Winning Space Race with Data Science

TD

15/04/2022

Outline

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

Executive Summary

- Summary of methodologies
  - Data Collection with Web Scraping and API intergration
  - Data Wrangling
  - Exploratory Analysis Using SQL and Data Visualization
  - Interactive Visual Analytics and Dashboard using Ploty and Dash
  - Predictive Analysis – SVM, KNN, Decision tree, Logistic Regression
- Summary of all results
  - Different launch sites have different success rate. CCAFS LC-40, has a success rate of 60 %, while KSC LC-39A and VAFB SLC 4E has a success rate of 77%.
  - there are no rockets launched for heavypayload mass (10~k kg) in VAFB-SLC launch site
  - All model using different methods presents similar accuracy. Succuss rate increased over time and remain steady in recent years

Introduction

- Project background
  - Space Y (the new company) that would like to compete with SpaceX founded by Billionaire industrialist Allon Musk. Your job is to determine the price of each launch. You will do this by gathering information about Space X and creating dashboards for your team. You will also determine if SpaceX will reuse the first stage. Instead of using rocket science to determine if the first stage will land successfully, you will train a machine learning model and use public information to predict if SpaceX will reuse the first stage.
- Problems you want to find answers
  - What determines a successful landing?
  - What are the factors?

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - Request to the SpaceX API
- Perform data wrangling
  - Exploratory Data analysis applied to gain insight of data set
  - Training Labels assigned and categorical data encoded with one-hot
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - How to build, tune, evaluate classification models

Data Collection

- Describe how data sets were collected.
  - Use HTTP REQUESTS to access SpaceX API and get a json file
  - Covert retrieved json file to dataframe use json_normalize().
  - Filter NaN and missing value.
  - Scrap additional information from Wikipedia about Falcon-9 historical launches. This was done with beautiful soup library.
  - Tables were parsed and converted into a readable pandas dataframe.

Data Collection – SpaceX API

- Data download through SpaceX API and assigned to a dataframe for easy manipulation
- https://github.com/td121/Applied-Data-Science-Capstone/blob/main/jupyter-labs-spacex-data-collection-api.ipynb

Now let's start requesting rocket launch data from SpaceX API with the following URL:

```
spacex_url="https://api.spacexdata.com/v4/launches/past"
```

```
response = requests.get(spacex_url)
```

Now we decode the response content as a Json using `.json()` and turn it into a Pandas dataframe using `.json_normalize()`

In [11]:
```
# Use json_normalize meethod to convert the json result into a dataframe
data = pd.json_normalize(response.json())
```

Using the dataframe `data` print the first 5 rows

In [12]:
```
# Get the head of the dataframe
data.head()
```

Out[12]:

	static_fire_date_utc	static_fire_date_unix	net	window	rocket	success	failures	details	crew	ships	capsules
0	2006-03-17T00:00:00.000Z	1.142554e+09	False	0.0	5e9d0d95eda69955f709d1eb	False	[{'time': 33, 'altitude': None, 'reason': 'merlin engine failure'}]	Engine failure at 33 seconds and loss of vehicle	[]	[]	[]
1	None	NaN	False	0.0	5e9d0d95eda69955f709d1eb	False	[{'time': 301, 'altitude': 289, 'reason': 'harmonic oscillation leading to premature	Successful first stage burn and transition to second stage, maximum altitude 289 km, Premature engine shutdown at T+7 min	[]	[]	[]

Data Collection - Scraping

- https://github.com/td121/Applied-Data-Science-Capstone/blob/main/jupyter-labs-webscraping.ipynb

To keep the lab tasks consistent, you will be asked to scrape the data from a snapshot of the `List of Falcon 9 and Falcon Heavy launches` Wikipage updated on `9th June 2021`

```
static_url = "https://en.wikipedia.org/w/index.php?title=List_of_Falcon_9_and_Falcon_Heavy_launches&oldid=1027686922"
```

Next, request the HTML page from the above URL and get a `response` object

TASK 1: Request the Falcon9 Launch Wiki page from its URL

First, let's perform an HTTP GET method to request the Falcon9 Launch HTML page, as an HTTP response.

```
# use requests.get() method with the provided static_url
# assign the response to a object
data  = requests.get(static_url).text
```

Create a `BeautifulSoup` object from the HTML `response`

```
# Use BeautifulSoup() to create a BeautifulSoup object from a response text content

soup = BeautifulSoup(data,"html.parser")
```

After you have fill in the parsed launch record values into `launch_dict`, you can create a dataframe from it.

```
df=pd.DataFrame(launch_dict)
df
```

[15]:

	Flight No.	Launch site	Payload	Payload mass	Orbit	Customer	Launch outcome	Version Booster	Booster landing	Date	Time
0	1	CCAFS	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success\n	F9 v1.0B0003.1	Failure	4 June 2010	18:45
1	2	CCAFS	Dragon	0	LEO	NASA (COTS)\nNRO	Success	F9 v1.0B0004.1	Failure	8 December 2010	15:43
2	3	CCAFS	Dragon	525 kg	LEO	NASA (COTS)	Success	F9 v1.0B0005.1	No attempt\n	22 May 2012	07:44
3	4	CCAFS	SpaceX CRS-1	4,700 kg	LEO	NASA (CRS)	Success\n	F9 v1.0B0006.1	No attempt	8 October 2012	00:35
4	5	CCAFS	SpaceX CRS-2	4,877 kg	LEO	NASA (CRS)	Success\n	F9 v1.0B0007.1	No attempt\n	1 March 2013	15:10
...	...	...	...	...	...	...	...	...	...	...	...
116	117	CCSFS	Starlink	15,600 kg	LEO	SpaceX	Success\n	F9 B5B1051.10	Success	9 May 2021	06:42
117	118	KSC	Starlink	~14,000 kg	LEO	SpaceX Capella Space and Tyvak	Success\n	F9 B5B1058.8	Success	15 May 2021	22:56
118	119	CCSFS	Starlink	15,600 kg	LEO	SpaceX	Success\n	F9 B5B1063.2	Success	26 May 2021	18:59
119	120	KSC	SpaceX CRS-22	3,328 kg	LEO	NASA (CRS)	Success\n	F9 B5B1067.1	Success	3 June 2021	17:29
120	121	CCSFS	SXM-8	7,000 kg	GTO	Sirius XM	Success\n	F9 B5	Success	6 June 2021	04:26

