IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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6 July 2025

Outline

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

Executive Summary

- Defining the problem and the objectives
- Methodology
  - Data gathering
  - Data Analysis
  - Data Visualization
- Analysing the results
- Discussion on findings and limitations
- Final conclusion and future steps

Introduction

- Our biggest competitor, Space X offers the most affordable rocket launches in the sector
- SpaceX differs from its competitors because it can recover the first stage and reuse it again
- The first stage is quite large and expensive. Besides most of the work is done by the first stage
- There are different factors that have effect on reusability of the first stage
- Understanding these factors in order to compete with SpaceX

Section 1

Methodology

Methodology

Executive Summary

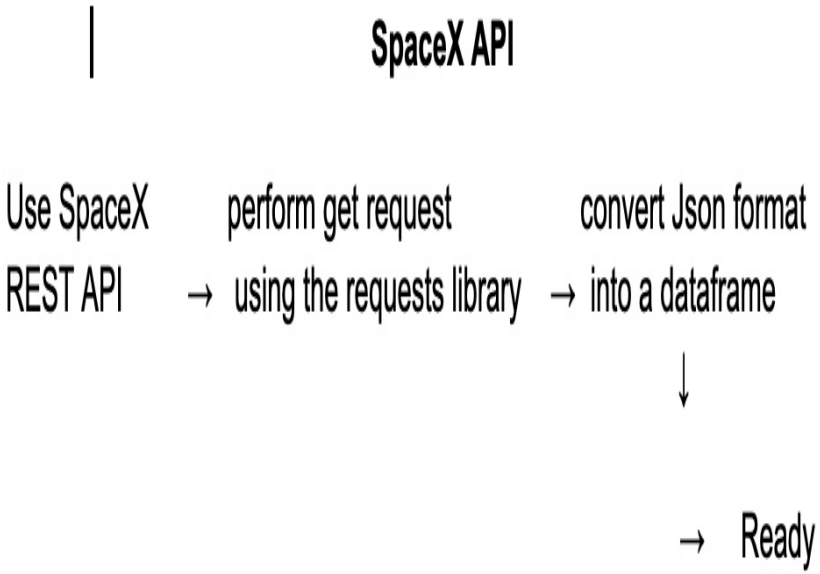
- Data collection methodology:
  - Web Scraping, APIs (SpaceX REST API), Request library
- Perform data wrangling
  - Sampling data
  - Dealing with missing values and outliers
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - Train different classification models
  - Optimiye the Hyperparameter grid search
  - Build a predictive model in order to function more efficiently

Data Collection

- SpaceX launch data is gathered from SpaceX REST API which provides data about launches, the rocket used, payload delivered, launch specifications, landing specifications and landing outcome.
- Perform a *get request* using the requests library to obtain the launch data, which used to get the data from the API.
- The json_normalize function were used to convert the JSON format to a dataframe
- Another data source for Falcon 9 Launch Data is web scrape related Wiki pages with the help of BeautifulSoup package
- Parse the data from tables and convert them into a Pandas data frame

Data Collection – SpaceX API

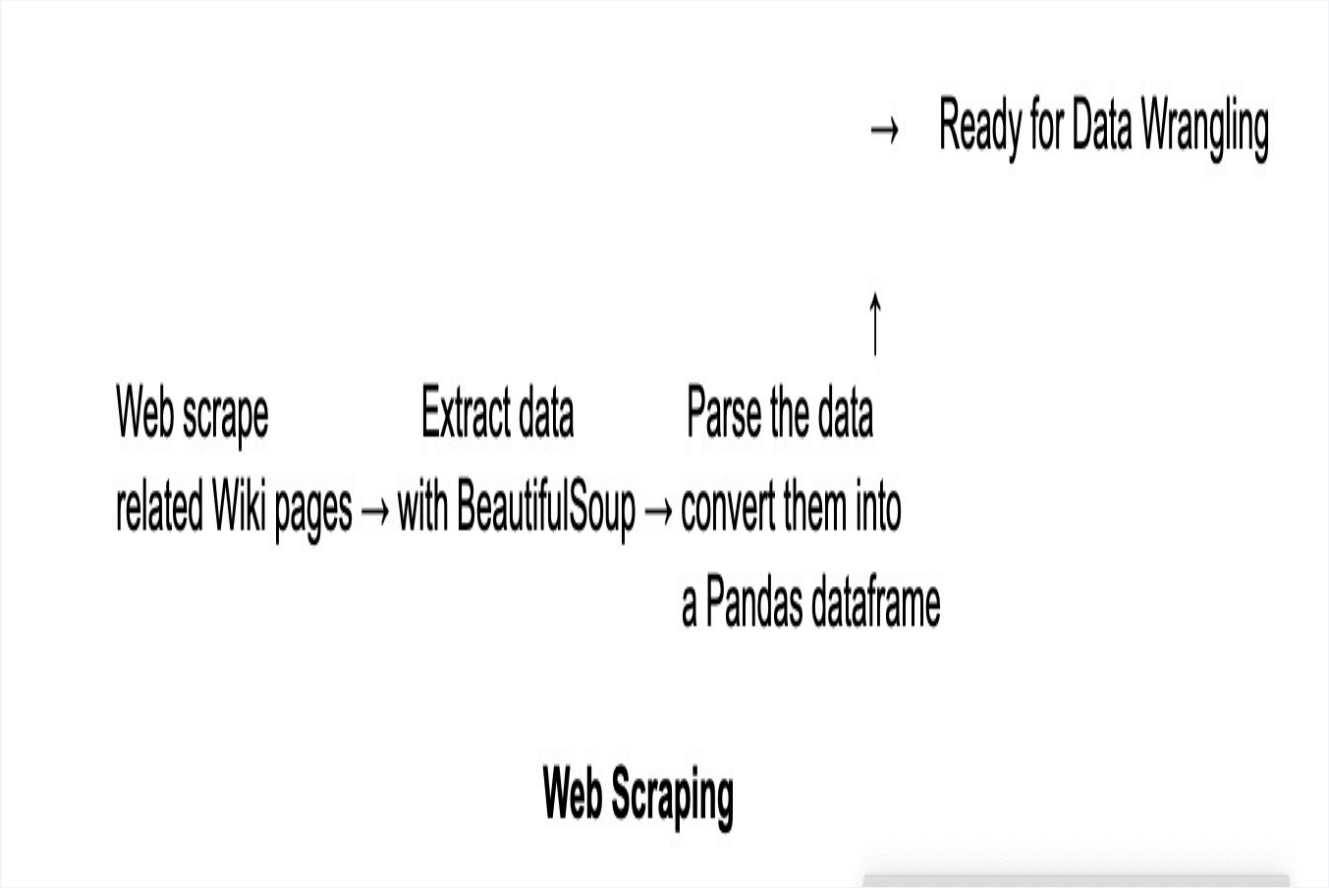
- Flowchart of SpaceX API



https://github.com/simge-git/IBM-SpaceX-Capstone-Project/blob/main/SpaceX_Data_Lab/spacex-data-collection-api.ipynb

Data Collection - Scraping

- The flowchart of Web Scraping



https://github.com/simge-git/IBM-SpaceX-Capstone-Project/blob/main/SpaceX_Data_Lab/Webscraping.ipynb

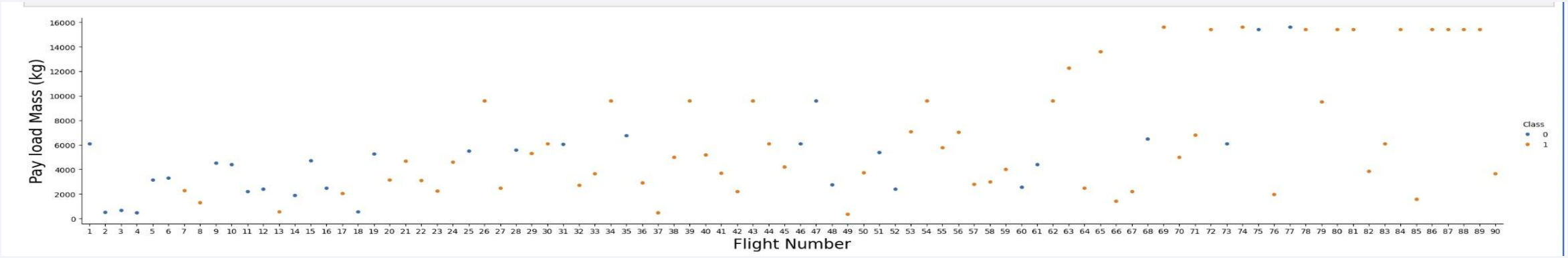
Data Wrangling

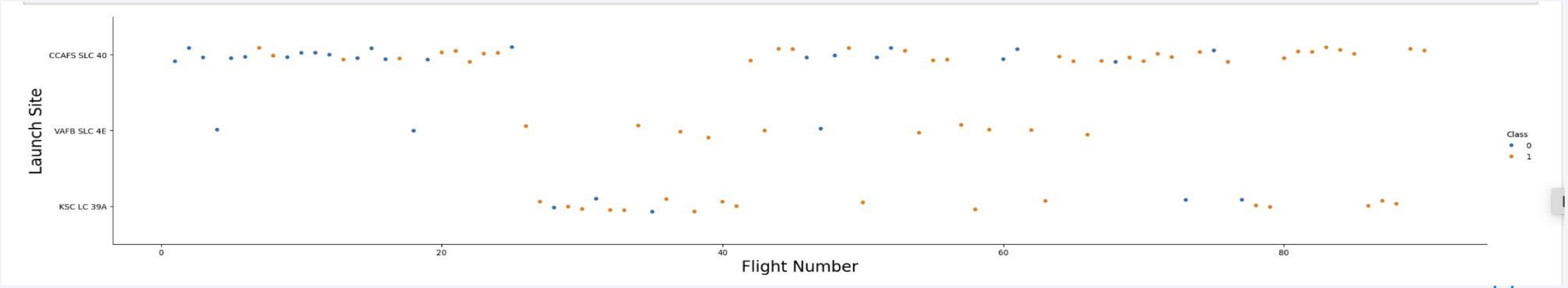
- Remove blank rows from table
- List the attributes in order to understand the data
- Rank the outcomes to determine relationship

https://github.com/simge-git/IBM-SpaceX-Capstone-Project/blob/main/SpaceX_Data_Lab/labs-jupyter-spacex-Data%20wrangling.ipynb

