A Data-Driven Flight Difficulty Score

Enhancing Operational Efficiency at ORD

United Airlines Hackathon Submission

By-The Avengers

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Executive Summary

The Problem

Nearly 50% of flights from ORD depart late, driven by inconsistent, experience-based resource planning

Our solution

A daily Flight Difficulty Score that Systematically ranks every flight by its operational complexity

Key Finding

The Primary Drivers of Difficulty are extreme ground time pressure ad high volumes of transfer baggage

Top Recommedation

Proactivelly allocate specialized ground crews to the top 5% Difficult flights each day, starting with the STL route.

Key Findings from the Data

49.7%

Flight Depart Late

With an average delay of 21.2 minutes, widespread delays impact the entire operation

621

Flights Face a Bottleneck

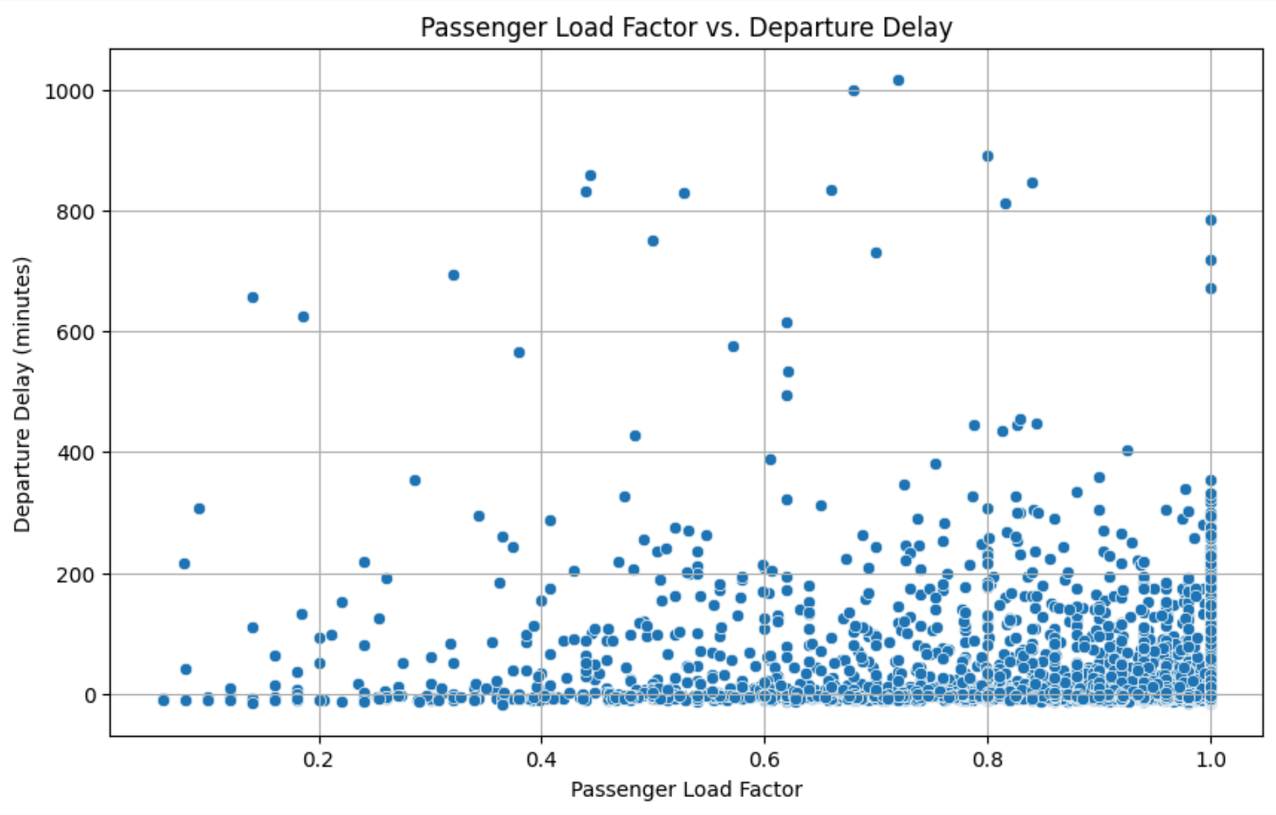
Scheduled with less than minimum turn around time, putting them at risk of delay from the start

3:1

Complex Transfer Hub

The High ratio of Transfer bags to checked bags highlights immense pressure on baggage handling

