IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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20 April 2023

Outline

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

Executive Summary

- Summary of methodologies
  - Data collection
  - Data wrangling
  - Exploratory Data Analysis with Data Visualization
  - Exploratory Data Analysis with SQL
  - Building an interactive map with Folium
  - Building a Dashboard with Plotly Dash
  - Predictive analysis (Classification)
- Summary of all results
  - Exploratory Data Analysis results
  - Interactive analytics demo in screenshots
  - Predictive analysis results

Introduction

- Project background and context

  SpaceX is the most successful company of the commercial space age, making space travel affordable. The company 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 we can determine if the first stage will land, we can determine the cost of a launch. Based on public information and machine learning models, we are going to predict if SpaceX will reuse the first stage

- Problems you want to find answers
  - How do variables such as payload mass, launch site, number of flights, and orbits affect the success of the first stage landing?
  - Does the rate of successful landings increase over the years?
  - What is the best algorithm that can be used for binary classification in this case?

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - Using SpaceX Rest API
  - Using Web Scrapping from Wikipedia
- Perform data wrangling
  - Filtering the data
  - Dealing with missing values
  - Using One Hot Encoding to prepare the data to a binary classification
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - Building, tuning and evaluation of classification models to ensure the best results

Data Collection

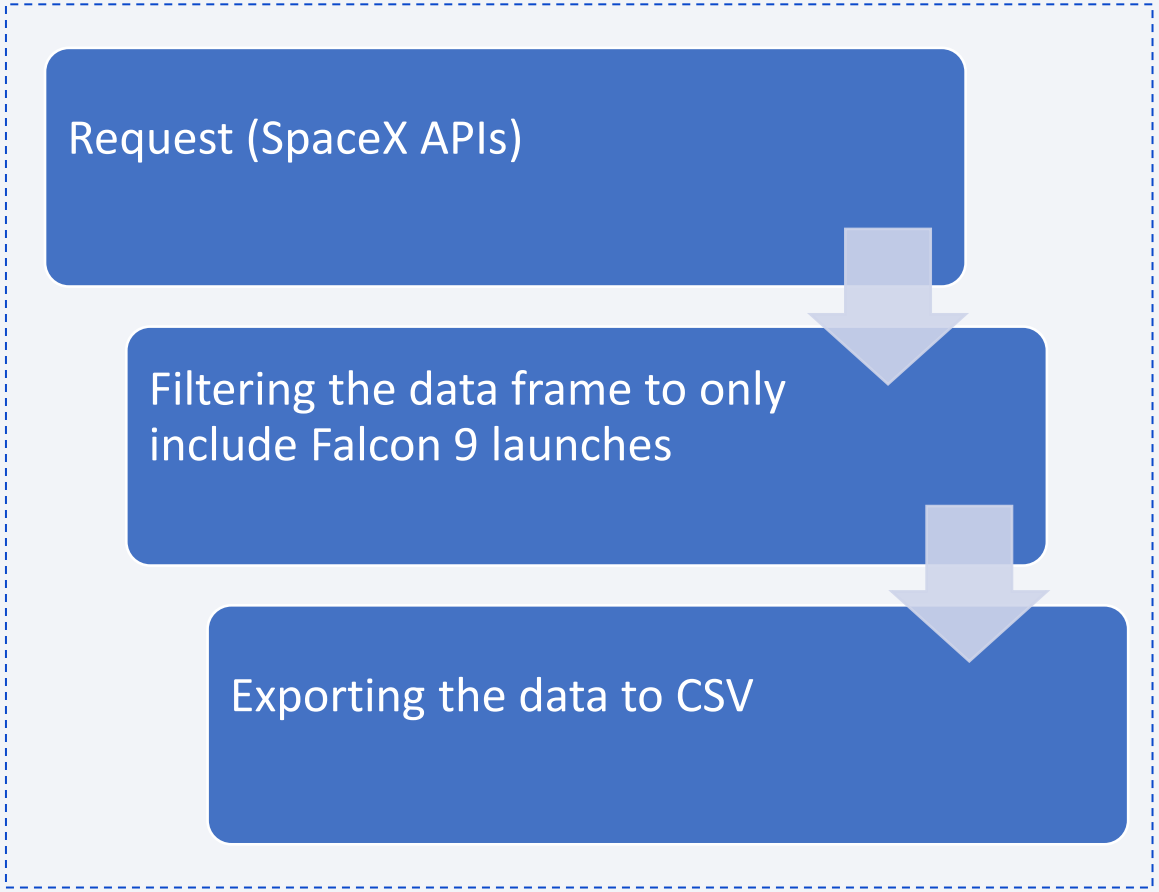
Data collection process involved a combination of API requests from SpaceX REST API and Web Scraping data from a table in SpaceX's Wikipedia entry.

We had to use both of these data collection methods in order to get complete information about the launches for a more detailed analysis.

- Data Columns are obtained by using SpaceX REST API:
  - FlightNumber, Date, BoosterVersion, PayloadMass, Orbit, LaunchSite, Outcome, Flights, GridFins, Reused, Legs, LandingPad, Block, ReusedCount, Serial, Longitude, Latitude
- Data Columns are obtained by using Wikipedia Web Scraping:
  - Flight No., Launch site, Payload, PayloadMass, Orbit, Customer, Launch outcome, Version Booster, Booster landing, Date, Time

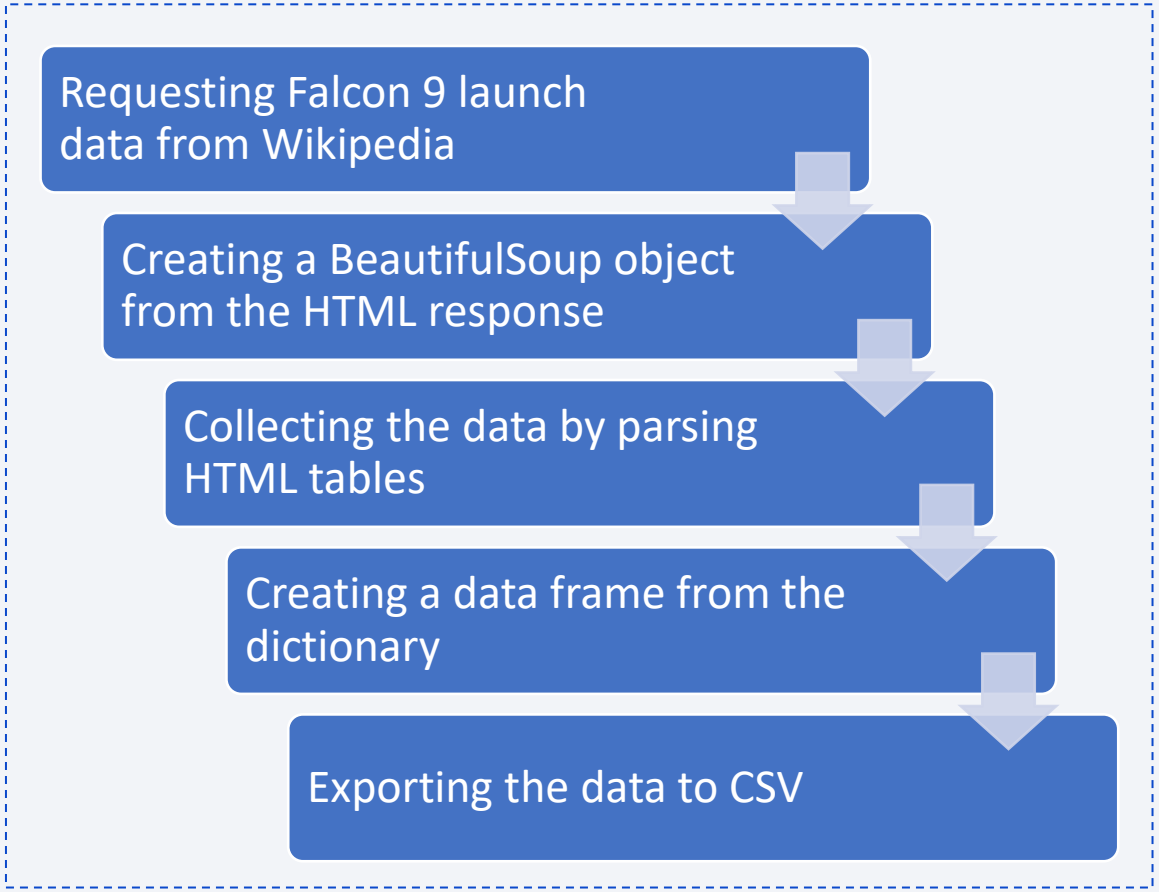
Data Collection – SpaceX API

- The GitHub URL of the completed SpaceX API calls notebook (https://github.com/Abdallah-Kareem/Applied_Data_Science_Capstone/blob/59424a250188a57feb3ad734e46d7b9f746198dc/Data%20Collection%20API%20Lab.ipynb)



Data Collection - Scraping

- The GitHub URL of the completed web scraping notebook(https://github.com/Abdallah-Kareem/Applied_Data_Science_Capstone/blob/59424a250188a57feb3ad734e46d7b9f746198dc/Data%20Collection%20with%20Web%20Scraping.ipynb)

