IBM Developer SKILLS NETWORK

Winning Space Race with Data Science

NNAEMEKA CHINKE

23/05/2025

Outline

- Executive Summary
- Introduction
- Methodology
- Results
- Conclusion

Executive Summary

- In this capstone project, we will predict if the SpaceX Falcon 9 first stage will land successfully using several machine learning classification algorithms.
- The main steps in this project include:
- Data collection, wrangling, and formatting
- Exploratory data analysis
- Interactive data visualization
- Machine learning prediction •

Our graphs show that some features of the rocket launches have a correlation with the outcome of the launches, i.e., success or failure.

- It is also concluded that decision tree may be the best machine learning algorithm to predict if the Falcon 9 first stage will land successfully.

Introduction

- In this capstone, we will predict if the Falcon 9 first stage will land successfully. SpaceX 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. This information can be used if an alternate company wants to bid against SpaceX for a rocket launch.

- Most unsuccessful landings are planned. Sometimes, SpaceX will perform a controlled landing in the ocean.

- The main question that we are trying to answer is, for a given set of features about a Falcon 9 rocket launch which include its payload mass, orbit type, launch site, and so on, will the first stage of the rocket land successfully?

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - Web scraped from web
- Perform data wrangling
  - Python Environment
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - Logistic Regression
  - Support Vector Machine
  - Decision Tree
  - K-nearest neighbors(KNN)

Data Collection

- The data was collected and scraped using Beautiful Soup. The link of the dataset https://en.wikipedia.org/wiki/List_of_Falcon_9_and_Falcon_Heavy_launches
- The website was tailored to contain data about Falcon9 launch.
- It contains 90 rows and 17 columns.

	FlightNumber	Date	BoosterVersion	PayloadMass	Orbit	LaunchSite	Outcome	Flights	GridFins	Reused	Legs	LandingPad	Block	ReusedCount	Serial	Longitude	Latitude
4	1	2010-06-04	Falcon 9	NaN	LEO	CCSFS SLC 40	None None	1	False	False	False	None	1.0	0	B0003	-80.577366	28.561857
5	2	2012-05-22	Falcon 9	525.0	LEO	CCSFS SLC 40	None None	1	False	False	False	None	1.0	0	B0005	-80.577366	28.561857
6	3	2013-03-01	Falcon 9	677.0	ISS	CCSFS SLC 40	None None	1	False	False	False	None	1.0	0	B0007	-80.577366	28.561857
7	4	2013-09-29	Falcon 9	500.0	PO	VAFB SLC 4E	False Ocean	1	False	False	False	None	1.0	0	B1003	-120.610829	34.632093
8	5	2013-12-03	Falcon 9	3170.0	GTO	CCSFS SLC 40	None None	1	False	False	False	None	1.0	0	B1004	-80.577366	28.561857

Data Collection – SpaceX API

- The flowchart to the API is shown.
- The Github link to the project https://github.com/Nnaemeka13/Data-Science-Capstone-Project.git

```
[9]: static_json_url='https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/API_call_spacex_api.json'
```

We should see that the request was successfull with the 200 status response code

```
[10]: response=requests.get(static_json_url)
```

```
[11]: response.status_code
```

```
[11]: 200
```

Now we decode the response content as a Json using `.json()` and turn it into a Pandas dataframe using `.json_normalize()`

...

Using the dataframe `data` print the first 5 rows

```
[13]: # Get the head of the dataframe
      data.head()
```

Data Collection - Scraping

- The code for parsing the data using BeautifulSoup is shown.
- The github URL : https://github.com/Nnaemeka13/Data-Science-Capstone-Project/blob/main/jupyter-labs-webscraping.ipynb

```
[5]: # use requests.get() method with the provided static_url
     # assign the response to a object
     response = requests.get(static_url)
```

Create a `BeautifulSoup` object from the HTML `response`

```
[6]: # Use BeautifulSoup() to create a BeautifulSoup object from a response text conten
     soup = BeautifulSoup(response.text, 'html.parser')
```

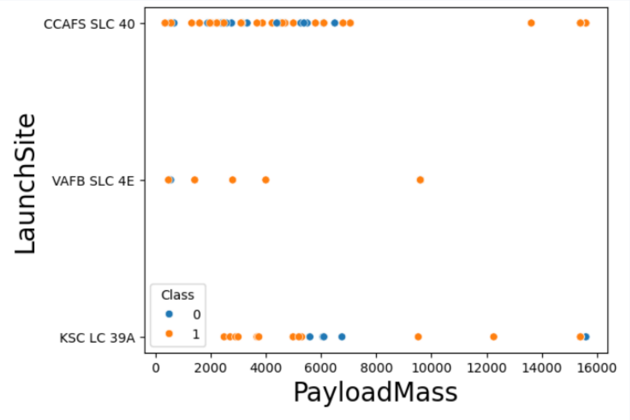
Print the page title to verify if the `BeautifulSoup` object was created properly

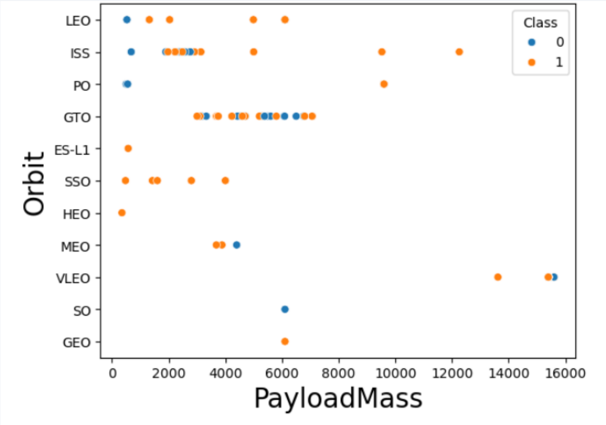
```
[10]: # Use soup.title attribute
      print("Title text:", soup.title.string)

Title text: List of Falcon 9 and Falcon Heavy launches - Wikipedia
```

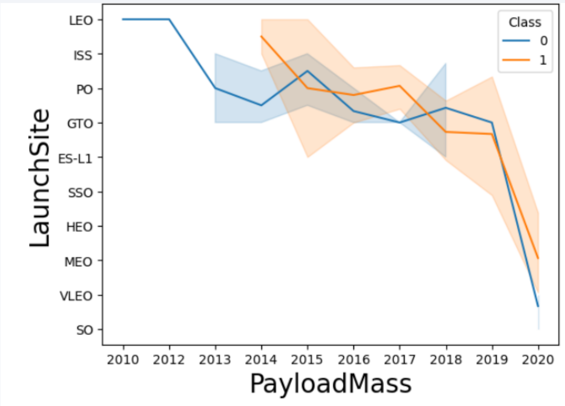
Data Wrangling

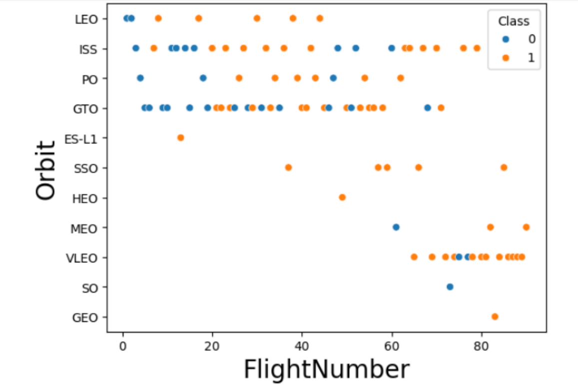
- The data is later processed so that there are no missing entries and categorical features are encoded using one-hot encoding.
- An extra column called ‘Class’ is also added to the data frame. The column ‘Class’ contains 0 if a given launch is failed and 1 if it is successful.
- In the end, we end up with 90 rows or instances and 83 columns or features.

