EPSC Abstracts
Vol. 11, EPSC2017-614, 2017
European Planetary Science Congress 2017

Atmospheric Mars Entry and Landing Investigations & Analysis (AMELIA) by ExoMars 2016 Schiaparelli Entry Descent Module

F. Ferri (1), O. Karatekin (2), A. Aboudan (1), B. VanHove (2), G. Colombatti (1), C. Bettanini (1), S. Debei (1), S. Lewis (3), F. Forget (4) and the AMELIA team
(1) Università degli Studi di Padova, Centro di Ateneo di Studi e Attività Spaziali "Giuseppe Colombo" (CISAS) (francesca.ferri@unipd.it / Fax +39-049-8276855), (2) Royal Observatory of Belgium (ROB), Brussels, Belgium, (3) School of Physical Sciences, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK, (4) Laboratoire de Météorologie Dynamique, UPMC BP 99, 4 place Jussieu, 75005, Paris, France

1. Introduction

The Entry, Descent and Landing System (EDLS) of an atmospheric entry probe or lander requires measurements in order to trigger the events of the descent sequence. These measurements besides being aimed at guaranteeing a safe landing, could provide essential information for the study of planetary atmosphere. The ESA *ExoMars* program, with the Schiaparelli Entry Demonstrator Module (EDM) in 2016 and the entry module containing the Surface Platform and Rover in 2020 provides the rare (one-per-mission) opportunity for new direct *in situ* measurements over a wide altitude range and with resolution not achievable over the full altitude range by remote sensing observations.
The Atmospheric Mars Entry and Landing Investigations & Analysis (AMELIA) experiment aimed at exploiting the EDLS engineering measurements for scientific investigations of Mars' atmosphere and surface. The data recorded during the different phases can be used for an accurate trajectory and attitude reconstruction and for the retrieval of the atmospheric profile to study the atmospheric structure, dynamics and static stability and to characterize the landing site context [1].

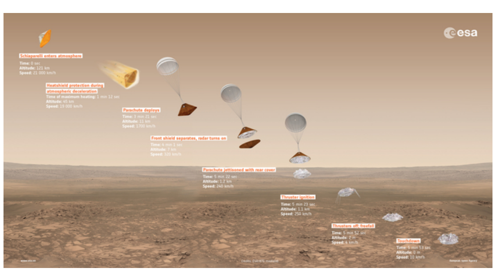

Figure 1: ExoMars 2016 Schiaparelli EDL scenario.

2. ExoMars 2016 Schiaparelli mission

On 19th October 2016, Schiaparelli entered into the martian atmosphere. Although it did not complete a safe landing on Mars, it transmitted data throughout its descent to the surface, until signal was lost about 1 minute before the expected touch-down on Mars' surface. The EDL sequence (Fig. 1) should have lasted for 6 minutes starting with a hypersonic atmospheric entry protected by an instrumented heatshield, followed by a passive descent under parachute and an active proximity phase during which retrorockets are activated in order to slow down and ensuring a final horizontal position of the Schiaparelli platform at touch down, and finally a landing on a crushable structure for damping the impact [2].

The atmospheric entry and the majority of the descent phases were performed nominally: the aerobraking under the frontshield occurred as expected, the parachute deployed normally, and the heatshield, having served its purpose, was released 40 seconds after (as programmed). The unexpected dynamics of the vehicle at parachute inflation resulted in the saturation of one of the gyroscope that caused the fatal error in the guidance and control system. The erroneous information in the attitude generated a negative altitude estimation that in turn successively triggered a premature release of the parachute and backshell, a too brief firing of the retrorockets and finally the activation of the on-ground systems (including DREAMS) as if Schiaparelli was landed. In reality Schiaparelli was still at an altitude of around 3.7 km, therefore it continued in free fall to the crash landing on the surface of Mars (33 seconds later at a velocity of 150 m/s) (Fig. 2).

