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**
  - 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 results
  - Interactive analytics in screenshots
  - Predictive Analytics result

Introduction

Project Definition and Context

Worked on a new rocket company named "SpaceY" that would like to compete with SpaceX founded by Billionaire industrialist Ellon Musk. 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.

Solutions

- - Find the features that affect the first stage landing success
- - predict if the first stage will land successfully

Section 1

Methodology

Methodology

Executive Summary

- **Data collection methodology:**

  - Collected the rocket launch data from the SpaceX API

  - Collected Falcon 9 historical launch records using Web scraping

- **Performed data wrangling:**

  - Used one hot encoding to deal with categorical data

- **Performed exploratory data analysis (EDA) using visualization and SQL**
- **Performed interactive visual analytics using Folium and Plotly Dash**
- **Performed predictive analysis using classification models**

Data Collection

- Collected the rocket launch data from the SpaceX API
- Web-scraped the SpaceX table in the Wikipedia page to collect Falcon 9 historical launch records

Data Collection – SpaceX API

- the GitHub URL https://github.com/bobhunk/New_Rocket_Company_Project_Bob/blob/main/collectingTheData.ipynb

Data Collection - Scraping

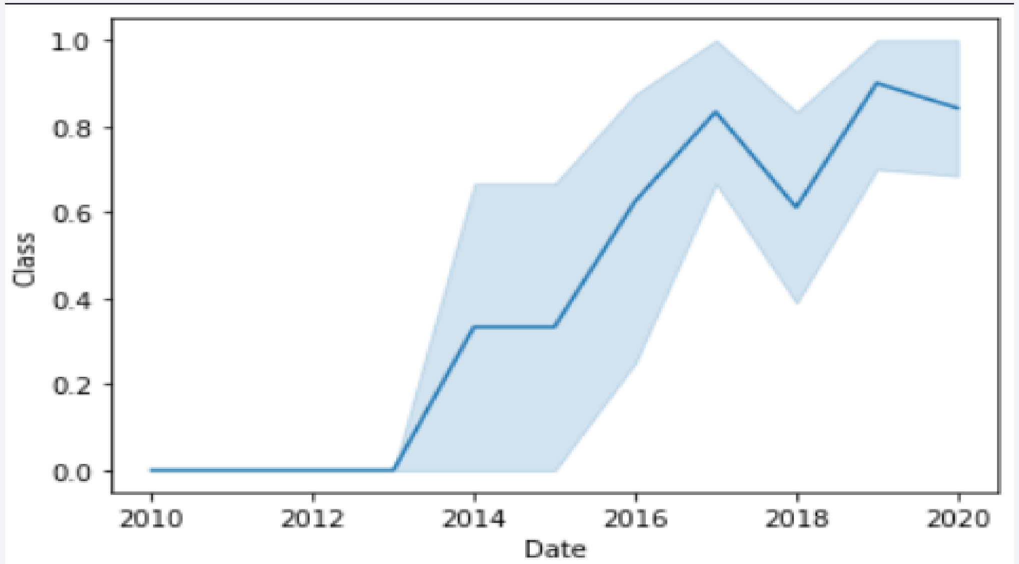
- The GitHub URL: https://github.com/bobhunk/New_Rocket_Company_Project_Bob/blob/main/collectingTheData-webscraping.ipynb

Data Wrangling

- Calculated the number of launches on each site
- Calculated the number and occurrence of each orbit
- Calculated the number and occurrence of mission outcome per orbit type
- Created a landing outcome label from Outcome column

- The GitHub URL: https://github.com/bobhunk/New_Rocket_Company_Project_Bob/blob/main/Data%20wrangling.ipynb

EDA with Data Visualization



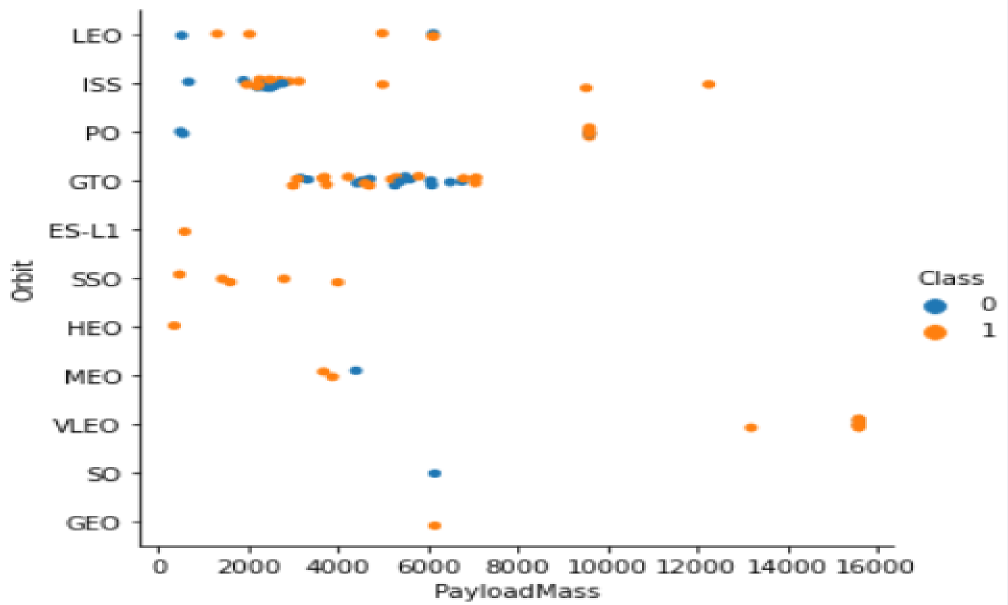
Visualized the relationship between the date and the average success rate across the years.

Conclusion: the success rate since 2013 kept increasing till 2020

- The GitHub URL:https://github.com/bobhunk/New_Rocket_Company_Project_Bob/blob/main/eda-

Visualized the relation between the Orbit and the payload mass.

Conclusion: With heavy payloads the successful landing or positive landing rate are more for Polar, LEO and ISS.



EDA with SQL

- Loaded the SpaceX dataset into a sqllite database.
- Applied EDA with SQL to get insight from the data. 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 names.
- The GitHub URL: https://github.com/bobhunk/New_Rocket_Company_Project_Bob/blob/main/eda-sql.ipynb

Build an Interactive Map with Folium

- Finding an optimal location for building a launch site certainly involves many factors and hopefully we could discover some of the factors by analyzing the existing launch site locations.
- Marked all launch sites, and added map objects such as markers, circles, lines to mark the success or failure of launches for each site on the folium map.
- Using the color-labeled marker clusters, I identified which launch sites have relatively high success rate.
- Calculated the distances between a launch site to its proximities. We answered some question for instance:
  - Are launch sites near railways, highways and coastlines.
  - Do launch sites keep certain distance away from cities.

- The GitHub URL: https://github.com/bobhunk/New_Rocket_Company_Project_Bob/blob/main/site_location.ipynb

Build a Dashboard with Plotly Dash

- Built an interactive dashboard with Plotly dash
- Plotted pie charts showing the total launches by a certain sites
- Plotted scatter graph showing the relationship with Outcome and Payload Mass (Kg) for the different booster version.
- The GitHub URL:

Predictive Analysis (Classification)

- Loaded the data using numpy and pandas, transformed the data, split the data into training and testing.
- Built different machine learning models and tune different hyperparameters using GridSearchCV.
- Used accuracy as the metric for our model, improved the model using feature engineering and algorithm tuning.
- Found the best performing classification model.
- The GitHub URL: https://github.com/bobhunk/New_Rocket_Company_Project_Bob/blob/main/Machine%20Learning%20Prediction.ipynb

Results

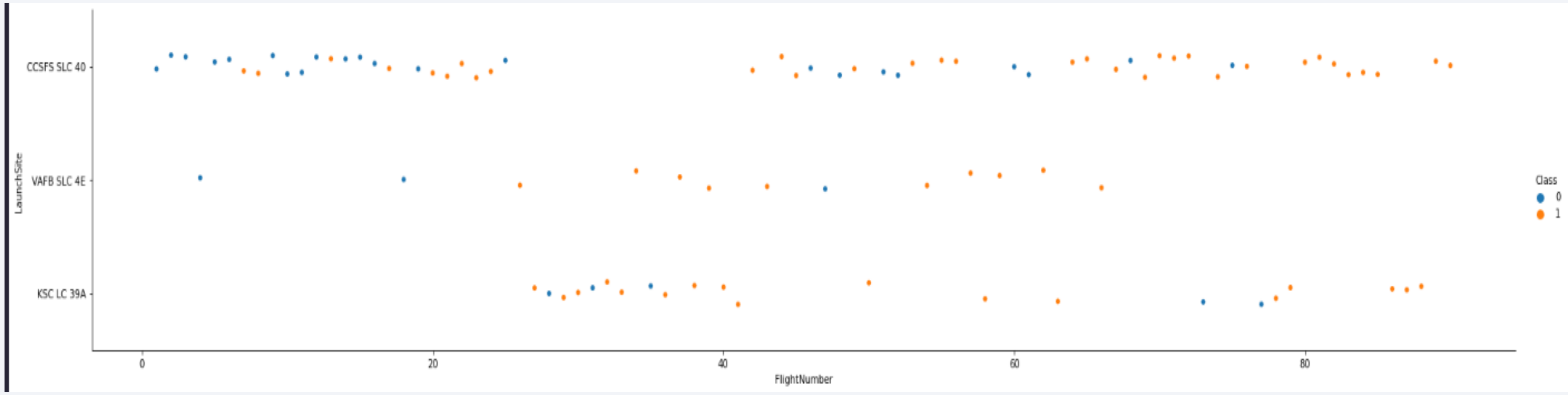
- Exploratory data analysis results
- Interactive analytics demo in screenshots
- Predictive analysis results

