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

The data for this project was gathered by web scraping with BeautifulSoup and the SpaceX API to obtain information about the Falcon 9 launch wiki page. The data was then saved in a CSV file for comprehensive examination. Prior to doing exploratory and visual analysis, the data was cleansed by eliminating superfluous features, filling in the missing values, assigning a label for the predictive analysis, and lastly, transforming all of the categorical components into numerical representations. To get more understanding of the features and their relationship to the launch outcome, multiple visual analytics were then carried out. Several models were subjected to a predictive analysis in order to determine "whether a landing would be successful or not," and the model that performed the best overall was selected.

- Summary of all results
- Exploratory and Visual Analysis:
  - From 2010 to 2019, 61 missions had successful landing whereas 10 missions had failure landing, leading a success rate of 67.78%
  - Among the four Launch sites “KSC LC-39A” had the highest success rate (41.7%) whereas, “VAFB SLC-4E” had the lowest success rate (12.5%)

Executive Summary [Continued]

- Exploratory and Visual Analysis:
    - Among 11 orbit types , ES-L1, GEO, HEO, SSO were 100% successful with less than 6000 kg payload
    - Payload greater than 7500 kg had a higher chance of successful landing
    - In 0-10000 kg payload range “FT” booster version has the largest success rate
- Launch Site Proximity Analysis:
    - SpaceX has 4 launch sites, one is near California, the other three is near Florida and South Texas.
    - All the sites are in near proximity to ocean
    - All the sites are bit far away from the city
    - All the sites are nearer to the railroads than highways
- Predictive Analysis:
    - Logistic Regression and Decision Tree performed well in comparison with other models, with the highest accuracy of 83.3%

Introduction

Project background and context

- SpaceX is a company that aims to make commercial space travel more affordable for everyone. By reusing the first stage of the rocket *Falcon9* (the first orbital class rocket capable of re-flight), this company can launch rockets in a relatively high cost-efficient manner.
- In this project, we are working for a company, Space Y, which is going to compete with SpaceX. Our goal is to find the cost of each launch. And this cost primarily depends on the successful landing of the first stage. Hence, we are presenting a classification analysis on whether the first stage would be successful or not.

Problems we want to find answers

- Will SpaceX reuse the first stage?
- Will SpaceX attempt to land a rocket or not? i.e., will the first stage land successfully

Section 1

Methodology

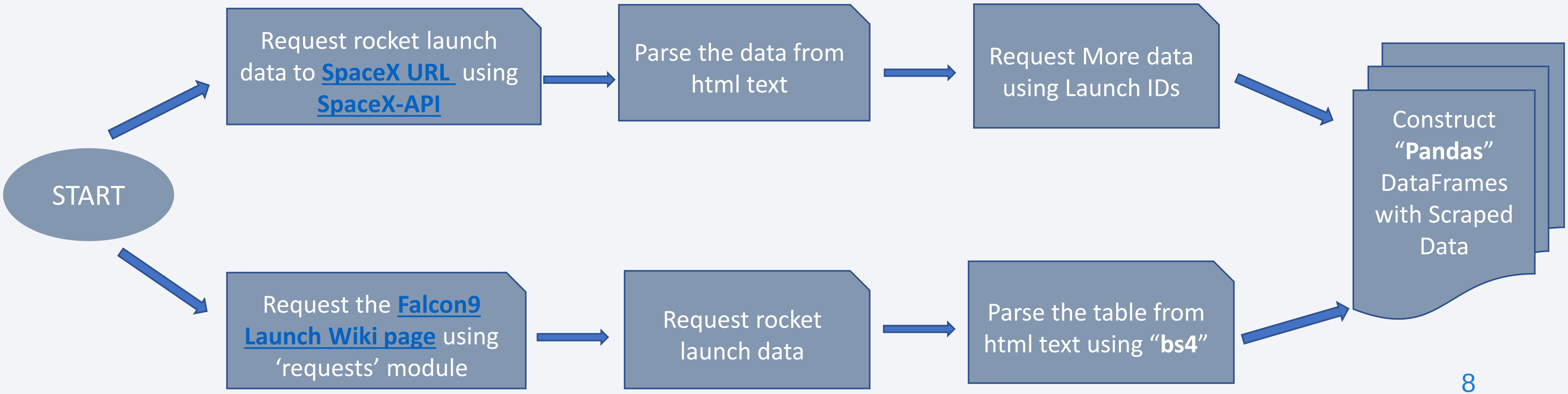
Methodology

Executive Summary

- Data collection methodology:
  - Data was collected via SpaceX API and web scraping using python “bs4” package.
- Perform data wrangling
  - Data was processed via python “pandas”, “numpy” packages.
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - Classification models were built, tuned, evaluated using python “sklearn”, “pandas”, and, “matplotlib” packages

Data Collection

- Data sets were collected in two separate processes – using SpaceX API and web scraping SpaceX wiki page. Scraped datasets were later preprocessed and stored in separate CSV files.

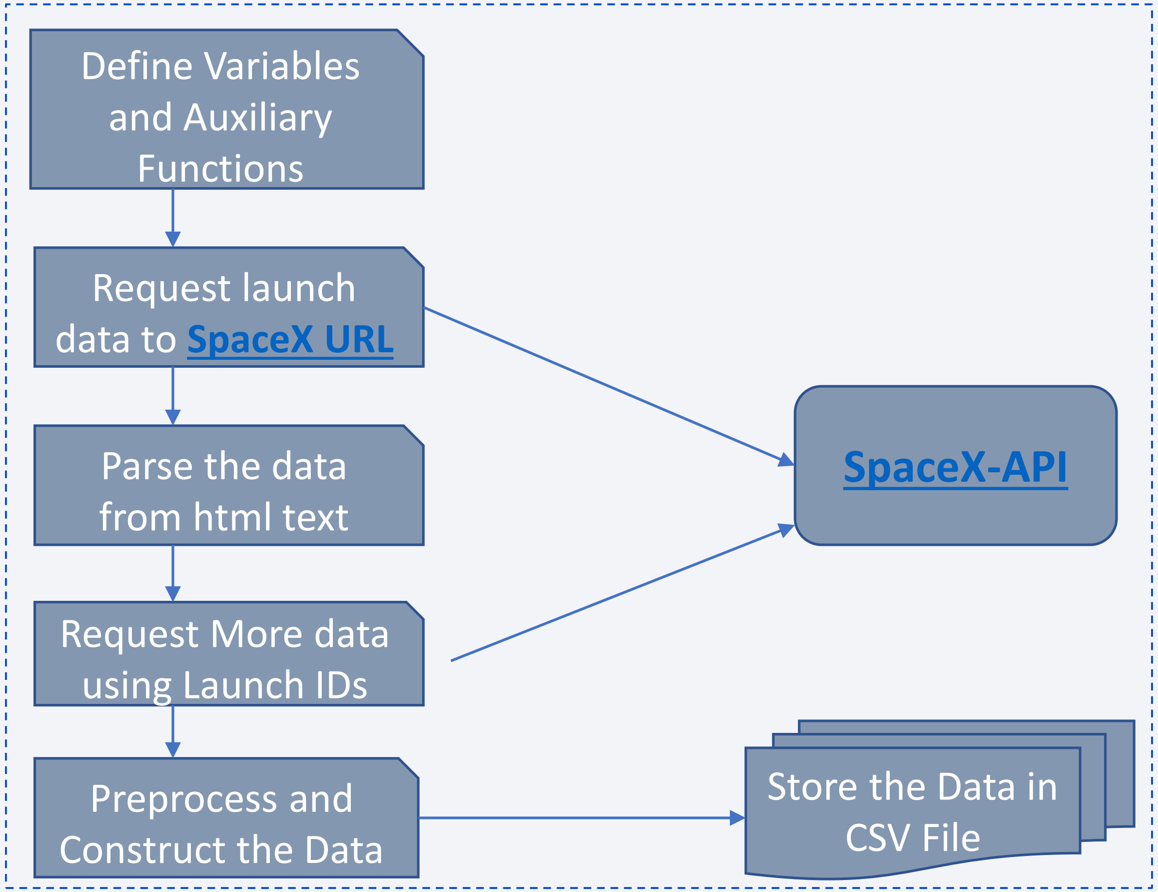


Data Collection – SpaceX API

In this Process:

- The data is collected by using *SpaceX REST API*
- Perform a get request using the *requests library* to obtain the launch data
- Use the *SpaceX URL* to target a specific endpoint of the API to get past launch data

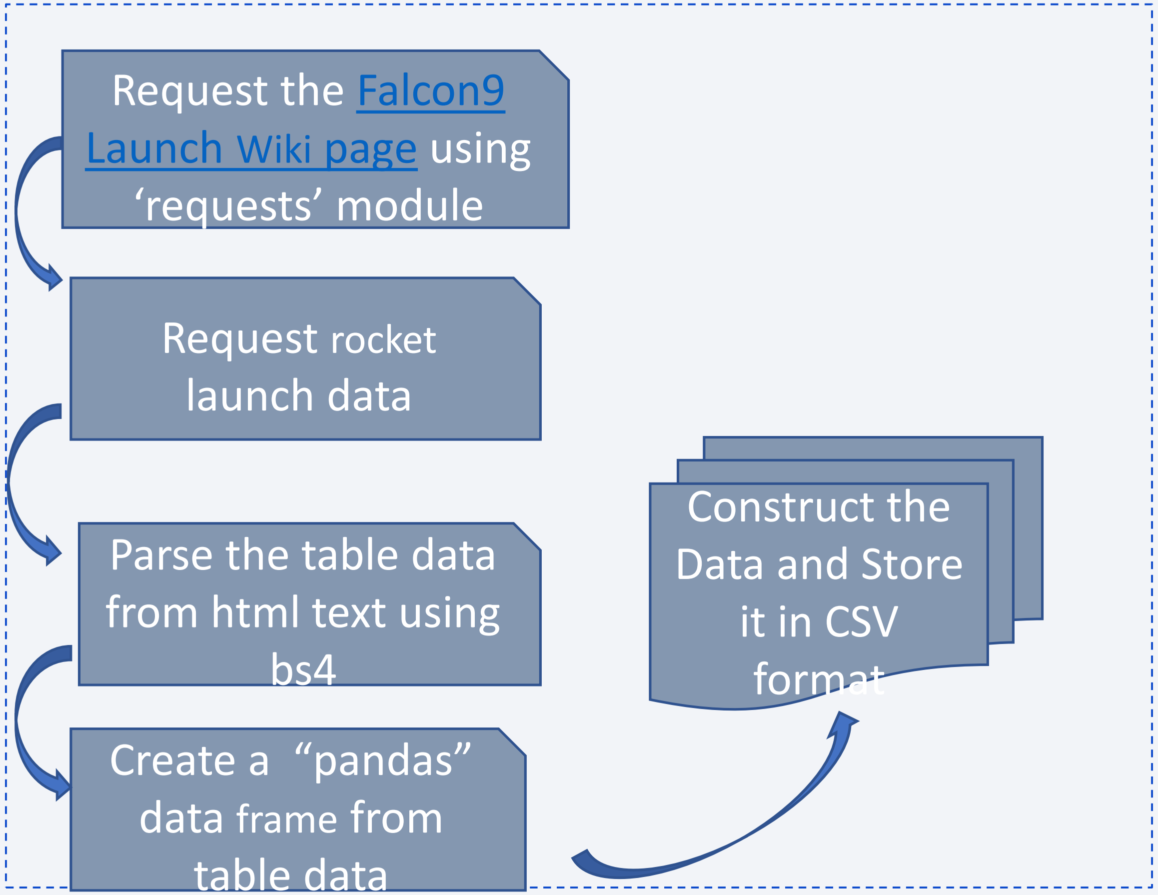
[GitHub URL of the completed SpaceX API calls notebook]



