Winning Space Race with Data Science

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15-08-2023

Outline

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- Methodology
- Results
- Conclusion
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Executive Summary

- Summary of methodologies
  - Data Collection through API
  - Data Collection with Web Scraping
  - Data Wrangling
  - Exploratory Data Analysis with SQL
  - Exploratory Data Analysis with Data Visualization
  - Interactive Visual Analytics with Folium
  - Machine Learning Prediction
- Summary of all results
  - Exploratory Data Analysis result
  - Interactive analytics in screenshots
  - Predictive Analytics result

Introduction

- Project background and context

  Space X advertises Falcon 9 rocket launches on its website with a cost of 62 million dollars; other providers
  million dollars each, much of the savings is because Space X can reuse the first stage. Therefore, if we c
  first stage will land, we can determine the cost of a launch. This information can be used if an alternate co
  against space X for a rocket launch. This goal of the project is to create a machine learning pipeline to pred
  will land successfully.

- Problems you want to find answers
  - What factors determine if the rocket will land successfully?
  - The interaction among-st various features that determine the success rate of a successful landing.
  - What operating conditions needs to be in place to ensure a successful landing program.

Section 1

Methodology

Methodology

Executive Summary

Data collection methodology:

Data was collected using SpaceX API and web scraping from Wikipedia.

Perform data wrangling

One-hot encoding was applied to categorical features

Perform exploratory data analysis (EDA) using visualization and SQL

Perform interactive visual analytics using Folium and Plotly Da

Perform predictive analysis using classification models

How to build, tune, evaluate classification models

Data Collection

The data was collected using various methods

Data collection was done using get request to the SpaceX API.

Next, we decoded the response content as a Json using .json() function call and tu
pandas dataframe using .json_normalize().

We then cleaned the data, checked for missing values and fill in missing valu
necessary.

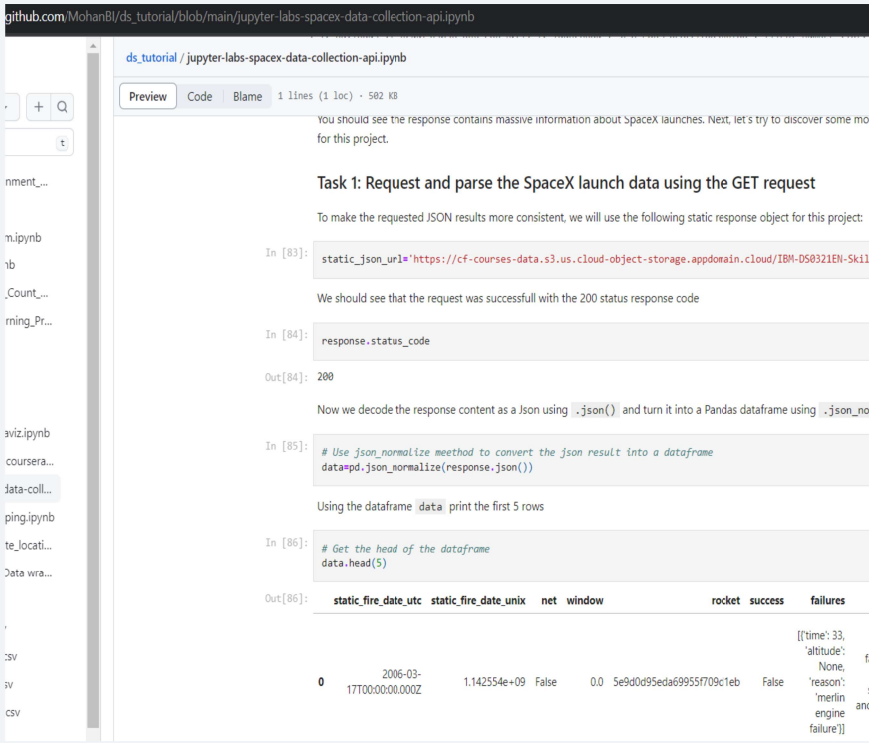
In addition, we performed web scraping from Wikipedia for Falcon 9 launch re
BeautifulSoup.

The objective was to extract the launch records as HTML table, parse the table and c
a pandas dataframe for future analysis.

Data Collection – SpaceX API

- We used the get request to the SpaceX API to collect data, clean the requested data and did some basic data wrangling and formatting.

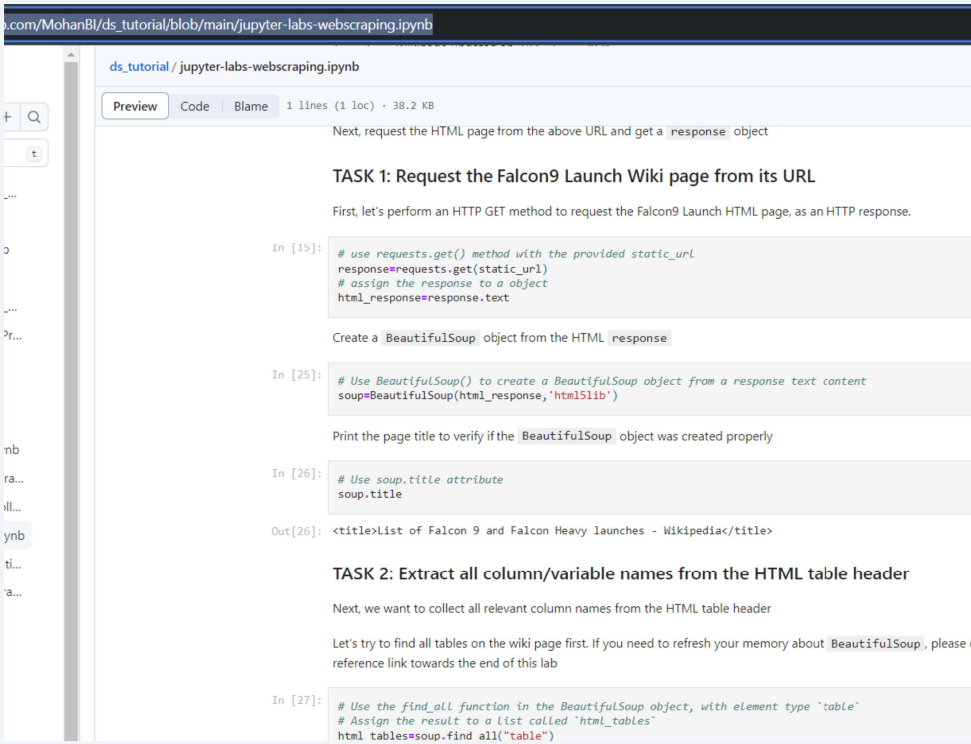
- https://github.com/MohanBI/ds_tutorial/blob/main/jupyter-labs-spacex-data-collection-api.ipynb



Data Collection - Scraping

- We applied web scrapping to webscrap Falcon 9 launch records with BeautifulSoup
- We parsed the table and converted it into a pandas data frame.

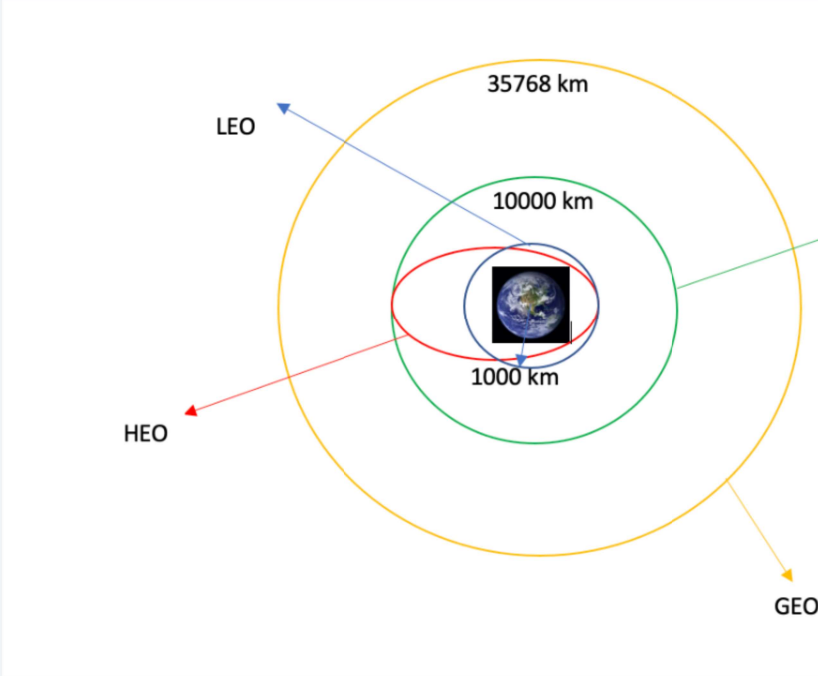
https://github.com/MohanBI/ds_tutorial/blob/main/jupyter-labs-webscraping.ipynb