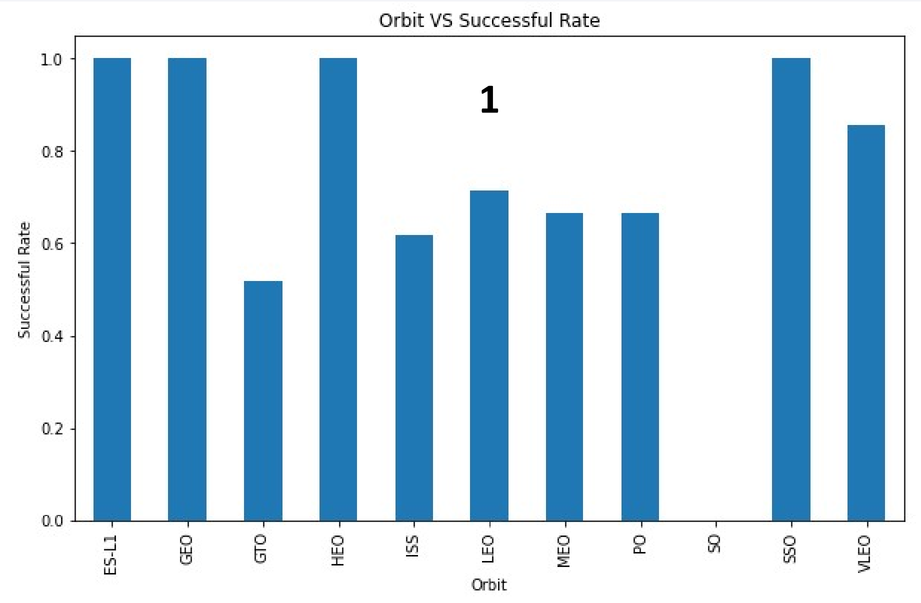
Data Wrangling

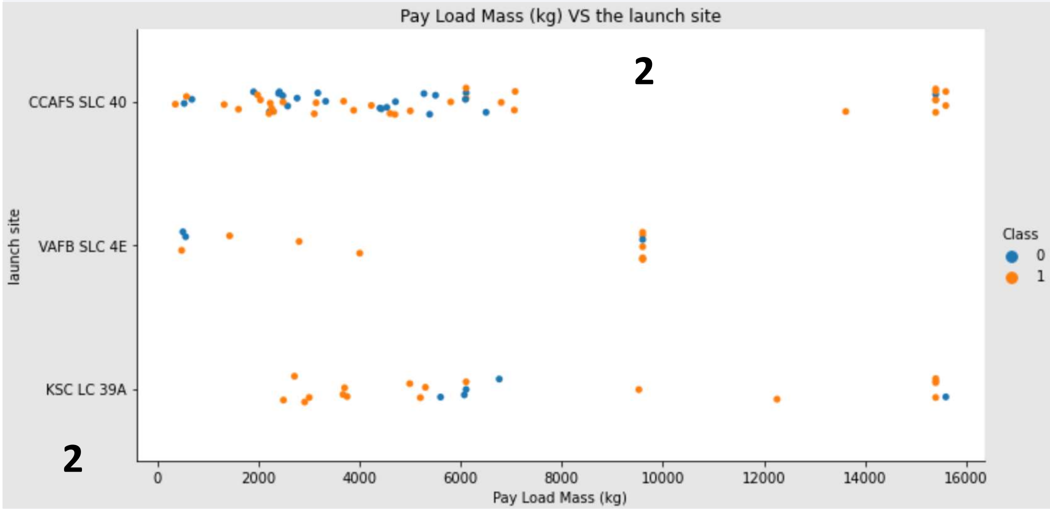
- Exploratory Data Analysis and Determine Training Labels
- We calculate and update the table:
    - 1. the number of launches on each site
    - 2. occurrence of each orbit
    - 3. number of mission outcome
    - 4. Add new landing outcome label

https://github.com/td121/Applied-Data-Science-Capstone/blob/main/labs-jupyter-spacex-Data%20wrangling.ipynb

EDA with Data Visualization

- Fig.1 : the relationship between success rate of each orbit type
- Fig.2 : the relationship between Payload and Launch Site
- https://github.com/td121/Applied-Data-Science-Capstone/blob/main/jupyter-labs-eda-dataviz.ipynb





EDA with SQL

- Load the SpaceX dataset into a PostgreSQL database.
- Apply EDA with SQL to get insight from the data. Following are considered:
  - Names of unique launch
  - Total payload mass carried by boosters launched by NASA (CRS)
  - Mean payload mass carried by booster version F9 v1.1
  - Total number of successful and failure mission outcomes
  - Total number of successful and failure mission outcomes