Data Collection - Scraping

In this Process:

- Using *requests module*, get request from *Falcon9 Launch Wiki page.*
- Using python’s *BeautifulSoup package*, web scrape HTML tables containing valuable Falcon 9 launch recording
- Parse the data from the tables and convert them into a pandas data frame

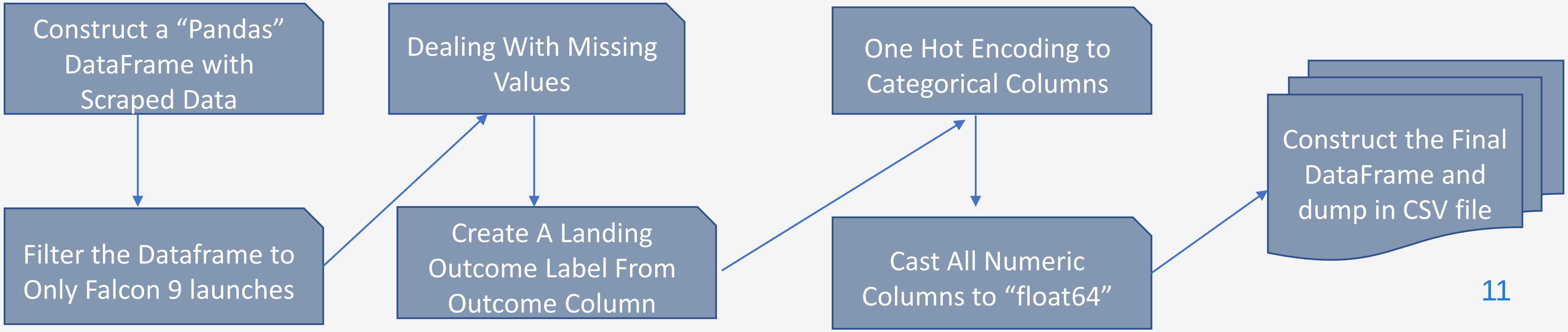


[GitHub URL of the completed web scraping notebook]()

Data Wrangling

- Filtered out the Falcon 1 launches data
- Replaced the null values inside of PayLoadMass by its mean value
- Created a Landing Outcome label from Outcome column
- Converted all categorical columns to One Hot Encode

GitHub URL of completed data wrangling related notebook-1, notebook-2, notebook-3



EDA with Data Visualization

For Explorative Data Analysis, following charts were used:

CatPlot :

- FlightNumber vs LaunchSite : To visualize the relationship between Flight Number and Launch Site
- Payload vs Launch Site : To visualize the relationship between Payload and Launch Site
- FlightNumber vs Orbit type : To visualize the relationship between Flight Number and Orbit type
- Payload vs Orbit type : To visualize the relationship between Payload and Orbit type

EDA with Data Visualization [Continued]

Bar Chart

- Orbit vs Success Rate : To visualize the relationship between success rate of each orbit type

Line chart

- Year vs Class : To visualize the launch success yearly trend.

GitHub URL of the completed EDA with data visualization notebook

EDA with SQL

SQL queries performed :

- To display the names of the unique launch sites in the space mission
- To display 5 records where launch sites begin with the string 'CCA’
- To display the total payload mass carried by boosters launched by NASA (CRS)
- To display average payload mass carried by booster version “F9 v1.1”
- To list the date when the first successful landing outcome in ground pad was achieved
- To list the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 6000

EDA with SQL [Continued]

SQL queries performed:

- To list the total number of successful and failure mission outcomes
- To list the names of the booster versions which have carried the maximum payload mass. Use a subquery
- To list the failed landing outcomes in drone ship, their booster versions, and launch site names for in year 2015
- To 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

GitHub URL of the completed EDA with SQL notebook

Build an Interactive Map with Folium

Map objects which are created and added to the folium map are given below :

- Markers : It marked a specific area with a text label on a specific coordinate
- Circles : It highlighted circle area with a text label on a specific coordinate
- MarkerCluster : Marker clusters are used to simplify the containing many markers having the same coordinates.
- MousePosition : To get coordinate for a mouse over a point on the map. It helps to find the coordinates easily of any points of interests while exploring the map.
- PolyLine : It draws polyline overlays on a map. It is used to denote the distance between a launch site and its proximities.

GitHub URL of the completed interactive map with Folium map

Build a Dashboard with Plotly Dash

Plots/graphs and interactions which are added to the dashboard -

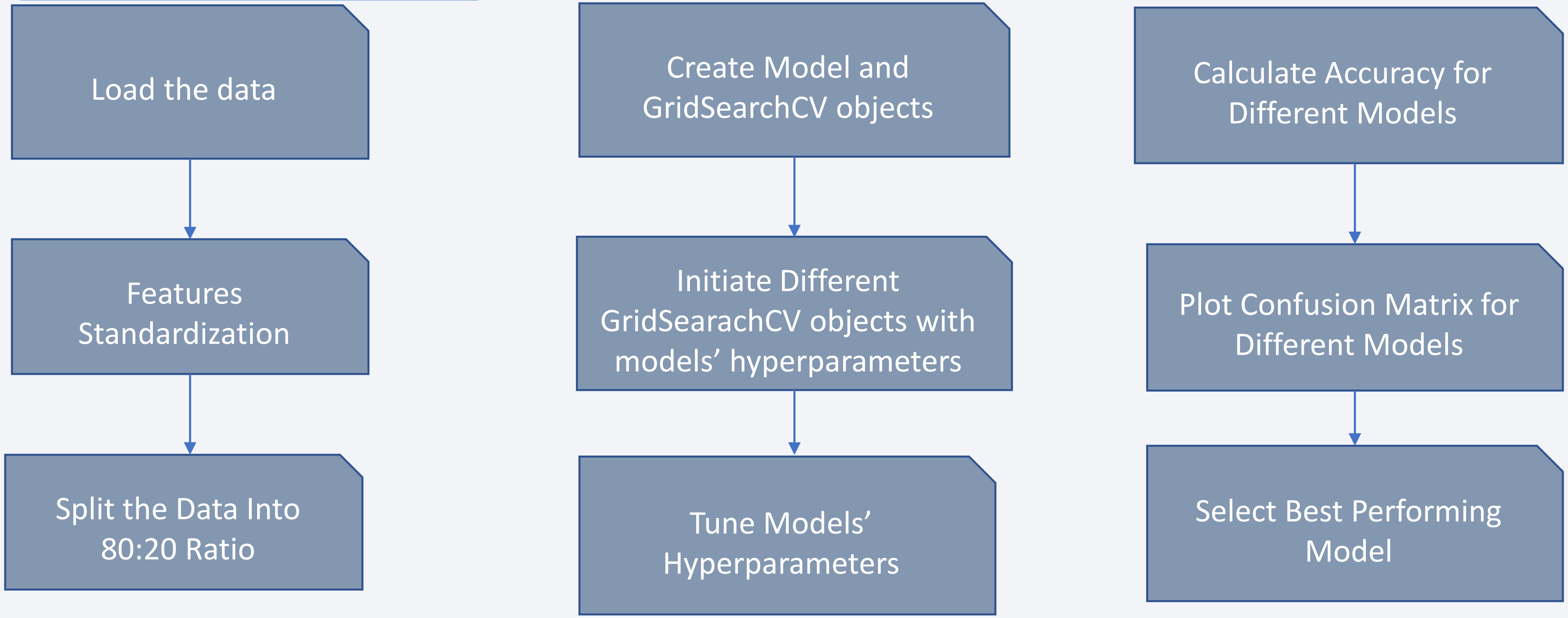
- Drop-down Input Component : To select different launch sites
- Pie-chart : To visualize total success launches ratio by site
- Range Slider : To select range of payload mass (kg)
- Scatter Plot : To visualize the correlation between payload and success launch for all sites

1. GitHub URL of the completed Plotly Dash Lab Python file

Predictive Analysis (Classification)

The Following chart illustrates the whole predictive analysis workflow: from loading the data to selecting best model for classification.

[GitHub Notebook URL]



Results

- Exploratory data analysis results
  - From 2010 to 2019, 61 missions had successful landing whereas 10 missions had failure landing, leading a success rate of 67.78%
  - Among the four Launch sites “KSC LC-39A” had the highest success rate (41.7%) whereas, “VAFB SLC-4E” had the lowest success rate (12.5%)
  - Payload greater than 7500 kg had a higher chance of successful landing
  - Among 11 orbit types , ES-L1, GEO, HEO, SSO were 100% successful with less than 6000 kg payload
  - In 0-10000 kg payload range “FT” booster version has the largest success rate.