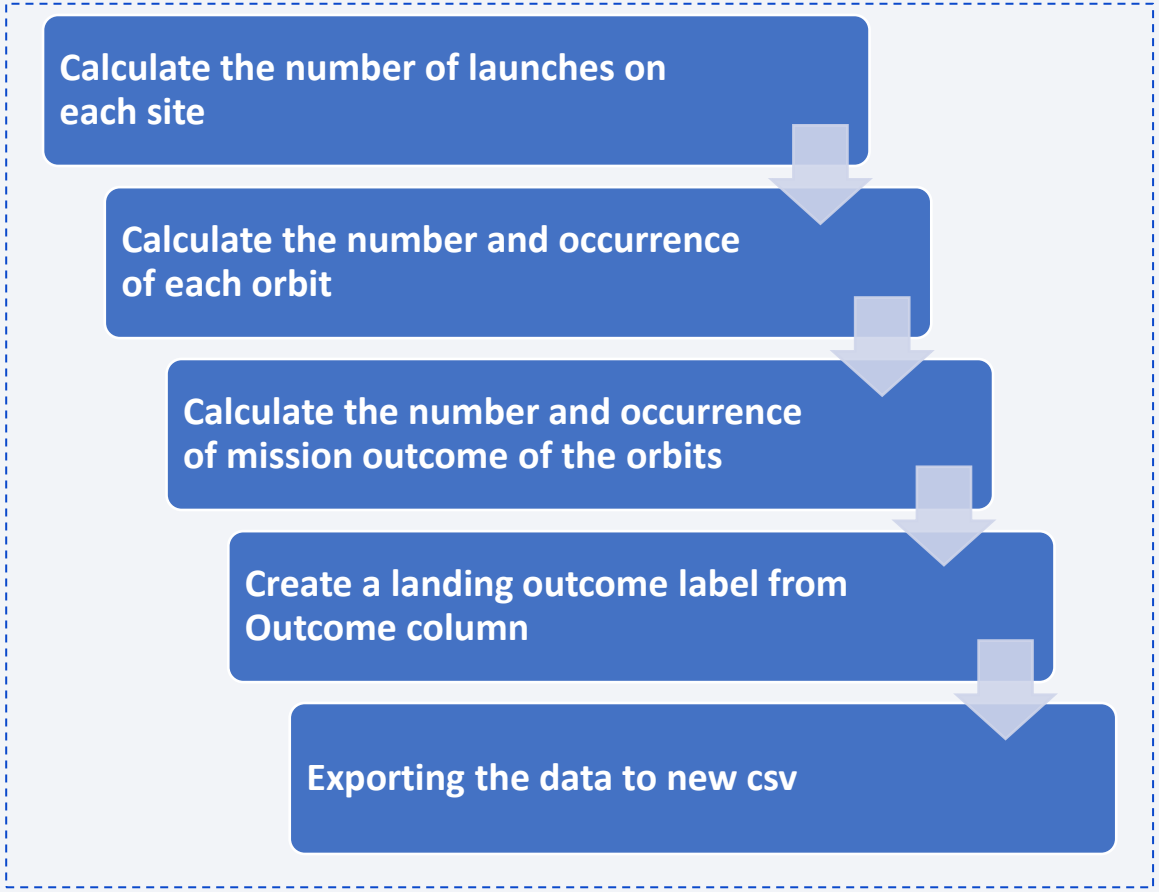


Data Wrangling

Create a training label with landing outcomes where successful = 1 and failure = 0.

Outcome column has two components: ‘Mission Outcome’ ‘Landing Location’
New training label column ‘class’ with a value of 1 if ‘Mission Outcome’ is True and
0 otherwise

GitHub URL (https://github.com/Abdallah-Kareem/Applied_Data_Science_Capstone/blob/59424a250188a57feb3ad734e46d7b9f746198dc/Data%20Wrangling.ipynb)



EDA with Data Visualization

Charts were plotted:

- Flight Number vs. Payload Mass, Flight Number vs. Launch Site, Payload Mass vs. Launch Site, Orbit Type vs. Success Rate, Flight Number vs. Orbit Type, Payload Mass vs Orbit Type and Success Rate Yearly Trend
  - Scatter plots show the relationship between variables. If a relationship exists, they could be used in machine learning model.
  - Bar charts show comparisons among discrete categories. The goal is to show the relationship between the specific categories being compared and a measured value.
  - Line charts show trends in data over time (time series).

GitHub URL: (https://github.com/Abdallah-Kareem/Applied_Data_Science_Capstone/blob/59424a250188a57feb3ad734e46d7b9f746198dc/Complete%20the%20EDA%20with%20Visualization.ipynb)

EDA with SQL

Performed SQL queries:

- Displaying the names of the unique launch sites in the space mission
- Displaying 5 records where launch sites begin with the string ‘CCA'
- Displaying the total payload mass carried by boosters launched by NASA (CRS)
- Displaying average payload mass carried by booster version F9 v1.1
- Listing the date when the first successful landing outcome in ground pad was achieved
- Listing the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 6000
- Listing the total number of successful and failure mission outcomes
- Listing the names of the booster versions which have carried the maximum payload mass
- Listing the failed landing outcomes in drone ship, their booster versions and launch site names for the months in year 2015
- Ranking 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

GitHub URL: (https://github.com/Abdallah-Kareem/Applied_Data_Science_Capstone/blob/59424a250188a57feb3ad734e46d7b9f746198dc/Exploratory%20Analysis%20Using%20SQL.ipynb)

Build an Interactive Map with Folium

Markers of all Launch Sites:

- Added Marker with Circle, Popup Label and Text Label of NASA Johnson Space Center using its latitude and longitude coordinates as a start location.
- Added Markers with Circle, Popup Label and Text Label of all Launch Sites using their latitude and longitude coordinates to show their geographical locations and proximity to Equator and coasts.

Colored Markers of the launch outcomes for each Launch Site:

- Added colored Markers of success (Green) and failed (Red) launches using Marker Cluster to identify which launch sites have relatively high success rates.

Distances between a Launch Site to its proximities:

- Added colored Lines to show distances between the Launch Sites and its proximities like Railway, Highway, Coastline and Closest City

GitHub URL: (https://github.com/Abdallah-Kareem/Applied_Data_Science_Capstone/blob/59424a250188a57feb3ad734e46d7b9f746198dc/Data%20Visualization%20with%20Folium.ipynb)

Build a Dashboard with Plotly Dash

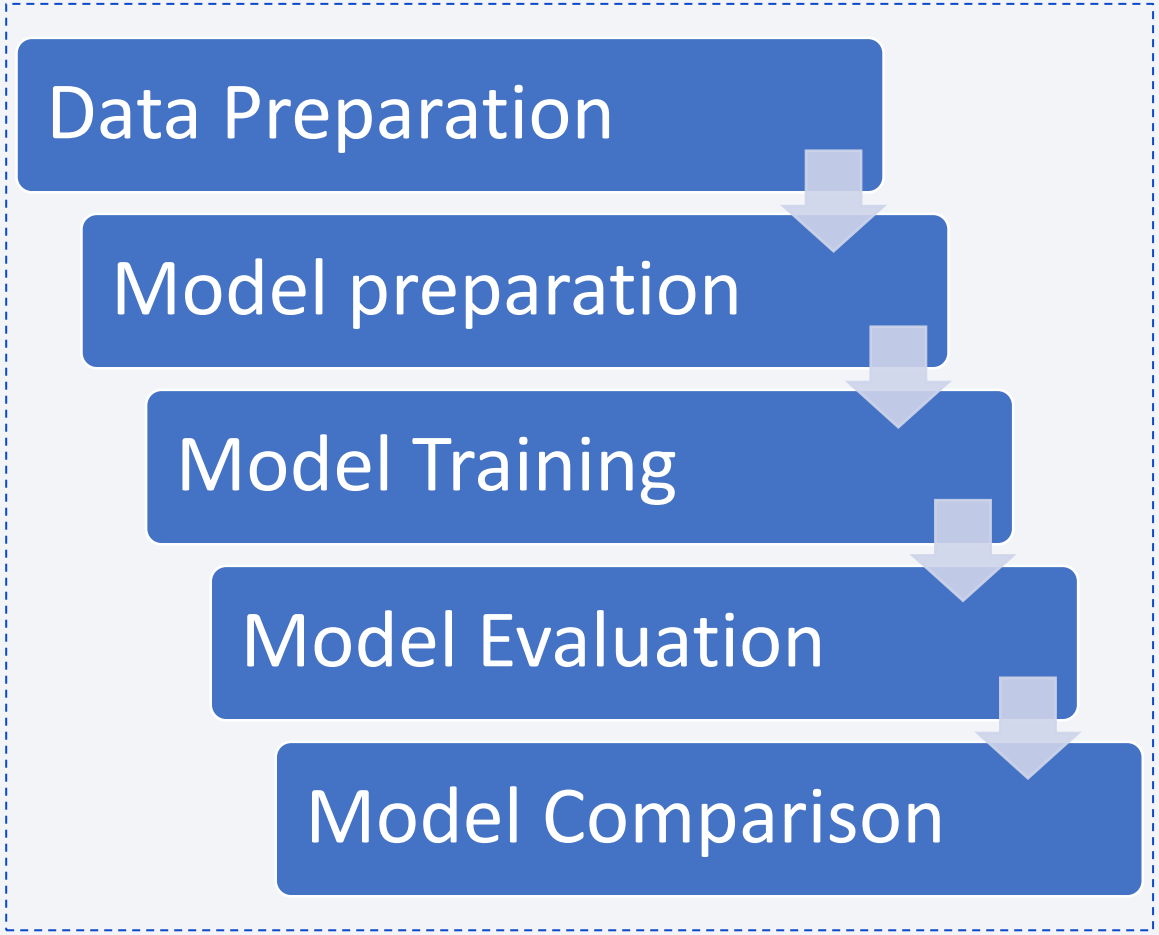
- Launch Sites Dropdown List:
  - Added a dropdown list to enable Launch Site selection.
- Pie Chart showing Success Launches (All Sites/Certain Site):
  - Added a pie chart to show the total successful launches count for all sites and the Success vs. Failed counts for the site, if a specific Launch Site was selected.
- Slider of Payload Mass Range:
  - Added a slider to select Payload range.
- Scatter Chart of Payload Mass vs. Success Rate for the different Booster Versions:
  - Added a scatter chart to show the correlation between Payload and Launch Success.

