IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

- Executive Summary
- Introduction
- Methodology
- Results
- Conclusion
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Executive Summary

Summary of methodologies

- Data collection
- Data wrangling
- Data Analysis using SQL
- EDA with data visualization
- Visual Analytics with Folium
- Predictive analysis (Classification)

Summary of all results

- Interactive Visual Analytics
- Exploratory Data Analysis using SQL
- Predictive analysis using a machine learning model

Introduction

- Project background and context

  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 because SpaceX can reuse the first stage. Therefore , if you can accurately predict the likelihood of the first stage rocket landing successfully , you can determine the cost of a launch. With the help of your Data Science findings and models, the competing start-up you have been hired by can make more informed bids against SpaceX for a rocket launch.

- Problems you want to find answers

  - Determined the price of each launch.
  - Predict if the Falcon 9 first stage will land successfully.

Section 1

Methodology

Methodology

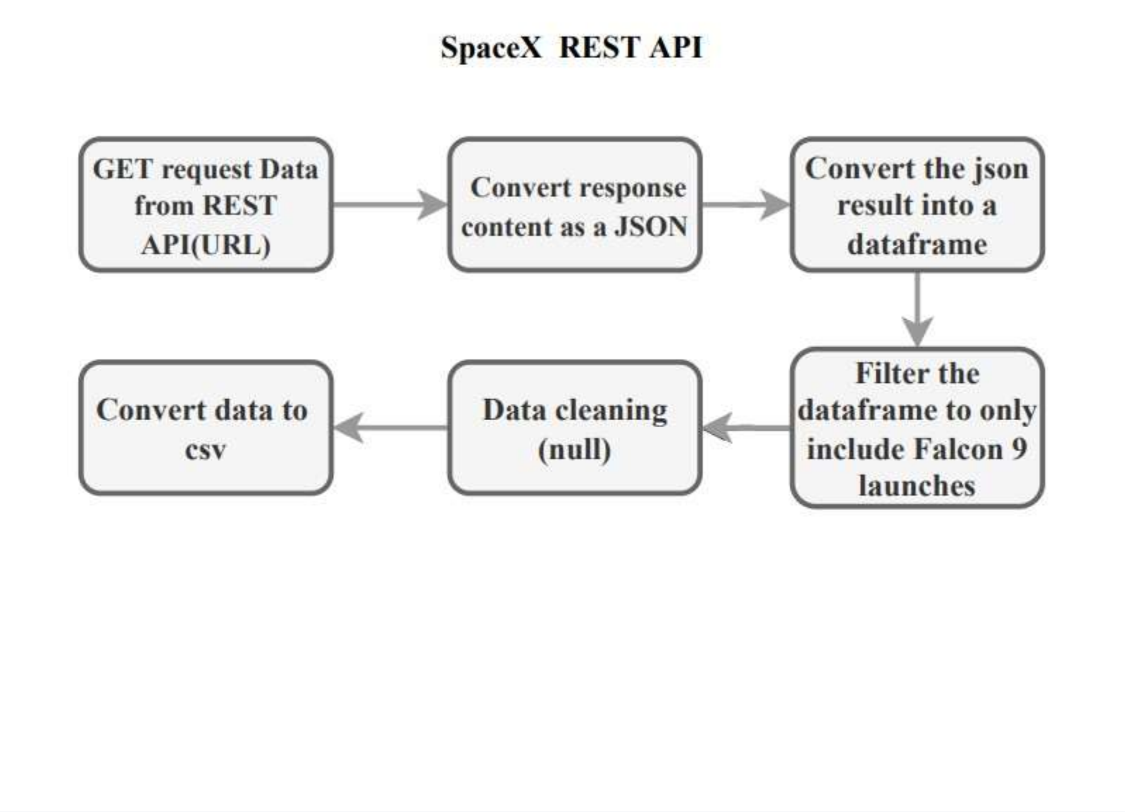
Executive Summary

- Data collection methodology:
  - Rest API and Web Scraping
- Perform data wrangling
  - Data are clean of null values, and irrelevant columns and transformed into one Hot Encoding to be applied to Machine Learning.
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
    - Use RL, KNN, SVM, DT models have been built and evaluated for the best classifier.

Data Collection

•Data that is collected launch data from SpaceX REST API.

- The SpaceX REST API endpoints, or URL, starts with api.spacexdata.com/v4/.



Data Collection - SpaceX API

1) Request the Falcon9 Launch Wiki page from its URL

```
response = requests.get(static_url)
```

Create a `BeautifulSoup` object from the HTML `response`

```
In [9]:  # Use BeautifulSoup() to create a BeautifulSoup object from a response text content
         BeautifulSoup = BeautifulSoup(response.content)
```

Print the page title to verify if the `BeautifulSoup` object was created properly

```
In [11]:  # Use soup.title attribute
          BeautifulSoup.title
Out[11]: <title>List of Falcon 9 and Falcon Heavy launches - Wikipedia</title>
```

2) Extract all column/variable names from the HTML table header

```
In [15]:  # Use the find_all function in the BeautifulSoup object, with element type `table`
          # Assign the result to a list called `html_tables`
          html_tables = BeautifulSoup.findAll('table')
          html_tables
```

Check the extracted column names

```
In [29]:  print(column_names)
          ['Flight No.', 'Date and time ( )', 'Launch site', 'Payload', 'Payload mass', 'Orbit', 'Customer', 'Launch outcome']
```

3) Create a data frame by parsing the launch HTML tables

```
0]:  launch_dict= dict.fromkeys(column_names)

     # Remove an irrelvant column
     del launch_dict['Date and time ( )']
```

```
In [31]:  extracted_row = 0
          #Extract each table
          for table_number,table in enumerate(BeautifulSoup .find_all('table',"wikitable plainrowheaders collapsible")):
             # get table row
              for rows in table.find_all("tr"):
                  #check to see if first table heading is as number corresponding to launch a number
```

4) Convert to dataframe then to csv

```
In [32]:  df=pd.DataFrame(launch_dict)
          df
```

Out[32]:

	Flight No.	Launch site	Payload	Payload mass	Orbit	Customer	Launch outcome	Version Booster	Booster landing	Date	Time
0	1	CCAFS	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success\n	F9 v1.0B0003.1	Failure	4 June 2010	18:45
1	2	CCAFS	Dragon	0	LEO	NASA (COTS)\nNRO	Success	F9	Failure	8 December	15:43