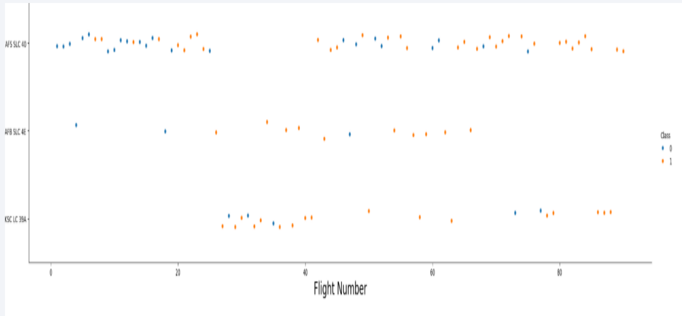
EDA with VISUALIZATION

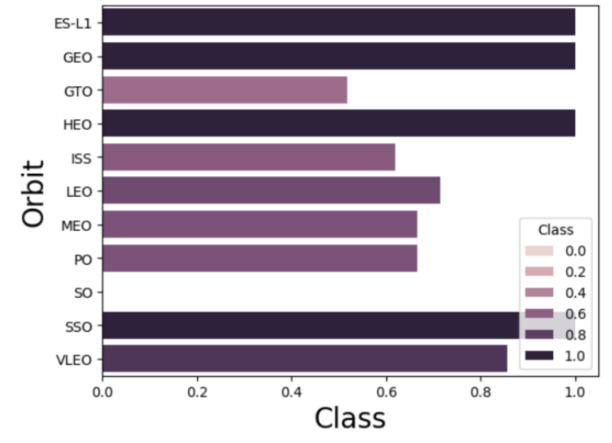


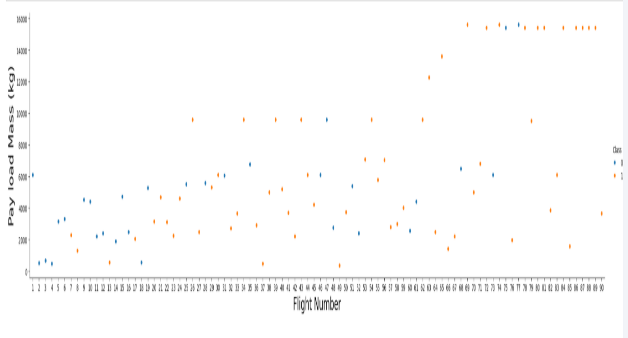












EDA with SQL

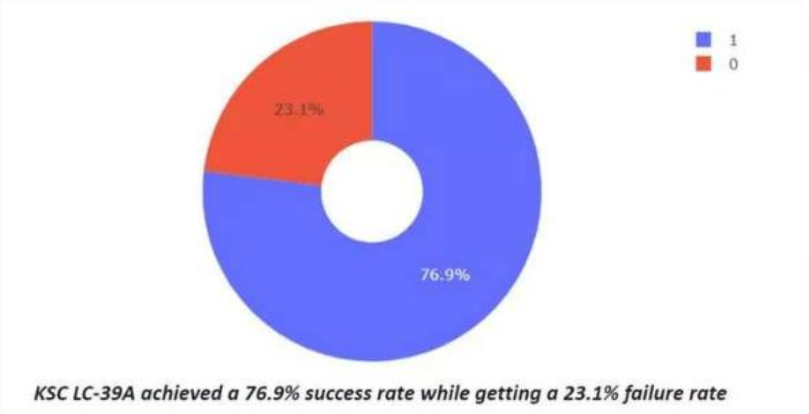
- Pandas and NumPy
  - Functions from the Pandas and NumPy libraries are used to derive basic information about the data collected, which includes:
  - The number of launches on each launch site
  - The number of occurrence of each orbit
  - The number and occurrence of each mission outcome
- SQL
  - The data is queried using SQL to answer several questions about the data such as:
  - The names of the unique launch sites in the space mission
  - The total payload mass carried by boosters launched by NASA (CRS)
  - The average payload mass carried by booster version F9 v1.1
  - List the date when the first successful landing outcome in ground pad was achieved
  - 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.

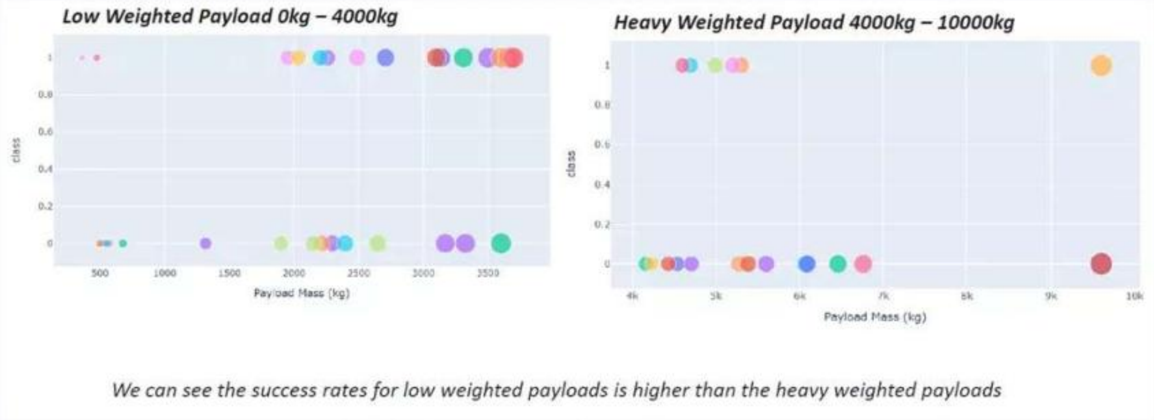
https://github.com/Nnaemeka13/Data-Science-Capstone-Project/blob/main/jupyter-labs-eda-sql-coursera_sqllite.ipynb

Build an Interactive Map with Folium

https://github.com/Nnaemeka13/Data-Science-Capstone-Project.git

Build a Dashboard with Plotly Dash

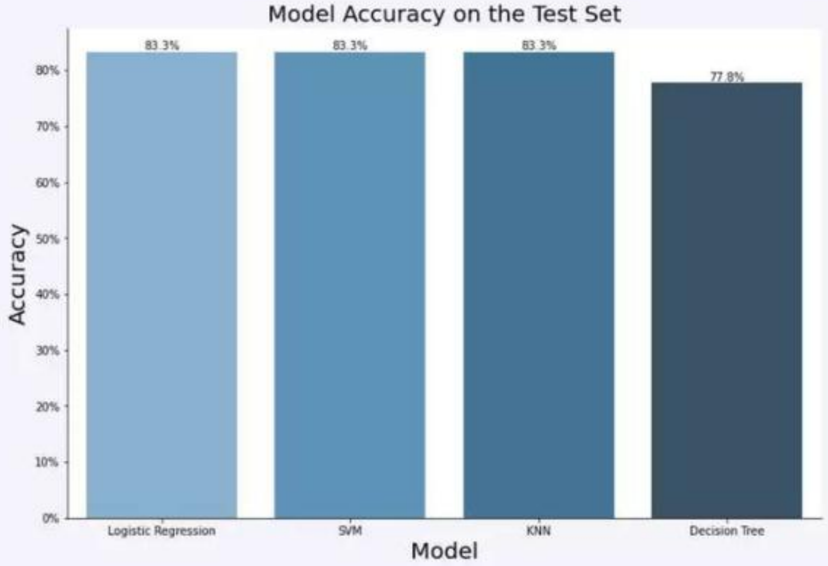


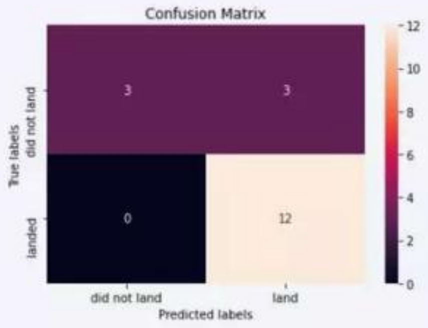


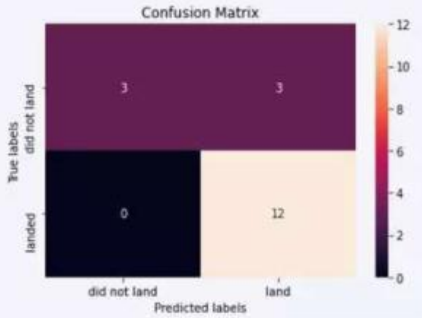
https://github.com/Nnaemeka13/Data-Science-Capstone-Project.git

