

Understanding Flight Delays: Insights for U.S. Aviation



GROUP
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Flight Delays Represent a Persistent and Costly Challenge for the Aviation Industry

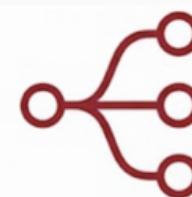
The Impact



Millions of passengers affected annually



Billions in economic costs to airlines and travelers



Cascading effects throughout the entire air transportation network



A **critical operational challenge** for every carrier

Our Research Objective

Our goal was to move beyond the simple fact that delays happen and instead identify the specific patterns and root causes. We analyzed comprehensive Department of Transportation data to answer:

- When do delays occur?
- Which airlines and airports are most affected?
- What are the primary, data-backed causes?

Our Analysis is Built on 3 Million Official DOT Flight Records from 2019-2023

Dataset Characteristics

Source: U.S. Department of Transportation,
Bureau of Transportation Statistics

Time Period: January 2019 - August 2023

Scale: Approx. 3 million flight records

Coverage: Domestic US flights with
comprehensive operational details

Key Attributes Available

Flight Identifiers

Date, airline,
flight number,
origin/destination

Timing Data

Scheduled vs.
actual
departure/arrival
times, taxi times

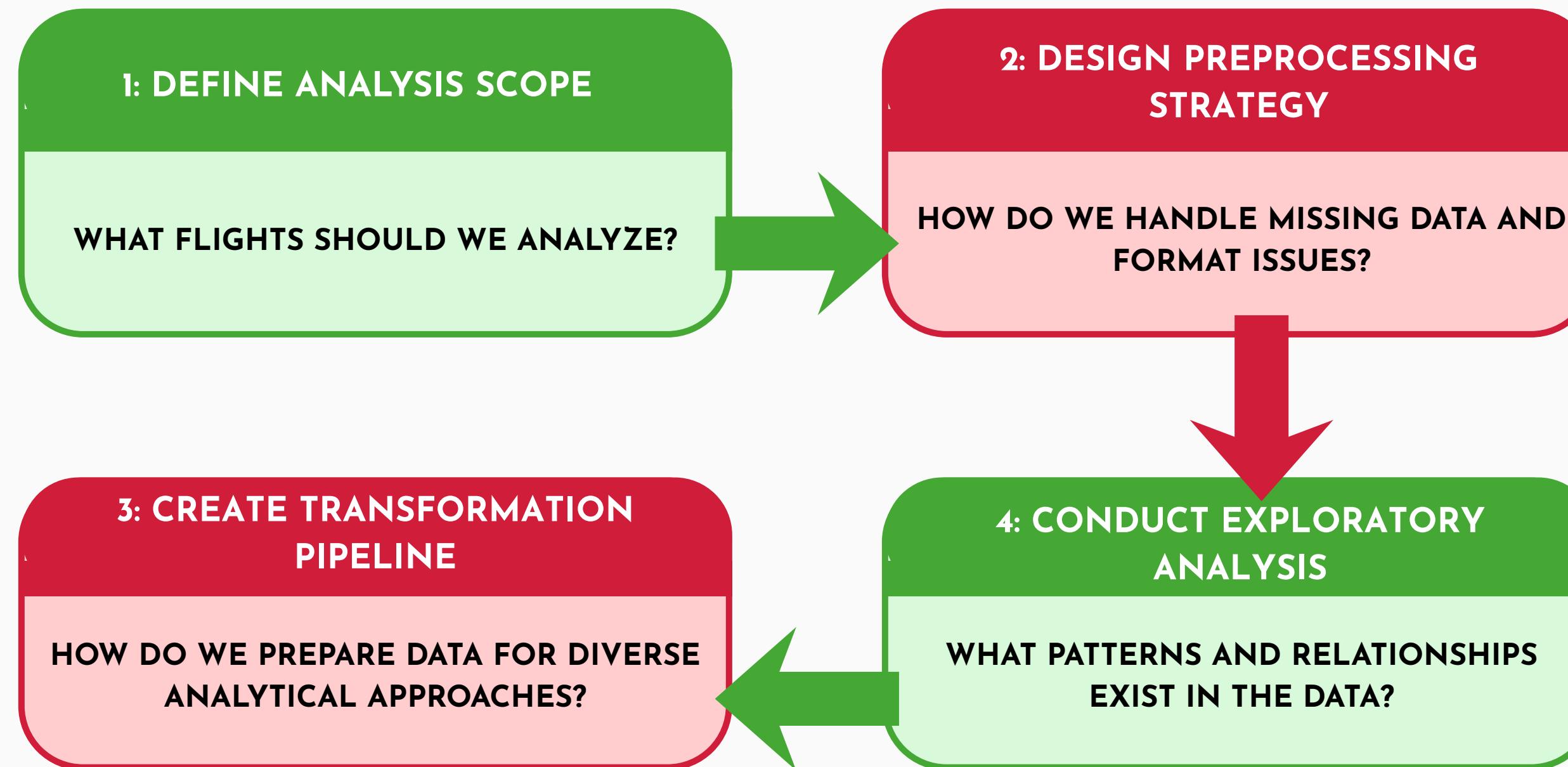
Delay Metrics

Total delay
minutes with
breakdowns
by specific
cause

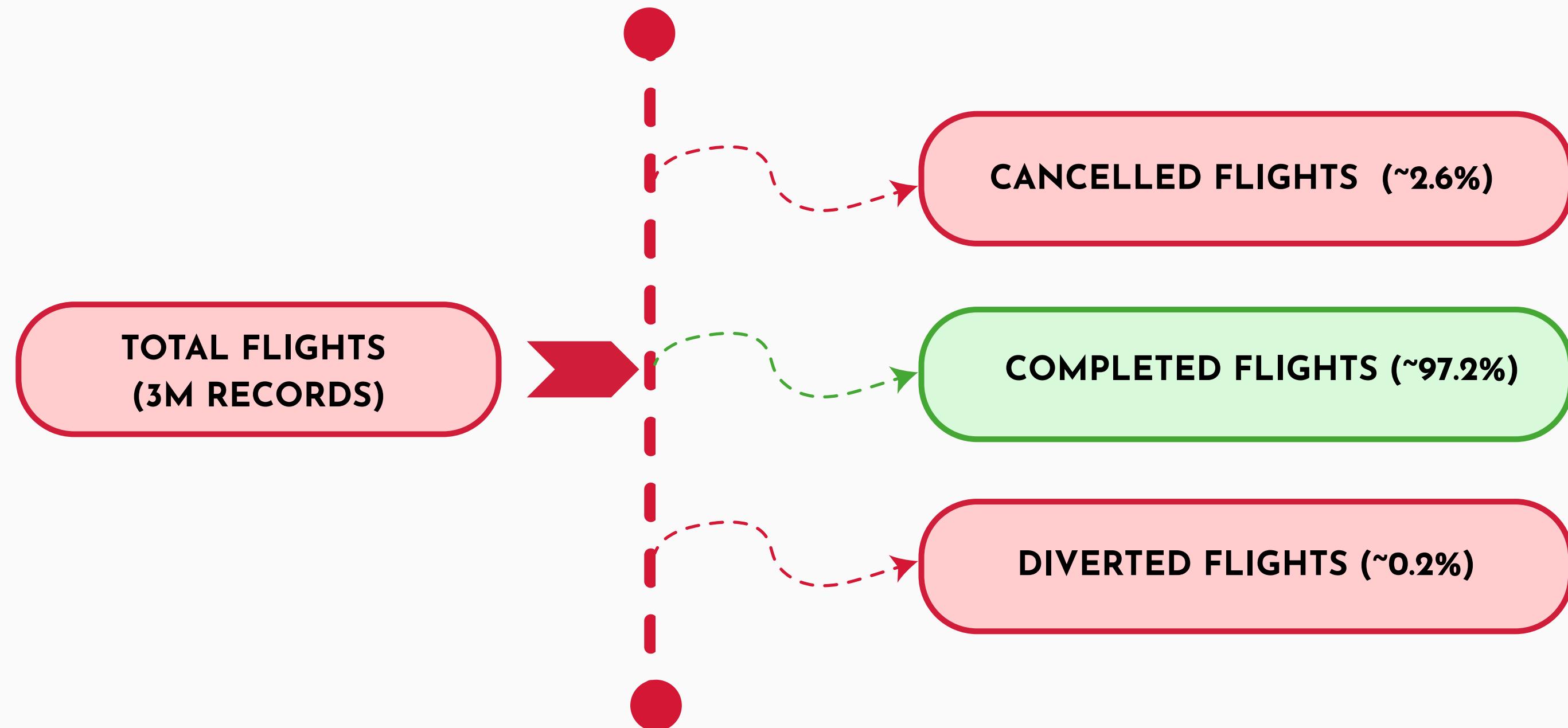
Operational Status

Completion,
Cancellation,
and diversion
indicators

We Employed a Deliberate Four-Point Analytical Decision Framework



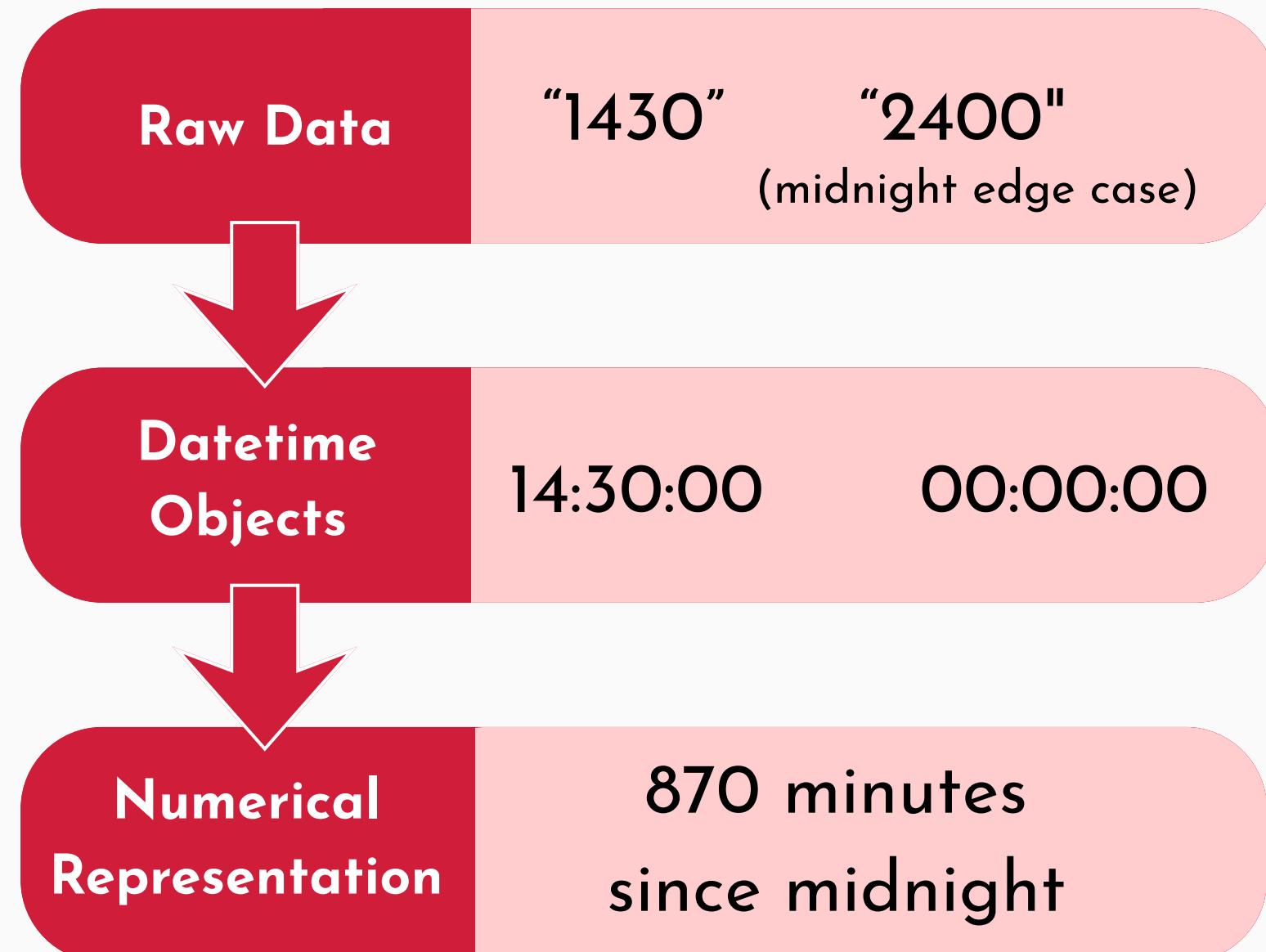
Decision 1 - We Focused the Analysis on Completed



Decision 2 - Missing Data Strategy