Surprising Insight: Fuller Flights Are Not Necessarily More Delayed

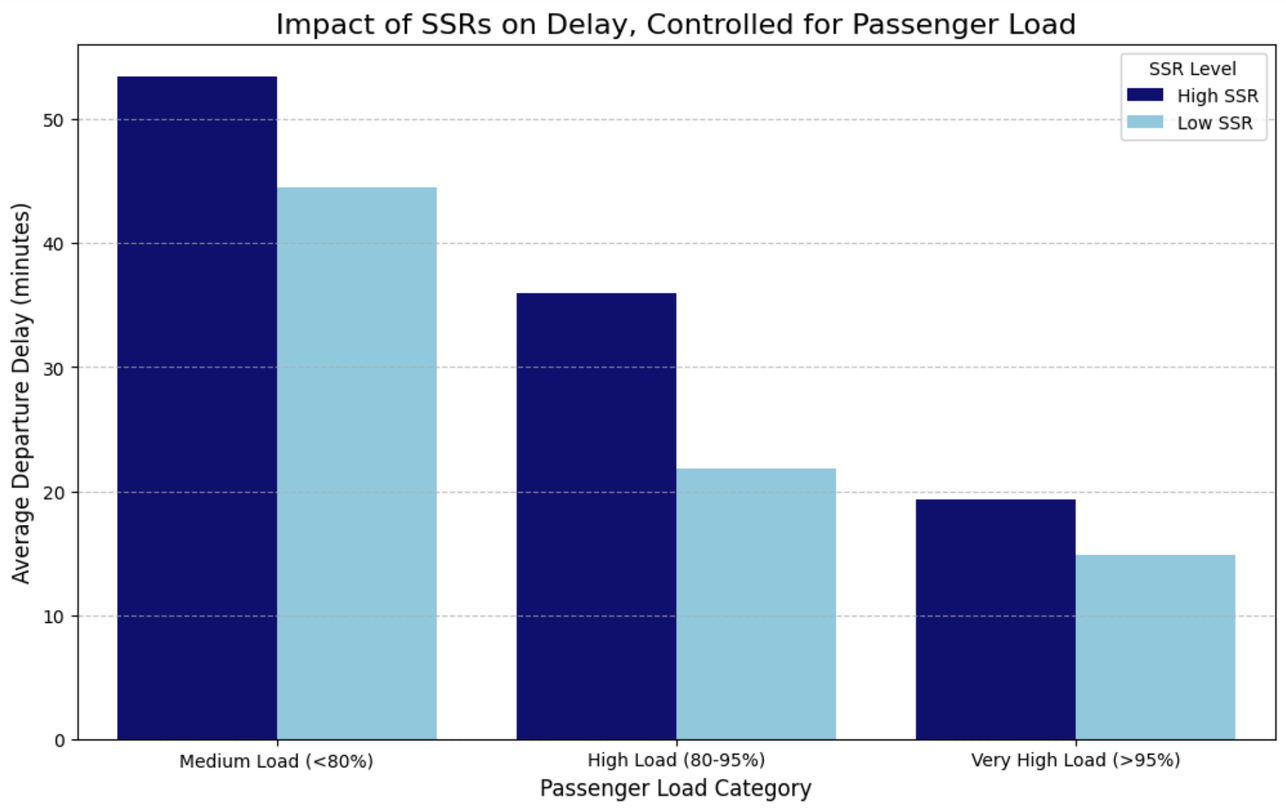


Key Insight

Analysis shows a weak negative correlation (-0.16), indicating that fuller flights are not a primary driver of delays on their own.

This suggests that while passenger volume matters (and is in our score), other factors like ground time and baggage are more critical predictors of difficulty.

Key Driver: Special Service Requests Increase Delays at All Load Levels



Key Insight

After controlling for passenger load, flights with a High number of Special Service Requests (SSRs) are consistently more delayed.

This proves that specific passenger needs are a significant driver of operational complexity, independent of how full the flight is

Our Solution: The Flight Difficulty Score

We Developed a Weighted scoring model to quantify Operational Complexity. The score is calculated daily, allowing for dynamic resource allocation and then it classified into 3 categories (Difficult, Medium, Easy).