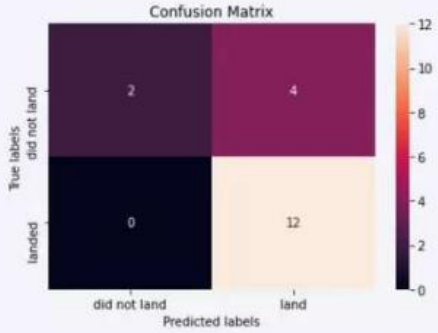
Predictive Analysis (Classification)

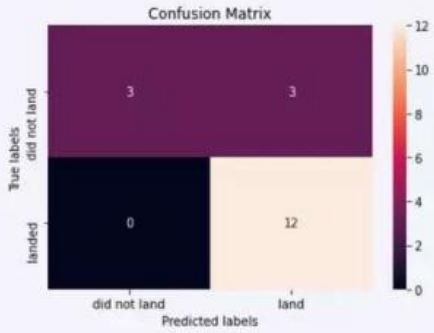
- The SVM, KNN, and Logistic Regression model achieved the highest accuracy at 83.3%, while the SVM performs the best in terms of Area Under the Curve at 0.958.











Results

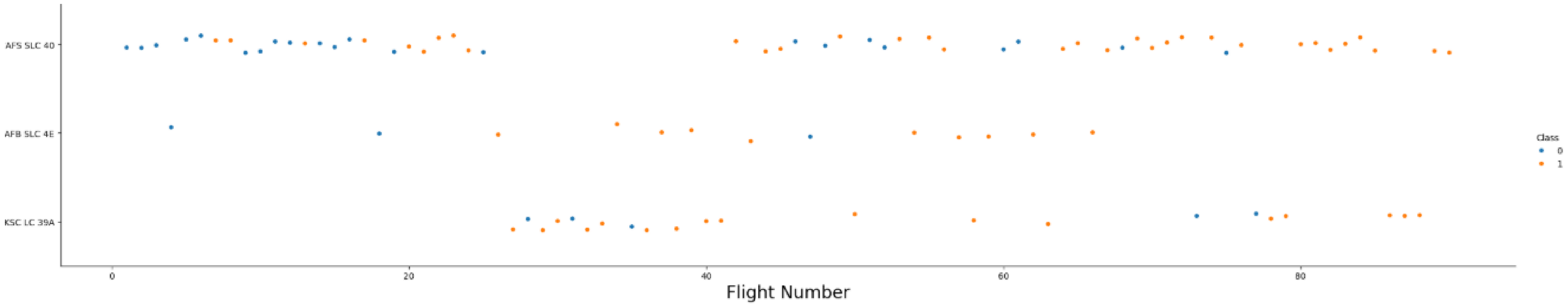
- The SVM, KNN, and Logistic Regression models are the best in terms of prediction accuracy for this dataset.
- Low weighted payloads perform better than the heavier payloads.
- The success rates for SpaceX launches is directly proportional time in years they will eventually perfect the launches.
- KSC LC 39A had the most successful launches from all the sites.
- Orbit GEO,HEO,SSO,ES L1 has the best Success Rate.

Section 2

Insights drawn from EDA

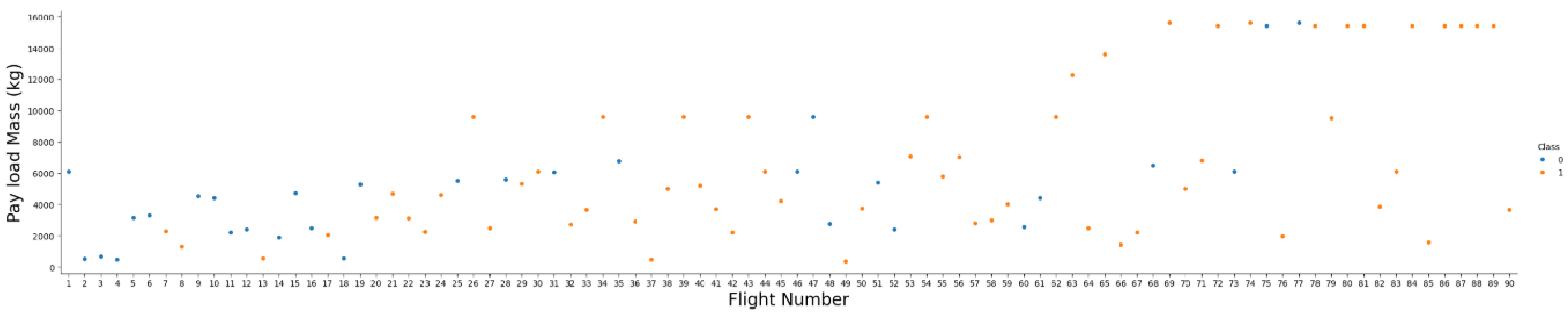
Flight Number vs. Launch Site

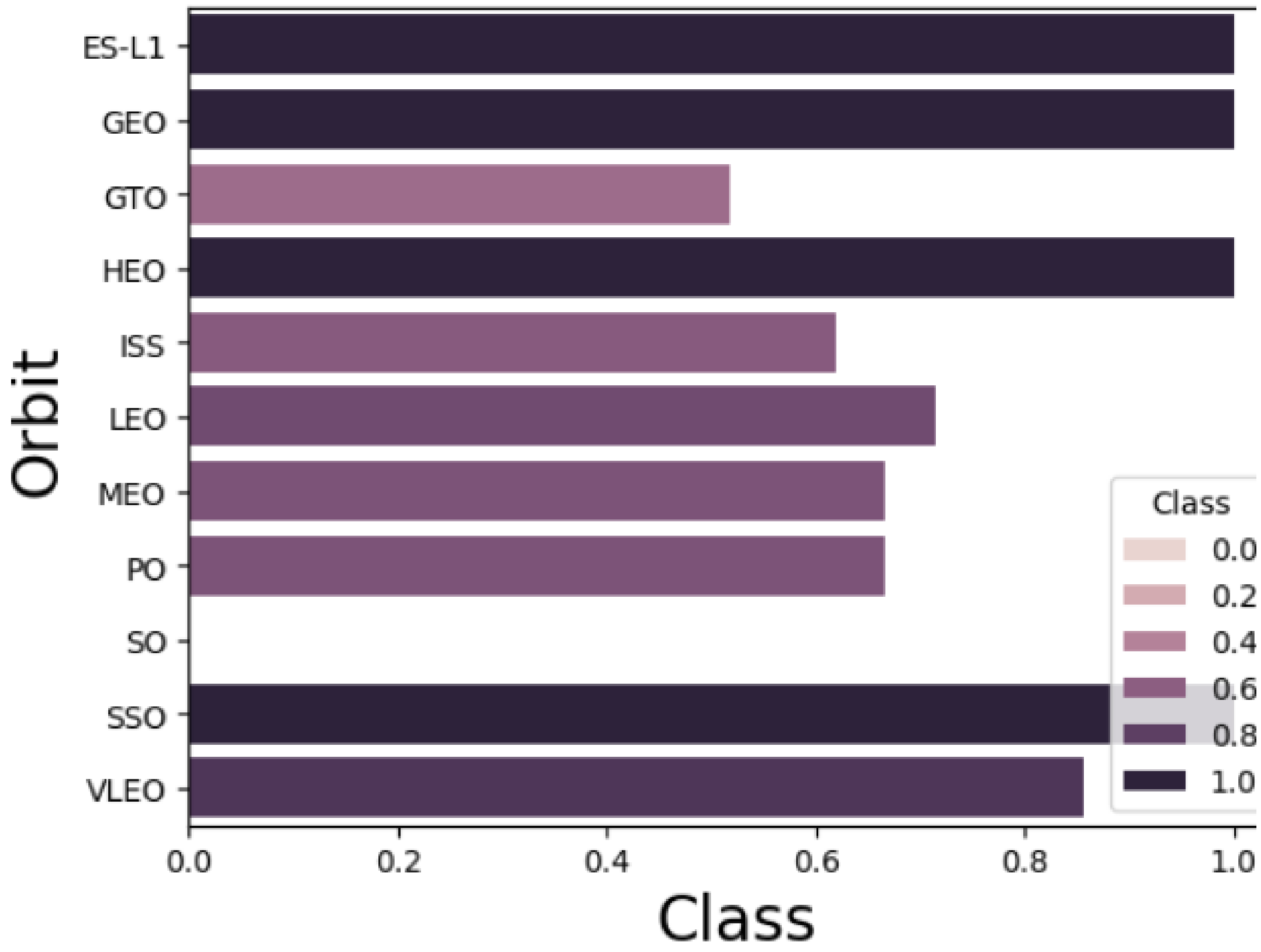
Show a scatter plot of Flight Number vs. Launch Site



