Winning Space Race with Data Science

VARSHITHA KESAMSETTY

21-03-2024

Outline

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

Executive Summary

Summary of methodologies

- Data collection with API and web scrapping
- Data wrangling
- Exploratory data analysis with SQL
- Exploratory data analysis with Data visualization
- Interactive analysis with Folium
- Machine learning prediction

Introduction

- We take the role of a data scientist to work for a new rocket company.
- By gathering the information about space X and creating dashboards for a new team space Y
- And also determine is space X will reuse the first stage.
- We use machine learning model to predict if space X will reuse first stage.

Section 1

Methodology

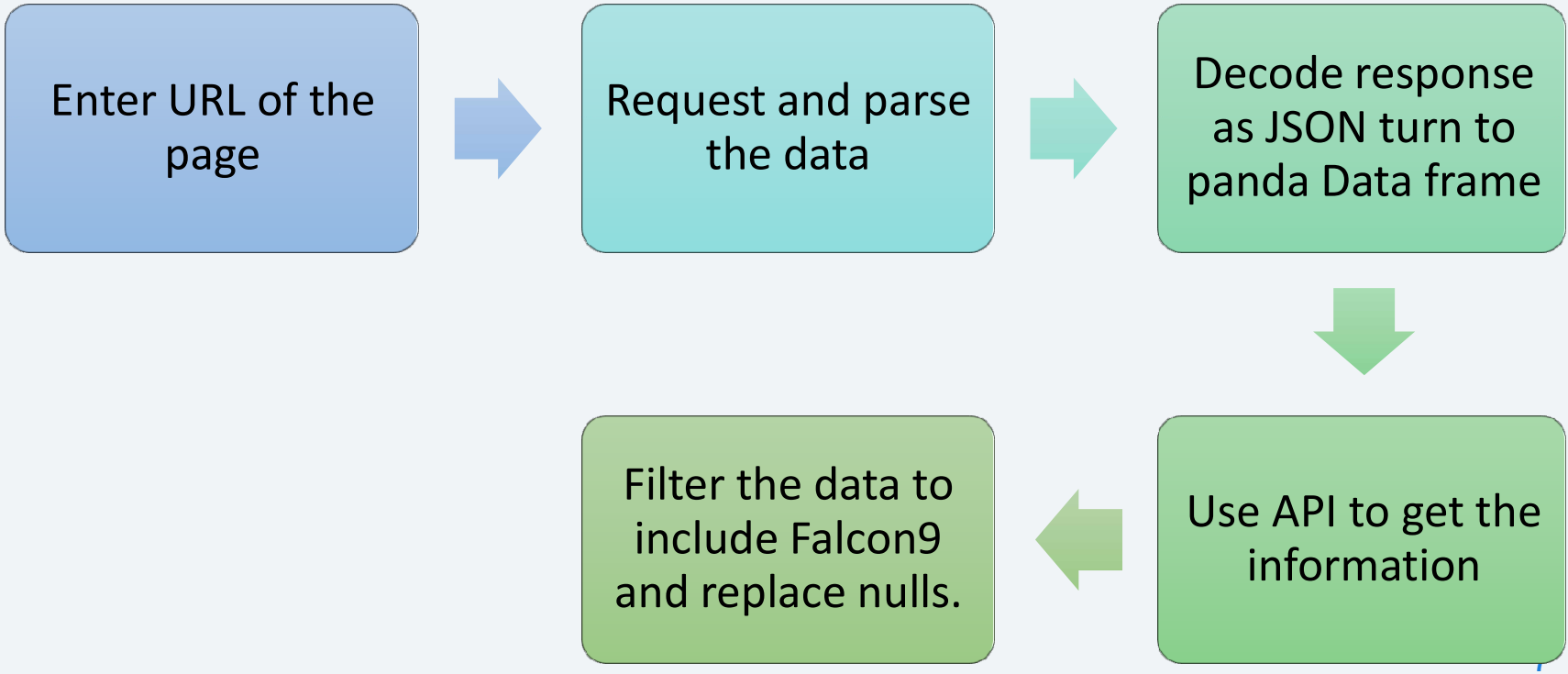
Methodology

Executive Summary

- Data collection methodology:
  - Using get requests to space X and web scrapping
- Perform data wrangling
  - Clean the data
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - Machine learning model

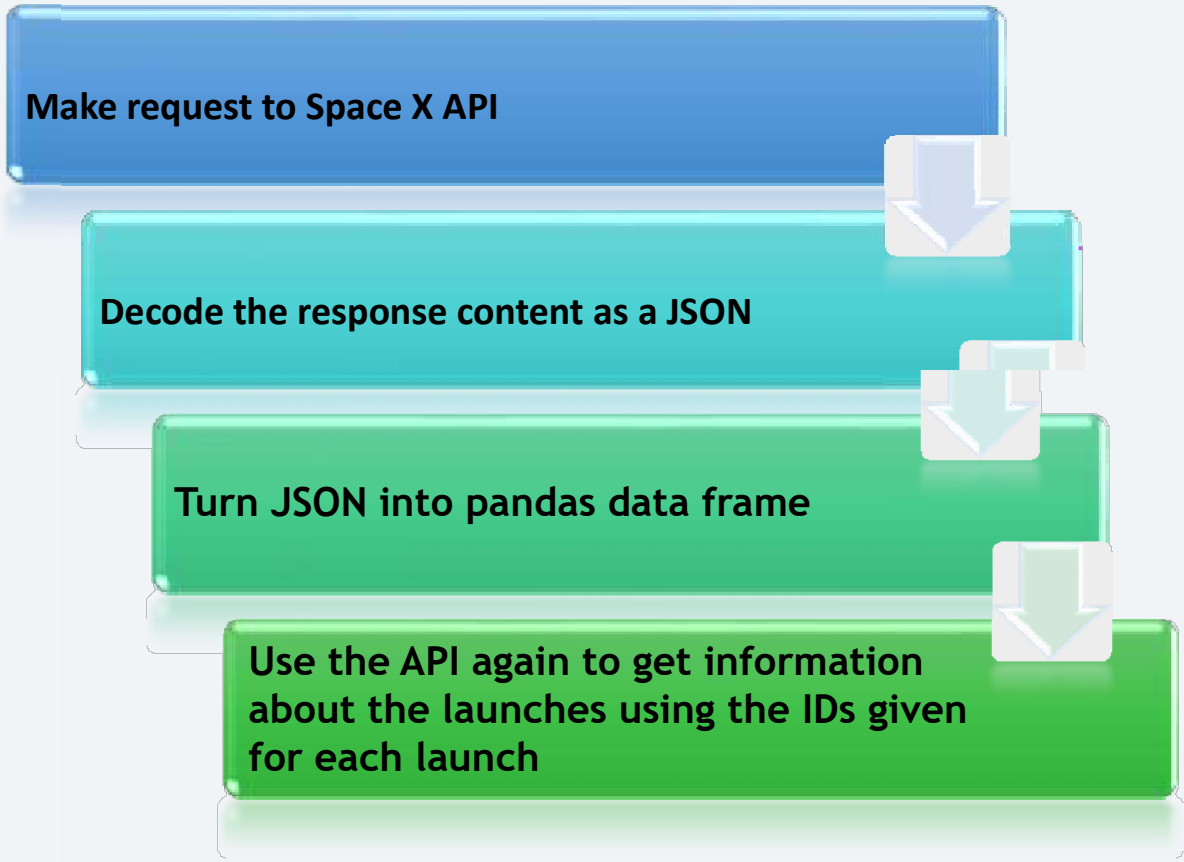
Data Collection

- Data sets were collected by following two methods
- Space X API request
- Web scraping