Results [Continued]

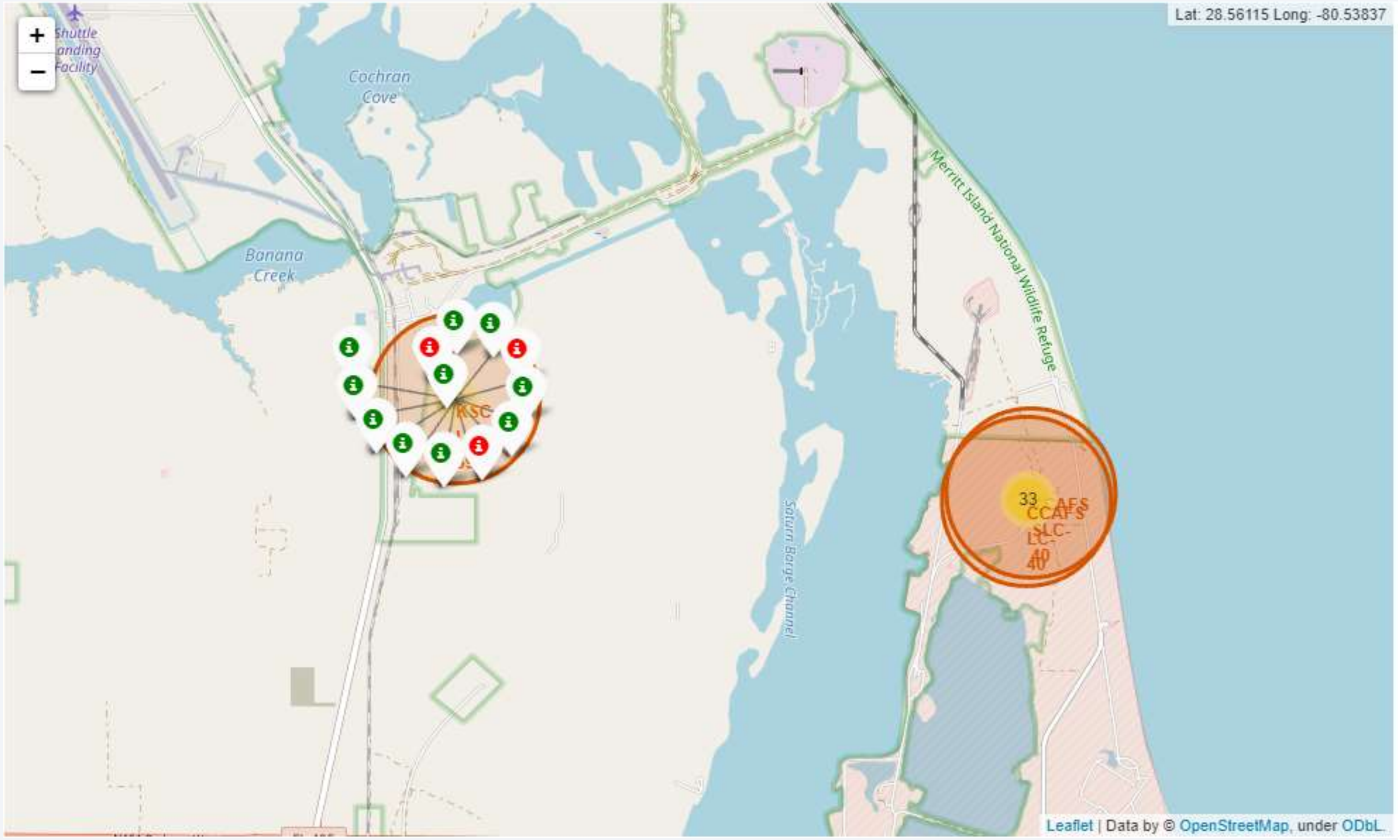
- Interactive analytics via Folium Map

Results [Continued]

- Interactive analytics via Folium Map

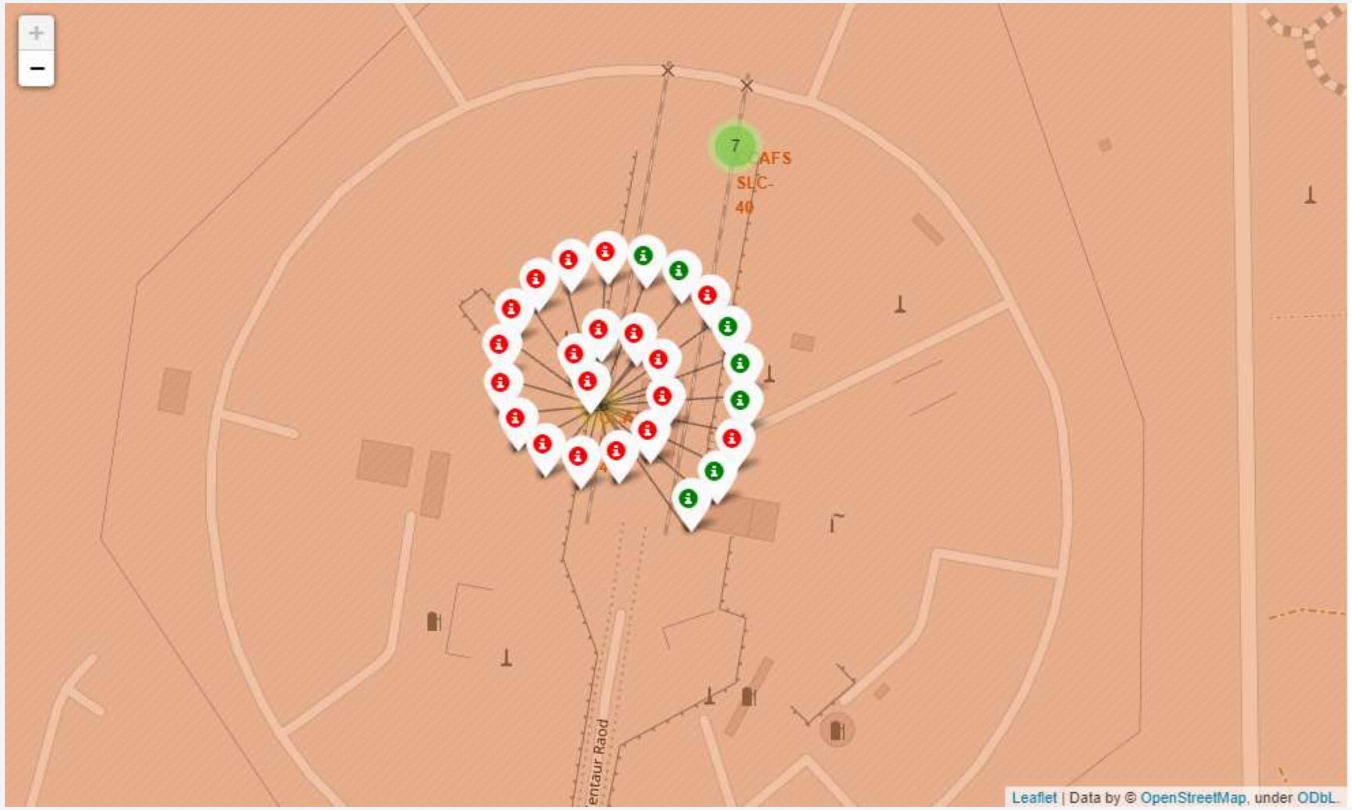
Results [Continued]

- Interactive analytics via Folium Map



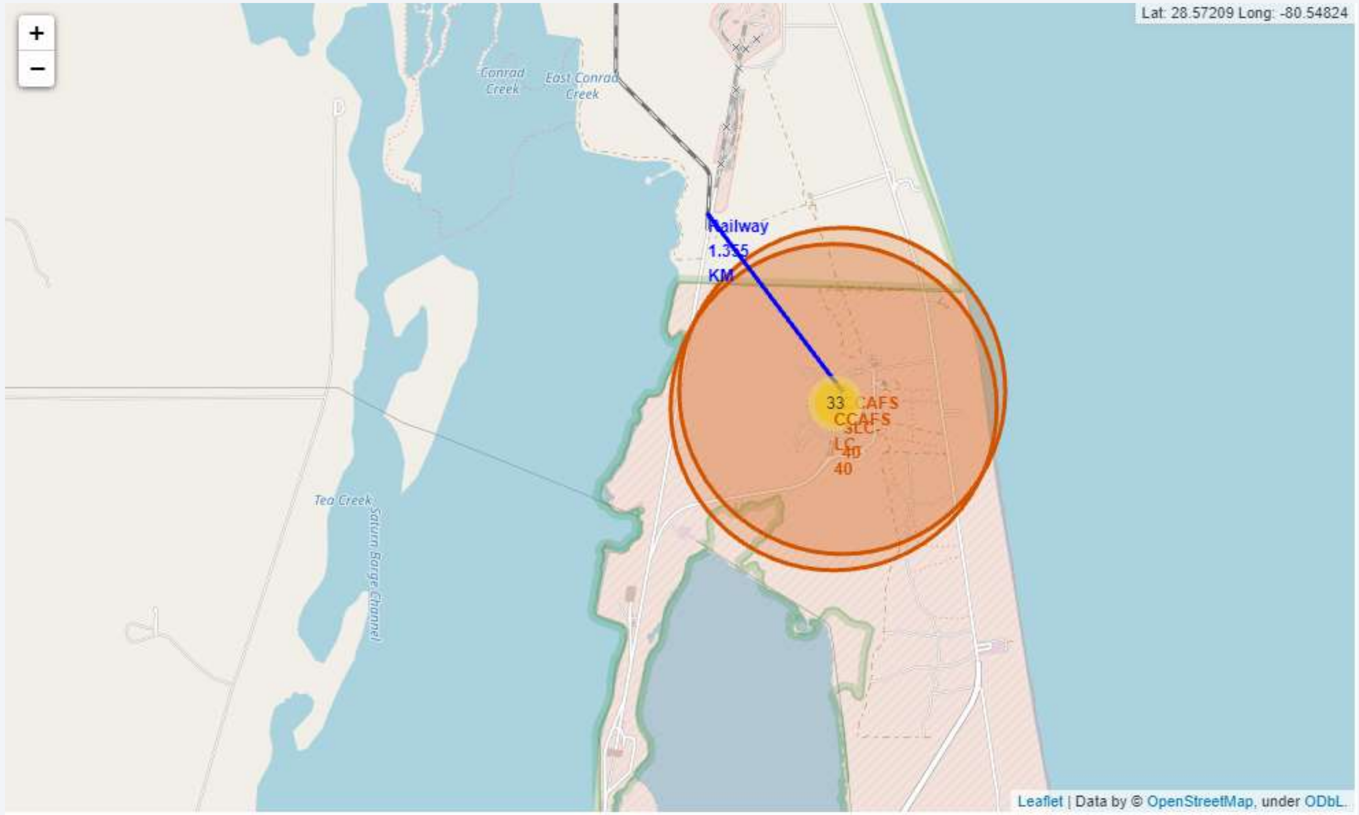
Results [Continued]

