IBM Data Science Capstone Project: SpaceX Launch Analysis

Abhijeet Singh

22/08/2022

OUTLINE

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- Methodology
- Results
  - Visualization – Charts
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- Discussion
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EXECUTIVE SUMMARY

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  - Data Collection
  - Data Wrangling
  - EDA with Data Visualization
  - EDA with SQL
  - Building an interactive map with Folium
  - Building a Dashboard with Plotly Dash
  - Predictive analysis(Classification)
- Summary of all results
  - EDA results
  - Interactive analytics
  - Predictive analysis

INTRODUCTION

- Project background:
  - SpaceX advertises Falcon9 rocket launches on its website, with a cost of 62 million dollars; other providers cost upward of 165 million dollar each, much of the saving is because SpaceX can reuse the first stage.
- Problem Statement:
  - The project task is to predicting if the first stage of the SpaceX Falcon9 rocket will land successfully.

Methodology

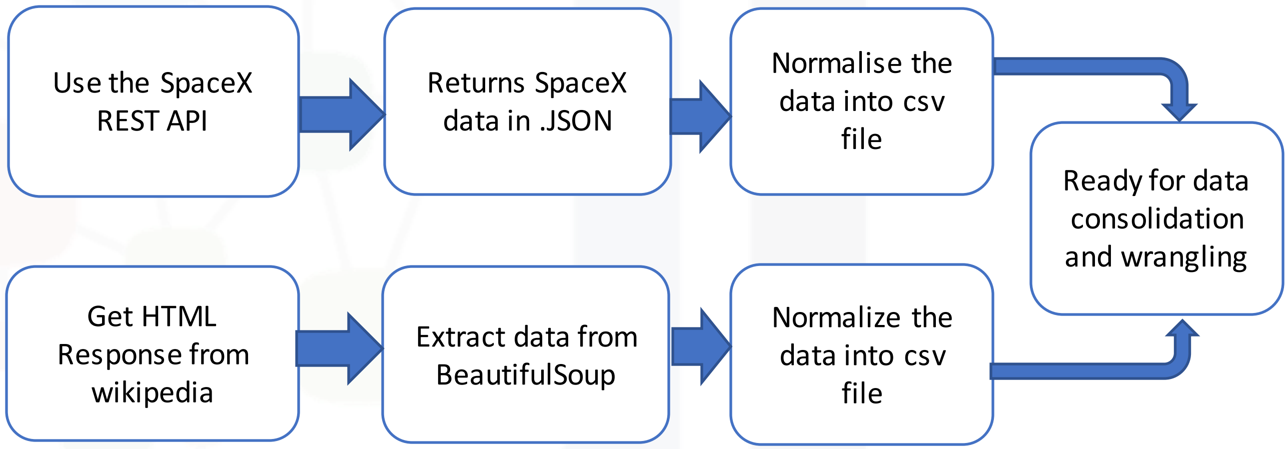
METHODOLOGY

- Executive Summary
  - Data collection methodology:
    - SpaceX Rest API
    - Web Scrapping from Wikipedia
  - Perform data wrangling:
    - One Hot Encoding data fields for machine learning and data cleaning of null values and irrelevant columns
  - Perform exploratory data analysis(EDA) using visualization and SQL
  - Perform interactive visual analytics using Folium and Plotly Dash
  - Perform predictive analysis using classification models
    - LR, KNN, SVM, DT models have been built and evaluated for the best classifier

Data Collection

- The following data set was collected:
  - SpaceX launch data that is gathered from the SpaceX REST API
  - This API will give us data about launches, including the information about the rocket used, payload delivered, launch specifications, landing specifications and landing outcome.
  - The SpaceX REST API endpoints, or URL, starts with https://api.spacexdata.com/v4/rockets/
  - Another popular data source for obtaining Falcon9 launch data is web scrapping wikipedia using BeautifulSoup

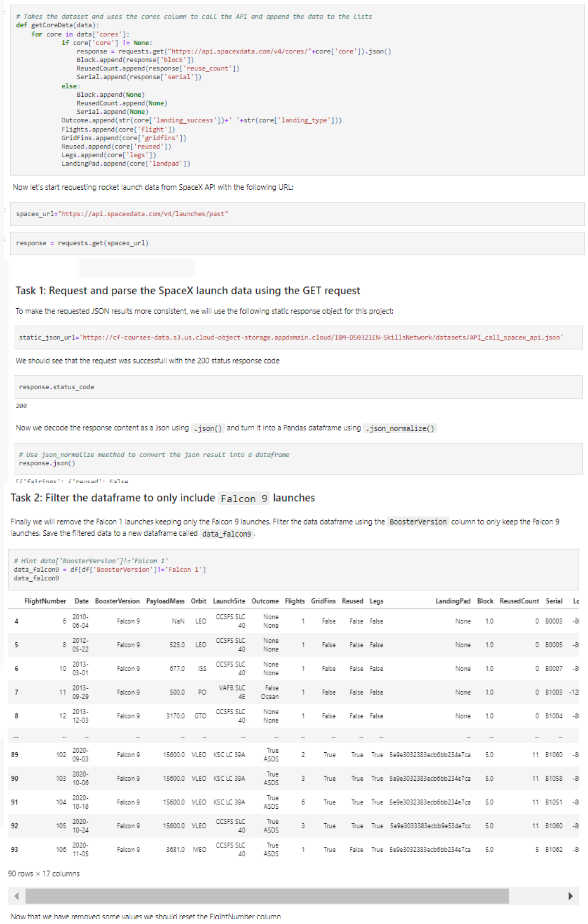
- SpaceX API



Data Collection And Scraping SpaceX API

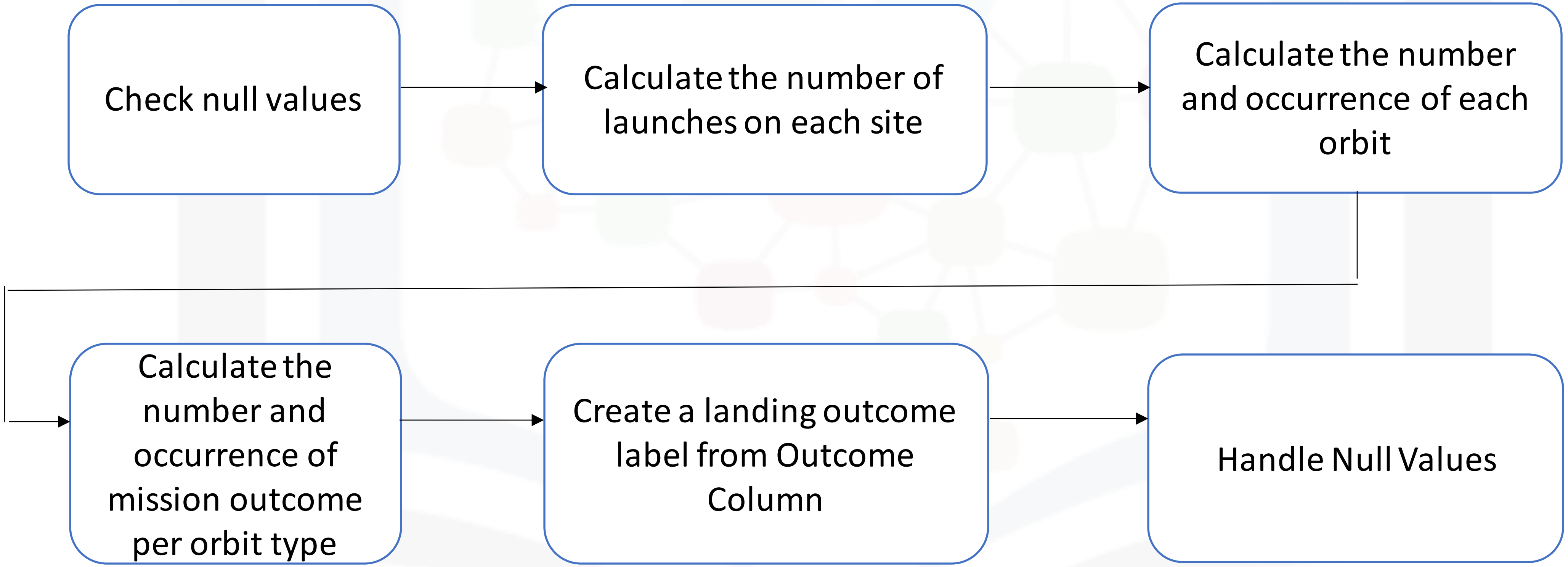
- Data collection with SpaceX REST calls and Web Scrapping from Wikipedia

- https://github.com/Abhijeet-Sih/Capstone-Project/blob/3823feec9a3d3263646de3fc7205b2332b08ac12/Data_Collection&Wrangling.ipynb