Data Collection – SpaceX API

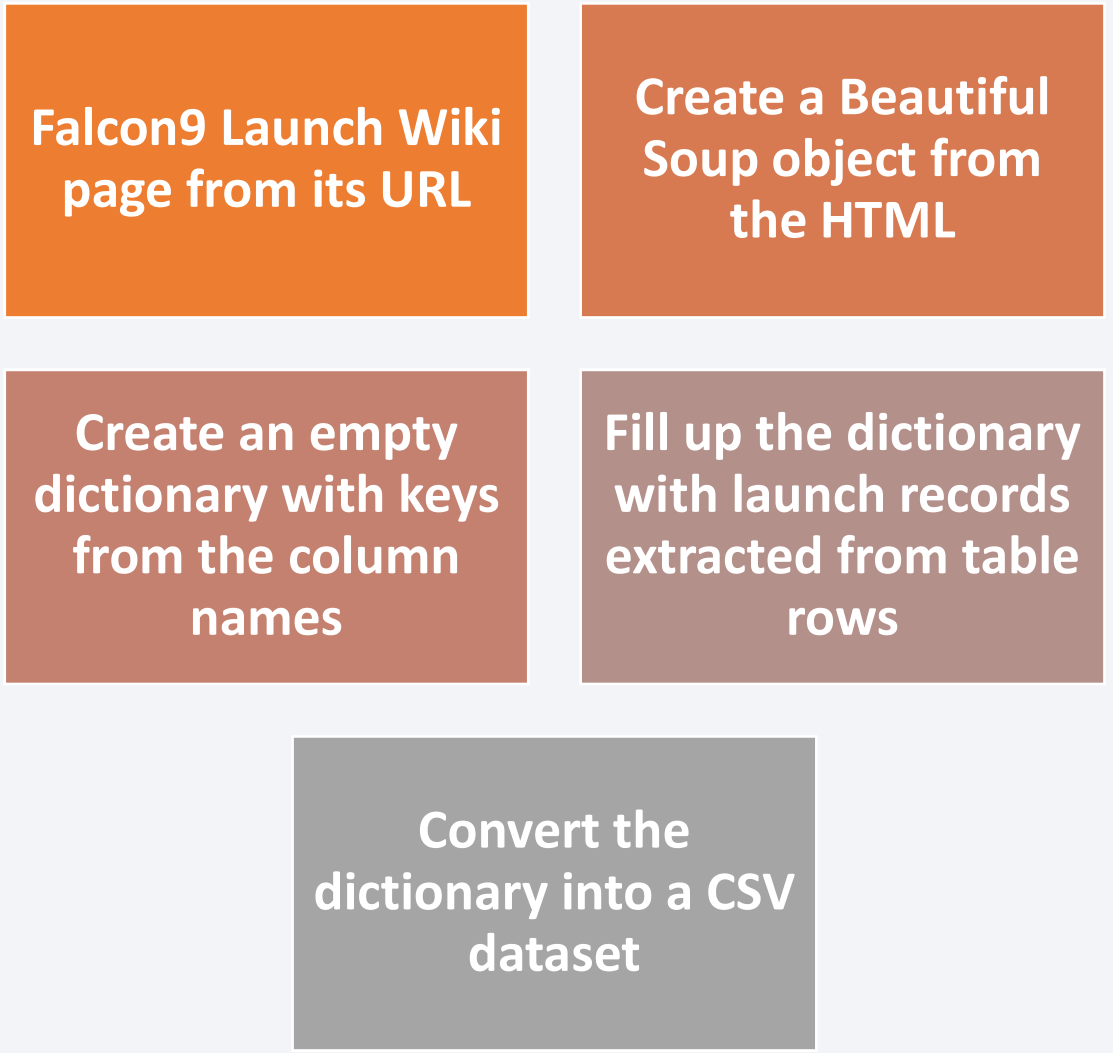
- How Data Collection has done is given in a form of flow chart for an overview.



- GIT HUB URL:
- https://github.com/varshitha-kesamsetty/data-science-capstone/blob/main/jupyter-labs-spacex-data-collection-api.ipynb

Data Collection - Scraping

- Data Collection BY Web Scraping process is given in flow chart for an overview
- GIT HUB URL:
- https://github.com/varshitha-kesamsetty/data-science-capstone/blob/main/jupyter-labs-spacex-data-collection-api.ipynb

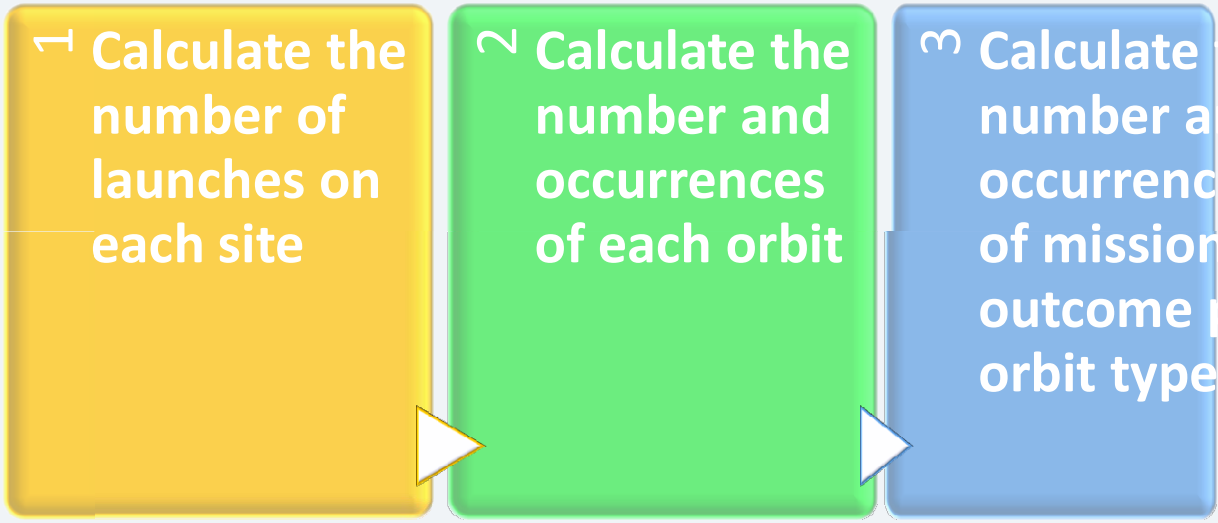


Data Wrangling

- Data Wrangling process is given in a flow chart for a over view

GIT HUB URL:

- https://github.com/varshitha-kesamsetty/data-science-capstone/blob/main/labs-jupyter-spacex-Data%20wrangling.ipynb



EDA with Data Visualization

- **Types of Charts Used :**
- **scatter plot** -Flight Number vs Payload Mass , Flight Number vs Launch Sites , Payload and Launch Sites , Flight Number and Orbit Type , Payload and Orbit Type
- **Bar chart** – Success rate of each orbit
- **Line plot** – success rate and Date
- GIT HUB URL:

  https://github.com/varshitha-kesamsetty/data-science-capstone/blob/main/jupyter-labs-eda-dataviz.ipynb.jupyterlite.ipynb

EDA with SQL

Summary of SQL queries that were used:

- 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

- GIT HUB URL:https://github.com/varshitha-kesamsetty/data-science-capstone/blob/main/jupyter-labs-eda-sql-coursera_sqllite.ipynb

Build an Interactive Map with Folium

- Folium Markers were used to show the Space X launch sites and their nearest important landmarks like railways, highways, cities and coastlines.
- Polylines were used to connect the launch sites to their nearest land marks.
- Red represents rocket launch failures
- Green represents the successes
- Git Hub URL:
- https://github.com/varshitha-kesamsetty/data-science-capstone/blob/main/lab_jupyter_launch_site_location.jupyterlite.ipynb