Section 2

Insights drawn from EDA

Flight Number vs. Launch Site

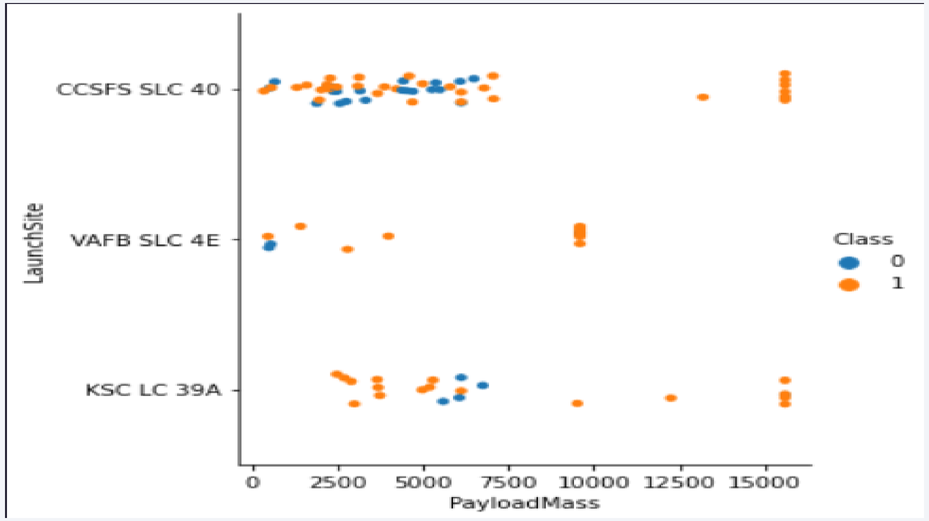
- Show a scatter plot of Flight Number vs. Launch Site



- **Explanation:** when the flight number is > 80 the success rate is 100%

Payload vs. Launch Site

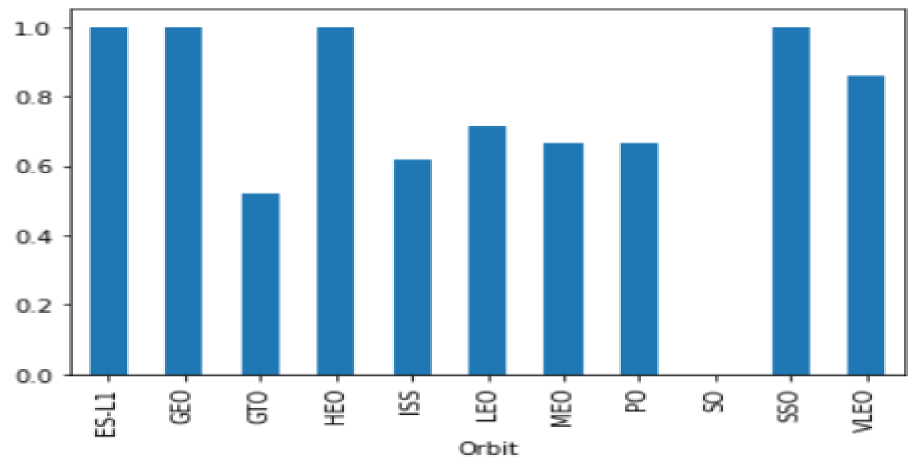
- Show a scatter plot of Payload vs. Launch Site



- **Explanation:** the VAFB-SLC launchsite there are no rockets launched for heavy payload mass(greater than 10000).

Success Rate vs. Orbit Type

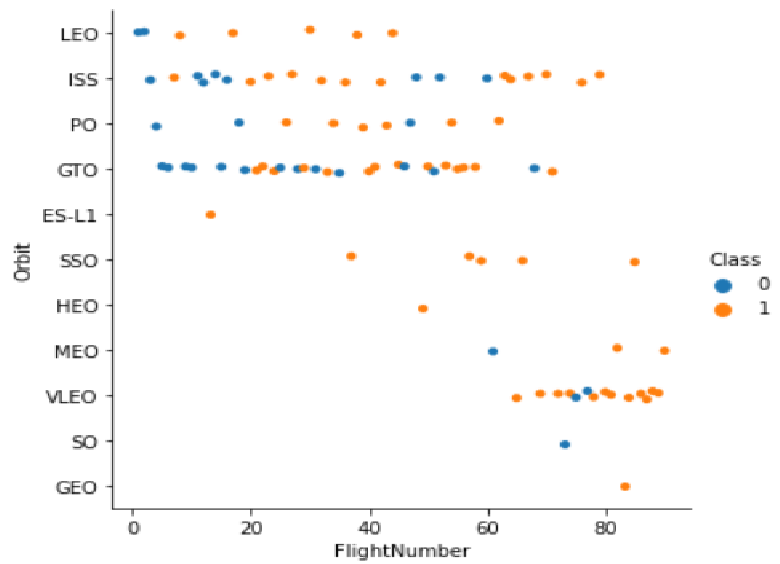
- Show a bar chart for the success rate of each orbit type



- **Explanation**: The ES-L1, GEO, HEO and SSO orbit have the maximum success rate.

Flight Number vs. Orbit Type

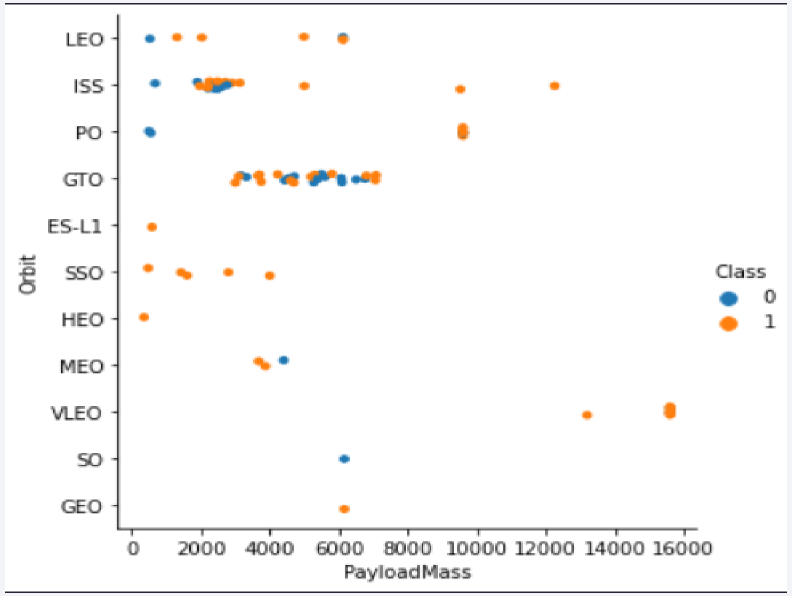
- Show a scatter point of Flight number vs. Orbit type



- **Explanation:** In the LEO orbit the Success appears related to the number of flights; on the other hand, there seems to be no relationship between flight number when in GTO orbit.

Payload vs. Orbit Type

- Show a scatter point of payload vs. orbit type

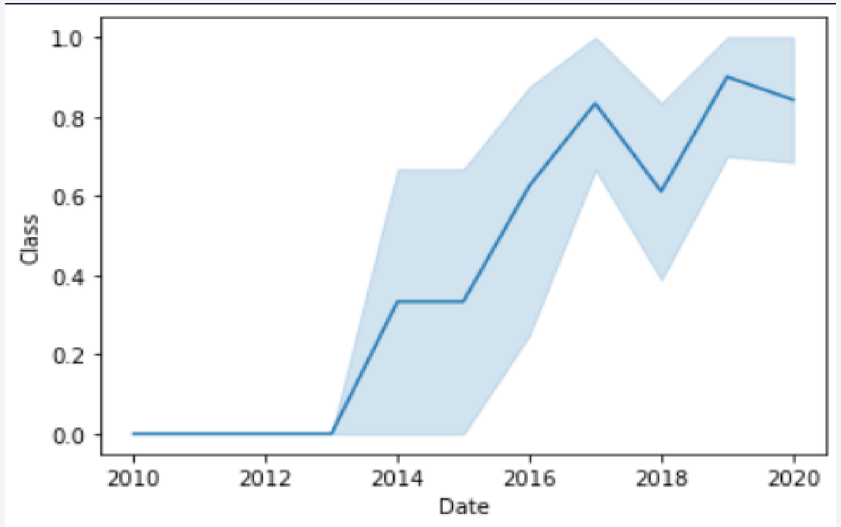


- **Explanation:** With heavy payloads the successful landing or positive landing rate are more for Polar,LEO and ISS.

However for GTO we cannot distinguish this well as both positive landing rate and negative landing(unsuccessful mission) are both there here.

