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Planning and Implementation of Pressure and Humidity Measurements on ExoMars 2016 Schiaparelli Lander

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Abstract

The ExoMars 2016 Schiaparelli lander offers a platform for meteorological and electric field observations ranging from timescales of seconds to Martian days, or *sols.* In the Finnish Meteorological Institute (FMI), this opportunity has been used to develop a new type of instrument controller unit for the already flight-proven FMI pressure and humidity instruments. The new controller allows for more flexible and autonomous data acquisition processes and planning than the previous FMI designs.

1. Introduction

The European Space Agency (ESA) is launching a soft lander, the Entry, descent and landing Demonstrator Module (EDM), also known as Schiaparelli towards Mars in 2016. The mission is part of the ExoMars program, which includes also the Trace Gas Orbiter launched in 2016 as well as a stationary lander and a rover launched in 2018. The primary objective of the Schiaparelli mission is to demonstrate ESA's capability to perform a precision landing on another planetary body. As a secondary goal, the lander will perform meteorological and electric field studies with its Dust characterization, Risk assessment, and Environmental Analyzer on the Martian Surface (DREAMS). The Finnish Meteorological Institute has developed the pressure instrument DREAMS-P, and the humidity instrument DREAMS-H, for the DREAMS science package. Other instruments on the package include the MetWIND anemometer, the MarsTEM temperature sensor, the Solar Irradiation Sensor (SIS) and the MicroARES electric field instrument, all seen in Fig. 1.

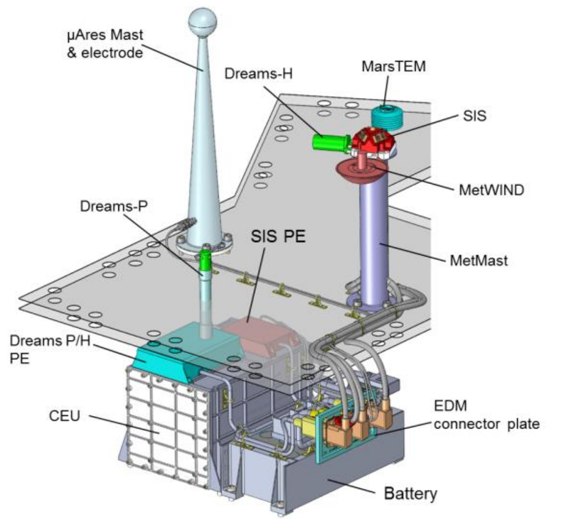

Figure 1: DREAMS instrument suite

2. Science mission challenges and opportunities

As the primary objective of the mission to perform a powered landing only requires a limited amount of energy for a limited time, no solar panels are installed on Schiaparelli. Thus, the DREAMS package operates relying solely on its internal battery. This limits the duration of the surface mission to 2-5 sols. Even so, the science package cannot be operated continuously, but has to follow a scheduling scheme. However, the brief nature of the mission allows for more risky operations planning and implementation of the instruments. Schiaparelli will land on Mars during the global dust storm season, allowing for in-situ observations of the related highly dynamic atmospheric phenomena. [1] Also, e.g. FMI is using a new data handling approach for DREAMS-P and DREAMS-H instruments, without prior flight heritage.

3. Mission operations plan

The science mission operations are based on a general daily timeline designed by the DREAMS team. The timeline includes *Sensor Switches* (SSW) ranging from 5 to 60 minutes, which are slots when the instruments may be woken up for scientific data acquisition and housekeeping. The preliminary mission operations plan foresees three longer SSWs ranging from 40 to 60 minutes. These switches are placed around the local time of sunrise, sunset and late afternoon. The sunrise and sunset switches are of great interest because of the dynamics caused by the relative rapid changes of temperatures in the thin Martian atmosphere. The possibility of dew detection during the sunrise switch is especially interesting for the DREAMS-H instrument. The late afternoon switch is placed around the most likely time of dust storm activity and dust devils. This SSW is interesting due to the possibility to detect passing dust devils with the DREAMS-P pressure data, perhaps with the combination of MetWIND wind data and MicroARES electric field data. Together with the longer SSWs, the shorter sensor switches are used to build a diurnal understanding of the landing site meteorology.

4. Pressure and humidity measurements implementation

FMI's DREAMS-P and DREAMS-H instruments consist of two pressure transducers and one humidity transducer, respectively. Each of the transducers contains 8 channels, including capacitive pressure or humidity sensors as well as reference temperature sensors and constant reference capacitors. Channel measurements are performed by determining the RC-oscillator frequency of a channel by simultaneously counting a number of sensor and reference clock pulses. These measurements on DREAMS-P and DREAMS-H are coordinated by a commercial automotive MicroController Unit (MCU), Freescale MC9S12XEP100, integrated onto the DREAMS-P printed circuit board.

The design is an evolution of the previous FMI meteorological Mars instruments implemented with Field Programmable Gate Array (FPGA) devices. The FPGA-based instruments required numerous external low level commands for operation. For example, each measurement sequence needed for acquiring the 8 pressure or humidity transducer data channels required a separate command.

In DREAMS-P and DREAMS-H the new MCU instrument controller design takes a more autonomous approach. Measurements are configured by tables describing the acquisition parameters for each individual measurement channel, interval between each measurement sequence of 8 channels and number of measurement sequences to perform. These modifiable configuration tables are stored in the MCU non-volatile memory and will retain their values also between resets. To start a measurement, the DREAMS Central Electronics Unit (CEU) needs only to send a "power on" command to the desired DREAMS-P and DREAMS-H transducers, followed by a "start measurement" command addressed to one or two transducers (it is possible to measure one of the –P transducers simultaneously with the –H transducer) to start a series of measurement sequences. After that the instrument controller will automatically send out data whenever a measurement sequence is completed.

5. Summary

With the Schiaparelli lander, ESA seeks mainly to advance its engineering capabilities to deliver science payloads on Martian surface. As a secondary objective, the Schiaparelli lander will study meteorological and electric field phenomena, potentially in the harsh environment of a Martian dust storm. The limited power supply available for DREAMS after landing has led to an operations plan with part-time scientific measurements to optimize science return of the mission. However, the short duration of the mission permits more easily the technology demonstration of new instrument designs. In case of DREAMS-P and DREAMS-H, a new instrument controller was implemented to allow largely independent instrument operation while coping with the strict power limitations of a battery powered system.

References

[1]F. Esposito, et al.: DREAMS for the ExoMars 2016 mission: a suite of sensors for the characterization of Martian environment. European Planetary Science Congress 2013. EPSC Abstracts, Vol. 8, EPSC2013-815