Data Category	Our Approach	Justification
CRITICAL IDENTIFIERS (FL_DATE, AIRLINE, ORIGIN, DEST)	DROP INCOMPLETE RECORDS	CANNOT IMPUTE FLIGHT IDENTITY; RECORDS WITHOUT THESE FIELDS ARE UNUSABLE FOR ANALYSIS
DELAY METRICS (ARR_DELAY, DEP_DELAY, DELAY CAUSE COLUMNS)	FILL MISSING WITH ZERO	MISSING DELAY VALUES MOST LIKELY INDICATE ON-TIME PERFORMANCE; CONFIRMED BY CROSS-CHECKING WITH TIMING DATA
TIMING DETAILS (WHEELS_OFF, WHEELS_ON, TAXI TIMES)	DROP RECORDS WITH MISSING VALUES	THESE FIELDS HAD MINIMAL MISSING DATA (<2%) AND ARE NEEDED FOR VALIDATION CALCULATIONS

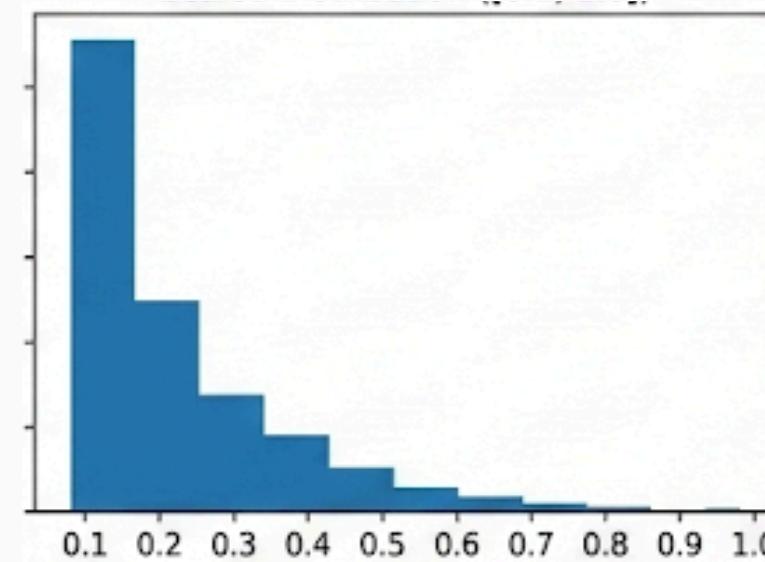
Decision 3 - Time Data Transformation



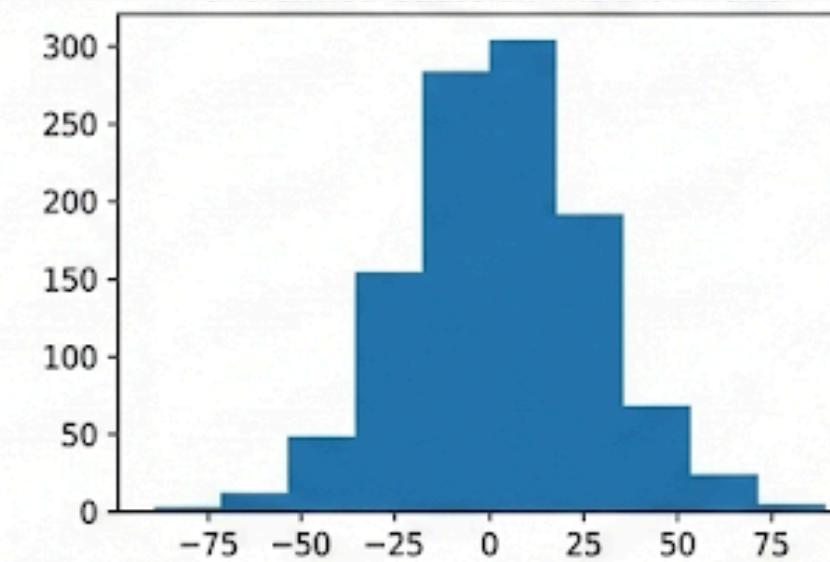
**This multi-step process
enables proper time
arithmetic, handles critical
edge cases, and produces a
clean numerical format
required for modeling and
calculations.**