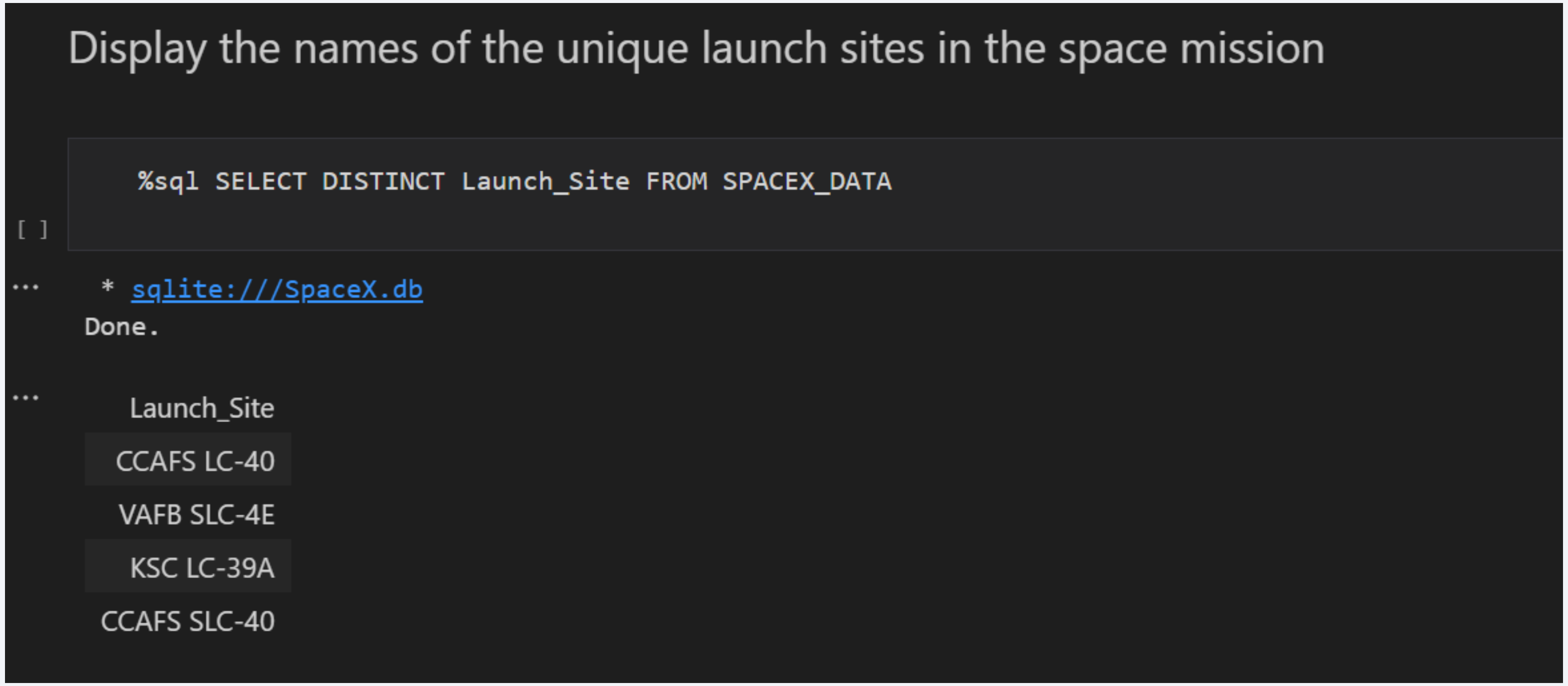
Launch Success Yearly Trend

- Show a line chart of yearly average success rate



- **Explanation:** the success rate since 2013 kept increasing till 2020

All Launch Site Names



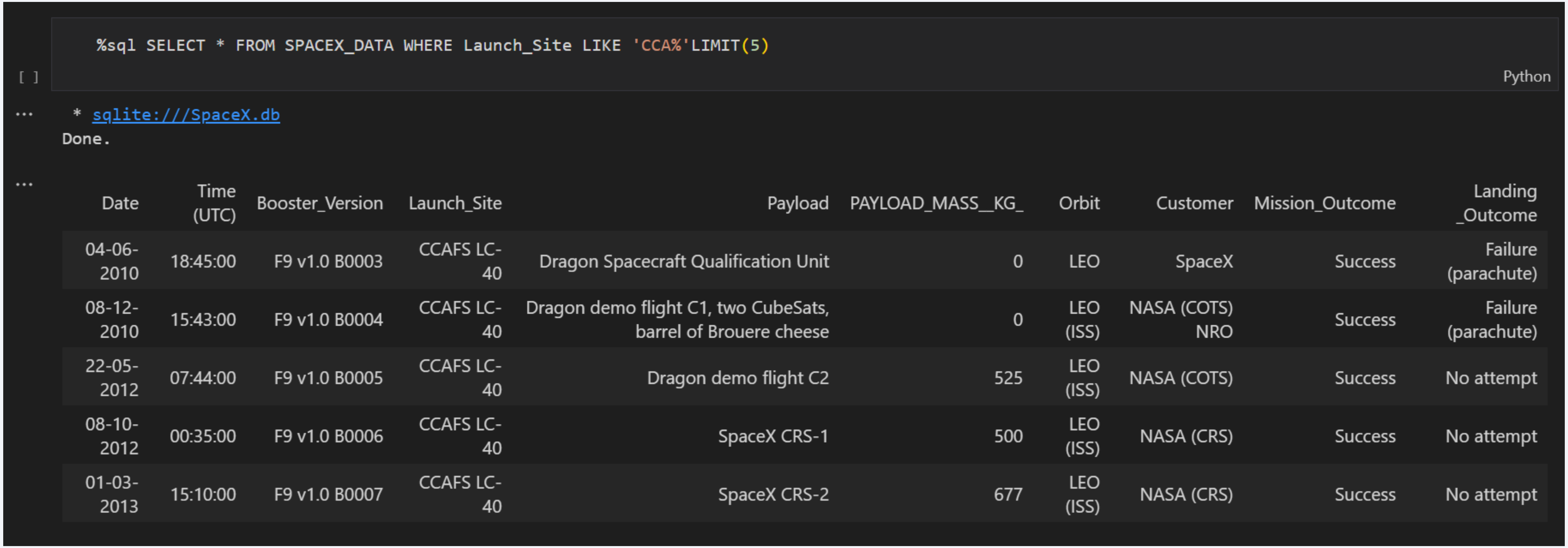
Display the names of the unique launch sites in the space mission

```
%sql SELECT DISTINCT Launch_Site FROM SPACEX_DATA
```

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

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

Launch Site Names Begin with 'CCA'

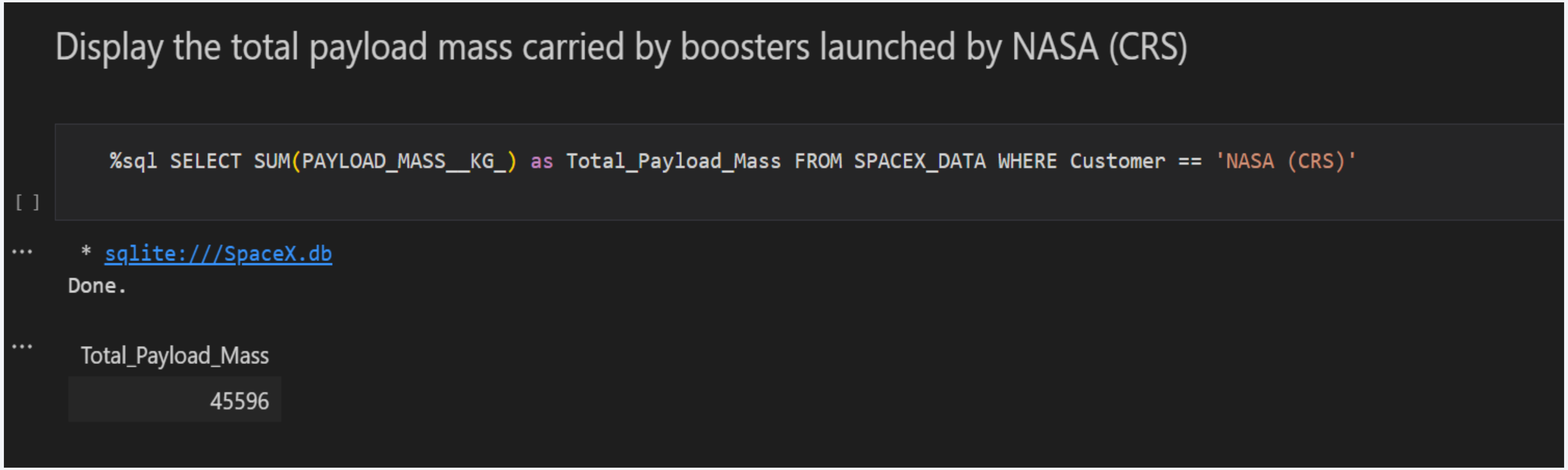


```
%sql SELECT * FROM SPACEX_DATA WHERE Launch_Site LIKE 'CCA%'LIMIT(5)
```

```
 * sqlite:///SpaceX.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



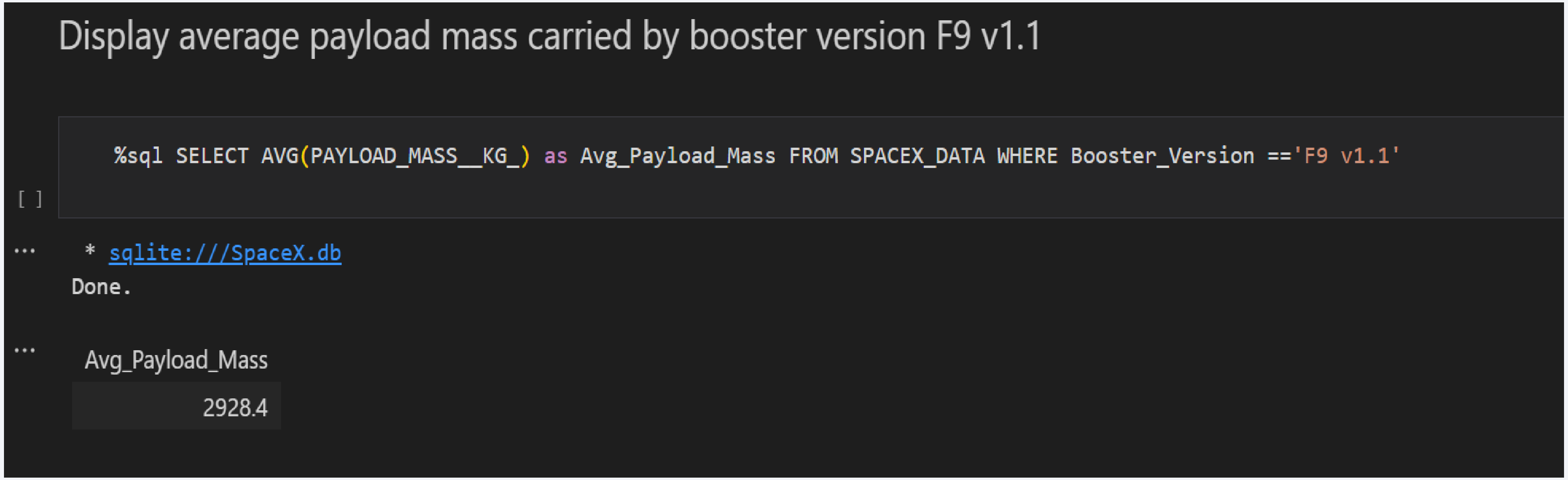
Display the total payload mass carried by boosters launched by NASA (CRS)