EDA with Data Visualization

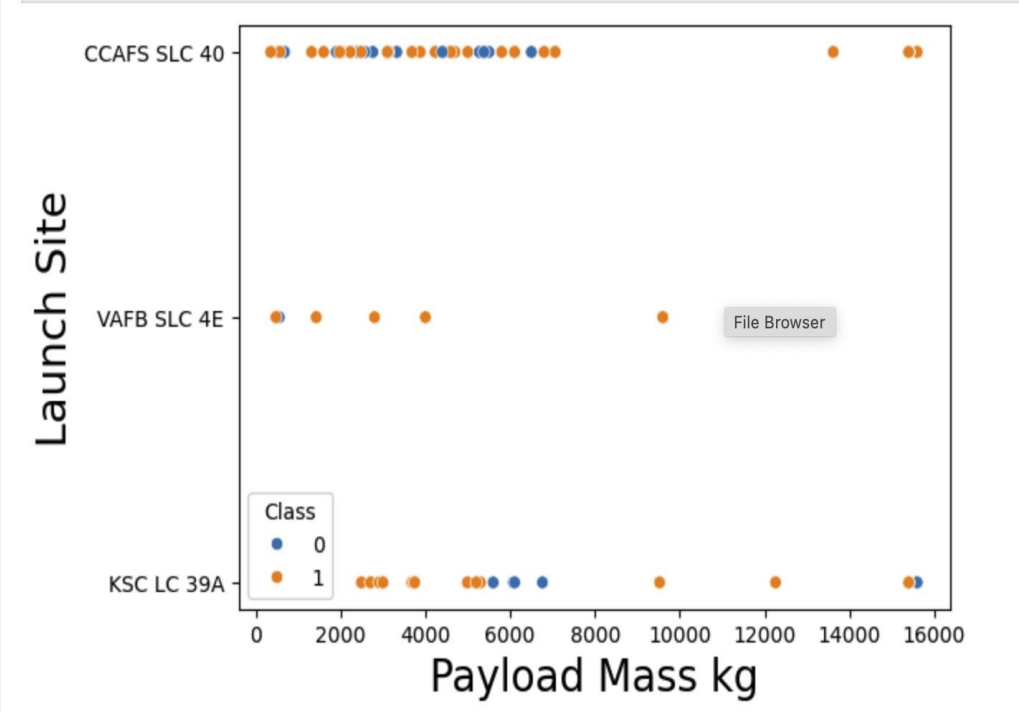
Charts to visualize relationship between Flight Number and Payload/Launch Site

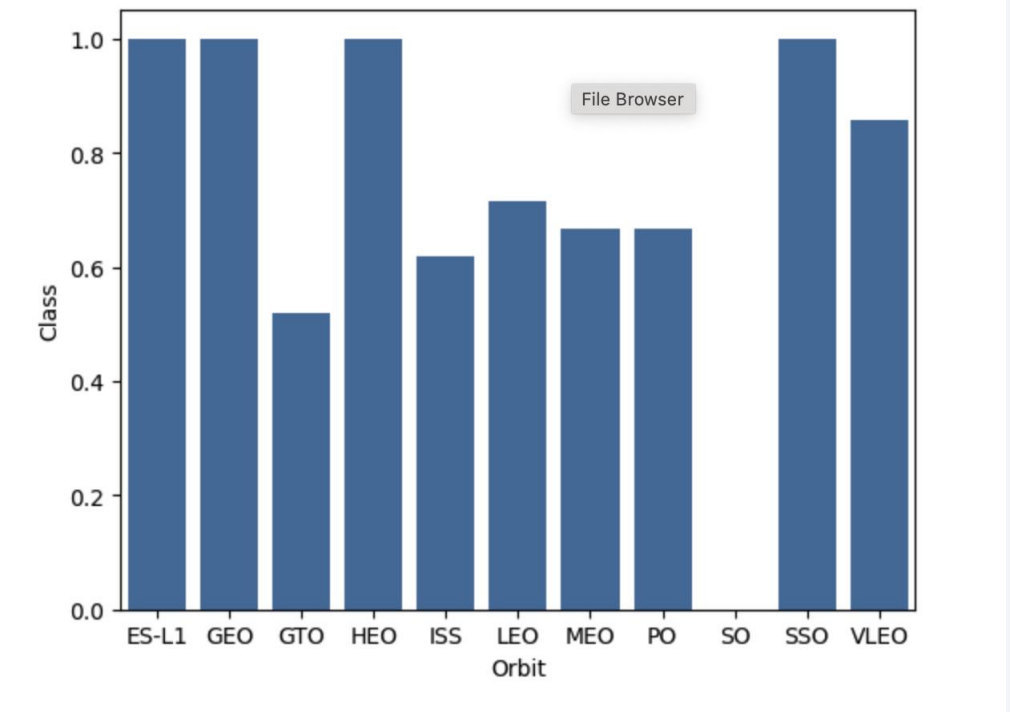




EDA with Data Visualization

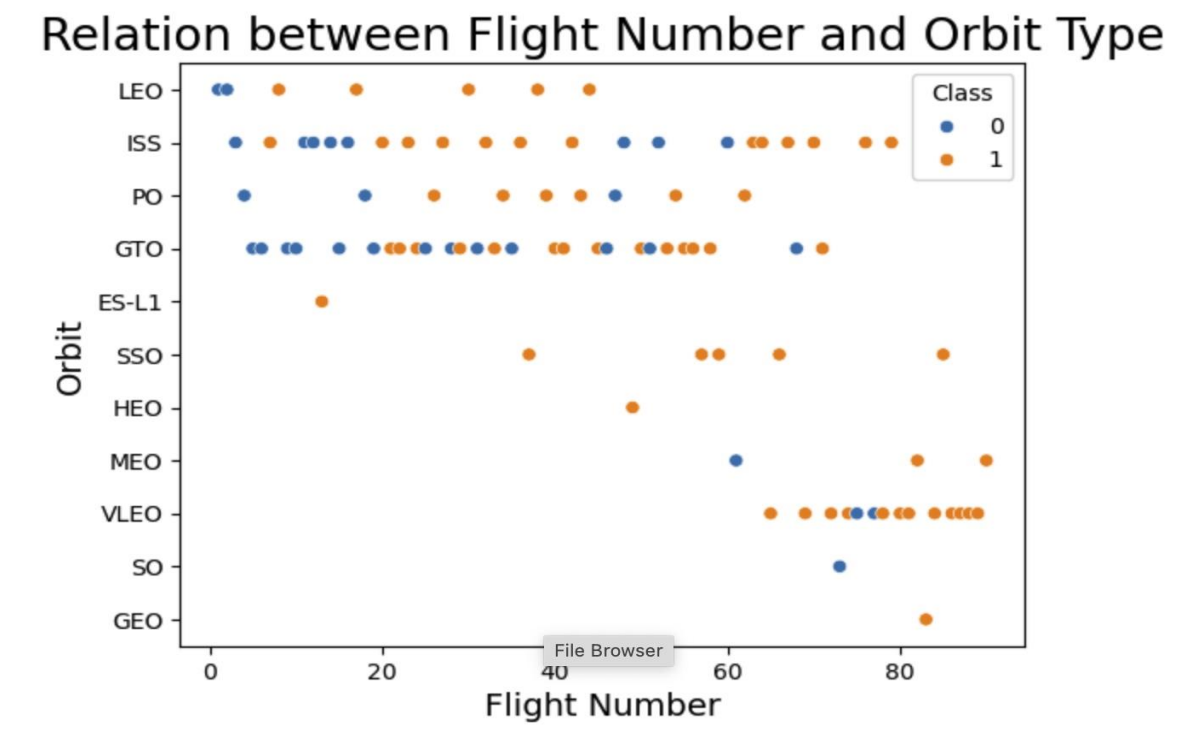
Charts to visualize the effects of each attributes

