Reaching Mars with data science

Bayarbat Bayarsaikhan

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Outline

1. Executive summary
2. Introduction
3. Methodology
4. Results
5. Conclusion

Executive summary

Summary of results

- Interactive map and dashboards
- Predictive result using machine learning
- Exploratory Data Analysis

Summary of methodologies

- Web scraping & API
- EDA with visualization and SQL
- Interactive map with Folium
- Dashboard with Plotly
- Predictive analysis

2: Introduction

The aim of this project is to predict if launch of Falcon 9 rocket of SpaceX will have successful land. For that we will need answers for:

- What is main variables of successful launch?
- What conditions will allow the best launch for SpaceX?

3: Methodology

3.1: Data section

3.2: Data wrangling

3.3: Exploratory Data Analysis

3.4: Interactive visual analytics

3.5: Predictive analysis

3.1 Data section

Data sets are extracted from SpaceX API and web scraping from Wikipedia.

- The information obtained by the web scrapping of Wikipedia are launches, landing, payload information.
  - URL is: https://en.wikipedia.org/w/index.php?title=List_of_Falcon_9_and_Falcon_Heavy_launches&oldid=1027686922
- The information obtained by the API are rocket, launches, payload information.
  - The SpaceX API URL is api.spacexdata.com/v4/

3.2 Data wrangling

Outcomes are indicated by many different variables in the dataset. For example. True Ocean, true RTLS, and true ASDS all means the mission has been successful while false Ocean, false RTLS, and false ASDS all means the mission was a failure. We can simplify it by assigning 0 to failure and 1 to succesful

```
landing_outcomes = df['Outcome'].value_counts()
landing_outcomes
```

```
True ASDS      41
None None      19
True RTLS      14
False ASDS      6
True Ocean      5
None ASDS       2
False Ocean     2
False RTLS      1
Name: Outcome, dtype: int64
```

```
for i,outcome in enumerate(landing_outcomes.keys()):
    print(i,outcome)
```

```
0 True ASDS
1 None None
2 True RTLS
3 False ASDS
4 True Ocean
5 None ASDS
6 False Ocean
7 False RTLS
```

We create a set of outcomes where the second stage did not land successfully:

```
bad_outcomes=set(landing_outcomes.keys()[[1,3,5,6,7]])
bad_outcomes
```

```
{'False ASDS', 'False Ocean', 'False RTLS', 'None ASDS', 'None None'}
```

```
# landing_class = 0 if bad_outcome
# landing_class = 1 otherwise
landing_class = []
for key,value in df["Outcome"].items():
    if value in bad_outcomes:
        landing_class.append(0)
    else:
        landing_class.append(1)
```

3.3 EDA with graphs

1. **Scatter plots:**
   - Flight Number vs. Payload Mass
   - Flight Number vs. Launch Site
   - Payload vs. Launch Site
   - Orbit vs. Flight Number
   - Payload vs. Orbit Type
2. **Bar Graph:**
   - Success rate vs. Orbit
3. **Line Graph:**
   - Success rate vs. Year

3.3 EDA with SQL

We performed SQL queries to gather and understand data from dataset:

- Displaying 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.
- 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.

3.4 Interactive visual analytics with Folium maps

Folium map object is a map centered on NASA Johnson Space Center at Houston, Texas:

- Red circle at NASA Johnson Space Center's coordinate with label showing its name (folium.Circle, folium.map.Marker).
- Red circles at each launch site coordinates with label showing launch site name (folium.Circle, folium.map.Marker, folium.features.DivIcon).
- The grouping of points in a cluster to display multiple and different information for the same coordinates (folium.plugins.MarkerCluster).
- Markers to show successful and unsuccessful landings. Green for successful landing and Red for unsuccessful landing. (folium.map.Marker, folium.Icon).
- Markers to show distance between launch site to key locations (railway, highway, coastway, city) and plot a line between them. (folium.map.Marker, folium.PolyLine, folium.features.DivIcon)

3.4 Interactive visual analytics with Plotly dashboard

Dashboard has dropdown, pie chart, rangeslider and scatter plot components:

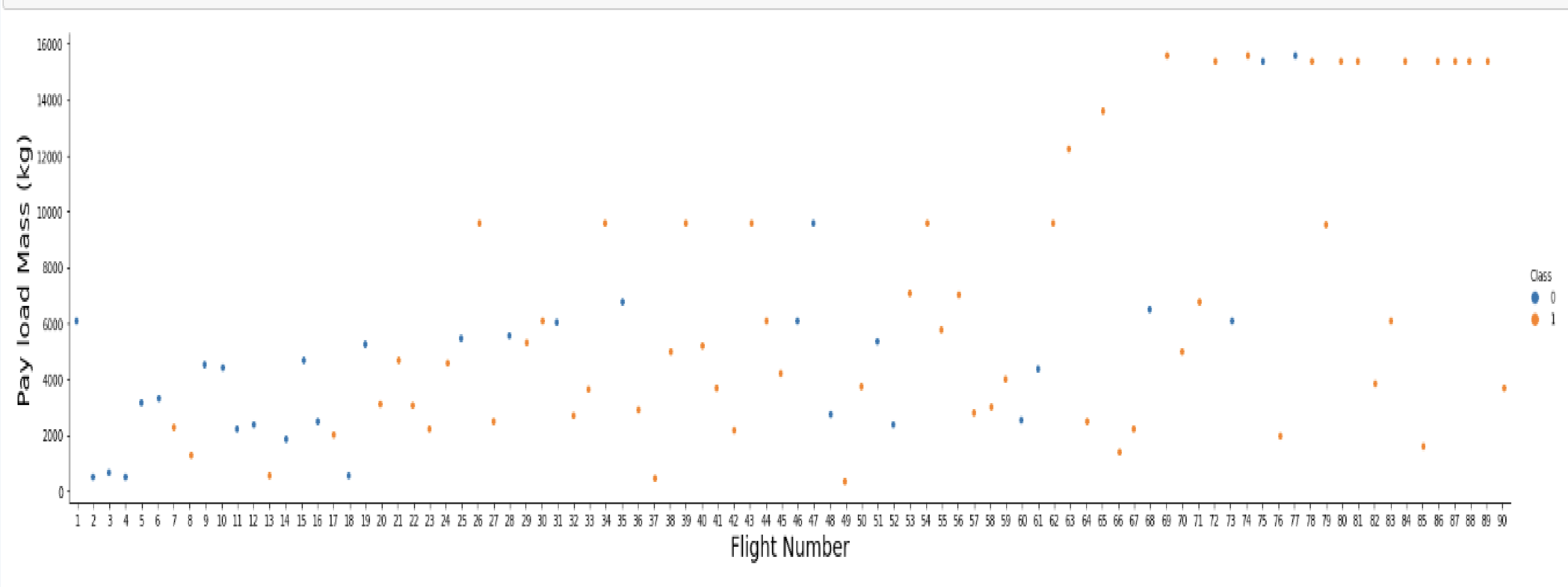
- Dropdown allows a user to choose the launch site or all launch sites (dash_core_components.Dropdown).
- Pie chart shows the total success and the total failure for the launch site chosen with the dropdown component (plotly.express.pie).
- Rangeslider allows a user to select a payload mass in a fixed range (dash_core_components.RangeSlider).
- Scatter chart shows the relationship between two variables, in particular Success vs Payload Mass (plotly.express.scatter).

