ONERA
THE FRENCH AEROSPACE LAB

www.onera.fr

PHD studentship

Reference: **MFE-DAAP-2013-04**
(to be recalled in each correspondence)

ONERA Laboratory:

Branch: Fluid Mechanics and Energetics — Place (ONERA Centre): MEUDON/LILLE

Department: Applied Aerodynamics

Unit: Civil Aircraft — Tel.: 01 46 73 42 66 — Fax: 01 46 73 41 46

ONERA advisor: Julien Dandois — Email: julien.dandois@onera.fr

PhD supervisor:

Adress: Dr. Jean-Marc Foucaut, L.M.L. UMR CNRS 8107, Bat M6, Bv Paul Langevin, Cité scientifique F 59655 Villeneuve d'Ascq Cédex

Tel.:+33 3 20 33 71 60 Fax:+33 3 20 33 71 69 Email:jean-marc.foucaut@ec-lille.fr

Title: Hybrid simulation/experimentation velocity field estimation from spare measurements

Subject:

Today, the need for more local and global aerologic data increases because of urbanisation, development of helicopter lift (hospitals, offshore activities…), windfarm installations or reinforcement in regulation and norms (dispersion of pollutants…). An example of application is helicopter landing on a frigate where, to improve safety during this difficult and perilous manoeuvre, it is needed to estimate the velocity field above the flight deck. Another example of application concerns airports where it would be interesting to estimate the turbulence field around the landing point from spare measurements to improve safety. The objective of this PhD thesis is thus to be able to estimate 2D (or 3D) velocity fields from 1D (or 2D) sparse measurements in the field (hot-wire) or at the wall (pressure, skin friction). Indeed, it is interesting from an economic point of view to estimate a velocity field from a limited number of sensors.

For example, in the separation behind a backward-facing step or a cube, the coherent turbulent structures, the vortices, leave a trace on the wall and the objective is to estimate the velocity field from these wall traces. The current method is the Linear Stochastic Estimation (LSE) [1] which, for example, enables from correlations between the 2D velocity field and spare wall pressure measurements to estimate this 2D field [2]. The LSE behaves like a model which can be trained either from time-resolved PIV measurements or from unsteady numerical simulations. Moreover, the proper orthogonal decomposition technique (POD) [2,3] enables to decompose the velocity field in a sum of modes ranked as function of their energy. Each mode corresponds to a more regularized velocity field which is easier to estimate from wall measurements.

This PhD thesis is part of a beginning, 4 years long, ONERA research project named PR HYBEXCIT. Two main parts can be identified:

- an experimental part which consists in performing the time-resolved PIV measurements in two wind tunnels from the ONERA Lille center;
- a numerical simulation part where hybrid RANS/LES simulations will be performed with the elsA software from ONERA.

The tested configuration will first be academic (backward-facing step, cube…) to aim at the end of the thesis to a more realistic configuration (separation behind a frigate for helicopter landing).

This PhD thesis can be decomposed in four steps:

- bibliographic review of velocity field reconstruction/reduction (LSE, POD…);
- management of the wind tunnel tests in the ONERA Lille center (the tests will be performed by a dedicated team);
- numerical simulations of the different test cases;
- development of a LSE/POD code.

[1] Adrian R.J. “Conditional eddies in isotropic turbulence”, Phys. Fluids, vol. 22, 1979
[2] Bonnet J.P., Cole D.R., Delville J., Glauser M.N., Ukeiley L.S. “Stochastic estimation and proper orthogonal techniques for identifying structure”, Exp. Fluids, vol. 17, 1994.
[3] Hudy L.M., Naguib A., Humphreys W.M. “Stochastic estimation of a separated-flow field using wall-pressure-array measurements”, Phys. Fluids, vol. 19, 2007.

Collaborations: Laboratory of Mechanics from Lille (LML, Lille 1)

CANDIDATE PROFILE

Requirements: M.S. degree in Fluid Mechanics

Knowledge/ Skills: Fluid Mechanics (aerodynamics, turbulence), Programming experience (Fortran, C++), Excellent written and oral communication skills, including the ability to publish and present scientific results.