Introduction (max 300 words)

Global interconnectivity largely depends on the airline industry, which fosters millions of journeys each day across every corner of the Earth. As businesses and telecommuting have burgeoned in the internet era, they too have benefited from direct airline services, which have proved to be a mainstay of our borderless world. Although technology and operational efficiency have improved, however, customers still confront what seem to be ever-occurrent airline delays. These delays can stem from any number of conditions: poor weather, maintenance problems, air traffic controller and pilot coordination, and good old-fashioned inefficiency.

The aim of this report is to analyse the patterns, causes, and impact of flight delays and to investigate the ways in which these delays affect the satisfaction of the passengers. It studies the delays in combination with the people's response to the delays to get a more nuanced and completed picture of what the delays really mean to the passengers.

The analysis is motived by a growing emphasis on the need to improve the passenger experience. Some studies and reports suggest that enhanced passenger experience is the primary path to improved customer loyalty and, in turn, better profitability. Among the many facets of passenger experience that might be improved, one demands the attention of an analyst: the passenger experience related to on-time performance is a key determinant of overall customer satisfaction.

The findings presented in this report aim to provide actionable recommendations for reducing delays, improving passenger satisfaction, and enhancing operational efficiency. Poor on-time performance can be caused by numerous factors, some of which are beyond the airlines' control (e.g., weather), and it can also arise from poor performance by the airline itself, by the staff at the airport, or any number of other things, some of which are related to the factors that determine the passenger satisfaction.

(300 words)

Analytical questions and data (max 300 words)

The research intends to answer a set of analytical questions:

1. What causes flight delays, and how are they classified?
   Various factors can lead to a flight delay, including inclement weather, air traffic control troubles, and aircraft maintenance. Two delay categories used: short delays (≤15) and medium delays (15-60 min).
2. How is passenger satisfaction affected by age group, travel class, and distance?
   We might expect satisfaction to vary alongside these demographic and travel-related variables. Not all of us have the same budget for travel, and some of us are much more preconscious than others. We must see exactly what comes with your class of travel in terms of service and comfort and how much of a difference that makes in your overall experience.
3. What is the effect of delay on passenger satisfaction? Does an extended length of time mean that lower satisfaction is certain?

When it comes to passenger experience, delays of any duration have the potential to create dissatisfaction. But with delays being a time-dependent phenomenon, one might reasonably conjecture that longer delays lead to a greater level of dissatisfaction.

4. Can satisfaction and delay be influenced by external factors like the time of day, a passenger's gender, or the nature of a flight route? For example, we know that flight booked during peak times have a good chance of not being on time, simply because of the airport congestion. So, satisfaction might vary by gender or specific flight routes with frequent disruptions.

This project examines what makes flight late and how that affects the people. I used two datasets:

1. Flight Delays: This dataset includes a comprehensive list of what goes into making a flight either on time or late.
2. Passenger Satisfaction: It captures a moment in time when airline passengers were asked how satisfied they were with their flight experience.

(300 words)

Analysis (max 1000 words)

Data Preparation

The process of preparing the data began with a structured approach to ensuring the datasets were clean, consistent, and of good enough quality to work with. Missing values in the DelayReason column were kept under the “Unknown” category, ensuring we maintained data completeness while also allowing us to identify the entries that were incomplete. I decided to keep the classifications simple. Delays were categorized into Short (≤15 minutes) and Medium (> 15-60 minutes), an effective classification that helped distinguish between minor disruptions from operationally significant delays.

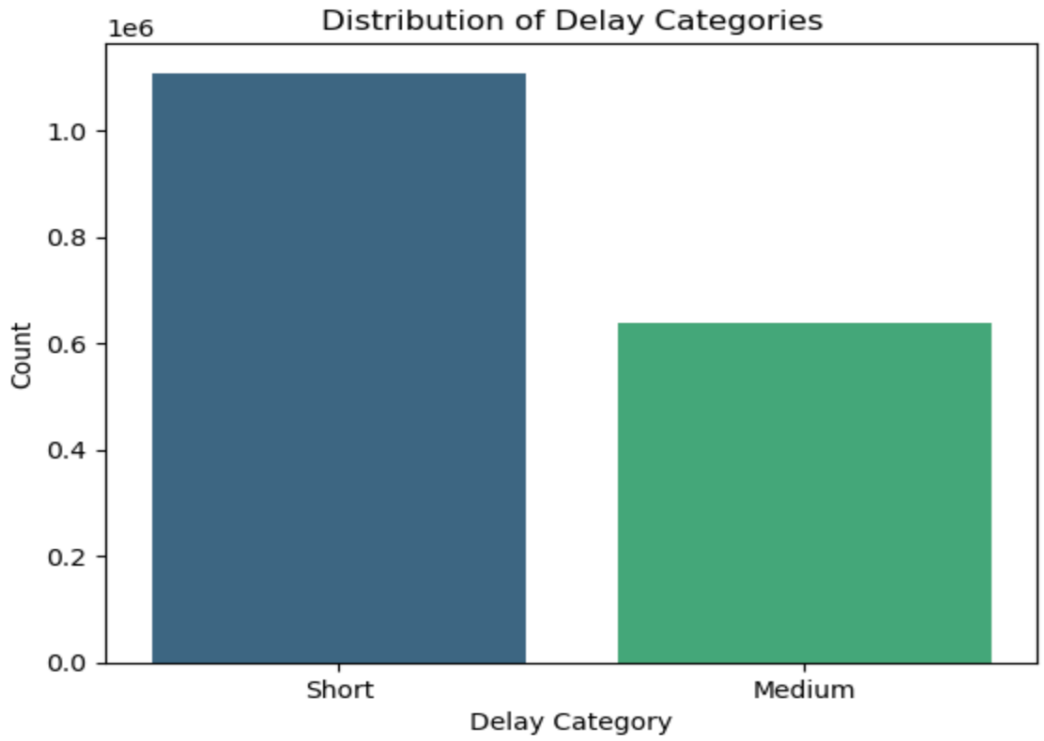


Figure 1

The passenger satisfaction data were simplified into two clear levels: High (satisfied) and Low (neutral or dissatisfied). This was done to create an unfettered comparison across demographics and travel-related variables. Passengers were further segmented into groups based on age: Child (0-17 years), Young Adult (18-35 years), Adult (18-35 years), and Senior (>60

years), which helps to see patterns and trends in satisfaction across different segments of the population.

Data Analysis

```
DelayCategory
Short     1108310
Medium     639317
Name: count, dtype: int64
```

```
DelayReason
Unknown                 468873
Air Traffic Control     426488
Maintenance             426168
Weather                 426098
Name: count, dtype: int64
```

The delays were mostly short, with 1108310 instances of short delays compared to 639,317 medium delays. Most of our known delay causes fit into three categories: weather, maintenance, and air traffic control, a significant number of delays, 468873 instances, are listed as “Unknown”.

