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
- Summary of all results

Introduction

SpaceX Falcon 9 First Stage Landing Prediction has as objective being able to predict if the first stage landing on the next launch is successful or not. This is relevant as it can be used to determine the total cost of the launch and compare with potential competitors.

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - Data acquisition through SpaceX API which enables access to launch historic data.
  - Web Scrapping from Wikipedia
- Perform data wrangling
  - Data cleaning: Removal of missing values and creating label to associate to a successful or failed landing.
- Perform exploratory data analysis (EDA) using visualization and SQL
  - Exploratory analysis through SQL and Seborn visualizations obtaining a base understanding of features and their relationship/correlation with success landing.
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - Classification models were evaluated and compared through use of GridSearchCV method to optimize hyperparameters and accuracy.

Data Collection

- Data acquisition through use of SpaceX API.
  - api.spacexdata.com/v4/…
- 4 different helper functions were built to request data:
  - Boster Version, Launch Site, Payload, and Core Data requests response in the form of .JSON files then get parsed and converted into Data Frames for further analysis.

Data Collection – SpaceX API

- A get requests issued to access past launch data.
- Data obtained is then parsed and filtered to issue additional get requests for our global variables.

GitHub


```
In [14]: #Global variables
BoosterVersion = []
PayloadMass = []
Orbit = []
LaunchSite = []
Outcome = []
Flights = []
GridFins = []
Reused = []
Legs = []
LandingPad = []
Block = []
ReusedCount = []
Serial = []
Longitude = []
Latitude = []
```

Data Collection - Scraping

- Web Scraping was done through the use html GET requests.
- Beautifulsoup library was used to parse html tables and convert them into data frames
- GitHub

```
response = requests.get(static_url).text
 soup = BeautifulSoup(response, 'html.parser')
 html_tables = soup.find_all("table")
 print(html_tables)
```

```
[<table class="multicol" role="presentation" style="bor
<tbody><tr>
<td style="text-align: left; vertical-align: top;">
```

```
first_launch_table = html_tables[2]
a = soup.find_all('th')
for x in range(len(a)):
    try:
     name = extract_column_from_header(a[x])
     if (name is not None and len(name) > 0):
        column_names.append(name)
    except:
     pass
```

Data Wrangling

Clean Null values

Determine number of launches per site

Determine occurence of launches at different orbital distances.

Sort mission outcome per orbit type

Create a label to help associate launch to outcome

- [GitHub]

EDA with Data Visualization

As part of the DV several graphs were generated to gain additional insights

- Launch Site vs Flight Number: as the number of launches increases so does the chance for a successful landing.
- Payload vs Launch Site: higher occurrence for launches below 10000kg.
- Class vs Orbit: ES-L1, GEO, HEO and SSO have the highest success rate.
- Orbit vs Flight Number: Class vs Orbit needs to be cross referenced with Flight Number to see that SSO and VLEO have the highest success rates backed by a number of flights while some other orbits were only attepted once.
- Orbit vs Payload: SSO launches at rather low payloads while VLEO Launch Payloads were at above 12000kg.
- Success Rate vs Year: there is a tendency towards successful landings since 2013.

GitHub

EDA with SQL

- SQL queries performed:
  - Displaying the names of the unique launch sites in the space mission
  - Displaying 5 records where launch sites begin with the string 'CCA'
  - Displaying the total payload mass carried by boosters launched by NASA (CRS)
  - Displaying 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 "drone ship" and have payload between 4000 and 6000kg.
  - Listing the total number of successful and failure mission outcomes
  - Listing the names of the booster versions which have carried the maximum payload mass.
  - List the failed landing_outcomes in drone ship, their booster versions, and launch site names for in year 2015
  - 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.

GitHub

Build an Interactive Map with Folium

- Summarize what map objects such as markers, circles, lines, etc. you created and added to a folium map
- Explain why you added those objects
- An interactive map was generated with Folium Library. The map shows the Markers for the different Launch Sites with ClusterMarkers to show the number of launches per site.
- Distances to coastline and transport infrastructure were added to support benefits for using Launch Sites.

GitHub

Build a Dashboard with Plotly Dash

An interactive dashboard was generated with Plotly Dash.

It offers a dropdown menu to select “ALL” or individual launch sites.

A slide bar representing payload values was added afterwards.

The dashboard shows dynamically a couple of graphs depending on the values selected for the dropdown menu and the slide bar.

The pie chart shows Success Rate while the scatterplot shows the correlation of Success vs Payload.

GitHub

Predictive Analysis (Classification)

