



✓ **SpaceX Falcon 9 First Stage Landing Prediction**

✓ Assignment: Exploring and Preparing Data

Estimated time needed: **70** minutes

In this assignment, we will predict if the Falcon 9 first stage will land successfully. SpaceX advertises Falcon 9 rocket launches on its website with a cost of 62 million dollars; other providers cost upward of 165 million dollars each, much of the savings is due to the fact that SpaceX can reuse the first stage.

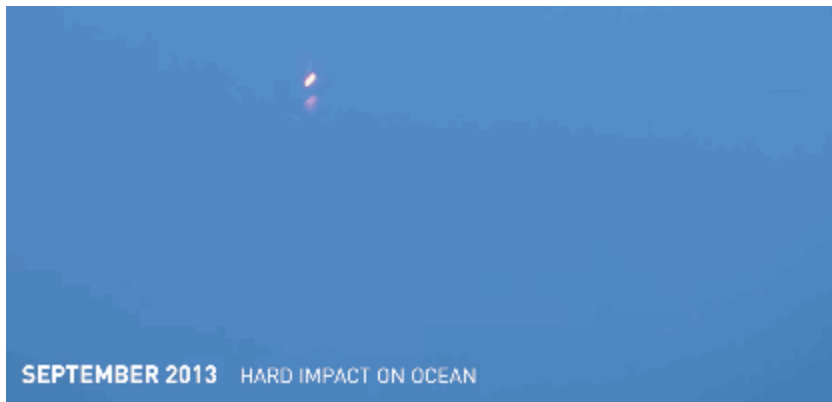
In this lab, you will perform Exploratory Data Analysis and Feature Engineering.

Falcon 9 first stage will land successfully



Several examples of an unsuccessful landing are shown here:





Most unsuccessful landings are planned. Space X performs a controlled landing in the oceans.

✓ Objectives

Perform exploratory Data Analysis and Feature Engineering using Pandas and Matplotlib

- Exploratory Data Analysis
 - Preparing Data Feature Engineering
-

✓ Import Libraries and Define Auxiliary Functions

We will import the following libraries the lab

```
1 # andas is a software library written for the Python programming language for data man
2 import pandas as pd
3 #NumPy is a library for the Python programming language, adding support for large, mul
4 import numpy as np
5 # Matplotlib is a plotting library for python and pyplot gives us a MatLab like plotti
6 import matplotlib.pyplot as plt
7 #Seaborn is a Python data visualization library based on matplotlib. It provides a hig
8 import seaborn as sns
```

✓ Exploratory Data Analysis

First, let's read the SpaceX dataset into a Pandas dataframe and print its summary

```
1 df = pd.read_csv("https://cf-courses-data.s3.us.cloud-object-storage.s.amazonaws.com/TPM
```

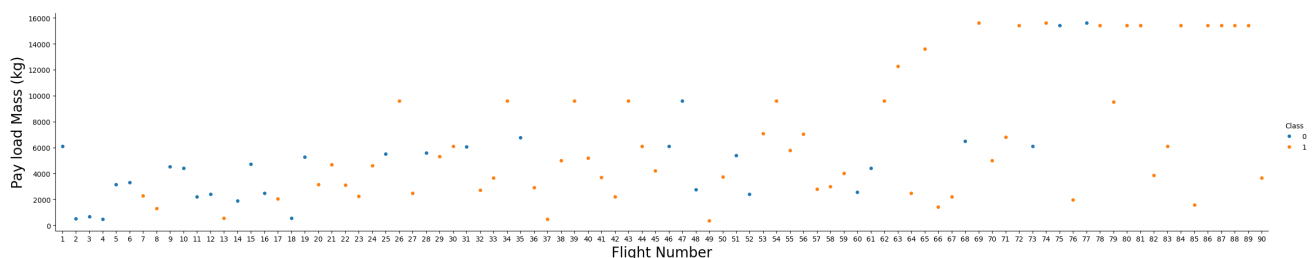
```
1 df=pd.read_csv('https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-
2
3 # If you were unable to complete the previous lab correctly you can uncomment and load
4
5 # df = pd.read_csv('https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud
6
7 df.head(5)
```

