Final year Internship – MASTER 2

Title: **Boundary conditions Uncertainty Quantification on aero-engine inter-turbine ducts**

Tutor(s):
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Place of the internship: DAEP - Aerodynamic and Propulsion Department
ISAE-Supaero campus
10 avenue Edouard Belin
31400 Toulouse (France)

Period: 6 month, starting period from February to beginning of April

To Apply for the position: send a CV, motivation letter and exams' grades to alessio.firrito@isae-supaero.fr.
For any doubt or question, please contact Alessio Firrito by mail or phone.

Salary will be decided in accord to standard university internship compensation

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Internship Description

Context
Nowadays, modern turbofan engines are growing in size in order to reduce the specific fuel consumption. This tendency generates a new integration problem: the larger the fan, the larger the mean radius of the low pressure turbine. Because of that, the integration of the high pressure and low pressure turbines, thanks to an inter-turbine duct, is becoming a demanding task and lots of recent research in turbomachinery is focused in the optimization of this component.
The flow in this component is strongly 3-dimensional and the inlet flow is highly distorted by the upstream high pressure turbine.
In designing a new engine, computational fluid dynamics is extensively used to forecast the aerodynamic performances of the turbomachine. Usually, these types of simulations are precise enough for industrial applications.

Motivations
The performance prediction of an inter-turbine duct is more complicated than a conventional turbine component due to several causes. One of them is the significant epistemic uncertainty (i.e. the uncertainty related to a lack of knowledge) of the inlet flow. Another possible cause is the unique shape of the component, showing a highly complex 3D flow.
The strong non-linearity of the Navier-Stokes equations can lead to a non-negligible variation of the component performance even with a small inlet perturbation. This might explain the difficult performance prediction, and an analysis in this sense needs to be accomplished.

Objectives
The main objectives of the internship are:
- to **implement a routine** to post-process CFD simulations in the sense of Uncertainty Quantification for our purposes (general subroutines are already available);
- to **analyse** in a critical way the results, trying to isolate boundary conditions variables having the worst impact on performances or flow pattern;
- to **compare** different configurations in order to identify the most impactful geometry feature on uncertainty;
- to **propose** further studies and research axis.

Internship main phases
The first part of the internship is dedicated to the bibliography study on Uncertainty Quantification (UQ) methods, variable space reduction, UQ applied to turbomachinery, typical values of boundary conditions uncertainties in turbomachinery. At the same time, a phase of skill-growth in mesh generation and in running CFD is needed.

In a second phase it will be necessary to implement a routine of CFD data pre- and post-processing by means of python or Matlab scripts (at your discretion). First analysis will be performed with a simple computational domain; the aim of this phase is to define the list of post-processing to be used for performance analysis and how UQ results will be presented in future studies.

In a third phase, more complex geometries will be studied, with the main purpose of identifying the combination of boundary condition vs geometrical features having the stronger impact on inter-turbine performance variability. In this phase a deep physical and statistical analysis of the results is required, in order to understand the behaviour of the flow leading to high performance uncertainty.

During the fourth phase you will be free to explore and test whatever you want inside the perimeter of the internship subject. The knowledge acquired during the previous months should enable you to propose different research axis and you will be free to choose the one you consider the most promising. Obviously, this part is subordinated to the achievement of primary objectives aforementioned.

The last phase is dedicated to write you final project report and to prepare the speech of your final project defence. You will be free to write the report in English or French, at your convenience.

During the internship, periodical presentations of your work will be done both at ISAE-Supaero and with Safran Aircraft Engines design office engineers.

What we are looking for

You are at last year of a Master of Science program in aeronautical engineering or mathematical engineering, familiar with programming language (Matlab or python), willing to learn outside your domain of competencies. Knowledge of at least one topic between Turbomachinery / Fluid Dynamics and Statistics / Uncertainty Quantification is compulsory.
A project in CFD or UQ/statistics is a plus.
Knowledge of the Numeca/Fine Turbo software is a moderate advantage (learn to run a simulation is fairly simple).
You speak English (intermediate level) and French or Italian (advanced level, working language).