Medium length interruptions were most affected by maintenance. This is probably since maintenance events take a certain minimum amount of time, and the technical resolution needed for some of these events makes them last longer. Air traffic control delays was something that affected short and medium-length interruptions equally, suggesting that the operational congestion causing the delays was concentrated during peak times.

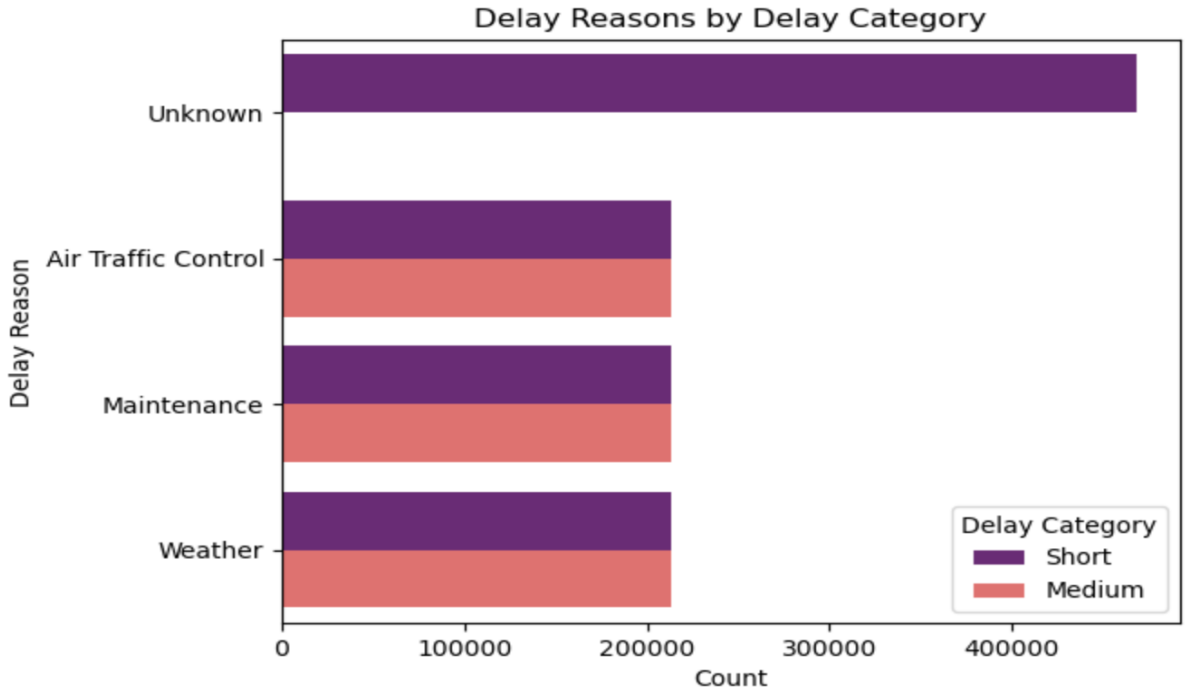


Figure 2

```
Average Delay by Airline:
 Airline
American Airlines     9.986951
Delta                 9.998505
United               10.002781
Southwest            10.008476
Name: DelayMinutes, dtype: float64

Satisfaction by Airline:
 SatisfactionCategory      High       Low
Class
Business               0.694434  0.305566
Economy                0.187673  0.812327
Economy Plus           0.246414  0.753586
```

When I looked at average delays across different airlines, I find very little variation. Most of the major carriers are either way above or way below on-time performance, but they're consistent with each other in terms of being late or being on time. For this part, picking a couple of these airlines as representative figures will do. Southwest, for example, has an average delay of about 10 minutes, closely followed by United, Delta, and America Airlines.

The data reveals a wide gap in satisfaction between travel classes. Economy class passengers are the most dissatisfied of all. Only 18.2% fall under the "High" satisfaction category and the rest, 81.8%, are in "Low" satisfaction category. Business class, on the other hand, fails to reach 18.2% satisfaction mark and there is a 10% satisfaction gap over the pass-rate for premium classes.

The results of this study highlight the fact that even when they are operationally delayed, airline passengers don't necessarily experience that delay in the same way. It's a divergence that, on the surface, may appear to be an outcome of the airlines in question simply not delivering on some key performance indicators. But looking a little deeper, and a consistent narrative starts to emerge that focuses on how the airlines communicate with passengers before, during, and after an unsatisfactory event; the nature of the recovery options; and the degree to which the airlines have enhanced their delayed-passenger experience, even if just slightly. When examining time of day, higher counts of delays were observed in the morning and night periods.