Build a Dashboard with Plotly Dash

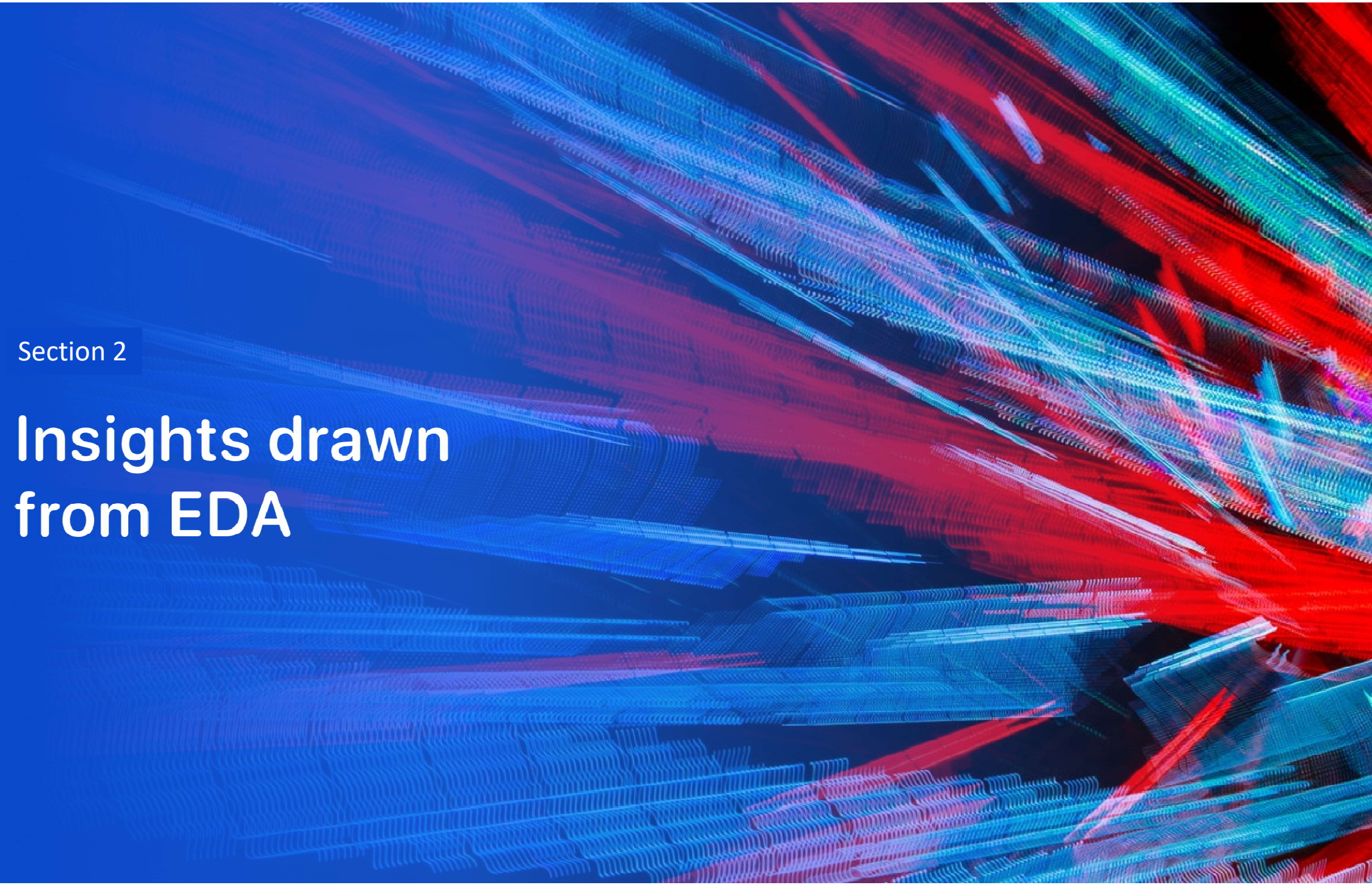
- Pie charts and scatter charts were used to visualize the launch records of Space X.
- These charts displayed the rocket launch success rate per launch site. We are were able to get an understanding of the factors that may have been influencing the success rate at each site. Such as the payload mass and booster versions.
- Successful launches were represented by 1 while failures were represented by 0.

Predictive Analysis (Classification)

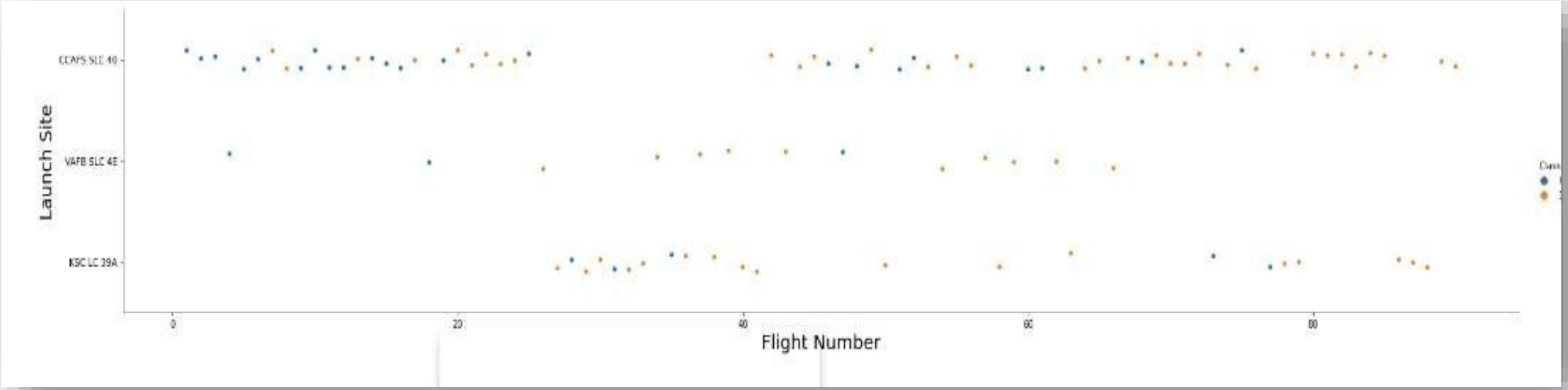
- Scikit-learn is Machine Learning library that was used for predictive analysis
- Created a machine learning pipeline to predict if the first stage will land given the data
- Git Hub URL :
- https://github.com/varshitha-kesamsetty/data-science-capstone/blob/main/SpaceX_Machine_Learning_Prediction_Part_5.jupyterlite.ipynb

Results

- The exploratory data analysis has shown us that successful landing outcomes are somewhat correlated with flight number. It was also apparent that successful landing outcomes have had a significant increase since the year 2015.
- All launch sites are located near the coast line. Perhaps, this makes it easier to test rocket landings in the water.
- sites are also located near highways and railways. This may facilitate transportation of equipment and research material.
- The machine learning were able to predict the landing success of rockets with an accuracy score of 83.33%.

