PhD offer: Towards a more operation-centric approach to aircraft design

Partners

Keywords: Overall Aircraft Design, Optimization, Concept of Operations, Architecture optimization

Department: Department of Aeronautical and Space Vehicle Design and Control

ISAE-SUPAERO is a higher education and research institution that offers a comprehensive and unique range of top-tier scientific programs in the aerospace field and. It pursues research activities largely focused on the future needs of the aerospace and high-tech industries. ISAE-SUPAERO comprises five research departments, including the Department of Aeronautical and Space Vehicle Design and Control (DCAS), where the thesis will be conducted.

The DCAS department develops methods and tools for the integrated multidisciplinary design of aerospace systems and vehicles and addresses the following scientific issues:

- the development of disciplinary models with varying levels of fidelity for conducting conceptual and preliminary studies of new aircraft configurations.
- the development of multidisciplinary design methodologies for sizing innovative aeronautical systems, and for analysing and optimising future aircraft architectures, particularly regarding certifiability, airworthiness, operability, maintainability and digitalisation requirements,
- the synthesis of robust or adaptive control laws for aircraft systems, and the development of co-design methodologies for flight control laws and aircraft characteristics to meet handling quality requirements,
- the study of the environmental impact of air transport.

The thesis is proposed in the framework of the EA²GLE Graduate school related to the electrification of Aircraft and Automobiles and is co-funded by the AMI CMA PEGASE and the Occitanie Region.

The research activities aim to develop design methodologies for low-carbon aviation by addressing the challenges of incorporating operational constraints, failure scenarios, and multi-mission requirements into the optimisation process. The developed methodologies will be applied to the design of architectures of more electric aircraft in the category CS23.

The outcomes of the thesis will enable aircraft manufacturers to design safer, more efficient and more environmentally sustainable aircraft, while reducing design risks, development costs, and time to market.

Description of the offer:

As part of the ecological transition of the aeronautics sector, many national and international agencies have set very ambitious targets to reduce the environmental footprint of aviation. A popular potential solution to the question of the sustainability of the aeronautics sector is the introduction of electrified technologies. Because of the technological maturity of those technologies and the constraints on the design of the aircraft, there is an urgent need for methodologies capable of estimating, in the preliminary design phase, the viability of those configurations. For this reason, MDAO (Multidisciplinary Design Analysis and Optimization) tools have been identified as a key enabler for the adoption of electrified technologies [1]. In particular, OAD (Overall Aircraft Design) frameworks like FAST-OAD [2] allow for vehicle-level optimization, thus enabling them to account for all the multidisciplinary synergies that the electrified propulsion allows to leverage [3].

