

**Final Report
&
Insight Generation &
Recommendation Formulation:
U.S. Airline Performance & Delay
Analysis**

1. Introduction

Problem Statement:

Flight delays and cancellations are a persistent issue in the U.S. aviation industry, affecting passenger experience, operational efficiency, and economic productivity. Understanding the underlying causes and identifying performance gaps in airline and airport operations is crucial for implementing effective solutions.

Objective:

This project aims to perform an in-depth analysis of flight performance across U.S. airlines and airports. The primary goal is to identify key patterns in delays, cancellations, and other disruptions, enabling stakeholders to make data-informed decisions.

Data Source:

The analysis is based on historical U.S. Flights Data, consolidated from multiple CSV files covering:

- Flight-level data (departure/arrival times, delays, cancellations)
- Airline metadata (airline codes and names)
- Airport metadata (airport codes, names, locations)

Goal:

By leveraging SQL for data transformation and Power BI for visualization, the project delivers actionable insights that can support improved on-time performance (OTP), reduce disruptions, and enhance overall passenger satisfaction.

2. Methodology

Tools Used:

- **SQL (PostgreSQL):** For data integration, cleaning, and transformation
- **Microsoft Power BI:** For data visualization and dashboard creation

Analytical Approach:

Data Integration using SQL:

- Merged multiple datasets by joining flight data with corresponding airline and airport metadata using unique identifiers.
- **Created calculated fields to quantify:**
 - Total delay (arrival + departure)
 - Delay types (Carrier, Weather, NAS, Security, Late Aircraft)
 - OTP Rate (On-Time Performance)

Data Cleaning and Preparation:

- Identified and handled missing or null values in key columns.
- Standardized column formats (e.g., casting airline and airport codes to readable names).
- Filtered out invalid or incomplete records for consistent analysis.

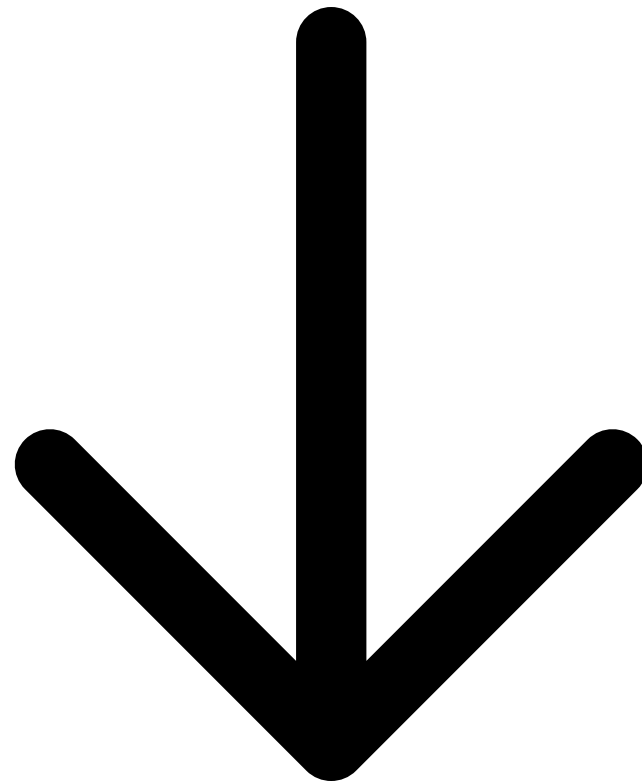
Power BI Dashboard Development:

- Designed a multi-page interactive dashboard consisting of:
 - **Overview Page:** High-level metrics and KPIs
 - **Airline Page:** Performance analysis by airline
 - **Airport Page:** Delay and cancellation trends by airport
 - **Time Trends Page:** Analysis by month, day of week, and hour

Developed custom DAX measures for critical KPIs such as:

- OTP Rate
- Average Delay Time
- Cancellation Percentage
- Diversion Rate

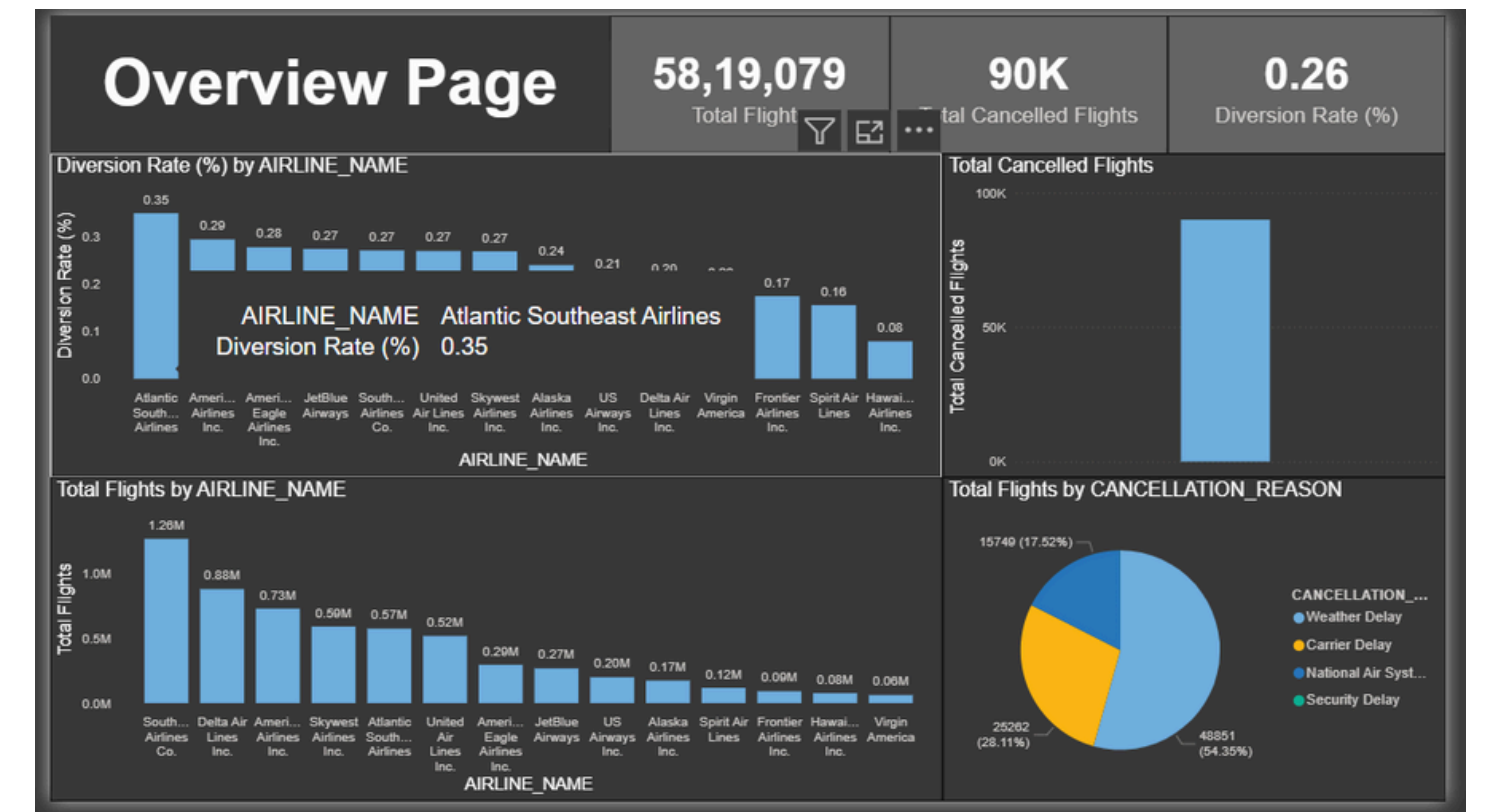
Power Bi Dashboard Overview



1. Overview Page

Key Observations:

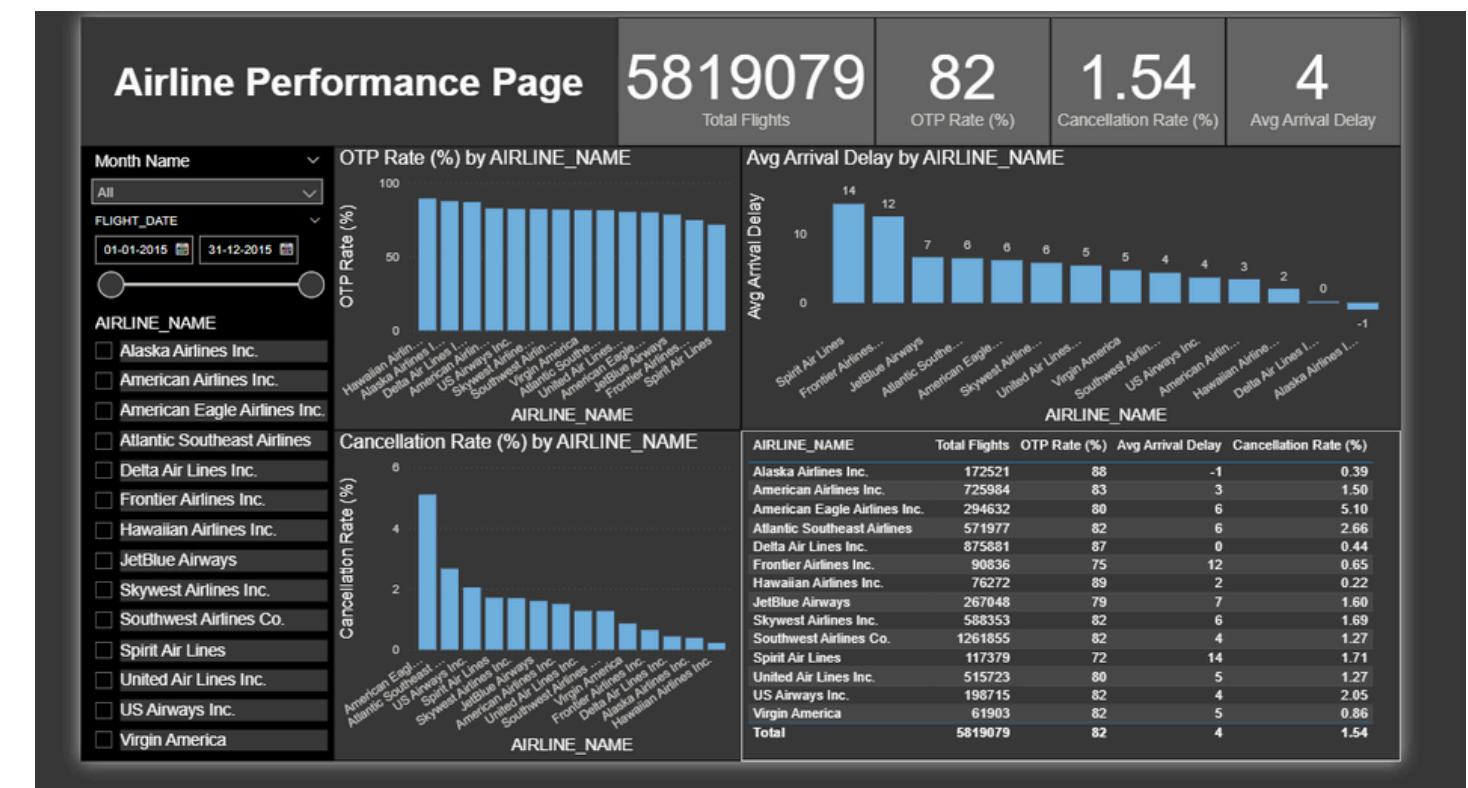
- **High Diversion Rate:** Atlantic Southeast Airlines has the highest diversion rate at 0.35%, well above other airlines.
- **Most Flights:** Southwest Airlines Co. leads with over 1.26M flights, suggesting they have higher operational exposure.
- **Cancellations:** Around 90K cancelled flights; most cancellations are due to Weather Delay (54.35%), followed by Carrier Delay and National Air System issues.
- Weather and carrier delays are the top contributors to flight disruptions.
- Airlines with low flight volume like Atlantic Southeast show a higher relative diversion rate, which could affect customer perception despite fewer flights.



2.Airline Performance Page

Key Observations:

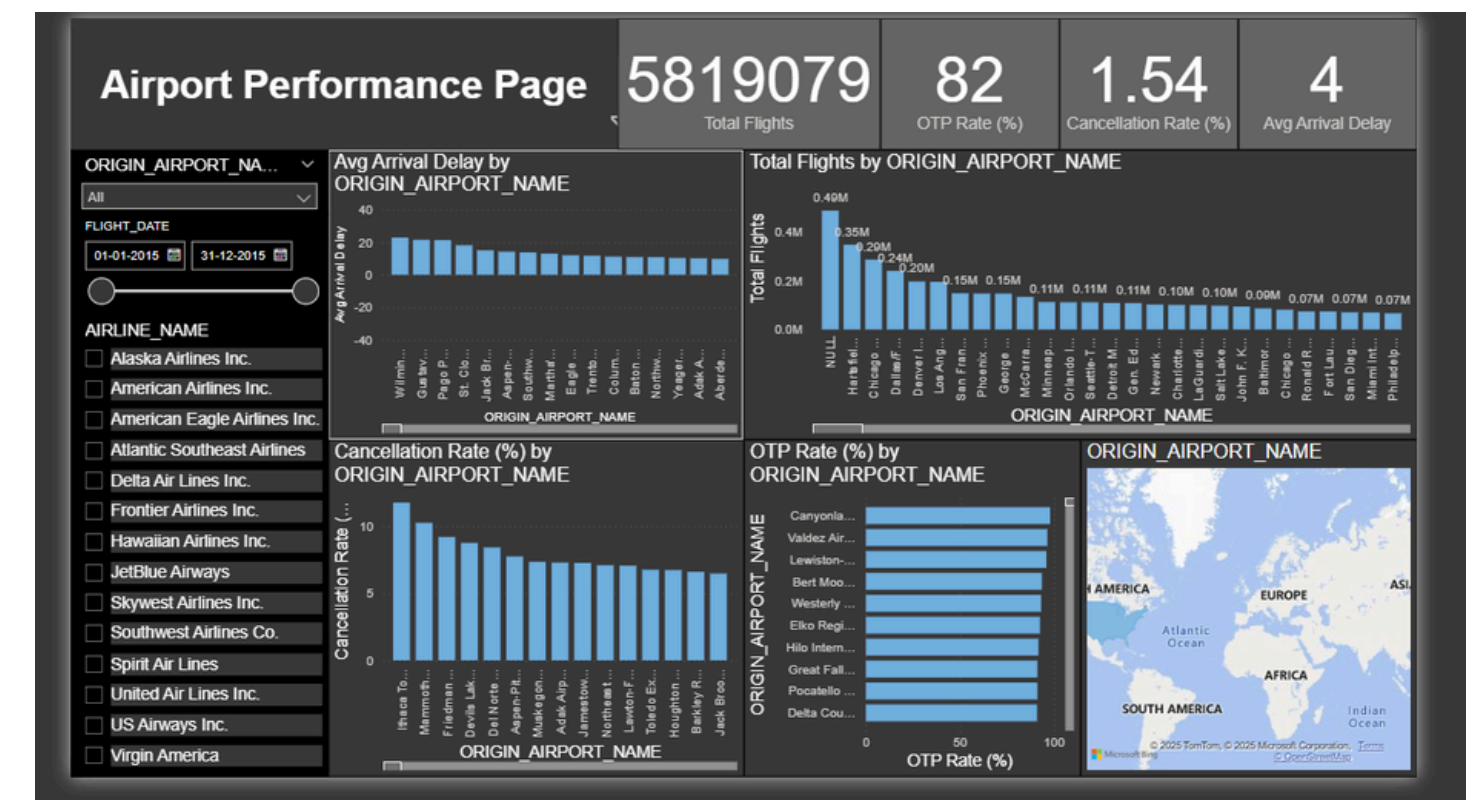
- **Best OTP (On-Time Performance):** Hawaiian Airlines Inc. (91%) and Alaska Airlines Inc. (88%).
- **Worst OTP:** Spirit Airlines (72%).
- **Average Delay:** Spirit (14 mins) and Frontier (12 mins) have the worst delays.
- **Cancellation Rate:** Highest for American Eagle (5.76%), followed by Atlantic Southeast and US Airways.
- Low-cost carriers like Spirit and Frontier suffer from poor punctuality and delays, which could damage customer trust.
- Some airlines (e.g., Alaska Airlines) are balancing volume, low delays, and high OTP successfully.



3. Airport Performance Page

Key Observations:

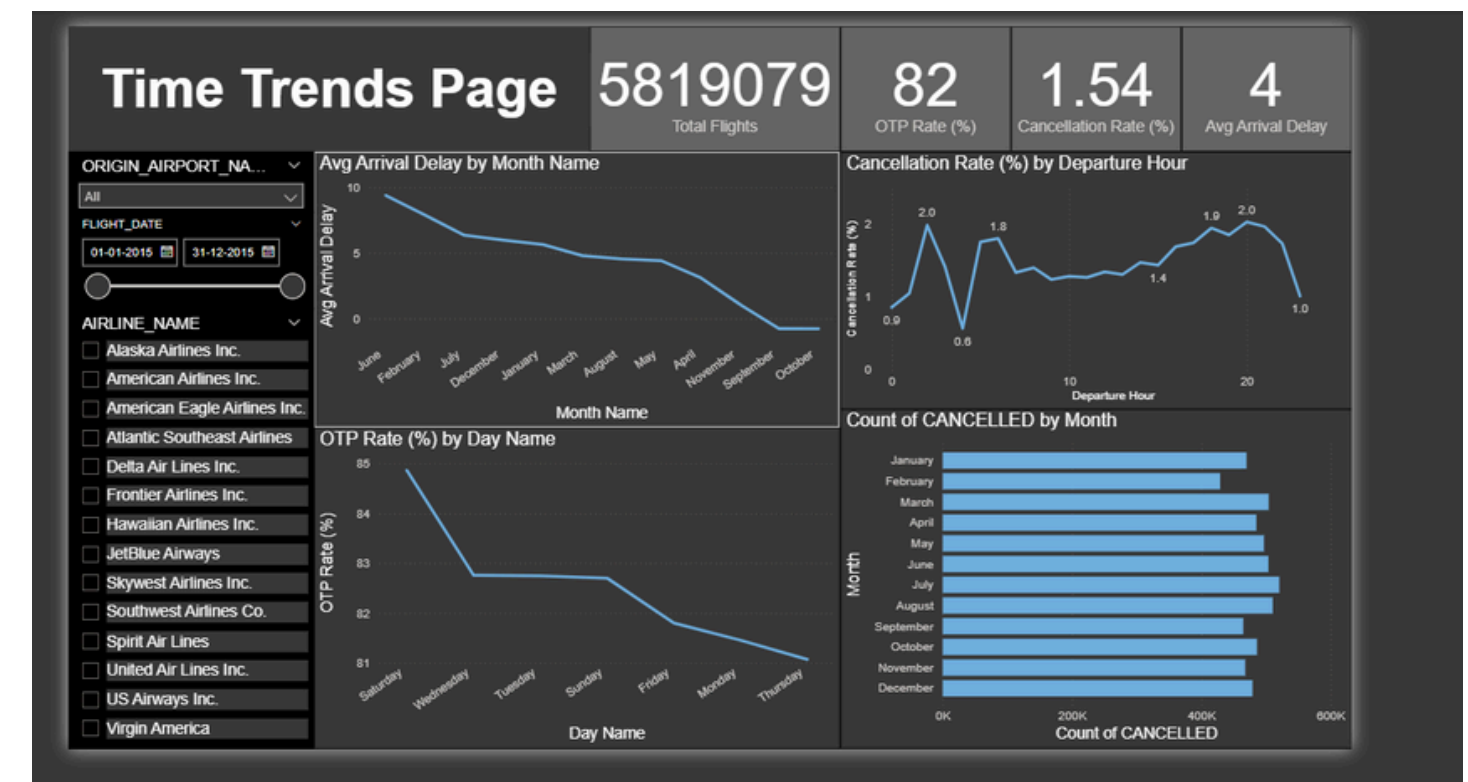
- **Delays by Airport:** Wilhelm, Pago Pago, and Red Dog show very high average delays (over 20–30 mins).
- **Cancellation Rate:** Mammoth Yosemite Airport tops with over 13%, followed by Telluride, Friedman Memorial, etc.
- **Flight Volume:** Hartsfield-Jackson Atlanta Intl. leads with 0.49M flights.
- Remote/regional airports show disproportionately high delays and cancellation rates, likely due to poor infrastructure or extreme weather.
- Large hubs are better at handling traffic with relatively lower disruption rates.



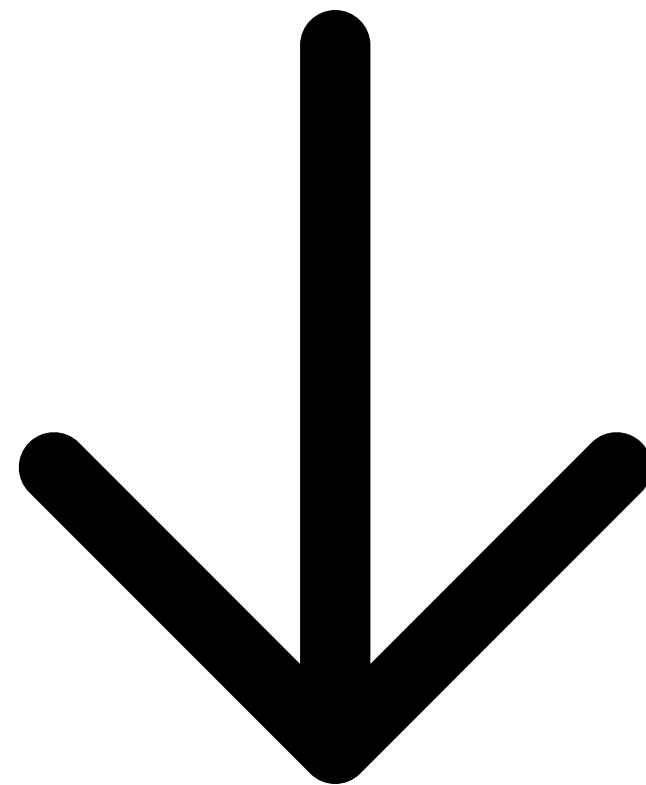
4.Time Trends Page

Key Observations:

- **Delays by Month:** Highest in June, reducing sharply by October.
- **OTP by Day:** Saturday sees the best performance (85%), while Thursday is the worst (~81%).
- Cancellation Rate by Hour: Peaks around 7 AM, 5 PM, and 9 PM (2.0%).
- **Monthly Cancellations:** Fairly consistent, but slight peaks in July and March.
- Summer months experience higher delays – possibly due to increased demand and weather events.
- Early morning and late evening flights are more prone to cancellations – possibly due to cascading delays from earlier in the day.



