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Report: InnovAero Competition

Lufthansa Technik

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October 31, 2024

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Chapter 1

Abstract

This report presents the results of the Lufthansa Technik InnovAero competition.

Chapter 2

Introduction

Contrails (short for "condensation trails") are line-shaped clouds produced by aircraft engine exhaust or changes in air pressure, typically at aircraft cruising altitudes several kilometres/miles above the Earth's surface [1]. Contrails trap longwave radiation, contributing to net positive radiative forcing. Persistent contrails can evolve into cirrus-like clouds, which enhance warming effects by trapping heat that would otherwise escape into space. Studies show that this radiative forcing from contrails may rival or exceed CO_2 emissions from aviation in the short term [2]. Hence, studying contrail formation and finding ways to avoid them is crucial for reducing the environmental impact of aviation.

This study relies on the theoretically established **Schmidt-Appleman Criterion** [3] to predict the formation of contrails and the length associated with it. Basic assumptions made here in deriving this criterion are (1) contrails are composed of ice crystals; (2) water vapor cannot be transformed into ice without first passing through the liquid phase, thus necessitating an intermediate state of saturation with respect to water. We will refer to some other studies and articles that propose the necessary equations used in thermodynamic calculations and argue upon their accuracy.

Chapter 3

Aircraft Components

Chapter 4

Component Installation

Chapter 5

Calculation of Possible Contrail Formation

Chapter 6

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Conclusion

Bibliography

[1] Wikipedia contributors. "Contrail — Wikipedia, The Free Encyclopedia". [Online; accessed 31-October-2024]. 2024. URL: https://en.wikipedia.org/w/index.php?title=Contrail&oldid=1250066651 (page 2).

[2] K. Wolf, N. Bellouin, and O. Boucher. "Distribution and morphology of non-persistent contrail and persistent contrail formation areas in ERA5". In: *Atmospheric Chemistry and Physics* 24.8 (2024), pp. 5009–5024. DOI: 10.5194/acp-24-5009-2024. URL: https://acp.copernicus.org/articles/24/5009/2024/ (page 2).

[3] Herbert Appleman. "The formation of exhaust condensation trails by jet aircraft". In: *Bulletin of the American Meteorological Society* 34.1 (1953), pp. 14–20 (page 2).