- Interactive analytics via Folium Map



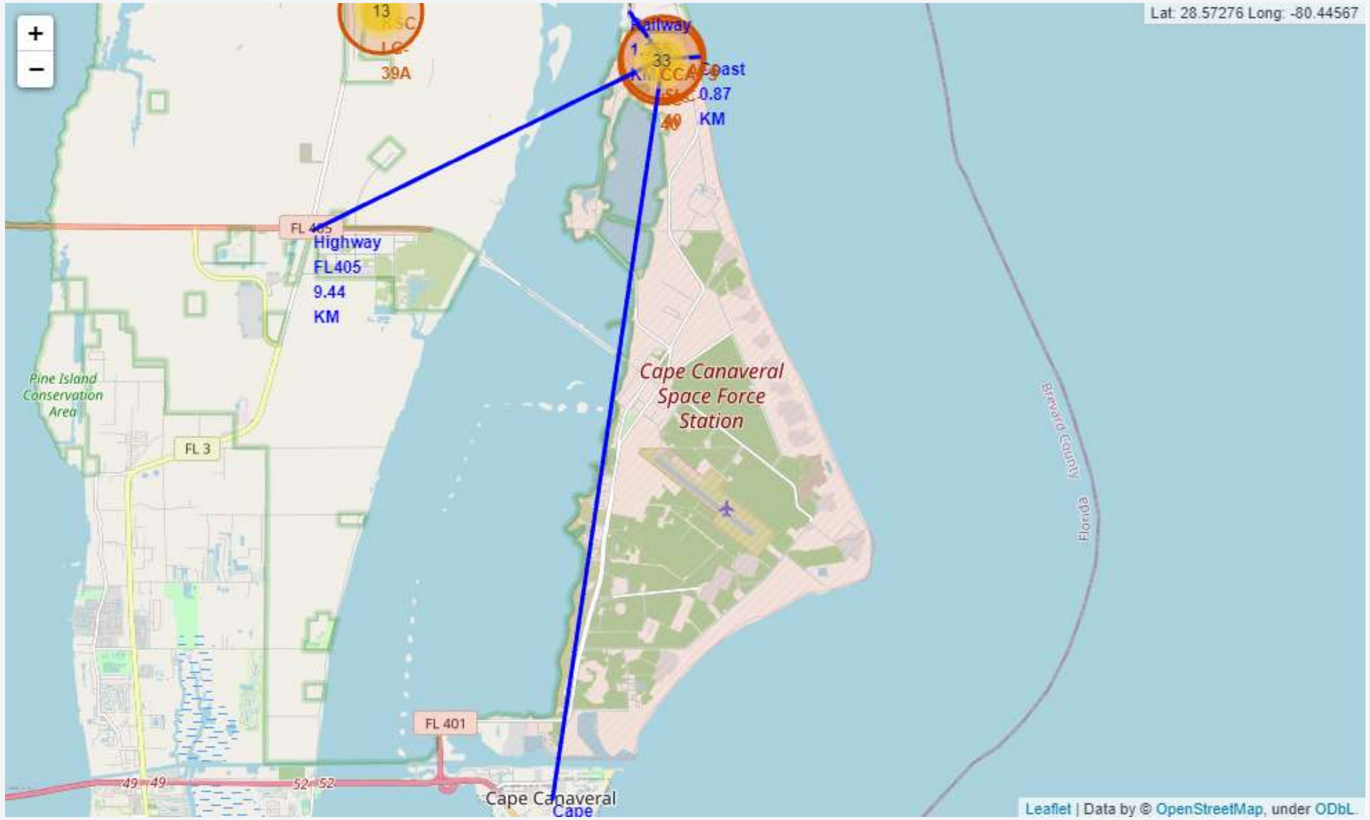
Results [Continued]

- Interactive analytics via Folium Map



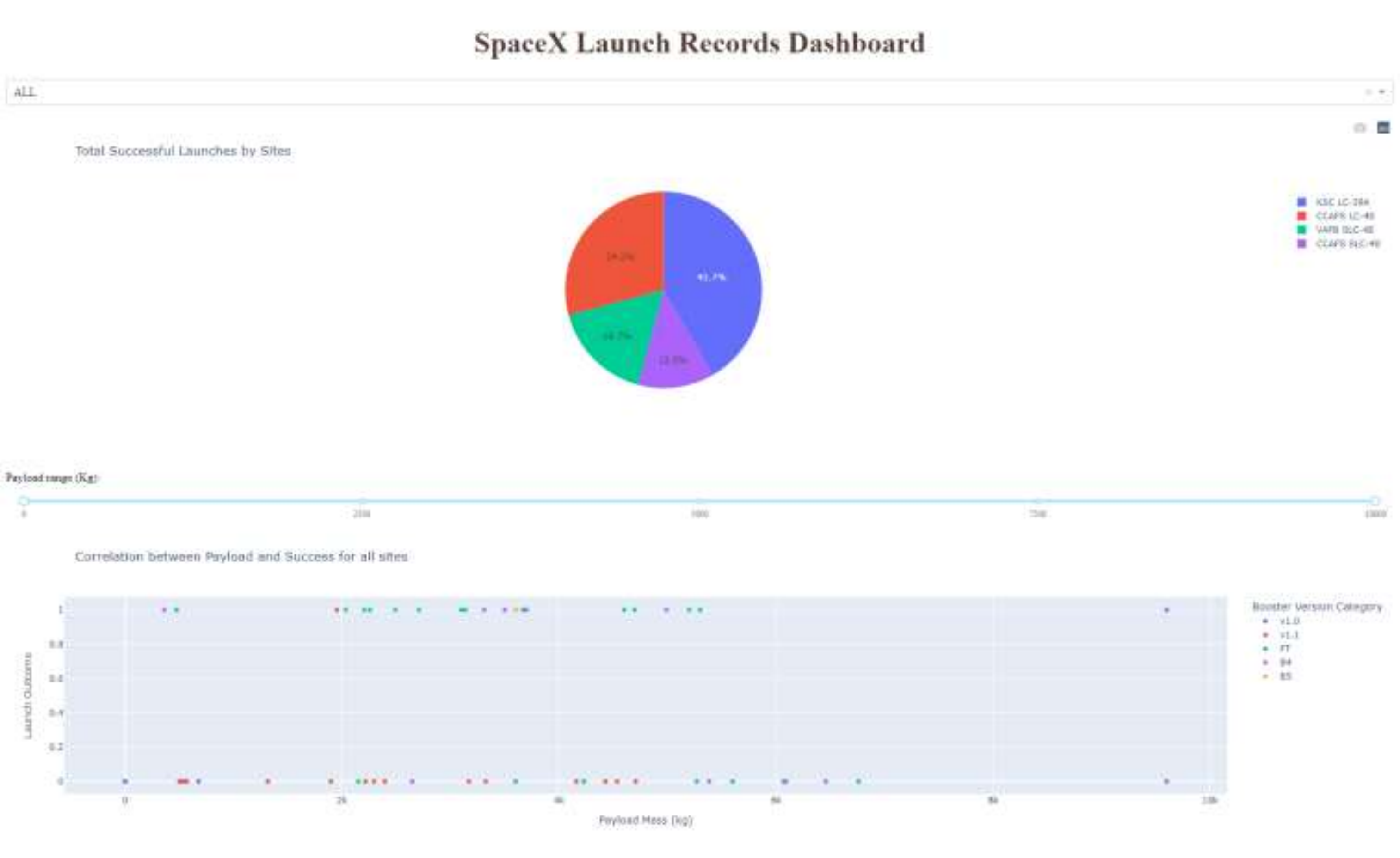
Results [Continued]

- Interactive analytics via Folium Map



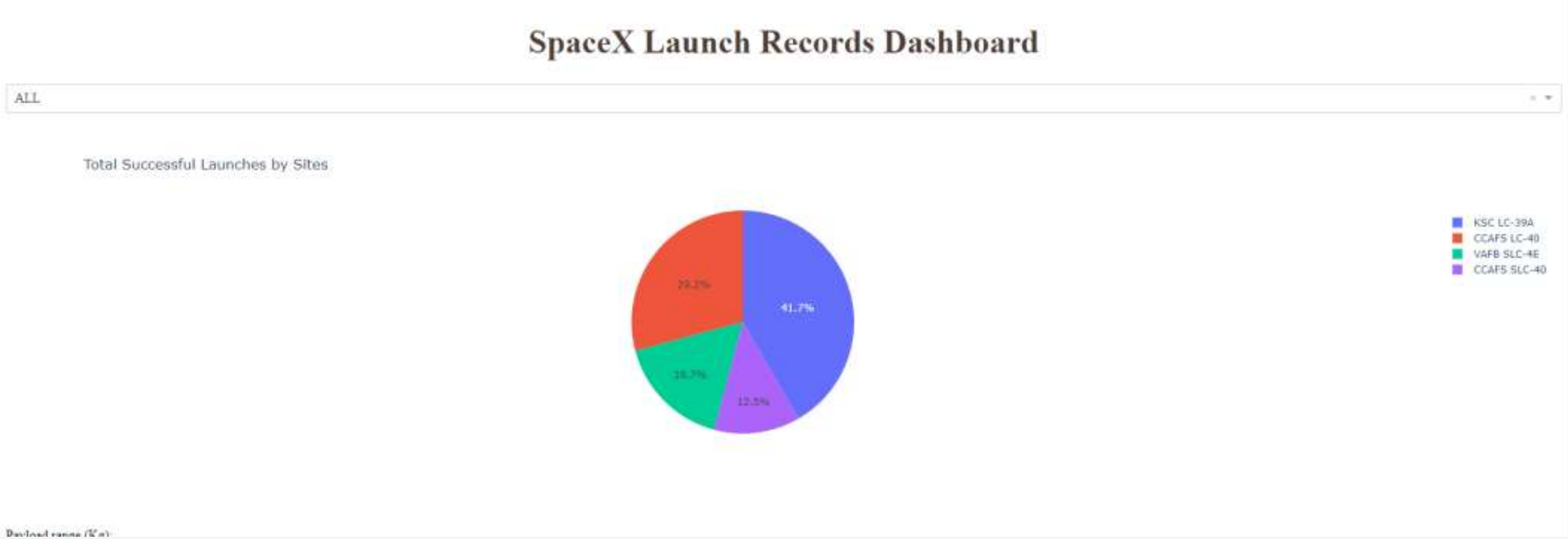
Results [Continued]