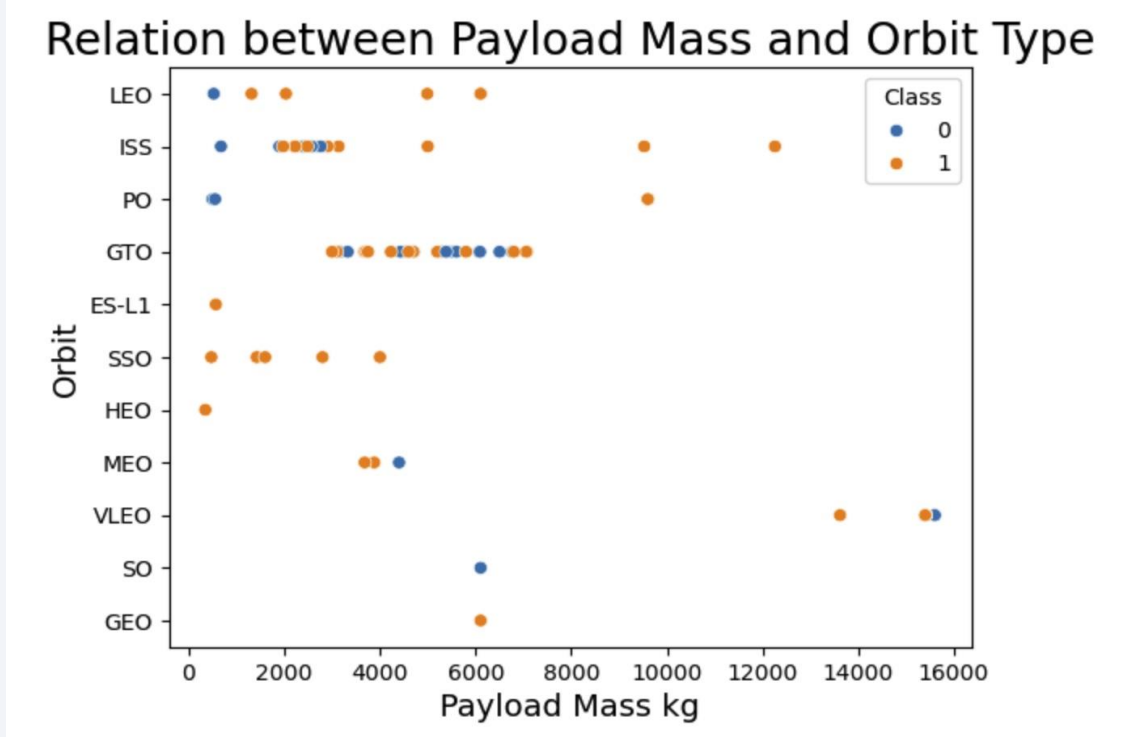




EDA with Data Visualization

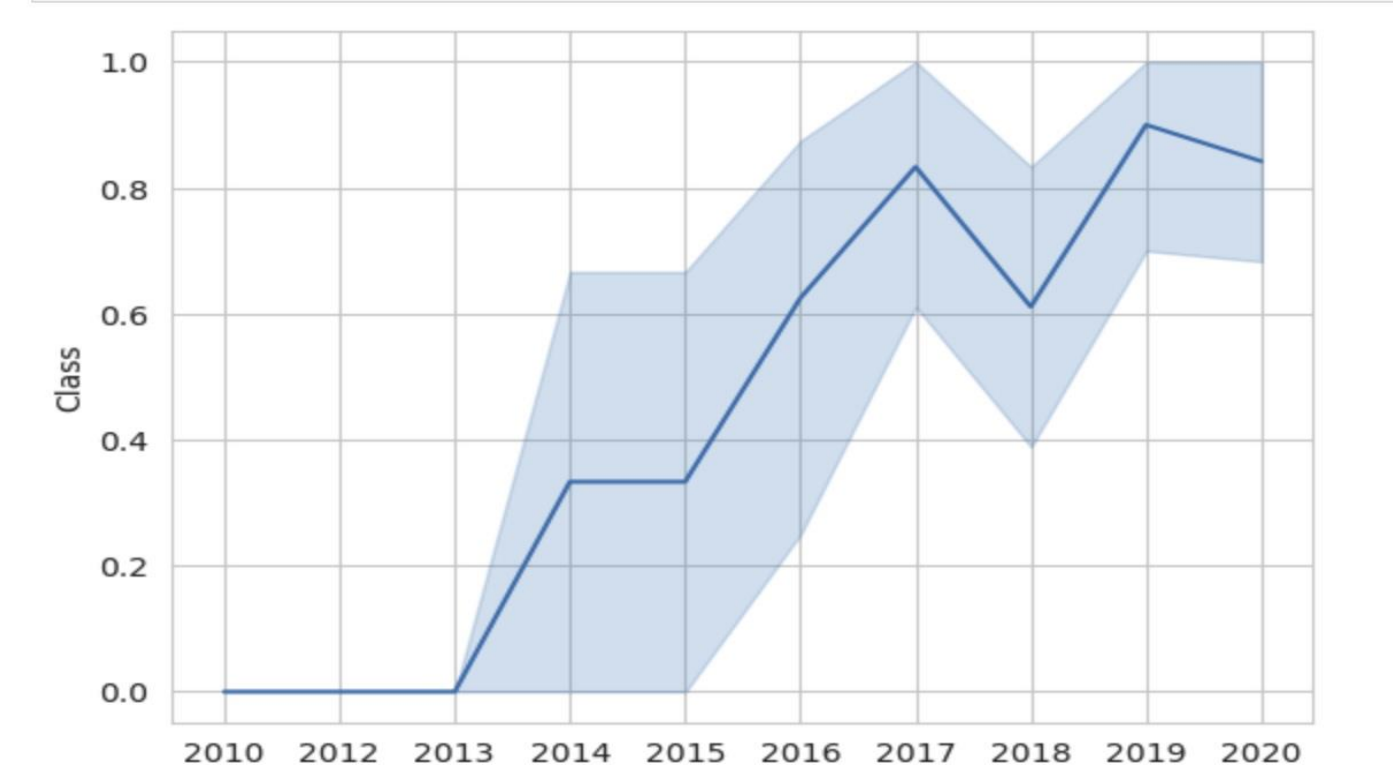
Charts to visualize the effects of each attributes





EDA with Data Visualization

The progress of SpaceX between 2010 and 2020



https://labs.cognitiveclass.ai/v2/tools/jupyterlite?ulid=ulid-bcb171190569d4ac32e7a0fba87ff5868cbfdd09

EDA with SQL

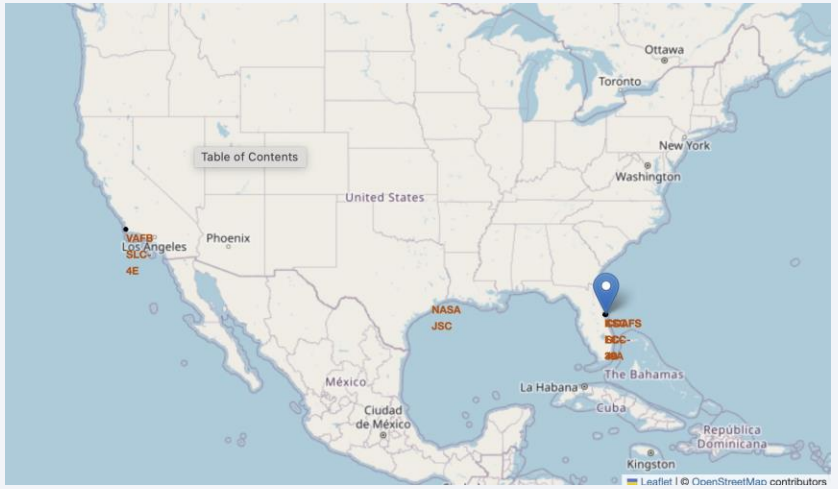
SQL queries performed:

- Display the unique launch sites
- 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 achieved
- List the names of the boosters which have success in drone ship and have payload greater than 400 but less than 6000
- List the total number of successful and failure mission outcomes
- List all the booster_versions that have carried the maximum payload mass
- List the records which will display the month names, failure landing outcomes in drone ship, booster version, launch site for 2015
- Rank the count of landing outcomes

https://github.com/simge-git/IBM-SpaceX-Capstone-Project/blob/main/SpaceX_Data_Lab/jupyter-labs-eda-sql-coursera_sqllite.ipynb

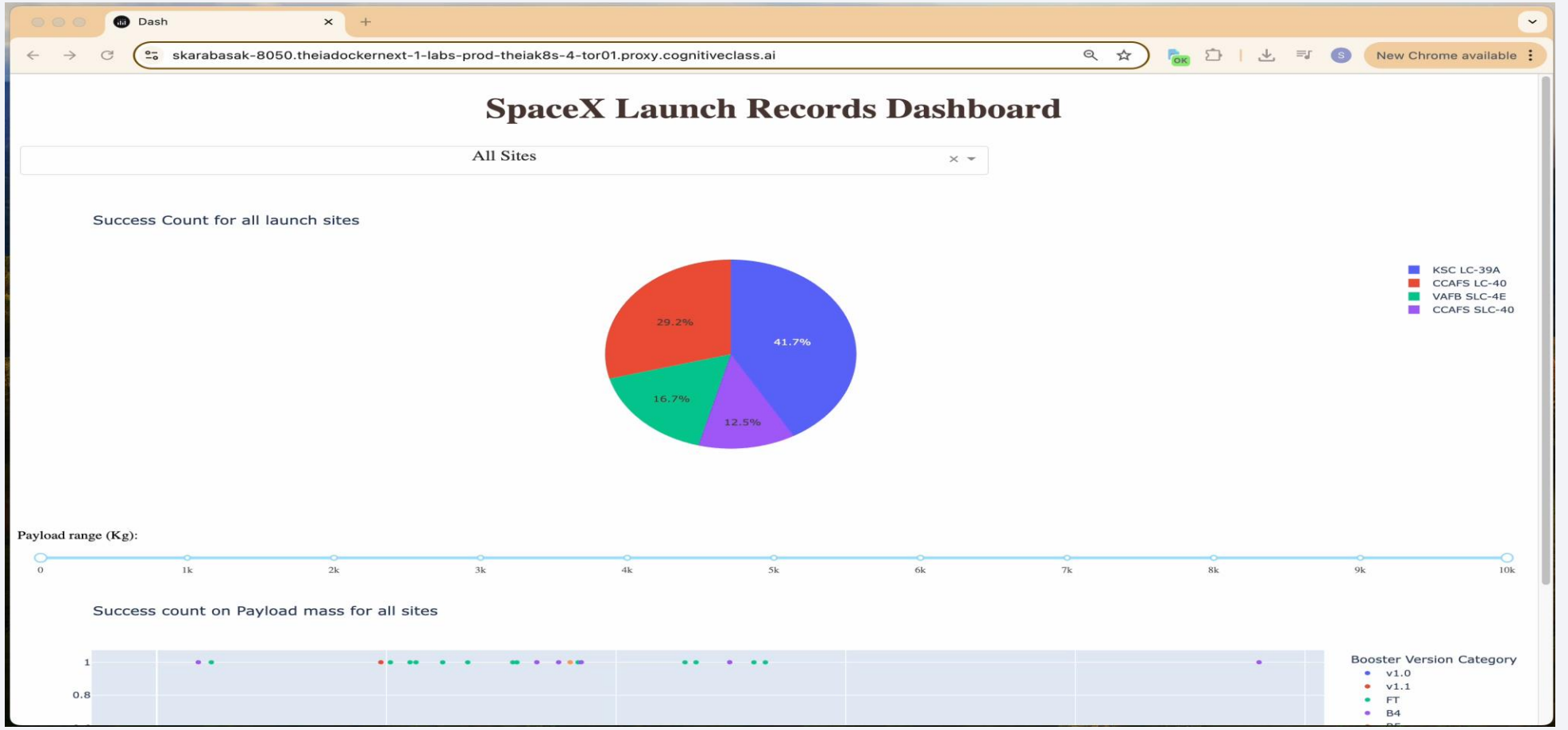
Build an Interactive Map with Folium

- Markers, circles, lines are created and added to a folium map
  - Circle is used to highlight the circle area with a text label on a specific coordinate
  - Color-labeled markers in marker cluster helps to easily identify which launch site have relatively high success rates
  - Mouse position gets coordinate for a mouse over a point on the map



https://github.com/simge-git/IBM-SpaceX-Capstone-Project/blob/main/SpaceX_Data_Lab/lab_jupyter_launch_site_location.ipynb

Build a Dashboard with Plotly Dash



Predictive Analysis (Classification)

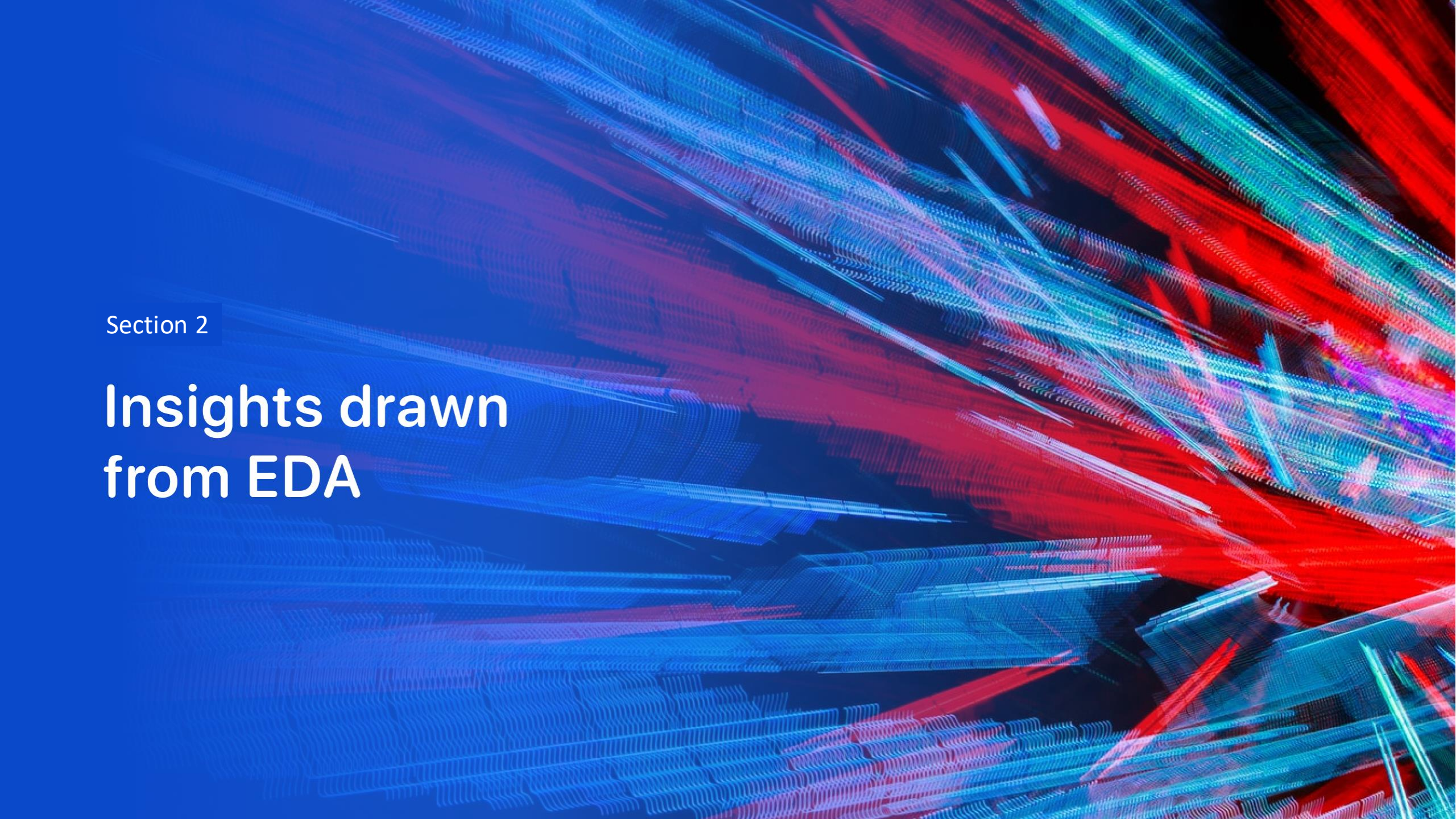
- Split the data into training testing data → Train different classification models. → Optimize the Hyperparameter grid search → Find the the method that performs best using test data

https://github.com/simge-git/IBM-SpaceX-Capstone-Project/blob/main/SpaceX_Data_Lab/SpaceX_Machine%20Learning%20Prediction_Part_5.ipynb