	FlightNumber	Date	BoosterVersion	PayloadMass	Orbit	LaunchSite	Outcome
0	1	2010-06-04	Falcon 9	6104.959412	LEO	CCAFS SLC 40	None None
1	2	2012-05-22	Falcon 9	525.000000	LEO	CCAFS SLC 40	None None
2	3	2013-03-01	Falcon 9	677.000000	ISS	CCAFS SLC 40	None None
3	4	2013-09-29	Falcon 9	500.000000	PO	VAFB SLC 4E	False Ocean
4	5	2013-12-03	Falcon 9	3170.000000	GTO	CCAFS SLC 40	None None

First, let's try to see how the FlightNumber (indicating the continuous launch attempts.) and Payload variables would affect the launch outcome.

We can plot out the FlightNumber vs. PayloadMass and overlay the outcome of the launch. We see that as the flight number increases, the first stage is more likely to land successfully. The payload mass is also important; it seems the more massive the payload, the less likely the first stage will return.

```
1 sns.catplot(y="PayloadMass", x="FlightNumber", hue="Class", data=df, aspect = 5)
2 plt.xlabel("Flight Number",fontsize=20)
3 plt.ylabel("Pay load Mass (kg)",fontsize=20)
4 plt.show()
```

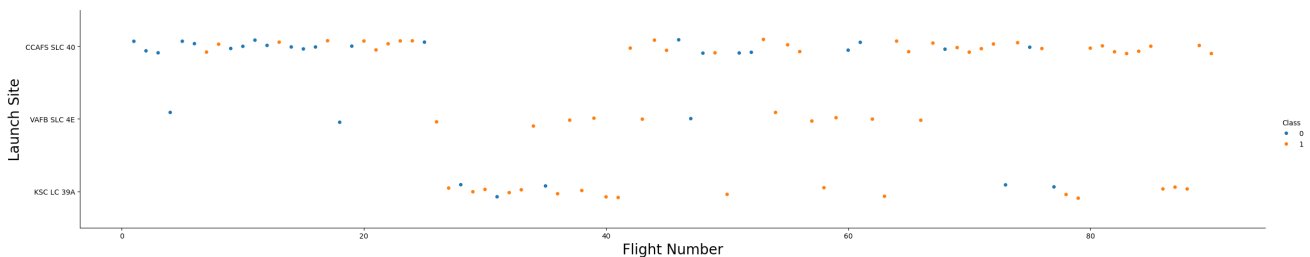


Next, let's drill down to each site visualize its detailed launch records.

✓ TASK 1: Visualize the relationship between Flight Number and Launch Site

Use the function `catplot` to plot `FlightNumber` vs `LaunchSite`, set the parameter `x` parameter to `FlightNumber`, set the `y` to `Launch Site` and set the parameter `hue` to `'class'`

```
1 # Plot a scatter point chart with x axis to be Flight Number and y axis to be the laun
2 sns.catplot(y="LaunchSite", x="FlightNumber", hue="Class", data=df, aspect = 5)
3 plt.xlabel("Flight Number", fontsize=20)
4 plt.ylabel("Launch Site", fontsize=20)
5 plt.show()
```



Now try to explain the patterns you found in the Flight Number vs. Launch Site scatter point plots.

