SkyHack 3.0: United Airlines

Team Incognito

Submission made by:

Shreshtha Jha
Sakshi Gupta

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Objective:

Frontline teams currently depend on intuition to identify complex flights — an approach that’s inconsistent and non-scalable.
We aim to build a data-driven framework that objectively measures flight difficulty to support proactive planning and on-time performance.

Goal:

To develop a Flight Difficulty Score (FDS) that:

- Quantifies relative flight complexity using operational and customer-level data.
- Provides a daily ranking of flights (Easy, Medium, Difficult).
- Helps teams anticipate challenges and plan resources proactively.

EDA (Exploratory Data Analysis)

We conducted a comprehensive Exploratory Data Analysis (EDA) to uncover operational patterns influencing flight difficulty. This analysis examines key aspects such as departure delays, ground time versus minimum turn requirements, baggage mix, passenger load variations, and special service requests. By analyzing these factors, we identified which flight characteristics contribute most to operational complexity, forming a data-driven foundation for our Flight Difficulty Score.

Datasets used

- Airports Data.csv
- Bag Level Data.csv
- Flight Level Data.csv
- PNR Flight Level Data.csv
- PNR Remark Level Data.csv

EDA (Exploratory Data Analysis)

Our Exploratory Data Analysis (EDA) went beyond the standard questions to uncover the hidden operational realities. These five core findings were critical in designing a difficulty score that is both accurate and robust.

1. The "**Wheelchair Dominance**": A staggering 97% of all Special Service Requests (SSRs) are for wheelchair assistance. "Passenger needs" are not a broad category but a highly specific one. This tells us that the total_ssr_count is a direct and powerful proxy for the passenger-handling workload on the ground.

2. The "**Ground Time Squeeze**": 75% of all flights are scheduled with a minimum turn time of under an hour, and our analysis shows actual turn times are often longer than scheduled. The ground_time_buffer_minutes is therefore the most critical leading indicator of a flight's vulnerability to cascading delays.

EDA (Exploratory Data Analysis)

3. The "**Hidden Baggage Challenge**": Transfer Bags are the most common baggage type, not standard checked bags. This finding proved that total_transfer_bags is a much stronger predictor of ground handling difficulty than the total number of bags.

4. The "**Passenger Flow vs. Flight Frequency**": DEN is the #1 destination by passenger bookings, but LGA is the #1 destination by flight frequency. This reveals that different routes have unique difficulty profiles. A route like DEN may have fewer flights but on consistently larger, fuller aircraft, making its flights inherently more complex than frequency alone would suggest.

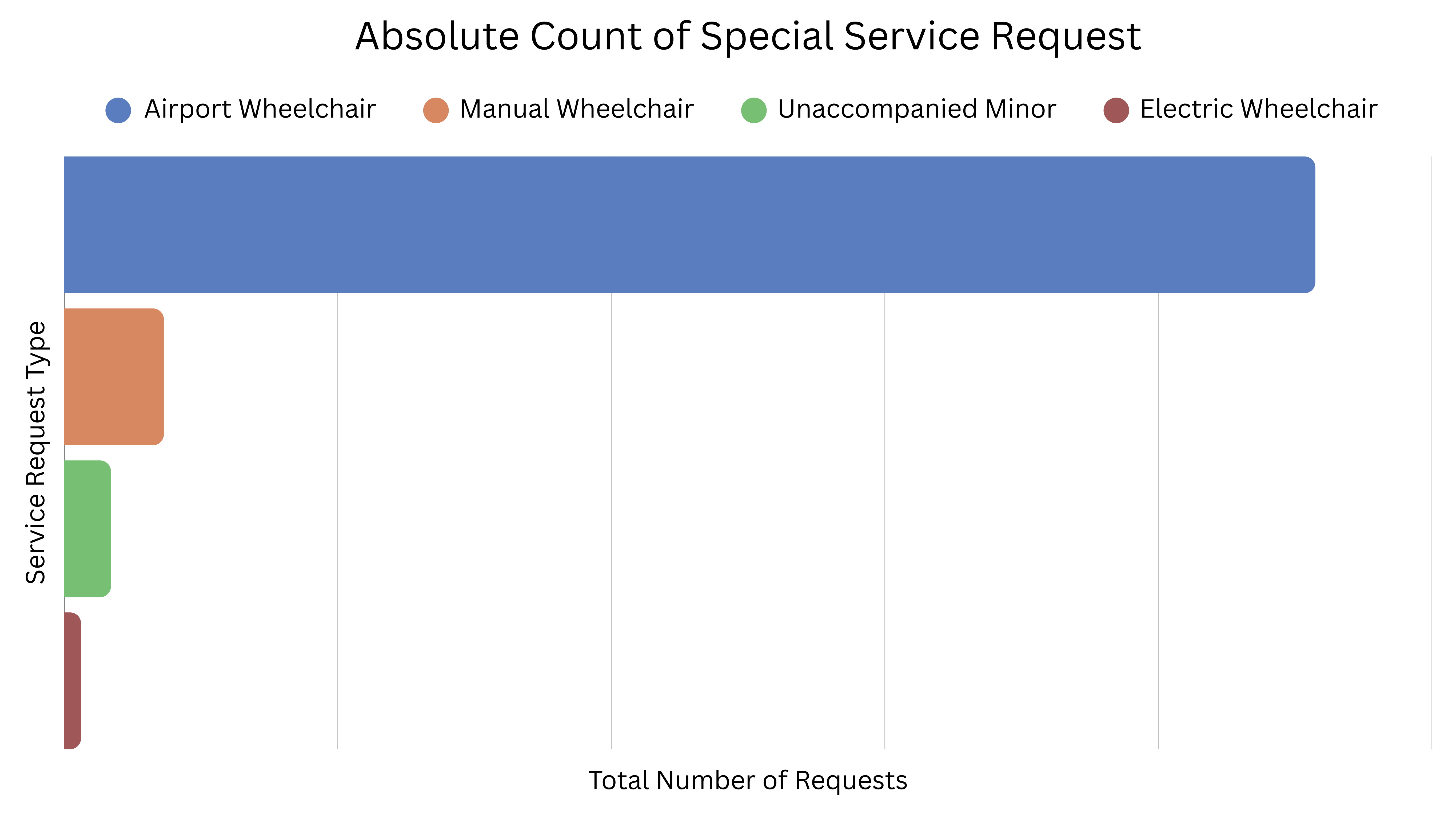
5. The "**Big Group Anomaly**": While most bookings are for 1-2 people, our data revealed group bookings as large as 55 passengers on a single PNR. A single large group can disrupt boarding and seating more than dozens of individual travelers. While not a feature in our final model due to rarity, this highlights a key area for future analysis on non-linear operational risks.