Payload vs. Launch Site

Show a scatter plot of Payload vs. Launch Site





Success Rate vs. Orbit Type

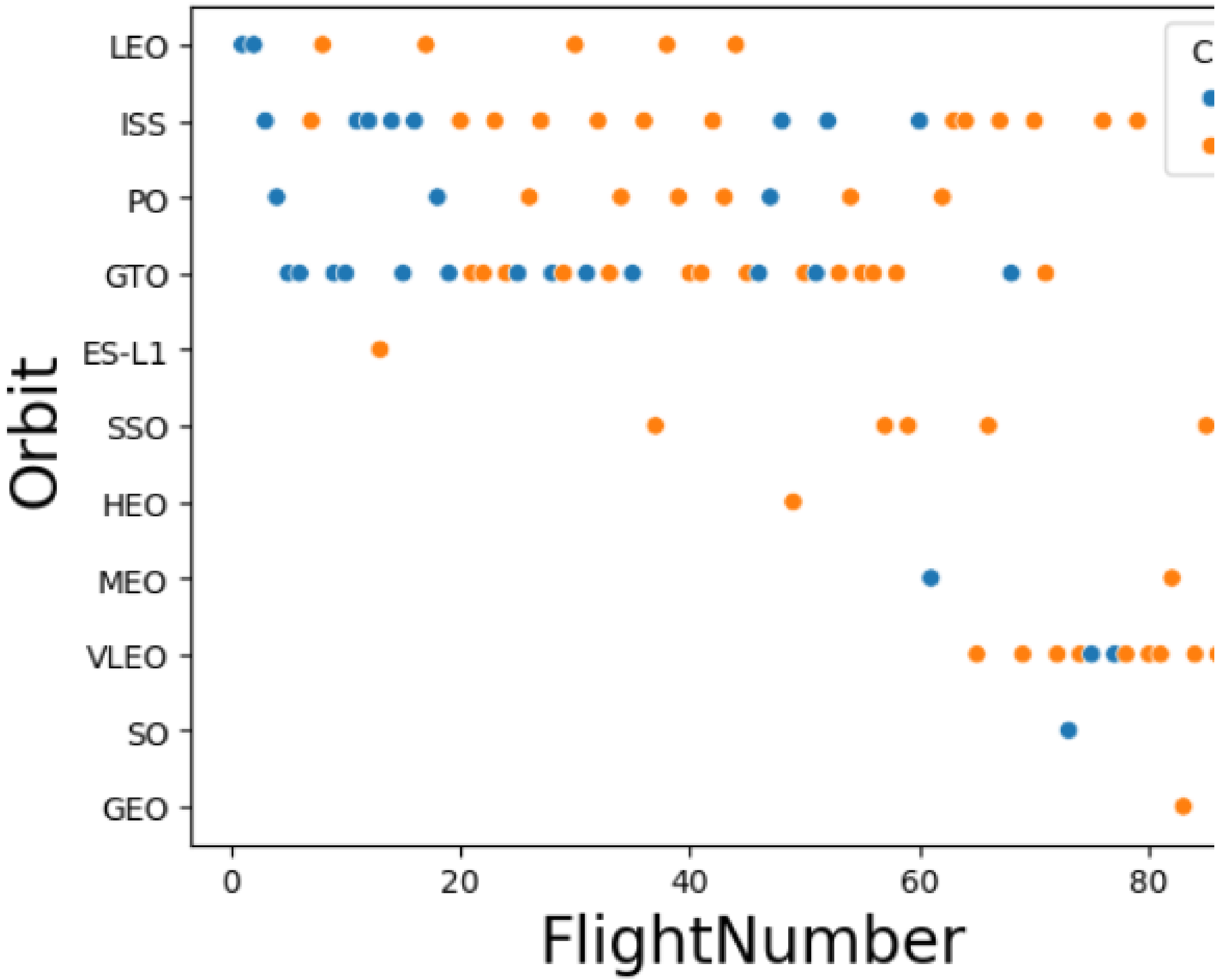
- Show a bar chart for the success rate of each orbit type

- Show the screenshot of the scatter plot with explanations

Flight Number vs. Orbit Type

- Show a scatter point of Flight number vs. Orbit type

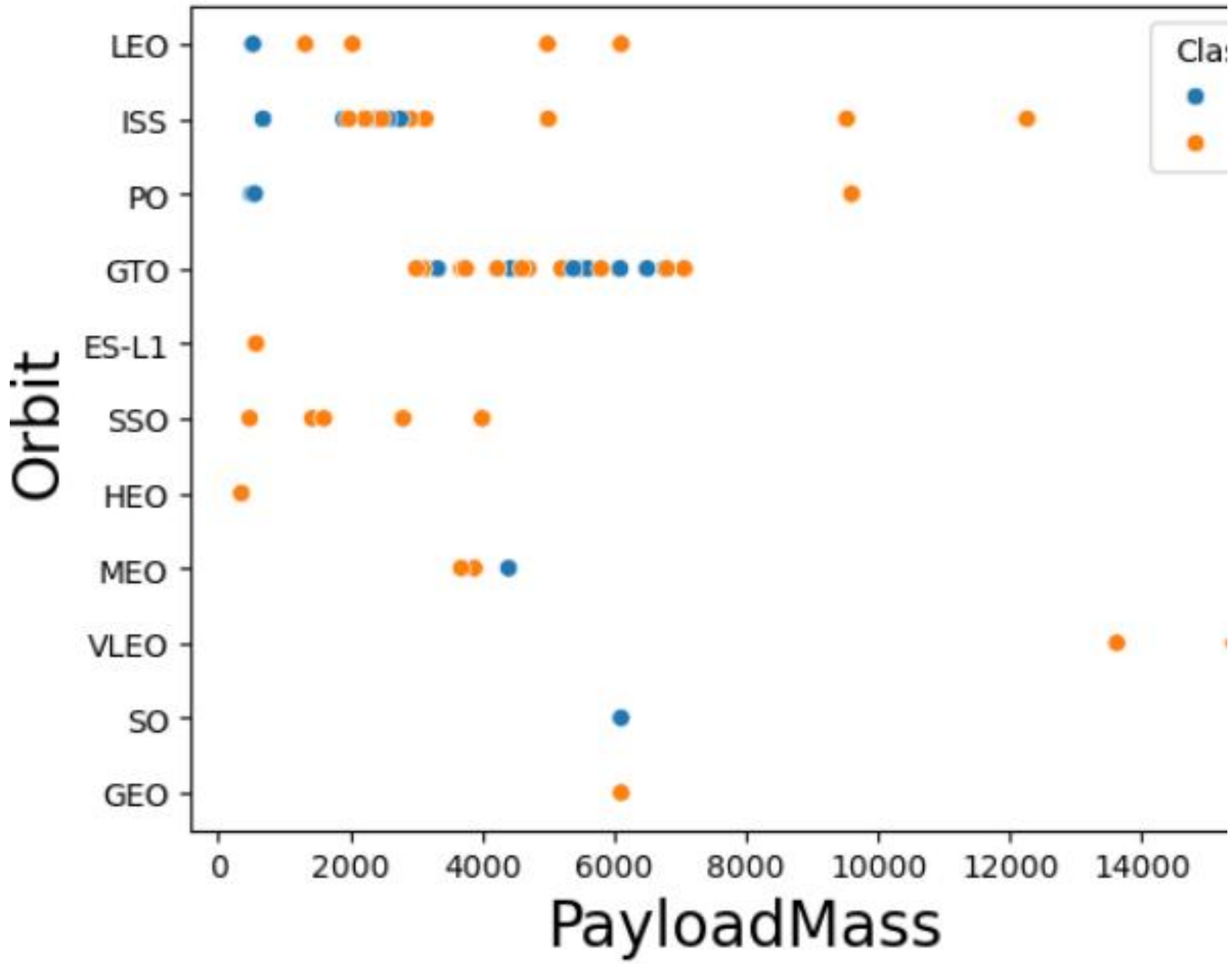
- Show the screenshot of the scatter plot with explanations

