IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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2023/03/02

Outline

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

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 cost upward of 165 million dollars each, much of the savings is because Space X 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 space X for a rocket launch. This goal of the project is to create a machine learning pipeline to predict if the first stage will land successfully.

- Problems you want to find answers

  - What factors determine if the rocket will land successfully?
  - The interaction amongst 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

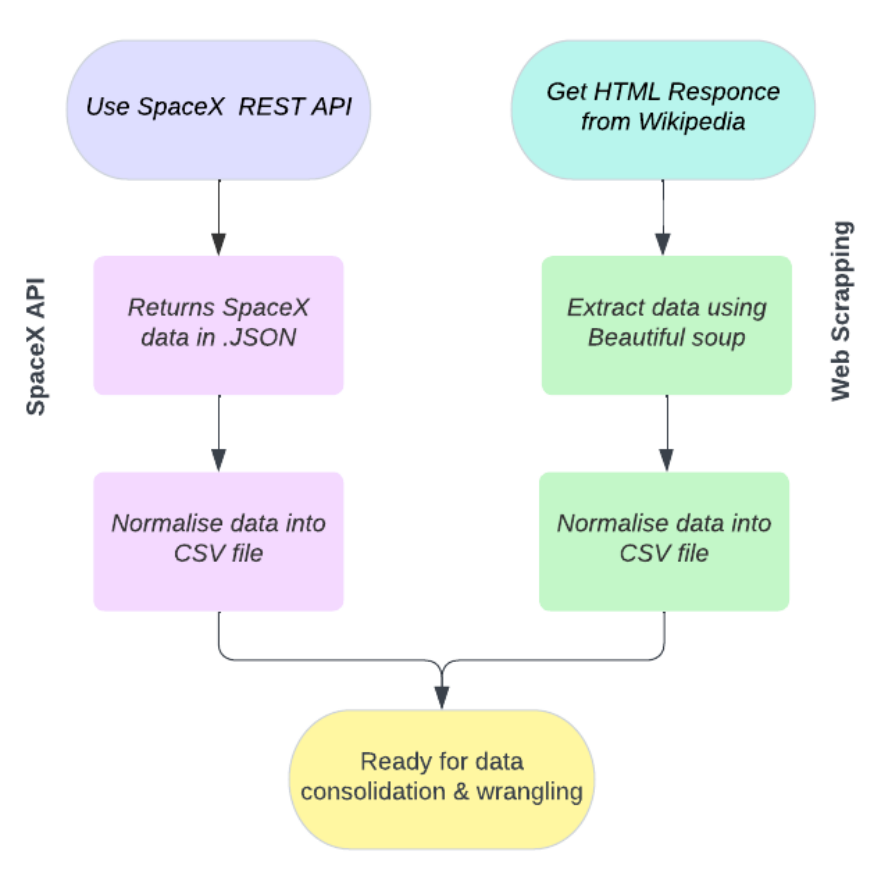
Methodology

Executive Summary

- Data collection methodology:
  - SpaceX Rest API
  - Web Scrapping from Wikipedia
- Perform data wrangling
  - One-hot encoding ,data cleaning of null values and remove unnecessary features for applying Machine learning algorithm.
- 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, KNN, SVM and Decision tree models have been built and evaluated for best classifier.

Data Collection

- The following datasets was collected
  - SpaceX launch data that is gathered from the SpaceX REST API.
  - This API will give us data about launches, including information about the rocket used, payload delivered, launch specifications, landing specifications, and landing outcome.
  - The SpaceX REST API endpoints, or URL, starts with api.spacexdata.com/v4/.
  - Another popular data source for obtaining Falcon 9 Launch data is web scraping Wikipedia using BeautifulSoup.

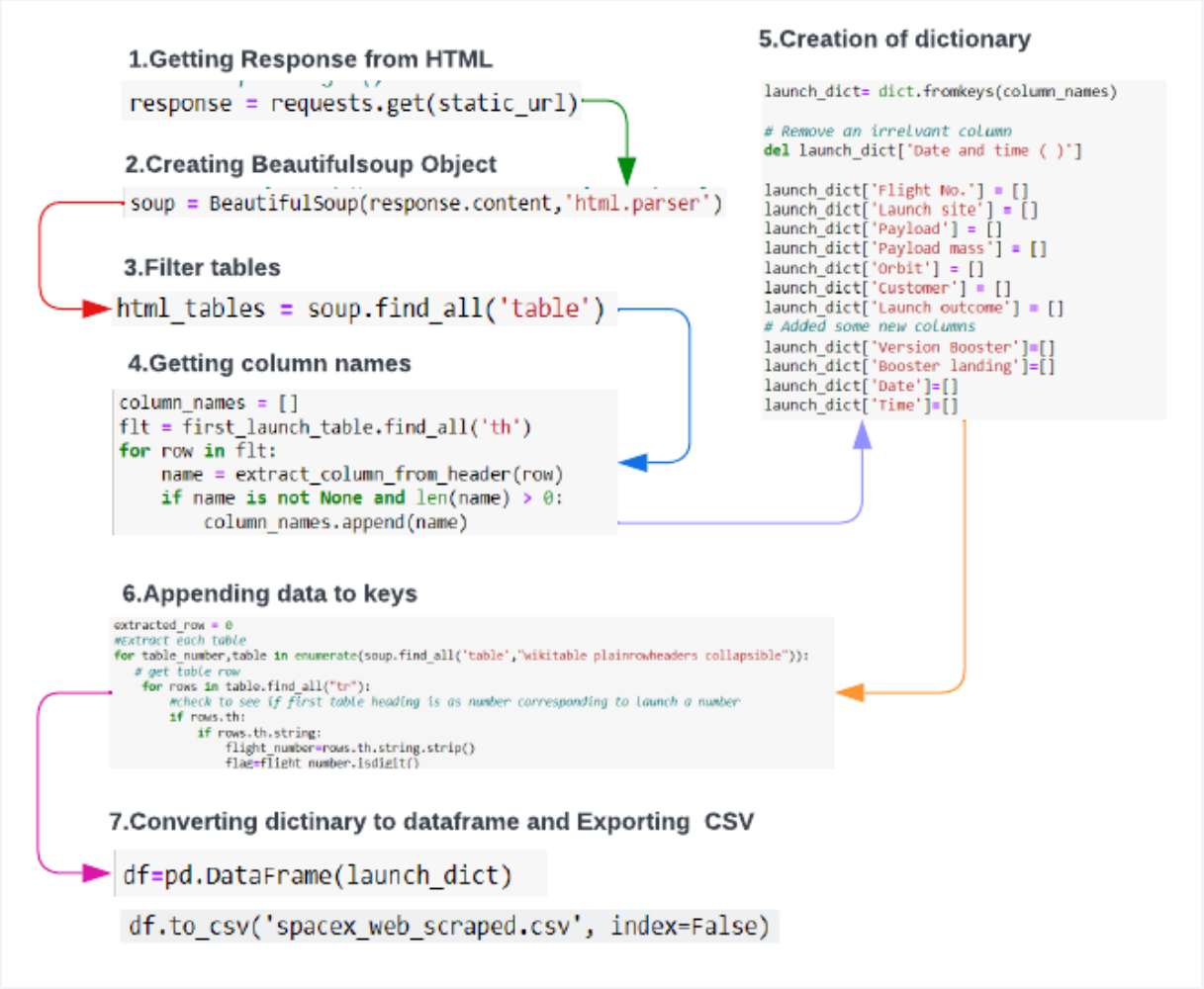


Data Collection – SpaceX API

- Data collecting with SpaceX REST API.
- GitHub URL - https://github.com/WCSW/IBM-Data-Science-Capstone-SpaceX/blob/main/Collecting%20the%20data.ipynb

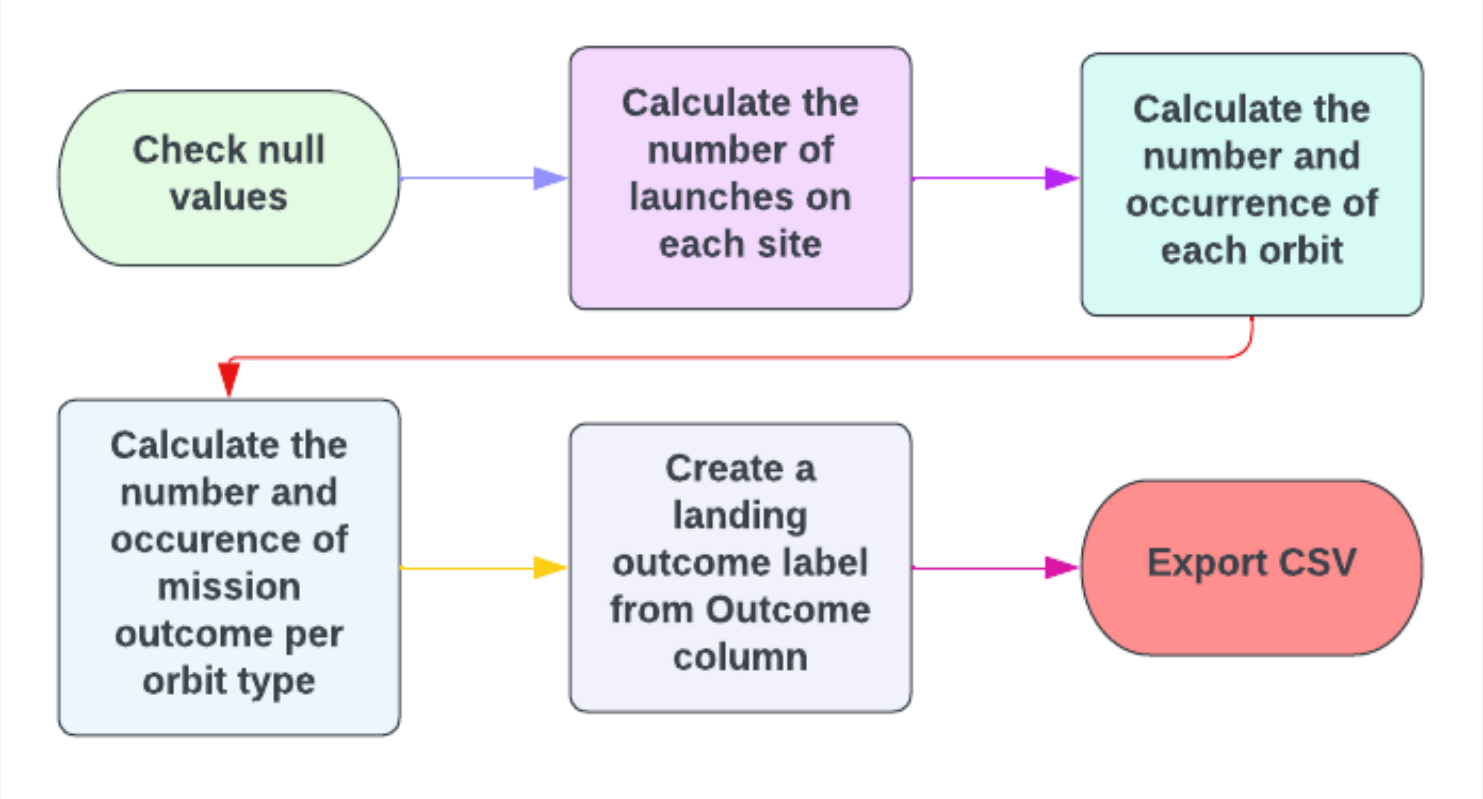
Data Collection - Scraping

- Web Scrapping from Wikipedia
- GitHub URL - https://github.com/WCSW/IBM-Data-Science-Capstone-SpaceX/blob/main/jupyter-labs-webscraping.ipynb



