Airlines On-Time Performance, Delays, Cancellations and Diversions

Milestone 1 -

Introduction:

> Airline cancellations or delays are one of the major causes of passenger inconvenience. With the publicly available dataset, using data science, I am hoping to gain meaningful insights into the best-performing airlines and understand the causes of delays, diversions and cancellations across different airline carriers. For the final project, I would like to analyze airline data to identify different factors and their effects on a carrier's performance. As a performance measure, I would like to explore on-time arrivals, and the number of cancellations by the carrier and explore different reasons for delays and diversions. Based on the outcome, carriers can take necessary actions to focus on the problem areas.

Data Source:

- Flat File: Excel files from BTS. The Excel data has airline performance factors such as cancelled, diverted, delayed and on-time data. The downloaded raw data has up to 34 columns. https://www.transtats.bts.gov/OT_Delay/OT_DelayCause1.asp?20=E (Download Raw Data link for data).
- API: API provides historical weather information. https://visual-crossing-weather.p.rapidapi.com/history?startDateTime={}&aggregateHours=24&location={}&endDateTime={}&unitGroup=us
- Website: The website consists of a list of diverted flights. https://www.diverted.eu/

Relationships:

> The Flat file is the main data source with scheduled flight information.
>
> Flat File - API:
>
> Data from the flat file has cancellations and delays due to weather. I would like to look up the weather information for the flight date at the origin/destination of flights cancelled or delayed due to bad weather. The Bureau data has up to January 2023 data. To look up the weather for a past date, I would need historic weather data. The API gets the historic weather data for a location (origin or destination city name). This will enable us to validate if there truly was a bad weather situation for a flight to be delayed or cancelled. With this, we can also identify the cause of bad weather like storms, snow, wind, etc.
>
> - Flat file has many to many relation with the API. We will need to pass the flight date and the origin or destination city to the API to get weather information for a particular date and place.
>
>   Flat File - Website:
>
>   The flat file has a column for diverted flights but does not have any information on the cause for diversion. I would like to look up the reason for a flight being diverted. The

> website and flat file can be matched on flight date, origin and destination to lookup diverted flight information.
>
> - Flat file has many to many relation with the Website. We will need to pass the flight date and the origin and destination city to the website to get flight diversion details for a particular date and route.

Project Subject Area:

> The project aims on identifying various performance measures in airline operations. Using the statistical analysis we can gain insights into the best and least performing airline carriers and the most common reasons for delays and cancellations.

Challenges:

> The flight performance data size is huge (flat file). I would have to find ways to reduce data to a reasonable size without losing meaningful information.

Conclusion:

> For the first project milestone, I have identified data from different sources in different formats. I will be applying various data cleansing and visualization techniques on this dataset to gain meaningful insights in the upcoming project milestones.

Milestone 2 - Cleaning/Formatting Flat File Source

> Flat File: Excel files from BTS. The Excel data has airline performance factors such as cancelled, diverted, delayed and on-time data. The downloaded raw data has up to 34 columns. https://www.transtats.bts.gov/OT_Delay/OT_DelayCause1.asp?20=E (Download Raw Data link for data). The Flat file is the main data source with scheduled flight information.

In [2]:

```
# Import necessary libraries

import pandas as pd
from datetime import datetime
import numpy as np

#Milestone 3 libraries
from urllib.request import Request, urlopen
from bs4 import BeautifulSoup

#Milestone 4 libraries
#import requests
import urllib.request, urllib.parse, urllib.error
import json
import requests
import re

import sqlite3
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px
```

In [3]:

```
#Read flight data from "https://www.transtats.bts.gov/OT_Delay/OT_DelayCause1.asp?20=E"

flight_data_df = pd.read_csv('T_ONTIME_MARKETING_May.csv')
flight_data_df.head(5)
```

Out[3]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_DATE	MKT_UNIQUE_CARRIER	OP_UNIQUE_CAI
0	2022	2	5	1	7	5/1/2022 12:00:00 AM	AA	
1	2022	2	5	1	7	5/1/2022 12:00:00 AM	AA	
2	2022	2	5	1	7	5/1/2022 12:00:00 AM	AA	
3	2022	2	5	1	7	5/1/2022 12:00:00 AM	AA	
4	2022	2	5	1	7	5/1/2022 12:00:00 AM	AA	

5 rows × 39 columns

Data Transformation

i. Drop Columns

> Drop unwanted columns to reduce the data size and improve data readability. Columns that I will not be using for this project are as follows:
>
> - ORIGIN_AIRPORT_ID
> - ACTUAL_ELAPSED_TIME
> - AIR_TIME
> - FLIGHTS
> - ORIGIN_WAC
> - DEST_AIRPORT_ID
> - DEST_WAC
> - AIR_TIME

In [4]:

```
flight_data_df = flight_data_df.drop(columns=['ORIGIN_AIRPORT_ID','ACTUAL_ELAPSED_TIME',
                                   'ORIGIN_WAC','DEST_AIRPORT_ID','DEST_WAC','AIR_TIME'])
flight_data_df.head(5)
```

Out[4]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_DATE	MKT_UNIQUE_CARRIER	OP_UNIQUE_CAI
0	2022	2	5	1	7	5/1/2022 12:00:00 AM	AA	
1	2022	2	5	1	7	5/1/2022 12:00:00 AM	AA	

2	2022	2	5	1	7	5/1/2022 12:00:00 AM	AA
3	2022	2	5	1	7	5/1/2022 12:00:00 AM	AA
4	2022	2	5	1	7	5/1/2022 12:00:00 AM	AA

5 rows × 32 columns

ii. Look for Duplicates

> Duplicates cause inconsistent results when dealing with statistics. Hence dropping duplicate rows.

In [5]:
```
print('Dataframe before dropping duplicates :', flight_data_df.shape)
flight_data_df = flight_data_df.drop_duplicates() # 1,389 rows dropped
print('Dataframe after dropping duplicates :',flight_data_df.shape)
```

```
Dataframe before dropping duplicates : (602950, 32)
Dataframe after dropping duplicates : (601561, 32)
```

iii. Replace values in a column

> Cancellation code is represented as A, B, C and D, which is not very informative. The BTS website provided details on this code as follows:

```
- A Carrier

- B Weather

- C National Air System

- D Security
```

In [6]:
```
flight_data_df.CANCELLATION_CODE = np.where(flight_data_df.CANCELLATION_CODE=='A', 'Carr
                                  np.where(flight_data_df.CANCELLATION_CODE=='B', 'Weathe
                                           np.where(flight_data_df.CANCELLATION_CODE=='C'
                                                    np.where(flight_data_df.CANCELLATION_

flight_data_df.groupby(['CANCELLATION_CODE'])['CANCELLATION_CODE'].count().sort_index()
```

Out[6]:
```
CANCELLATION_CODE
                       590957
Carrier                  4902
National Air System      1394
Security                    1
Weather                  4307
Name: CANCELLATION_CODE, dtype: int64
```

In [7]:
```
flight_data_df.FL_DATE = pd.to_datetime(flight_data_df['FL_DATE'], format='%m/%d/%Y %H:%
flight_data_df.head(5)
#5/1/2022 12:00:00 AM
```

Out[7]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_DATE	MKT_UNIQUE_CARRIER	OP_UNIQUE_CAI

0	2022	2	5	1	7	2022-05-01	AA
1	2022	2	5	1	7	2022-05-01	AA
2	2022	2	5	1	7	2022-05-01	AA
3	2022	2	5	1	7	2022-05-01	AA
4	2022	2	5	1	7	2022-05-01	AA

5 rows × 32 columns

iv. Rename Column

> To make more sense of the information in cancellation_code, replacing the column to cancellation reason.

In [8]:

```
flight_data_df = flight_data_df.rename(columns={"CANCELLATION_CODE": "CANCELLATION_REASO
flight_data_df.columns
```

Out[8]:

```
Index(['YEAR', 'QUARTER', 'MONTH', 'DAY_OF_MONTH', 'DAY_OF_WEEK', 'FL_DATE',
       'MKT_UNIQUE_CARRIER', 'OP_UNIQUE_CARRIER', 'ORIGIN', 'ORIGIN_CITY_NAME',
       'ORIGIN_STATE_ABR', 'ORIGIN_STATE_NM', 'DEST', 'DEST_CITY_NAME',
       'DEST_STATE_ABR', 'DEST_STATE_NM', 'DEP_DELAY', 'DEP_DELAY_NEW',
       'TAXI_OUT', 'TAXI_IN', 'ARR_TIME', 'ARR_DELAY', 'ARR_DELAY_NEW',
       'CANCELLED', 'CANCELLATION_REASON', 'DIVERTED', 'DISTANCE',
       'CARRIER_DELAY', 'WEATHER_DELAY', 'NAS_DELAY', 'SECURITY_DELAY',
       'LATE_AIRCRAFT_DELAY'],
      dtype='object')
```

v. Add new columns

STATUS

In [9]:

```
#Adding a new column 'STATUS' that tells the status of a flight
flight_data_df['STATUS'] = ''

flight_data_df.STATUS = np.where(flight_data_df.CANCELLED==1, 'Cancelled',
                                 np.where(flight_data_df.DIVERTED==1, 'Diverted',
                                          np.where(flight_data_df.ARR_DELAY<=15, 'On-Tim
                                                   np.where(flight_data_df.ARR_DELAY>15,
flight_data_df.groupby(['STATUS'])['STATUS'].count().sort_index()
```

Out[9]:

```
STATUS
Cancelled     10604
Delayed      119624
Diverted       1581
On-Time      469752
Name: STATUS, dtype: int64
```

DELAYED

> As a step to data reduction, I will be considering flights arriving 15 minutes or later as delayed

In [10]:

```
#Creating a new column 'DELAYED'. A flag that represents if a flight was delayed. Simila

flight_data_df.loc[(flight_data_df['ARR_DELAY']>15), 'DELAYED'] = True
flight_data_df.loc[(flight_data_df['ARR_DELAY']<=15), 'DELAYED'] = False

flight_data_df.groupby(['DELAYED'])['DELAYED'].count().sort_index()
```

Out[10]:

```
DELAYED
False    469752
True     119624
Name: DELAYED, dtype: int64
```

DELAY REASON

In [11]:

```
#Adding a new column 'DELAY_REASON' that tells the reason for a flight getting delayed
#Using the newly created DELAYED flag and the available columns for each type of delay t

flight_data_df['DELAY_REASON'] = np.where(((flight_data_df.DELAYED==True) & (flight_data
                                          np.where(((flight_data_df.DELAYED==True) & (fl
                                                   np.where(((flight_data_df.DELAYED==Tr
                                                            np.where(((flight_data_df.DE
                                                                     np.where(((flight_d

flight_data_df.groupby(['DELAY_REASON'])['DELAY_REASON'].count().sort_index()
```

Out[11]:

```
DELAY_REASON
                   481937
Carrier             72453
LateAircraft        25504
NAS                 17384
Security              131
Weather              4152
Name: DELAY_REASON, dtype: int64
```

vi. Implementing arithmetic functions for statistical analysis

In [12]:

```
# Create a new dataframe with total number of flights per operating carrier to calculate

flight_totals = flight_data_df.value_counts(subset=['OP_UNIQUE_CARRIER']).reset_index()
flight_totals_df = pd.DataFrame(flight_totals) # Convert to dataframe
flight_totals_df.columns = ['OP_UNIQUE_CARRIER','TOTAL'] # Assign Column names
flight_totals_df['PERCENTAGE'] = round(flight_totals_df.TOTAL/flight_totals_df.TOTAL.sum

flight_totals_df = flight_totals_df.sort_values('PERCENTAGE',ascending=False) #Sort by p
flight_totals_df.head(5)
```

Out[12]:

	OP_UNIQUE_CARRIER	TOTAL	PERCENTAGE
0	WN	107950	17.94
1	DL	76021	12.64
2	AA	71471	11.88
3	OO	66615	11.07
4	UA	53535	8.90

In [13]:

```
# Calculate percentage by carrier and flight status
flight_status = flight_data_df.value_counts(subset=['OP_UNIQUE_CARRIER','STATUS']).reset
flight_status_df = pd.DataFrame(flight_status) #create a dataframe
flight_status_df.columns = ['OP_UNIQUE_CARRIER','STATUS', 'COUNT'] #Add column names
flight_status_df = flight_status_df.sort_values('OP_UNIQUE_CARRIER') #Sort by operating

flight_status_df['PERCENTAGE'] = ''
```

```
for index, row in flight_status_df.iterrows():
    tot = flight_totals.loc[flight_totals.OP_UNIQUE_CARRIER==row.OP_UNIQUE_CARRIER].TOTA
    val = (row.COUNT/tot * 100)
    flight_status_df.at[index,'PERCENTAGE'] = round(val[0].astype(float),2) #Calculate t

flight_status_df.head(10)
```

Out[13]:

	OP_UNIQUE_CARRIER	STATUS	COUNT	PERCENTAGE
33	9E	Delayed	3113	15.33
48	9E	Cancelled	542	2.67
74	9E	Diverted	35	0.17
8	9E	On-Time	16613	81.83
41	AA	Cancelled	973	1.36
56	AA	Diverted	215	0.3
3	AA	On-Time	55403	77.52
11	AA	Delayed	14880	20.82
47	AS	Cancelled	608	3.12
10	AS	On-Time	15502	79.49

In [14]:

```
#Create a new dataframe with the percentage by origin airport and status
flight_origin_totals = flight_data_df.value_counts(subset=['ORIGIN']).reset_index() #get
flight_origin_totals_df = pd.DataFrame(flight_origin_totals) #create a dataframe
flight_origin_totals_df.columns = ['ORIGIN','TOTAL'] #Add column names
flight_origin_totals_df['PERCENTAGE'] = round(flight_origin_totals_df.TOTAL/flight_origi


origin_airport_delays = flight_data_df.value_counts(subset=['ORIGIN','STATUS']).reset_in
origin_airport_df = pd.DataFrame(origin_airport_delays) #create a dataframe
origin_airport_df.columns = ['ORIGIN','STATUS', 'COUNT'] #add column names
origin_airport_df = origin_airport_df.sort_values('ORIGIN') #sort by origin
origin_airport_df['PERCENTAGE'] = ''

for index, row in origin_airport_df.iterrows():
    tot = flight_origin_totals.loc[flight_origin_totals.ORIGIN==row.ORIGIN].TOTAL.values
    val = (row.COUNT/tot * 100)
    origin_airport_df.at[index,'PERCENTAGE'] = round(val[0].astype(float),2) #calulate t

origin_airport_df = origin_airport_df.sort_values('PERCENTAGE',ascending=False) #sort by

origin_airport_df.head(10)
```

Out[14]:

	ORIGIN	STATUS	COUNT	PERCENTAGE
770	GST	On-Time	12	100.0
1208	STC	On-Time	1	100.0
385	LWS	On-Time	95	96.94
623	BGM	On-Time	30	96.77
470	DRT	On-Time	60	96.77
517	PLN	On-Time	51	96.23
488	MCW	On-Time	55	94.83
490	FOD	On-Time	55	94.83

515	TBN	On-Time	51	94.44
529	LAR	On-Time	50	94.34

vii. NULL check

In [15]:
```
#Looking for null values to further reduce the data size.
flight_data_df.isnull().sum()
```

Out[15]:
```
YEAR                          0
QUARTER                       0
MONTH                         0
DAY_OF_MONTH                  0
DAY_OF_WEEK                   0
FL_DATE                       0
MKT_UNIQUE_CARRIER            0
OP_UNIQUE_CARRIER             0
ORIGIN                        0
ORIGIN_CITY_NAME              0
ORIGIN_STATE_ABR              0
ORIGIN_STATE_NM               0
DEST                          0
DEST_CITY_NAME                0
DEST_STATE_ABR                0
DEST_STATE_NM                 0
DEP_DELAY                 10201
DEP_DELAY_NEW             10201
TAXI_OUT                  10558
TAXI_IN                   10769
ARR_TIME                  10769
ARR_DELAY                 12185
ARR_DELAY_NEW             12185
CANCELLED                     0
CANCELLATION_REASON           0
DIVERTED                      0
DISTANCE                      0
CARRIER_DELAY            477611
WEATHER_DELAY            477611
NAS_DELAY                477611
SECURITY_DELAY           477611
LATE_AIRCRAFT_DELAY      477611
STATUS                        0
DELAYED                   12185
DELAY_REASON                  0
dtype: int64
```

> Based on the above, it doesn't appear there are any null rows that are irrelevant. Status is a significant column that tells if there are any flights with no relevant status. All flights are now categorized under On-Time, Delayed, Cancelled or Diverted.