Data Collection - Scraping

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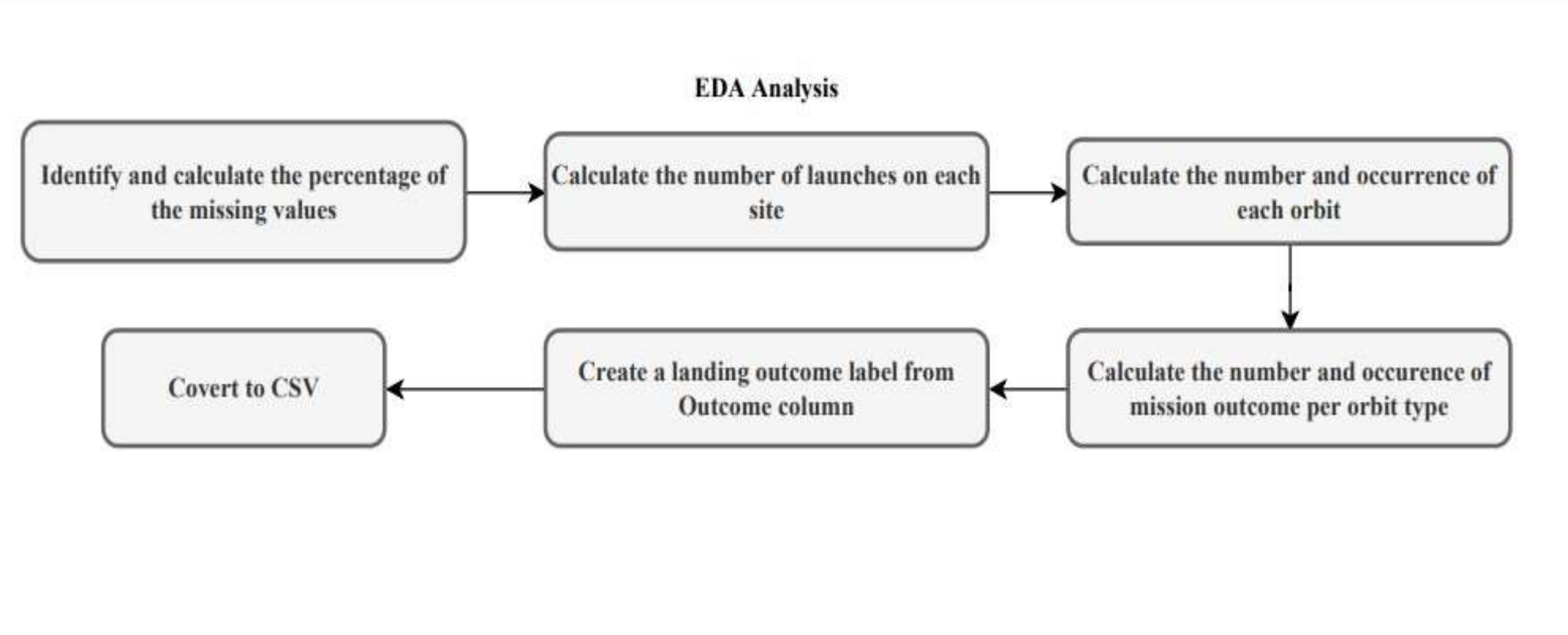
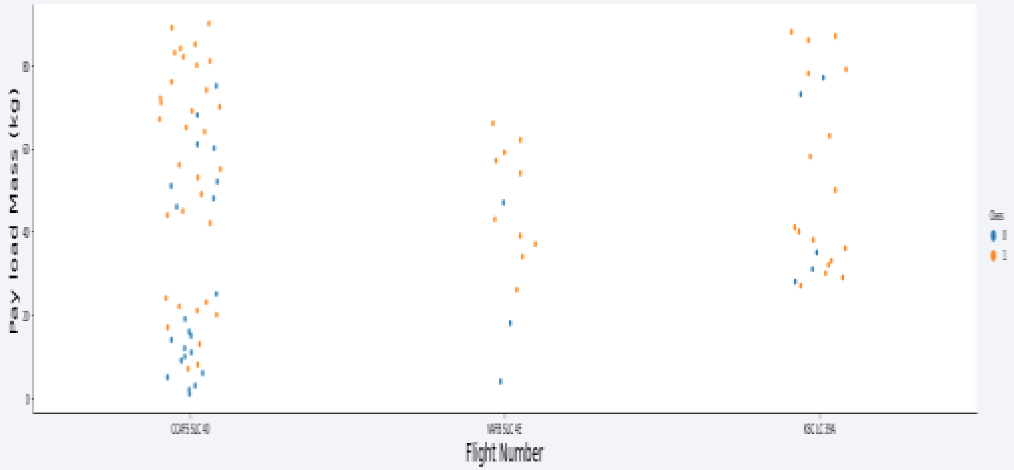
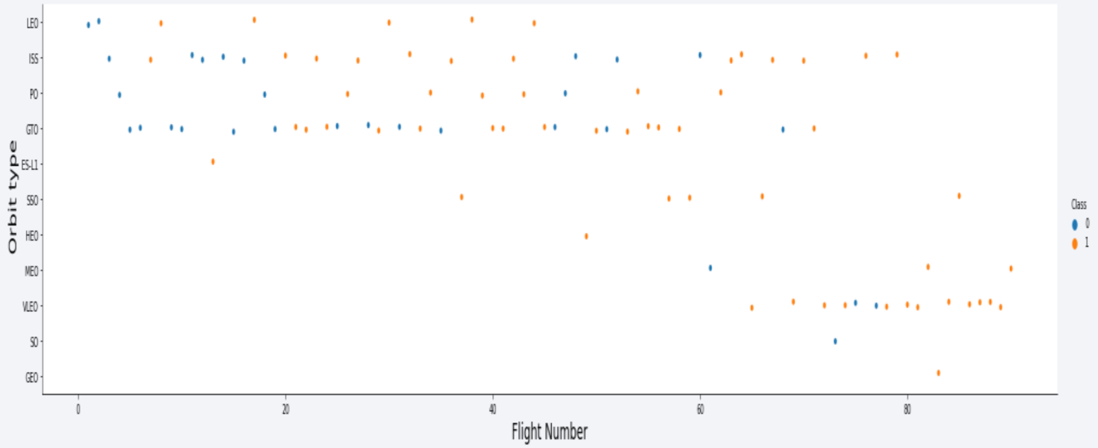
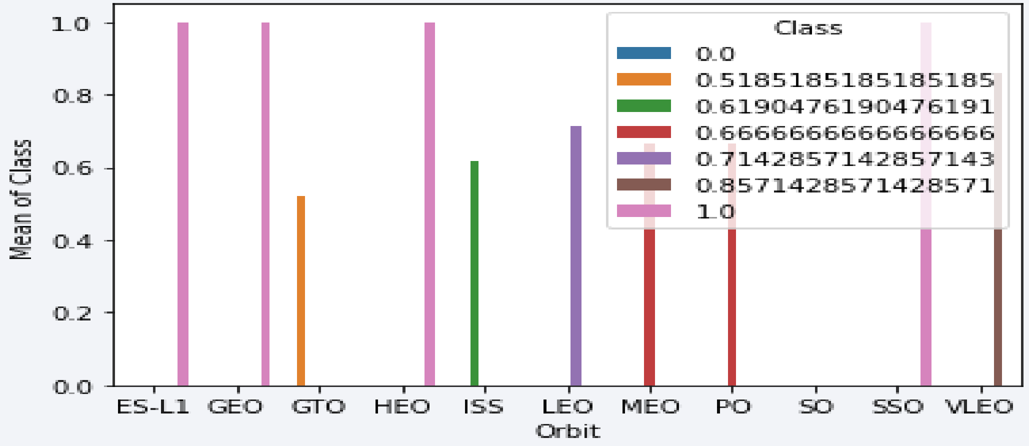
Data Wrangling