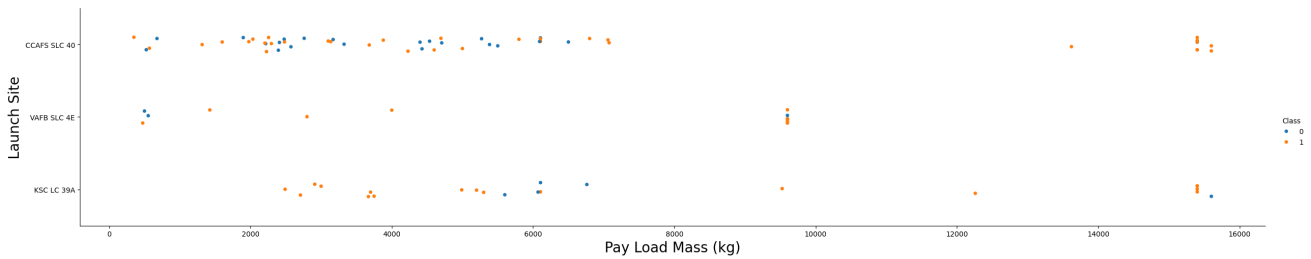
✓ TASK 2: Visualize the relationship between Payload and Launch Site

We also want to observe if there is any relationship between launch sites and their payload mass.

```

1 # Plot a scatter point chart with x axis to be Pay Load Mass (kg) and y axis to be the
2 sns.catplot(y="LaunchSite", x="PayloadMass", hue="Class", data=df, aspect = 5)
3 plt.xlabel("Pay Load Mass (kg)",fontsize=20)
4 plt.ylabel("Launch Site",fontsize=20)
5 plt.show()

```



Now if you observe Payload Vs. Launch Site scatter point chart you will find for the VAFB-SLC launchsite there are no rockets launched for heavypayload mass(greater than 10000).

✓ TASK 3: Visualize the relationship between success rate of each orbit type

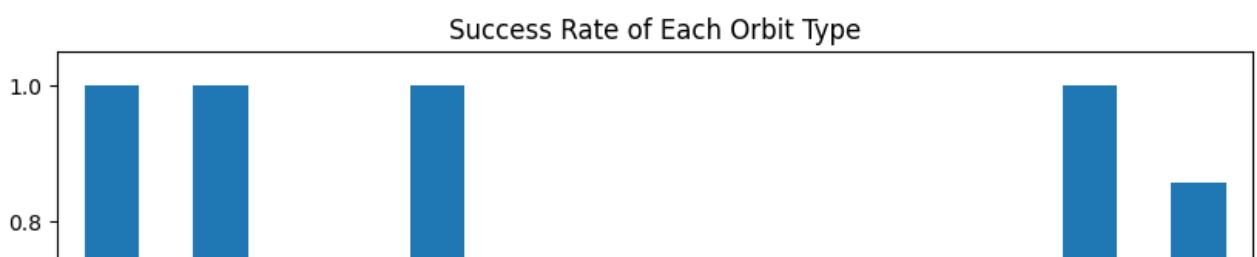
Next, we want to visually check if there are any relationship between success rate and orbit type.

