JOB OFFER – INTERNSHIP

Modeling of reactive supersonic boundary layer

OFFER INFORMATION

Reference: AAM-2026-DAV-01
Team: AAM

Location: 42 Avenue Gaspard Coriolis – 31057 Toulouse

Supervisors:

- Guillaume Daviller, daviller@cerfacs.fr

Gratification: 800€ net per month - M2 level or last year at engineering school
Period: 6 months – from Février 2026 (adaptive)

Keywords: Reusable rocket launcher, retro-propulsion, CFD, supersonic boundary layer

CERFACS

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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

Improving the propulsion performance of rocket engines is a major challenge in the context of reusable launchers designed to carry payloads at lower cost. Atmospheric reentry of a launcher is characterized by extreme conditions in the flows around the vehicle, particularly within the boundary layer, where the most intense thermal, chemical, and mechanical gradients are concentrated. In this context, precise modeling of the boundary layer becomes crucial for predicting heat transfer that could compromise material integrity and, consequently, flight stability. This need becomes essential in the context of the development of reusable space launchers, whose atmospheric reentry phases impose extreme thermodynamic conditions on the exposed surfaces. In particular, the retro-propulsion phase, characterized by the motor reignition used to actively slow down the launcher, profoundly alters the flow conditions by introducing hot and reactive jets that interact with the supersonic boundary layer, complicating its structure and transition mechanisms.

This internship project aims to test different wall models [1, 2] to simulate a reactive boundary layer in supersonic flow [3], by coupling the compressible Navier-Stokes equations with non-equilibrium chemical kinetics models [4]. The objective is to accurately capture the complex interactions between gas dynamics, chemical reactions (dissociation, recombination), and thermal effects near the walls.

[1] O. Cabrit and F. Nicoud. “Direct simulations for wall modeling of multicomponent reacting compressible turbulent flows”, *Phy. Fluids*, 2009.

[2] M. Cizeron, N. Odier, F. Duchaine, L. Gicquel and F. Nicoud. “Implementation of a TBLE-based wall model with pressure gradient in a massively parallel LES solver”. *ASME Turbo Expo*, 2024.

[3] G. Daviller, J. Dombard, G. Staffelbach, J. Herpe & D. Saucereau. “Prediction of Flow Separation and Side-loads in Rocket Nozzle Using Large-eddy Simulation”, *Int. J. Comp. Fluid Dyn*., 2020.

[4] S. Blanchard. “Multi-physics large-eddy simulation of methane oxy-combustion in liquid rocket engines”, PhD Thesis – INP Toulouse, 2021.

MISSION

The objective of this internship is to implement and compare different wall law models for reactive supersonic boundary layers. The candidate will use the AVBP code developed by Cerfacs for simulations, as well as the CFD Antares library (https://cerfacs.fr/antares), which Airbus, Safran, ArianeGroup, and CNES use. Initially, the candidate will need to become familiar with the codes and methods dedicated to performing simulations of reactive supersonic boundary layers. Direct Numerical Simulations (DNS) and large-scale simulations will then be carried out to compare existing models. An initial analysis of the interaction mechanisms between gases in the boundary layer and chemical reactions will be conducted. These studies will be carried out in collaboration with researchers from the AAM team.

DESIRED PROFILE

- Currently in the final year of an engineering degree or equivalent, specializing in Aeronautics, Compressible Aerodynamics, and Combustion.
- Initial project-based experience in unsteady computational fluid dynamics (CFD) programming is required.
- In particular, skills in combustion are an advantage.
- As this is a research-oriented internship, the candidate, who is preparing for a Research Master's degree, will be required to present his/her work both orally and in writing in English, in line with the standards expected in an international research laboratory.

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- 50% reimbursement of public transport costs.

HOW TO APPLY ?

To apply, please send your CV and cover letter to daviller@cerfacs.fr , applications are open until 31/01/2026

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