

An Analysis of U.S. Flight Arrival Performance Using SQL and Power BI (2010–2025)



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1. Introduction

Aviation industry provides an essential part of the transportation system, as it promotes economic development, mobility, and connectivity on the regional level. Effective flight operations play a crucial role in ensuring passenger satisfaction and profitability of the airlines. However, the delays, cancellations, and diversions are still the issues that continue to influence the performance of operations at the airline and airport levels. It is therefore necessary to analyze historical flight arrival data in order to examine these disruptions and enhance overall system efficiency.

The report provides a detailed discussion of the airline arrival performance in the U.S. based on data available through the Bureau of Transportation Statistics (BTS) -TranStats OT Delay dataset. The dataset covers a lengthy period starting in January 2010 until September 2025, which gives an opportunity to analyze trends over a long time and compare performance of various airlines, airports, and years.

The BTS OT Delay dataset provides detailed information about the operations of flights, including the total flights attended, delayed flights, delay duration, cancellations, diversion, delay root cause, carrier-related, late aircraft arrival, weather, air traffic system constraint (NAS) and security factors. The rich data makes it possible to assess the flight arrival performance in the U.S. aviation network holistically.

For this project, data preparation and transformation were done using SQL because of the raw data processing and analysis, and interactive dashboards were created using Power BI because of visualization and analysis. Key performance indicators (KPIs) like number of flights, total delay impact (in the number of hours), average delay per flight, cancellation rates, diversion rates, and airport level performance indicators were computed, to enable meaningful information.

The main aim of this analysis is to give a high level but detailed overview of the airline and airport performance in the U.S. with a particular focus on:

- Flight delay, cancellation, and diversion trends over time.
- Root causes of significant delays identified.
- Comparison between airline and airport performance.
- Data operational and strategic decision-making support.

This project will use authoritative government data, interactive visual analytics to provide actionable insights that can guide aviation stakeholders, analysts, and decision-makers to learn more about trends in performance and enhance the reliability of flight arrival.

2. Methodology

2.1 Data Source and Scope

The dataset analyzed in this paper is Flight Arrival Performance dataset (flight_arrival_performance.csv), provided by the Bureau of Transportation Statistics (BTS) via the TranStats On-Time Delay (OT) database. The dataset is publicly available at: <https://www.transtats.bts.gov>

The data includes the domestic flight arrivals to the U.S. between January 2010 and September 2025 and gives detailed data about the volume of flights, delays, cancellations, diversion, and causes of operational delays.

The BTS TranStats database was chosen because it is an official U.S. government data source and covers the performance of airlines and airports over a long period of time.

2.2 Data Storage and Preprocessing

The raw data was loaded into a relational database to be processed structurally in SQL. The first data cleaning focused on addressing missing values, standardizing delay-related data, and ensuring data consistency across records. Delay, cancellation, diversion, and delay-minute columns contained missing values, which were addressed with logical default values to ensure skewed aggregations and arrival flight counts with unknown values were retained to ensure incorrect percentage calculations.

Further computed variables were implemented to obtain delay percentages, cancellation rates, and diversion rates according to volumes of arrivals. These changes ensured that the performance metrics were computed across all analytical views.

All the SQL data preparation and transformation scripts are included in [Appendix A](#).

2.3 Data Aggregation and SQL Views

In order to facilitate effective analysis and reporting, the views of the aggregated databases were developed both at airline level and airport level. These perspectives indicate important operational indicators like total flights, delayed flights, cancelled flights, diverted flights, and total delay minutes. Percentage-based performance indicators were calculated using weighted calculations to determine the effect of flight volumes accurately.

Through database-level aggregation, the redundancy of data was reduced, and the performance of Power BI models contributed to better performance.

[Appendix A](#) contains the SQL view definition of the aggregation.

2.4 Data Modelling and DAX Calculations in Power BI

The power BI was used to import the aggregated SQL views and then model and visualize them. The month and the year were properly ordered in time, and a specific date dimension table was developed in order to support the analysis of the data and provided the correct chronological order of the months and years.

Custom DAX measures have been created to compute advanced performance indicators, such as total delay impact (converted to hours from minutes), average delay per flight, weighted cancellation and diversion rates, and the percentage of delay contribution by root cause. Filter context management methodology was used to ensure accurate totals and KPI values in the case of slicers.