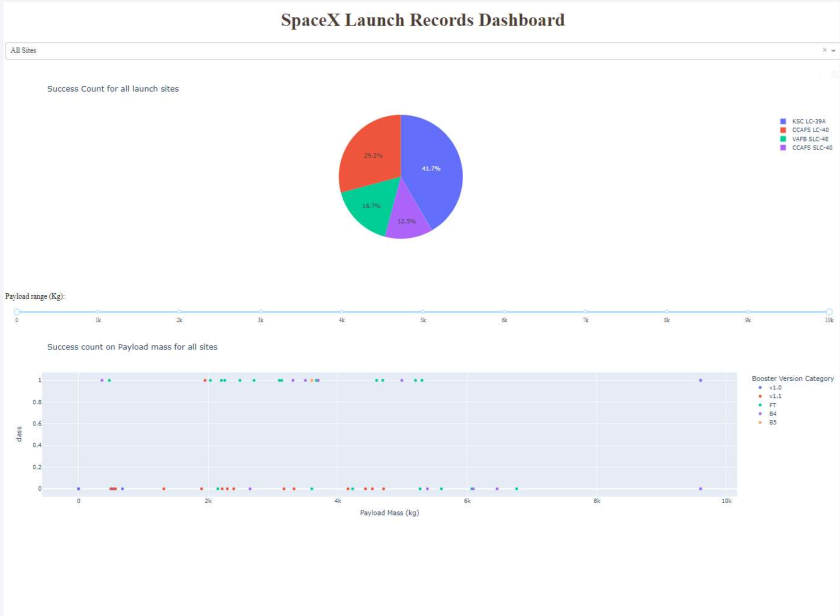
Build an Interactive Map with Folium

- Mark all launch sites on a map
- Mark the success and failed launches for each site on the map
- Distance between a launch site to its proximities

- https://github.com/td121/Applied-Data-Science-Capstone/blob/main/lab_jupyter_launch_site_location.ipynb

Build a Dashboard with Plotly Dash

- A dropdown list consist of a summarized item and each launch site
- A pie chart to show successful launches with respect to different sites
- A slider to adjust payload size
- Scatter plot show correlation between payload size and successful rate



https://github.com/td121/Applied-Data-Science-Capstone/blob/main/jupyter-plotly-dash.ipynb

Predictive Analysis (Classification)

- Find the method performs best using test data
  - To Numpy array conversion of successful rate
  - Data standardization and split training data
  - Method performed
    - Logistic regression
    - Support vector machines (SVMs)
    - Decision tree
    - k-nearest neighbours algorithm (KNNs)
- https://github.com/td121/Applied-Data-Science-Capstone/blob/main/SpaceX_Machine%20Learning%20Prediction_Part_5.ipynb