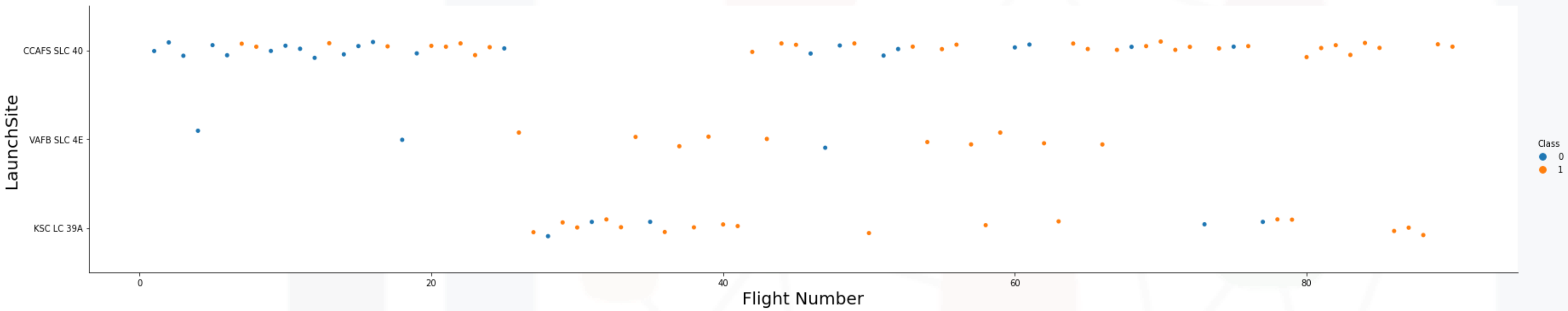
Data Wrangling

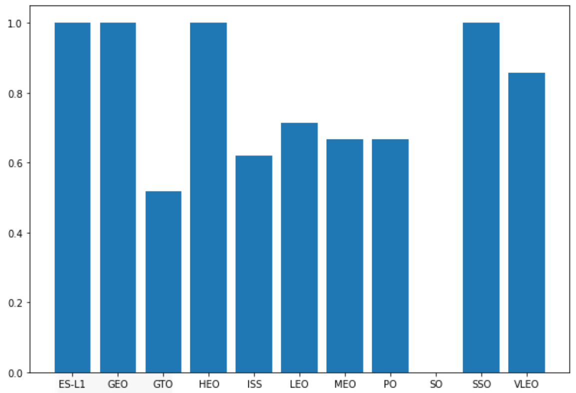
EDA Analysis

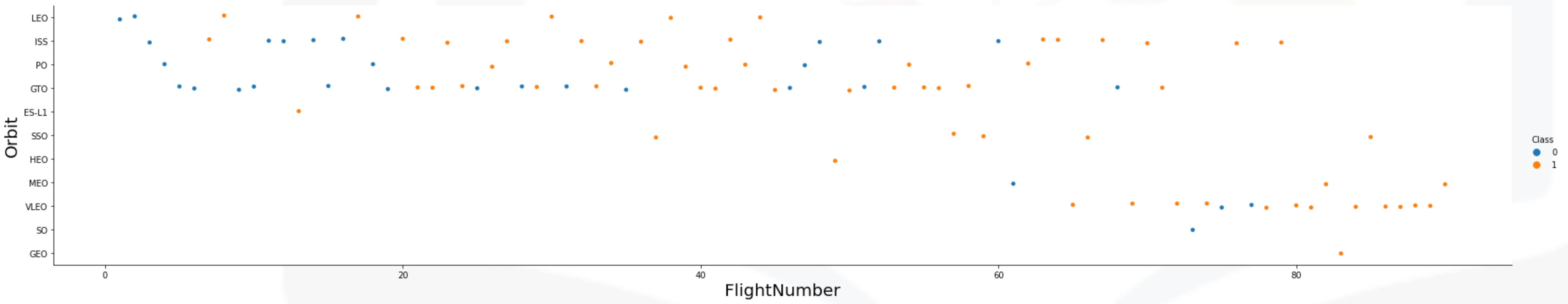


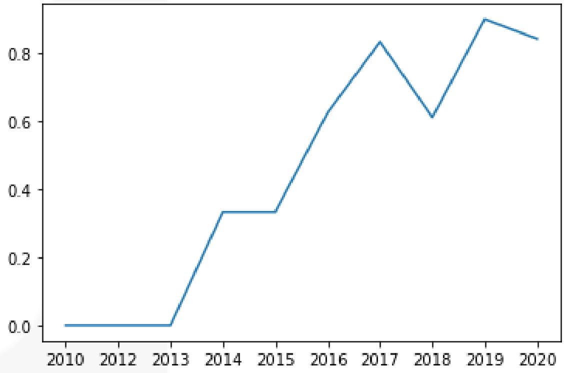
https://github.com/Abhijeet-Sih/Capstone-Project/blob/a8a0052333ba3732c8596652b90352d70bc977f9/Data%20Wrangling.ipynb

EDA with Data Visualization

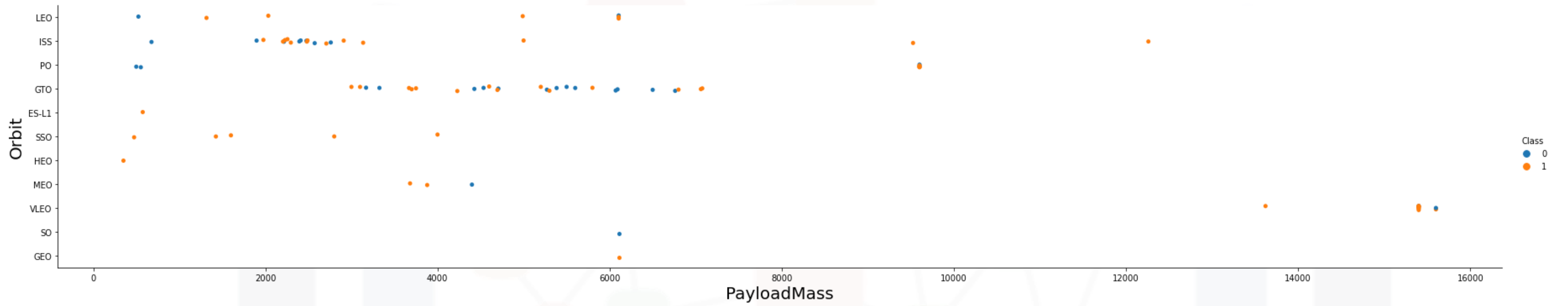


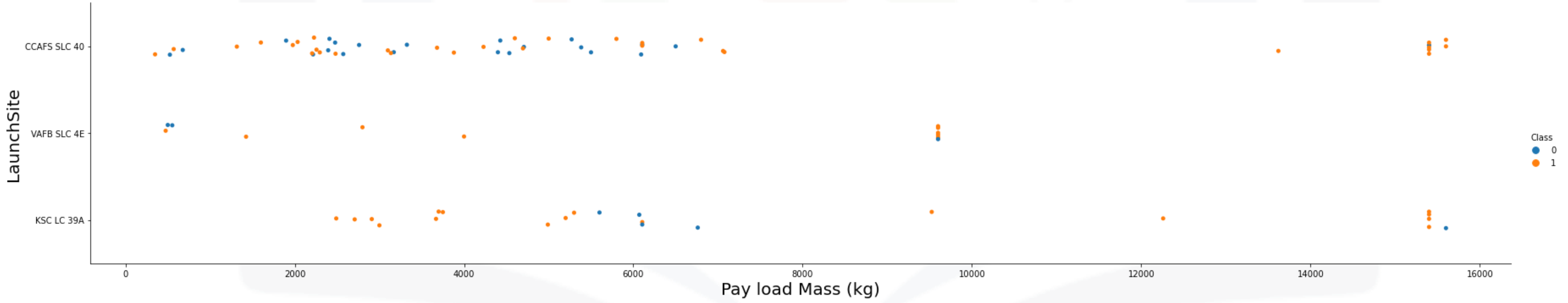






EDA with Data Visualization





https://github.com/Abhijeet-Sih/Capstone-Project/blob/fe12ded58389b2faf89ef4bb1b32d95594580cb8/EDA_with_data_visualization.ipynb