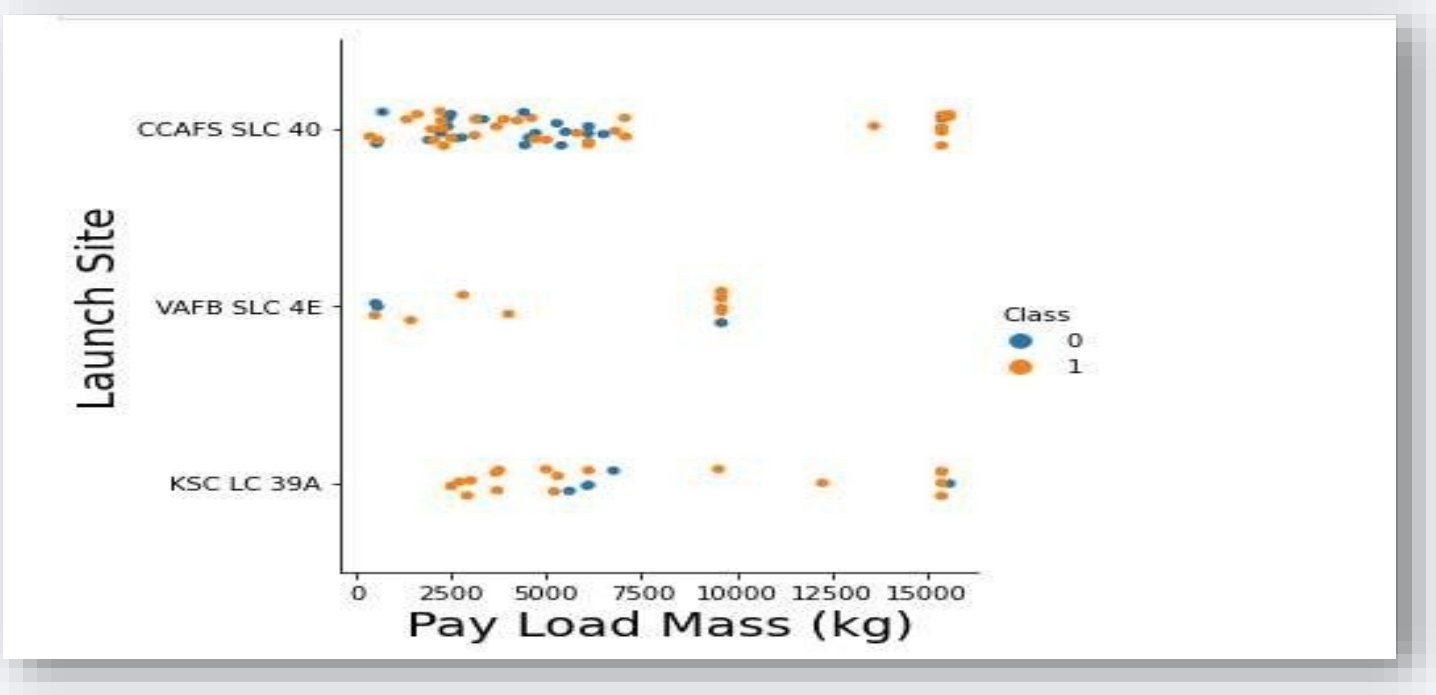

Section 2
Insights drawn from EDA

Flight Number vs. Launch Site



- It appears that there were more successful landings as the flight numbers increased. launch site CCAFS SLC 40 had the most number of landing

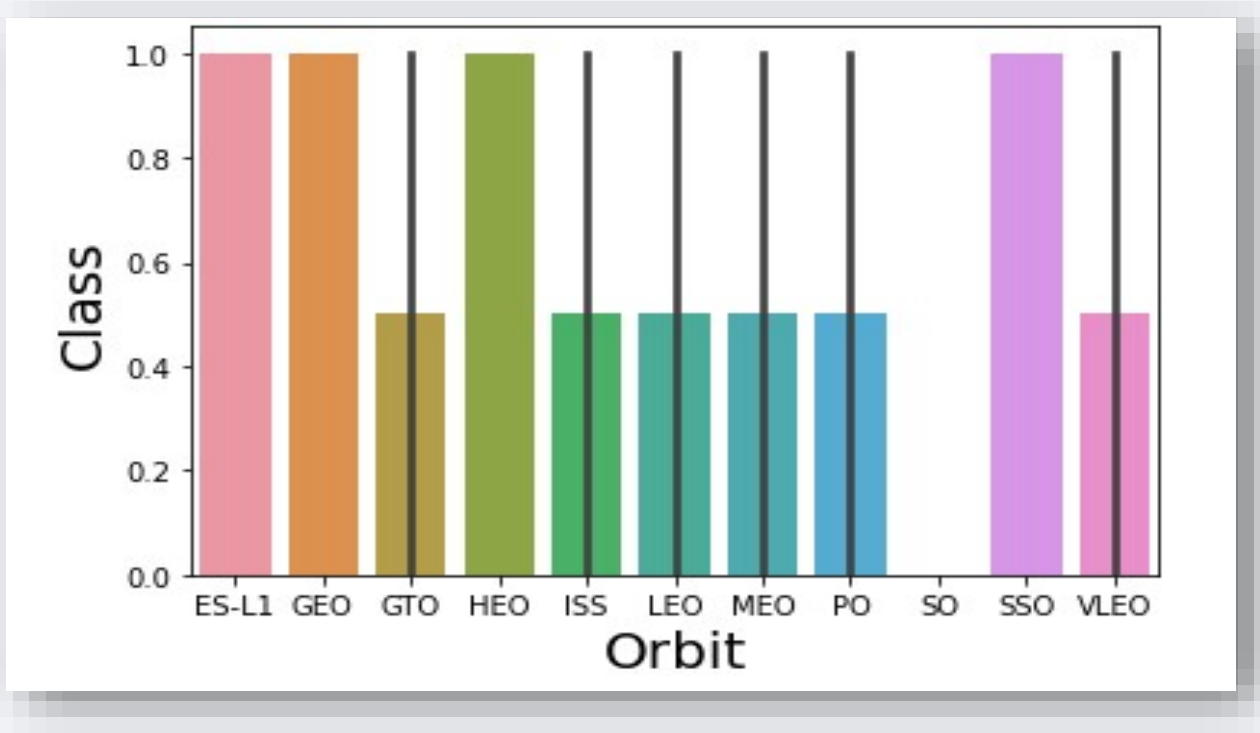
Payload vs. Launch Site



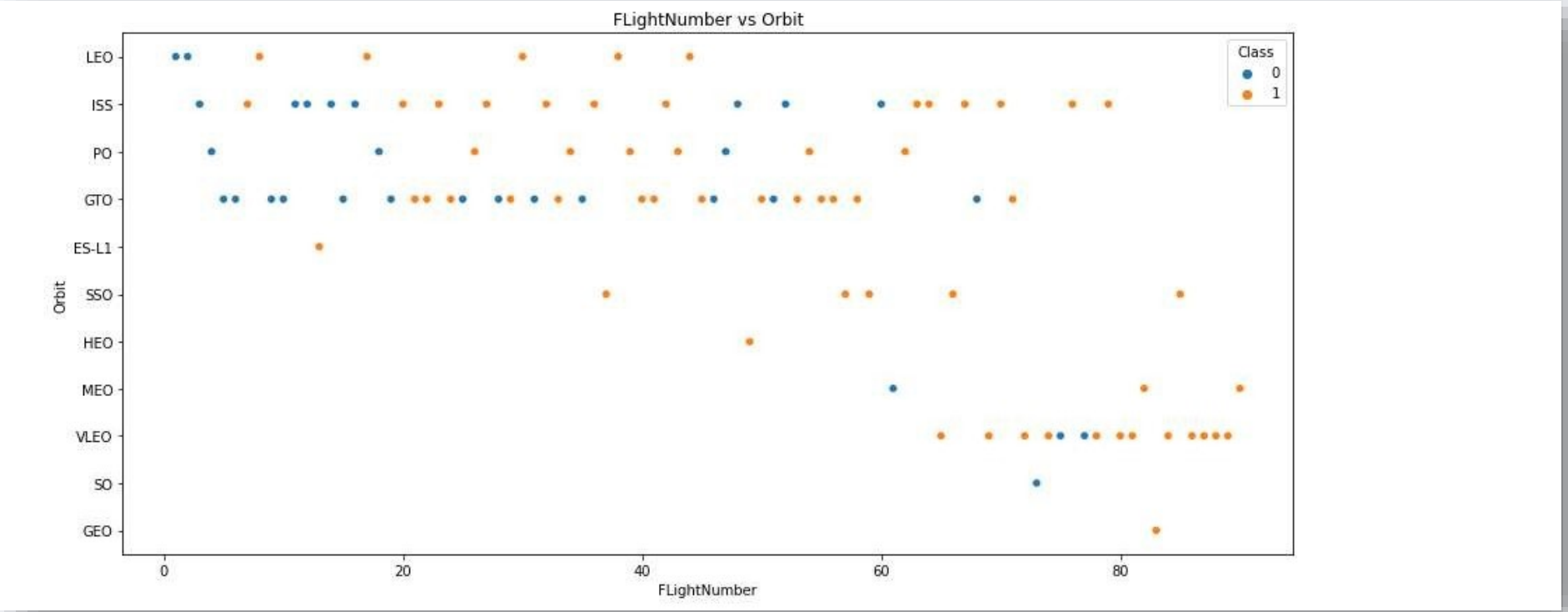
- Now if you observe the scatter point chart, you will find for the VAFB-SLC launch si there are no rockets launched for heavy payload mass(greater than 10000).