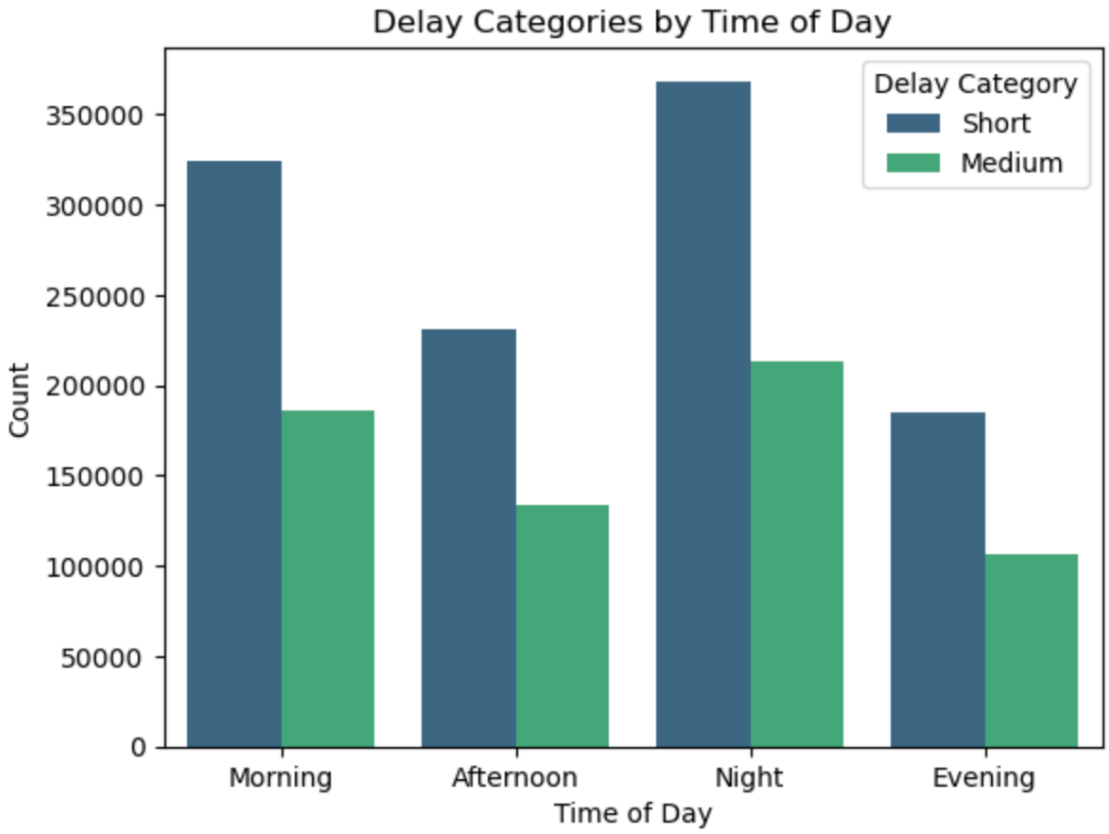


Figure 3

Morning delays were likely a result of cumulative late-night disruptions affecting early departures, while night delays reflected congestion in the final operational windows of the day. This trend suggests that schedule optimization during these hours could significantly mitigate delays.

Passenger Satisfaction Analysis

```
SatisfactionCategory
Low     73452
High    56428
Name: count, dtype: int64
```

An analysis of satisfaction levels highlighted a clear disparity, with low satisfaction (73452 passengers) significantly outweighing high satisfaction (56428 passengers).

Economy Class passengers express the most disappointment, 81.2% of all dissatisfaction responses, while Business Class passengers in the

opposite 69.4% of them are very satisfied, a figure that comes close to the almost 30% of economy passengers who are very satisfied. This pattern suggests a gap in service quality.

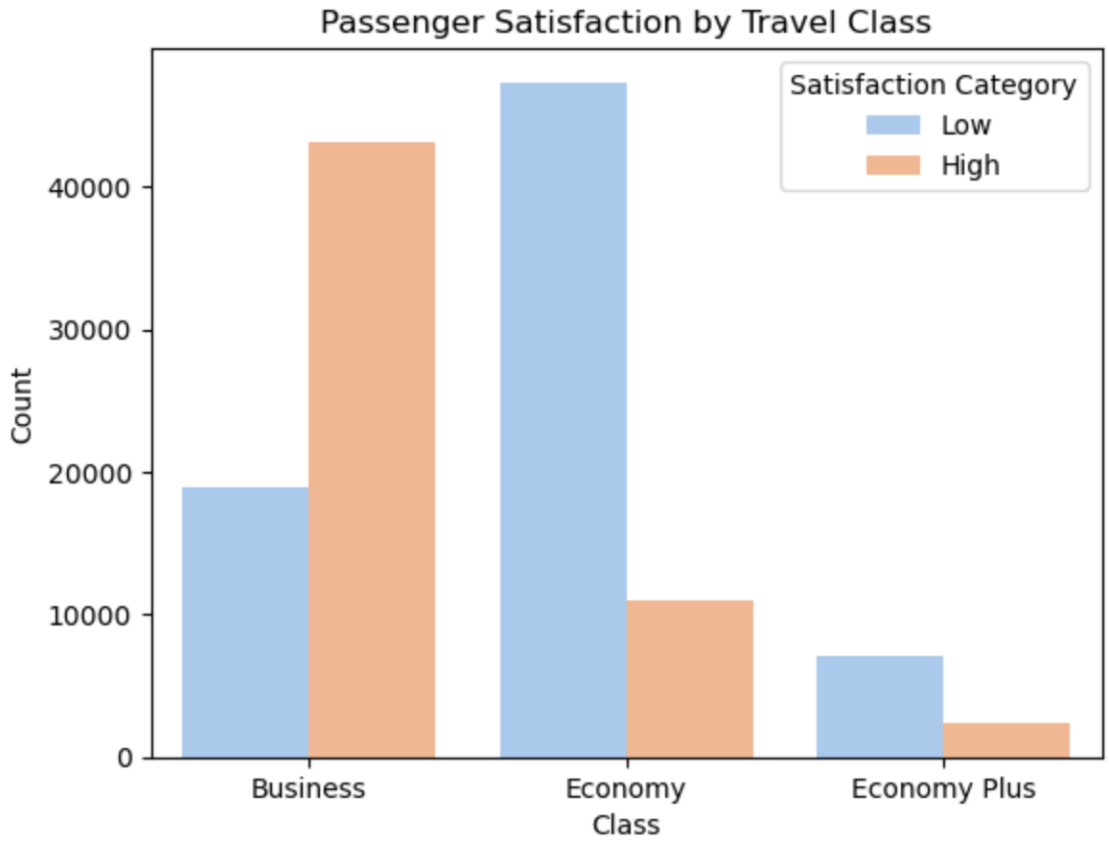


Figure 4

A closer look at the demographic trends reveals that the group with the highest levels of dissatisfaction are the two adult categories: Adults (36-60 years) and Young Adults (18-35 years). These two groups account for 68081 adults and 41898 young adults reporting “Low” satisfaction.

