RECONSTRUCTION OF SCHIAPARELLI AND COMARS FLIGHT DATA

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Brief Presenter Biography: Aaron Brandis received his undergraduate Bachelor of Engineering (Mechanical and Space) in 2003 and his PhD from the University of Queensland and Ecole Central Paris, France in 2009. Dr Brandis is a senior research scientist employed by AMA, Inc. in the Aerothermodynamics branch at NASA Ames. He is currently the deputy PI for the Entry Systems Modeling project and PM/PI for NEQAIR, Co-PI for the Electric Arc Shock Tube, Aerothermal and ESI lead for Dragonfly.

Abstract: ESA recently flew an entry, descent, and landing demonstrator module called Schiaparelli that entered the atmosphere of Mars on the 19th of October, 2016. The instrumentation suite included heatshield and backshell pressure transducers and thermocouples (known as AMELIA) and backshell radiation and direct heatflux-sensing sensors (known as COMARS and ICOTOM). Due to the failed landing of Schiaparelli, only a subset of the flight data was transmitted before and after plasma black-out. The goal of this paper is to present comparisons of the flight data with calculations from NASA simulation tools, DPLR/NEQAIR and LAURA/HARA. DPLR and LAURA are used to calculate the flowfield around the vehicle and surface properties, such as pressure and convective heating. The flowfield data are passed to NEQAIR and HARA to calculate the radiative heat flux. Comparisons will be made to the COMARS total heat flux, radiative heat flux and pressure measurements. Results will also be shown against the reconstructed heat flux which was calculated from an inverse analysis of the AMELIA thermocouple data performed by Astrium. Preliminary calculations are presented in this abstract. The aerodynamics of the vehicle and certain as yet unexplained features of the inverse analysis and forebody data will be investigated.

Introduction: Researchers from the European Space Agency's ExoMars mission recently published flight data from the Schiaparelli descent module's entry into the Martian atmosphere [1,2]. The data obtained during Schiaparelli's descent are invaluable for further validating models used to design thermal protection systems for future Mars missions and can be used to complement the data MEDLI measured during the Mars Science Laboratory entry in 2012. In order to assess the performance of the heat shield, characterize the atmosphere and better understand the trajectory, the Atmospheric Mars Entry and Landing Investigations and Analysis (AMELIA) [3] package led out of the Università degli Studi di Padova in Italy was integrated with Schiaparelli. Due to backshell environments having large uncertainties with high margins used during spacecraft design, up to 3x [4], DLR, the German Aerospace Center, developed the Combined Aerothermal and Radiation Sensor package, called COMARS+, to measure the total heat flux, pressure and radiative loads at different backshell positions on Schiaparelli [1]. COMARS+ consisted of three combined aerothermal sensors, one broadband radiometer sensor and an electronics box. The failed landing of Schiaparelli meant it was not possible to retrieve the complete data package. However, communications between the Schiaparelli module and the orbiter during entry allowed data to be transmitted at ten trajectory points.

Preliminary Results: Figure 1 shows the locations of the various COMARS sensors. More detail will be provided in the final paper; for the abstract, preliminary results are presented in Figure 2. Figure 2 shows a comparison of the total heat flux calculated by DPLR and NEQAIR with the COMARS 1 flight data and inverse analysis as performed by Pinaud et al. [3]. The preliminary unmargined simulation results shown in Figure 2 generally over-predict the flight data and show trends similar to the inverse analysis. From these initial comparisons, it is clear that valuable flight data were gathered by both COMARS and AMELIA, even though some of the data were lost to radio black-out.

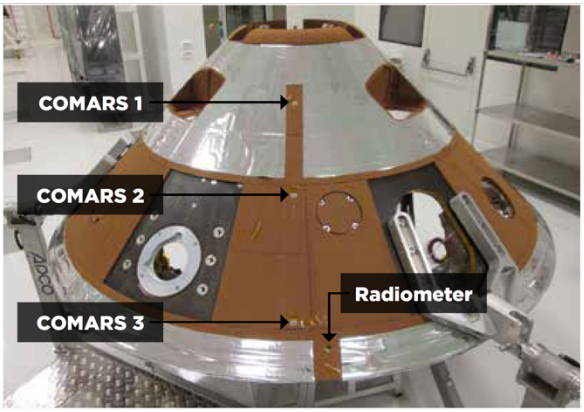

Figure 1. Location of COMARS sensors [1]

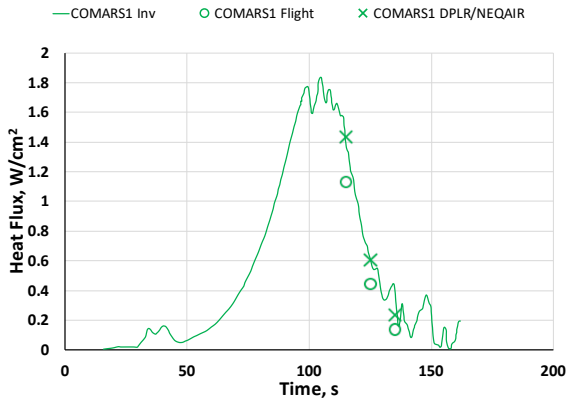

Figure 2. Preliminary comparison of simulations of total heat flux for COMARS 1 including the inverse analysis from [3].

References:

1. A. Gülhan. et al. "Aerothermal Measurements from the ExoMars Schiaparelli Capsule Entry," Journal of Spacecraft and Rockets, 2018.

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4. M. Wright et al., "Sizing and Margins Assessment of Mars Science Laboratory Aeroshell Thermal Protection System," Journal of Spacecraft and Rockets, Vol. 51, 2014.