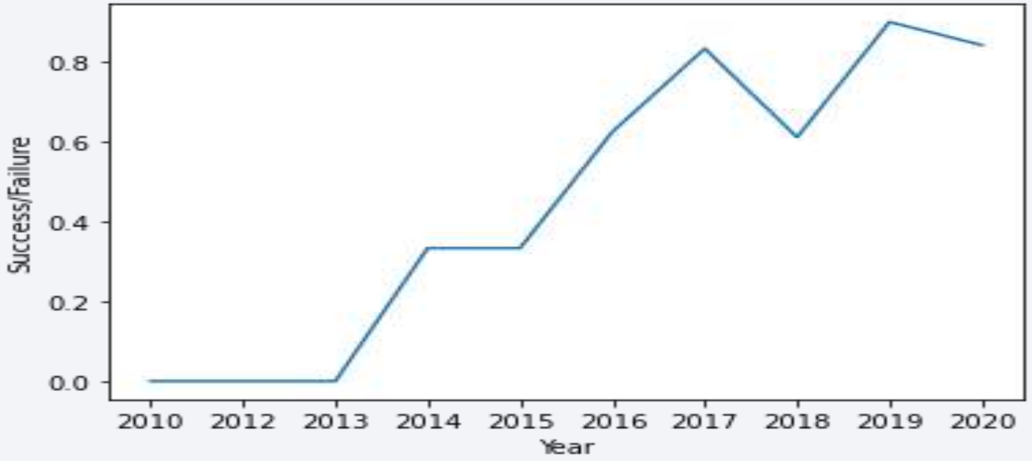


EDA with Data Visualization









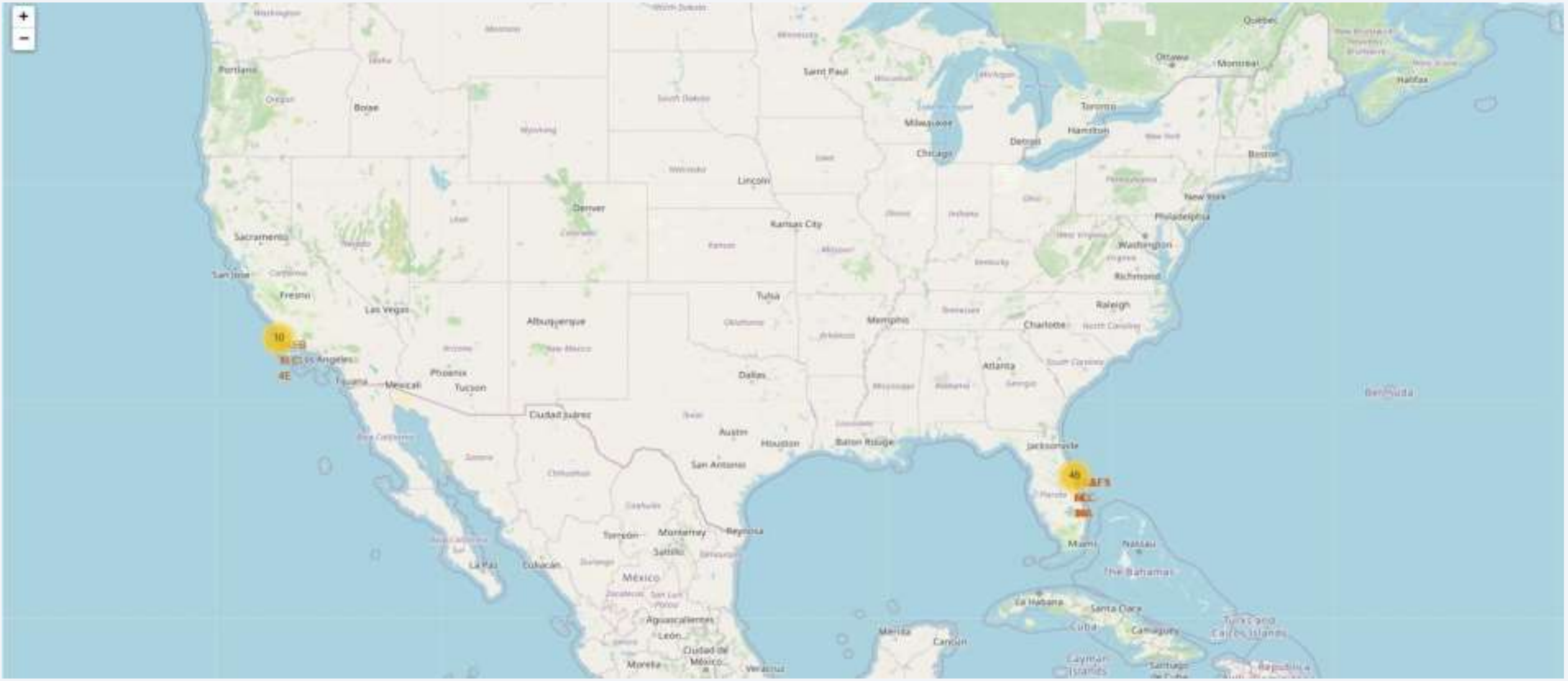
EDA with SQL

SQL queries you performed include:

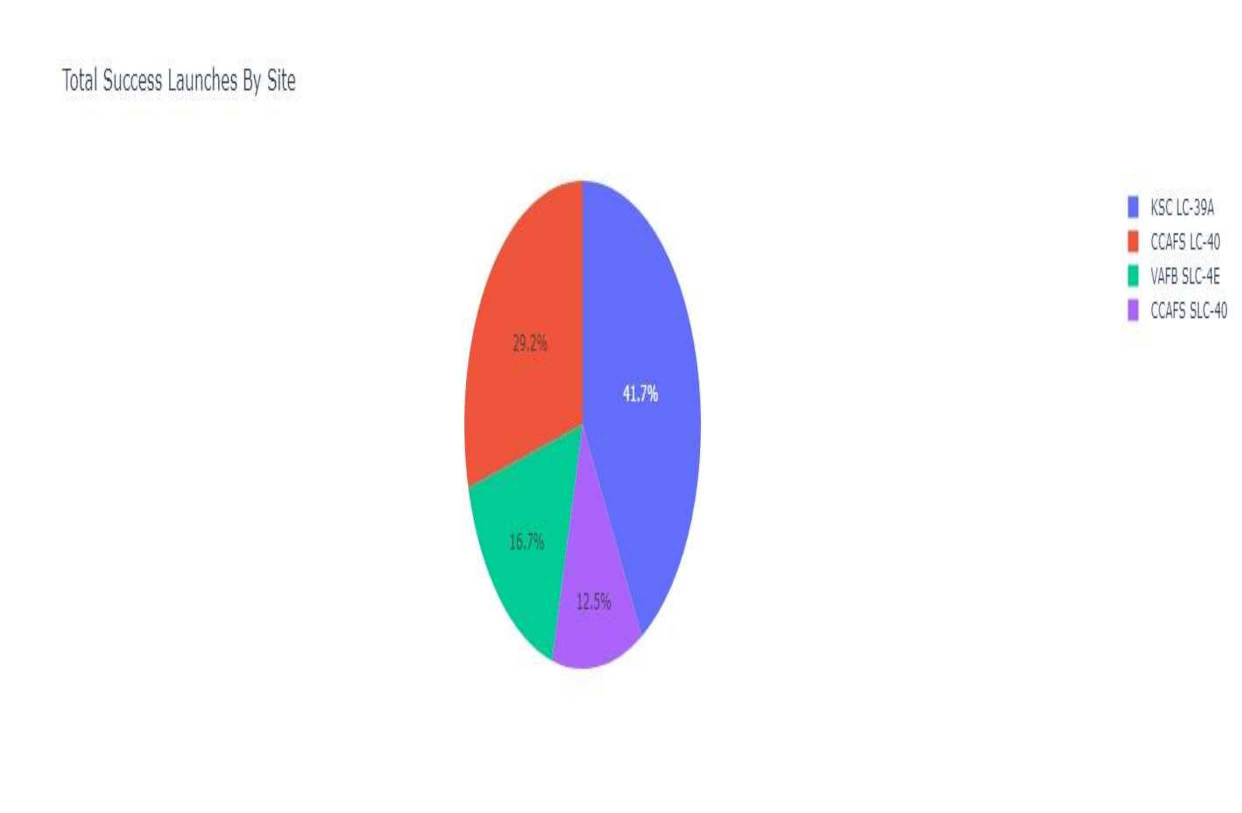
- Display the names of the unique launch sites in the space mission
- Display 5 records where launch sites begin with the string 'CCA'
- Display the total payload mass carried by boosters launched by NASA (CRS)
- Display average payload mass carried by booster version F9 v1.1
- List the date when the first successful landing outcome in ground pad was acheived
- List the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 6000
- List the total number of successful and failure mission outcomes
- List the names of the booster_versions which have carried the maximum payload mass. Use a subquery
- List the failed landing_outcomes in drone ship, their booster versions, and launch site names for in year 2015
- Rank the count of landing outcomes (such as Failure (drone ship) or Success (ground pad)) between the date 2010-06-04 and 2017-03-20, in descending order

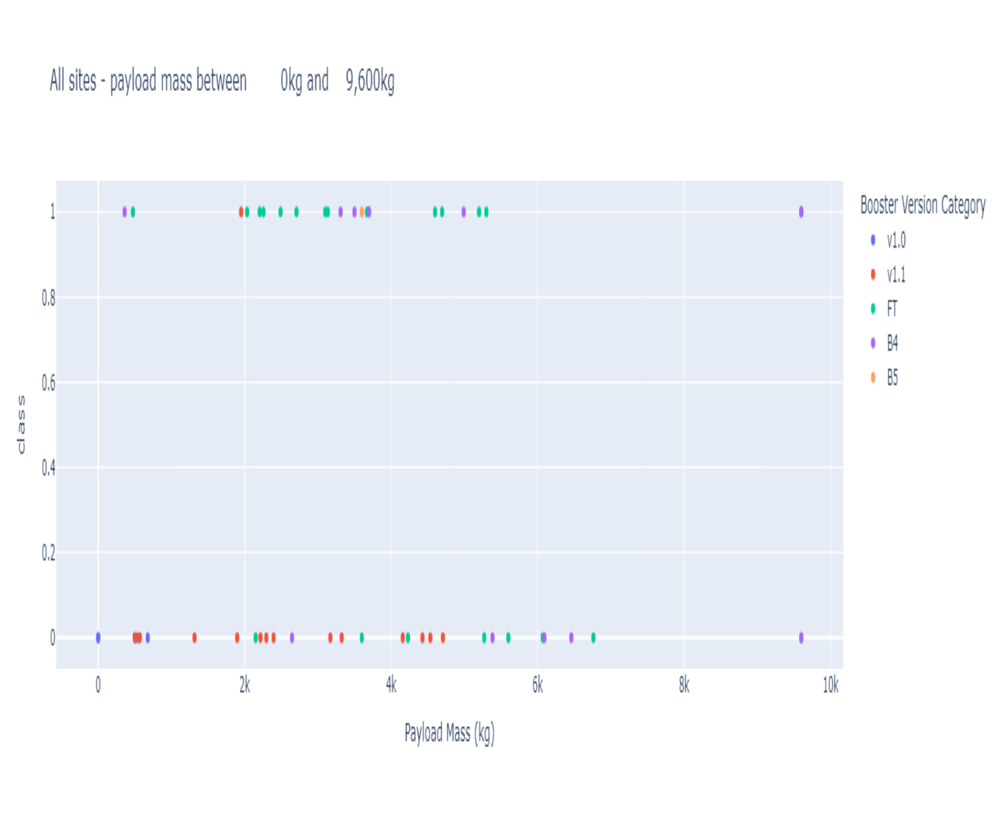
Build an Interactive Map with Folium

By using Marker Cluster, I'm able to add the markers having the same coordinate for launch outcomes to each site.



