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HIGH FIDELITY CFD SHOCK WAVE AND CONTROL SURFACE EVALUATION

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Abstract: Shock waves are a recurring topic of aircraft manufacturers and researchers when dealing with transonic flows. Aircraft performance, stability, noise levels and even structural integrity may be severely impacted by shock wave occurrences. Moreover, these effects can also manifest near control surfaces such as the elevator, the ailerons or the rudder, threatening the aircraft's controllability. The unsteady motion of control surfaces will impact the shock wave position and formation, thus introducing multiple coefficient fluctuations in normal operation. It can happen in multiple conditions, commanded or not, such as when the aircraft is adapting its trajectory in high speed cruise, when the control law is attenuating external turbulence or even when a failure condition such as an oscillatory malfunction may occur. A deep understanding of the phenomena and of its consequences will improve aircraft designs and safety as newer technologies improve manufactures capabilities to deliver jets that cruise on higher speeds. In order to understand the dynamics between shock formation and control surfaces, this study investigates hinge moments and the shock formation near the control surface position on a 2.5D NACA 64A006 airfoil setting using high fidelity methods such as DES (Dettached Eddy Simulation) implemented on the open-source CFD solver SU2. This airfoil is placed in a uniform flow condition with a flapped end that is oscillating at a fixed frequency for each Mach Number. Following previous studies [1] [2] conducted with the same solver using Unsteady RANS (Reynolds-Averaged Navier-Stokes) simulations, the goal of this paper is to compare the results of both simulation settings in predicting the shock wave behaviour and impact on the control surface with regards to reference wind tunnel test setups from the literature in which the same setup has been evaluated in a wind tunnel test campaign [3]. Therefore, this article aims to contribute for the trade-off between the different simulation types in properly modeling the shock formation phenomena and its impacts with respect to its relative computing cost and processing time. Figure 1 and Figure 2 ilustrate some of the evaluated scenarios for the 2D and 2.5D simulations. This research results will allow for a more robust investigation and characterization of the oscillatory motion of the shock wave formation on handling qualities and stability evaluations of an aircraft on follow-up studies of transonic flow projects either using common models such as the CRM (Common Research Model) or proprietary projects that may require to fly under these conditions.

1 REFERENCES

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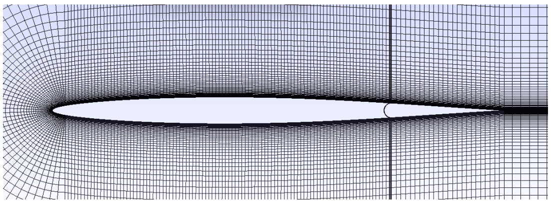

Figure 1: 2D Mesh proposal for URANS CFD Simulations. Extracted from [2].

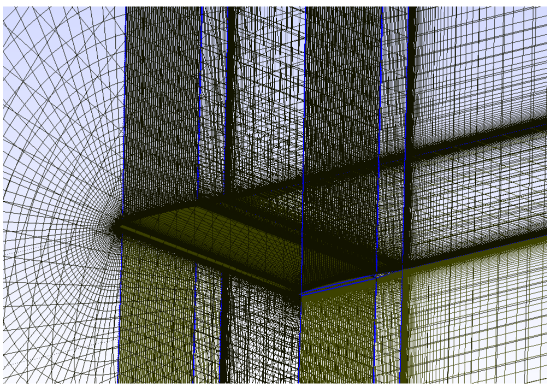

Figure 2: 2.5D Mesh proposal for DDES CFD Simulations.