Success Rate vs. Orbit Type

- The highest success rate orbits are
- ES-L1
- GEO
- SSO
- HEO

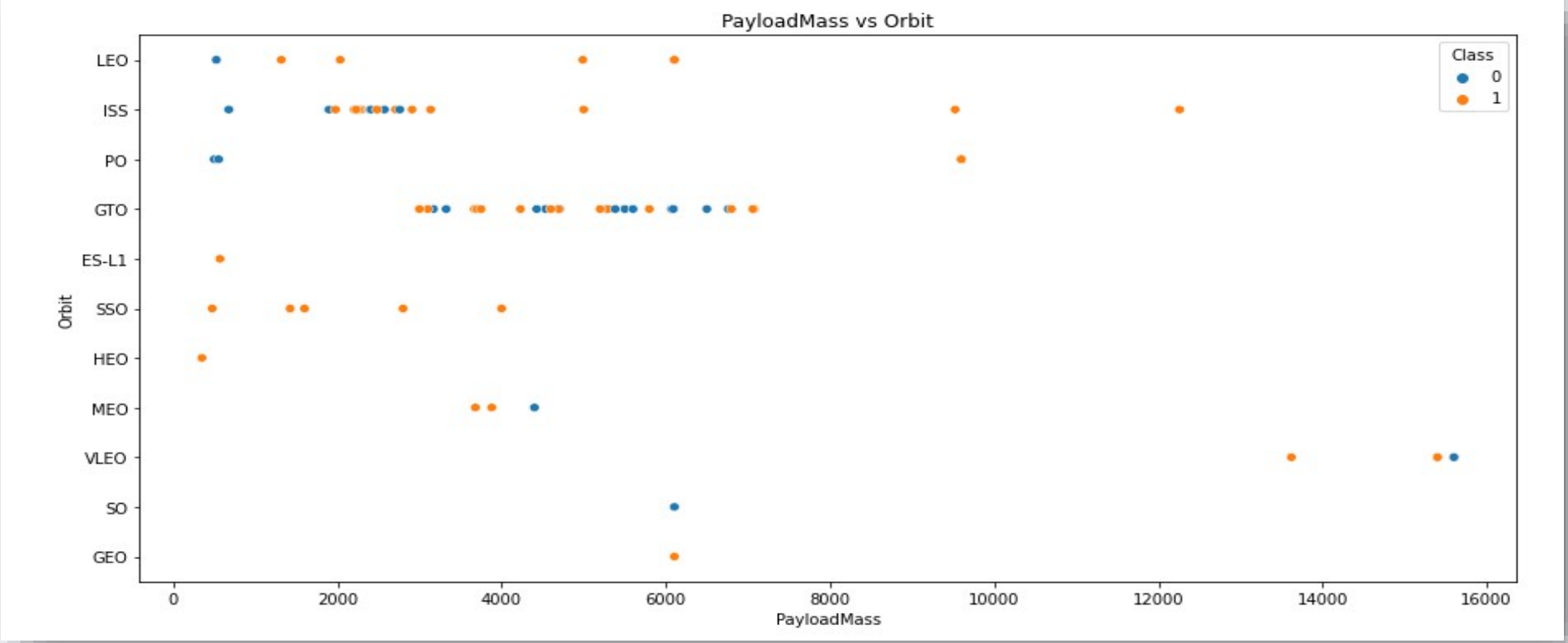


Flight Number vs. Orbit Type



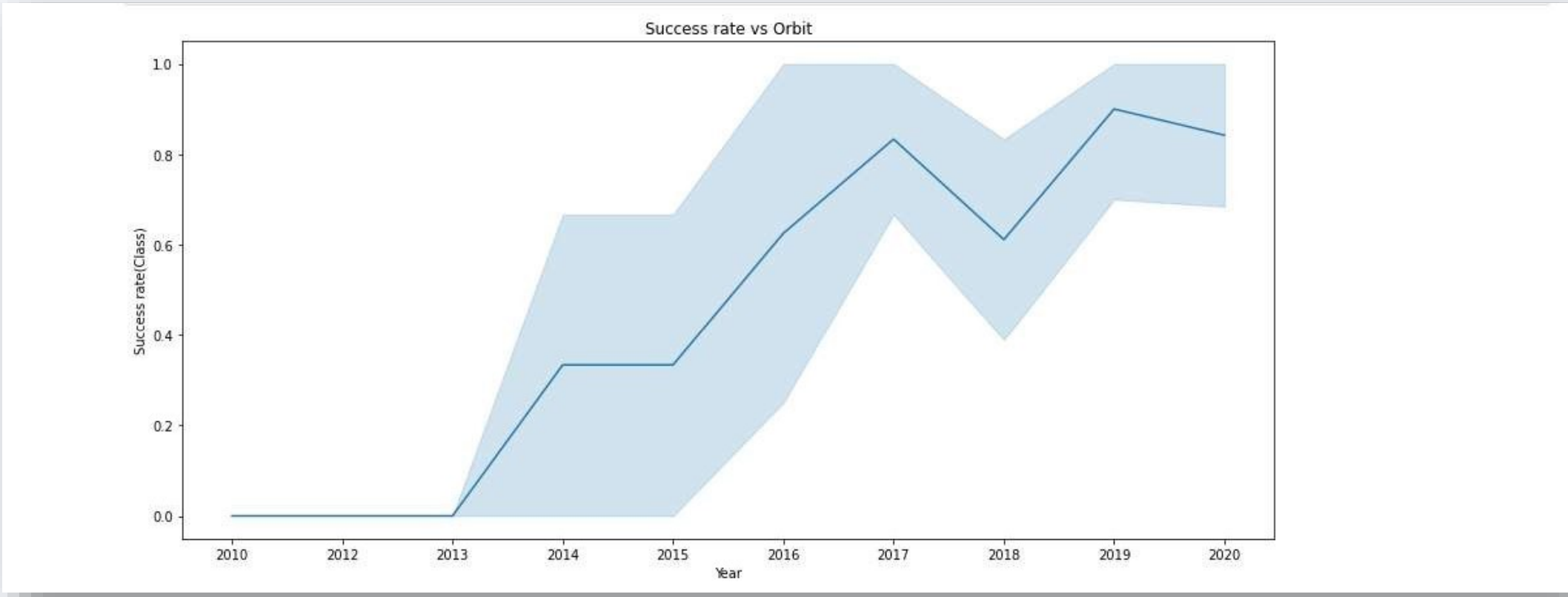
- You can see that in the LEO orbit the Success appears related to the number of flights; on the other hand, there seems to be no relationship between flight number when in GTO orbit.

Payload vs. Orbit Type



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

Launch Success Yearly Trend



is apparent that the success rate has significantly increased from 2013 to 2020

All Launch Site Names

- Given the data, these are the names of the launch sites where different rocket landings where attempted:
- CCAFS LC-40
- CCAFS SLC-40
- KSC LC-39A
- VAFB SLC-4E

Launch Site Names Begin with 'CCA'

In [18]:
```
%sql SELECT * FROM SPACEXTBL WHERE LAUNCH_SITE LIKE 'CCA%' LIMIT 5;
```

```
 * ibm_db_sa://gfd86828:***@3883e7e4-18f5-4afe-be8c-fa31c41761d2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31498/bludb
Done.
```

Out[18]:

DATE	time_utc_	booster_version	launch_site	payload	payload_mass_kg_	orbit	customer	mission_outcome	landing_outcome
2010-06-04	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
2010-12-08	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)
2012-05-22	07:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)	Success	No attempt
2012-10-08	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
2013-03-01	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attempt

- These are 5 records where launch sites begin with the letters 'CCA'. As we can see, thereare other organizations besides Space X that were testing their rockets

Total Payload Mass

Display the total payload mass carried by boosters launched by NASA (CRS)

In [23]:
```
%sql SELECT SUM(PAYLOAD_MASS__KG_) FROM SPACEXTBL WHERE CUSTOMER = 'NASA(CRS)';
```

```
 * ibm_db_sa://gfd86828:***@3883e7e4-18f5-4afe-be8c-fa31c41761d2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31498/bludb
Done.
```

Out[23]:

1

- The information in the picture displays the total payload mass carried by boosters launched by NASA

Average Payload Mass by F9 v1.1

- The average payload mass carried by F9 v1.1 was 2928.4 kg.