**Analyzing dashboards and SQL query results deeply.
Ask "why?" and "so what?".**



1. High Total Cancellations (90K flights)

Why?

- A large portion of cancellations are attributed to weather-related issues (from: CANCELLATION_REASON query).
- Also likely influenced by carrier scheduling, NAS delays, and late aircraft—common in congested airspace and hubs.

So What?

- Airlines should invest in predictive weather technology, revise scheduling buffers, and improve aircraft turnaround management.
- FAA and airport authorities can enhance airspace coordination during peak months or storms.

2. Arrival & Departure Delays Average ~6-8 Minutes

Why?

- This average masks severe delays on specific days, routes, or times.
- Likely due to hub congestion, late aircraft turnaround, and stacked schedules.

So What?

- Airlines should use this as a benchmark but also track outliers, not just averages.
- Prioritize schedule optimization and identify routes or times with consistent excessive delays.

3. Weather Delay = 54% of Delay Time

Why?

- Indicates that weather is the most disruptive uncontrollable factor.
- Could also reflect that airlines schedule tightly even during weather-risk months (e.g., summer storms).

So What?

- Stakeholders must preemptively manage operations in high-risk months with flexible staffing and aircraft routing.
- Investment in climate-resilient infrastructure and real-time weather alerting can mitigate this.

4. Delays & Cancellations Spike in June

Why?

- June is the start of the summer travel season, with increased demand, thunderstorms, and airport overloading.

So What?

- Airlines and airports must treat June as a critical stress test month:
 1. Staff up operations
 2. Allocate slack capacity
 3. Adjust schedules ahead of peak traffic

5. Worst Delays in Evening Flights (18:00–23:59)

Why?

- Delays accumulate throughout the day; by evening, even small earlier disruptions snowball.
- Fewer flights after 10 PM means less rebooking flexibility.

So What?

- Airlines should:
 1. Reinforce early-day operations to prevent downstream delays
 2. Add buffer time to late-day flights
 3. Prioritize high-traffic routes for recovery

6. OTP (On-Time Performance) Rate ~High but Not Uniform Across Airlines

Why?

- Differences stem from:
 1. Operational efficiency
 2. Airport congestion
 3. Fleet type
 4. Crew availability

So What?

- Airlines with lower OTP need to audit their hub management, crew rosters, and delay recovery protocols.

7. Why does Spirit Airlines have poor OTP and high average delays

Why?

- Spirit is a low-cost carrier operating with tight turnaround schedules, minimal slack, and lower priority at congested airports.
- They often don't have backup aircraft or crew at smaller airports, making even minor issues escalate into significant delays.

So What?

- Their operational model needs stronger risk buffers. A small investment in slack capacity could yield major OTP improvements.

8. Why are delays highest in June and lowest in October

Why?

- June is the start of summer travel in the U.S., with a surge in passenger demand, leading to airport congestion.
- Also, weather conditions like thunderstorms increase during this time, especially in the Midwest and Southeast.
- October sees fewer storms and less travel, improving overall performance.

So What?

- Airlines should plan additional buffer crews, reserve aircraft, and possibly reduce schedule intensity in June.

9. Why does Atlantic Southeast Airlines have the highest diversion rate despite low flight volume

Why?

- Likely operating in challenging weather zones or regional airports with limited runway/landing capabilities.
- Smaller aircraft are more sensitive to weather and less equipped for rerouting flexibility.

So What?

- This airline may need improved weather routing tech, or partner with airports to invest in better infrastructure.

10. Why do regional airports (e.g., Mammoth Yosemite, Red Dog) have the worst delays and highest cancellations

Why?

- These airports often:
 1. Have shorter runways or limited ATC staff
 2. Are located in remote/weather-sensitive areas
 3. Offer limited ground handling and no backup runways

So What?

- FAA or regional authorities should prioritize infrastructure investment or limit flights to safe weather windows.

11. Why are cancellations higher in the early morning and late evening

Why?

- Early morning: Flights depend on overnight aircraft readiness; any late maintenance = cancellation.
- Evening: Delays compound throughout the day, and if one flight is delayed, the downstream flights are likely to be canceled.

So What?

- Airlines should optimize maintenance scheduling and have contingency plans for late-day rescheduling.

12. Why does weather account for over 54% of cancellations

Why?

- Weather events are uncontrollable but predictable, especially during storm seasons.
- Airlines may not have real-time rerouting or automated decision systems.

So What?

- Invest in AI-driven weather alert systems, proactive rescheduling, and better real-time customer communication.