- Interactive analytics Dashboard



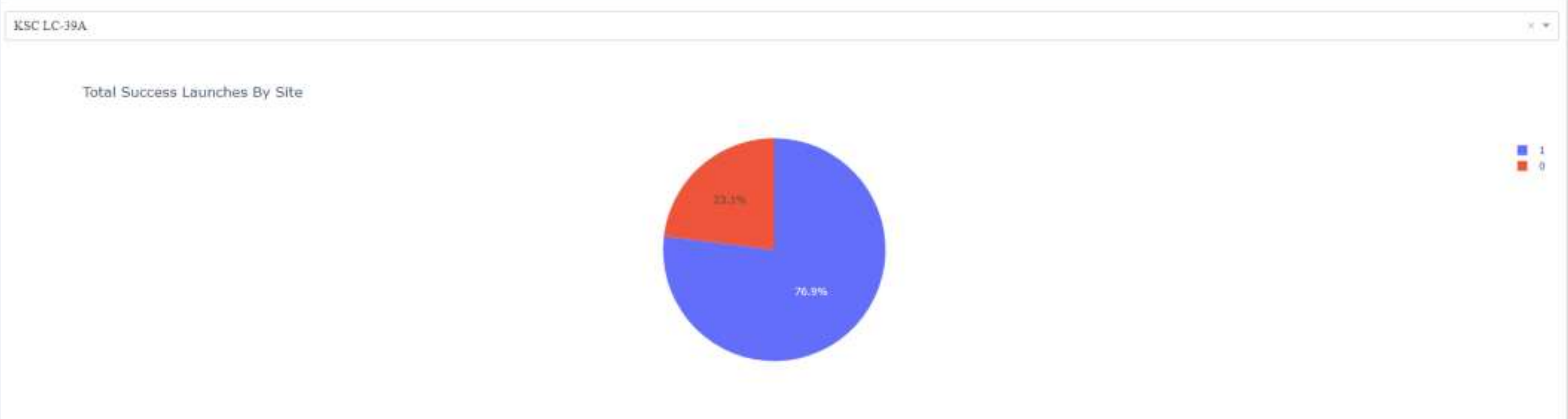
Results [Continued]

- Interactive analytics Dashboard



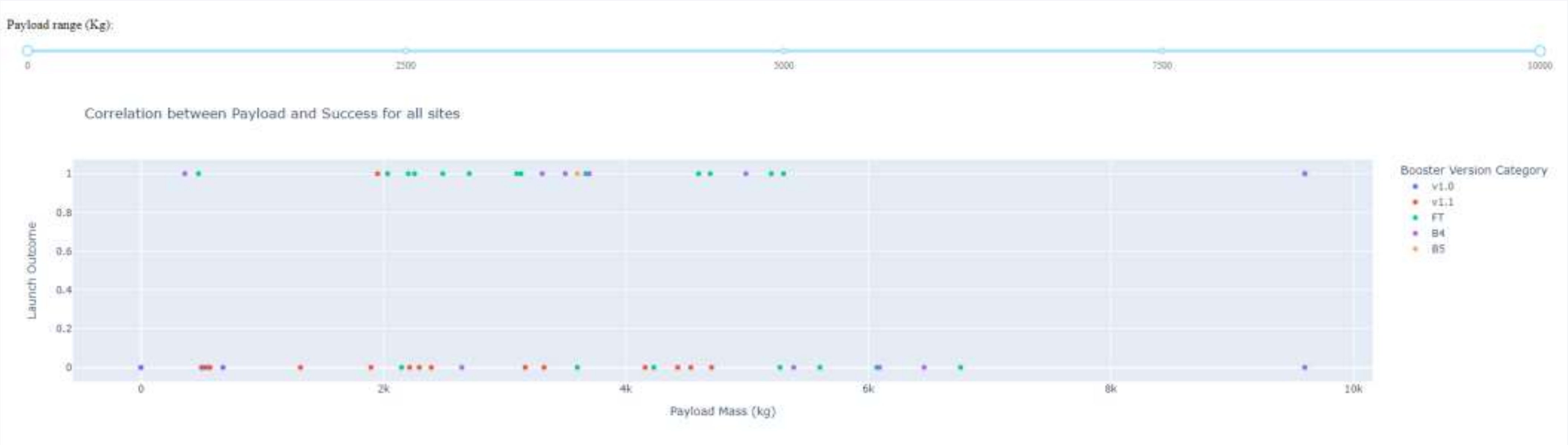
Results [Continued]

- Interactive analytics Dashboard



Results [Continued]

- Interactive analytics Dashboard



Results [Continued]

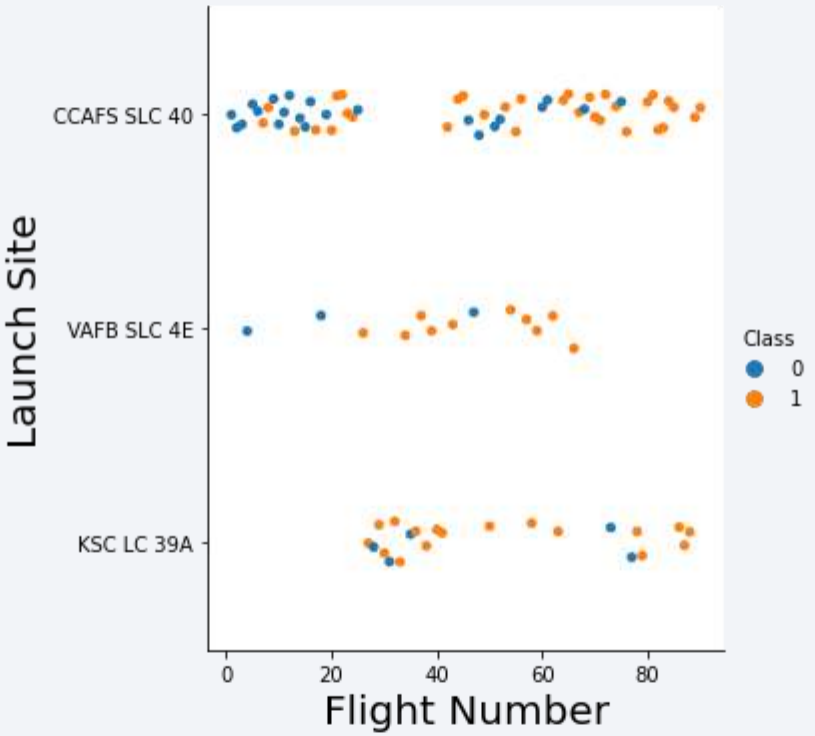
- Predictive analysis results
  - Performed a predictive analysis on the dataset using Logistic Regression, SVM, Decision Tree and KNN Classifier
  - Logistic Regression and Decision Tree performed well in comparison with other models, with the highest accuracy of 83.3%

Section 2

Insights drawn from EDA

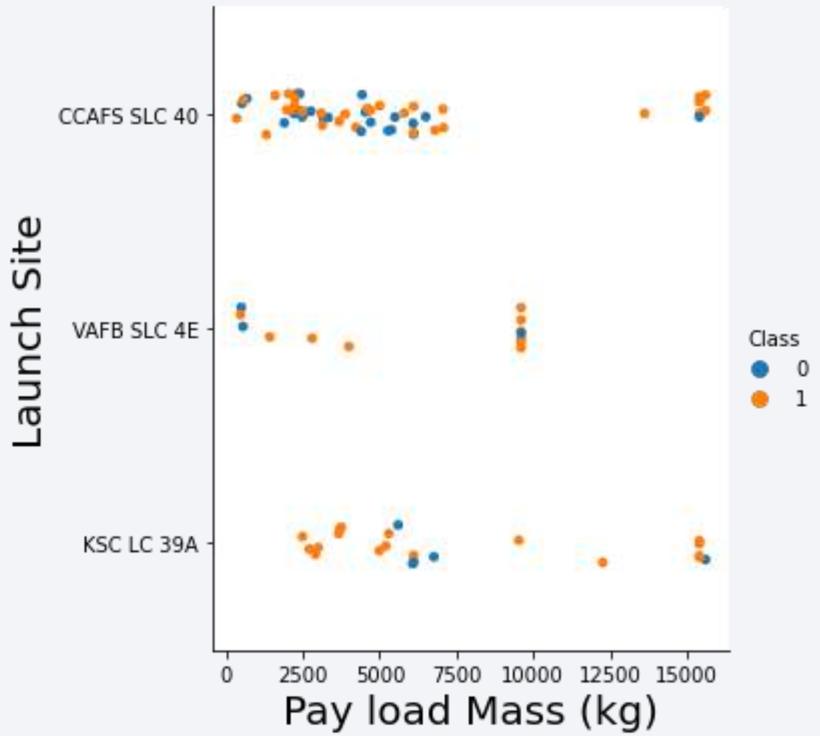
Flight Number vs. Launch Site

- Success rate was gradually increasing for every launch site
- After flight count reached 40, success rate increased dramatically



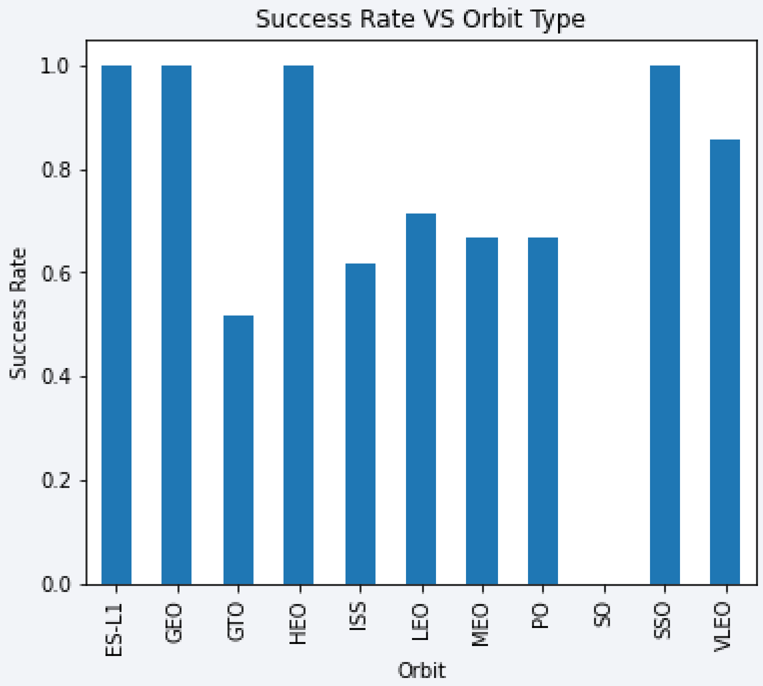
Payload vs. Launch Site

- Payload greater than 7500 kg had a higher chance of successful landing (in all cases)
- KSC LC 39A had the highest success rate among the 4 launch sites