GitHub URL: (https://github.com/Abdallah-Kareem/Applied_Data_Science_Capstone/blob/59424a250188a57feb3ad734e46d7b9f746198dc/Interactive%20Dashboard%20with%20Ploty%20Dash.py)

Predictive Analysis (Classification)

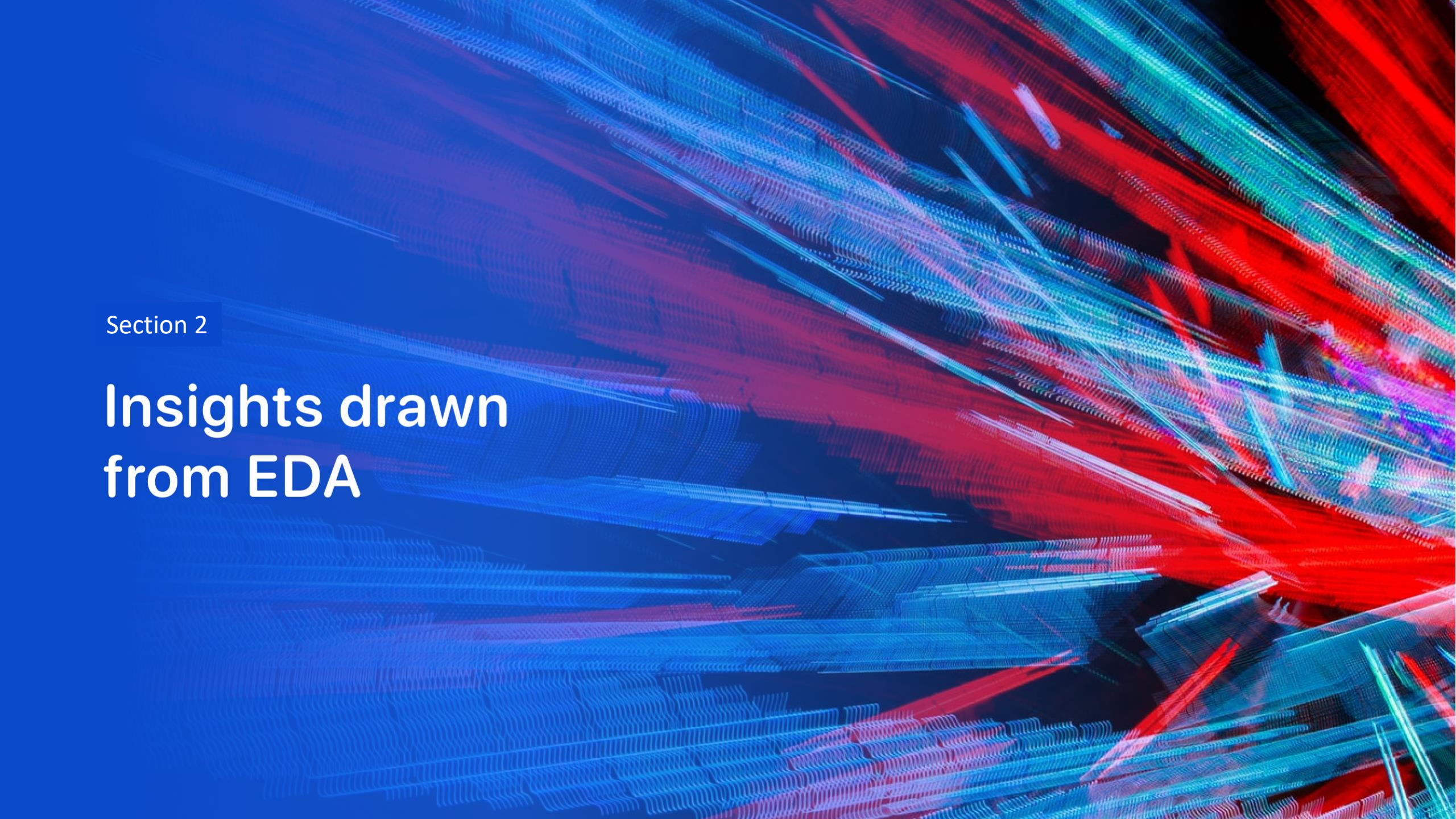
Using Four Classification models to determine which works better with the data using set of hyperparameters

GitHub URL (https://github.com/Abdallah-Kareem/Applied_Data_Science_Capstone/blob/59424a250188a57feb3ad734e46d7b9f746198dc/Predictive%20Analysis%20Machine%20Learning%20Prediction.ipynb)

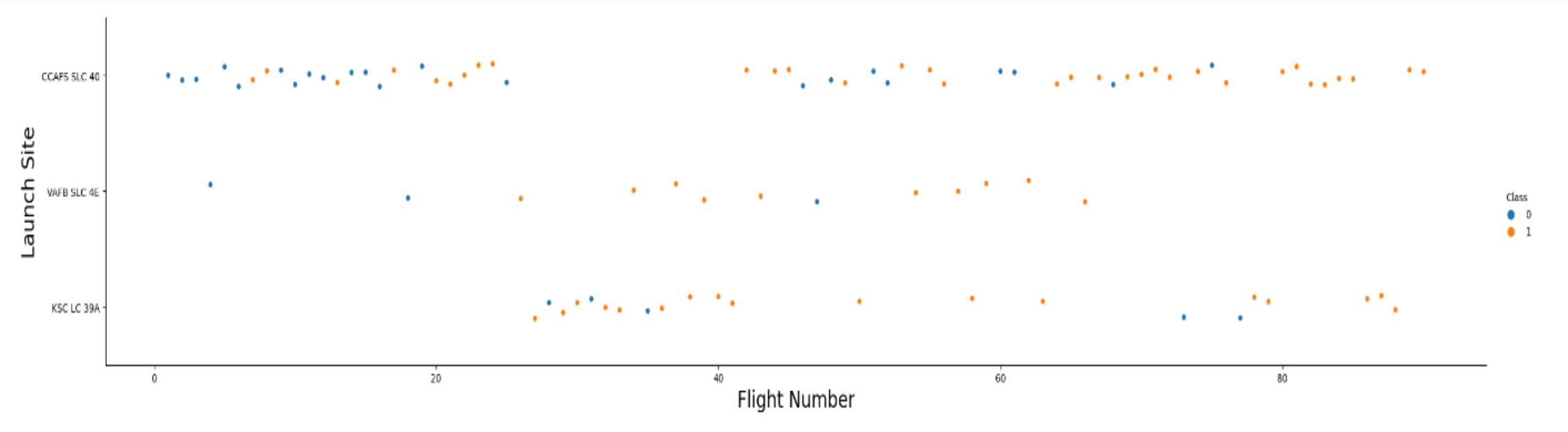


Results

- Exploratory data analysis results
- Interactive analytics demo in screenshots
- Predictive analysis results


Section 2
Insights drawn from EDA

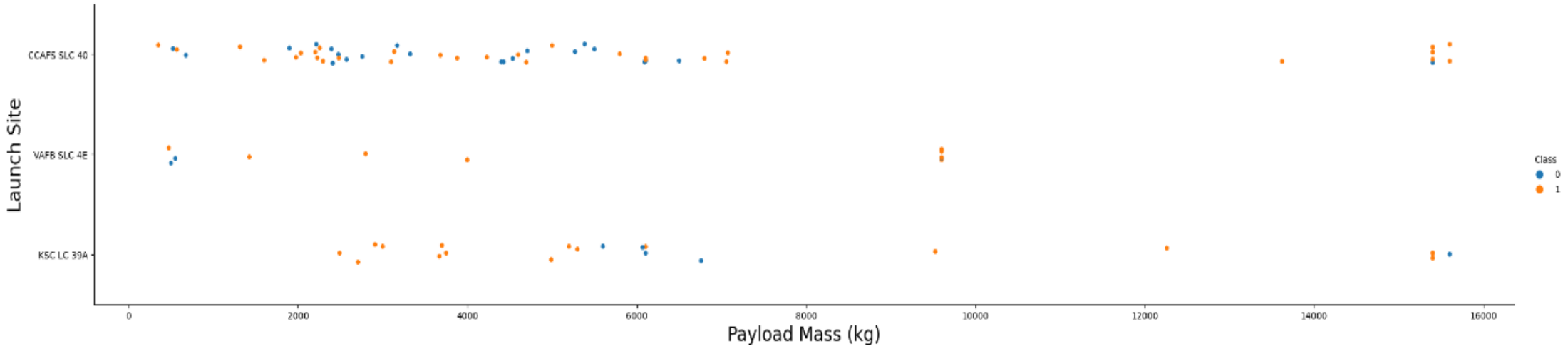
Flight Number vs. Launch Site



Explanation:

- The earliest flights all failed while the latest flights all succeeded.
- The CCAFS SLC 40 launch site has about a half of all launches.

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).

