THE EUROPEAN HIGH LIFT PROGRAMME II

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EXTENDED ABSTRACT

The design of high lift systems for commercial aircraft has a substantial potential to contribute to the achievements of the challenging goals formulated in the European Vision for 2020. Basically, efficient innovative high lift devices are the pre-requisite for improvements in two fields: the first is the reduction of the perceived aircraft noise, as the airframe, more precisely the slat, has become the main source of noise during the landing phase. The second field is the strong reduction of CO_2 emissions. Whatever advanced aerodynamic concept is considered, the objective is to achieve a reduced perceived noise level for the airport and its residents while sustaining or improving the high lift performance itself, e.g. by means of flow control. High fidelity numerical methods together with a detailed understanding of the high lift flow physics and scaling effects are key issues to accomplish the envisaged improvements.

Therefore, the European projects EUROLIFT (I), as part of the 5th European framework program, and EUROLIFT II in the 6^{th} framework program have been launched with two major objectives: The first one was to provide a comprehensive experimental and numerical database for the validation of state-of-the-art CFD methods together with a deeper understanding of the related flow phenomena, scale effects, and wind tunnel mounting effects. The second one was to study alternative high lift concepts. While most of the activities in EUROLIFT (I) were limited to wing fuselage configurations, the follow-on project EUROLIFT II extended the studies to complete high lift aircraft configurations with pylon-mounted engines. The emphasis of the presented results will be on numerical analysis, but also optimization tools as well as advanced transition and deformation techniques for cryogenic testing will be covered.

Thirteen partners form the consortium of EUROLIFT II, three sides of Airbus Industry, two aerospace companies, one SME, six research establishments and one transonic wind tunnel company. The project structure consists of three main work packages:

1. Improved Validation Based on EUROLIFT (I)
2. Realistic High-Lift Configurations
3. Methods and Tools

Lots of effort has been spent on improving the validation base on the former EUROLIFT I WT-measurements. Key focus of these activities is the analysis and the understanding of the influence of different geometrical features on the high-lift performance. Such geometrical features are the model deformation, wind tunnel wall effects and the slat tracks and the pressure tube bundles. Latter are bundles of pressure

tubes, necessary to monitor the slat pressure distribution in different cross sections. These tubes are installed between the slat and the main wing aside of the slat tracks. According to WT-measurements, these pressure bundles significantly affect the high-lift performance. To simulate and understand this behaviour with today's state-of-the-art Navier-Stokes flow solvers are the key issues in this work package. CFD results indeed capture this effect. The next figure depicts the position of the pressure tube bundles:

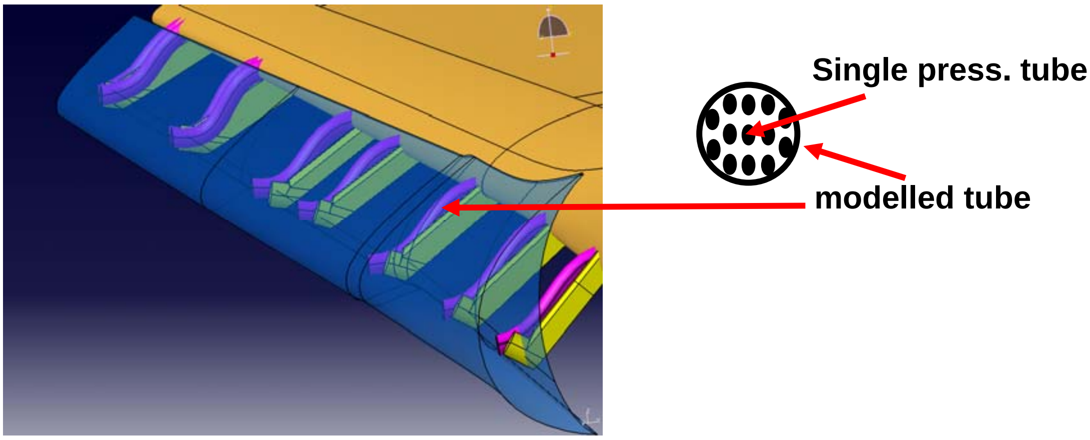

Figure 1: Pressure tube bundels on the EUROLIFT II high-lift configuration

The influence of the wind tunnel walls on the spanwise loading and the high-lift performance is also investigated and of special interest, since the WT-measurements have been performed with non-slotted walls. The analysis is done using today's capabilities of CFD-methods. The outcome clearly underlines the distinct influence of the WT-walls on the high-lift performance.

In the second work package the activities focus on a more realistic high-lift configuration. While in EUROLIFT (I) the configuration consist of a full span flap and a full span slat without an engine, the EUROLIFT II configuration is much closer to a realistic A/C. Since the key issue of this work package is the understanding of the high-lift flow and high-lift performance of a realistic high-lift configuration, the EUROLIFT (I) configuration is stepwise modified towards a realistic configuration, equipped with an onglet, slat horn, engine, and nacelle strake.

