AEROELASTIC MODEL UPDATE FOR A FLEXIBLE WING USING EXPERIMENTAL DATA

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ABSTRACT

Aeroelastic models describe the coupled interaction between aerodynamic loads, structural deformation, and inertial effects in flexible structures such as aircraft wings. They are used to predict phenomena like static divergence, control reversal, gust response, and flutter, and are a vital part in the development of new flexible aircraft. The validation of these numerical models using wind tunnel experiments is indispensable in the field of aeroelasticity. Particularly with flexible, high-aspect-ratio wings, theoretical models can show large discrepancies in predicted loads and dynamic response compared to experimental results.

The field of aeroelastic model updating is one of active research. Many published methods refer to the Correction Factor Technique by Giesing et al. [1] which uses correction factors to match theoretical values of box lift, moment and initial pressure coefficient obtained from panel methods to match experimental pressure measurements. Currently many aeroelastic updating methods use pressure data gathered from CFD simulations to correct panel models and do not consider experimental data [2, 3, 4].

The department of Flight Mechanics, Flight Control and Aeroelasticity of the TU Berlin, in cooperation with the DLR's Institute of Aeroelasticity, has developed the TU-Flex demonstrator with a modular, high-aspect-ratio, transport aircraft configuration. The TU-Flex platform, among other applications, allows the collection of coupled motion between flight and aeroelastic dynamics in response to control inputs and serves as a ground experiment testbed to define new procedures to characterize the elastic and aeroelastic properties of flexible and very flexible aircraft by static, ground vibration and wind tunnel testing.

An aeroelastic model of the TU-Flex flexible wing (FW) was developed using Nastran and the DLR developed software Loads Kernel [5,6]. The structural FE model was validated using static deflection measurements and GVT results. The aerodynamic panel model is shown in figure 1 and consists of a total of 708 boxes to represent the wing and wind tunnel fairing.

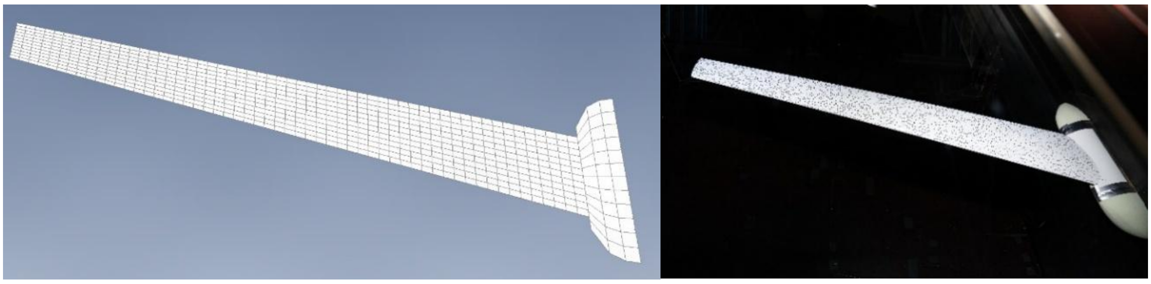

Figure 1: Aerodynamic panel model of the TU-Flex FW side by side with the wing inside the wind tunnel

Wind tunnel tests of the TU-Flex FW at the Crosswind Simulation Facility (SWG) at the DLR-AE in Göttingen have resulted in a large dataset that provides the basis for model updating. Static and dynamic maneuver cases have been investigated; wing root loads and structural dynamic data have been measured using a balance measurement system and inertial measurement units [7].

This work presents a methodology for updating the aeroelastic model of the TU-Flex FW for use in Nastran and Loads Kernel simulations in the absence of pressure measurements or CFD data. The methodology uses an optimization routine to find the distribution of correction factors to alter the lift and moment distribution so that the error between measured and calculated wing root loads in the static cases is minimized, while fulfilling constraints to preserve a physical consistency of the obtained correction factors. The obtained correction factors are applied to Nastran and Loads Kernel simulations, and the updated model is validated by comparisons to both static and dynamic test case measurements. Figure 2 shows the distribution of the box force correction factors for the 30m/s airspeed case. Figure 3 shows a comparison of the results of an aileron chirp maneuver at 30m/s run in the wind tunnel and simulated using Loads Kernel.

