FSD3831 Future sustainable aviation 6 Credits

1 Introduction

Aviation accounts for 3-5% of global warming, with the industry projected to grow at 4.4% annually over the next 20 years, leading to significant environmental impacts. Aviation's climate impact includes CO_2 and non-CO_2 emissions (such as NO_x and contrails), with non-CO_2 emissions causing two-thirds of global aviation's radiative imbalance. Future environmental concerns also include rising noise levels from smaller aircraft in urban areas, contributing to health issues. To meet the 2050 climate-neutral strategy, which aims to reduce transport GHG by 60% and limit global temperature rise to below 1.5ºC, it is crucial to reduce both CO_2 and non-CO_2 emissions and minimize aviation's environmental footprint, improving air quality and reducing noise. For that, the aviation industry is focusing on technical improvements, alternative fuels, operational changes, and regulations.

This paradigm shift means future aircraft will use different energy sources, propulsion systems, and materials, with new architectures, infrastructure requirements, and optimized operations. To lead this change, new Ph.D. students and engineers will need to acquire a holistic perspective with broader knowledge across various fields. This course provides an overview of the technologies, fuels, operations, and regulations necessary to achieve zero-emission airborne transportation.

2 Content and learning outcomes

2.1 Course contents

The course is organized around six different modules with the aim to address the topic of sustainable aviation from a holistic perspective. The first module gives an introduction to sustainability and then focuses on the environmental impact of aviation finishing with an overview of possibilities and challenges. Then the focus is set on the different mitigation measures to tackle the environmental impact of aviation within the areas of technology, alternative fuels, operations, and regulations in the following way:

- **Technology**: The students will learn about the basics of aeronautics to then move towards future designs, propulsion systems and structural materials complemented with an overview of greener aviation technologies.
- **Alternative fuels**: This module will include sustainable aviation fuels (SAF), hydrogen propulsion, and electric aircraft with some basics on batteries finishing with a lecture on life cycle assessment.
- **Operations**: How aircraft fly has also a crucial impact on the environment. To understand it better, we approach the topic of trajectory optimization but also infrastructure needs and provide an introduction to air traffic management to understand the complexity of the systems involved and its boundaries for sustainable measures.
- **Regulations**: The different European and international regulations are presented, fostering the development and implementation of the mentioned measures for aircraft environmental impact reduction.

Finally, a module on innovation and commercialization is provided regarding potential sustainable measures ideas.

2.2 Intended learning outcomes

The **overall objectives** of the course are that you should be able to:

- Motivate the role and impact of aviation on the Sustainable Development Goals (SDGs)
- Evaluate the environmental impact of aviation based on current and future systems
- Explain how emissions from aviation can be reduced using new technologies, alternative fuels, operations, and regulations.
- Identify the constraints and limitations in the application of sustainable measures in aviation.
- Explain the basic steps involved in turning new ideas into sustainable, market-ready solutions while identifying the challenges (e.g. costs and regulations).

3 Prerequisites and availability

Prerequisites: Being a Ph.D. student is required and preferably in an area with some relation to any of the subjects covered in the course.

Availability: The course is limited to **maximum 30 students** on a first come, first served basis.

4 Examination

The examination will be based on a poster session (P, F). Additional assessments may apply during the course and will be indicated at the beginning of each lecture.

5 Literature

The course literature will be indicated at the beginning of each lecture.

6 Education cycle

Third cycle

7 Teachers

- **Evelyn Otero Sola** (course responsible and examiner), KTH, otero@kth.se
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- **Tim Rossiter**, Heart Aerospace, tim.rossiter@heartaerospace.com
- **David Rytter**, AVTECH, david.rytter@avtech.aero
- **Christopher Jouannet**, Saab, Christopher.Jouannet@saabgroup.com
- **John Nilsson**, Swedavia, john.nilsson@swedavia.se
- **Simon Blakey**, University of Birmingham, s.g.blakey@bham.ac.uk
- **Manuel Soler**, UC3M, masolera@ing.uc3m.es

8 Course Program

The course program is organized around the following modules:

- Sustainability and Environmental Impact
- Technology
- Alternative Fuels
- Operations
- Regulations
- Innovation and Commercialization

#	Date	Time	Place	Module	Teacher	Topic
1	Thu, Nov 28	13-14	TBD	Sust.Env.	Evelyn O.	Introduction: Sustainability and aviation's role
		14-15	TBD	Sust.Env.	Evelyn O.	Aircraft emissions
		15-16	TBD	Sust.Env.	Karl B.	Aircraft noise
		16-17	TBD	Sust.Env.	Christopher J.	Sustainable aviation, possibilities and challenges
2	Wed, Dec 04	13-15	TBD	Tech.	Fredrik K.	Introduction to greener aviation technologies
	Fri, Dec 06	13-17	TBD	Tech.	Raffaello M.	Aeronautics and aircraft basics
3	Thu, Dec 12	13-17	TBD	Tech.	Raffaello M.	Future aircraft designs
4	Tue, Jan 14	13-14	TBD	Tech.	Jens F.	Fundamentals of aircraft propulsion
		14-15	TBD	Tech.	Nenad G.	Aircraft propulsion - SoA and future trends
		15-16	TBD	Tech.	Malin Å.	Structural materials
5	Wed, Jan 22	13-14	TBD	A. fuels	Efthymios K.	Production pathways and standards for SAF
		14-15	TBD	A. fuels	Simon B.	Engine certification, fuel specifications and SAF emissions
		15-16	TBD	A. fuels	Göran L.	Batteries
6	Wed, Jan 29	13-14	TBD	A.fuels	Tomas G.	Hydrogen aircraft and their propulsion systems
		14-15	TBD	A. fuels	Tim R.	Hybrid electric aircraft
		15-16	TBD	A. fuels	Luca P.	Components and infrastructure for airplane electrification
		16-17	TBD	A. fuels	Anna B.	Life cycle assessment (LCA)
7	Wed, Feb 05	13-14	TBD	Op.	David R.	Introduction to air traffic management (ATM)
		14-15	TBD	Op.	Tatiana P.	Optimization of arrival traffic for greener descents
		15-17	TBD	Op.	Manuel S.	Climate-based trajectory optimization
	Thu, Feb 06	13-15	TBD	Op.	Lina B.	Electrification and power grids for a sustainable aviation
		15-17	TBD	Op.	John N.	Infrastructure needs for future zero-emission air travel
8	Wed, Feb 12	13-15	TBD	Reg.	Fredrik K.	International, regional and national regulations
		15-17	TBD	Reg.	Pernilla U.	Policy problem formulations & environmental laws
9	Wed, Feb 19	13-14	TBD	Innov.	Donnie L.	Innovation processes
		14-15	TBD	Innov.	Donnie L.	Certification and commercialization
		15-17	TBD	Innov.	Pernilla U.	Industrial dynamics in sustainable transformation
	Wed, Mar 12	13-18	TBD	WS	-	**Poster session**

Table 1: Course program based on lectures and a last workshop (WS).

9 Poster Session

This session consists of creating a poster (individually or in a group) that describes your research area from the perspective of the course content, namely sustainability with a focus on aviation, and how your research area can contribute to sustainable aviation. This will then be presented to all course participants during a workshop at the end of the course.

10 Requirements

To be approved for the course you must:

- Create a poster linked to your research and including the notions learned on sustainable aviation.
- Attend all the lectures.