All measures of dashboards (DAX) are recorded in [Appendix B](#).

2.5 Dashboard Design and Analytical Framework

Three interactive dashboards were designed to address different analytical objectives:

- US Airline Performance Overview
- Delay Root Cause Analysis
- Airport Performance Analysis

All dashboards have an executive-based design, which integrates KPI cards, summary tables, and comparative visualizations to reflect trends, operational inefficiencies and performance variances. Slicers were also added to enable users to navigate dynamically through time, airlines and airports. Such analytical framework allows both the high level insight and operational analysis.

All dashboards are given in [Appendix C](#).

3. Results and Analysis

The section will contain the most significant findings based on the analysis of the Flight Arrival Performance dataset on the basis of the SQL data preparation and Power BI analytical visualization. The findings are arranged in three dashboards: US Airline Performance Overview, Delay Root Cause Analysis, and Airport Performance Analysis. All dashboards focus on the various operational perspective of the performance of U.S. airlines over the period of January 2010 to September 2025.

The entire dashboards are attached in [Appendix C](#), and some of the main key visuals are discussed in this section to outline the most important findings.

3.1 US Airline Performance Overview

US Airline Performance Overview dashboard gives a general overview of the flight operations in terms of airlines and time. It focus on core operational indicators as total flight handled, cancellation rate, diversion rate, and total delay impact. The full US Airline Performance Overview dashboard will be found in [Appendix C.1](#).

[Figure 1](#) displays the key performance indicators that give the general picture of the airline's performance throughout the system. The total number of flights made by all airlines during the analysis period was 102.84 million. The total cancellation rate is 1.89%, and the diversion rate is 23.97%, which means that the majority of scheduled flights were completed, but the percentage of those that encountered a diversion event was quite high. Although this relative stability in operations regarding cancellations is observed, the overall delay impact is estimated at 20.33 million hours, which points to flight delays as the greatest operational issue in the system.



Figure 1: Total Flights, Overall Cancellation Rate%, Overall Diversion Rate% and Total Delay Hours

To investigate further disruptions in carriers, [Figure 2](#) shows top 10 airlines with the highest number of cancelled flights. The top 10 airlines allow enhancing readability and mentioning the carriers that had the largest cancellation volumes throughout the analysis timeframe. The chart indicates that there is a perceptible difference amongst carriers, which implies that operations resilience, network structure, and disruption management strategies vary.

The findings show that JetBlue Airways has the greatest number of cancelled flights, followed by Spirit Airlines. This implies that these carriers had relatively more operational interruptions that can be affected by the route structure, fleet usage, weather exposure, or scheduling policies.



Figure 2: Total Cancelled Flights by Airline

In addition, [Figure 3](#) shows the annual pattern of flight disruptions in terms of cancellations, delays, and diversions. The line chart reflects a sharp decrease in all the three types of disruption in 2020, which is the lowest point in the analysis period. This is in line with the fact that air traffic volumes have been significantly reduced in the COVID-19 pandemic and this has had a massive effect on the airline operations. The disruption rates resume rising, in line with the flight activity recovery in the following years.

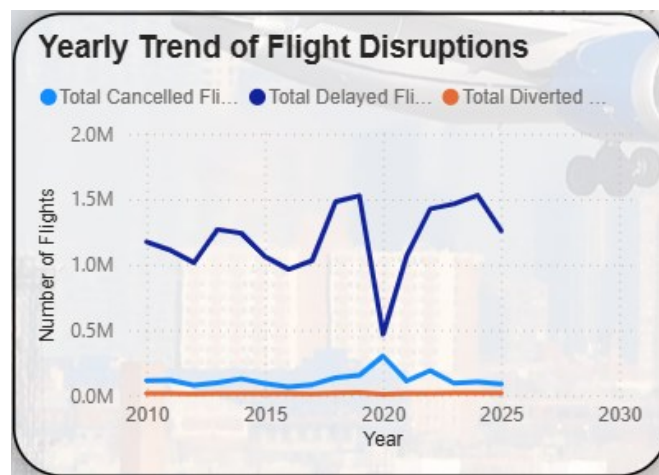


Figure 3: Yearly Trend of Flight Disruptions (Cancellations, Delays, and Diversions)

There are also interactive year and month slicers present in the dashboard, allowing the user to navigate seasonal trends and year-over-year trends. This interactivity facilitates executive-level monitoring and exploratory analysis where the stakeholders can determine when the operations are at a high level of stress.