Insights from EDA

The graph shows that DEN is the most popular destination, having the highest number of passenger bookings, close to 27,500.

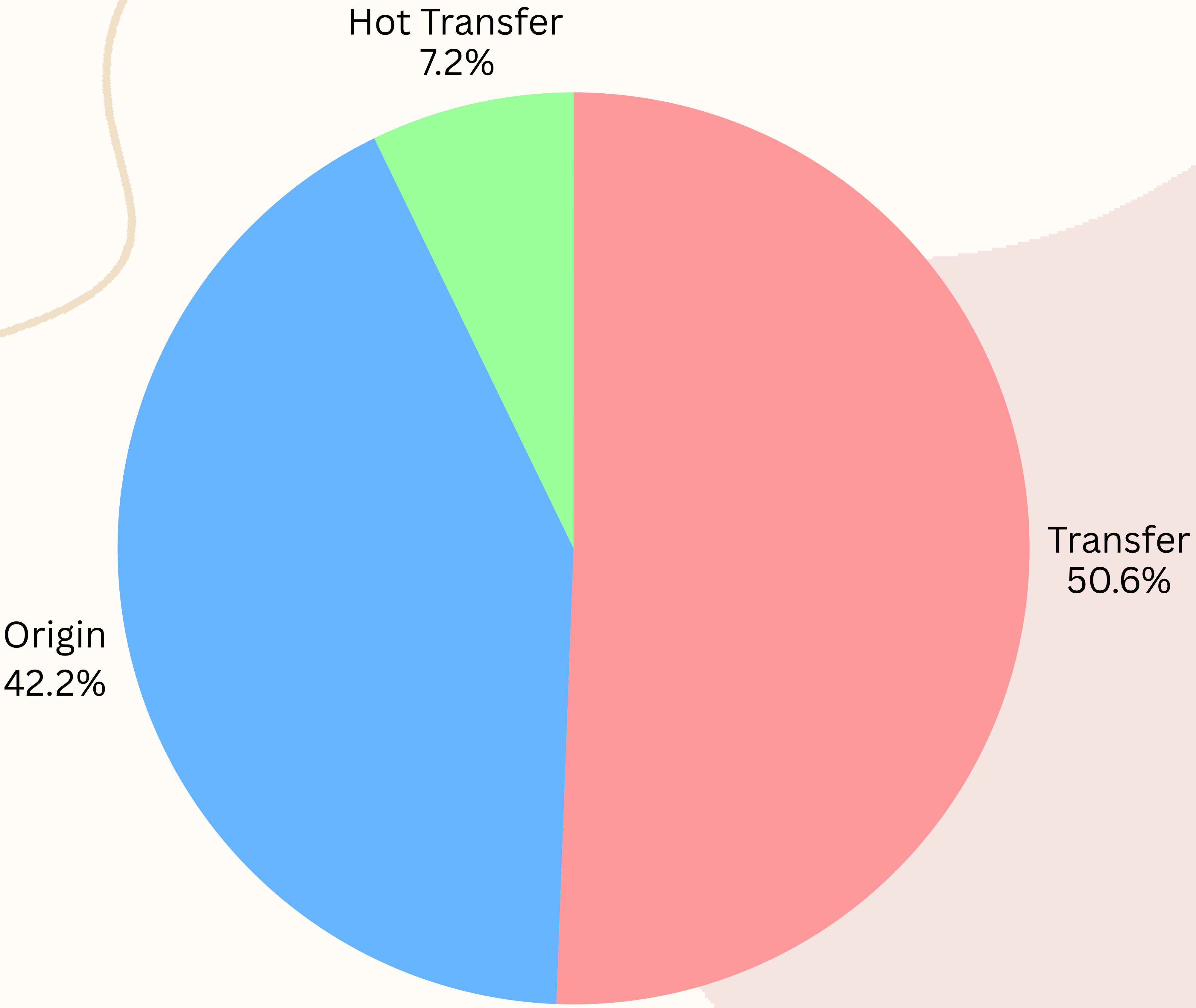
The top three destinations by a significant margin are DEN, San Francisco (SFO), and New York (LGA), all with bookings well over 22,500.

Insights from EDA



Airport Wheelchair is the most common SSR by a huge margin, with the number of requests exceeding 45,000. There is an extreme imbalance in the number of requests between the first-ranked and the subsequent SSRs.