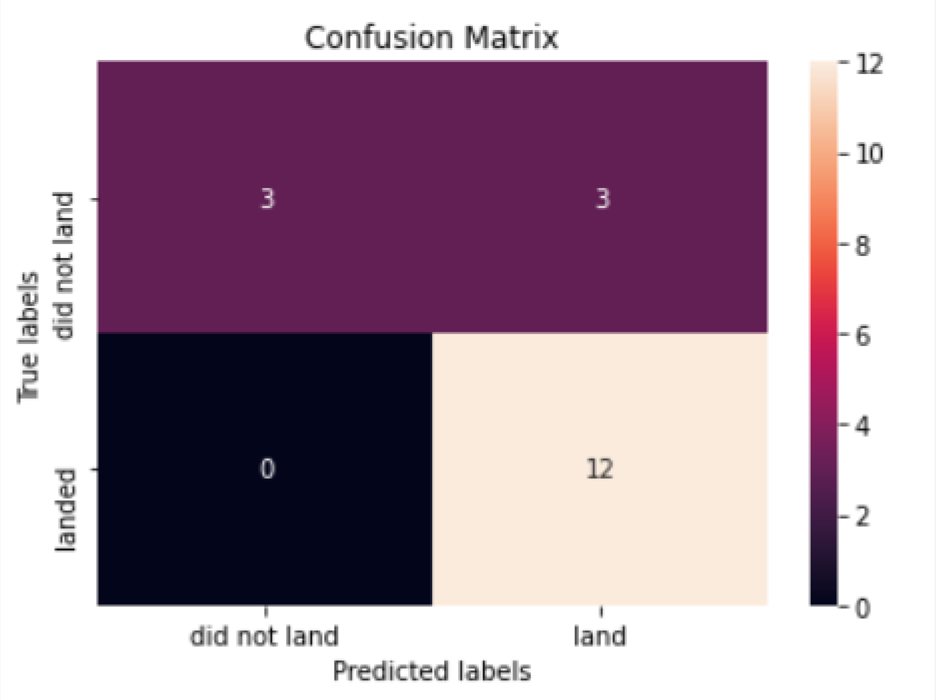
- Summarize how you built, evaluated, improved, and found the best performing classification model
- You need present your model development process using key phrases and flowchart
- For the predictive analysis, the data set was preprocessed by normalizing the data.
- train_test_split method was used to create a training set and a testing set.
- GridSearchCV was then used to optimize and find the best hyperparameters for all models.
- Confusion Matrices and Accuracy scores were used to compare the different models.

[GitHub]

Results

- For this particular dataset all models perform the same at 83.3% accuracy.
- Low payload launches perform better than heavy ones.
- KSC LC 39A had the highest success rate while also presenting launches at load and high loads.
- Orbits ISS has the better associated performance followed by VLEO considering the frequency of success landings.

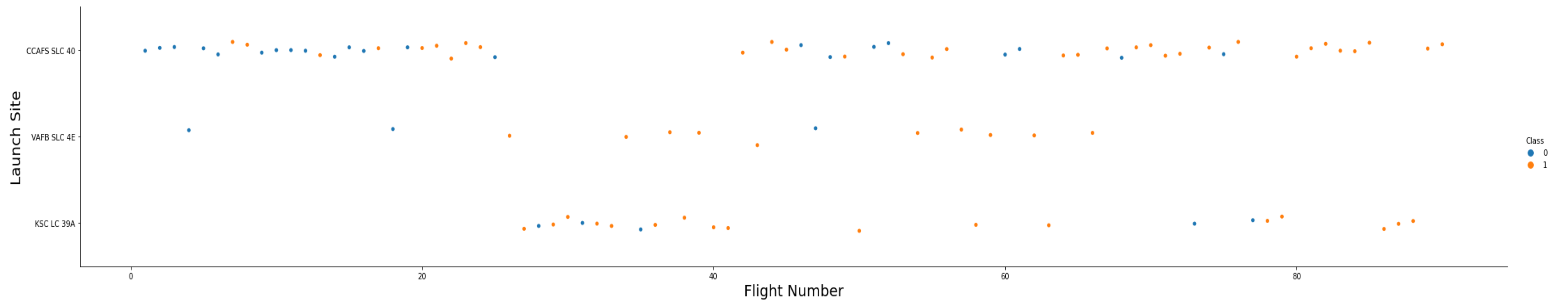
Model	Score
knn_cv	0.833333
tree_cv	0.833333
svm_cv	0.833333
logreg_cv	0.833333



Section 2

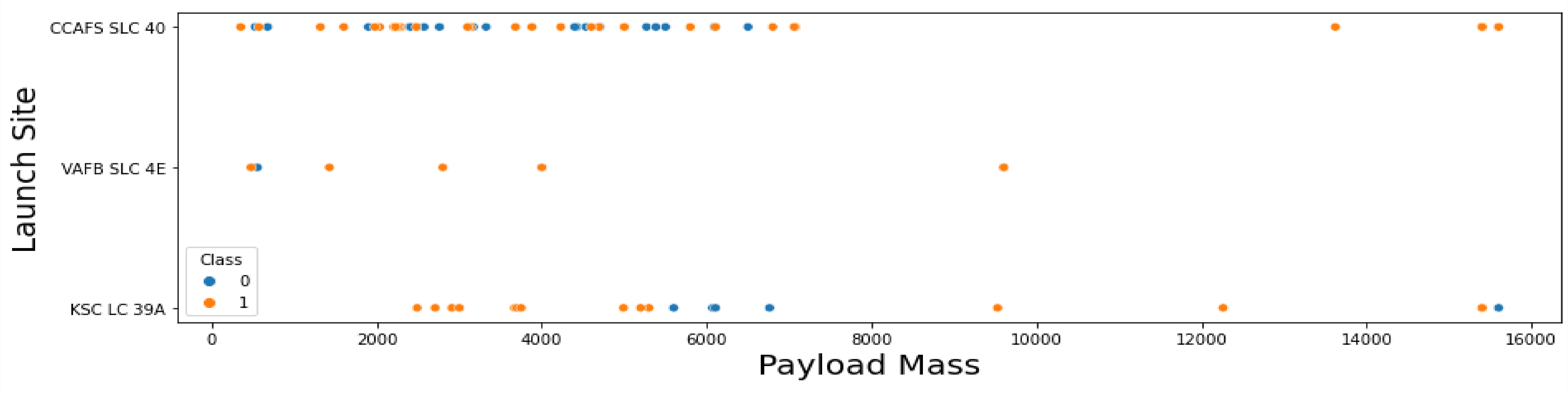
Insights drawn from EDA

Flight Number vs. Launch Site



Site CCAFS SLC 40 was used for the initial launches showing a high occurrence of failed landings.