FEATURE	WEIGHT	RATIONALE
Ground Time Pressure	**30%**	Our EDA Revealed this as a significant and direct operational constraint.
Transfer Bag Ratio	**20%**	Reflects ORD’s complexity as a major hub and the labor required
SSR Count	**15%**	Accounts for the extra time and coordination needed for passenger assistance.
Passenger Load Factor	**15%**	Fuller Planes requires more time for boarding and deplaning.
Hot Transfer Bags	**10%**	These time-sensitive bags and an extra layer of urgency and complexity.
Child & Lap Child Count	**10%**	Accounts for additional boarding time and family needs

Analysis Deep Dive :Identifying the Hotspots

Top 10 Difficult Destinations

Airport	No. of Difficult Flights
STL	**88**
DTW	54
GRR	53
DSM	53
MSP	51
DAY	51

THE Story: Why STL is so Difficult

Flights to St.Louis are 44% more delayed than the airport average. Our Analysis reveals two clear reasons why

-51%

Less Ground Time Buffer

+50%

More Transfer Bags

Actionable Recommendations

1.Deploy a Turnaround Taskforce for STL

For the top 5 daily Difficult flights to STL, pre-assign an expanded ground crew to guarantee the aircraft is ready for boarding ahead of schedule, directly countering the -51% ground time pressure.

2.Implement a Priority Protocol

For STL-bound flights, baggage handlers should prioritize sorting and loading transfer bags first. Since these flights handle 50% more transfer, this targeted approach will reduce mishandled bags and departure delays.

Conclusion & Business Impact

From Reactive to Proactive

This Score allows teams to anticipate and plan for difficulty before it happens, moving resources where they’ll be needed most.

Data-Driven Decisions

This System Replaces inconsistent guesswork with a consistent, scalable and fair method for resources allocation across the airport

Expected Outcomes

By Targeting the most Difficult Flights, we Expect to see improved on-time performance more efficient use of resources , and reduced employee Stress.

Appendix

https://github.com/prince22g/united_airlines_hackathon_final

Appendix A: Detailed Methodology

Data Integrity & Preparation

- Data Aggregation: Merged five datasets (Flight, PNR, Bag, Remarks, Airport) to create a single flight-level view.
- Data Cleaning: Handled missing values through mode imputation for airport country codes. Converted all date/time fields to a standardized format.
- Duplicate Removal: Identified and removed 23 duplicate flight records using a composite key (flight number, departure time, and station) to ensure data integrity.
- Feature Engineering: Created new metrics like ground_time_pressure, passenger_load_factor, and transfer_bag_ratio to quantify operational stress.

Appendex A: Detailed Methodology(Continue)