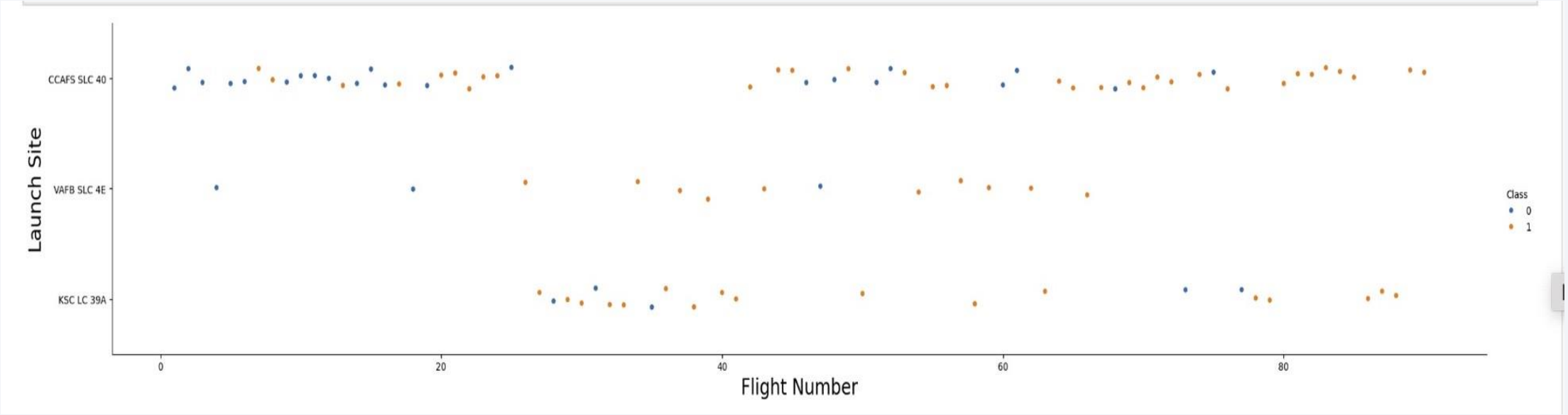
Results

- Exploratory data analysis results:
  - Increase in flight number has positive effect on the success
  - There is no rockets launched for heavypayload mass (greater than 10000) at VAFB-SLC
  - ES-L1, GEO, HEO and SSO orbits have the highest success rates
  - Success rate kept increasing between 2013 and 2020

- The SVM, KNN and Logistic Regression models have best accuracy rate

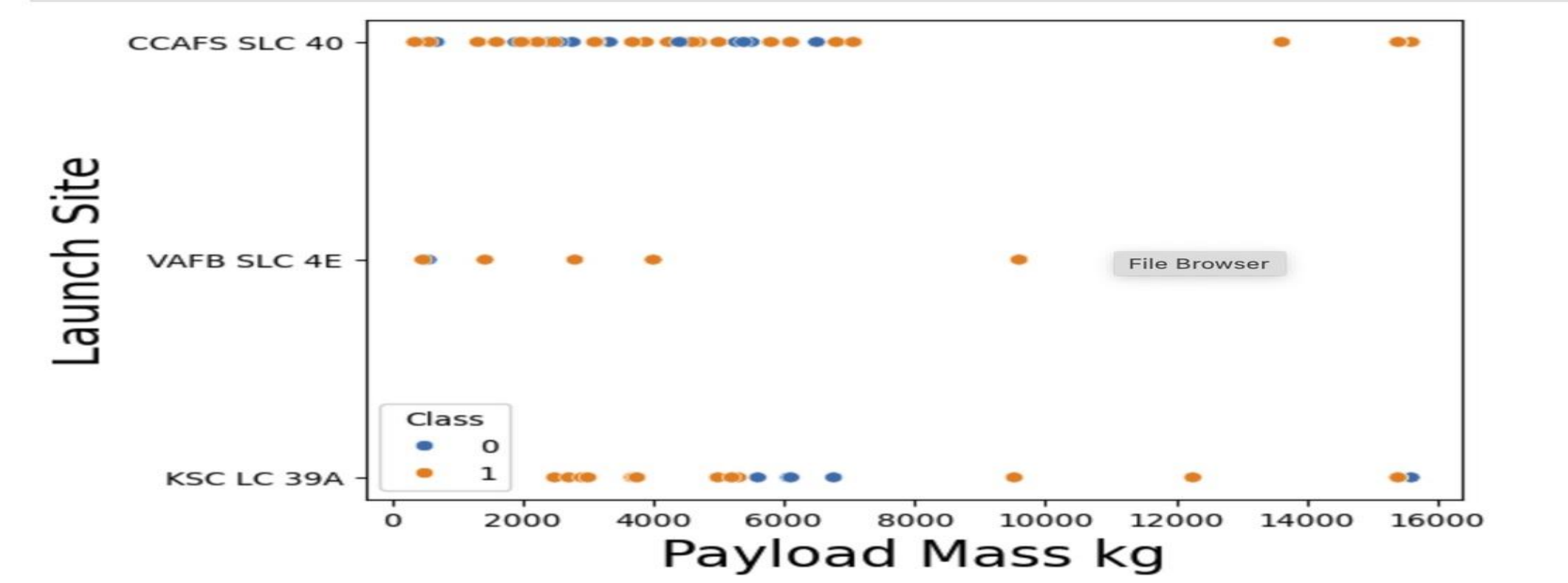

Section 2
Insights drawn from EDA

Flight Number vs. Launch Site



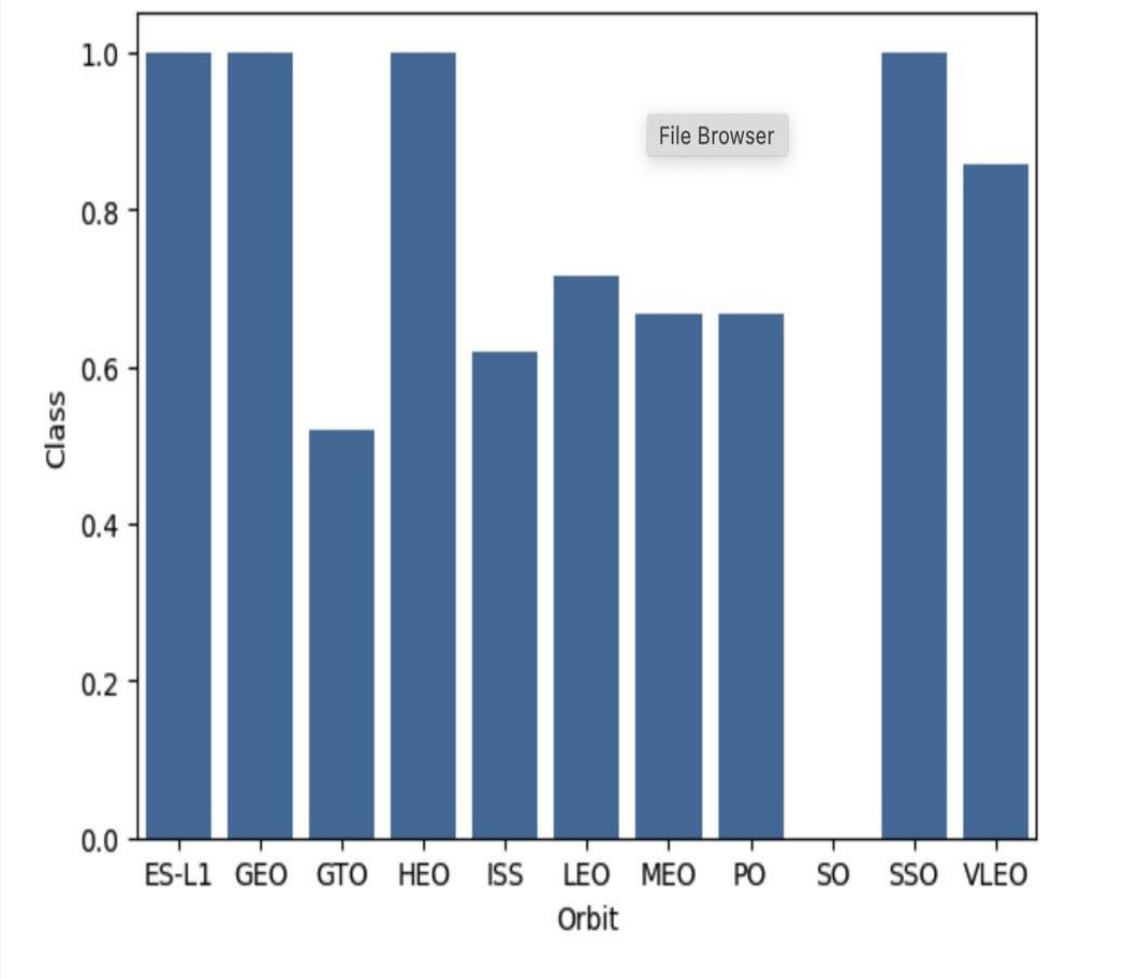
- When the number of flight increases, the success rate also increases