```
%sql SELECT SUM(PAYLOAD_MASS__KG_) as Total_Payload_Mass FROM SPACEX_DATA WHERE Customer == 'NASA (CRS)'
```

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

Total_Payload_Mass
45596

Average Payload Mass by F9 v1.1



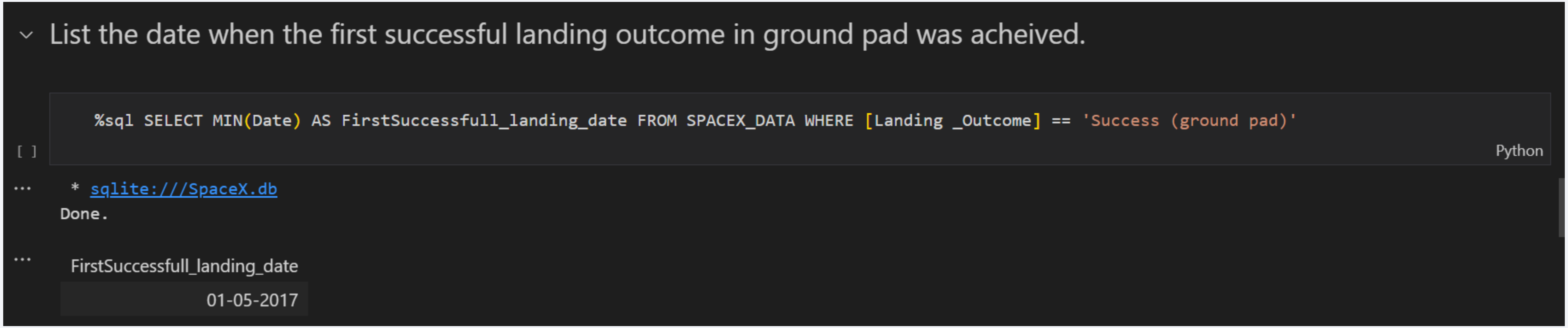
Display average payload mass carried by booster version F9 v1.1

```
%sql SELECT AVG(PAYLOAD_MASS__KG_) as Avg_Payload_Mass FROM SPACEX_DATA WHERE Booster_Version =='F9 v1.1'
```

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

Avg_Payload_Mass
2928.4

First Successful Ground Landing Date



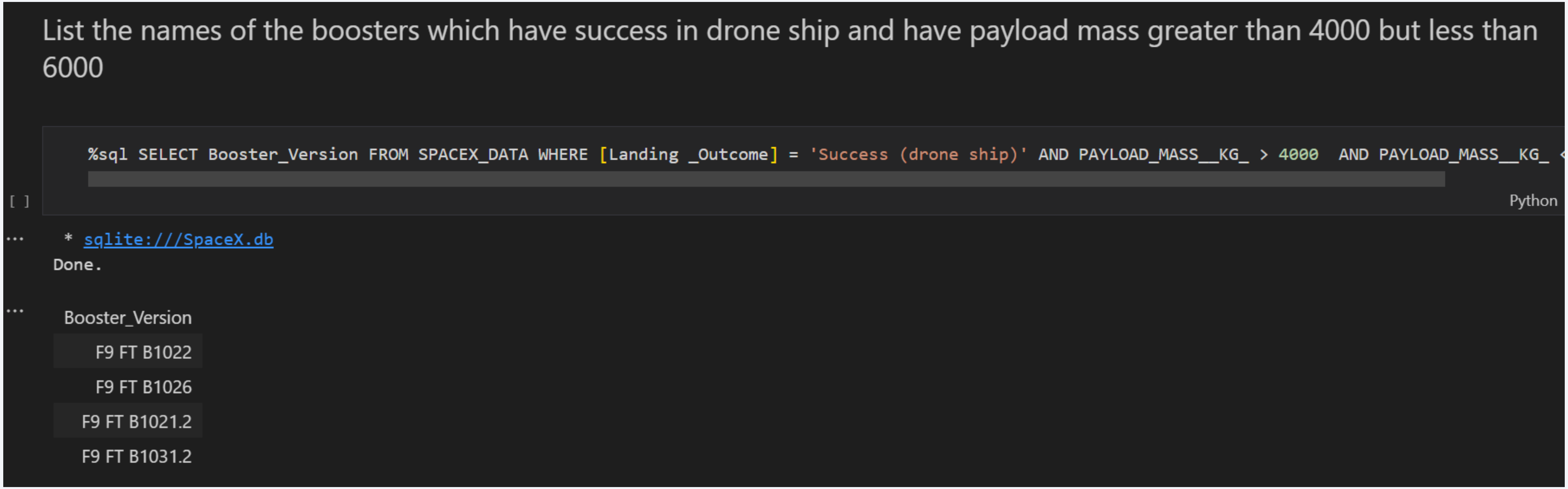
List the date when the first successful landing outcome in ground pad was acheived.

```
%sql SELECT MIN(Date) AS FirstSuccessfull_landing_date FROM SPACEX_DATA WHERE [Landing _Outcome] == 'Success (ground pad)'
```

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

FirstSuccessfull_landing_date
01-05-2017

Successful Drone Ship Landing with Payload between 4000 and 6000



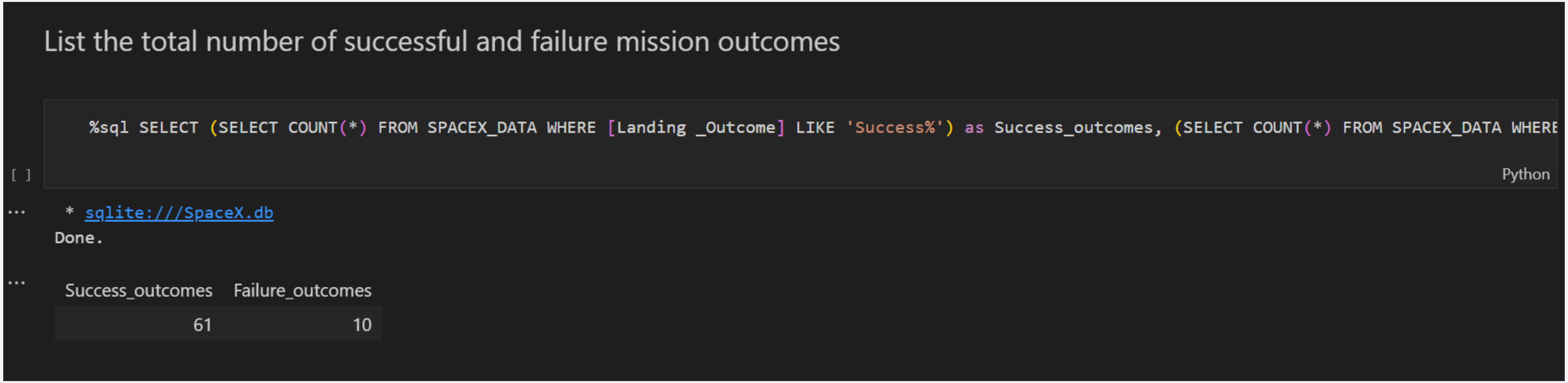
List the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 6000

```
%sql SELECT Booster_Version FROM SPACEX_DATA WHERE [Landing _Outcome] = 'Success (drone ship)' AND PAYLOAD_MASS__KG_ > 4000  AND PAYLOAD_MASS__KG_ <
```