Display average payload mass carried by booster version F9 v1.1

In [24]:
```
%sql SELECT AVG(PAYLOAD_MASS__KG_) FROM SPACEXTBL WHERE BOOSTER_VERSION = 'F9 v1.1'
```

```
 * ibm_db_sa://gfd86828:***@3883e7e4-18f5-4afe-be8c-fa31c41761d2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31498/bludb
Done.
```

Out[24]:

1
2928

First Successful Ground Landing Date

- From the picture given above you can see that the first successful ground pad was in 22 December 2015.

List the date when the first successful landing outcome in ground pad was acheived.

Hint:Use min function

In [28]:
```
%sql select min(DATE) from SPACEXTBL where Landing__Outcome = 'Success (ground pad)';
```

```
 * ibm_db_sa://gfd86828:***@3883e7e4-18f5-4afe-be8c-fa31c41761d2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31498/bludb
Done.
```

Out[28]:

1
2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

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

List the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 6000

In [32]:
```
%sql SELECT BOOSTER_VERSION from SPACEXTBL WHERE LANDING__OUTCOME = 'Success (drone ship)' and  PAYLOAD_MASS__KG_  >4000 and PAYLOAD_MASS__KG_ <6000;
```

```
 * ibm_db_sa://gfd86828:***@3883e7e4-18f5-4afe-be8c-fa31c41761d2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31498/bludb
Done.
```

Out[32]:

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

Total Number of Successful and Failure Mission Outcomes

- Picture show the total number of successful and failure mission outcomes

List the total number of successful and failure mission outcomes

In [33]:
```
%sql select count(MISSION_OUTCOME) from SPACEXTBL where MISSION_OUTCOME = 'Success' or MISSION_OUTCOME = 'Failure (in flight)'
```

```
 * ibm_db_sa://gfd86828:***@3883e7e4-18f5-4afe-be8c-fa31c41761d2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31498/bludb
Done.
```

Out[33]:

1
100

Boosters Carried Maximum Payload

- 12 boosters have carried the maximum payload mass of 15600

List the names of the booster_versions which have carried the maximum payload mass. Use a subquery

In [34]:
```
%sql SELECT BOOSTER_VERSION FROM SPACEXTBL WHERE PAYLOAD_MASS__KG_ = (SELECT max(PAYLOAD_MASS__KG_) FROM SPACEXTBL);
```

```
 * ibm_db_sa://gfd86828:***@3883e7e4-18f5-4afe-be8c-fa31c41761d2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31498/bludb
Done.
```

Out[34]:

booster_version
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

- 2 boosters F9 v1.1B1012_CCAFS LC-40 and F9v1.1B1015 CCAFS LC-40 failed to land at 2015

List the failed landing_outcomes in drone ship, their booster versions, and launch site names for in year 2015

In [18]:
```
task_9 = '''
        SELECT BoosterVersion, LaunchSite, LandingOutcome
        FROM SpaceX
        WHERE LandingOutcome LIKE 'Failure (drone ship)'
            AND Date BETWEEN '2015-01-01' AND '2015-12-31'
        '''
create_pandas_df(task_9, database=conn)
```

Out[18]:

	boosterversion	launchsite	landingoutcome
0	F9 v1.1 B1012	CCAFS LC-40	Failure (drone ship)
1	F9 v1.1 B1015	CCAFS LC-40	Failure (drone ship)

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

- The number of successful landings have increased since 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

In [42]:
```
%sql select * from SPACEXTBL where Landing__Outcome = 'Success (ground pad)' or and (DATE between '2010-06-04' and '2017-03-20') order by date desc
```

```
 * ibm_db_sa://gfd86828:***@3883e7e4-18f5-4afe-be8c-fa31c41761d2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31498/bludb
Done.
```

Out[42]:

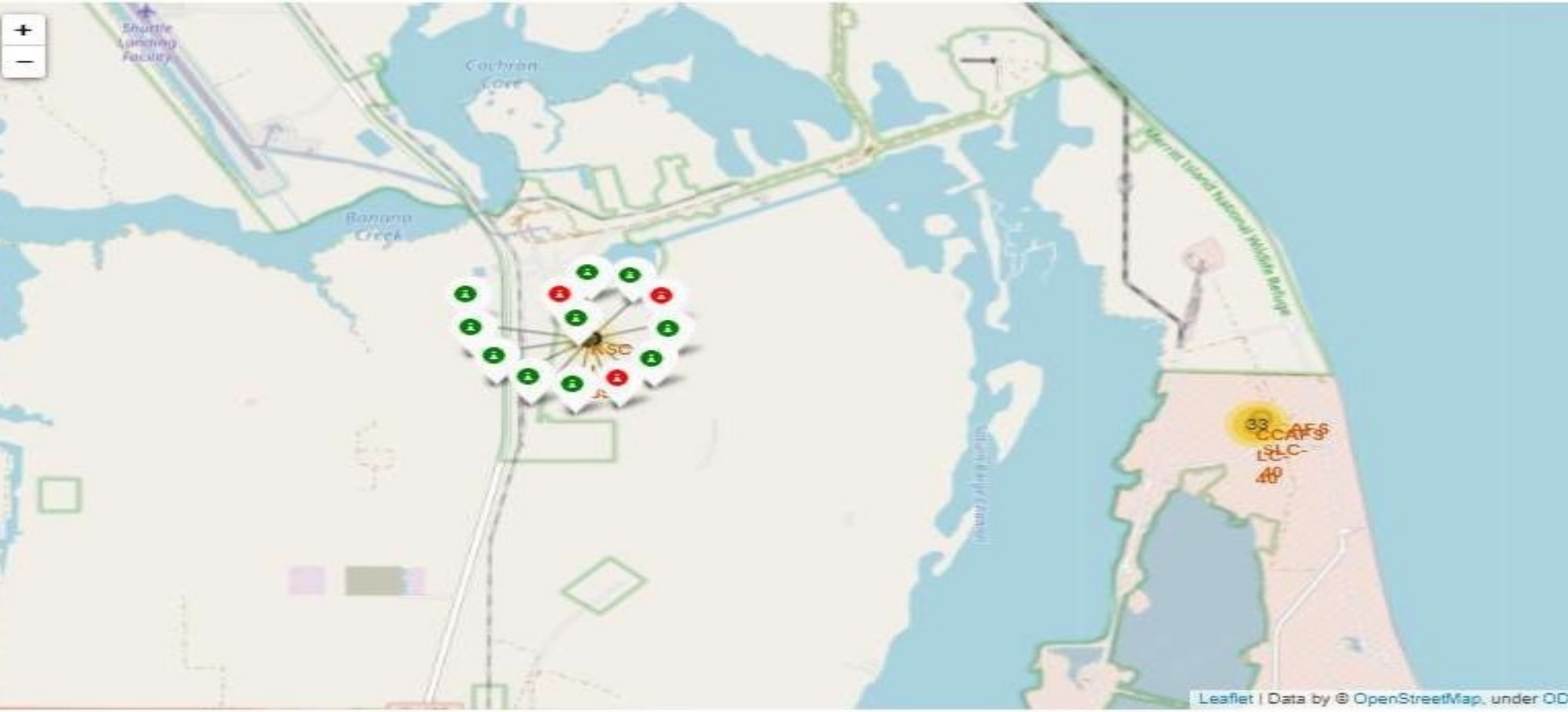
DATE	time_utc_	booster_version	launch_site	payload	payload_mass__kg_	orbit	customer	mission_outcome	landing__outcome
2017-02-19	14:39:00	F9 FT B1031.1	KSC LC-39A	SpaceX CRS-10	2490	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
2016-07-18	04:45:00	F9 FT B1025.1	CCAFS LC-40	SpaceX CRS-9	2257	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
2015-12-22	01:29:00	F9 FT B1019	CCAFS LC-40	OG2 Mission 2 11 Orbcomm-OG2 satellites	2034	LEO	Orbcomm	Success	Success (ground pad)


