IBM Developer
SKILLS NETWORK

# Winning Space Race with Data Science

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# Outline

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

# Executive Summary

- Summary of methodologies
- Summary of all results

# Introduction

- Project background and context
- Problems you want to find answers

Section 1

# Methodology

# Methodology

## Executive Summary

- Data collection methodology:
  - Request to the SpaceX API
  - Extract a Falcon 9 launch records HTML table from Wikipedia
- Perform data wrangling
  - Describe how data was processed
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - How to build, tune, evaluate classification models

# Data Collection

## SpaceX API:

**Method:** Data was collected using the SpaceX RESTful API by making a GET request to the API. Helper functions were defined to extract specific information from the API, particularly using identification numbers from the launch data.

**Process:** After requesting rocket launch data from the SpaceX API URL, the returned JSON response was parsed and decoded. The result was then converted into a **Pandas DataFrame** for easier manipulation and analysis.

## Web Scraping:

**Method:** Web scraping was performed to gather historical launch data for Falcon 9 from the **Wikipedia page** titled "List of Falcon 9 and Falcon Heavy launches."

**Process:** Using the **BeautifulSoup** and **requests** libraries, HTML table records of Falcon 9 launches were extracted. The parsed data was then converted into a **Pandas DataFrame** for further use.

```
+-----------------------------------+
| 1. Define API Helper Functions    |
+-----------------------------------+
                |
                v
+-----------------------------------+
| 2. Request SpaceX API Data        |
| (GET request, parse JSON)         |
+-----------------------------------+
                |
                v
+-----------------------------------+
| 3. Web Scraping Wikipedia Page    |
| (Use BeautifulSoup, requests)     |
+-----------------------------------+
                |
                v
+-----------------------------------+
| 4. Final Data Preparation         |
| (Combine, Clean, Store Data)      |
+-----------------------------------+
```

# Data Collection

**Define API Helper Functions:**

- Created functions to handle API calls.
- Extracted specific data using IDs from the API.

**Request SpaceX API Data:**

- Made a GET request to SpaceX API for launch data.
- Parsed the JSON response and converted it to a Pandas DataFrame.

**Web Scraping Wikipedia Page:**

- Targeted the Wikipedia page for Falcon 9 launch data.
- Used BeautifulSoup and requests to extract HTML table data.
- Parsed the table and converted it to a Pandas DataFrame.

**Final Data Preparation:**

- Combined and cleaned the data from both sources.
- Stored the data in a usable format for analysis.

# Data Collection – SpaceX API

- Data collected using SpaceX API (a RESTful API) by making a get request to the SpaceX API then requested and parsed the SpaceX launch data using the GET request and decoded the response content as a Json result which was then converted into a Pandas data frame

- SpaceX-Data-Analysis/1. SpaceX Data Collection API.ipynb at main · ThiruMath/SpaceX-Data-Analysis (github.com)

**Define API Helper Functions:**

- Created functions to handle API calls.
- Extracted specific data using IDs from the API.

**Request SpaceX API Data:**

- Made a GET request to SpaceX API for launch data.
- Parsed the JSON response and converted it to a Pandas DataFrame

# Data Collection - Scraping

- Performed web scraping to collect Falcon 9 historical launch records from a Wikipedia using BeautifulSoup and request, to extract the Falcon 9 launch records from HTML table of the Wikipedia page, then created a data frame by parsing the launch HTML
- [2. SpaceX Data Web Scraping from Wikipedia.ipynb (github.com)]()

**Web Scraping Falcon 9 Launch Data:**

- Used **BeautifulSoup** and **requests** libraries to scrape **Falcon 9 historical launch records** from a Wikipedia page.

**Extract HTML Table:**

- Targeted the **HTML table** containing launch records on the Wikipedia page.

**Parse and Convert Data:**

- Parsed the table using **BeautifulSoup** and extracted relevant data.
- Converted the parsed data into a **Pandas DataFrame** for analysis and further manipulation.

# Data Wrangling

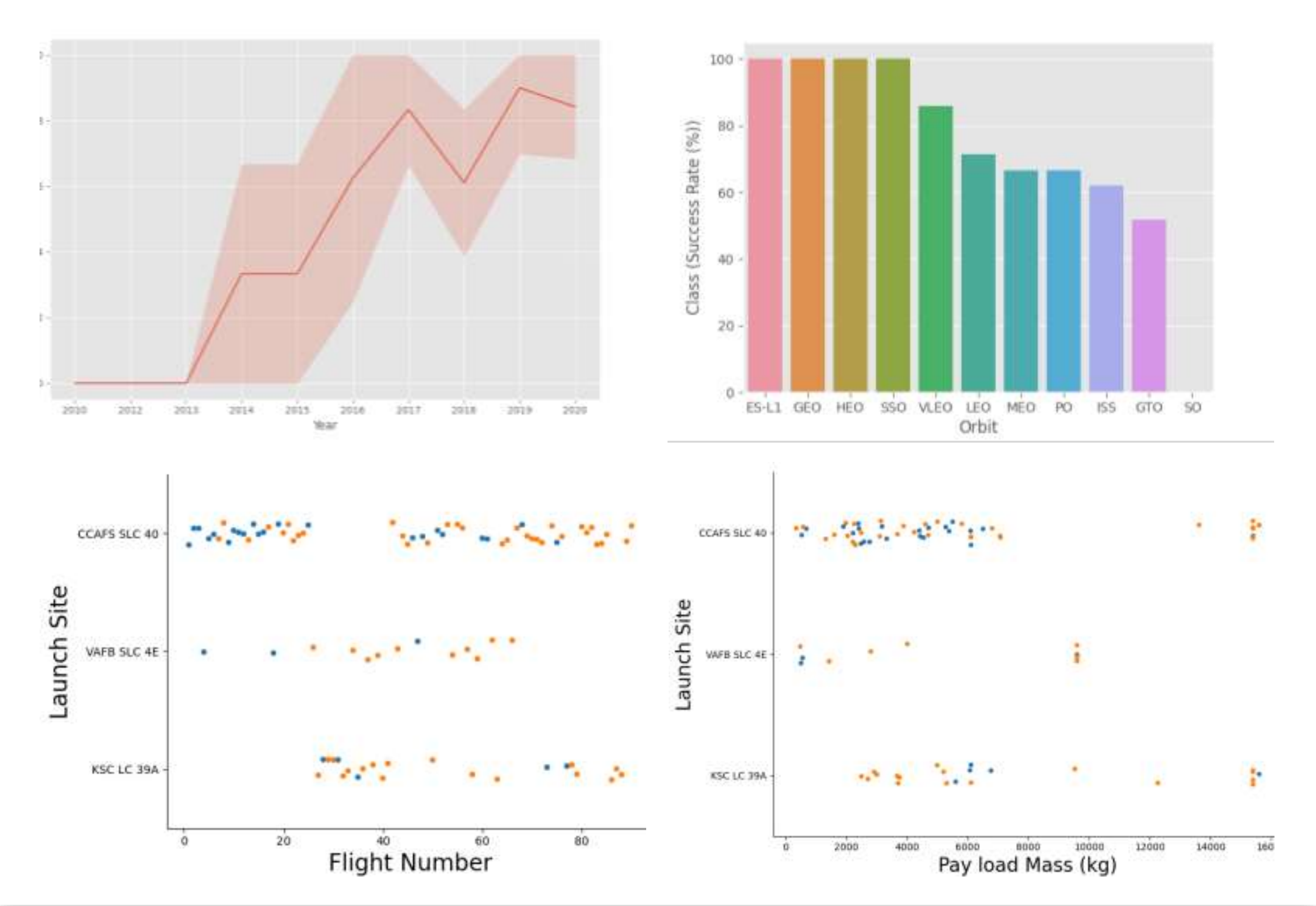
- After obtaining and creating a Pandas DF from the collected data, data was filtered using the BoosterVersion column to only keep the Falcon 9 launches, then dealt with the missing data values in the LandingPad and PayloadMass columns. For the PayloadMass , missing data values were replaced using mean value of column.
- Also performed some Exploratory Data Analysis (EDA) to find some patterns in the data and determine what would be the label for training supervised models

- SpaceX-Data-Analysis/3. SpaceX Data Wrangling.ipynb at main · ThiruMath/SpaceX-Data-Analysis (github.com)

# EDA with Data Visualization

- Performed data Analysis and Feature Engineering using Pandas and Matplotlib.i.e.
  - Exploratory Data Analysis
  - Preparing Data Feature Engineering
- Used scatter plots to Visualize the relationship between Flight Number and Launch Site, Payload and Launch Site, FlightNumber and Orbit type, Payload and Orbit type.
- Used Bar chart to Visualize the relationship between success rate of each orbit type • Line plot to Visualize the launch success yearly trend
- SpaceX-Data-Analysis/5. SpaceX EDA Dataviz.ipynb at main · ThiruMath/SpaceX-Data-Analysis (github.com)

# EDA with Data Visualization



# EDA with SQL

- Task 1
  - Display the names of the unique launch sites in the space mission
  - %sql SELECT DISTINCT LAUNCH_SITE as "Launch_Sites" FROM SPACEXTBL;
- Task 2
  - Display 5 records where launch sites begin with the string 'CCA'
  - %sql SELECT * FROM 'SPACEXTBL' WHERE Launch_Site LIKE 'CCA%' LIMIT 5;
- Task3
  - Display the total payload mass carried by boosters launched by NASA (CRS)
  - `%sql SELECT SUM(PAYLOAD_MASS__KG_) as "Total Payload Mass(Kgs)", Customer FROM 'SPACEXTBL' WHERE Customer = 'NASA (CRS)';`
- Task 4
  - Display average payload mass carried by booster version F9 v1.1
  - `%sql SELECT AVG(PAYLOAD_MASS__KG_) as "Payload Mass Kgs", Customer, Booster_Version FROM 'SPACEXTBL' WHERE Booster_Version LIKE 'F9 v1.1%';`
- Task 5
  - List the date when the first succesful landing outcome in ground pad was acheived.
  - `%sql SELECT MIN(DATE) FROM 'SPACEXTBL' WHERE "Landing _Outcome" = "Success (ground pad)";`

# EDA with SQL

[SpaceX-Data-Analysis/4. SpaceX EDA SQL.ipynb at main · ThiruMath/SpaceX-Data-Analysis (github.com)]

- Task 6
  - List the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 6000
  - *%sql SELECT * FROM 'SPACEXTBL'*
  - **%sql** SELECT DISTINCT Booster_Version, Payload FROM SPACEXTBL WHERE "Landing _Outcome" = "Success (drone ship)" AND PAYLOAD_MASS__KG_ > 4000 AND PAYLOAD_MASS__KG_ < 6000;
- Task 7
  - List the total number of successful and failure mission outcomes
  - **%sql** SELECT "Mission_Outcome", COUNT("Mission_Outcome") as Total FROM SPACEXTBL GROUP BY "Mission_Outcome";
- Task 8
  - List the names of the booster_versions which have carried the maximum payload mass. Use a subquery
  - **%sql** SELECT "Booster_Version",Payload, "PAYLOAD_MASS__KG_" FROM SPACEXTBL WHERE "PAYLOAD_MASS__KG_" = (SELECT MAX("PAYLOAD_MASS__KG_") FROM SPACEXTBL);
- Task 9
  - List the records which will display the month names, failure landing_outcomes in drone ship ,booster versions, launch_site for the months in year 2015.
  - **%sql** SELECT substr(Date,7,4), substr(Date, 4, 2),"Booster_Version", "Launch_Site", Payload, "PAYLOAD_MASS__KG_", "Mission_Outcome", "Landing _Outcome" FROM SPACEXTBL WHERE substr(Date,7,4)='2015' AND "Landing _Outcome" = 'Failure (drone ship)';
- Task 10
  - Rank the count of successful landing_outcomes between the date 04-06-2010 and 20-03-2017 in descending order.
  - **%sql** SELECT * FROM SPACEXTBL WHERE "Landing _Outcome" LIKE 'Success%' AND (Date BETWEEN '04-06-2010' AND '20-03-2017') ORDER BY Date DESC;

# Build an Interactive Map with Folium

Map Objects Added:

- **Markers:** To mark key locations like SpaceX launch sites.
- **Circles:** To highlight regions of significance around these sites.
- **Polylines (Lines):** To represent flight paths or routes.
- **Circle Markers:** To indicate important data points with size and color.