Data Wrangling

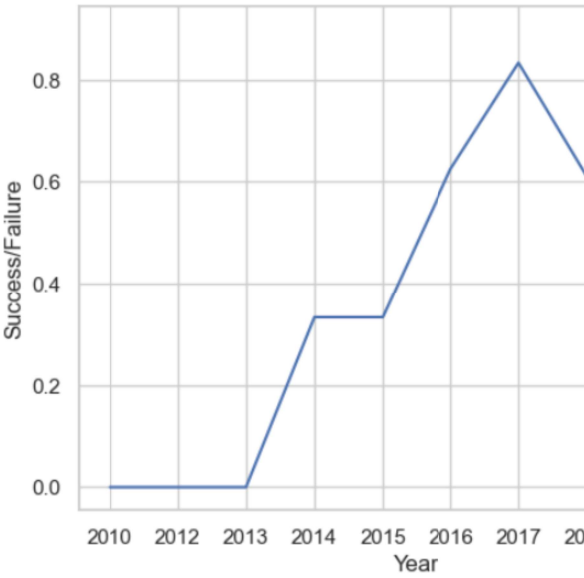
We performed exploratory data analysis and determined the training labels.
We calculated the number of launches at each site, and the number and occurrence of each orbits
We created landing outcome label from outcome column and exported the results to csv.

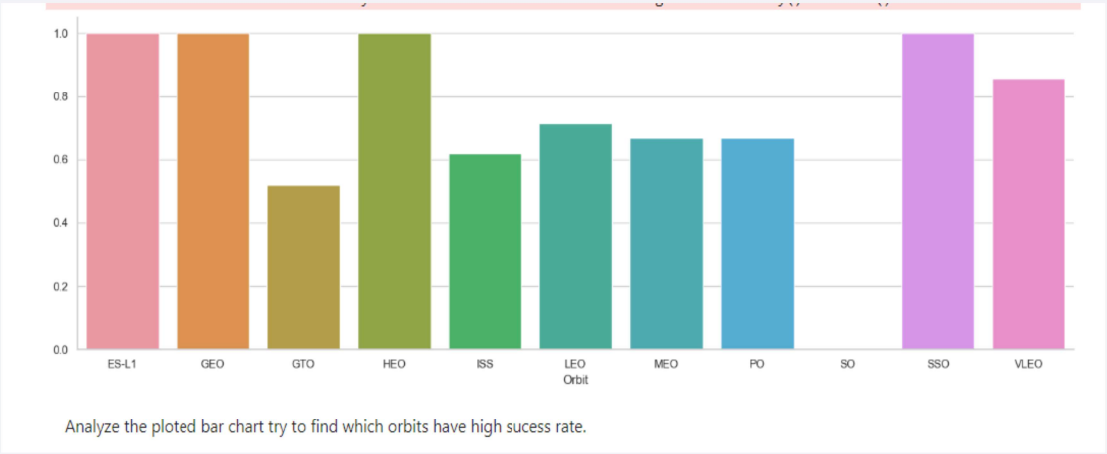
https://github.com/MohanBI/ds_tutorial/blob/main/labs-jupyter-spacex-Data%20wrangling.ipynb



EDA with Data Visualization

We explored the data by visualizing the relationship between flight number and launch Site, payload and launch site, success rate of each orbit type, flight number and orbit type, the launch success yearly trend.





https://github.com/MohanBI/ial/blob/main/jupyter-labs-eda z.ipynb

EDA with SQL

We loaded the SpaceX dataset into a PostgreSQL database withou
leaving the jupyter notebook.

We applied EDA with SQL to get insight from the data. We wrote
queries to find out for instance:

- The names of 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
- The total number of successful and failure mission outcomes
- The failed landing outcomes in drone ship, their booster version and launch site n

https://github.com/MohanBI/ds_tutorial/blob/main/jupyter-labs-eda-sql-coursera_sqllit
b

Build an Interactive Map with Folium

We marked all launch sites, and added map objects such as markers, circ
to mark the success or failure of launches for each site on the folium map.

We assigned the feature launch outcomes (failure or success) to class 0 a
0 for failure, and 1 for success.

Using the color-labeled marker clusters, we identified which launch sites h
relatively high success rate.

We calculated the distances between a launch site to its proximities. We a
some question for instance:

Are launch sites near railways, highways and coastlines.

Do launch sites keep certain distance away from cities.

Build a Dashboard with Plotly Dash

We built an interactive dashboard with Plotly dash

We plotted pie charts showing the total launches by a certain sites

We plotted scatter graph showing the relationship with Outcome and Paylo
Mass (Kg) for the different booster version.

https://github.com/MohanBI/ds_tutorial/blob/main/spacex_dashboard.py

Predictive Analysis (Classification)

We loaded the data using numpy and pandas, transformed the data, split d
data into training and testing.

We built different machine learning models and tune different
hyperparameters using GridSearchCV.

We used accuracy as the metric for our model, improved the model using
feature engineering and algorithm tuning.

We found the best performing classification model.

https://github.com/MohanBI/ds_tutorial/blob/main/SpaceX_Machine_Learn
_Prediction_Part_5.jupyterlite.ipynb

Results

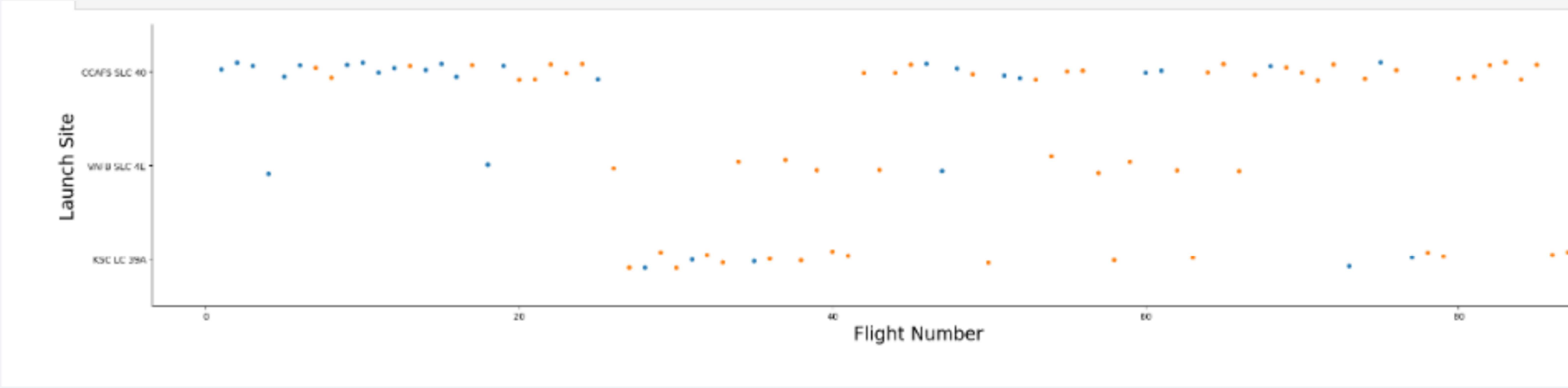
- Exploratory data analysis results
- Interactive analytics demo in screenshots
- Predictive analysis results

