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FINAL DEGREE PROJECT

Reference : **DMPE-2019-25**

Location : Toulouse

Department : Multi-physics for Energetics (DMPE)

Phone :

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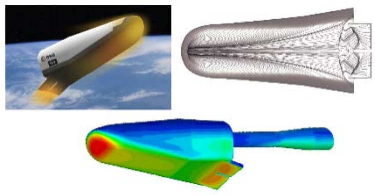
PROJECT DESCRIPTION

Keywords : Computational Fluid Dynamics, Shape Optimization, Hypersonic Flows

Project Type : Required for completion of a Master's degree

Title: Shape optimization of an isolated roughness element in hypersonic flow

Summary: The hypersonic flow regime is one where the heat generated within the fluid can be so intense that the vehicle structure faces irreversible damage without an adequate thermal protection system (TPS). The surface of lifting body re-entry vehicles, for instance, can reach peak temperatures in excess of 1000°C around specific hot spots such as the vehicle nose and the flaps (see figures on the right), the loss of which leads to immediate mission failure. The present project aims at developing an optimization framework around a computational fluid dynamics (CFD) solver. The main goal is to design a roughness element on the lifting body surface that interacts with the flow in such a way as to reduce the heat transfer peak measured on the flap. Simplified 2D geometries inspired from recent literature will be first considered [1], the main novelty being to include the unsteadiness of the flow in the optimization framework. Time-dependent simulations will be run using high-performance computing (HPC). In fact, an important requirement is that each design configuration be solved in a reasonable amount of time. This will allow us to explore a large part of the design space while converging towards an optimum roughness shape. To this end, a GPU-accelerated CFD code will be employed. The successful candidate is expected to become proficient in batch processing of simulation runs on clusters of CPU/GPUs. Optimization methods based on gradient-free or gradient-based (adjoint) approaches will be thoroughly explored.



Examples of vehicles designed for atmospheric reentry. Source: ESA et [2].

This funded project has a duration of 5 months. The start/end dates in 2023 are flexible (see below). It will take place at the ONERA site in Toulouse, next to the ISAE-SUPAERO campus. Interested candidates must send their application by email (CV, motivation letter, grade transcripts and contact details of referees).

[1] Chiapparino, Stemmer, *Int. J. Heat Fluid Flow*, 2022
[2] Lüdeke, Heinrich, et al. *Proceedings of the 6th Launcher Symposium, Munich, Germany*. 2005

Project duration : Minimum : 5 months Maximum : 5 months

Possible period span by the project : February - September 2023

CANDIDATE PROFILE

Required knowledge in :	Higher education :
Computational fluid dynamics, compressible flow, working knowledge of linux.	Enrolled in a Master's degree in engineering, physics or applied mathematics.