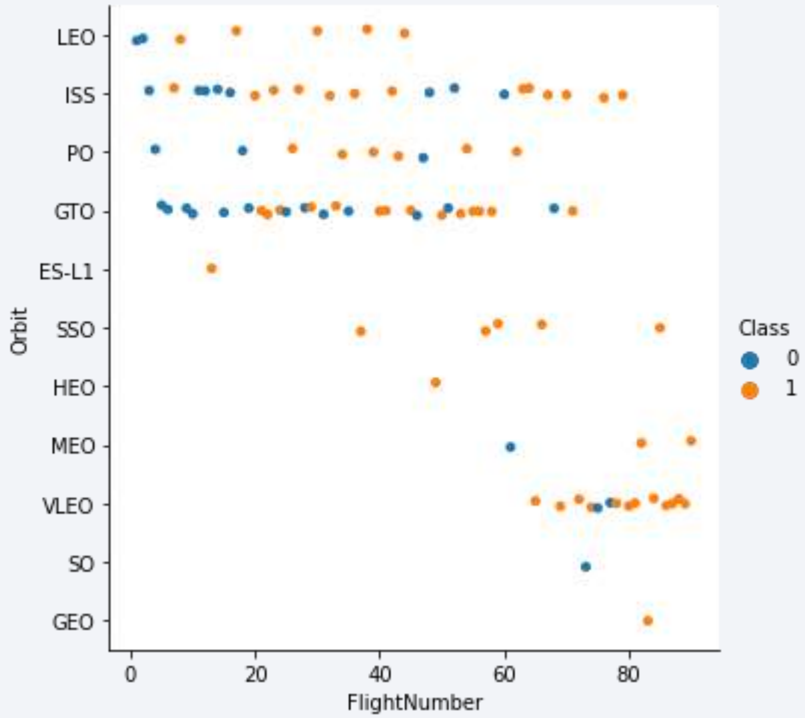
Success Rate vs. Orbit Type

- “SO” orbit had no success
- Among 11 orbit types , 4 types were 100% successful(ES-L1, GEO, HEO, SSO)
- “GTO” had approximately 50% success rate whereas the rest of the orbit types had more than 50% success rate



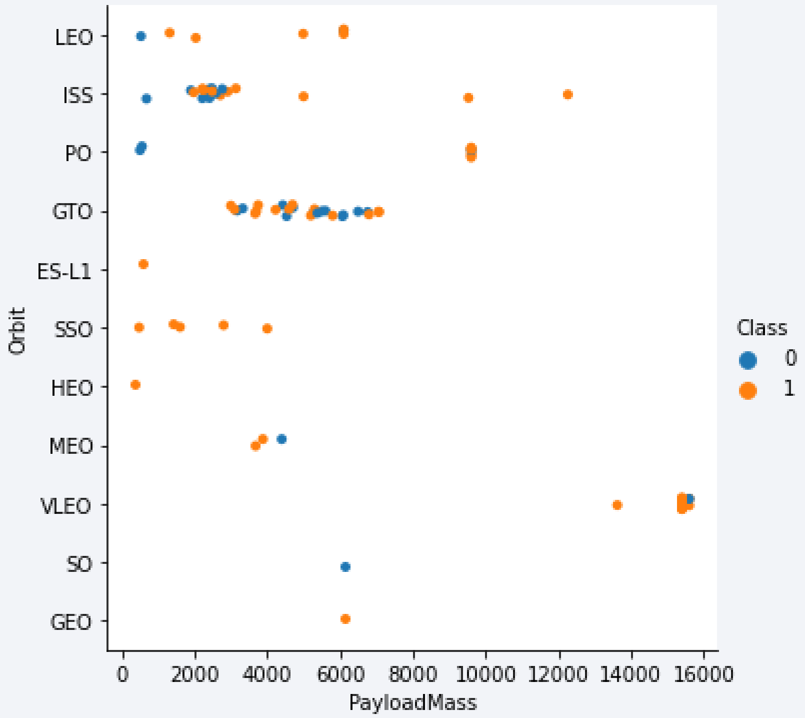
Flight Number vs. Orbit Type

- LEO , ISS, PO ,GTO had more flight counts than other orbit types
- SO,GEO,HEO orbit type had only 1 flight which was a failure, success and success respectively
- ES-L1, SSO, GEO, HEO had 100% success landing in terms of flights.



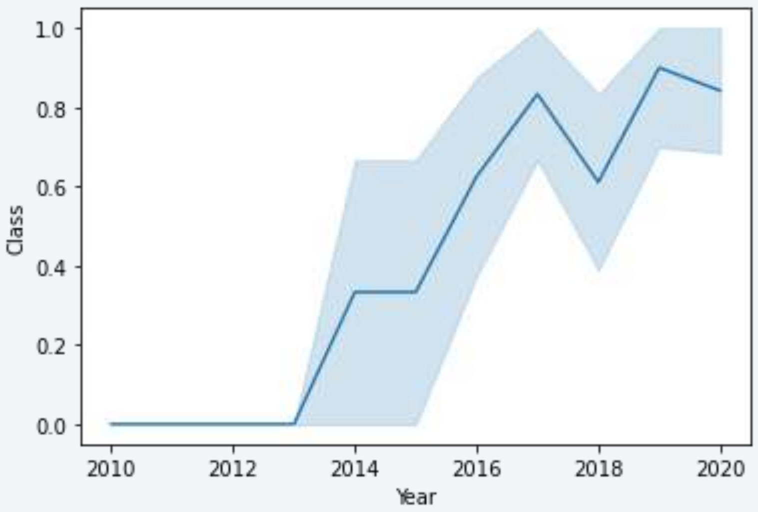
Payload vs. Orbit Type

- Only ISS, PO and VLEO orbits carried more than 8000 kg payload.
- ES-L1, SSO, HEO,GEO had less than 6000 kg payload in their orbit with 100% success



Launch Success Yearly Trend

- Before 2013, there was no success
- After 2013 success rate increased dramatically
- Launch success peaked in 2019



All Launch Site Names

- There are total of 4 launch sites, the list is given below -

Launch Site
CCAFS LC-40
CCAFS SLC-40
KSC LC-39A
VAFB SLC-4E

Launch Site Names Begin with 'CCA'

- The below list represents 5 records where launch sites begin with `CCA`, all of them refers to the same launch site

Launch Site
CCAFS LC-40
CCAFS LC-40
CCAFS LC-40
CCAFS LC-40
CCAFS LC-40

Total Payload Mass

- Total payload carried by boosters from NASA (CRS)

Total Payload Mass
48213

Average Payload Mass by F9 v1.1

- The average payload mass carried by booster version F9 v1.1. It is approximately 2500 kg.

Avg Payload Mass (F9 v1.1)
2534.666666

First Successful Ground Landing Date

- The date of the first successful landing outcome on ground pad. It is at the end of 2015.

Date
2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

- The below list represents the names of boosters which have successfully landed on drone ship and had payload mass greater than 4000 but less than 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

- The total number of successful and failure mission outcome. The successful outcomes is 6 times of the failure outcomes.

Successful outcomes	Failure outcomes
61	10

Boosters Carried Maximum Payload

- The below list represents the names of the booster which have carried the maximum payload mass. There are total of 12 them.

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

2015 Launch Records

- The below list represents the failed landing outcomes in drone ship, their booster versions, and launch site names for in year 2015. It happened in the same launch site.

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

- The below list represents the ranking of 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.

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

Section 3

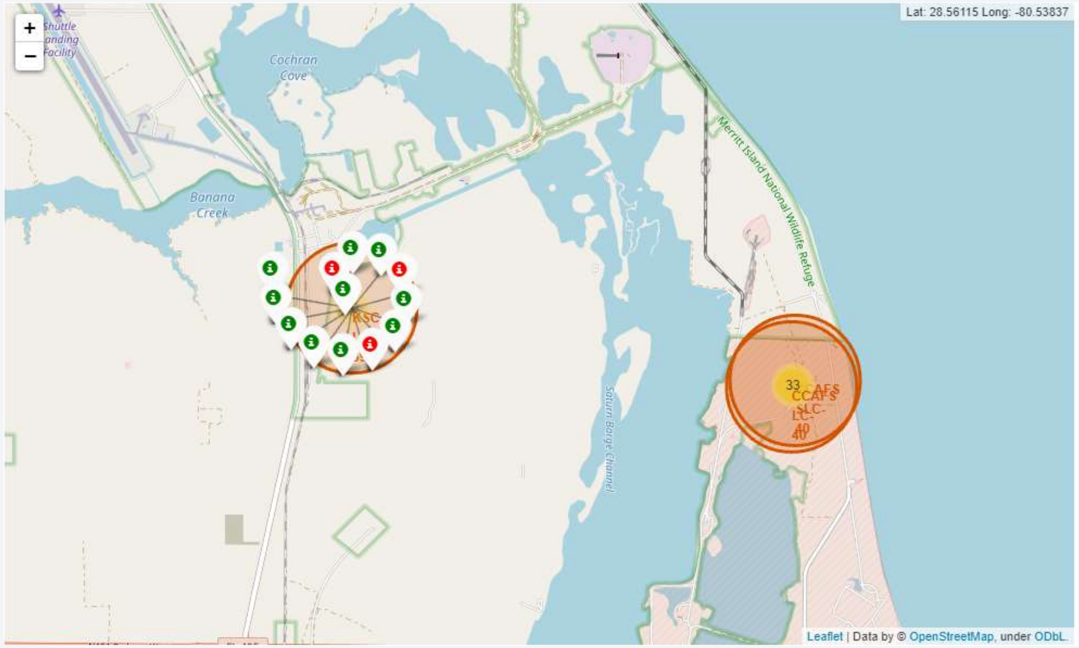
Launch Sites Proximities Analysis

All Launch Sites Of SpaceX On The Map

SpaceX has 4 launch facilities, one is near California, the other three is near Florida and South Texas. All facilities are near the ocean.