Section 2

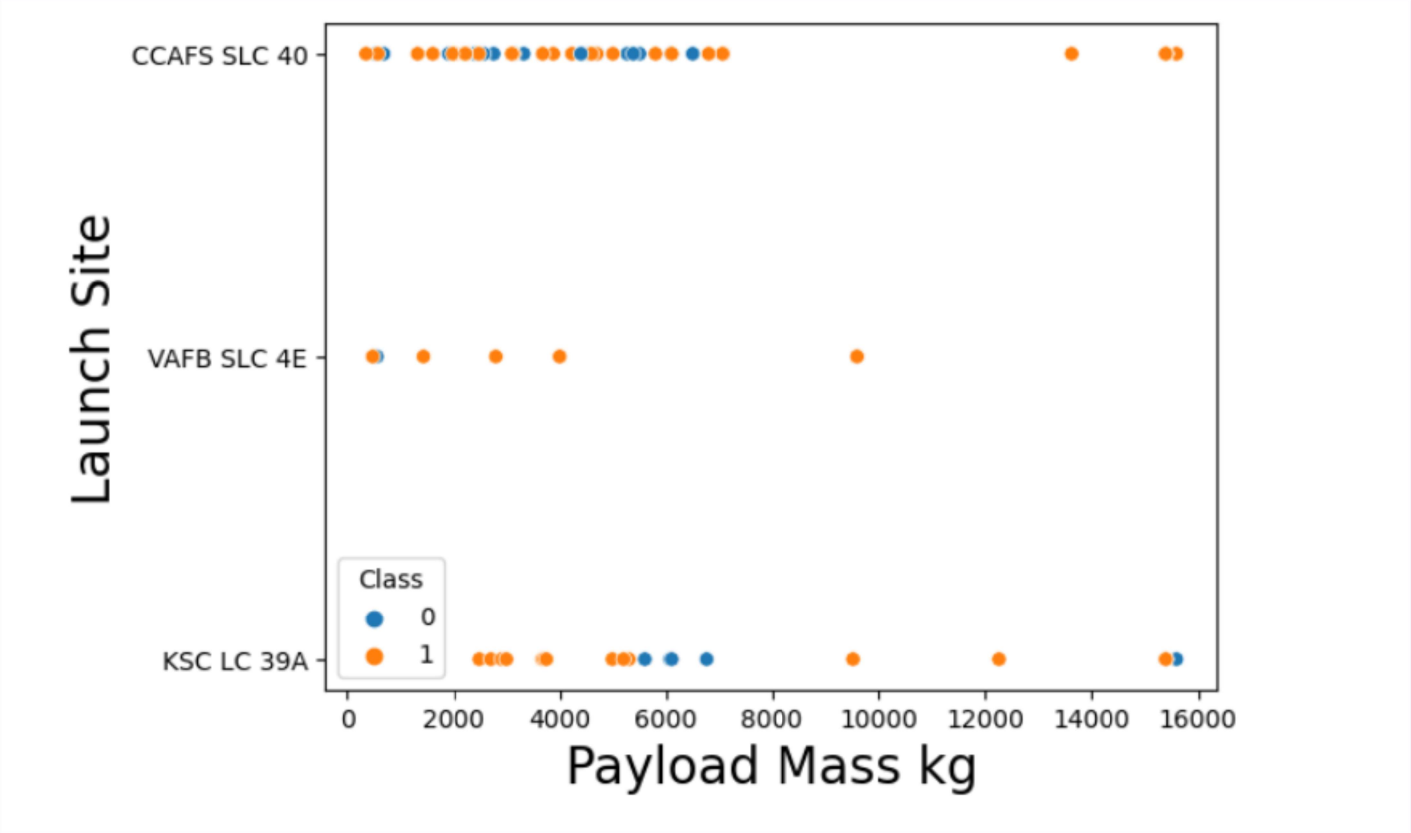
Insights drawn from EDA

Flight Number vs. Launch Site

- From the plot, we found that the larger the flight amount at a launch site, greater the success rate at a launch site.

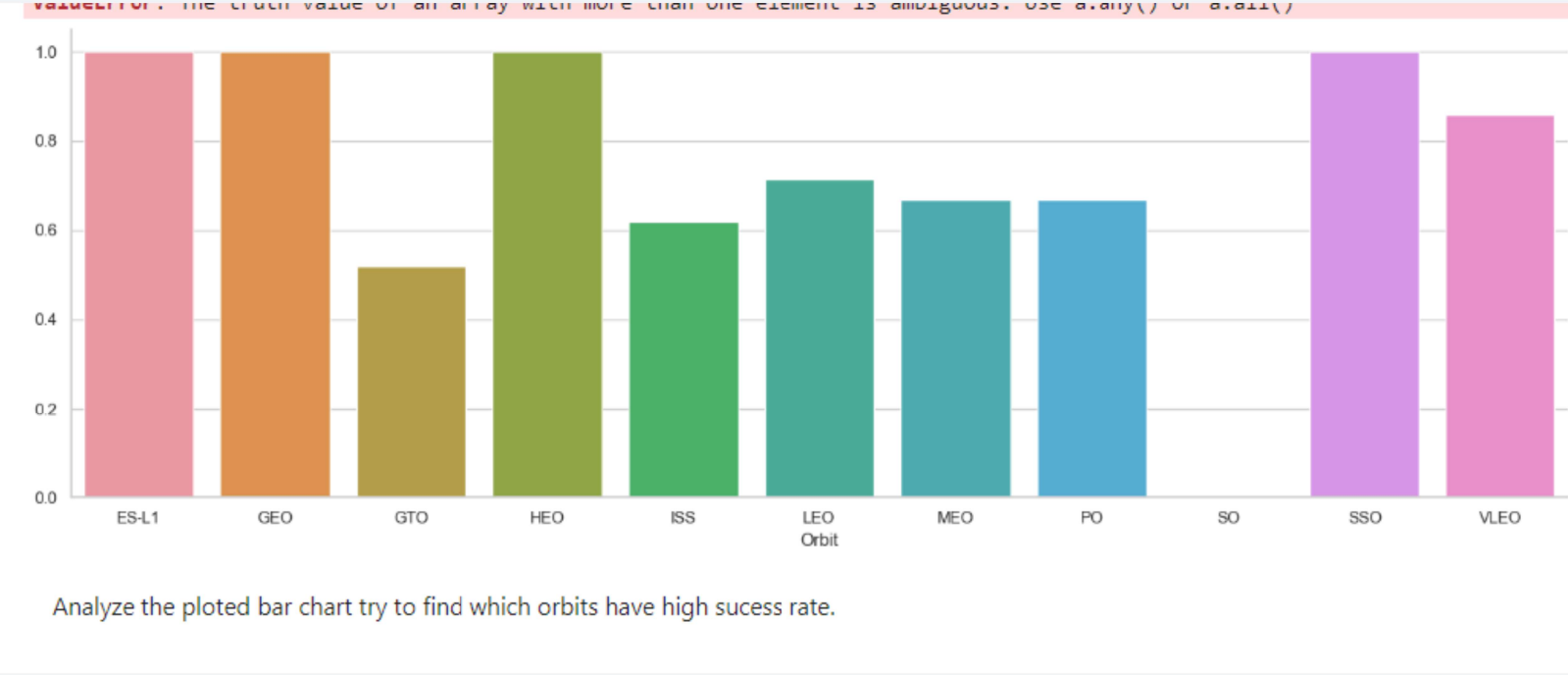


Payload vs. Launch Site



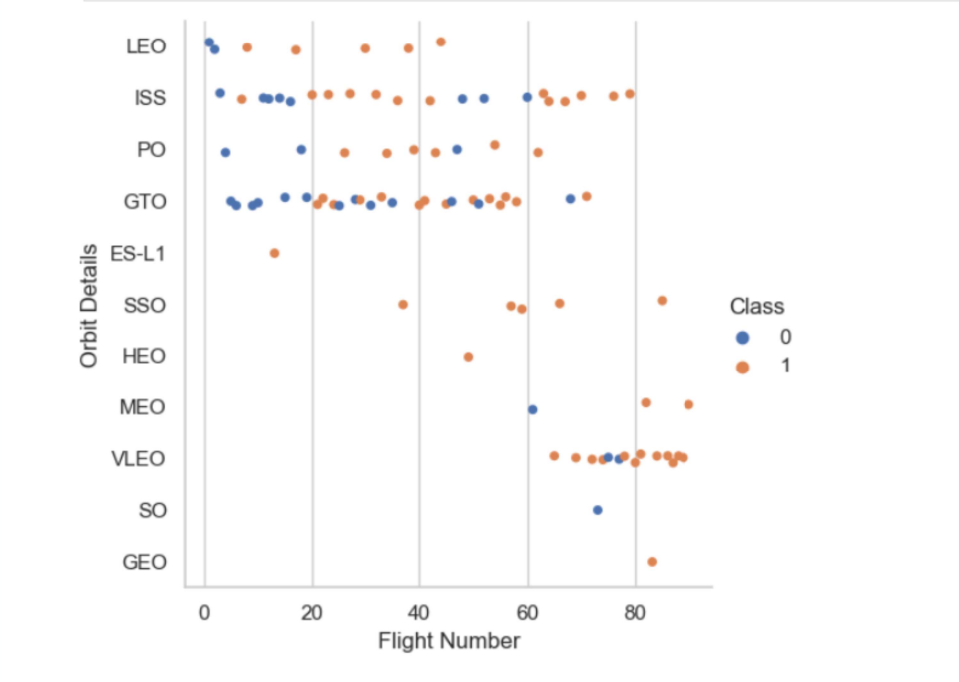
Success Rate vs. Orbit Type

- From the plot, we can see that ES-L1, GEO, HEO, SSO, VLEO had the r
  success rate.