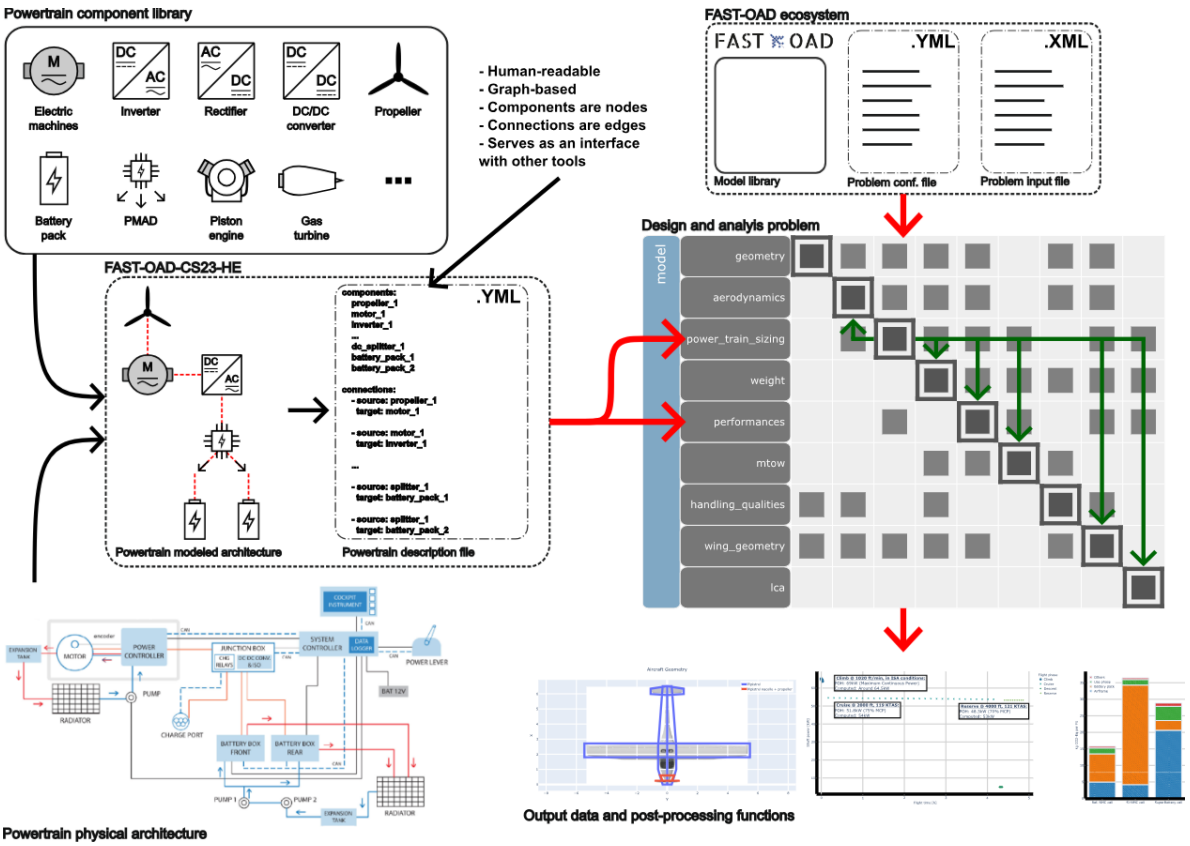


Fig1. FAST-OAD: Integration of electric powertrain components in Overall Aircraft Design processes

Preliminary investigations into electrified configurations have, however, shown limitations regarding the potential of those novel technologies. For one, beyond applications to small aircraft, current electric technologies could be better suited as a way to optimize thermal branch (through the relief of design constraints or reducing bleed air extraction) as opposed to replacing it. Additionally, traditional methodologies tend to evaluate aircraft on a single representative mission. While this was shown to severely limit optimization prospects [4] for conventional configurations, it is even more important considering the impact on the lifespan and price of batteries for electric configurations.

This thesis proposes to advance the methodologies for the design of electrified aircraft by proposing a Concept of Operations (ConOps) for those aircraft, including failure scenarios and different use cases, and to develop within FAST-OAD a multi-mission optimization approach to propose and evaluate novel configurations.

Missions:

This thesis will be organized based on several well-defined research axes which will structure the project:

Axis 1 (Month 1 to 6): this axis will focus on proposing a ConOps for aircraft in the General Aviation segment (which will be the scope of this thesis) and more specifically for larger aircraft specified under CS-23. This will be done thanks to a review of current aircraft in this category, not only including missions but also geographical profiles, and will also include a review of design constraints for propulsive and non-propulsive systems.

Axis 2 (Month 7 to16): this axis will aim at improving the models in the FAST-OAD-CS23-HE framework which is developed to assess Hybrid Electric aircraft of category CS23. It will include the proposition of models for the sizing of non-propulsive systems on General Aviation aircraft and their impact on the sizing of propulsive systems (which therefore requires higher fidelity modeling on thermal machines). Additional work on the impacts of usage of thermal machines and batteries on their respective lifespan and performances is also expected.

Axis 3 (Month 17 to 24): this axis will focus on the methodological aspect of deploying multi-mission optimization in an OAD framework. In particular, tradeoffs between different objective functions such as costs or environmental impacts will be investigated. The use of a simplified test case is proposed for this axis.

Axis 4 (Month 25 to 30): this axis will further develop the work done in the previous months with a specific application to the TBM900 family and will investigate the possibility and viability of electrifying propulsive and non-propulsive functions.

Month 31 to 36 will be dedicated to the redaction of the manuscript and preparation of the defense.

This work is expected to lead to the publication of at least 1 scientific article in a top-tier journal and at least two international conferences.

Candidate profile:
An applicant with a Master of Science Degree (or equivalent) with experience in research. Strong knowledge of aircraft design, systems engineering, and multidisciplinary analysis and optimization is required. The candidate will work on the OAD tools developed at ISAE-SUPAERO (FAST-OAD), so proficiency in Python is expected. Proficiency in spoken and written English as well as the ability to work in a team are also required skills.

Experience: 0 to 3 years

Salary: .... 2153 € net pay before income tax /month

Duration: 36 months

Location: ISAE-SUPAERO, Toulouse

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Application conditions:
Applicants will be judged based on a cover letter, letters of recommendation (at least 2) and grade transcripts. Applicants selected after the first round will be asked to perform an interview with the committee supervising the thesis.

Starting date: October 2026

End of applications: 31/06/2026

References:

[1] Afonso, Frederico, et al. "Strategies towards a more sustainable aviation: A systematic review." Progress in Aerospace Sciences 137 (2023): 100878.
[2] David, Christophe, et al. "From FAST to FAST-OAD: An open source framework for rapid Overall Aircraft Design." *IOP Conference Series: Materials Science and Engineering*. Vol. 1024. No. 1. IOP Publishing, 2021.
[3] Lutz, Florent, et al. "Open-source framework for sizing hybrid and electric general aviation aircraft." *Journal of Aircraft* 62.2 (2025): 381-395.
[4] Liem, Rhea P., Gaetan KW Kenway, and Joaquim RRA Martins. "Multimission aircraft fuel-burn minimization via multipoint aerostructural optimization." *AIAA Journal* 53.1 (2015): 104-122.