Reasons for Adding:

- **Markers:** Pinpoint key sites and provide information.
- **Circles:** Emphasize important areas around launch sites.
- **Polylines:** Show connections or paths between locations.
- **Circle Markers:** Visualize data like success rates or frequencies.

- SpaceX-Data-Analysis/6. SpaceX Launch Sites Locations Analysis with Folium.ipynb at main · ThiruMath/SpaceX-Data-Analysis (github.com)

# Build a Dashboard with Plotly Dash

Plots/Graphs Added:

- **Bar Charts:** To show the number of rocket launches per year.
- **Line Charts:** To track trends in payload mass over time.
- **Pie Charts:** To display the distribution of successful vs. failed launches.
- **Scatter Plots:** To visualize the relationship between payload mass and launch outcomes.
- **Maps (Folium):** To highlight launch locations and trajectories.

Interactions Added:

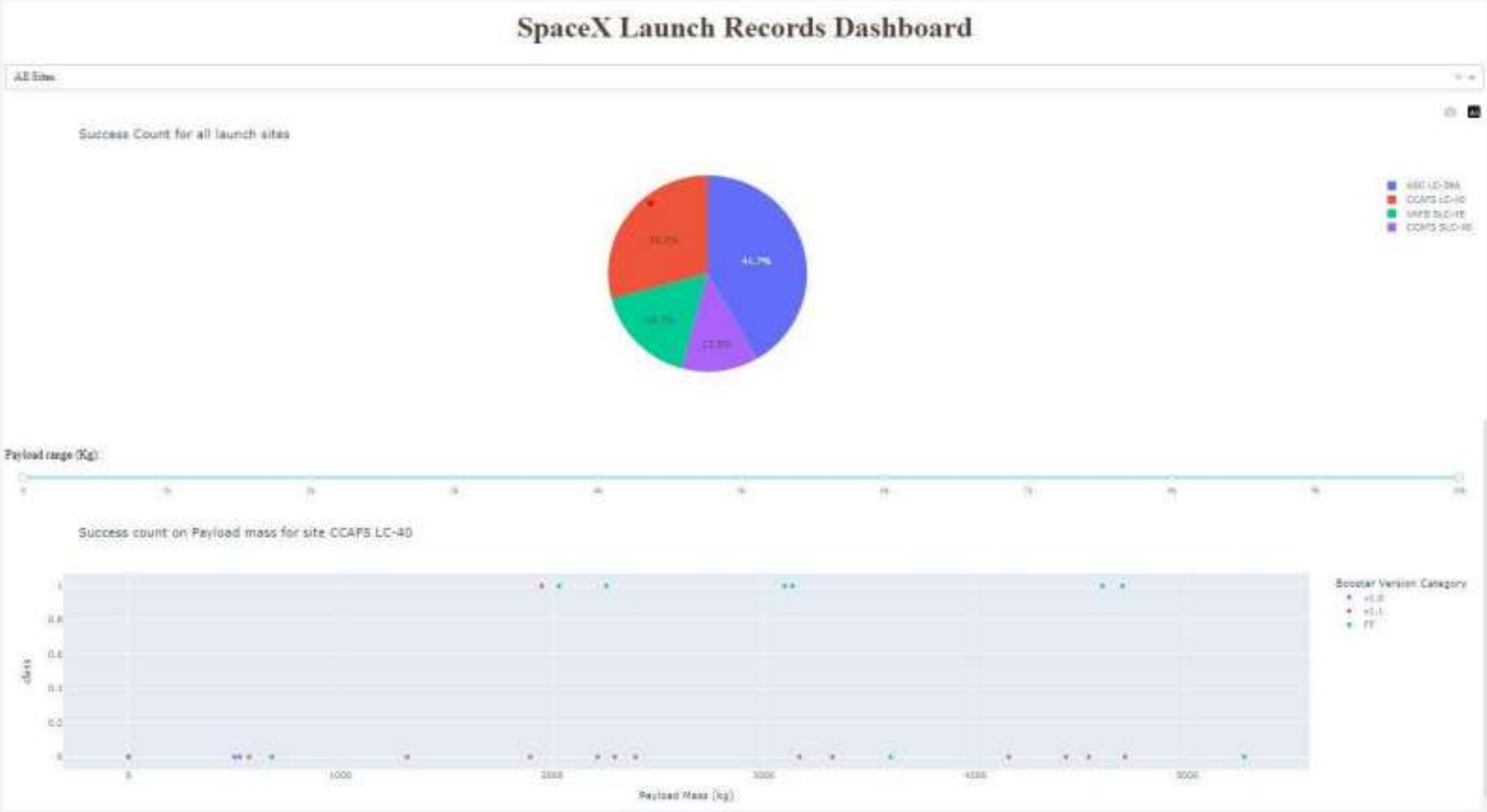
- **Dropdowns:** To filter data by year, rocket type, or launch site.
- **Hover Tooltips:** To display additional information when hovering over specific data points.
- **Zoom and Pan:** For better exploration of the map and graphs.
- **Clickable Markers:** On maps to show detailed launch information.

Reasons for Adding:

- **Bar and Line Charts:** To track trends over time and provide a clear visual representation of data.
- **Pie Charts:** To compare categories like success vs. failure rates.
- **Scatter Plots:** To analyze relationships between variables, such as payload and launch success.
- **Maps:** To visualize geographic data and provide a spatial perspective.
- **Dropdowns & Filters:** For user control and personalized data exploration.
- **Hover and Click Interactions:** To provide detailed insights without cluttering the dashboard.

7.SpaceX Build an Interactive Dashboard with Ploty Dash - spacex_dash_app.py (github.com)

# Build a Dashboard with Plotly Dash



# Predictive Analysis (Classification)

- Model Building:
- **Selected Algorithms:** Tested multiple classification models (e.g., Logistic Regression, Random Forest, SVM).
- **Data Preparation:** Cleaned and preprocessed data, handled missing values, and performed feature scaling.
- Model Evaluation:
- **Metrics Used:** Evaluated models using accuracy, precision, recall, F1-score, and confusion matrix.
- **Cross-Validation:** Applied cross-validation to ensure the model's robustness.
- Model Improvement:
- **Hyperparameter Tuning:** Used techniques like GridSearchCV or RandomizedSearchCV to optimize model parameters.
- **Feature Engineering:** Created new features and removed irrelevant ones to improve model performance.
- Best Model Selection:
- **Final Model:** Chose the model with the best balance of performance metrics after tuning and validation.
- **Evaluation:** Assessed final model using unseen test data to confirm its generalization capability.

- SpaceX-Data-Analysis/8. SpaceX Machine Learning Prediction.ipynb at main · ThiruMath/SpaceX-Data-Analysis (github.com)

# Results

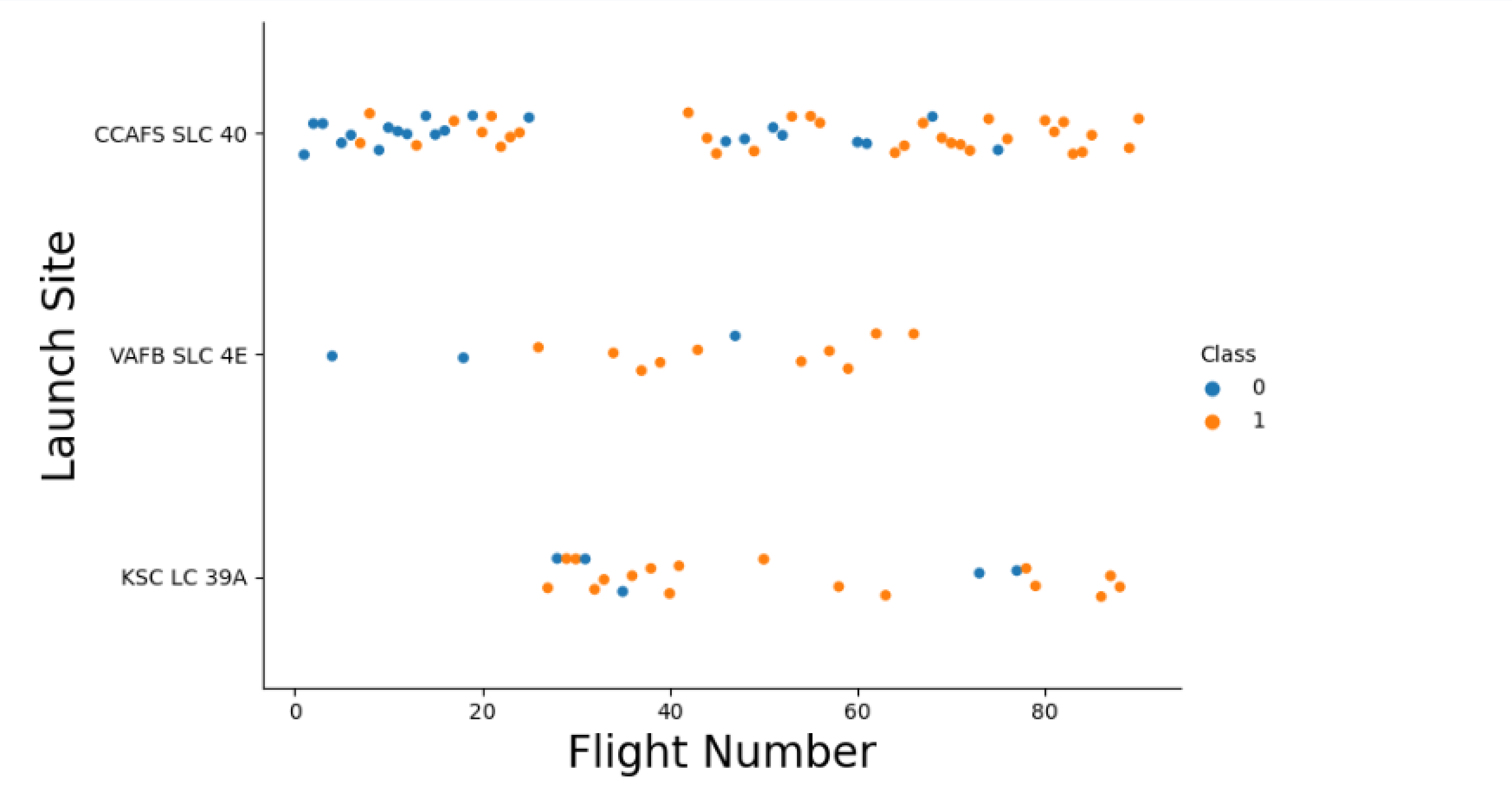
| | 0 |
|---|---|
| Method | Test Data Accuracy |
| Logistic_Reg | 0.833333 |
| SVM | 0.833333 |
| Decision Tree | 0.833333 |
| KNN | 0.833333 |