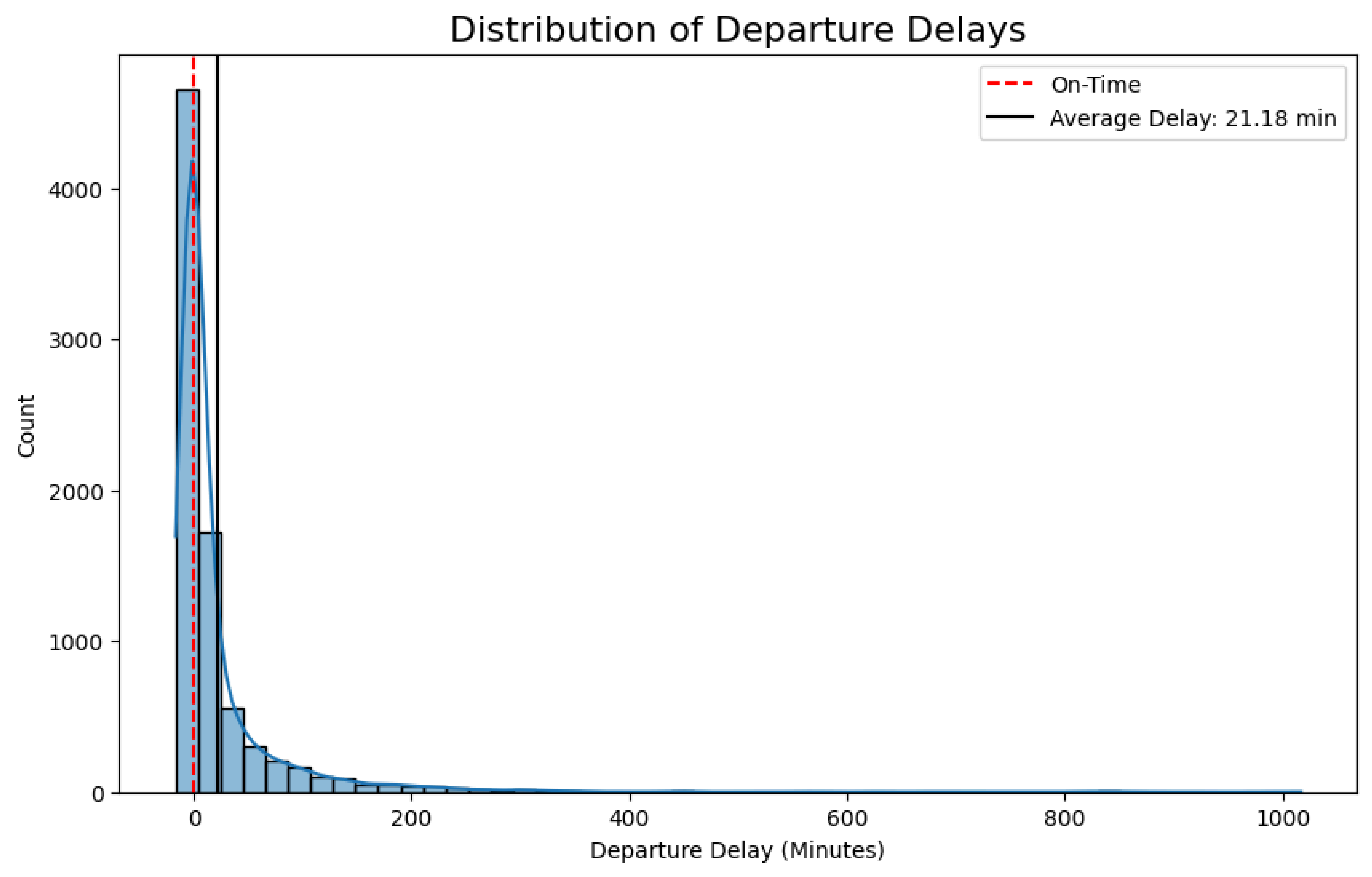
Insights from EDA



Critical Insight: Transfer bags dominate workload. They constitute 50.6% of total bag types.

EDA QUESTIONS

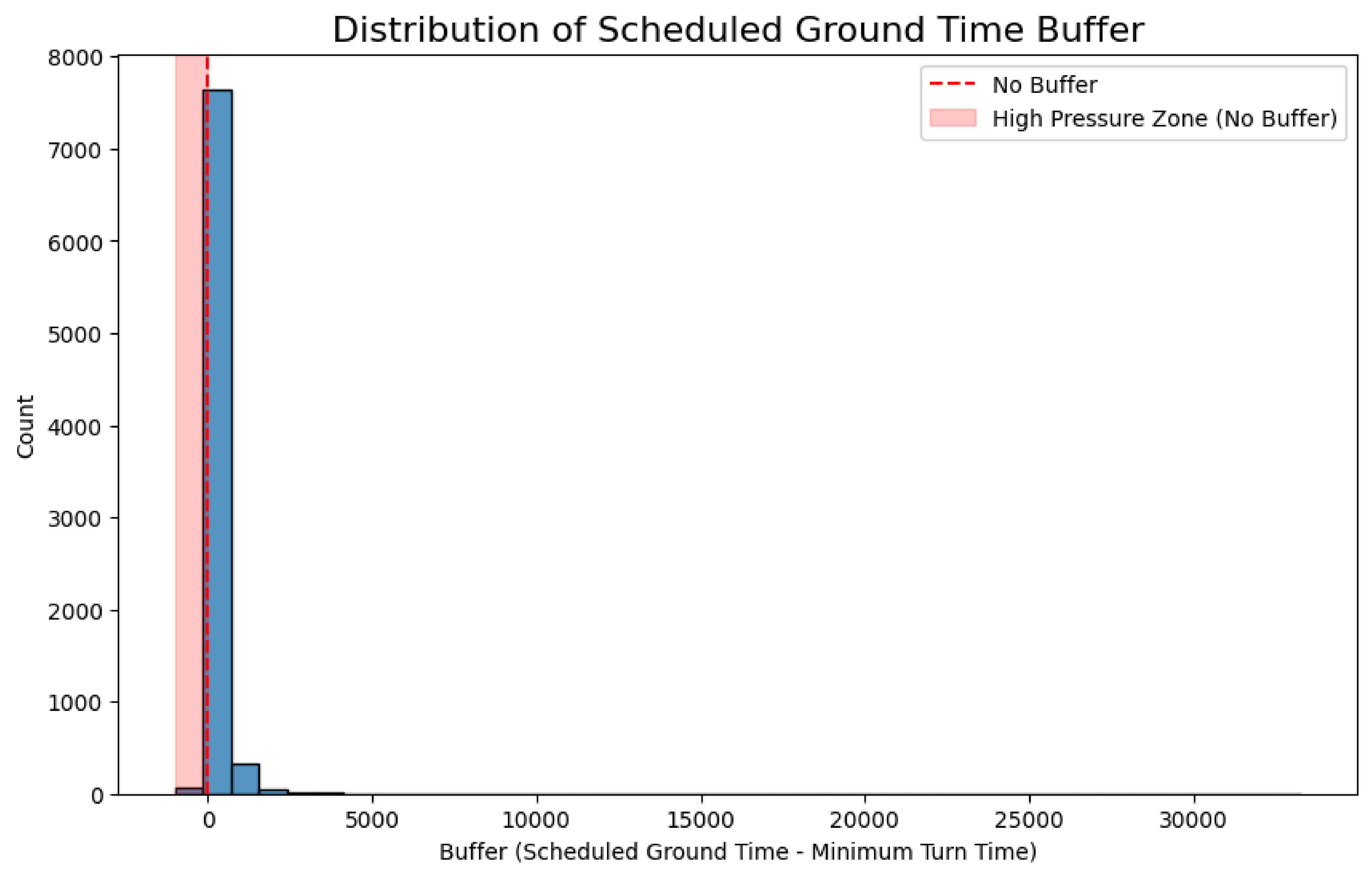
1. **What is the average delay and what percentage of flights depart later than scheduled?**



