Flight Delay Prediction

LOOI JIA WEN | DSIF 3

CONTENTS

BACKGROUND

- Flight punctuality determines an airline's reliability & quality of service
- Airlines must constantly improve their flight punctuality to stay competitive
- Flight delay causes financial losses & decreases customers satisfaction

Average Cost of Flight Delay:

USD$7,420

per minute

SOURCE: https://www.allthingsontimeperformance.com/flight-delays-in-numbers-not-only-painful-for-passengers/

PROBLEM STATEMENT

- Accurately **predict** a flight delay
  - Airlines can prepare for delay contingency plans to cushion the loss
- Identify **features** that cause flights to delay (feature importance)
  - Plan better connecting flights and routes

DEFINING
FLIGHT DELAY

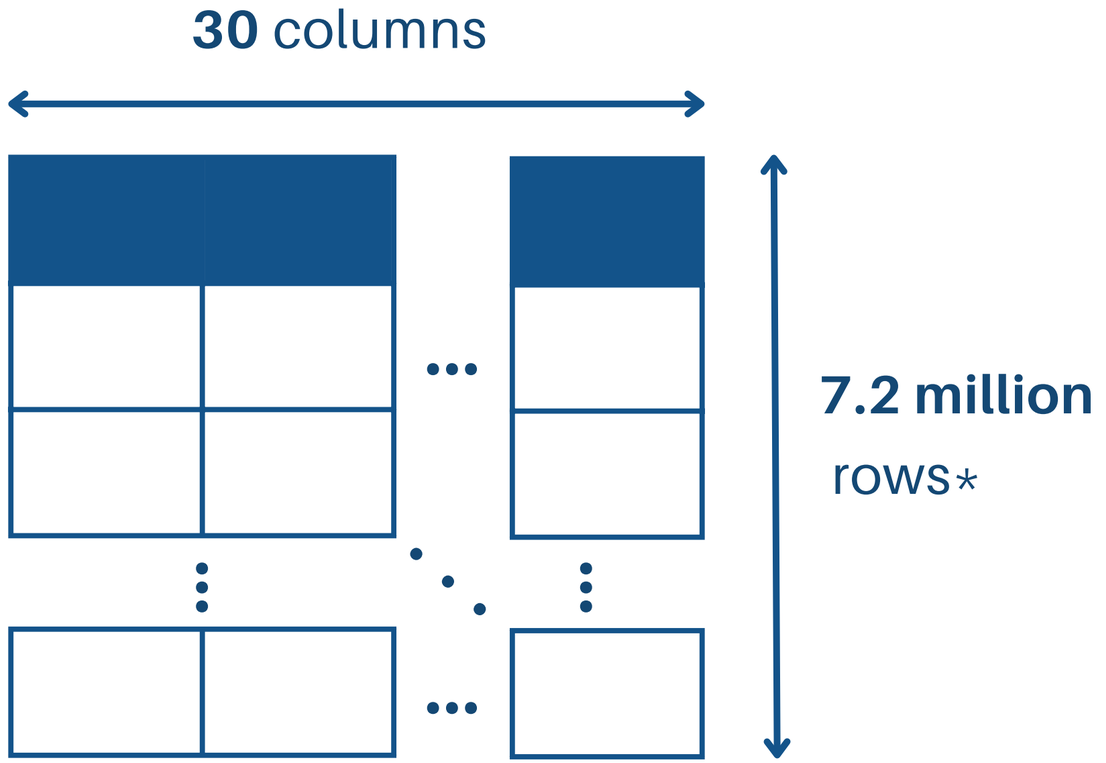
Flight takes off/lands **15 minutes** later than its scheduled time

- Federal Aviation Administration

SOURCE: https://en.wikipedia.org/wiki/Flight_cancellation_and_delay

DATASET

- Bureau of Transportation Statistics
  (United States Department of Transportation)
- Flight Data from **2019**
  (Pre-covid, peak airtravel)
- Features
  - Scheduled & Actual Flight Time
  - Origin & Destination
  - Airlines & Aircraft
  - Delay Types