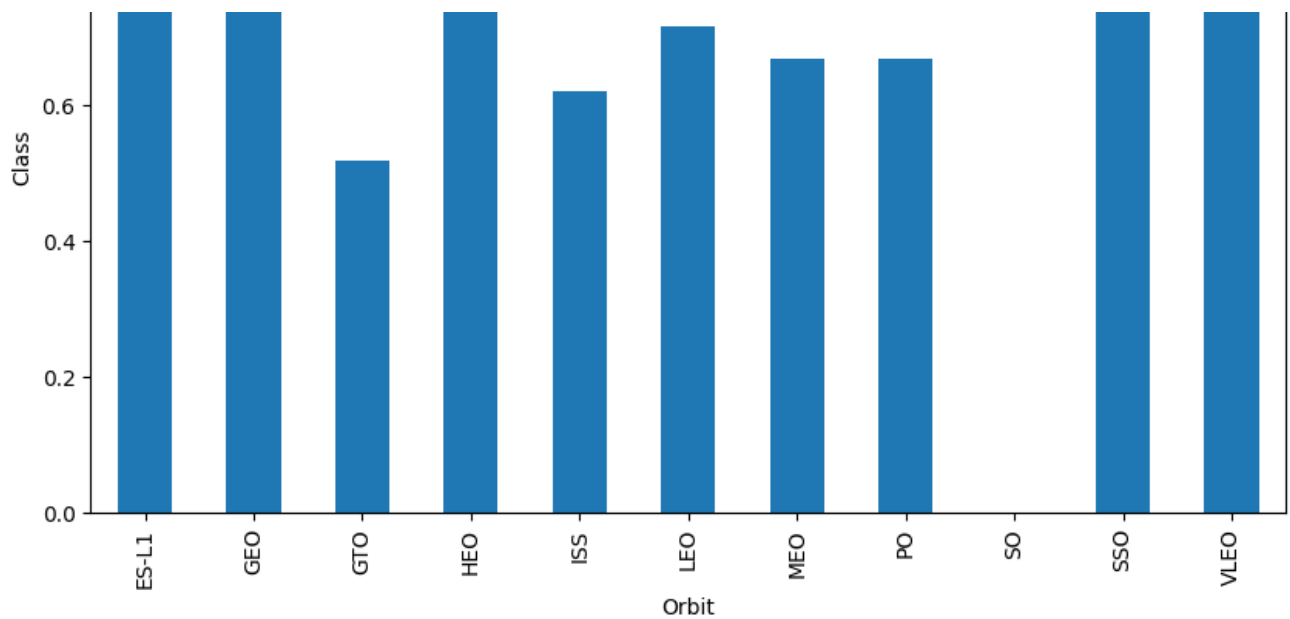
Let's create a bar chart for the success rate of each orbit

```

1 # HINT use groupby method on Orbit column and get the mean of Class column
2 df_bar = df.groupby(['Orbit'])['Class'].mean()
3 df_bar.plot(kind='bar', figsize=(10, 6))
4 plt.xlabel('Orbit') # add to x-label to the plot
5 plt.ylabel('Class') # add y-label to the plot
6 plt.title('Success Rate of Each Orbit Type') # add title to the plot
7 plt.show()

```





Analyze the plotted bar chart try to find which orbits have high sucess rate.

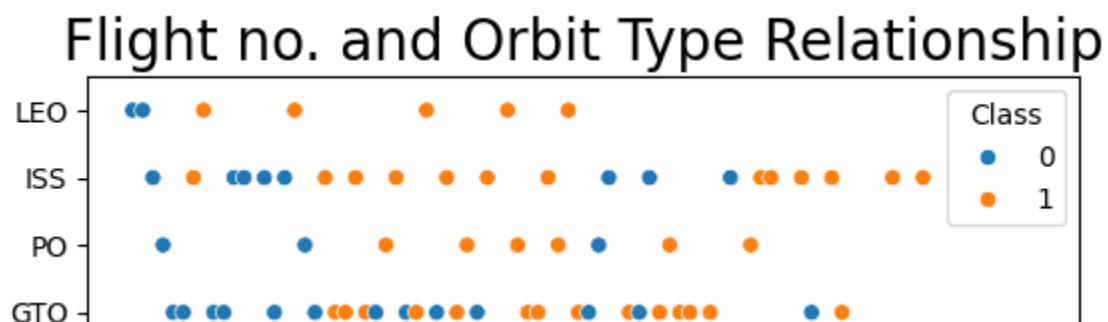
✓ TASK 4: Visualize the relationship between FlightNumber and Orbit type