3.2 Delay Root Cause Analysis Dashboard

The Delay Root Cause Analysis dashboard is aimed at determining the major causes of flight delays by segmenting the delay minutes into operational causes which include carrier delays, weather delays, National Aviation System (NAS) delays, security delays and late arriving aircraft delays. The entire dashboard is attached in [Appendix C.2](#).

[Figure 4](#) shows the distribution of total delay hours per month by cause of delay and graphical representation is done by ribbon chart between January and December. The chart brings out the variations in the relative contribution of each delay cause over the year. The findings reveal that late-arriving aircraft and NAS-related delays are always the largest contributors to the overall delay effect during the majority of the months, which implies the significant role of downstream scheduling dependencies and airspace or infrastructure constraints.

There is also a definite seasonal trend with July registering the highest total delay impact as measured by various delay categories. This peak is in line with the summer travel season where more passengers are on demand, higher flights and weather-related disruptions all increase the pressure of the aviation system.

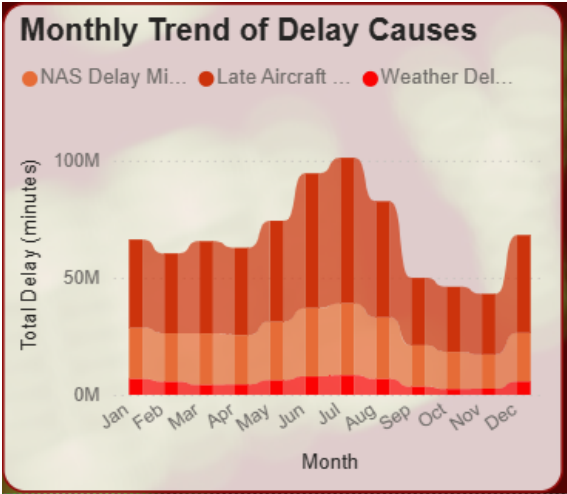


Figure 4: Monthly Trend of Delay Hours by Cause

Delays related to weather, which are not the leading ones on the aggregate scale, nevertheless depict certain significant growths in particular months, especially in the middle of the year, which can be attributed to the influence of the weather conditions. The Carrier related delays continue to be an annual source in the year round, and the airline operational efficiency has been highlighted to be a source of delay propagation. The security-related delays have the least share but are operationally active during the time of increased congestion.

In order to provide additional context to the trend-based analysis, [Figure 5](#) presents total delay hours by cause in absolute terms, which summarize the overall effect of each delay type on operations over the entire period of analysis. This visualization assists in ranking the areas of improvement to make by visually identifying the causes of delays that have the most significant total impact.

Cause	Delay Hours by Cause	Delay Contribution %
Carrier	6,719,330.92	33.05%
Late Aircraft	8,076,735.00	39.73%
NAS	4,430,707.42	21.79%
Security	32,586.13	0.16%
Weather	1,071,977.78	5.27%
Total	20,331,386.75	100.00%

Figure 5: Total Delay Hours by Delay Cause

Overall, this dashboard can provide the stakeholders with an insight into the seasonal dynamics as well as the cumulative effect of various causes of delays. The analysis results based on the combination of monthly trends and total delay contributions support specific data-driven solutions to mitigating delay propagation and enhancing schedule performance.

3.3 Airport Performance Analysis Dashboard

The Airport Performance Analysis dashboard measures the level of operational efficiency at the airport level, which identifies the contribution of individual airports to airport delays, cancellations, and diversions. The full dashboard will be found in [Appendix C.3](#).

There are 413 airports in the dataset. Figure 6 shows some of the major airport-level performance indicators such as the number of flights served, total delay affected, the rate of cancellations, and the rate of diversion. The rate of cancellations at the airport level (1.89%) is the same as the system-wide rate, but the level of diversion at the airport level is much higher (23.97%). It means that, on the overall system level, the presence of diversions is relatively low, but some airports have an excessively high rate of such flights, which is probably caused by local circumstances, including weather conditions, capacity shortages, or operational restrictions. These findings demonstrate the significance of the airport-specific analysis in the context of determining the operational reliability of the U.S. aviation network.