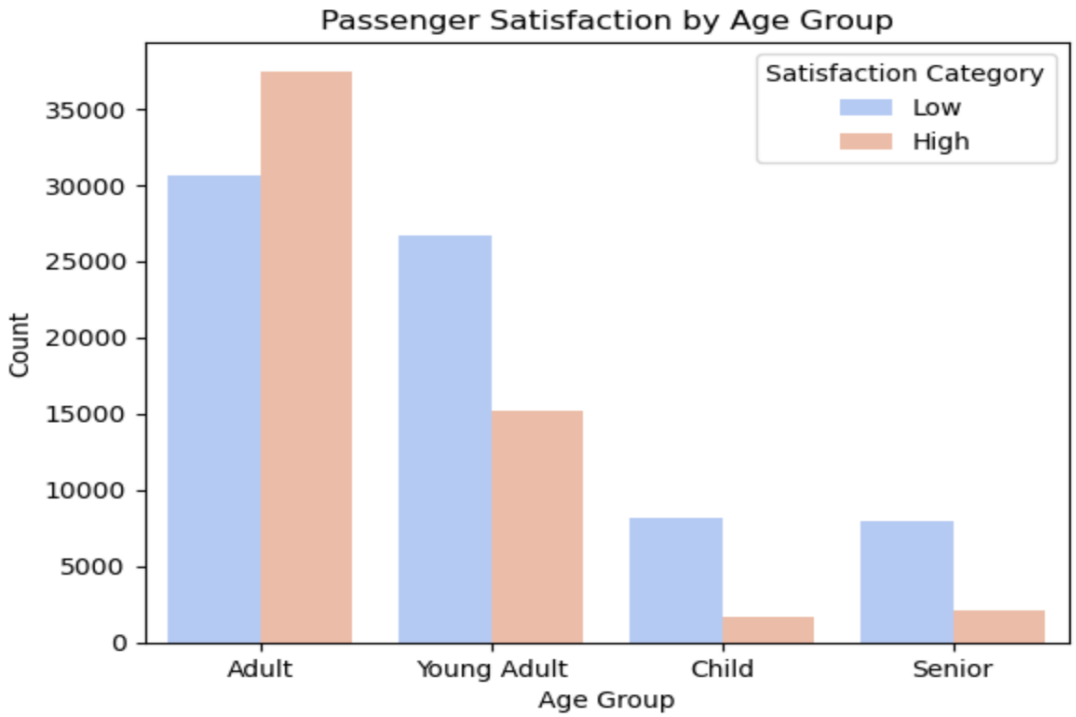


Figure 5

```
SatisfactionCategory
Low     73452
High    56428
Name: count, dtype: int64
AgeGroup
Adult          68081
Young Adult    41898
Senior         10054
Child           9847
Name: count, dtype: int64
```

On the other hand, dissatisfaction expressed by Senior (10054) and Children (9847) were much lower. This could be because these groups are less exposed to travel delays and have travel priorities. It could be because these group have fewer travel experiences that could result in dissatisfaction.

The Impact of delay on Satisfaction

Delay duration and satisfaction level are related in a way that provides very key insights into not just what the passengers think of the system, but also how they may behave given certain conditions. This boxplot shows that as the delay increases, the satisfaction level moves downward dramatically.

Passengers who express dissatisfaction have a median delay time that is considerably higher than what those expressing satisfaction have.

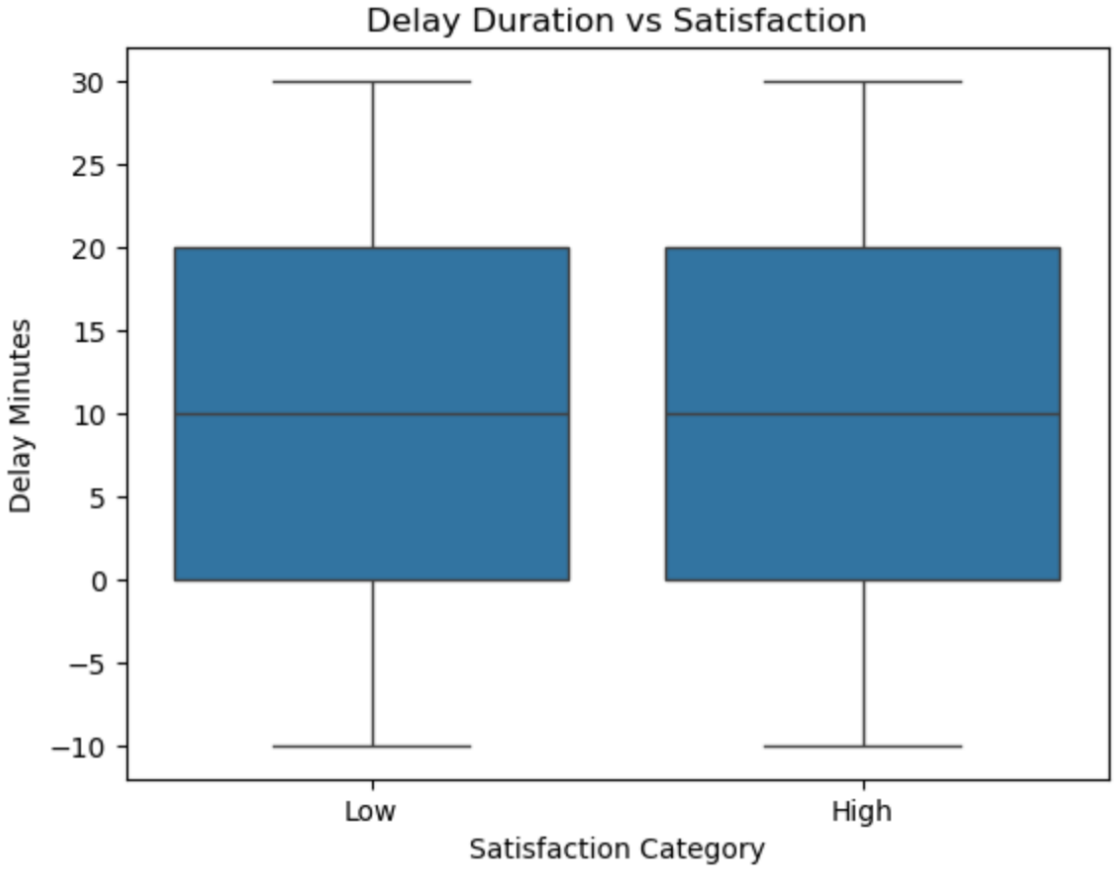


Figure 6

These findings emphasize the importance of minimizing flight delays, particularly for travellers with tight schedules or heightened expectations.

When analysing flight distances, a clear inverse relationship between distance and dissatisfaction emerged. Short-haul flights, defined as those covering less than 500 miles, recorded the lowest satisfaction levels.