Payload vs. Launch Site



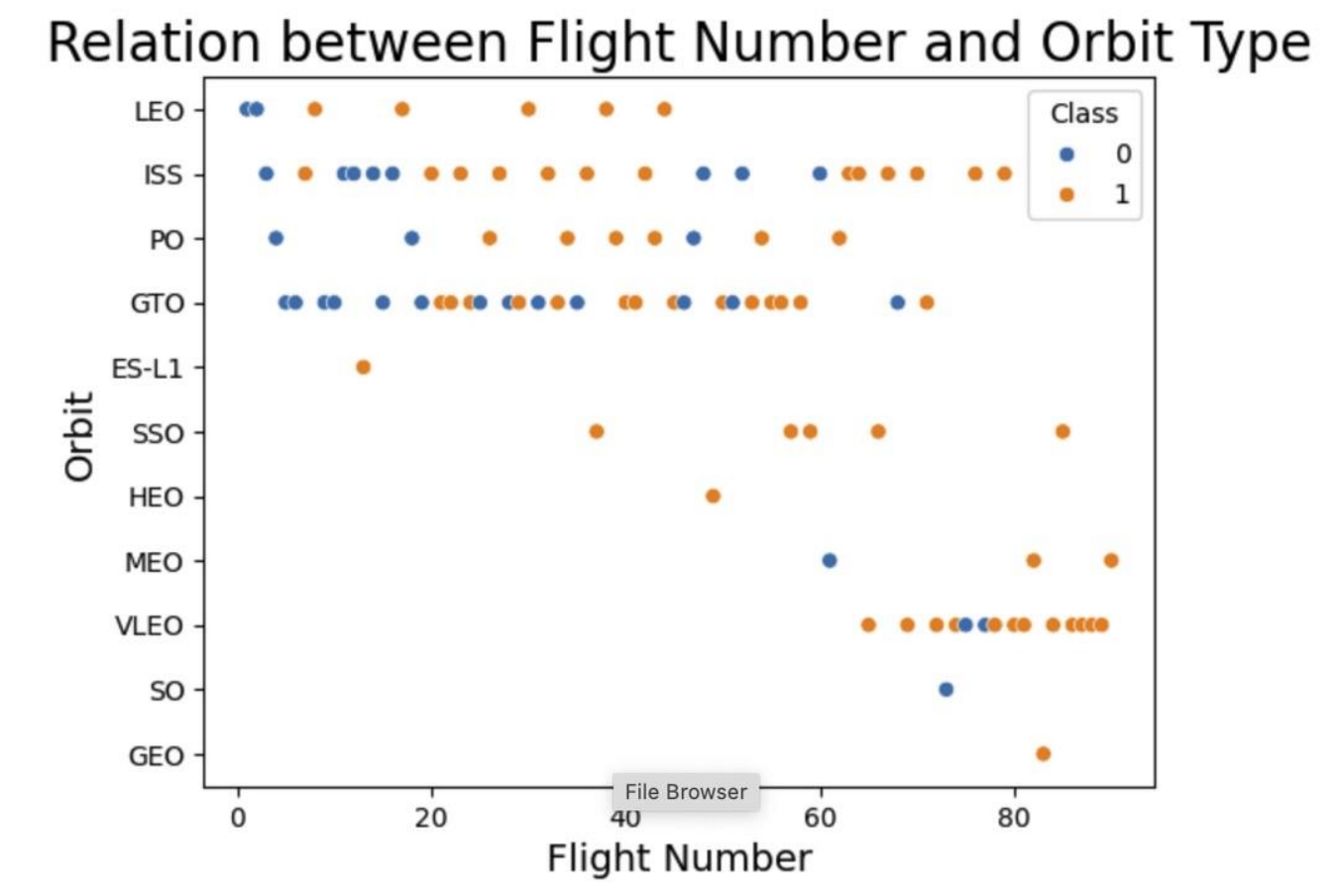
There is no rockets launched for heavypayload mass (greater than 10000) at VAFB-SLC

Success Rate vs. Orbit Type



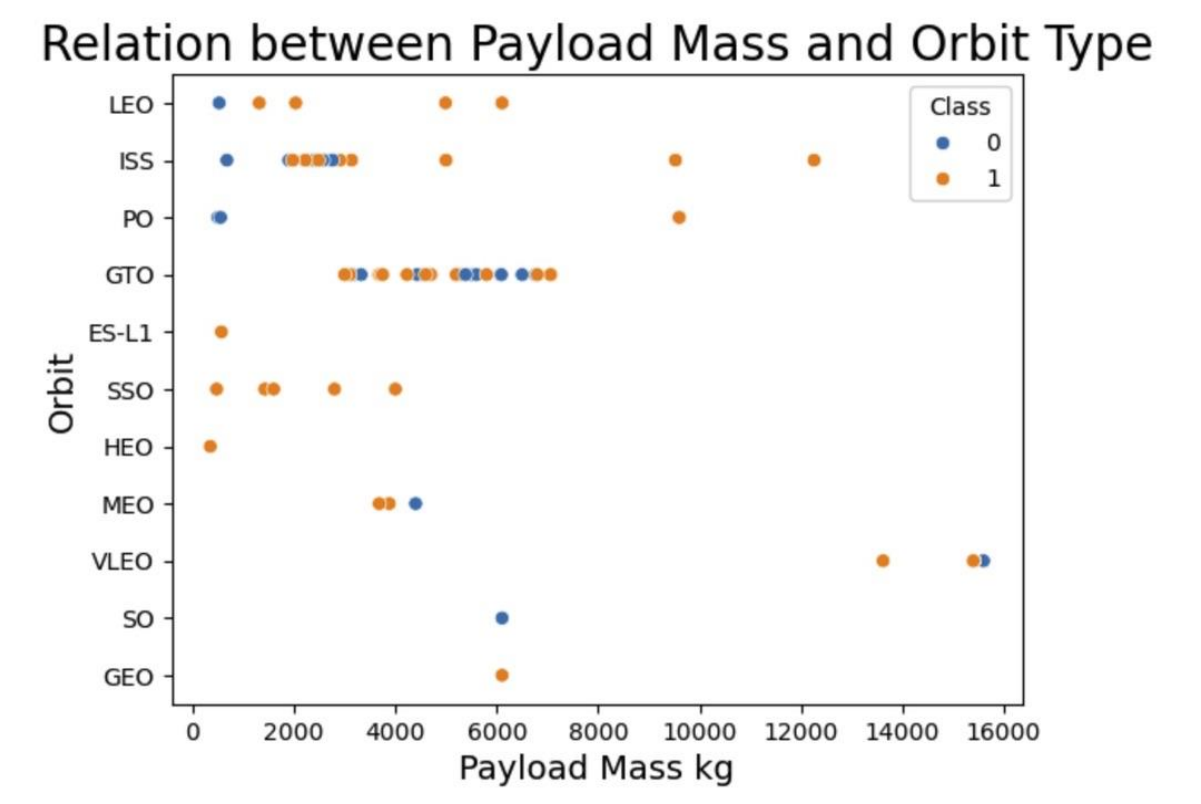
- ES-L1, GEO, HEO and SSO orbits have the highest success rates

Flight Number vs. Orbit Type



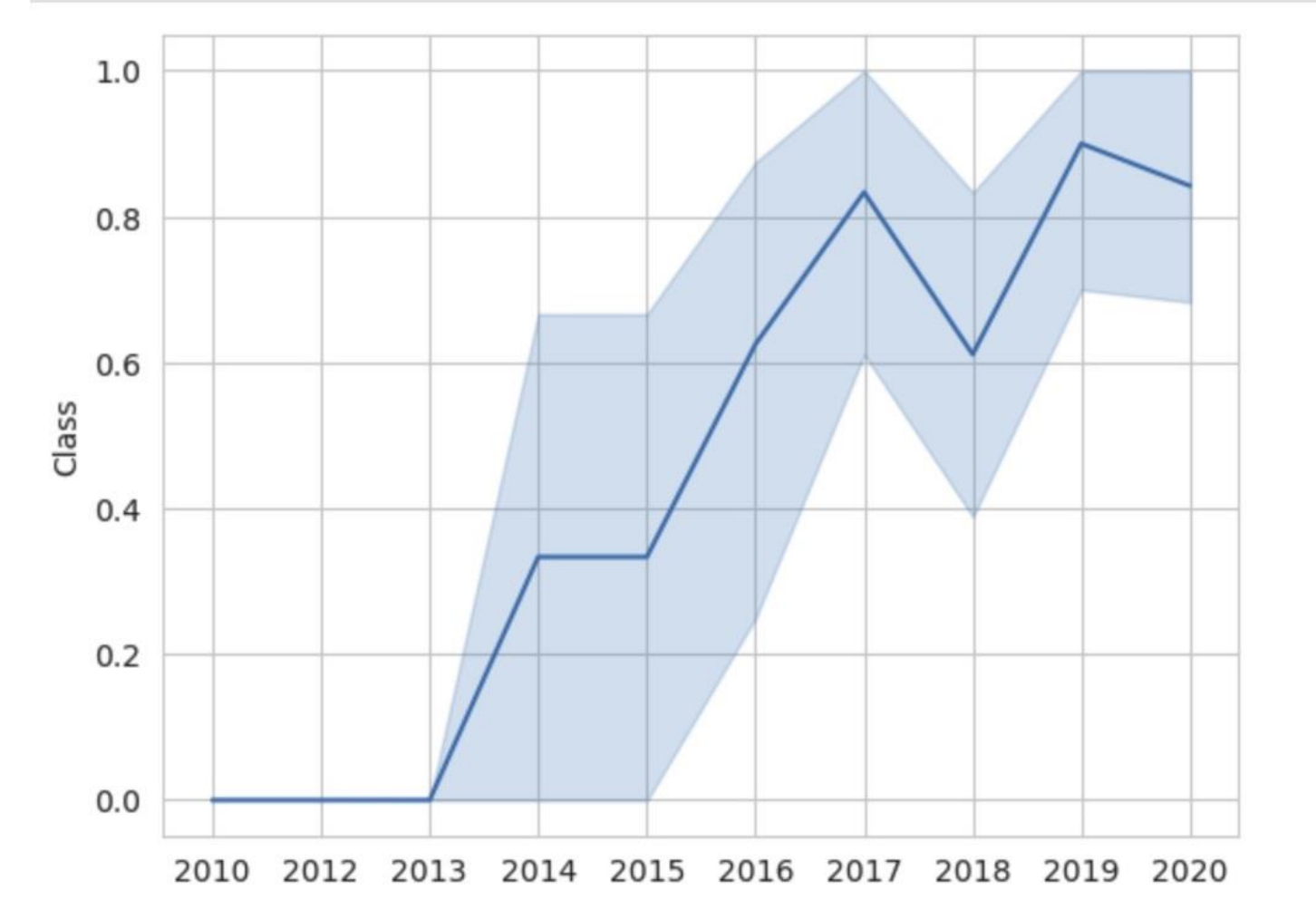
- In the LEO orbit, success seems to be related to the number of flights. Conversely, in the GTO orbit, there appears to be no relationship between flight number and success

Payload vs. Orbit Type



- With heavy payloads the successful landing or positive landing rate are more for Polar, LEO and ISS
- However, for GTO, it's difficult to distinguish between successful and unsuccessful landings as both outcomes are present.