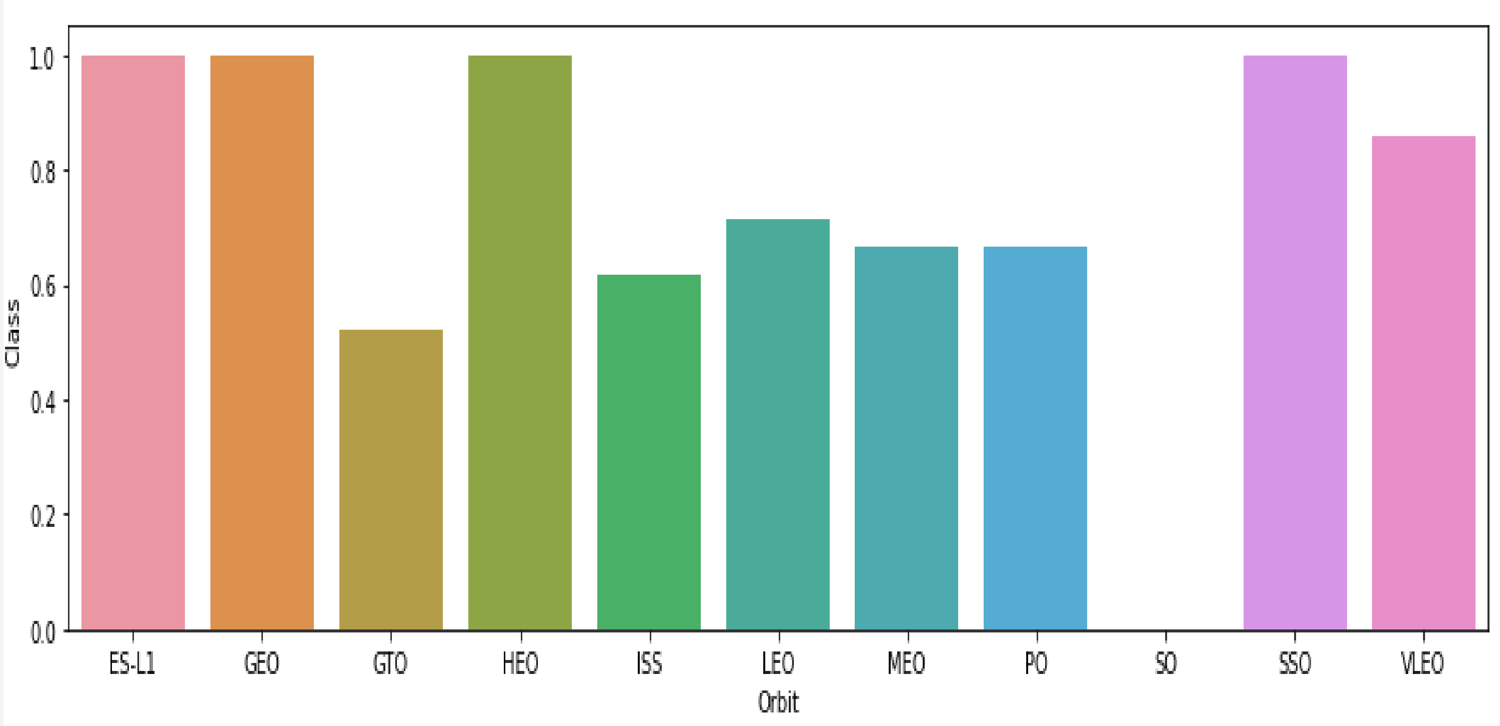
Payload vs. Launch Site



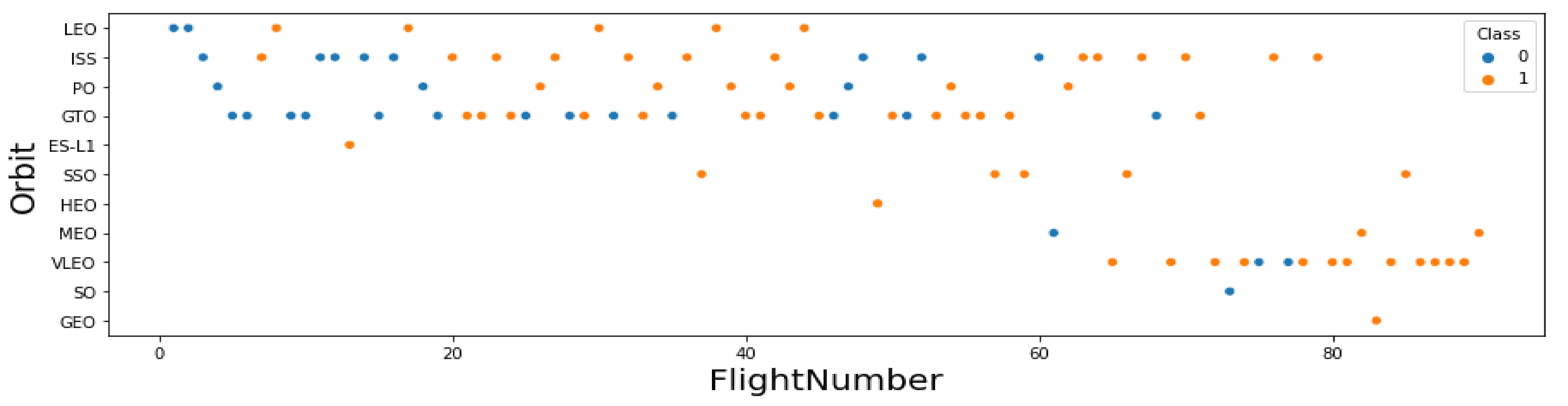
- On this graph it is easier to see the correspondance Success Rate to Low Payload