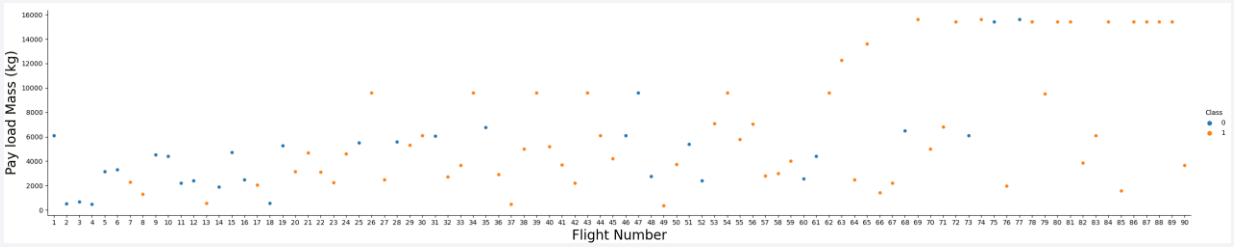
Data Wrangling

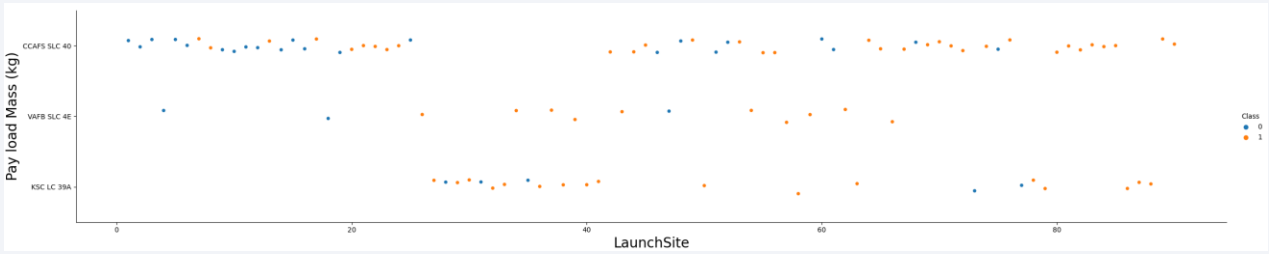
- Exploratory Data Analysis

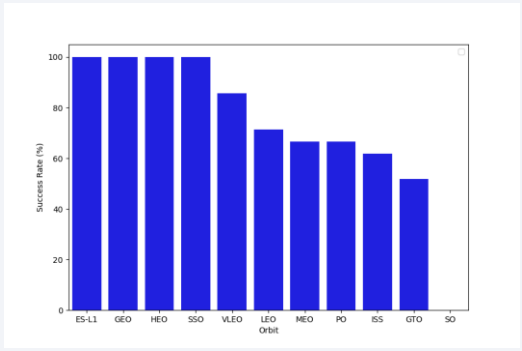


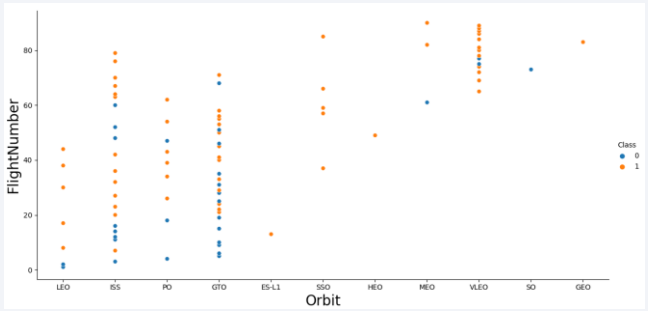
- GitHub URL - https://github.com/WCSW/IBM-Data-Science-Capstone-SpaceX/blob/main/IBM-DS0321EN-SkillsNetwork_labs_module_1_L3_labs-jupyter-spacex-data_wrangling_jupyterlite.jupyterlite.ipynb

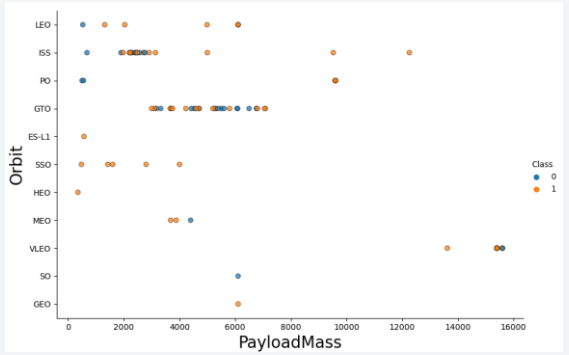
EDA with Data Visualization

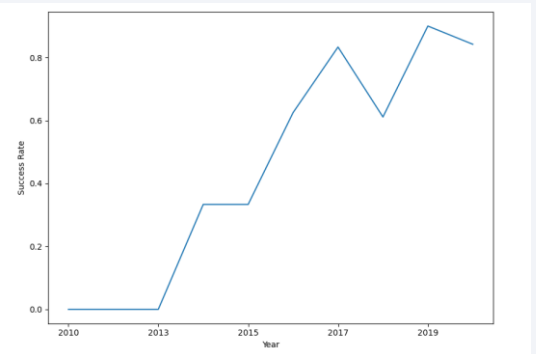


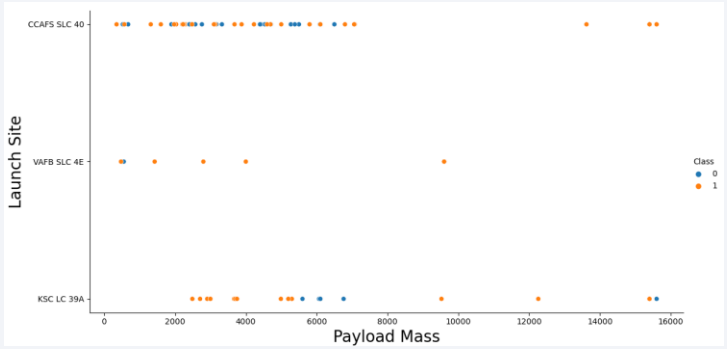












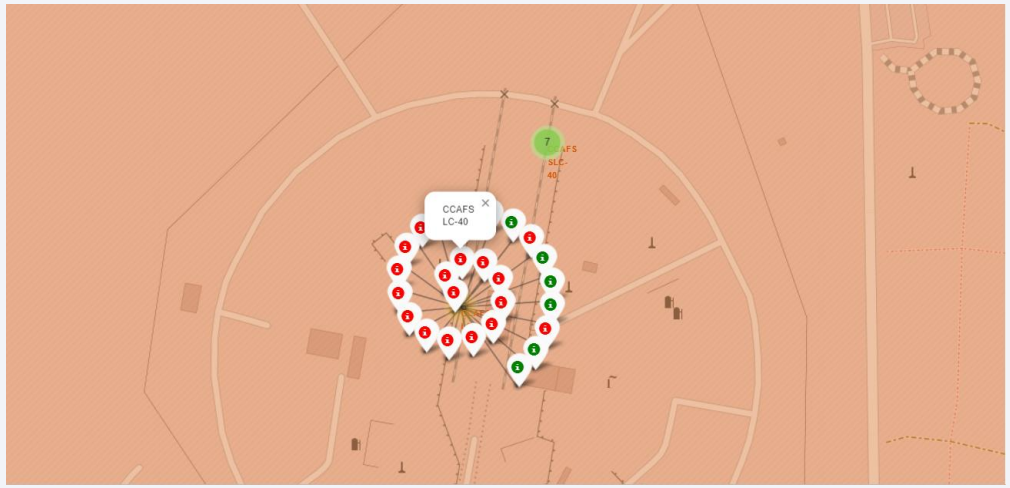
- GitHub URL - https://github.com/WCSW/IBM-Data-Science-Capstone-SpaceX/blob/main/IBM-DS0321EN-SkillsNetwork_labs_module_2_jupyter-labs-eda-dataviz.ipynb.jupyterlite%20(1).ipynb

EDA with SQL

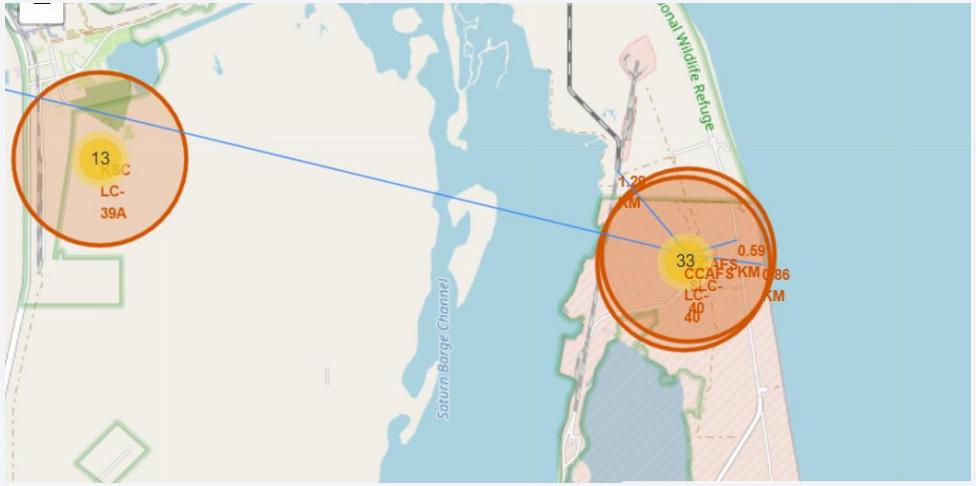
- SQL queries performed include:
  - Display the names of the unique launch sites in the space mission.
  - Display 5 records where launch sites begin with the string 'CCA’.
  - Display the total payload mass carried by boosters launched by NASA (CRS).
  - Display average payload mass carried by booster 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 mass greater than 4000 but less than 6000.
  - List the total number of successful and failure mission outcomes.
  - List the names of the booster versions which have carried the maximum payload mass. Use a subquery.
  - 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.
  - Rank the count of successful landing outcomes between the date 04-06-2010 and 20-03-2017 in descending order.
- GitHub URL - https://github.com/WCSW/IBM-Data-Science-Capstone-SpaceX/blob/main/jupyter-labs-eda-sql-coursera_sqllite%20(1).ipynb

Build an Interactive Map with Folium

Create and add Circle and Marker for each launch site on the site map



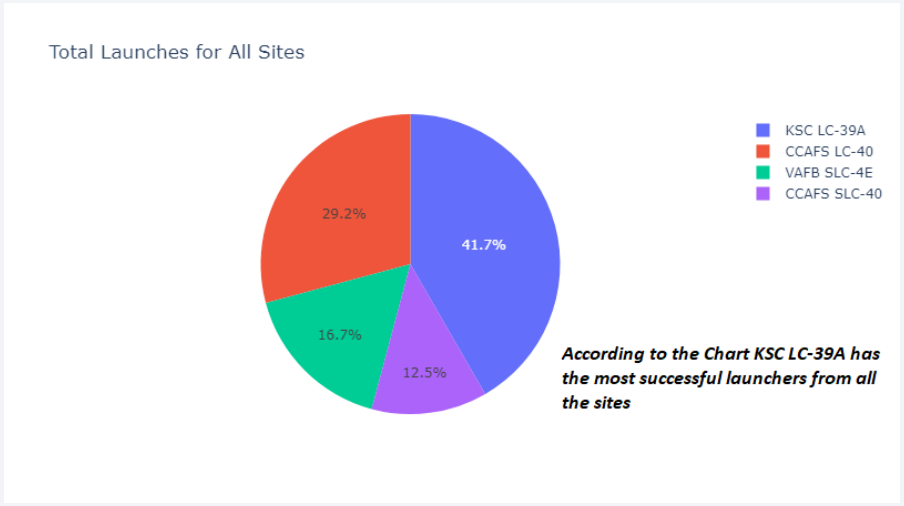
Add red mark for unsuccessful launch and green mark for successful launch