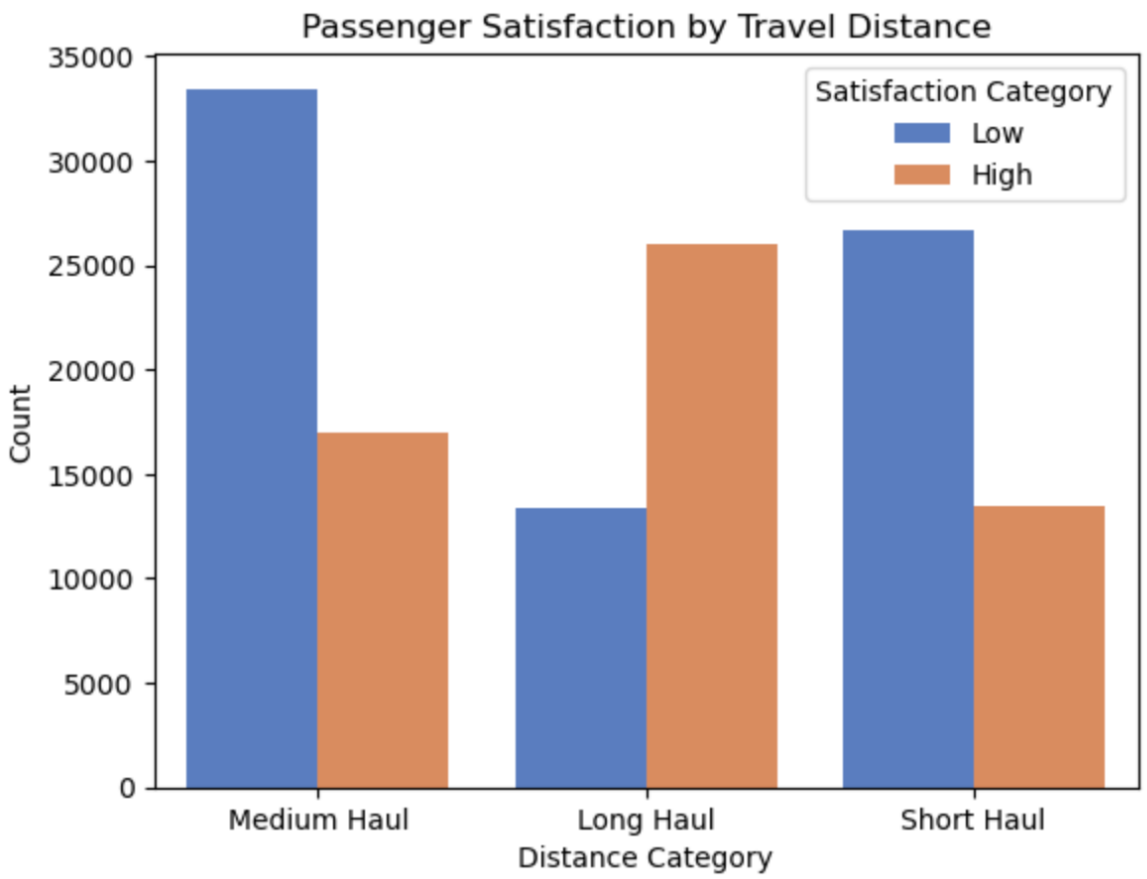


Figure 7

Often, there are no premium services or amenities along with these routes, leaving us with few recovery options when delay happens. In contrast, long flights (over 1500 miles) had much higher levels of satisfied passengers, and the likely reason stems from the customer experience that the airlines have a greater capacity to deliver on long journeys.

Route and Aircraft Insights

I examined flight paths and aircraft types to find out what was behind the delays. Some of the most travelled routes, like those from JFK to MIA and LAX to BOS, had the highest average delay duration, which were almost 15 minutes.

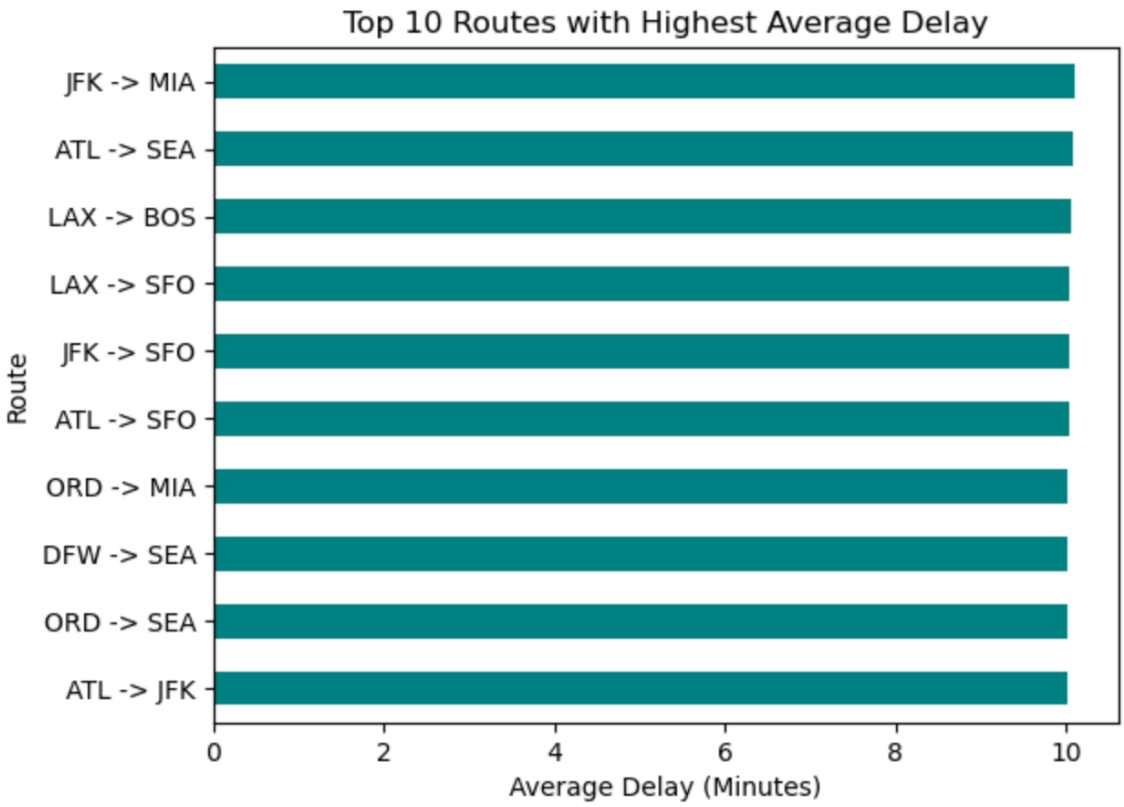
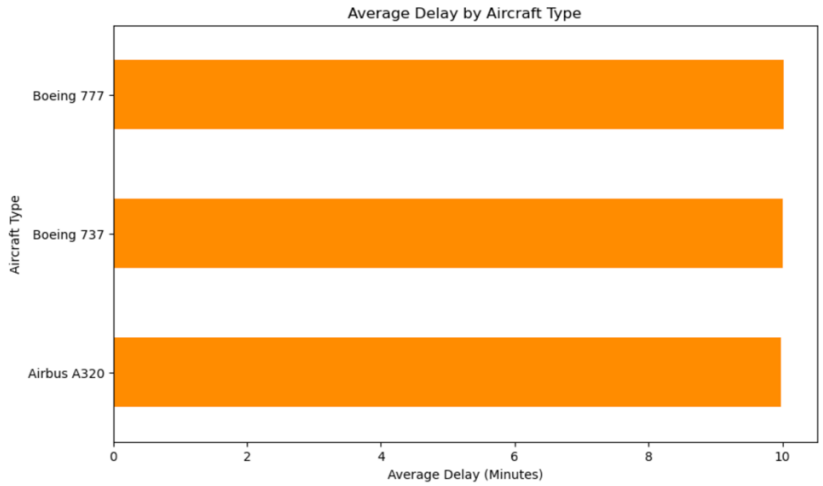


Figure 8



These discovering point to critical areas in which intervene, where specific actions can be taken to decrease the likelihood of disruptions.