Section 2

# Insights drawn from EDA

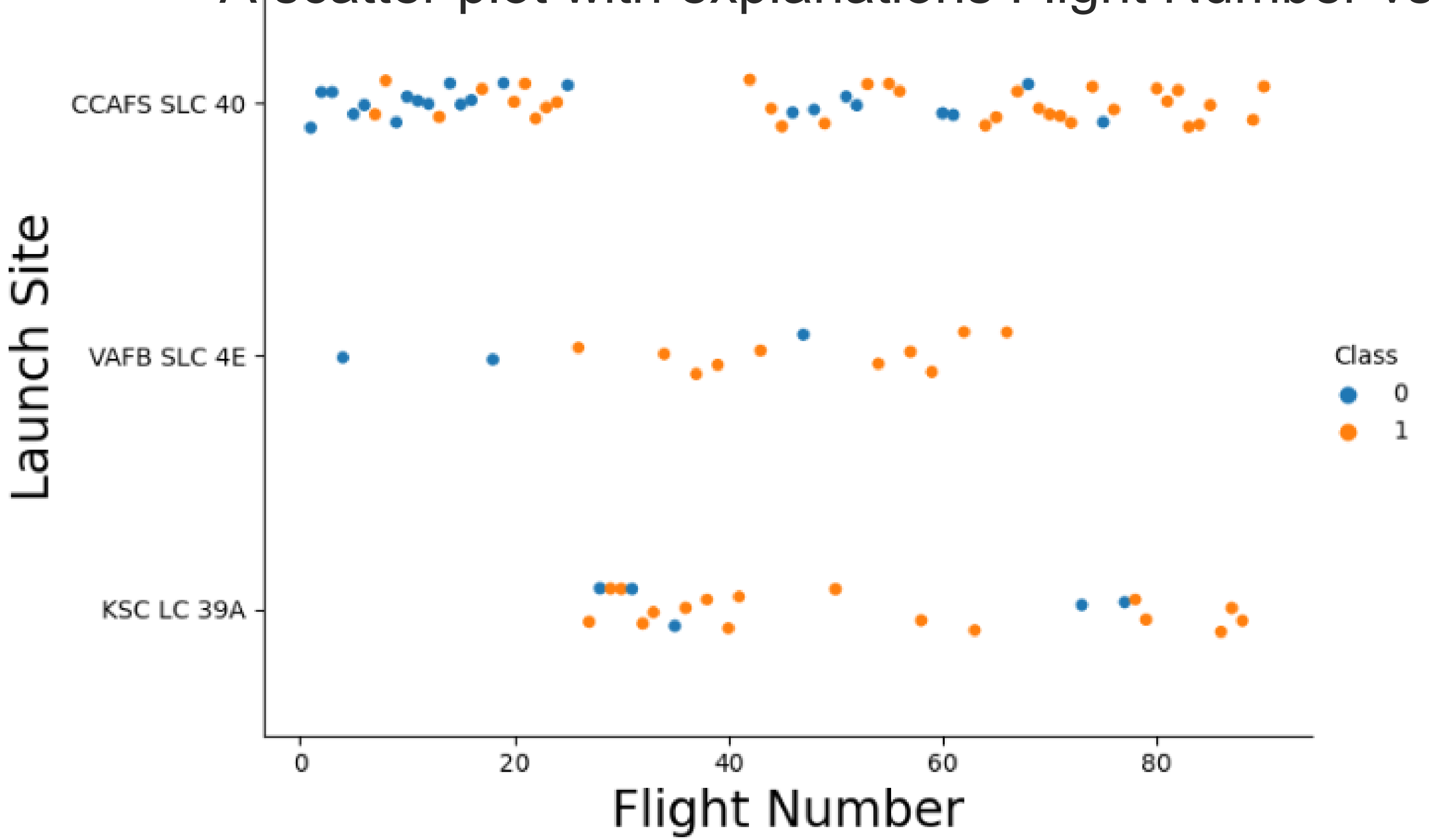
# Flight Number vs. Launch Site

A scatter plot of Flight Number vs. Launch Site



# Flight Number vs. Launch Site with explanations

A scatter plot with explanations Flight Number vs. Launch Site

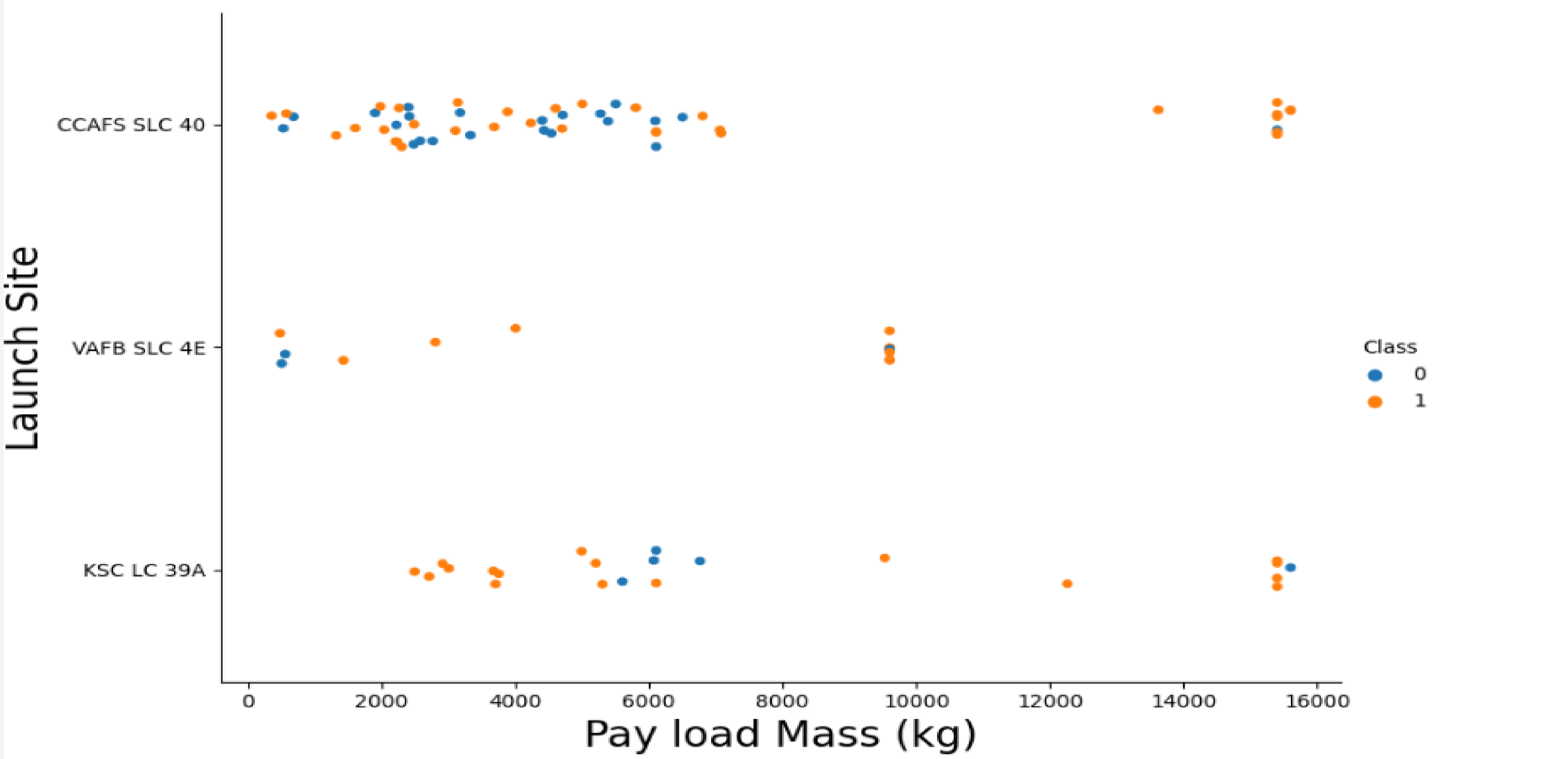



Now try to explain the patterns you found in the Flight Number vs. Launch Site scatter point plots.

We can deduce that, as the flight number increases in each of the 3 launcg sites, so does the success rate. For instance, the success rate for the VAFB SLC 4E launch site is 100% after the Flight number 50. Both KSC LC 39A and CCAFS SLC 40 have a 100% success rates after 80th flight.