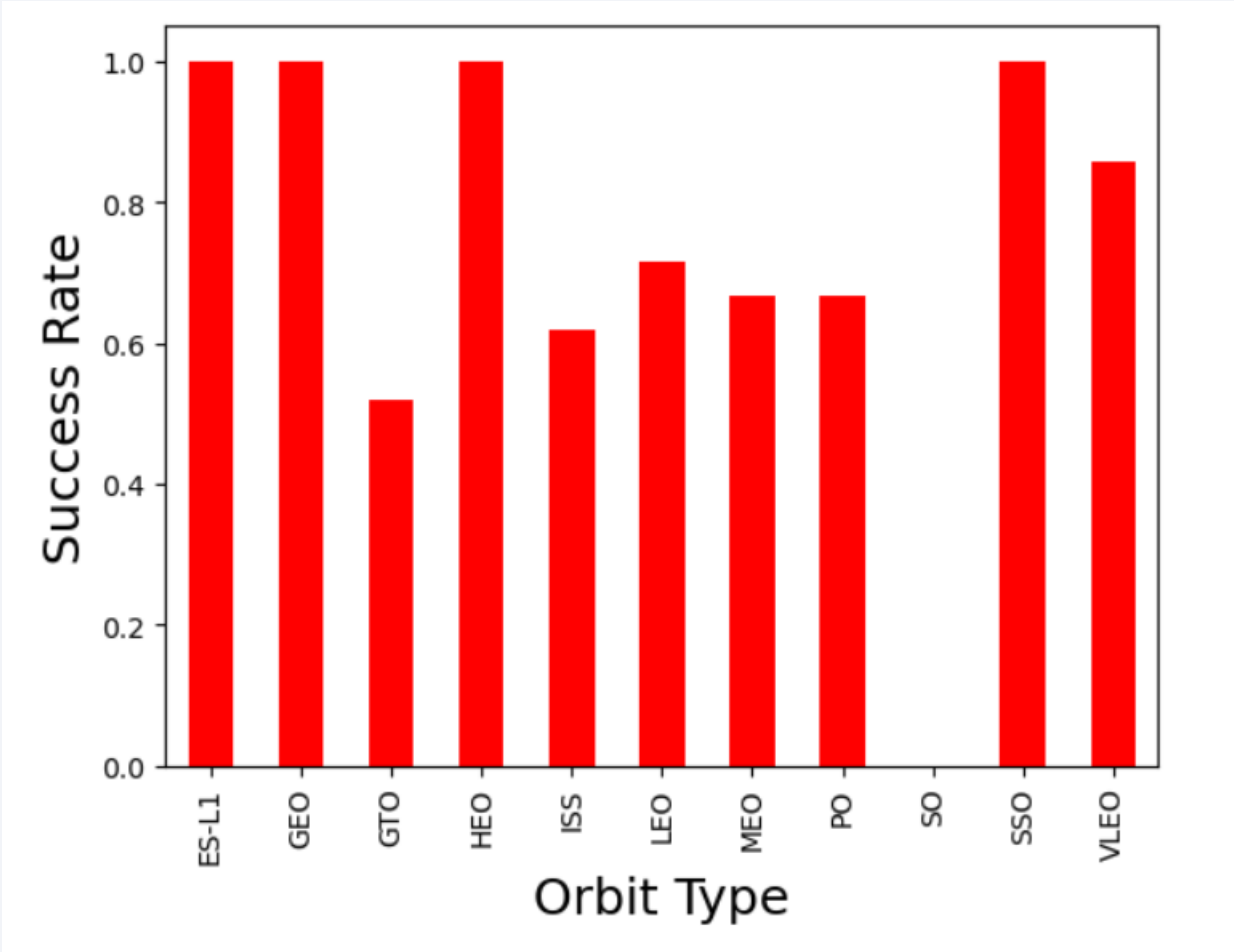
Explanation:

- KSC LC 39A has a 100% success rate for payload mass under 5500 kg too.

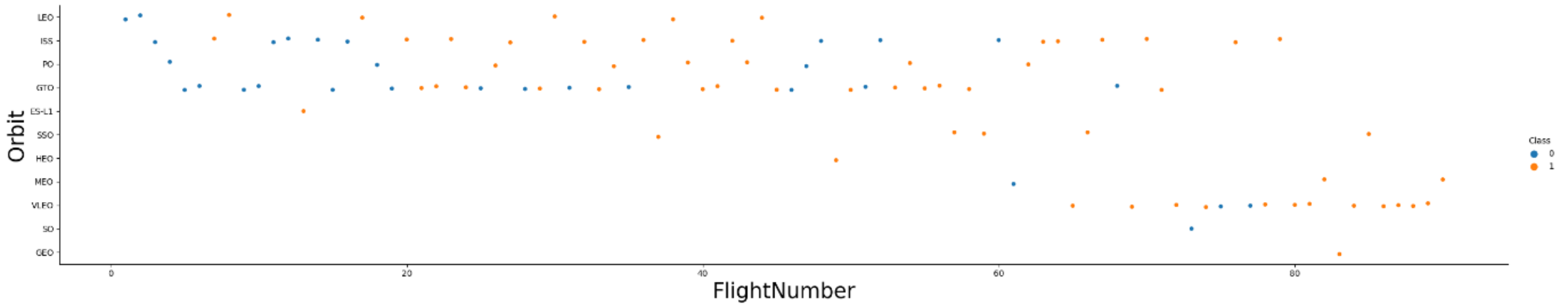
Success Rate vs. Orbit Type

Explanation:

- Orbits ES-L1, GEO, HEO, SSO have the highest success rate
- Orbit SO have no Success rate



Flight Number vs. Orbit Type

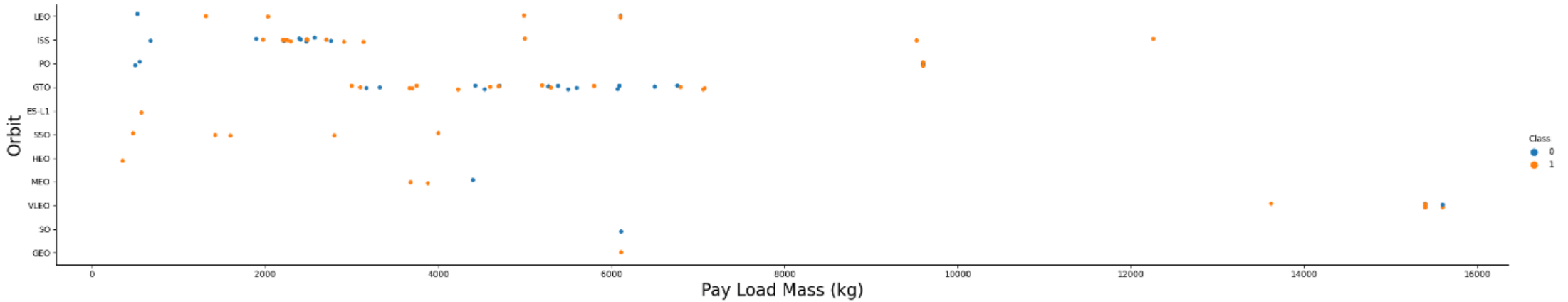


You should see that in the LEO orbit the Success appears related to the number of flights; on the other hand, there seems to be no relationship between flight number when in GTO orbit.

Explanation

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

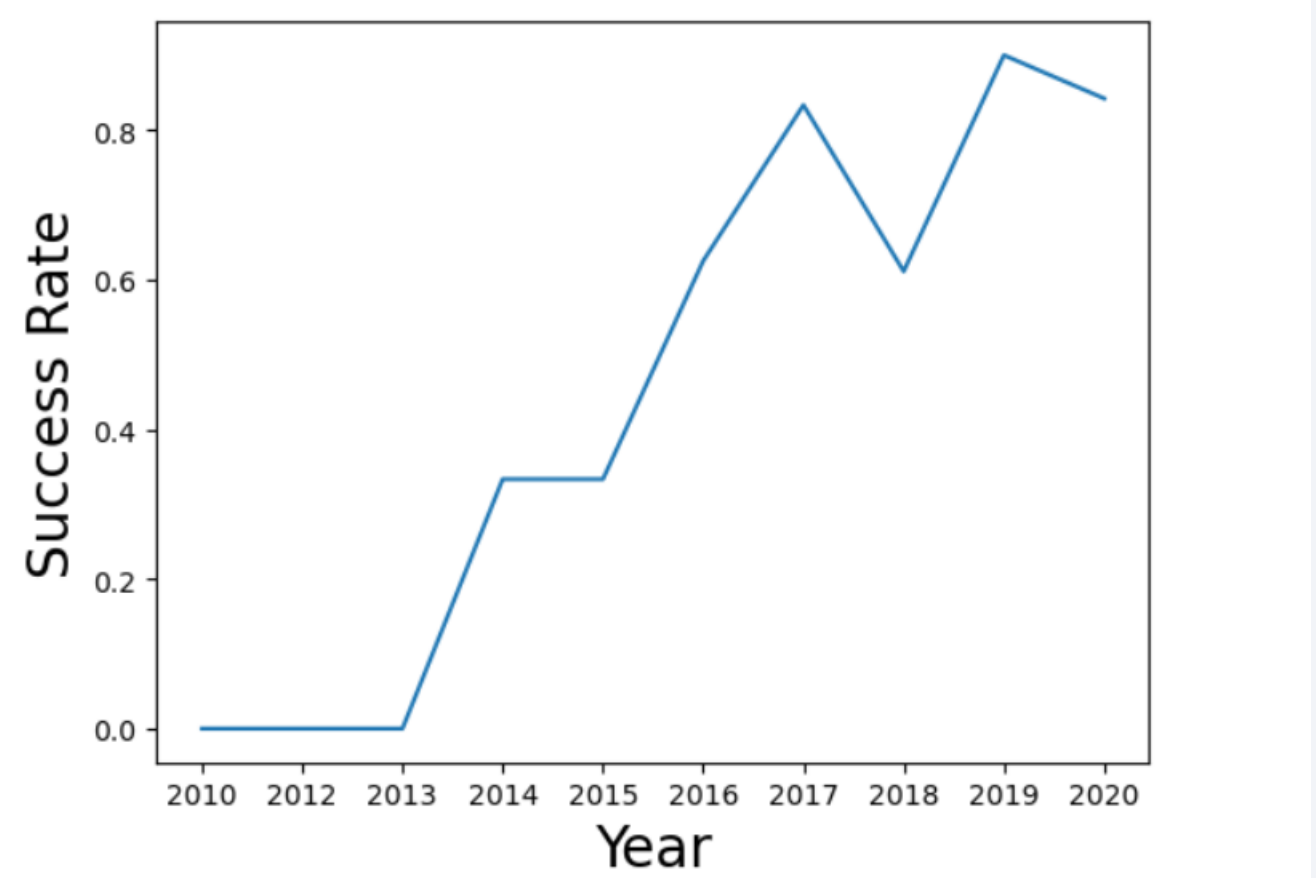
Payload vs. Orbit Type



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) are both there here.

