Paper ID: 45007
oral
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation & Control (1) (5)

Author: Mr. Diego Navarro-Tapia
University of Bristol, United Kingdom

Dr. Andres Marcos
University of Bristol, United Kingdom
Dr. Samir Bennani
ESA - European Space Agency, The Netherlands
Dr. Christophe Roux
AVIO S.p.A., Italy

# JOINT ROBUST STRUCTURED DESIGN OF VEGA LAUNCHER'S RIGID-BODY CONTROLLER AND BENDING FILTER

**Abstract**

This article presents the design of a robust atmospheric control system for the rigid and flexible motion of the VEGA launcher. The significance of the work is in the augmentation of capabilities of the classical VEGA Thrust Vector Control (TVC) system via its formulation as a robust control problem framed around the structured H-infinity technique. Indeed, unlike the state-of-practice where the design of the rigid-body controller and bending filters are traditionally addressed sequentially in three steps (with the latter involving an iterative, ad hoc integration process), in this work the rigid-body controller and bending filters are first parameterized and then optimized simultaneously. This joint design simplifies the synthesis process and reduces the tuning effort prior to each launcher mission. Furthermore, it is shown how the legacy information from the classically-designed baseline controller can be used to guide the controller parametrization.

In addition to the joint rigid-flexible controller design, the proposed framework augments the design capabilities to address well known limitations in launcher control – specifically, wind disturbance and parametric uncertainties. Towards this end, it is shown that the introduction of a wind disturbance model in the design interconnection allows the designer to modulate the level of performance versus the level of wind/gust disturbance (i.e. mild to severe) in a methodological manner. Then, the design interconnection is augmented to deal with parametric uncertainties by using linear fractional transformation (LFT) models. The above augmentation steps are standard in robust control design theory, but they have seldom been integrated and applied in a methodological manner for the control design of a complex nonlinear, high-fidelity system (in the present case the actual VEGA VV05 mission flight).

The resulting individual linear structured H-infinity point designs are analysed, in terms of stability via classical stability margins as well as robustness metrics (such as the structured singular value). And then, the performance and robustness of the global scheduled structured H-infinity controller is evaluated (and compared to the VEGA baseline controller) through Monte-Carlo nonlinear simulations using VEGA's non-linear, high-fidelity simulator.

The results show that the structured H-infinity synthesis technique, and proposed methodology, improve the performance and robustness of the launcher (event accounting for competing trade-offs such as wind and parametric uncertainty) while keeping the classical VEGA TVC architecture. This represents a paradigm change in terms of the control design process followed by VEGA but not in terms of the objectives and accumulated flight heritage.