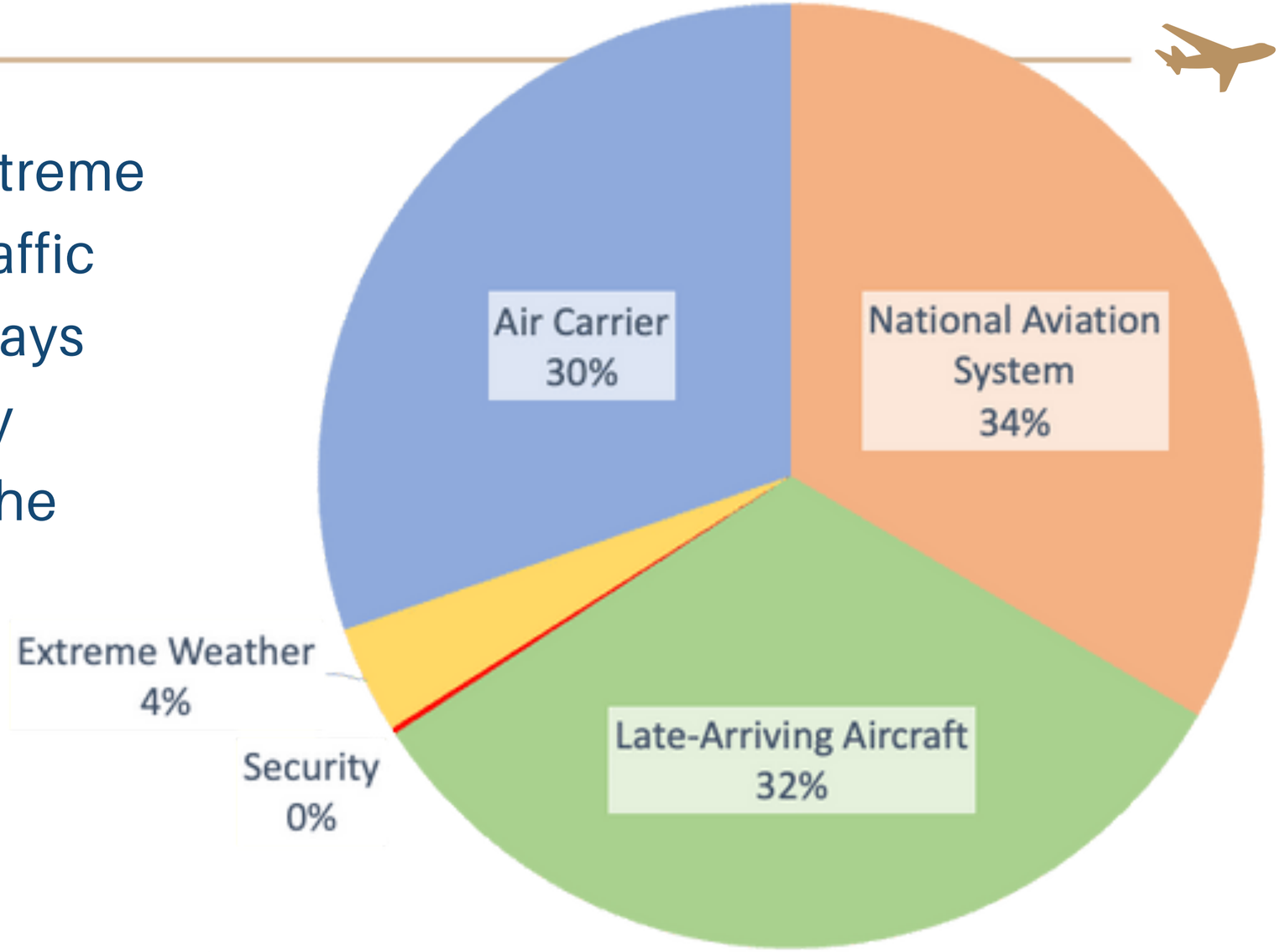


**Cancelled & Diverted flights are dropped*

SOURCE: https://www.transtats.bts.gov/

TYPES OF DELAY

1. **NAS:** Delays due to non-extreme weather conditions & air traffic
2. **Late-Arriving Aircraft:** Delays due to previous flight delay
3. **Air Carrier:** Delays within the airline's control

