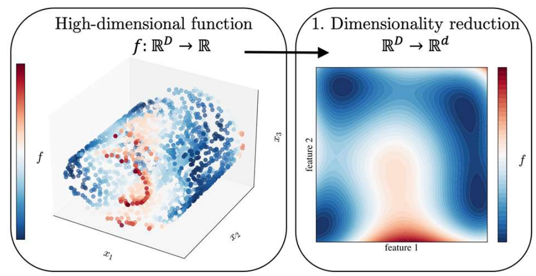
# MAchine LEArning for Fluid system Efficiency (ANR porject: MALEAF)

**Type of offer :**
Ph.D.

**Location :**
Mathematical & Numerical Modelling Laboratory (M2N)
Applied Mathematics & Statistics Department (EPN6)
Conservatoire Nationale Arts et Métiers (le CNAM)
2 rue Conté
75003, Paris Cedex 03




**Context :**
The objective of the project MALEAF is to obtain a new generation of predictive tools for the analysis of the performance of rotating machines for applications of industrial interest. The developed models will be able to provide fast and accurate flow predictions using smart data instead of big data. This change in perspective is necessary in operative conditions, where the sampling of data may be limited to local (pressure taps) or integral (drag, lift) quantities. In addition, big data storage and manipulation can be extremely expensive, in particular for advanced ML applications such as deep learning. The spectrum of tools proposed, which includes experiments, CFD and data-driven approaches such as Data-Assimilation (DA), Machine Learning (ML) and Reduced-order Modeling (ROM), has the potential to produce a large amount of reliable data from a limited amount of localized measurements. The data, which can be efficiently used for training purposes, can be safely eliminated at the end of the learning phases of the data driven algorithms, dramatically reducing the need for big data storage. From an applicative point of view, the objective of the project is to develop a family of high-accuracy, low-cost ROM. The first series of tools proposed will aim to detect early signals of stall, in order to activate control strategies able to anticipate the full development of such problematic issue. In case of fast success for this objective, ROM able to describe on-the-fly the main local and global physical quantities of the flow will be targeted. The training of the ROM will rely on smart and local data, principally obtained from experiments, which will be expanded using DA algorithms based on CFD runs aided by predictive models, similarly to what is currently done in meteorological sciences [1]. This multifidelity framework will produce a large quantity of high- fidelity data continuously distributed in the physical domain, which will be fed to the training algorithms to produce the ROM. The interest of such tools for industrial applications as hydro or aerodynamic design would be quick prediction of the flow features and production of many samples for different operating conditions. Obtaining such tools will provide a breakthrough for optimization studies and uncertainty propagation studies (robust design).

The workflow for this Ph.D. project is twofold: first, to develop fast and predictive reduced-order models for transient complex simulations of interest to this project, starting with methodologies already present in the group [2,3], and second, to integrate this modelling framework, into an existing DA tool to produce on-the-fly detailed data for analysis.

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M2N
Modélisation mathématique et numérique

**Profile :**
The candidate should have a MSc degree or equivalent in fluid mechanics or applied mathematics, with experience in scientific computing.

**Skills :**
Programming experience and expertise in data-driven techniques will be considered very positively.

**Duration and start date :**
The position is offered for the duration of 36 months, between October 1st, 2025 and September 30th, 2028. **Deadline for applications: 31/05/2024**

**Required documents :**
The applicant should include a CV, and a motivation letter.

**Contacts :**
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**References :**
[1] M. Asch, M. Bocquet and M. Nodet. Data Assimilation: Methods, Algorithms, and Applications, Philadelphia: Society for Industrial and Applied Mathematics, 2016.
[2] S. Kneer, T. Sayadi, D. Sipp, P. Schmid and G. Rigas. Symmetry-aware autoencoders: s-PCA and s-nlPCA,» arXiv:2111.02893v3, 2023.
[3] Data-driven framework for input/output lookup tables reduction -- with application to hypersonic flows in chemical non-equilibrium. C. Scherding, G. Rigas, D. Sipp, P.J. Schmid, & T. Sayadi. *Phys. Ref. Fluids.* (2023)