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Author: Ms. Monica Valli
Politecnico di Milano, Italy, valli@aero.com

Prof. Michèle Lavagna
Politecnico di Milano, Italy, michelle.lavagna@polimi.it
Mr. Thomas Panozzo
Arianespace, France, t.panozzo@arianespace.fr

DESIGN OF A ROBUST CONTROL LAW FOR THE VEGA LAUNCHER BALLISTIC PHASE

Abstract

Over the last years worldwide space agencies focused on small satellite missions requiring lower investments and shorter development time. Small satellites are increasingly being considered a suitable alternative to traditional satellites: new standardised satellite platforms have been proposed and developed in Europe, with mass, cost and manufacturing time considerably reduced. Moreover science-based, Earth observation as well as telecommunication missions are, more often, based on multiple small missions instead of relying on a single large satellite. To guarantee access to space and commercial success in this new scenario, Europe solved the need of appropriate launch services in the light payload class by developing the Vega small launcher. Vega, Ariane-5 and Soyuz launchers will ensure a full range of launch services for Europe, allowing cost-effective and customized mission planning to exactly satisfy each payload requrirements. The ballistic phase is one of the most challenging flight phases for a launcher: even a minimal error during manoeuvres execution can seriously compromise the payload release and lead the mission to a failure. In this phase, the dedicated control system must be able to manage any manoeuvre set in the flight program respecting accuracy, especially regarding the composite(i.e. launch vehicle last stage, adapter and payloads) pointing direction before separation. This work presents the design of a robust control law, and the related control system architecture, for the Vega launcher ballistic phase, taking into account the complete six degrees of freedom dynamics. To gain robustness a non-linear control approach has been preferred: more specifically the Lyapunov's second stability theorem has been exploited, being a very powerful tool to guarantee asymptotic stability of the controlled dynamics.

The dynamics of Vega's actuators has also been taken into account.

The system performance has been checked and critically analyzed by numerical simulations run on real mission data for different operational and configuration scenarios, and the effectiveness of the synthesized control highlighted: in particular scenarios including a wide range of composite's inertial configurations performing various typologies of manoeuvres - such as variable-angle slew manoeuvres, waiting phases, spin up/down as well as controlled boost phases – have been run. The robustness of the controlled dynamics has been validated by a 100 cases Montecarlo analysis campaign: the containment of the dispersion for the controlled variables–say the composite roll, yaw and pitch angles-confirmed the wide validity and generality of the proposed control law.

The paper will show the theoretical approach and discuss the obtained results.