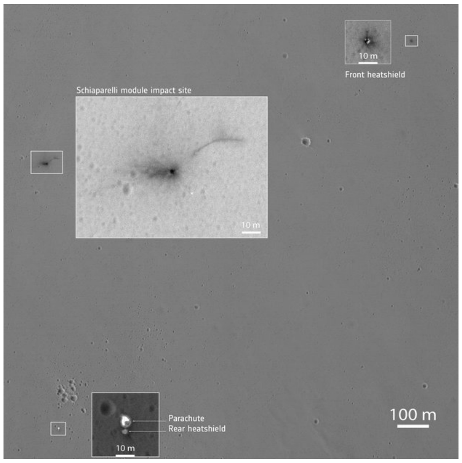

Figure 2: HIRISE image of Schiaparelli crash landing

Schiaparelli continuously transmitted telemetry that was received from the TGO (Trace Gas Orbiter) while the signal carrier was recorded by the Giant Metre-wave Radio Telescope (GMRT) in Pune (India) and by ESA MarsExpress orbiter until the loss of signal.

The radio signal and the telemetry data set, although limited, are essential to investigate the anomaly that caused the crash landing, but also for the achievement of AMELIA experiments scientific objectives. At the time of writing, these data are still under analysis to investigate the reasons for the Schiaparelli's landing failure and are under embargo.

3. AMELIA simulations and reconstructions

The measurements transmitted during entry and descent have been used for the reconstruction of the Schiaparelli EDM trajectory and attitude determination and for the retrieval of an atmospheric profile of parameters such as density, temperature and pressure along the entry and descent trajectory. Within the AMELIA team, different algorithms, methods and data sets are used to simulate and reconstruct the EDM dynamics in order to retrieve and validate the most accurate atmospheric profile [1]. A strong effort was also put into atmospheric modelling and data assimilation in order to improve predictions and weather forecasts, monitoring weather conditions and to assess the atmospheric context at entry, so as to forecast the environmental conditions that Schiaparelli was going to face, but also in view of scientific analysis and interpretation of the AMELIA results.

The flight data of Schiaparelli, besides providing a technical assessment of the EDL, allowed for sounding the atmosphere along its trajectory, so as per the seven atmospheric profiles retrieved by previous successful Mars entry probes [3, 4, 5, 6, 7, 8]. These *in situ* measurements are fundamental for studying the martian atmospheric structure and dynamics, and also for the investigation of the meteorology and the planetary boundary layer on Mars.

4. Conclusions

Despite the ultimate failure of Schiaparelli to land safely, sufficient EDL data was returned in order to reconstruct the trajectory and attitude of the EDM and retrieve atmospheric profiles over the altitude range from 121 km to 4 km above the surface.
We will report the results on the atmospheric reconstruction in terms of the assessment of the atmospheric science.

Acknowledgements

AMELIA is an experiment for scientific investigations of Mars' atmosphere and surface by means of the Schiaparelli measurements during its entry, descent and landing on Mars. The International AMELIA team built under the joint coordination of Principal Investigator: Francesca Ferri (Italy) and 3 Co-Principal Investigators (CoPIs): Özgür Karatekin (Belgium), Stephen R. Lewis (United Kingdom), François Forget (France) (*Interdisciplinary Scientist*). The team included scientists from Italy, France, UK, Belgium, Finland, Germany, Australia and USA.

References

[1] F. Ferri et al. (2017) submitted to *Space Science Rev.*
[2] T. Blancquaert et al., (2017) *14th International Planetary Probe Workshop*, The Hague, NL.
[3] Seiff, A., D.B. Kirk, (1977) *J. Geophys. Res* **82**, 4364.
[4] Schofield, T., et al. (1997) *Science* **278**, 1752-1758.
[5] Magalhães, J.A., J.T. Schofield, A. Seiff, (1999) *J. Geophys. Res.***104**, 8943-8945.
[6] Withers, P. and M. D. Smith (2006) *Icarus* **185**.
[7] Withers, P., Catling, D.C. (2010) *Geophys. Res. Lett.* **37**.
[8] Holstein-Rathlou, C., A. Maue, and P. Withers (2016) *Planet. Space Scie.* **120**: 15-23.