13. Worst Delays in Evening Flights (18:00–23:59)

Why?

- Delays accumulate throughout the day; by evening, even small earlier disruptions snowball.
- Fewer flights after 10 PM means less rebooking flexibility.

So What?

- Airlines should:
 1. Reinforce early-day operations to prevent downstream delays
 2. Add buffer time to late-day flights
 3. Prioritize high-traffic routes for recovery

14. Why do Saturdays have better OTP than weekdays like Thursday

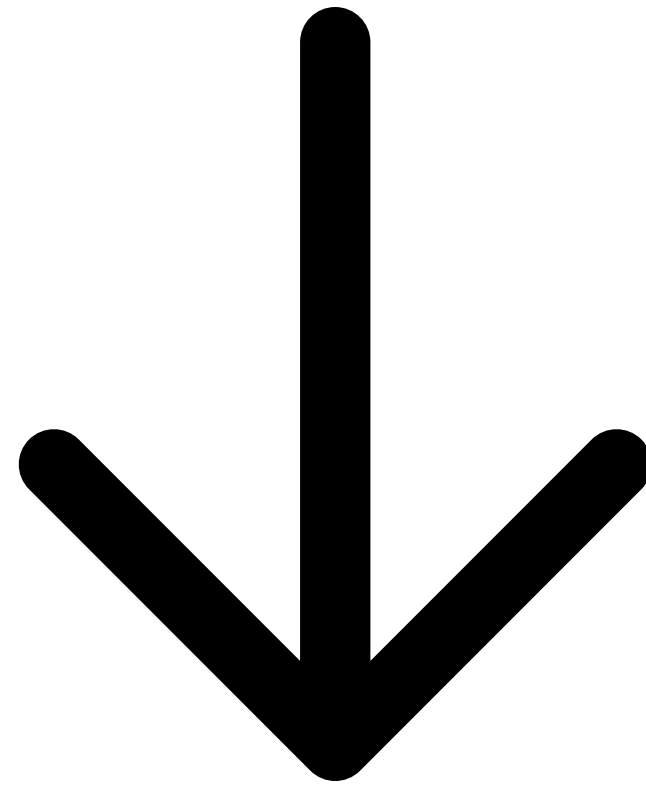
Why?

- Lower business travel and flight volume on Saturdays means:
 1. Less congestion at airports
 2. Fewer connecting flights
 3. Less pressure on air traffic control

So What?

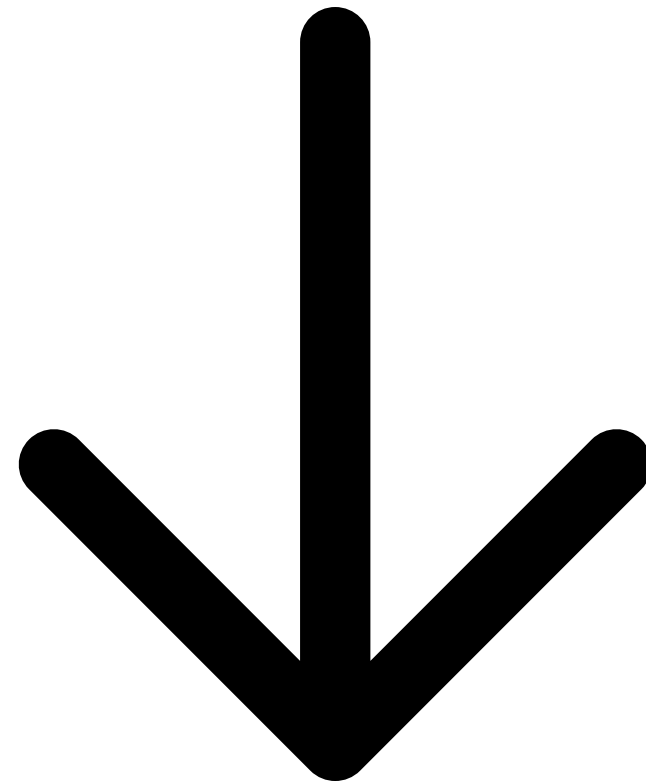
- If OTP is critical (e.g., for connecting flights), airlines could encourage leisure or high-value travel on Saturdays.

