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Aeroservoelastic analysis, design and wind tunnel testing of a three degree-of-freedom binary flutter model

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Abstract

Aeroelastic problems are typically limiting factors in the performance and flight envelopes of aircraft. Aeroelastic constraints can be relaxed through active control of the flutter modes at and above the uncontrolled flutter speed of aircraft using primary flight control surfaces. To demonstrate the concept and associated benefits of aeroservoelasticity, a low speed, three degree-of-freedom binary flutter model incorporating a full-span trailing edge control surface was designed, modelled mathematically and wind tunnel tested. Open-loop flutter test results agreed well with predictions from classical flutter theory, and gentle low speed flutter was demonstrated. Closed-loop wind tunnel testing using a linear quadratic Gaussian controller proved that flutter could be suppressed successfully, allowing the flutter boundary of the model to be increased significantly. Flutter suppression was demonstrated up to a speed $54 m/s$, an increase of 116% over the model's open-loop flutter speed of $25 m/s$, using a controller optimised for an airspeed of $25 m/s$.