iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** X **Month of publication:** October 2025

DOI: https://doi.org/10.22214/ijraset.2025.74407

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue X Oct 2025- Available at www.ijraset.com

Quantum Assisted Flight Path Optimization

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Abstract: Modern aviation faces increasing operational complexity due to rising air traffic, fluctuating fuel costs, dynamic weather patterns, and stringent safety and environmental regulations. Traditional flight planning methods are often insufficient to handle the scale and variability of modern aviation. This paper proposes a Django-based backend platform that integrates classical algorithms, quantum-inspired optimization, real-time data analytics, and artificial intelligence for efficient flight planning and operational support. The system consolidates airport data, route optimization using QAOA-inspired algorithms, weather analytics, fuel and emissions estimation, and safety metrics into a unified API. To improve usability, a chatbot interface powered by Google Gemini provides natural language interaction. Results demonstrate improved operational efficiency, explainability, and robustness, highlighting the potential of AI and quantum-assisted methods for enhancing aviation safety and sustainability.
Keywords: Flight Analytics, Route Optimization, Quantum Approximate Optimization Algorithm (QAOA), Aviation Safety, Conversational AI.

I. INTRODUCTION

Modern aviation faces increasing operational complexity due to rising air traffic, fluctuating fuel costs, dynamic weather patterns, and stringent safety and environmental regulations. Airlines, pilots, dispatchers, and air traffic management authorities must make critical decisions in real time, balancing efficiency with safety, cost, and sustainability. Traditional flight planning methods, which rely heavily on static schedules and manual assessments, are often insufficient. The Flight Analytics & Optimization project addresses this need by combining classical algorithms, quantum-inspired optimization, real-time data analytics, and artificial intelligence.

Key features include:

1) Route optimization using classical and QAOA-inspired algorithms.
2) Weather analytics using real-time and forecast-based data.
3) Fuel and emissions estimation using Airbus A380 performance coefficients.
4) Safety metrics derived from telemetry, simulations, and heuristics.
5) A chatbot interface powered by Google Gemini.

II. LITERATURE SURVEY

Flight trajectory optimization has its roots in operations research, aerospace engineering, and software engineering. Traditional methods rely on algorithms like Dijkstra and Bellman-Ford, while modern approaches integrate machine learning, quantum-inspired heuristics, and real-time APIs.

Key references include:

1) NASA Glenn Research Centre resources on lift-to-drag ratio, drag equation, and propulsion notes.
2) NASA Technical Reports Server publications on guidance and trajectory optimization.
3) Studies on Quantum Genetic Algorithms and QAOA for trajectory optimization.
4) APIs like OpenSky Network (telemetry) and Open-Meteo (weather).
5) Research on quantum speedup for aeroscience, QUAV UAV navigation, and quantum annealing for fleet management.

III.SYSTEM ANALYSIS

A. Proposed System

The backend is a modular Django system exposing REST APIs for:

1) Pathfinding (Dijkstra, QAOA-transformed Dijkstra).
2) Weather aggregation.
3) Fuel and safety estimations.
4) Conversational chatbot service.

B. Problem Statement

The objective is to design a backend that generates aggregated reports containing optimized routes, weather snapshots, safety summaries, and fuel/emission estimates.