> The final flat file dataset is as follows:

In [16]:
```
print(flight_data_df.columns)
flight_data_df.head(5)
```

```
Index(['YEAR', 'QUARTER', 'MONTH', 'DAY_OF_MONTH', 'DAY_OF_WEEK', 'FL_DATE',
       'MKT_UNIQUE_CARRIER', 'OP_UNIQUE_CARRIER', 'ORIGIN', 'ORIGIN_CITY_NAME',
       'ORIGIN_STATE_ABR', 'ORIGIN_STATE_NM', 'DEST', 'DEST_CITY_NAME',
       'DEST_STATE_ABR', 'DEST_STATE_NM', 'DEP_DELAY', 'DEP_DELAY_NEW',
       'TAXI_OUT', 'TAXI_IN', 'ARR_TIME', 'ARR_DELAY', 'ARR_DELAY_NEW',
       'CANCELLED', 'CANCELLATION_REASON', 'DIVERTED', 'DISTANCE',
       'CARRIER_DELAY', 'WEATHER_DELAY', 'NAS_DELAY', 'SECURITY_DELAY',
       'LATE_AIRCRAFT_DELAY', 'STATUS', 'DELAYED', 'DELAY_REASON'],
      dtype='object')
```

Out[16]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_DATE	MKT_UNIQUE_CARRIER	OP_UNIQUE_CA
0	2022	2	5	1	7	2022-05-01	AA	
1	2022	2	5	1	7	2022-05-01	AA	
2	2022	2	5	1	7	2022-05-01	AA	
3	2022	2	5	1	7	2022-05-01	AA	
4	2022	2	5	1	7	2022-05-01	AA	

5 rows × 35 columns

Ethical implications:

> BTS data - Flat File I do not see any ethical implications for this dataset as it is from a federal government source and is made accessible to public. The only concern I have is that, the dataset I am referring to is old and it's possible the trend has changed over time. The reason for using old dataset is because I need the flight diversion information which I was only able to find for the year 2022.

Conclusion:

> As a part of this milestone, the following Data Transformation steps have been performed.
>
> 1. Dropped columns
> 2. Dropped duplicate rows
> 3. Replaced values in a dataframe column
> 4. Renamed a column
> 5. Added new columns to the dataframe
> 6. Implemented arithmetic functions for statistical analysis
> 7. Performed null check to drop rows with null values.

Milestone 3 - Cleaning/Formatting Website Data

> Flat File - Website: The flat file has a column for diverted flights but does not have any information on the cause for diversion. I would like to look up the reason for a flight being diverted. The website and flat file can be matched on flight date, origin and destination to lookup diverted flight information. Flat file has many to many relation with the Website. We will need to pass the flight date and the origin and destination city to the website to get flight diversion details for a particular date and route.

In [17]:

```
url = 'https://www.diverted.eu/' #Website with diverted flight information
```

In [18]:

```
# Parsing HTML using BeautifulSoup
html = urlopen(url)
soup = BeautifulSoup(html, 'html.parser')
```

In [19]:

```
#Parse HTML for the diverted data table
flight_diverted_table = soup.findAll("table", { 'id' : 'tablepress-current_month' })
```

In [20]:

```
#Load the data table to a dataframe
flight_diverted_table = pd.read_html(str(flight_diverted_table))
flight_diverted_df = flight_diverted_table[0]
flight_diverted_df
```

Out[20]:

	Date	Airlines/Operator	Flight number	Departure airport	Destination airport	Diverted to	Emergency code	Alleged reason	Airc
0	20.07.2022	Go First	G8151 / GOW151	Delhi	Guwahati	Jaipur	NaN	cracked windshield	Ai A3 2
1	20.07.2022	Wizz Air	W65058 / WZZ101S	Bari	Krakow	Budapest	NaN	bomb threat	Ai A3 27
2	19.07.2022	Go First	G8386 / GOW386	Mumbai	Leh	Delhi	NaN	engine issue	Ai A3 2
3	19.07.2022	Go First	G86202 / GOW6202	Srinagar	Delhi	Srinagar	NaN	engine issue	Ai A3 2
4	19.07.2022	LOT	LO6297 / LOT6297	Prague	Zanzibar	Warsaw	NaN	brakes issue	Boe 78 Dreaml
...	...	...	...	...	...	...	...	...	
679	04.11.2021	Azul Linhas Aéreas	AD4327 / AZU4327	Goiani	Campinas	Brasilia	NaN	technical issue	Emb E19
680	02.11.2021	United Airlines	UA818 / UAL818	Buenos Aires	Houston	Buenos Aires	NaN	pressurisation issue	Boe 78 Dreaml
681	01.11.2021	Delta Air Lines	DL9962 / DAL9962	Atlanta	Key West	Atlanta	NaN	airspeed issue	Ai A319-
682	01.11.2021	Delta Air Lines	DL365 / DAL365	Atlanta	Los Angeles	Dallas	NaN	disruptive passenger	Ai A321-
683	01.11.2021	El Al	LY82 / ELY082	Bangkok	Tel Aviv	Goa	NaN	possible fuel (system) issue	Boe 78 Dreaml

684 rows × 10 columns

# Another way of reading html data without having to parse it #Read Diverted data from "https://www.diverted.eu/" into a dataframe url = 'https://www.diverted.eu/' df = pd.read_html(url) data = df[0]

Data Transformation

String to Date conversion

In [21]:

```
flight_diverted_df.Date.dtype
```

Out[21]:

```
dtype('O')
```

> Flight date is formatted as a string (Pandas type 'O' is a string).

In [22]:

```
#Format Flight date from string to Date
flight_diverted_df.Date = pd.to_datetime(flight_diverted_df["Date"], format='%d.%m.%Y').
flight_diverted_df.head(5)
```

Out[22]:

	Date	Airlines/Operator	Flight number	Departure airport	Destination airport	Diverted to	Emergency code	Alleged reason	Aircraft	Regi
0	2022-07-20	Go First	G8151 / GOW151	Delhi	Guwahati	Jaipur	NaN	cracked windshield	Airbus A320-271N	
1	2022-07-20	Wizz Air	W65058 / WZZ101S	Bari	Krakow	Budapest	NaN	bomb threat	Airbus A321-271NX	
2	2022-07-19	Go First	G8386 / GOW386	Mumbai	Leh	Delhi	NaN	engine issue	Airbus A320-271N	
3	2022-07-19	Go First	G86202 / GOW6202	Srinagar	Delhi	Srinagar	NaN	engine issue	Airbus A320-271N	
4	2022-07-19	LOT	LO6297 / LOT6297	Prague	Zanzibar	Warsaw	NaN	brakes issue	Boeing 787-9 Dreamliner	

Filter Flights by Date

> Only select data for May'22, since our excel data is for May 2022

In [23]:

```
diverted_df = flight_diverted_df[(flight_diverted_df.Date >= pd.to_datetime("2022-05-01"
```

In [24]:

```
diverted_df.head(5)
```

Out[24]:

	Date	Airlines/Operator	Flight number	Departure airport	Destination airport	Diverted to	Emergency code	Alleged reason	Aircraft	Re
147	2022-05-31	Virgin Australia	VA9223 / VOZ9223	Perth	Boolgeeda	Perth	NaN	hydraulic issue	Airbus A320-232	
148	2022-05-31	Aer Lingus	EI3326 / EAI26MH	Dublin	Manchester	Dublin	7700.0	technical issue	ATR 72-600	
149	2022-05-30	American Airlines	AA720 / AAL720	Charlotte	Rome	Charlotte	NaN	maintenance issue	Boeing 777-223(ER)	
150	2022-05-29	Swiss	LX340 / SWR340V	Zurich	London	Zurich	NaN	odor in cockpit	Airbus A220-100	
151	2022-05-29	Qantas	QF2008 / QLK8D	Sydney	Tamworth	Sydney	NaN	hydraulic issue	De Havilland	

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Repalce Headers

In [25]:
```
#Columns before renaming
diverted_df.columns
```

Out[25]:
```
Index(['Date', 'Airlines/Operator', 'Flight number', 'Departure airport',
       'Destination airport', 'Diverted to', 'Emergency code',
       'Alleged reason', 'Aircraft', 'Registration'],
      dtype='object')
```

In [26]:
```
#Renaming columns
diverted_df.columns = ['FL_DATE', 'OP_UNIQUE_CARRIER_NAME', 'FL_NUM', 'ORIGIN_CITY', 'DE
```

In [27]:
```
#Columns after renaming
diverted_df.head(5)
```

Out[27]:

	FL_DATE	OP_UNIQUE_CARRIER_NAME	FL_NUM	ORIGIN_CITY	DEST_CITY	DIVERTED_TO	EMERGENCY_CODE
147	2022-05-31	Virgin Australia	VA9223 / VOZ9223	Perth	Boolgeeda	Perth	NaN
148	2022-05-31	Aer Lingus	EI3326 / EAI26MH	Dublin	Manchester	Dublin	7700.0
149	2022-05-30	American Airlines	AA720 / AAL720	Charlotte	Rome	Charlotte	NaN
150	2022-05-29	Swiss	LX340 / SWR340V	Zurich	London	Zurich	NaN
151	2022-05-29	Qantas	QF2008 / QLK8D	Sydney	Tamworth	Sydney	NaN

In [28]:
```
diverted_df['OP_UNIQUE_CARRIER'] = diverted_df.FL_NUM.str.slice(0, 2).astype(str)

#diverted_df['ORIGIN'] = diverted_df.FL_NUM.str.slice(0, 2).astype(str)
```

```
C:\Users\aarti\AppData\Local\Temp\ipykernel_74008\2621418547.py:1: SettingWithCopyWarnin
g:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
  diverted_df['OP_UNIQUE_CARRIER'] = diverted_df.FL_NUM.str.slice(0, 2).astype(str)
```

Drop rows

Drop null rows, if any

In [29]:
```
print('Data before dropping null rows : ',diverted_df.shape)
diverted_df.dropna()
print('Data after dropping null rows : ', diverted_df.shape)
```

```
Data before dropping null rows :  (87, 11)
Data after dropping null rows :  (87, 11)
```

> No null rows to drop

Drop duplicates, if any

In [30]:
```
print('Dataframe before dropping duplicates :', diverted_df.shape)
diverted_df = diverted_df.drop_duplicates()
print('Dataframe after dropping duplicates :',diverted_df.shape)
#No duplicates in the website data table
```

```
Dataframe before dropping duplicates : (87, 11)
Dataframe after dropping duplicates : (87, 11)
```

Update rows

> Look for rows with inconsistent reason for diversion

In [31]:
```
diverted_df.groupby(['DIVERTED_REASON'])['DIVERTED_REASON'].count()
```

Out[31]:
```
DIVERTED_REASON
air conditioning issue          1
bird strike                     8
bomb threat                     1
brakes issue                    1
cracked windshield              1
disruptive passenger            5
engine issue                    4
hydraulic issue                 5
landing gear issue              3
maintenance issue               1
medical emergency              14
odor in cockpit                 1
odor on board                   2
operational reasons             1
possible landing gear issue     1
possible medical emergency      1
possible technical issue        2
pressurisation issue            6
smell on board                  3
smoke indication                1
smoke on board                  1
technical issue                 8
weather radar issue             1
winglet issue                   1
“rostering error”               1
Name: DIVERTED_REASON, dtype: int64
```

> Rostering error has unwanted quotes. Removing them for consistency.

In [32]:
```
diverted_df.loc[diverted_df.DIVERTED_REASON == '“rostering error”', 'DIVERTED_REASON'] =
```

In [33]:
```
#Validate data after update
diverted_df.groupby(['DIVERTED_REASON'])['DIVERTED_REASON'].count()
```

Out[33]:
```
DIVERTED_REASON
air conditioning issue          1
bird strike                     8
bomb threat                     1
brakes issue                    1
cracked windshield              1
```

```
disruptive passenger            5
engine issue                    4
hydraulic issue                 5
landing gear issue              3
maintenance issue               1
medical emergency              14
odor in cockpit                 1
odor on board                   2
operational reasons             1
possible landing gear issue     1
possible medical emergency      1
possible technical issue        2
pressurisation issue            6
rostering_error                 1
smell on board                  3
smoke indication                1
smoke on board                  1
technical issue                 8
weather radar issue             1
winglet issue                   1
Name: DIVERTED_REASON, dtype: int64
```

Fill NA/NaN values

In [34]:

```
print('EMERGENCY_CODE before updating NA/NAN : ',diverted_df.EMERGENCY_CODE.unique())
```

```
EMERGENCY_CODE before updating NA/NAN :  [   nan 7700.]
```

In [35]:

```
diverted_df = diverted_df.replace(np.nan,'')
#diverted_df = diverted_df.replace(0,'')
```

In [36]:

```
diverted_df['ORIGIN'] = "" #Create a new column ORIGIN with the airport code from flight
for idx2, div in diverted_df.iterrows():
    #print(idx2, div['ORIGIN_CITY'])
    for idx1, flt in flight_data_df[flight_data_df.DIVERTED==1].iterrows():
        if div['ORIGIN_CITY'] in flt['ORIGIN_CITY_NAME']:
            diverted_df.at[idx2,'ORIGIN'] = flt['ORIGIN']
            break;
```

In [37]:

```
diverted_df['DESTINATION'] = "" #Create a new column DEST with the airport code from fli
for idx2, div in diverted_df.iterrows():
    #print(idx2, div['DEST_CITY'])
    for idx1, flt in flight_data_df[flight_data_df.DIVERTED==1].iterrows():
        if div['DEST_CITY'] in flt['DEST_CITY_NAME']:
            diverted_df.at[idx2,'DESTINATION'] = flt['DEST']
            break;
```

In [38]:

```
print('EMERGENCY_CODE after updating NA/NAN : ',diverted_df.EMERGENCY_CODE.unique())
```

```
EMERGENCY_CODE after updating NA/NAN :  ['' 7700.0]
```