Figure 9

Similarly, analysis of aircraft types showed that delays were consistent across models. The Boeing 777, Airbus A320, and Boeing 737 all experience average delays that are comparable to the other aircraft.

This reliability suggests that outside factors, like scheduling difficulties or overextended operations are responsible for slowdowns, not the aircraft themselves.

(979 words)

Findings, reflection and further work (max 600 words)

The analysis of the delays showed that the main factors were weather, maintenance, and air traffic control. As illustrated in ***Figure 10***, weather was the predominant short and medium delay cause. Maintenance was the primary long delay cause. Air traffic control was the predominant medium delay cause. Also, there appears “Unknown” causes of delay reasons.

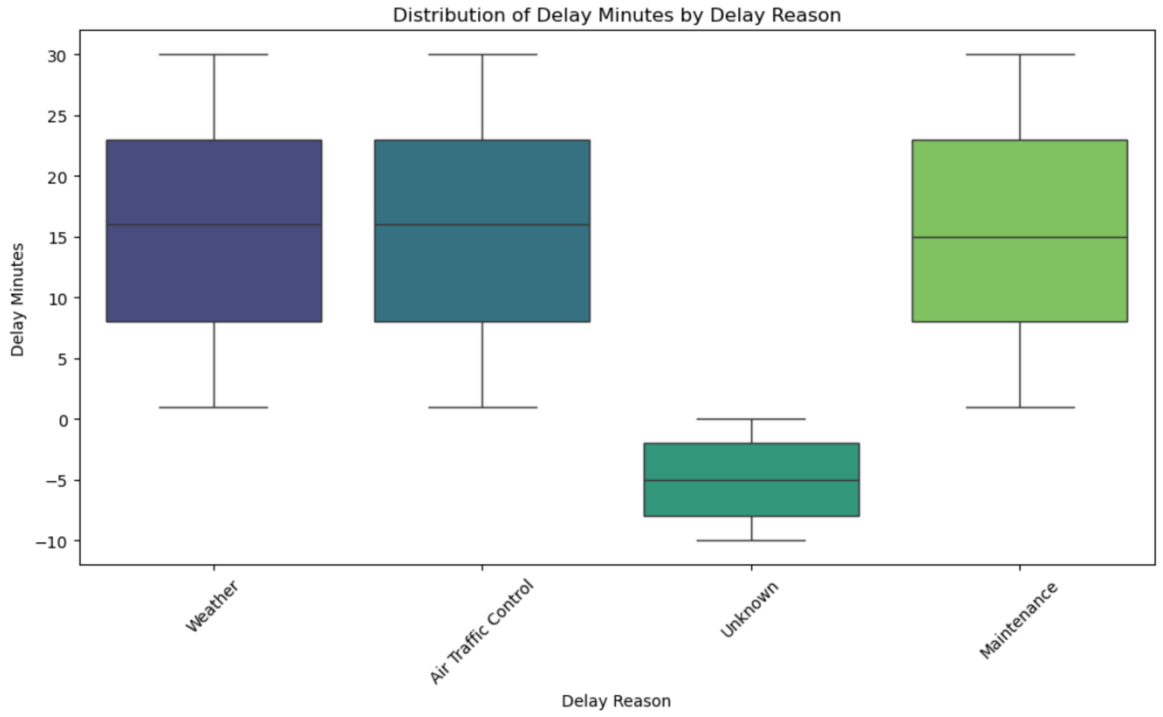


Figure 10

Passenger satisfaction exhibited significant variability across travel classes. As visualized in ***Figure 11***, Economy Class passengers reported the lowest satisfaction, accounting for 81.2% of dissatisfaction responses. In contrast, Business Class passengers showed higher satisfaction due to premium services and reduced delays.

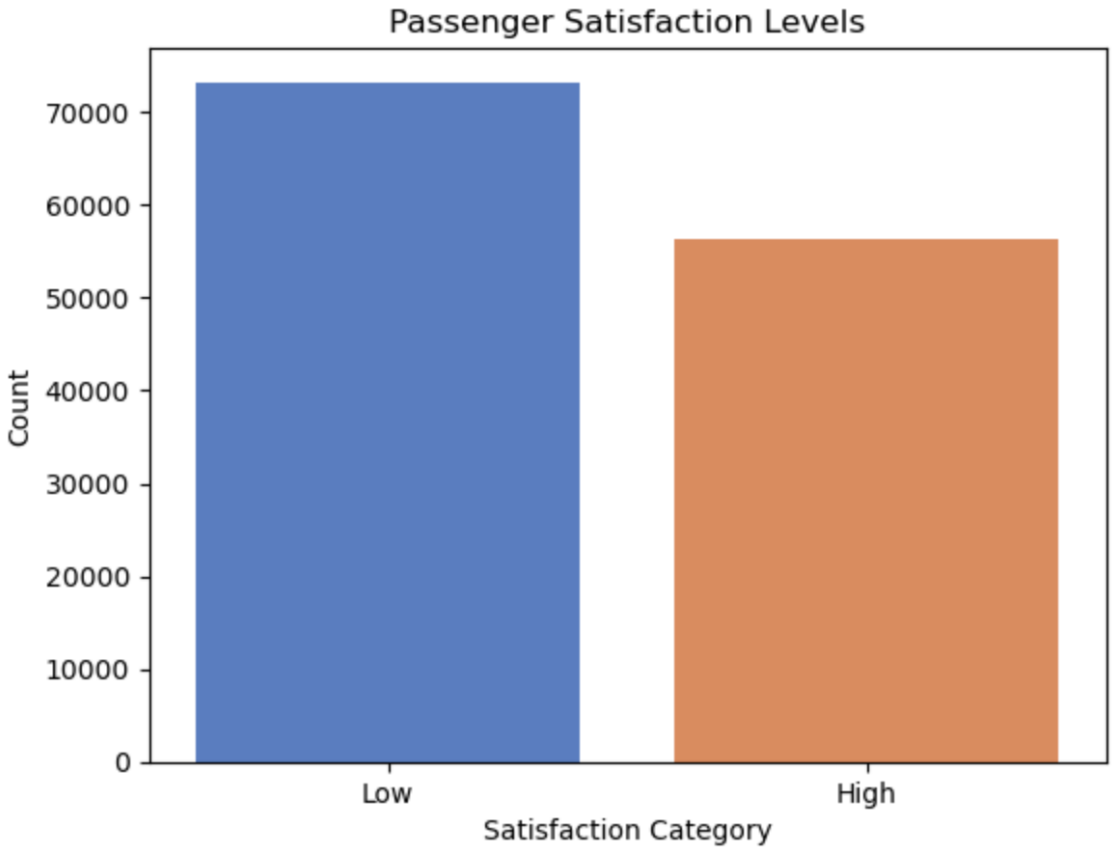


Figure 11

An even closer examination of the onboard conveniences, specifically in-flight entertainment, showed that it has a favourable impact on satisfaction. ***Figure 12*** illustrates that those rated in-flight entertainment higher were markedly more likely to be very satisfied with their overall experience.

