS-P&H), UK (MetWind), France (microARES), and Spain (SIS). It is in an advanced stage of development. The Flight Model will be delivered to ESA in the first half of 2014.

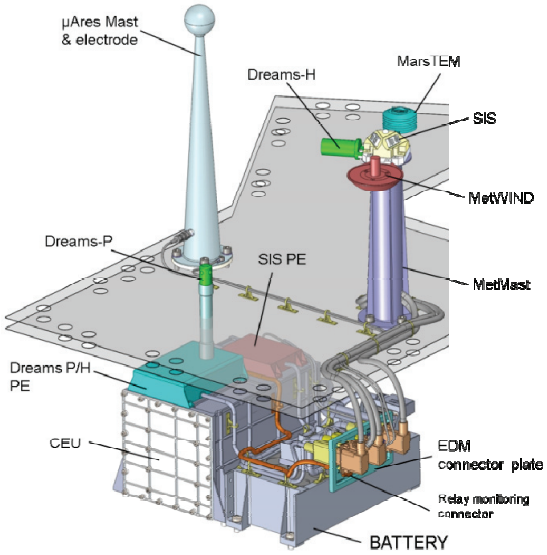

Figure 1: DREAMS payload accommodated on the EDM.

Field campaign in the Moroccan desert

Scope of the field campaign in the Moroccan desert is the study of the rising and evolution of dust storms. For this aim, a meteorological station (see Fi. 2), particularly devoted to the monitoring of sand *saltation* process and dust entrainment in the atmosphere, has been deployed in the region around Merzouga (Errachidia) in the Moroccan desert. The Moroccan desert has a Martian-like terrain and offers a good chance to understand the physics behind aeolian processes. The chosen area is particularly rich in both sand and dust particles and it is very active from the aeolian point of view.

The following physical quantities have been monitored for 3 months during the Summer 2013 (dust storm season in Morocco): wind speed and direction at three different altitudes (wind vertical profile), atmospheric humidity, temperature at two heights, pressure, solar irradiance, soil moisture and temperature, sand saltation rate (by detecting the impacts of sand particles over two impact sensors), atmospheric electric field and the size distribution and number density of dust entering into the atmosphere. The goal was to correlate environmental parameters to sand movements and dust entrainment and, in particular, verify the effect of sand *saltation* process on the generation/enhancement of the atmospheric electric field. This field study will pose the basis for the interpretation of the output data that will be collected on Mars by the DREAMS experiment.

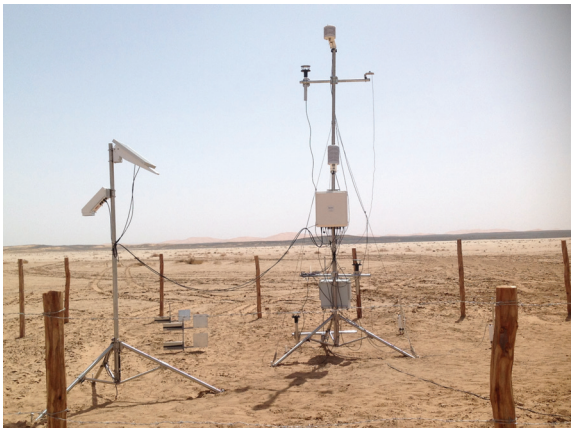

Figure 2: Instrumentation deployed by the DREAMS team in the Moroccan desert.