Launch Success Yearly Trend



- Launch success rate kept increasing between 2013 and 2020

All Launch Site Names

```
%sql select Distinct LAUNCH_SITE from SPACEXTBL;
```

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

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

Launch Site Names Begin with 'CCA'

```
%sql select Distinct LAUNCH_SITE from SPACEXTBL;
```

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

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

Total Payload Mass

```
%sql select AVG(PAYLOAD_MASS__KG_) from SPACEXTBL where "Booster_Version" like "F9 v1.1%"
```

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

AVG(PAYLOAD_MASS__KG_)
2534.6666666666665

Average Payload Mass by F9 v1.1

```
%sql select AVG(PAYLOAD_MASS__KG_) from SPACEXTBL where "Booster_Version" like "F9 v1.1%"
```

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

AVG(PAYLOAD_MASS__KG_)
2534.6666666666665

First Successful Ground Landing Date

```
%sql select min("Date") from SPACEXTBL where "Landing_Outcome" = "Success (ground pad)"
```

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

min("Date")
2015-12-22

Name: jupyter-labs-eda-sql-coursera_sqllite.ipynb
Size: 35.9 KB
Path: DS0321EN/labs/module_2/SQLLIte
Created: 7/4/25, 9:48 PM

Successful Drone Ship Landing with Payload between 4000 and 6000

```
%sql Select "Booster_Version" from SPACEXTBL where "Landing_Outcome"="Success (drone ship)" and "PAYLOAD_MASS__KG_" between 40
```

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

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 missionoutcome from SPACEXTBL Group by Mission_Outcome
```

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

missionoutcome
1
98
1
1

Boosters Carried Maximum Payload

```
%sql select Booster_version as BoosterVersion, PAYLOAD_MASS__KG_ as payload from SPACEXTBL where PAYLOAD_MASS__KG_ = (select m
```

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

BoosterVersion	payload
F9 B5 B1048.4	15600
F9 B5 B1049.4	15600
F9 B5 B1051.3	15600
F9 B5 B1056.4	15600
F9 B5 B1048.5	15600
F9 B5 B1051.4	15600
F9 B5 B1049.5	15600
F9 B5 B1060.2	15600
F9 B5 B1058.3	15600
F9 B5 B1051.6	15600
F9 B5 B1060.3	15600
F9 B5 B1049.7	15600

2015 Launch Records

```
%sql Select CASE SUBSTR("Date", 6, 2) when "01" then "January" when "02" then "February" when "03" then "MArch" when "04" ther
```

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

month	"Landing_Outcome" = "Failure (drone ship)"	Booster_Version	Launch_Site
January	1	F9 v1.1 B1012	CCAFS LC-40
February	0	F9 v1.1 B1013	CCAFS LC-40
MArch	0	F9 v1.1 B1014	CCAFS LC-40
April	1	F9 v1.1 B1015	CCAFS LC-40
April	0	F9 v1.1 B1016	CCAFS LC-40
June	0	F9 v1.1 B1018	CCAFS LC-40
December	0	F9 FT B1019	CCAFS LC-40

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