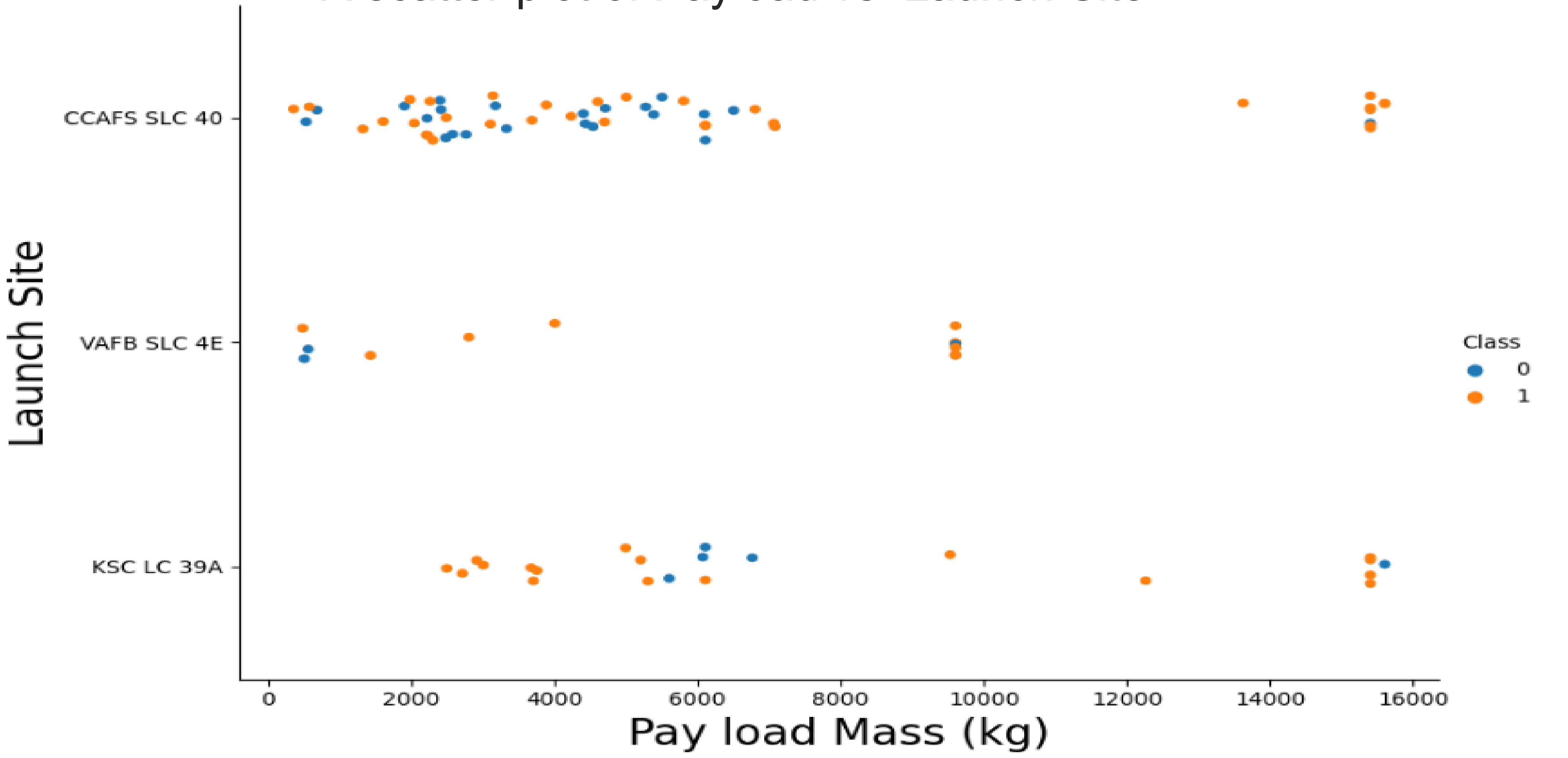
# Payload vs. Launch Site

A scatter plot of Payload vs. Launch Site



# Payload vs. Launch Site with explanations

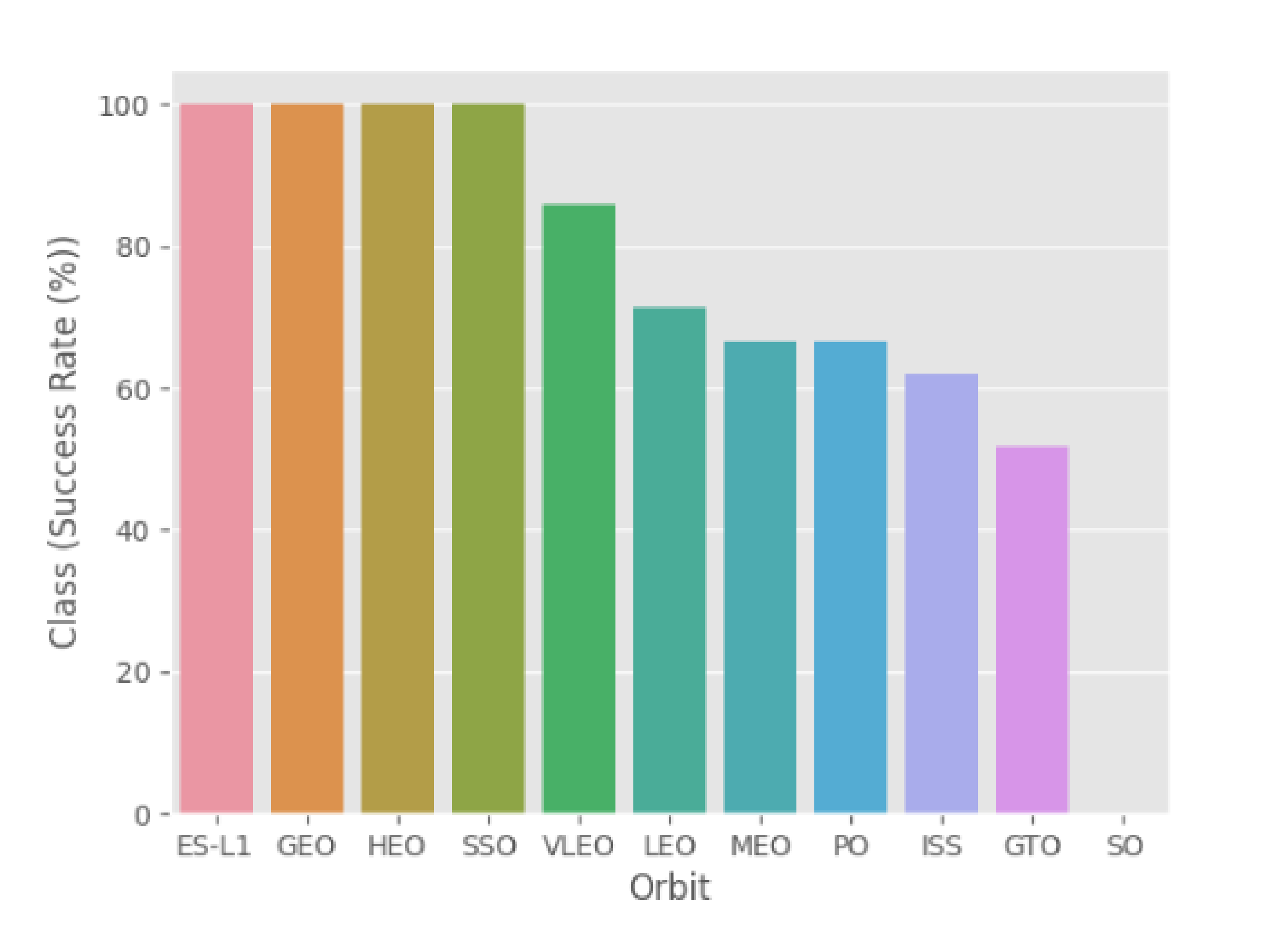
A scatter plot of Payload vs. Launch Site




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).