Decision 4 - Multi-Scale Preprocessing

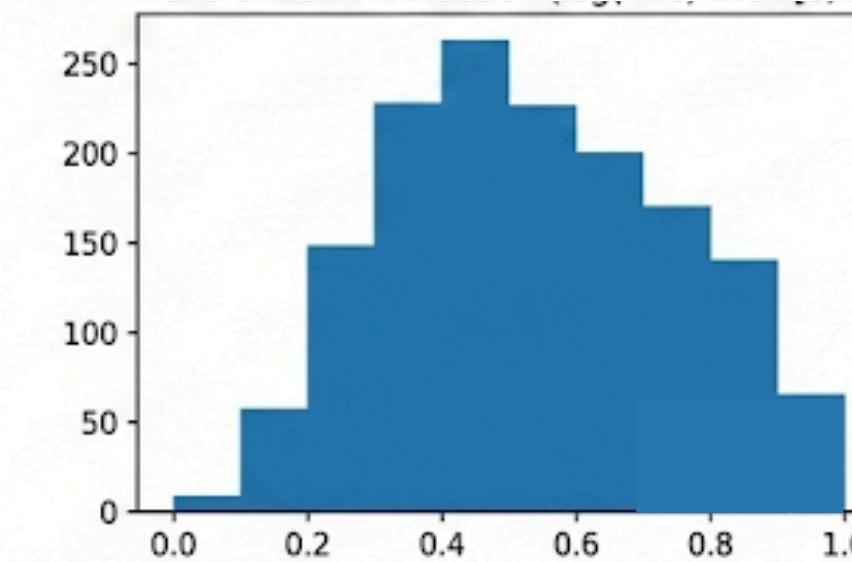
Min Max



**Yeo-Johnson Power
Transform**



Log Scaling



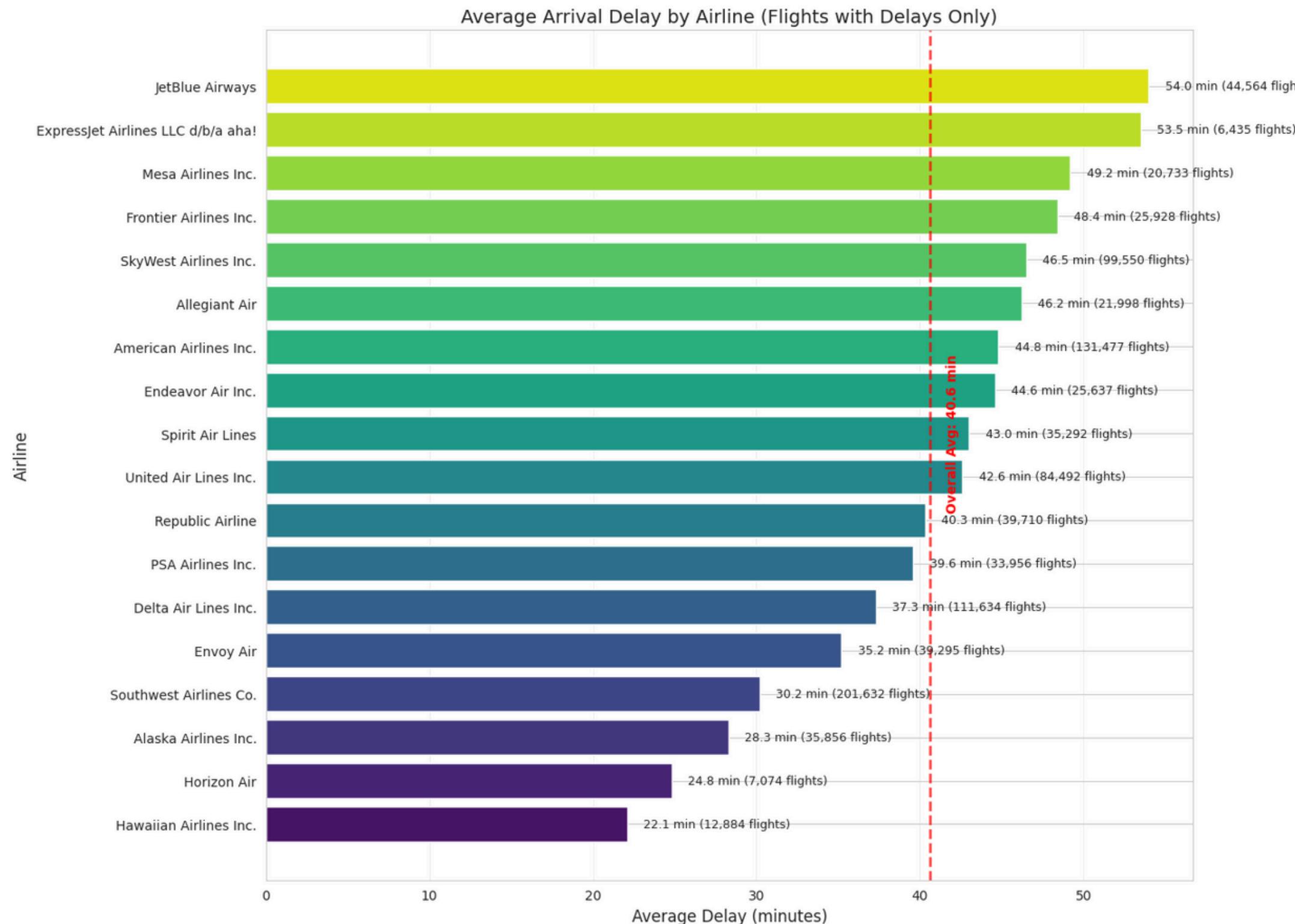
Scale to range
[0.1, 1.0]