C. Data Flow, and Architecture Diagrams

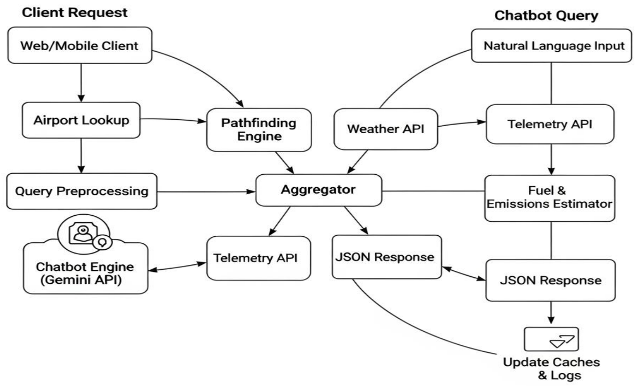


Fig 1. Data Flow Diagram

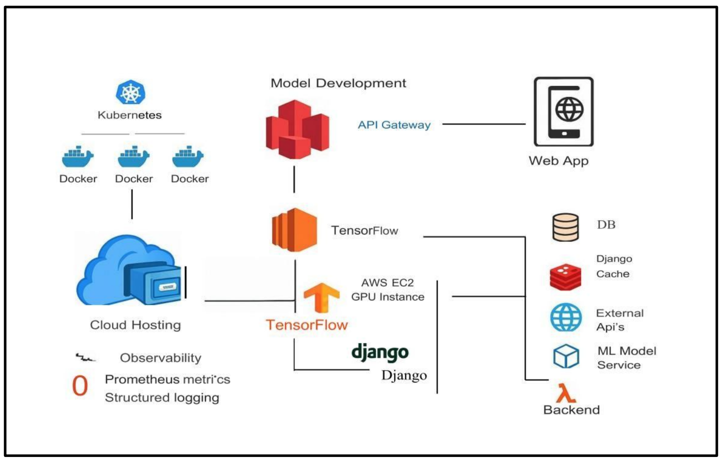


Fig 2: System Architecture of the Flight Analytics & Optimization System

IV. OBJECTIVES AND ANALYSIS

1) Objective 1: Provide accurate, explainable route recommendations combining classical and QAOA-inspired optimization.
2) Objective 2: Enable multi-metric analytics including cost, fuel, emissions, and safety with deterministic fallbacks.
3) Analysis: Hybrid QAOA improves trade-offs between safety and fuel efficiency while chatbot integration improves explainability.

A. System Architecture

The proposed system follows a layered architecture consisting of:

1) Input Layer – Users provide origin, destination, and optimization preferences via a web or mobile interface.
2) Data Layer – Manages static data (airports database, historical routes) and dynamic data (real-time weather via Open-Meteo, flight telemetry via OpenSky). Caching mechanisms improve availability.
3) Optimization Engine – Performs pathfinding using Dijkstra (classical) and QAOA-inspired edge transforms (quantum-assisted). ML models predict QAOA parameters (β, γ).
4) Analytics Module – Estimates cost, fuel consumption, emissions, and safety metrics, with deterministic fallbacks when APIs fail.

5) API Services Layer – Exposes REST endpoints (/search_airports, /optimize, /full_report, /chatbot).
6) Conversational AI Interface – Google Gemini-powered chatbot allows natural language interaction with reports.
7) Output Layer – Aggregated results (routes, metrics, safety indices) are returned to the user through dashboards and chatbot responses.

B. Algorithms Used

1) Dijkstra Algorithm(Classical Shortest Path).
2) QAOA- Inspired Edge Transform.
3) Deterministic Fallback Algorithm.
4) Multi- Meteric Analytics Computation.

V. .SYSTEM REQUIREMENTS AND SPECIFICATIONS

A. Algorithms Used Tools and Technologies

1) Python 3.10+, Django REST Framework.
2) TensorFlow/Keras for ML predication of QAOA parameters.
3) OpenSky Network and Open-Meteo APIs.
4) Google Gemini API for conversational AI.

B. Functional Requirements

1) Search airports.
2) Optimize routes (classical or QAOA).
3) Generate full reports (distance, weather, fuel, safety).
4) Support fallback behaviour when APIs fail.

C. Non-Functional Requirements

1) High availability with graceful degradation.
2) Performance: response under 500ms for high-traffic routes.
3) Scalability using containerization and caching.
4) Secure handling of API keys and data.

VI. SYSTEM DESIGN AND IMPLEMENTATION

1) Layered architecture with models, services, views, utilities, and chatbot integration.
2) Backend workflow integrates APIs and ML for real-time analytics.
3) Frontend displays results in dashboards with maps and chatbot interaction.
4) Performance optimization via caching, precomputation, and parallel API calls.