```
%sql select "Landing_Outcome", count("Landing_Outcome") from SPACEXTBL where "Date" between 20100604 and 20170320 group by "La
```

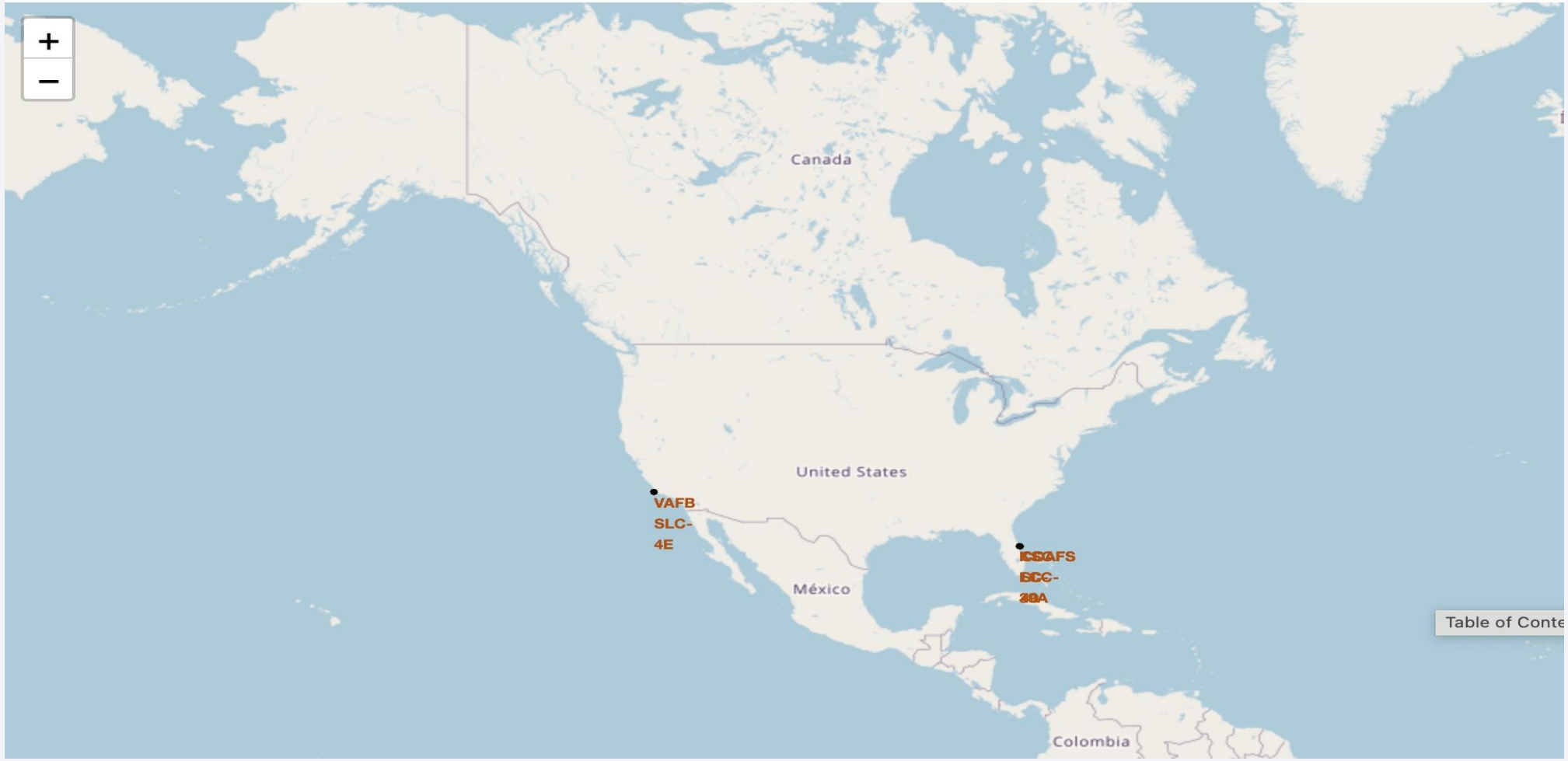
```
 * sqlite:///my_data1.db
Done.
```

Landing_Outcome	count("Landing_Outcome")
Success (drone ship)	12
No attempt	12
Success (ground pad)	8
Failure (drone ship)	5
Controlled (ocean)	4
Uncontrolled (ocean)	2
Precluded (drone ship)	1

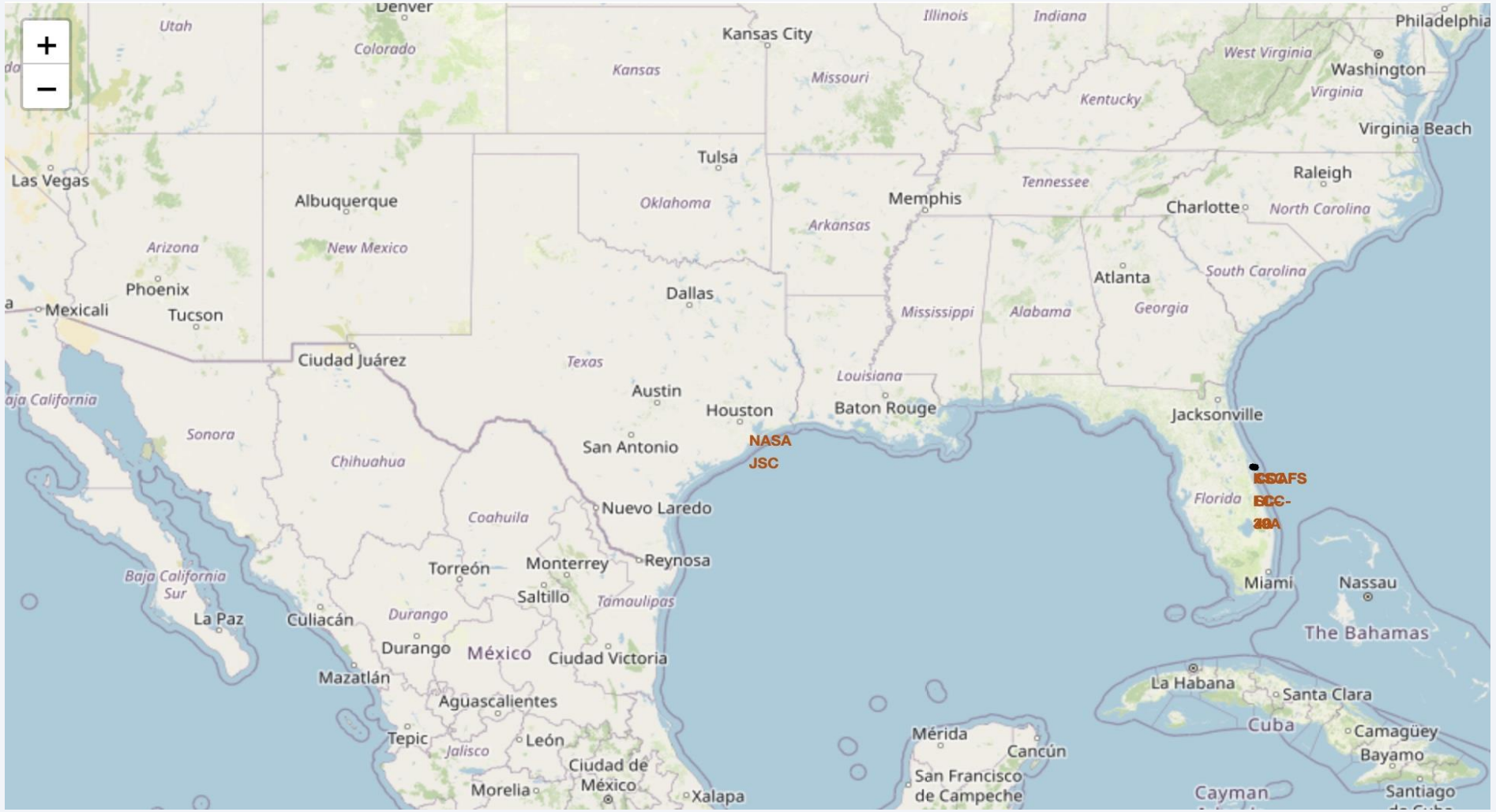
Section 3

Launch Sites Proximities Analysis

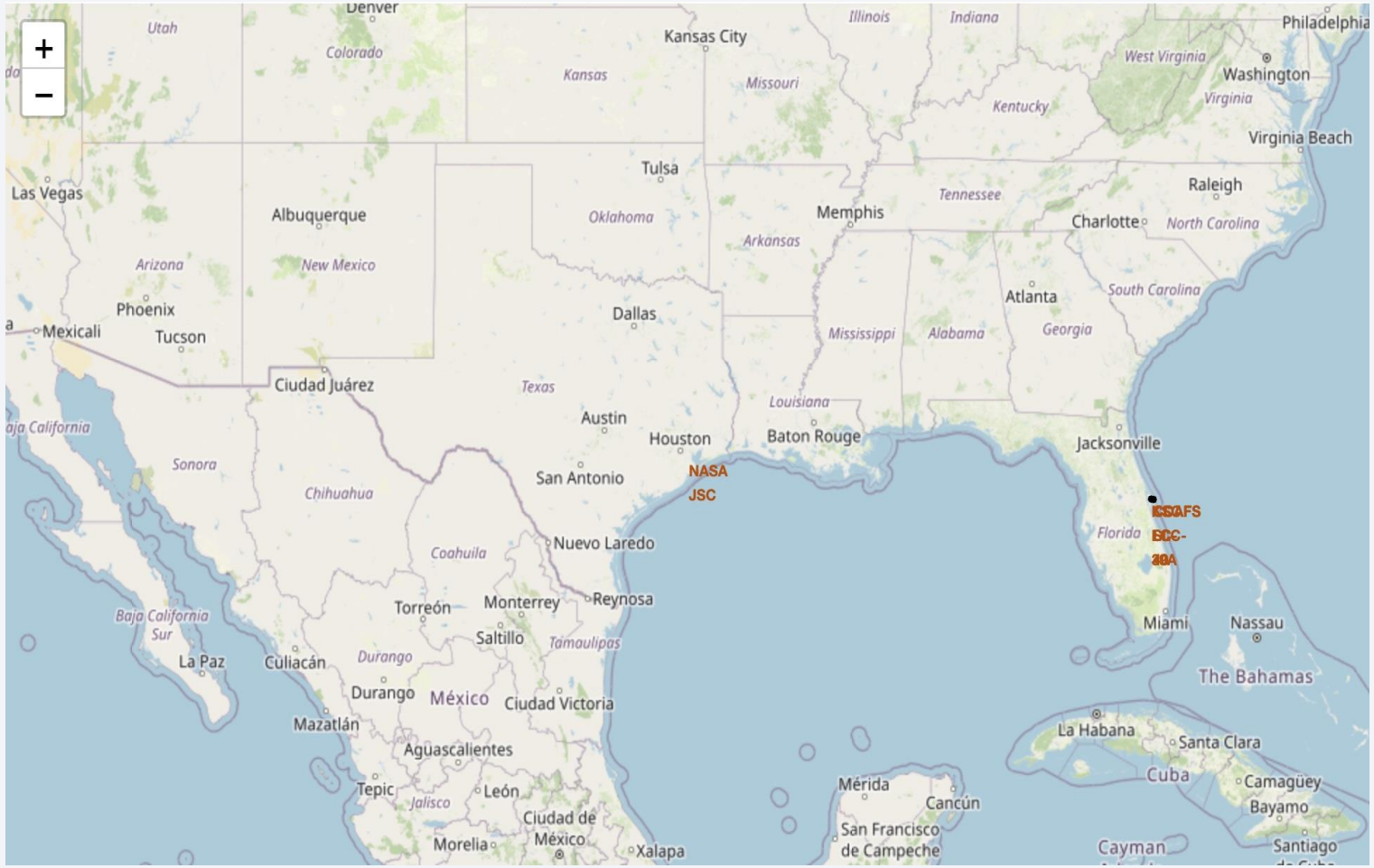
All Launch Sites on a Global Map

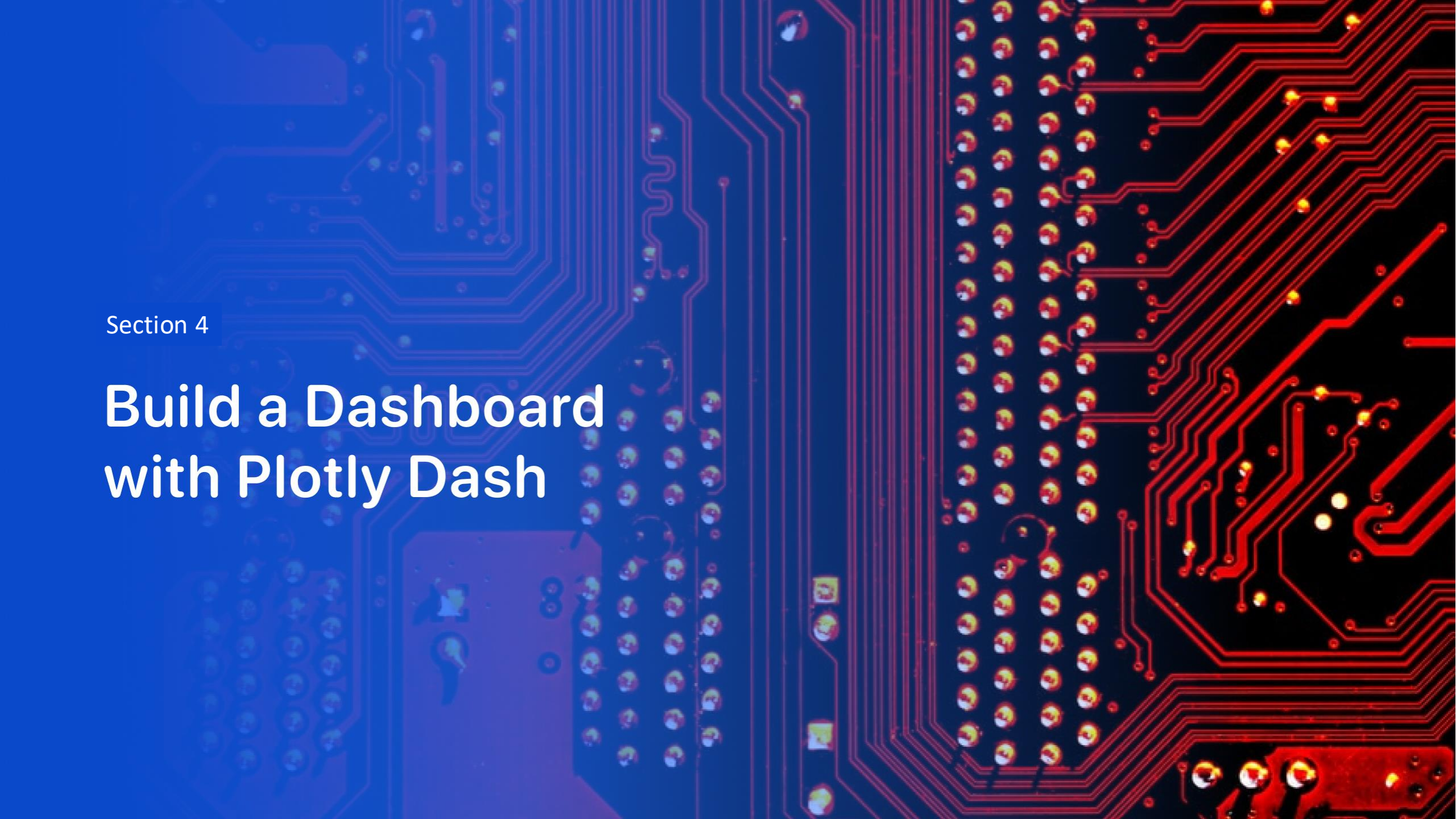


Color-labeled Launch Outcomes on the Map

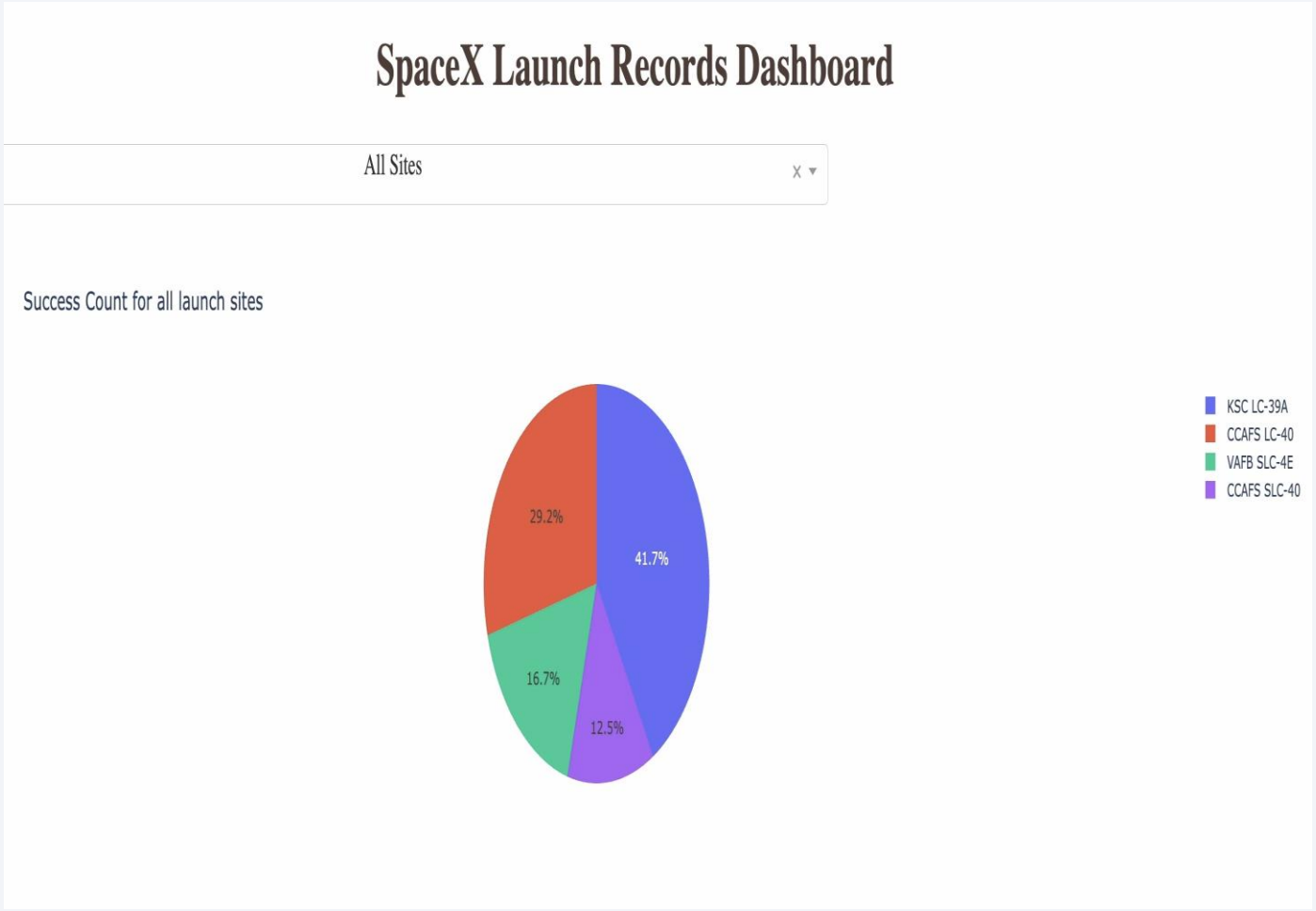


Launch Site Proximities Map



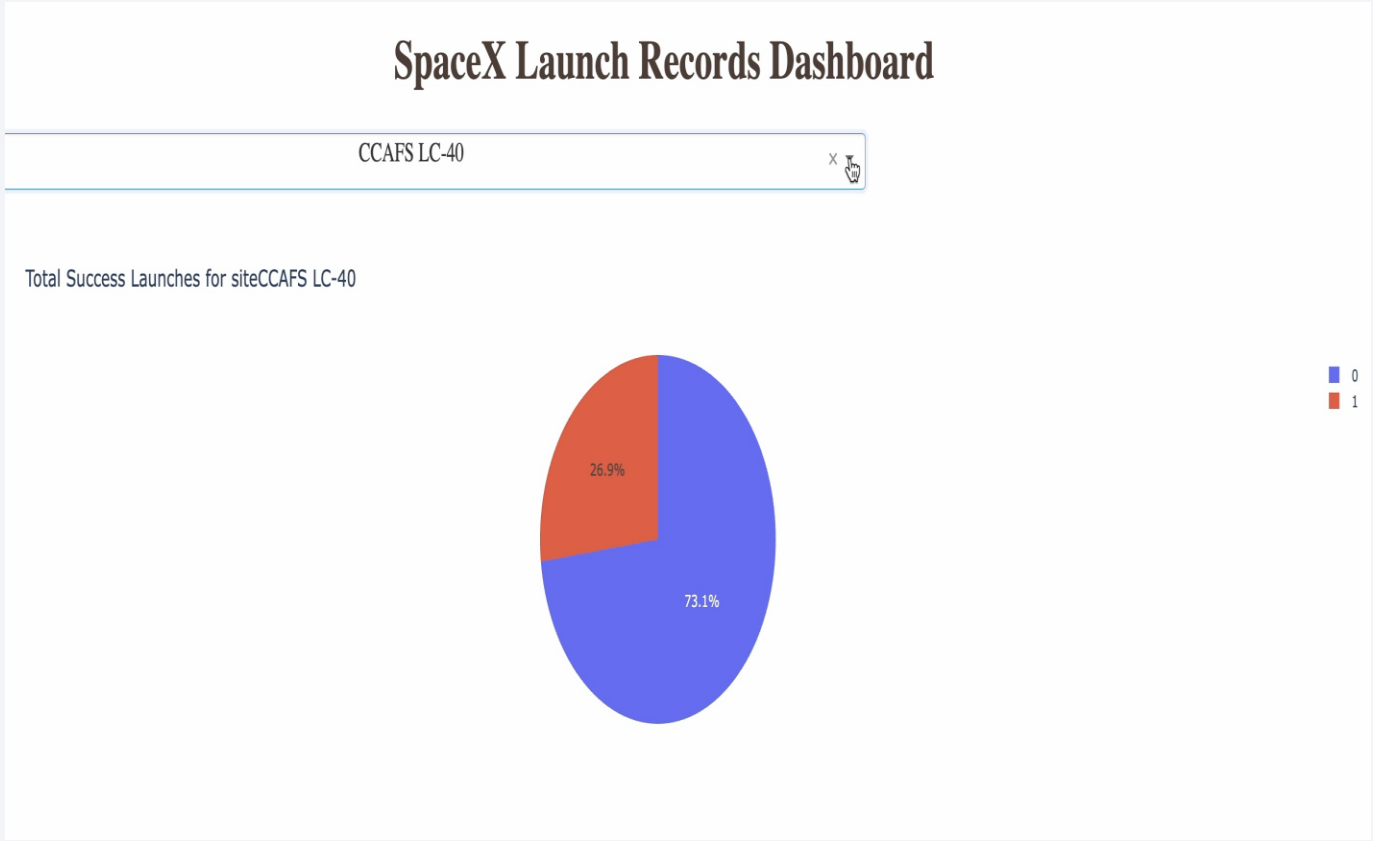

Section 4
Build a Dashboard with Plotly Dash

Success Count for All Sites



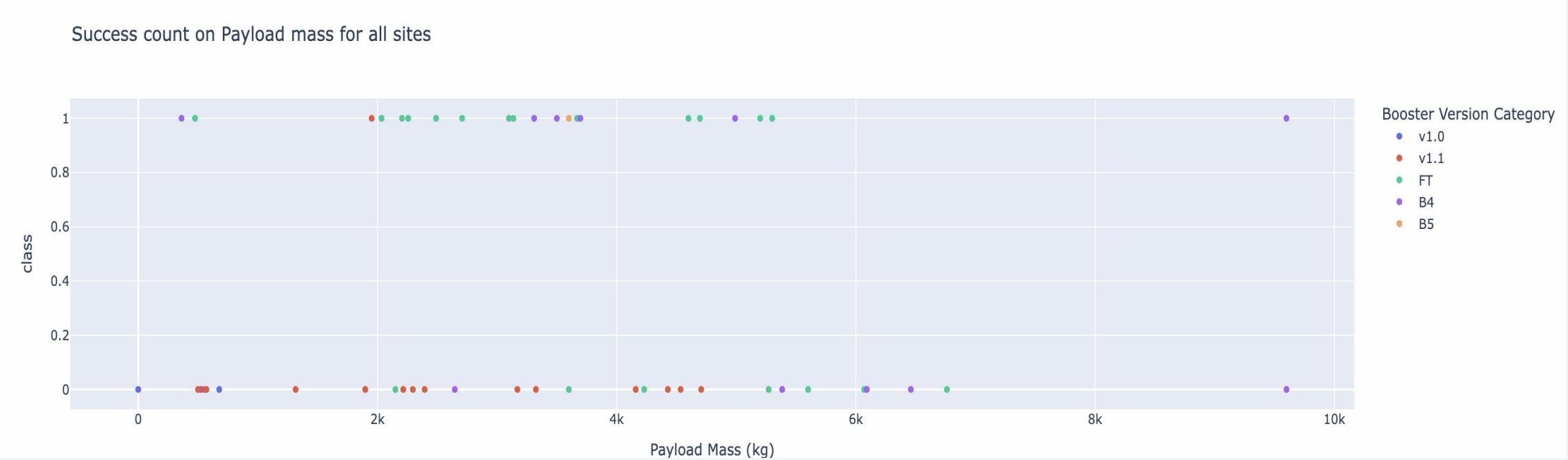
- KSC LC-39A has the most successful launces rate with 41.7%