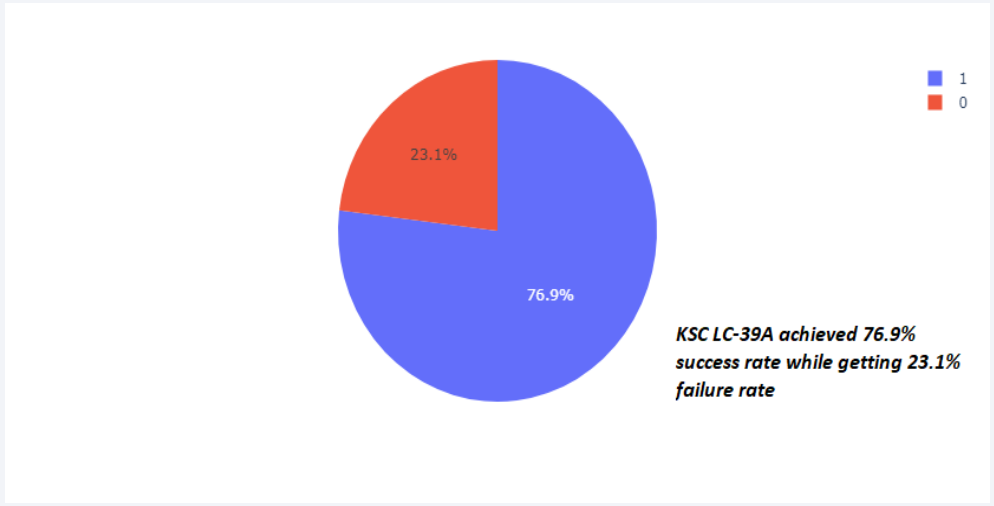


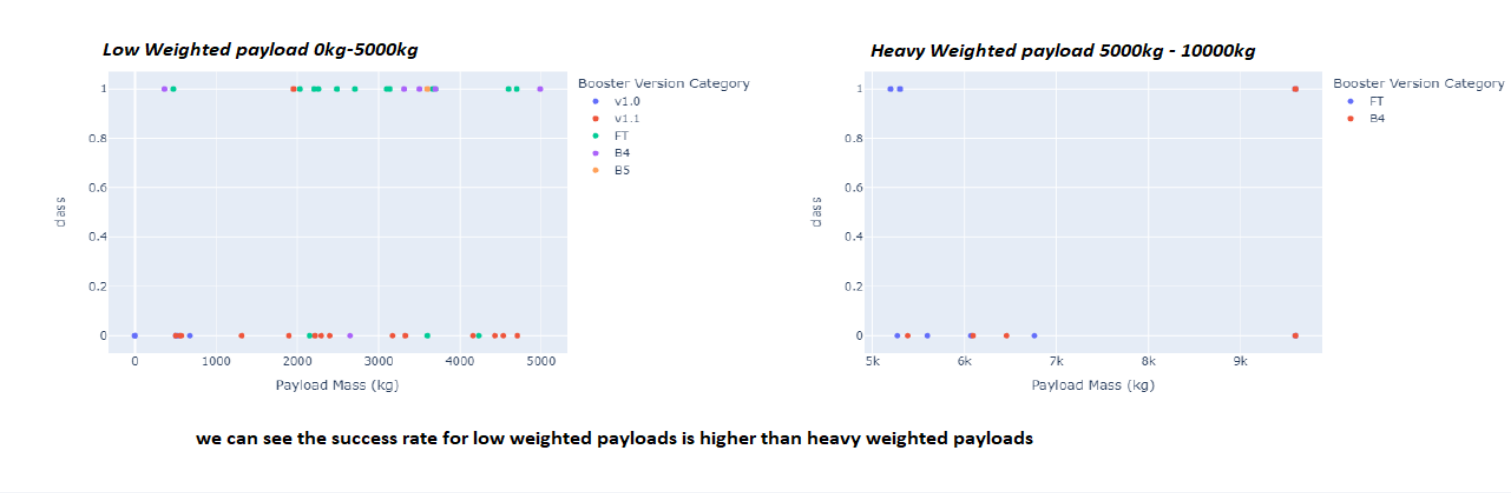
Draw a line between the closest city, railway, highway, etc. to the launch site

- GitHub URL - https://github.com/WCSW/IBM-Data-Science-Capstone-SpaceX/blob/main/IBM-DS0321EN-SkillsNetwork_labs_module_3_lab_jupyter_launch_site_location.jupyterlite%20(1).ipynb

Build a Dashboard with Plotly Dash



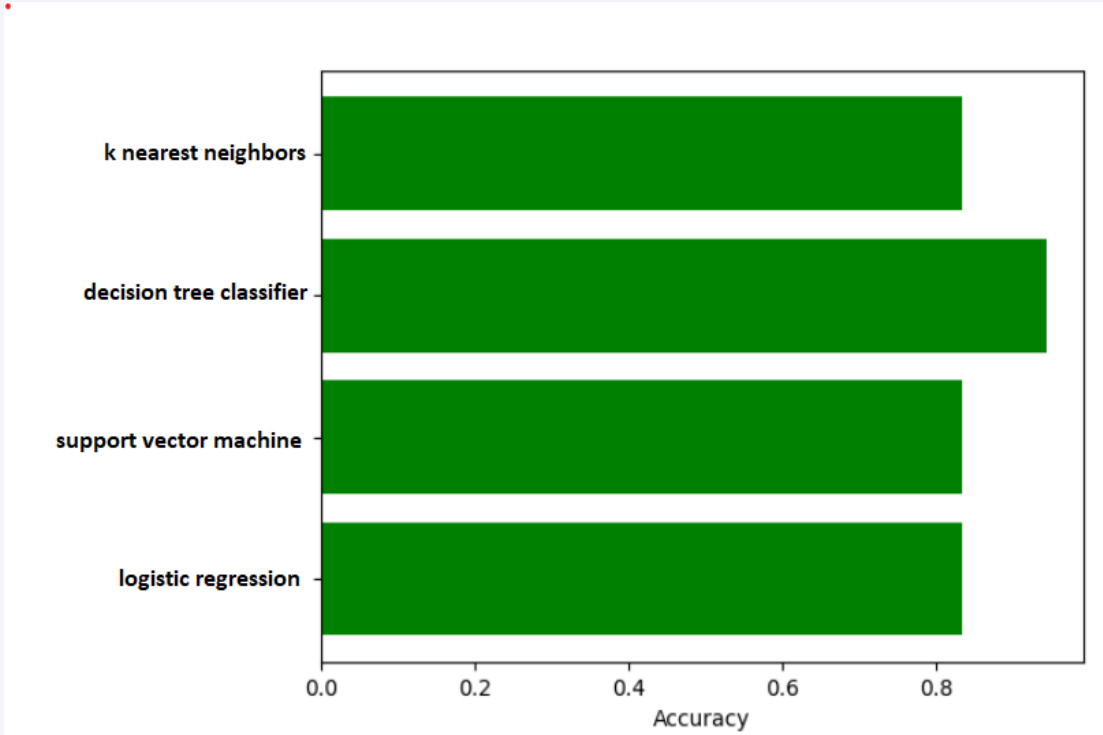


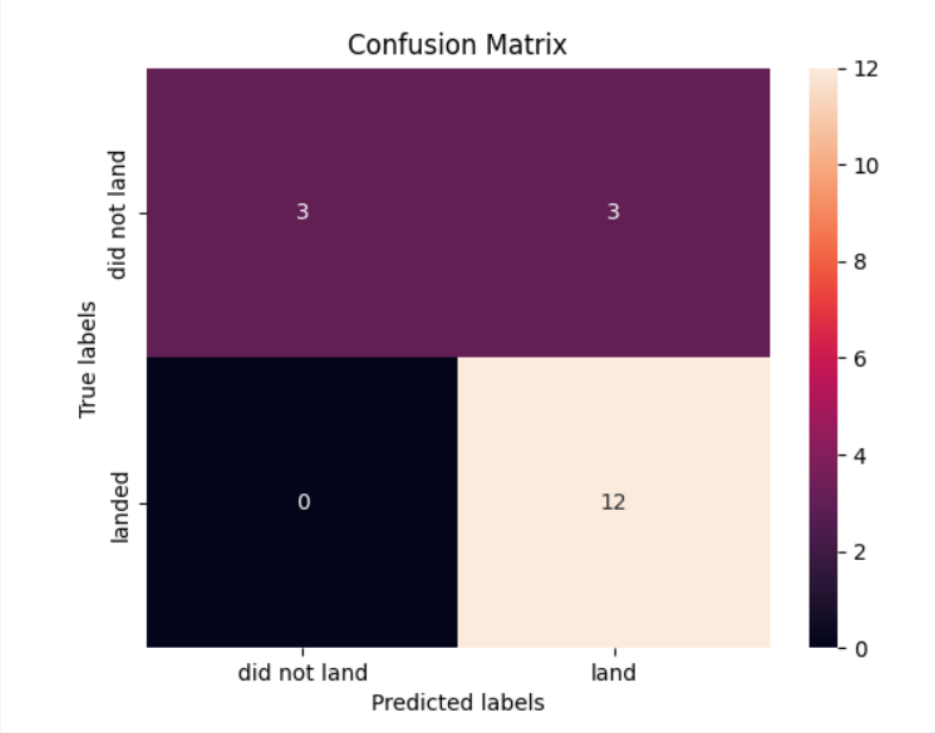


- GitHub URL - https://github.com/WCSW/IBM-Data-Science-Capstone-SpaceX/blob/main/spacex_dash_app.py

Predictive Analysis (Classification)

- The SVM,KNN and logistic regression models achieved the highest accuracy of 83.33% while decision tree classifier performs 94.44% accuracy.