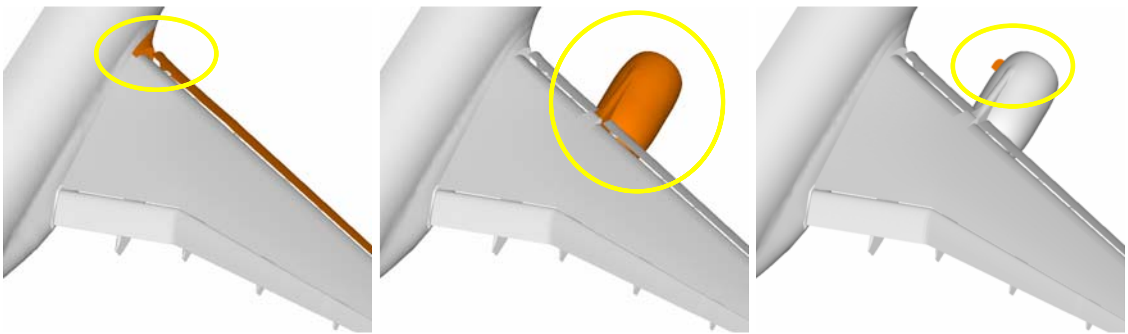

Figure 2: Model modifications towards a realistic High-Lift configuration
stage I (left), stage II (middle), stage III (right)

Low speed wind tunnel tests have been conducted in the LSWT wind tunnel of Airbus Deutschland for of all of these three stages [1]. Polars beyond maximum lift were measured, the strake position was optimized, and flow measurements including

3D-PIV and wake-rake measurements were performed. Infra Read (IR) imaging was used to detect transition. The full set of pressure distributions on the wing, the slat, the flap and the nacelle is measured for each Angle of Attack (AoA). In order to extend the Reynolds (Re) number towards flight Re, all three stages were measured in the European Transonic Wind Tunnel (ETW) up to a Re-number of Re=25Mio. Since model deformation becomes of interest, a special deformation measurement system was applied. Pressure distributions, forces and moments are the further quantities monitored and measured during the ETW-test. In order to visualise the flow patterns close to the surface of the model, minitufts were used. In the presentation key results of the measurements will be exemplary discussed.

The second key focus in this work package is the numerical simulation of the high-lift performance for all three stages at low and high Reynolds-numbers using state-of-the art Navier-Stokes solvers. Compared to the WT-model setup some simplifications are necessary. The main simplifications are the neglect of the wind tunnel walls and the model deformation. The reasons for these simplifications are the following: Considering the WT-wall influence requires the computation of the model fully installed in the corresponding wind tunnel. As demonstrated in the first work package, such a computation is possible in principle, but the numerical effort in terms of resources is immense. The same reason holds for the case of considering model deformation. In this case a close coupled computation of aerodynamics and structure is required, which is beyond the scope of the numerical activity in the work package. Using the symmetry condition the required sizes of the hybrid meshes reaches 18Mio. nodes. As an exemplary result Figure 3 depicts the structure of the different vortices of stage II and stage III in comparison at ETW-conditions. The presentation will further outline obtained results in comparison to the WT-measurements:

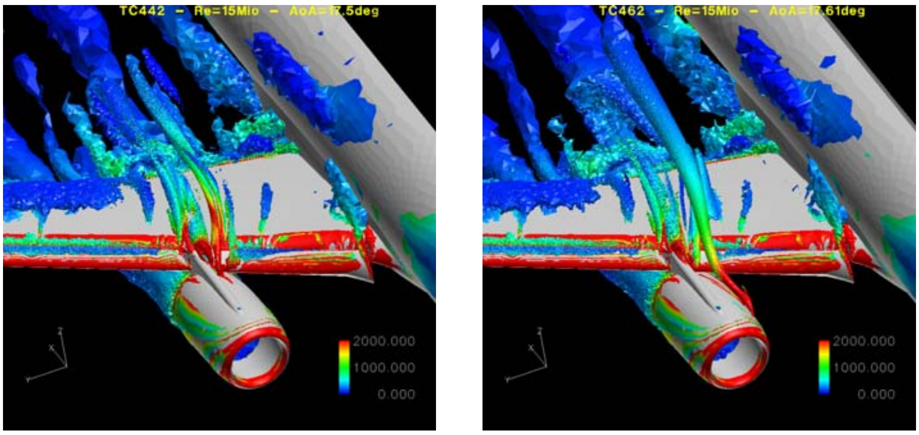

Figure 3: Structure of the generated vortices for stage II (left) and stage III (right) at ETW-conditions

Within work package 2 an effort is devoted to an advanced flap design using numerical optimization [2]. The key issue here is the performance increase of the inboard flap in take-off position. Several partners applied numerical optimization strategies in combination with RANS-solvers to re-shape the flap and optimize the settings. These optimizations were performed in 2D applying extrapolation techniques of the results to a 3D-flap. The new flap was manufactured and installed on the model. ETW-tests were conducted in order to measure the performance of the new flap compared to the former one. The measured performance increase is in almost perfect agreement to the predictions of the numerical methods. These results clearly demonstrate the accuracy of today’s Navier-Stokes solvers.

Advanced high-lift devices are the topic of the third task in work package 2. Within EUROLIFT II two devices, the Sub Boundary layer Vortex Generators (SBVGs) and the constant blowing have been designed and manufactured. The design phase was accompanied by numerical flow simulations to analyse for example the geometrical shapes and the positioning of the SBVGs as well as the rate of blowing for the second device. The presentation will outline the devices, which are about to be tested in the wind tunnel.

The more theoretical work is done in the third work package “Methods and Tools”. Here the focus is put on turbulence modelling, transition [3], advanced mesh generation and advanced transition and deformation detection/measurements. The presentation will outline some of the key results obtained so far.

REFERENCES

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