
# Tracking the sustainability of long-haul flights

**TakeAIM 2021 – 1st Place**

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The Smith Institute, enabled by the generous sponsorship of our leading corporate partners, ran the TakeAIM competition in 2021 to make visible the crucial role that mathematics will increasingly play in all aspects of our lives. The competition, also celebrating its 11th anniversary this year, was open to undergraduate and postgraduate students working in the mathematical sciences. The first-place prize was £1000, the two second-place prizes were £500, and the two third-place prizes were £250.

By 2050 the aviation industry aims to be carbon neutral, requiring huge changes, that could take decades to implement. However, with commercial flight responsible for more than 2% of manmade greenhouse gas emissions, efforts to reduce carbon dioxide released during flights, must start now. An improvement in operational efficiency is the only way to make these immediate changes. With new satellite coverage of the North Atlantic, planning individual trajectories to minimise emissions can be a reality. My research applies optimal control theory to plan trajectories that exploit daily wind field information.

In the first instance I compared time minimal flights at a constant altitude and airspeed with daily flight tracks. This research showed that the distance flown by an aircraft relative to the wind is currently up to 16% longer than is necessary, amounting to 6.7 million kg of unnecessary $CO_2$ emissions each winter. This research was cited by National Air Traffic Services (NATS), in their decision to remove the set tracks on some days.

Operationally, minimum time routes are not always practical, so in my recent research I have generated minimum fuel routes for a fixed time flight. By controlling heading angle, altitude and airspeed of an aircraft, emissions for each small stage of a trajectory can be minimised, reducing the flight's total climate impact. By comparing results for different combinations of these control variables the importance of each factor can be assessed.

My work shows that greater route flexibility can provide substantial and immediate cuts to emissions.