Power transformation
for normalization

$\log(x + \varepsilon)$ then
normalize to [0,1]

Airline-Wise Average Arrival Delay

2019-2023 sample from DOT flight records



Best On Time Performance

Delta (DL) has the lowest average arrival delay.



Most Delayed Carrier

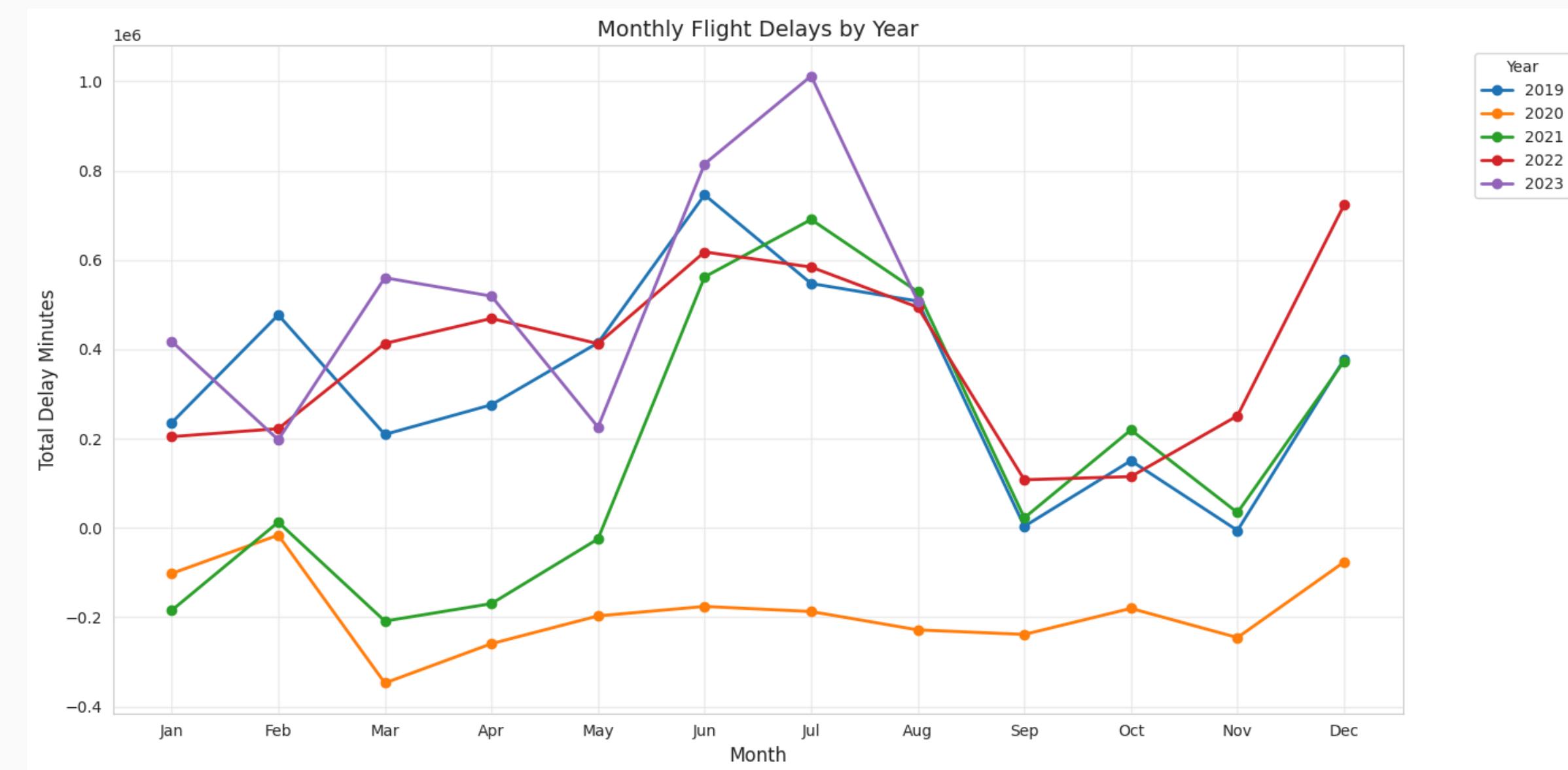
Spirit (NK) shows highest average arrival delay.



Overall Pattern

Most major carriers cluster are within a small delay range, but low cost carrier skew higher.

What We Learned



What We Did

Aggregate delays by month and year,
EDA of Temporal trends.



Why We Did it

To understand seasonal patterns and
pandemic impact.



