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Session:

Hybrid RANS/LES Simulation Strategy for High-Lift Applications with Disturbed Inflow

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Introduction

The prediction of gust loads during take off and landing is relevant for the safety of an airplane and should be already considered during the design process. Therefore, we present a framework to investigate the effects of atmospheric gusts on high-lift airfoils with the help of hybrid RANS/LES models (HRLM). To estimate the relevance of different turbulent length scales in the gust, the method relies on the ADDES [1], which uses algebraic sensors to distinguish RANS and LES regions. The model is used in combination with a vorticity-based LES filter scale and a numerical scheme with low dissipation. High-quality experimental data from [2], which include PIV measurements, are used to validate the simulation results. We will focus on the effects that prevent the flow separation at the flap in the HRLM.

Simulation Setup

The simulation setup shown in Fig. 1 (left) comprises a NACA0021 airfoil as vortex generator (VG) and the DLR F15 high-lift (HL) airfoil with deployed flap. The gust is generated through the rapid deflection of the VG airfoil, which is performed by mesh deformation. The vortex generation and its transport by the background flow are modeled with RANS, while the scale-resolving mode is confined to the region near the high-lift flap in accordance with precursor investigations [3].

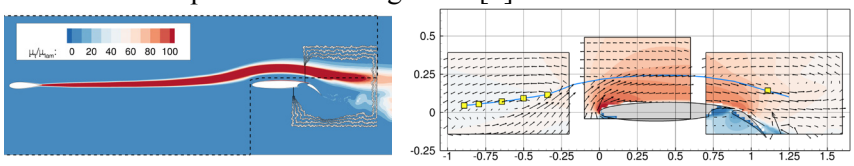

Fig. 1 Simulation setup: viscosity ratio indicates RANS and LES regions (left). Three positions of the vortex passing the HL airfoil (right).

Results of the successfully applied method will be presented in the paper, e.g., Fig. 1 (right) depicts three positions of the vortex as it passes the HL airfoil. In [4] it was shown, that the overall effect of the vortex on

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the surface pressure at the HL airfoil could be predicted in good agreement with the experimental data. However, in the HRLM simulations the flow on the flap stayed attached, while the experimental data indicate flow separation on the flap.

Therefore, the paper will present a detailed analysis of the flow about the flap in the case with undisturbed onflow. The confluent shear layer downstream the main element trailing edge and the gap flow have a significant influence on the boundary layer on the flap. The correct representation of those phenomena is thus considered essential for predicting the separation. In [4] synthetic turbulence was introduced on the suction side of the main element to force the break-up of the shear layer, but still the flow stayed attached.

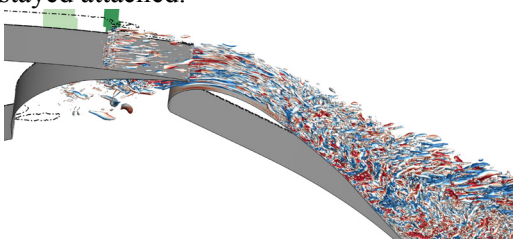

Fig. 2 Turbulent structures depicted by Q-criterion, forcing region in green.

We will present a further simulation, where synthetic turbulence is also introduced on the pressure side of the main element to enrich the resolved turbulent structures in the cove region and the gap flow. We will investigate the influence of this measure on the resolved turbulent stresses and on the tendency towards separation.

References

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