Launch Success Yearly Trend



you can observe that the sucess rate since 2013 kept increasing till 2020

All Launch Site Names

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

```
%sql SELECT DISTINCT LAUNCH_SITE FROM SPACEX;
```

```
 * ibm_db_sa://vbf73082:***@2d46b6b4-cbf6-40eb-bbce-6251e6ba0300.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32328/bludb
Done.
```

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

Launch Site Names Begin with 'CCA'

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

```
%%sql
SELECT *
FROM SPACEX
WHERE LAUNCH_SITE LIKE 'CCA%'
LIMIT 5;
```

```
* ibm_db_sa://vbf73082:***@2d46b6b4-cbf6-40eb-bbce-6251e6ba0300.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32328/bludb
Done.
```

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	7:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)	Success	No attempt
2012-10-08	0:35:00	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

Total Payload Mass

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

```
%%sql
SELECT SUM(PAYLOAD_MASS_KG_)
FROM SPACEX
WHERE Customer = 'NASA (CRS)'
```

```
 * ibm_db_sa://vbf73082:***@2d46b6b4-cbf6-40eb-bbce-6251e6ba0300.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32328/bludb
Done.
```

1
45596

Average Payload Mass by F9 v1.1

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

```
%%sql
SELECT AVG(PAYLOAD_MASS_KG_)
FROM SPACEX
WHERE BOOSTER_VERSION LIKE 'F9 v1.0%';
```

```
 * ibm_db_sa://vbf73082:***@2d46b6b4-cbf6-40eb-bbce-6251e6ba0300.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32328/bludb
Done.
```

1
340

First Successful Ground Landing Date

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

Hint:Use min function

```
%%sql
SELECT MIN(Date)
FROM SPACEX
WHERE Landing_Outcome = 'Success (ground pad)';
```

```
 * ibm_db_sa://vbf73082:***@2d46b6b4-cbf6-40eb-bbce-6251e6ba0300.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32328/bludb
Done.
```

1
2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

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 BOOSTER_VERSION
FROM SPACEX
WHERE LANDING_OUTCOME = 'Success (drone ship)'
    AND 4000 < PAYLOAD_MASS_KG_ < 6000;
```

```
 * ibm_db_sa://vbf73082:***@2d46b6b4-cbf6-40eb-bbce-6251e6ba0300.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32328/bludb
Done.
```

booster_version
F9 FT B1021.1
F9 FT B1023.1
F9 FT B1029.2
F9 FT B1038.1
F9 B4 B1042.1
F9 B4 B1045.1
F9 B5 B1046.1

Total Number of Successful and Failure Mission Outcomes

```
%%sql
SELECT MISSION_OUTCOME, COUNT(MISSION_OUTCOME) AS TOTAL_NUMBER
FROM SPACEX
GROUP BY MISSION_OUTCOME;
```

```
 * ibm_db_sa://vbf73082:***@2d46b6b4-cbf6-40eb-bbce-6251e6ba0300.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32328/bludb
Done.
```

mission_outcome	total_number
Failure (in flight)	1
Success	99
Success (payload status unclear)	1

Boosters Carried Maximum Payload

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

```
%%sql
SELECT DISTINCT BOOSTER_VERSION
FROM SPACEX
WHERE PAYLOAD_MASS_KG_ = (
    SELECT MAX(PAYLOAD_MASS_KG_)
    FROM SPACEX);
```

```
 * ibm_db_sa://vbf73082:***@2d46b6b4-cbf6-40eb-bbce-6251e6ba0300.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32328/bludb
Done.
```

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

2015 Launch Records

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

```
%%sql
SELECT LANDING_OUTCOME, BOOSTER_VERSION, LAUNCH_SITE
FROM SPACEX
WHERE Landing_Outcome = 'Failure (drone ship)'
    AND YEAR(DATE) = 2015;
```

```
* ibm_db_sa://vbf73082:***@2d46b6b4-cbf6-40eb-bbce-6251e6ba0300.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32328/bludb
Done.
```

landing_outcome	booster_version	launch_site
Failure (drone ship)	F9 v1.1 B1012	CCAFS LC-40
Failure (drone ship)	F9 v1.1 B1015	CCAFS LC-40

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