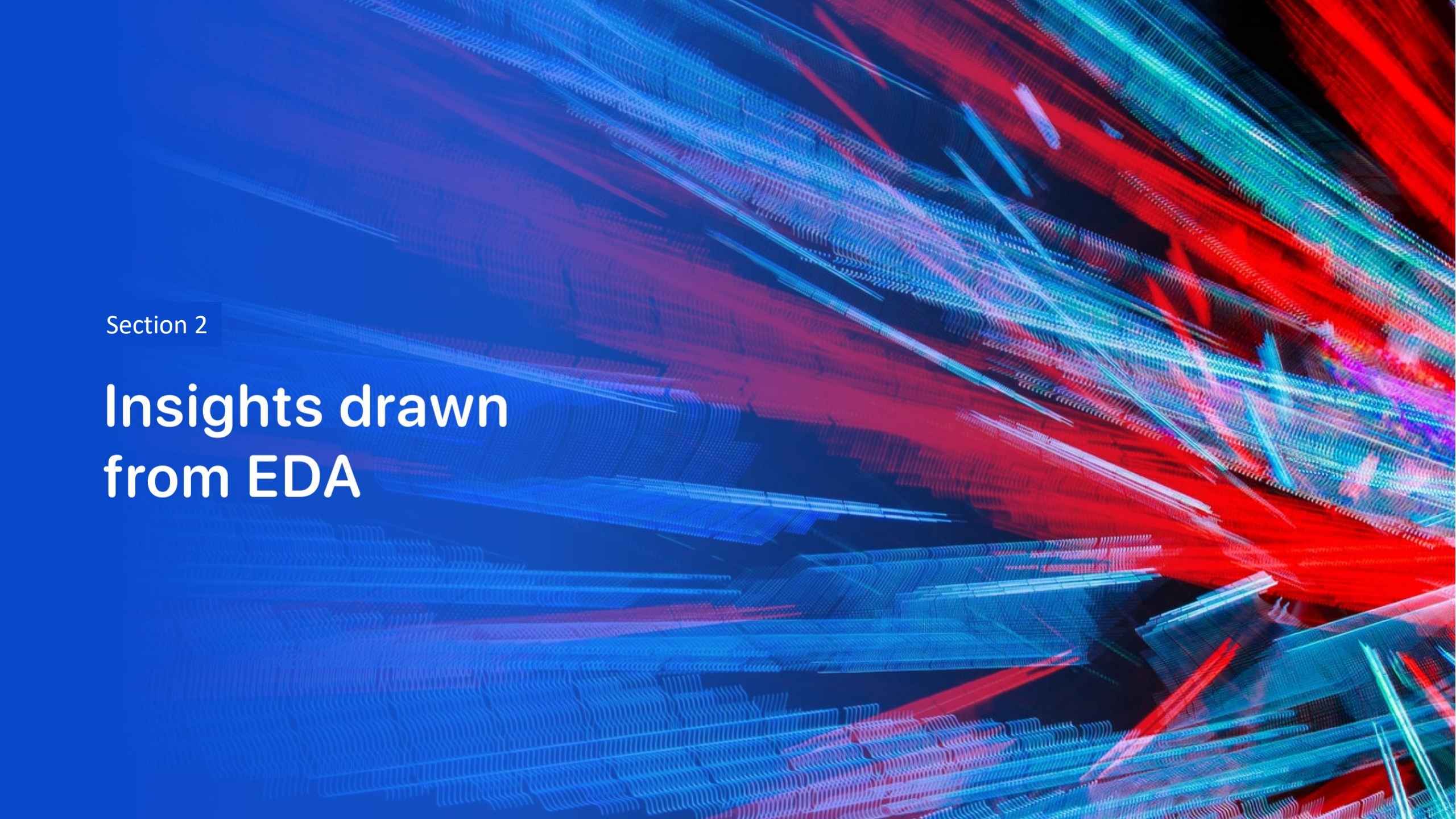




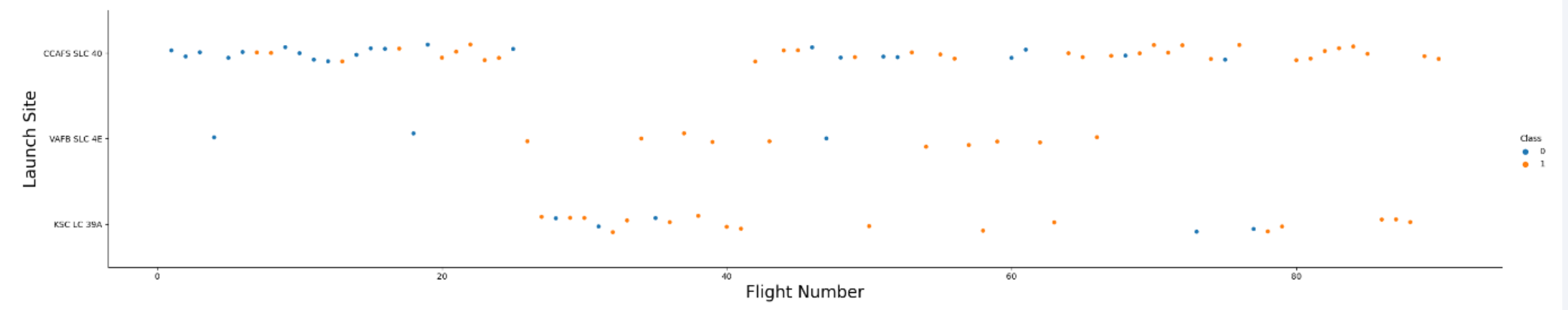
- GitHub URL - https://github.com/WCSW/IBM-Data-Science-Capstone-SpaceX/blob/main/IBM-DS0321EN-SkillsNetwork_labs_module_4_SpaceX_Machine_Learning_Prediction_Part_5.jupyterlite%20(1).ipynb

Results

- In terms of accuracy decision tree classifier is the best machine learning model for dataset.
- Low weighted payloads preform better than 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 ES-L1,GEO,HEO and SSO has the best success rates.

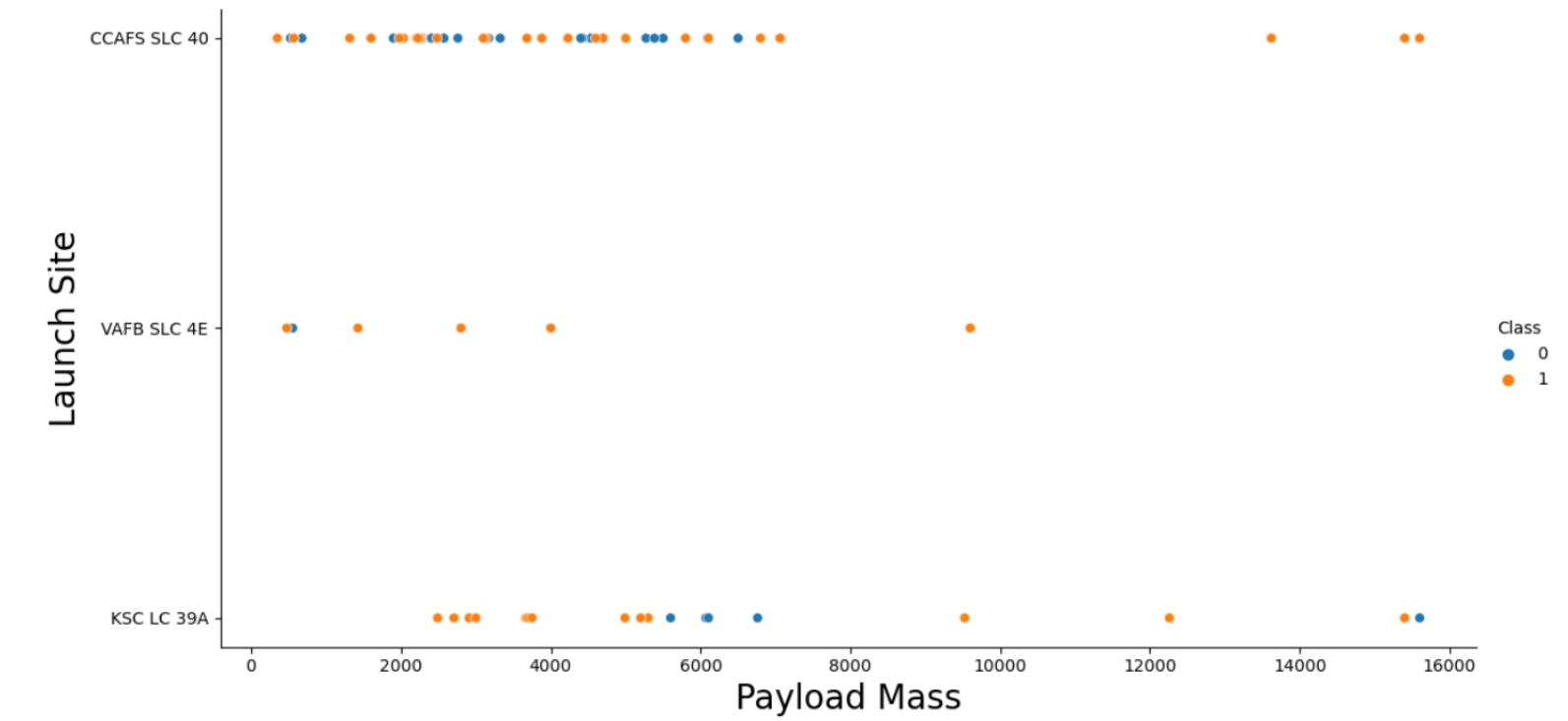

Section 2
Insights drawn from EDA

Flight Number vs. Launch Site



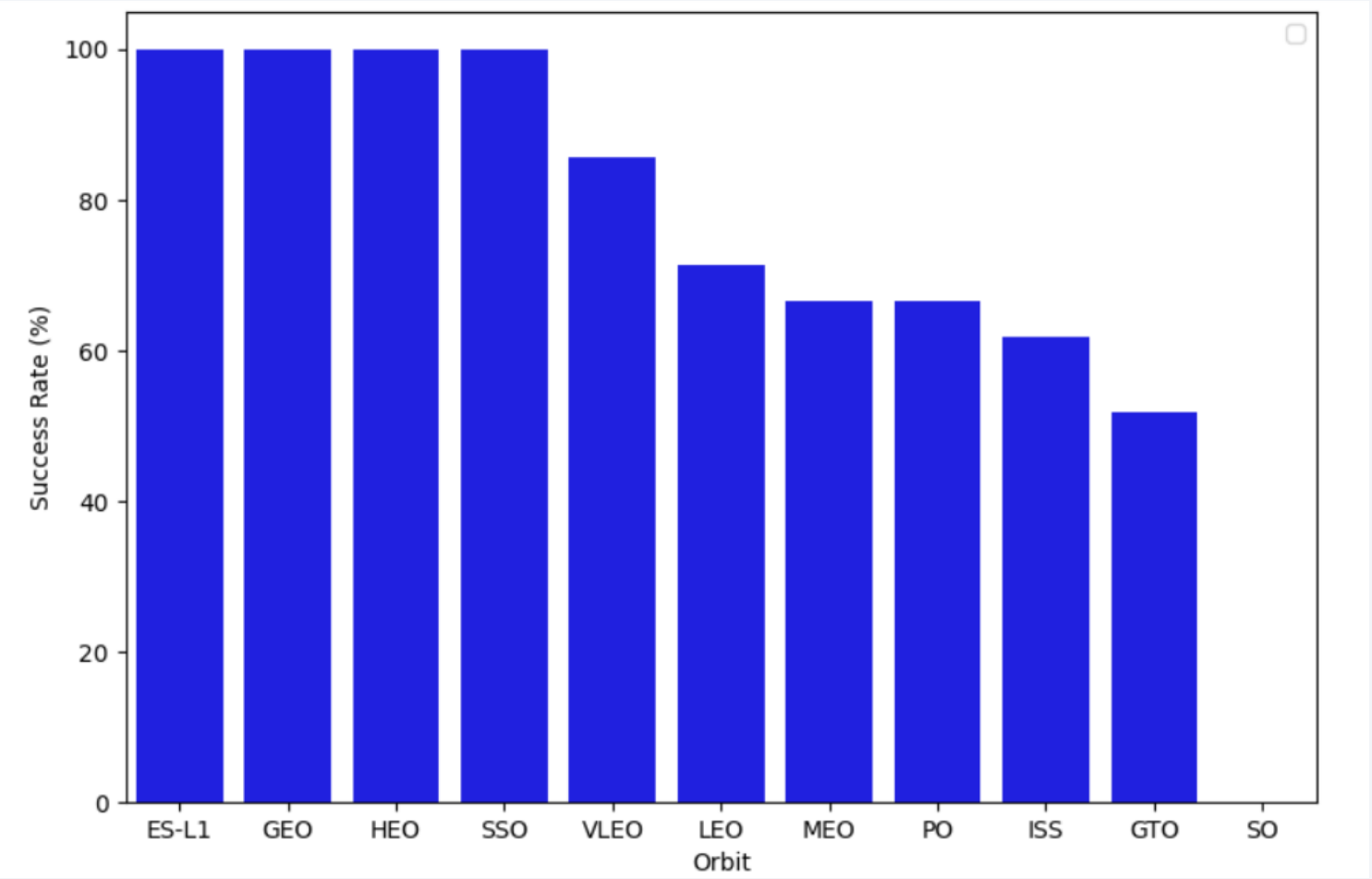
- Launches from the site of CCAFS SLC 40 are significantly higher than launches from other sites.