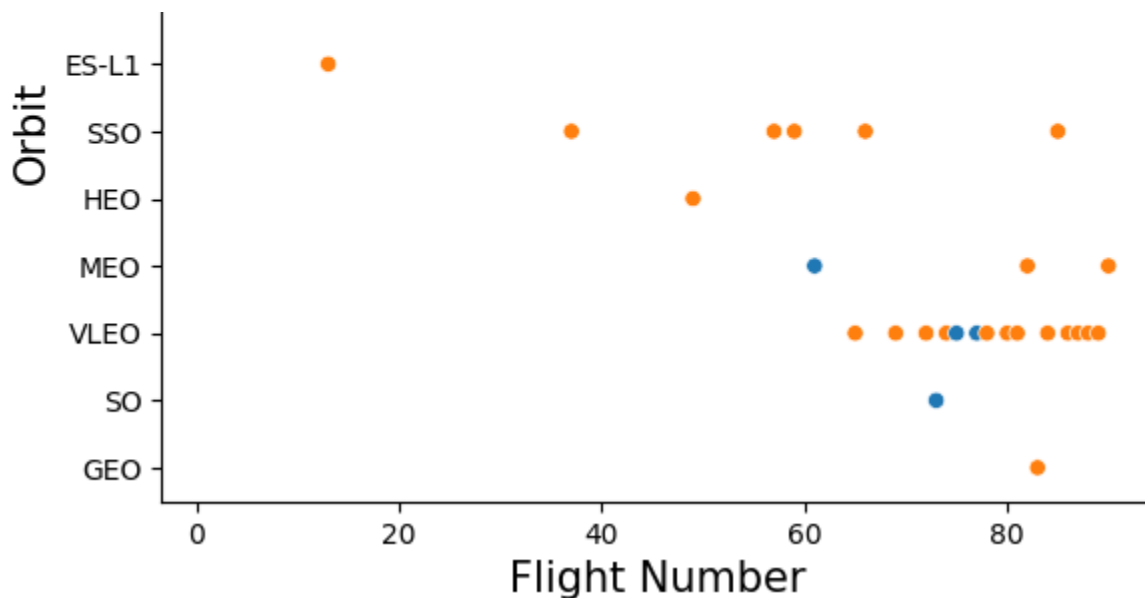
For each orbit, we want to see if there is any relationship between FlightNumber and Orbit type.

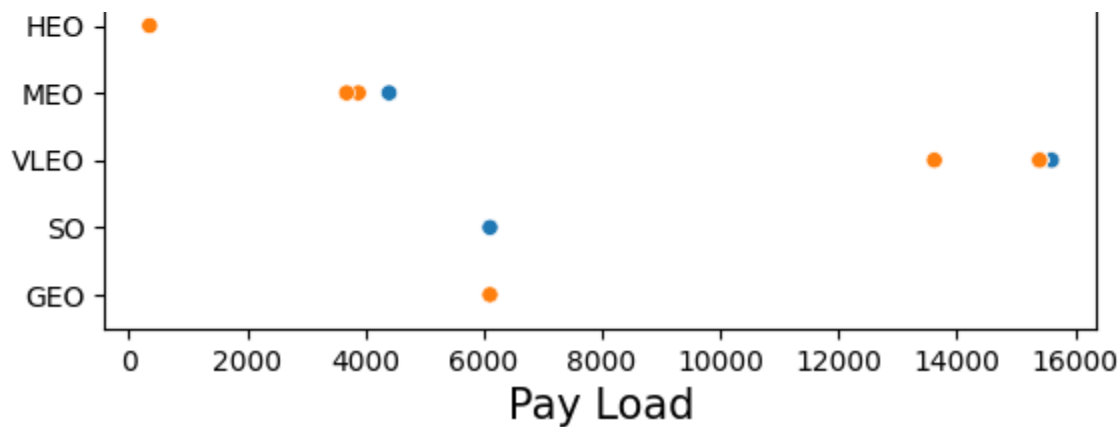
```

1 # Plot a scatter point chart with x axis to be FlightNumber and y axis to be the Orbit
2 sns.scatterplot(y="Orbit", x="FlightNumber", hue="Class", data=df)
3 plt.xlabel("Flight Number",fontsize=15)
4 plt.ylabel("Orbit",fontsize=15)
5 plt.title("Flight no. and Orbit Type Relationship", fontsize = 20)
6 plt.show()

```







With heavy payloads the successful landing or positive landing rate are more for Polar,LEO and ISS.