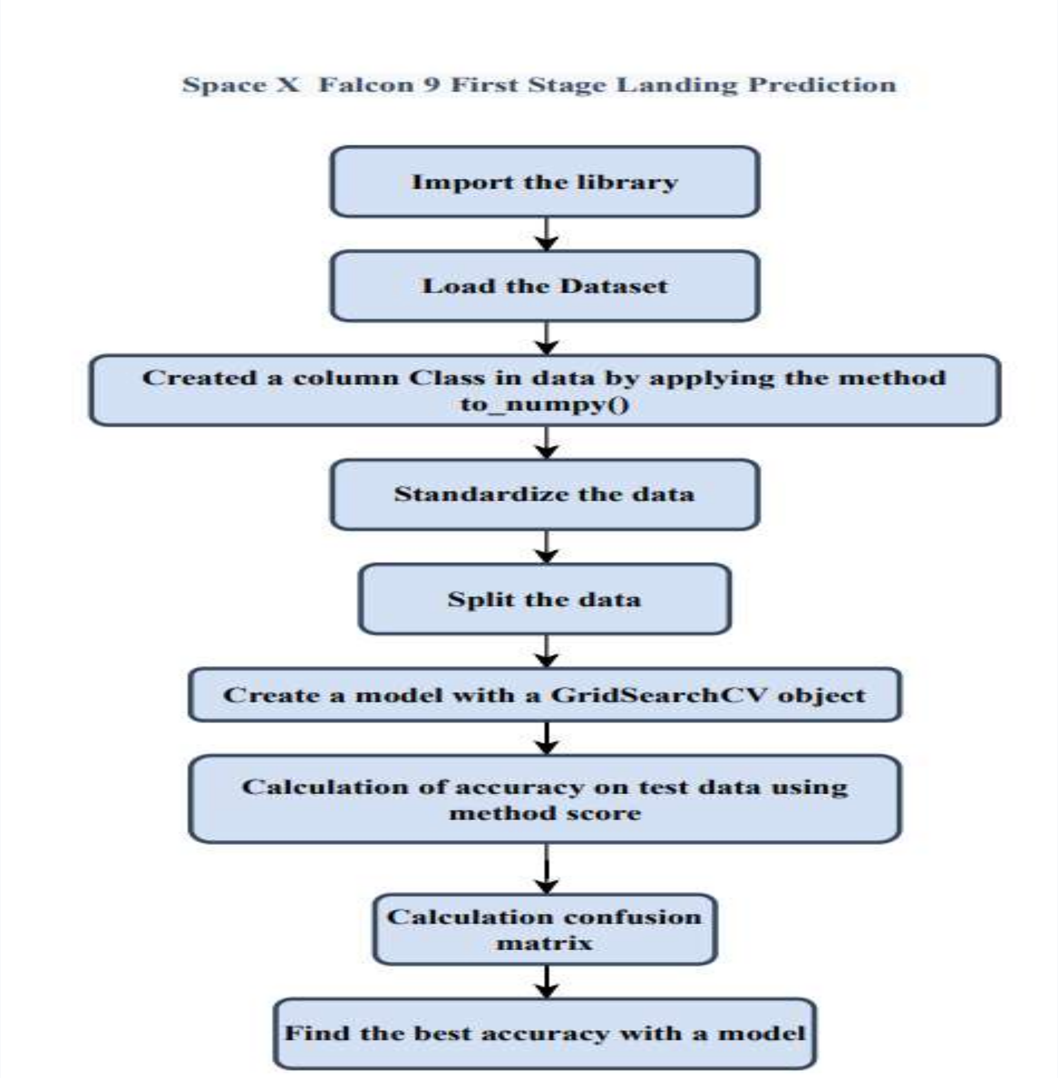
Build a Dashboard with Plotly Dash





Predictive Analysis (Classification)

- Load the Dataset
- Standardize the data
- Split the data into training and testing data
- Create a model with a GridSearchCV object
- Calculation of accuracy on test data using method score
- Calculation confusion matrix
- Find the best accuracy with a model



Results

•After analysis data the CCAFS SLC-40 site and KSCLC-39A site are has most successful launches from all the sites.

• Orbit GEO,HEO,SSOES L1 has the best Success Rate.

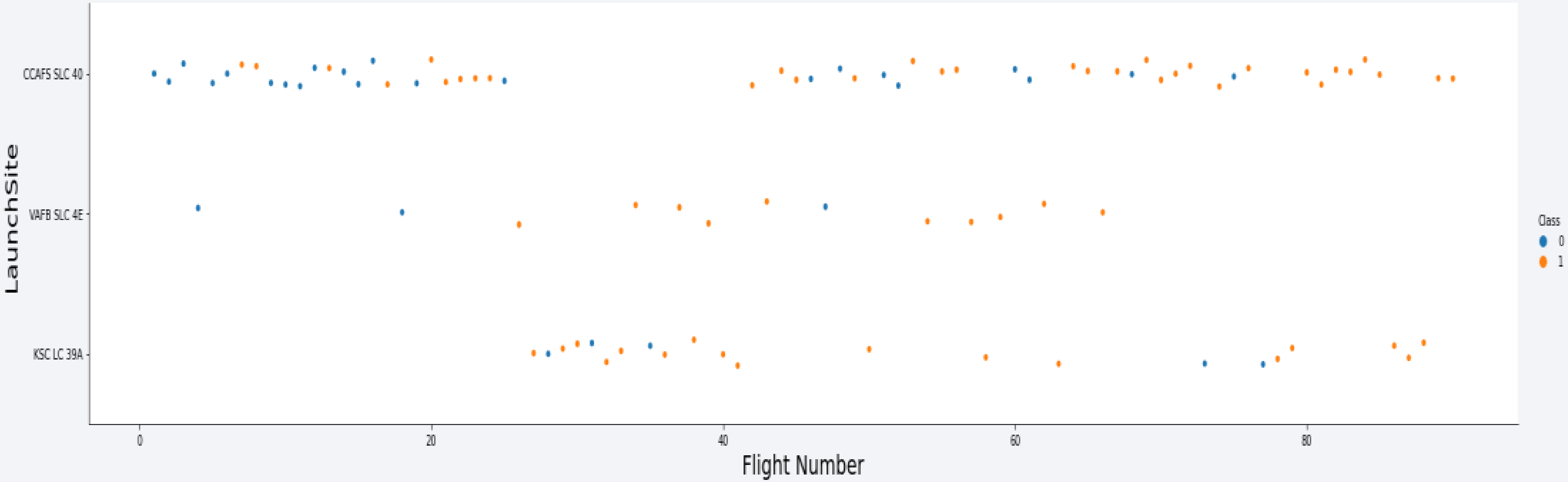
•Decision Tree model are the best in terms of prediction accuracy for this dataset.

