Examples of research on air transport

Dr Majid Soolaki

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Autumn school 2025

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Aircraft Trajectory Planning for Climate Hotspot Avoidance Considering Air Traffic Complexity: A Constrained Multi-Agent Reinforcement Learning Approach

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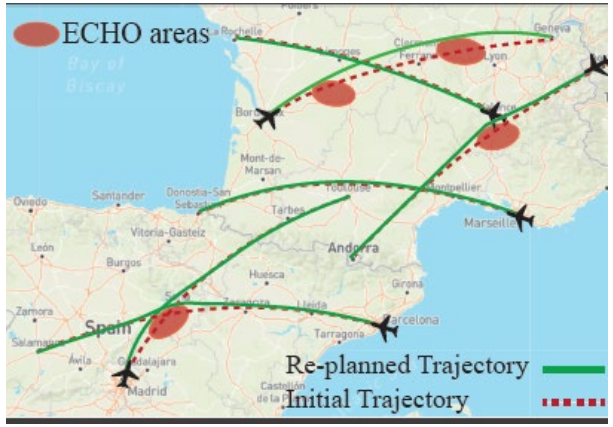
- This paper tries to solve that **trajectory planning problem** — how to reduce climate impact **without making the air traffic system too complicated**.
- Reduce hotspots violations
- Reduce traffic

Link of paper



IV. Case Study

We performed an experiment utilizing a real traffic scenario over ECAC[1] airspace on December 20, 2018. The case study includes all the flights within ECAC airspace from 12:00 UTC to 16:00 UTC. The weather data, including wind and temperature, was obtained from the ERA5 reanalysis data products available at the Copernicus Data Store[2]. The initial flight trajectories were obtained using our in-house tool, ROOST. [3] Although the initial trajectories in this study were generated using ROOST, the framework is flexible and can use other planned trajectories, such as those available from Eurocontrol's demand data repository (DDR2) dataset[4]. Each aircraft's trajectory includes detailed information on latitude, longitude, altitude, time, true airspeed, Mach number, mass, heading angle, and flight phase.

SESAR Innovation Days 2024
12 - 15 November 2024, Rome

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Evaluating Transatlantic Flight Emissions and Inefficiencies Using Space-Based ADS-B Data

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- This paper studies how to **measure aircraft emissions** more accurately for **flights across the Atlantic Ocean**.
- Space-based ADS-B data from satellites (by Spire Global)
- Ground data from the OpenSky Network.

Link of paper

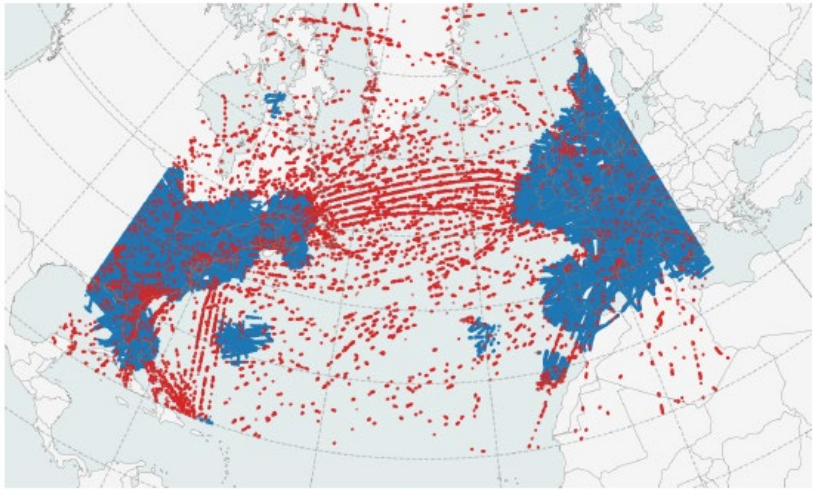

Figure 3. Combined ADS-B coverage from OpenSky and Spire on 10 March 2021.

II. Data Sources

The data for this study originates from multiple sources, including space-based ADS-B information from Spire satellites, ground-based ADS-B information from the OpenSky Network, and reanalysis weather data from ECMWF ERA5. In total, we employ three months of data covering each March from 2020 to 2022 for the analysis presented in this paper.

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Arrival Optimization with Point Merge in a Dual-runway Environment

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- **Smart scheduling** and **flexible routing** can make airport operations **greener** and **more efficient**, even in busy airspaces.
- Allowing some flexibility (shortcuts) improved efficiency — **saving about 20% fuel** per flight and cutting emissions.

