Internship proposal – 6 months (June-December 2019)
ISAE-SUPAERO, 10 avenue Edouard Belin, BP 54032 - 31055 Toulouse Cedex 4

Supervisors: Annafederica Urbano and Michael Bauerheim
E-mails: annafederica.urbano@isae-supaerp.fr, michael.bauerheim@isae-supaero.fr
Tel: +33 (0)5 61 33 81 55

Title
Coaxial-injector design optimization using surrogate models based on RANS simulations.

Context
CFD simulations have shown their capability in helping understanding physical phenomena undergoing in liquid rocket engines. The development of fine modeling coupled with the increase of computer capabilities have permit great achievements in the field. In the today space scenario, CFD could play an important role at the design level of liquid rocket engines. Specifically, CFD studies should permit in the future to reduce the number of experimental tests by providing more accurate preliminary designs. However, how to exploit the high fidelity CFD simulations capabilities at a design level remains an open question in the literature. The scope of our project is to give an answer to this question and the present internship belongs to this project. One possibility, which has shown interesting features, is the use of surrogate models for design optimization based on CFD results [1,3,4]. During the present internship this possibility will be investigated.

Goals of the internship
The goal of the internship will be to investigate neural networks methodologies [2] to extract surrogate models for the design optimization of a shear coaxial injector. The student will carry out RANS numerical simulations of a single element injector. The selected test case is a coaxial injector with GCH4/GOx. A commercial software will be used to carry out the 2D axisymmetric numerical simulations. Attention will be given to the proper simulation of the conjugate heat transfer between the solid wall and the fluid. Different design parameters will be varied: the distance from the wall, the tip thickness, the recess length. The mass flowrate will also be varied in order to analyze a throttlable injector. The goal of the optimization process will be to minimize the maximum wall heat flux while keeping the highest combustion efficiency (i.e. minimizing the combustion length). Neural networks will be used to extract a surrogate model for the optimization problem. The results of the internship should provide insight into the use of such techniques for LRE design. These techniques can be used in future works on more complex problems using high fidelity simulations.

Required skills
Master 2 student. Basics in CFD simulations. Basics in LRE. Python scripting.

[1] R. Vaidyanathan, P. K. Tucker, N. Papila and W. Shyy, 'Computational-Fluid-Dynamics-Based Design Optimization for Single-Element Rocket Injector', Journal of Propulsion and Power, 20:4, p705-717 (2004)
[2] Y. Tulunay, E. Tulunay and E.T. Senalp, "The neural network technique—1: a general exposition", *Advandes in Space Research,* 33:983-987 (2004)
[3] Y. Mack, "CFD-Based surrogate modeling of liquid rocket engine components via design space refinement and sensitivity assessment", *PhD Thesis University of Florida,* (2007)
[4] R. Hellmann, P. Jochmann, K. Georg Stapf, E. Schueneman, L. Daróczy and D. Thévenin , "Towards design optimization of high-pressure gasoline injectors using Genetic Algorithm coupled with Computational Fluid Dynamics (CFD)", *ILASS-EUROPE conference,* (2017)