Section 2

Insights drawn from EDA

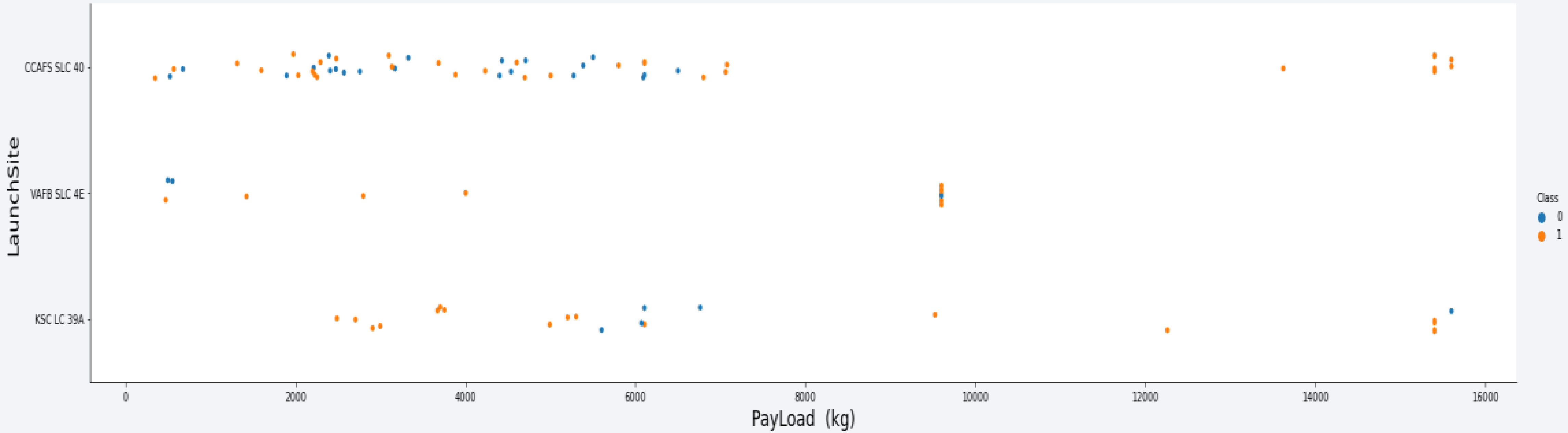
Flight Number vs. Launch Site

Visualize the relationship between Flight Number and Launch Site
We see that different launch sites have different success rates. But as we increase the number of flights the success rate increase.



Payload vs. Launch Site

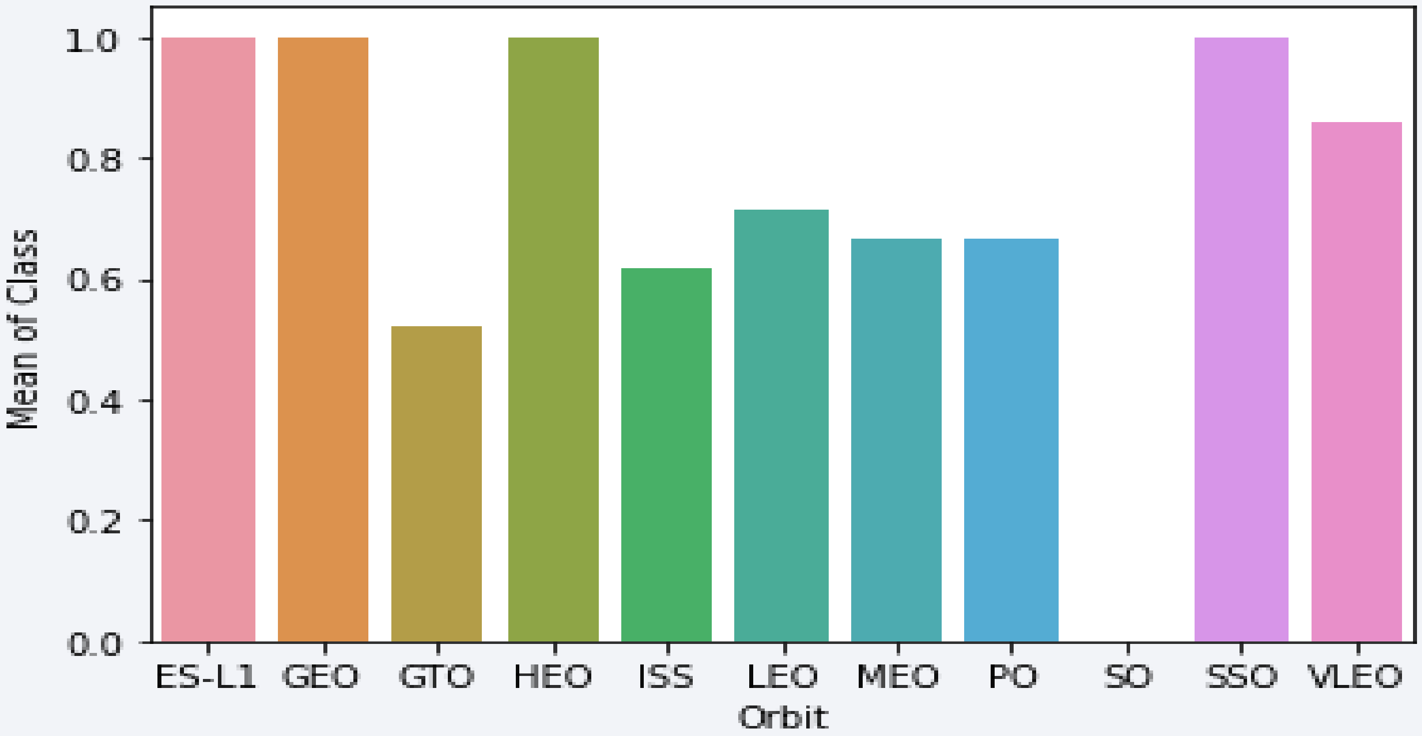
Visualize the relationship between Payload and Launch Site
As well, if increase the number of we Pay Load Mass (kg) the success rate increase.



Success Rate vs Orbit Type

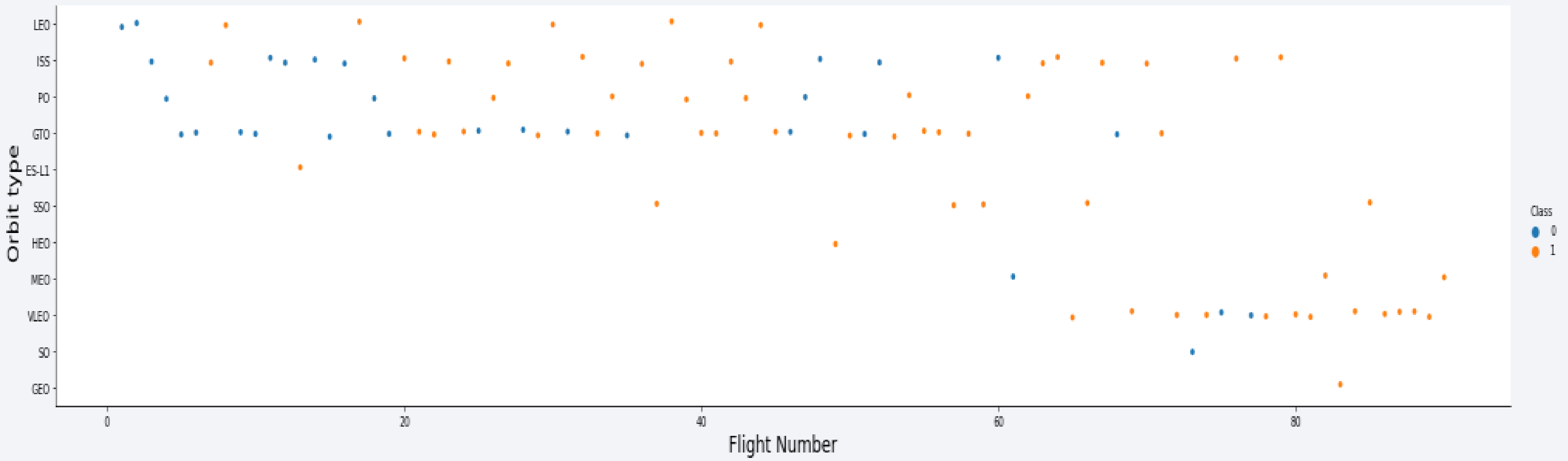
Visualize the relationship between success rate of each orbit type

- AS we can see ES-L1 , GEO, HEO and SSO have a success rates 100%.