Success Rate vs. Orbit Type

- ES-L1, GEO, HEO and SSO have a mean success rate of 100%.
-

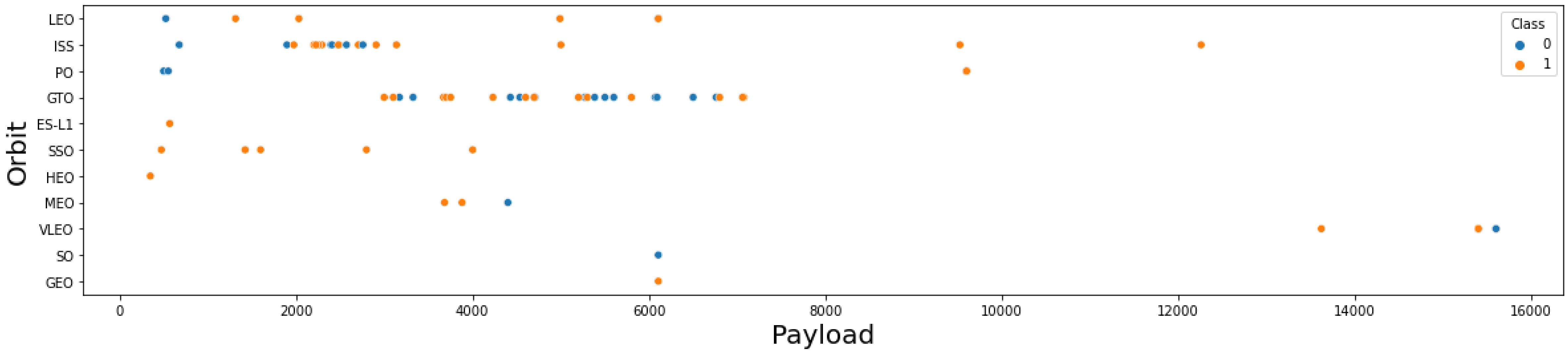


Flight Number vs. Orbit Type



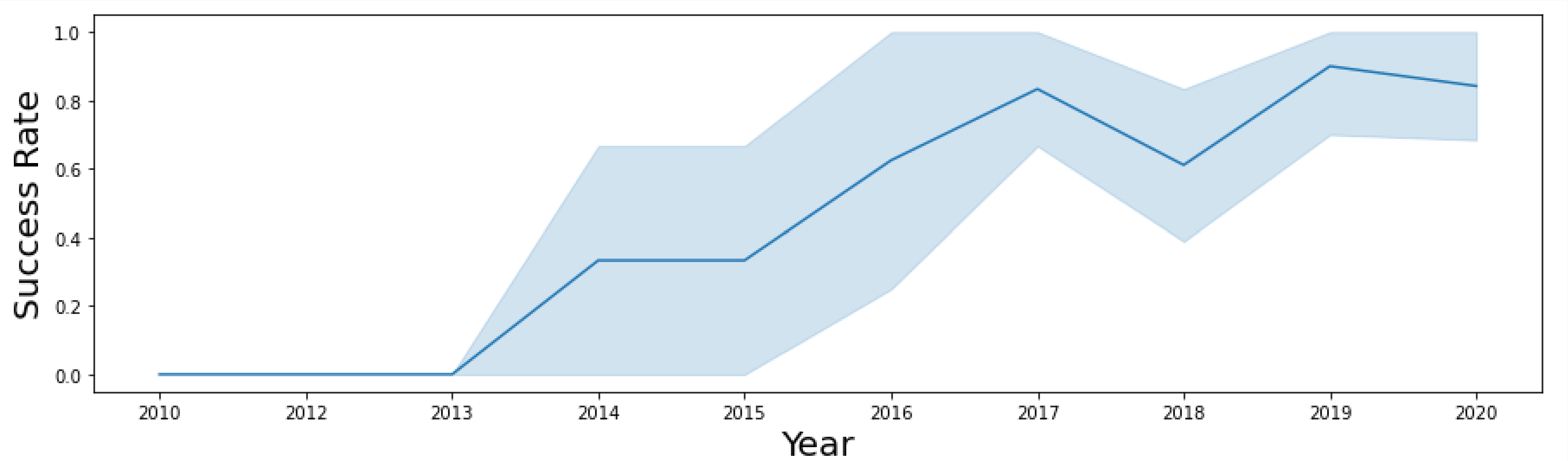
This graph shows how while some orbits have a 100% success rate, they have only a few associated flights (ES-L1, GEO, HEO). At the same time it is observed that SSO has several associated flights and all were succesfull landings.

Payload vs. Orbit Type



With this graph we can further associate the success rate per orbit type to the relatively low payload used for the highest performance (ES-L1, GEO, HEO, SSO)

Launch Success Yearly Trend



With this graph we see the start of the positive trend during 2013.

All Launch Site Names

List all site names from SPACEX

```
%%sql
select DISTINCT(LAUNCH_SITE) from SPACEX
```

```
 * ibm_db_sa://bqn92294:***@b0aebb68-94fa-46ec-a1fc-1c999edb6187.c3n41cmd0nqnrk39u98g.databases.appdomain.cloud:31249/bludb
Done.
```

]:

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

Launch Site Names Begin with 'CCA'

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

```
%%sql
select LAUNCH_SITE from SPACEX
where LAUNCH_SITE LIKE 'CCA%'
limit 5
```

```
 * ibm_db_sa://bqn92294:***@b0aebb68-94fa-46ec-a1fc-1c999edb6187.c3n41cmd0nqnrk39u98g.databases.appdomain.cloud:31249/bludb
Done.
```