Payload vs. Launch Site



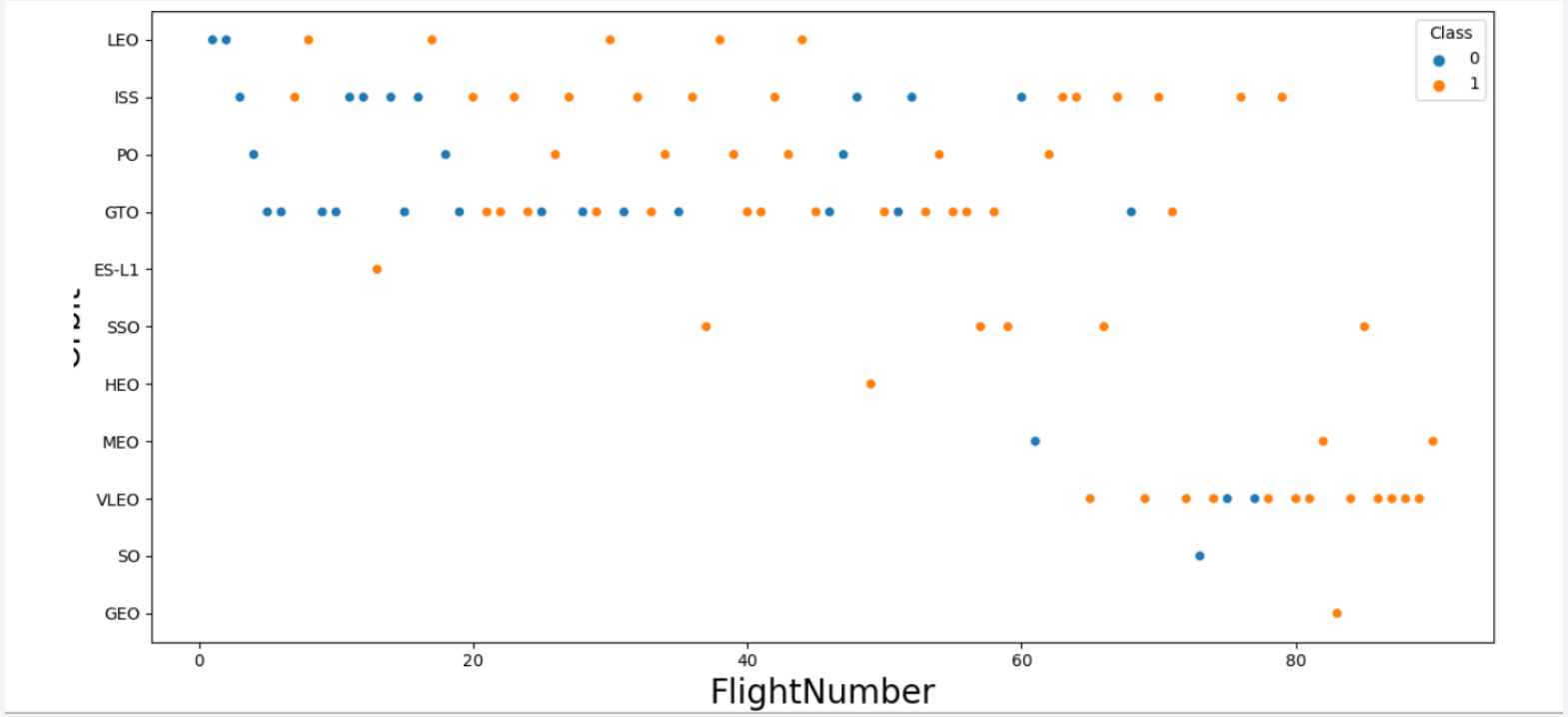
- The majority payload with lower Mass have been launched from CCAFS SLC 40.

Success Rate vs. Orbit Type



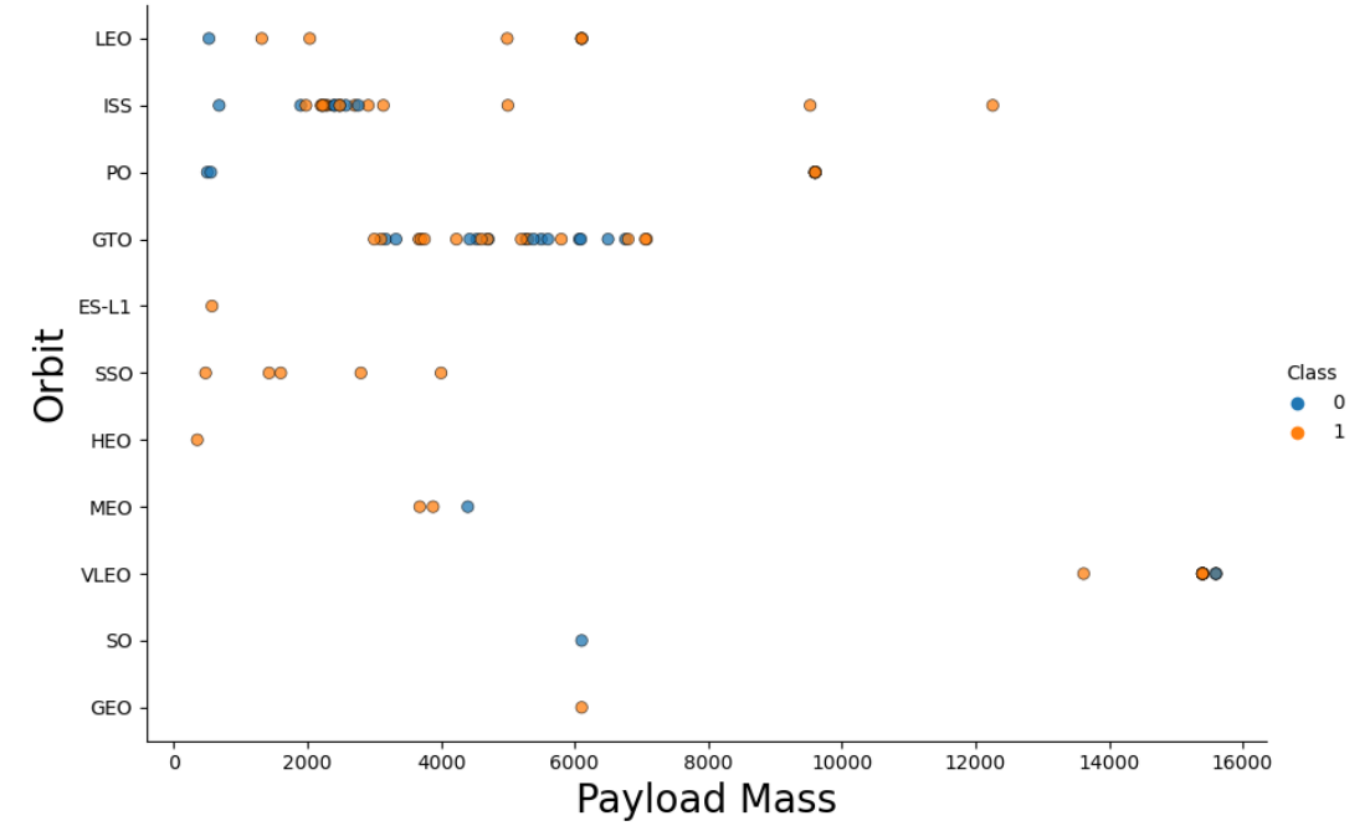
- The orbit types of ES-L1,GEO,HEO and SSO are among the highest success rate.

Flight Number vs. Orbit Type



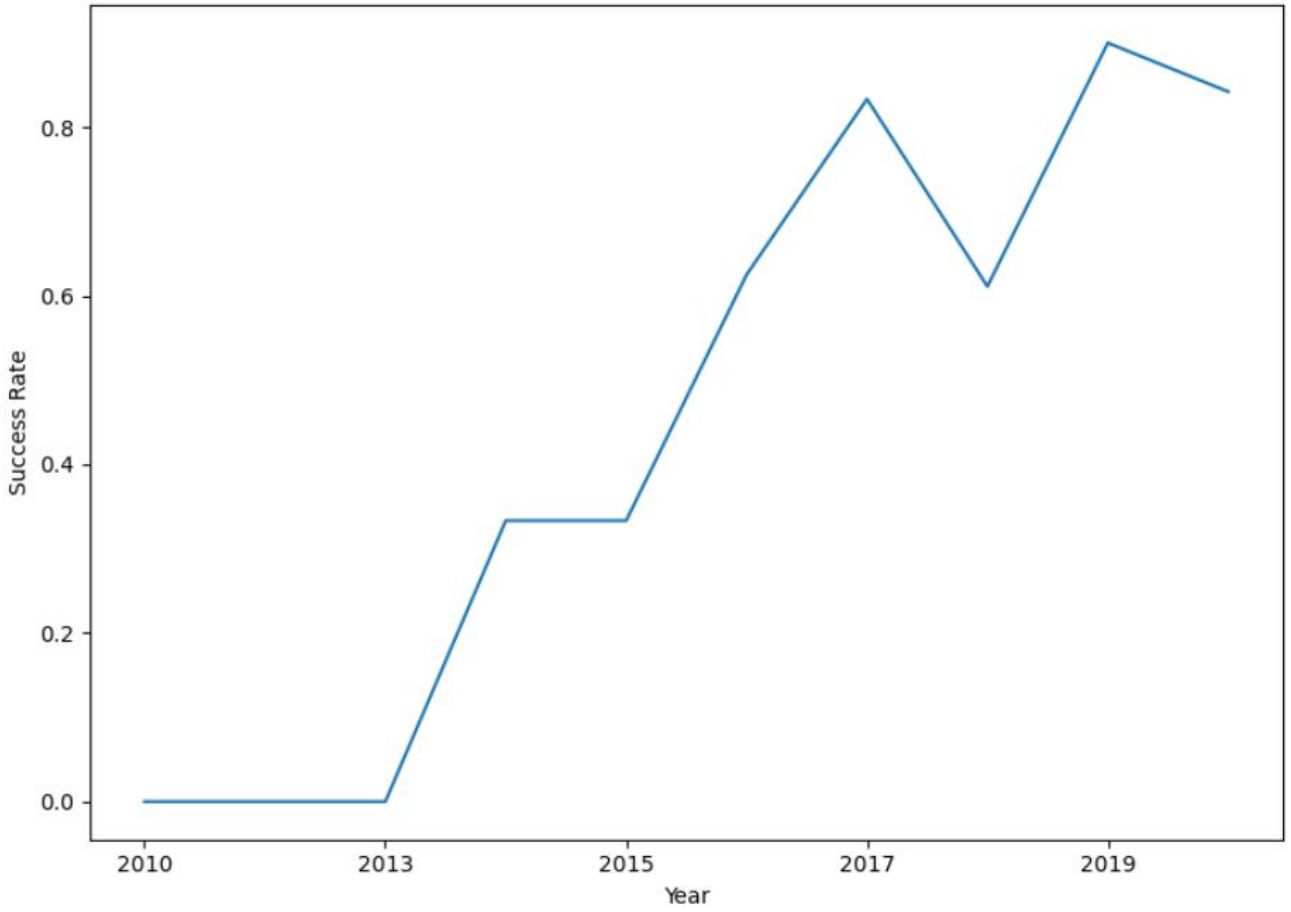
- A trend can be observed of shifting to VLEO launches in recent years

Payload vs. Orbit Type



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

Launch Success Yearly Trend



- Launch success rate has increased significantly since 2013 potentially due to advance in technology and lessons learned.
- Launch success rate has drop significantly at the time period 2017 to 2018.
- After 2018 launch success rate increased.