3.5 Predictive analysis

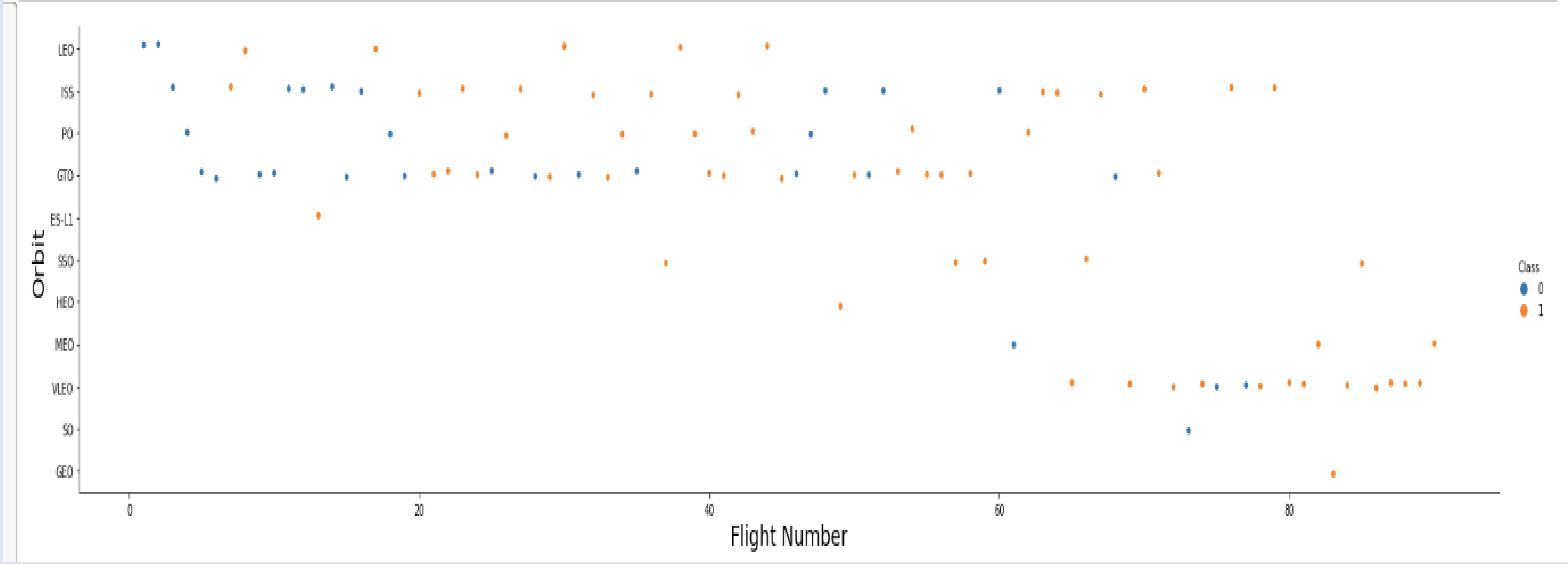
For predictive analysis we first split data into training and test sets. After models are trained we test the accuracy using the test sets and choose the best one.