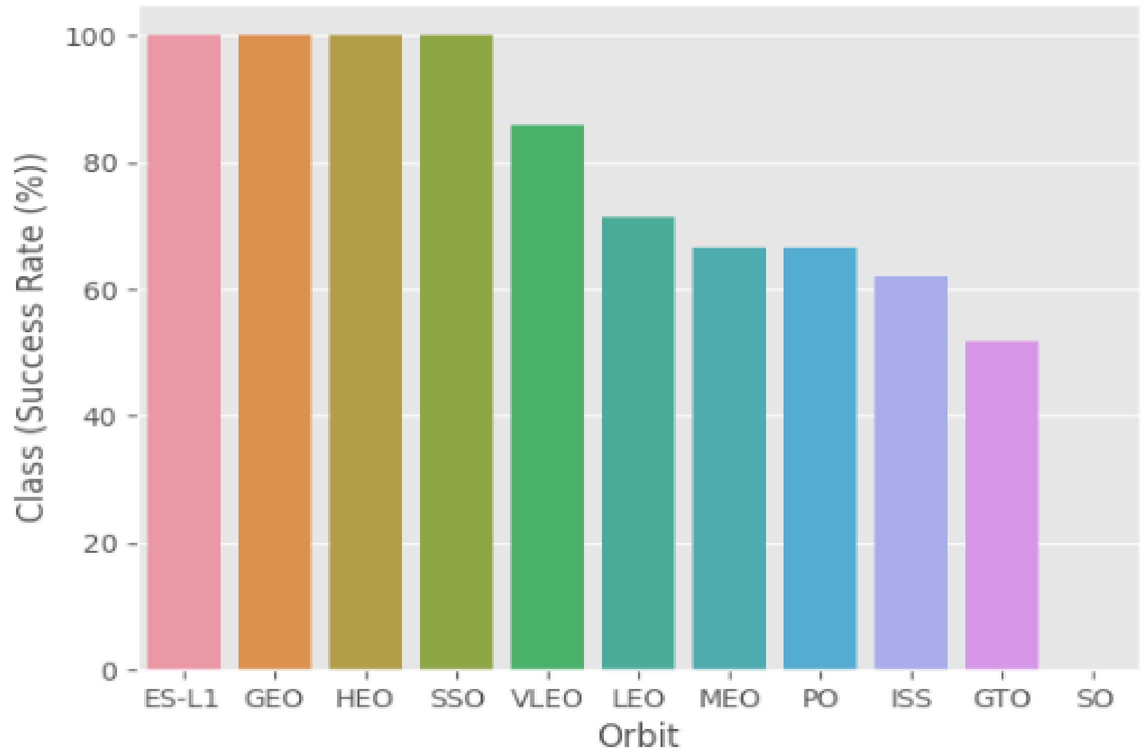
# Success Rate vs. Orbit Type

- Show a bar chart for the success rate of each orbit type



# Success Rate vs. Orbit Type with explanations

- Show the screenshot of the bar chart with explanations

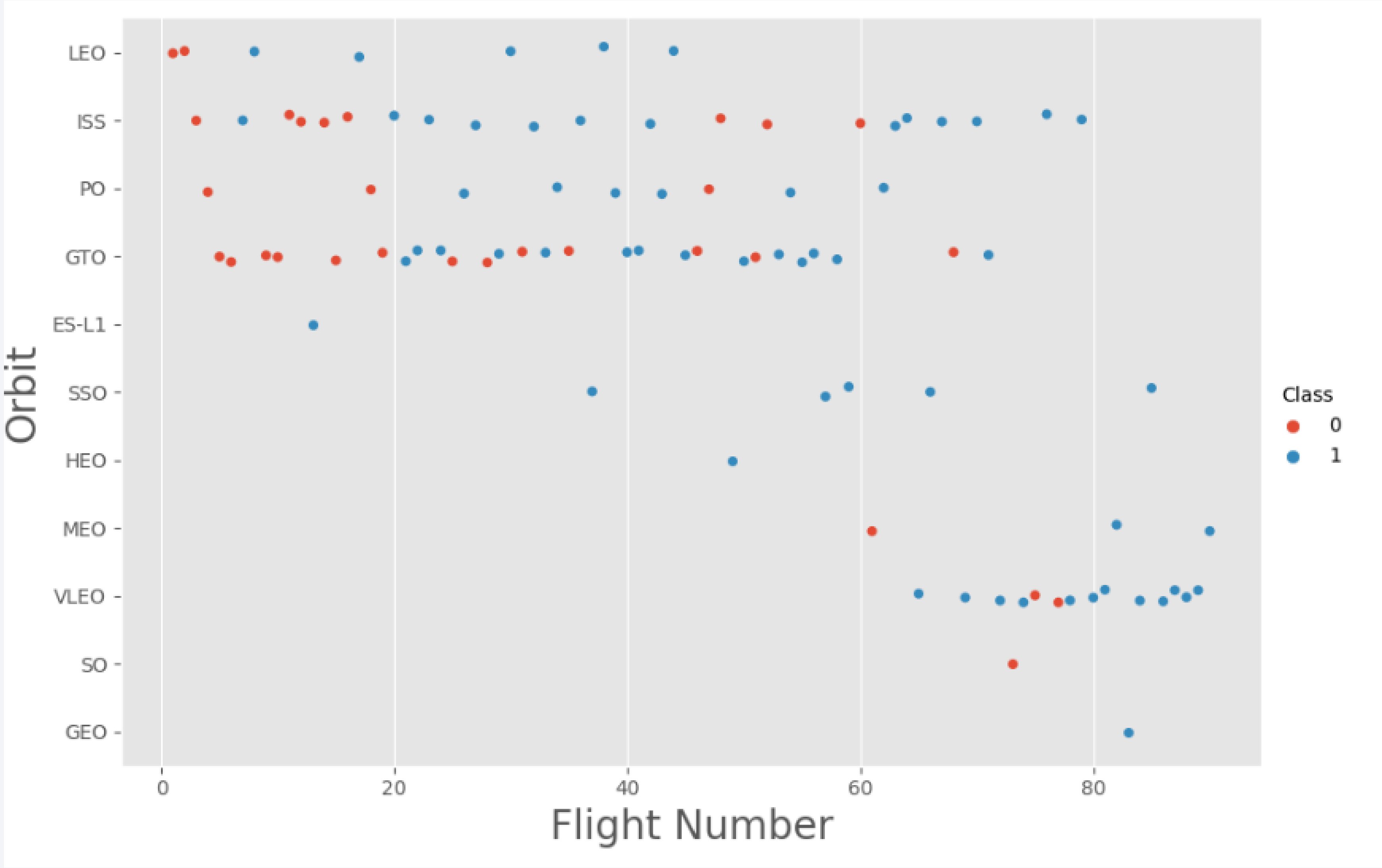



**Analyze the ploted bar chart try to find which orbits have high sucess rate.**

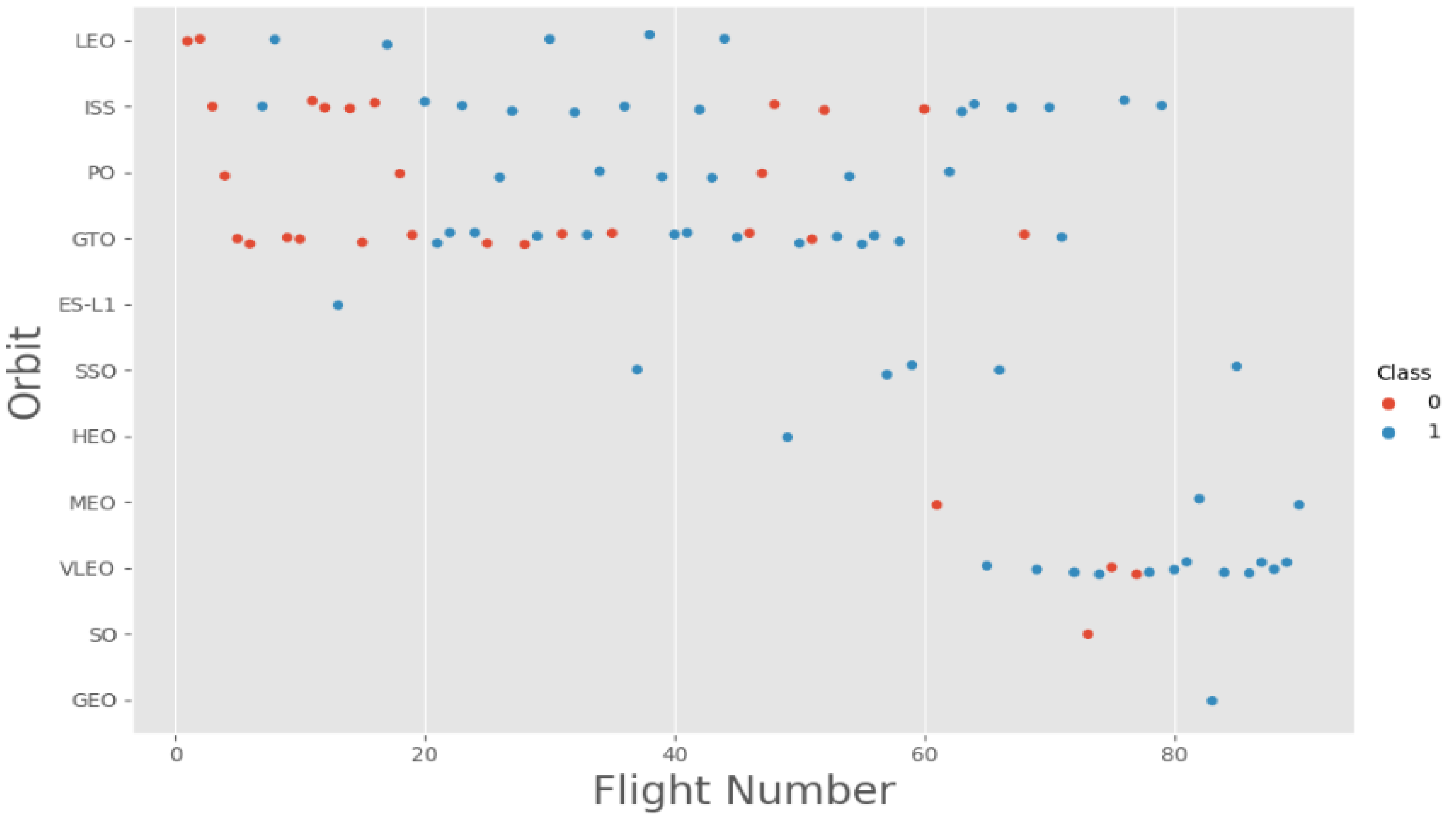
Orbits ES-L1, GEO, HEO & SSO have the highest success rates at 100%, with SO orbit having the lowest success rate at ~50%. Orbit SO has 0% success rate.

# Flight Number vs. Orbit Type

- A scatter point of Flight number vs. Orbit type



# Flight Number vs. Orbit Typewith explanations




You should 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.

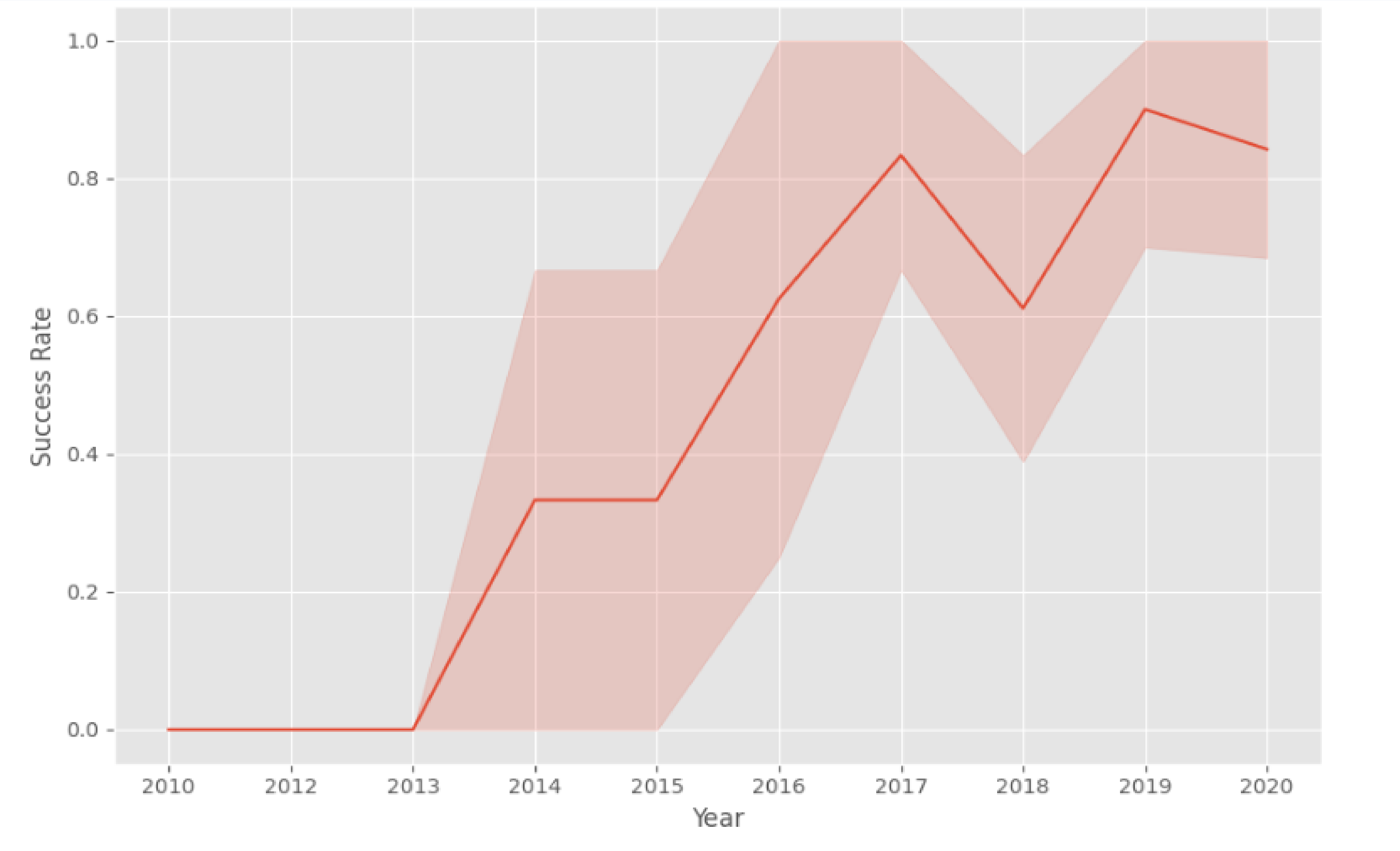
# Payload vs. Orbit Type

- With heavy payloads the successful landing or positive landing rate are more for Polar,LEO and ISS.
- However for GTO we cannot distinguish this well as both positive landing rate and negative landing(unsuccessful mission) both have near equal chances.

# Launch Success Yearly Trend

- Since 2013, the success rate kept going up till 2020

A line chart of yearly average success rate



# All Launch Site Names

- Find the names of the unique launch sites

- Used 'SELECT DISTINCT' statement to return only the unique launch sites from the 'LAUNCH_SITE' column of the SPACEXTBL table

## Task 1

Display the names of the unique launch sites in the space mission

In [31]:
```
%sql SELECT DISTINCT LAUNCH_SITE as "Launch_Sites" FROM SPACEXTBL;
```

```
 * sqlite:///my_data1.db
Done.
```

Out[31]:

| Launch_Sites |
|---|
| CCAFS LC-40 |
| VAFB SLC-4E |
| KSC LC-39A |
| CCAFS SLC-40 |

# Launch Site Names Begin with 'CCA'

- Find 5 records where launch sites begin with `CCA`

### Task 2

Display 5 records where launch sites begin with the string 'CCA'

In [72]:
```
%sql SELECT * FROM 'SPACEXTBL' WHERE Launch_Site LIKE 'CCA%' LIMIT 5;
```

```
 * sqlite:///my_data1.db
Done.
```

Out[72]:

| Date | Time (UTC) | Booster_Version | Launch_Site | Payload | PAYLOAD_MASS__KG_ | Orbit | Customer | Mission_Outcome | Landing _Outcome |
|---|---|---|---|---|---|---|---|---|---|
| 04-06-2010 | 18:45:00 | F9 v1.0 B0003 | CCAFS LC-40 | Dragon Spacecraft Qualification Unit | 0 | LEO | SpaceX | Success | Failure (parachute) |
| 08-12-2010 | 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) |
| 22-05-2012 | 07:44:00 | F9 v1.0 B0005 | CCAFS LC-40 | Dragon demo flight C2 | 525 | LEO (ISS) | NASA (COTS) | Success | No attempt |
| 08-10-2012 | 00:35:00 | F9 v1.0 B0006 | CCAFS LC-40 | SpaceX CRS-1 | 500 | LEO (ISS) | NASA (CRS) | Success | No attempt |
| 01-03-2013 | 15:10:00 | F9 v1.0 B0007 | CCAFS LC-40 | SpaceX CRS-2 | 677 | LEO (ISS) | NASA (CRS) | Success | No attempt |

- Used ‘LIKE’ command with ‘%’ wildcard in ‘WHERE’ clause to select and dispay a table of all records where **launch sites begin with the string 'CCA'**

# Total Payload Mass

- Calculate and Display the total payload carried by boosters from NASA

## Task 3

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

In [17]:

```
%sql SELECT SUM(PAYLOAD_MASS__KG_) as "Total Payload Mass(Kgs)", Customer FROM 'SPACEXTBL' WHERE Customer = 'NASA (CRS)';
```

```
 * sqlite:///my_data1.db
Done.
```

Out[17]:

| Total Payload Mass(Kgs) | Customer |
|---|---|
| 45596 | NASA (CRS) |

- Used the ‘SUM()’ function to return and dispaly the total sum of ‘**PAYLOAD_MASS_KG**’ column for Customer ‘**NASA(CRS**’

# Average Payload Mass by F9 v1.1

- Calculate the average payload mass carried by booster version F9 v1.1

## Task 4

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

```
%sql SELECT AVG(PAYLOAD_MASS__KG_) as "Payload Mass Kgs", Customer, Booster_Version FROM 'SPACEXTBL' WHERE Booster_Version LIKE 'F9 v1.1%';
```

```
 * sqlite:///my_data1.db
Done.
```

| Payload Mass Kgs | Customer | Booster_Version |
|---|---|---|
| 2534.6666666666665 | MDA | F9 v1.1 B1003 |

- Used the ‘AVG()’ function to return and dispaly the average payload mass carried by booster version F9 v1.1

# First Successful Ground Landing Date

- Find the dates of the first successful landing outcome on ground pad

## Task 5

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

*Hint:Use min function*

```
%sql SELECT MIN(DATE) FROM 'SPACEXTBL' WHERE "Landing _Outcome" = "Success (ground pad)";
```

```
 * sqlite:///my_data1.db
Done.
```

| MIN(DATE) |
|---|
| 01-05-2017 |

- Used the 'MIN()' function to return and dispaly the first (oldest) date when first successful landing outcome on ground pad '***Success (ground pad)***' happened.

