

## PROPOSITION DE STAGE – MASTER 2 DET

Dynamique des fluides, Énergétique et transferts

Université Toulouse 3 Paul Sabatier - Toulouse INP - INSA Toulouse - ISAE SUPAERO – IMT Mines Albi

### **Titre : Generating swirl inlet distortion for low fan-pressure propulsors**

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### **Sujet**

#### **Context and motivation**

As the bypass ratio (BPR) is increased for improved fuel burn and reduced noise, the fan diameter grows, leading to shorter nacelles with reduced distortion-free operating ranges, and the fan pressure ratio (FPR) decreases, leading to less distortion-tolerant fan designs. Swirl distortion is often divided into three overall categories: bulk swirl, twin swirl and localized swirl in the form of ingested vortices. Twin swirl being mostly present in S-duct inlets and partially embedded inlets is of growing interest for new disruptive airframe configurations such as blended-wing body concepts. This project aims at designing means of generating swirl distortion for a turbofan test bed, through numerical simulation and shape optimization.

Early experimental studies on the impact of swirl distortion on turbofan performance report the use of either a symmetric delta wing under incidence to generate a symmetric pair of counter-rotating vortices [1], or a non-symmetric half delta wing to generate one large vortex and simulate bulk swirl [2]. Work on wishbone and doublet vortex generators [3] show that these devices generate a vortex pair rotating in the opposite direction compared to a delta wing. Recent work on swirl distortion vanes [4] introduce a different method, particularly suited to generate non-symmetric vortex pairs.

#### **Proposed work**

The aim is to propose a method to design devices to recreate different swirl flow distortion conditions at the inlet of a turbofan in a ground test bed, using a combination of vortex generators. To this end, we will begin by studying and modelling the flow structures generated by a variety of vortex generator types placed inside a cylindrical duct, using low-cost methods (e.g. potential flow or inviscid, supported by a literature review). In parallel, we will set-up an optimization framework using an in-house CST-curve based geometry parameterization method [5], existing tools (like openMDAO or RCE), and the proposed flow model. Finally, we will define and explore the design space and design distortion generators for target flow of increasing complexity, symmetric and non-symmetric, and establish the limits of the approach.

#### **References**

- [1] W. Pazur *et al.*, The Influence of Inlet Swirl Distortions on the Performance of a Jet Propulsion Two-Stage Axial Compressor, in *Turbo Expo: Power for Land, Sea, and Air*, 1990.
- [2] N. R. Schmid *et al.*, Steady performance measurements of a turbofan engine with inlet distortions containing co- and counterrotating swirl from an intake diffuser for hypersonic flight, *Journal of Turbomachinery*, 2001.
- [3] S. Farokhi, Propulsion system design with smart vortex generators, *Aircraft Design*, 1998.
- [4] T. Guimarães *et al.*, StreamVane turbofan inlet swirl distortion generator: mean flow and turbulence structure, *Journal of Propulsion and Power*, 2018.
- [5] B. M. Kulfan, Recent extensions and applications of the CST universal parametric geometry representation method, *The Aeronautical Journal*, 2010.
- [6] T. Guimarães *et al.*, Complex flow generation and development in a full-scale turbofan inlet, *Journal of Engineering for Gas Turbines and Power*, 2018.