Internship proposal – M2

Data-driven inference of unsteady inlet conditions for the numerical simulation of the BARC test case

Subject: Among the test cases in the literature of fluid mechanics, the Benchmark on the Aerodynamics of a Rectangular 5:1 Cylinder (BARC) [1] has been extensively used for the investigation of essential characteristics external flows which are observed in transportation engineering applications and urban setting studies. This apparently simple configuration, shown in figure 1, presents complex physical mechanisms such as boundary layer separation, flow reattachment, recirculation zones and Von Karman street. These mechanisms and their interactions, which affect the propagation of acoustic waves and the structural organization of the flow, must be fully understood and mastered to predict the behavior of practical systems. One of the major difficulties in studying this flow configuration via numerical tools is its sensitivity to the geometric characteristics or the boundary conditions, in particular the velocity field imposed at the inlet [2]. This is particularly true for scale-resolving approaches such as Large Eddy Simulation (LES) [3], which is nowadays extensively used for the analysis of bluff bodies.

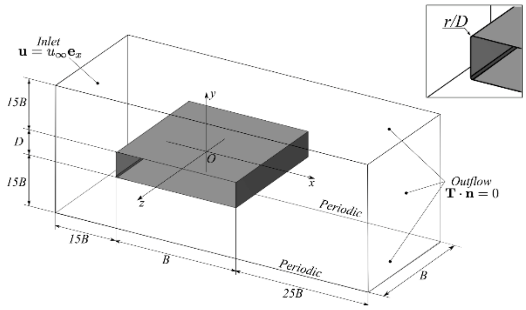

Figure 1: BARC test case

Objectives: the work proposed for this internship, within the framework of the ANR IWP-IBM-DA project, relies on the usage of recently presented data-driven techniques [4,5] to infer the behavior of precise inlet conditions and to quantify the sensitivity of the numerical system to uncertainties for the BARC test case. These objectives will be achieved via the development of the following tasks:

1. Preparation of the test case and run of initial LES simulations (prior) using the opensource code OpenFOAM [6].
2. Inference of the features of the time-dependent inlet behavior using the software CONES currently under development by the research team.
3. In case of early success of the previous two objectives, numerical analysis will be performed using the Immersed Boundary Method (IBM) also developed by the research team.

Host Partner: LMFL – Arts et Métiers. The candidate will be hosted in Arts et Métiers - Campus Lille

Scientific Leader: M. Meldi (marcello.meldi@ensam.eu)

Duration & start date: 6 month beginning spring 2023, accordingly to the availability of the candidate

Expected skills and knowledge : competences in numerical simulation, statistics, turbulence are welcome

References

1. Bruno, L., Salvetti, M. V. & Ricciardelli, F. Benchmark on the Aerodynamics of a Rectangular 5:1 Cylinder: an overview after the first four years of activity. *J. Wind Eng. Ind. Aerodyn*. 126, 87–106 (2014).
2. Mariotti, A., Siconolfi, L. & Salvetti, M. V. Stochastic sensitivity analysis of large-eddy simulation predictions of the flow around a 5:1 rectangular cylinder. *Eur. J. Mech. B-Fluids* 62, 149–165 (2017).
3. Sagaut, P. Large-eddy simulation for incompressible flows. An introduction, third edition. Springer-Verlag (2005).
4. Moldovan, G., Lehnasch, G., Cordier, L. & Meldi, M. A multigrid/ensemble Kalman Filter strategy for assimilation of unsteady flows. *Journal of Computational Physics* 443, 110481 (2021).
5. Moldovan, G., Lehnasch, G., Cordier, L. & Meldi, M. Optimized parametric inference for the inner loop of the multigrid ensemble kalman filter. *Journal of Computational Physics,* p. 111621 (2022).
6. www.openfoam.com