# Successful Drone Ship Landing with Payload between 4000 and 6000

- List of Boosters which have successfully landed on drone ship and had payload mass greater than 4000 but less than 6000

## Task 6

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

```
# %sql SELECT * FROM 'SPACEXTBL'
```

```
%sql SELECT DISTINCT Booster_Version, Payload FROM SPACEXTBL WHERE "Landing _Outcome" = "Success (drone ship)" AND PAYLOAD_MASS__KG_ > 4000 AND PAYLOA
```

```
 * sqlite:///my_data1.db
Done.
```

| Booster_Version | Payload |
|---|---|
| F9 FT B1022 | JCSAT-14 |
| F9 FT B1026 | JCSAT-16 |
| F9 FT B1021.2 | SES-10 |
| F9 FT B1031.2 | SES-11 / EchoStar 105 |

- Used ‘Select Distinct’ statement to return and list the ‘unique’ names of boosters with operators >4000 and <6000 to only list booster with payloads btween 4000-6000 with landing outcome of ‘Success (drone ship)’.

# Total Number of Successful and Failure Mission Outcomes

- Calculate the total number of successful and failure mission outcomes

## Task 7

List the total number of successful and failure mission outcomes

```
%sql SELECT "Mission_Outcome", COUNT("Mission_Outcome") as Total FROM SPACEXTBL GROUP BY "Mission_Outcome";
```

```
 * sqlite:///my_data1.db
Done.
```

| Mission_Outcome | Total |
|---|---|
| Failure (in flight) | 1 |
| Success | 98 |
| Success | 1 |
| Success (payload status unclear) | 1 |

- Used the 'COUNT()' together with the 'GROUP BY' statement to return total number of missions outcomes

# Boosters Carried Maximum Payload

- List of the boosters which have carried the maximum payload mass

```
%sql SELECT "Booster_Version",Payload, "PAYLOAD_MASS__KG_" FROM SPACEXTBL WHERE "PAYLOAD_MASS__KG_" = (SELECT MAX("PAYLOAD_MASS__KG_") FROM SPACEXTBL)
```

```
 * sqlite:///my_data1.db
Done.
```

| Booster_Version | Payload | PAYLOAD_MASS__KG_ |
|---|---|---|
| F9 B5 B1048.4 | Starlink 1 v1.0, SpaceX CRS-19 | 15600 |
| F9 B5 B1049.4 | Starlink 2 v1.0, Crew Dragon in-flight abort test | 15600 |
| F9 B5 B1051.3 | Starlink 3 v1.0, Starlink 4 v1.0 | 15600 |
| F9 B5 B1056.4 | Starlink 4 v1.0, SpaceX CRS-20 | 15600 |
| F9 B5 B1048.5 | Starlink 5 v1.0, Starlink 6 v1.0 | 15600 |
| F9 B5 B1051.4 | Starlink 6 v1.0, Crew Dragon Demo-2 | 15600 |
| F9 B5 B1049.5 | Starlink 7 v1.0, Starlink 8 v1.0 | 15600 |
| F9 B5 B1060.2 | Starlink 11 v1.0, Starlink 12 v1.0 | 15600 |
| F9 B5 B1058.3 | Starlink 12 v1.0, Starlink 13 v1.0 | 15600 |
| F9 B5 B1051.6 | Starlink 13 v1.0, Starlink 14 v1.0 | 15600 |
| F9 B5 B1060.3 | Starlink 14 v1.0, GPS III-04 | 15600 |
| F9 B5 B1049.7 | Starlink 15 v1.0, SpaceX CRS-21 | 15600 |

- Using a Subquerry to return and pass the Max payload and used it list all the boosters that have carried the Max payload of 15600kgs

# 2015 Launch Records

- List of failed landing outcomes in drone ship, with their booster versions, and launch site names  in 2015

## Task 9

List the records which will display the month names, failure landing_outcomes in drone ship ,booster versions, launch_site for the months in year 2015.

```
%sql SELECT substr(Date,7,4), substr(Date, 4, 2),"Booster_Version", "Launch_Site", Payload, "PAYLOAD_MASS__KG_", "Mission_Outcome", "Landing _Outcome"
```

```
 * sqlite:///my_data1.db
Done.
```

| substr(Date,7,4) | substr(Date, 4, 2) | Booster_Version | Launch_Site | Payload | PAYLOAD_MASS__KG_ | Mission_Outcome | Landing _Outcome |
|---|---|---|---|---|---|---|---|
| 2015 | 01 | F9 v1.1 B1012 | CCAFS LC-40 | SpaceX CRS-5 | 2395 | Success | Failure (drone ship) |
| 2015 | 04 | F9 v1.1 B1015 | CCAFS LC-40 | SpaceX CRS-6 | 1898 | Success | Failure (drone ship) |

- Used the ‘subsrt()’ in the select statement to get the month and year from the date column where substr(Date,7,4)='2015' for year and Landing_outcome was ‘Failure (drone ship’) and return the records nmatching the filter.

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

- 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

## Task 10

Rank the count of successful landing_outcomes between the date 04-06-2010 and 20-03-2017 in descending order.

```
%sql SELECT * FROM SPACEXTBL WHERE "Landing _Outcome" LIKE 'Success%' AND (Date BETWEEN '04-06-2010' AND '20-03-2017') ORDER BY Date DESC;
```

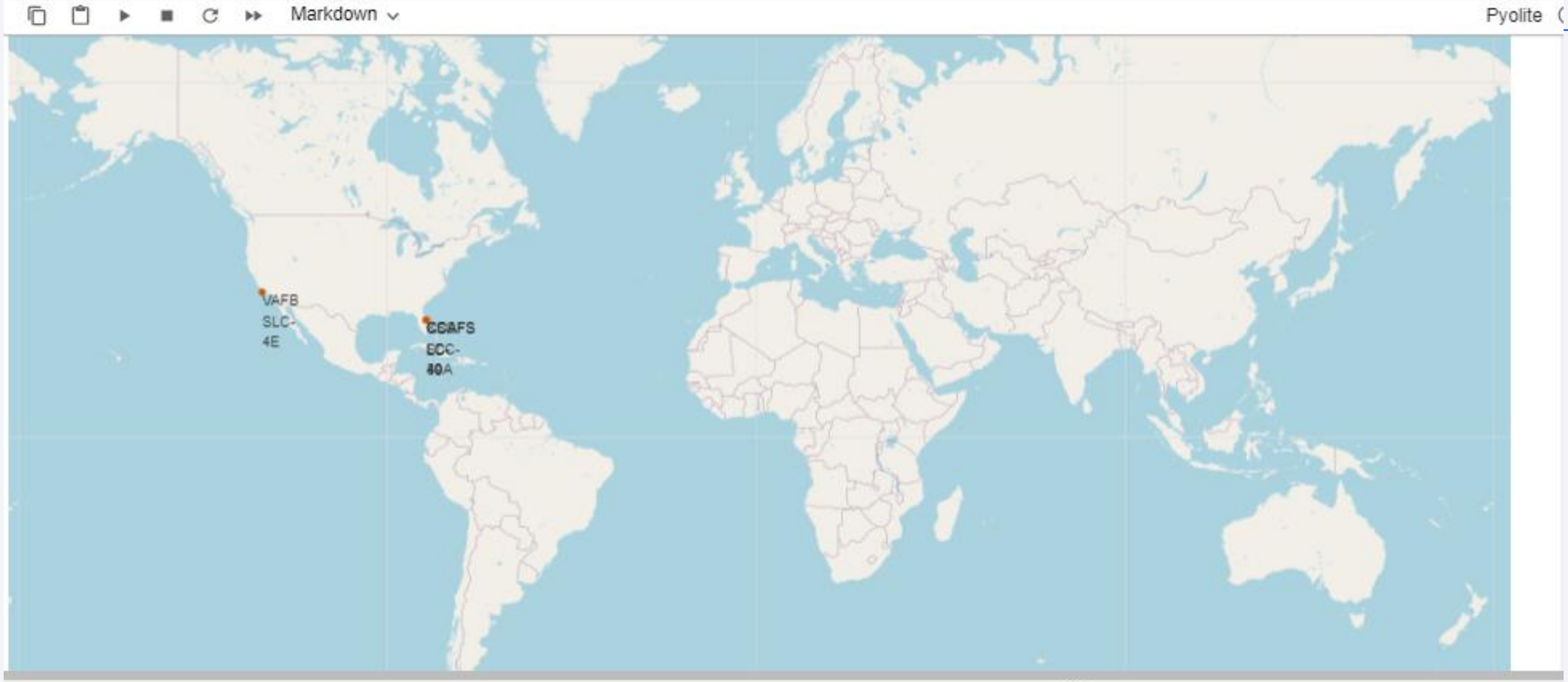
```
 * sqlite:///my_data1.db
Done.
```

| Date | Time (UTC) | Booster_Version | Launch_Site | Payload | PAYLOAD_MASS_KG_ | Orbit | Customer | Mission_Outcome | Landing _Outcome |
|---|---|---|---|---|---|---|---|---|---|
| 19-02-2017 | 14:39:00 | F9 FT B1031.1 | KSC LC-39A | SpaceX CRS-10 | 2490 | LEO (ISS) | NASA (CRS) | Success | Success (ground pad) |
| 18-10-2020 | 12:25:57 | F9 B5 B1051.6 | KSC LC-39A | Starlink 13 v1.0, Starlink 14 v1.0 | 15600 | LEO | SpaceX | Success | Success |
| 18-08-2020 | 14:31:00 | F9 B5 B1049.6 | CCAFS SLC-40 | Starlink 10 v1.0, SkySat-19, -20, -21, SAOCOM 1B | 15440 | LEO | SpaceX, Planet Labs, PlanetIQ | Success | Success |
| 18-07-2016 | 04:45:00 | F9 FT B1025.1 | CCAFS LC-40 | SpaceX CRS-9 | 2257 | LEO (ISS) | NASA (CRS) | Success | Success (ground pad) |
| 18-04-2018 | 22:51:00 | F9 B4 B1045.1 | CCAFS SLC-40 | Transiting Exoplanet Survey Satellite (TESS) | 362 | HEO | NASA (LSP) | Success | Success (drone ship) |

Section 3

# Launch Sites Proximities Analysis

# Markers of all launch sites on global map

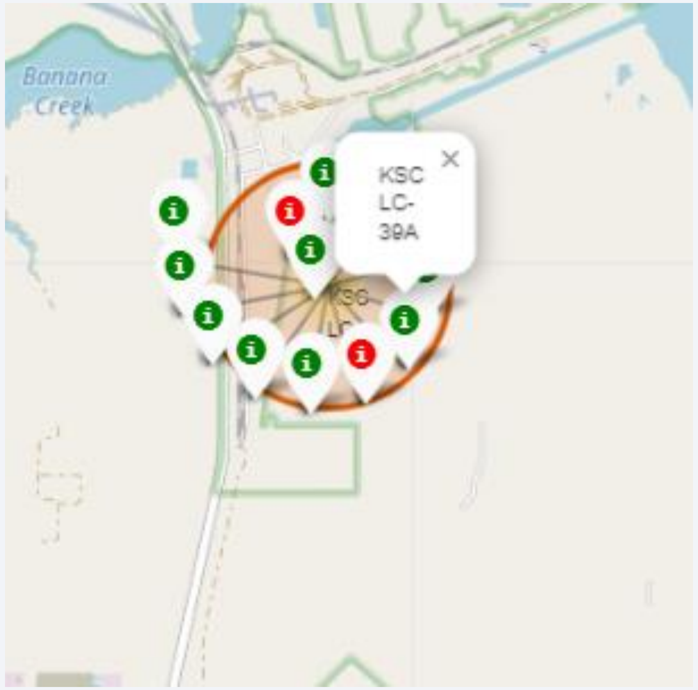



- All launch sites are in proximity to the Equator, (located southwards of the US map). Also all the laumch sites are in very close proximity to the coast.