- Average Delay: 21.18
- Percentage of flights that depart later than scheduled: 49.61

EDA QUESTIONS

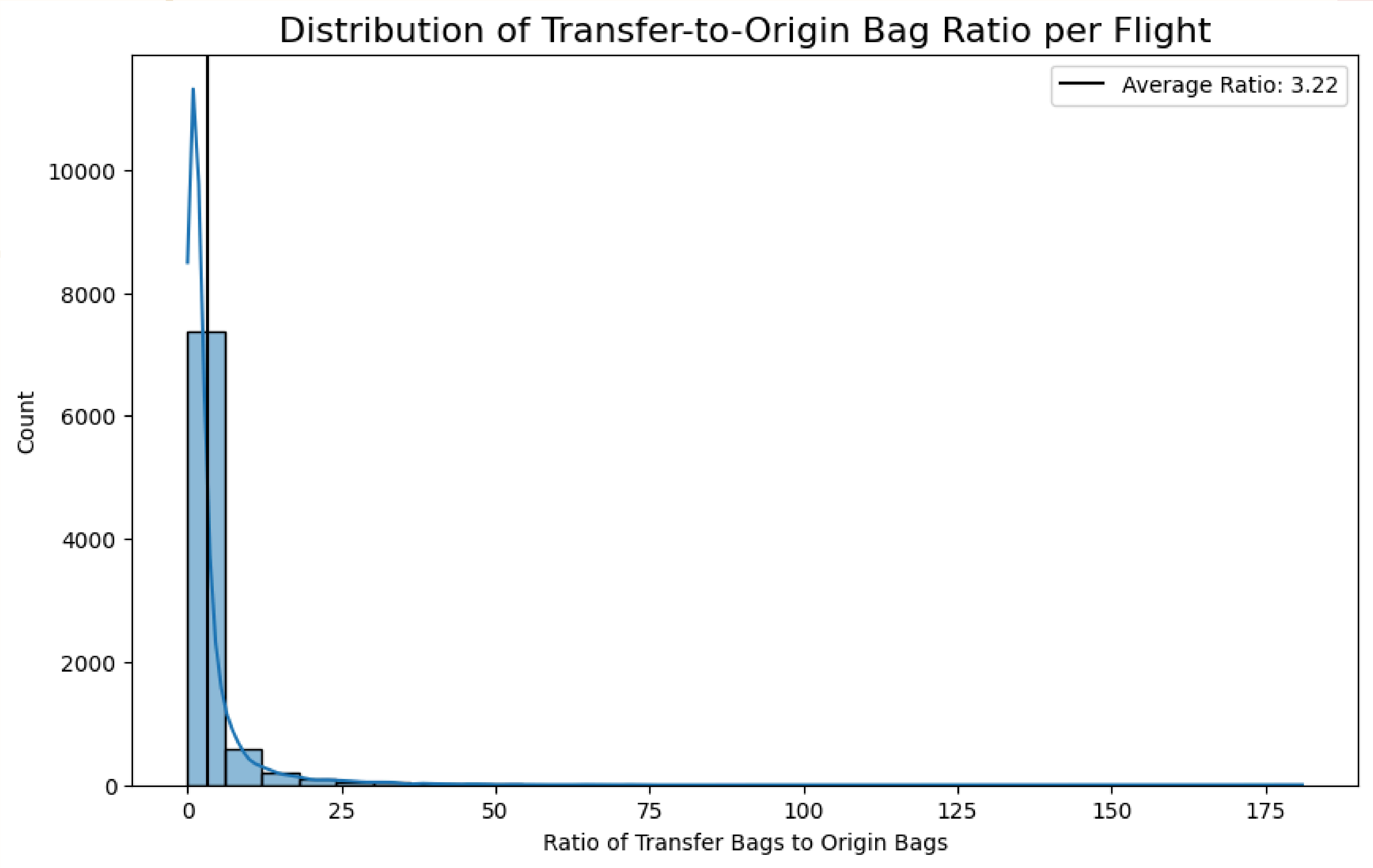
2. How many flights have scheduled ground time close to or below the minimum turn mins?



