Technische Hochschule Ingolstadt

Faculty of Computer Science

The Future of AI in Air Traffic Management: Coordinating Autonomous Airliners and UAM within Busy Airspaces using AI

Seminar Paper

Jiahui Dai

Supervisor: Prof. Christian Seidel

Date: 5 May 2025

Affidavit

I certify that I have completed the work without outside help and without using sources other than those specified and that the work has not yet been submitted in the same or a similar form to any other examination authority and has been accepted by them as part of an examination. All statements that have been adopted literally or analogously are marked as such.

Ingolstadt, 5 May 2025

Signature

Abstract

The summary gives the reader a rough overview of the content (brief problem definition, approach, solution approaches and possibly key findings). The scope should be about half a page. This chapter is not mandatory and should only be considered optional.

Contents

1 Introduction

Air Traffic Management (ATM) refers to the systems and services that ensure the safe anf efficient movement of aircrafts during all phases of operations, through controlled airspaces and on the ground [7]. Traditionally, this has been a highly human-centered system, relying on air traffic controllers, pilots, and pre-defined procedures. However, as global air traffic continues to rise and with emerging aerial technologies such as Urban Air Mobility (UAM) and autonomous airliners, the complexity of managing airspace is set to increase dramatically [5].

UAM, which includes Vertical Take-Off and Landing (VTOL) aircrafts, such as helicopters, operating in densely populated urban areas, introduces a new dimension of aerial activity. These vehicles are expected to operated at lower altitudes and with higher frequencies compared to traditional aircraft, leading to increased airspace density, especially near cities [5]. Simultaneously, advances in autonomous flight systems are enabling a shift towards single pilot operated aircraft or even pilotless airliners in the future [9].

Artificial Intelligence (AI), machine learning and deep learning, branches of AI, have emerged as fundamental tools in addressing the challenges of this evolving landscape. From predictive analytics to real-time decision-making and autonomous coordination, AI has the potential to transform how we manage air traffic. The increase in air traffic density and increasing volume of information sending through the system, it is necessitating more efficient optimization algorithms to maintain safety and efficiency in the airspace [8].

This report explores the roles of AI in shaping the future of ATM, focusing particularly on its application to autonomous airliners and UAM integration.

2 Background

In the early days of ATM, Air Traffic Control (ATC) was a largely manual process which heavily relied on visual observations and human judgement. As the industry expanded, the need for more advanced, reliable, and efficient technologies emerged to manage the exponential growing air traffic. Modern ATM system are built around a network of surveillance (e.g. radar, Automatic Dependent Surveillance-Broadcast (ADS-B)), communication (e.g. radio), and navigation (e.g. satelite and Global Positioning System (GPS)) technologies, all coordinated by human operators [1]. Air traffic controllers issue clearances, separate aircraft to maintain safe distances, and manage takeoffs and landings based on real-time information and experience [2].

However, this model has several shortfalls. Human controllers are subject to workload constraints and cognitive overload, especially in congested airspace [3]. As traffic increases,

the system becomes harder to scale. Moreover, human reaction times and decision-making are limited compared to what could be achieved with intelligent, automated systems.

With the current shortage of ATC operators and the expected growth of air traffic, the need for AI tools in ATM is of increasing demand [3]. Though automations already exist in some areas [6], these systems often follow fixed rules and lack adaptability [3]. Integrating autonomous aircrafts and UAM operations into this system would not only stress current infrastructure but also require faster, more adaptive decision-making [4] – precisely where AI offers value .

Acronyms

ADS-B Automatic Dependent Surveillance-Broadcast. 1

AI Artificial Intelligence. 1, 2

ATC Air Traffic Control. 1, 2

ATM Air Traffic Management. 1, 2

GPS Global Positioning System. 1

UAM Urban Air Mobility. 1, 2

VTOL Vertical Take-Off and Landing. 1

References

[1] Careerroo. *The Role of Technology in Modern Air Traffic Control*. Accessed: 2025-05-05. Apr. 2024. URL: https://www.careerroo.com/magazine/the-role-of-technology-in-modern-air-traffic-control/.

[2] DFS Deutsche Flugsicherung GmbH. *The job of an air traffic controller*. Accessed: 2025-05-05. 2025. URL: https://www.dfs.de/dfs_karriereportal_2016/en/Becoming%20an%20air%20traffic%20controller/.

[3] J. Meier et al. "Flexible Air Traffic Controller Deployment with Artificial Intelligence based Decision Support: Literature Survey and Evaluation Framework". In: *Deutsche Gesellschaft für Luft- und Raumfahrt - Lilienthal-Oberth e.V.* (2024). DOI: 10.25967/630258.

[4] Rudolfs Rumba and Agris Nikitenko. "The Wild West of drones: A review on autonomous-UAV traffic-management". In: *2020 International Conference on Unmanned Aircraft Systems (ICUAS)* (Sept. 2020). DOI: 10.1109/icuas48674.2020.9214031.

[5] Bianca I. Schuchardt et al. "Air Traffic Management as a vital part of Urban Air Mobility—a review of DLR's research work from 1995 to 2022". In: *Aerospace* 10.1 (Jan. 2023), p. 81. DOI: 10.3390/aerospace10010081.

[6] SKYbrary. *Automation and ATM*. Accessed: 2025-05-05. 2025. URL: https://skybrary.aero/articles/automation-and-atm.

[7] SKYbrary Aviation Safety. *Air Traffic Management (ATM)*. Accessed: 2025-05-04. 2023. URL: https://skybrary.aero/articles/air-traffic-management-atm.

[8] Cristian Lozano Tafur et al. "Applications of artificial intelligence in air operations: A systematic review". In: *Results in Engineering* 25 (Mar. 2025), p. 103742. DOI: 10.1016/j.rineng.2024.103742.

[9] Samuel M. Vance, Evan C. Bird, and Daniel J. Tiffin. "Autonomous airliners anytime soon?" In: *International Journal of Aviation, Aeronautics, and Aerospace* 6.4 (2019). DOI: 10.15394/ijaaa.2019.1402.