4: Results

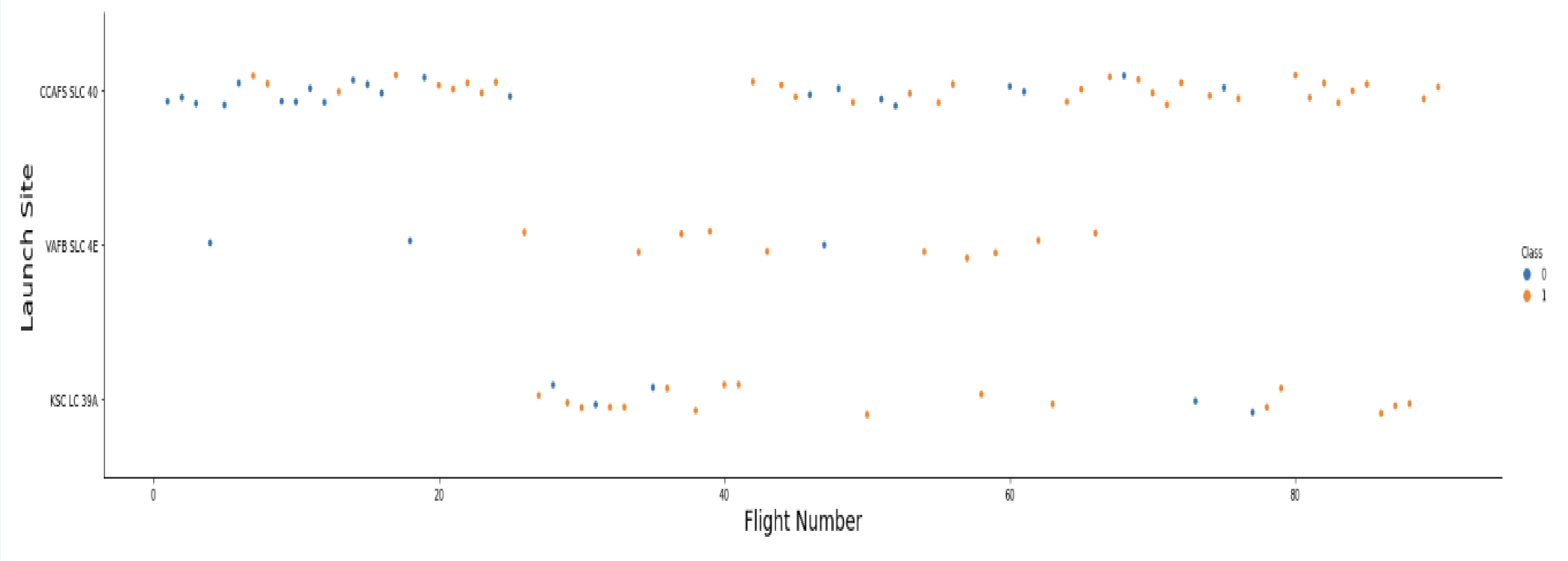
Payload mass vs Flight number



Orbit vs Flight number



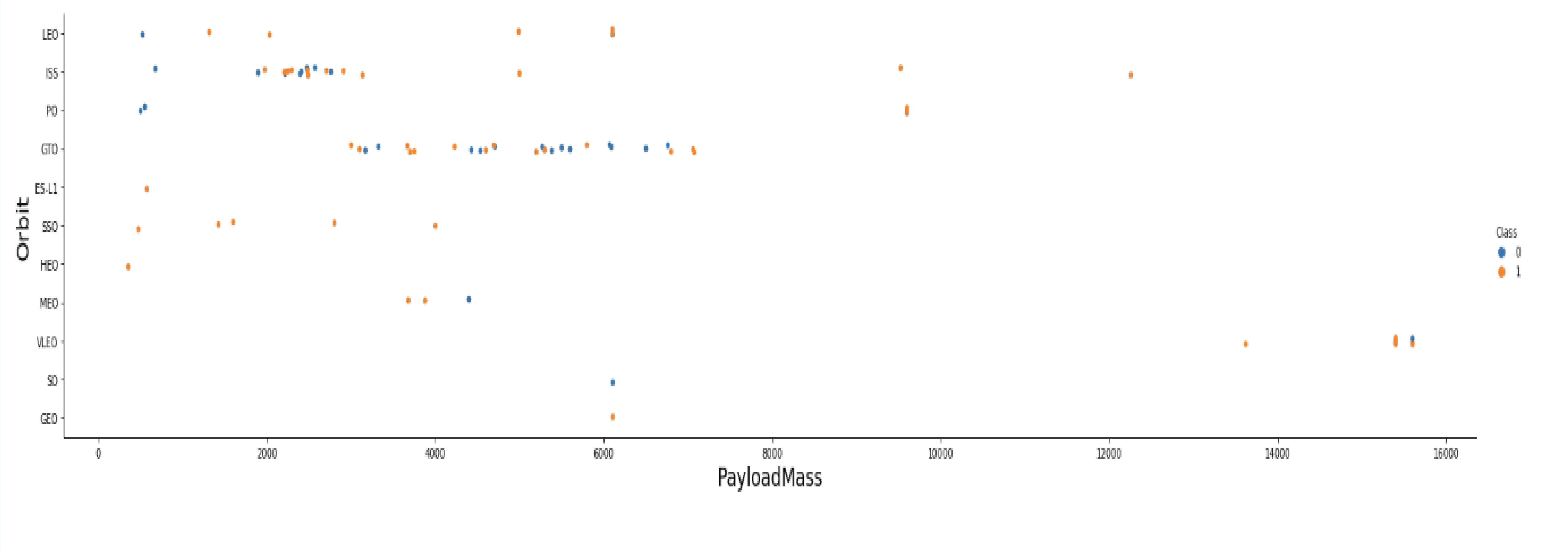
Launch site vs Flight number



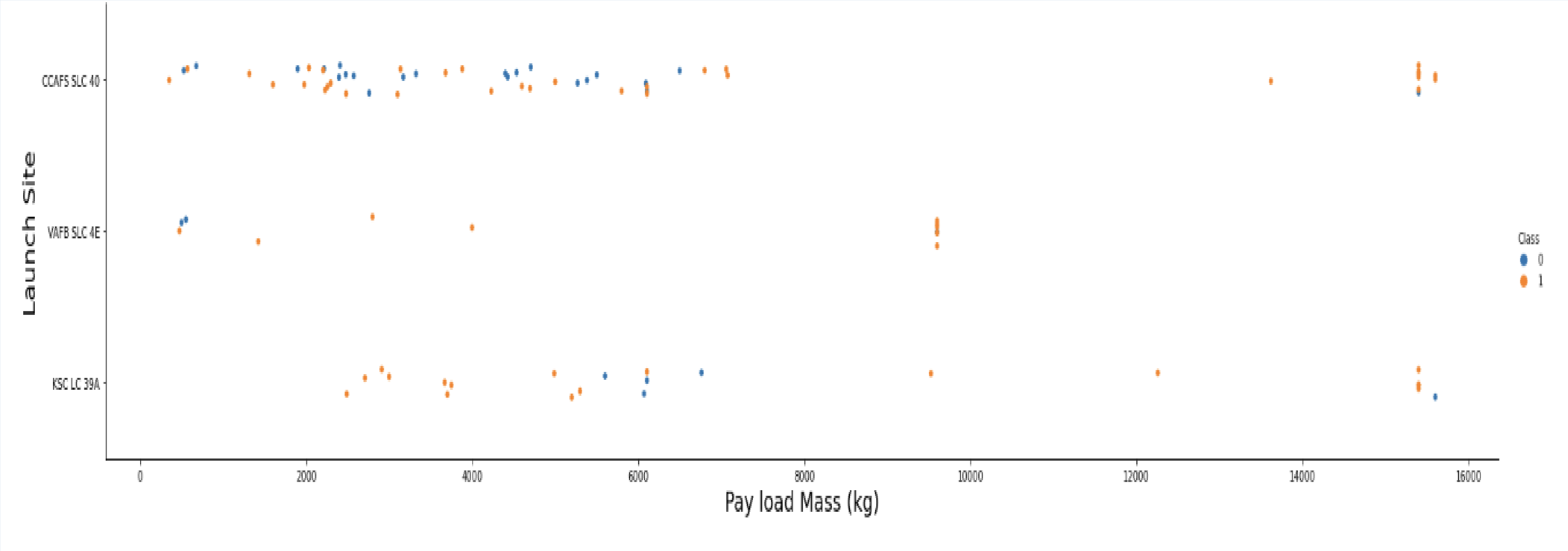
Insight drawn from the graphs:

- As we expected success rate is going up for pay load masses, orbits, and launch sites as SpaceX gets more experience.