Figure 6: Airport Cancellation Rate% and Airport Diversion Rate%

[Figure 7](#) shows the top 10 airports in terms of average delay per flight (in minutes). Interestingly, several smaller or regional-level airports like Youngstown (OH), Wilmington (DE), Williston (ND), Worcester (MA), and Wilmington (NC) have a much greater average delay per flight than larger hub airports. Youngstown has the longest average delay, which is more than 60 minutes per flight, which means that there are local operational or infrastructure issues.



Figure 7: Top 10 Airports by Average Delay per Flight (Minutes)

As a complete comparison, [Figure 8](#) displays the Airport Performance Summary Table that summarizes the essential metrics, such as the number of flights, average delay per flight, the total delay in terms of hours, cancellation rate, and diversion rate. An airport name slicer enables users to dynamically filter the analysis holding overall KPIs constant so that high-level comparisons remain consistent.

Airport Name	Flights Handled	Average Delay per Flight (min)	Total Delay impact(Hours)	Airport Cancellation Rate %	Airport Diversion Rate %
Aberdeen, SD: Aberdeen Regional	9,991.00	8.94	1,488.13	1.58%	35.03%
Abilene, TX: Abilene Regional	30,493.00	10.08	5,123.32	2.59%	12.13%
Adak Island, AK: Adak	1,641.00	7.19	196.63	6.09%	42.66%
Aguadilla, PR: Rafael Hernandez	27,999.00	18.31	8,543.38	2.07%	19.29%
Akron, OH: Akron-Canton Regional	96,634.00	13.93	22,439.33	2.08%	17.59%
Alamosa, CO: San Luis Valley Regional/Bergman Field	991.00	15.88	262.22	3.73%	20.18%
Albany, GA: Southwest Georgia Regional	14,803.00	11.77	2,904.03	1.05%	29.05%
Albany, NY: Albany International	191,748.00	13.14	42,002.82	2.29%	17.63%
Albuquerque, NM: Albuquerque International Sunport	388,486.00	10.22	66,156.38	1.15%	14.90%
Alexandria, LA: Alexandria International	45,897.00	10.43	7,981.33	2.21%	33.99%
Total	102,839,938.00	11.86	20,331,386.75	1.89%	23.97%

Figure 8: Airport Performance Summary Table

4. Discussion

This paper is an in-depth investigation of U.S. performance in the arrival of flights during the year 2010 to September 2025 and combines massive operational information and interactive visual analytics. The findings indicate that, despite the relatively low rates of cancellations and diversion throughout the system, flight delays still carry a significant operational cost.

In the Executive Overview dashboard, it is indicated that over 102 million flights were processed within the study period. In general, the total cancellation rate is rather low (1.89%), but the diversion rate is much higher (23.97%), which means that a big percentage of the flights was operationally rerouted, but not cancelled. This implies that diversions are considered by airlines to

be the most important in accomplishing flights when disruption arises, which is an approach to network continuity. Despite these mitigation actions, the number of delay hours accrued to more than 20 million hours shows that schedule reliability and punctuality are the main operational challenges and not the completion of the flight.

The information presented in the Delay Root Cause Analysis dashboard indicates that the preponderant causes of total delay hours are due to late-arriving aircraft and carrier delay. This trend shows that there are significant delay propagation properties in the interrelated flight schedules where flight disruptions in the previous flight legs propagate to other operations. The seasonal peak in July noted also underscores the effect of the overall demand on travel, coupled with weather variability and airspace congestion, on the overall operational pressure in summer.

The analysis at the airport level shows that there is a significant difference between the performance. Although the volume of traffic handled by major hub airports is relatively constant and average delays remain relatively constant, some smaller or regional airports have much higher average delays per flight. The examples of Youngstown (OH) and Wilmington (DE) airports show that the localized airspace and infrastructure restrictions or inefficient schedules may result in the disproportionately high delay effects even with lower traffic flows. These results support the need of airport-specific operation plans, as opposed to system-wide interventions.

Altogether, the combination of SQL-based data preparation with Power BI dashboards allows evaluating the whole system and individual operations, allowing airlines, airports, and regulators to make informed decisions based on data.

