# Title:

**Efficient resolution of complex robust reversal problems**
**Application in wind turbine design**

## Duration of the internship

5 to 6 months between February and September, 2020

## Description of the internship subject

Many of the problems studied at IFPEN are formalized as an inversion problem consisting in finding all the admissible values of a set of parameters so that an amount of interest (or several) remains in a certain domain, below a threshold for example. An example is the study of a vehicle exhaust after-treatment pollution control system for which the aim is to estimate all the values of the controller's parameters to obtain pollutant emissions below a certain threshold. To solve such a robust inversion problem, several difficulties must be overcome. You must be able to take into account both the presence of intrinsic uncertainty in the system (for example in the case of the pollution control system, through different sensors) and the presence of uncertainties in the inputs of this system (always in the case of the depollution system, the uncertainty on the driving cycles for example), and this so that the solution of the inversion is robust. On the other hand, we must face the complexity of certain inputs and outputs of the system: uncertain functional inputs often modeled by stochastic processes (eg, a time-dependent driving profile in the example of the pollution control system) and quantities of interest of a vectorial or even functional type (the evolution of a quantity of pollutant as a function of time).
In the context of the depollution system, we formalized in a previous work the problem as follows:

$$\Gamma = \{ x \in R^d, E[g(x,U)] \leq s\}$$

where

- $x \in R^d$ are the deterministic or controllable parameters to invert,
- U $\in H$ the random variable modeling the different sources of uncertainty (intrinsic to the system, or on the inputs of the system),
- the function g : $R$^$d \times H \rightarrow F$ allows the computation of the quantity of interest related to the system.

The expectation is taken with respect to the uncertain variable U. We then say that one wants to solve the problem with the expectation as robustness measure.

Usually in the studies, we have $F = L^2(\Omega, R, P_F)$,
$H = L^2(\Omega, R^m, P_H)$ which are respectively the set of variables $\Omega \rightarrow R$ (vectors from $\Omega \rightarrow R^m$) with finite second-order moment with respect to the measure $P_F$ $(P_H)$.

One of the main objectives of the internship is to extend the resolution to different and more or less complex sets $F$ $and$ $H$, and by considering as a measure of robustness a quantile rather than the expectation. Formally, the problem is then written as:
$\Gamma = \{ x \in R^d, P[g(x, U) > s] \leq \boldsymbol{\alpha}$, with $\boldsymbol{\alpha}$ a low to very low risk level.
It is also important to reduce the computation time required for the inversion, all the more critical since the quantities of interest are calculated from an expensive simulator in CPU. Finally, we will apply the methodology developed to a test case in wind turbine design.

## Required profile:

Master in statistics-probability/machine learning

**Practical information:**
The internship will be hold at Grenoble Alpes University, in narrow collaboration with Ecole Centrale in Lyon and IFPEN, the French Renewable Energy Institute. Usual indemnities will be paid for the internship.

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A PhD thesis on the same subject and in the continuity of the internship could be considered.