In [39]:

```
#diverted_df.drop(columns =['ORIGIN_DIV'], axis=1, inplace=True)
cols=['FL_DATE','OP_UNIQUE_CARRIER_NAME','FL_NUM','ORIGIN_CITY','DEST_CITY','DIVERTED_TO
      'DIVERTED_REASON','AIRCRAFT','AIRCRAFT_REGISTRATION','OP_UNIQUE_CARRIER','ORIGIN',
diverted_df.columns = cols
```

In [40]:

```
#diverted_df.loc[diverted_df.DIVERTED_REASON == '0','DIVERTED_REASON']='Reason Unavailab
diverted_df.loc[diverted_df.DIVERTED_REASON == '','DIVERTED_REASON']='Reason Unavailable
```

In [41]:

```
diverted_df.DIVERTED_REASON.unique()
```

Out[41]:

```
array(['hydraulic issue', 'technical issue', 'maintenance issue',
       'odor in cockpit', 'medical emergency', 'Reason Unavailable',
       'bird strike', 'cracked windshield', 'smoke indication',
       'possible technical issue', 'landing gear issue',
       'pressurisation issue', 'air conditioning issue',
       'possible medical emergency', 'odor on board', 'engine issue',
       'smell on board', 'disruptive passenger', 'bomb threat',
       'brakes issue', 'weather radar issue',
       'possible landing gear issue', 'operational reasons',
       'winglet issue', 'smoke on board', 'rostering_error'], dtype=object)
```

In [42]:

```
diverted_df.head(5)
```

Out[42]:

	FL_DATE	OP_UNIQUE_CARRIER_NAME	FL_NUM	ORIGIN_CITY	DEST_CITY	DIVERTED_TO	EMERGENCY_CODE
147	2022-05-31	Virgin Australia	VA9223 / VOZ9223	Perth	Boolgeeda	Perth	
148	2022-05-31	Aer Lingus	EI3326 / EAI26MH	Dublin	Manchester	Dublin	7700.0
149	2022-05-30	American Airlines	AA720 / AAL720	Charlotte	Rome	Charlotte	
150	2022-05-29	Swiss	LX340 / SWR340V	Zurich	London	Zurich	
151	2022-05-29	Qantas	QF2008 / QLK8D	Sydney	Tamworth	Sydney	

Ethical implications:

> Website Data - The data source of the flat file is genuine and reliable (Bureau of Transportation). However, the website may not hold accurate information because it is not government or FAA authorized source. The webiste does not mention the source of data, making the accuracy and legality of data questionable. The website also states the same in the disclaimer. However, on running a high level search for a couple of diverted flight information, we are able to confirm the accuracy of the data.

Conclusion:

> As a part of this milestone, the following Data Transformation steps have been performed.
>
> 1. Data Type conversion
> 2. Renamed columns
> 3. Replaced values in a dataframe column
> 4. Filtered data
> 5. Filled NA/NAN values
> 6. Performed checks for duplicates and null rows

Milestone 4 - Connecting to an API/Pulling in the Data and Cleaning/Formatting

> Data from the flat file has cancellations and delays due to weather. The API gets the historic

> weather data for a location (origin or destination city name). This will enable us to validate if there truly was a bad weather situation for a flight to be delayed or cancelled. With this, we can also identify the cause of bad weather like storms, snow, wind, etc.

In [43]:

```
#Working with weather delays. Creating a dataframe with only weather delays.
weather_delay_df = flight_data_df[flight_data_df.DELAY_REASON=='Weather']
print(weather_delay_df.shape)
weather_delay_df.head(5)
```

```
(4152, 35)
```

Out[43]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_DATE	MKT_UNIQUE_CARRIER	OP_UNIQUE_
87	2022	2	5	1	7	2022-05-01	AA	
191	2022	2	5	1	7	2022-05-01	AA	
227	2022	2	5	1	7	2022-05-01	AA	
1962	2022	2	5	1	7	2022-05-01	AA	
2000	2022	2	5	1	7	2022-05-01	AA	

5 rows × 35 columns

In [44]:

```
#Working with weather cancellation. Creating a dataframe with only weather cancellations
weather_cancel_df = flight_data_df[flight_data_df.CANCELLATION_REASON=='Weather']
print(weather_cancel_df.shape)
weather_cancel_df.head(5)
```

```
(4307, 35)
```

Out[44]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_DATE	MKT_UNIQUE_CARRIER	OP_UNIQUE_
145	2022	2	5	1	7	2022-05-01	AA	
511	2022	2	5	1	7	2022-05-01	AA	
543	2022	2	5	1	7	2022-05-01	AA	
1024	2022	2	5	1	7	2022-05-01	AA	
1606	2022	2	5	1	7	2022-05-01	AA	

5 rows × 35 columns

Function to make the API call to get historic weather data based on flight time and origin.

In [45]:

```
def get_historic_geo_data_by_zip(startDateTime, originCityName, endDateTime):
    #url = 'https://visual-crossing-weather.p.rapidapi.com/history?'
    #API key Request Headers
    headers = {"X-RapidAPI-Key": "046c439acamshd081e11265aa749p15f219jsn1275dc460233",
               "X-RapidAPI-Host": "visual-crossing-weather.p.rapidapi.com"}
    #URL
    geocode_request_url = "https://visual-crossing-weather.p.rapidapi.com/history?"
    #Request Parameters
    parms = {'startDateTime': startDateTime, 'aggregateHours': 24, 'location': originCit
             'endDateTime': endDateTime, 'unitGroup': 'us'}
    try:
        #API call to get the weather data at the scheduled time of flight.
        response = requests.get(geocode_request_url, params=parms, headers=headers)
    except requests.exceptions.RequestException as e:  # This is the correct syntax
        print('There was an error in the API call : ', e)
    except requests.exceptions.Timeout as t:
        print('The API call timedout. Please retry.')
    return response
```

Data Transformation

1. Data manipulation using regular expressions to convert response text into a list of keys and values

2. Data transformation to parse the list of keys and values to form a dictionary (key-value pair)

In [46]:

```
#Function to process the API response
def process_api_data(response, index):
    try:
        if response.status_code==200: #OK
            try:
                # The API response is not a formatted JSON. Parsing through the text to
                json_data = response.text.splitlines()
                if len(json_data) <= 2: #We only expect a list of keys and values. Ideal
                    keys = (re.split(',', json_data[0]))
                    # replace ', ' by | to be able to split the strings correctly for ke
                    values = (json_data[1].replace(', ','|').replace('"', '')).split(','
                    #print(len(keys), len(values))
                    if len(keys) == len(values): #Converting to dict only when keys and
                        for i in range(len(keys)):
                            historic_weather_data[keys[i]] = values[i]
                    else:
                        print("Key value pair counts don't match")
            except RuntimeError as ex:
                print('There was an error in processing the API response : ', ex)
        elif response.status_code==404:
            print("Requested historic weather data not found for parms : Fl_Date - ",sta
        else:
            print('Unable to get historic weather data for parms : Fl_Date - ',start_dat
    except RuntimeError as ex:
        print("There was an error in dictionary creation from API response.")

    return historic_weather_data
```

Function call to create the API request, get and process the response.

3. Data transformation to convert the dictionary to a dataframe

In [ ]:

```
index = 0
historic_weather_data = {}
weather_delay_api_df = pd.DataFrame()

for inx, row in weather_delay_df.iterrows():
    start_date_time = pd.to_datetime(row.FL_DATE).strftime("%Y-%m-%dT%H:%M:%S") #Fl star
    end_date_time=start_date_time
    #Switching back the if condition and reducing the API calls to 2, incase of a rerun
    #Since this is a public API there is a limit to the number of calls I can make per m
    #The loop for entire dataframe has been run and the weather_data_df is created for a
    #This condition will be removed again for the final project submission

    #if index < 100:
    #Call funtion to get weather at origin and flight time
    response = get_historic_geo_data_by_zip(start_date_time,row.ORIGIN_CITY_NAME , end_d

    weather_dict={}
    weather_dict = process_api_data(response, index) #Get each API response in a dict

    df  = pd.DataFrame([weather_dict], columns=weather_dict.keys()) #Convert dict to a d
    df['ORIGIN'] = row['ORIGIN']
    df['DEST_W'] = row['DEST']
    df['FL_DATE'] = row['FL_DATE']
    df['MKT_CARRIER'] = row['MKT_UNIQUE_CARRIER']
    df['OP_CARRIER'] = row['OP_UNIQUE_CARRIER']
    weather_delay_api_df = pd.concat([weather_delay_api_df, df], axis =0).reset_index(dr

    index = index + 1
```

#Take a backup of the API data in case of a rerun, since the API calls are restricted #weather_delay_api_df = pd.read_csv('weather_data_api_df_100.csv') weather_delay_api_df.to_csv('weather_delay_data_api.csv')

In [47]:

```
weather_delay_api_df = pd.read_csv("weather_delay_data_api-1.csv")
```

In [48]:

```
# Final weather_data_df
print(weather_delay_api_df.shape)
weather_delay_api_df.head(2)
```

```
(4152, 30)
```

Out[48]:

	Address	Date time	Minimum Temperature	Maximum Temperature	Temperature	Dew Point	Relative Humidity	Heat Index	Wind Speed	Wind Gust	...
0	Birmingham|AL	5/1/2022	65.0	82.1	73.0	63.6	73.68	83.5	10.8	36.7	...
1	Cleveland|OH	5/1/2022	53.1	74.0	62.2	45.6	60.20	NaN	18.3	30.2	...

2 rows × 30 columns

> Now that we have the weather data in dataframe, we'll perform the Data Transformation Steps

4. Look for empty rows and null values

In [49]:

```
weather_delay_api_df.dropna()
```

Out[49]:

Address	Date time	Minimum Temperature	Maximum Temperature	Temperature	Dew Point	Relative Humidity	Heat Index	Wind Speed	Wind Gust	...	Longitude

0 rows × 30 columns

> No null rows to drop.

5. Drop Columns

In [50]:
```
weather_delay_api_df.groupby(['Info'])['Info'].count().sort_index()
#There doesn't seem to be any relevant information in the Info column.
```

Out[50]:
```
Series([], Name: Info, dtype: int64)
```

In [51]:
```
 weather_delay_api_df[weather_delay_api_df['Resolved Address'] != weather_delay_api_df['
```

Out[51]:

Address	Date time	Minimum Temperature	Maximum Temperature	Temperature	Dew Point	Relative Humidity	Heat Index	Wind Speed	Wind Gust	...	Longitude

0 rows × 30 columns

> All rows have same data from resolved area and Name. Dropping one of these columns since its a duplicate. Info has all NAN values. Dropping the 2 columns

In [52]:
```
weather_delay_api_df.drop(columns=['Info', 'Resolved Address','Address', 'Date time'], a
```

In [53]:
```
weather_delay_api_df.shape
```

Out[53]:
```
(4152, 26)
```

In [54]:
```
weather_delay_api_df.groupby(['Conditions'])['Conditions'].value_counts().sort_index()
```

Out[54]:
```
Conditions             Conditions
Clear                  Clear                    310
Overcast               Overcast                 197
Partially cloudy       Partially cloudy         722
Rain                   Rain                      60
Rain|Overcast          Rain|Overcast           1170
Rain|Partially cloudy  Rain|Partially cloudy   1693
Name: Conditions, dtype: int64
```

6. Drop Duplicates

In [55]:
```
#Dropping dups from the copy and retaining the original df,
#to avoid having to recreate the df with multiple hits to the API.
weather_data_df_copy = weather_delay_api_df
```

In [56]:
```
weather_data_df_copy.shape, weather_delay_api_df.shape
```

Out[56]:
```
((4152, 26), (4152, 26))
```

In [57]:
```
print('Dataframe before dropping duplicates :', weather_data_df_copy.shape)
weather_data_df_copy = weather_data_df_copy.drop_duplicates() # 1,389 rows dropped
print('Dataframe after dropping duplicates :',weather_data_df_copy.shape)
```

```
Dataframe before dropping duplicates : (4152, 26)
Dataframe after dropping duplicates : (3905, 26)
```

7. Replace column names

In [58]:
```
columns = ['MIN_TEMP', 'MAX_TEMP','TEMP', 'DEW_POINT', 'RELATIVE_HUMIDITY', 'HEAT_INDEX'
           'WIND_GUST', 'WIND_DIRECTION', 'WIND_CHILL', 'PRECIPITATION', 'PRECIPITATION_
           'VISIBILITY','CLOUD_COVER', 'SEA_LEVEL_PRESSURE', 'WEATHER_TYPE', 'LATITUDE',
           'CONDITIONS','ORIGIN_W', 'DEST_W','FL_DATE', 'MKT_CARRIER', 'OP_CARRIER']

weather_delay_api_df.columns = columns
weather_data_df_copy.columns = columns
```

8. Fill NA/NaN values, if any

In [59]:

```
print('MIN_TEMP           : ',len(weather_data_df_copy[weather_data_df_copy.MIN_TEMP.isn
print('MAX_TEMP           : ',len(weather_data_df_copy[weather_data_df_copy.MAX_TEMP.isn
print('TEMP               : ',len(weather_data_df_copy[weather_data_df_copy.TEMP.isna()=
print('DEW_POINT          : ',len(weather_data_df_copy[weather_data_df_copy.DEW_POINT.is
print('RELATIVE_HUMIDITY  : ',len(weather_data_df_copy[weather_data_df_copy.RELATIVE_HUM
print('HEAT_INDEX         : ',len(weather_data_df_copy[weather_data_df_copy.HEAT_INDEX.i
print('WIND_SPEED         : ',len(weather_data_df_copy[weather_data_df_copy.WIND_SPEED.i
print('WIND_GUST          : ',len(weather_data_df_copy[weather_data_df_copy.WIND_GUST.is
print('WIND_DIRECTION     : ',len(weather_data_df_copy[weather_data_df_copy.WIND_DIRECTI
print('WIND_CHILL         : ',len(weather_data_df_copy[weather_data_df_copy.WIND_CHILL.i
print('PRECIPITATION      : ',len(weather_data_df_copy[weather_data_df_copy.PRECIPITATIO
print('PRECIPITATION_COVER: ',len(weather_data_df_copy[weather_data_df_copy.PRECIPITATIO
print('SNOW_DEPTH         : ',len(weather_data_df_copy[weather_data_df_copy.SNOW_DEPTH.i
print('VISIBILITY         : ',len(weather_data_df_copy[weather_data_df_copy.VISIBILITY.i
print('CLOUD_COVER        : ',len(weather_data_df_copy[weather_data_df_copy.CLOUD_COVER.
print('SEA_LEVEL_PRESSURE : ',len(weather_data_df_copy[weather_data_df_copy.SEA_LEVEL_PR
print('WEATHER_TYPE       : ',len(weather_data_df_copy[weather_data_df_copy.WEATHER_TYPE
print('LATITUDE           : ',len(weather_data_df_copy[weather_data_df_copy.LATITUDE.isn
print('LONGITUDE          : ',len(weather_data_df_copy[weather_data_df_copy.LONGITUDE.is
print('CITY_NAME          : ',len(weather_data_df_copy[weather_data_df_copy.CITY_NAME.is
print('CONDITIONS         : ',len(weather_data_df_copy[weather_data_df_copy.CONDITIONS.i
print('ORIGIN_W           : ',len(weather_data_df_copy[weather_data_df_copy.ORIGIN_W.isn
print('DEST_W             : ',len(weather_data_df_copy[weather_data_df_copy.DEST_W.isna(
print('FL_DATE            : ',len(weather_data_df_copy[weather_data_df_copy.FL_DATE.isna
print('MKT_CARRIER        : ',len(weather_data_df_copy[weather_data_df_copy.MKT_CARRIER.
print('OP_CARRIER         : ',len(weather_data_df_copy[weather_data_df_copy.OP_CARRIER.i
```

```
MIN_TEMP           :  0
MAX_TEMP           :  0
TEMP               :  0
DEW_POINT          :  0
RELATIVE_HUMIDITY  :  0
HEAT_INDEX         :  1707
WIND_SPEED         :  0
WIND_GUST          :  288
WIND_DIRECTION     :  0
WIND_CHILL         :  3486
PRECIPITATION      :  0
PRECIPITATION_COVER:  0
SNOW_DEPTH         :  3902
VISIBILITY         :  1
CLOUD_COVER        :  0
SEA_LEVEL_PRESSURE :  0
WEATHER_TYPE       :  634
LATITUDE           :  0
LONGITUDE          :  0
CITY_NAME          :  0
CONDITIONS         :  0
ORIGIN_W           :  0
DEST_W             :  0
FL_DATE            :  0
MKT_CARRIER        :  0
OP_CARRIER         :  0
```