5. Conclusion

This paper examined the U.S. flight arrivals performance based on the Bureau of Transportation Statistics (BTS) On-Time Performance data, which spans between the years January 2010 and September 2025. The analysis involved the interactive Power BI dashboards in combination with structured SQL data processing to investigate the issue of flight delays, cancellations, and diversions and their causes at airline and airport levels.

The findings show that although flight cancellations are quite rare, diversions and delays are major issues in the aviation system. The diversion rate (23.97) is rather high, indicating that airlines are often guided by the rerouting policy to resolve the disruption, and the size of cumulative delay hours remains high, indicating the continued inefficiency in schedule performance. Delays caused by late-arriving flights and carrier-associated delays are detected as the main sources of overall delay effect with obvious seasonal trends being observed during the busiest times.

The analysis at the airport level also shows that the performance in operations differs significantly among the locations. Smaller and regional airports, especially, can have high average delays, which may be disproportionate, which is why operational changes should be location-specific instead of being generalized.

The dashboards established in this research offer a scalable and easy to use framework of tracking the performance of airlines and airports over time. These observations can be used to facilitate operational planning, benchmarking performance and evidence-based policy development to address the issues of punctuality, delay propagation and passenger experience. In general, the paper shows that business intelligence and visual analytics solutions have the potential to turn intricate transportation data into operational insights that can be acted upon.

6. Limitations and Future Work

This research is limited in a number of ways despite its extensive nature. First, the analysis is based on aggregated arrival-level data, which does not allow one to investigate operational factors at flight-level, such as aircraft type, crew availability, or real-time decisions of air traffic control. Second, the causes of delays are grounded on the pre-determined categories of BTS that may not adequately reflect the complex interrelations among operational, environmental, and infrastructural factors.

Also, although the dataset covers a long period of time, there is a risk of external disturbances like the COVID-19 pandemic to break the structure of operational patterns in ways that are not directly modeled in this analysis. The research also looks solely at arrival performance, not considering departure delays and passenger-oriented results, e.g. missed connections or customer satisfaction.

This analysis may be expanded in the future to include flight-level data, weather data, and infrastructure indicators of the airport in order to elaborate on delay patterns observed. Gauging mechanisms such as predictive modeling and anomaly detection could also be employed to predict the delay risks and assist in the proactive operations decision-making.

6. Appendices

Appendix A: SQL Scripts for Data Preparation and Views

```
SQLQuery1.sql - DE...2N1H\DeII i3 (54))*  X
-- =====
-- STEP 1: Clean NULL values
-- =====
-- Keep arr_flights as NULL if unknown (do NOT set 0)
UPDATE Flight_Arrival_Performance
SET arr_del15 = 0 WHERE arr_del15 IS NULL;
UPDATE Flight_Arrival_Performance
SET arr_cancelled = 0 WHERE arr_cancelled IS NULL;
UPDATE Flight_Arrival_Performance
SET arr_diverted = 0 WHERE arr_diverted IS NULL;
UPDATE Flight_Arrival_Performance
SET arr_delay = 0 WHERE arr_delay IS NULL;
UPDATE Flight_Arrival_Performance
SET carrier_delay = 0 WHERE carrier_delay IS NULL;
UPDATE Flight_Arrival_Performance
SET weather_delay = 0 WHERE weather_delay IS NULL;
UPDATE Flight_Arrival_Performance
SET nas_delay = 0 WHERE nas_delay IS NULL;
UPDATE Flight_Arrival_Performance
SET security_delay = 0 WHERE security_delay IS NULL;
UPDATE Flight_Arrival_Performance
SET late_aircraft_delay = 0 WHERE late_aircraft_delay IS NULL;
UPDATE Flight_Arrival_Performance
SET carrier_ct = 0 WHERE carrier_ct IS NULL;
UPDATE Flight_Arrival_Performance
SET weather_ct = 0 WHERE weather_ct IS NULL;
UPDATE Flight_Arrival_Performance
SET nas_ct = 0 WHERE nas_ct IS NULL;
UPDATE Flight_Arrival_Performance
SET security_ct = 0 WHERE security_ct IS NULL;
UPDATE Flight_Arrival_Performance
SET late_aircraft_ct = 0 WHERE late_aircraft_ct IS NULL;
-- =====
-- STEP 2: Add calculated columns
-- =====
-- Delay %
ALTER TABLE Flight_Arrival_Performance
ADD delay_percentage FLOAT;
UPDATE Flight_Arrival_Performance
SET delay_percentage =
CASE
    WHEN arr_flights IS NULL OR arr_flights = 0 THEN NULL
    ELSE arr_del15 * 100.0 / arr_flights
END;
```

```
SQLQuery1.sql - DE...2N1H\DeII i3 (54))*  X
-- Cancellation Rate %
ALTER TABLE Flight_Arrival_Performance
ADD cancellation_rate FLOAT;
UPDATE Flight_Arrival_Performance
SET cancellation_rate =
CASE
    WHEN arr_flights IS NULL OR arr_flights = 0 THEN NULL
    ELSE arr_cancelled * 100.0 / arr_flights
END;
-- Diversion Rate %
ALTER TABLE Flight_Arrival_Performance
ADD diversion_rate FLOAT;
UPDATE Flight_Arrival_Performance
SET diversion_rate =
CASE
    WHEN arr_flights IS NULL OR arr_flights = 0 THEN NULL
    ELSE arr_diverted * 100.0 / arr_flights
END;
```