```
 * sqlite:///SpaceX.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



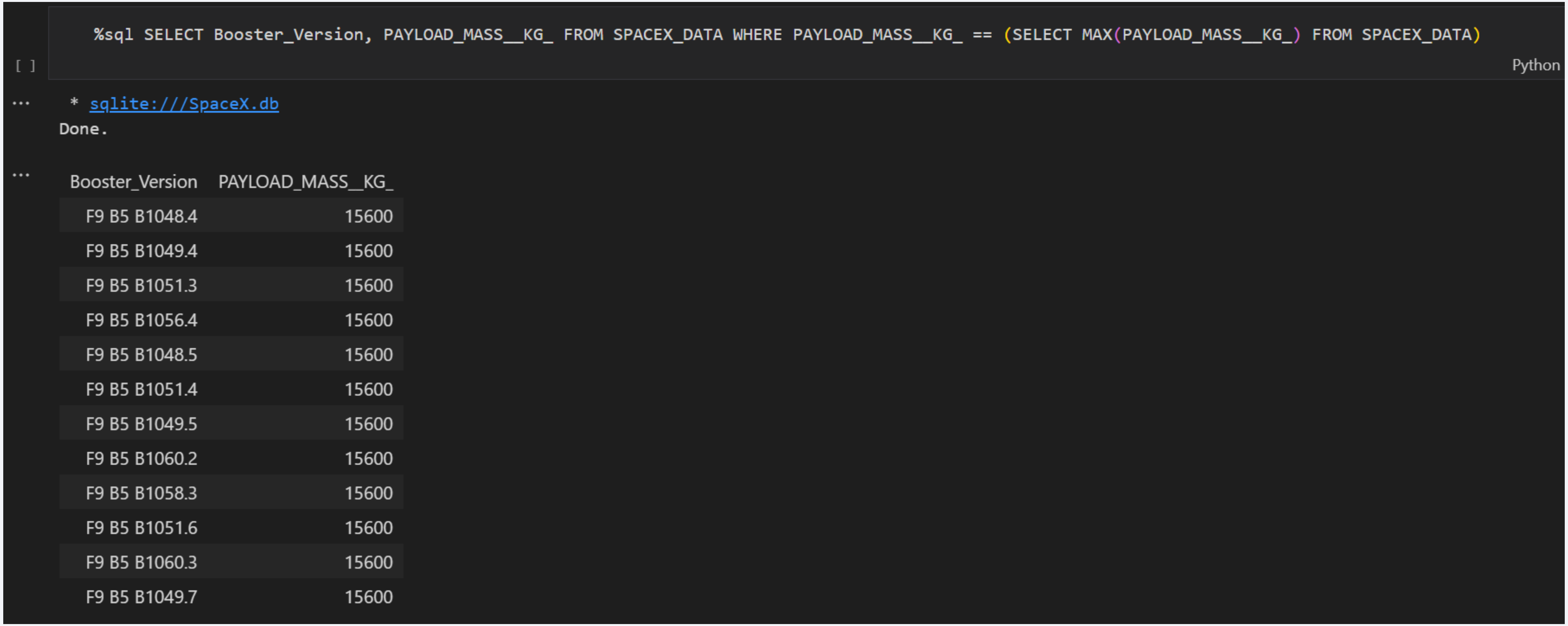
List the total number of successful and failure mission outcomes

```
%sql SELECT (SELECT COUNT(*) FROM SPACEX_DATA WHERE [Landing _Outcome] LIKE 'Success%') as Success_outcomes, (SELECT COUNT(*) FROM SPACEX_DATA WHERE
```

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

Success_outcomes	Failure_outcomes
61	10

Boosters Carried Maximum Payload



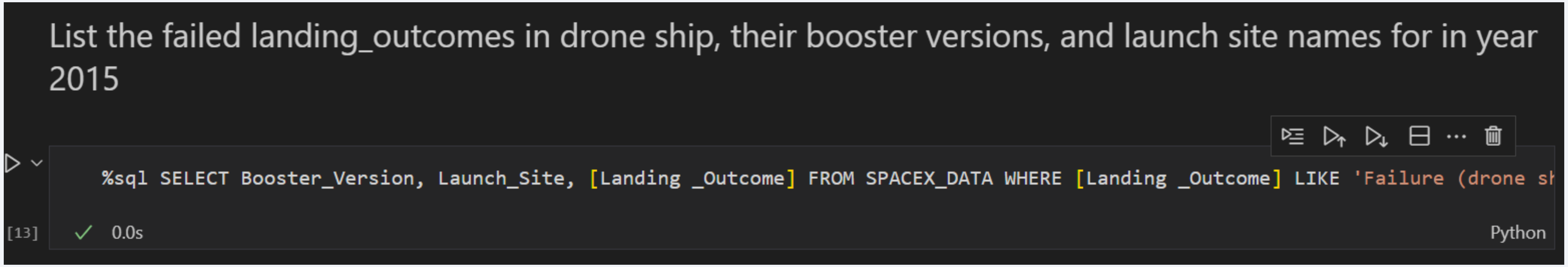
```
%sql SELECT Booster_Version, PAYLOAD_MASS__KG_ FROM SPACEX_DATA WHERE PAYLOAD_MASS__KG_ == (SELECT MAX(PAYLOAD_MASS__KG_) FROM SPACEX_DATA)
```

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

Booster_Version	PAYLOAD_MASS__KG_
F9 B5 B1048.4	15600
F9 B5 B1049.4	15600
F9 B5 B1051.3	15600
F9 B5 B1056.4	15600
F9 B5 B1048.5	15600
F9 B5 B1051.4	15600
F9 B5 B1049.5	15600
F9 B5 B1060.2	15600
F9 B5 B1058.3	15600
F9 B5 B1051.6	15600
F9 B5 B1060.3	15600
F9 B5 B1049.7	15600

2015 Launch Records

- List the failed landing_outcomes in drone ship, their booster versions, and launch site names for in year 2015



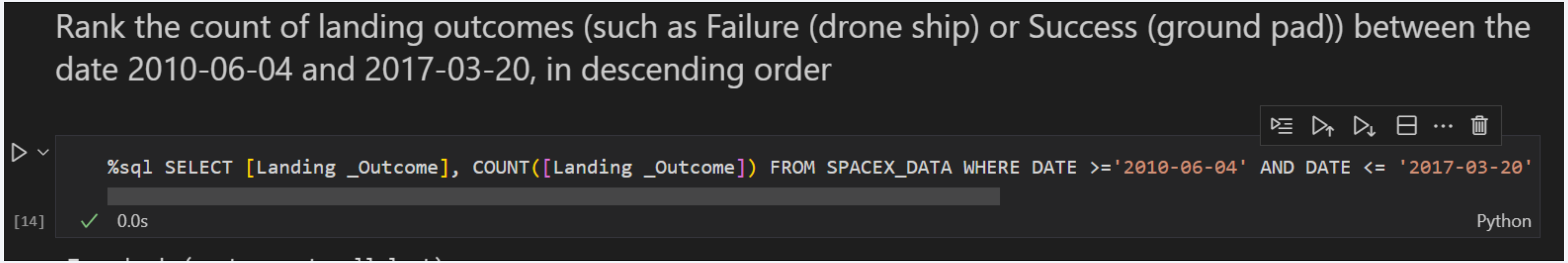
List the failed landing_outcomes in drone ship, their booster versions, and launch site names for in year 2015

```
%sql SELECT Booster_Version, Launch_Site, [Landing _Outcome] FROM SPACEX_DATA WHERE [Landing _Outcome] LIKE 'Failure (drone sh
```

[13] ✓ 0.0s

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

- 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



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

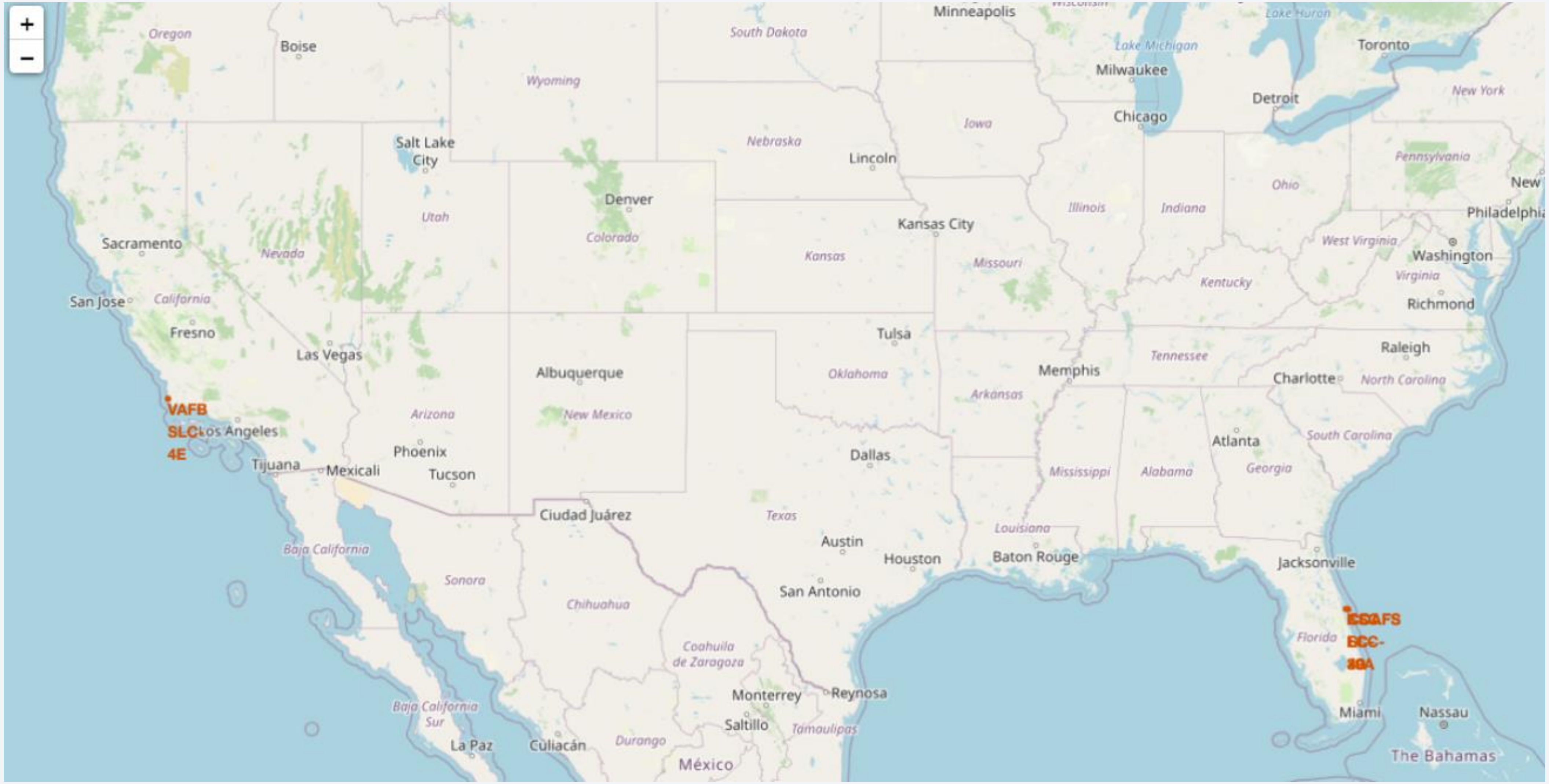
```
%sql SELECT [Landing _Outcome], COUNT([Landing _Outcome]) FROM SPACEX_DATA WHERE DATE >='2010-06-04' AND DATE <= '2017-03-20'
```

