2SC5693 – Hybrid aeronautical propulsion

Instructors: Antoine Renaud
Department: DOMINANTE - ENERGIE
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 40
On-site hours (HPE): 27,00

Description
The electrification of aviation is a topical issue, given the challenges of reducing polluting emissions to which the air transport community has committed itself: by the middle of the 21st century, the aim is to halve CO2 emissions from all air traffic. At the same time, it is estimated that the volume of passengers carried will almost double.

In this context, it is legitimate to focus on electrically-powered aircraft, which raises the problem of energy storage: batteries are still very heavy and are barely sufficient to move light aircraft with two passengers over a few hundred kilometers.

During this challenge week, we will focus on a light aircraft of the high-end ultralight class. For this category of aircraft, we can already consider electrification of the propulsion with existing technologies. We will consider a hybrid architecture combining a battery with a hydrogen fuel cell.

Quarter number
ST5

Prerequisites (in terms of CS courses)
Transport phenomena or Electrical energy courses

Syllabus
A general Simulink template of the model will be provided, with a number of blank sub-templates that will need to be completed. Validation tests will then have to be carried out on each of the sub-systems.

1. Fuel Cell

- Battery core electrochemistry
- Thermal management
- Sequencing logic

2. Electrical distribution and motorization

- Engine and its regulation
- Battery and its management system
- Power regulation

3. Airframe

- Flight mechanics and taxiing
- Control loops and piloting

4. Preparation of the test procedure

- Definition of mission profiles
- Pre- and post-processing

In a second part, the groups will be redistributed into three teams and the models of the sub-systems will be shared. Each team will be in charge of assembling its aircraft and testing it.

Class components (lecture, labs, etc.)
The work will be supervised by speakers from SafranTech as well as CentraleSupélec teachers. Students will be divided into groups and sub-groups according to the different tasks to be accomplished. Reconfigurations will take place during the week according to the progress of the work.

Grading
The evaluation is based on attendance, motivation and efficiency throughout the week as well as on two group presentations, one in the middle of the week and the second on the last day.

Resources
The whole activity will take place using Matlab/Simulink software to simulate the problem.

Learning outcomes covered on the course
By the end of the week, students will have learned about flight mechanics, how to fly an airplane, and how electric motors and fuel cells work. Most importantly, they will have learned how to manage the constraints associated with these different elements when they are assembled in a complex system. Finally, the scope and complexity of the problem necessarily require teamwork with different core businesses, replicating real-life work situations.

Description of the skills acquired at the end of the course

C1.3: Apply problem-solving through approximation, simulation and experimentation.
C1.4: Design, detail and corroborate a whole or part of a complex system.
C2.3: Rapidly identify and acquire the new knowledge and skills necessary in applicable/relevant domains, be they technical, economic or others.
C7.1: Persuade at core value level; to be clear about objectives and expected results. To apply rigour when it comes to assumptions and structured undertakings, and in doing so structure and problematise the ideas themselves. Highlight the added value.
C8.1: Work collaboratively in a team