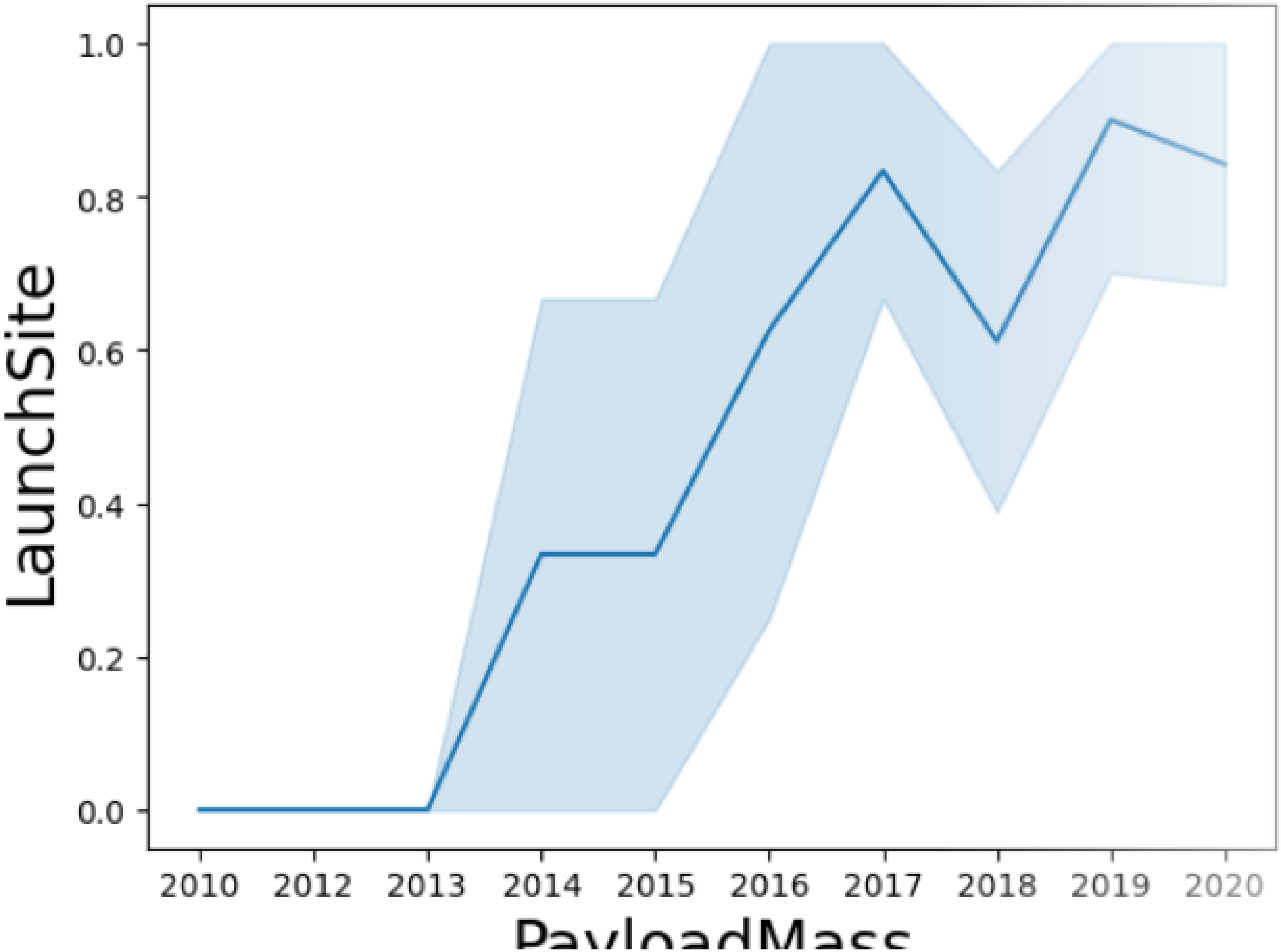


Payload vs. Orbit Type

- Show a scatter point of payload vs. orbit type

- Show the screenshot of the scatter plot with explanations





Launch Success Yearly Trend

- Show a line chart of yearly average success rate
- Show the screenshot of the scatter plot with explanations

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 Launch_Site FROM SPACEXTBL WHERE Launch_Site like 'CCA%' Limit 5;
```

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

Launch_Site
CCAFS LC-40
CCAFS LC-40
CCAFS LC-40
CCAFS LC-40
CCAFS LC-40

Total Payload Mass

- %sql select sum(PAYLOAD_MASS__KG_) from SPACEXTBL where CUSTOMER = 'NASA (CRS)'

45596

Average Payload Mass by F9 v1.1

- %sql select avg(PAYLOAD_MASS__KG_) from SPACEXTBL where BOOSTER_VERSION = 'F9 v1.1'

2928.400000

First Successful Ground Landing Date

```
%sql SELECT MIN(Date) AS First_Successful_Ground_Pad_Landing FROM SPACEXTBL WHERE Landing_Outcome = 'Success (ground pa
```

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

First_Successful_Ground_Pad_Landing
2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

```
%sql SELECT DISTINCT Booster_Version FROM SPACEXTBL WHERE Landing_Outcome = 'Success (drone ship)'AND PAYLOAD_MASS__KG_ > 4000 AND PAYLOAD_MASS__KG_ < 6000;
```

```
 * 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

[18]:
```
%sql SELECT Mission_Outcome, COUNT(*) AS Total_Count FROM SPACEXTBL GROUP BY Mission_Outcome;
```

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

[18]:

Mission_Outcome	Total_Count
Failure (in flight)	1
Success	98
Success	1
Success (payload status unclear)	1

Boosters Carried Maximum Payload

[19]:
```
%sql SELECT Booster_Version FROM SPACEXTBL WHERE PAYLOAD_MASS__KG_ = (SELECT MAX(PAYLOAD_MASS__KG_) FROM SPACEXTBL);
```

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

[19]:

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

Month_Name	Landing_Outcome	Booster_Version	Launch_Site
January	Failure (drone ship)	F9 v1.1 B1012	CCAFS LC-40
April	Failure (drone ship)	F9 v1.1 B1015	CCAFS LC-40