Link of paper

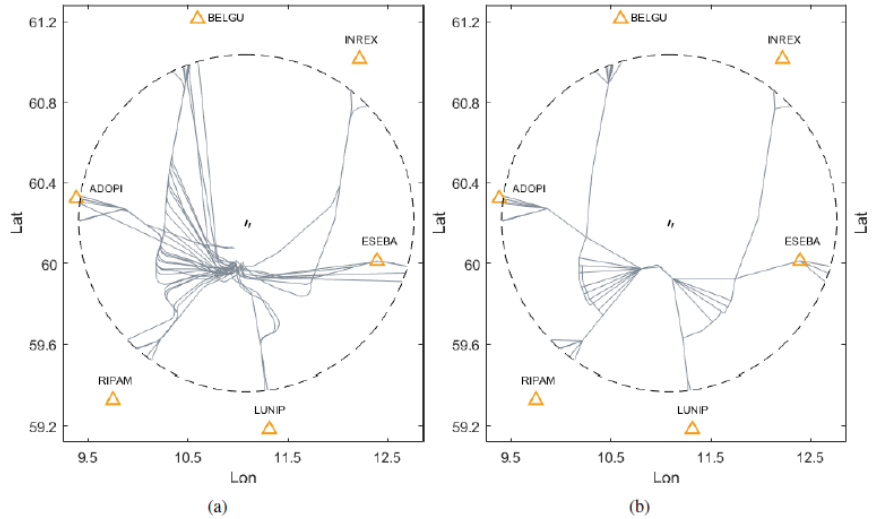

Figure 3. Actual trajectories (a), optimized trajectories without shortcuts (b) and optimized trajectories

A. *Dataset*

In order to find a suitable scenario to apply our optimization framework to, we use the historical database of Opensky Network [15]. We analyzed the Oslo-Gardermoen Opensky data for the year 2019 and identified the busiest hour as October 1, 05:00-06:00 UTC (07:00-08:00 local time). The local weather at the airport during this hour was a temperature of 2°C, air pressure of 990 hPa, relative humidity of 86% and a headwind of 2 kt. There were 41 arriving aircraft present

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Alternative 4D Trajectories for the avoidance of weather- and contrail-sensitive volumes

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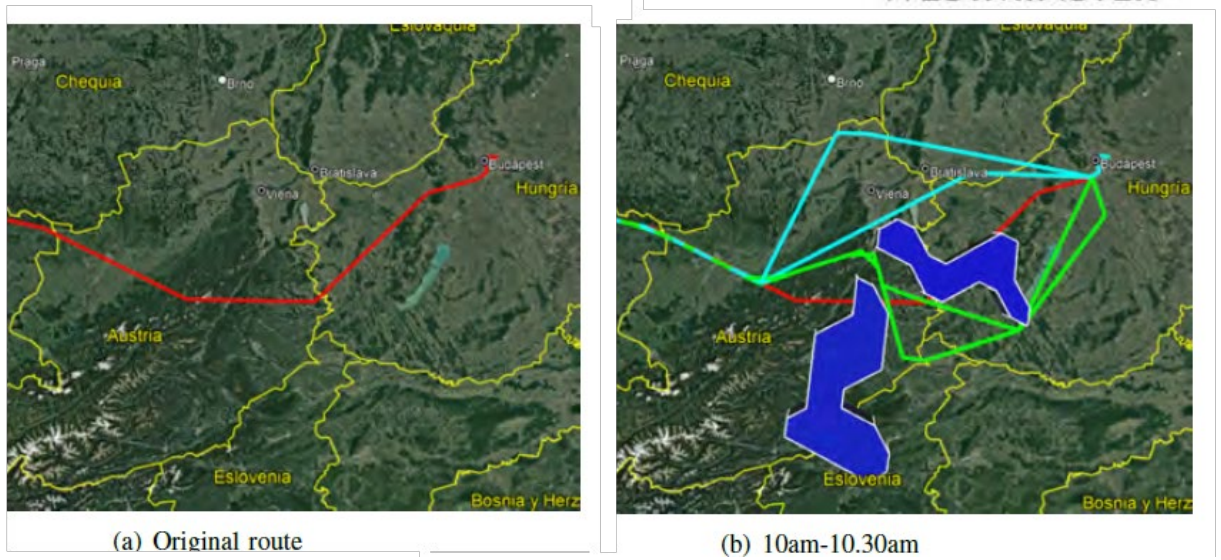
- They presented a framework to generate, in a multi aircraft environment, **4D optimized trajectories in a scenario** with several weather constraints.
- Develop innovative procedures in the air traffic management system to **reduce the climate and environmental impact of aviation.**

Link of paper



(a) Original route (b) 10am-10.30am

A. Experimental Setup

In this work, we used flight plans obtained from Eurocontrol's data demand repository (DDR2) [12], which contains information about the trajectories flown in Europe every day. The scenario tackled considers 5,000 flights for July 27, 2018. More specifically, we considered the following case studies:

- **Case study 1**: 5 iterations from 9 am to 11 am with $T_u = 30\ minutes$ and $T_a = 35\ minutes$.
- **Case study 2**: 6 iterations from 4 pm to 6.30 pm with $T_u = 30\ minutes$ and $T_a = 35\ minutes$.

In order to optimize the trajectories, we needed an aircraft performance model, which in this work was obtained from Eurocontrol's Base of Aircraft Data (BADA) version 4 [13].