What We Learned

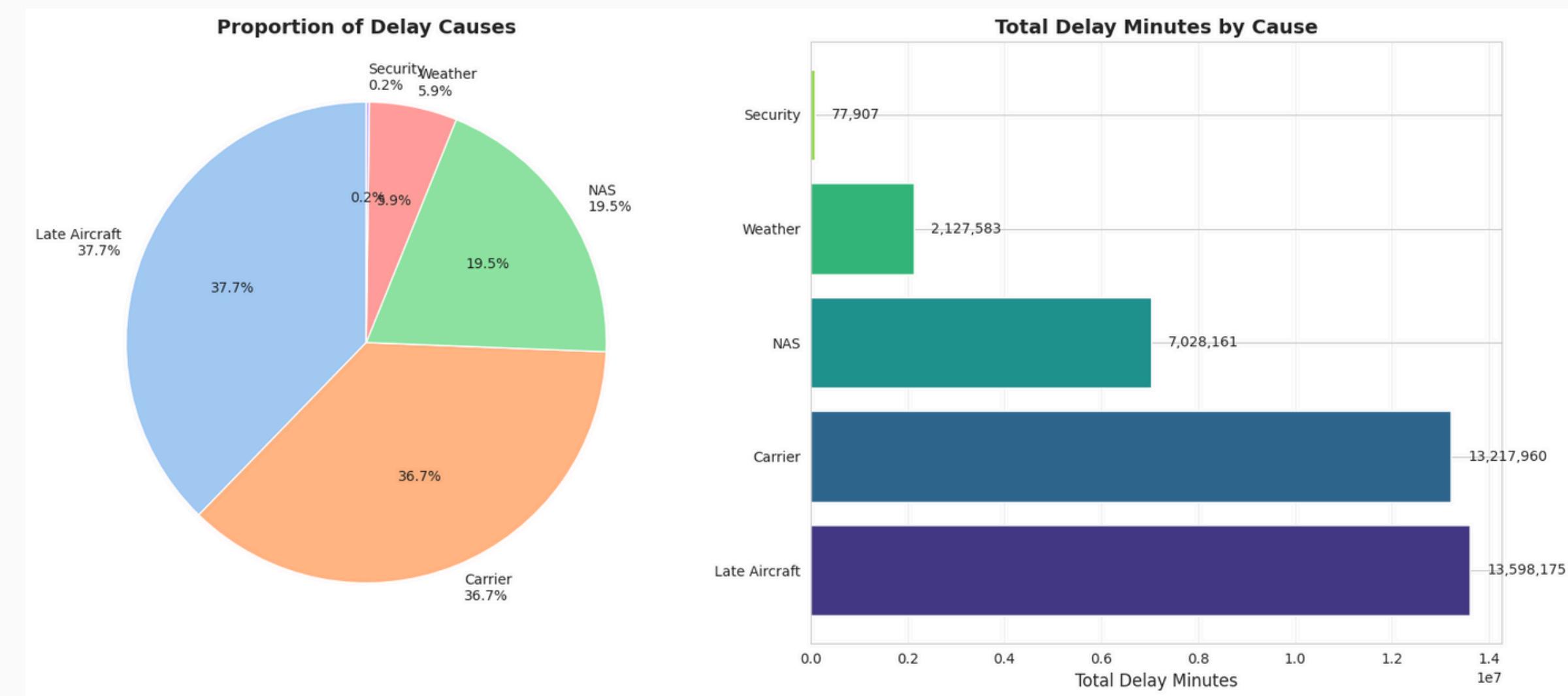
2020 drop, consistent Summer
peak, 2022 spike, variability in
Winter.

What Drives Flight Delays?