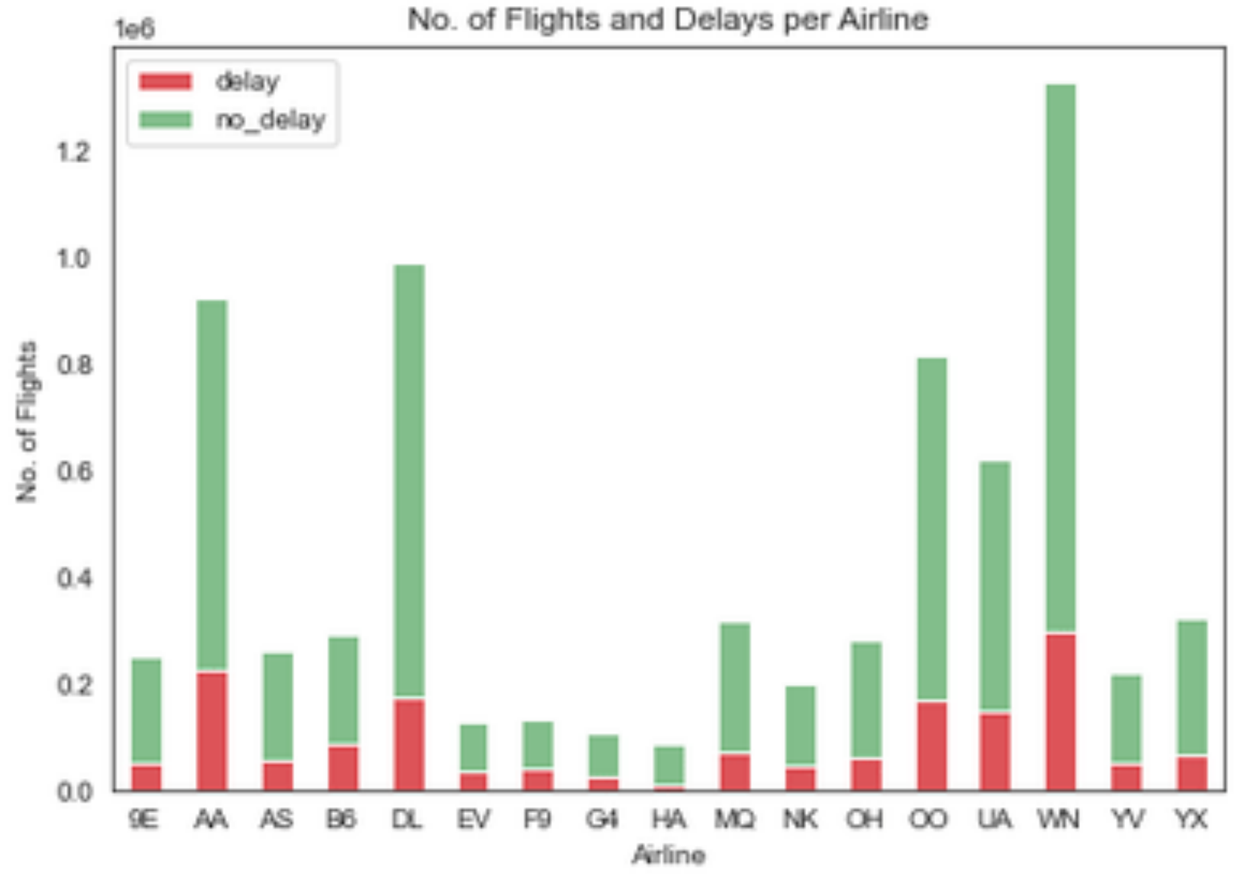


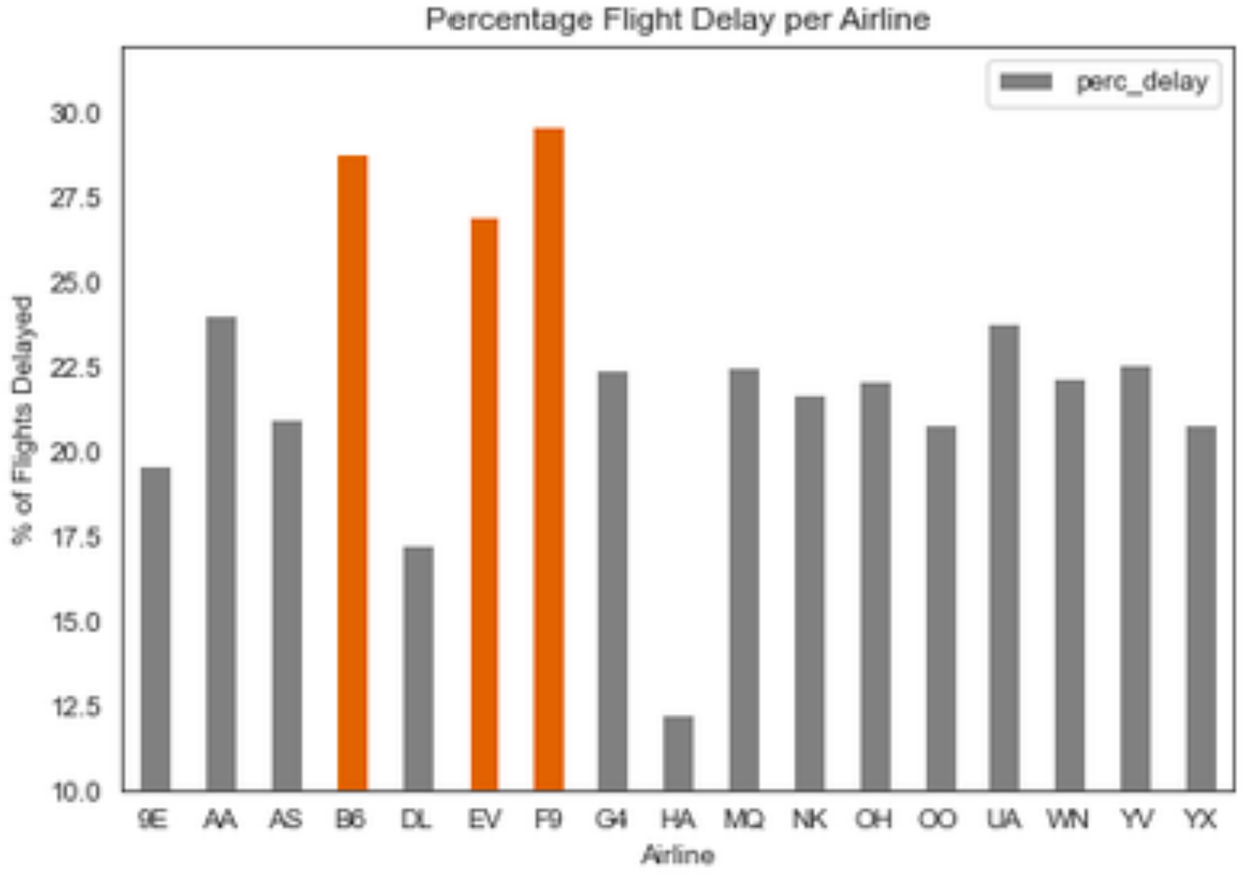
SOURCE: https://www.bts.dot.gov/topics/airlines-and-airports/understanding-reporting-causes-flight-delays-and-cancellations

