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ONERA
THE FRENCH AEROSPACE LAB

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PROPOSITION DE STAGE EN COURS D'ETUDES

Référence : **DTIS-2025-24**
(à rappeler dans toute correspondance)

Lieu : Palaiseau

Département/Dir./Serv. : DTIS/CASH

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Responsable(s) du stage : Paul Russell Lancry

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DESCRIPTION DU STAGE

Thématique(s) : Conception et optimisation des systèmes

Type de stage : ☒ Fin d'études bac+5 ☒ Master 2 ☐ Bac+2 à bac+4 ☐ Autres

Intitulé : Implementation of analytical methods under Python for the pre-sizing of primary and secondary structures of hypersonic air-breathing vehicles

Sujet :

In recent years, the aerospace community has taken an ever-growing interest in the study and design of hypersonic vehicles. For instance, air-breathing hypersonic vehicles could represent a viable alternative for a capable and affordable reusable space launch system if combined with a solid rocket booster.

However, many challenges exist when dealing with the conceptual design phase of a hypersonic vehicle. Most notably, at such speeds, different physical disciplines (structures, aerodynamics, thermodynamics, electromagnetics etc.) display a high level of interdependence between them making the overall design challenging from the vehicle architect's point of view.

In order to tackle these challenges, the French aerospace lab ONERA wishes to develop a MDAO (Multi-Disciplinary Design and Optimization) approach to the design of hypersonic vehicles. This internship would focus on the structure 'brick' of the multi-disciplinary design, using inputs generated from previous disciplines modelling such as thermodynamics and providing outputs for the multi-disciplinary design loop of the vehicle.

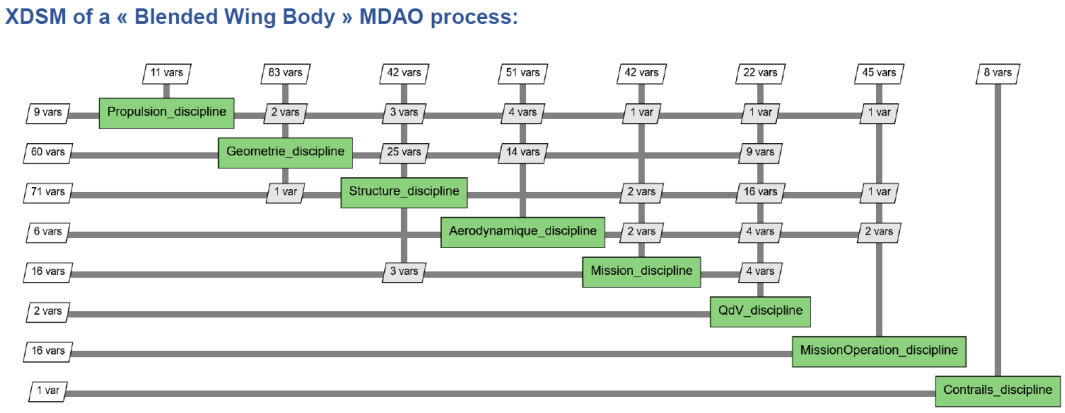

Figure 1: Example of an MDAO process from an ONERA study on blended wing body aircrafts

Different approaches can be envisioned for the modelling of the structural 'brick' of an MDAO process such as low order finite elements, surrogate modelling or analytical methods. Not all methods will offer the same level of accuracy but also, not all methods are sufficiently cost-effective to be envisioned into an MDAO loop.

In this internship, the student will **implement the structural 'module' of an MDAO process under Python using analytical methods** and estimate its viability for such studies. Such analytical models should be able to ideally pre-size primary and secondary structures of the vehicle given an arbitrary aerodynamic shape of a vehicle chosen by both the tutor and the student.

The proposed timeline of the internship could go as following depending on the student's ability and schedule:

1) Choose a vehicle test case to use as reference with your tutor and referent teacher. This test case will impose the aerodynamic shape of the vehicle but also serve as the basis for the validation (or not) of the methods.
2) Review bibliographic documents that are available directly at ONERA and in open-source in order to identify a set of required inputs (aerodynamic shapes, thermal loads etc) and desired structural outputs that could be fed into a future MDAO loop (thicknesses , material selection , mass distribution , center of gravity , mechanical stiffnesses , number of spars & ribs etc)
3) Implement the analytical methods retained under Python
4) Test these methods on the chosen test case discussed by the tutor and student, and evaluate if the analytical methods are able to give a satisfying pre-sizing of the structural elements studied or not
5) Write your report or Master thesis and make suggestions for the future in your conclusion

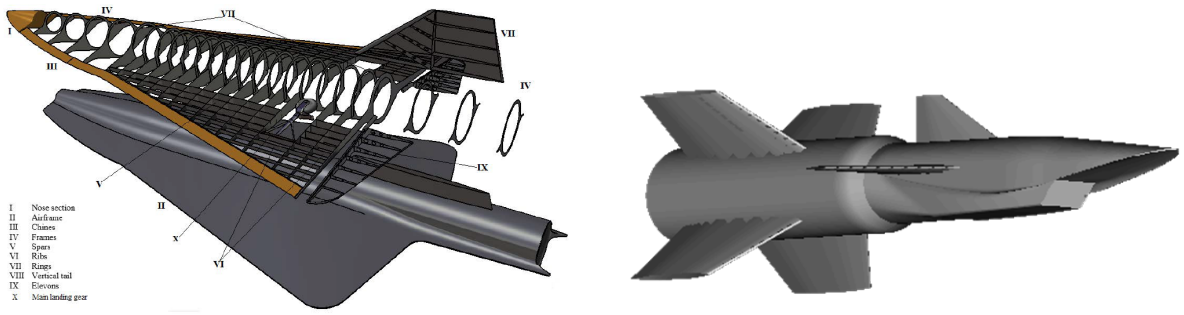

Figure 2: On the left, the main structural elements of a Hypersonic UAV based on the Lockheed Martin D-21 drone concept from Delft University [1], on the right a concept of an ONERA conceptual design of a hypersonic launcher "Japhar"

[1] : "Preliminary Structural design for a Hypersonic UAV" C.Terhes , TU Delft , Delft University of Tevhnology Faculty of Aerospace Engineering (2014)

Est-il possible d'envisager un travail en binôme ? Non

Méthodes à mettre en oeuvre :

☐ Recherche théorique	☒ Travail de synthèse
☒ Recherche appliquée	☒ Travail de documentation
☐ Recherche expérimentale	☐ Participation à une réalisation

Possibilité de prolongation en thèse : Non

Durée du stage : Minimum : 5 months Maximum : 6 months

Période souhaitée : 6 months , starting in March 2025

PROFIL DU STAGIAIRE

Connaissances et niveau requis :	Ecoles ou établissements souhaités :
Good Python skills, Structural engineering basics, Aerospace vehicle design skills appreciated, Some MDAO knowledge appreciated, Good level of English (writing especially), Knowledge of French appreciated Ability to work in team, with the tutor	Etudiants français : Grandes écoles / universités équivalentes (Ecoles des Mines, écoles Centrales, ENSTA, SUPAREO, X, Arts et Métiers etc …) Foreign students: Master in aerospace engineering, mechanical engineering, mathematics engineering etc