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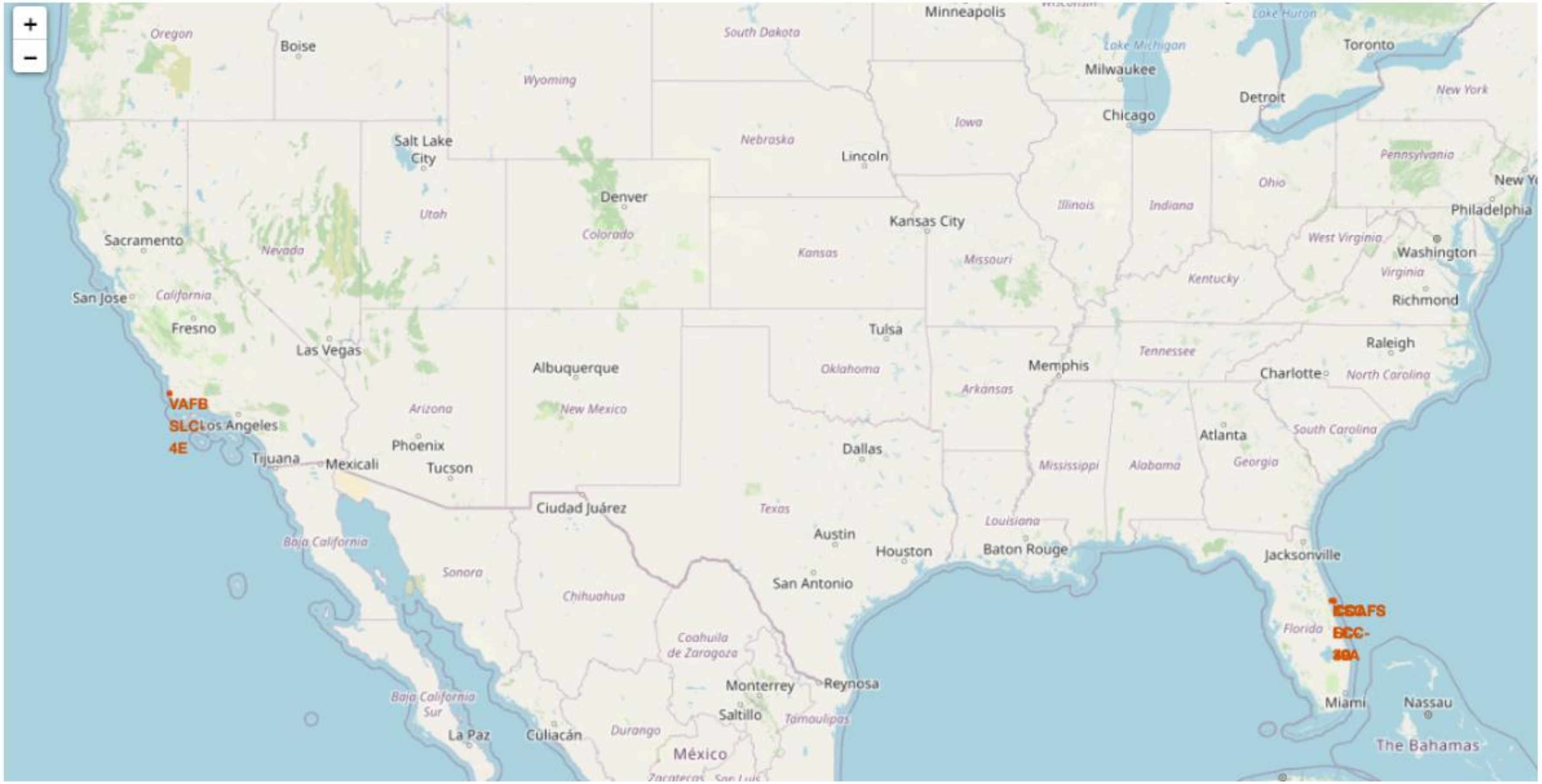
SKILLS NETWORK

EDA with SQL

- SQL queries performed include:
  - Displaying the names of the unique launch sites in the space mission.
  - Displaying 5 records where launch site begin with string 'KSC'
  - Displaying the total payload mass carried by boosters launched by NASA (CRS)
  - Displaying the average payload mass carried by booster version F9 v1.1
  - Listing the date where the successful landing outcome in drone ship was achieved
  - Listing the names of the boosters which have success in ground pad 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 records which will display the month names, successful landing outcomes in ground pad, booster versions, launch site for the months in year 2017
  - Ranking the count of successful landing outcomes between the date 2010-06-04 and 2017-03-30 in descending order

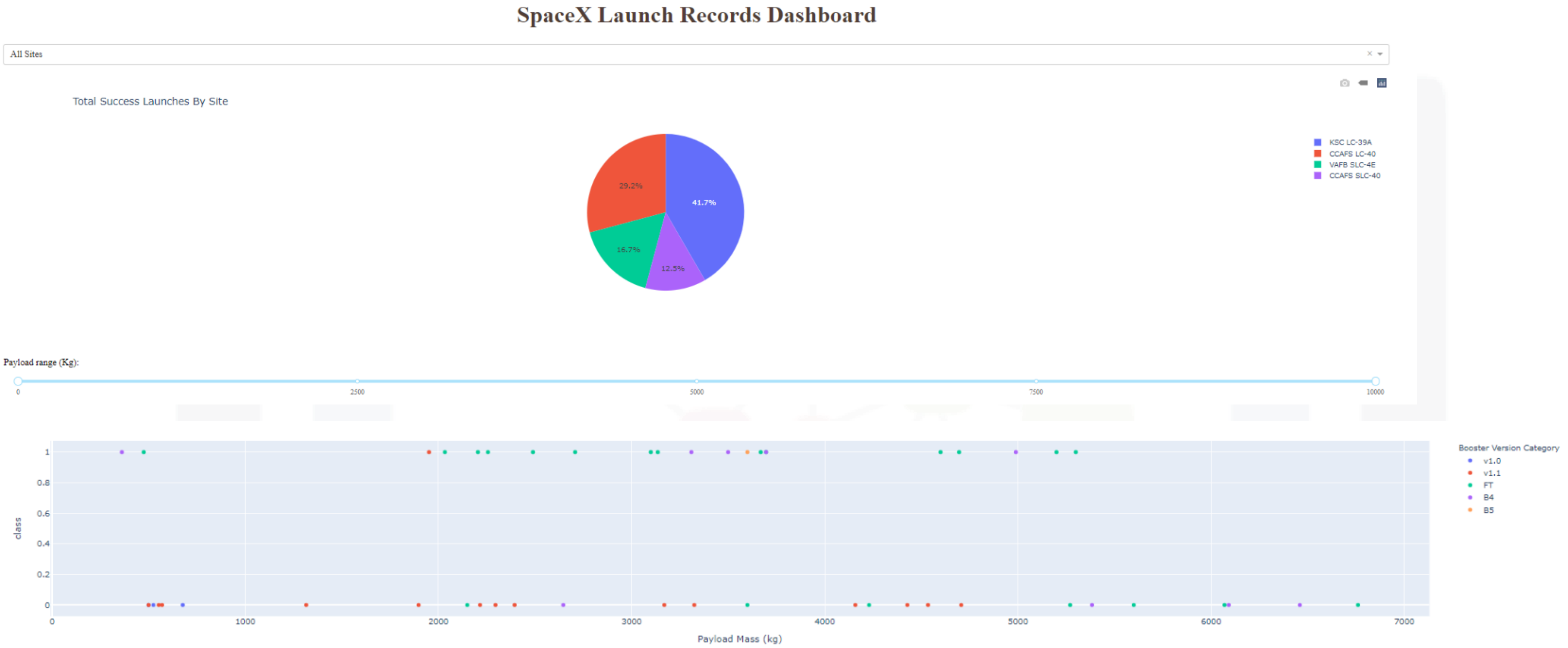
https://github.com/Abhijeet-Sih/Capstone-Project/blob/a92bcd2fd68e2567bdb2a96a83b726fab373ded2/EDA%20with%20SQL%20.ipynb

Build an Interactive Map with Folium



https://github.com/Abhijeet-Sih/Capstone-Project/blob/cf77b026ce8c28ab9a0df03ec0969ad9058e92a9/Interactive_map_with_Folium.ipynb

Build a dashboard with Plotly Dash

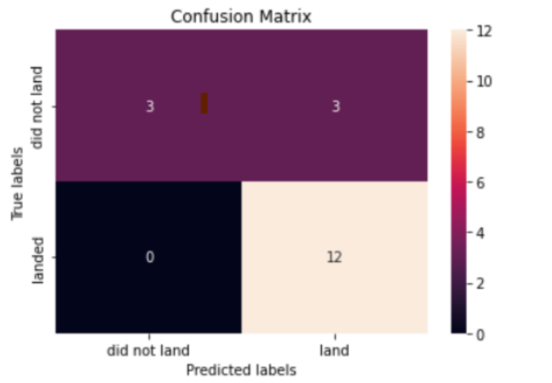


https://github.com/Abhijeet-Sih/Capstone-Project/blob/f93695b96205823667675c05df9b06ec3b2f3752/spacex_dash_app.py