9]:

launch_site
CCAFS LC-40
CCAFS LC-40
CCAFS LC-40
CCAFS LC-40
CCAFS LC-40

5 records where launch sites begin with `CCA`

Total Payload Mass

```
%%sql
select SUM(PAYLOAD_MASS__KG_) from SPACEX
where LAUNCH_SITE LIKE 'CCA%'
```

```
 * ibm_db_sa://bqn92294:***@b0aebb68-94fa-46ec-a1fc-1c999edb6187.c3n41cmd0nqnrk39u98g.databases.appdomain.cloud:31249/bludb
Done.
```

]:

1
321400

Total payload carried by boosters from NASA

Average Payload Mass by F9 v1.1

- Calculate the average payload mass carried by booster version F9 v1.1
- Present your query result with a short explanation here

First Successful Ground Landing Date

Dates of the first successful landing outcome on ground pad

```
%%sql
select min(DATE) from SPACEX
where LANDING__OUTCOME LIKE 'Success%'
```

```
 * ibm_db_sa://bqn92294:***@b0aebb68-94fa-46ec-a1fc-1c999edb6187.c3n41cmd0nqnrk39u98g.databases.appdomain.cloud:31249/bludb
Done.
```

]:

1
2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

List of the of boosters names which have successfully landed on drone ship and had payload mass greater than 4000 but less than 6000

```
%%sql
select BOOSTER_VERSION, PAYLOAD_MASS__KG_  from SPACEX
where (LANDING__OUTCOME LIKE 'Success (drone ship)') AND (PAYLOAD_MASS__KG_ BETWEEN 4000 AND 6000)
```

```
 * ibm_db_sa://bqn92294:***@b0aebb68-94fa-46ec-a1fc-1c999edb6187.c3n41cmd0nqnrk39u98g.databases.appdomain.cloud:31249/bludb
Done.
```

]:

booster_version	payload_mass__kg_
F9 FT B1022	4696
F9 FT B1026	4600
F9 FT B1021.2	5300
F9 FT B1031.2	5200
F9 FT B1022	4696
F9 FT B1026	4600
F9 FT B1021.2	5300
F9 FT B1031.2	5200

Total Number of Successful and Failure Mission Outcomes

Total number of successful and failure mission outcomes

```
%%sql
select COUNT(MISSION_OUTCOME) FROM SPACEX
```

```
 * ibm_db_sa://bqn92294:***@b0aebb68-94fa-46e
Done.
```

1
202

Boosters Carried Maximum Payload

Names of the booster which have carried the maximum payload mass

```
%%sql
SELECT DISTINCT(BOOSTER_VERSION), PAYLOAD_MASS__KG_ FROM SPACEX
WHERE PAYLOAD_MASS__KG_ = (SELECT MAX(PAYLOAD_MASS__KG_) FROM SPACEX)
```

```
 * ibm_db_sa://bqn92294:***@b0aebb68-94fa-46ec-a1fc-1c999edb6187.c3n41cmd0r
Done.
```

]:

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

2015 Launch Records

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

```
%%sql
SELECT BOOSTER_VERSION, LAUNCH_SITE, DATE, LANDING__OUTCOME FROM SPACEX
WHERE LANDING__OUTCOME LIKE 'Failure (drone ship)' AND YEAR(DATE)=2015
```

```
 * ibm_db_sa://bqn92294:***@b0aebb68-94fa-46ec-a1fc-1c999edb6187.c3n4
Done.
```

4]:

booster_version	launch_site	DATE	landing__outcome
F9 v1.1 B1012	CCAFS LC-40	2015-01-10	Failure (drone ship)
F9 v1.1 B1015	CCAFS LC-40	2015-04-14	Failure (drone ship)
F9 v1.1 B1012	CCAFS LC-40	2015-01-10	Failure (drone ship)
F9 v1.1 B1015	CCAFS LC-40	2015-04-14	Failure (drone ship)

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

Ranking of 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(*) AS count FROM SPACEX
WHERE DATE BETWEEN '2010-06-04'and'2017-03-20'
GROUP BY landing__outcome
ORDER BY COUNT(landing__outcome) DESC
```