SQLQuery1.sql - DE...2N1H\DeII i3 (54))*

```
-- =====
-- STEP 3: Create Views for Aggregation
-- =====
-- Airline-level performance

CREATE OR ALTER VIEW vw_Airline_Performance AS
SELECT
    carrier,
    carrier_name,
    year,
    month,

    SUM(arr_flights) AS Total_Flights,
    SUM(arr_del15) AS Delayed_Flights,
    SUM(arr_cancelled) AS Total_Cancelled,
    SUM(arr_diverted) AS Total_Diverted,

    ROUND(SUM(arr_del15) * 100.0 / NULLIF(SUM(arr_flights), 0), 2) AS Delay_Percentage,
    ROUND(SUM(arr_cancelled) * 100.0 / NULLIF(SUM(arr_flights), 0), 2) AS Cancellation_Rate,
    ROUND(SUM(arr_diverted) * 100.0 / NULLIF(SUM(arr_flights), 0), 2) AS Diversion_Rate,

    SUM(arr_delay) AS Total_Delay_Minutes,
    SUM(carrier_delay) AS Carrier_Delay_Minutes,
    SUM(weather_delay) AS Weather_Delay_Minutes,
    SUM(nas_delay) AS NAS_Delay_Minutes,
    SUM(security_delay) AS Security_Delay_Minutes,
    SUM(late_aircraft_delay) AS Late_Aircraft_Delay_Minutes

FROM Flight_Arrival_Performance
GROUP BY carrier, carrier_name, year, month;
```

SQLQuery1.sql - DE...2N1H\DeII i3 (54))*

```
-- Airport-level performance

CREATE OR ALTER VIEW vw_Airport_Performance AS
SELECT
    airport,
    airport_name,
    year,
    month,

    -- Volumes
    SUM(arr_flights) AS Total_Flights,
    SUM(arr_del15) AS Delayed_Flights,
    SUM(arr_cancelled) AS Total_Cancelled,
    SUM(arr_diverted) AS Total_Diverted,

    -- Percentages
    ROUND(SUM(arr_del15) * 100.0 / NULLIF(SUM(arr_flights), 0), 2) AS Delay_Percentage,
    ROUND(SUM(arr_cancelled) * 100.0 / NULLIF(SUM(arr_flights), 0), 2) AS Cancellation_Rate,
    ROUND(SUM(arr_diverted) * 100.0 / NULLIF(SUM(arr_flights), 0), 2) AS Diversion_Rate,

    -- Delay minutes
    SUM(arr_delay) AS Total_Delay_Minutes

FROM Flight_Arrival_Performance
GROUP BY airport, airport_name, year, month;

-- =====
-- STEP 4: Select top 20 for verification
-- =====
SELECT TOP 20 * FROM vw_Airline_Performance;
SELECT TOP 20 * FROM vw_Airport_Performance;
```

Appendix B: DAX Measures for Power BI

Appendix B.1: Overall Cancellation Rate%

```
1 Overall Cancellation Rate % =  
2 DIVIDE(  
3     SUM(vw_Airline_Performance[Total_Cancelled]),  
4     SUM(vw_Airline_Performance[Total_Flights])  
5 )
```