All Launch Site Names

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

```
%sql SELECT DISTINCT LAUNCH_SITE as "Launch_Sites" From SPACEXTBL;
```

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

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

Launch Site Names Begin with 'CCA'

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

```
%sql SELECT * FROM SPACEXTBL WHERE LAUNCH_SITE LIKE "CCA%" LIMIT 5;
```

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

Date	Time (UTC)	Booster_Version	Launch_Site	Payload	PAYLOAD_MASS__KG_	Orbit	Customer	Mission_Outcome	Landing _Outcome
04-06-2010	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
08-12-2010	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)
22-05-2012	07:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)	Success	No attempt
08-10-2012	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
01-03-2013	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attempt

Total Payload Mass

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

```
%sql SELECT SUM(PAYLOAD_MASS__KG_) as NASA_CRS_TOTAL_PM FROM SPACEXTBL WHERE Customer= "NASA (CRS)";
```

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

NASA_CRS_TOTAL_PM
45596

Average Payload Mass by F9 v1.1

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

```
%sql SELECT AVG(PAYLOAD_MASS__KG_) as AVG_F9_v1_1 FROM SPACEXTBL WHERE Booster_Version LIKE "F9 v1.1%";
```

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

AVG_F9_v1_1
2534.6666666666665

First Successful Ground Landing Date

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

Hint:Use min function

```
%sql SELECT MIN(Date), "Landing _Outcome" FROM SPACEXTBL WHERE "Landing _Outcome" ="Success (ground pad)";
```

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

MIN(Date)	Landing _Outcome
01-05-2017	Success (ground pad)

Successful Drone Ship Landing with Payload between 4000 and 6000

List the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 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

List the total number of successful and failure mission outcomes

```
%sql SELECT Mission_Outcome ,COUNT(Mission_Outcome)as Total FROM SPACEXTBL GROUP BY Mission_Outcome;
```

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

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

Boosters Carried Maximum Payload

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

```
%sql SELECT Booster_Version FROM SPACEXTBL WHERE "PAYLOAD_MASS__KG_" = (SELECT MAX(PAYLOAD_MASS__KG_) FROM SPACEXTBL);
```

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

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

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.

```
%sql SELECT * FROM SPACEXTBL WHERE "Landing _Outcome" LIKE 'Failure%' AND ("Date" BETWEEN "01-01-2015" AND "31-12-2015" ) ORDER BY "Date" DESC;
```

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

Date	Time (UTC)	Booster_Version	Launch_Site	Payload	PAYLOAD_MASS__KG_	Orbit	Customer	Mission_Outcome	Landing _Outcome
18-03-2020	12:16:00	F9 B5 B1048.5	KSC LC-39A	Starlink 5 v1.0, Starlink 6 v1.0	15600	LEO	SpaceX	Success	Failure
17-02-2020	15:05:00	F9 B5 B1056.4	CCAFS SLC-40	Starlink 4 v1.0, SpaceX CRS-20	15600	LEO	SpaceX	Success	Failure
17-01-2016	18:42:00	F9 v1.1 B1017	VAFB SLC-4E	Jason-3	553	LEO	NASA (LSP) NOAA CNES	Success	Failure (drone ship)
15-06-2016	14:29:00	F9 FT B1024	CCAFS LC-40	ABS-2A Eutelsat 117 West B	3600	GTO	ABS Eutelsat	Success	Failure (drone ship)
14-04-2015	20:10:00	F9 v1.1 B1015	CCAFS LC-40	SpaceX CRS-6	1898	LEO (ISS)	NASA (CRS)	Success	Failure (drone ship)
10-01-2015	09:47:00	F9 v1.1 B1012	CCAFS LC-40	SpaceX CRS-5	2395	LEO (ISS)	NASA (CRS)	Success	Failure (drone ship)
08-12-2010	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)
05-12-2018	18:16:00	F9 B5B1050	CCAFS SLC-40	SpaceX CRS-16	2500	LEO (ISS)	NASA (CRS)	Success	Failure
04-06-2010	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
04-03-2016	23:35:00	F9 FT B1020	CCAFS LC-40	SES-9	5271	GTO	SES	Success	Failure (drone ship)

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

Rank the count of successful landing_outcomes between the date 04-06-2010 and 20-03-2017 in descending order.

```
%sql SELECT "Landing _Outcome",COUNT("Landing _Outcome") AS Landing_Count FROM SPACEXTBL WHERE ("Date" BETWEEN "04-06-2010" AND "20-03-2017") ORDER BY "Landing _Outcome" DESC;
```