Section 3
Launch Sites
Proximities Analysis

Launch site

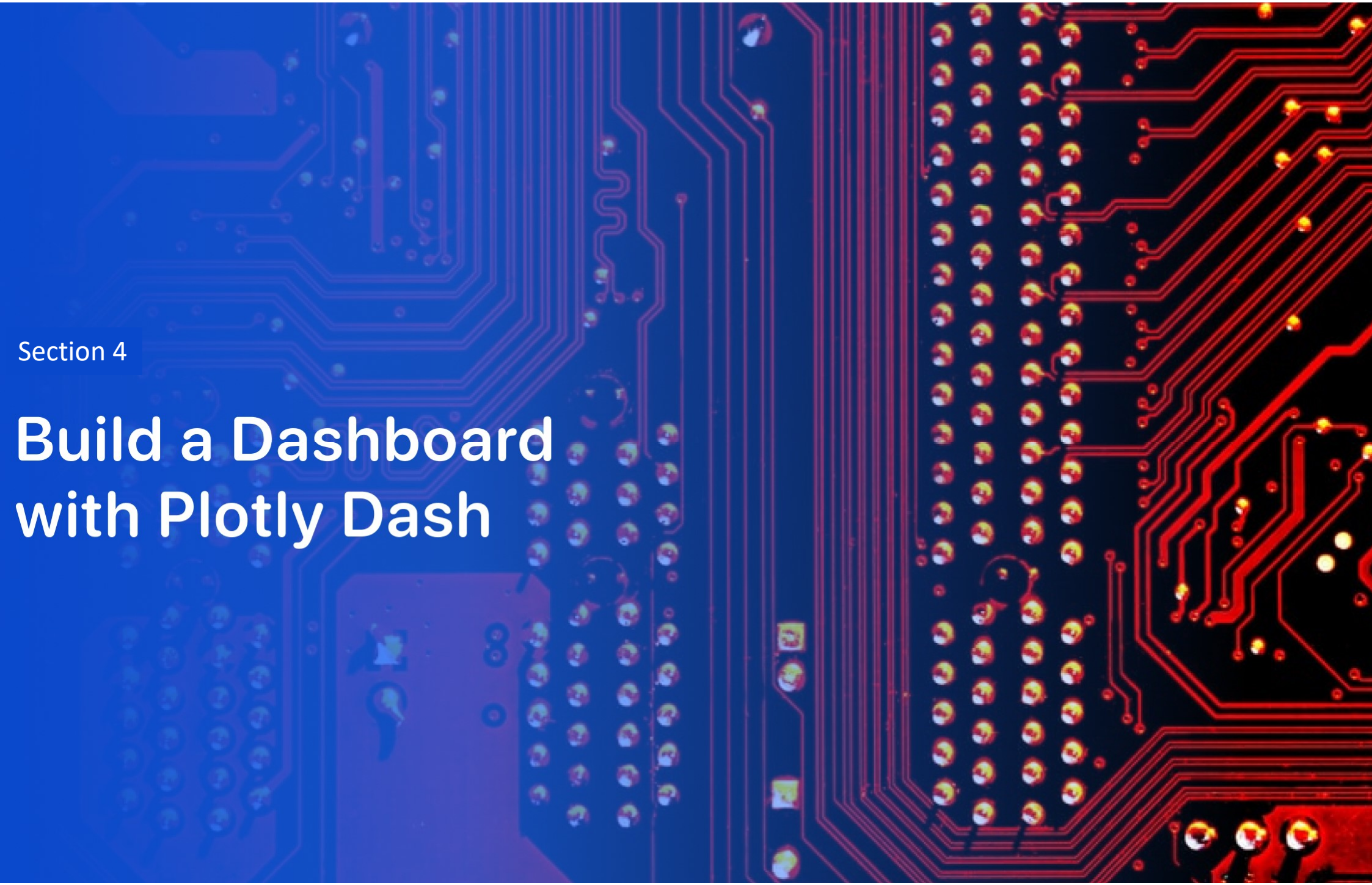

Denver
Kansas City
Fresno
Las Vegas
Albuquerque
Tulsa
Memphis
Charlotte
Atlanta
Dallas
Phoenix
Tucson
Tijuana
Mexicali
Ciudad Juárez
Austin
Houston
Baton Rouge
NASA
JSC
San Antonio
Monterrey
Reynosa
Torreón
Saltillo
Culiacán
La Paz
México
Aguascalientes
León
Ciudad de México
Morelia
Veracruz
Puebla
Mérida
Cancún
La Habana
Miami
Cuba
Cayman Islands
Leaflet | Data by © OpenStreetMap, under ODbL

Success rate of rocket launches



Surrounding landmarks

Map Object	Colour
Nearest Highway	Green
Nearest Railway	Purple
Nearest City	Crimson
Nearest Coastline	Dark Blue