# Launch outcomes for each site on the map With Color Markers

## Florida Sites

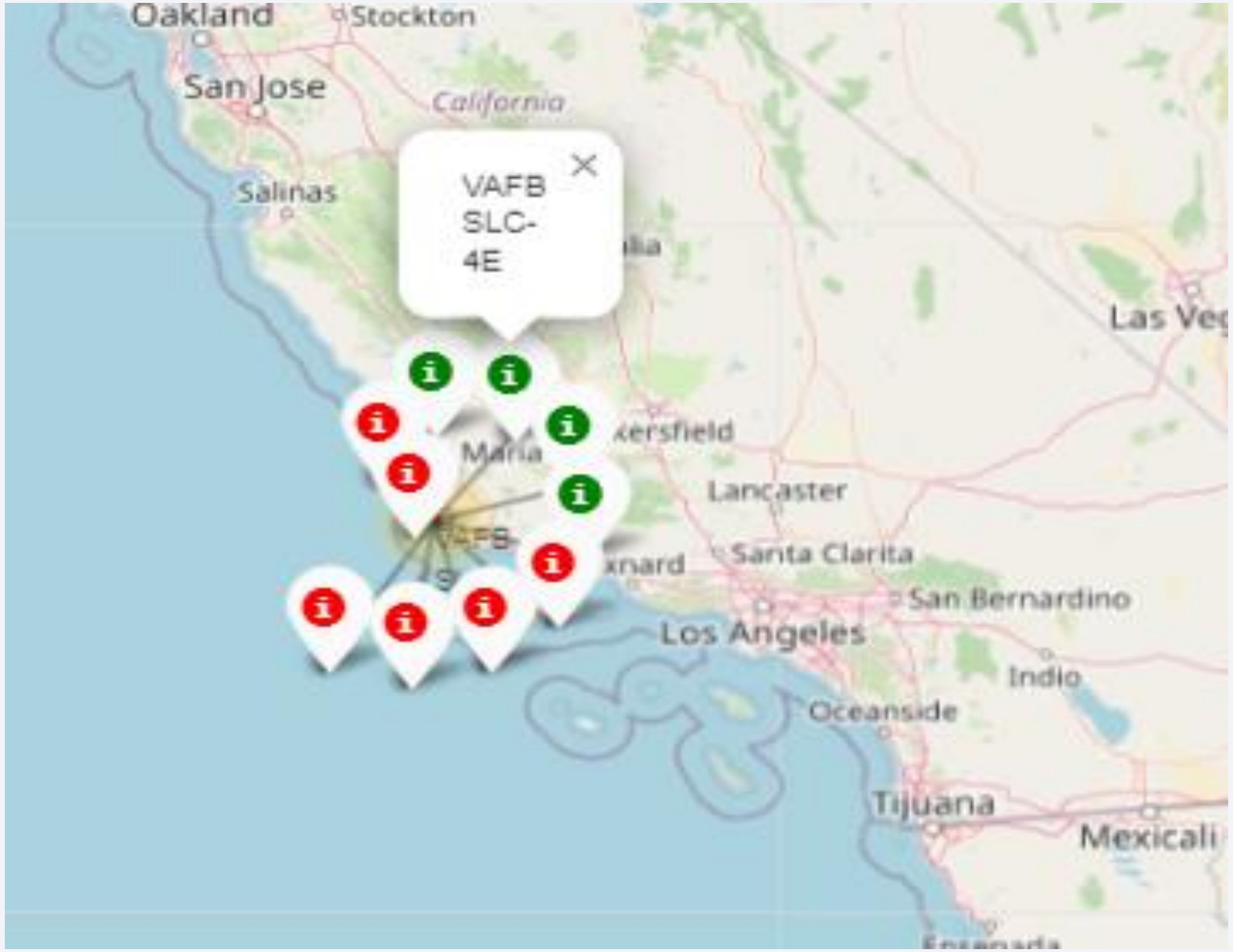





- In the Eastern coast (Florida) Launch site KSC LC-39A has relatively high success rates compared to CCAFS SLC-40 & CCAFS LC-40.

# Launch outcomes for each site on the map With Color Markers

## West Coast/ Carlifonia

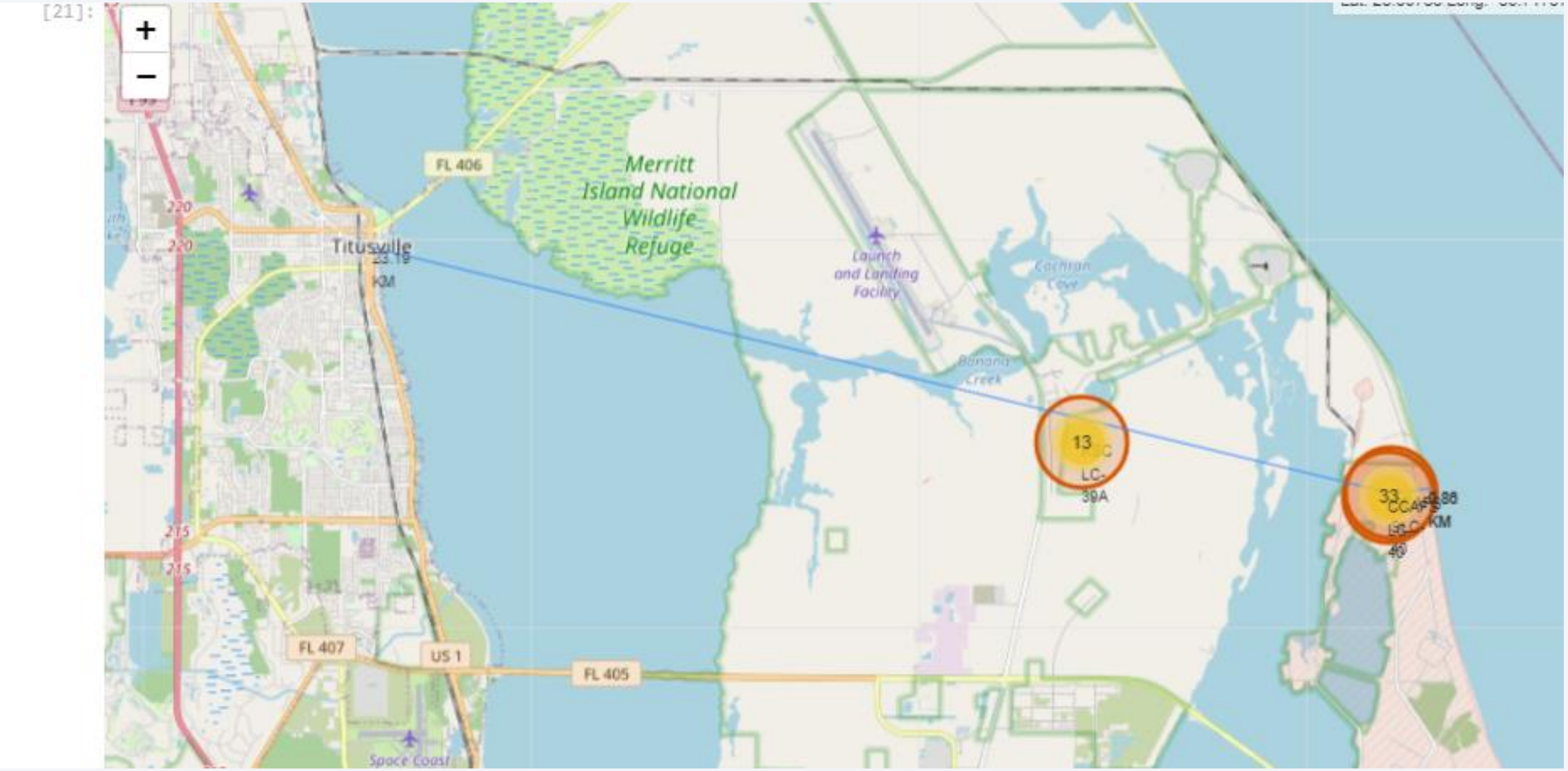



- In the West Coast (Californai) Launch site VAFB SLC-4E has relatively lower success rates 4/10 compared to KSC LC-39A launch site in the Eastern Coast of Florida.