However for GTO we cannot distinguish this well as both positive landing rate and negative landing(unsuccesful mission) are both there here.

✓ TASK 6: Visualize the launch success yearly trend

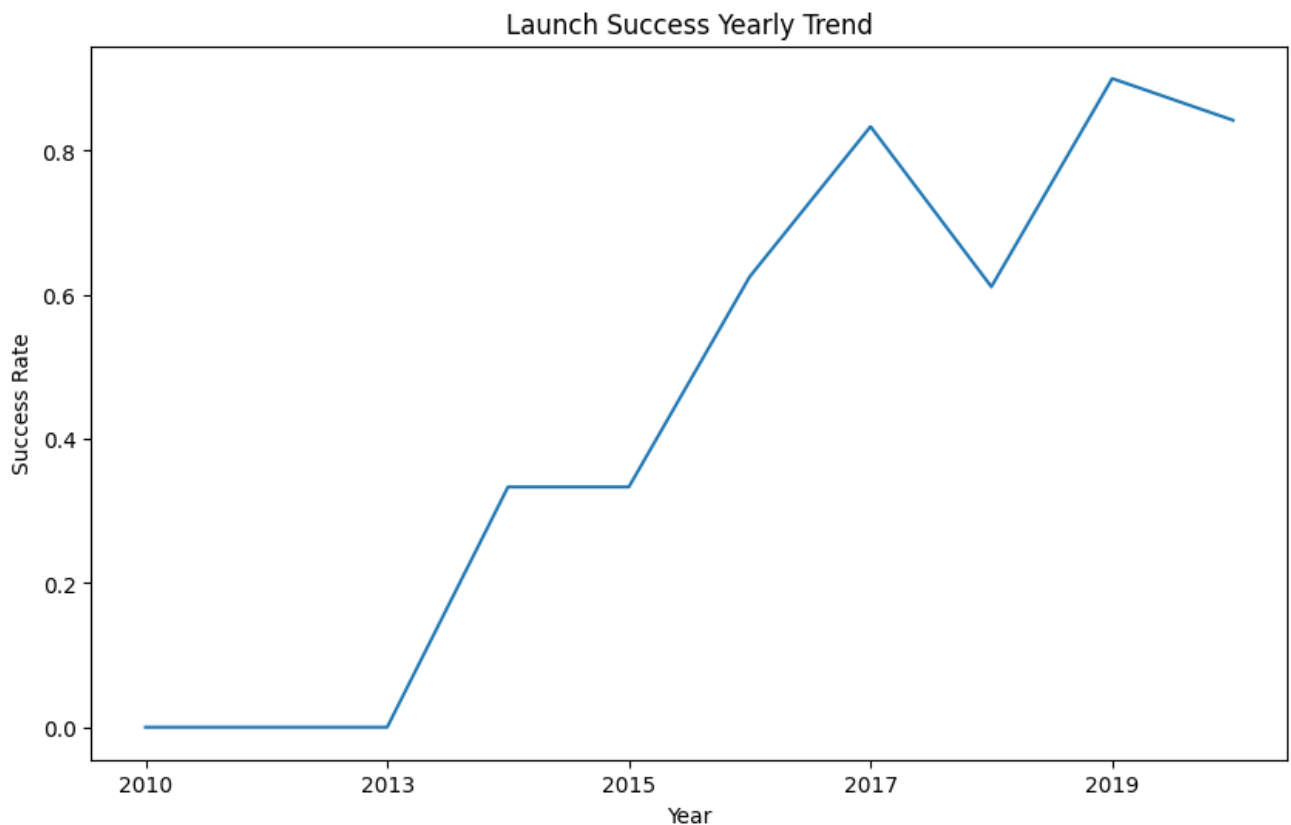
You can plot a line chart with x axis to be Year and y axis to be average success rate, to get the average launch success trend.