AIRLINES

WITH THE HIGHEST FREQUENCY OF DELAYS

1. JetBlue (B6) - 29%
2. ExpressJet (EV) - 27%
3. Frontier (F9) - 30%

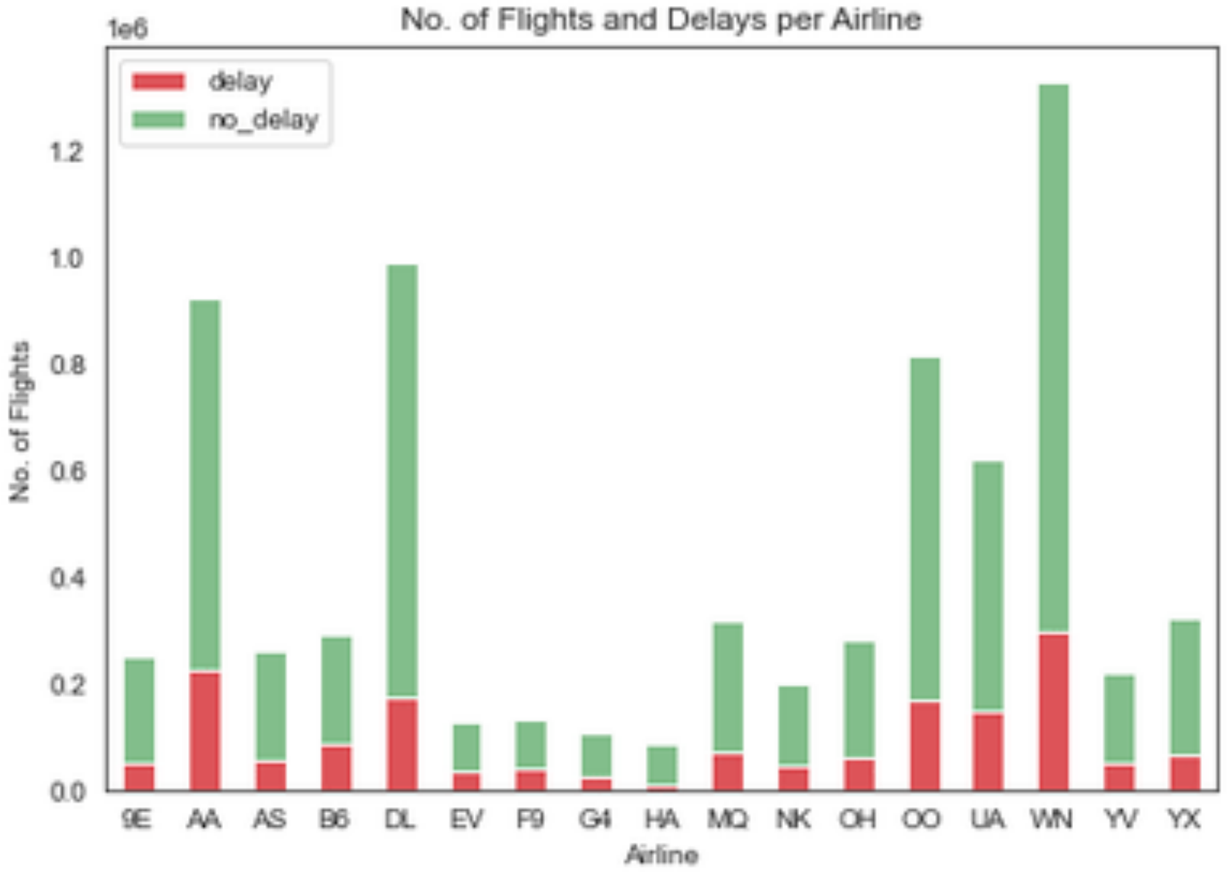


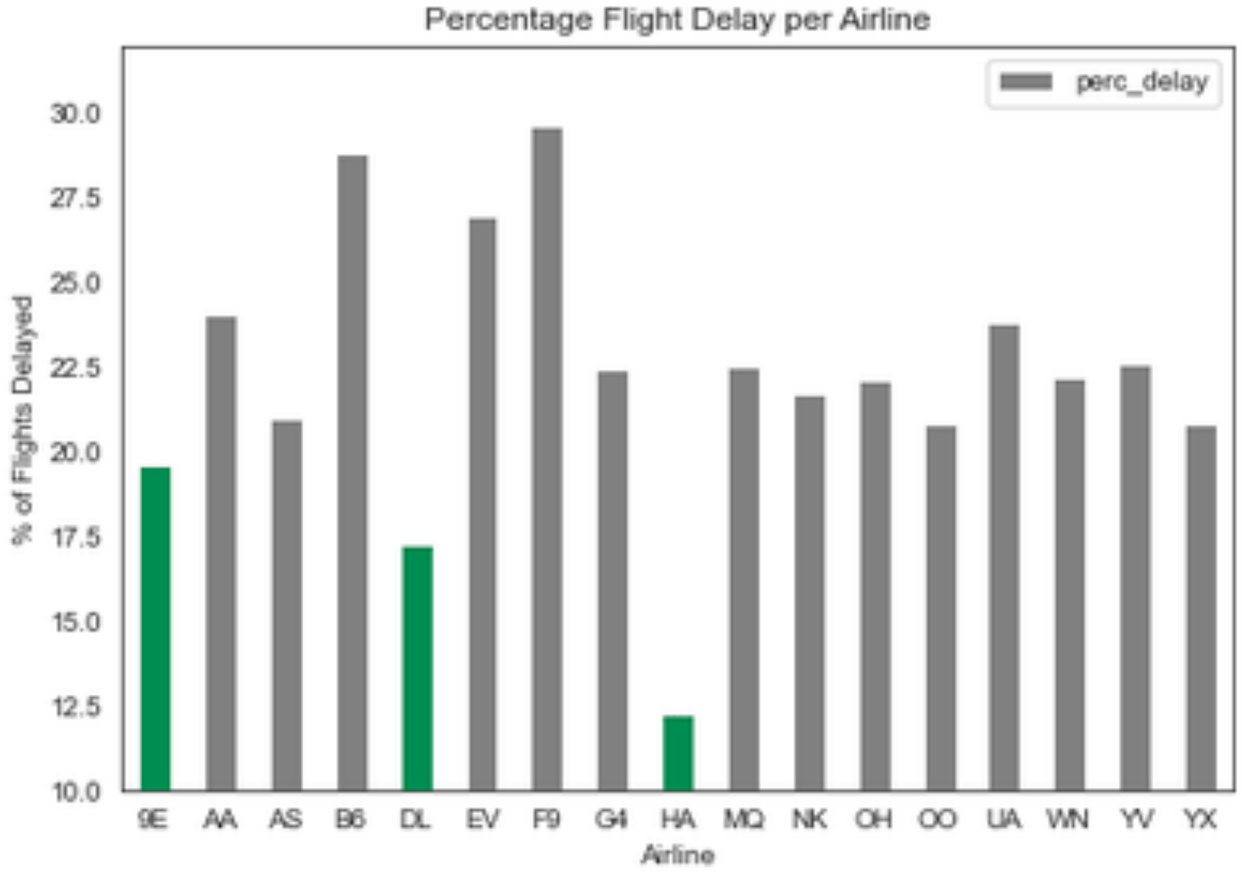


AIRLINES

WITH THE LOWEST FREQUENCY OF DELAYS

1. Hawaiian (HA) - 12%
2. Delta (DL) - 17%
3. Endeavor (9E) - 19%





FEATURE ENGINEERING

1 - Log Transform

2 - Sector per Day & Previous Sector Delay

3 - Cyclical Features Encoding

4 - Statistical Test

5 - Polynomial Features

6 - One-Hot Encoding

Dummifying our categorical features

FEATURE ENGINEERING

1 - Log Transform

2 - Sector per Day & Previous Sector Delay

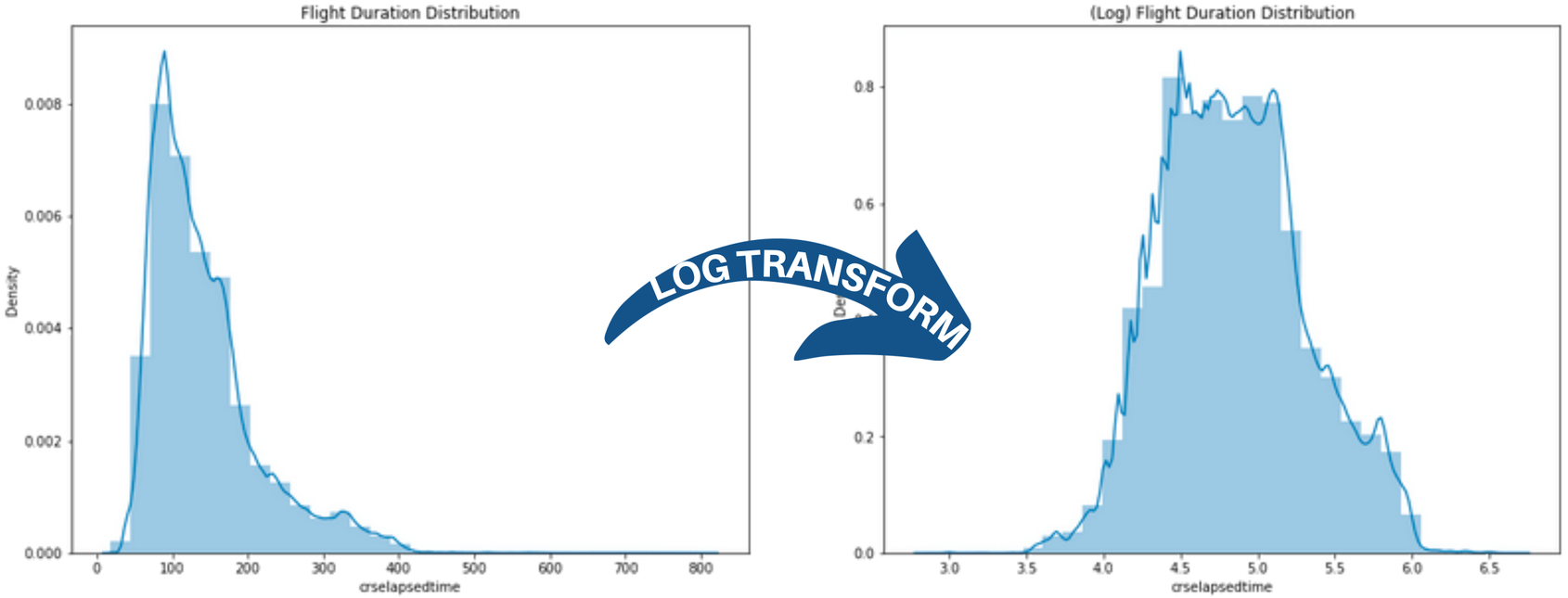
3 - Cyclical Features Encoding

4 - Statistical Test

5 - Polynomial Features

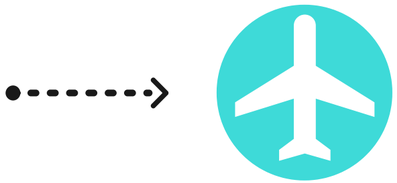
6 - One-Hot Encoding

- Flight duration & flight distance distributions are **positively skewed**
- More normally distributed after **Log-Transformation**



FEATURE ENGINEERING

1 - Log Transform



2 - Sector per Day & Previous Sector Delay

3 - Cyclical Features Encoding

4 - Statistical Test

5 - Polynomial Features

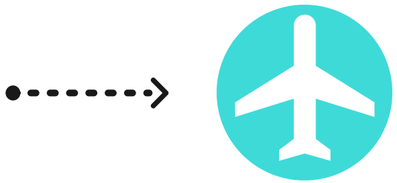
6 - One-Hot Encoding

- ***nth_sector*** covered by an aircraft in a day, in **chronological order**
- e.g., **10 Sectors** covered by flight no. N489HA on 01 Jan 2019

nth_sector	crsdeptime	origin	crsarrtime	dest
1	0503	HNL	0543	OGG
2	0611	OGG	0649	HNL
3	0725	HNL	0806	LIH
4	0834	LIH	0910	HNL
5	0950	HNL	1031	LIH
6	1059	LIH	1145	OGG
7	1215	OGG	1255	HNL
8	1405	HNL	1450	OGG
9	1518	OGG	1555	KOA
10	1625	KOA	1713	HNL