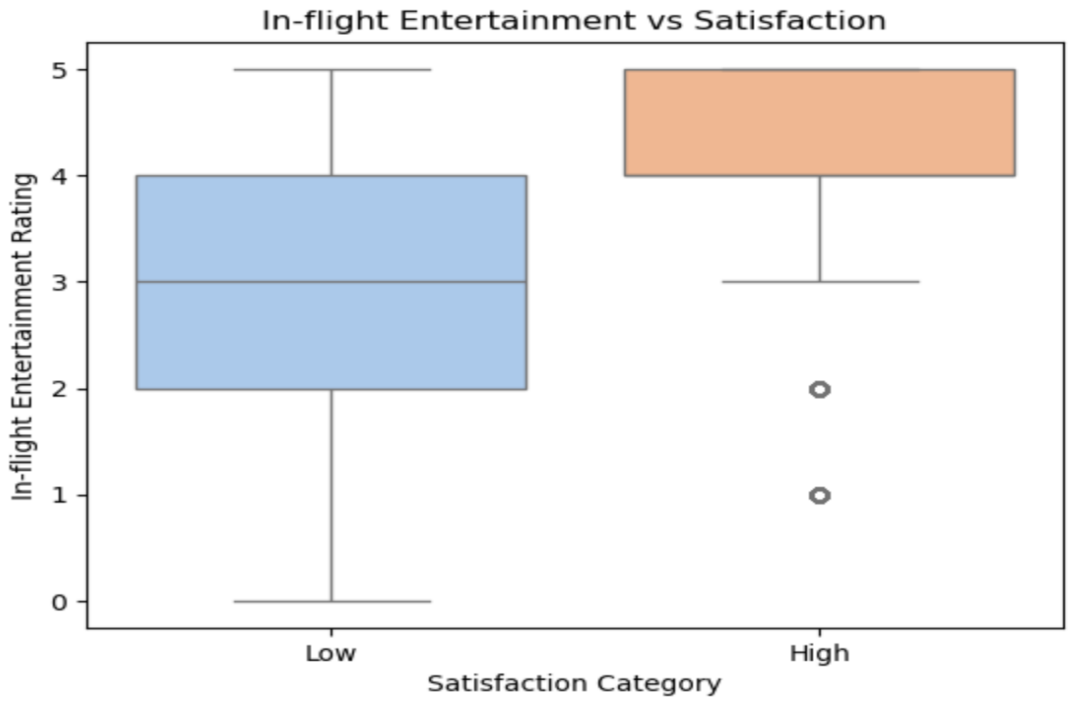


Figure 12

The satisfaction of passengers clearly revealed disparities across different classes of travel and demographic groups. Economy Class passenger consistently reported lower satisfaction, with 81.2% of dissatisfaction responses steaming from this segment. On the other hand, Business Class passengers reported higher satisfaction rates, largely driven by premium services. This pattern is reinforced visually in the figure provide below, which highlights low satisfaction levels in Economy Class for both male and female passengers.

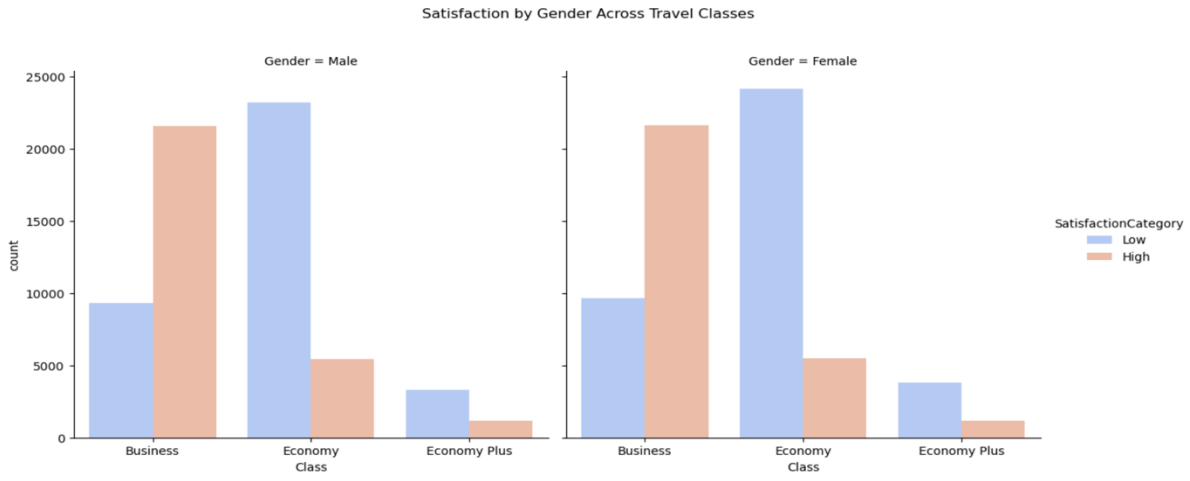


Figure 13

Analysing the delay trends by month provided even more significant insights. As shown in ***Figure 14***, the short delays occurred more often than the medium delays. This indicates that the attention paid to the medium-duration delays today will help avoid serious impacts on the overall customer satisfaction of tomorrow.

