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ExoMars Entry, Descent and Landing Science

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Abstract

The entry, descent and landing of *ExoMars* offer a rare (once-per-mission) opportunity to perform *in situ* investigation of the martian environment over a wide altitude range. Entry, Descent and Landing System (EDLS) measurements can provide essential data for atmospheric scientific investigations. We intend to perform atmospheric science measurements by exploiting data from EDLS engineering sensors and exploiting their readings beyond the expected engineering information.

1. Introduction

EDL phases are critical with reference to mission achievement and require development and validation of technologies linked to the environmental and aerodynamical conditions the vehicle will face. An accurate knowledge of the dynamics of the probe during entry and descent (i.e. trajectory and attitude determination) allows the retrieval of the atmospheric vertical profile of values such as density, temperature and pressure at a vertical resolution far higher than previously explored and/or reachable by remote sensing.
ExoMars 2016 will provide the opportunity for new direct *in situ* measurements during the martian statistical dust storm season. These data will contribute to exploring an altitude range not covered by an orbiter, providing surface and atmosphere a "ground truth" for remote sensing observations and important constrains for updates and validations of the Mars atmosphere General Circulation models [1].

2. Background

Mars' atmosphere is highly variable in time and space, due to phenomena including inertio-gravity waves, thermal tide effects, dust, solar wind conditions, and diurnal, seasonal and topographic effects. Atmospheric profile measurements, drawing on scientific analysis heritage from the Huygens Atmospheric Structure Instrument (HASI), which encountered Titan's atmosphere in 2005 [2], and various previous Mars missions such as the Mars Exploration Rovers (MER) and Mars Phoenix (PHX) will allow us to address questions of the martian atmosphere's structure, dynamics and variability.
By careful consideration of EDLS measurements to yield science as well as a successful landing, we will obtain continuous atmospheric density, temperature and pressure profiles over the widest ever explored altitude range, with the highest sensitivity and spatial resolution.
The first *in situ* measurements of Mars planetary atmospheric structure have been obtained by the USSR spacecraft Mars 6 in 1974 during its entry into the martian atmosphere. These data confirmed the remote sensing observations of 5.45 mbar surface pressure and estimated the lapse rate in the lower and middle atmosphere [3]. To date, only six vertical profiles of density, pressure and temperature of the martian atmosphere have been obtained from in situ measurements. Three high vertical resolution and high accuracy atmospheric vertical profiles have been retrieved from measurements performed by Viking 1 and 2 during the day [4] and by Mars Pathfinder (MPF) during the night [5, 6]. Two more vertical profiles have been retrieved from the deceleration curves and aeroshell drag properties of the two Mars Exploration Rovers (MER) during atmospheric entry [7], but with a much lower accuracy. Recently the Mars Phoenix EDL data have been used to obtain the first profile of atmospheric density, pressure and temperature at the martian polar regions [8].

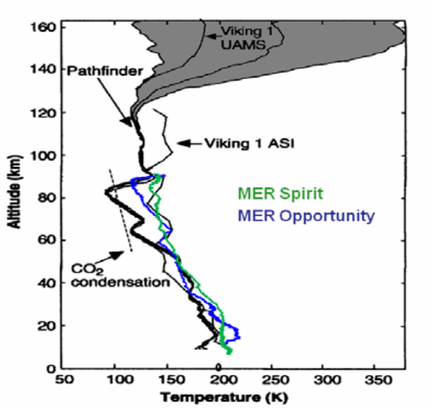

Figure 1: The atmospheric temperature profile derived from the Pathfinder ASI/MET (in **black** ±2σ uncertainty shaded in grey) [6] and by MER Spirit (**green**) and Opportunity (**blue**) EDL engineering data [7]. Temperature profiles from the Viking lander 1 ASI and upper atmosphere mass spectrometer (UAMS), the CO_2 condensation temperature profile, and the surface temperature measured by Pathfinder MET (circle) are also shown for comparison [5].

Such profiles are vital for testing of atmospheric models used in numerous studies of atmospheric variability, on a range of temporal and spatial scales, as well as for the practical issue of reaching the martian surface reliably [e.g. 9] and to investigate the climate of Mars.

New data from a different site, season and time period, and over a greater range of altitudes than previously possible, are essential to investigate the thermal balance of the surface and atmosphere of Mars, diurnal variations in the depth of the planetary boundary layer, propagating atmospheric waves and the effects of these processes on the martian general circulation.

3. Summary and Conclusions

The main objective of the ExoMars EDL Science team is to exploit the Entry Descent and Landing System (EDLS) engineering measurements for scientific investigations of Mars' atmosphere and surface.

From the measurements recorded during entry and descent, using similar methods and analysis employed on previous in situ missions (e.g. ESA Huygens, NASA MPF, MER and Phoenix) we will retrieve an atmospheric vertical profile along the entry and descent trajectory. The experience and lessons learned in the framework of the Huygens project will be put in perspective for the ExoMars Entry, Descent and Landing (EDL) science experiment.

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