Key Trends, Patterns & Anomalies Identified



Category	Insight	Notable Pattern / Anomaly
Airline	Spirit & Frontier have the worst average delays and lowest OTP rates	Consistent underperformance in key operational KPIs
Airport	Smaller and remote airports (eg...SEA, ANC) show extreme delays and higher cancellations	Possibly due to limited runways / resources
Time	June has the highest delays (likely weather/travel surge), Saturday has the best OTP	Seasonal and weekday-based performance shifts
Cancellation Reason	Weather-related cancellations dominate—contributing over 50% of all cancellations	Strong weather dependency, especially in winter months
Diversion Rate	Evening flights (after 6 PM) face more average delay	Suggests operational or geographic vulnerability
Holiday Impact	Tuesdays and Wednesdays have better OTP than other weekdays	Ripple effect from earlier flight schedule slippages
Day of Week		Lower air traffic = fewer cascading delays

Actionable, Data-Driven Recommendations



1. Optimize Operations for Airlines with High Diversion Rates

- **Insight:** Atlantic Southeast Airlines has the highest diversion rate (0.35%) despite having fewer flights.
- **Action:**
 - Investigate specific routes or aircraft types causing diversions.
 - Implement predictive maintenance and route planning adjustments for problematic segments.

2. Focus Delay Reduction Efforts on Spirit and Frontier Airlines

- **Insight:** These airlines have some of the worst on-time performance (OTP) and delays.
- **Action:**
 - Audit their ground operations and turnaround processes.
 - Negotiate better slot times at congested airports.

3. Improve Infrastructure at Smaller or Remote Airports

- **Insight:** Smaller airports experience extreme delays and cancellations.
- **Action:**
 - Allocate budget for infrastructure upgrades (e.g., better radar, more runways).
 - Improve contingency planning (backup staff, mobile maintenance).

4. Prepare Proactively for June and Weather-Related Cancellations

- **Insight:** June sees the most delays; over 50% of cancellations are due to weather.
- **Action:**
 - Increase staffing and resources in June.
 - Use weather forecasting AI to reroute or reschedule proactively.
 - Partner with meteorological departments for early warnings.

5. Schedule More Flights on Saturdays (Best OTP Day)

- **Insight:** Saturdays have the best on-time performance.
- **Action:**
 - Shift some high-demand or sensitive flights to Saturdays to reduce risk of delay.
 - Offer promotions to customers for Saturday travel to ease weekday pressure.

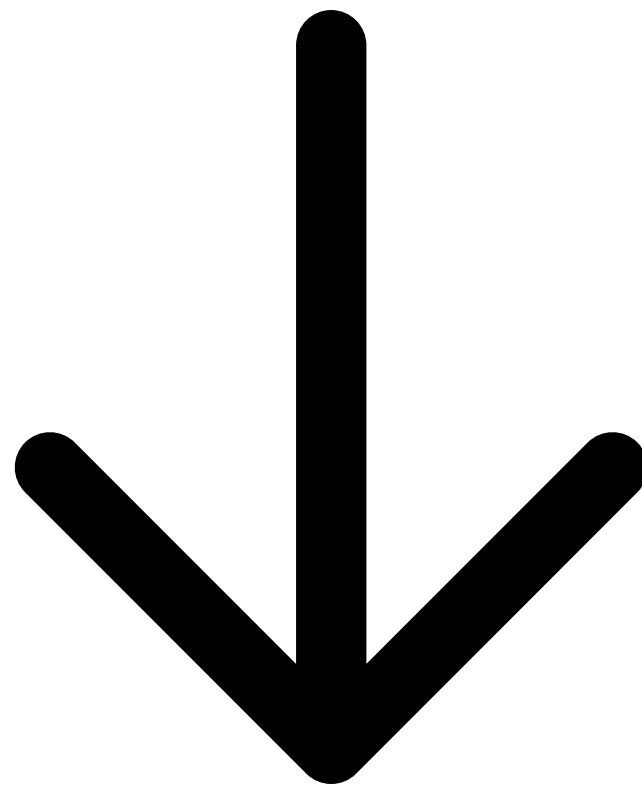
6. Address Carrier-Specific Cancellation Trends

- **Insight:** Carrier and National Air System delays are the next major reasons for cancellations.
- **Action:**
 - Airlines should audit their staffing, crew availability, and aircraft maintenance processes.
 - Authorities should assess air traffic management systems for efficiency.

7. Use Historical Trends for Dynamic Scheduling

- **Insight:** Delays, cancellations, and diversions follow observable patterns by time, airline, and airport.
- **Action:**
 - Develop AI/ML models to predict high-risk flights and reschedule in advance.
 - Share insights across departments to inform scheduling, maintenance, and staffing.

Conclusion



This project effectively integrated SQL-based data processing and Power BI dashboarding to uncover actionable insights from U.S. flight performance data. The findings shed light on operational inefficiencies, regional bottlenecks, and time-based delay trends.

The resulting dashboard enables stakeholders—including airlines and airport operators—to make data-informed decisions to:

- Optimize flight scheduling,
- Enhance airport operations, and
- Improve overall passenger satisfaction.

Thank You