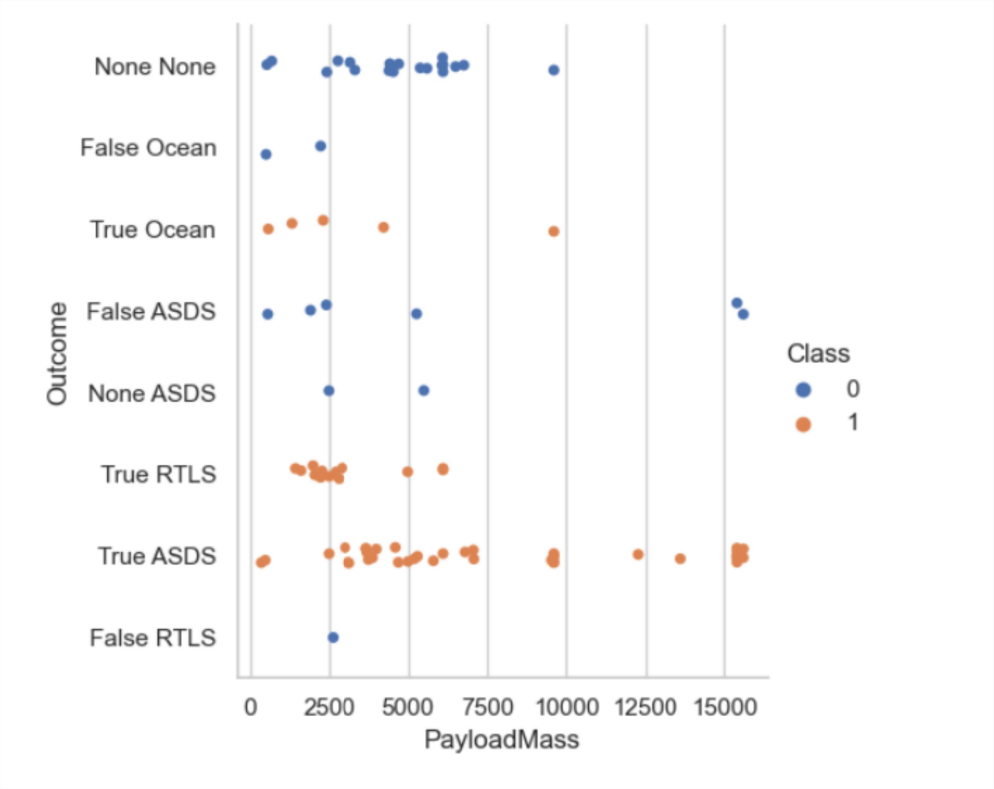
Flight Number vs. Orbit Type

- The plot below shows the Flight Number vs. Orbit type. We observe that i
  LEO orbit, success is related to the number of flights whereas in the GTO
  there is no relationship between flight number and the orbit.



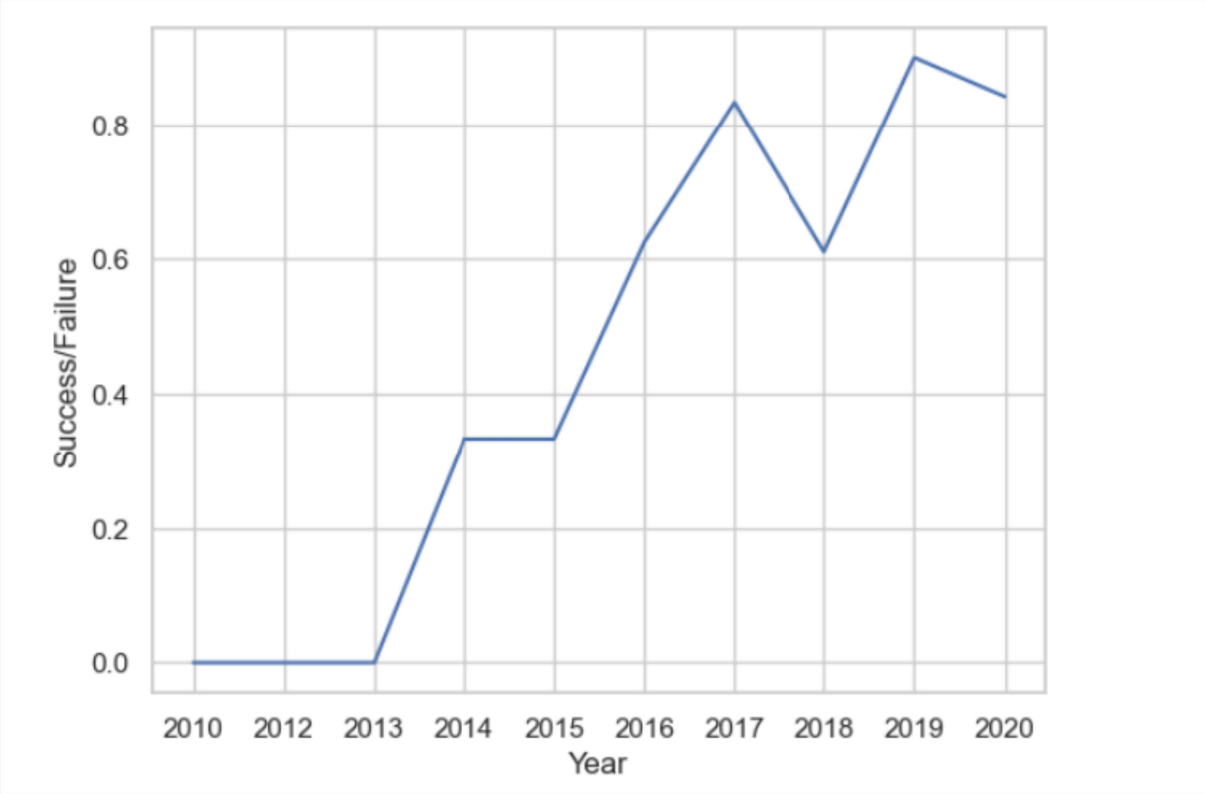
Payload vs. Orbit Type

- We can observe that with heavy payloads, the successful landing are more for PO, LEO and ISS orbits.



Launch Success Yearly Trend

- From the plot, we can observe that success rate since 2013 kept on incre till 2020.



All Launch Site Names

We used the key word **DISTINCT** to show only unique launch sites from t
SpaceX data.

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

In [7]:
```
%sql select distinct Launch_Site from SPACEXTABLE
```

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

Out[7]:

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

Launch Site Names Begin with 'CCA'

Task 2

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

In [13]:
```
%sql select * from SPACEXTABLE where Launch_Site like 'CCA%' limit 5
```

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

Out[13]:

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

Total Payload Mass

We calculated the total payload carried by boosters from NASA as 45596 u
query below

Task 3

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

In [22]:
```
%sql select sum("PAYLOAD_MASS__KG_")  as Total from SPACEXTABLE where customer='NASA (CRS)'
```

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

Out[22]:

Total
45596

Average Payload Mass by F9 v1.1

We calculated the average payload mass carried by booster version F9 v1.1 as 2928.4

Task 4

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

In [27]:
```
%sql select avg(Payload_Mass__KG_) as average_payload_mass from SPACEXTABLE where booster_Version='F9 v1.1'
```

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

Out[27]:

average_payload_mass
2928.4

First Successful Ground Landing Date

We observed that the dates of the first successful landing outcome on ground pad was 22nd December 2015

Task 5

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

Hint:Use min function

In [31]:
```
%sql select min(date) as first_successful_landing from SPACEXTABLE where mission_outcome='Success'
```

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

Out[31]:

first_successful_landing
2010-04-06

Successful Drone Ship Landing with Payload between 4000 and 6000

We used the **WHERE** clause to filter for boosters which have successfully landed drone ship and applied the **AND** condition to determine successful landing with 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

In [33]:
```
%sql select Booster_version from SPACEXTABLE where payload_mass__kg_ > 4000 and payload_mass__kg_ < 6000 and Landing_outcome
```

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

Out[33]:

Booster_Version
F9 FT B1022
F9 FT B1026
F9 FT B1021.2
F9 FT B1031.2

Total Number of Successful and Failure Mission Outco

We used wildcard like '%' to filter for **WHERE** MissionOutcome was a success or failure.