[14] ✓ 0.0s

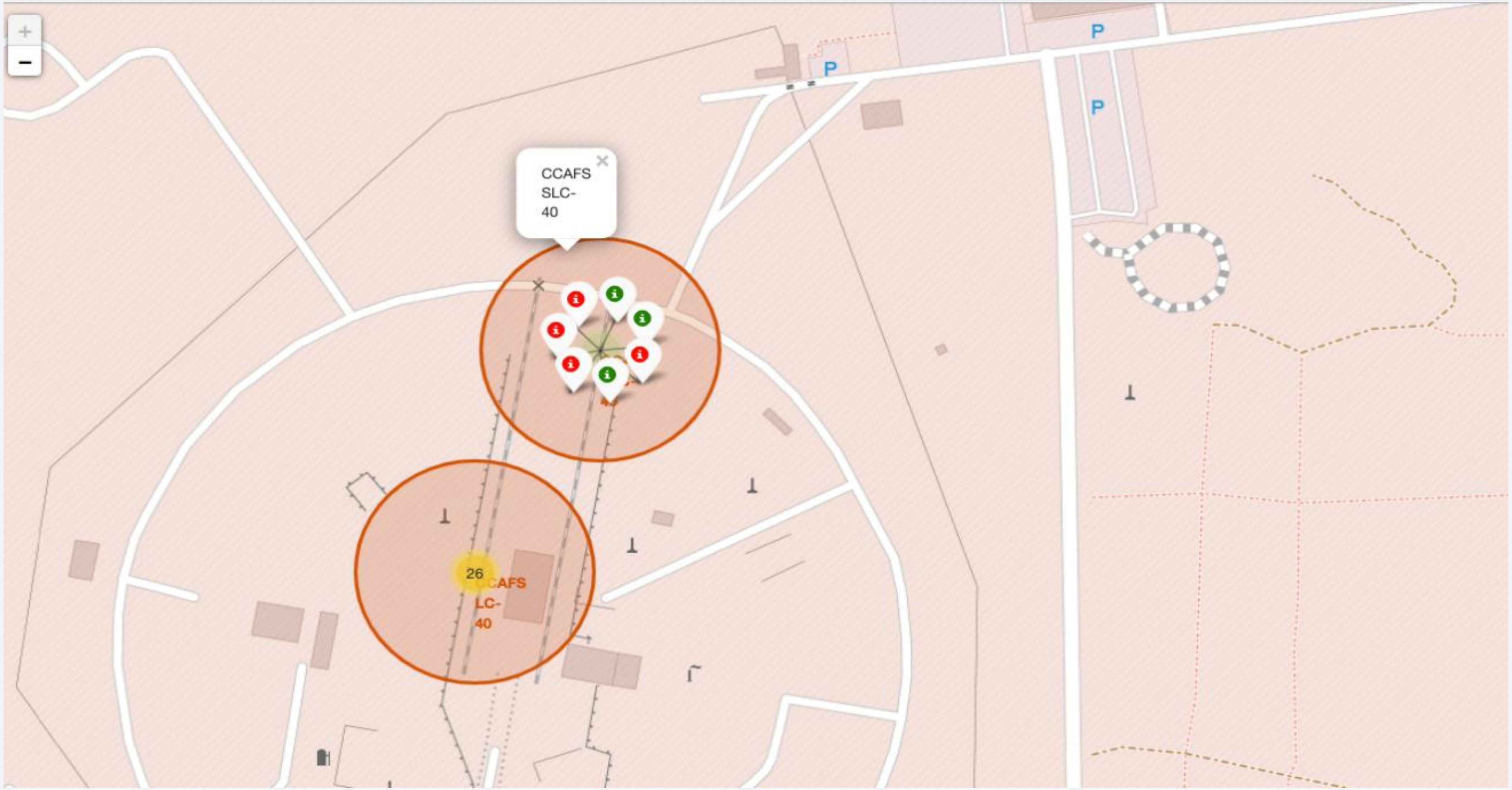
Section 3

Launch Sites Proximities Analysis

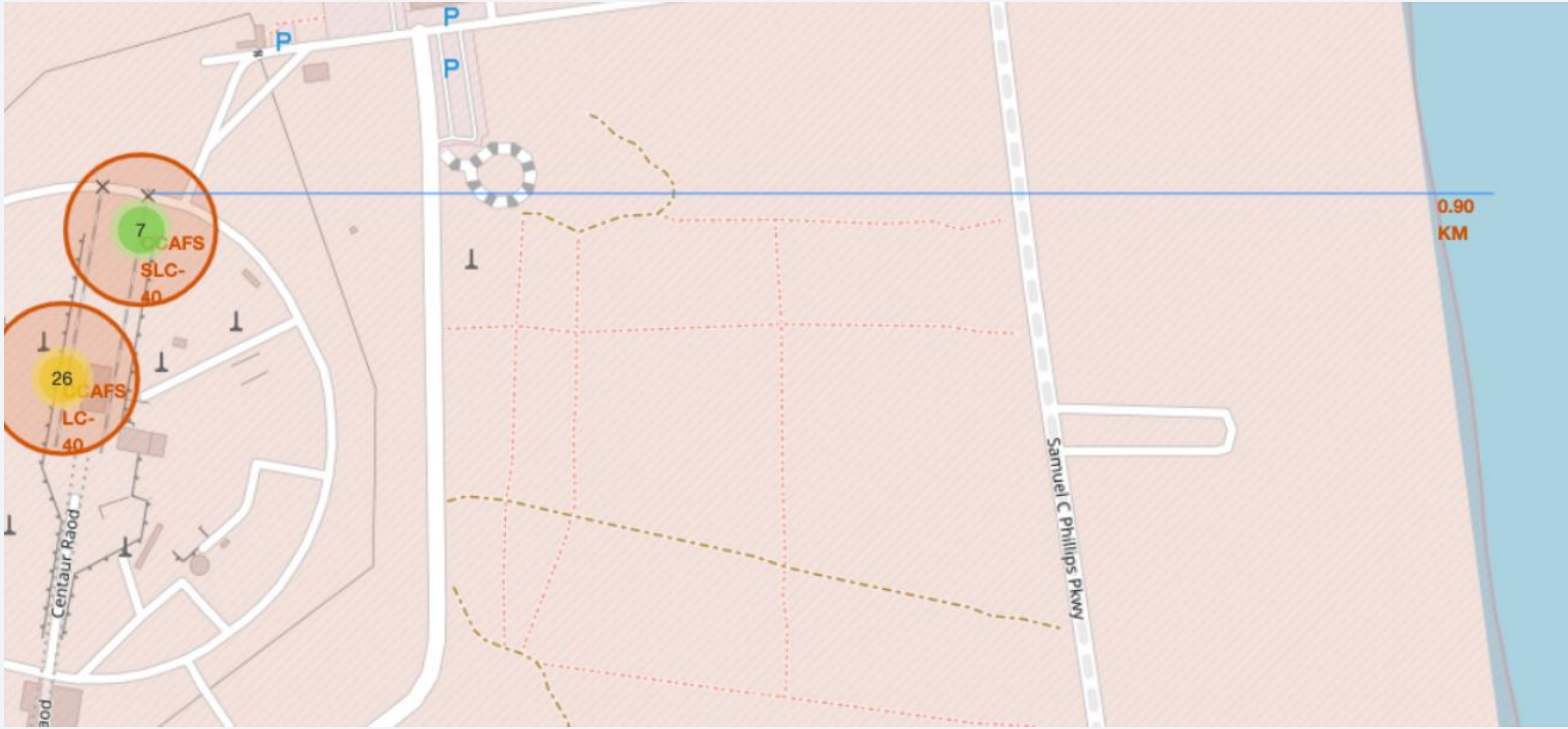
All launch sites global map markers

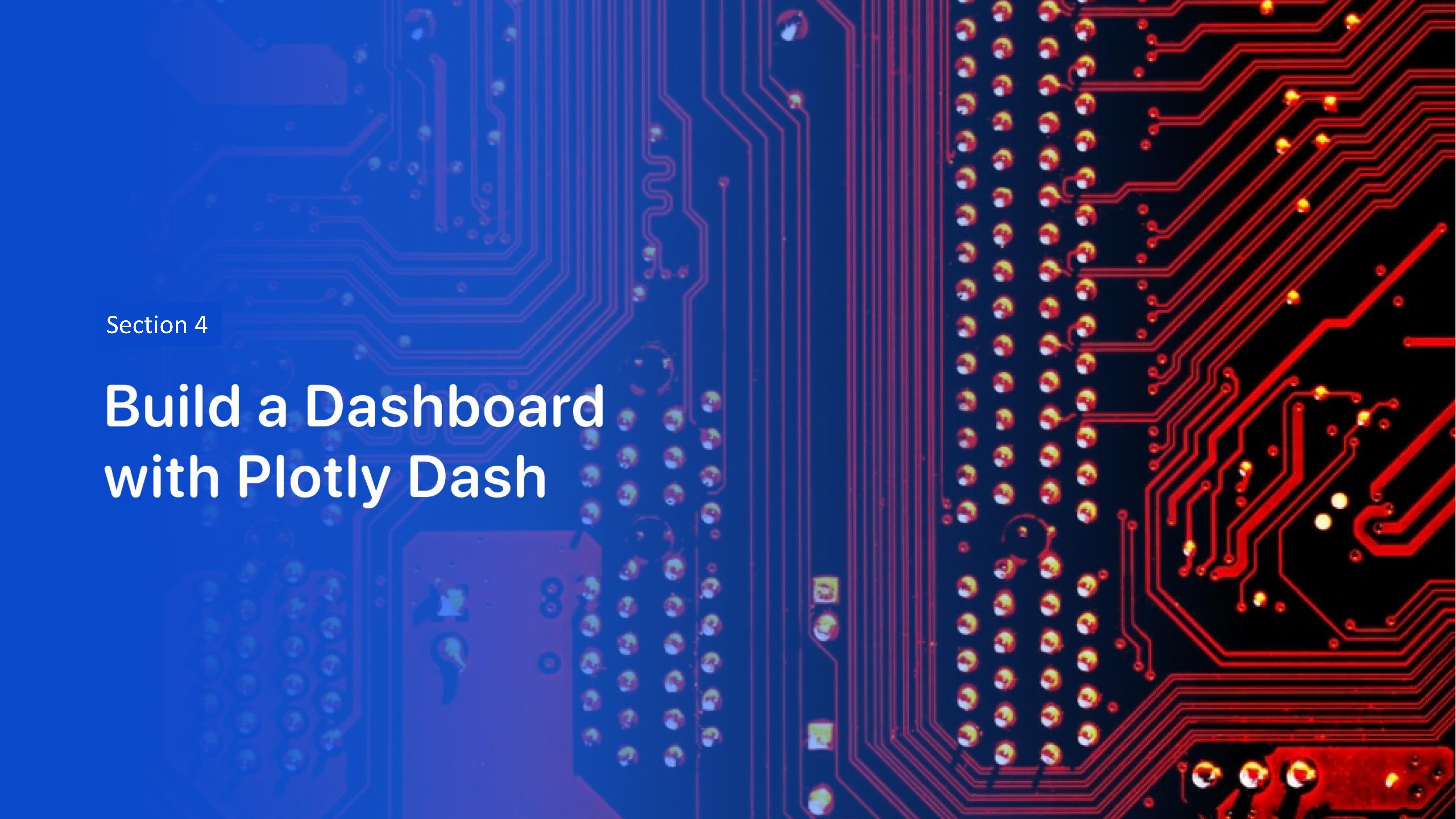


Markers showing launch sites with color labels



