PhD project title: Contrail mitigation in the context of operational oceanic airspace

Keywords: aviation, air traffic control, climate, non-CO2, contrails.

Overview:
Applications are invited for a fully-funded PhD scholarship that will advance the field of operational contrail mitigation by combining the latest science on contrails with state-of-the-art contrail forecasting tools, ATC procedures and systems to produce an end-to-end concept of operations (CONOPS).

The successful applicant will be based in the Department of Civil and Environmental Engineering, supervised by prof Marc Stettler (Professor in Transport and Environment)

The project is in collaboration with NATS, the leading Air Navigation Service Provider (ANSP) in the UK, and responsible for North Atlantic airspace. To ensure the PhD candidate is developing research fit for purpose, they will be embedded within NATS in organised placements and have access to data and regular exchanges with subject matter experts.

Project details:
Aviation emissions consist of CO_2 and non-CO_2 emissions that contribute to around 3.5% of human-induced climate forcing. Condensation trails ("contrails") result from the condensation of water vapour onto particles emitted by aircraft engines at sufficiently cold and humid conditions at cruise altitudes. The climate forcing resulting from contrails is comparable to that due to aviation's cumulative CO_2 emissions since 1945, which means that they represent a significant contribution to global climate change. Significant efforts are underway to reduce the climate impacts of contrails, in addition to reducing aviation's CO_2 emissions.

Previous studies have shown significant potential to reduce contrail climate forcing by the management of flight routes to avoid regions of the atmosphere where contrails form and persist. A recent study from our group found that around 10% of all flights in the North Atlantic region contribute to 80% of the annual contrail climate forcing. While this implies that there is potential to greatly reduce contrail climate effects by modifying a fraction of flights, further research is needed to understand how these impacts might vary by time of day and season, and to develop a concept of operations required to enable implementation of contrail avoidance in the real-world, accounting for other procedures, priorities and constraints.

The research questions to be addressed by this project include:

- What is the state-of-the-art in contrail prediction and forecasting?
- What are the different concepts of operations for management of contrail impacts by flight routing changes and who are the stakeholders? What is the role of air navigation service providers (ANSPs)?
- What are the appropriate concepts of operations that could scale across oceanic airspace?
- How can human actors act on decision data of varying confidence levels?
- What is the predicted effect of flight route efficiency, air traffic capacity, aircraft emissions, contrail impacts of a contrail management concept applied to oceanic airspace?
- What are the synergies and conflicts between contrail management and other efforts to make airspace more efficient?

The PhD candidate will advance the field of operational contrail mitigation by combining the latest contrail formation area prediction tools with state-of-the-art ATC procedures and systems to produce an end-to-end concept of operations (CONOPS). For this purpose, the student will: (i) perform a literature study, data analysis and interviews with subject matter experts to

understand the state of the art; (ii) assess the impact of the mitigation CONOPS on key performance indicators using digital modelling platforms; (iii) evaluation of interaction of human actors and various decision data categories (binary vs. gradual); and (iv) validate suitable decision making architectures using rapid HMI prototyping methodologies such as Wizard-of-Oz.

So that the research fit for purpose, the PhD student will be embedded within NATS in organised placements and have access to data and regular exchanges with subject matter experts. These placements will add up to at least three months in aggregate.

Requirements:

- A First Class Degree (or international equivalent) in engineering, mathematics, physics or computing
- A Masters level degree qualification
- Research experience on a project related to aviation, human machine interfaces, transport, aeronautical or environmental engineering is desirable
- Strong computational programming skills are desirable
- Experience with Python is desirable
- Excellent English communication skills, including strong writing abilities (for journal and industry publications) and excellent presentation skills (for industry meetings and public outreach)

How to apply:

Applicants are recommended to contact Prof Marc Stettler (m.stettler@imperial.ac.uk) for further details, informal discussions and information about the project.

Applicants wishing to be considered for this opportunity should send the following application documents to Prof Stettler:

1. Current CV including details of their academic record, and if possible, class ranking (2 pages maximum)
2. Covering letter explaining their motivation, suitability, skills and/or experiences (1 page maximum)
3. Contact details of two academic referees

Application via the Imperial College Registry is not necessary at this stage. Applications will be regularly reviewed until the position is filled.

Administrative questions should be emailed to civilphdadmin@imperial.ac.uk.

Funding:

The studentship will provide funding for 4 years from the start date of the PhD. The PhD project must start before 1 October 2025. The funding includes tuition fees (at the home rate, for 2024/25 this is ~£7,340/year) and a tax-free stipend at the standard UKRI London rate (for 2024/25 this is ~£21,237/year). The successful candidate will receive the to-be-announced equivalent 2025/26 funding. This funding can also be used to partly support an international student.