**ATMOSPHERIC ENTRY AEROTHERMODYNAMICS FLIGHT TEST ON CUBESAT PLATFORM**

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The extreme aerodynamic heating and the exothermic chemical reactions due to the gas-surface interaction at hypersonic free stream velocities make the thermal protection system design and testing a challenging process. The chemically reacting hypersonic flight regime cannot be fully duplicated in ground facilities and the design methodologies, experimental and numerical, have to be validated by real flight data which come with high costs. It is the objective of QARMAN CubeSat, QubeSat for Aerothermodynamic Research and Measurements on AblatioN, to perform an atmospheric entry experiment to Earth and collect real flight data for highly affordable costs. QARMAN is a spacecraft respecting the triple unit CubeSat standards; a rectangular prism with dimensions 34x10x10 cm (Figure 1). It has an ablative TPS in the front unit and a ceramic TPS on the side panels. It also has an aerodynamic de-orbiting system which will allow the vehicle to achieve the desired conditions for atmospheric entry experiment. The mission is representative of real re-entry missions with 7.5 km/s velocity at 120 km of altitude and a stagnation heat flux of 2.5 MW/m$^2$. It will be launched together with the other QB50 satellites at 380 km in early-2016.

**Figure 1: QARMAN vehicle.**

The collected real flight data is intended to be used for validating the ground testing methodologies. At the von Karman Institute, the primary facility for aerothermodynamic research is the Plasmatron, an inductively coupled plasma generator providing subsonic or supersonic plasma. The aerothermochemical environment behind the hypersonic bow shock can fully be duplicated. The ground facilities in the world generally deal with spherical nose shapes. However doing an atmospheric entry research on a CubeSat platform like QARMAN brought up the necessity of a detailed investigation of blunt and non-axisymmetric geometries. An iterative methodology is developed for accurately simulating the nose region of such vehicles. This methodology is to be validated by QARMAN's real flight data.

QARMAN carries a number of aerothermodynamic experiments on board and a Flush Air Data Sensing (FADS) system. It should be noted that the CubeSat platforms are slightly different than the big brother missions in terms of payload-subsystem interdependency. Each payload has to be designed by separating the measurement chain and the payload head taking into account the tight power, mass, volume and data link budgets.

At the nose region where the ablative material is, it is foreseen to have three thermal plugs for heat flux and recession measurements as well as three pressure ports to monitor pressure and contribute to the FADS system. The breadboard tests are done to optimize the designs and the thermal plug and the pressure spools are tested successfully at Plasmatron (Figure 2).

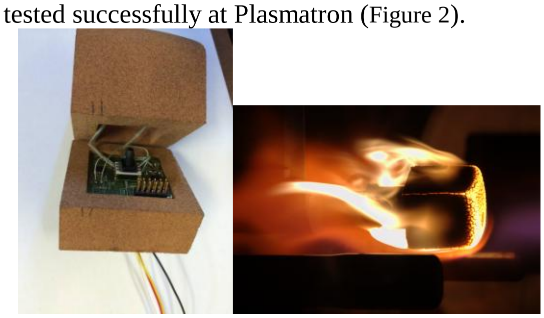

**Figure 2: Thermal Plug/Pressure Test with Ablative TPS at Plasmatron.**

The ceramic TPS side panels include ten temperature measurement stations and four to eight pressure stations contributing to three payloads and the FADS system. The first one is the detection of laminar to turbulence transition. It is known that in case of the transition to turbulence, a sudden jump occurs in both temperature and pressure. The second is aiming to determine the stability and the attitude determination of the vehicle by aerothermodynamic measurements. These data will be combined with the gyroscopes and the accelerometer onboard at post flight analysis. The third one is the heating on the ceramic side TPS and characterize the material's response along the entry trajectory. All these measurements will also be used for CFD validation in terms of temperature, pressure and density evolution on the side panels.