Flight Number vs. Orbit Type

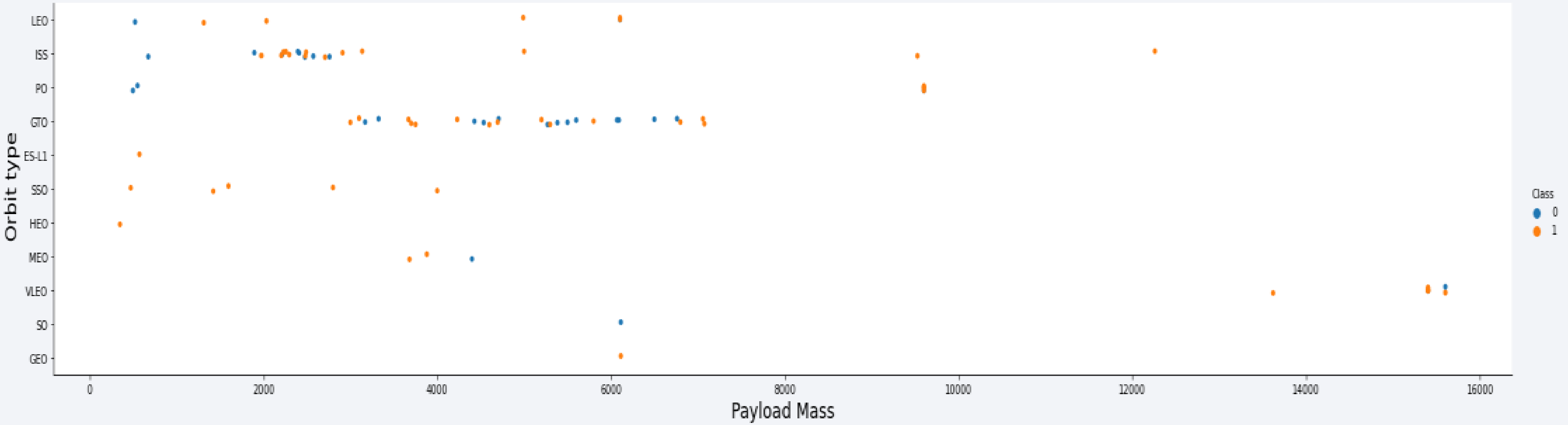
Visualize the relationship between FlightNumber and Orbit type



Payload vs. Orbit Type

Visualize the relationship between Payload and Orbit type

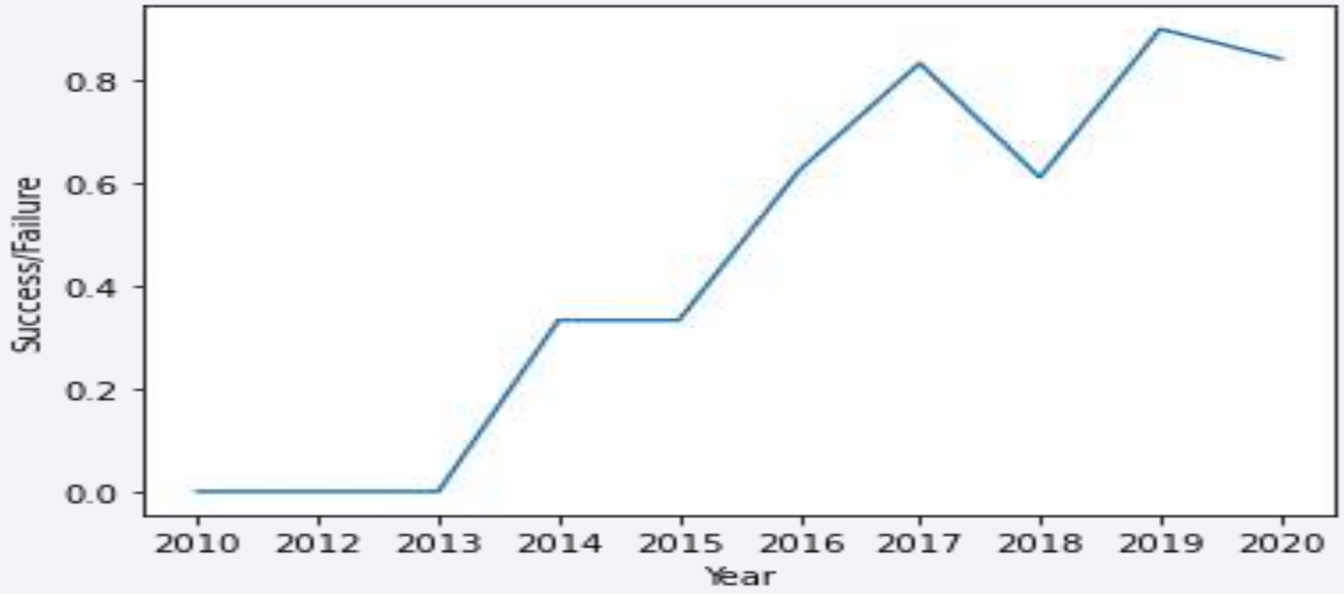
There is a connection between ISSand payload in the range of 2000 to 3000. Also between GTEand Payload at 4000 to 8000.



Launch Success Yearly Trend

Visualize the launch success yearly trend

We can note in the figure that the launch sites begin to increase in success rate from 2013 to approximately 2018, decreases slightly, and then returns to increase with the passage of the year



All Launch Site Names

- %sql SELECT DISTINCT(launch_site) FROM Spacex

launch_site
CCAFS LC-40
CCAFS SLC-40
KSC LC-39A
VAFB SLC-4E

Launch Site names beginning with “CCA”

- %sql SELECT * FROM Spacex WHERE launch_site LIKE'CCA%' LIMIT 5

DATE	time__utc_	booster_version	launch_site	payload	payload_mass__kg_	orbit	customer	mission_outcome	landing__outcome
2010-04-06	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
2010-08-12	15:43:00	F9 v1.0 B0004	CCAFS LC-40	Dragon demo flight C1, two CubeSats, barrel of Brouere cheese	0	LEO (ISS)	NASA (COTS) NRO	Success	Failure (parachute)
2012-08-10	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
2013-01-03	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attempt
2013-03-12	22:41:00	F9 v1.1	CCAFS LC-40	SES-8	3170	GTO	SES	Success	No attempt

Total Payload Mass

- %sql SELECT SUM(payload_mass__kg_) FROM Spacex WHERE customer='NASA (CRS)'

1
45596

Average Payload Mass by F9 v1.1

- %sql SELECT AVG(payload_mass__kg_) FROM Spacex WHERE booster_version='F9 v1.1'

1
2928

First Successful Ground Landing Date

- %sql SELECT MIN(DATE) FROM Spacex WHERE landing__outcome='Success (ground pad)'

1
2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

- %sql SELECT booster_version FROM Spacex WHERE landing__outcome='Success (drone ship)' AND payload_mass__kg_ BETWEEN 4000 AND 6000

booster_version
F9 FT B1022
F9 FT B1026
F9 FT B1021.2
F9 FT B1031.2

Total Number of Successful and Failure Mission Outcomes

- %sql SELECT COUNT(MISSION_OUTCOME) AS missionoutcomes FROM Spacex WHERE mission_outcome LIKE 'Success%’

missionoutcomes
100

- %sql SELECT COUNT(MISSION_OUTCOME) AS missionoutcomes FROM Spacex WHERE mission_outcome LIKE 'Failure

missionoutcomes
1

Boosters Carried Maximum Payload

- %sql SELECT booster_version AS Maxboosterversion FROM Spacex WHERE payload_mass__kg_=(SELECT MAX(payload_mass__kg_) FROM Spacex)

maxboosterversion
F9 B5 B1048.4
F9 B5 B1049.4
F9 B5 B1051.3
F9 B5 B1056.4
F9 B5 B1048.5
F9 B5 B1051.4
F9 B5 B1049.5
F9 B5 B1060.2
F9 B5 B1058.3
F9 B5 B1051.6
F9 B5 B1060.3
F9 B5 B1049.7

2015 Launch Records

- %sql SELECT landing__outcome,booster_version,launch_site,DATE FROM Spacex WHERE landing__outcome='Failure (drone ship)' AND EXTRACT(YEAR FROM DATE)='2015'

landing__outcome	booster_version	launch_site	DATE
Failure (drone ship)	F9 v1.1 B1012	CCAFS LC-40	2015-10-01
Failure (drone ship)	F9 v1.1 B1015	CCAFS LC-40	2015-04-14

Rank Landing Outcomes Between 2010-06-04 and 2017-03-20

- %sql SELECT landing__outcome , COUNT(landing__outcome) FROM Spacex WHERE DATE BETWEEN '2010-06-04' AND '2017-03-20' GROUP BY landing__outcome ORDER BY COUNT(landing__outcome) DESC