```
%%sql
SELECT landing_outcome ,COUNT(LANDING_OUTCOME) as "count"
FROM SPACEX
WHERE Date > '2010-06-04' AND Date < '2017-03-20'
GROUP BY landing_outcome
ORDER BY COUNT(landing_outcome) DESC;
```

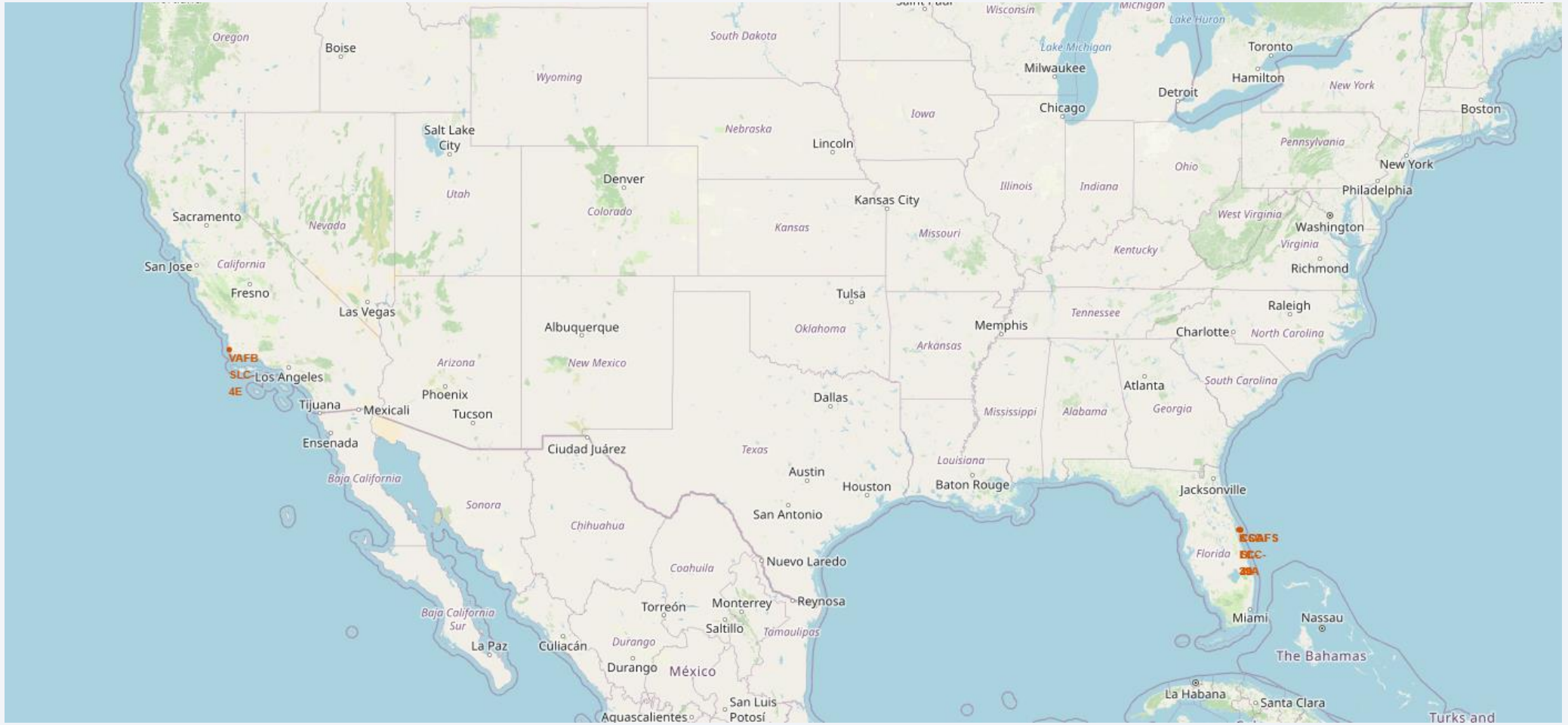
```
 * ibm_db_sa://vbf73082:***@2d46b6b4-cbf6-40eb-bbce-6251e6ba0300.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32328/bludb
Done.
```

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

Section 3

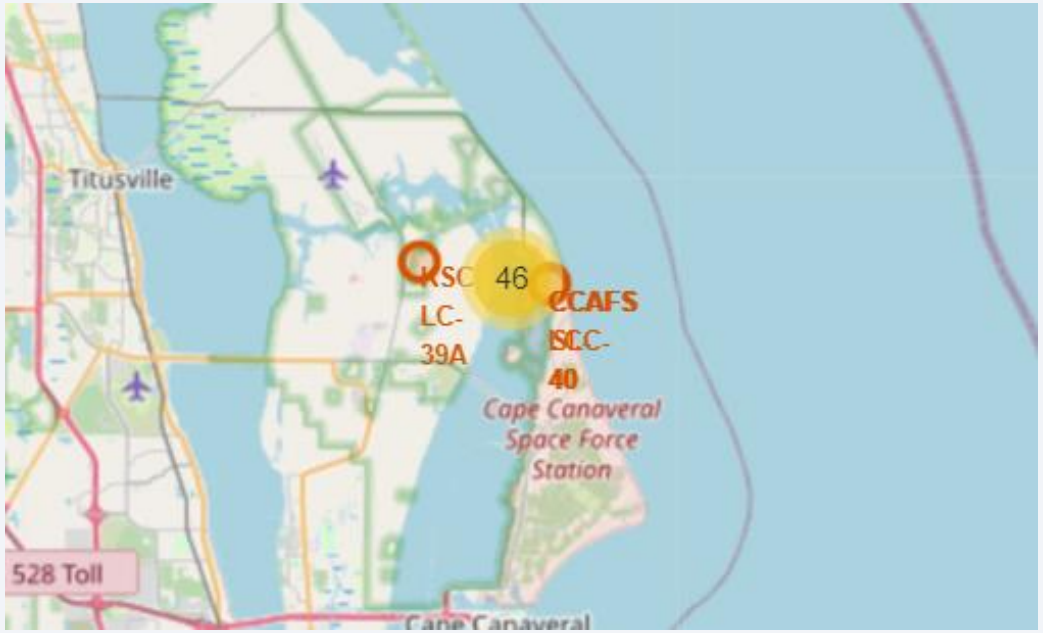
Launch Sites Proximities Analysis

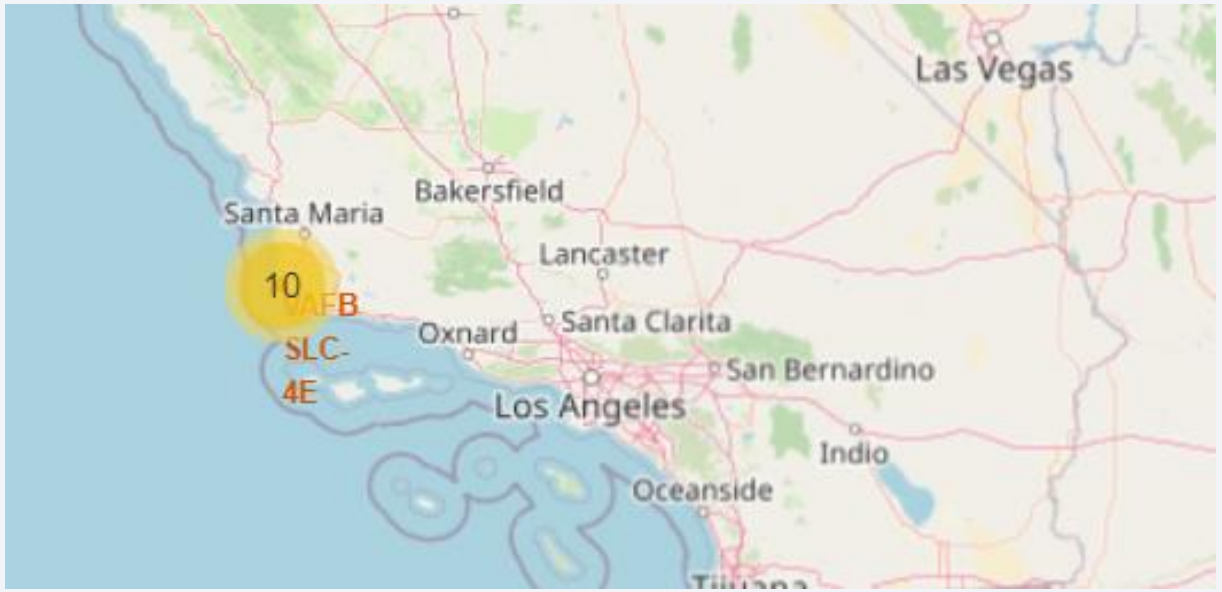
Launch Sites



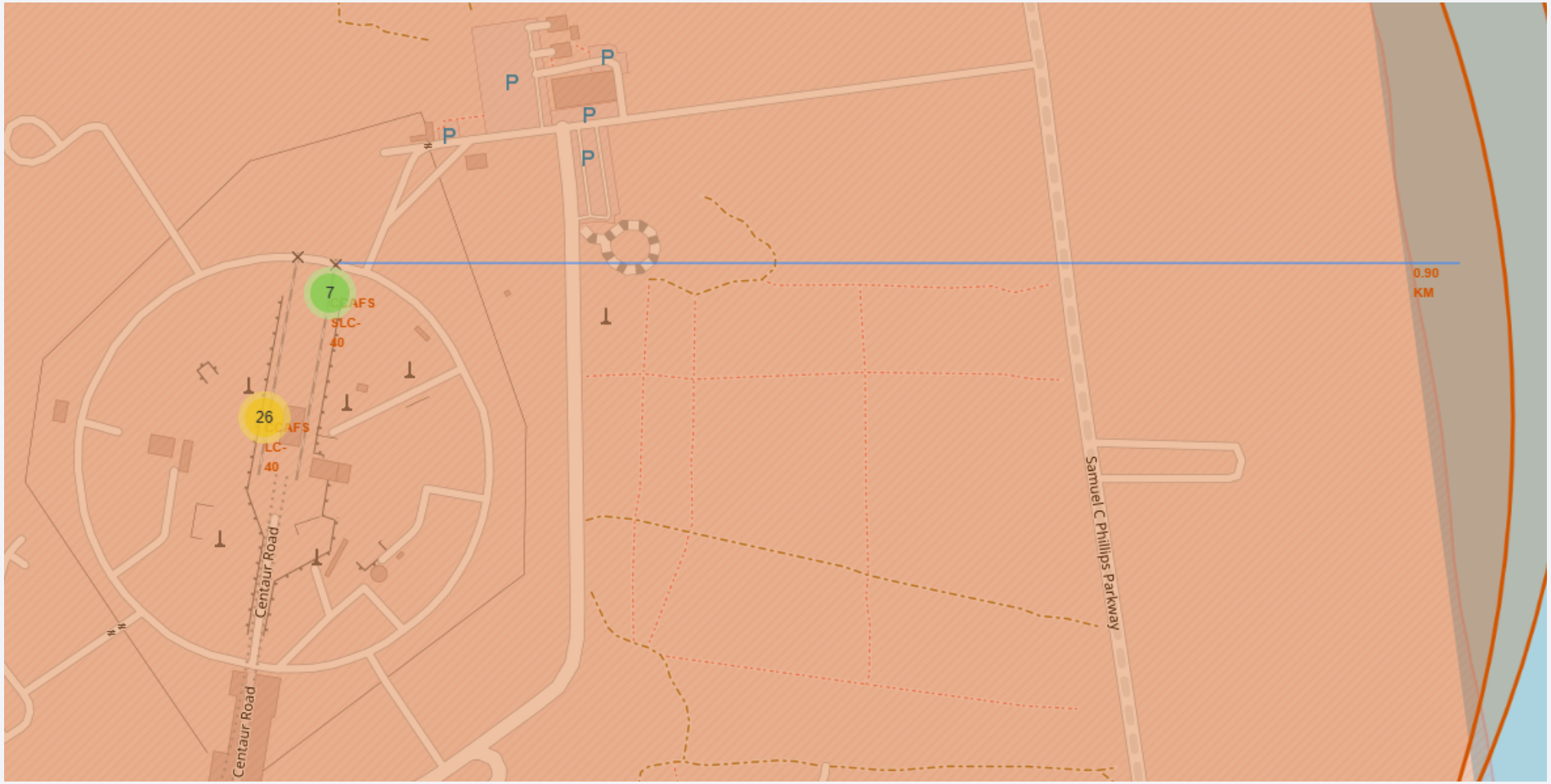
All Launch Sites Locations

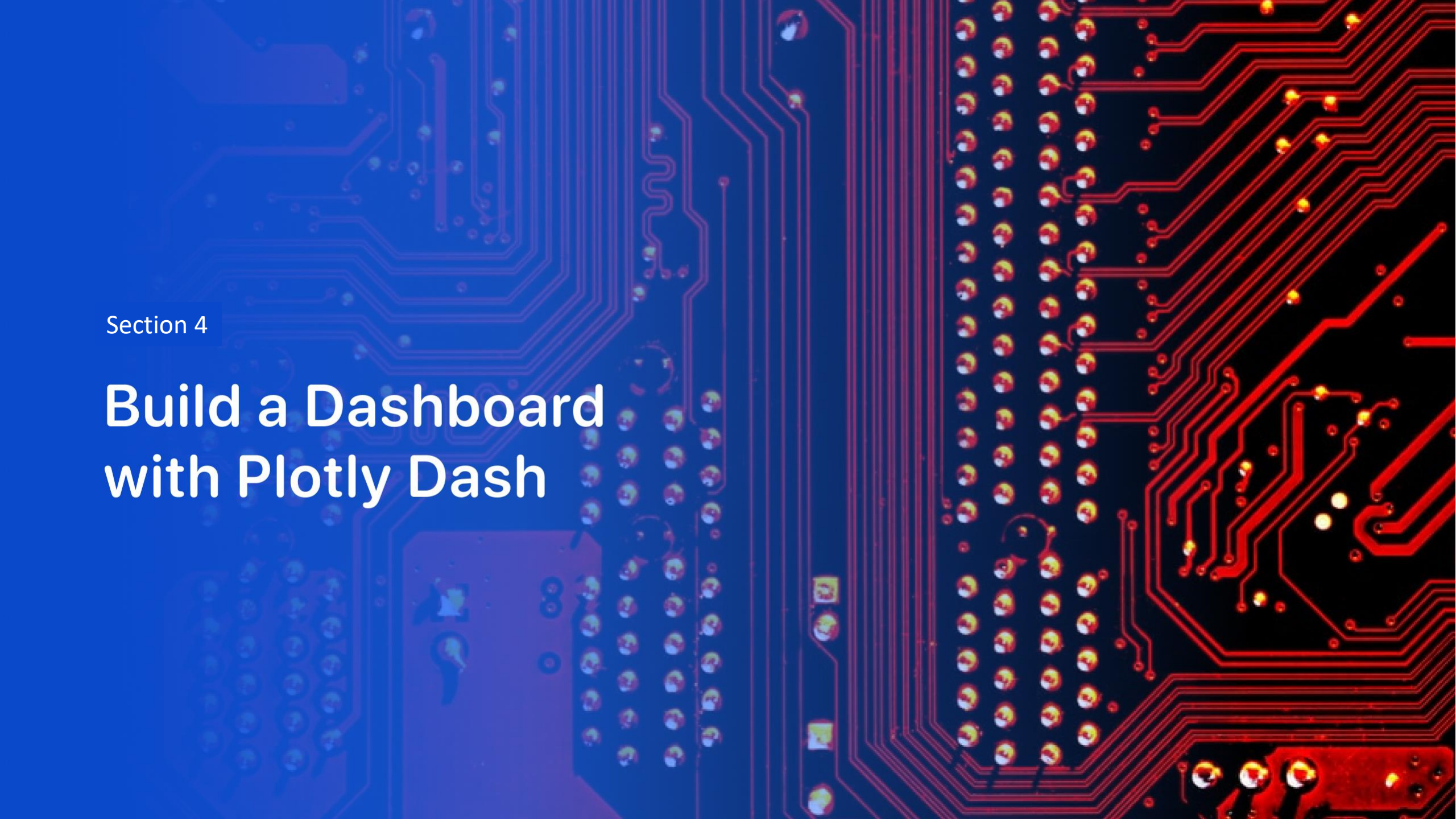
