Dr. Susan Liscouët-Hanke, August 2023

M.Eng. project/ M.Eng. Aerospace internship or Ugrad research project (ENGR412)

Aircraft Systems Laboratory

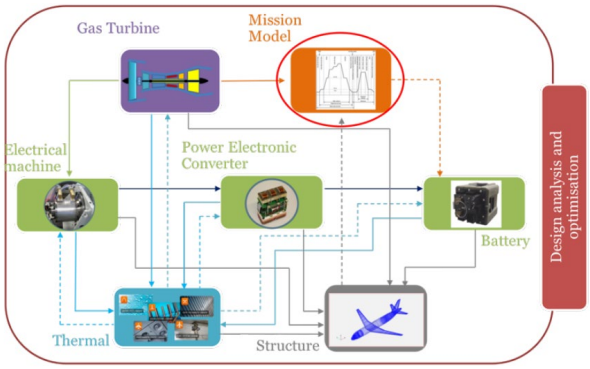
Multidisciplinary Design Analysis and Optimisation (MDAO) Framework Development for the Design Analysis and Optimization of Hybrid-Electric Aircraft

This project at the Aircraft Systems Lab aims to develop a framework that integrates the various aircraft and subsystem tools based on multidisciplinary design optimization techniques for the conceptual design stage to address current system integration challenges.

Timeframe: **Winter 2023** (this project may extend into a MASc or Ph.D. position, depending on the student's performance).

Background

The aviation industry aims to reduce pollution and noise to fulfill the COP26 goal of worldwide net-zero emissions by 2050. Hybrid-electric propulsion is one avenue to reduce aviation's environmental effects. The fuel efficiency improvements of such propulsion system configurations are realized at the aircraft level. A radical shift in the subsystem modeling requirements and an integrated conceptual aircraft design environment is necessary to assess such benefits. The goal is to develop effective strategies, tools, and architecture to deploy Multidisciplinary Design Analysis and Optimisation (MDAO) techniques in this subsystem modeling.



Schematic of Model interfaces [2]

At the Aircraft Systems Lab, several modules are implemented in an in-house tool that can be used to determine the overall performance of different systems of hybrid and/or all-electric aircraft applications, such as by incorporating a sizing analysis for an aircraft's electric propulsion system components into an initial sizing module that takes into account aircraft with hybrid-electric propulsion systems, power-to-weight ratio (P/W), hybridization of power as inputs to a mission analysis. In addition, systematic analysis of the hybridization assessment through Design Space Exploration studies will be investigated. The hybridization assessment deals with multiple operating segments with discrete values. Therefore, the Design Of an Experiment (DOE) study using a full factorial sampling method will be required.

The subsystem models, such as the propulsion system, electrical power system, Thermal management system, etc., are integrated using OpenMDAO, "an open-source framework for efficient multidisciplinary optimization." This study presents the integration of an in-house hybrid aircraft toolbox on top of OpenMDAO. The project will provide an opportunity to contribute to designing and optimizing hybrid-electric aircraft. This role is crucial in shaping the future of aviation by developing frameworks that enhance the efficiency, performance, and sustainability of novel aircraft. At the Aircraft Systems Lab, a collaborative effort between industrial and academic partners takes place to advance MDAO methodologies. Integration and optimization tools must be developed for the conceptual design stage to address current system integration challenges, such as space utilization, power distribution, electrification, safety, and thermal management. Therefore, this project contributes to further developing an MDAO framework integrating aircraft and subsystem tools [1].

Objectives* - Several topics are available based on this research subject. The topics with detailed objectives are outlined below:

- **Topic 1: Framework development for the design and optimization of hybrid-electric aircraft**
  - To understand and integrate an in-house hybrid aircraft toolbox on top of OpenMDAO.
  - To determine the overall performance of different hybrid and/or all-electric aircraft application systems by optimization studies.

- **Topic 2: System-Level Integration and Design Space Exploration of a Hybrid Electric Propulsion System**
  - Investigate the integration of subsystem models, such as the propulsion system and the mission model, thermal management system, electrical power system, power electronics converter modeling, and battery modeling within the MDO framework.
  - Develop a DOE model for systematically analyzing the hybridization assessment through Design Space Exploration studies.

- **Topic 3: Subsystem Architecture Integration for the Design Analysis and Optimization of Hybrid-Electric Aircraft**
  - Investigate different methods, tools, and architecture to deploy MDAO that integrates the various aircraft and subsystem tools.
  - Develop a simulation and optimization platform for the systems integration considerations for the conceptual aircraft design stage.

*The scope of the individual project will be defined in more detail based on the background of the student and the type of the project

Required Qualifications

- Experience in programming (ideally in Python)
- Background in aircraft design and/or MDAO

Excellent candidates possess initiative and autonomy, are committed to high-quality research, and are willing to develop excellent communication skills.

How to apply

Qualified and highly motivated candidates are invited to send their application by **Dec 7, 2023,** via email to susan.liscouet-hanke@concordia.ca and musavir.bashir@concordia.ca using the subject ***" Multidisciplinary Design Analysis and Optimization (MDAO) "*** with the following elements:

- Email with your motivation and relevant experience (***indicate the topic with the most interest***)
- A complete and up-to-date CV
- Up-to-date transcript or overall grade of your current and/or past program
- Sample of writing skills (e.g., publication, term paper, project report)

Equity, Diversity, and Inclusion

We are committed to creating an inclusive research environment in the Aircraft Systems Lab. Applications from all qualified candidates are encouraged, particularly from underrepresented groups, such as women, visible minorities, indigenous persons, sexual minorities, persons with disabilities, and others who may contribute to diversification; candidates are invited to self-identify in their application.

References

[1] V. Mohan, A. K. Jeyaraj, and S. Liscouët-Hanke, "Systems Integration Framework for Hybrid-Electric Commuter and Regional Aircraft," *Aerospace*, vol. 10, no. 533, 2023, doi: https://doi.org/10.3390/aerospace10060533.

[2] X. Zhao, S. Sahoo, K. Kyprianidis, Sumsurooah, S., Valente, G., Rashed, M., ... & Ekstedt, E. (2019, June). A framework for optimization of hybrid aircraft. In *Turbo Expo: Power for Land, Sea, and Air* (Vol. 58608, p. V003T06A012). American Society of Mechanical Engineers. https://doi.org/10.1115/GT2019-91335