Launch Site distance to landmarks

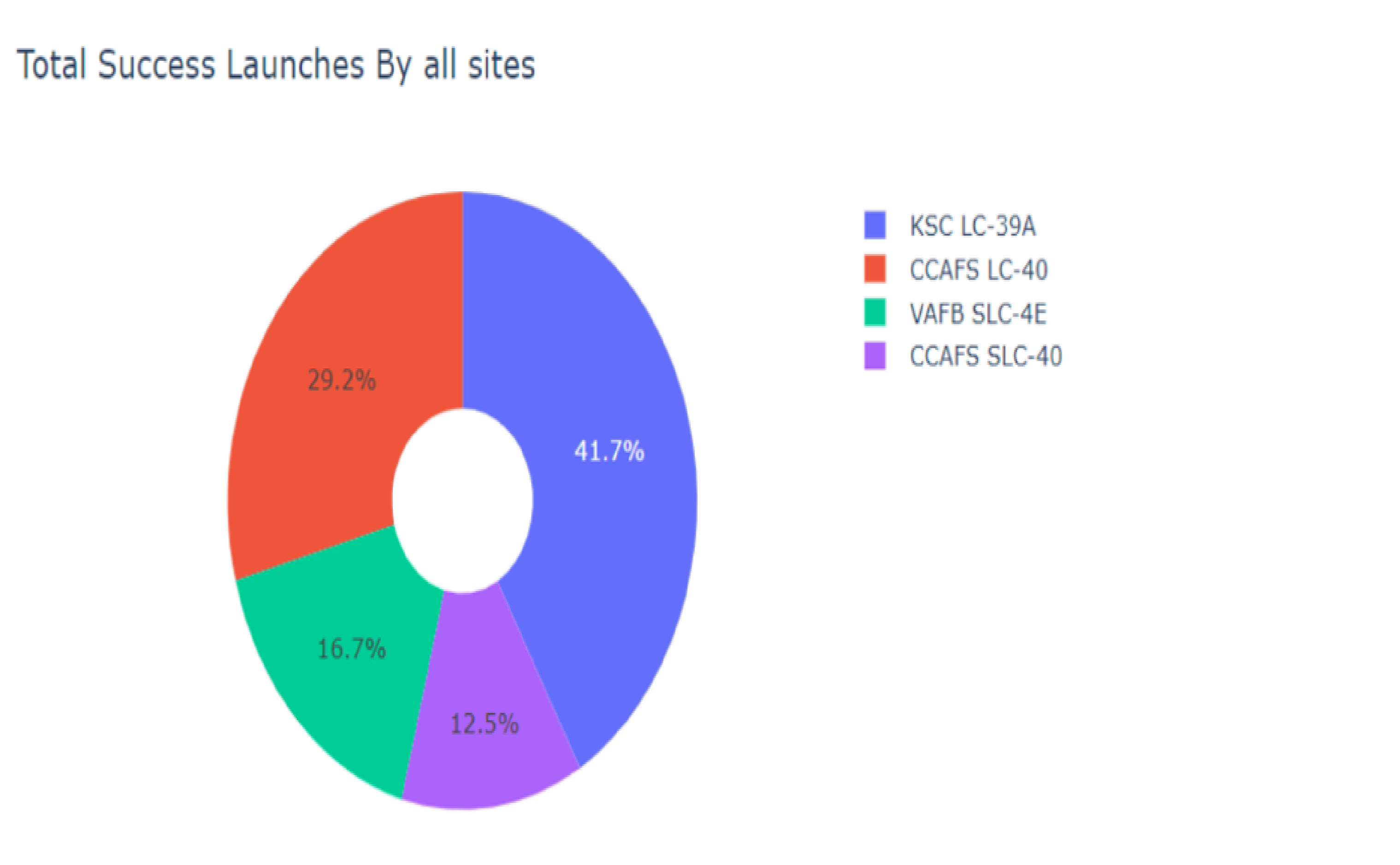




Section 4

Build a Dashboard with Plotly Dash

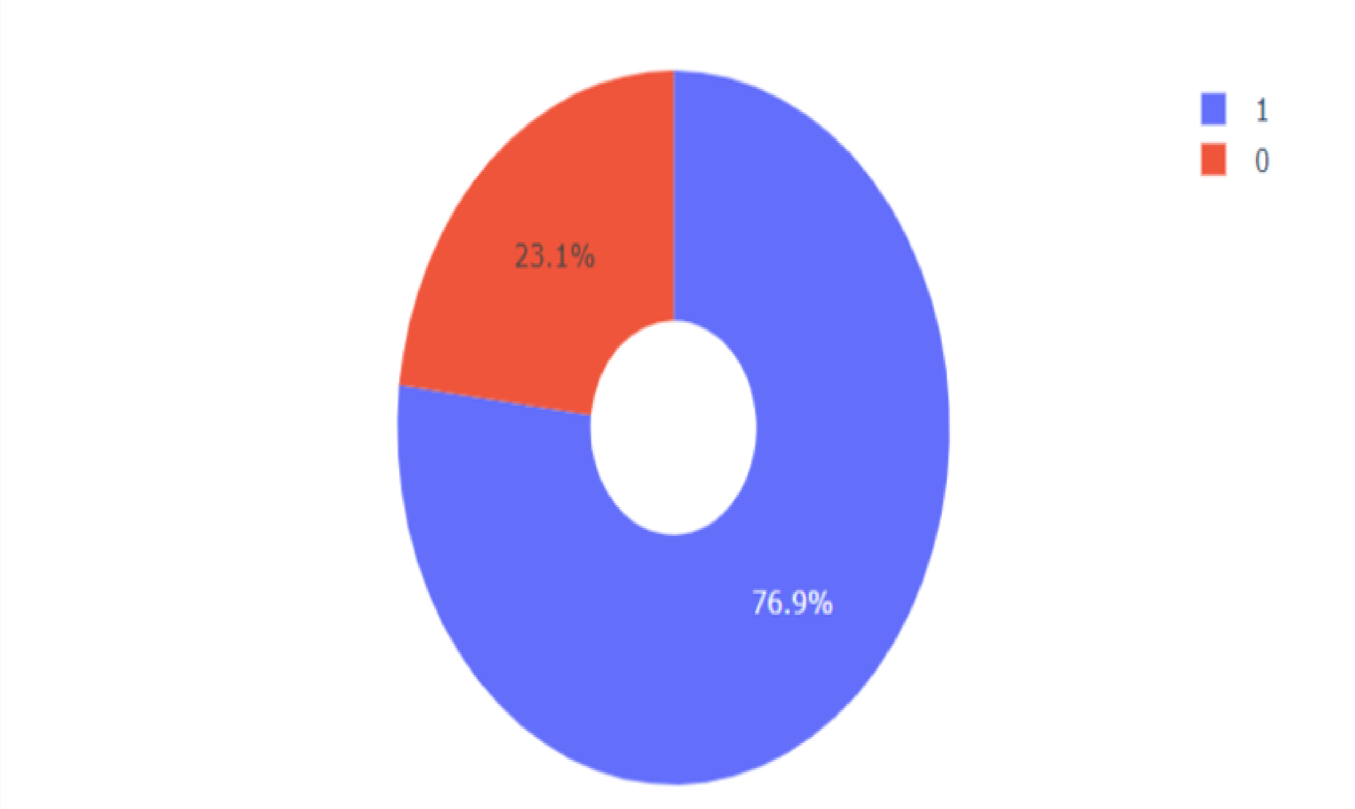
Pie chart showing the success percentage achieved by each launch site