Predictive Analysis

- The SVM, KNN and Logistic Regression model achieved the highest accuracy at 83.33%.

```
yhat=logreg_cv.predict(X_test)
plot_confusion_matrix(Y_test,yhat)
```

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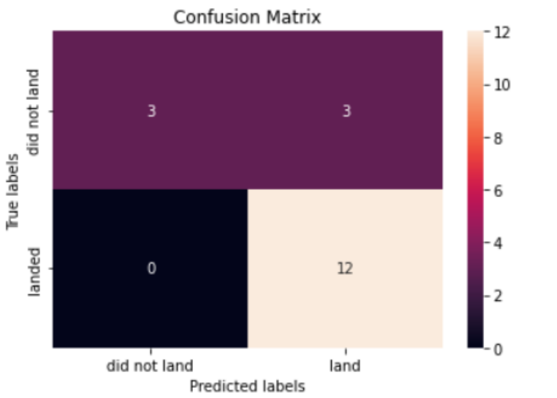


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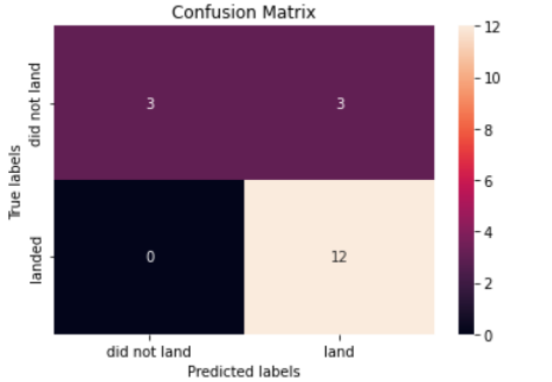
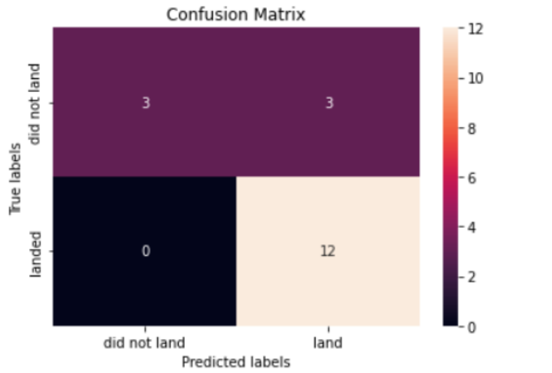



```
yhat = knn_cv.predict(X_test)
plot_confusion_matrix(Y_test,yhat)
```



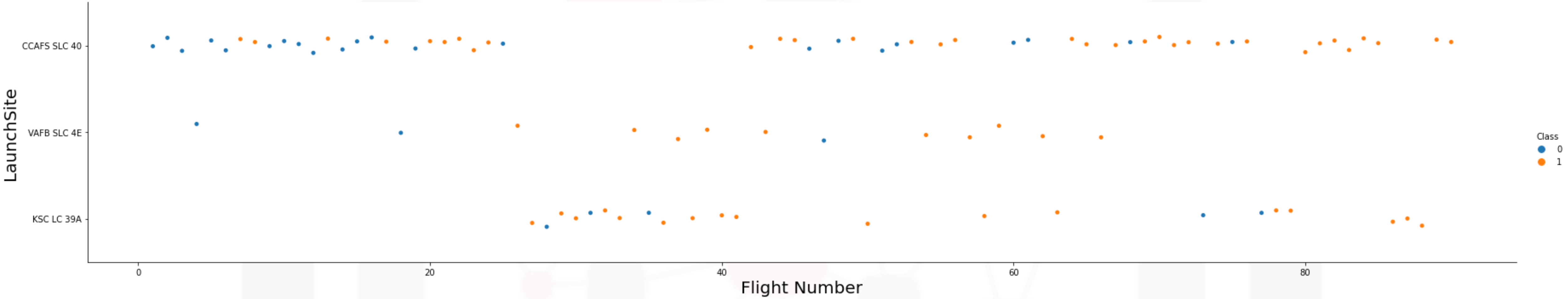
https://github.com/Abhijeet-Sih/Capstone-Project/blob/0bf4e589b04fe1b175e05ecb31ae87fd827239e0/Predictive%20Analysis.ipynb

Results

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

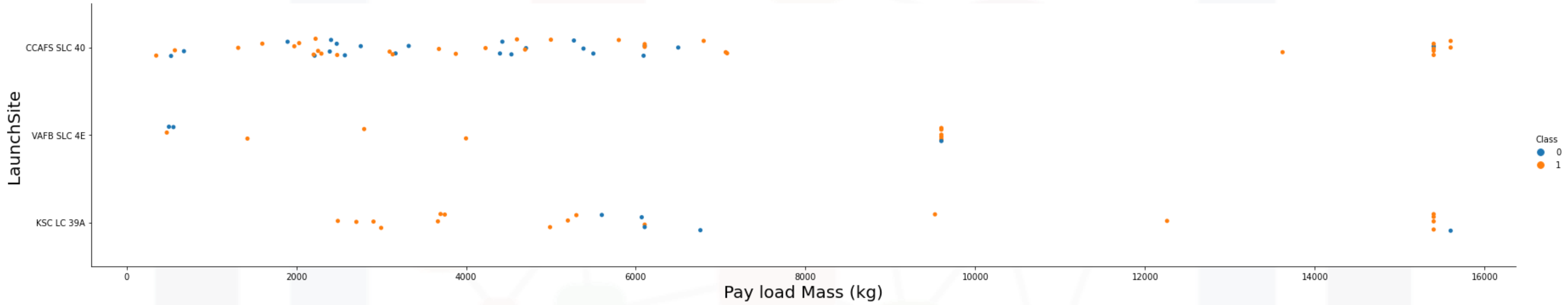
Insights Drawn From EDA

Flight Number vs. Launch Site



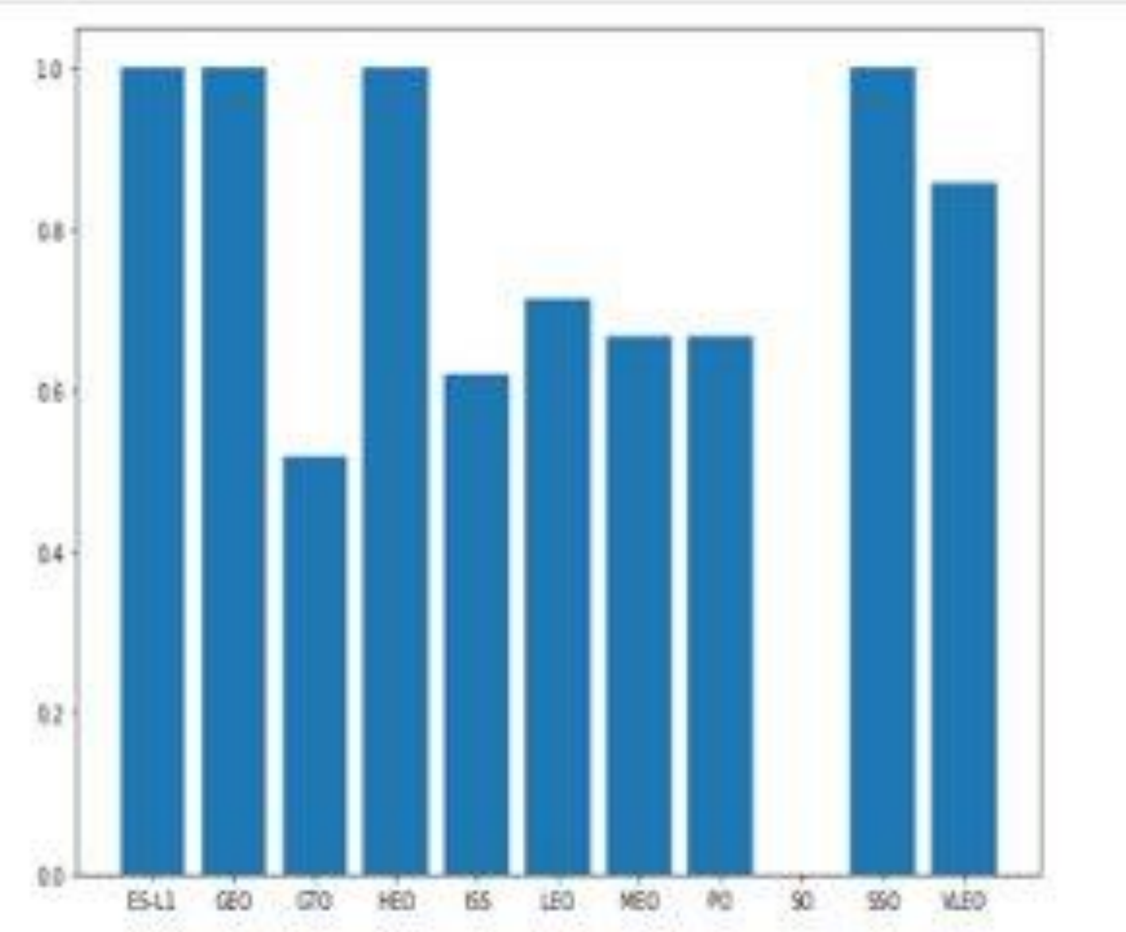
- Launches from the site of CCAFS SLC 40 are significantly higher than the launches from the other sites.