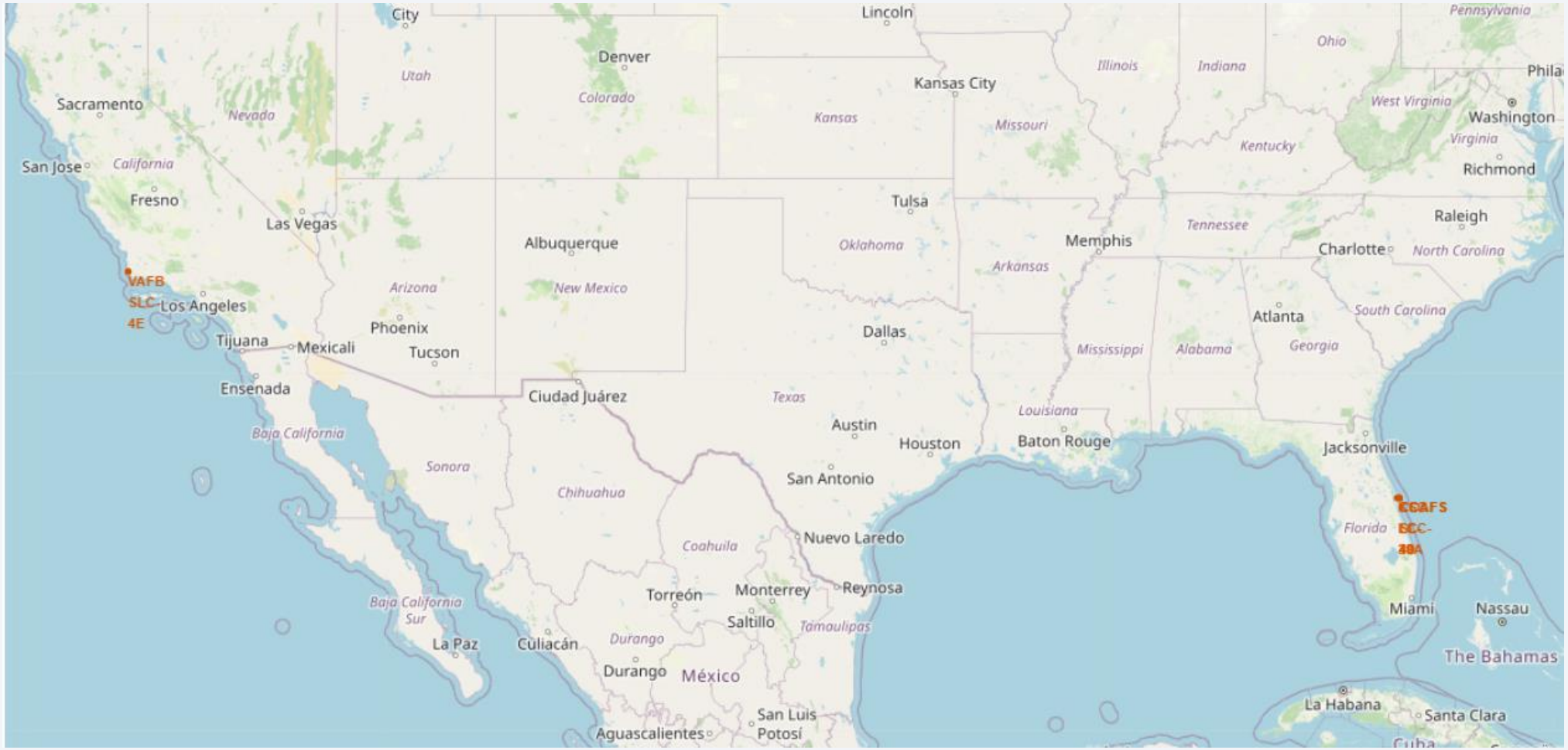
```
 * sqlite:///my_data1.db
Done.
```

Landing _Outcome	Landing_Count
Failure (parachute)	57

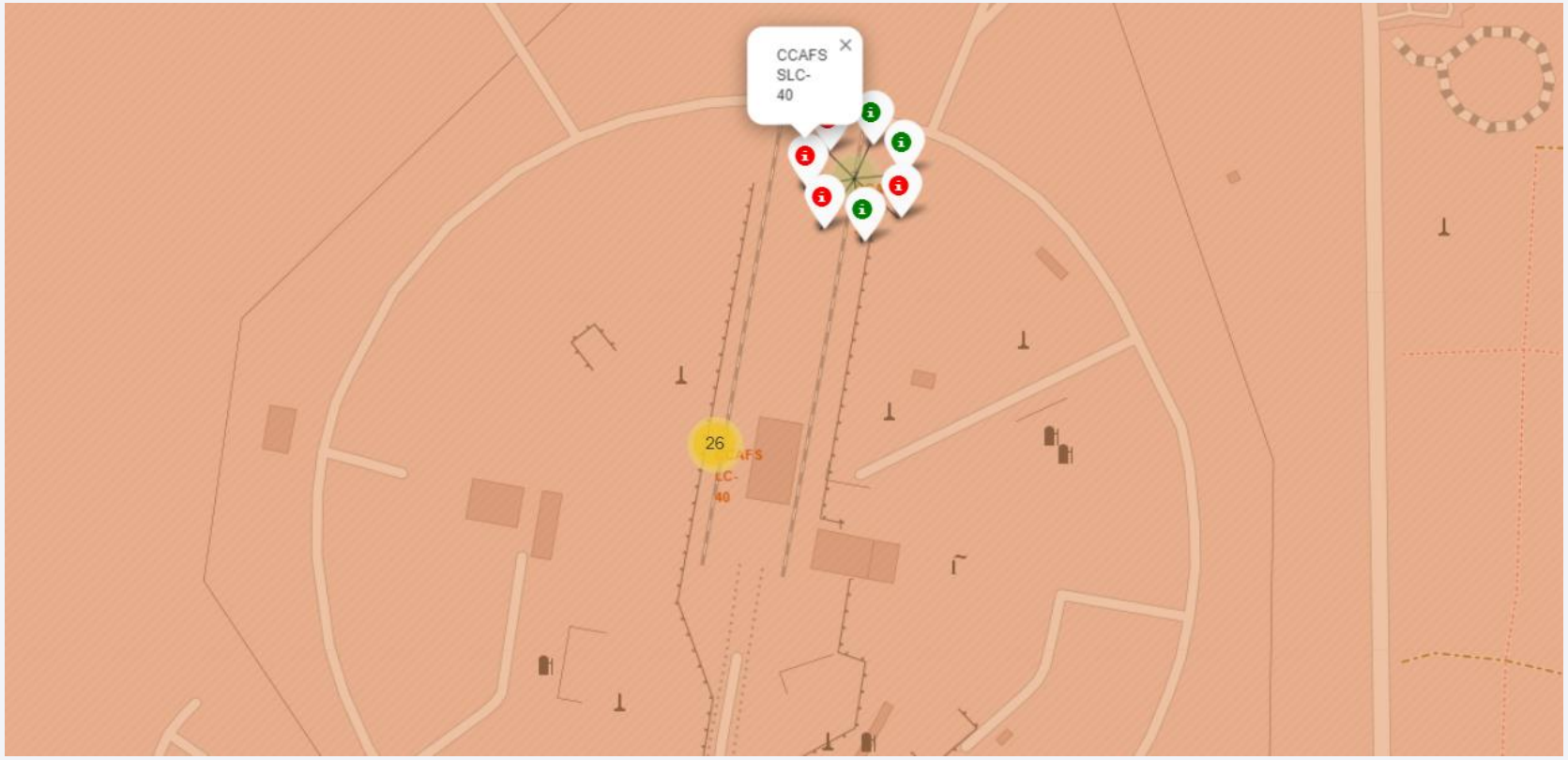
Section 3

Launch Sites Proximities Analysis

SpaceX Launch Sites Locations

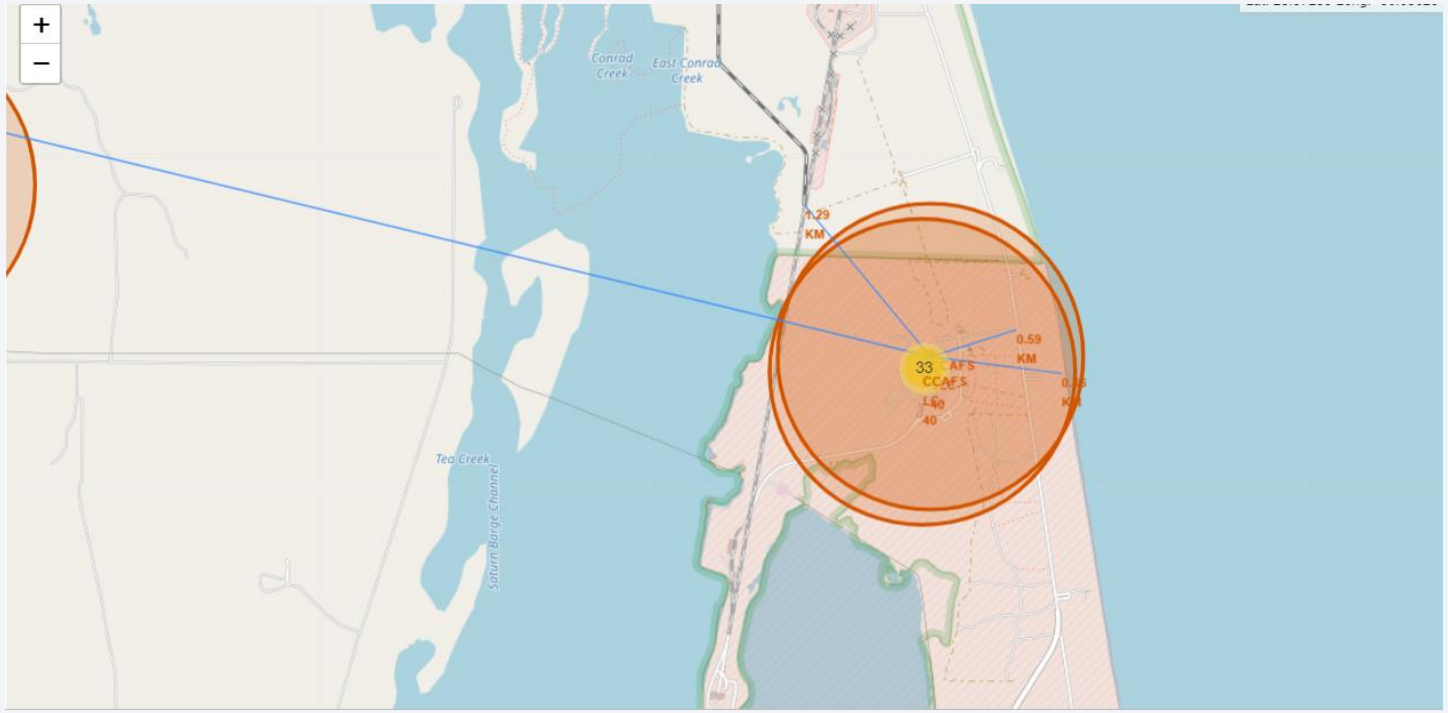


Success / Failed launches

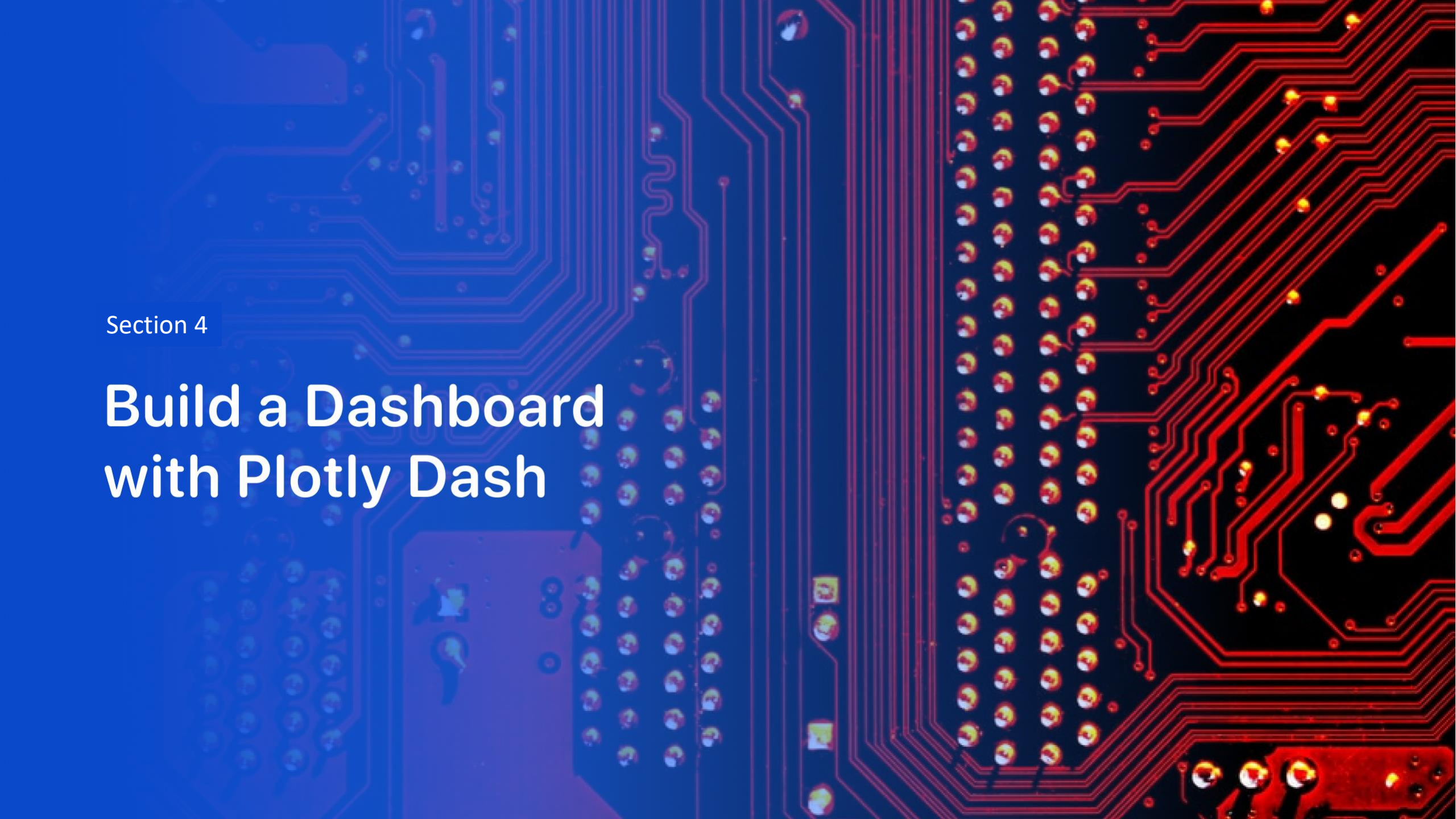


- Green color mark represent successful launches and red color mark represent unsuccessful launches

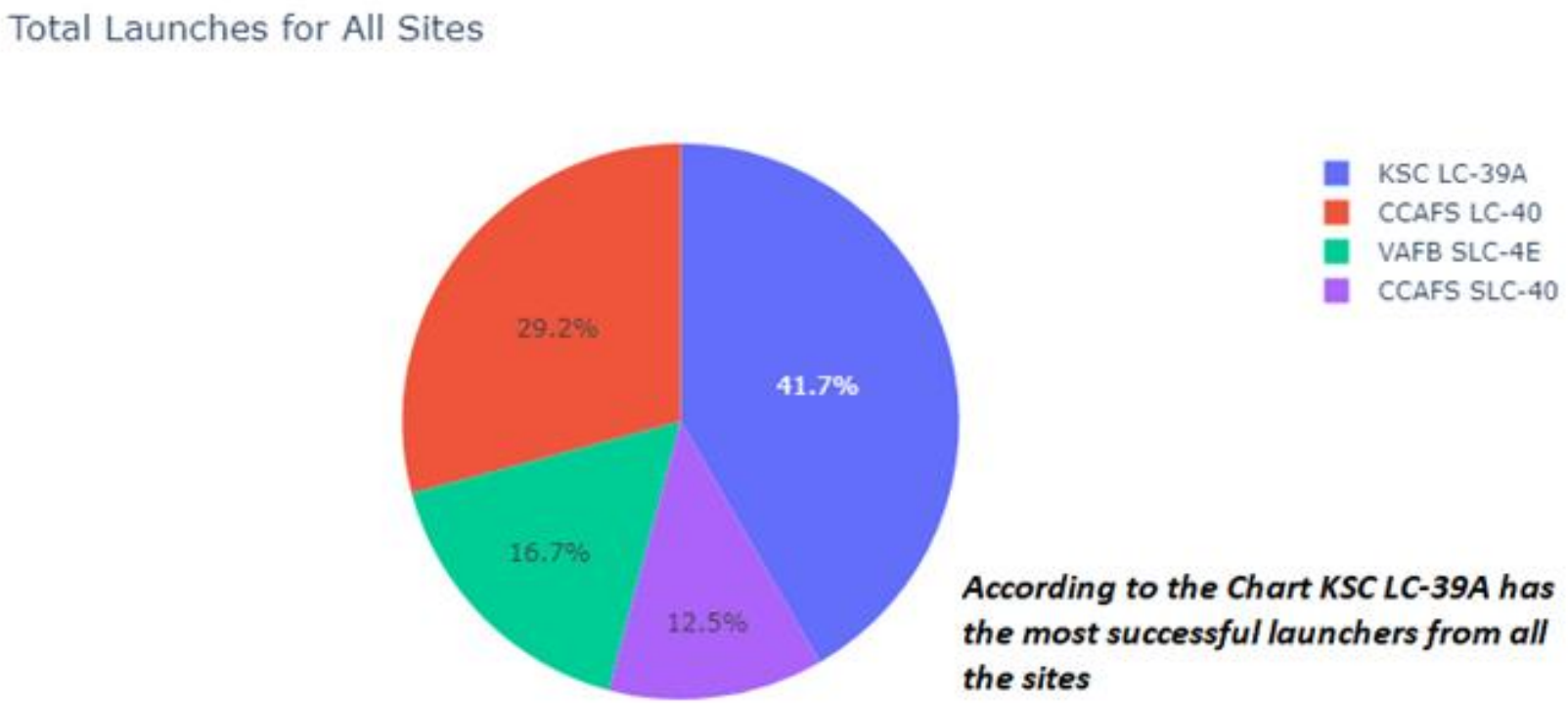
Launch Site Proximities



- Each line represent distances launch site to its proximities such as railway, highway, coastline, with distance.

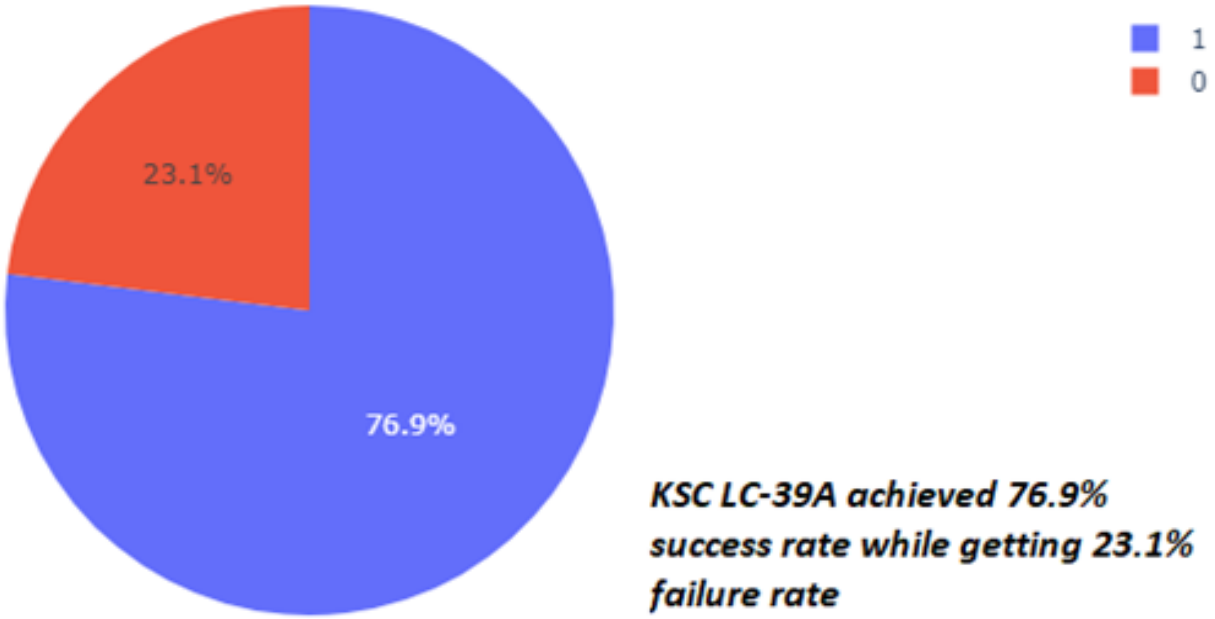

Section 4
Build a Dashboard with Plotly Dash

Total success launches by all sites



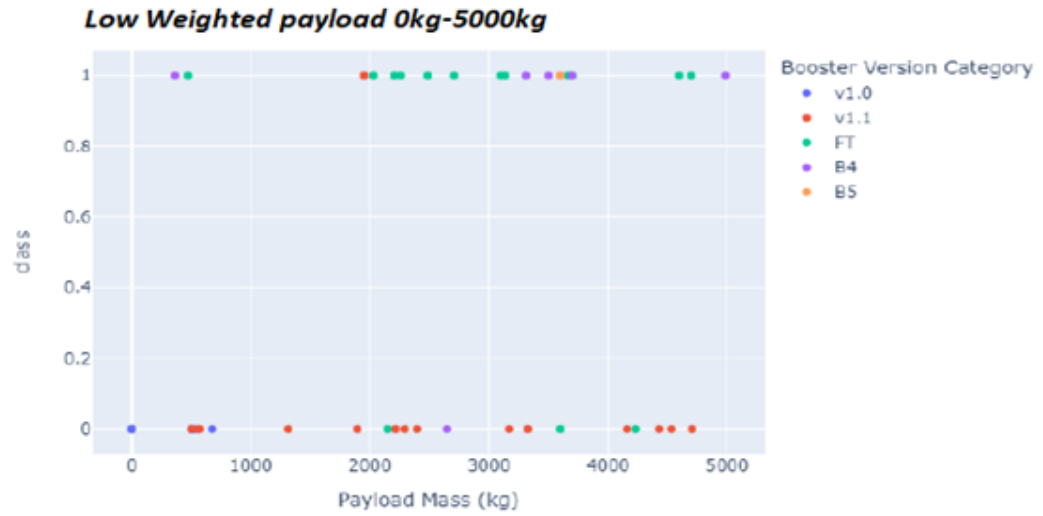
According to the Chart KSC LC-39A has the most successful launchers from all the sites