```
 * ibm_db_sa://bqn92294:***@b0aebb68-94fa-46ec-a1fc-1c9
Done.
```

]:

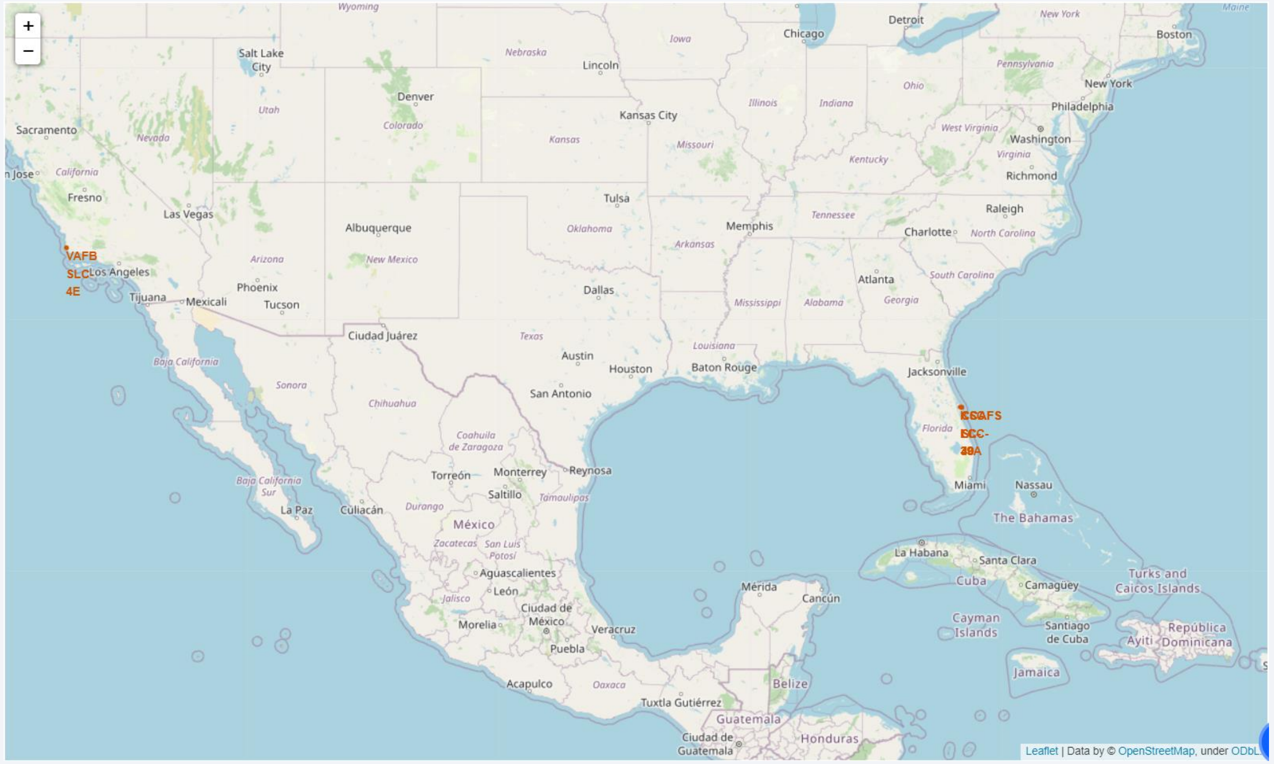
landing__outcome	COUNT
No attempt	20
Failure (drone ship)	10
Success (drone ship)	10
Controlled (ocean)	6
Success (ground pad)	6
Failure (parachute)	4
Uncontrolled (ocean)	4
Precluded (drone ship)	2

Section 4

Launch Sites Proximities Analysis

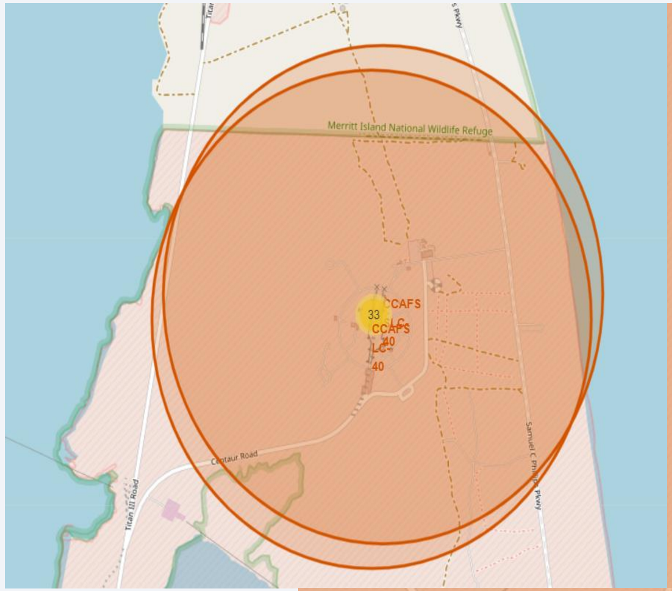
Interactive Map

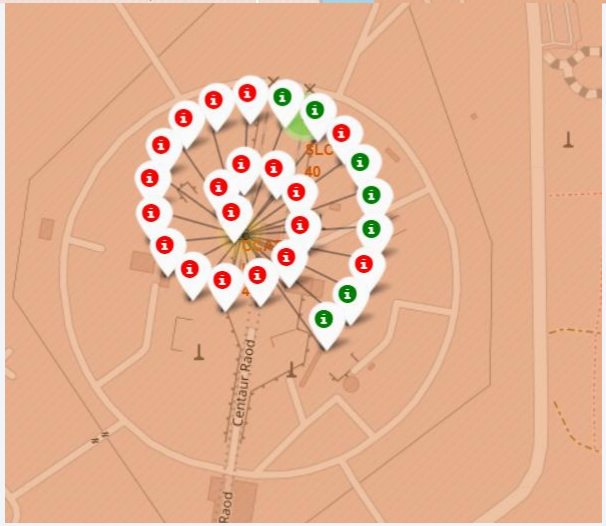
This is a screenshot of the Folim map showing the different sites across the US



Interactive Markers

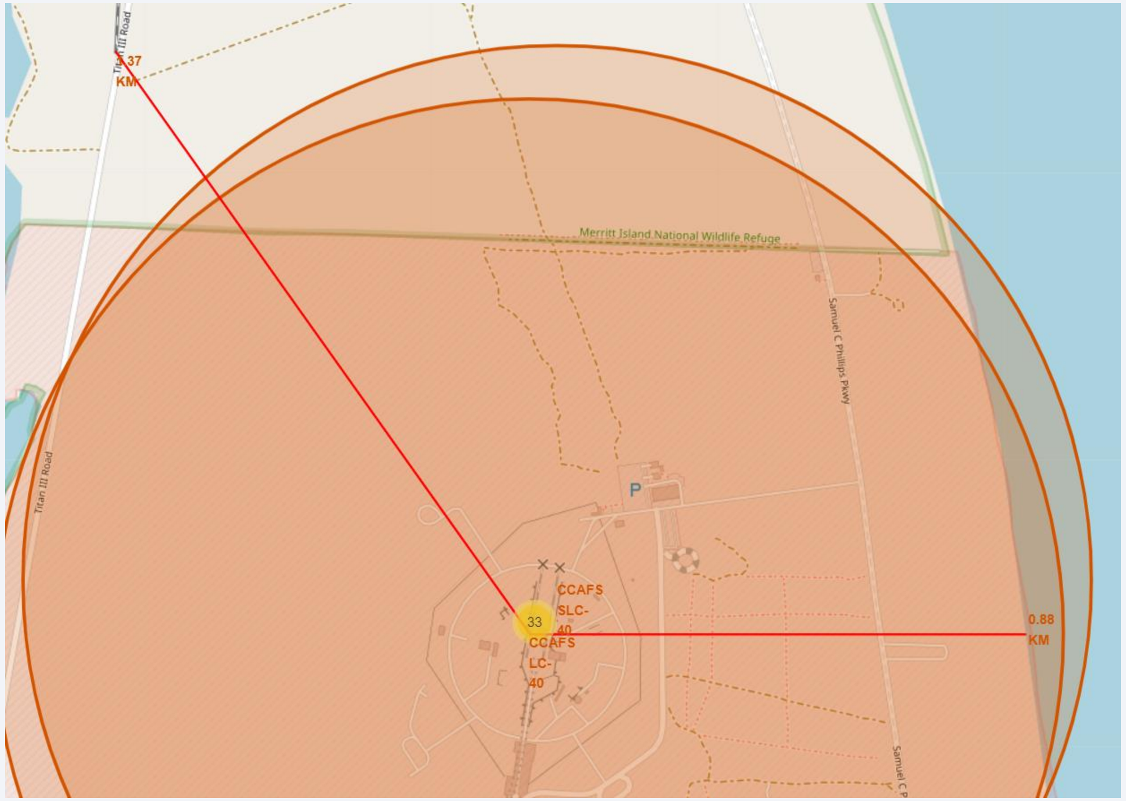