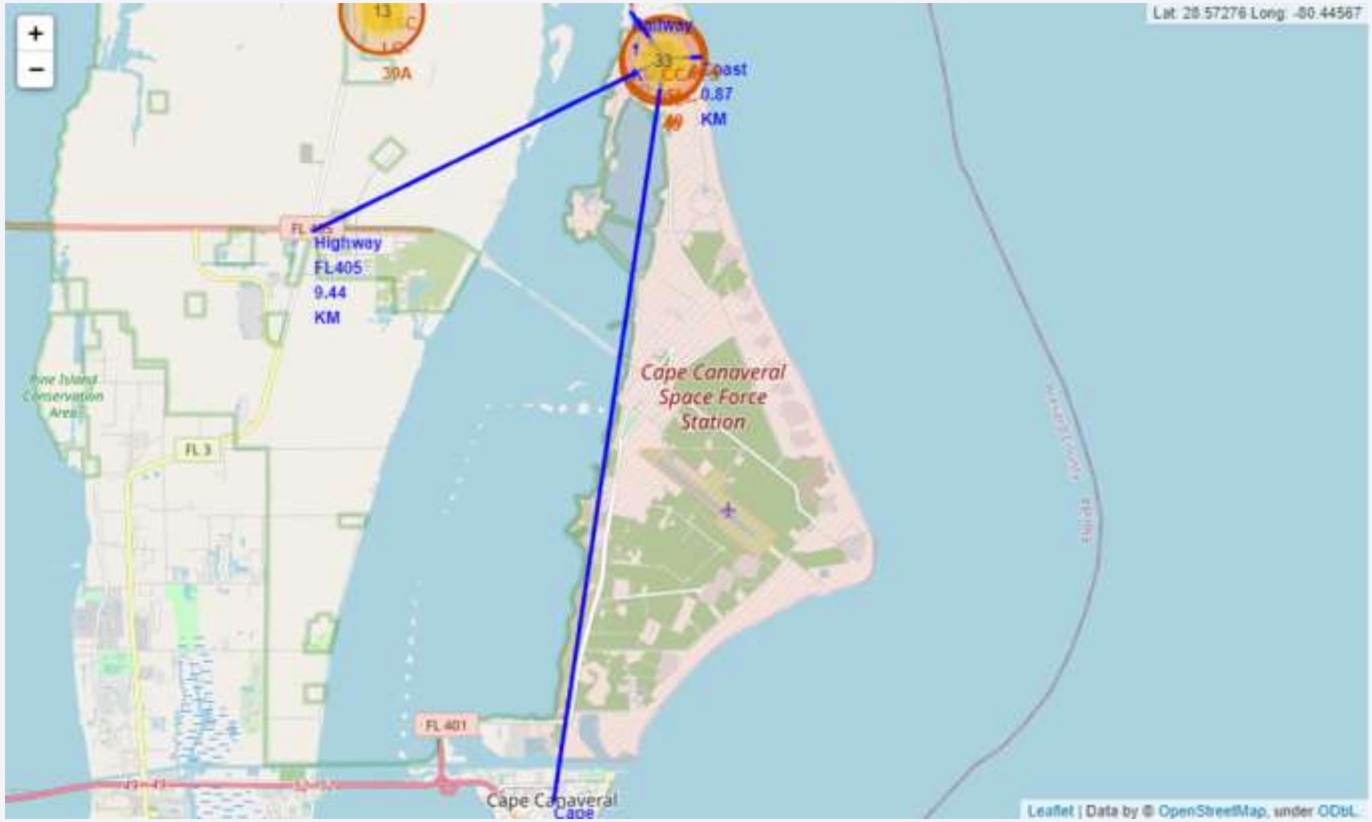
Success/Failed Launches For Each Site On The Map

Marker clusters is used to simplify the map containing many markers having the same coordinate (check 3 locations near Florida). Successful launches are marked using a green marker and failed launches are marked using a red marker.



Distance Between A Launch Site To Its Proximities

- A blue distance line denotes the distance between a launch site (CCAFS SLC-40) to its near proximities (Coast line, Railroad, Highway and City)

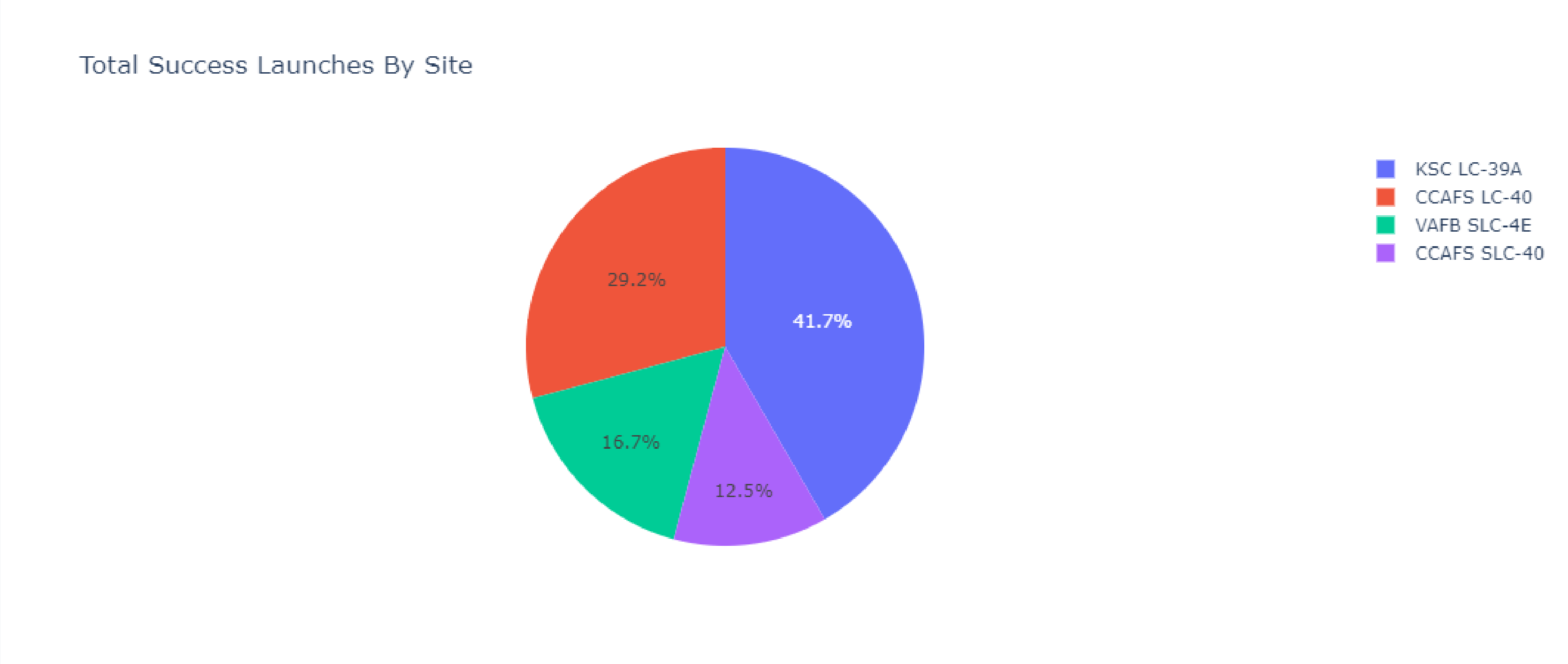


Section 4

Build a Dashboard with Plotly Dash

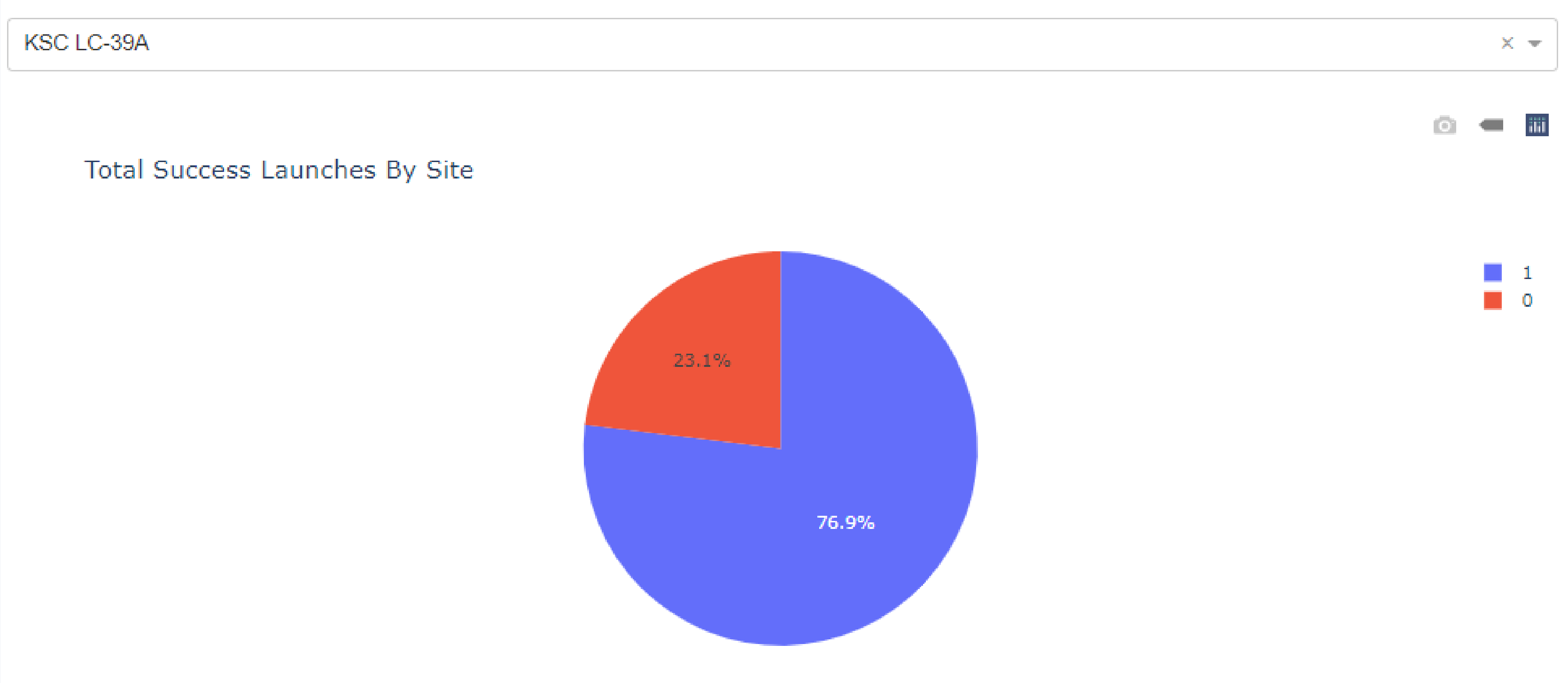
Total Success Launches By Site

- Below is the screenshot of launch success count for all sites, in a pie-chart
- “KSC LC-39A” has the highest success ratio whereas “VAFB SLC-4E” had the lowest success ratio among all four launch sites.