Payload vs. Launch Site



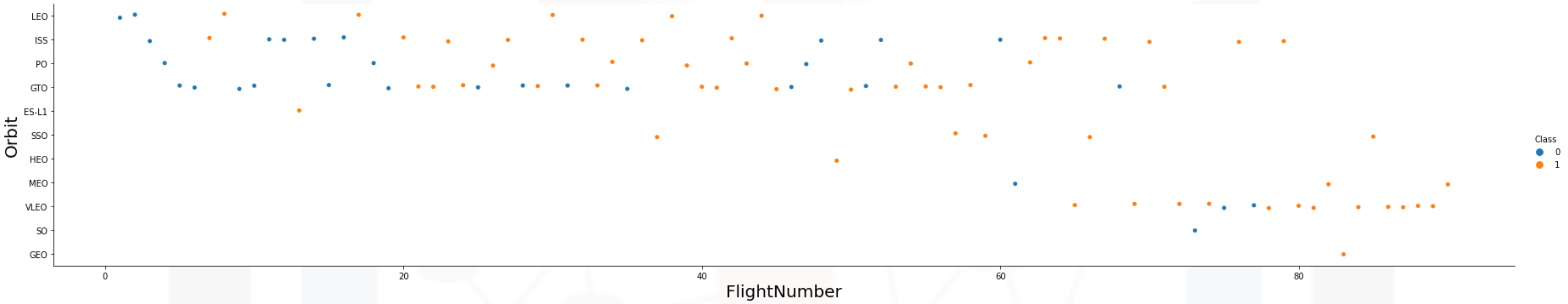
- Majority of payloads with lower mass have been launched from CCAFS SLC 40.

Success Rate vs. Orbit Type



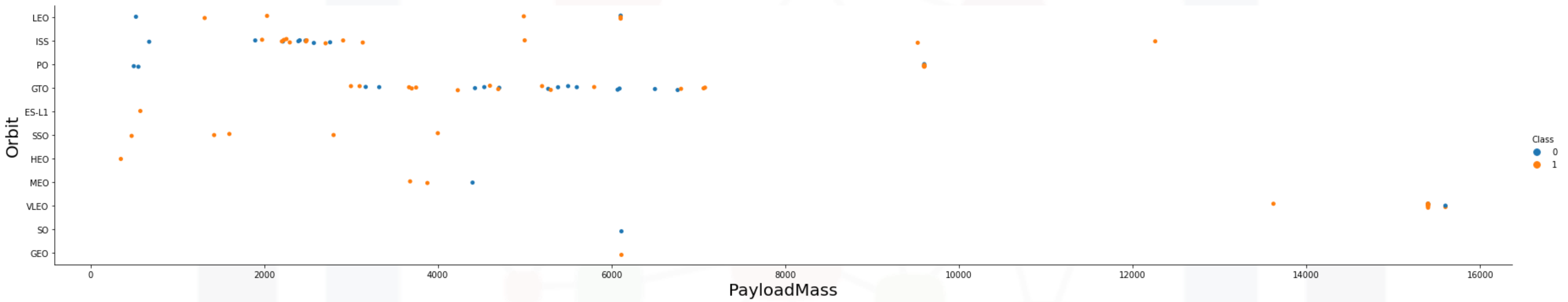
- The orbit types ES-L1, GEO, HEO, SSO are among the highest success rates.

Flight Number vs. Orbit Type



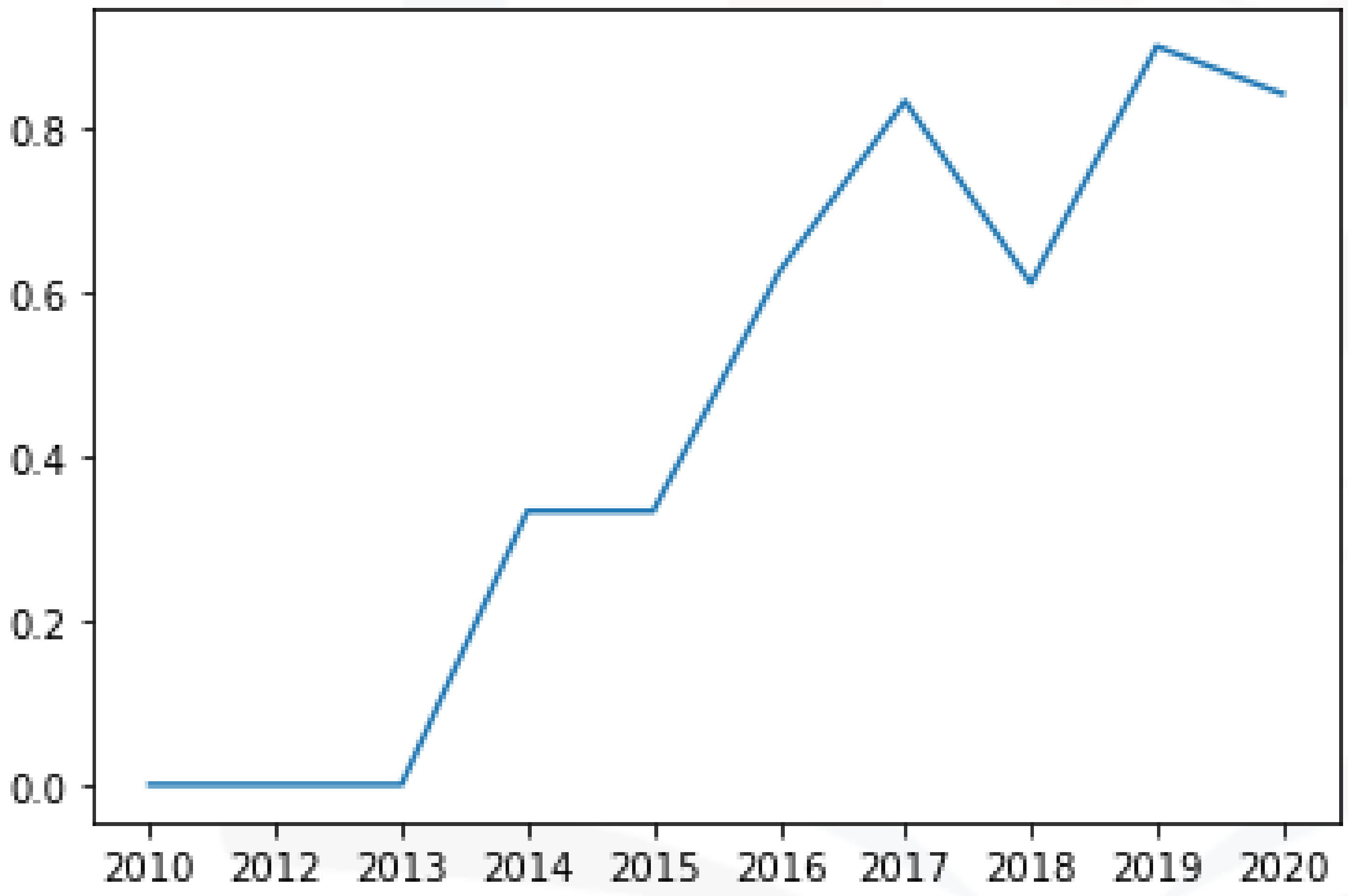
- A trend can be observed of shifting to VLEO launches in recent years

Payload vs. Orbit Type



- There are strong correlation between ISS and payload at the range around 2000, as well as between GTO and the range of 4000-8000.

Launch Success Yearly Trend



- Launch success rate has increased significantly since 2013 and has stabilized since 2019, potentially due to advance in technologies and lessons learned.