Orbit vs Payload mass



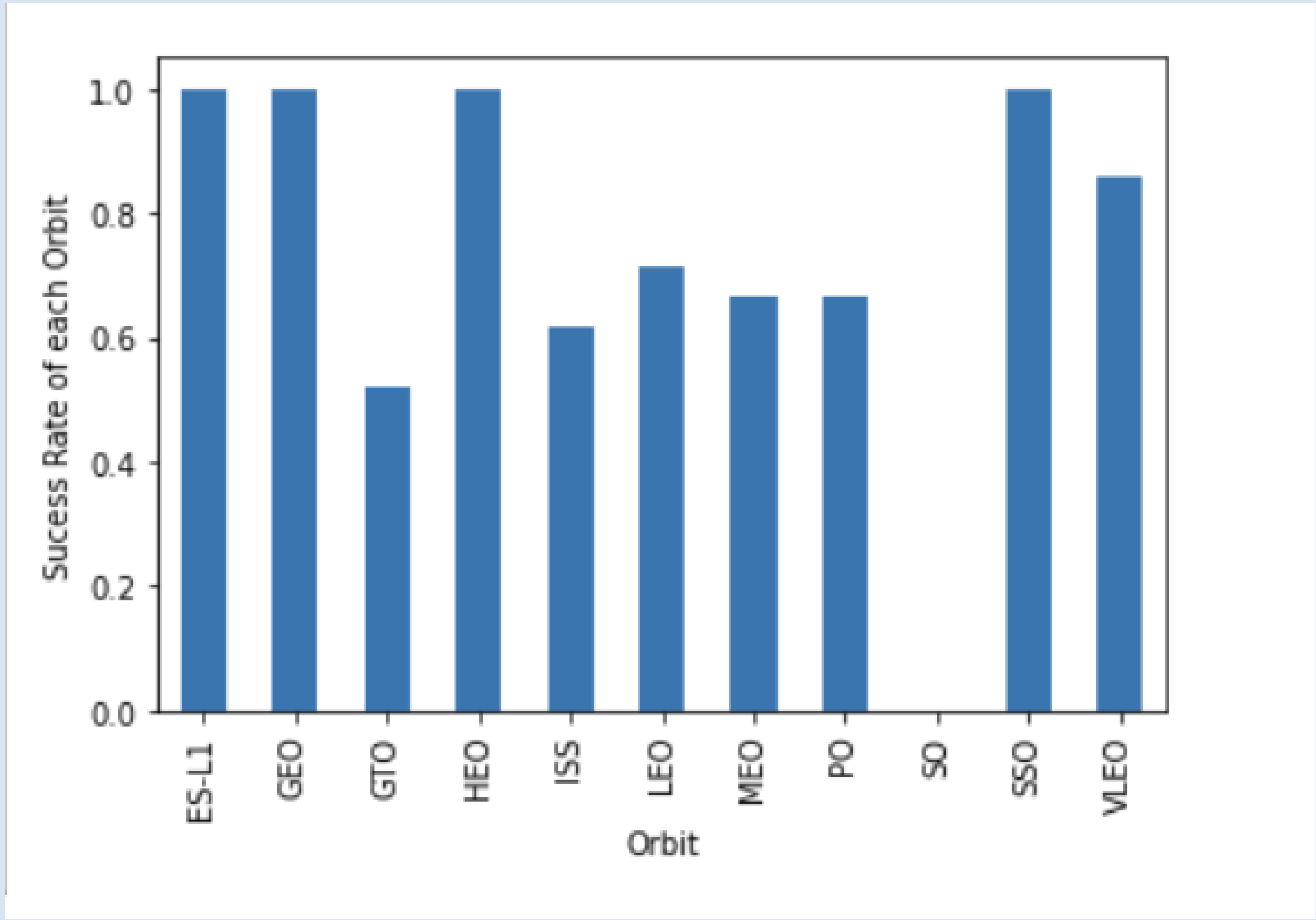
Launch site vs Payload mass



Insight drawn from the graphs:

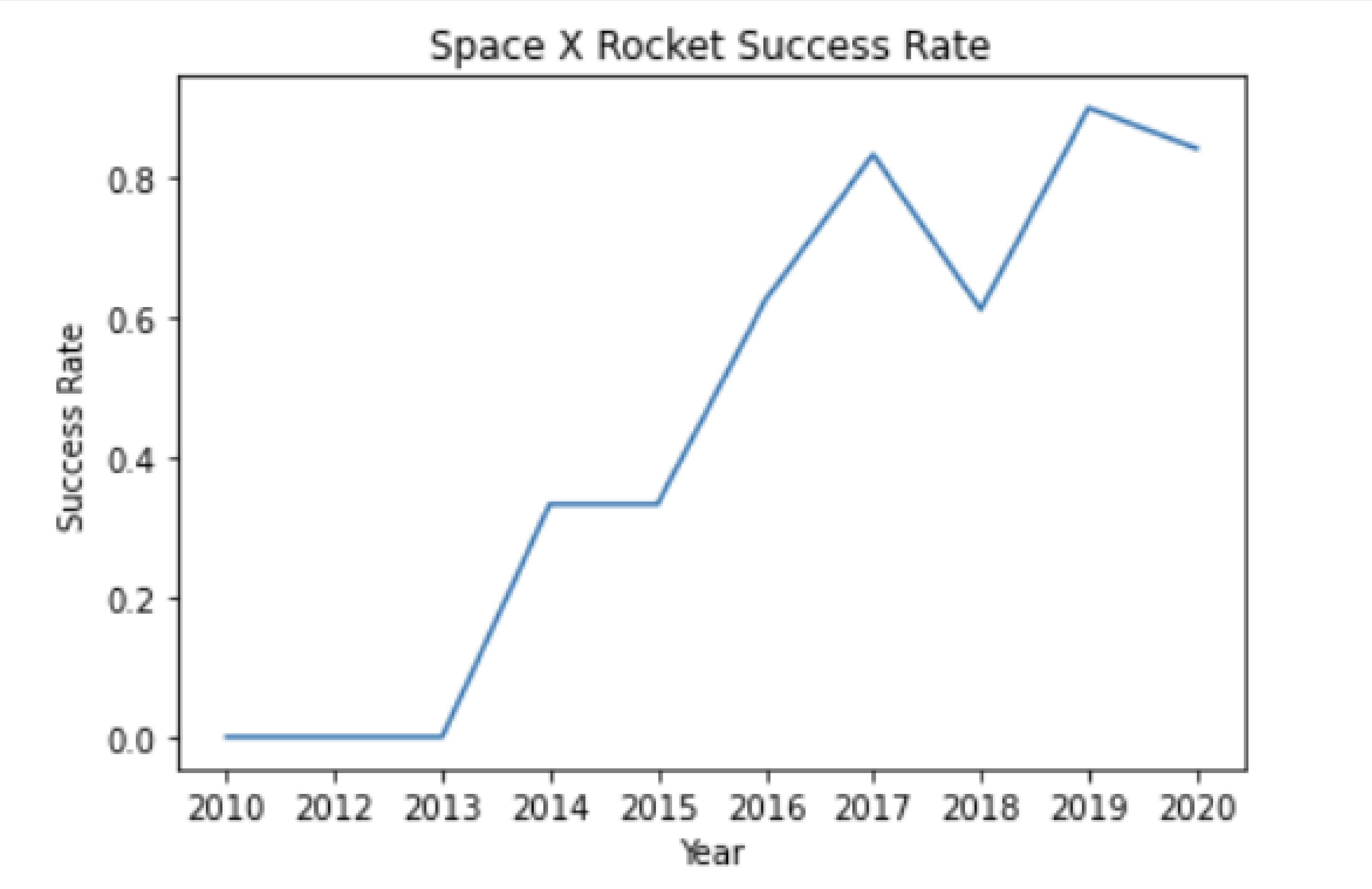
- Surprisingly heavier payload masses seem to improve the success rate of the launch in certain orbits and launch sites. For example VAFB and CCAFS launch sites show better success rate when weight of cargo is heavier.