VII. RESULTS AND DISCUSSION

1) Hybrid QAOA produced safer routes with better fuel/risk trade-offs than classical Dijkstra.
2) Deterministic fallback modules ensured robustness under API failures.
3) System provided explainable, real-time insights through chatbot interaction.

A. Comparison with Existing Methods

1) Classical methods: shortest distance, deterministic, less adaptable.
2) Proposed QAOA-ML hybrid: improved safety, cost-efficiency, robustness, and explainability.

VIII. CONCLUSION AND FUTURE WORK

The proposed backend integrates quantum-inspired optimization, classical algorithms, and conversational AI for aviation decision support. Results validate its ability to improve safety, cost-efficiency, and robustness in real-world conditions.

A. Future Enhancements

1) Integration of NOTAMs and dynamic airspace closures.
2) Multi-objective Pareto optimization.
3) Broader aircraft profiles beyond Airbus A380.
4) Airline-specific calibration with historical logs.

IX. CONFLICT OF INTEREST

The authors declare no conflict of interest.

X. AUTHOR CONTRIBUTIONS

The primary Anusha K to the design and implementation of the flight analytics and optimization platform, including the integration of heterogeneous data sources (static airports data, OpenSky telemetry, Open-Meteo weather). They developed the graph-based route optimization engine with both Dijkstra and QAOA- inspired edge transformation, and trained machine learning models for predicting QAOA parameters. They implemented safety metric simulations, AIRBUS A380 fallback models, and the conversational AI interface powered by Google Gemini additional contributions included containerizing the system with docker, optimizing performance with caching, and integrating chatbot support with LangChain/ LangGraph.

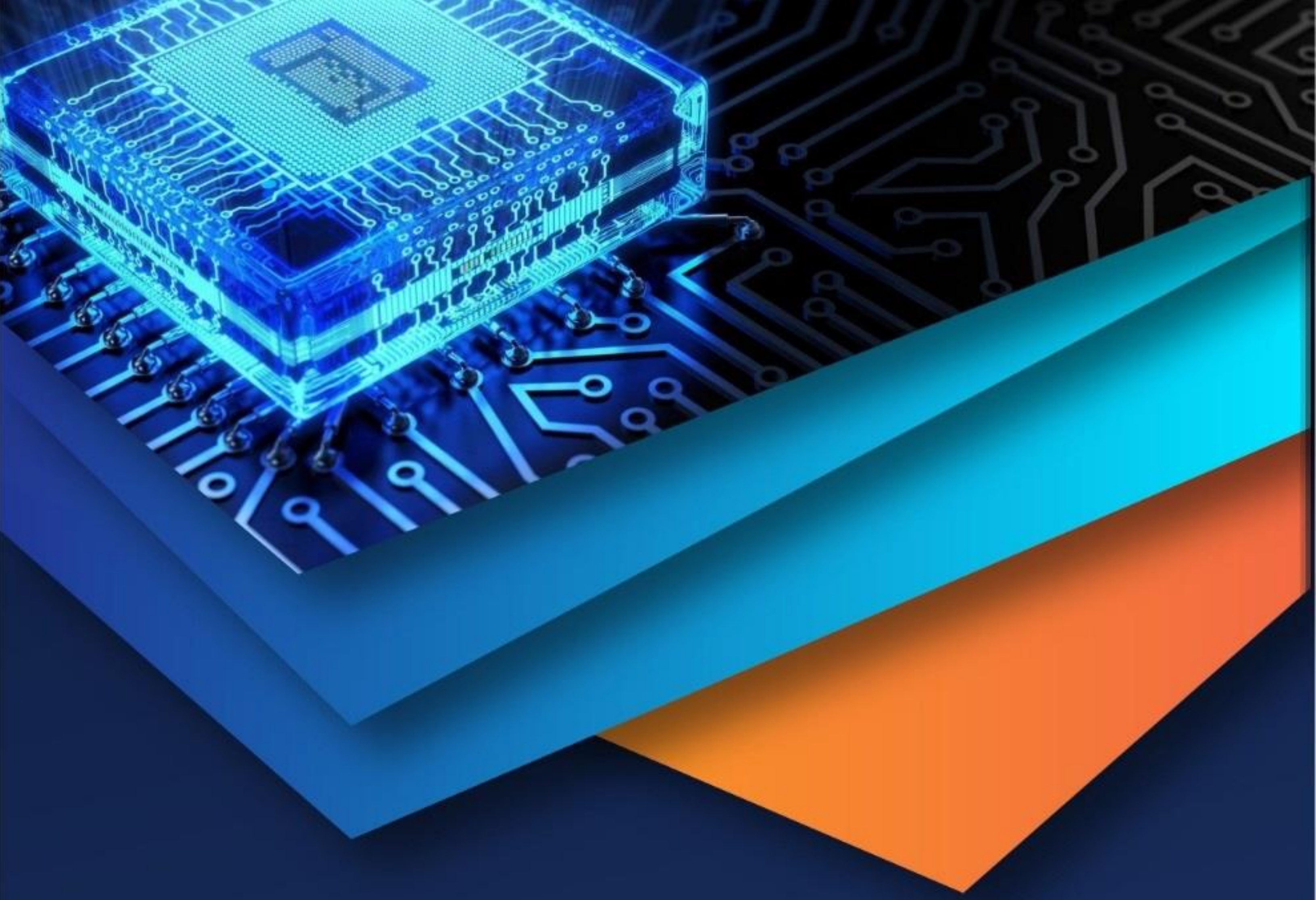
The Dr. R. Kanagavalli the overall research direction, reviewed the system design, and provided critical feedback on architecture, optimization strategies, and manuscript preparation.