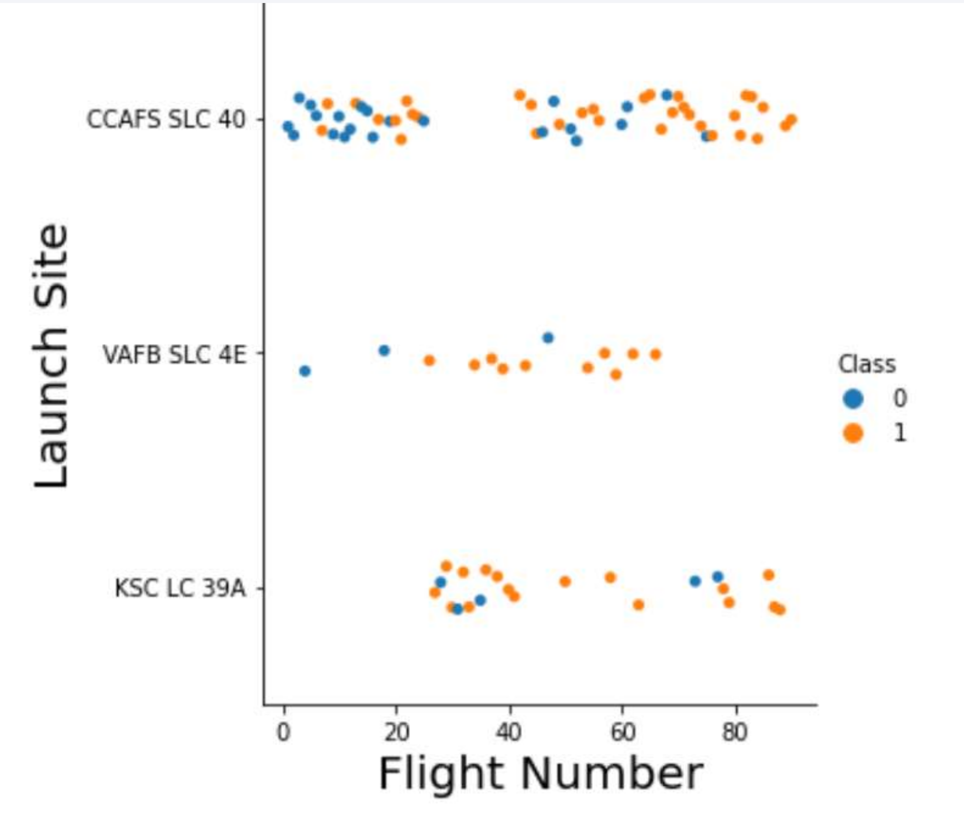
Results

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

Section 2

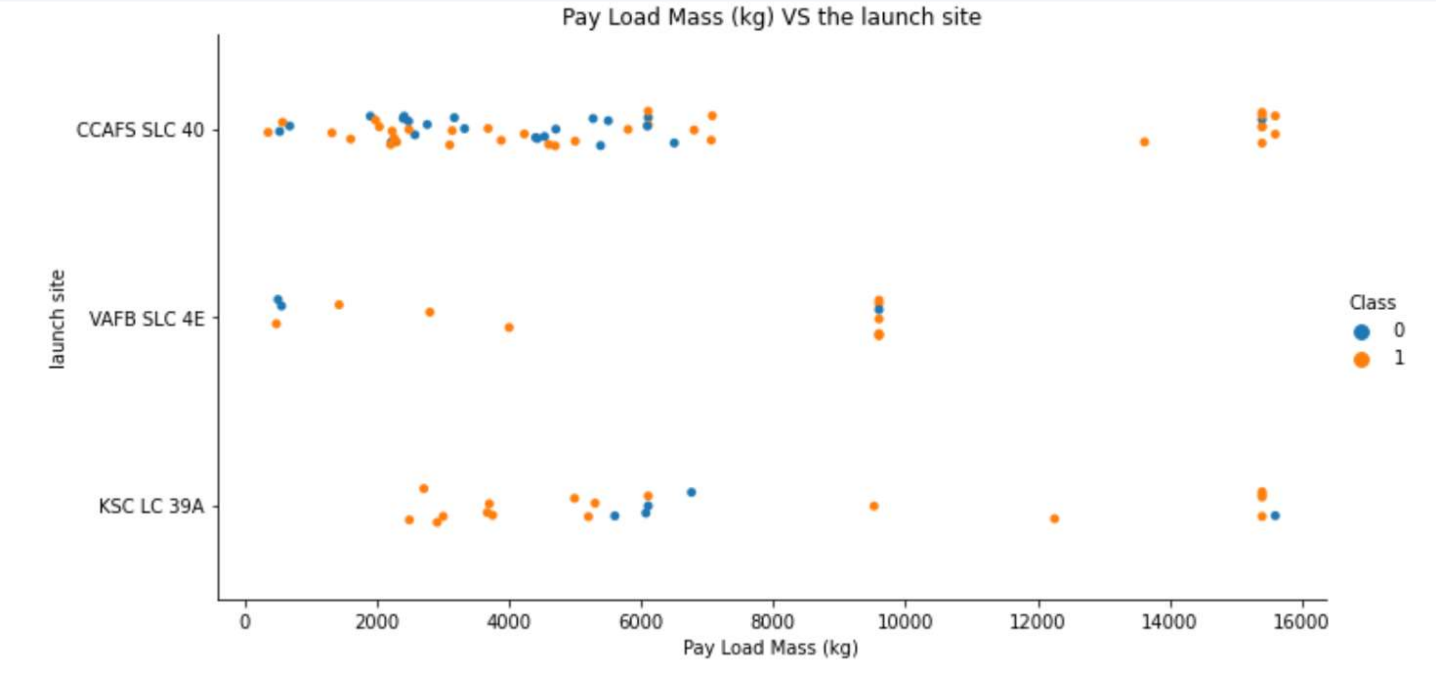
Insights drawn from EDA

Flight Number vs. Launch Site



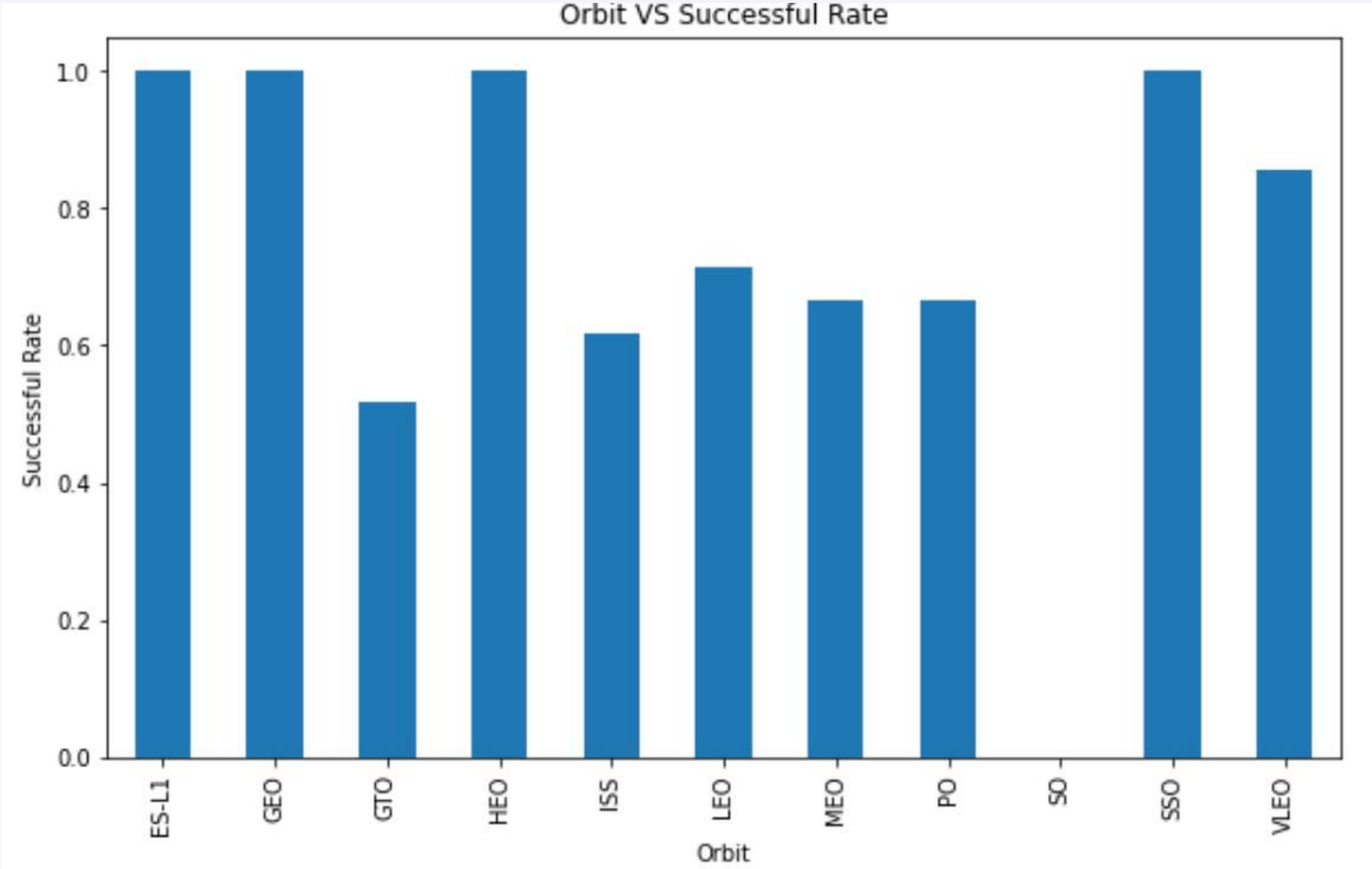
WE can see more launches taken place in VAFB SLC 4E are successful. CCAFS SLC 40 presents a diverse range of success/fail rate.