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PROCEEDINGS | *The 12th OpenSky Symposium*

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Data-Driven Prediction of Aircraft Holding Times Using OpenSky Data

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- Big airports like London Heathrow often get **too crowded**, so planes must wait ("**hold**") in the air before landing.
- These holding patterns waste fuel, increase **delays**, and add **CO_2 emissions**.
- Air Traffic Controllers need better tools **to predict and manage these waits**.
- Used **machine learning (ML)** to predict how long aircraft will hold before landing.

Link of paper

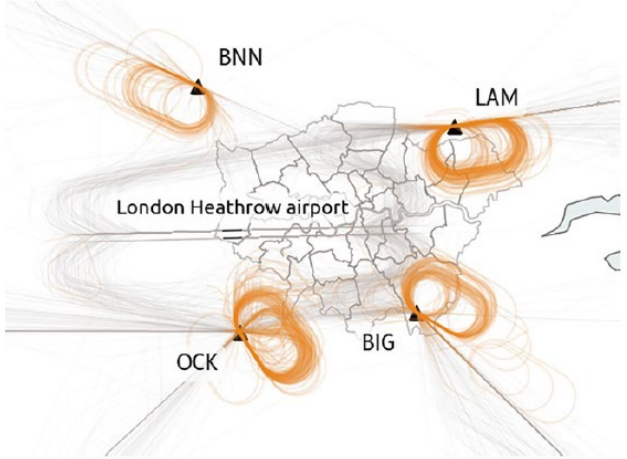

Figure 1. London Heathrow holding stacks [3].

3.1 Data Acquisition

For this study, three main types of historical data were acquired: traffic surveillance data, airport weather data, and airport delay data.

Raw Automatic Dependent Surveillance-Broadcast data was acquired from the OpenSky database [11] using the Traffic API [12]. This data includes parameters such as: ICAO24 identifier, aircraft

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Automating the Estimation of Noise and Emissions Near Airports With ADS-B Data

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- Aircraft take offs and landings create **noise and air pollution** around airports.
- The idea is using **ADS-B flight data** (open-source aircraft tracking) to **automate** noise and emission calculations.

Link of paper

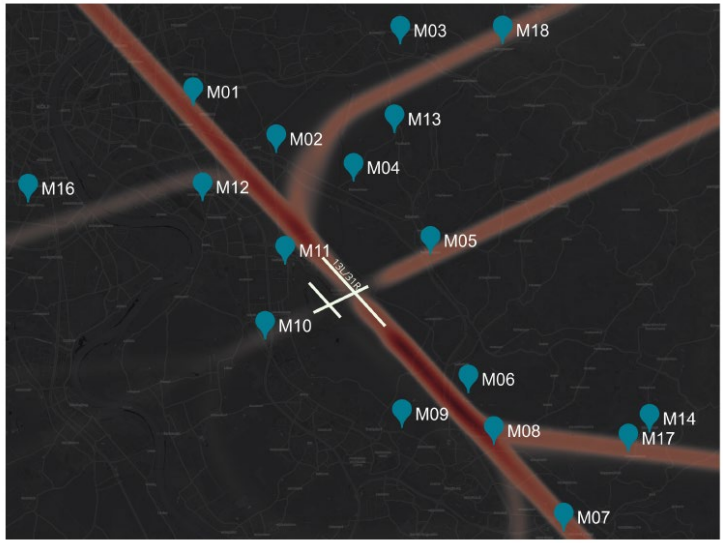

Figure 2. Layout of noise measurement stations around the airport

2. Data Sources and Association

2.1 Data Sources

To estimate the environmental impacts of each arrival and departure at a given airport within a specific time frame, the first challenge is obtaining complete trajectory data for each operation within a specified distance from the airport. For this, we rely on ADS-B data provided by the Opensky Network. The task of identifying the departure or arrival airport for a given trajectory has been addressed in previous research [14], and the solution has been integrated into the available API.

Ideas for problems for hackathon

Dr Michal Weiszer

October2025

Autumn school 2025

R&D Archive

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Problems:

- Rotation times analysis
- Route and trajectory clustering
- Airport usage analysis
    - Departures and arrival distributions and characterisations
- Runway usage and operations
    - Which airport configuration in use?
    - How many times airport configuration change while flight in the air?
- Airlines operations analysis
    - Airports usage identification
    - Airport market concentration

ADS-B / Opensky

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Flight list (2019-2022): https://zenodo.org/records/7923702

full 24h set of ADS-B in 10s resolution (2017-2022): https://opensky-network.org/datasets/#states/

Problems:

- Detecting holdings for arrivals
- Calculation of turnaround times, classified by aircraft type
- Calculation of runway occupancy times, classified by runway exit
- Calculation of airport taxi times
- Detecting runway configurations and their durations
- Detecting aircraft rotations (flights one aircraft performs in a day)

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- How to characterise the dynamicity of the state-of-atmosphere – i.e. how fast are hotspots and the hotspot area changes
    - For accf_merged and the contrail accfs

- Are some areas in Europe more prone to hotspots?

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- **THANK YOU**