Task 7

List the total number of successful and failure mission outcomes

In [38]:
```
%sql select mission_outcome,count(*) as total from SPACEXTABLE  group by mission_outcome
```

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

Out[38]:

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

Boosters Carried Maximum Payload

We determined the booster that have carried the maximum payload using a subquery in the **WHERE** clause and the **MAX()** function.

Task 8

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

In [45]:
```
%sql select Booster_version from SPACEXTABLE where payload_mass__kg_ = (select max(payload_mass__kg_)  from SPACEXTABLE)
```

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

Out[45]:

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

We used a combinations of the **WHERE** clause, **LIKE**, **AND**, and **BETWEEN** conditions to filter for failed landing outcomes in drone ship, their booster versions, and launch site names for year 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.

Note: SQLLite does not support monthnames. So you need to use substr(Date, 4, 2) as month to get the months and substr(Date,7,4)='2015' for year.

In [56]:
```
%sql select substr(Date,4,1) as Month,Landing_outcome,booster_version,launch_site from SPACEXTABLE where landing_outcome lik
```

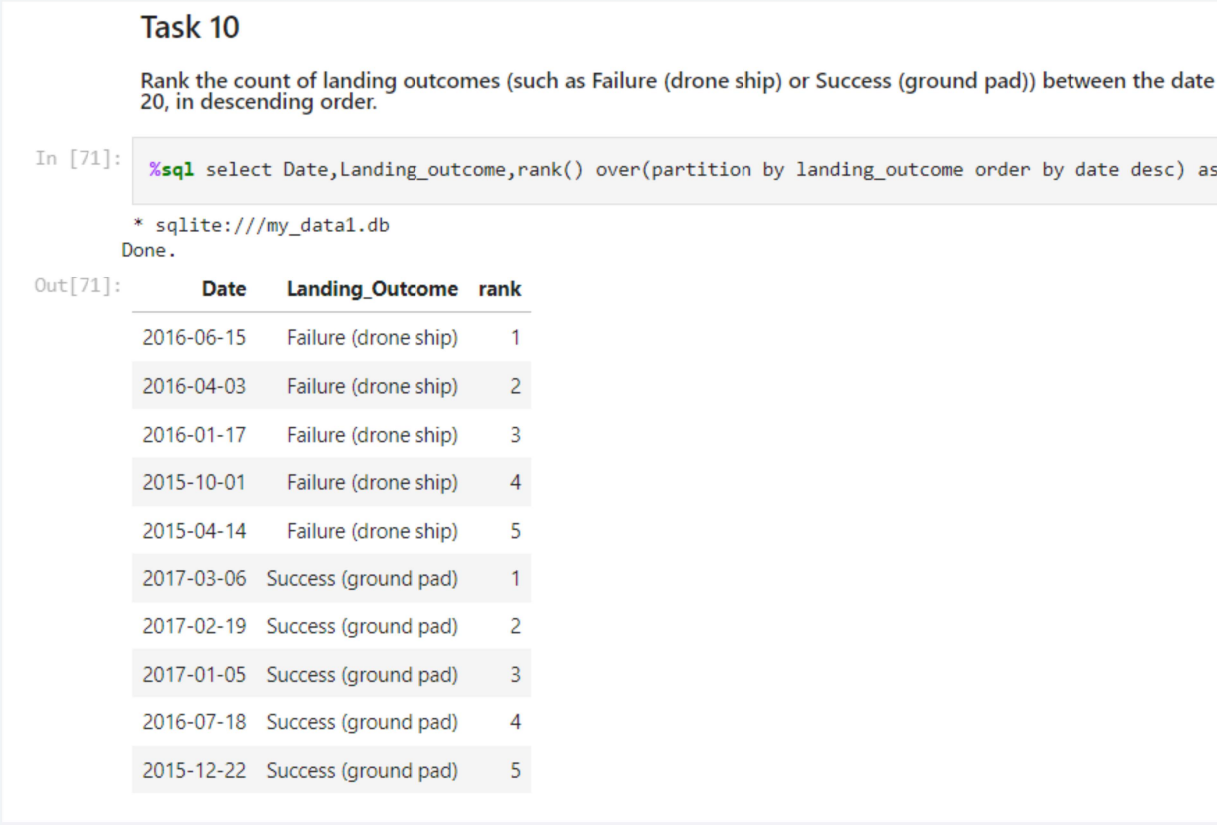
```
 * sqlite:///my_data1.db
Done.
```

Out[56]:

Month	Landing_Outcome	Booster_Version	Launch_Site
5	Failure (drone ship)	F9 v1.1 B1012	CCAFS LC-40
5	Failure (drone ship)	F9 v1.1 B1015	CCAFS LC-40

Rank Landing Outcomes Between 2010-06-04 and 2017

- We selected Landing outcomes and the **COUNT** of landing outcomes from the data and used the **WHERE** clause to filter for landing outcomes **BETWEEN** 2010-06-04 to 2010-03-20.
- We applied the **GROUP BY** clause to group the landing outcomes and the **ORDER BY** clause to order the grouped landing outcome in descending order.



Task 10

Rank the count of landing outcomes (such as Failure (drone ship) or Success (ground pad)) between the date
20, in descending order.

In [71]:
```
%sql select Date,Landing_outcome,rank() over(partition by landing_outcome order by date desc) as
```

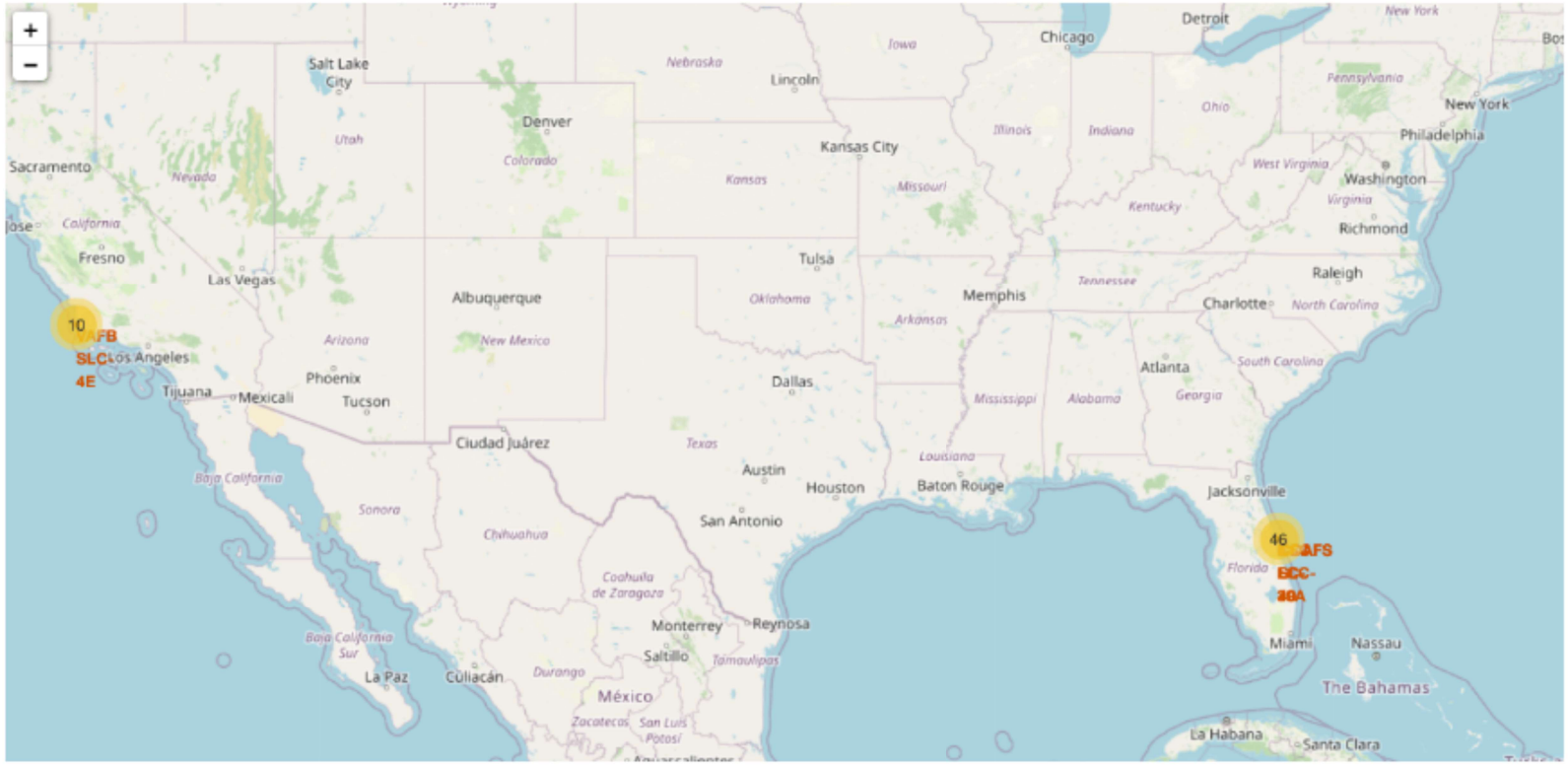
```
* sqlite:///my_data1.db
Done.
```

Out[71]:

Date	Landing_Outcome	rank
2016-06-15	Failure (drone ship)	1
2016-04-03	Failure (drone ship)	2
2016-01-17	Failure (drone ship)	3
2015-10-01	Failure (drone ship)	4
2015-04-14	Failure (drone ship)	5
2017-03-06	Success (ground pad)	1
2017-02-19	Success (ground pad)	2
2017-01-05	Success (ground pad)	3
2016-07-18	Success (ground pad)	4
2015-12-22	Success (ground pad)	5

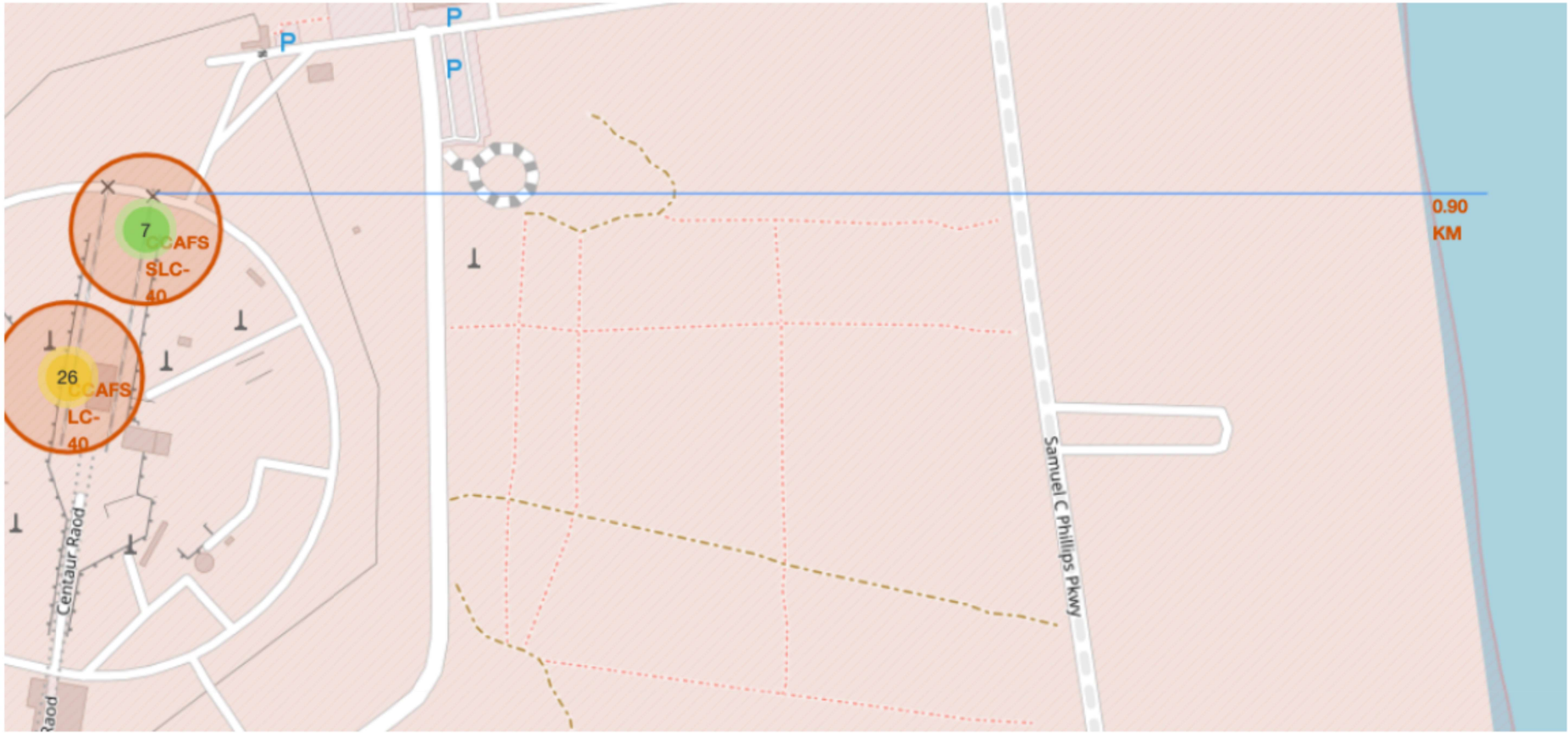

Section 3
Launch Sites
Proximities Analysis

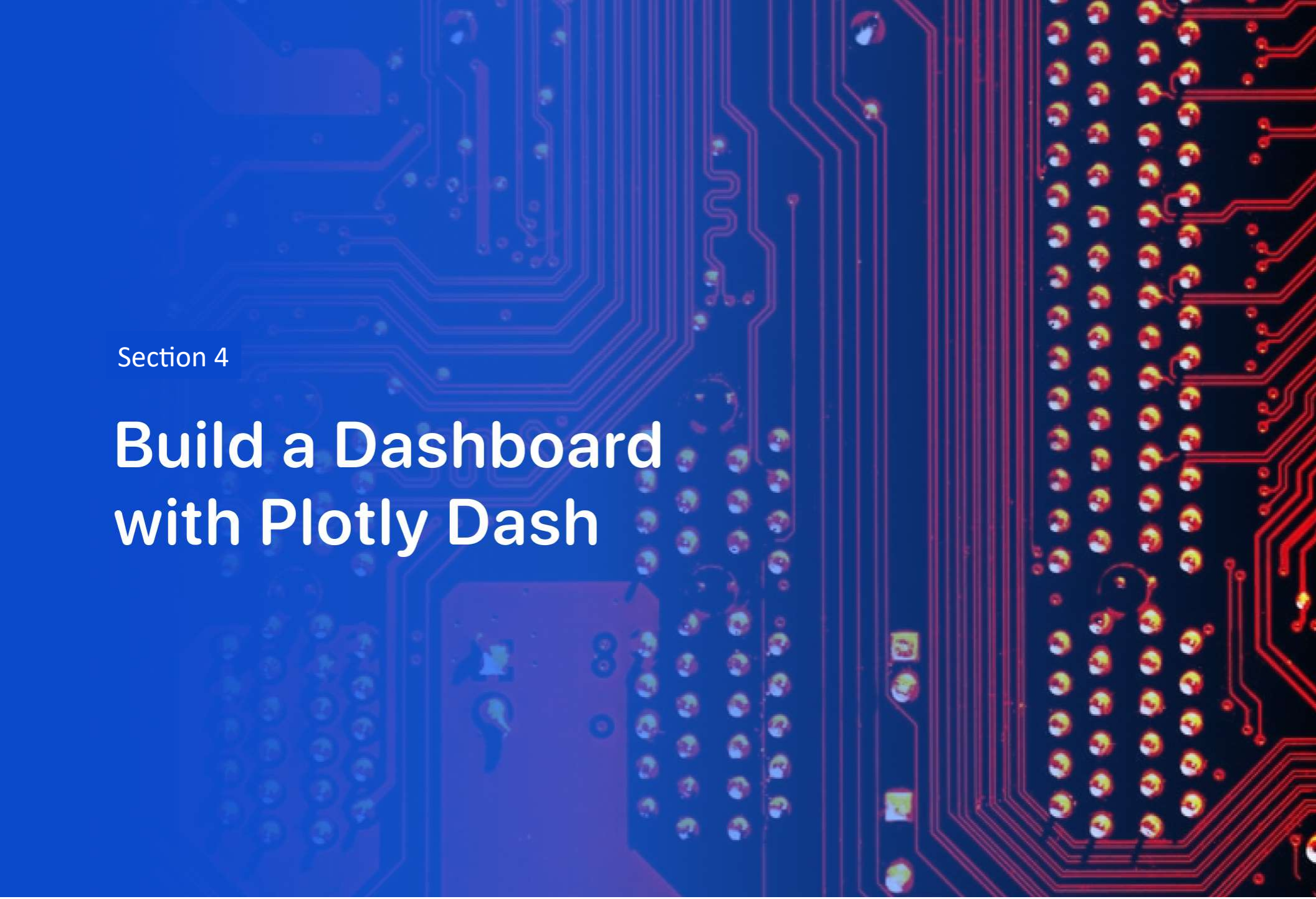
All launch sites global map markers



Markers showing launch sites with color lab

Launch Site distance to landmarks

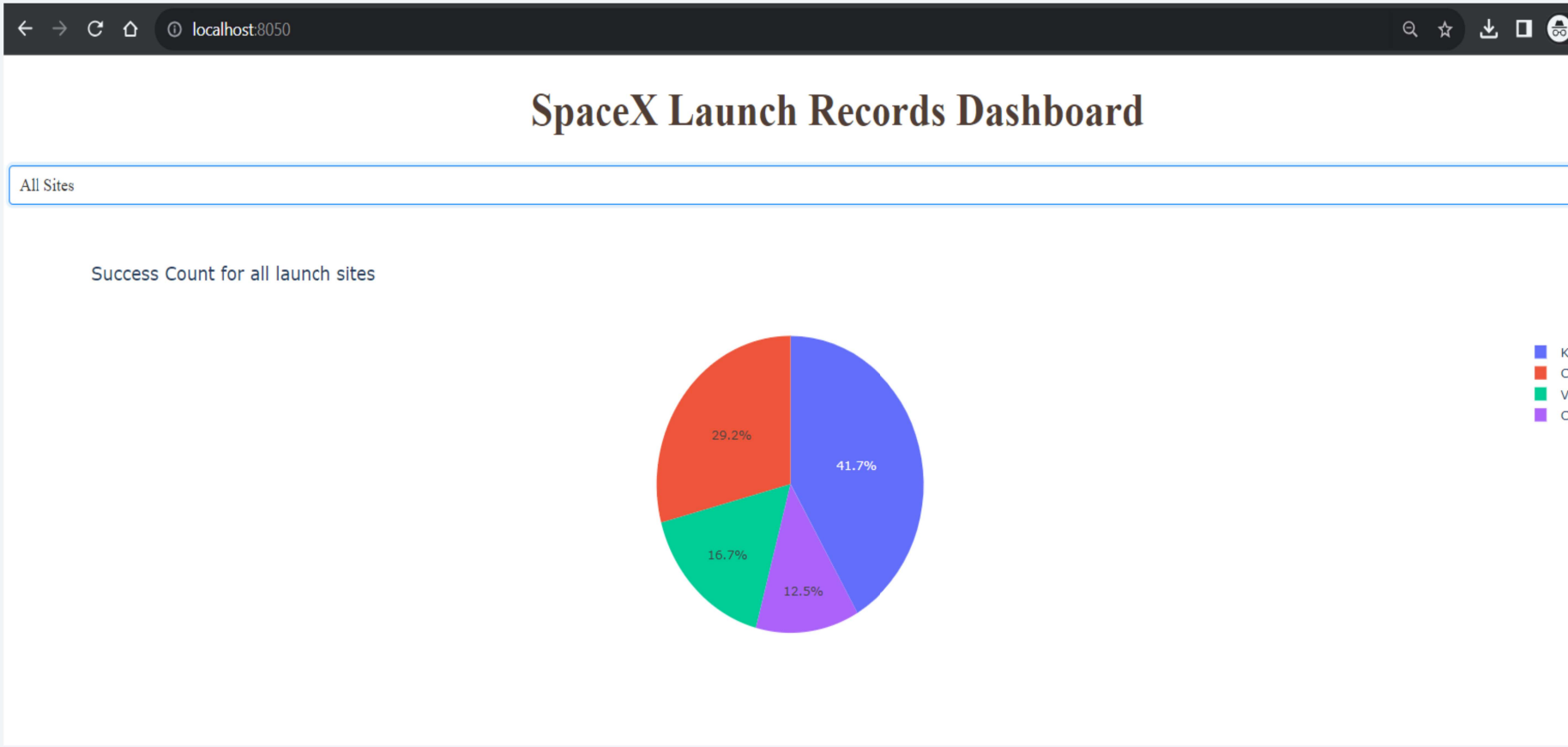




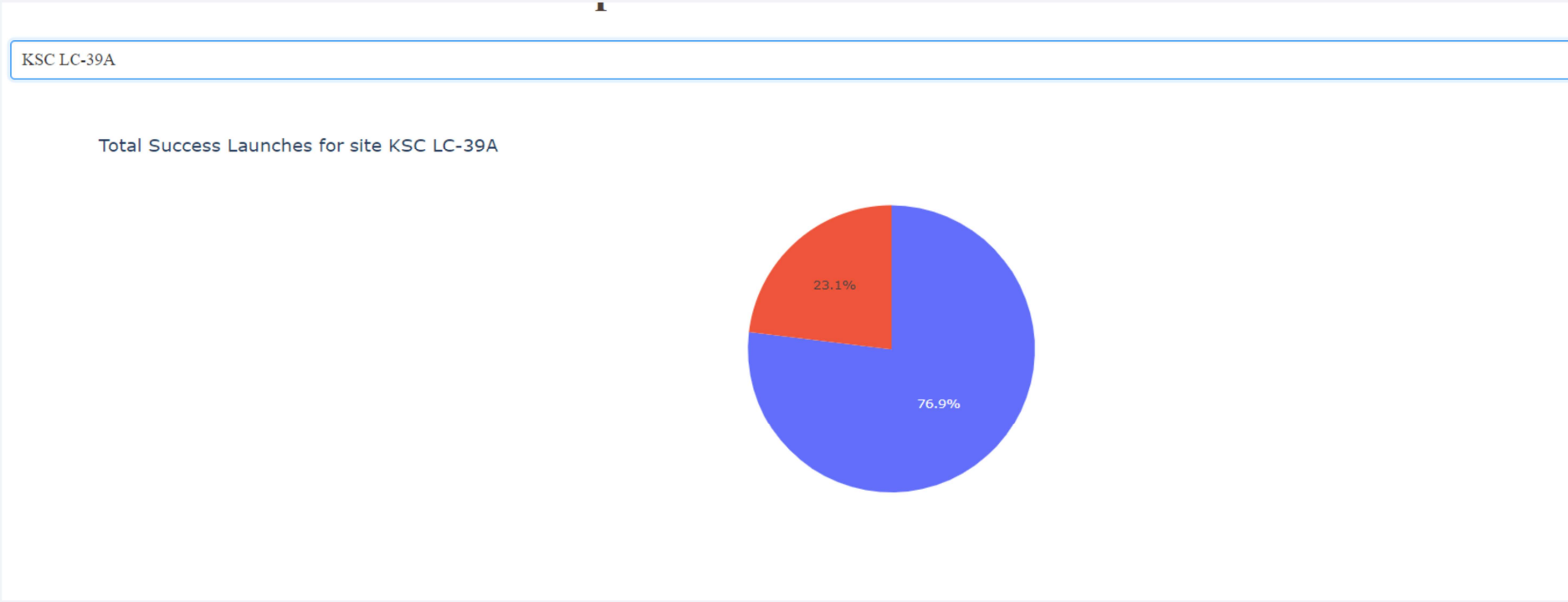
Section 4

Build a Dashboard with Plotly Dash

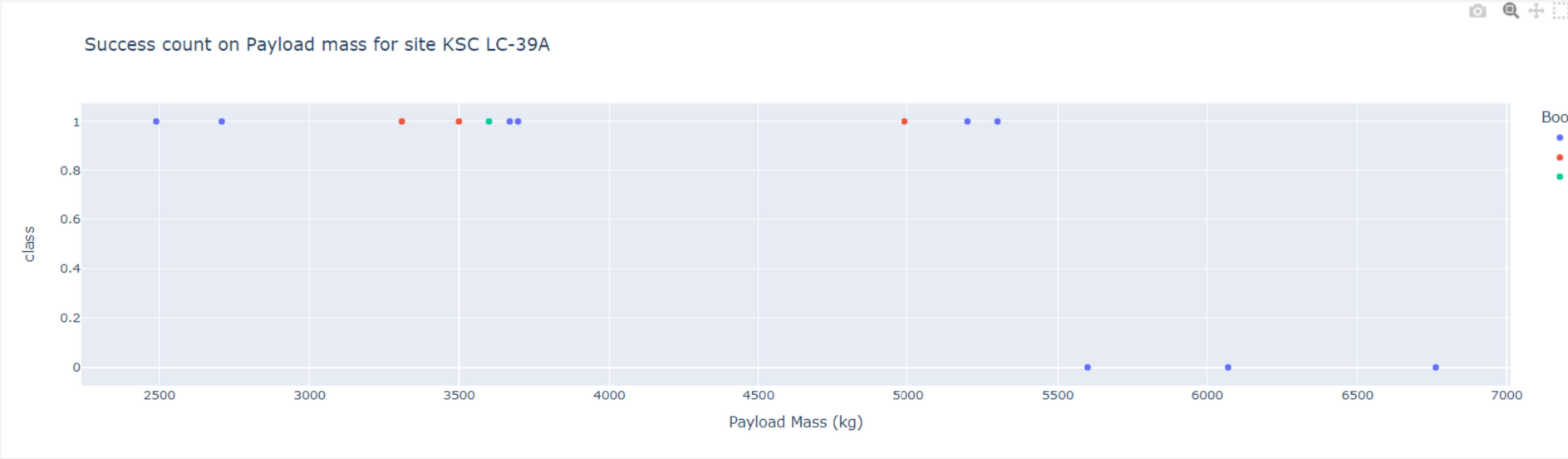
Pie chart showing the success percentage achieved by each launch s



Pie chart showing the Launch site with the highest launch success ra



Scatter plot of Payload vs Launch Outcome for all sites, with different payload selected in the ra

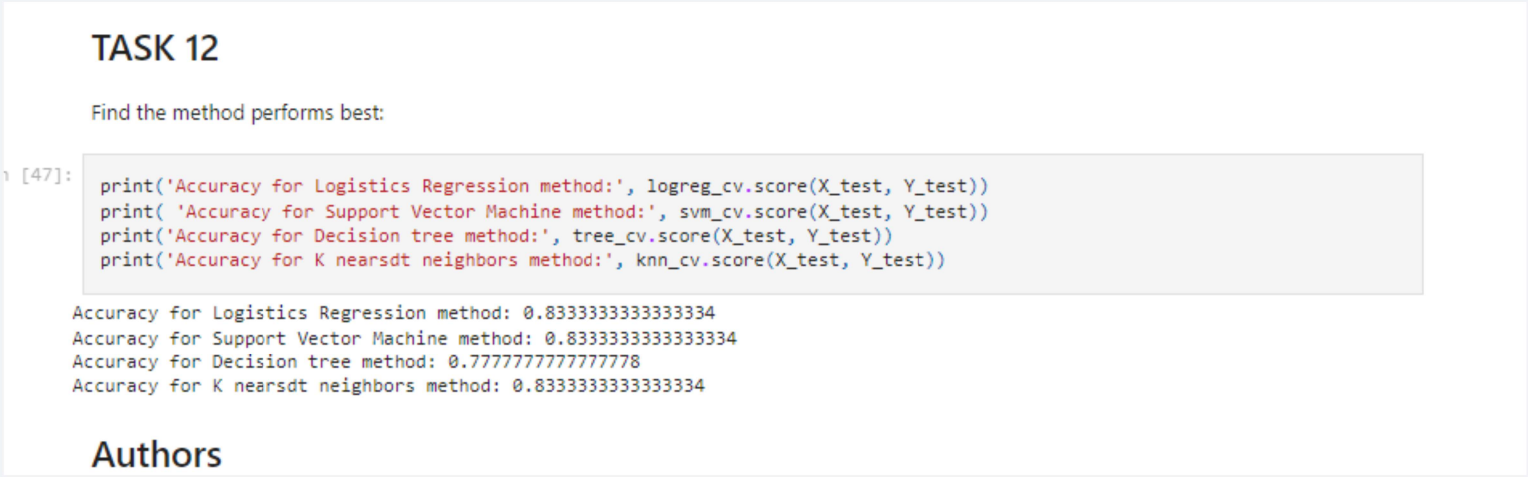


Section 5

Predictive Analysis (Classification)

