

JOB OFFER – STAGE

Wind Turbine Numerical Simulation: Development of an Actuator Line Model in LBM

OFFER INFORMATION

Reference: AAM-2026-PW-02**Location:** 42 Avenue Gaspard Coriolis – 31057 Toulouse**Team:** AAM**Supervisors:**

- Paul Werner, werner@cerfacs.fr
- Jean-François Boussuge, boussuge@cerfacs.fr

Gratification: 800€ net per month - M2 level or last year at engineering school**Period:** 6 months - from: 09/02/2026**Key words:** LBM, Rotors, Wind Turbine, Actuator Line Model

CERFACS

Cerfacs is a private research, development, transfer and training center for modeling, simulation and high-performance computing. Cerfacs designs, develops and proposes innovative software methods and solutions to meet the needs of its partners in the aeronautics, space, climate, environment and energy sectors. Cerfacs trains students, researchers and engineers in simulation and high-performance computing.

Cerfacs works closely with its seven partners: [Airbus](#), [Cnes](#), [EDF](#), [Météo France](#), [Onera](#), [Safran](#) et [TotalEnergies](#).



HOSTING TEAM - AAM

The Advanced Aerodynamic & Multiphysics (AAM) team is dedicated to developing cutting-edge numerical methods, physical modeling, and High-Performance Computing (HPC) techniques for new Computational Fluid Dynamics (CFD) solvers. The work focuses on fluid dynamics simulations for aircraft, rockets, and turbomachinery, in close collaboration with Cerfacs partners.

CONTEXT

At the heart of the global energy transition, renewable energies play an important role in the decarbonization and diversification of our electricity production mix. Wind energy, in particular, is experiencing unprecedented development with the emergence of new technologies (offshore wind turbines, large-scale rotors, high-density wind farms). This internship offers you an opportunity to participate in a strategic collaboration between several industrial partners and CERFACS aimed at developing the next generation of high-fidelity computational fluid dynamics (CFD) simulation tools.

Optimizing wind turbine performance and designing efficient wind farms require accurately predicting complex interactions between blades and atmospheric flow, as well as wake interactions between turbines. These simulations must capture essential aerodynamic phenomena (wakes, tip vortices, turbine-to-turbine interactions) while enabling parametric studies to explore different configurations. Faced with these challenges, traditional approaches based on body-fitted mesh simulations around blades reach their limits in terms of computational time, particularly for optimization studies or full wind farm simulations.

To address this need, we are developing innovative methods coupling solvers based on the Lattice Boltzmann Method (LBM) [1] with reduced-order models [2]. This LBM operates at a mesoscopic scale and stands out for its strategic advantages for industry: massively parallelizable, fast, and inherently unsteady. These characteristics make it an ideal candidate for drastically accelerating simulations. Among reduced-order models, the Actuator Line Model (ALM) [2] emerges as a particularly effective approach for fully modeling rotor blades without requiring fine meshing of their geometry. This method consists of representing each blade by an actuator line along its axis, on which distributed forces are applied to model the aerodynamic effects of lift and drag. The ALM thus captures essential phenomena (wake, tip vortices, blade-flow interactions) while considerably reducing computational cost compared to body-fitted mesh approaches.

This 6-month internship at CERFACS lies precisely at this frontier: the development and implementation of an ALM method in a LBM research code written in Julia, in order to evaluate the potential of this approach for **wind turbine simulations**.

[1] Krüger, T., Kusumaatmaja, H., Kuzmin, A., Shardt, O., Silva, G., Viggien, E.M., The Lattice Boltzmann Method: Principles and Practice, 2017, <https://doi.org/10.1007/978-3-319-44649-3>.

[2] Sørensen, J.N., Shen, W.Z., Numerical modelling of Wind Turbine Wakes. Journal of Fluids Engineering, Vol. 124, Issue 2, pp. 393-399, 2002 <https://doi.org/10.1115/1.1471361>

MISSION

Within the AAM research team at CERFACS, your role will be to implement and validate an Actuator Line Model (ALM) method in our LBM solver developed in Julia. This work aims to evaluate the potential of combining these two approaches (LBM+ALM) for wind turbine simulations, combining physical accuracy with computational efficiency. The work will be divided into several stages:

1. **Literature review and solver familiarization:** Understanding the theory of the Actuator Line Model and existing work combining ALM and LBM [4, 5, 6], particularly for wind turbines. Familiarization with the LBM method and the code developed in Julia with its specificities (athermal and weakly compressible method).
2. **2D development and implementation:** You will develop and implement in Julia a first 2D version of the ALM coupled with the LBM solver. This stage includes:
 - Modeling of lift and drag forces along the actuator line
 - Spatial distribution of forces in the flow field (kernel function)
 - Integration of the Actuator Line Model into the LBM algorithm via source terms
3. **2D validation:** Validation of the 2D implementation on reference academic cases [5], allowing verification of result consistency with the literature and evaluation of sensitivity to numerical parameters (kernel size, mesh resolution).
4. **3D extension:** Extension of the implementation to a full 3D version [4], capable of simulating more realistic wind turbine configurations with consideration of three-dimensional effects (tip vortices, tip losses, wake-blade interactions).
5. **Academic validation:** Application of your development to the reference case of the DTU 10MW wind turbine [7], a widely documented configuration in the literature. You will compare your results with available data (load distributions, wake velocity fields, power coefficient) to validate the predictive capability of the model.

