Numerical Investigations of Aerodynamic Properties of a Propeller Blown Circulation Control System on a High Wing Aircraft

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Abstract

A novel transport aircraft design with short take-off and landing (STOL) capabilities is investigated within the German collaborative research center 880 (*CRC 880*) [1]. To achieve STOL capabilities, the aircraft utilizes a smart droop nose and a circulation control for its high-lift system in in conjunction with wing-mounted turboprop engines to allow further lift augmentation (Fig. 1).

In order to investigate the impact of these technologies in the present context, a comprehensive aerodynamic database had to be created [2]. The focus is laid on the aerodynamic performance characteristics, but also on flight dynamics aspects of the whole aircraft, such as the determination of static and dynamic derivatives. RANS simulations of the trimmed aircraft in landing configuration with thrust and circulation control were performed in order to investigate the longitudinal and lateral static stability [3, 4]. Additionally, tail-off calculations led to important information regarding the variation of the flowfield at the location of the horizontal stabilizer. Moreover, asymmetric failure cases of the circulation control as well as the engine were simulated (Fig. 4). For the study of the dynamic behavior, three dimensional URANS calculations were carried out [5].

Besides the analysis of the aircraft behavior, the simulations also aimed at optimizing the preliminary aircraft design. As a result, revised tail planes were integrated into the design. Furthermore, the high-lift performance could be improved due to the use of a nacelle strake (Fig. 5).

The paper gives an overview of the wide range of highly complex pilot numerical simulations, which were performed in this context. Selected results of the investigations are presented and analyzed. Various features of the underlying process and simulations are described, such as modular

meshing, mesh deformation, trimming algorithm, actuator disk and motion simulation, which were utilized.

Furthermore, the paper addresses meshing challenges due to the geometry complexity and the wide dimensional range between the farfield size and the jet exit slot.

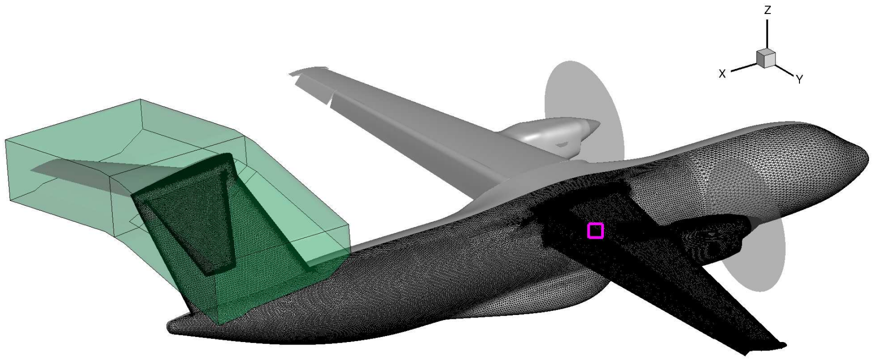


Figure 1: Geometry overview with module box and mesh detail (Fig. 3) location

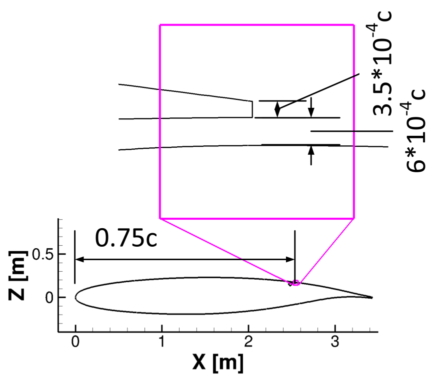


Figure 2: Blowing slot geometry

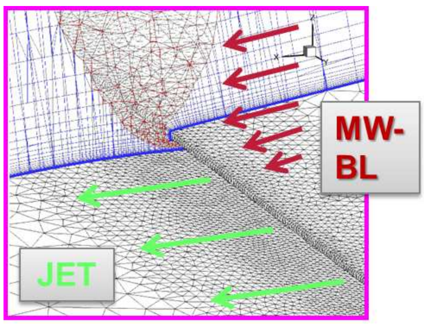


Figure 3: Mesh topology in slot region

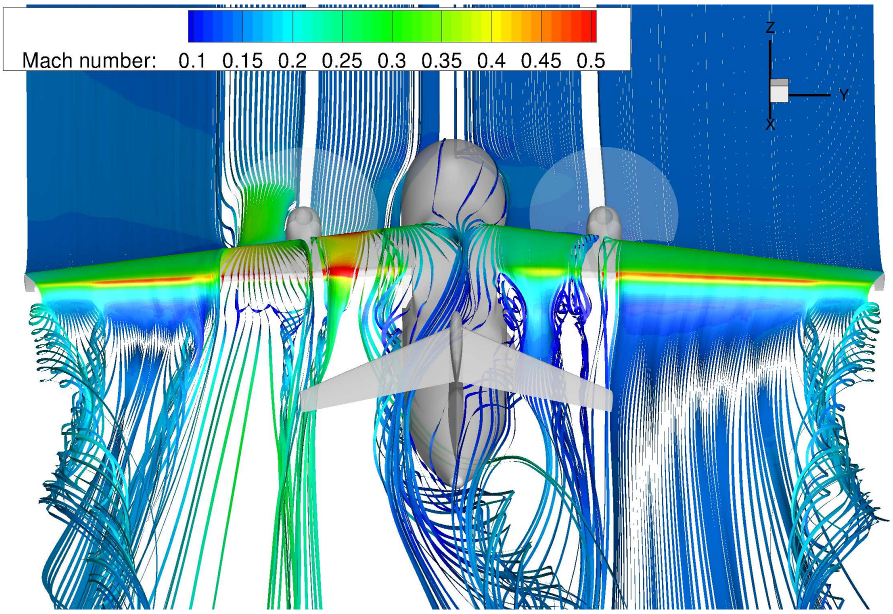
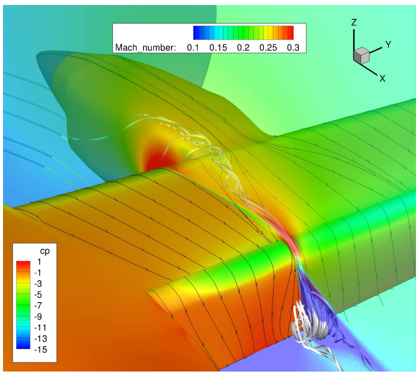
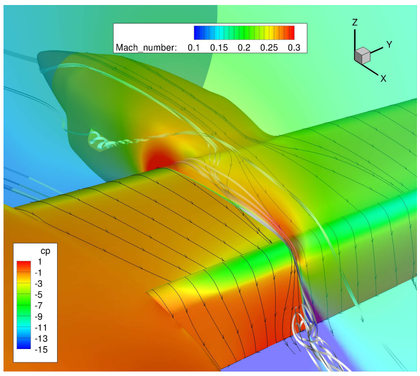


Figure 4: Main wing wake evolution at one engine inoperative



(a) without strake



(b) with strake

Figure 5: Nacelle vortex evolution and flow separation above the flap

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