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AFS-ACTIVE FLUTTER SUPPRESSION PROJECT: ACTIVITIES OVERVIEW AND FINAL RESULTS

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Summary: AFS – Active Flutter Suppression is a research project leaded by University of Washington (Seattle), sponsored by FAA and participated as subcontractor by the Department of Aerospace Science and Technology (DAER) of Politecnico di Milano, started in 2017 and close to the end, scheduled next April 2020. The main goal of AFS project is the investigation and validation of technologies for active flutter suppression and includes both numerical and experimental phases. This paper summarizes the activities and results carried out, with a special emphasis on the results collected during the last phase of the test campaign on the complete F-XDIA wind tunnel model, in both open and closed loop.

ABSTRACT

Despite the first studies on active flutter suppression date back to end of '70s, still today aircraft have to be certified as flutter free on the entire flight envelope. However, recent enhancements of the capabilities and reliability of aircraft control system hardware and software, combined with the growing structural flexibility typical of modern transport aircraft, and hence potential for flutter problems and for related weight reduction of optimized composite airframes, seem to have made the implementation of Active Flutter Suppression (AFS) technology closer than ever before [1]. This makes the experimental study of the current state of the art of AFS important, especially from the perspective of uncertainty, reliability, and the safety of flight vehicles in which this technology will be used.

Contributing to both aeroelastic active control and AFS technology development for many years, DAER-POLIMI developed in the mid-2000s a scaled actively controlled aeroservoelastic model of a three-surface passenger airplane [2-5] and tested it in its large low-speed wind tunnel. Motivated by the need to return to the wind tunnel with an aeroservoelastic model of a configuration that would better capture the aeroelastic behavior of current and emerging commercial passenger and cargo flight vehicles that may benefit from AFS, a research program has been launched by the Politecnico di Milano and the University of Washington to focus on the reliability and safety of AFS-dependent flight vehicles using a wind tunnel model that would be representative in complexity and aeroelastic characteristic to real aircraft.

The F-XDIA aeroservoelastic model has been thoroughly modified, by changing the configuration and by the addition of wind tunnel model features that would allow the study of the effects of uncertainty on the performance and reliability of AFS. The experimental activity has been divided in two main PHASES: the first one focused on the wing only, while the second one dedicated to the complete model and carried out in the POLIMI's Large Wind Tunnel. While the activity and results obtained during PHASE I have been extensively described in [6,7], this paper describes in more detail the activities carried out to complete the model as well as the results collected during PHASE II in both open and close loop configurations. The model is entirely aeroelastic, and the active control system has been

designed ad realized in house from both the hardware and software point of view. A dedicated anti-flutter system installed in a wing tip pod has been realized to automatically stop the flutter when the wing acceleration exceeds a pre-defined threshold for global safety purpose. Different active flutter suppression laws have been developed and successfully tested in an extended experimental campaign inside the large POLIMI's wind tunnel.

The model, and especially the instrumentation and onboard data acquisition system and controllers appeared as very reliable allowing to completely manage the test remotely from the control room. The anti-flutter device worked properly enabling safe testing near the flutter point without breaking the model. The flutter identification results confirmed the numerical predictions. Finally, the results in close loop configuration demonstrates the validity of the approach adopted. The final part of the AFS project will be focused on the robustness aspects analysis related to the experimentation of advanced controllers, aiming at the derivation of a series of best practices to be followed in the future to implement these technologies on real aircraft.

Figure 1: Onboard computer (a), GVT of complete model (b), final validation WT flutter test (c)

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