FEATURE ENGINEERING

1 - Log Transform



2 - Sector per Day & Previous Sector Delay

3 - Cyclical Features Encoding

4 - Statistical Test

5 - Polynomial Features

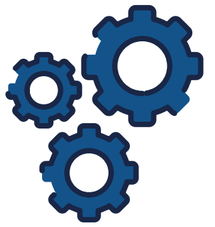
6 - One-Hot Encoding

- **Previous Sector Information**

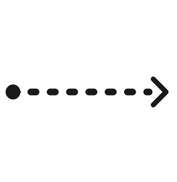
  e.g. Origin Airport, Arrival Hour, Flight Duration, Flight Distance, Time Delayed

nth_sector	origin	previous_origin	arrdelay	previous_arrdelay
1	SFB	NaN	46	NaN
2	XNA	SFB	35	46.0
3	SFB	XNA	27	35.0
4	FWA	SFB	27	27.0

FEATURE ENGINEERING



1 - Log Transform



2 - Sector per Day & Previous Sector Delay

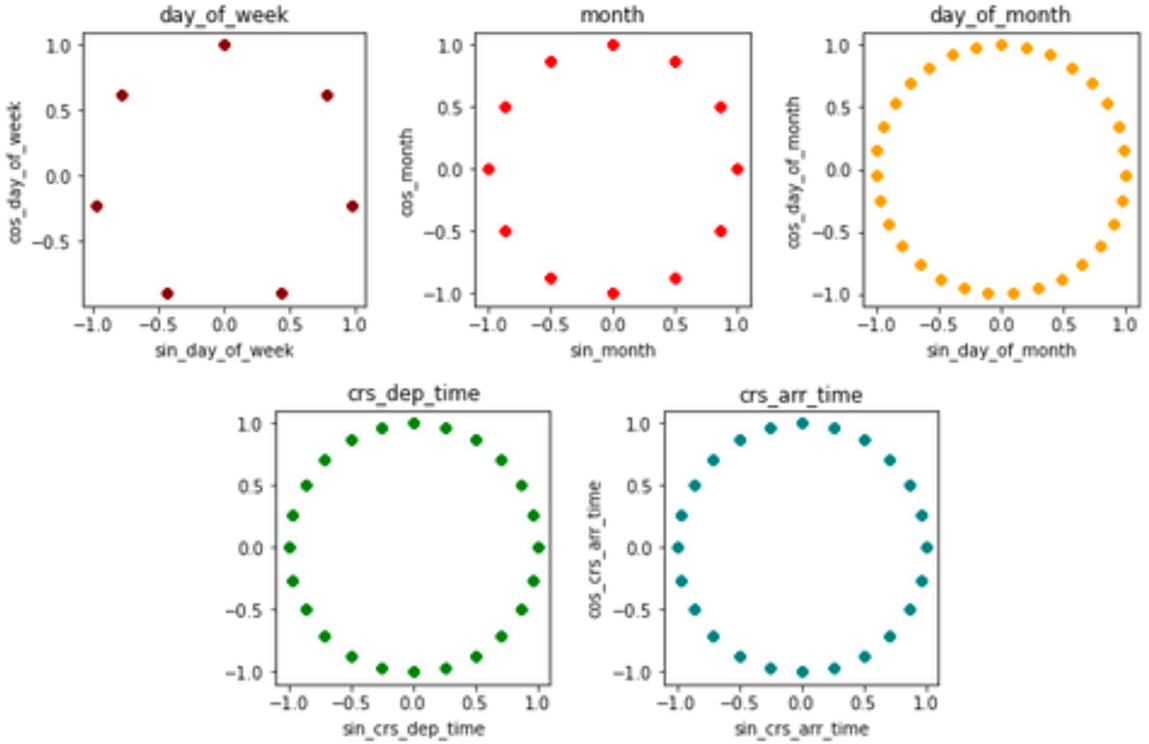
3 - Cyclical Features Encoding

4 - Statistical Test

5 - Polynomial Features

6 - One-Hot Encoding

- **Cyclical Features Encoding** by trigonometric data conversion
- Convert features into a representation that can preserve the cyclical properties of time data