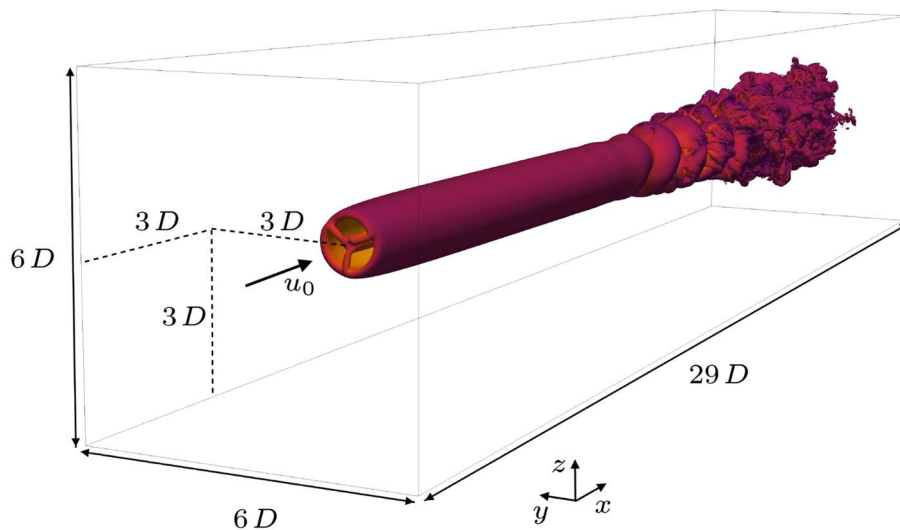


Figure: Schematic of the 3D case with dimensions, computational domain, turbine position, and vorticity iso-contours obtained with an LBM solver [6].

You will work in close collaboration with the team's researchers and engineers, and contribute directly to the development of a strategic simulation tool for our industrial partners. **This end-of-study internship may lead to a CIFRE PhD proposal with our partners (SAFRAN, AIRBUS).**

[4] Cacciali, L., Hansen, M.O.L., Rogowski, K., Highly Stable Lattice Boltzmann Method with a 2-D Actuator Line Model for Vertical Axis Wind Turbines, *Energies*, 2024, 17, 4847.

[5] Rullaud, S., Blondel, F., Cathelain, M., Actuator-Line Model in a Lattice Boltzmann Framework for Wind Turbine Simulations, *Journal of Physics: Conference Series*, 2018, 1037, 022023.

[6] Asmuth, H., Olivares-Espinosa, H., Ivanell, S., Actuator Line Simulations of Wind Turbine Wakes Using the Lattice Boltzmann Method, *Wind Energy Science*, 2020, 5, 623–645.

[7] Christian Bak et al., The DTU 10-MW Reference Wind Turbine, <https://orbit.dtu.dk/en/publications/the-dtu-10-mw-reference-wind-turbine>

DESIRED PROFILE

We are seeking a final-year engineering student or a Master's 2 student with a specialization in **fluid mechanics, aerodynamics, scientific computing, or numerical methods**, and a strong interest in research. A **Research Master's** profile is particularly welcome given the perspective of pursuing a PhD.

The following skills and qualities are expected:

- **Fundamental knowledge:** In-depth knowledge of computational fluid dynamics (CFD) is essential. A good understanding of numerical methods for partial differential equations (PDEs) and fluid dynamics is essential. Any prior knowledge of the Lattice Boltzmann Method (LBM) or the Actuator Line Model (ALM) is a major asset.
- **Programming skills:** Proven programming experience is required. Knowledge of the Julia language can be an asset, but solid experience in Python, C++, or Fortran with a quick adaptation capacity is also highly acceptable. Familiarity with high-performance computing (HPC) and GPU computing is greatly appreciated.
- **Personal qualities:** Scientific rigor, autonomy, curiosity, and the ability to take initiative are essential qualities for integrating into our team and successfully completing this research mission. A taste for software development and numerical experimentation is indispensable.

- **Additional assets:** Experience in developing scientific computing codes is an asset for quickly getting up to speed with the subject. Any experience in propeller aerodynamics will be valued.
- **Communication:** As the internship takes place in an international research context, strong command of English (reading, writing, speaking) is necessary for the literature review, report writing, and presenting your work.

WHAT WE OFFER AT CERFACS

- Broad access to technology, a rich interpersonal environment, in-house skills recognized nationally and internationally.
- An inclusive and equitable work environment.
- A structure accessible to people with disabilities.
- Possibility of benefiting from 1.83 days of reduced working hours per month, linked to your choice of a 39-hour rather than 35-hour working week.
- 50% reimbursement of public transport costs.

HOW TO APPLY?

To apply, please send your CV and covering letter to werner@cerfacs.fr , applications are open until 31/12/2025.

See you soon at CERFACS!