In [60]:

```
weather_data_df_copy.loc[weather_data_df_copy.HEAT_INDEX.isna()==True, 'HEAT_INDEX']=0
weather_data_df_copy.loc[weather_data_df_copy.WIND_GUST.isna()==True, 'WIND_GUST']=0
weather_data_df_copy.loc[weather_data_df_copy.WIND_CHILL.isna()==True, 'WIND_CHILL']=0
weather_data_df_copy.loc[weather_data_df_copy.SNOW_DEPTH.isna()==True, 'SNOW_DEPTH']=0
weather_data_df_copy.loc[weather_data_df_copy.VISIBILITY.isna()==True, 'VISIBILITY']=0
weather_data_df_copy.loc[weather_data_df_copy.WEATHER_TYPE.isna()==True, 'WEATHER_TYPE']
```

In [61]:

```
print('MIN_TEMP           : ',len(weather_data_df_copy[weather_data_df_copy.MIN_TEMP.isn
print('MAX_TEMP           : ',len(weather_data_df_copy[weather_data_df_copy.MAX_TEMP.isn
print('TEMP               : ',len(weather_data_df_copy[weather_data_df_copy.TEMP.isna()=
print('DEW_POINT          : ',len(weather_data_df_copy[weather_data_df_copy.DEW_POINT.is
print('RELATIVE_HUMIDITY  : ',len(weather_data_df_copy[weather_data_df_copy.RELATIVE_HUM
print('HEAT_INDEX         : ',len(weather_data_df_copy[weather_data_df_copy.HEAT_INDEX.i
print('WIND_SPEED         : ',len(weather_data_df_copy[weather_data_df_copy.WIND_SPEED.i
print('WIND_GUST          : ',len(weather_data_df_copy[weather_data_df_copy.WIND_GUST.is
print('WIND_DIRECTION     : ',len(weather_data_df_copy[weather_data_df_copy.WIND_DIRECTI
print('WIND_CHILL         : ',len(weather_data_df_copy[weather_data_df_copy.WIND_CHILL.i
print('PRECIPITATION      : ',len(weather_data_df_copy[weather_data_df_copy.PRECIPITATIO
print('PRECIPITATION_COVER: ',len(weather_data_df_copy[weather_data_df_copy.PRECIPITATIO
print('SNOW_DEPTH         : ',len(weather_data_df_copy[weather_data_df_copy.SNOW_DEPTH.i
print('VISIBILITY         : ',len(weather_data_df_copy[weather_data_df_copy.VISIBILITY.i
print('CLOUD_COVER        : ',len(weather_data_df_copy[weather_data_df_copy.CLOUD_COVER.
print('SEA_LEVEL_PRESSURE : ',len(weather_data_df_copy[weather_data_df_copy.SEA_LEVEL_PR
print('WEATHER_TYPE       : ',len(weather_data_df_copy[weather_data_df_copy.WEATHER_TYPE
print('LATITUDE           : ',len(weather_data_df_copy[weather_data_df_copy.LATITUDE.isn
print('LONGITUDE          : ',len(weather_data_df_copy[weather_data_df_copy.LONGITUDE.is
print('CITY_NAME          : ',len(weather_data_df_copy[weather_data_df_copy.CITY_NAME.is
print('CONDITIONS         : ',len(weather_data_df_copy[weather_data_df_copy.CONDITIONS.i
print('ORIGIN_W           : ',len(weather_data_df_copy[weather_data_df_copy.ORIGIN_W.isn
print('DEST_W             : ',len(weather_data_df_copy[weather_data_df_copy.DEST_W.isna(
print('FL_DATE            : ',len(weather_data_df_copy[weather_data_df_copy.FL_DATE.isna
print('MKT_CARRIER        : ',len(weather_data_df_copy[weather_data_df_copy.MKT_CARRIER.
print('OP_CARRIER         : ',len(weather_data_df_copy[weather_data_df_copy.OP_CARRIER.i
```

```
MIN_TEMP           :  0
MAX_TEMP           :  0
TEMP               :  0
DEW_POINT          :  0
RELATIVE_HUMIDITY  :  0
HEAT_INDEX         :  0
WIND_SPEED         :  0
WIND_GUST          :  0
WIND_DIRECTION     :  0
WIND_CHILL         :  0
PRECIPITATION      :  0
PRECIPITATION_COVER:  0
SNOW_DEPTH         :  0
VISIBILITY         :  0
CLOUD_COVER        :  0
SEA_LEVEL_PRESSURE :  0
WEATHER_TYPE       :  0
LATITUDE           :  0
LONGITUDE          :  0
CITY_NAME          :  0
CONDITIONS         :  0
ORIGIN_W           :  0
DEST_W             :  0
FL_DATE            :  0
MKT_CARRIER        :  0
OP_CARRIER         :  0
```

9. Reformat Flight Date

In [69]:

```
#API Date format
weather_delay_api_df.FL_DATE = pd.to_datetime(weather_delay_api_df['FL_DATE'], format='%

#csv Date format
#weather_delay_api_df.FL_DATE = pd.to_datetime(weather_delay_api_df['FL_DATE'], format='
```

In [70]:

```
weather_delay_api_df.head(2)
```

Out[70]:

	MIN_TEMP	MAX_TEMP	TEMP	DEW_POINT	RELATIVE_HUMIDITY	HEAT_INDEX	WIND_SPEED	WIND_GUST	W

0	65.0	82.1	73.0	63.6	73.68	83.5	10.8	36.7
1	53.1	74.0	62.2	45.6	60.20	NaN	18.3	30.2

2 rows × 26 columns

Ethical implications:

> API Data - The data source of the API is genuine and reliable as stated in the terms of use in the website and I do not see any legal concers in using the data. However, I would like to validate the accuracy of the data by looking up the weather at a certain place and time known to have a bad weather situation.

Conclusion:

> As a part of this milestone, the following Data Transformation steps have been performed.
>
> 1. Data manipulation using regular expressions to convert response text into a list of keys and values
> 2. Data transformation to parse the list of keys and values to form a dictionary (key-value pair)
> 3. Data transformation to convert the dictionary to a dataframe
> 4. Look for empty rows and null values
> 5. Drop Columns
> 6. Drop Duplicates
> 7. Replace column names
> 8. Fill NA/NaN values, if any
>
> During the final project analysis, if there was no concerning weather condition at the origin airport, the same can be run against the destination airport to see if a flight was delayed/cancelled due to bad weather at the destination airport

Milestone 5 - Merging the Data and Storing in a Database/Visualizing Data

In [71]:
```
flight_data_df.info() #Get the flight data dataframe info for SQL table creation
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 601561 entries, 0 to 602949
Data columns (total 35 columns):
 #   Column                Non-Null Count   Dtype
---  ------                --------------   -----
 0   YEAR                  601561 non-null  int64
 1   QUARTER               601561 non-null  int64
 2   MONTH                 601561 non-null  int64
 3   DAY_OF_MONTH          601561 non-null  int64
 4   DAY_OF_WEEK           601561 non-null  int64
 5   FL_DATE               601561 non-null  object
 6   MKT_UNIQUE_CARRIER    601561 non-null  object
 7   OP_UNIQUE_CARRIER     601561 non-null  object
 8   ORIGIN                601561 non-null  object
 9   ORIGIN_CITY_NAME     601561 non-null  object 
 10  ORIGIN_STATE_ABR     601561 non-null  object 
 11  ORIGIN_STATE_NM      601561 non-null  object 
 12  DEST                 601561 non-null  object 
 13  DEST_CITY_NAME       601561 non-null  object 
 14  DEST_STATE_ABR       601561 non-null  object 
 15  DEST_STATE_NM        601561 non-null  object 
 16  DEP_DELAY            591360 non-null  float64
 17  DEP_DELAY_NEW        591360 non-null  float64
 18  TAXI_OUT             591003 non-null  float64
 19  TAXI_IN              590792 non-null  float64
 20  ARR_TIME             590792 non-null  float64
 21  ARR_DELAY            589376 non-null  float64
 22  ARR_DELAY_NEW        589376 non-null  float64
 23  CANCELLED            601561 non-null  float64
 24  CANCELLATION_REASON  601561 non-null  object 
 25  DIVERTED             601561 non-null  float64
 26  DISTANCE             601561 non-null  float64
 27  CARRIER_DELAY        123950 non-null  float64
 28  WEATHER_DELAY        123950 non-null  float64
 29  NAS_DELAY            123950 non-null  float64
 30  SECURITY_DELAY       123950 non-null  float64
 31  LATE_AIRCRAFT_DELAY  123950 non-null  float64
 32  STATUS               601561 non-null  object 
 33  DELAYED              589376 non-null  object 
 34  DELAY_REASON         601561 non-null  object 
dtypes: float64(15), int64(5), object(15)
memory usage: 165.2+ MB
```

In [72]:
```
weather_delay_api_df.info() #Get the flight data dataframe info for SQL table creation
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4152 entries, 0 to 4151
Data columns (total 26 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   MIN_TEMP              4152 non-null   float64
 1   MAX_TEMP              4152 non-null   float64
 2   TEMP                  4152 non-null   float64
 3   DEW_POINT             4152 non-null   float64
 4   RELATIVE_HUMIDITY     4152 non-null   float64
 5   HEAT_INDEX            2329 non-null   float64
 6   WIND_SPEED            4152 non-null   float64
 7   WIND_GUST             3831 non-null   float64
 8   WIND_DIRECTION        4152 non-null   float64
 9   WIND_CHILL            438 non-null    float64
 10  PRECIPITATION         4152 non-null   float64
 11  PRECIPITATION_COVER   4152 non-null   float64
 12  SNOW_DEPTH            3 non-null      float64
 13  VISIBILITY            4151 non-null   float64
 14  CLOUD_COVER           4152 non-null   float64
 15  SEA_LEVEL_PRESSURE    4152 non-null   float64
 16  WEATHER_TYPE          3471 non-null   object 
 17  LATITUDE              4152 non-null   float64
 18  LONGITUDE             4152 non-null   float64
 19  CITY_NAME             4152 non-null   object 
 20  CONDITIONS            4152 non-null   object 
 21  ORIGIN_W              4152 non-null   object 
 22  DEST_W                4152 non-null   object 
 23  FL_DATE               4152 non-null   object 
 24  MKT_CARRIER           4152 non-null   object 
 25  OP_CARRIER            4152 non-null   object 
dtypes: float64(18), object(8)
memory usage: 843.5+ KB
```

In [73]:
```
#Drop query string to drop table before creating it again.
```

```
#Need this to avoid error from multiple executions of the create table.
drop_flight_data = """DROP TABLE IF EXISTS Flight_Data;"""

#Query string for table creation
create_flight_data = """ CREATE TABLE IF NOT EXISTS Flight_Data (
                                YEAR                   INTEGER  ,
                                QUARTER                INTEGER  ,
                                MONTH                  INTEGER  ,
                                DAY_OF_MONTH           INTEGER  ,
                                DAY_OF_WEEK            INTEGER  ,
                                FL_DATE                text   ,
                                MKT_UNIQUE_CARRIER     text   ,
                                OP_UNIQUE_CARRIER      text   ,
                                ORIGIN                 text   ,
                                ORIGIN_CITY_NAME       text   ,
                                ORIGIN_STATE_ABR       text   ,
                                ORIGIN_STATE_NM        text   ,
                                DEST                   text   ,
                                DEST_CITY_NAME         text   ,
                                DEST_STATE_ABR         text   ,
                                DEST_STATE_NM          text   ,
                                DEP_DELAY              INTEGER  ,
                                DEP_DELAY_NEW          INTEGER  ,
                                TAXI_OUT               INTEGER  ,
                                TAXI_IN                INTEGER  ,
                                ARR_TIME               INTEGER  ,
                                ARR_DELAY              INTEGER  ,
                                ARR_DELAY_NEW          INTEGER  ,
                                CANCELLED              INTEGER  ,
                                CANCELLATION_REASON    text     ,
                                DIVERTED               INTEGER  ,
                                DISTANCE               INTEGER  ,
                                CARRIER_DELAY          INTEGER  ,
                                WEATHER_DELAY          INTEGER  ,
                                NAS_DELAY              INTEGER  ,
                                SECURITY_DELAY         INTEGER  ,
                                LATE_AIRCRAFT_DELAY    INTEGER  ,
                                STATUS                 text     ,
                                DELAYED                text     ,
                                DELAY_REASON           text     );"""


drop_diversion_data = """DROP TABLE IF EXISTS Diversion_Data;"""

#Query string for table creation
create_diversion_data = """ CREATE TABLE IF NOT EXISTS Diversion_Data (
                                FL_DATE                text,
                                OP_UNIQUE_CARRIER_NAME text,
                                FL_NUM                 text,
                                ORIGIN_CITY            text,
                                DEST_CITY              text,
                                DIVERTED_TO            text,
                                EMERGENCY_CODE         INTEGER,
                                DIVERTED_REASON        text,
                                AIRCRAFT               text,
                                AIRCRAFT_REGISTRATION  text,
                                OP_UNIQUE_CARRIER      text,
                                ORIGIN                 text,
                                DESTINATION            text);"""


drop_weather_data = """DROP TABLE IF EXISTS Weather_Data;"""

#Query string for table creation
create_weather_data = """ CREATE TABLE IF NOT EXISTS Weather_Data (
                                MIN_TEMP               TEXT,
                                MAX_TEMP               TEXT,
                                TEMP                   TEXT,
                                DEW_POINT              TEXT,
                                RELATIVE_HUMIDITY      TEXT,
                                HEAT_INDEX             TEXT,
                                WIND_SPEED             TEXT,
                                WIND_GUST              TEXT,
                                WIND_DIRECTION         TEXT,
                                WIND_CHILL             TEXT,
                                PRECIPITATION          TEXT,
                                PRECIPITATION_COVER    TEXT,
                                SNOW_DEPTH             TEXT,
                                VISIBILITY             TEXT,
                                CLOUD_COVER            TEXT,
                                SEA_LEVEL_PRESSURE     TEXT,
                                WEATHER_TYPE           TEXT,
                                LATITUDE               TEXT,
                                LONGITUDE              TEXT,
                                CITY_NAME              TEXT,
                                CONDITIONS             TEXT,
                                ORIGIN_W               TEXT,
                                DEST_W                 TEXT,
                                FL_DATE                TEXT,
                                MKT_CARRIER            TEXT,
                                OP_CARRIER             TEXT );"""
```