All Launch Site Names

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

- **%sql** SELECT DISTINCT(Launch_Site) from SPACEXTBL;

Launch Site Names Begin with 'CCA'

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	07:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)	Success	No attempt
2012-10-08	00:35:00	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

- %sql SELECT * FROM SPACEXTBL WHERE launch_site LIKE 'CCA%' LIMIT 5;

Total Payload Mass

total_payload_mass
45596

- **%sql** SELECT SUM(PAYLOAD_MASS__KG_) AS total_payload_mass FROM SPACEXTBL WHERE Customer = 'NASA (CRS)' GROUP BY Customer;

Average Payload Mass By F9 v1.1

payload_F9 v1.1
2928

- %sql SELECT AVG(PAYLOAD_MASS__KG_) AS "payload_F9 v1.1" FROM SPACEXTBL WHERE booster_version = 'F9 v1.1' GROUP BY booster_version;

First Successful Ground Landing Date

Date_first_success_launch
2015-12-22

- %sql SELECT MIN(DATE) as "Date_first_success_launch" FROM SPACEXTBL WHERE landing__outcome LIKE '%ground pad%';

Successful Drone Ship Landing with Payload Between 4000 and 6000

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

- %sql SELECT booster_version FROM SPACEXTBL WHERE landing__outcome = 'Success (drone ship)' AND payload_mass__kg_ BETWEEN 4000 and 6000;

Total Number of Successful and Failure Mission Outcome

success	failure
100	1

- %sql SELECT SUM(CASE WHEN mission_outcome LIKE 'Success%' THEN 1 ELSE 0 END) AS Success, SUM(CASE WHEN mission_outcome LIKE 'Failure%' THEN 1 ELSE 0 END) AS Failure FROM SPACEXTBL;

Boosters Carried Maximum Payload

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

- %sql SELECT booster_version FROM SPACEXTBL WHERE payload_mass__kg_ IN (SELECT MAX(payload_mass__kg_) FROM SPACEXTBL);

Failed Landing Outcomes in year 2015

Month	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

- %sql SELECT TO_CHAR(date, 'Month') AS "Month", landing__outcome, booster_version, launch_site FROM SPACEXTBL WHERE EXTRACT(YEAR FROM date) = 2015 AND landing__outcome = 'Failure (drone ship)';

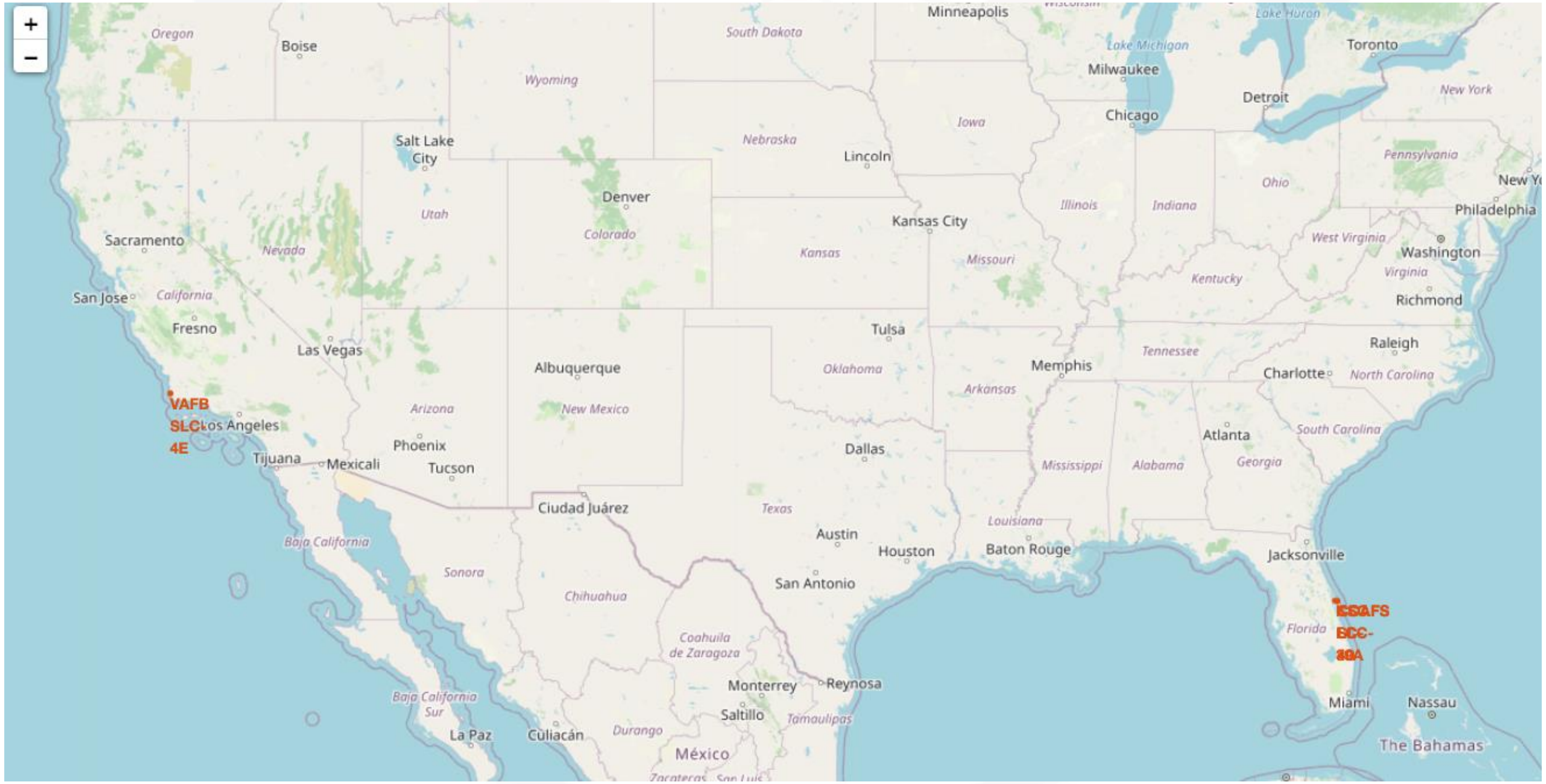
Rank the count of landing outcomes (such as Failure (drone ship) or Success (ground pad)) between the date 2010-06-04 and 2017-03-20, in descending order

landing__outcome	count_of_lo
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

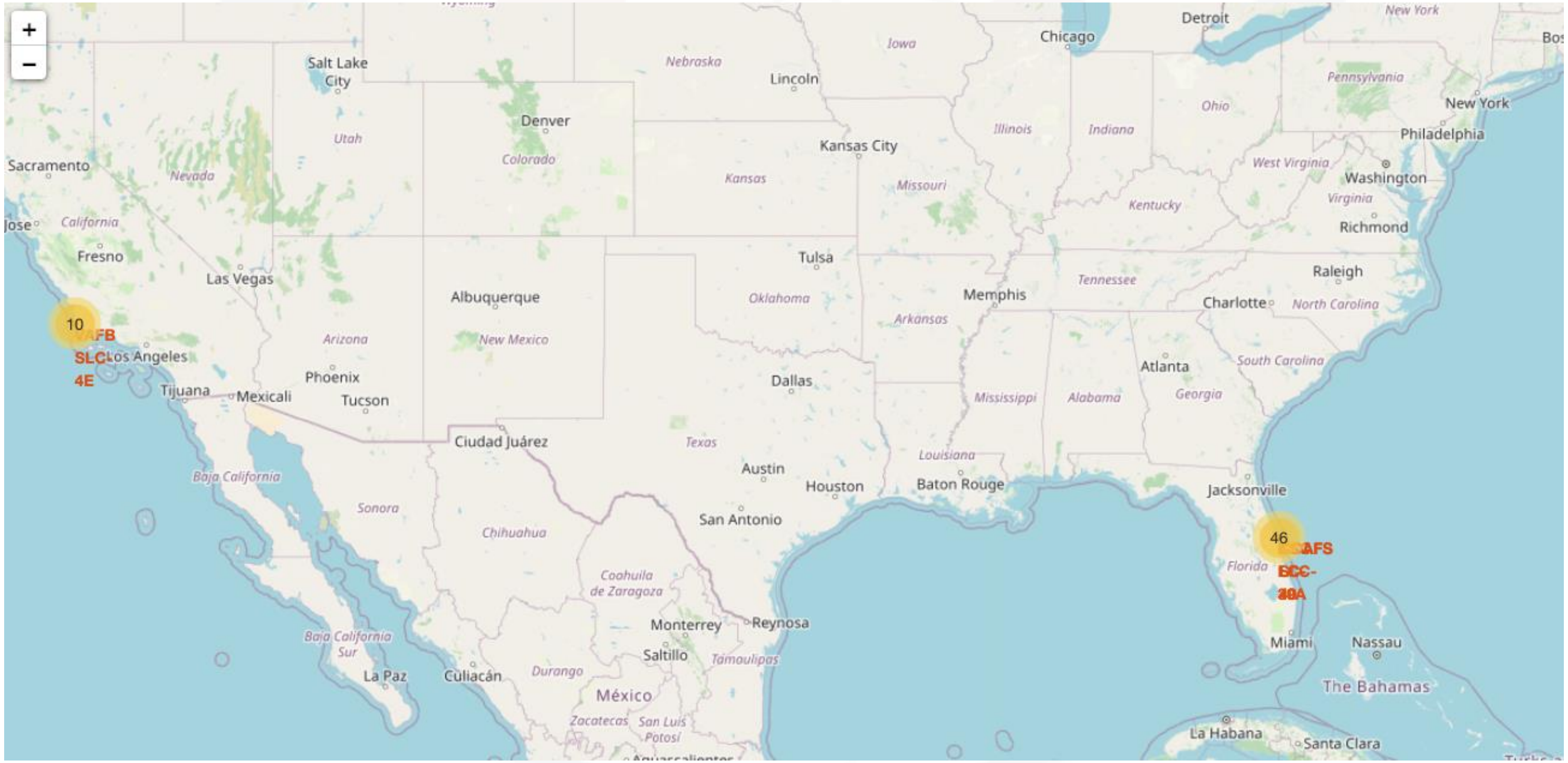
- %sql SELECT landing__outcome, COUNT(*) AS count_of_lo FROM SPACEXTBL WHERE DATE BETWEEN '2010-06-04' AND '2017-03-20' GROUP BY landing__outcome ORDER BY count_of_lo DESC;