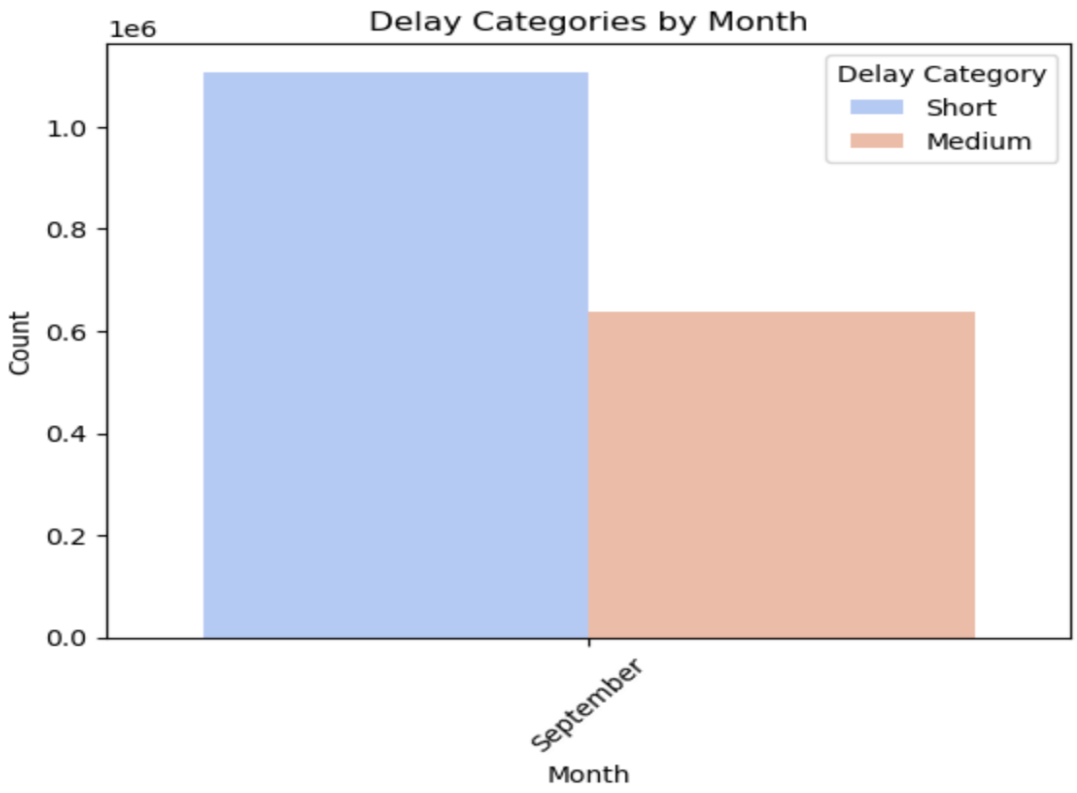


Figure 14

Reflection

Passenger satisfaction and effective operational efficiency are closely related, as our independent analysis reveals. The biggest challenge remains weather-related delays, which requires robust contingency measures, such as improving forecasting systems and allocating resources to weather-prone routes. The satisfaction levels between different classes of travel show the urgent need for better recovery efforts for Standard Class. Premium services in Business Class certainly do reduce dissatisfaction.

In ***Figure 12***, we see that satisfaction levels were highest for those who experienced better in-flight entertainment.

The delays that are often experienced during the early morning and the evening are really a reflection of the systemic congestion problems we're dealing with. That could be improved by looking at opportunities to optimize flight schedule, reduce peak-time, and work on some of the critical flight routes that affect us.

Further Work

The analysis yielded insights that could be acted upon, but several areas could use further exploration. One of those areas is predictive analytics. Predictive analytics could be done to say how many delays there would be in a certain day or week based on real-time data like weather, route congestion, or operational data for that day or weak. Airlines could use that to be much more proactive in terms of disruption management, not just for passenger safety but also for passenger service excellence.

The observed demographic trends suggest the need for targeted interventions. Offering personalized services, such as expedited boarding, improved Wi-Fi, or compensation packages for working-age travellers, could address dissatisfaction among adults and young adults. We should concentrate in the short-haul routes where most of the passenger dissatisfaction occurs and understand now why that is.

I think it would be very helpful to have a detailed seasonal analysis of satisfaction and delay trends that looks not just at the month-to-month variation shown in ***Figure 15*** but also at the longer-term seasonal trends for this part of the airline industry for delayed and non-delayed routes. Moreover, a passenger satisfaction analysis on the short-haul route delayer dataset could serve to highlight the more problematical routes that might need to be restructured.

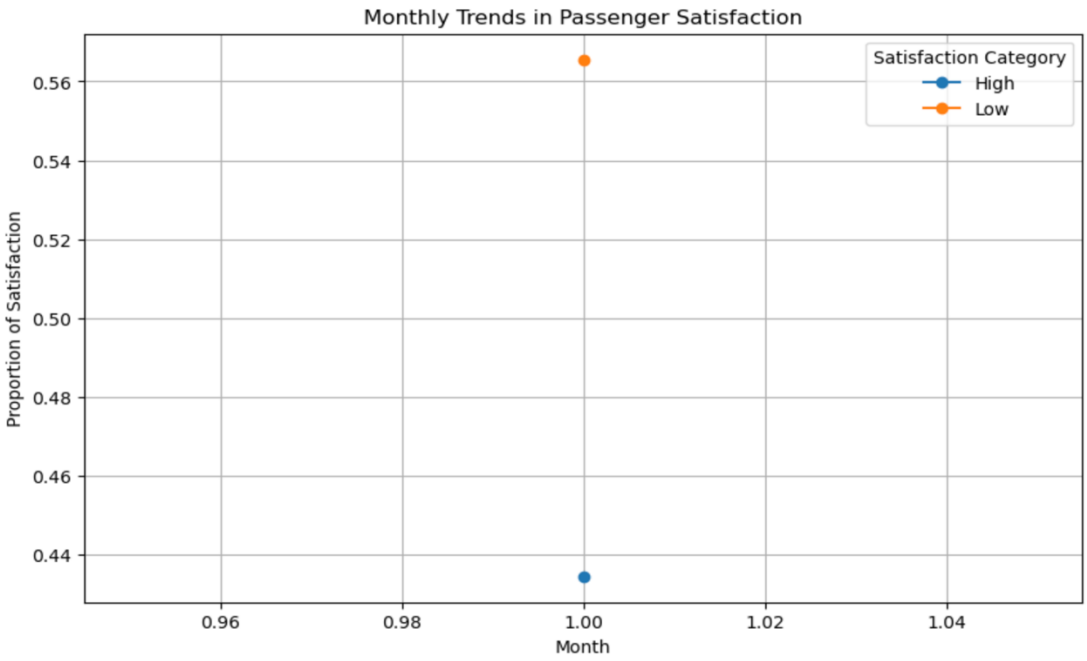


Figure 15

(599 words)

References

Kaggle Datasets:

- Samanta, N. (2024). *Airline Passenger Satisfaction Dataset*. Kaggle. Available at: https://www.kaggle.com/datasets/nilanjansamanta1210/airline-passenger-satisfaction (Accessed: [1 November]).
- U.S. Department of Transportation (2024). *Flight Delay Dataset (2019–2023)*. Kaggle. Available at: https://www.kaggle.com/datasets/umeradnaan/flight-delays-dataset?select=flight_delays.csv (Accessed: [1 November]).

Other Sources:

- Bureau of Transportation Statistics (2023). *Airline On-Time Performance*. Available at: https://www.bts.gov/explore-topics-and-geography/topics/airline-time-performance-and-causes-flight-delays(Accessed: [27 November]).
- Bowen, B., & Headley, D. E. (2019). *The Airline Quality Rating Report*. Aeronautical University. Available at: https://commons.erau.edu/aqrr (Accessed: [2 December]).

Word counts

- Introduction: 300 words (max 300)
- Analytical questions and data: 300 words (max 300)
- Analysis: 979 words (max 1000)
- Findings, Reflection, and Further Work: 599 words (max 600)