In [74]:

```
def Sql_execution(tablename, category):
    #Create a cursor to store the DB query return values, if any
    cur = con.cursor()

    try:
        #Execute the query string
        if category == "insert":
            try:
                if (tablename == 'Flight_Data'):
                    #Insert rows into the Flight_Data table
                    flight_data_df.to_sql(tablename,con,if_exists='replace',index=False)
                elif (tablename == 'Diversion_Data'):
                    #Insert rows into the Diversion_Data table .
                    diverted_df.to_sql(tablename,con,if_exists='replace',index=False) #I
                elif (tablename == 'Weather_Data'):
                    #Insert rows into the Weather_Data table
                    weather_delay_api_df.to_sql(tablename,con,if_exists='replace',index=
                elif (tablename == 'Flight_Info'):
                    #Insert rows into the Final Flight Data table
                    flight_info_df.to_sql(tablename,con,if_exists='replace',index=False)
            except sqlite3.Error as er:
                print('SQLite error: %s' % (' '.join(er.args)))
                print("Exception class is: ", er.__class__)
            except sqlite3.OperationalError:
                print("Error in inserting rows in Flight_Info table.")
            return cur

        elif category == "select":
            try:
                if (tablename == 'Flight_Data'):
                    # Get the stored df data from SQL and display - Test for data insert
                    db_flight_data_df = pd.read_sql("select * from Flight_Data",con)
                    return db_flight_data_df
                elif (tablename == 'Diversion_Data'):
                    # Get the stored df data from SQL and display - Test for data insert
                    db_diverted_data_df = pd.read_sql("select * from Diversion_Data",con
                    return db_diverted_data_df
                elif (tablename == 'Weather_Data'):
                    # Get the stored df data from SQL and display - Test for data insert
                    db_weather_data_df = pd.read_sql("select * from Weather_Data",con)
                    return db_weather_data_df
                elif (tablename == 'Flight_Info'):
                    # Get the stored df data from SQL and display - Test for data insert
                    db_flight_info_df = pd.read_sql("select * from Flight_Info",con)
                    return db_flight_info_df
            except sqlite3.Error as er:
                print('SQLite error: %s' % (' '.join(er.args)))
                print("Exception class is: ", er.__class__)
            except sqlite3.OperationalError:
                print('Error in reading table %s :' % tablename)
        elif category == "create":
            try:
                if (tablename == 'Flight_Data'):
                    #Create the table
                    cur.execute(create_flight_data)
                elif (tablename == 'Diversion_Data'):
                    #Create the table
                    cur.execute(create_diversion_data)
                elif (tablename == 'Weather_Data'):
                    #Create the table
                    cur.execute(create_weather_data)
                elif (tablename == 'Flight_Info'):
                    #Create the table
                    cur.execute(create_flight_info_data)
            except sqlite3.Error as er:
                print('SQLite error: %s' % (' '.join(er.args)))
                print("Exception class is: ", er.__class__)
            except sqlite3.OperationalError:
                print('Error in creating table %s' % tablename)
            return cur
        elif category == "drop":
            try:
                if (tablename == 'Flight_Data'):
                    cur.execute(drop_flight_data)
                elif (tablename == 'Diversion_Data'):
                    cur.execute(drop_diversion_data)
                elif (tablename == 'Weather_Data'):
                    cur.execute(drop_weather_data)
                elif (tablename == 'Flight_Info'):
                    cur.execute(drop_flight_info_data)
            except sqlite3.Error as er:
                print('SQLite error: %s' % (' '.join(er.args)))
                print("Exception class is: ", er.__class__)
            except sqlite3.Error as er:
                print('SQLite error in dropping the table : %s' % (' '.join(er.args)))
                return cur
        else:
            print("No SQL Execution")
    except RuntimeError as err:
        print("There was an error in the SQL Execution : ", err)
```

In [75]:

```
# create a database connection
con = sqlite3.connect('mydata.sqlite')
```

SQL table creation

In [76]:

```
#Create list of tables to create and insert
sql_exec_list = ['Flight_Data','Diversion_Data','Weather_Data']

if len(sql_exec_list) > 0:
    for i in range(len(sql_exec_list)):
        try:
            drop_resp = Sql_execution(sql_exec_list[i], "drop")
            #print('Drop table response : ',drop_resp.rowcount)
            create_resp = Sql_execution(sql_exec_list[i], "create")
            #print('Create table response : ',create_resp.rowcount)
            insert_resp = Sql_execution(sql_exec_list[i], "insert")
            insert_resp.rowcount
            #print('Insert table response : ',insert_resp.rowcount)
            select_resp = Sql_execution(sql_exec_list[i], "select")
            #print('Select table response : ',select_resp)
            if i==0:
                db_flight_data_df = select_resp
            elif i==1:
                db_diverted_data_df = select_resp
            elif i==2:
                db_weather_data_df = select_resp
        except RuntimeError as err:
            print('There was an error in the SQL execution : ', err)
```

In [77]:

```
db_flight_data_df.head(5)
```

Out[77]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_DATE	MKT_UNIQUE_CARRIER	OP_UNIQUE_CA
0	2022	2	5	1	7	2022-05-01	AA	
1	2022	2	5	1	7	2022-05-01	AA	
2	2022	2	5	1	7	2022-05-01	AA	
3	2022	2	5	1	7	2022-05-01	AA	
4	2022	2	5	1	7	2022-05-01	AA	

5 rows × 35 columns

In [78]:

```
db_diverted_data_df.head(5)
```

Out[78]:

	FL_DATE	OP_UNIQUE_CARRIER_NAME	FL_NUM	ORIGIN_CITY	DEST_CITY	DIVERTED_TO	EMERGENCY_CODE
0	2022-05-31	Virgin Australia	VA9223 / VOZ9223	Perth	Boolgeeda	Perth	
1	2022-05-31	Aer Lingus	EI3326 / EAI26MH	Dublin	Manchester	Dublin	7700.0
2	2022-05-30	American Airlines	AA720 / AAL720	Charlotte	Rome	Charlotte	
3	2022-05-29	Swiss	LX340 / SWR340V	Zurich	London	Zurich	
4	2022-05-29	Qantas	QF2008 / QLK8D	Sydney	Tamworth	Sydney	

In [79]:

```
db_weather_data_df.head(5)
```

Out[79]:

	MIN_TEMP	MAX_TEMP	TEMP	DEW_POINT	RELATIVE_HUMIDITY	HEAT_INDEX	WIND_SPEED	WIND_GUST

0	65.0	82.1	73.0	63.6	73.68	83.5	10.8	36.7
1	53.1	74.0	62.2	45.6	60.20	NaN	18.3	30.2
2	57.3	80.5	68.6	59.5	73.82	81.8	13.1	20.7
3	53.5	70.4	60.8	46.6	64.71	NaN	9.2	23.5
4	50.5	82.2	65.0	57.3	79.50	82.6	12.5	20.8

5 rows × 26 columns

In [80]:

```
drop_flight_info_data = """DROP TABLE IF EXISTS Flight_Info;"""

#Query string for table creation
create_flight_info_data = """ CREATE TABLE IF NOT EXISTS Flight_Info (
                            YEAR                    INTEGER,
                            QUARTER                 INTEGER,
                            MONTH                   INTEGER,
                            DAY_OF_MONTH            INTEGER,
                            DAY_OF_WEEK             INTEGER,
                            FL_DATE                 TEXT,
                            MKT_UNIQUE_CARRIER      TEXT,
                            OP_UNIQUE_CARRIER       TEXT,
                            ORIGIN                  TEXT,
                            ORIGIN_CITY_NAME        TEXT,
                            ORIGIN_STATE_ABR        TEXT,
                            ORIGIN_STATE_NM         TEXT,
                            DEST                    TEXT,
                            DEST_CITY_NAME          TEXT,
                            DEST_STATE_ABR          TEXT,
                            DEST_STATE_NM           TEXT,
                            DEP_DELAY               INTEGER,
                            DEP_DELAY_NEW           INTEGER,
                            TAXI_OUT                INTEGER,
                            TAXI_IN                 INTEGER,
                            ARR_TIME                INTEGER,
                            ARR_DELAY               INTEGER,
                            ARR_DELAY_NEW           INTEGER,
                            CANCELLED               INTEGER,
                            CANCELLATION_REASON     TEXT,
                            DIVERTED                INTEGER,
                            DISTANCE                INTEGER,
                            CARRIER_DELAY           INTEGER,
                            WEATHER_DELAY           INTEGER,
                            NAS_DELAY               INTEGER,
                            SECURITY_DELAY          INTEGER,
                            LATE_AIRCRAFT_DELAY     INTEGER,
                            STATUS                  TEXT,
                            DELAYED                 INTEGER,
                            DELAY_REASON            TEXT,
                            OP_UNIQUE_CARRIER_NAME  TEXT,
                            FL_NUM                  TEXT,
                            ORIGIN_CITY             TEXT,
                            DEST_CITY               TEXT,
                            DIVERTED_TO             TEXT,
                            EMERGENCY_CODE          INTEGER,
                            DIVERTED_REASON         TEXT,
                            AIRCRAFT                TEXT,
                            AIRCRAFT_REGISTRATION   TEXT,
                            DESTINATION             TEXT,
                            MIN_TEMP                INTEGER,
                            MAX_TEMP                INTEGER,
                            TEMP                    INTEGER,
                            DEW_POINT               INTEGER,
                            RELATIVE_HUMIDITY       INTEGER,
                            HEAT_INDEX              INTEGER,
                            WIND_SPEED              INTEGER,
                            WIND_GUST               INTEGER,
                            WIND_DIRECTION          INTEGER,
                            WIND_CHILL              INTEGER,
                            PRECIPITATION           INTEGER,
                            PRECIPITATION_COVER     INTEGER,
                            SNOW_DEPTH              INTEGER,
                            VISIBILITY              INTEGER,
                            CLOUD_COVER             INTEGER,
                            SEA_LEVEL_PRESSURE      INTEGER,
                            WEATHER_TYPE            TEXT,
                            LATITUDE                INTEGER,
                            LONGITUDE               INTEGER,
                            CITY_NAME               TEXT,
                            CONDITIONS              TEXT);"""
```

> Since our data is only focused on domestic flights within USA, we'll have to filter the flight diversion data to domestic flights.

In [81]:

```
#Filtering the list to domestic flights diverted
us_diverted_df = db_diverted_data_df[(db_diverted_data_df.ORIGIN.notnull() & (db_diverte
                              & db_diverted_data_df.DESTINATION.notnull() & (db_diverted
print(us_diverted_df.shape)
```

```
(12, 13)
```

In [82]:

```
us_diverted_df.head(5)
```

Out[82]:

	FL_DATE	OP_UNIQUE_CARRIER_NAME	FL_NUM	ORIGIN_CITY	DEST_CITY	DIVERTED_TO	EMERGENCY_CODE
18	2022-05-25	Delta Air Lines	DL5637 / RPA5637	Boston	Kansas City	Pittsburgh	7700.0
23	2022-05-24	United Airlines	UA574 / UAL574	San Francisco	Houston	San Francisco	
26	2022-05-23	American Airlines	AA1280 / AAL1280	Phoenix	New York	Pittsburgh	
31	2022-05-20	Delta Air Lines	DL4681 / EDV4681	Minneapolis	Cedar Rapids	Minneapolis	7700.0
32	2022-05-19	JetBlue	B6163 / JBU163	New York	Sarasota	New York	

Merging the 3 datasets

In [83]:

```
#Merge the 3 datasets

merge1 = (pd.merge(db_flight_data_df, us_diverted_df,
                                   how='outer',
                                   left_on=['MKT_UNIQUE_CARRIER','FL_DATE', 'ORIGIN', 'D
```

```
                         right_on = ['OP_UNIQUE_CARRIER','FL_DATE','ORIGIN','D
                         suffixes=('_FL','_DIV'))).drop_duplicates()
```

In [84]:
```
merge1 = merge1.drop_duplicates()  #drop duplicate rows from the merge
```

In [85]:
```
merge1.shape
```

Out[85]:
```
(601562, 46)
```

In [86]:
```
flight_info_df = pd.merge(merge1,db_weather_data_df,
                         how='outer',
                         left_on=['FL_DATE','ORIGIN','DEST', 'OP_UNIQUE_CARRIER_FL', 'MK
                         right_on = ['FL_DATE','ORIGIN_W','DEST_W', 'OP_CARRIER', 'MKT_C
                         suffixes=('_FL','_WT'))
```

In [87]:
```
flight_info_df = flight_info_df.drop_duplicates()
```

In [88]:
```
flight_info_df.shape
```

Out[88]:
```
(601562, 71)
```

Insert merged data from all three sources to a new database table

In [89]:
```
db_flight_info_df = pd.DataFrame()
try:
    #Drop table before re-execution
    drop_resp = Sql_execution('Flight_Info', "drop")
    #Create the final flight data table
    create_resp = Sql_execution('Flight_Info', "create")
    #Insert dataframe rows into the final table
    insert_resp = Sql_execution('Flight_Info', "insert")
    insert_resp.rowcount
    #Read the newly created table and map to a dataframe
    db_flight_info_df = Sql_execution('Flight_Info', "select")
except RuntimeError as err:
    print('There was an error in the SQL execution : ', err)


#Print the final dataframe
print(db_flight_info_df.shape)
db_flight_info_df.head(5)
```

```
(601562, 71)
```

Out[89]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_DATE	MKT_UNIQUE_CARRIER	OP_UNIQUE_CA
0	2022.0	2.0	5.0	1.0	7.0	2022-05-01	AA	
1	2022.0	2.0	5.0	1.0	7.0	2022-05-01	AA	
2	2022.0	2.0	5.0	1.0	7.0	2022-05-01	AA	
3	2022.0	2.0	5.0	1.0	7.0	2022-05-01	AA	
4	2022.0	2.0	5.0	1.0	7.0	2022-05-01	AA	

5 rows × 71 columns

In [90]:

```
con.commit() #commit and close the database connection
con.close()
```

VISUALIZATIONS

1. Reason for Flight Diversions (Web and Flat file data)

PIE

In [117…

```
#Update missing diverted reason in the merged dataset with 'Reason Unavailable'
db_flight_info_df.loc[((db_flight_info_df.DIVERTED==1) & (db_flight_info_df.DIVERTED_REA
```

In [118…

```
db_flight_info_df[db_flight_info_df.DIVERTED==1].groupby(['DIVERTED_REASON'])['DIVERTED_
```

Out[118]:

```
DIVERTED_REASON             DIVERTED_REASON
Reason Unavailable          Reason Unavailable          1570
bird strike                 bird strike                    2
hydraulic issue             hydraulic issue                1
landing gear issue          landing gear issue             1
possible medical emergency  possible medical emergency     1
pressurisation issue        pressurisation issue           2
smell on board              smell on board                 1
smoke on board              smoke on board                 1
winglet issue               winglet issue                  2
Name: DIVERTED_REASON, dtype: int64
```

> Because of a missing unique identifier in the flight data and diverted data, multiple rows have been updated with the diversion reason, when the 2 datasets were merged.
>
> Identifying the right rows and overriding diversion reason for others with an empty string.