Number of Launches per site



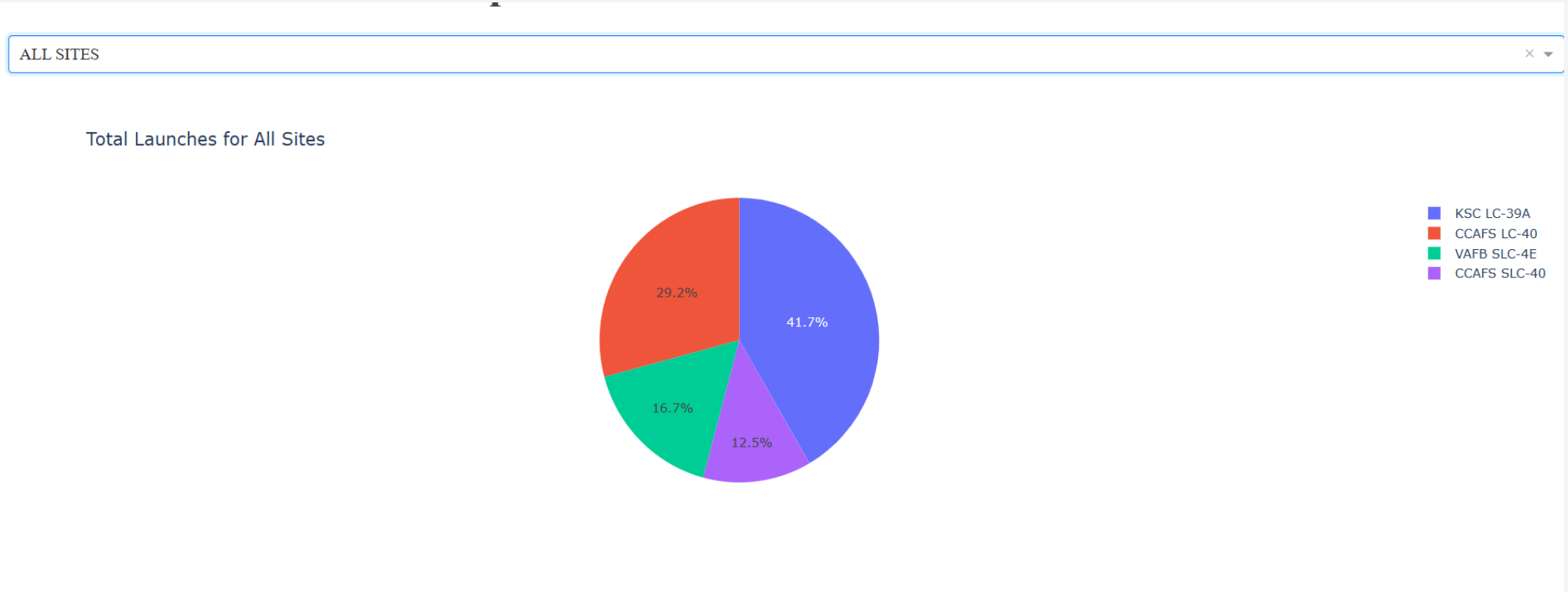


Distance between CCAFS SLC-40 and coastline



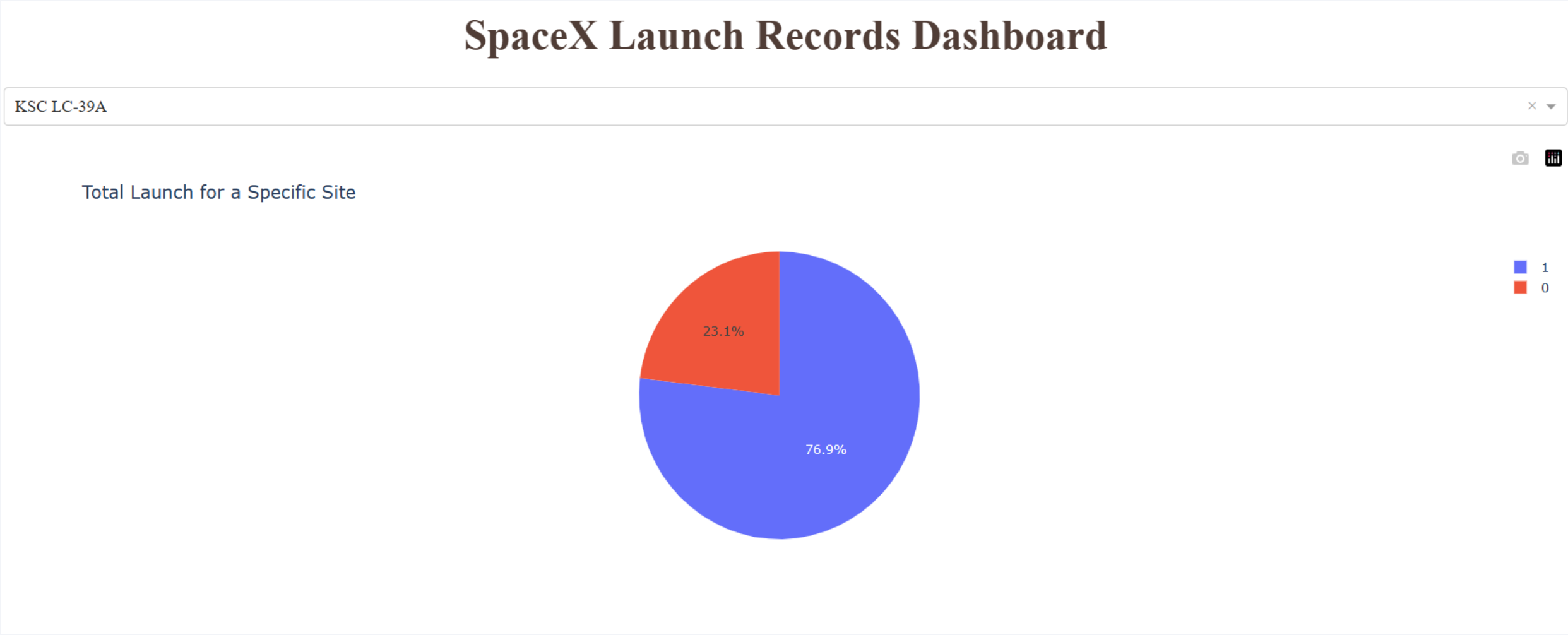

Section 4
Build a Dashboard with Plotly Dash

Launch success count for all sites



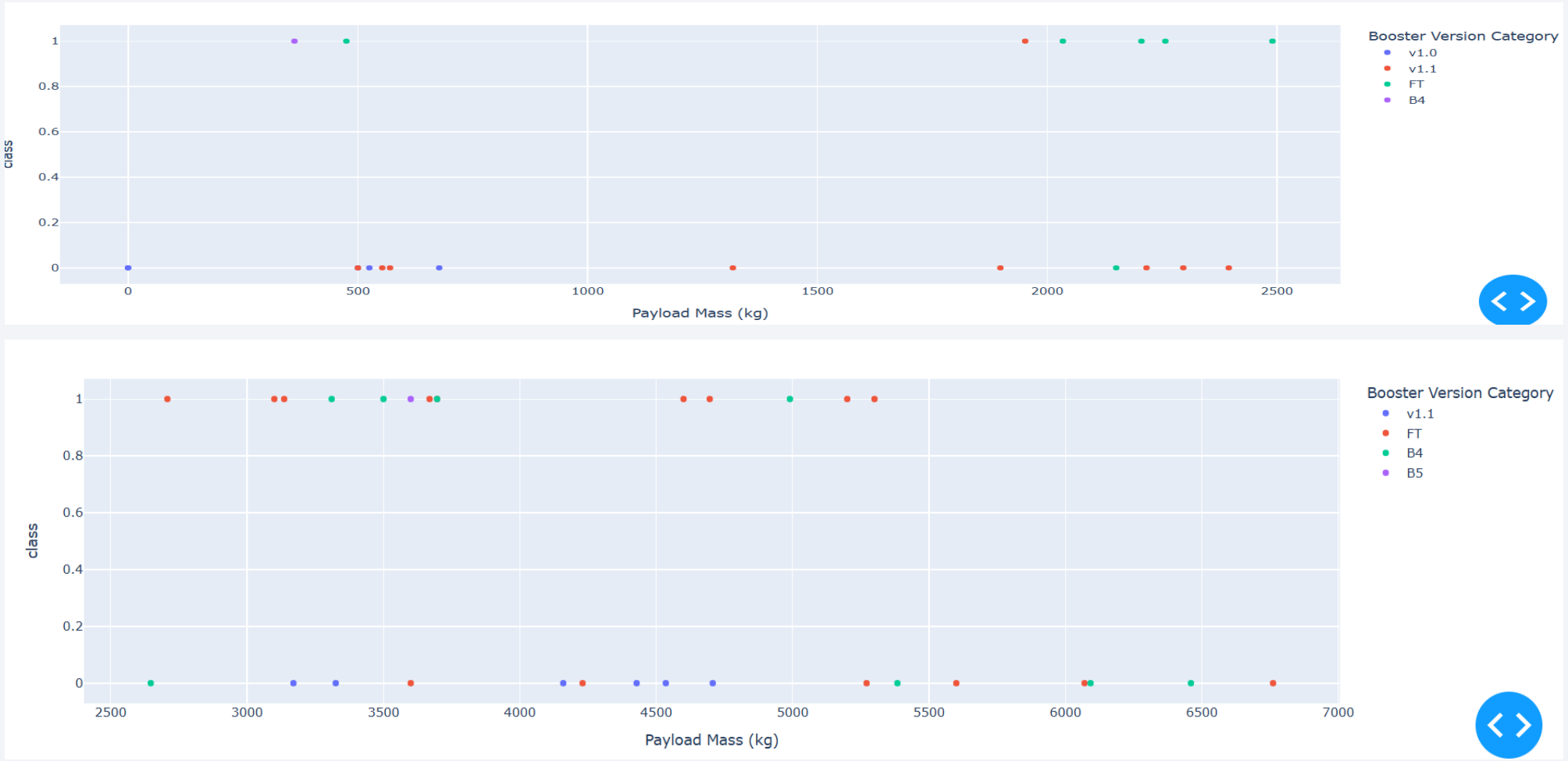
KSC LC 39A Have the highest Success rate of 40 percent

KSC LC 39A Success rate



KSC LC 39A has the highest success rate of 76.9 percent

Payload mass impact on outcome



The lower the Mass the higher the success rate

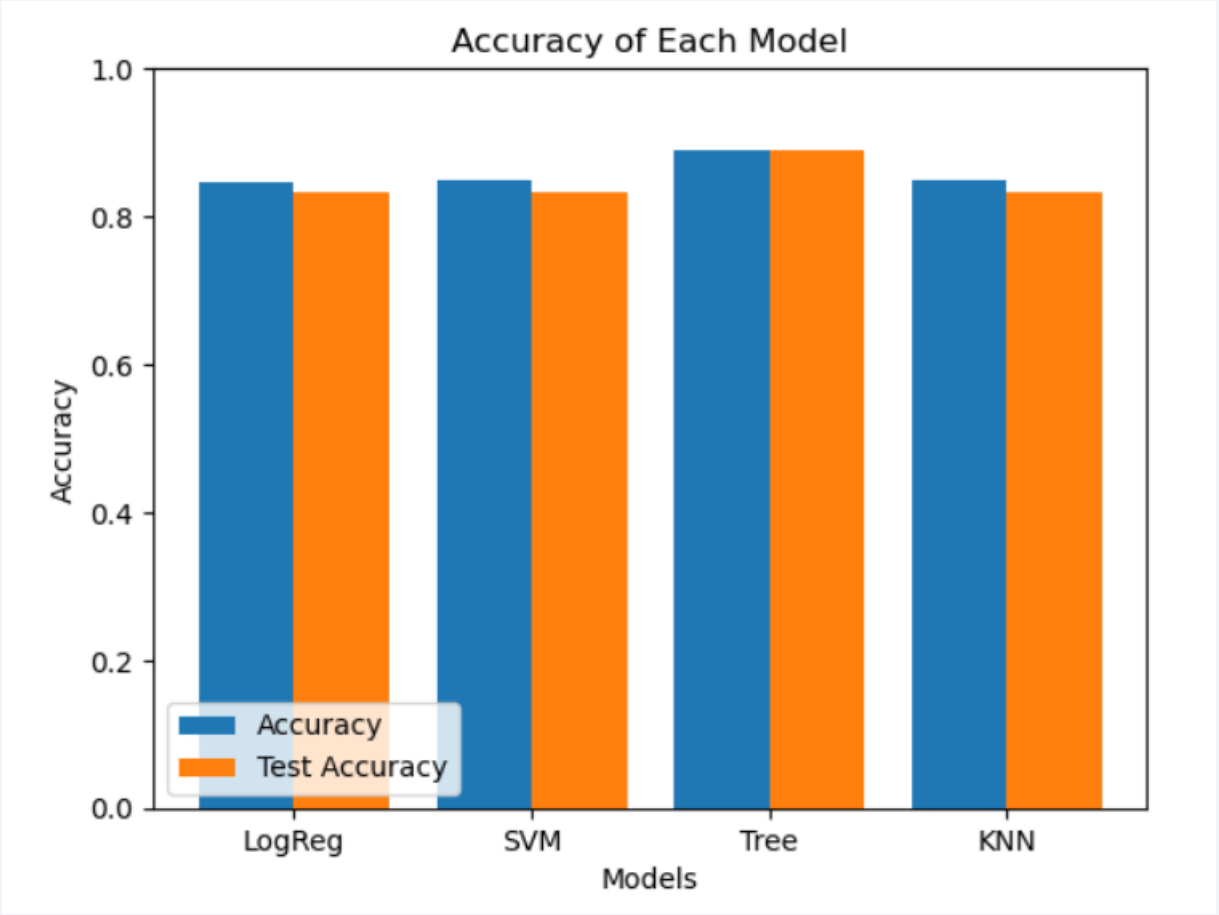
Section 5

Predictive Analysis (Classification)

Classification Accuracy

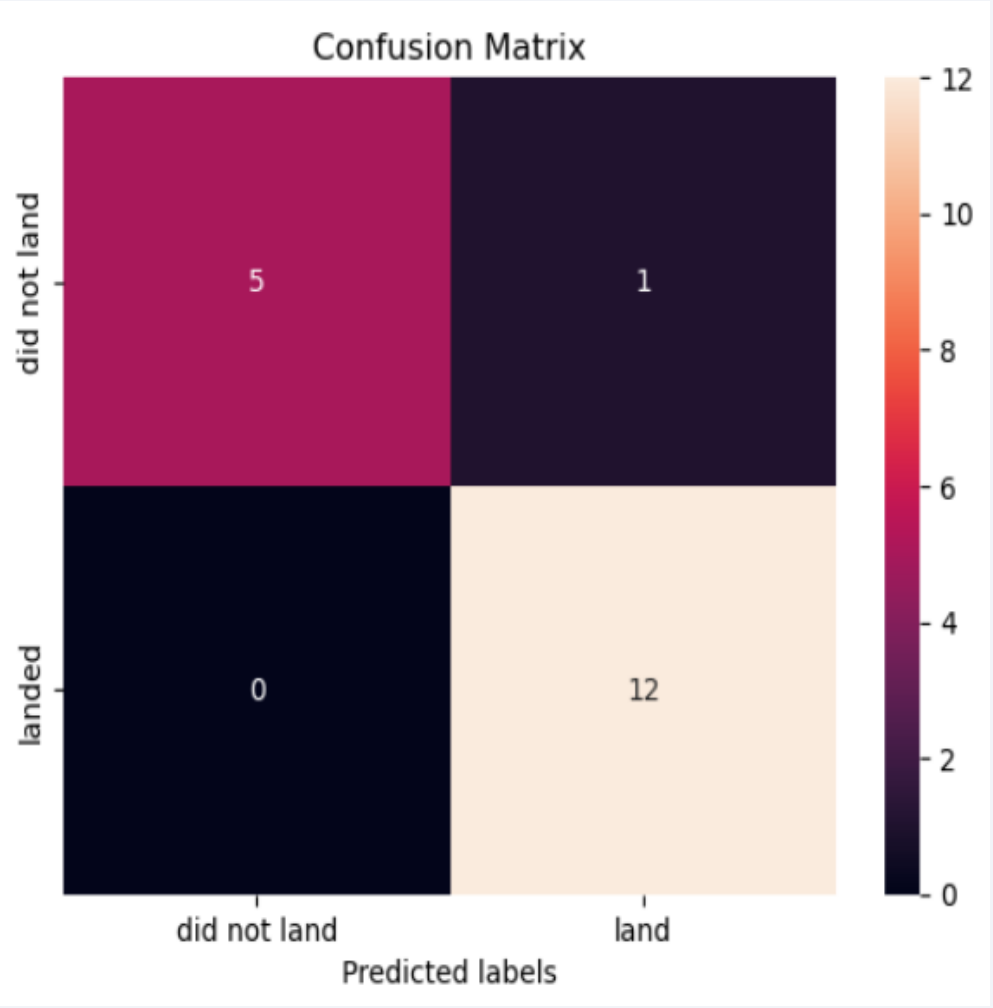
- Visualize the built modes accuracy for all built classification models, in a bar chart

- Decision Tree have the best Accuracy



Confusion Matrix

- The confusion matrix of the best performing model with an explanation



Conclusions

- Decision Tree Model is the best algorithm for this dataset.
- Launches with a low payload mass show better results than launches with a larger payload mass.
- Orbits ES-L1, GEO, HEO and SSO have the highst success rate
- KSC LC-39A has the highest success rate of the launches from all the sites
- The success rate of launches increases over the years

Appendix

- Git Repo : https://github.com/Abdallah-Kareem/Applied_Data_Science_Capstone

Thank you!