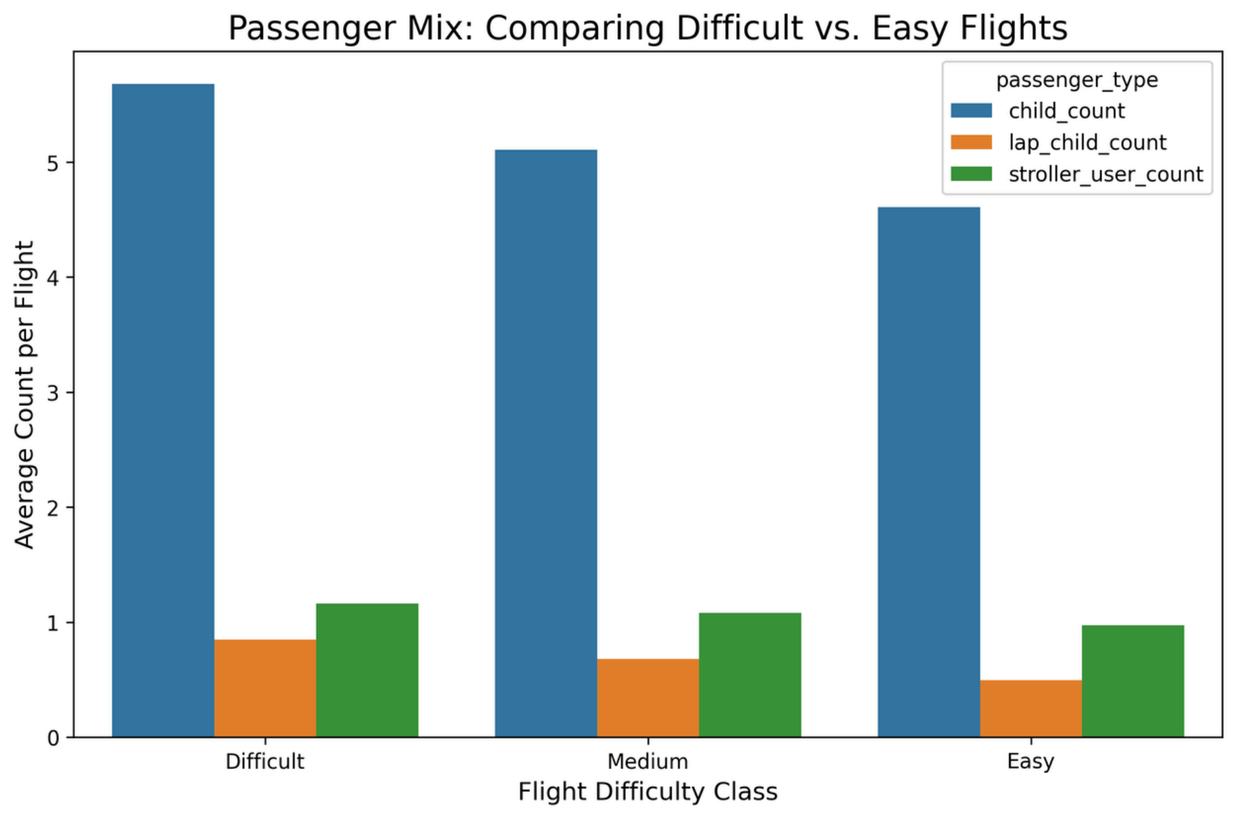
Feature Engineering

- **passenger_load_factor:** The percentage of occupied seats on the aircraft (Total Passengers / Total Seats).
- **ground_time_pressure:** The buffer time on the ground, calculated as scheduled ground time minus the minimum required turn time.
- **transfer_bag_ratio:** The proportion of transfer bags relative to the total checked bags on the flight.
- **ssr_count**: The total count of Special Service Requests (e.g., wheelchair) associated with a flight, aggregated from PNR remarks.
- **child & lap childcount:**The total number of passengers classified as children and infants not occupying a seat, aggregated for each flight from PNR data.
- **hot transfer bag count:**The total count of transfer bags with a tight connection time (less than 30 minutes), aggregated per flight.

Weight Selection

Weights were assigned based on our EDA findings. Ground Time Pressure and Transfer Bag Ratio received the highest weights as they showed the strongest connection to operational bottlenecks and delays during our initial analysis.

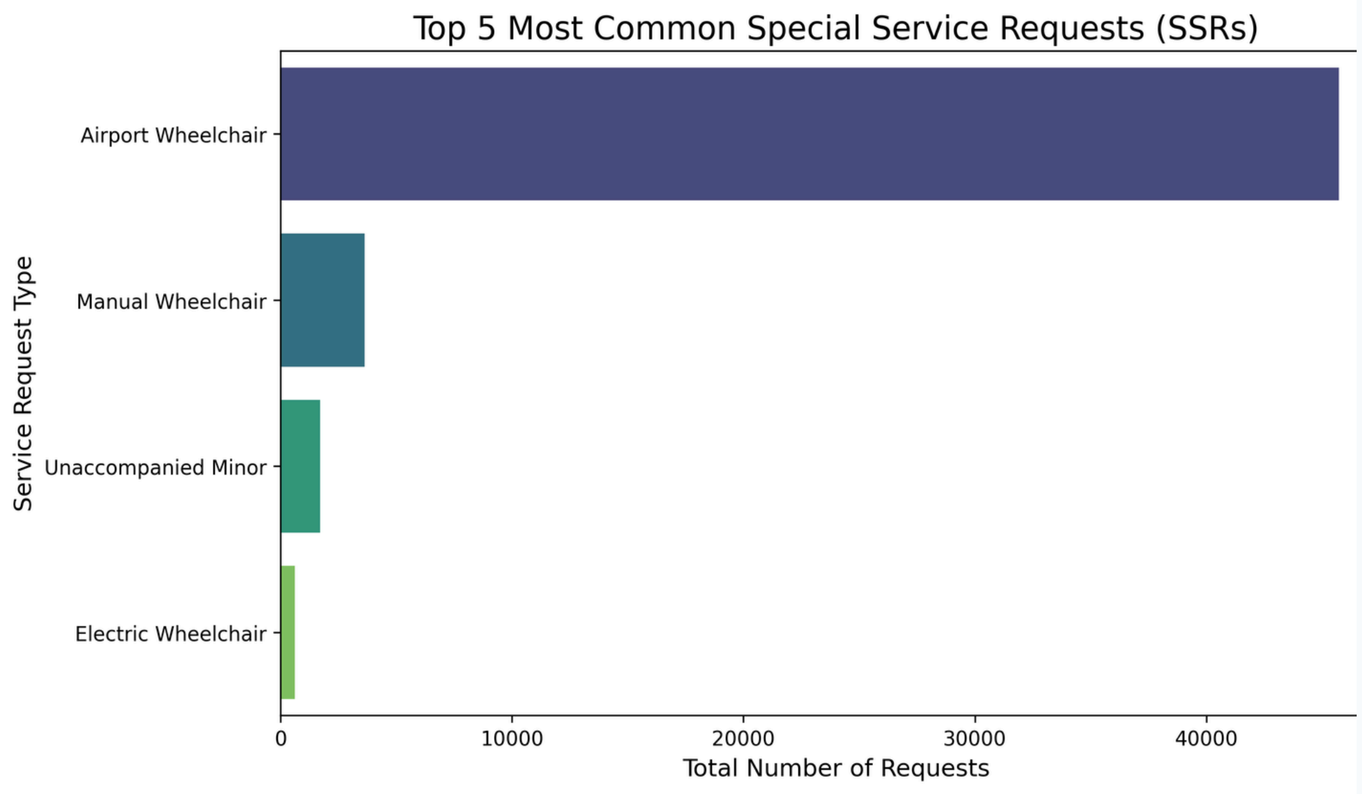
Appendex B: Chart: Passenger Mix on Difficult vs. Easy Flights



