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Active Aeroelastic Aircraft Structures

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ABSTRACT

Aeroelasticity results in problems such as structural divergence, aileron reversal, and flutter stability due to insufficient torsional stiffness of the wings and "aeroelastic weight penalty" became a widely used expression by engineers in aircraft design. Aeroelastic solutions generally involve increasing the structure stiffness or mass balance (passive solutions), which typically involve increase of weight and cost while decreasing performance. In the seventies, composite materials with highly anisotropic directional stiffness properties enabled the introduction of aeroelastic tailoring methods where the composition of thickness and orientation of the individual material layers could be tailored to minimize the added structural weight necessary to minimize the detrimental effects due to aeroelastic behavior.

This technology paved the way for looking at aeroelasticity from a different perspective. The new paradigm consists of looking at the structural deformations, caused by aerodynamic forces, to be used intentionally and in a beneficial way in order to improve aerodynamic performance and help to create the required control forces. In the last two decades, a new actuation concept for structural control has emerged. This concept uses the multifunctional materials properties to control the structural stiffness and shape of composite materials. Several studies have been performed to demonstrate applications of adaptive structures in aircraft, helicopters and submarines.

This paper presents the research and development of novel active aeroelastic control strategies, aimed at improved aircraft performance (structural weight, better control effectiveness) by controlling structural deformations to modulate the desired aerodynamic deformations. The proposed research was carried out in the framework of the European research project 3AS (Active Aeroelastic Aircraft Structures). To this end, the following research issues to enable active aeroelastic aircraft structures have been addressed:

- Demonstrate the application of piezoelectric actuators and sensors to dynamic aeroelastic control of a structure and design an experimental and computational setup that allows the quantification of the performance in flutter suppression, buffeting vibration reduction, and attenuation of other external mechanical vibrations.
- Develop an airborne flight test platform (RPV - Remotely Piloted Vehicle) to demonstrate the proposed concepts both in the wind tunnel and in actual flight conditions;
- Develop a methodology to design and integrate the proposed adaptive structures technology in real aircraft while reducing the weight of a wing for a given flight envelope.