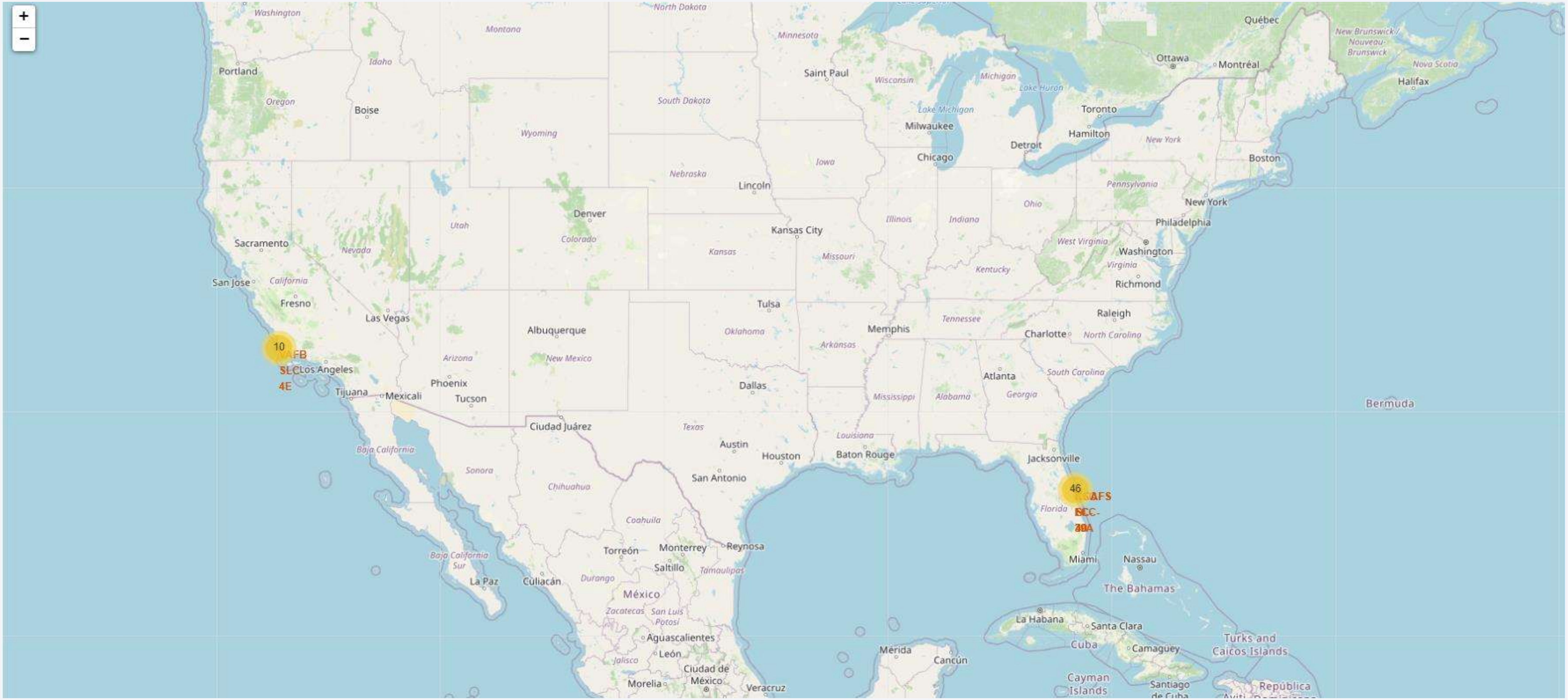
landing__outcome	2
No attempt	10
Success (drone ship)	6
Failure (drone ship)	5
Success (ground pad)	5
Controlled (ocean)	3
Uncontrolled (ocean)	2
Failure (parachute)	1
Precluded (drone ship)	1