Insight

This chart shows that "Difficult" flights have more children, lap children, and stroller users than "Easy" flights. This supports using these passenger demographics to calculate a flight's difficulty score, as they increase operational complexity.

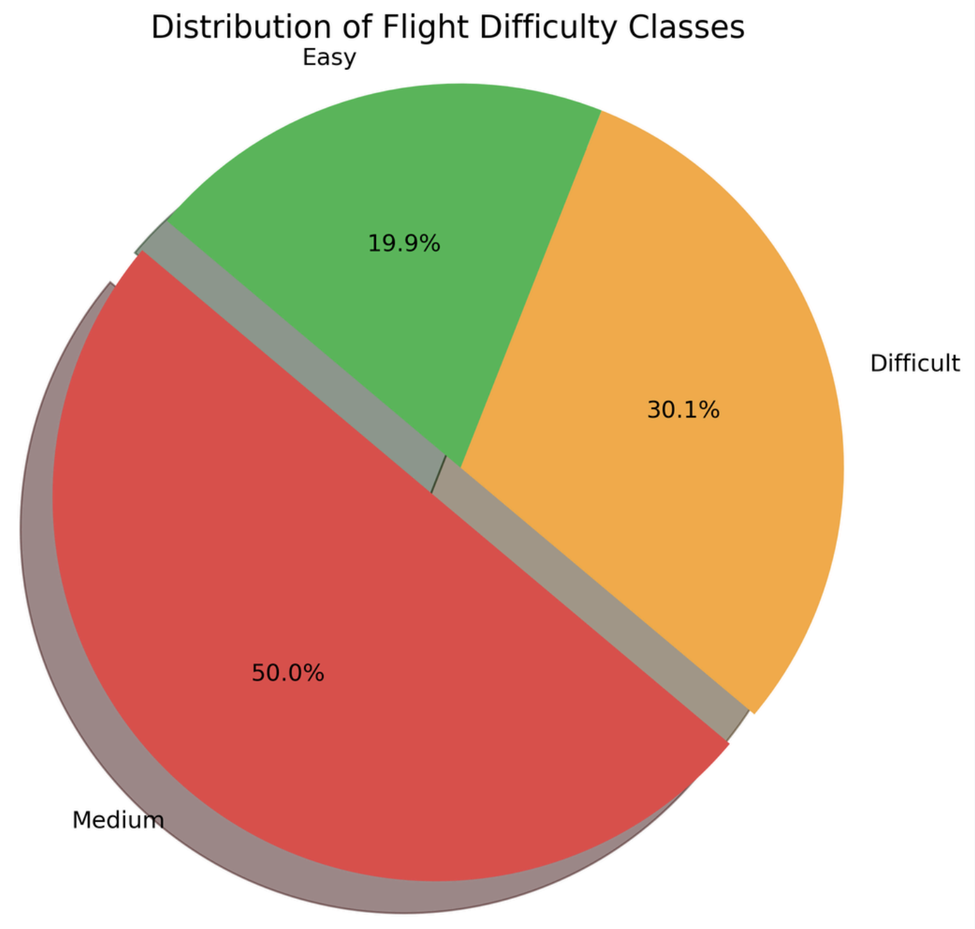
Appendex C: Chart: Top 5 Special Service Requests (SSRs)

