WEEK 4 — INSIGHTS & STORYTELLING REPORT

Flight Delay Analysis

Wings of Data Project

Course: IT300 – Business Intelligence
Institution: Tunis Business School

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1. Introduction

The aviation industry is characterized by high operational complexity, strict time constraints, and strong interdependencies between airlines, airports, and air traffic systems. Flight punctuality is a critical performance indicator, as delays directly affect customer satisfaction, operating costs, network congestion, and airline reputation.

This report presents insights derived from the Business Intelligence solution developed for the **Wings of Data** project, which analyzes historical flight operations to identify delay patterns across airlines, airports, time periods, and routes. The objective of this analysis is to provide decision-makers with data-driven insights that explain when, where, and why delays occur, and to translate these insights into actionable business recommendations that can improve operational performance and planning.

2. Key Findings and Business Implications

Finding 1: Delay performance varies significantly across airlines despite similar traffic volumes

Observation:
The analysis reveals notable differences in average departure and arrival delays among airlines,

even when operating comparable numbers of flights.

Evidence:
While the top airlines account for a large share of total flights, their average delay metrics differ substantially. Some high-volume carriers maintain relatively low average delays, whereas others exhibit consistently higher departure and arrival delays.

Why this matters:
This indicates that delays are not solely driven by scale but also by operational efficiency, scheduling discipline, and recovery capabilities. Airlines with weaker delay performance risk higher operational costs and reputational damage, despite having similar network sizes.

Finding 2: Delay severity is highly concentrated during specific periods of the day

Observation:
Flights operating during peak time bands experience a higher concentration of moderate and severe delays compared to off-peak periods.

Evidence:
The Peak-Time Delay Index shows that average delays during peak hours are significantly higher than during off-peak hours, with a larger share of flights falling into severe delay bands.

Why this matters:
Peak-time congestion amplifies operational stress across airports and airlines. Without adequate buffer strategies, small disruptions during these periods cascade into system-wide delays, reducing overall network reliability.

Finding 3: Flight activity is highly concentrated among a small number of airlines and airports

Observation:
A limited group of airlines and airports accounts for a disproportionately large share of total flight operations.

Evidence:

The concentration ratio shows that the top five airlines and top five airports together handle a substantial percentage of all flights in the dataset.

Why this matters:
Such dependency increases systemic risk. Operational disruptions at major hubs or among dominant carriers can rapidly propagate across the entire network, amplifying delays far beyond the original source.

Example of Airport Concentration (Top 5 Hubs)

Global flight activity is highly concentrated among a small number of major hub airports. For example, Hartsfield–Jackson Atlanta (ATL), Chicago O'Hare (ORD), Dallas/Fort Worth (DFW), Denver (DEN), and Istanbul Airport (IST) are consistently ranked among the world's busiest airports by aircraft movements.
These hubs handle a disproportionately large share of total flights, meaning operational disruptions at any of them can rapidly propagate delays across airline networks, increasing systemic risk and network-wide inefficiencies.

Finding 4: Departure delays usually lead to arrival delays

Observation:
For most airlines, flights that leave late also tend to arrive late, with little time made up during the flight.

Evidence:
The Delay Propagation Ratio is close to or higher than 1 for many airlines, showing that departure delays are rarely recovered before arrival.

Why this matters:
When delays are not absorbed, passengers experience longer waiting times and missed connections. Airlines that manage to recover delays during operations can improve punctuality and overall customer satisfaction.

Finding 5: Temporal patterns reveal consistent weekly and seasonal inefficiencies

Observation:
Certain days of the week and months consistently exhibit higher delay rates, even when traffic volumes are comparable.

Evidence:
Temporal analysis highlights recurring delay spikes that cannot be explained solely by flight frequency.

Why this matters:
These patterns suggest underlying structural or scheduling inefficiencies rather than random disruptions, offering opportunities for targeted operational improvements.

3. Business Recommendations

Recommendation 1: **Implement airline-specific delay benchmarking programs**
Linked finding: Variability in delay performance across airlines.
Action: Establish internal benchmarking to identify best-performing carriers and replicate effective operational practices.
Expected impact: Improved punctuality and reduced operational costs.

Recommendation 2: **Redesign peak-hour scheduling and buffer strategies**
Linked finding: High delay concentration during peak periods.
Action: Increase turnaround buffers and limit aggressive scheduling during peak hours.
Expected impact: Reduced congestion-induced delays and improved schedule resilience.

Recommendation 3: **Reduce dependency on high-concentration hubs**
Linked finding: Strong concentration among top airports.
Action: Diversify routing strategies and evaluate secondary airports for certain routes.

Expected impact: Lower systemic risk and improved network robustness.

Recommendation 4: Strengthen delay recovery mechanisms for airlines
Linked finding: Strong departure-to-arrival delay propagation.
Action: Improve in-flight recovery strategies, crew coordination, and real-time decision support.
Expected impact: Higher on-time arrival rates and better passenger experience.

Recommendation 5: Introduce time-specific operational planning
Linked finding: Weekly and seasonal delay patterns.
Action: Adjust staffing, maintenance, and scheduling policies during historically high-delay periods.
Expected impact: Smoother operations and more predictable performance.

Recommendation 6: Develop predictive maintenance scheduling
Linked finding: Temporal delay patterns and operational inefficiencies.
Action: Use historical delay data to optimize maintenance schedules, avoiding peak travel periods for critical aircraft.
Expected impact: Reduced maintenance-related delays and improved aircraft utilization.

Recommendation 7: Establish collaborative airport-airline task forces
Linked finding: Systemic delays affecting multiple airlines at hub airports.
Action: Create joint operational teams to coordinate ground handling and resource allocation in real-time.
Expected impact: Reduced ground delays and improved operational coordination.

Recommendation 8: Implement real-time delay prediction and alerting
Linked finding: Delays follow predictable patterns based on multiple factors.
Action: Deploy machine learning models that predict delays and alert operational teams before likely disruptions.
Expected impact: Proactive delay management and improved contingency planning.

4. Limitations and Future Improvements

Limitations:

- The dataset does not include weather, air traffic control, or maintenance data, limiting causal analysis.
- Passenger demographics and ticket class information are unavailable.
- The analysis relies on historical data and does not capture real-time operational dynamics.

Future Improvements:

- Integrate weather and airspace congestion data.
- Apply predictive analytics to forecast delays.
- Automate ETL pipelines for near real-time monitoring.
- Expand dashboards with scenario simulation and what-if analysis.

5. Conclusion

The Business Intelligence solution developed for the **Wings of Data** project provides a comprehensive view of flight delay dynamics across airlines, airports, and time periods. By transforming raw operational data into actionable insights, the analysis supports evidence-based decision-making aimed at improving punctuality, reducing operational risk, and enhancing passenger satisfaction.