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CFD STUDIES FOR PREDICTION OF FLOW SEPARATION FROM AIRCRAFT TAIL SURFACES

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Enhancing engineers' capability to predict flow separation from the surfaces of an aircraft would generate important benefits in terms of reduction of drag and fuel consumption for the aviation industry. In this study the attention is focused on one part of the aircraft that is usually large and requires a heavy assembly: the vertical tail plane (VTP). For a common multi-engine commercial airliner, the size of the VTP is driven by a particular flight condition: loss of an engine during take-off and low speed climb. In this condition, the fin and the rudder have to be in measure to balance the aircraft, generating sufficient forces and moments. The VTP has a crucial role also during crosswind take-off and landing, so it is import to study the behaviour of the flow around its surfaces when a sideslip angle is present.

Due to uncertainties in prediction of VTP effectiveness, aircraft designers keep a conservative approach, specifying a large size for the VTP. Uncertainties come from difficulty in predicting the separation of the flow from the surfaces of the aircraft using CFD. Improved predictive capabilities would allow a more optimal design approach with resultant weight and drag savings. Currently CFD studies are done using Reynolds Averaged Navier-Stokes equation (RANS), with the introduction of a turbulence model for the closure of the equations. At Airbus, RANS equations are solved with two eddy viscosity models (EVM): the Spalart-Allmaras and the Menter-SST two equation model. However, the behaviour of the flow computed with these models does not always match experimental observations when separation occurs. Moreover, massive separation on the VTP presents a challenge for the RANS approach. In addition, the swept shape of the surfaces leads to increased three-dimensionality and curvature in the separation process, presenting a further challenge for turbulence modelling. For these reasons, it is interesting to evaluate RANS techniques that implement a more advanced approach than EVM, in the form of second moment Reynolds Stress Models (RSM), due to the good abilities they can show in resolving separated turbulent flows on 3D bodies. In this study the RSM turbulence model SSG/LRR-ω has been implemented.

The research studies here presented investigate prediction of flow separation on an Airbus wind tunnel model. The model has been meshed with a hybrid (structured and unstructured) grid using Solar mesher. RANS and unsteady RANS simulations have been performed using the DLR TAU solver; for the assumption of steady flow, convergence acceleration by local time stepping and multigrid have been used. A Mach number of 0.2 and a Reynold number of 2.42×10^6 referred to the aerodynamic mean chord of the VTP have been considered. CFD computation have been made for several angles of rudder deflection up to 30° and sideslip angles from 0° to 20°.

It is interesting to compare the results obtained by RANS and URANS studies. In the first case, as it is possible to see from figure 1, the friction lines converge and then diverge close to the tip of the leading edge. This indicates flow separation and reattachment. For the same flow and geometry conditions, unsteady simulations show a wider zone of flow separation along the leading edge of the fin (figure 2). The time scale used for URANS is not enough sufficient to resolve turbulent structures, so a further refinement is necessary. This is the object of the ongoing work.

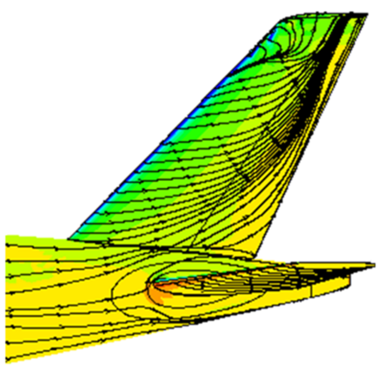

Figure 1: Friction lines on the VTP for a RANS study with Cp contours (no rudder deflection, no sideslip angle).

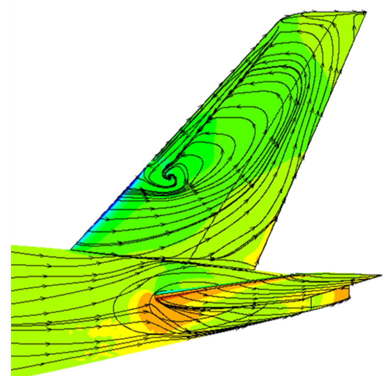

Figure 2: Friction lines on the VTP for an URANS study with Cp contours (no rudder deflection, no sideslip angle).

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