- The screenshots show the added Circle markers as well as the MarkerCluster which show the number of launches carried out at a site and if clicked it shows the outcome of the the individual launches.





Surounding Site Elements

- Screenshot showing distances from the CCAFS LC-40 to the coastline (0.88 km) to the east and a railway (1.37 km) to the northwest.



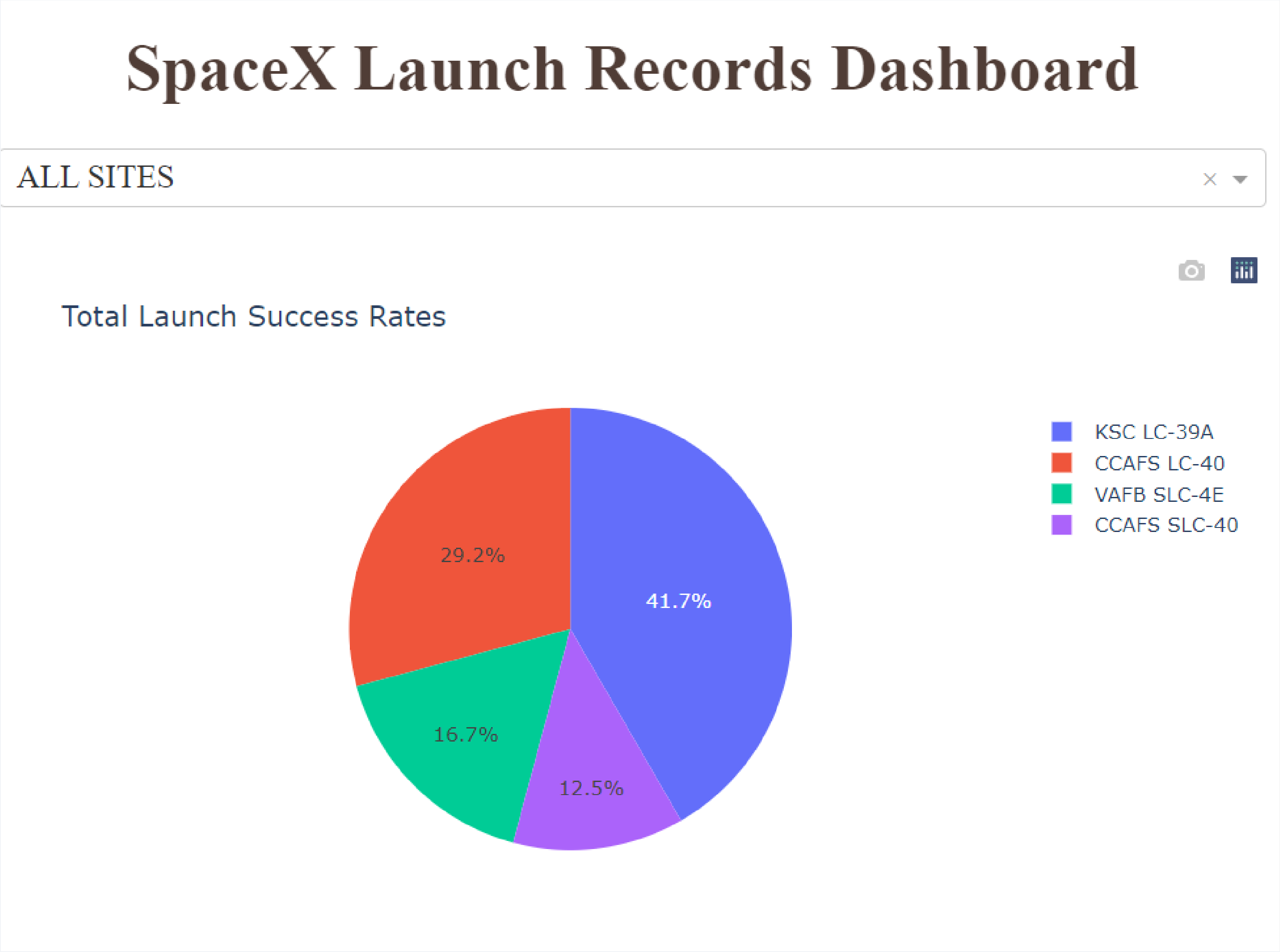
Section 5

Build a Dashboard with Plotly Dash

Total Success Rate

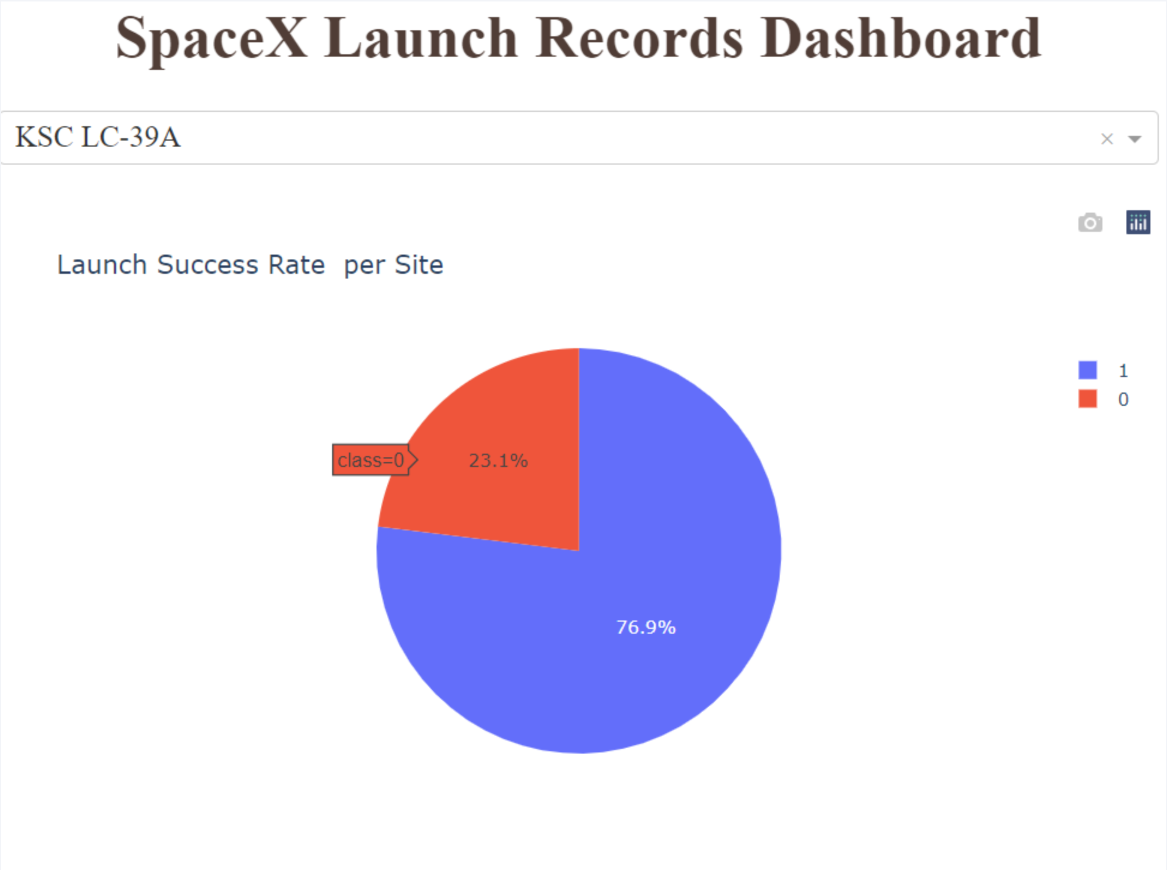
This is a screen shot of the interactive dashboard.

- The piechart shows the success rate for all sites while the color key separates the different sites.