Delay Minutes by Cause 2019 - 2023

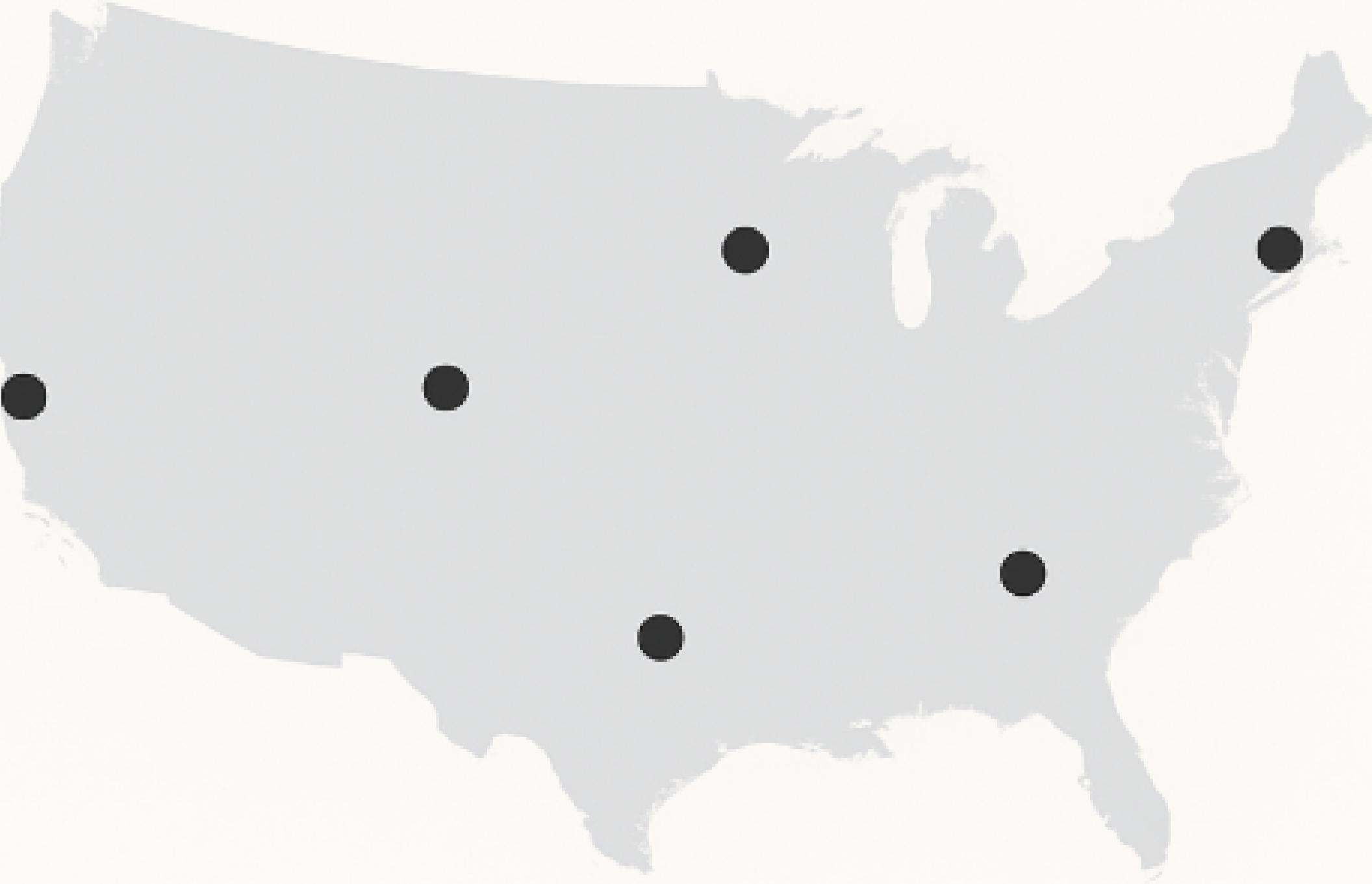
SDSU

San Diego State
University



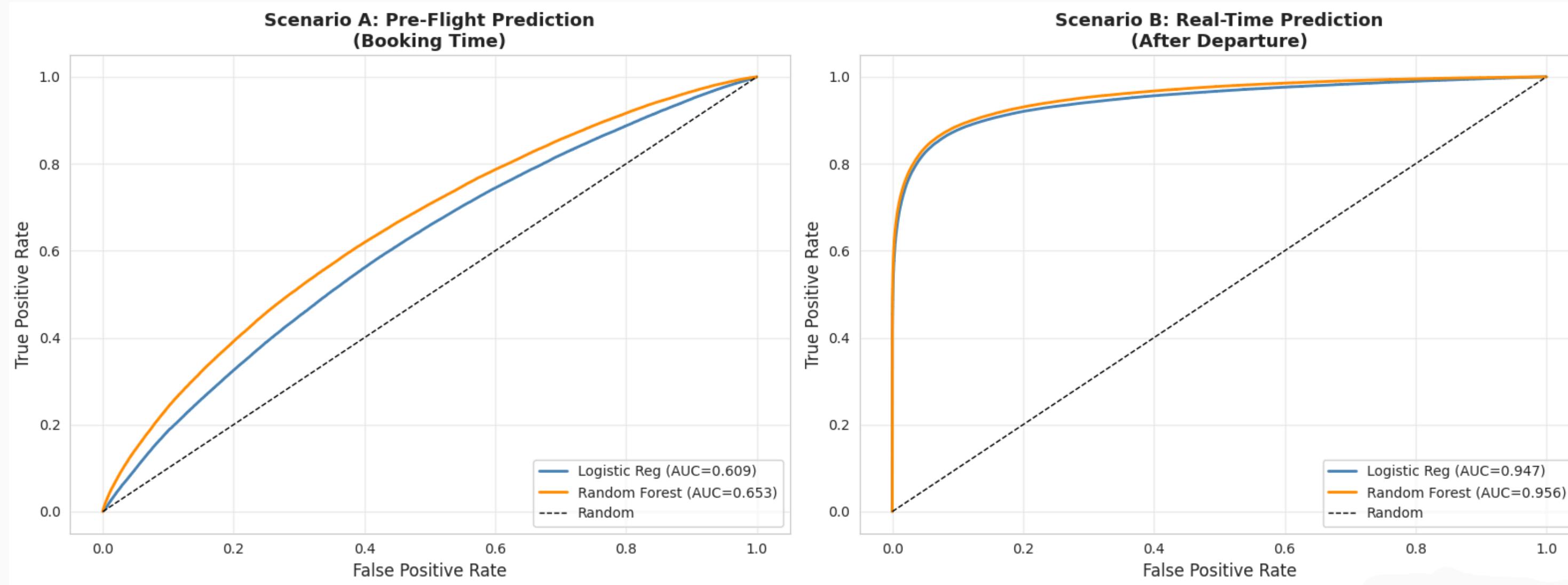
We focused on known delay facts to pinpoint largest contributors, Late Aircraft followed by carrier and NAS.