Payload vs. Launch Site

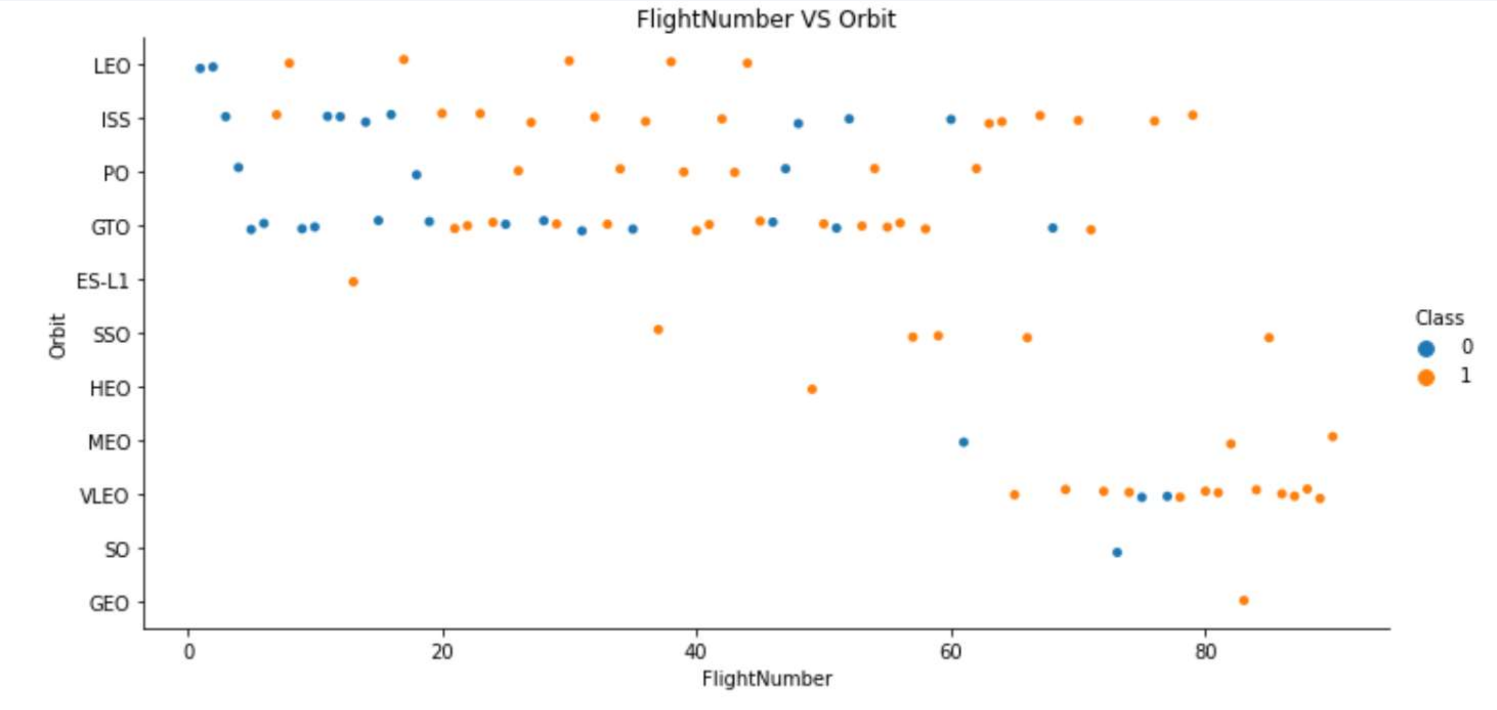


- Payload Vs. Launch Site scatter point chart show that the VAFB-SLC launch site there are no rockets launched for heavy payload mass(greater than 10000).