Launch Site With Highest Launch Success Ratio

- Below is the screenshot of the pie-chart for the launch site with the highest launch success ratio – “KSC LC-39A”
- It has 77% of success ratio.



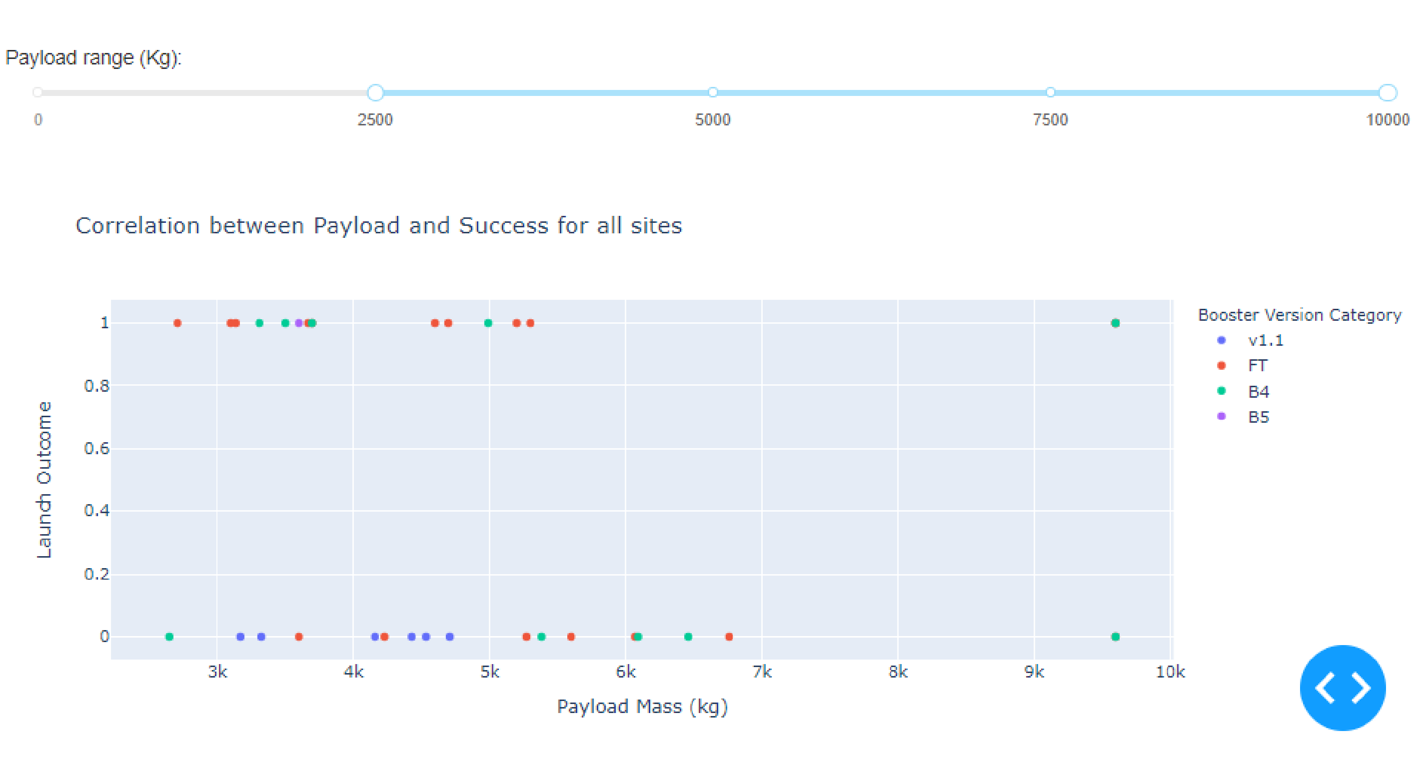
Payload vs. Launch Outcome

- Below are the screenshot of Payload vs. Launch Outcome scatter plot for all sites, with different payload selected in the range slider
- In 0-10000 kg payload range “FT” booster version has the largest success rate.

Payload vs. Launch Outcome [Continued]

Payload vs. Launch Outcome between 2500 kg and 10000 kg.

- In this range “FT” booster version has the largest success rate.



Payload vs. Launch Outcome [Continued]

Payload vs. Launch Outcome between 5000 kg and 10000 kg.

- In this range “FT” booster version has the largest success rate whereas “B4” booster version has no success.

Payload vs. Launch Outcome [Continued]

Payload vs. Launch Outcome between 7500 kg and 10000 kg.

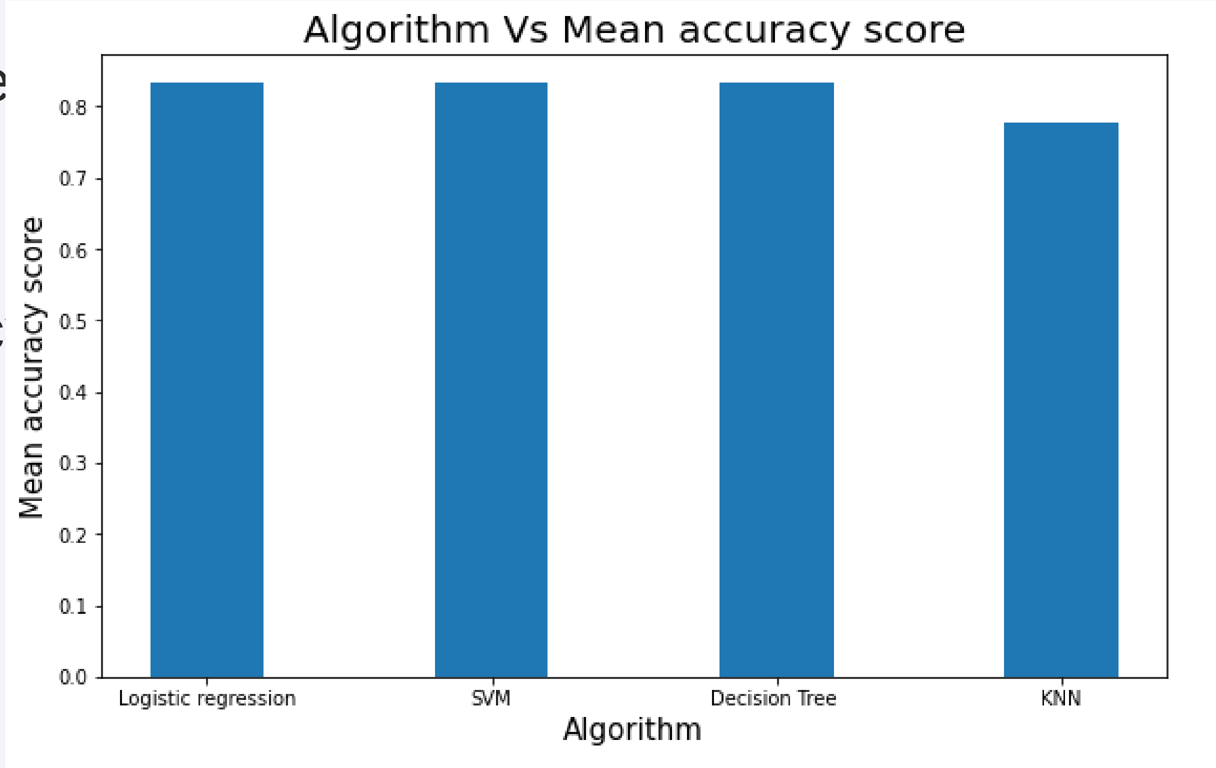
- In this range only “B4” booster version is used and has equal success / failure rate.

Section 5

Predictive Analysis (Classification)

Classification Accuracy

- Logistic Regression and Decision Tree has the highest accuracy which is approximately 0.83
- KNN Classifier has the lowest accurac (0.78) among all four models



Confusion Matrix

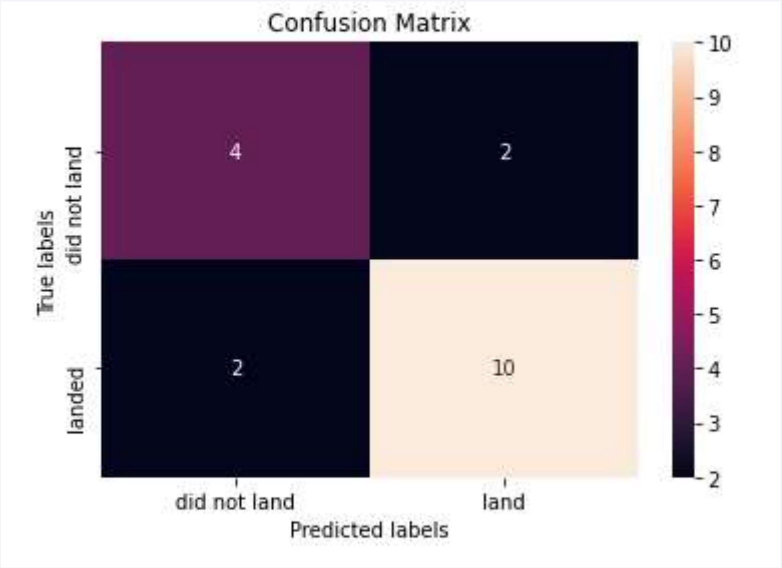
- Here is the confusion matrix of the best performing model (**Logistic Regression** and **Decision Tree**– both generates the same result).
- It has True Positive value of 12 and False Negative of 0. It means this model correctly identified 12 instances which actually belong to class 1(successful landing), conversely it predicted correctly only 50% (3 out of 6) of the class 0 (landing failure).

Conclusions

- Here on this project we explored the SpaceX data and built a classifier on whether a rocket launch outcome (landing) would be successful or not
- For a more robust analysis, this dataset is not adequate. More data is needed.
- Different types of algorithms should be explored to generate a better and robust classifier (Gradient boosting, Neural Network etc.)
- An end-to-end pipeline should be built for classification model that automates most of its process.

Appendix

- Here, is the confusion matrix of **KNN Classifier**, which gave the lowest accuracy.
- It has True Positive value of 10 and False Negative of 2. It means this model correctly identified 10 instances which actually belong to class 1(successful landing), conversely it predicted correctly 66% (4 out of 6) of the class 0 (landing failure).
- Although, its accuracy is lower than the other ones, its Specificity (True Negative Rate) is 66.67%, which is higher than the other models.



Thank you!