# DESIGN OF A DECENTRALIZED GUST LOAD ALLEVIATION CONTROL LAW WITH A PRIMARY FLIGHT CONTROLLER IN THE LOOP

***João Martins*, Gertjan Looye and Thiemo Kier***

** German Aerospace Center (DLR), Institute of Aeroelasticity,*
*Münchener Str. 20, 82234 Wessling*
*Germany*

## ABSTRACT

Reducing overall loads of aircraft is desirable in order to decrease structural weight and required maintenance during the aircraft's life span. Specially for new wing concepts with high aspect ratios, load reduction is crucial for their feasibility and will enable significant weight reductions. Active methods such as control functions have shown to be a feasible method to reduce the loads of aircraft. Flight control functions such as gust load alleviation (GLA) controllers for reducing local loads on the wings are examples of it. GLA controllers work to alleviate loads around the frequencies of the flexible modes of the aircraft. These are typically higher than the rigid-body modes, which are controlled by a primary flight controller. The interaction between these two types of modes and both controllers, primary and GLA controller, are of extreme importance. In a decentralized GLA approach, the controller is though as being isolated from the main flight computer and only using locally accessible information. In this approach, the controller becomes far less complex to design and tune, and it can be thought as a modular feature introduced at the actuator level capable of deploying GLA properties to any aircraft. The expected load reductions are smaller, however, the complexity of these controllers and their design are significantly reduced, allowing a simpler integration and certification process on aircraft. This work will extend previous works by redeveloping the control design of a decentralized GLA controller and introducing a primary flight controller in the loop. The research focus is on how GLA controllers can be designed so that no interaction exists between the flexible and rigid-body modes. Two filters are introduced to the acceleration measurements of the wing to filter out the low rigid-body frequencies, and the higher frequency modes in order to avoid limit cycles. The controller core is a proportional-integral (PI) control law tuned to achieve robust performance properties. For it, an optimization framework is considered by using the Multi-Objective Parameter Synthesis (MOPS) toolbox. To achieve robust performance multiple uncertain plants are considered, and various performance and stability criteria and constraints are defined. To validate the GLA controller, it is deployed into a nonlinear aeroelastic model of an aircraft. Gust encounters and flight manoeuvres are simulated to test the GLA controller and address the differences when not using it. Reductions of the wing's vertical accelerations and bending moments are analysed when simulating gust encounters, and the interaction between primary and GLA controllers is addressed by simulating flight manoeuvres. Some preliminary results are shown in Figures 1 and 2, where a gust encounter and a heading change manoeuvre are simulated on the nonlinear aircraft model with and without the GLA controller. The results already show some reduction of loads even in an extreme case of controller delay. The results also show how little interaction there is between the designed GLA controller and the primary flight controller. The work demonstrates the potential of this decentralized GLA approach at enabling any aircraft to have feasible GLA properties alongside a primary flight controller with minimal work and integration steps.

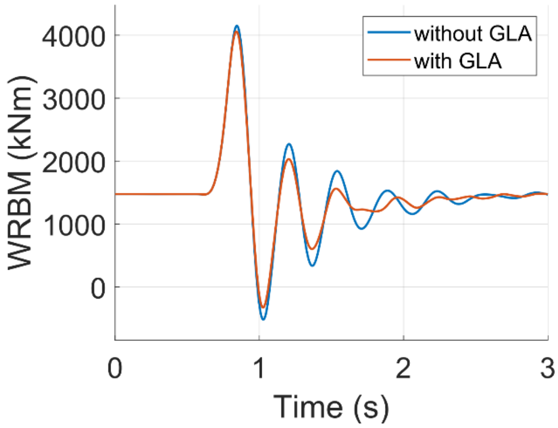


*Figure 1: Simulation comparing the wing-root bending moment of a gust with L = 40 m encounter with and without a GLA controller considering a delay of 0.01 s for this controller.*

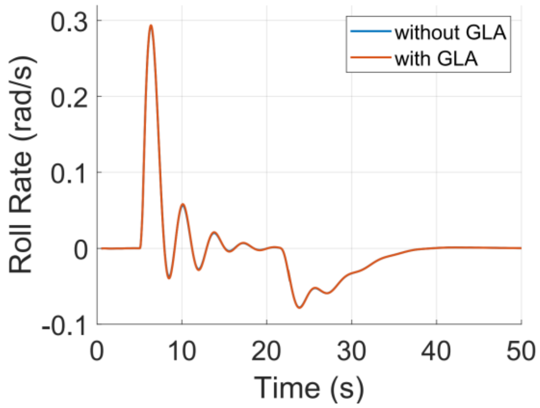


*Figure 2: Simulation comparing the roll rate for a heading change manoeuvre with and without a GLA controller considering a delay of 0.01 s for this controller*