- Flights with scheduled ground time close to or below minimum turn mins: 652

EDA QUESTIONS

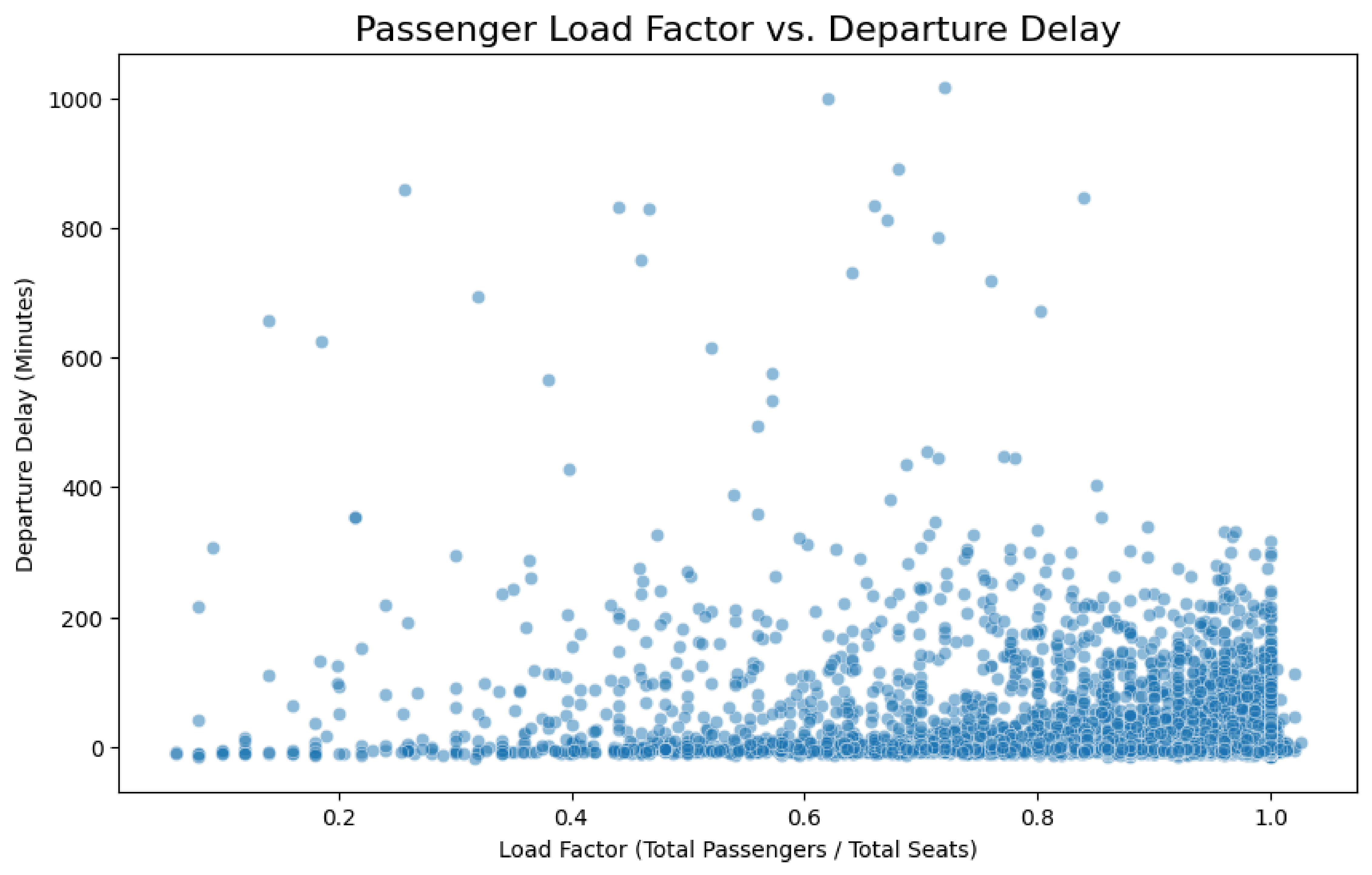
3. What is the average ratio of transfer bags vs. checked bags across flights?