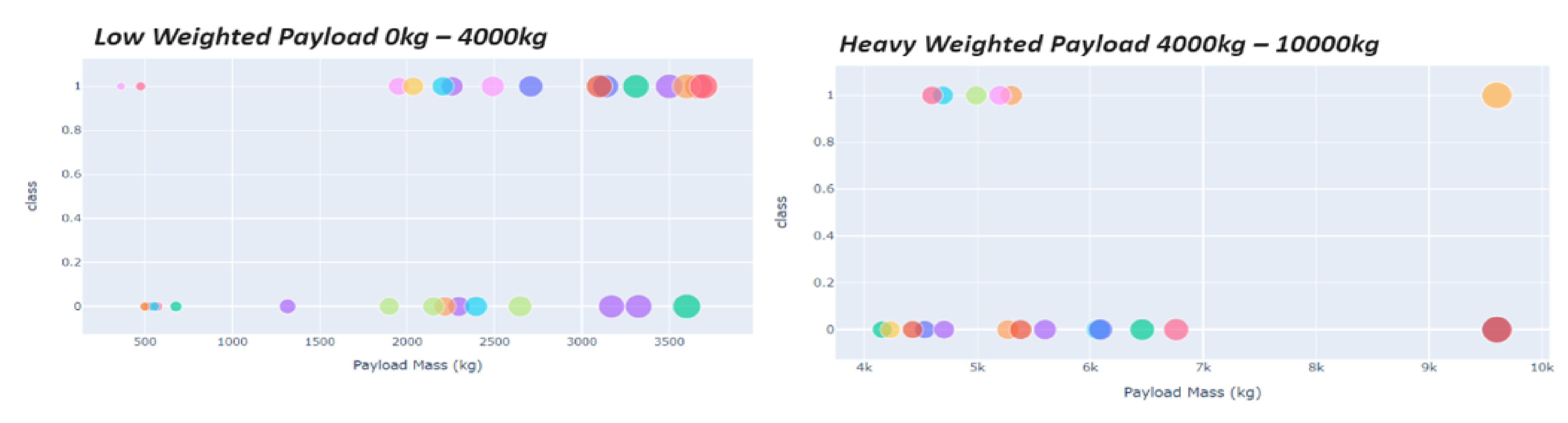
We conclude that the KSC LC-39A have the most successful launches

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

the KSC LC-39A success is 76.9%



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



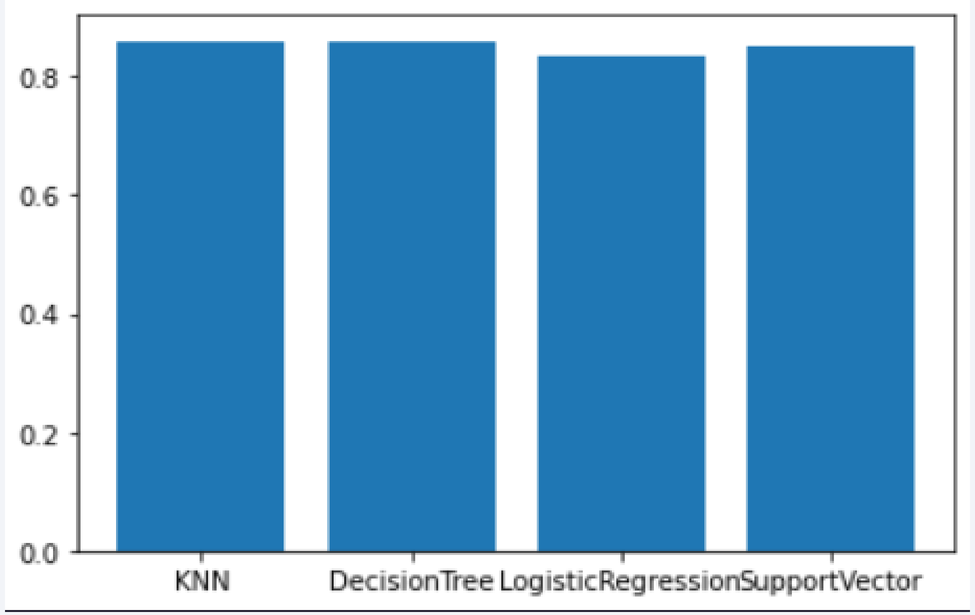
The success rate of low weighted payload is higher than high weighted payload

Section 5

Predictive Analysis (Classification)

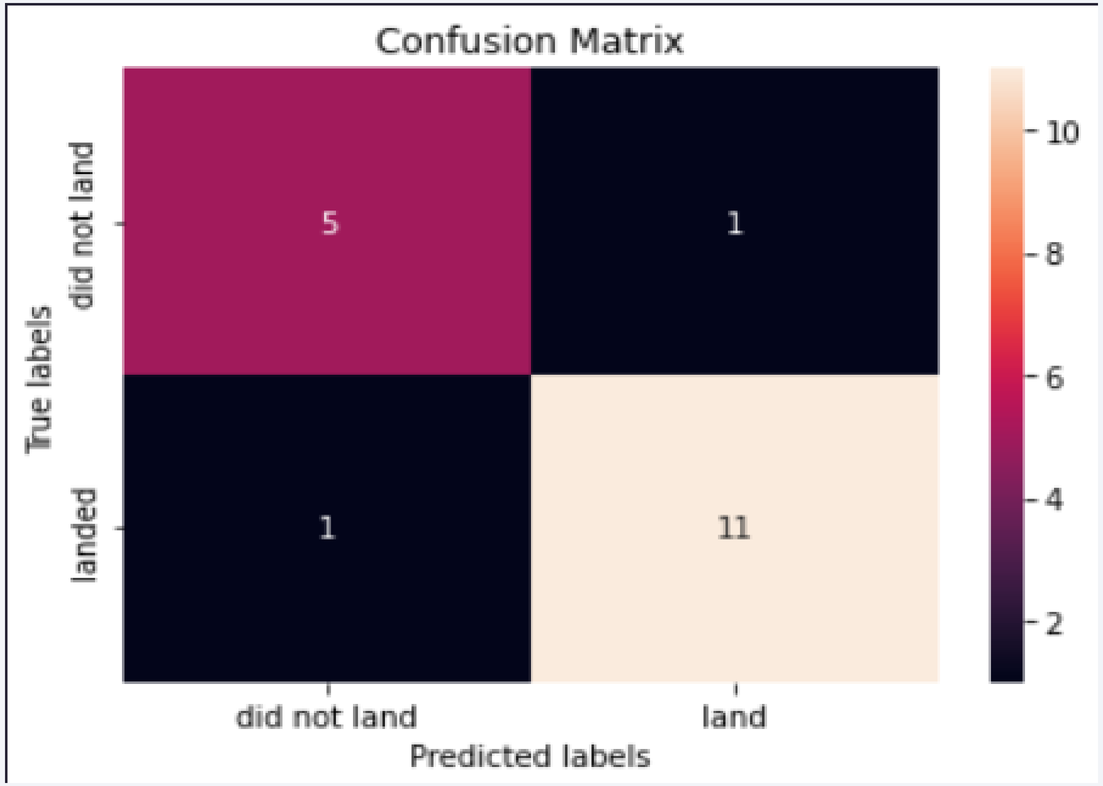
Classification Accuracy

- Visualize the built model accuracy for all built classification models, in a bar chart



- Find which model has the highest classification accuracy: KNN

Confusion Matrix



The knn model classify well the True positive and True negative and the percentage of False positive and false negative is too small.

Conclusions

- 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 KNN classifier is the best machine learning algorithm for this task.

Appendix

Data Collected Links:

- https://github.com/bobhunk/New_Rocket_Company_Project_Bob/blob/main/dataset_part_1.csv
- https://github.com/bobhunk/New_Rocket_Company_Project_Bob/blob/main/dataset_part_2.csv
- https://github.com/bobhunk/New_Rocket_Company_Project_Bob/blob/main/dataset_part_3.csv

Thank you!