In [119…

```
len(db_flight_info_df[(db_flight_info_df.DIVERTED==0) & db_flight_info_df.DIVERTED_REASO
```

Out[119]:

```
27
```

In [120…

```
db_flight_info_df.loc[(db_flight_info_df.DIVERTED==0) & db_flight_info_df.DIVERTED_REASO
```

```
C:\Users\aarti\AppData\Local\Temp\ipykernel_74008\2726017710.py:1: SettingWithCopyWarnin
g:


A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
```

> Overall reasons for flight diversions in May 2022

In [121…

```
db_diverted_data_df.groupby(['DIVERTED_REASON'])['DIVERTED_REASON'].value_counts().sort_
```

Out[121]:

```
DIVERTED_REASON             DIVERTED_REASON
Reason Unavailable          Reason Unavailable            13
air conditioning issue      air conditioning issue         1
bird strike                 bird strike                    8
bomb threat                 bomb threat                    1
brakes issue                brakes issue                   1
```

```
cracked windshield           cracked windshield              1
disruptive passenger         disruptive passenger            5
engine issue                 engine issue                    4
hydraulic issue              hydraulic issue                 5
landing gear issue           landing gear issue              3
maintenance issue            maintenance issue               1
medical emergency            medical emergency              14
odor in cockpit              odor in cockpit                 1
odor on board                odor on board                   2
operational reasons          operational reasons             1
possible landing gear issue  possible landing gear issue     1
possible medical emergency   possible medical emergency      1
possible technical issue     possible technical issue        2
pressurisation issue         pressurisation issue            6
rostering_error              rostering_error                 1
smell on board               smell on board                  3
smoke indication             smoke indication                1
smoke on board               smoke on board                  1
technical issue              technical issue                 8
weather radar issue          weather radar issue             1
winglet issue                winglet issue                   1
Name: DIVERTED_REASON, dtype: int64
```

In [122…

```
len(db_diverted_data_df)
```

Out[122]:

```
87
```

In [123…

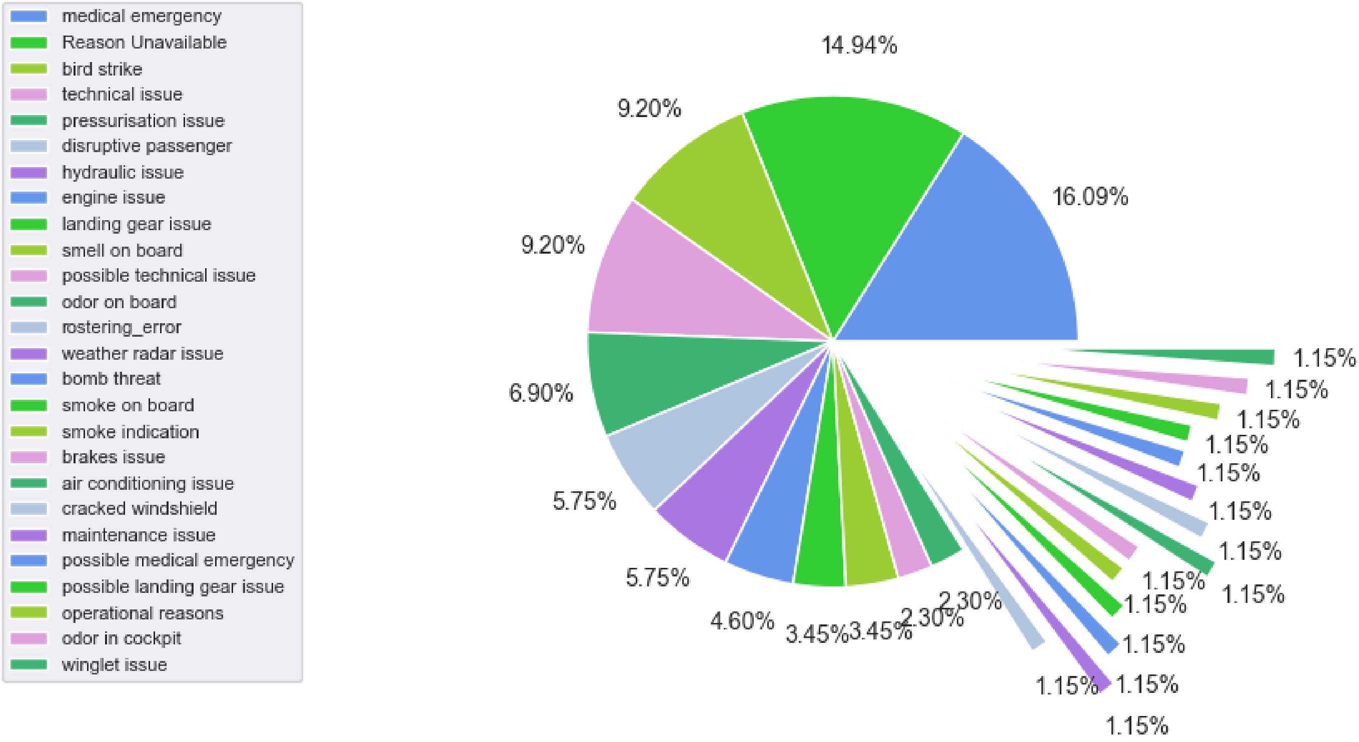
```
#Calculate the overall diversion reason percentage from the web source
overall_diversions = db_diverted_data_df.value_counts(subset=['DIVERTED_REASON']).reset_
overall_diversions_df = pd.DataFrame(overall_diversions)
overall_diversions_df.columns = ['DIVERTED_REASON','TOTAL']
overall_diversions_df['PERCENTAGE'] = round(overall_diversions_df.TOTAL/overall_diversio

overall_diversions_df = overall_diversions_df.sort_values('PERCENTAGE',ascending=False)

colors = [ # matplotlib named colors
         'cornflowerblue','limegreen','yellowgreen','plum','mediumseagreen','lightsteelb
        # any color using the color codes
        "#a977e2"]
plt.pie(overall_diversions_df['PERCENTAGE'],colors=colors,
        autopct='%.2f%%',  pctdistance=1.2,
        explode = [0,0,0,0,0,0,0,0,0,0,0,0,0.5,0.8,0.7,0.6,0.5,0.5,0.8,0.7,0.6,0.5,0.5,0
plt.legend(labels = overall_diversions_df['DIVERTED_REASON'],
           loc='center right', bbox_to_anchor=(-0.35, .5), fontsize=8)
```

Out[123]:

```
<matplotlib.legend.Legend at 0x1f27221e460>
```



> From the above plot, we can see that majority of flight diversions in May'2022 were because of Medical emergencies. Around 15% of the overall flights diversion reason is unavailable.

In [124…

```
#Get the flight diversion reason from the Domestic Flights dataset
flights_diverted = db_flight_info_df[db_flight_info_df.DIVERTED==1].value_counts(subset=
flights_diverted_df = pd.DataFrame(flights_diverted)
flights_diverted_df.columns = ['DIVERTED_REASON','TOTAL']
flights_diverted_df['PERCENTAGE'] = round(flights_diverted_df.TOTAL/flights_diverted_df.

flights_diverted_df = flights_diverted_df.sort_values('PERCENTAGE',ascending=False)
flights_diverted_df
```

Out[124]:

	DIVERTED_REASON	TOTAL	PERCENTAGE
0	Reason Unavailable	1570	99.30
1	bird strike	2	0.13
2	pressurisation issue	2	0.13
3	winglet issue	2	0.13
4	hydraulic issue	1	0.06
5	landing gear issue	1	0.06
6	possible medical emergency	1	0.06
7	smell on board	1	0.06
8	smoke on board	1	0.06

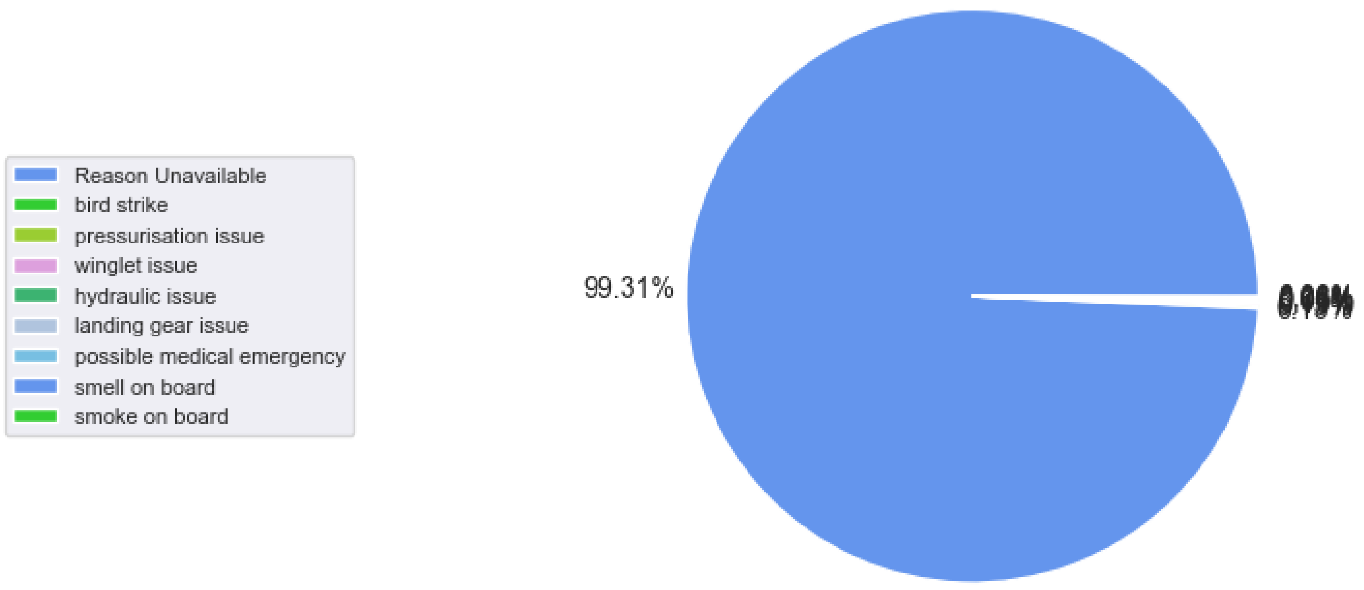
In [125…

```
colors = [ # matplotlib named colors
     'cornflowerblue','limegreen','yellowgreen','plum','mediumseagreen','lightsteelblue'
        # any color using the color codes
        "#77BFE2"]
plt.pie(flights_diverted['PERCENTAGE'],
        #labels = flights_diverted['DIVERTED_REASON'],
        colors=colors, autopct='%.2f%%', pctdistance=1.2)
```

```
plt.legend(labels = flights_diverted['DIVERTED_REASON'],
           loc='center right', bbox_to_anchor=(-0.35, .5), fontsize=8)
```

Out[125]:

```
<matplotlib.legend.Legend at 0x1f271659790>
```



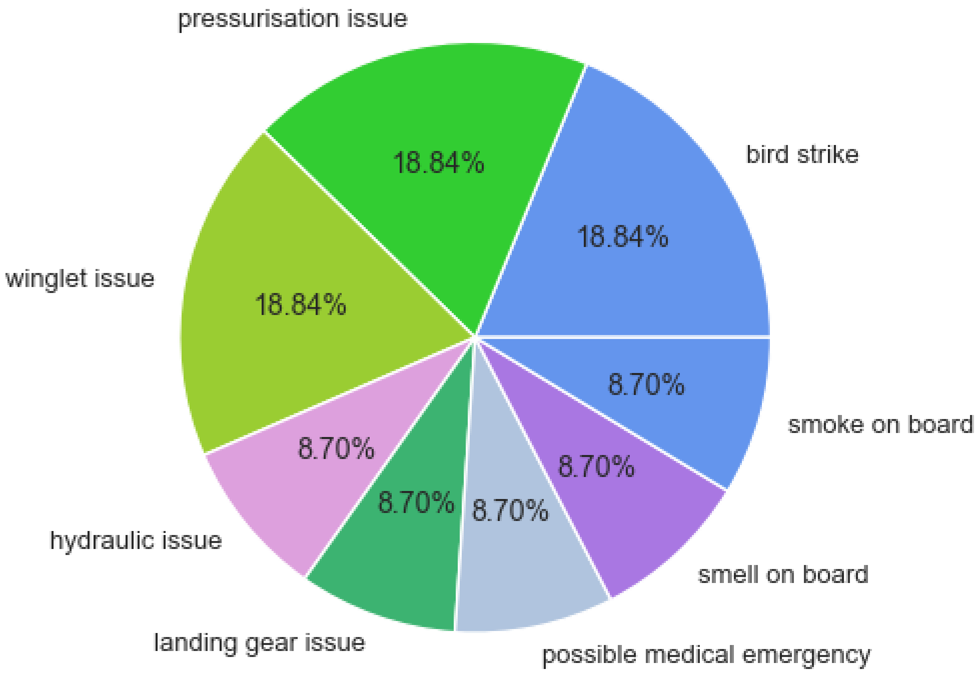
> This plot does not provide any necessary observations because over 95% entries in the flight dataset do not have a match in the diverted data (Web). Reducing the dataset to domestic flights with a match and valid reason for diversion.