- Average ratio of transfer bags vs. checked bags: 3.22

EDA QUESTIONS

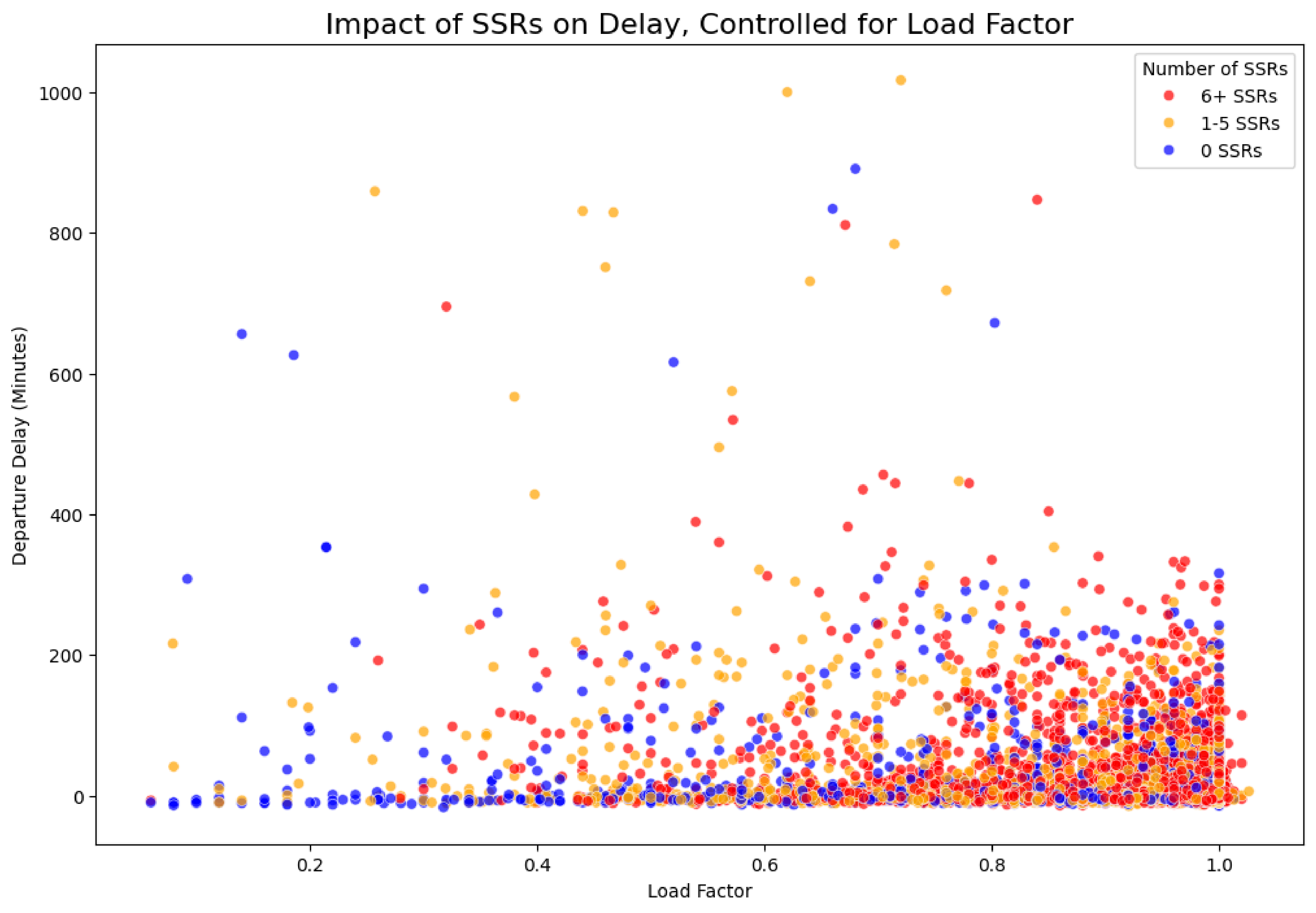
4. How do passenger loads compare across flights, and do higher loads correlate with operational difficulty?



- Passenger loads across flights are generally low, with an average Load Factor of 36.4% and a mid-range (25th to 75th percentile) of 31.6% to 42.0%. The maximum load observed is 66.5%.
- Operational difficulty (delay) shows a weak, negative correlation (−0.1245) with the Load Factor. This suggests that higher passenger loads are associated with a slight tendency for fewer operational delays.

EDA QUESTIONS

5. Are high special service requests flights also high-delay after controlling for load?



- Correlation (SSR Count vs. Delay, Uncontrolled): 0.0234
- Partial Correlation (SSR Count vs. Delay, controlled for Load): 0.0430

Flight Difficulty Score and Classification

Our methodology transforms multi-source data into a single score by first engineering 5 key features that capture the true drivers of operational complexity. A key challenge was a data mismatch between flight and bag files, which we solved using a "short key" for a successful merge.

1. Feature Engineering

The 5 Drivers of Difficulty:

- Ground Time Buffer: The "slack" in the schedule; a low or negative buffer is the biggest risk factor.
- Total Transfer Bags: A direct measure of baggage handling complexity.
- Total Special Service Requests (SSRs): Quantifies the demand for passenger assistance like wheelchairs.
- Load Factor: How full the flight is, amplifying all other operational tasks.
- Total Child Passengers: Influences boarding and in-flight service needs.

Flight Difficulty Score and Classification

2. Scoring Methodology

A Standardized, Weighted Formula: We first standardize these features using a **Z-score** to ensure fair comparison across different scales. We then combine them into a single Flight Difficulty Score using a weighted formula that reflects their real-world impact.

Feature	Weight
Ground Time Buffer	40%
Total SSRs	25%
Total Transfer Bags	15%
Load Factor	10%
Total Child Pax	10%