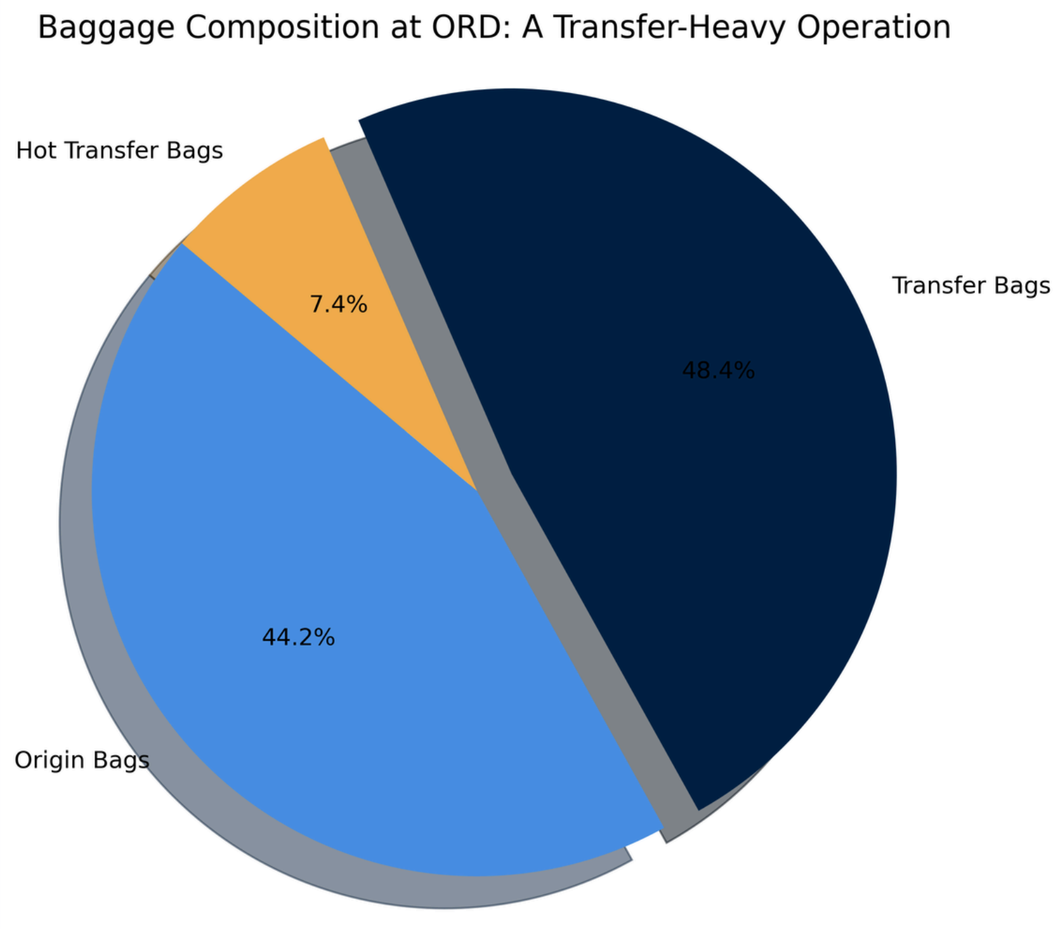


Insight

- This chart adds context to the ssr_count feature by breaking down the most common service requests.
- It highlights that requests like "Airport Wheelchair" are highly frequent, which has a direct operational impact as it requires coordination of specialized staff and equipment, often impacting boarding and deplaning times.

More Charts


Distribution of Flight Difficulty Classes
Easy
19.9%
Difficult
30.1%
50.0%
Medium


Baggage Composition at ORD: A Transfer-Heavy Operation
Hot Transfer Bags
7.4%
Transfer Bags
48.4%
44.2%
Origin Bags

Thank You