TVC Control, First Bending Mode and Aero-elastic Effects: Post flight reconstruction of VEGA LARES mission

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The maiden flight of VEGA from Kourou on February 13th 2012, putting in orbit the LARES satellite as well as several microsatellites, has been a success. In the frame of the Level 1 exploitation campaign, the analysis of the Flight Data sent by Telemetry has been used to confirm assumptions and to explain phenomena of various disciplines and in particular to validate the GNC algorithms.

One of the main concerns of a Launch Vehicle mission is the Control during atmospheric flight especially the coupling with bending modes.

The analysis of Telemetry (both IRS outputs used by GNC and additional sensors dedicated to flight reconstruction) allowed estimating the modal frequencies in particular the first mode frequency around 4 Hz, the most critical. The excitation of the first bending mode has been compared to the reconstruction of the Flight variables by a full 6 DOF simulator, taking into account post-flight model updating (propulsion, masses, atmosphere…).

After recalling the architecture of the VEGA Control algorithms in atmospheric flight and the values of the different parameters involved in the tuning (rigid mode, bending mode, actuators dynamics, sampling rate) we will explore several hypotheses to improve the fitting between flight and simulated data.

The first one is based on the closed loop behaviour of the TVC Control and the comparison with predicted stability margins. The conclusion is that this assumption is not sufficient to explain the behaviour of the bending modes.

The second assumption is based on aero-elastic excitation of the bending mode by the wind. It is likely that the excitation is produced by meso-scale components (between 50 m and 2000 m of wavelength) of the wind spectrum which lie in the modal frequency bandwidth.

The excitation due to the TVC nozzle deflection is also compared with the levels observed during the flight.