SOURCE: http://blog.davidkaleko.com/feature-engineering-cyclical-features

FEATURE ENGINEERING

1 - Log Transform

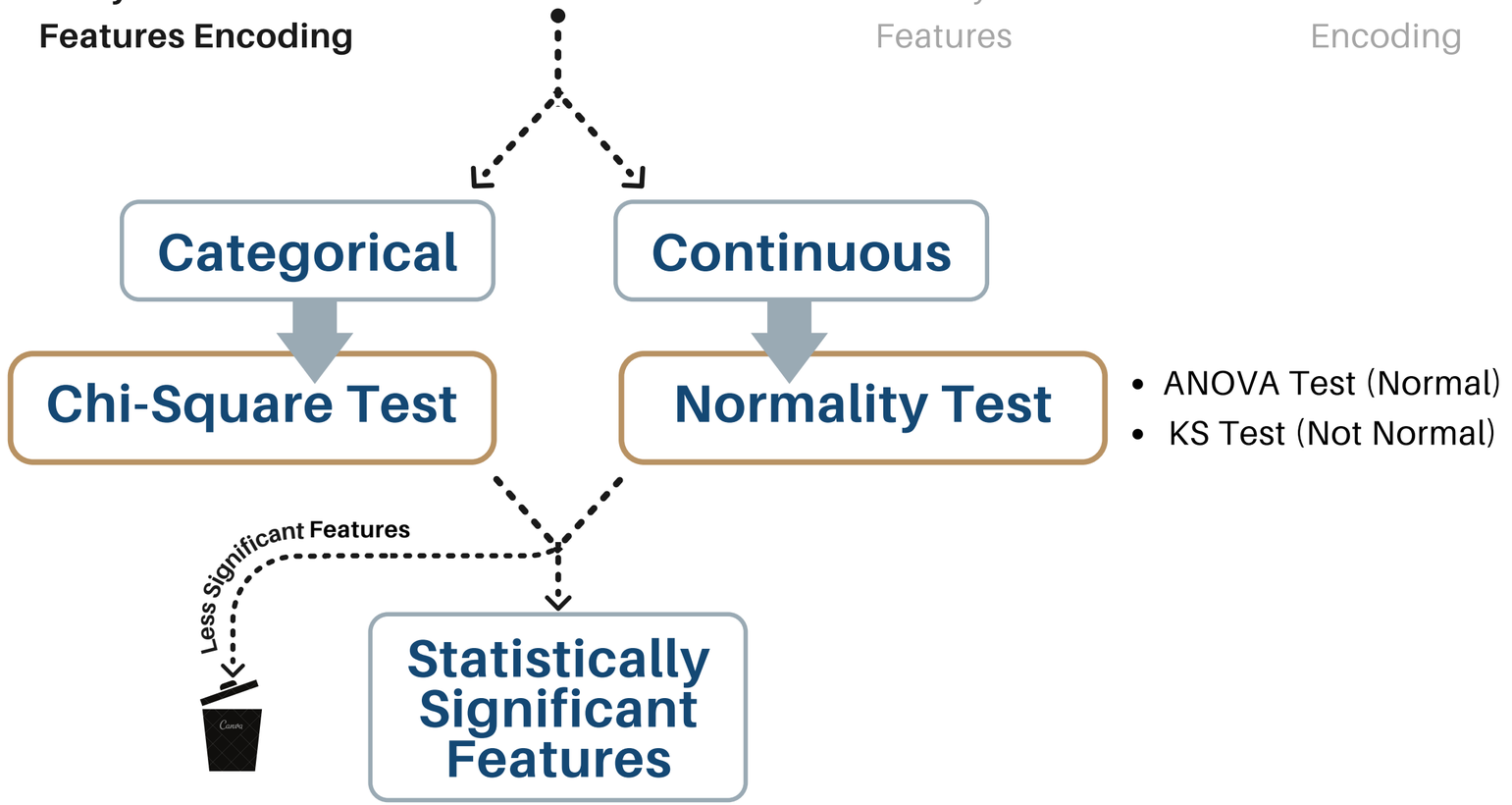
2 - Sector per Day & Previous Sector Delay

3 - Cyclical Features Encoding

4 - Statistical Test

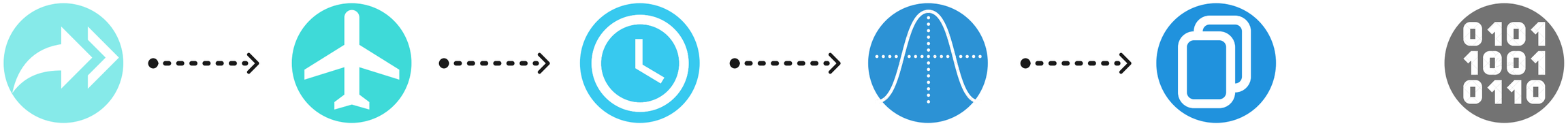
5 - Polynomial Features

6 - One-Hot Encoding



SOURCE: https://github.com/shilpaleo/customer_churn_prediction

FEATURE ENGINEERING



1 - Log Transform

2 - Sector per Day & Previous Sector Delay

3 - Cyclical Features Encoding

4 - Statistical Test

5 - Polynomial Features

6 - One-Hot Encoding

taxi out duration * log(estimated flight duration)

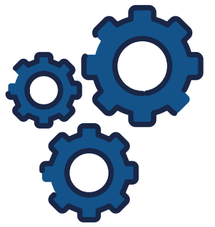
nth number of sector * taxi out duration

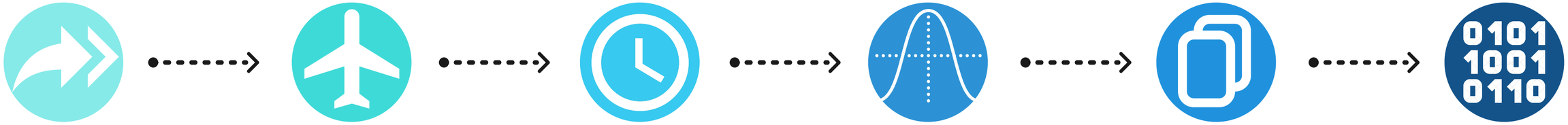
taxi out duration * taxi out duration

	delay
taxiout	0.24
taxiout_X_log_crselapsedtime	0.24
nth_sector_X_taxiout	0.23
taxiout_X_taxiout	0.23
cos_crs_arr_time	0.13
nth_sector	0.11

- Our original features have a relatively weak correlation to our target variable
- Polynomial features were manually chosen to **avoid multicollinearity** issues

FEATURE ENGINEERING





1 - Log Transform

2 - Sector per Day & Previous Sector Delay

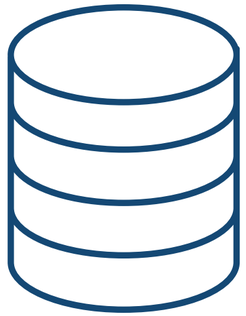
3 - Cyclical Features Encoding

4 - Statistical Test

5 - Polynomial Features

6 - One-Hot Encoding

Dummifying our categorical features



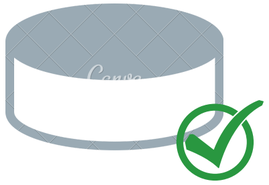
After Dummifying

~7,200K X 1,120

Choosing Dummified Feautures

based on r-value

Randomly Selecting 10% of the Data



Ready for Modelling

~720K X 50

IMBALANCED DATASET

ON-TIME (0)