Launch Site Proximities Analysis

All Launch Site on The Map



Marked the success/failed launches for each site on the map



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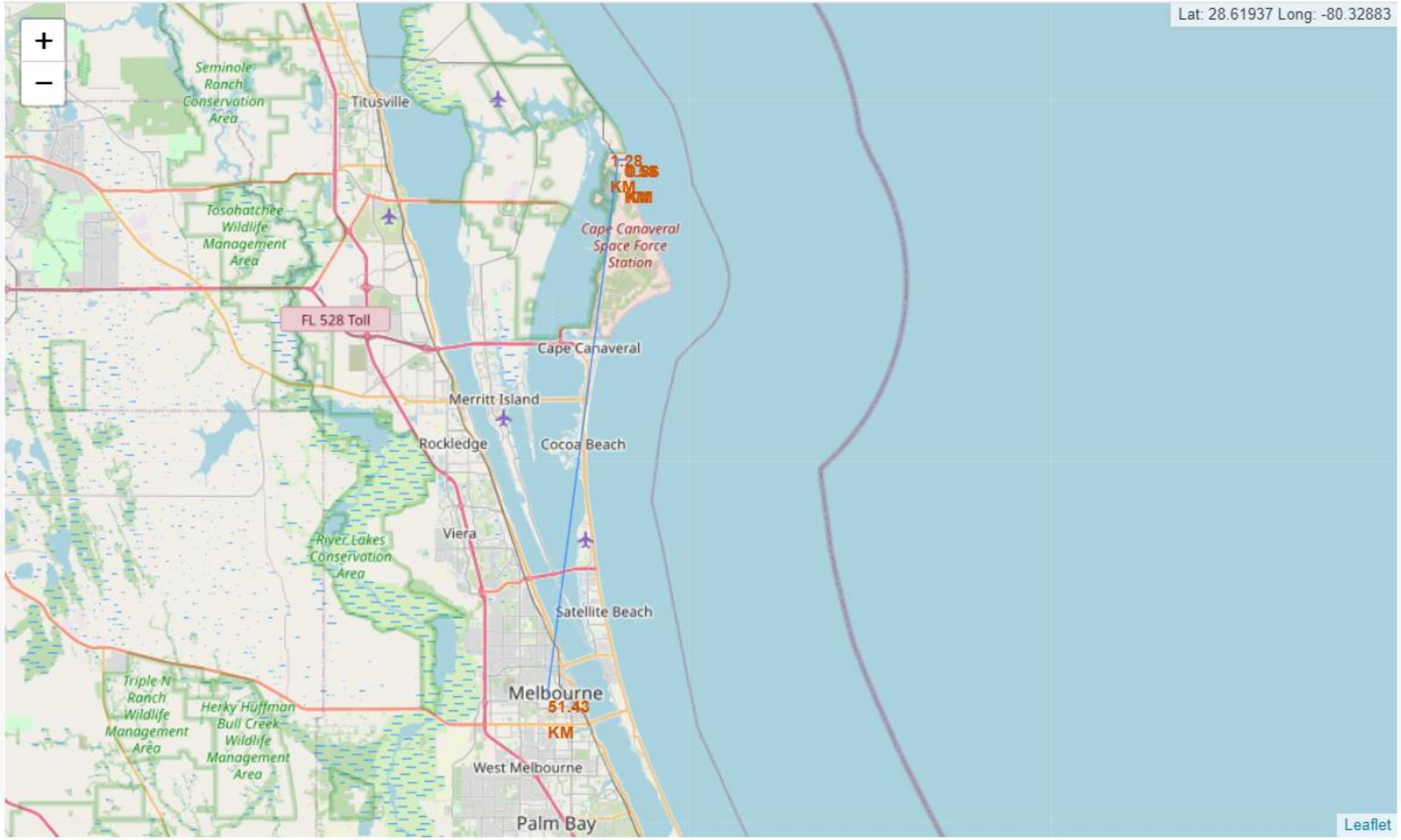
SKILLS NETWORK