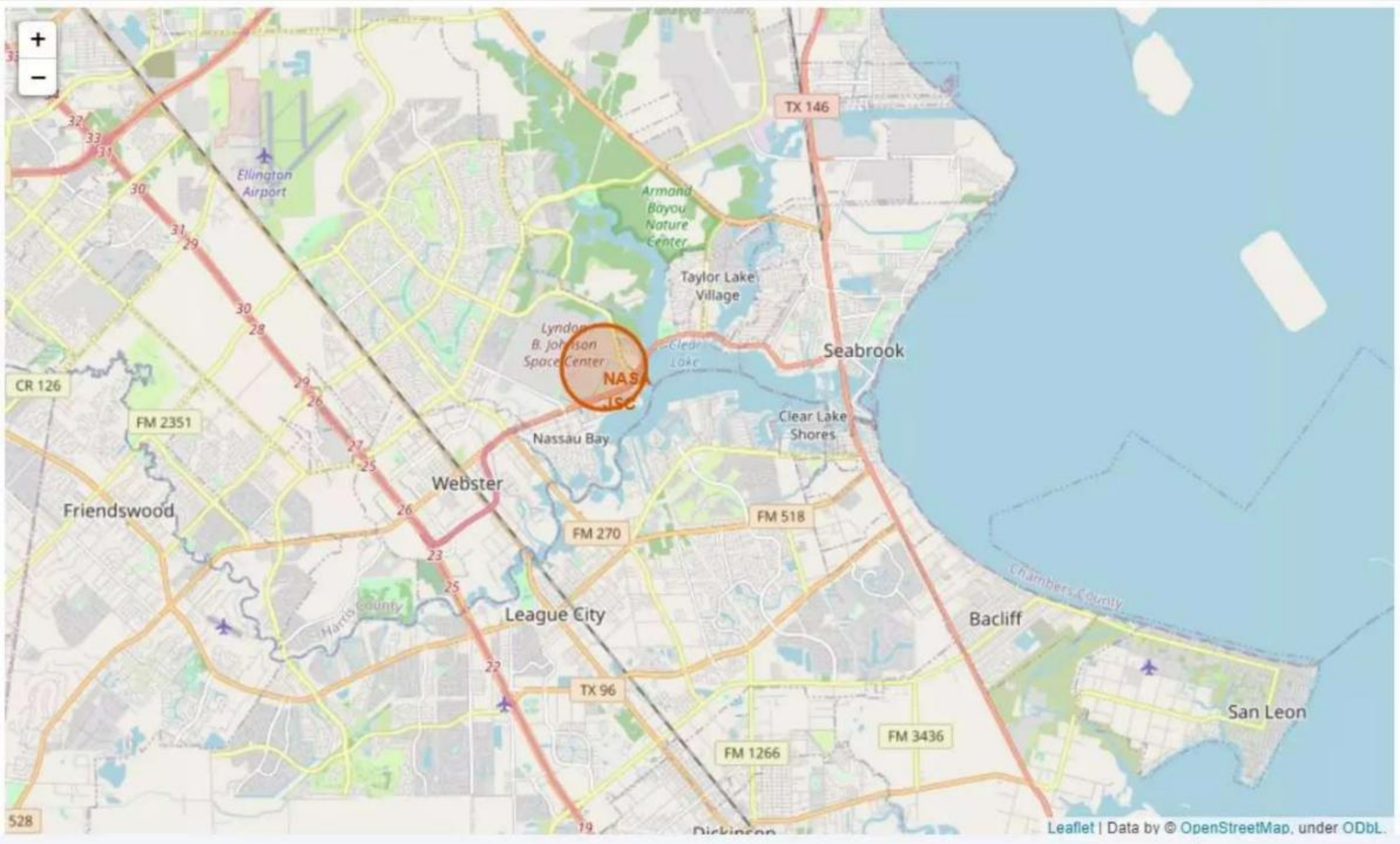
Landing_Outcome	Outcome_Count
No attempt	10
Success (drone ship)	5
Failure (drone ship)	5
Success (ground pad)	3
Controlled (ocean)	3
Uncontrolled (ocean)	2
Failure (parachute)	2
Precluded (drone ship)	1