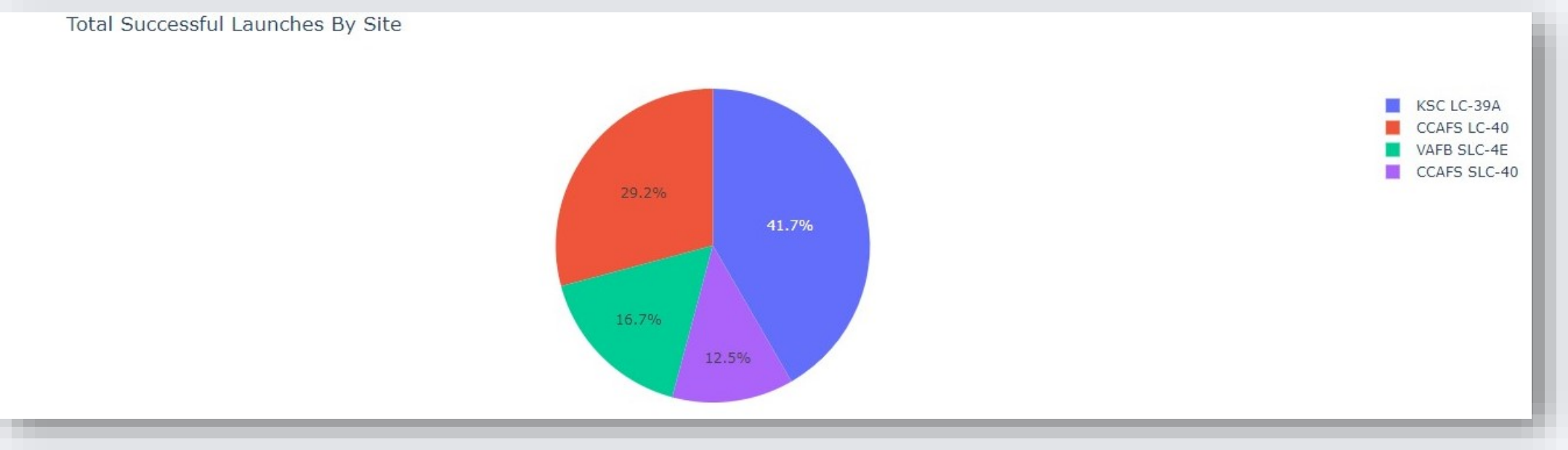


Section 4

Build a Dashboard with Plotly Dash

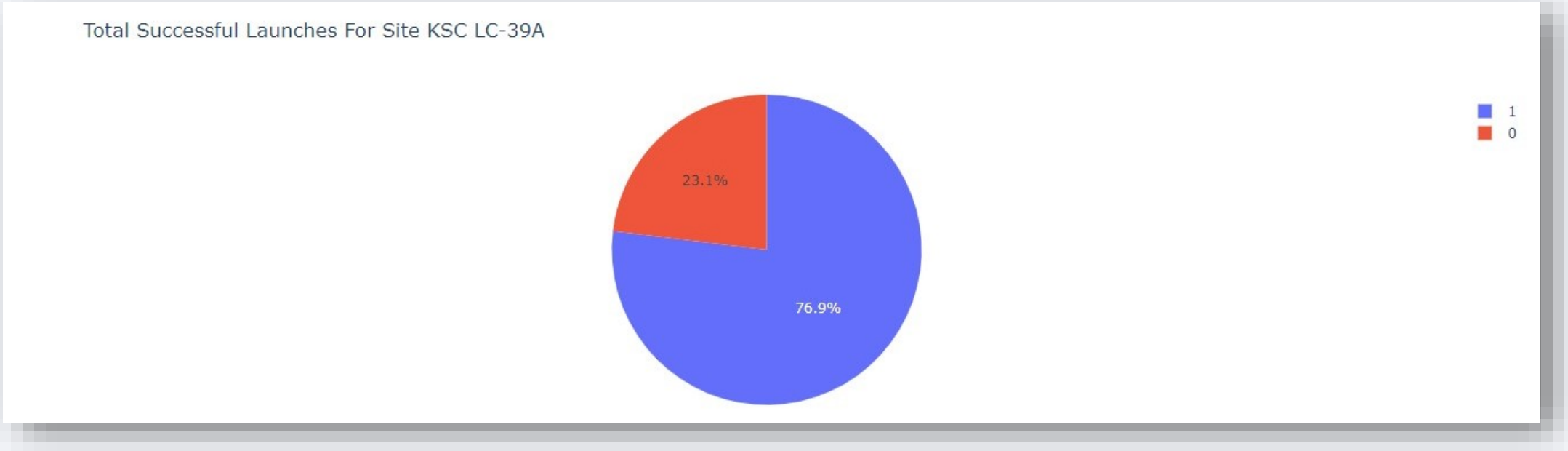
Success launch

- You can see from the plot that Site KSC LC-39A has the largest successful launches as well the highest launch success rate.



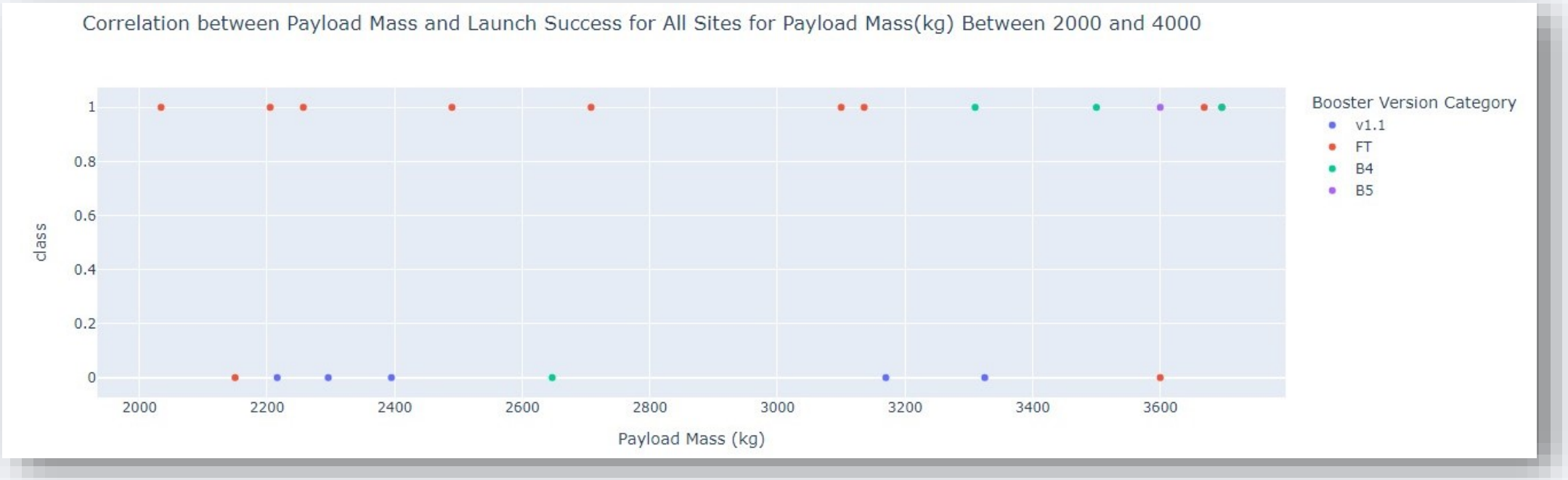
Total Successful Launches for Site KSC LC-39A

- You can see that 76.9% of the total launches at site KSC LC-39A were successful. This is a the highest success rate of all the different launch sites.



Payload Mass vs. Launch Success for All Sites

- It appears that the payload range between 2000 kg and 4000 kg has the highest success rate.



Section 5

Predictive Analysis (Classification)

Classification Accuracy

Find the method performs best:

In [28]:
```
accuracy = [svm_cv_score, logreg_score, knn_cv_score, tree_cv_score]
accuracy = [i * 100 for i in accuracy]

method = ['Support Vector Machine', 'Logistic Regression', 'K Nearest Neighbour', 'Decision Tree']
models = {'ML Method':method, 'Accuracy Score (%)':accuracy}

ML_df = pd.DataFrame(models)
ML_df
```

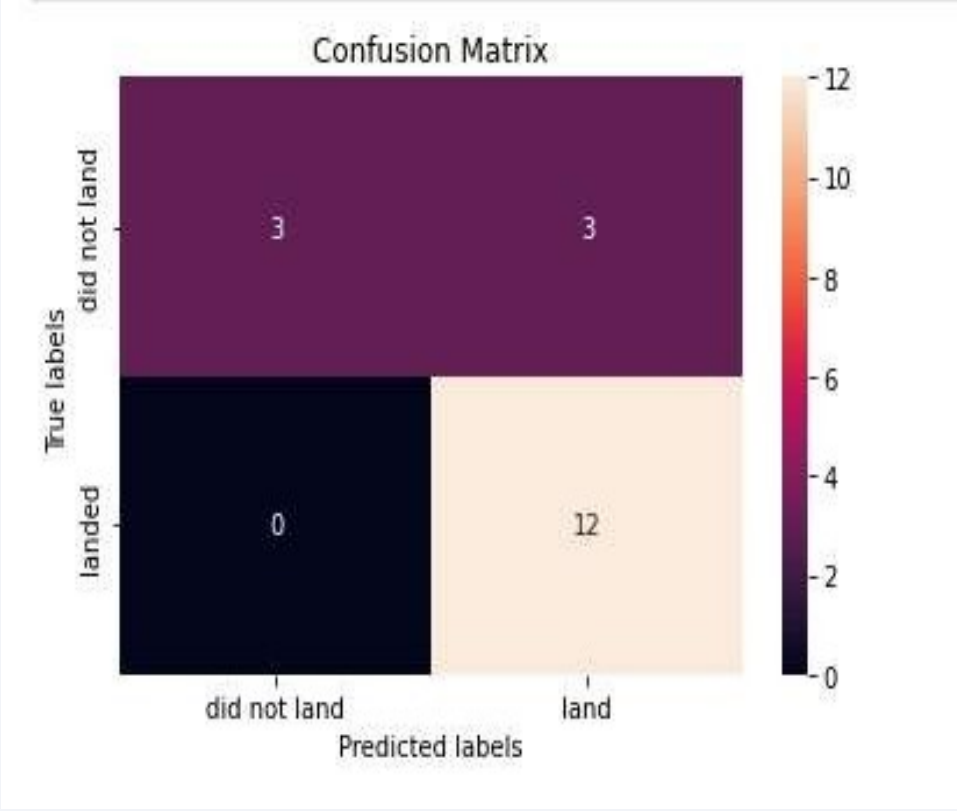
Out[28]:

	ML Method	Accuracy Score (%)
0	Support Vector Machine	83.333333
1	Logistic Regression	83.333333
2	K Nearest Neighbour	83.333333
3	Decision Tree	83.333333

- You can see that All the methods have an identical accuracy score of 83.33%, so we decided to use Logistic Regression for the classification

Confusion Matrix

- The chart shows the confusion matrix of the Logistic Regression model that was chosen



Conclusions

- All their launch sites are located near the coast, away from nearby cities. This enabled to them to testtheir rocket landings without much interference.
- Site KSC LC-39A had the highest launch success rate out of all the launch sites.
- From 2015 onwards, the success rate of rocket landings significantly increased. It was also apparent that landing success increased with flight number

- All this data was used to train a machine learning model that is able to predict the landing outcome of rocket launches with 83.33% accuracy

Thank you!