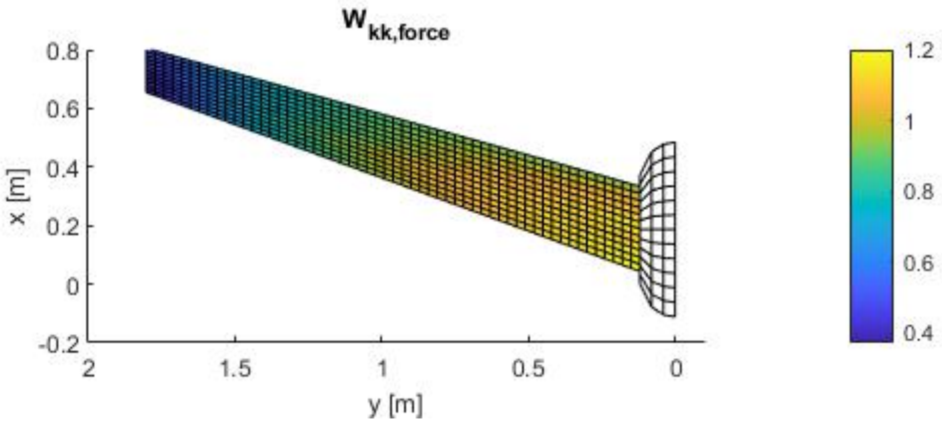

Figure 2: Distribution of box force correction factors for an airspeed of 30m/s

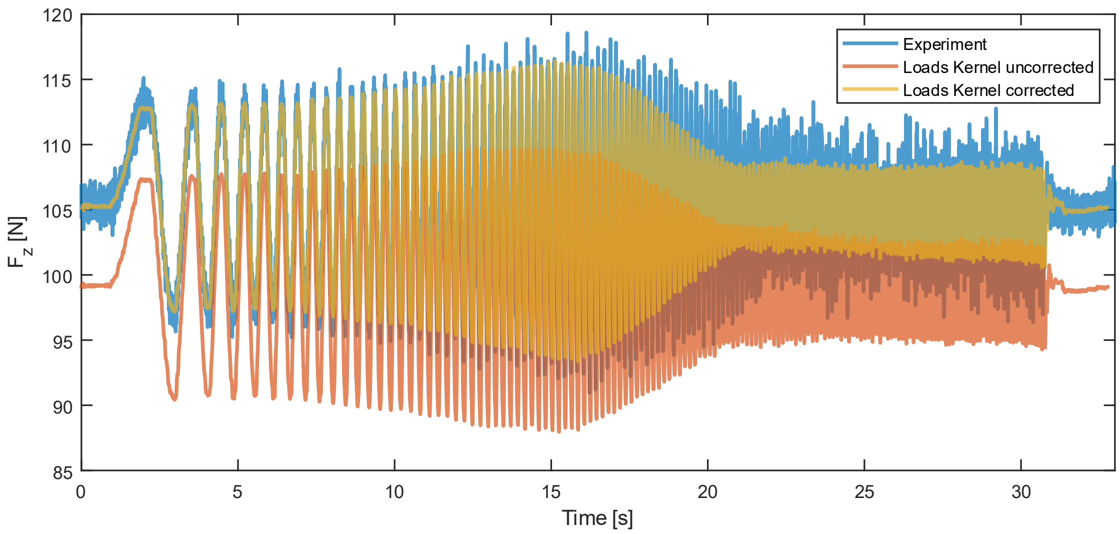

Figure 3: Lift force balance measurement during a 0-10Hz aileron chirp, compared to Loads Kernel time simulations using the uncorrected and corrected model

In the full paper the procedure to update the aeroelastic model as well as more comparisons with static and dynamic experimental cases for validation will be presented. Additionally, the application of the correction to a model of the whole TU-Flex demonstrator and simulations of flight test maneuvers are explored.

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