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

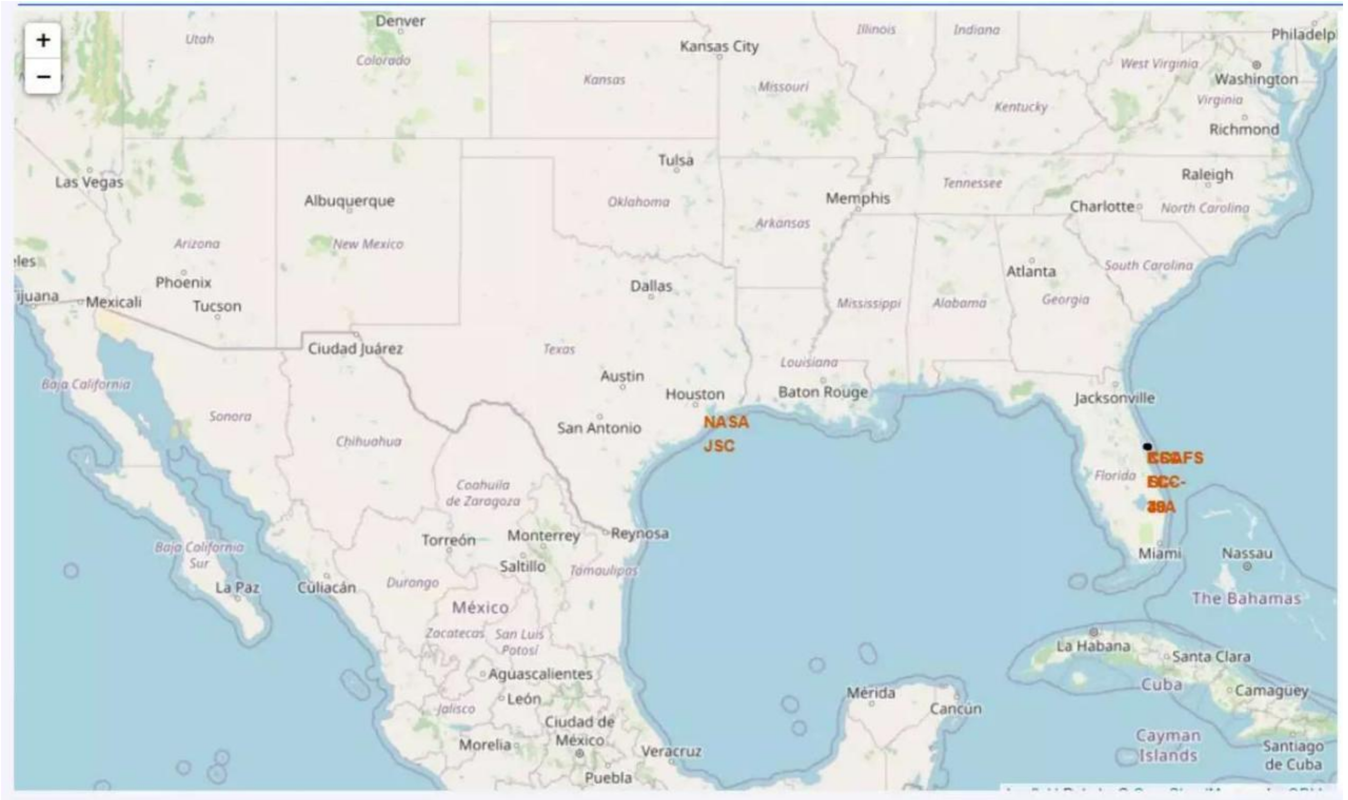
Section 3

Launch Sites Proximities Analysis

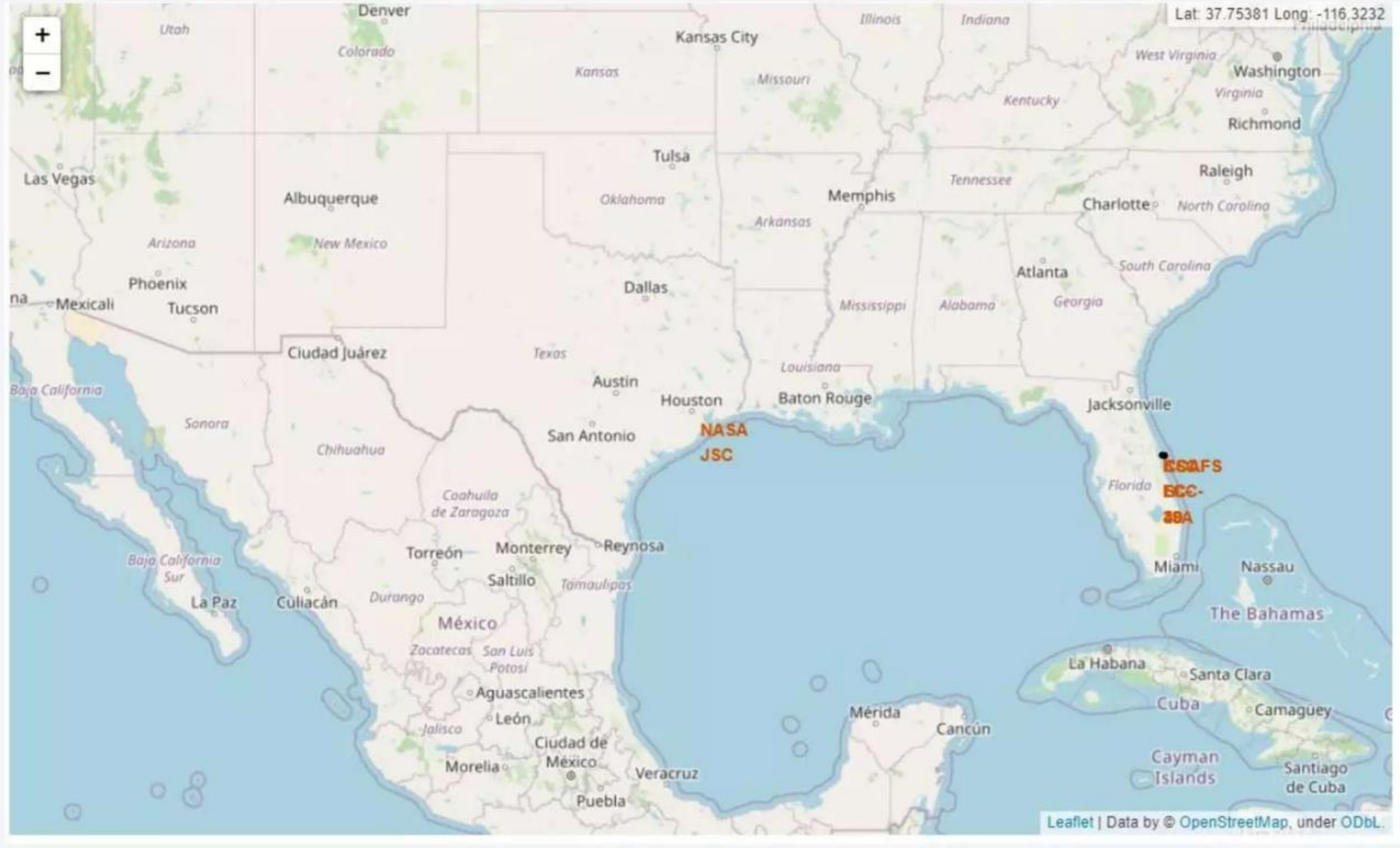
ALL MAPPED LAUNCH SITES



SUCCESS AND FAILED LAUNCHES MARKED



DISTANCE BETWEEN LAUNVH SITE AND ITS PROXIMITIES

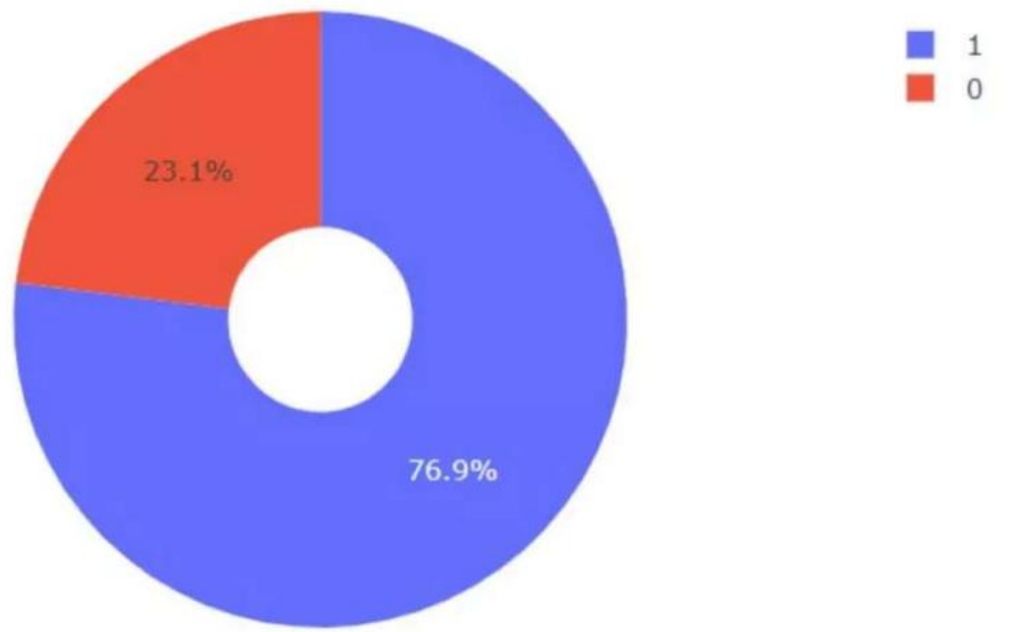


Section 4

Build a Dashboard with Plotly Dash

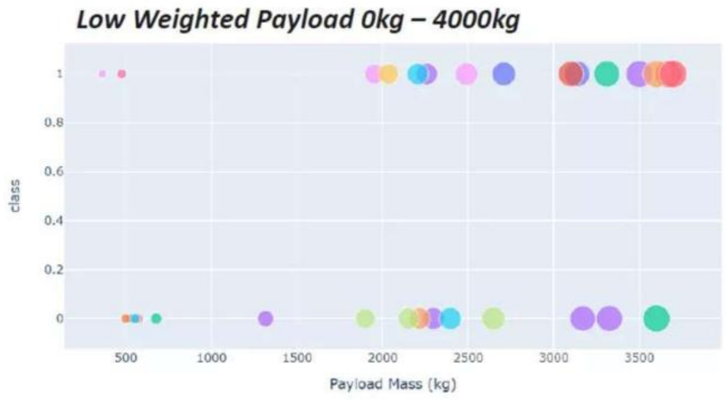
Total Success Launches By All Sites

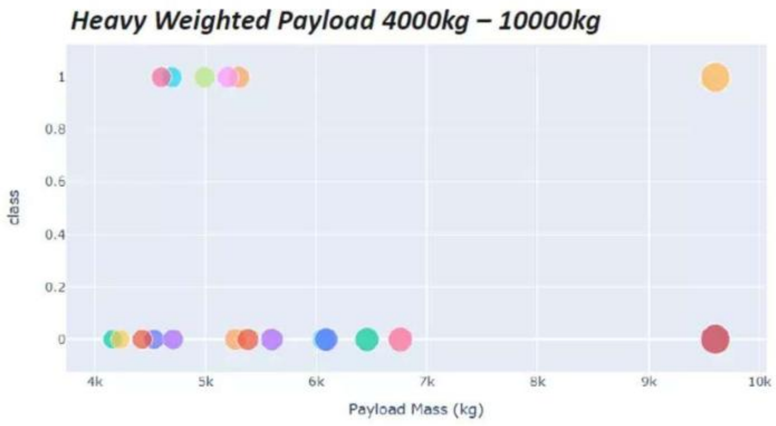
Success Rate By Class



KSC LC-39A achieved a 76.9% success rate while getting a 23.1% failure rate

Payload Vs Launch Outcome



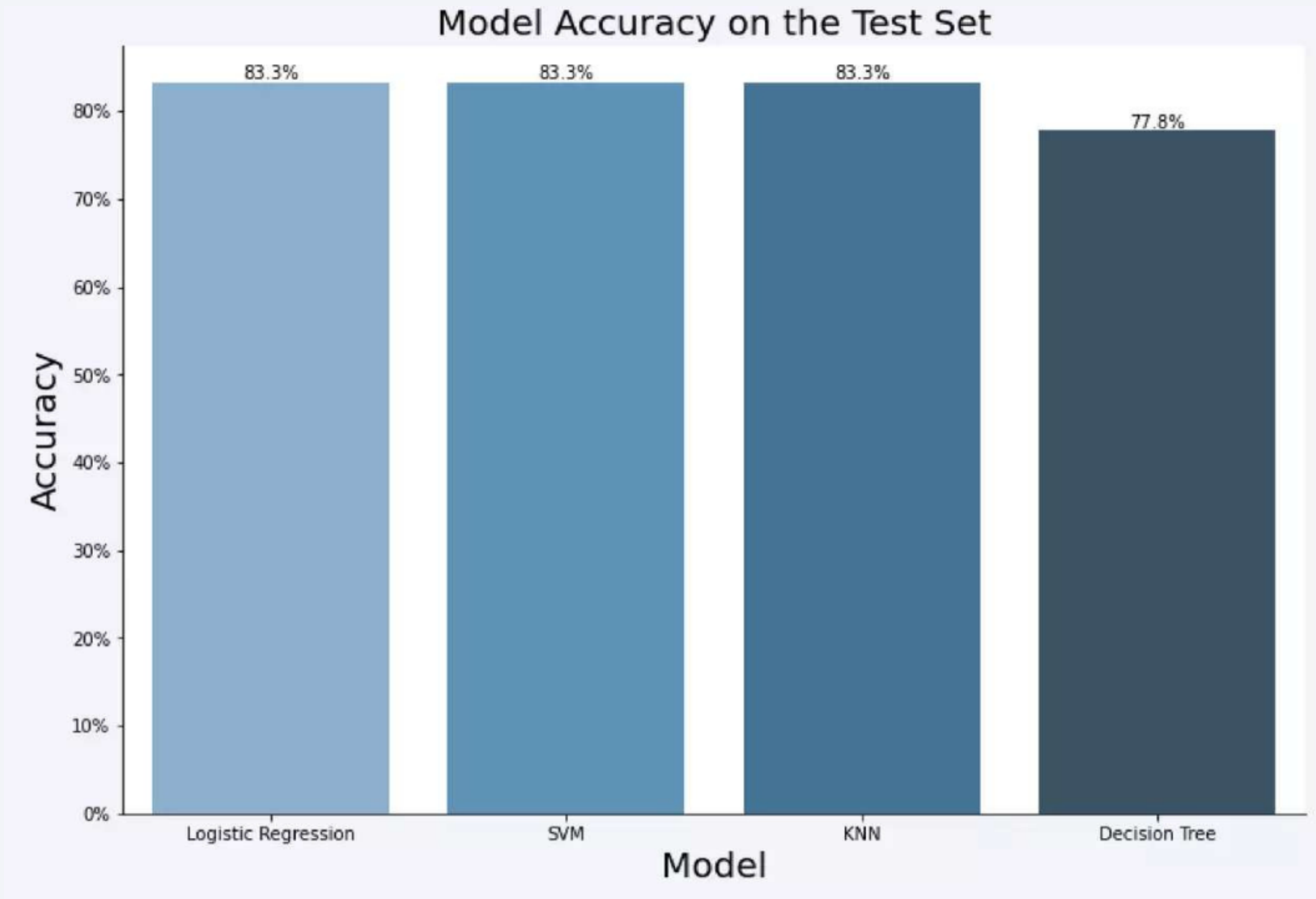