Section 3

Launch Sites Proximities Analysis

All launch sites on the site map

launch sites by using Marker Cluster

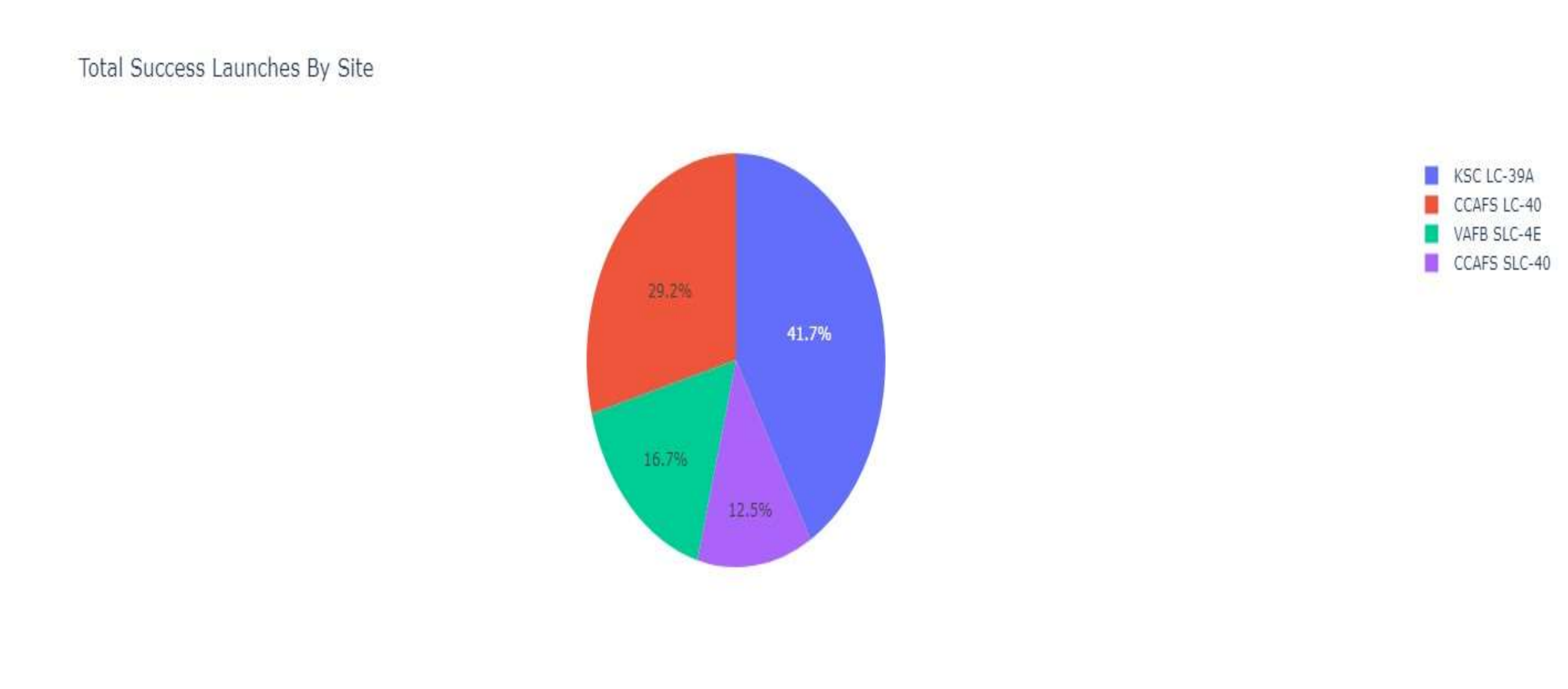


Marker distance between the coastline point and the launch site

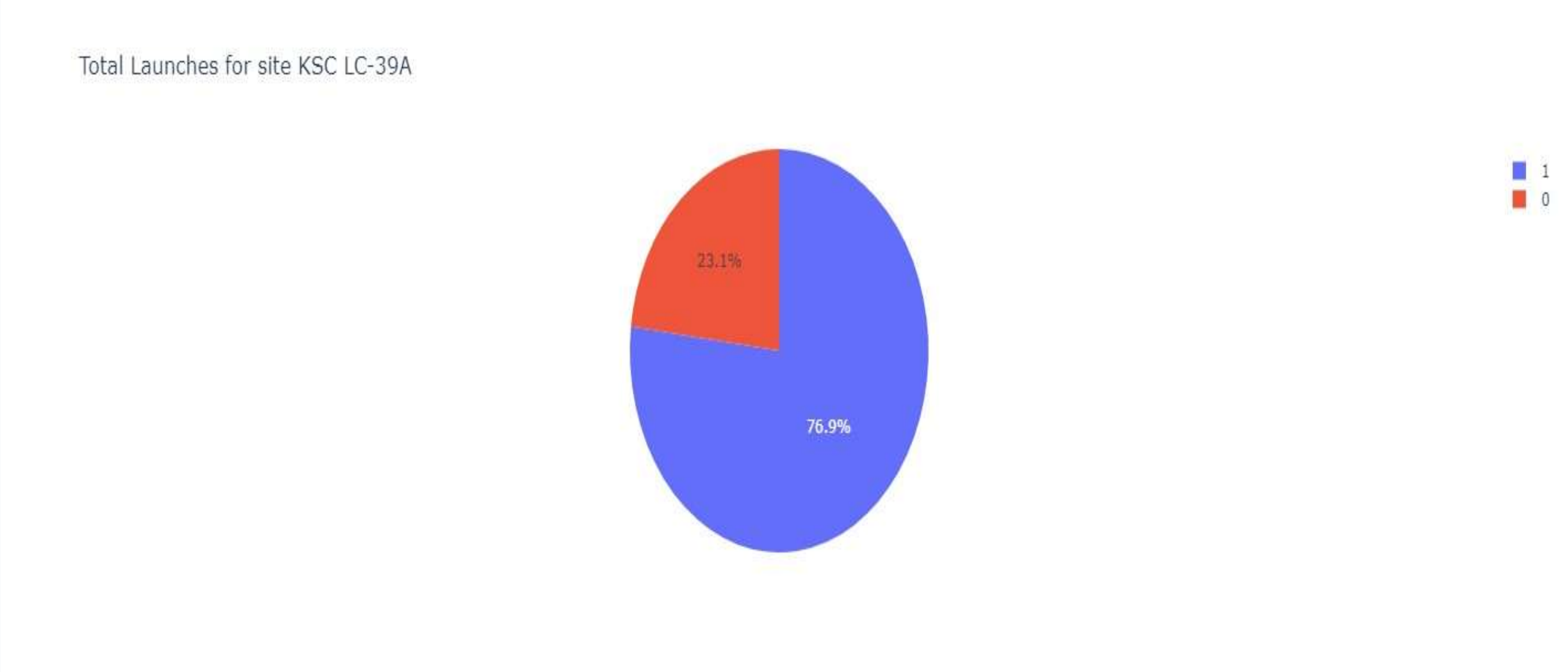
Section 4

Build a Dashboard with Plotly Dash

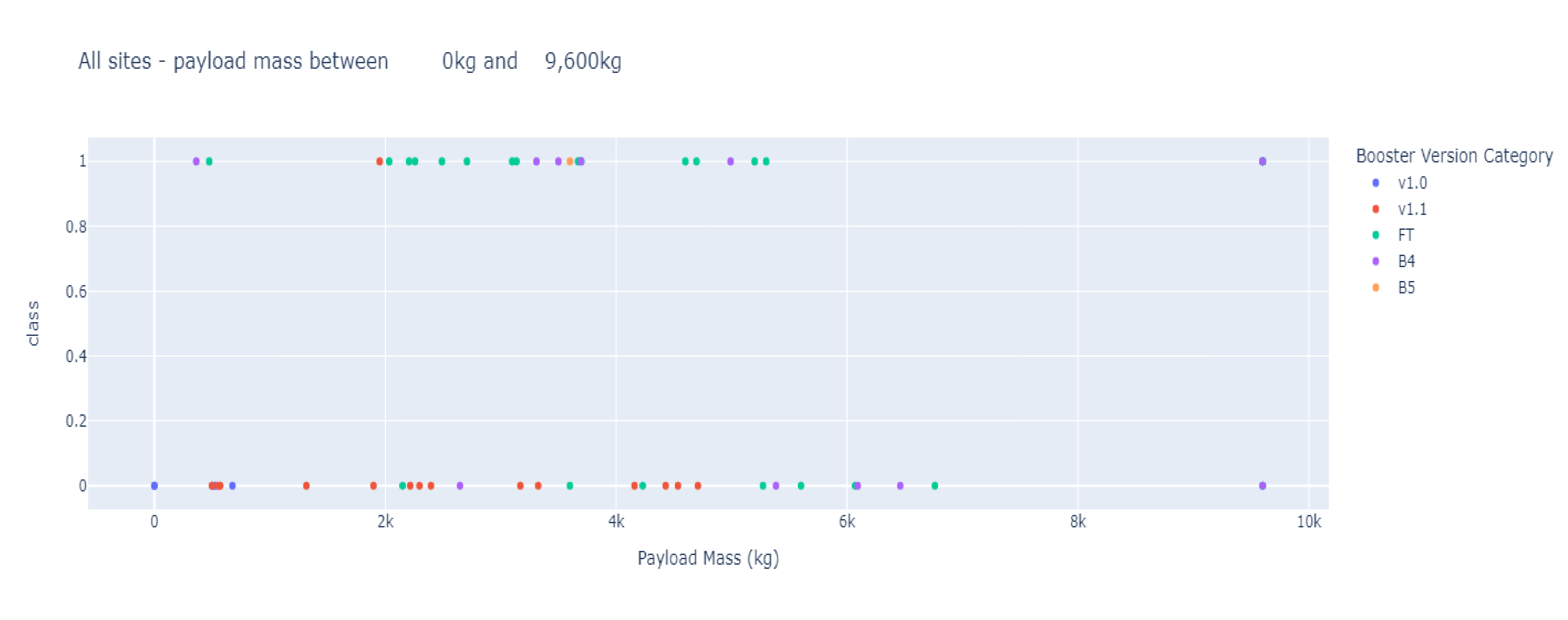
Total Success Launches



Launches for Hight site Score



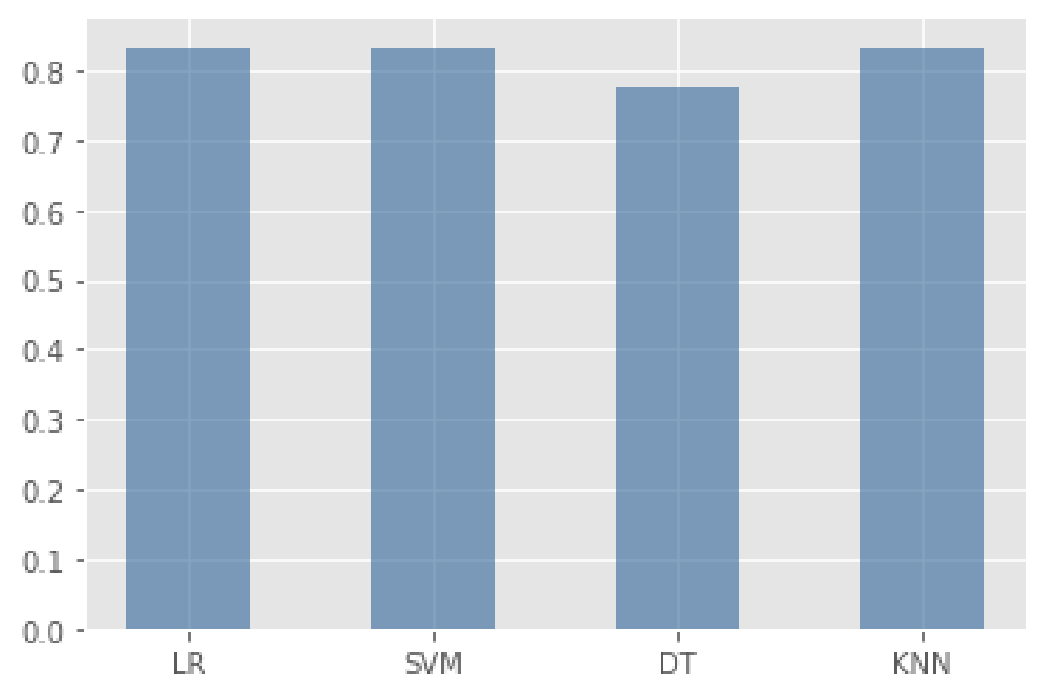
Payload vs. All Launch



Section 5

Predictive Analysis (Classification)

Classification Accuracy



As we can see Decision Tree has the highest accuracy with almost 0.89, then comes the remaining models with almost the same accuracy of 0.84.

Confusion Matrix

Measure	Derivations	Result
Precision	PPV = TP / (TP + FP)	0.67
Accuracy	ACC = (TP + TN) / (P + N)	0.89
F1 Score	F1 = 2TP / (2TP + FP + FN)	0.80

Conclusions

- After analysis data the CCAFS SLC-40 site and KSC LC-39A site are has most successful launches from all the sites.
- Orbit GEO,HEO,SSOES L1 has the best Success Rate.
- The payload of O kg to 5000 kg was more diverse than 6000 kg to 10000
- The Decision Tree model is the best in terms of prediction accuracy for this dataset.

References

- Confusion Matrix : https://onlineconfusionmatrix.com/
- Matplotlib - Bar Plot : https://www.tutorialspoint.com/matplotlib/matplotlib_bar_plot.htm
- https://towardsdatascience.com/7-points-to-create-better-histograms-with-seaborn-5fb542763169
- https://www.researchgate.net/figure/Bar-chart-showing-the-performance-evaluation-in-our-data-loading-tests_fig4_268150621

Thank you!