Appendix B.2: Overall Diversion Rate%

```
1 Overall Diversion Rate % =  
2 DIVIDE(  
3     SUM(vw_Airline_Performance[Total_Diverted]),  
4     SUM(vw_Airline_Performance[Total_Flights])  
5 ) * 100
```

Appendix B.3: Overall Airline Delay%

```
1 Overall Airline Delay % =  
2 DIVIDE(  
3     SUM(vw_Airline_Performance[Delayed_Flights]),  
4     SUM(vw_Airline_Performance[Total_Flights])  
5 )
```

Appendix B.4: Average Delay per Flight (min)

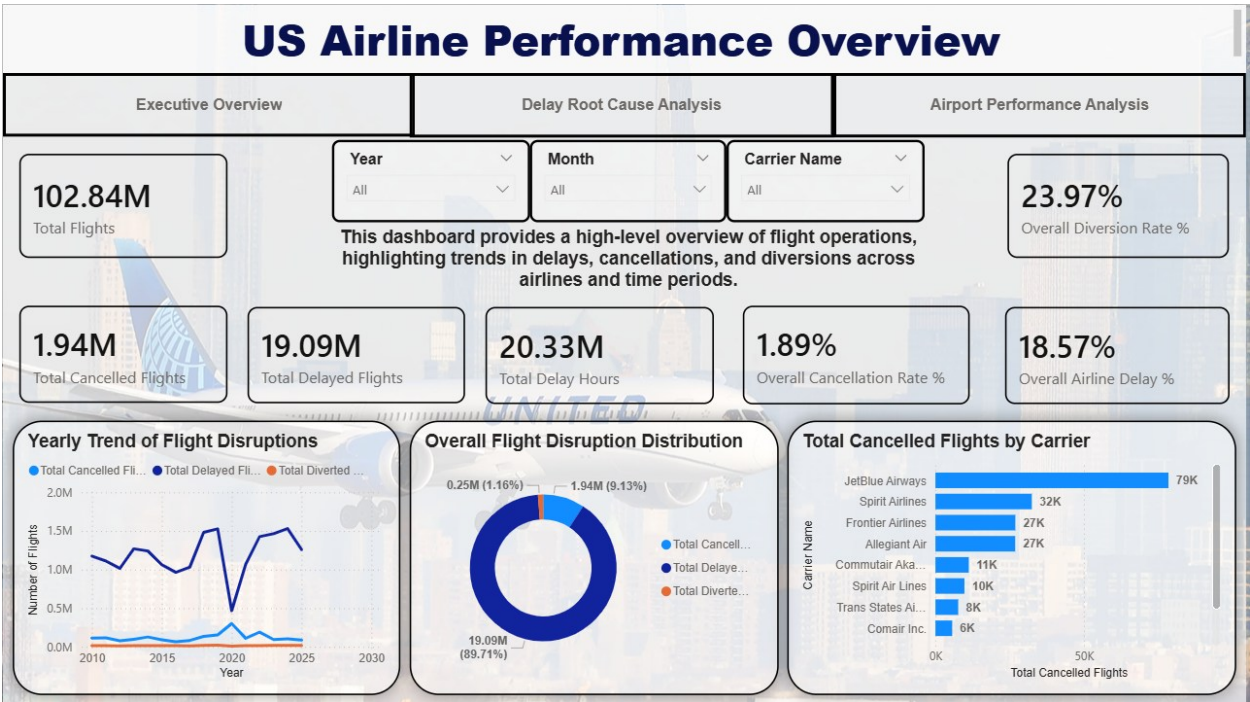
```
1 Avg Delay per Flight (min) =  
2 DIVIDE(  
3     SUM(vw_Airline_Performance[Total_Delay_Minutes]),  
4     SUM(vw_Airline_Performance[Total_Flights])  
5 )
```

Appendix B.5: Total Delay Impact (Hours)

```
1 Total Delay impact(Hours) =  
2 DIVIDE(  
3     SUM(vw_Airport_Performance[Total_Delay_Minutes]),  
4     60  
5 )
```


Appendix C: Dashboards and Visuals

C.1 US Airline Performance Overview



C.3 Airport Performance Analysis

