Overview of Dragonfly Entry Aerosciences Measurements (DrEAM)

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Abstract: NASA Ames Research Center (ARC) leads the Dragonfly Entry Aerosciences Measurements (DrEAM) project, which is an aeroshell instrumentation suite on the Dragonfly mission that fulfills the Engineering Science Investigation requirement for the New Frontiers mission. NASA ARC is partnering with NASA Langley Research Center (LaRC) and the German Aerospace Center (DLR) to provide a comprehensive sensor suite, including a DLR-provided Data Acquisition System (DAS). DrEAM will provide key aerothermodynamic data and performance analysis for Dragonfly's forebody and backshell Thermal Protection System (TPS).

Titan's atmosphere predominantly consists of nitrogen (~98% by mole) with small amounts of methane (~2% by mole) and other trace gases. CN is a strong radiator, and is found in nonequilibrium concentrations for Titan entry. The accurate modeling of nonequilibrium CN radiation has proven to be a difficult task. Prompted by the Huygens mission, many experimental campaigns and analyses were performed to better understand the aerothermal environments experienced by the probe during Titan entry [1]. However, the Huygens probe carried no heatshield instrumentation. Therefore, the DrEAM sensor suite will significantly advance the state-of-the-art not only by documenting the environment and performance of Dragonfly's entry system but also by making key *in situ* measurements in Titan's atmosphere for the first time.

Aerothermal environments and TPS response will be measured using sensors whose flight heritage is taken from the Mars Entry, Descent, and Landing Instrumentation 2 (MEDLI2) thermocouple plugs and the COMbined Aerothermal and Radiometer Sensor (COMARS) suite [2], with the latter supplied by DLR. The MEDLI2 project used embedded thermocouples to directly measure the in-depth TPS temperature-time history at several locations on the heat shield and backshell of the Mars 2020 entry vehicle. These temperature measurements, in turn, can be used to infer surface environments via an inverse analysis procedure analogous to that used for MEDLI. For DrEAM, the thermocouple plug subsystem will be known as Dragonfly Sensors for Aero-Thermal Reconstruction (DragSTR). On Schiaparelli, the COMARS suite included three total surface-mounted heat flux sensors, three pressure sensors, and one radiometer. For DrEAM, the COMARS package will be known as the COmbined Sensor System for Titan Atmosphere (COSSTA). Since the methane concentration in the Titan atmosphere is directly proportional to the radiative heat flux, the COSSTA measurements will be used to reduce the current uncertainty in the methane volume fraction. Atmospheric density measurements and capsule aerodynamic data will be obtained through the onboard Inertial Measurement Unit (IMU), supplemented by pressure transducers similar to those used by the MEDLI and MEDLI2 projects. The DrEAM pressure sensors will be known as the Dragonfly Atmospheric Flight Transducers. (DrAFT). The pressure measurements, when combined with data from the onboard IMU, will allow for reconstruction of such quantities as vehicle Mach number, freestream density, and atmospheric winds. DrAFT measurements will enhance Dragonfly trajectory reconstruction and enable a separation of the aerodynamics from the atmosphere, as was done for MEDLI [3] and is currently in process for the MEDLI2 flight data set. A preliminary layout of the DrEAM sensors is shown in Figure 1.

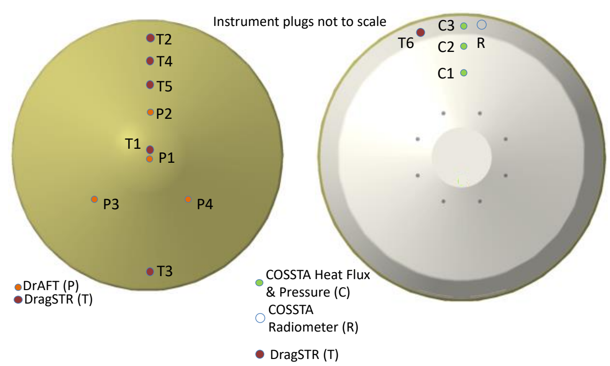

Figure 1. DrEAM preliminary sensor layout

References:

[1] M. Wright, et. al., "A Code Calibration Study for Huygens Entry Aeroheating," AIAA 2006-382.

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

[3] C. Karlgaard, et. al. "Mars Entry Atmospheric Data System Trajectory Reconstruction Algorithms and Flight Results," AIAA 2013-0028.