Launch Success Ratio for CCAFS LC-40



- The second most successful Launch Site CCAFS LC-40 has % success rate

Payload vs. Launch Outcome for All Sites

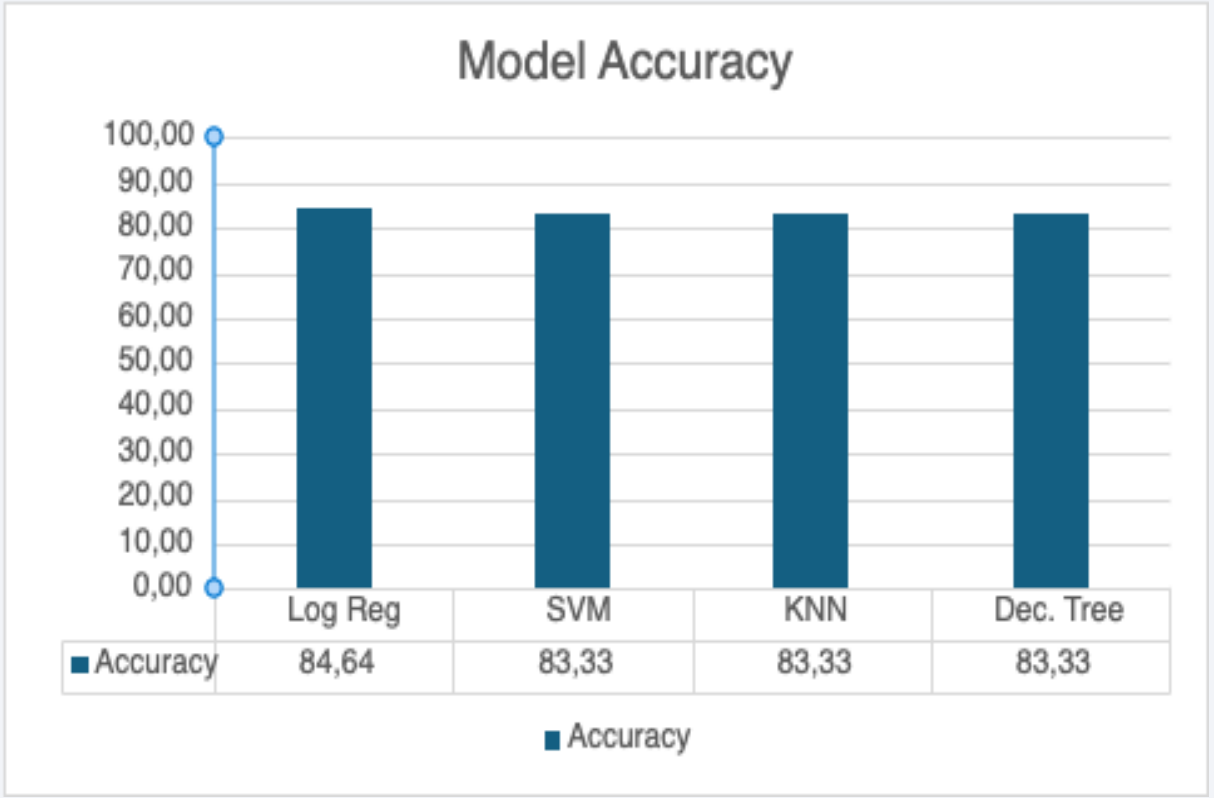


The success rates for low-weighted payloads is higher than the heavy-weighted payloads

Section 5

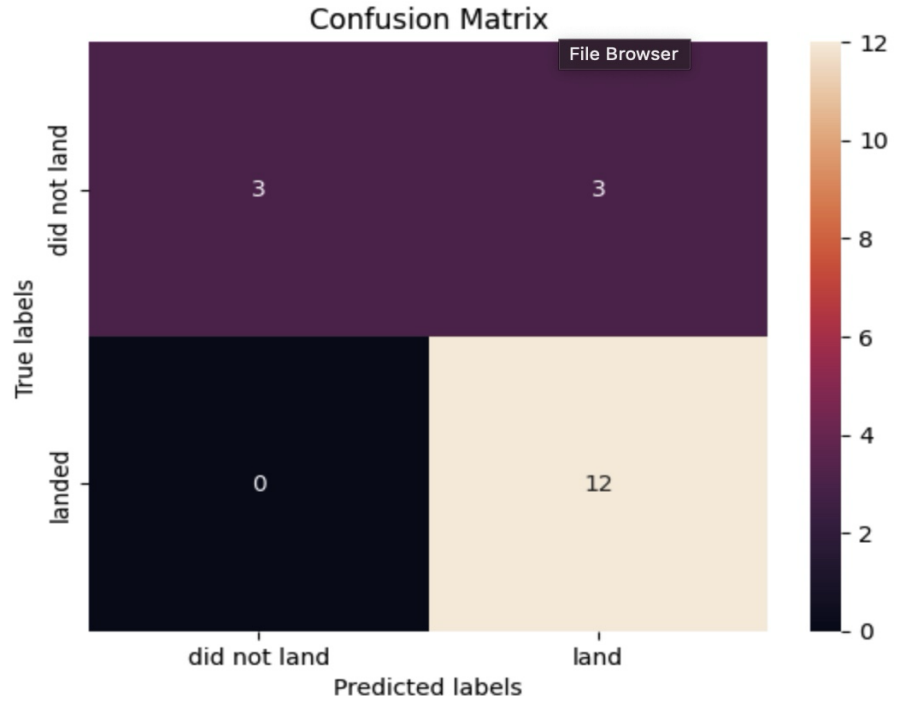
Predictive Analysis (Classification)

Classification Accuracy



Logictic Regression model has the highest classification accuracy

Confusion Matrix



Logistic Regression Confusion matrix

Examining the confusion matrix, we see that logistic regression can distinguish between the different classes. We see that the problem is false positives.

Overview:

True Postive - 12 (True label is landed, Predicted label is also landed)

False Postive - 3 (True label is not landed, Predicted label is landed)

Conclusions

- Logistic Regression model has better accuracy
- There are 12 True Positive and 3 False Positive

Thank you!