DELAYED (1)

MODEL EVALUATION

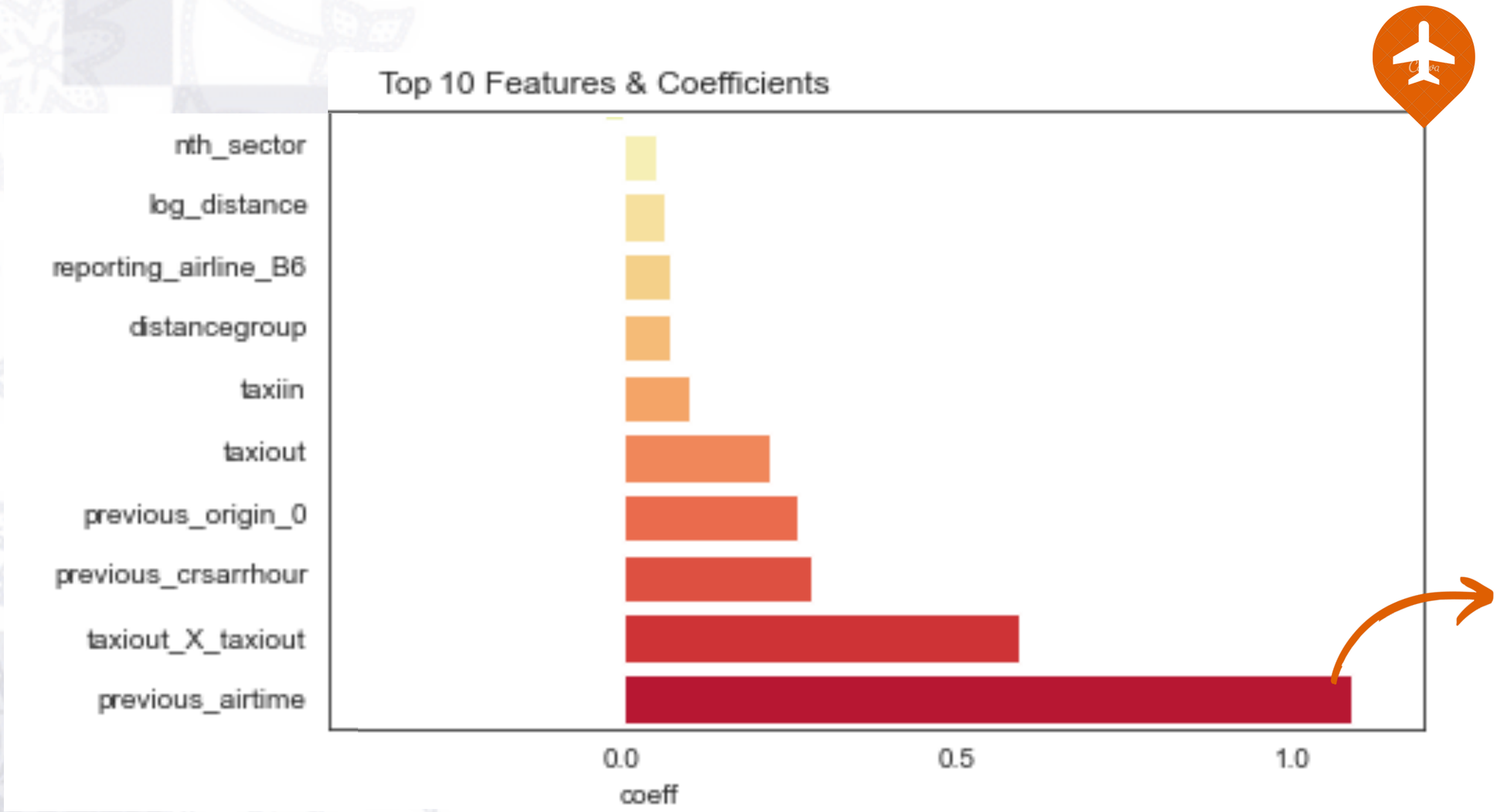
Success Metrics:
1. F1-Score
2. Recall

} Best Model: **Logistic Regression**

Model	Train	Test	Recall	F1 Score
Logistic Regression	0.6467	0.6464	**0.6211**	**0.4342**
Random Forest	0.9859	0.8011	0.1748	0.2195
AdaBoost	0.7998	0.799	0.1381	0.2195

CONFUSION MATRIX

FEATURE IMPORTANCE



Longer **previous** flight's **airtime** ⇒ higher chance of flight delay

RECOMMENDATIONS

MAINTAINING CUSTOMER SATISFACTION

Unavoidable Delays

- Notifying in advance
- Deploy extra staff
- Passenger welfare

BETTER FLIGHT PLANNING

Avoiding Delays

- ↑ Buffer time for aircraft turnaround
- ↓ Connecting flights
- ↑ Point-to-point flights

LIMITATIONS

1. Poor F1 & Precision Score

2. No International Flight Data

3. Change in Future Flight Patterns (Post-COVID)

POSSIBLE ENHANCEMENTS

01 **Handle Imbalanced Data**

Methods: SMOTE, Threshold Moving, Random Undersampling/Oversampling, Class Weights

02 **Analyse Airports**

Analyse airport delays and traffic

03 **Predict Extent of Delay**

Regression Analysis for Prediction

04 **Weather Forecast**

Complementing weather forecast to do real-time delay prediction

Thank You!