Success rate vs Orbit



With this plot, we can see success rate for different orbit types. We note that ES-L1, GEO, HEO, SSO have the best success rate.

Success rate vs Year



As we observed before as the time goes SpaceX is getting more successful at landing the rockets

EDA with SQL

Name of launch sites:

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

```
%sql SELECT DISTINCT "LAUNCH_SITE" FROM SPACEXTBL
```

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

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

EDA with SQL

First 5 launches made from CCA site

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

EDA with SQL

Total payload mass carried by NASA boosters

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

```
%sql SELECT SUM("PAYLOAD_MASS__KG_") FROM SPACEXTBL WHERE "CUSTOMER" = 'NASA (CRS)'
```

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

SUM("PAYLOAD_MASS__KG_")
45596

EDA with SQL

Average payload mass carried by F9 booster

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

```
%sql SELECT AVG("PAYLOAD_MASS__KG_") FROM SPACEXTBL WHERE "BOOSTER_VERSION" LIKE '%F9 v1.1%'
```

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

AVG("PAYLOAD_MASS__KG_")
2534.6666666666665

EDA with SQL

First successful launch made with ground pad

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

Hint:Use min function

```
%sql SELECT MIN("DATE") FROM SPACEXTBL WHERE "Landing _Outcome" LIKE '%Success%'
```

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

MIN("DATE")
01-05-2017

EDA with SQL

List of boosters name that made successful landing with payload mass between 4000kg to 6000kg

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 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

EDA with SQL

Number of successful and failure missions

List the total number of successful and failure mission outcomes

```
%sql SELECT (SELECT COUNT("MISSION_OUTCOME") FROM SPACEXTBL WHERE "MISSION_OUTCOME" LIKE '%Success%') AS SUCCESS, \
(SELECT COUNT("MISSION_OUTCOME") FROM SPACEXTBL WHERE "MISSION_OUTCOME" LIKE '%Failure%') AS FAILURE
```

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

SUCCESS	FAILURE
100	1

EDA with SQL

Name of boosters which carried the maximum payload mass

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

```
%sql SELECT DISTINCT "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

EDA with SQL

List of months, booster versions, and launch sites that failed to land in 2015

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 substr("DATE", 4, 2) AS MONTH, "BOOSTER_VERSION", "LAUNCH_SITE" FROM SPACEXTBL\
WHERE "LANDING _OUTCOME" = 'Failure (drone ship)' and substr("DATE",7,4) = '2015'
```

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

MONTH	Booster_Version	Launch_Site
01	F9 v1.1 B1012	CCAFS LC-40
04	F9 v1.1 B1015	CCAFS LC-40