Success Rate vs. Orbit Type

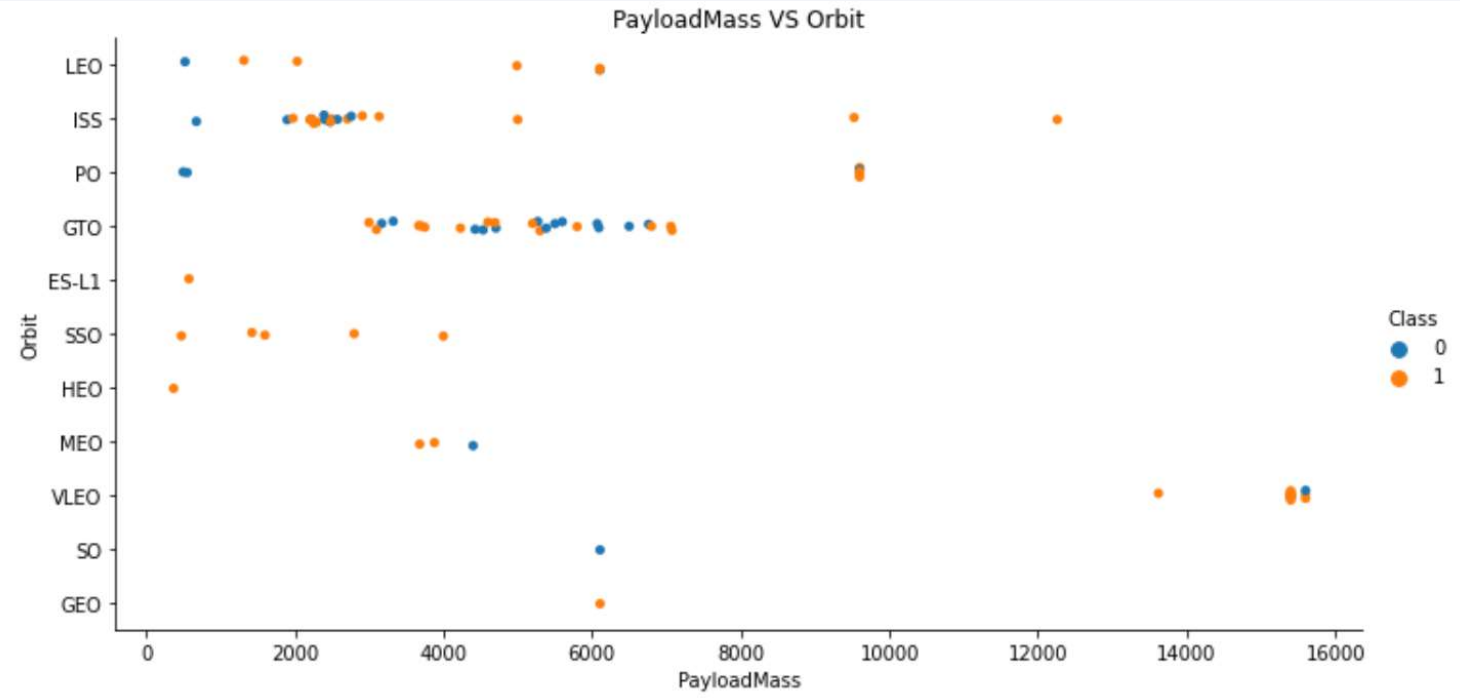


Flight Number vs. Orbit Type



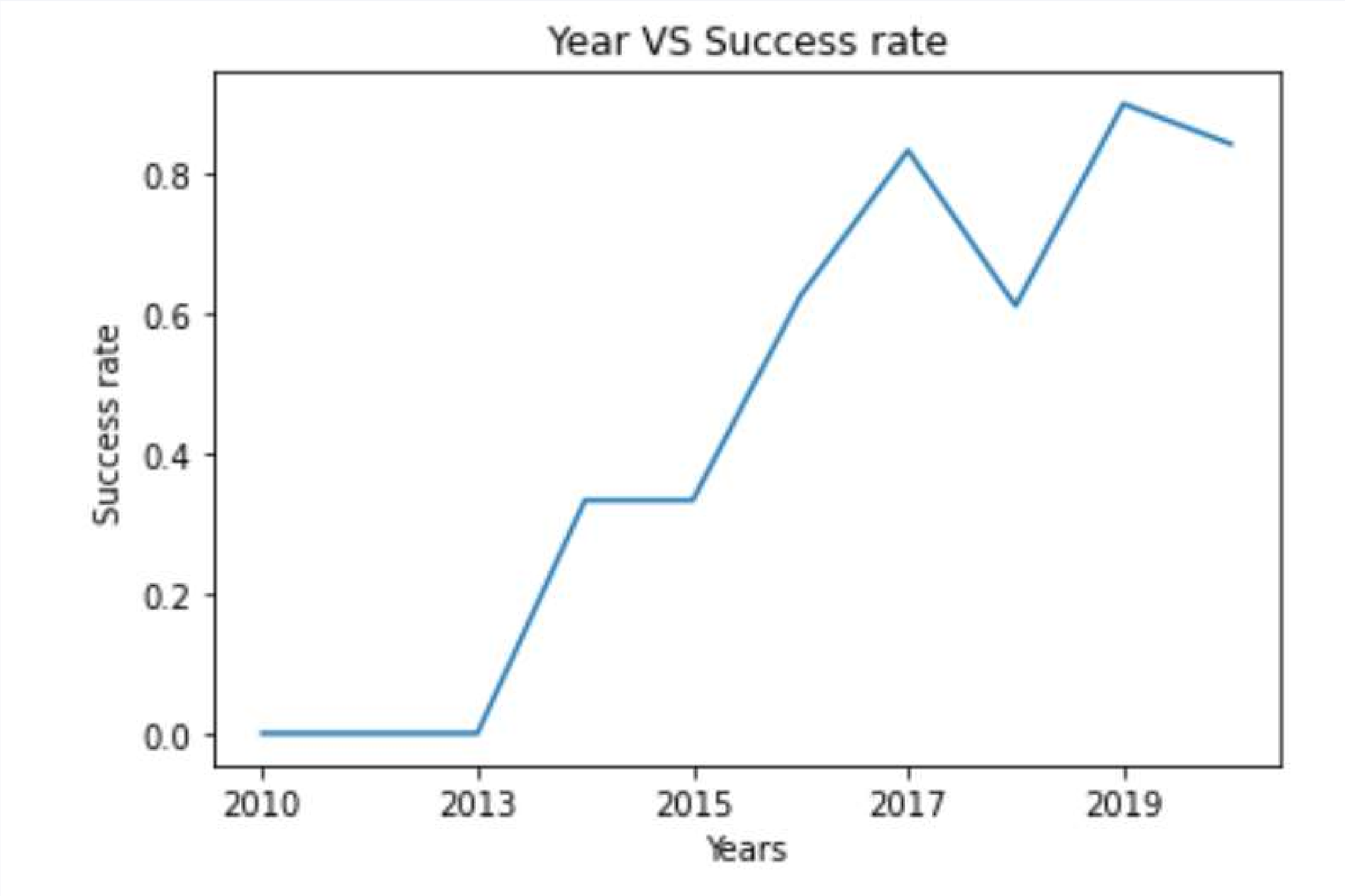
It can be seen that in the LEO orbit the Success appears related to the number of flights; on the other hand, there seems to be no relationship between flight number when in GTO orbit.

