Experimental & Computational validation of Junction Flow for a Strut Braced Wing

Topic Background

The initial European Climate Law has set the goal of achieving climate neutrality by 2050. Within this context, the European aviation industry must play a crucial role in advancing sustainable practices, setting global benchmarks for safety, reliability, and affordability. On that note, HERWINGT is an EU-backed initiative that aims to create a Hybrid Electric regional aircraft (HER) capable of accommodating up to 100 seats and covering a range of 500 to 1000 km.

In order to achieve these goals, the aircraft design must be reconsidered. Specifically, higher aspect ratio wings are an important design consideration, and to support such wings, the aircraft might need supporting struts.

This leads to the central topic of the thesis, which is studying the effects of junction flow, a phenomenon encountered when a boundary layer interacts with protruding surfaces, which in the case of the HERWINGT strut braced wing (SBW) would be between the strut and the wing. Thus, gaining an understanding of the impact of the junction flow might prove important in optimizing the design of the HER.

Thesis Objective

The objective of the thesis is to validate the capabilities of a Lattice Boltzmann Method (LBM) computational fluid dynamics (CFD) solver in predicting the flow of a strut braced wing with respect to wind tunnel results. [Ding et al., 2022] has shown that conventional Reynolds Averaged Navier Stokes (RANS) models are incapable of correctly predicting the transient behavior of a rood wing and show noticeable differences with wind tunnel models. Furthermore, regarding simulating the acoustics of a rood wing, the inability for RANS or URANS models in capturing the fluctuating flow patterns that are responsible for noise generation makes them unfit for this study [Lam et al., 2014].

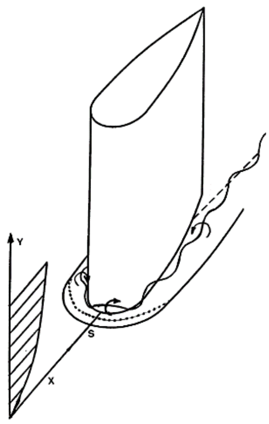

Figure 1The horseshoe vortex system around a Wing junction (rood wing) at zero angle of attack. [Simpson, 2001]

The pressure fluctuations that produce sounds are on a much smaller scale than those that influence the aerodynamic performance of a wing. Hence, the necessary meshes are computationally more expensive. To that effect, LBM solvers are much more parallelizable than conventional Navier Stokes solvers, lending themselves better to being used in high-performance computers. Furthermore, an LBM solver is well suited in capturing the transient behavior of the fluid, as it is based on a Lagrangian reference frame and being inherently unsteady, allowing it to handle the smaller pressure waves more easily [Astoul et al., 2021] and lending itself better to acoustics analysis.

References:

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[Simpson, 2001] Simpson, R. L. (2001). Junction flows. Annual Review of Fluid Mechanics, 33(1):415–443.

[Astoul et al., 2021] Astoul, T., Wissocq, G., Boussuge, J.-F., Sengissen, A., and Sagaut, P. (2021). Lattice boltzmann method for computational aeroacoustics on non-uniform meshes: A direct grid coupling approach. Journal of Computational Physics, 447:110667.