Classification Accuracy

- The decision tree classifier is the model with the highest classification accuracy



TASK 12

Find the method performs best:

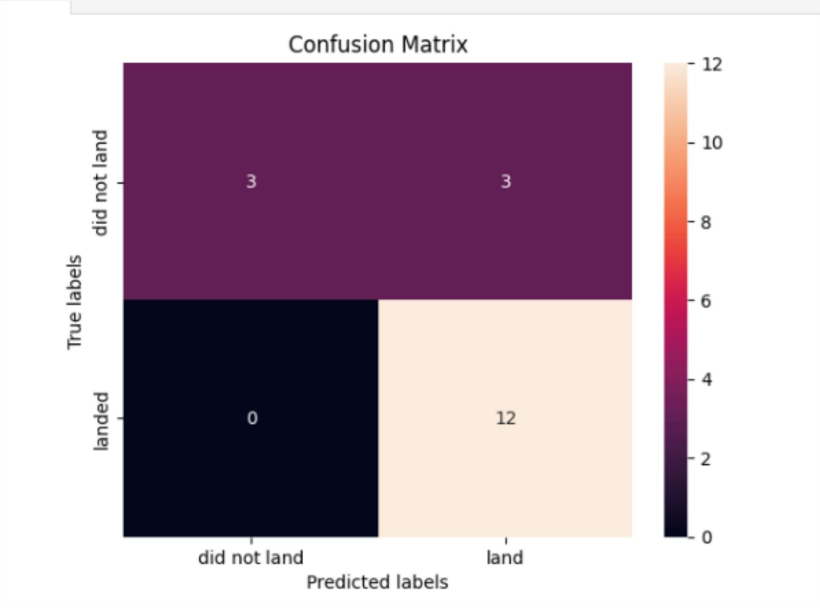
[47]:
```
print('Accuracy for Logistics Regression method:', logreg_cv.score(X_test, Y_test))
print( 'Accuracy for Support Vector Machine method:', svm_cv.score(X_test, Y_test))
print('Accuracy for Decision tree method:', tree_cv.score(X_test, Y_test))
print('Accuracy for K nearsdt neighbors method:', knn_cv.score(X_test, Y_test))
```

```
Accuracy for Logistics Regression method: 0.8333333333333334
Accuracy for Support Vector Machine method: 0.8333333333333334
Accuracy for Decision tree method: 0.7777777777777778
Accuracy for K nearsdt neighbors method: 0.8333333333333334
```

Authors

Confusion Matrix

- A confusion matrix is a table that is often used to describe the performance of a classification model on a set of data for which the true values are known. It is a fundamental tool in the field of machine learning and provides insights into the performance of a classifier, highlighting the types of errors it makes.



Conclusions

We can conclude that:

The larger the flight amount at a launch site, the greater the success rate at a launch site.

Launch success rate started to increase in 2013 till 2020.

Orbits ES-L1, GEO, HEO, SSO, VLEO had the most success rate.

KSC LC-39A had the most successful launches of any sites.

The Decision tree classifier is the best machine learning algorithm for this task.

Appendix

https://github.com/MohanBI/ds_tutorial/blob/main/SpaceX_Machine_Learning_Prediction_Part_5.jupyterlite.ipynb

https://github.com/MohanBI/ds_tutorial/blob/main/jupyter-labs-eda-dataviz.ipynb

https://github.com/MohanBI/ds_tutorial/blob/main/jupyter-labs-eda-sql-coursera_sqllite.ipynb

https://github.com/MohanBI/ds_tutorial/blob/main/jupyter-labs-spacex-data-collection-api.ipynb

https://github.com/MohanBI/ds_tutorial/blob/main/jupyter-labs-webscraping.ipynb

https://github.com/MohanBI/ds_tutorial/blob/main/lab_jupyter_launch_site_location.ipynb

https://github.com/MohanBI/ds_tutorial/blob/main/labs-jupyter-spacex-Data%20wrangling.ipynb

Thank you!