VEGA LV Qualification Process: GNC aspects on HWIL Testing and Analysis

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Abstract

Vega is the new small European launcher designed to cope with a wide range of missions and payload configurations, from single satellite up to main-plus-six-micro-satellites missions. Compatible PL masses range from 300 kg to 2500 kg, depending on the type and altitude of the required orbit. Vega has been designed as a single body launcher with three solid propulsion stages and an additional liquid propulsion upper module used for attitude and orbit control, and satellite release. The fully successful maiden Qualification Flight (QF) dated 13th February 2012, is a result of a deep pre-flight analysis oriented towards the achievement of a robust Launch Vehicle.

The present paper is aimed at providing a technical overview of the final step of the Flight Program Software (FPS) qualification process, that consists in the Hardware-in-the-loop (HWIL) simulation campaign, addressed to prove the correct functioning of the software, in which the GNC algorithms are embedded.

The HWIL test analysis, from a GNC point of view, is focused above all in investigate and evaluate the effect of the introduction of the real hardware in the simulation loop in particular non nominal (scattered) conditions, both in terms of representativeness of the models in the numerical (SWIL, Software-in-the-loop) campaign, both in terms of introduction of physical effects (delays and non linearities) in the control chain that can eventually lead to a limit behavior of the actuators.

The scattered test cases to be run in the frame of HWIL test campaign are defined differently according to the various GNC aspects on which the analysis will be focused on: for control topics, a set of Worst Cases (WC) are defined reasonably with respect to realistic disturbs scenario which the LV can face during different flight phases that would lead the control performances to a limit condition. On the other side, Guidance and Navigation test conditions are defined by means of the outputs of 3DoF and 6DoF MonteCarlo (MC) simulation campaigns as, differently from control tests, the worst combination of parameters scattering cannot be *a priori* individuated.

As last aspect of the test plan, also some degraded mode tests are included, in which the Failure Detection and Isolation Recovery (FDIR) functionalities are tested, forcing the LV to very extreme conditions in order to make the GNC switch on non-nominal working mode.

Depending on the goal of the test case, a certain number of different setup configuration are defined, ranging from the basic PIL configuration, in which just the real OBC is in the simulation loop, up to a full HW configuration that has the highest level of flight representativeness.

The test analysis is then finalized by veryfing all the system requirements defined in the technical specification, by means of a dedicated tool developed in a Matlab - Simulink ® environment, that offers a wide range of verification functionalities (both graphical and numerical) depending on the kind of the condition that has to be verified.