Distances Between a Launch Site and its Proximities



Predictive Analysis

Classification Accuracy

```
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
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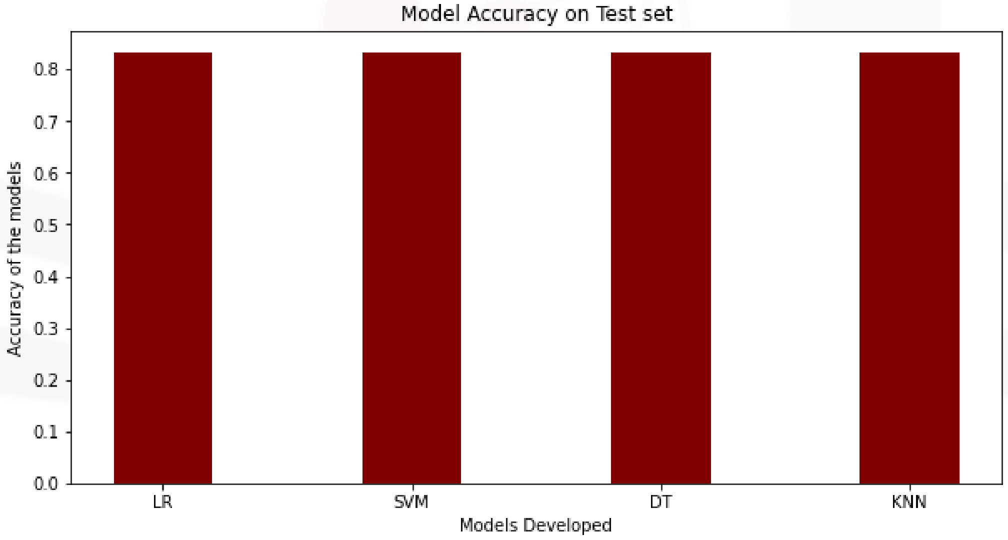

Confusion Matrix

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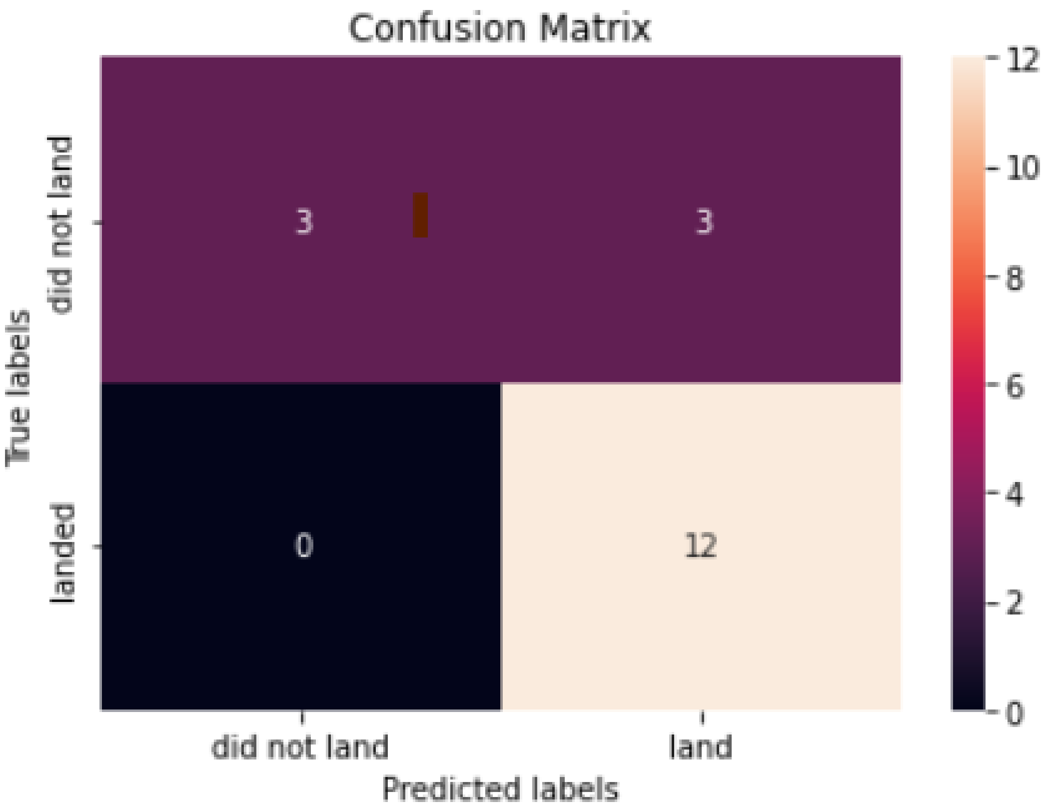


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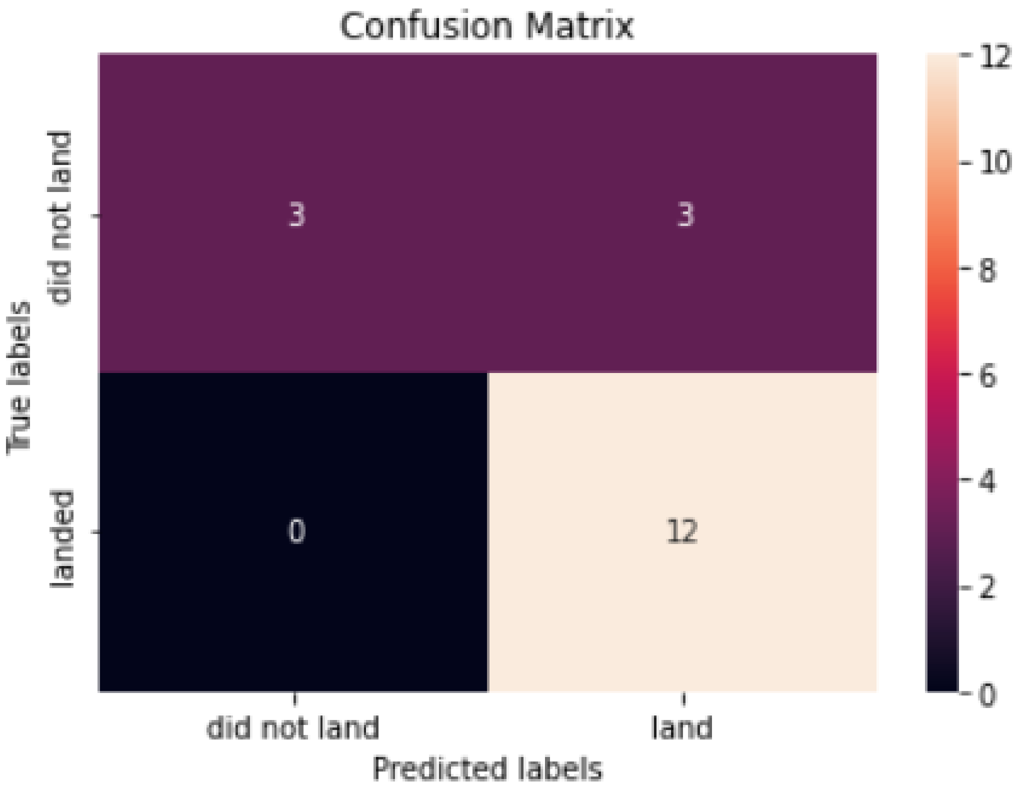

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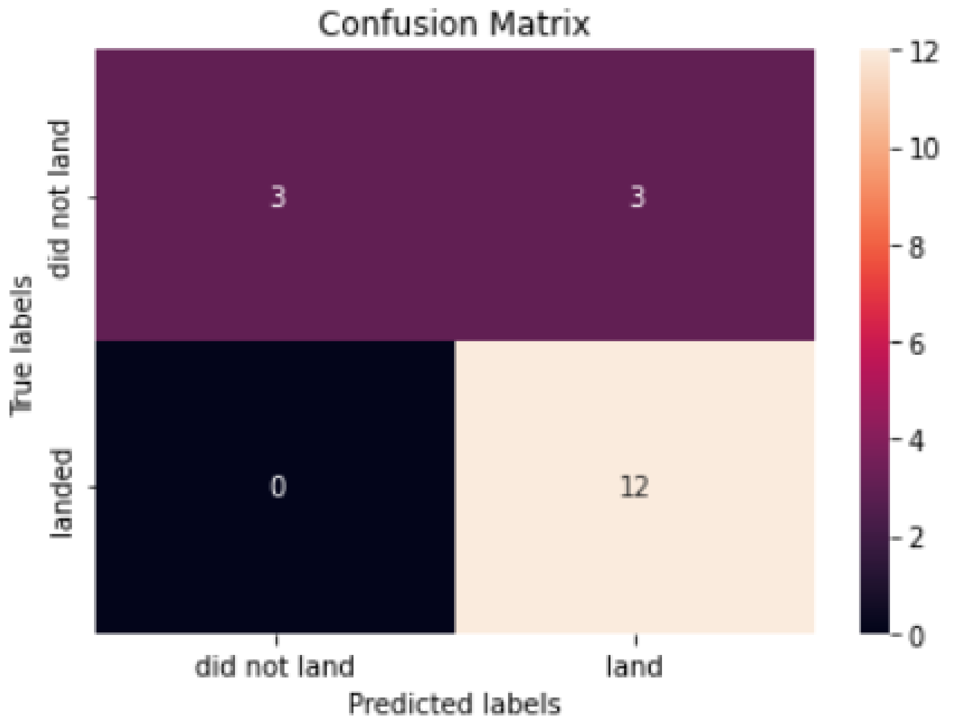


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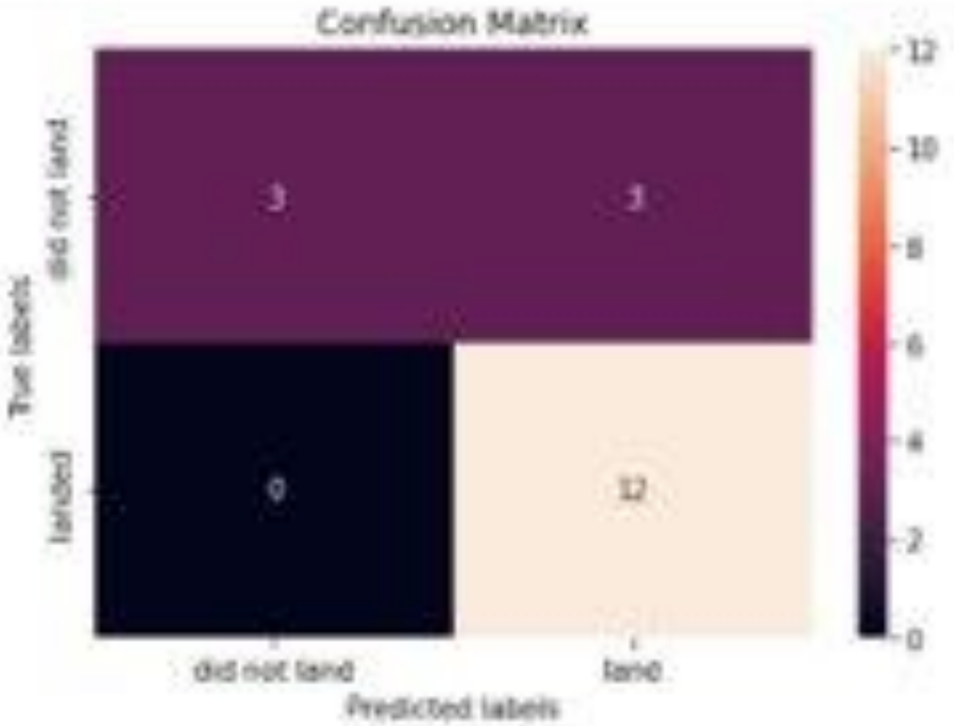

Conclusions

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- The success rates for the SpaceX launches is directly proportional to time in years.
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Thank You!!!