# Distances between a launch site to its proximities


- Launch site CCAFS SLC-40 proximity to coastline is 0.86km

# Distances between a launch site to its proximities

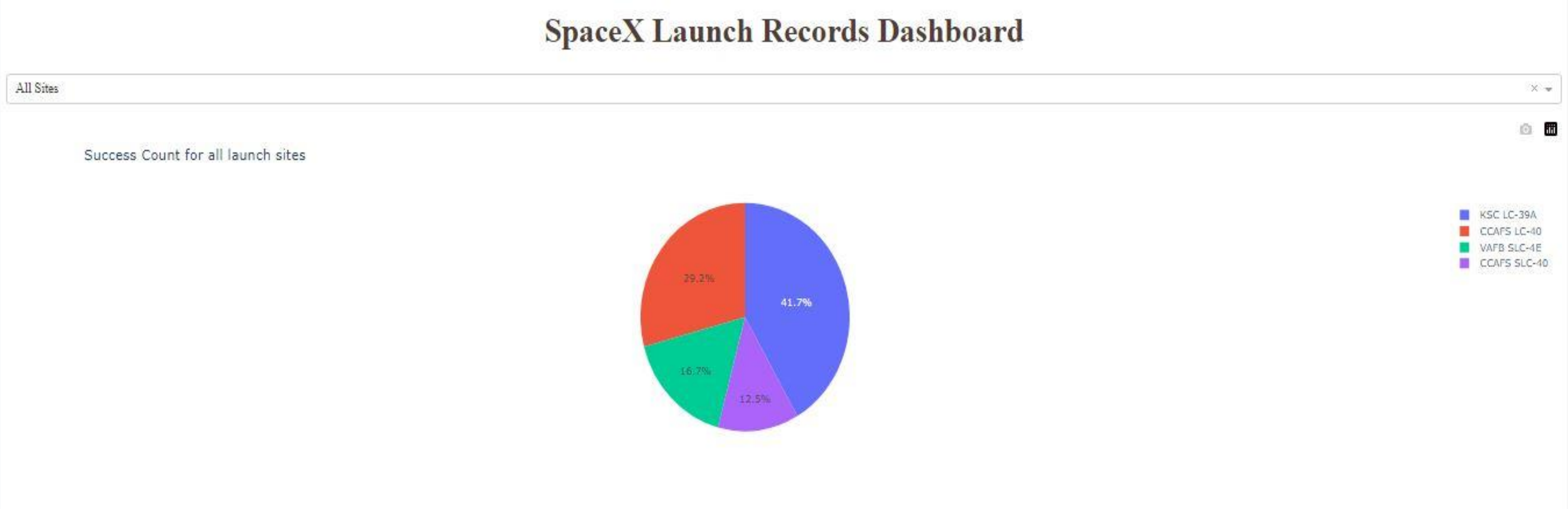



- Launch site CCAFS SLC-40 closest to highway (Washington Avenue) is 23.19km

Section 4

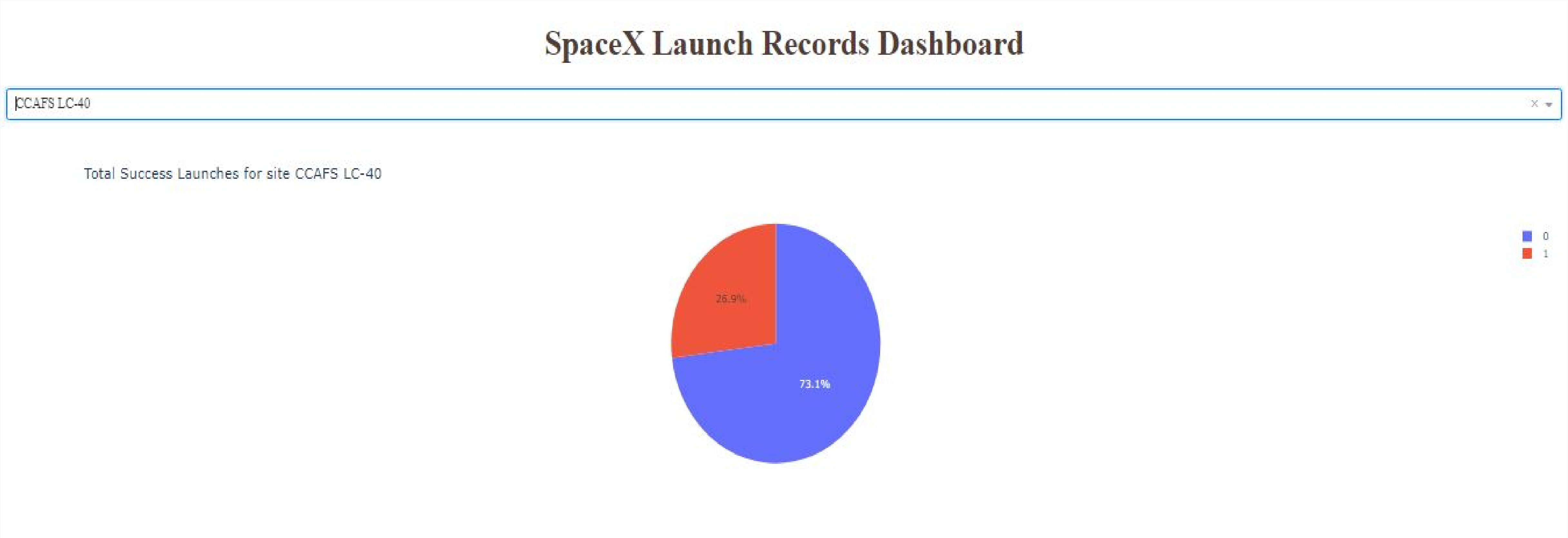
# Build a Dashboard with Plotly Dash

# Pie-Chart for launch success count for all sites



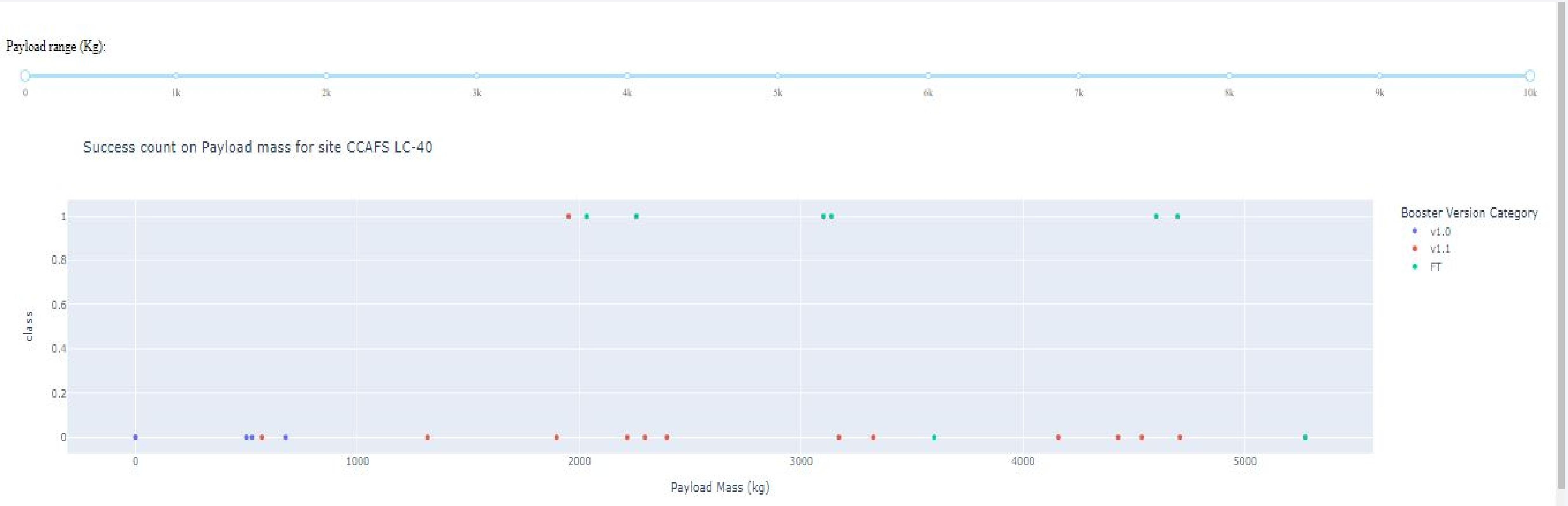

- Launch site KSC LC-39A has the highest launch success rate at 42% followed by CCAFS LC-40 at 29%, VAFB SLC-4E at 17% and lastly launch site CCAFS SLC-40 with a success rate of 13%

# Pie chart for the launch site with 2nd highest launch success ratio




- Launch site CCAFS LC-40 had the 2nd highest success ratio of 73% success against 27% failed launches

# Payload vs. Launch Outcome scatter plot for all sites




- For Launch site CCAFS LC-40 the booster version FT has the largest success rate from a payload mass of >2000kg

Section 5

# Predictive Analysis (Classification)

# Classification Models Accuracy

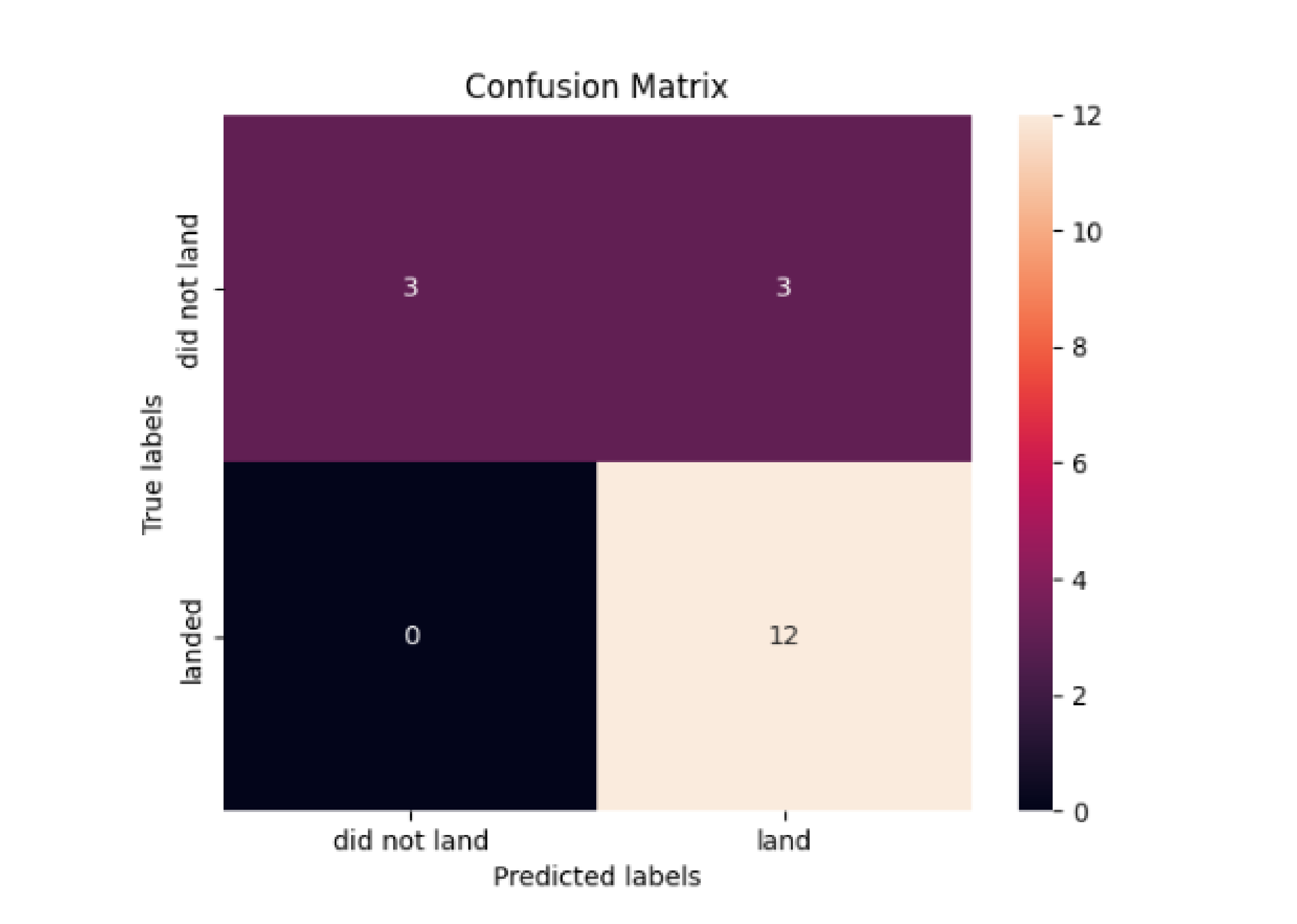
Out[68]:

| | 0 |
|---|---|
| Method | Test Data Accuracy |
| Logistic_Reg | 0.833333 |
| SVM | 0.833333 |
| Decision Tree | 0.833333 |
| KNN | 0.833333 |

*All the methods perform equally on the test data: i.e. They all have the same accuracy of 0.833333 on the test Data*

# Confusion Matrix

- All the 4 classification model had the same confusion matrixes and were able equally distinguish between the different classes. The major problem is false positives for all the models.



# Conclusions

- Different launch sites have different success rates. CCAFS LC-40, has a success rate of 60 %, while KSC LC-39A and VAFB SLC 4E has a success rate of 77%.
- We can deduce that, as the flight number increases in each of the 3 launcg sites, so does the success rate. For instance, the success rate for the VAFB SLC 4E launch site is 100% after the Flight number 50. Both KSC LC 39A and CCAFS SLC 40 have a 100% success rates after 80th flight
- 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).
- Orbits ES-L1, GEO, HEO & SSO have the highest success rates at 100%, with SO orbit having the lowest success rate at ~50%. Orbit SO has 0% success rate.
- 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

# Conclusions Cont….

- 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(unsuccessful mission) are both there here
- Anf finally the sucess rate since 2013 kept increasing till 2020.

# Thank you!