The function will help you get the year from the date:

```
1 # A function to Extract years from the date
2 year=[]
3 def Extract_year(date):
4     for i in df["Date"]:
5         year.append(i.split("-")[0])
6     return year
7
```

```
1 # Plot a line chart with x axis to be the extracted year and y axis to be the success
2 # df_bar = df.groupby(['Orbit'])['Class'].mean()
3 df['Year'] = Extract_year(df['Date'])
```

```
1 df_success_yearly = df.groupby(['Year'])['Class'].mean()
2 df_success_yearly.plot(kind='line', figsize=(10, 6))
3 plt.xlabel('Year') # add to x-label to the plot
4 plt.ylabel('Success Rate') # add y-label to the plot
5 plt.title('Launch Success Yearly Trend') # add title to the plot
6 plt.show()
```

You can observe that the success rate since 2013 kept increasing till 2017 (stable in 2014) and after 2015 it started increasing.

✓ Features Engineering

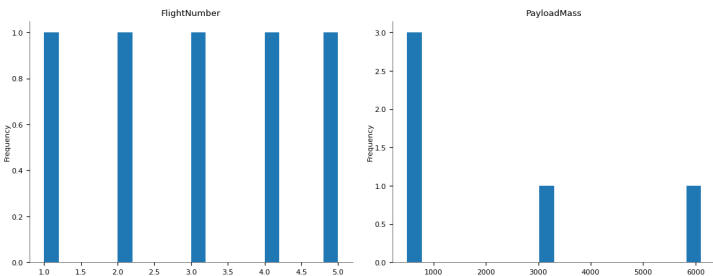
By now, you should obtain some preliminary insights about how each important variable would affect the success rate, we will select the features that will be used in success prediction in the future module.

```
1 features = df[['FlightNumber', 'PayloadMass', 'Orbit', 'LaunchSite', 'Flights', 'GridF  
2 features.head()
```

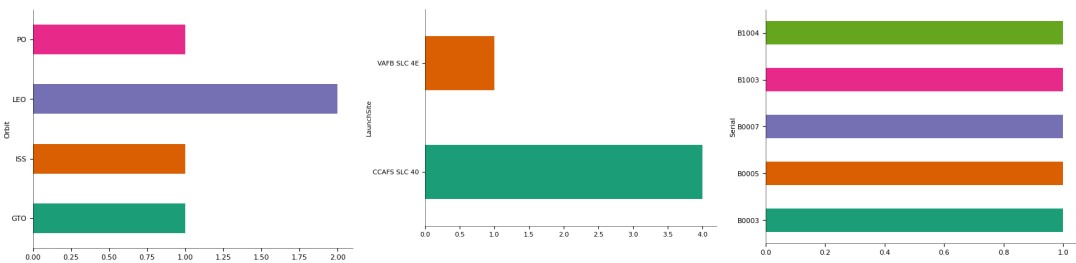
FlightNumber	PayloadMass	Orbit	LaunchSite	Flights	GridFins	Reused	Legs	Lan
--------------	-------------	-------	------------	---------	----------	--------	------	-----

0	1	6104.959412	LEO	CCAFS SLC 40	1	False	False	False
1	2	525.000000	LEO	CCAFS SLC 40	1	False	False	False
2	3	677.000000	ISS	CCAFS SLC 40	1	False	False	False
3	4	500.000000	PO	VAFB SLC 4E	1	False	False	False
4	5	3170.000000	GTO	CCAFS SLC 40	1	False	False	False