Top Destination Airports

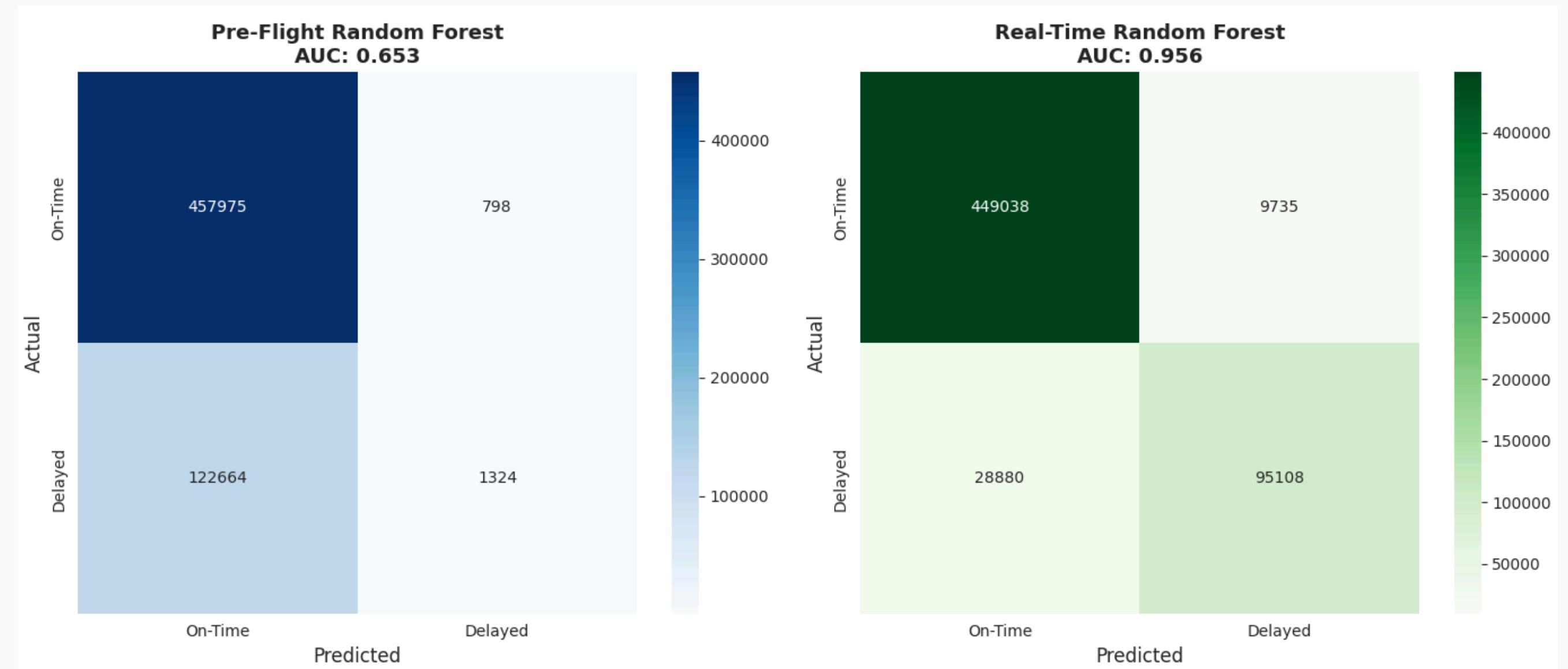
- 
- We've filtered data to focus on most frequently visited airports.
 - This is to ensure statistical reliability and meaningful results.
 - We noticed the patterns of delays are common at major airport hubs.

Predictive Modeling: Can We Forecast Flight Delays?

ROC-AUC Curve



Confusion Matrix





Limitations

- Analyzed only top 6 airports
- We've excluded the cancelled flights
- Time zones not normalized

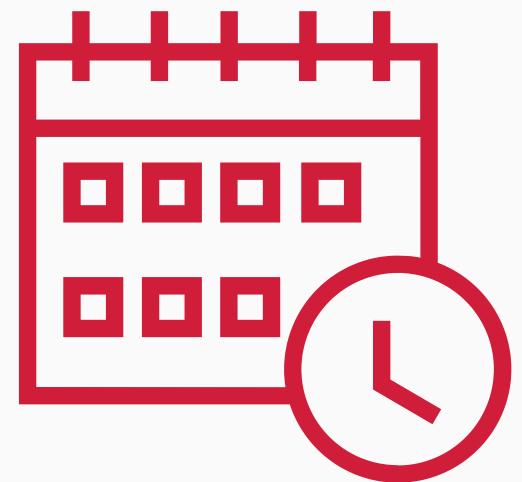


Future Work

- Cancellation classification
- Stratified sampling & cancellation
- Time series & analysis

Key Takeaways

Seasonal Patterns



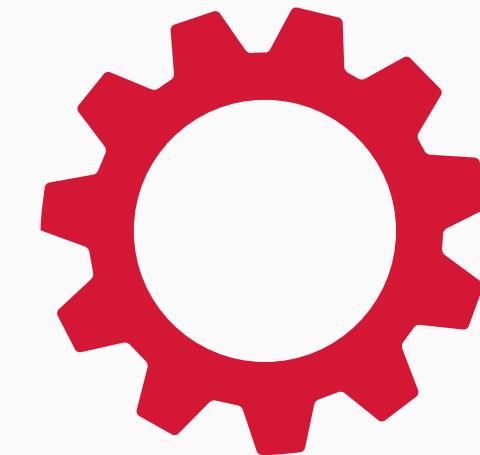
Clear Summer Peaks
each year

Carrier Differences



Strong variation in
airline by mean delay

Operations Matter



Internal processes huge
drivers of delay

THANK YOU