We can see the success rates for low weighted payloads is higher than the heavy weighted payloads

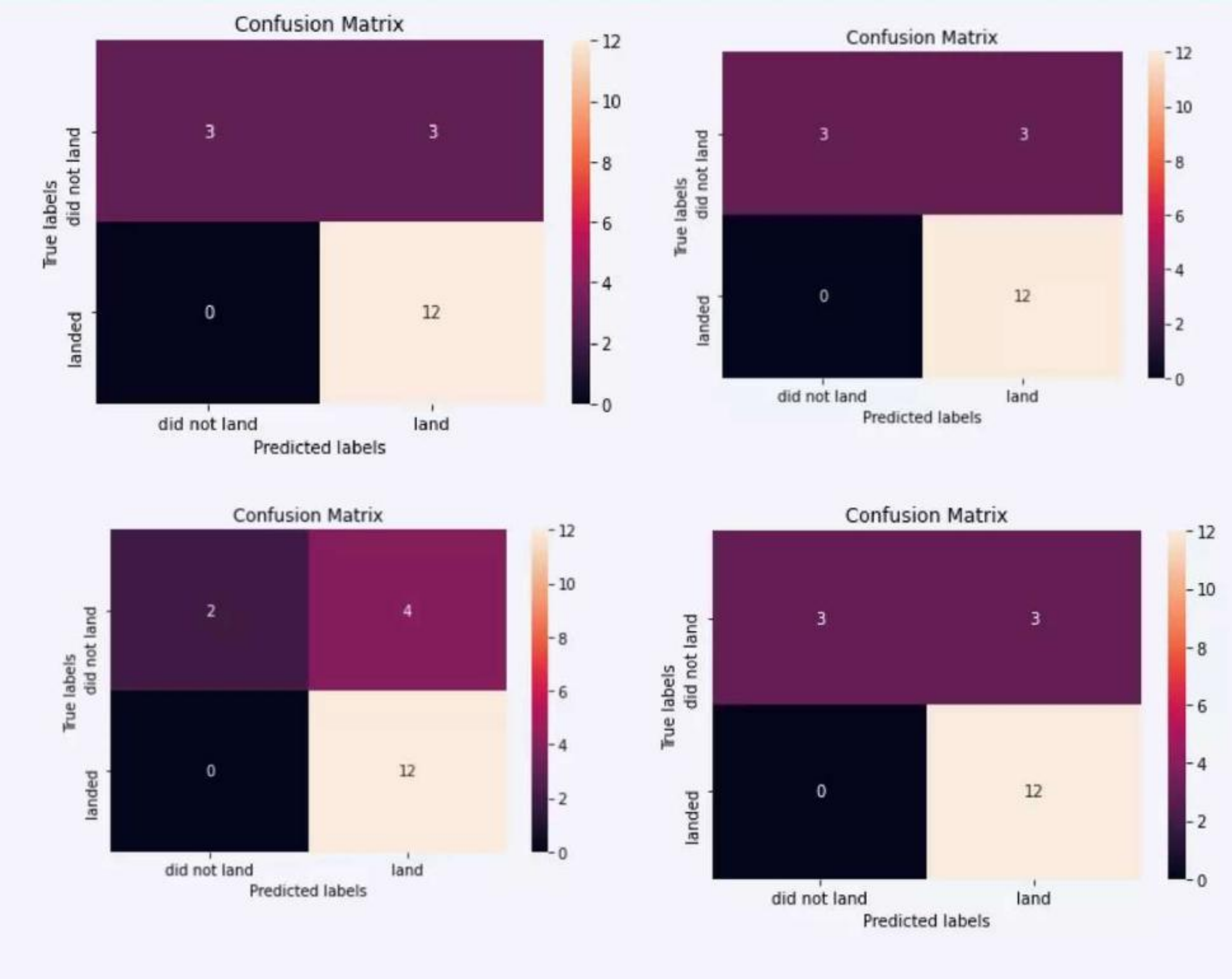
Section 5

Predictive Analysis (Classification)

Classification Accuracy



Confusion Matrix



Conclusions

- Putting the results of all 4 models' side by side, we can see that they all share the same accuracy score and confusion matrix when tested on the test set.
- Low weighted payloads performed better than the heavy weighted payload.
- KSC LC 39A has the most successful launches from all the sites.
- The predictive model produced by decision tree algorithm performed the best among the 4 machine learning algorithms employed

Thank you!