In [126…

```
colors = [ # matplotlib named colors
          'cornflowerblue','limegreen','yellowgreen','plum','mediumseagreen','lightsteelb
         # any color using the color codes
         "#a977e2"]
plt.pie(flights_diverted[flights_diverted.DIVERTED_REASON != 'Reason Unavailable']['PERC
         colors=colors,
         labels = flights_diverted[flights_diverted.DIVERTED_REASON != 'Reason Unavailabl
         autopct='%.2f%%')
```

Out[126]:

```
([<matplotlib.patches.Wedge at 0x1f270fe69a0>,
  <matplotlib.patches.Wedge at 0x1f270fe68e0>,
  <matplotlib.patches.Wedge at 0x1f270dd5670>,
  <matplotlib.patches.Wedge at 0x1f270dd5d00>,
  <matplotlib.patches.Wedge at 0x1f270d083d0>,
  <matplotlib.patches.Wedge at 0x1f270d08a60>,
  <matplotlib.patches.Wedge at 0x1f270b7c130>,
  <matplotlib.patches.Wedge at 0x1f270fe68b0>],
 [Text(0.912873821615314, 0.6137274523837531, 'bird strike'),
  Text(-0.22380161216582517, 1.0769924969060731, 'pressurisation issue'),
  Text(-1.081807871121281, 0.19922783435062993, 'winglet issue'),
  Text(-0.853282419068390 3, -0.6941967396270282, 'hydraulic issue'),
  Text(-0.368367561785127, -1.0364870184543948, 'landing gear issue'),
  Text(0.22380163737465342, -1.0769924916676181, 'possible medical emergency'),
  Text(0.7508084829026913, -0.803919537019321, 'smell on board'),
  Text(1.059209028465566, -0.29677640407726485, 'smoke on board')],
 [Text(0.49793117542653487, 0.33476042857295624, '18.84%'),
  Text(-0.12207360663590462, 0.587450452857858, '18.84%'),
  Text(-0.5900770206116077, 0.10866972782761632, '18.84%'),
  Text(-0.46542677403730376, -0.3786527670692881, '8.70%'),
  Text(-0.20092776097370 56, -0.565356555520579, '8.70%'),
  Text(0.12207362038617457, -0.5874504500005189, '8.70%'),
  Text(0.4095318997651043, -0.4385015656469023, '8.70%'),
  Text(0.577750379163036, -0.161878038587599, '8.70%')])
```



> The percentage is based on the few matches we got from the diverted data. It is not enough data but we get an idea of most common diversion reasons. As suspected, the web data is not 100% accurate. We did not get the diversion reason for all flights diverted in May'2022

2. Flight Delay Reasons

Histogram

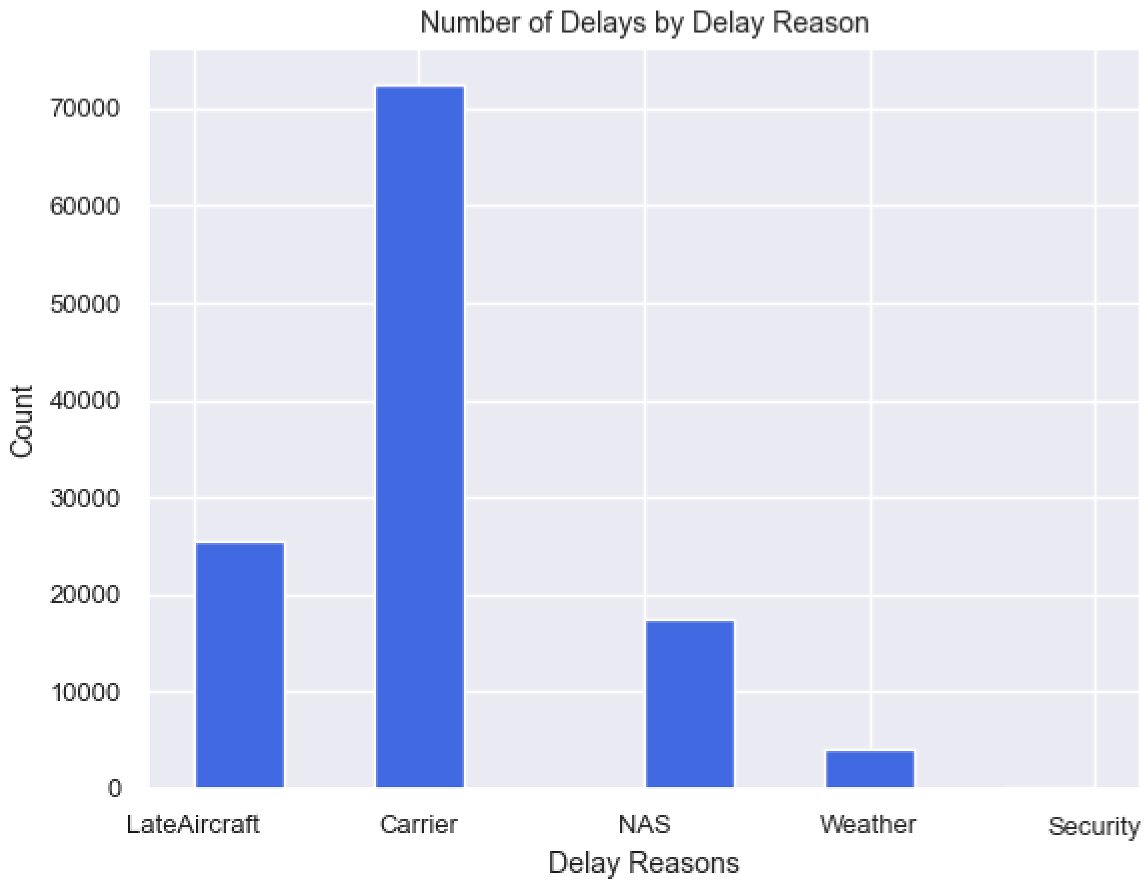
In [127…

```
plt.hist(x = db_flight_info_df[db_flight_info_df.STATUS=='Delayed'].DELAY_REASON, color
plt.xlabel('Delay Reasons')
plt.ylabel('Count')

# displaying the title
plt.title("Number of Delays by Delay Reason")
```

Out[127]:

```
Text(0.5, 1.0, 'Number of Delays by Delay Reason')
```



3. Weather Delay Reasons (API and Flat file data)

BAR

In [128…

```
db_flight_info_df.CONDITIONS.unique()
```

Out[128]:

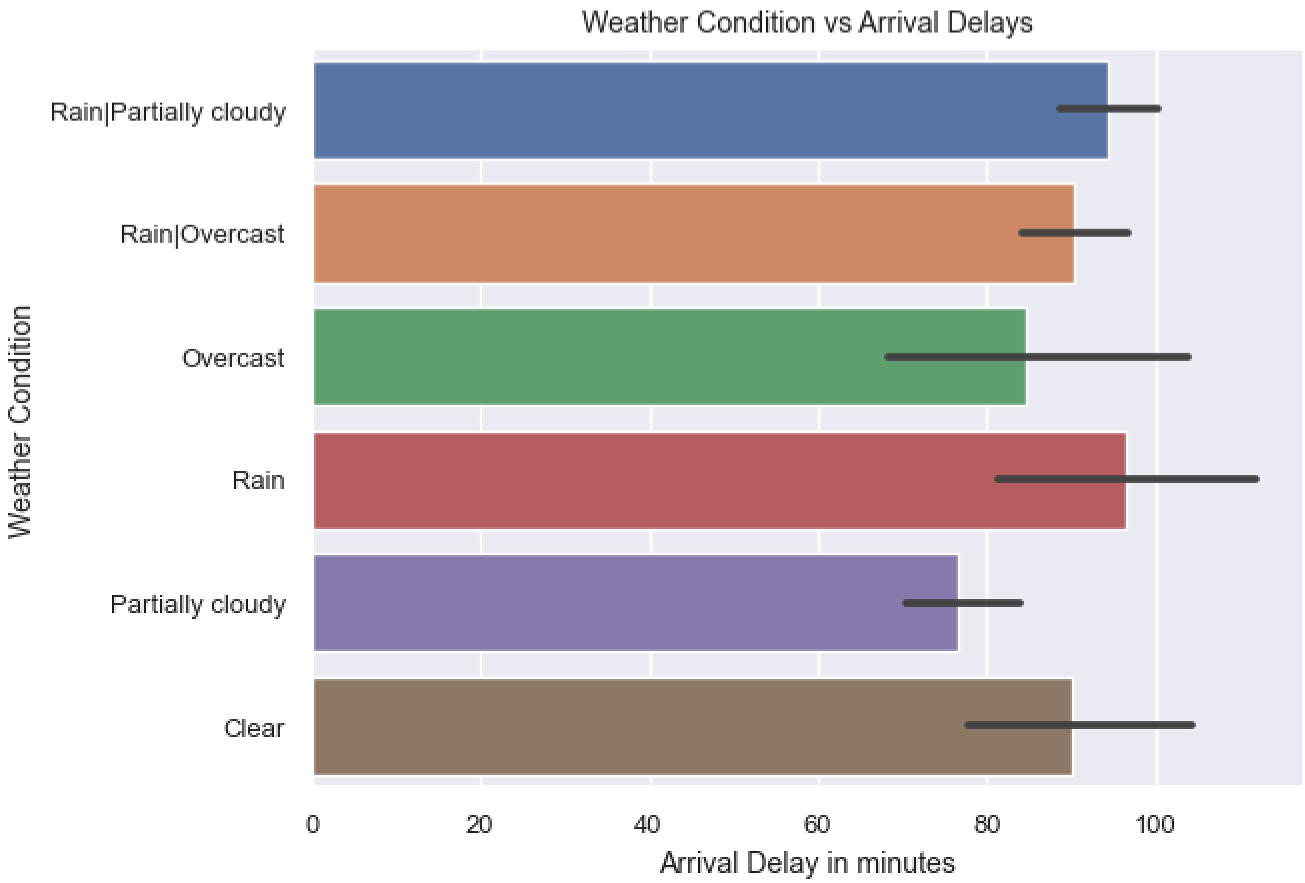
```
array([None, 'Rain|Partially cloudy', 'Rain|Overcast', 'Overcast', 'Rain',
       'Partially cloudy', 'Clear'], dtype=object)
```

In [129…

```
sns.set(font_scale=0.85)
ax=sns.barplot(x = 'ARR_DELAY',y ='CONDITIONS',
               data = db_flight_info_df[((db_flight_info_df.STATUS =='Delayed') &
                                         (db_flight_info_df.DELAY_REASON == 'Weather'))]
ax.set_title("Weather Condition vs Arrival Delays")
ax.set_ylabel('Weather Condition')
ax.set_xlabel('Arrival Delay in minutes')
#ax.tick_params(axis='x', rotation=90)
```

Out[129]:

```
Text(0.5, 0, 'Arrival Delay in minutes')
```



> Since the project is restricted to the month of May, we can see most of the weather delays are due to rain. The average arrival delay is over an hour.

4. Correlation heatmap (Merged data from all 3 sources)

Heatmap

In [130…

```
corr_df = db_flight_info_df.select_dtypes([np.number])
corr_df.head(2)
```

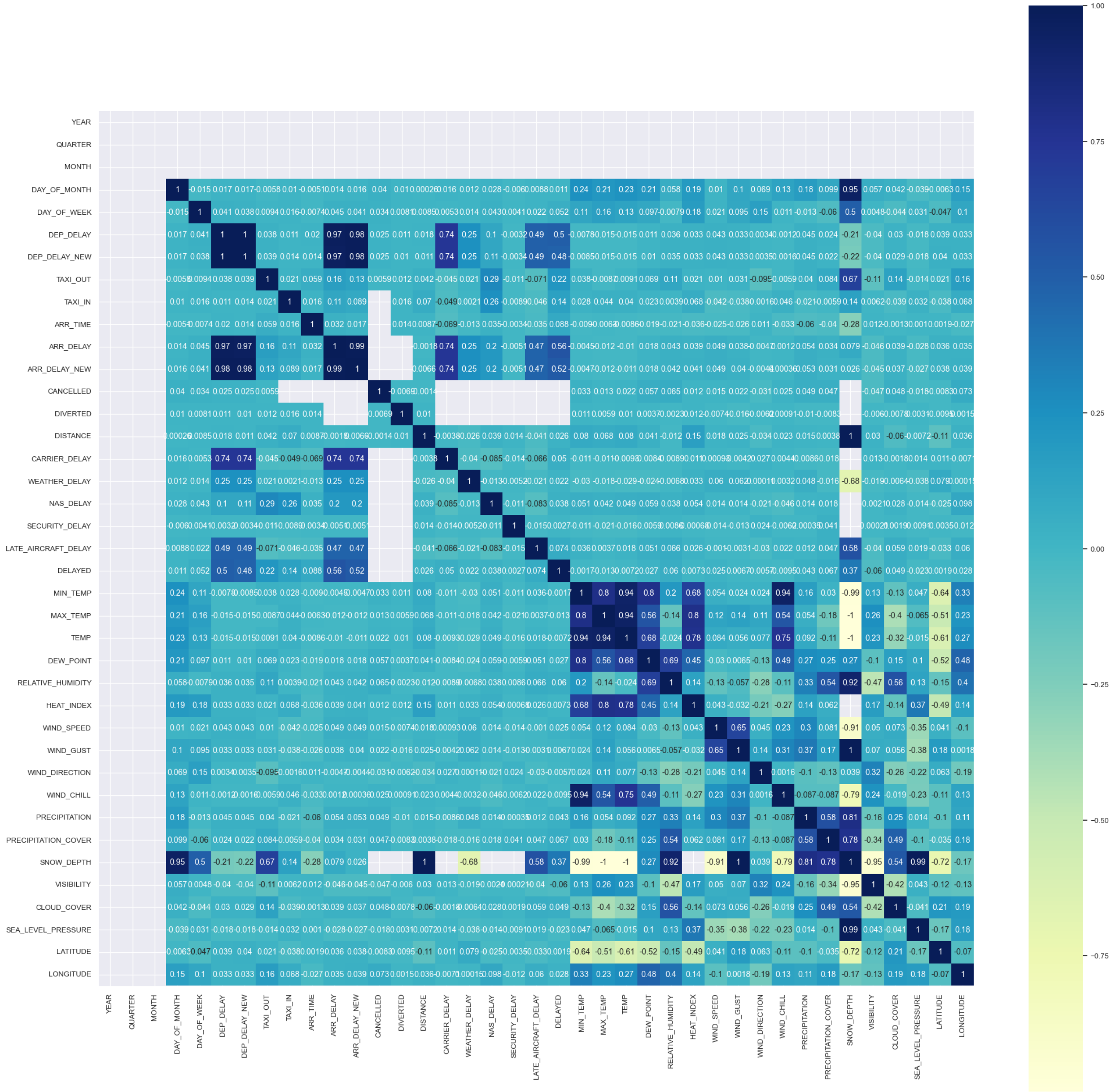
Out[130]:

	YEAR	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	DEP_DELAY	DEP_DELAY_NEW	TAXI_OUT	TAXI_I
0	2022.0	2.0	5.0	1.0	7.0	-9.0	0.0	11.0	22.
1	2022.0	2.0	5.0	1.0	7.0	-8.0	0.0	13.0	12.