Payload vs. Orbit Type



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

Launch Success Yearly Trend



It is observe that the sucess rate since 2013 kept increasing till 2020

All Launch Site Names

```
# Select relevant sub-columns: `Launch Site`, `Lat(Latitude)`, `Long(Longitude)`, `class`
spacex_df = spacex_df[['Launch Site', 'Lat', 'Long', 'class']]
launch_sites_df = spacex_df.groupby(['Launch Site'], as_index=False).first()
launch_sites_df = launch_sites_df[['Launch Site', 'Lat', 'Long']]
launch_sites_df
```

	Launch Site	Lat	Long
0	CCAFS LC-40	28.562302	-80.577356
1	CCAFS SLC-40	28.563197	-80.576820
2	KSC LC-39A	28.573255	-80.646895
3	VAFB SLC-4E	34.632834	-120.610745

Launch Site Names Begin with 'CCA'

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

```
task_2 = '''
        SELECT *
        FROM SpaceX
        WHERE LaunchSite LIKE 'CCA%'
        LIMIT 5
        '''
create_pandas_df(task_2, database=conn)
```

	date	time	boosterversion	launchsite	payload	payloadmasskg	orbit	customer	missionoutcome	landingoutcome
0	2010-04-06	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
1	2010-08-12	15:43:00	F9 v1.0 B0004	CCAFS LC-40	Dragon demo flight C1, two CubeSats, barrel of...	0	LEO (ISS)	NASA (COTS) NRO	Success	Failure (parachute)
2	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
3	2012-08-10	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
4	2013-01-03	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)

```
task_3 = '''
        SELECT SUM(PayloadMassKG) AS Total_PayloadMass
        FROM SpaceX
        WHERE Customer LIKE 'NASA (CRS)'
        '''
create_pandas_df(task_3, database=conn)
```

	total_payloadmass
0	45596

Average Payload Mass by F9 v1.1

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

```
task_4 = '''
        SELECT AVG(PayloadMassKG) AS Avg_PayloadMass
        FROM SpaceX
        WHERE BoosterVersion = 'F9 v1.1'
        '''
create_pandas_df(task_4, database=conn)
```

	avg_payloadmass
0	2928.4

First Successful Ground Landing Date

```
task_5 = '''
        SELECT MIN(Date) AS FirstSuccessfull_landing_date
        FROM SpaceX
        WHERE LandingOutcome LIKE 'Success (ground pad)'
        '''
create_pandas_df(task_5, database=conn)
```

	firstsuccessfull_landing_date
0	2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

```
task_6 = '''
        SELECT BoosterVersion
        FROM SpaceX
        WHERE LandingOutcome = 'Success (drone ship)'
            AND PayloadMassKG > 4000
            AND PayloadMassKG < 6000
        '''
create_pandas_df(task_6, database=conn)
```

	boosterversion
0	F9 FT B1022
1	F9 FT B1026
2	F9 FT B1021.2
3	F9 FT B1031.2

Total Number of Successful and Failure Mission Outcomes

List the total number of successful and failure mission outcomes

```
task_7a = '''
        SELECT COUNT(MissionOutcome) AS SuccessOutcome
        FROM SpaceX
        WHERE MissionOutcome LIKE 'Success%'
        '''

task_7b = '''
        SELECT COUNT(MissionOutcome) AS FailureOutcome
        FROM SpaceX
        WHERE MissionOutcome LIKE 'Failure%'
        '''
print('The total number of successful mission outcome is:')
display(create_pandas_df(task_7a, database=conn))
print()
print('The total number of failed mission outcome is:')
create_pandas_df(task_7b, database=conn)
```

```
The total number of successful mission outcome is:
```

	successoutcome
0	100

```
The total number of failed mission outcome is:
```

	failureoutcome
0	1

Boosters Carried Maximum Payload

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

```
task_8 = '''
        SELECT BoosterVersion, PayloadMassKG
        FROM SpaceX
        WHERE PayloadMassKG = (
                                SELECT MAX(PayloadMassKG)
                                FROM SpaceX
                                )
        ORDER BY BoosterVersion
        '''
create_pandas_df(task_8, database=conn)
```

	boosterversion	payloadmasskg
0	F9 B5 B1048.4	15600
1	F9 B5 B1048.5	15600
2	F9 B5 B1049.4	15600
3	F9 B5 B1049.5	15600
4	F9 B5 B1049.7	15600
5	F9 B5 B1051.3	15600
6	F9 B5 B1051.4	15600
7	F9 B5 B1051.6	15600
8	F9 B5 B1056.4	15600
9	F9 B5 B1058.3	15600
10	F9 B5 B1060.2	15600
11	F9 B5 B1060.3	15600