EDA with SQL

Rank of successful landing outcomes made in 2010 to 2017

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") FROM SPACEXTBL\
WHERE "DATE" >= '04-06-2010' and "DATE" <= '20-03-2017' and "LANDING _OUTCOME" LIKE '%Success%'\
GROUP BY "LANDING _OUTCOME" \
ORDER BY COUNT("LANDING _OUTCOME") DESC ;
```

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

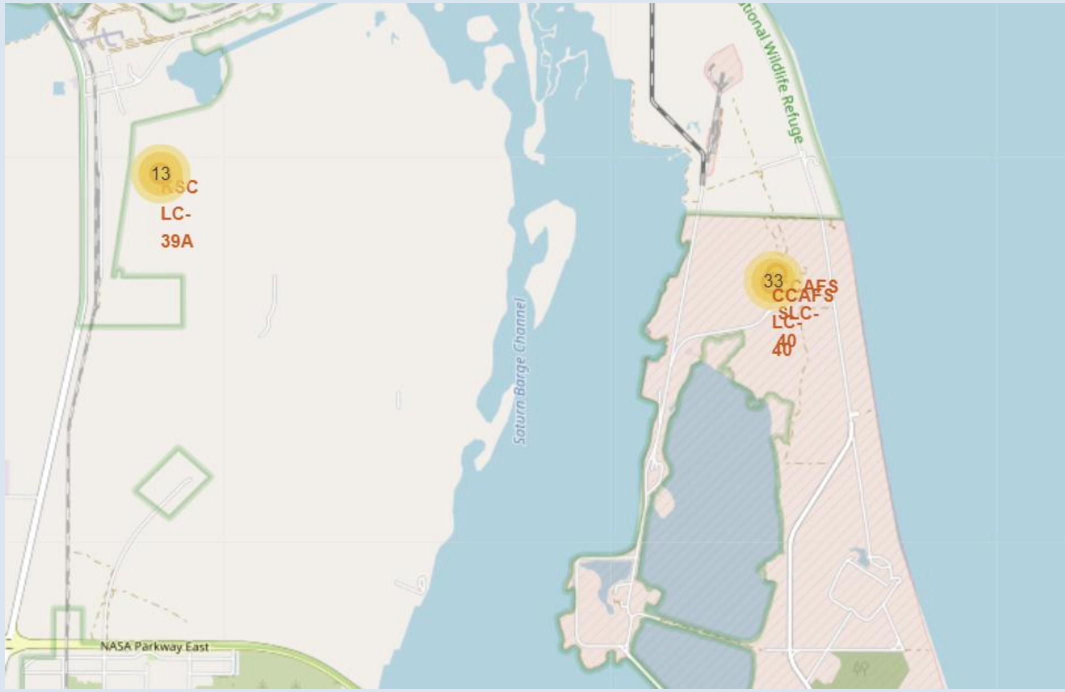
Landing _Outcome	COUNT("LANDING _OUTCOME")
Success	20
Success (drone ship)	8
Success (ground pad)	6

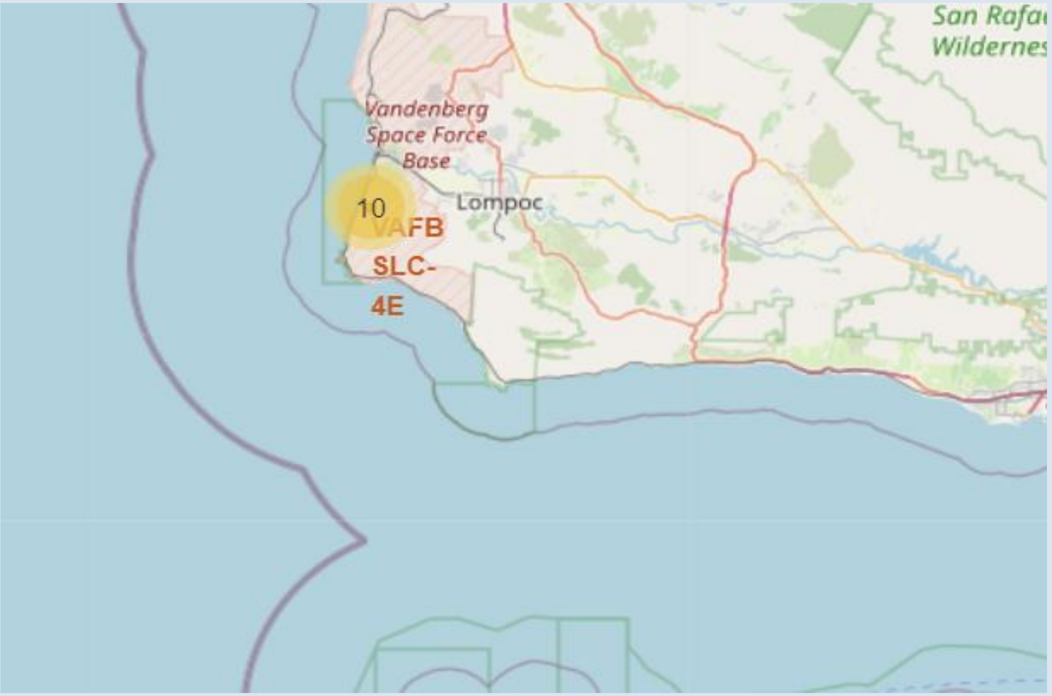
Interactive Folium maps

Launch site locations:

Interactive Folium maps

Launch numbers for each site:



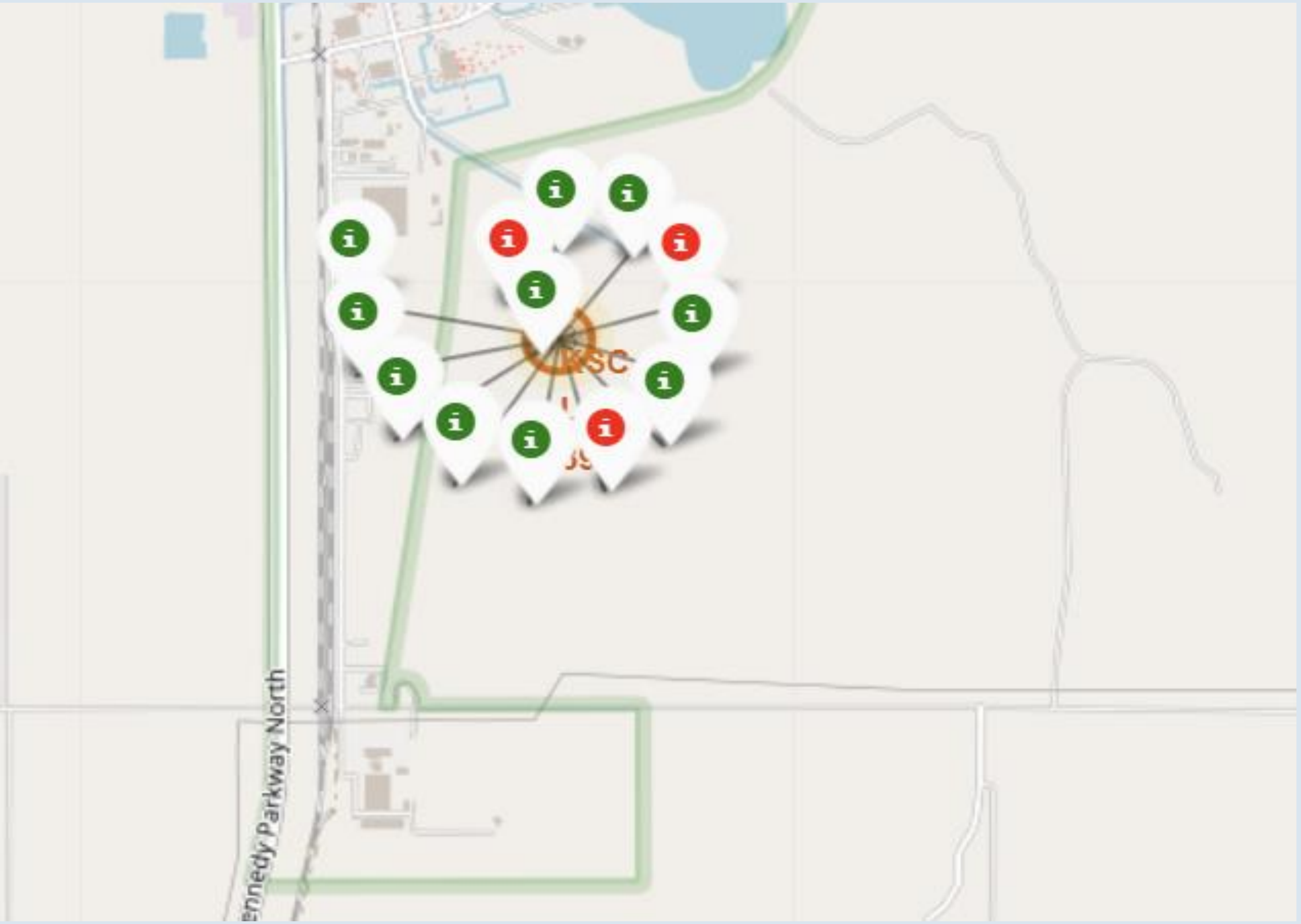


Interactive Folium maps

Successful and failure launch positions made from VAFB site:

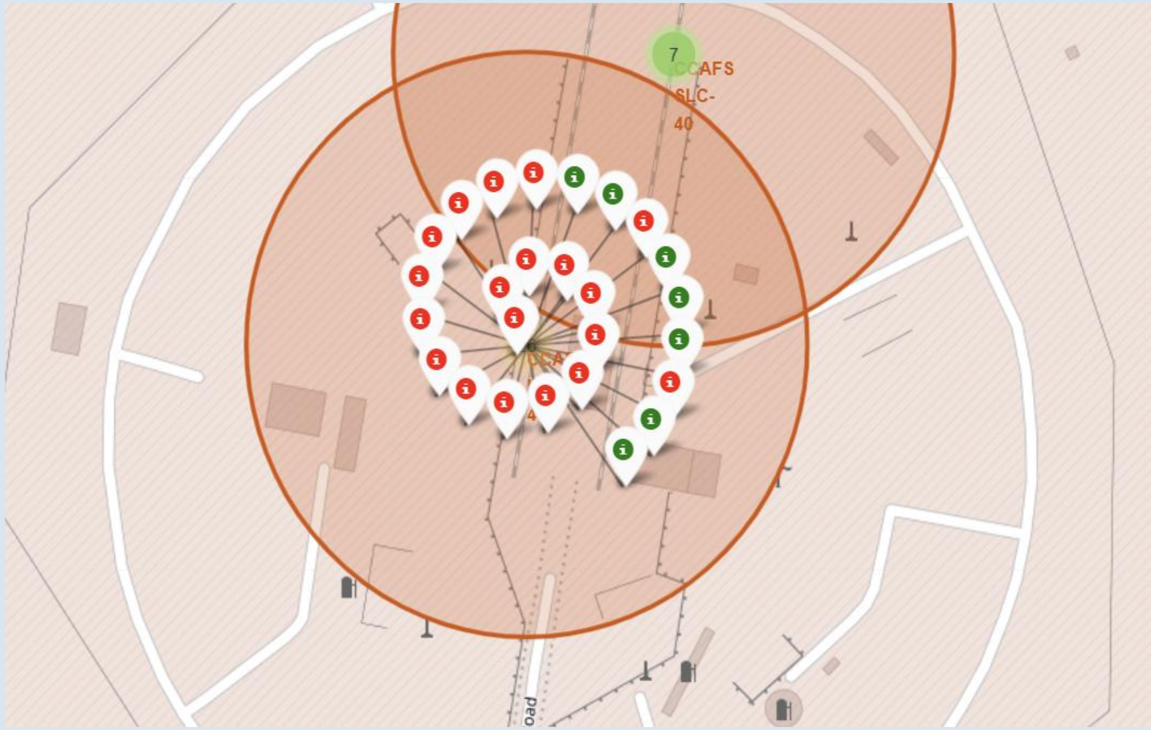
Interactive Folium maps

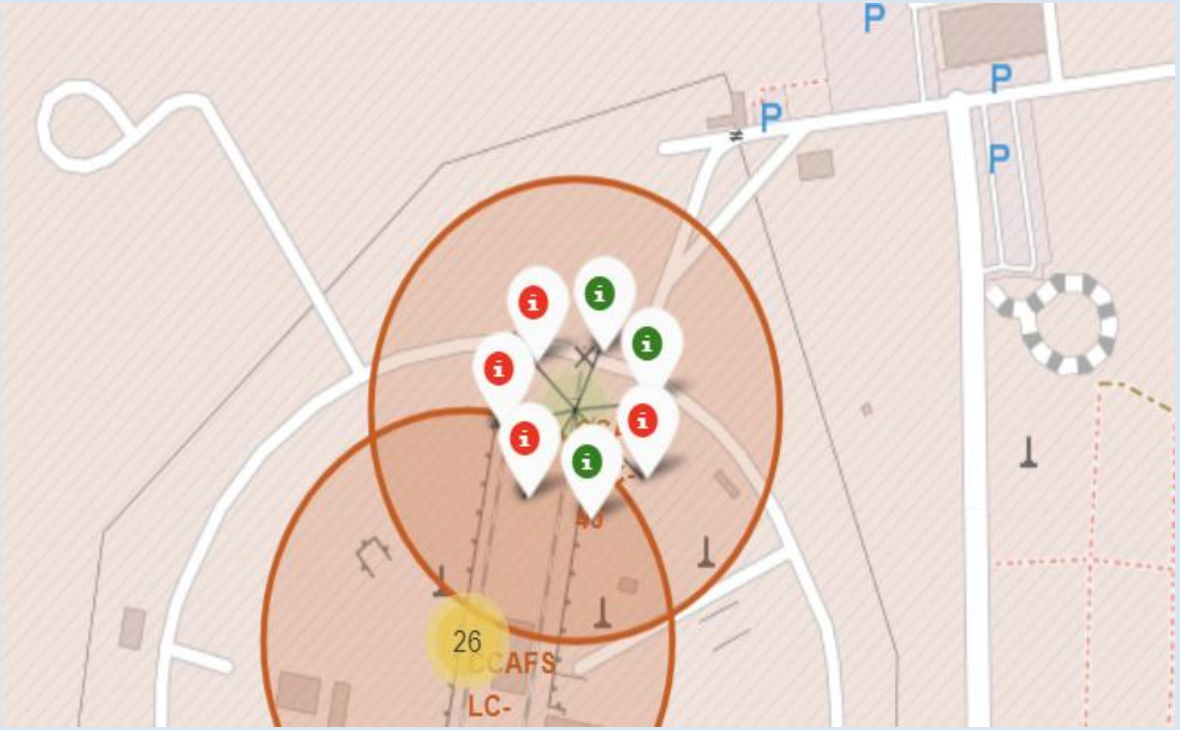
Successful and failure launch positions made from KSC site:



Interactive Folium maps