2 rows × 39 columns

In [131…

```
corrmat = corr_df.corr()
f, ax = plt.subplots(figsize=(25, 25))
sns.heatmap(corrmat, vmax=1, square=True,annot=True,cmap='YlGnBu');
plt.show()
```



5. Operating Airline and Weather Conditions

BAR

In [132…

```
#Calculate the percentage of operating flights by carrier that were delayed due to weath
flight_carrier_totals = db_flight_info_df[((db_flight_info_df.STATUS =='Delayed')  & (db
flight_carrier_totals = pd.DataFrame(flight_carrier_totals)
flight_carrier_totals.columns = ['OP_UNIQUE_CARRIER_FL','TOTAL']
flight_carrier_totals['PERCENTAGE'] = round(flight_carrier_totals.TOTAL/flight_carrier_t
flight_carrier_totals = flight_carrier_totals.sort_values('PERCENTAGE',ascending=False)
flight_carrier_totals.head(5)
```

Out[132]:

	OP_UNIQUE_CARRIER_FL	TOTAL	PERCENTAGE
0	OO	926	22.30
1	AA	659	15.87
2	DL	314	7.56
3	NK	268	6.45

4	UA	263	6.33

In [133…

```
#Get the counts of flights by weather reason and calculate the percentage o
carrier_weather_condition = db_flight_info_df[((db_flight_info_df.STATUS =='Delayed')   &
carrier_weather_condition_df = pd.DataFrame(carrier_weather_condition)
carrier_weather_condition_df.columns = ['OP_UNIQUE_CARRIER_FL','CONDITIONS','COUNT']
carrier_weather_condition_df = carrier_weather_condition_df.sort_values('OP_UNIQUE_CARRI
carrier_weather_condition_df['PERCENTAGE'] = ''

#print(weather_condition_df.head(10))
for index, row in carrier_weather_condition_df.iterrows():
    tot = flight_carrier_totals.loc[flight_carrier_totals.OP_UNIQUE_CARRIER_FL==row.OP_U
    val = (row.COUNT/tot * 100)
    carrier_weather_condition_df.at[index,'PERCENTAGE'] = round(val[0].astype(float),2)
carrier_weather_condition_df = carrier_weather_condition_df.sort_values(by = ['CONDITION
carrier_weather_condition_df.head(5)
```

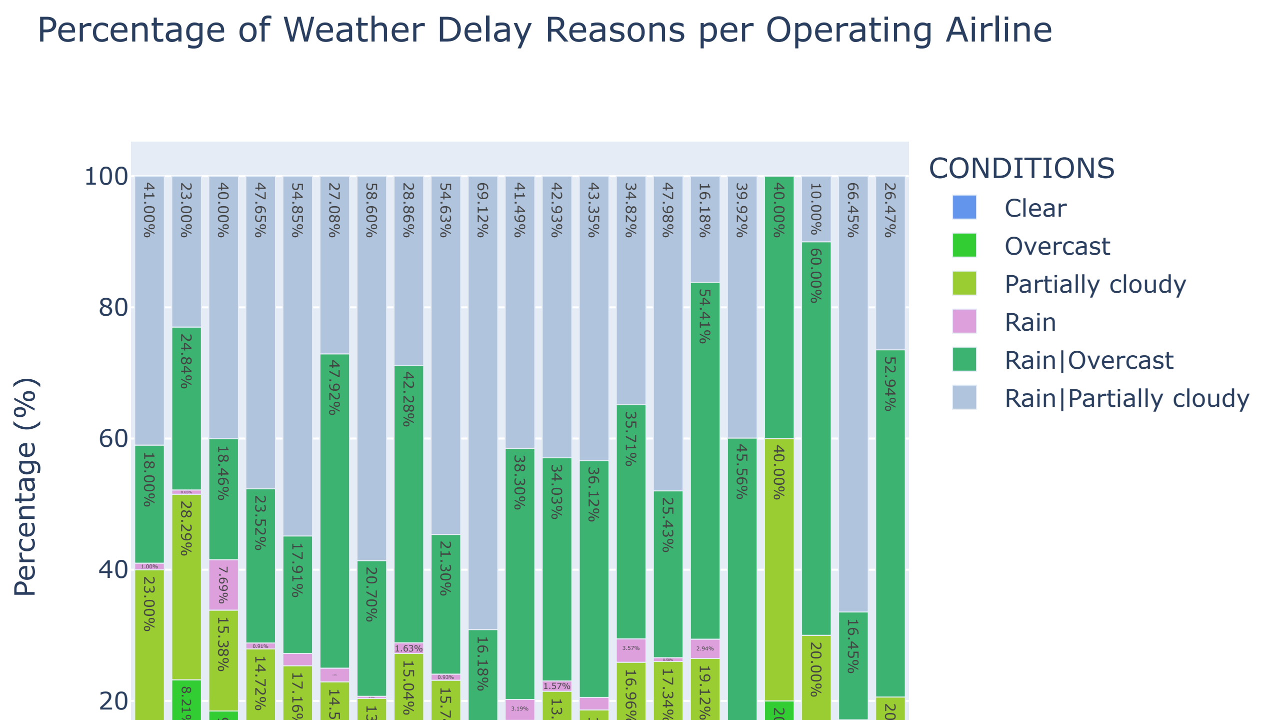
Out[133]:

	OP_UNIQUE_CARRIER_FL	CONDITIONS	COUNT	PERCENTAGE
53	G4	Clear	16	16.0
7	OO	Clear	139	15.01
77	AS	Clear	6	9.23
24	AA	Clear	46	6.98
49	NK	Clear	17	6.34

Plotly

In [134…

```
fig = px.bar(carrier_weather_condition_df, x="OP_UNIQUE_CARRIER_FL", y="PERCENTAGE",
             color="CONDITIONS",title="Percentage of Weather Delay Reasons per Operating
             text=carrier_weather_condition_df.PERCENTAGE.apply(lambda x: '{0:1.2f}%'.fo
             labels=dict(OP_UNIQUE_CARRIER_FL="Operating Airlines", PERCENTAGE="Percenta
             color_discrete_sequence=colors)
fig.update_xaxes(tickangle=80)
fig.update_layout(autosize=True)
fig.show('notebook')
```



> Plotly charts cannot be exported to a pdf, sometimes. We'll try to build the same visualization with seaborn and matplotlib. We'll only consider the plotly chart for this project.

Seaborn

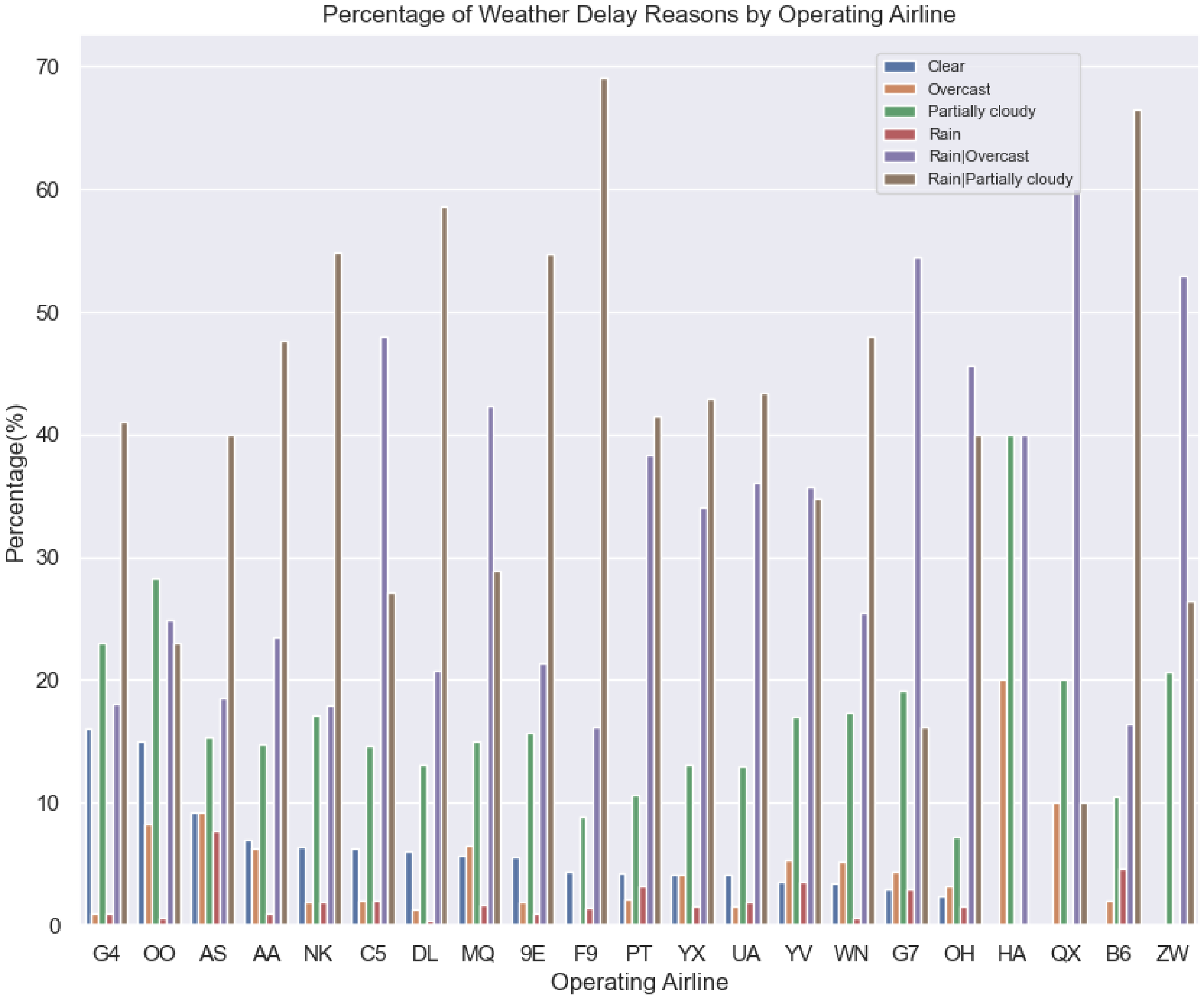
In [141…

```
sns.set(rc={'figure.figsize':(10,8)})
sns.barplot(data=carrier_weather_condition_df,x="OP_UNIQUE_CARRIER_FL",y="PERCENTAGE",
plt.legend(loc='right', bbox_to_anchor=(0.9, 0.9), fontsize=8)
plt.xlabel('Operating Airline')
plt.ylabel('Percentage(%)')

# displaying the title
plt.title("Percentage of Weather Delay Reasons by Operating Airline")
```

Out[141]:

```
Text(0.5, 1.0, 'Percentage of Weather Delay Reasons by Operating Airline')
```

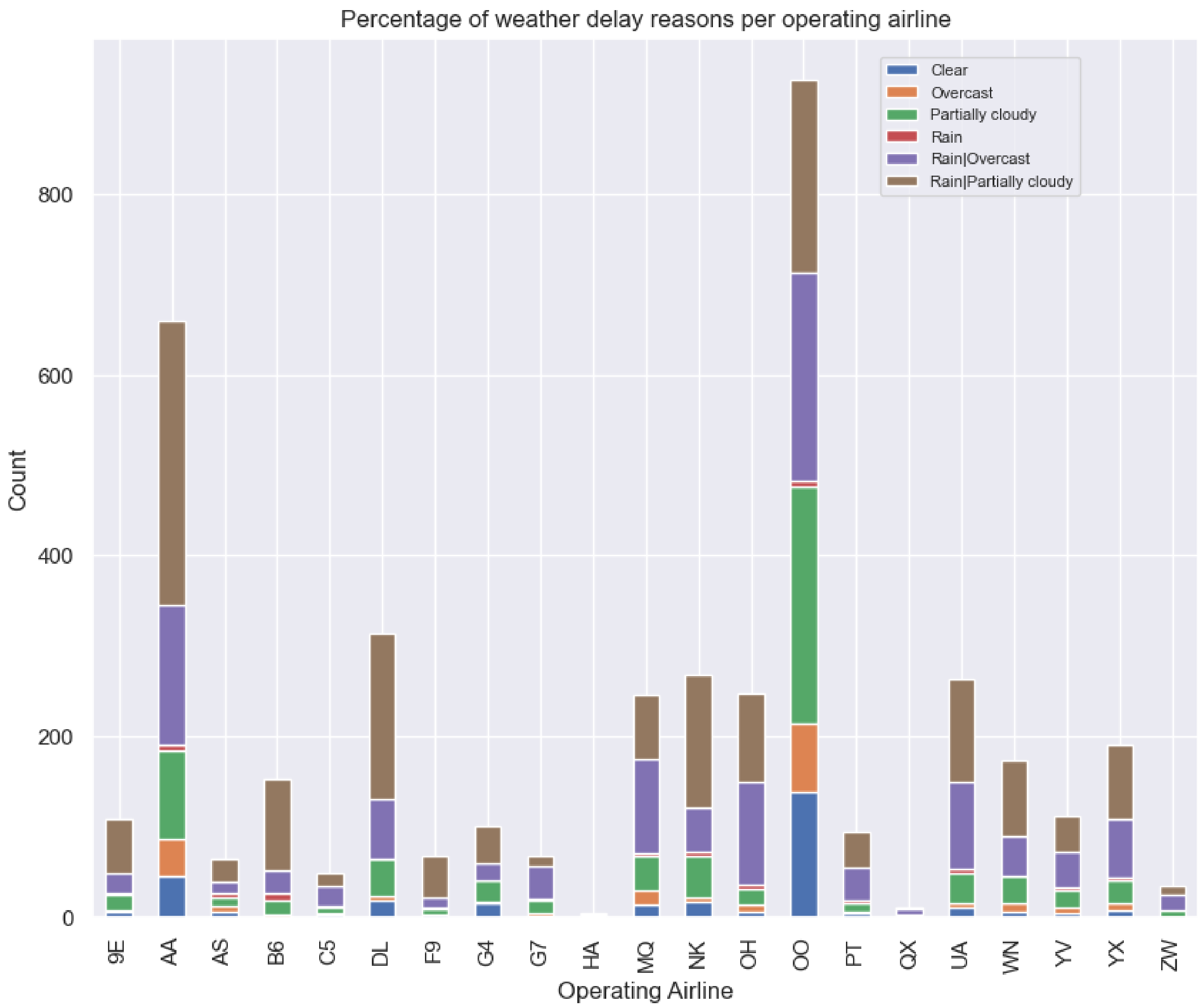


Matplotlib

```
In [144…  figsize=(8,8)
          db_flight_info_df[((db_flight_info_df.STATUS =='Delayed')  & (db_flight_info_df.DELAY_RE
          plt.legend(loc='right', bbox_to_anchor=(0.9, 0.9), fontsize=8)
          plt.xlabel('Operating Airline')
          plt.ylabel('Count')

          # displaying the title
          plt.title("Percentage of weather delay reasons per operating airline")
```

```
Out[144]: Text(0.5, 1.0, 'Percentage of weather delay reasons per operating airline')
```



Conclusion

> For the term project's final milestone, we combined data from three sources: a flat file in CSV format, diverted flight information from a webpage, and weather data from an API. However, we needed to perform additional transformation steps to merge the datasets successfully.
>
> To prepare the diverted data, we had to modify the flight date format and convert the origin and destination information to match the flat file's 3-character airport codes. Similarly, we modified the flight date format for the weather data and included the operating and marketing carriers in the data frame to merge it with the flight dataset.

> This project highlighted the crucial role of data cleaning and transformation in data science. In real-world scenarios, we encounter complex data sources that require processing and merging for analysis. Throughout this course, I gained valuable skills in web scraping, transforming data into a consistent format, creating tables, storing and retrieving data from SQL tables, and applying visualizations to the final cleansed dataset.

> ### Visualization
>
> The following visualizations were created from the final dataset -
>
> - PIE CHART - A pie chart with different reasons for flight diversions.
> - HISTOGRAM - A histogram with different delay reasons
> - BAR CHART - A bar chart with reasons for weather delay
> - HEAT MAP – A visual representation of how data is distributed in the dataframe 1. The annotation is set to get the correlation for columns.
> - BAR CHART - A stacked bar chart with the percentage of delay per weather condition by operating airline

> ### Ethical Implications
>
> While API and Flat file data are reliable, we discovered inaccuracies in the website's data on diverted flights. Additionally, the lack of information on the data source raises concerns about its accuracy and legality. After merging datasets, we found only 12 matching rows with diversion data out of 1581, highlighting the importance of verifying and vetting our data sources.