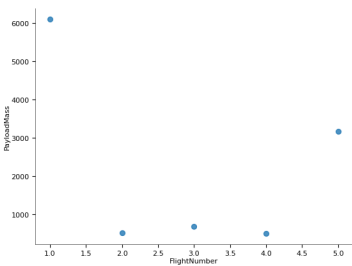
Distributions



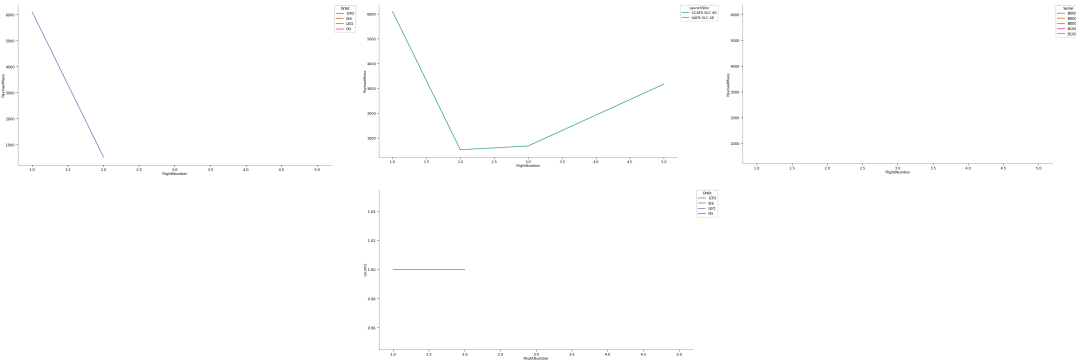
Categorical distributions



2-d distributions



Time series



Values

✓ TASK 7: Create dummy variables to categorical columns

Use the function `get_dummies` and `features` dataframe to apply `OneHotEncoder` to the column `Orbits`, `LaunchSite`, `LandingPad`, and `Serial`. Assign the value to the variable `features_one_hot`, display the results using the method `head`. Your result dataframe must include all features including the encoded ones.

```
1 # HINT: Use get_dummies() function on the categorical columns
2 features_one_hot = pd.get_dummies(features, drop_first=True)
3 features_one_hot.head()
```

	FlightNumber	PayloadMass	Flights	GridFins	Reused	Legs	Block	ReusedCount	Or
0	1	6104.959412	1	False	False	False	1.0	0	
1	2	525.000000	1	False	False	False	1.0	0	
2	3	677.000000	1	False	False	False	1.0	0	
3	4	500.000000	1	False	False	False	1.0	0	
4	5	3170.000000	1	False	False	False	1.0	0	

5 rows × 76 columns

✓ TASK 8: Cast all numeric columns to `float64`

Now that our `features_one_hot` dataframe only contains numbers cast the entire dataframe to variable type `float64`

```
1 # HINT: use astype function
2 features_one_hot = features_one_hot.astype(float)
3 features_one_hot.dtypes
```

FlightNumber	float64
PayloadMass	float64
Flights	float64
GridFins	float64
Reused	float64
...	
Serial_B1056	float64
Serial_B1058	float64
Serial_B1059	float64
Serial_B1060	float64
Serial_B1062	float64
...	...

```
Length: 76, dtype: object
```

We can now export it to a **CSV** for the next section, but to make the answers consistent, in the next lab we will provide data in a pre-selected date range.

```
features_one_hot.to_csv('dataset_part_3.csv', index=False)
```

✓ Authors

[Joseph Santarcangelo](#) has a PhD in Electrical Engineering, his research focused on using machine learning, signal processing, and computer vision to determine how videos impact human cognition. Joseph has been working for IBM since he completed his PhD.

[Nayef Abou Tayoun](#) is a Data Scientist at IBM and pursuing a Master of Management in Artificial intelligence degree at Queen's University.

✓ Change Log

Date (YYYY-MM-DD)	Version	Changed By	Change Description
2021-10-12	1.1	Lakshmi Holla	Modified markdown
2020-09-20	1.0	Joseph	Modified Multiple Areas
2020-11-10	1.1	Nayef	updating the input data

Copyright © 2020 IBM Corporation. All rights reserved.