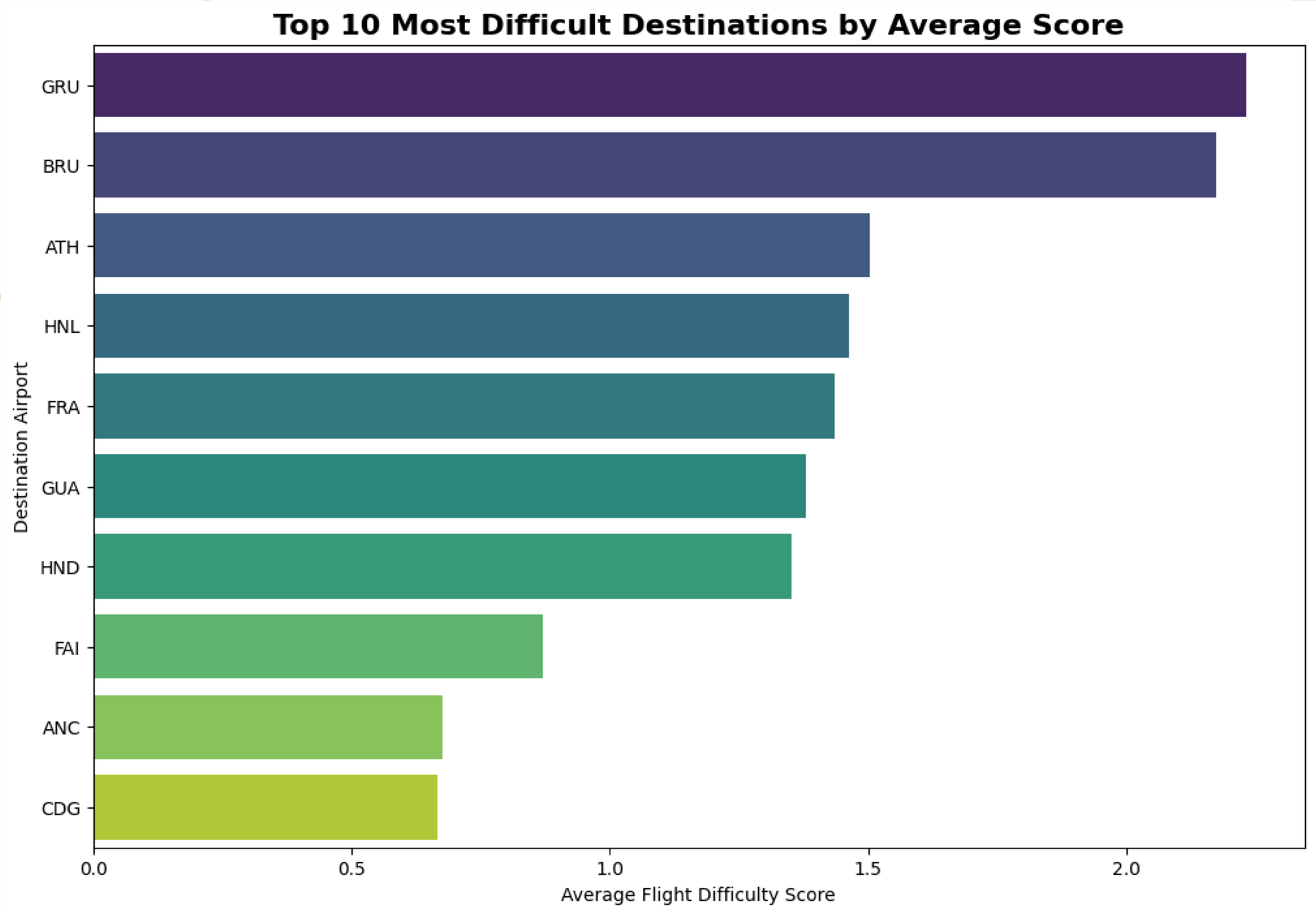
Flight Difficulty Score and Classification

3. Daily Ranking and Classification

- Daily Ranking : To meet the requirement for a daily-level score, we rank every flight from #1 (most difficult) to last only against other flights departing on the same day. This is achieved using a *groupby('date').rank()* operation, which ensures the difficulty is always relative to the current day's specific operational context.
- Classification - Difficult, Medium, Easy: To make the ranking instantly understandable, we classify flights into three intuitive categories. We use a percentile-based method that is stable and avoids errors, even on days with few flights or tied scores.
    - Difficult: The top 33% of ranked flights for the day.
    - Medium: The middle 33% of ranked flights.
    - Easy: The bottom 33% of ranked flights.

Post-Analysis & Operational Insights

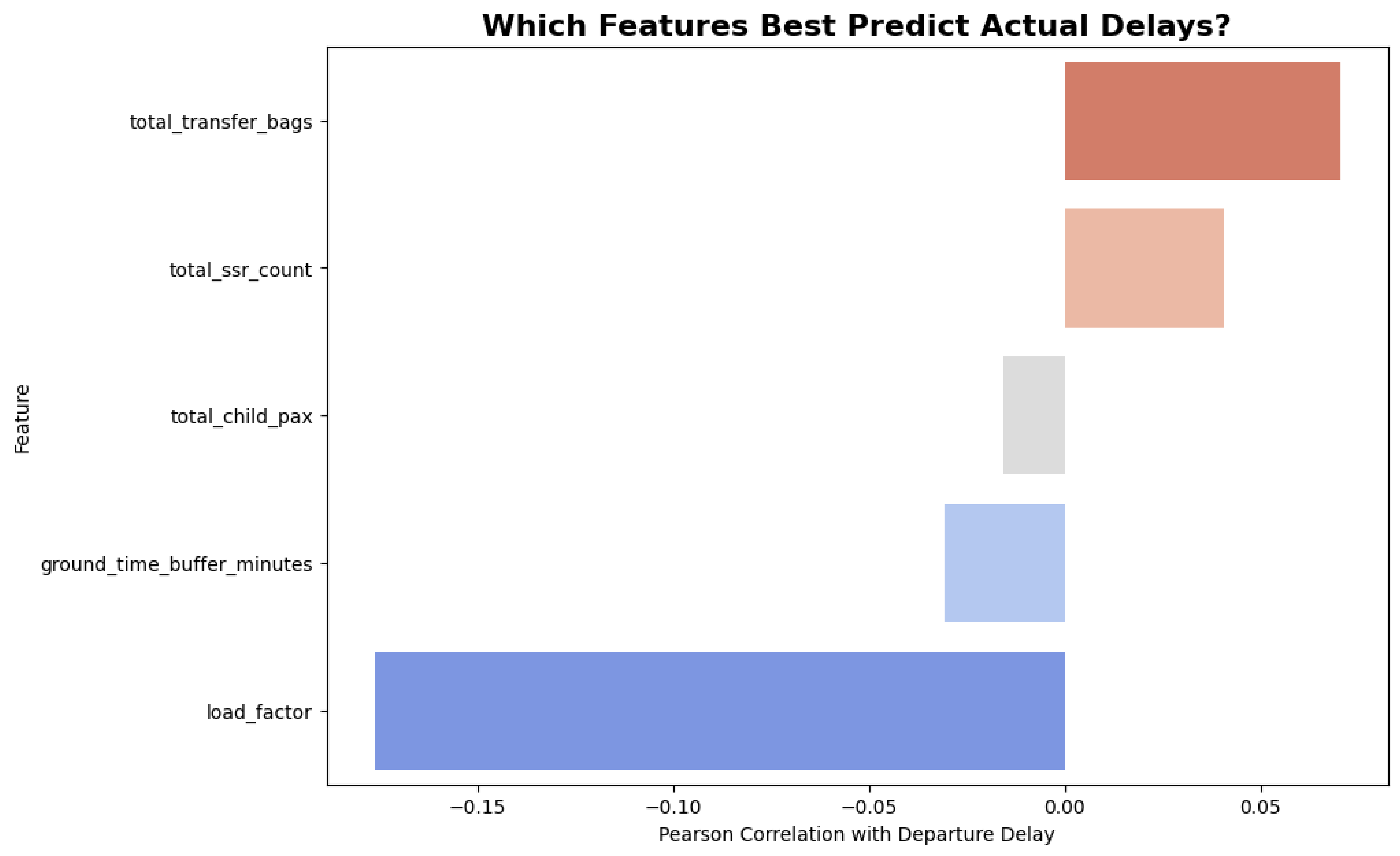
Top 10 Destinations by Average Difficulty Score:



The top difficult destinations by average difficulty score are GRU (2.23), BRU (2.17), ATH (1.50), HNL (1.46), and FRA (1.44).

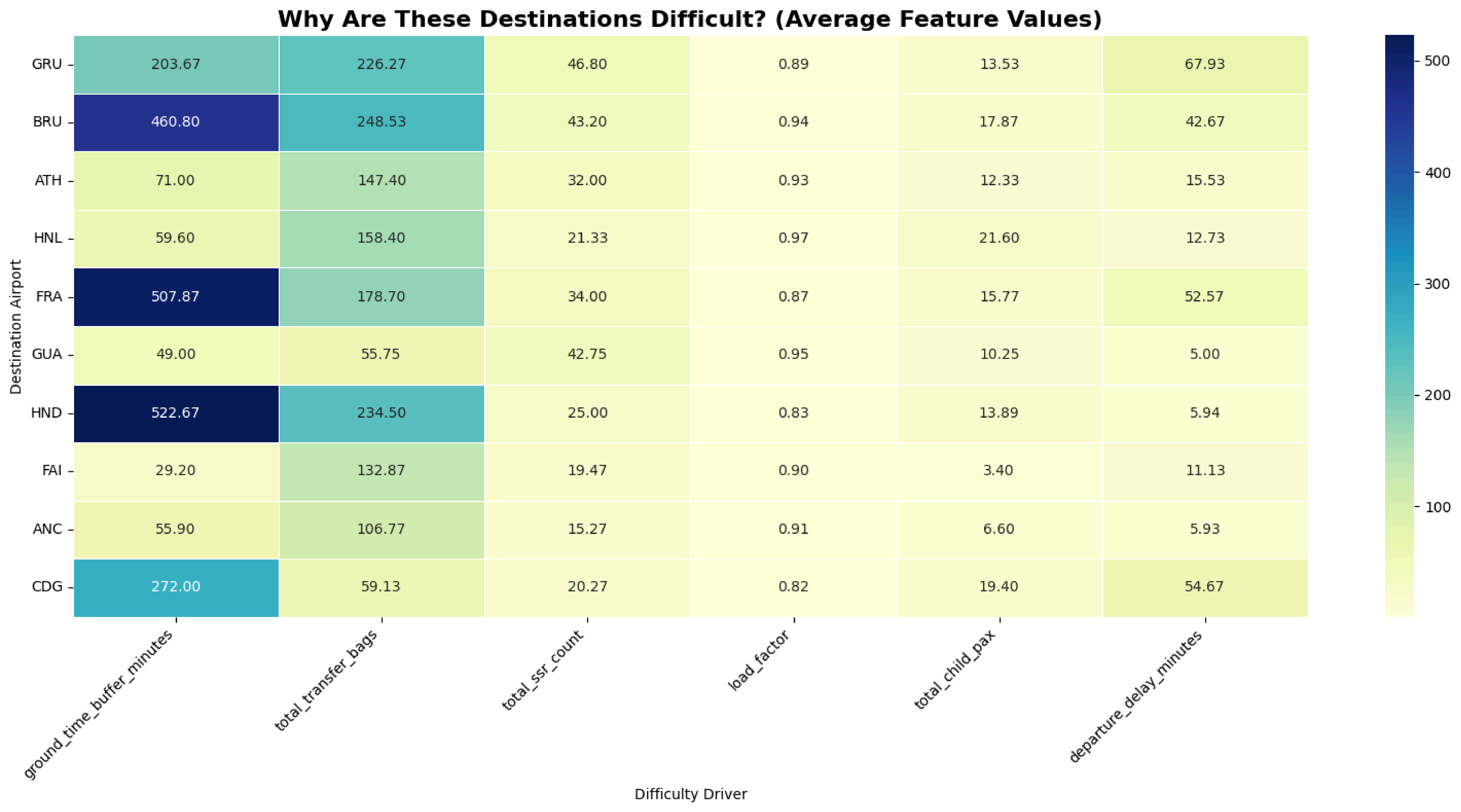
Post-Analysis & Operational Insights

Common Drivers Analysis (Correlation of Features with Actual Delay):



Post-Analysis & Operational Insights

Detailed Drivers for Top 10 Difficult Destinations:



This heatmap provides a deep dive into why the top 10 destinations are difficult.

Post-Analysis & Operational Insights

Recommended actions based on the findings for better operational efficiency:

Area of Focus	Recommendation
Tight Ground Time	Form specialized *Priority Turn Teams* and establish streamlined procedures to manage low-buffer turnarounds efficiently.
Transfer Baggage	Automate or allocate dedicated resources to the baggage transfer process to minimize delays and missed connections.
Special Service Requests	Pre-assign specialized support teams (e.g. wheelchair assistance) using predictive scores to ensure timely service delivery.
Scheduling	Incorporate longer and more realistic ground-time buffers for routes with consistently high operational difficulty.

THANK YOU