XI. ACKNOWLEDGMENT

The author wishes to thank the project Dr. R. Kanagavalli for valuable guidance throughout the work, and acknowledges the support of faculty members for providing resources and feedback during system development. Special thanks are extended to peers who assisted in pilot testing, validating datasets, and offering constructive discussions that contributed to the success of this research.

REFERENCES

[1] NASA Glenn Research Center, “Lift-to-Drag Ratio,” [Online]. Available: https://www.grc.nasa.gov/www/k-12/airplane/lift_drag.html
[2] NASA Glenn Research Center, “Drag Equation,” [Online]. Available: https://www.grc.nasa.gov/www/k12/airplane/drageq.html
[3] NASA Glenn Research Center, “Thrust Equation,” [Online]. Available: https://www.grc.nasa.gov/www/k-12/airplane/thrsteq.html
[4] NASA Technical Reports Server, “Guidance, Flight Mechanics and Trajectory Optimization,” [Online]. Available: https://ntrs.nasa.gov
[5] Y. Li et al., “Research on Flight Trajectory Optimization Based on Quantum Genetic Algorithm,” Journal of Physics: Conference Series, 2020.
[6] OpenSky Network, “OpenSky Network API Documentation,” 2025.
[7] Open-Meteo, “Open-Meteo Weather API Documentation,” 2025.
[8] P. Givi et al., “Quantum Speedup for Aeroscience and Engineering,” AIAA Journal, 2020.
[9] H. Makhanov et al., “Quantum Computing Application for Flight Trajectory Optimization,” arXiv preprint, 2023.
[10] N. Innan et al., “QUAV: Quantum-Assisted Path Planning and Optimization for UAV Navigation,” arXiv preprint, 2025.
[11] R. Haba et al., “Routing and Scheduling Optimization for Urban Air Mobility Fleet Management using Quantum Annealing,” Scientific Reports, 2025.
[12] M. Gili et al., “Optimization of Flight Routes: QAOA for Tail Assignment Problem,” arXiv preprint, 2024.



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