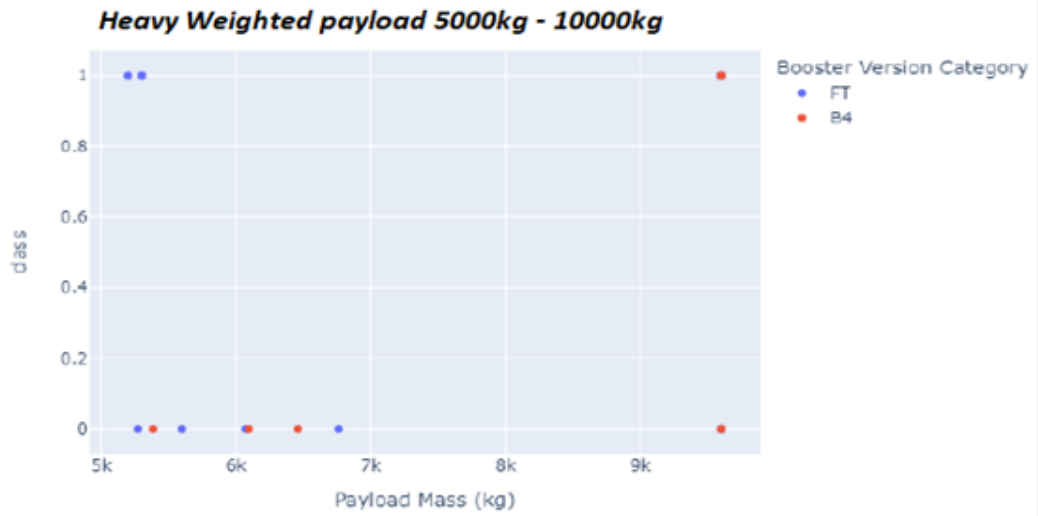
Success rate by site



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

Payload vs launch outcome





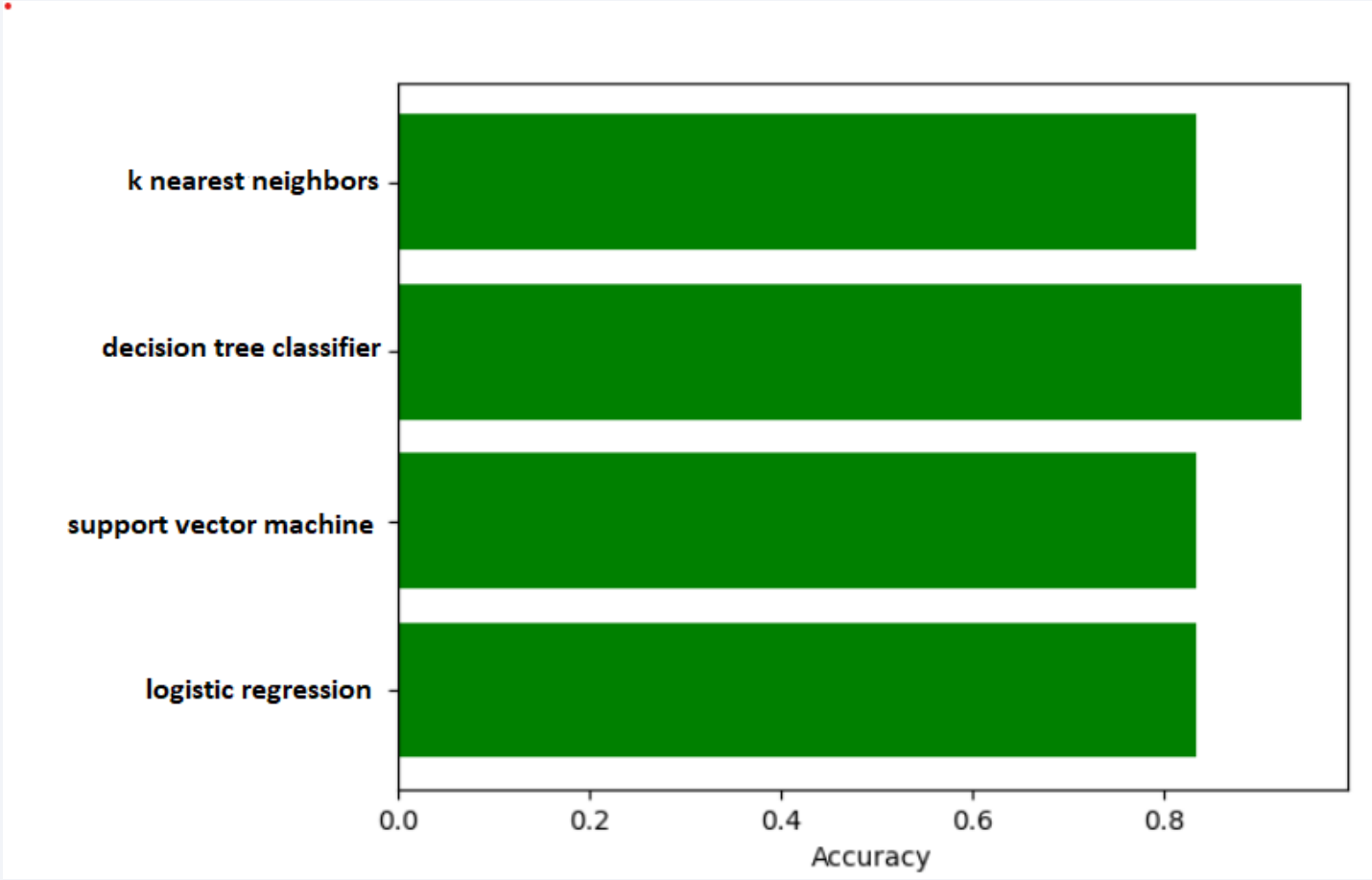
we can see the success rate for low weighted payloads is higher than heavy weighted payloads

Section 5

Predictive Analysis (Classification)

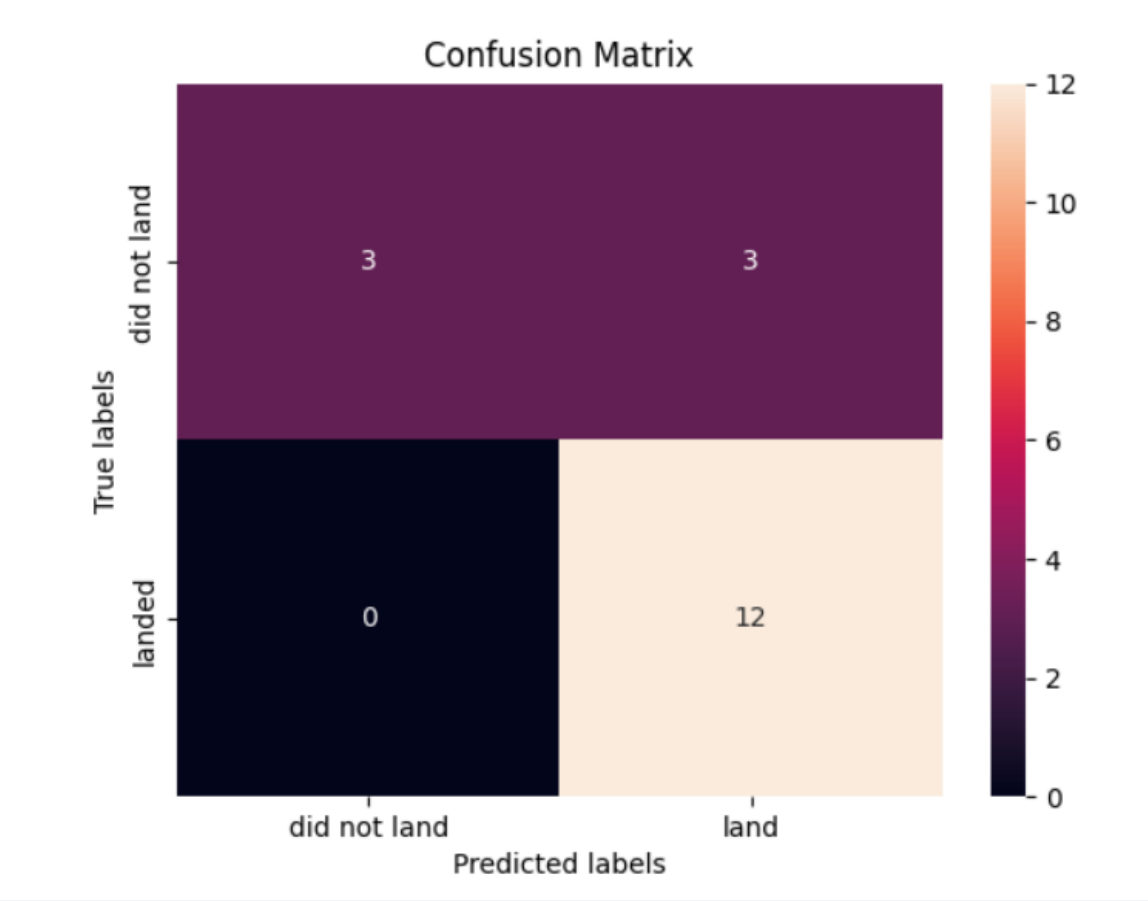
Classification Accuracy

- Model Accuracy on the test data set



	Method	Accuracy
0	logistic regression	0.833333
1	support vector machine	0.833333
2	decision tree classifier	0.944444
3	k nearest neighbors	0.833333

Confusion Matrix



- The model predicted 12 successful landings when the True label was successful (True Positive) and 3 unsuccessful landings when the True label was failure (True Negative).
- The model also predicted 3 successful landings when the True label was unsuccessful landing (False Positive).
- The model generally predicted successful landings.

Conclusions

- The analysis showed that there is a positive correlation between number of flights and success rate as the success rate has improved over the years.
- There are certain orbits like SSO, HEO, GEO, and ES-L1 where launches were the most successful.
- Success rate can be linked to payload mass as the lighter payloads generally proved to be more successful than the heavier payloads.
- The launch sites are strategically located near highways and railways for transportation of personal and cargo, but also far away from cities for safety.
- The best predictive model to use for this dataset is the Decision Tree Classifier as it had the highest accuracy with 94%.

Appendix

- Include any relevant assets like Python code snippets, SQL queries, charts, Notebook outputs, or data sets that you may have created during this project

Thank you!