PROPOSITION DE STAGE EN COURS D'ETUDES

Référence : **DAAA-2025-38**
(à rappeler dans toute correspondance)

Lieu : Meudon

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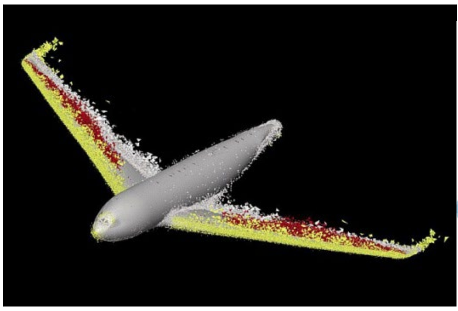
DESCRIPTION DU STAGE

Thématique(s) : Exploitations des données expérimentales et numériques

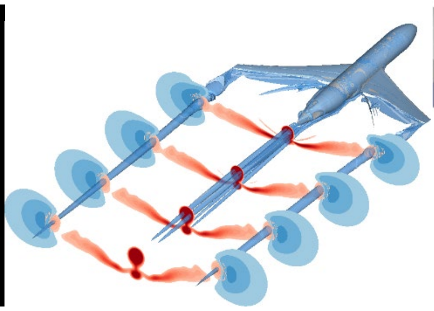
Type de stage : ☒ Fin d'études bac+5 ☒ Master 2 ☐ Bac+2 à bac+4 ☐ Autres

Title: Lift-induced Drag Analyses on Wing Configurations from CFD Simulations

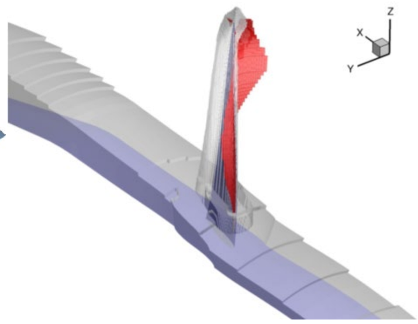
Subject: ONERA has been developing for many years several post-processing codes aimed at evaluating lift, drag, thrust and torque exerted on aircraft and rotors. Those codes allow for a near-field/far-field balance of the drag in terms of pressure and friction drag (near-field approach) or lift-induced, viscous and wave drag (far-field approach) [1, 2]. Using the near-field approach consists in computing the drag by considering the effect of the airflow onto the aircraft, whereas using the far-field approach comes down to appreciating this time the effect of the presence of the aircraft onto the surrounding airflow. With the phenomenological information of the drag decomposition (lift-induced, viscous and wave), aerodynamicists and aeronautical engineers may then improve the design of airplanes, engines and blades. At ONERA, the FFD code allows to assess all those drag contributions starting from the analysis of a CFD solution:



FFD capabilities on aircraft



Drag sources in the wake



FFD volumes around a propeller [2]

It is based on a thermodynamic formula developed by Destarac and van der Vooren [1], which was initially devised for the analysis of aerofoils, wings and aircraft configurations in steady flows. However, in this formulation, the lift-induced drag is defined by default as the subtraction of the profile drag (viscous plus wave drag) from the total far-field drag. Consequently, all physics is lost in the analysis of the lift-induced drag sources.

That is why recent studies proposed alternative formulations related to, or based on the vorticity vector in order to define unambiguously the lift-induced drag in viscous transonic flows. Unfortunately, they all tend to underestimate the lift-induced drag compared to classical incompressible formulations from the literature.

One of those alternative formulations is called the Kutta-Joukowski-Maskell-Betz (KJMB) formulation and was developed at ONERA [3]. It extends Kutta-Joukowski classical lift formula, Maskell's lift-induced drag formula [4] and Betz's profile drag formula to viscous transonic flows [5]. Preliminary work has been carried out very recently on this formulation in order to improve the lift-induced drag predictions.

The goal of this internship is to study an untwisted elliptic wing planform using CFD simulations in order to compare the lift-induced drag predicted by the Destarac/van der Vooren formula [1], the KJMB formula [3], an improved KJMB formula and Maskell's formula [4] to Prandtl's analytical result. It implies to run both Euler and RANS simulations at a given wing loading, in order to understand why the KJMB formula tends to underestimate the lift-induced drag. The work is to be organized as follows:

- Literature review of the various lift-induced drag formulations.
- Meshing of the selected elliptic wing configuration (Pointwise, ICEM, etc.).
- Preparation and realization of the CFD computations:
  - Euler computations at given Mach numbers and lift coefficient.
  - RANS computations with varying Reynolds numbers at the previously selected Mach numbers and lift coefficient.
- Post-processing of the CFD results using the FFD code to investigate the effect of Mach and Reynolds numbers on lift-induced drag predictions.
- In parallel of the latter task, theoretical investigations of the causes for lift-induced drag underestimation by the KJMB formulation.

Depending on the progress made on the aforementioned objectives, a simple propeller geometry will be investigated.

References:

[1] D. Destarac and J. van der Vooren, “Drag/Thrust Analysis of Jet-Propelled Transonic Transport Aircraft; Definition of Physical Components,” Aerospace Science and Technology, vol. 8, no. 6, pp. 545-556, 2004.

[2] M. Méheut, “Thrust and Torque Far-Field Analysis of Propeller and Counter Rotating Open Rotor Configurations”, 31st AIAA Applied Aerodynamics Conference, 2013.

[3] C. Fournis, D. Bailly and R. Tognaccini, “Invariant Vortex-Force Theory Extending Classical Aerodynamic Theories to Transonic Flows,” AIAA Journal, vol. 60, no. 9, pp. 5070-5082, 2022.

[4] E. C. Maskell, “Progress Towards a Method for the Measurement of the Components of the Drag of a Wing of Finite Span,” Tech. Rep. 72232, Procurement Executive, Ministry of Defence, Royal Aircraft Establishment, 1972.

[5] A. Betz, “A Method for the Direct Determination of Wing-Section Drag,” Tech. Rep. NACA TM37, National Advisory Committee for Aeronautics, 1925.

Est-il possible d'envisager un travail en binôme ? Non

Méthodes à mettre en œuvre :

☒ Recherche théorique	☒ Travail de synthèse
☒ Recherche appliquée	☐ Travail de documentation
☐ Recherche expérimentale	☐ Participation à une réalisation

Possibilité de prolongation en thèse : Non

Durée du stage : Minimum : 5 mois Maximum : 5 mois (sauf dérogation)

Période souhaitée : between January and September 2025.

PROFIL DU STAGIAIRE

Connaissances et niveau requis :	Ecoles ou établissements souhaités :
Good knowledge in fluid mechanics, CFD and strong interest in physical interpretation. Python (required), Linux, meshing skills is a plus.	Graduate School of Engineering or Master 2 or Graduate School of Engineering + Master 2.