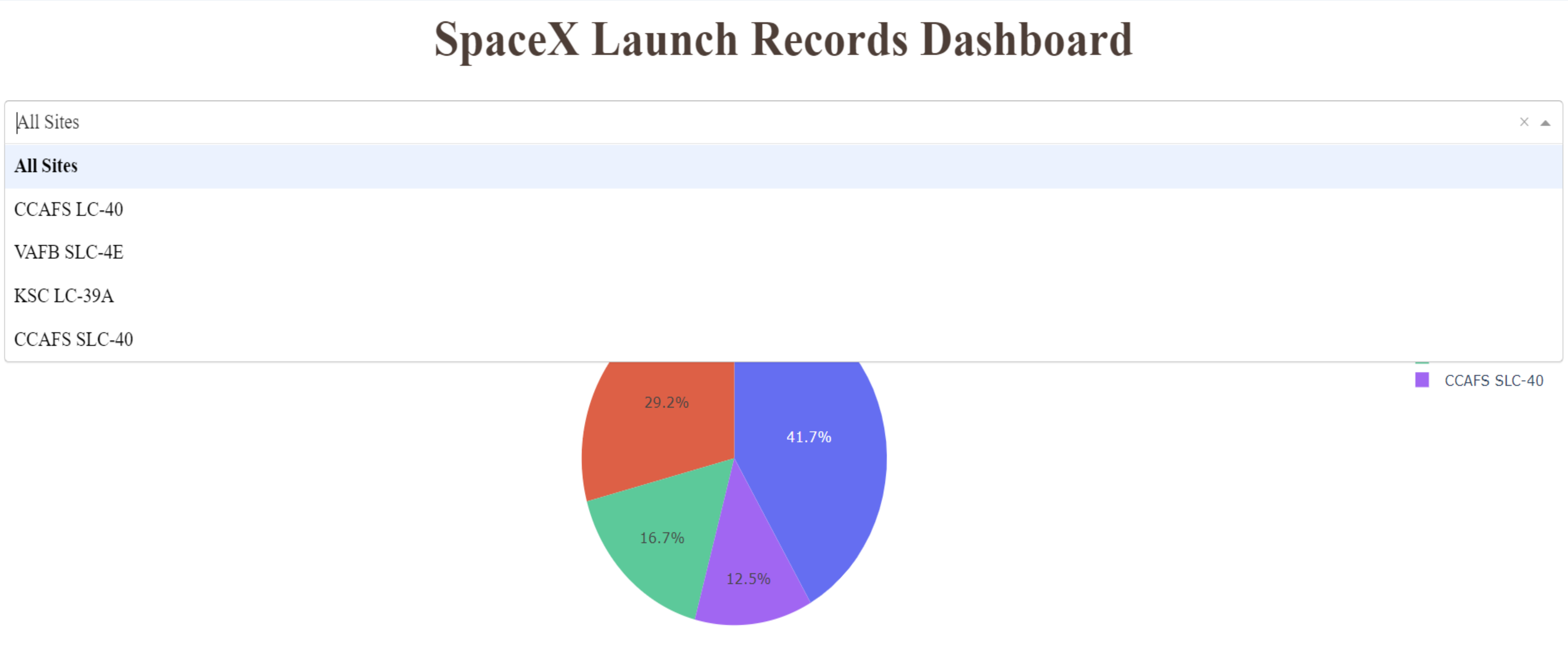
Successful and failure launch positions made from CCAF site:





Interactive dashboard made by Plotly

Dashboard drop menu for launch sites



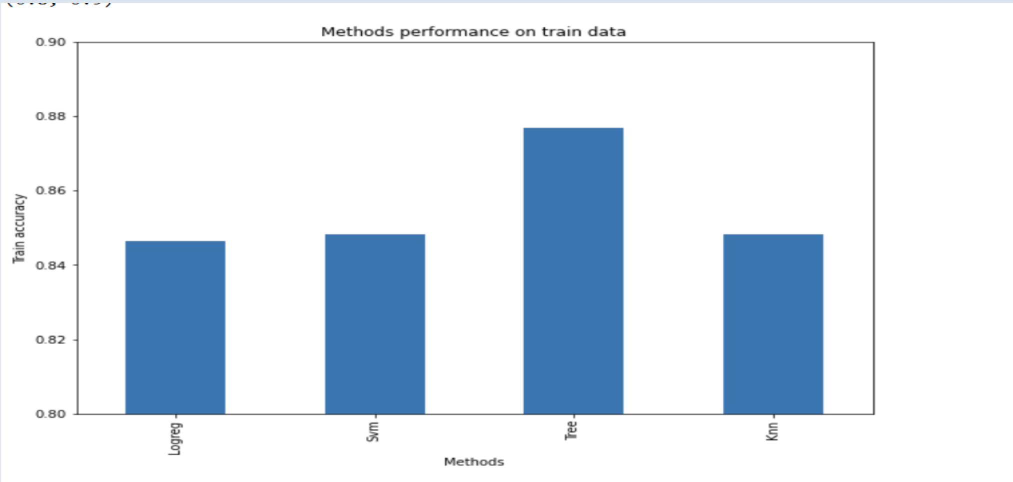
Interactive dashboard made by Plotly

Payload mass range and responding graph

Predictive analysis

We trained the data with log regression, support vector machine (SVM), K-nearest neighbors (Knn), and tree decision classifications. Then accuracy tested 4 models with test data sets:

	Accuracy Train	Accuracy Test
Tree	0.876786	0.833333
Knn	0.848214	0.833333
Svm	0.848214	0.833333
Logreg	0.846429	0.833333



Since the data is not big enough 4 models accuracy tests are not that different from each other but we can see that tree classification has the best accuracy train so we will use it.

5: Conclusion

- The success of a mission can be explained by several factors such as the launch site, the orbit and especially the number of previous launches. Indeed, we can assume that there has been a gain in knowledge between launches that allowed to go from a launch failure to a success. •
- The orbits with the best success rates are GEO, HEO, SSO, ES-L1.
- Depending on the orbits, the payload mass can be a criterion to take into account for the success of a mission. Some orbits require a light or heavy payload mass. But generally heavy weighted payloads perform better than the low weighted payloads.
- With the current data, we cannot explain why some launch sites are better than others (KSC LC-39A is the best launch site). To get an answer to this problem, we could obtain atmospheric or other relevant data.
- • For this dataset, we choose the Decision Tree Algorithm as the best model even if the test accuracy between all the models used is identical. We choose Decision Tree Algorithm because it has a better train accuracy

Thank you

Bayarbat Bayarsaikhan

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