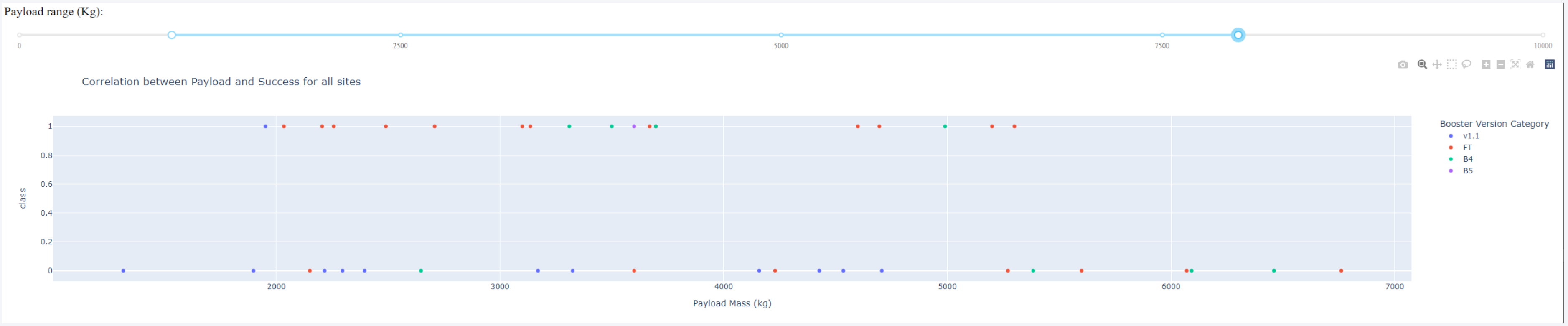


Success Rate per Site

Dashboard showing individual success rate for site KSC LC-39A which is the one with the highest success rate with 76.9%



Payload vs Success rate correlation



This screenshot shows how there is a higer frequency for success landings at low payload values vs high payload values.

Section 6

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

Confusion Matrix

- Show the confusion matrix of the best performing model with an explanation

Conclusions

- Point 1
- Point 2
- Point 3
- Point 4
- …

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!