2015 Launch Records

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

```
task_9 = '''
        SELECT BoosterVersion, LaunchSite, LandingOutcome
        FROM SpaceX
        WHERE LandingOutcome LIKE 'Failure (drone ship)'
            AND Date BETWEEN '2015-01-01' AND '2015-12-31'
        '''
create_pandas_df(task_9, database=conn)
```

	boosterversion	launchsite	landingoutcome
0	F9 v1.1 B1012	CCAFS LC-40	Failure (drone ship)
1	F9 v1.1 B1015	CCAFS LC-40	Failure (drone ship)

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))

```
task_10 = '''
        SELECT LandingOutcome, COUNT(LandingOutcome)
        FROM SpaceX
        WHERE DATE BETWEEN '2010-06-04' AND '2017-03-20'
        GROUP BY LandingOutcome
        ORDER BY COUNT(LandingOutcome) DESC
        '''
create_pandas_df(task_10, database=conn)
```

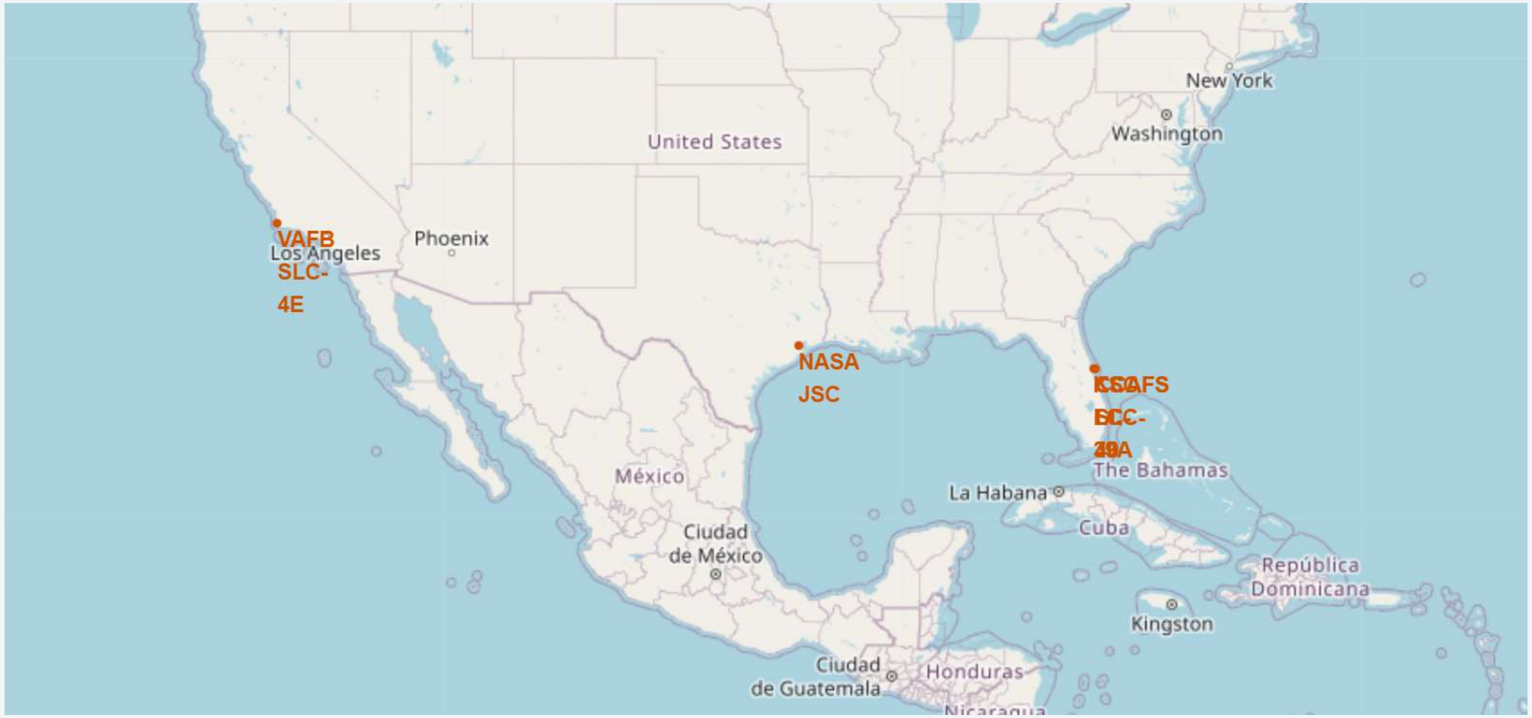
	landingoutcome	count
0	No attempt	10
1	Success (drone ship)	6
2	Failure (drone ship)	5
3	Success (ground pad)	5
4	Controlled (ocean)	3
5	Uncontrolled (ocean)	2
6	Precluded (drone ship)	1
7	Failure (parachute)	1

Section 3

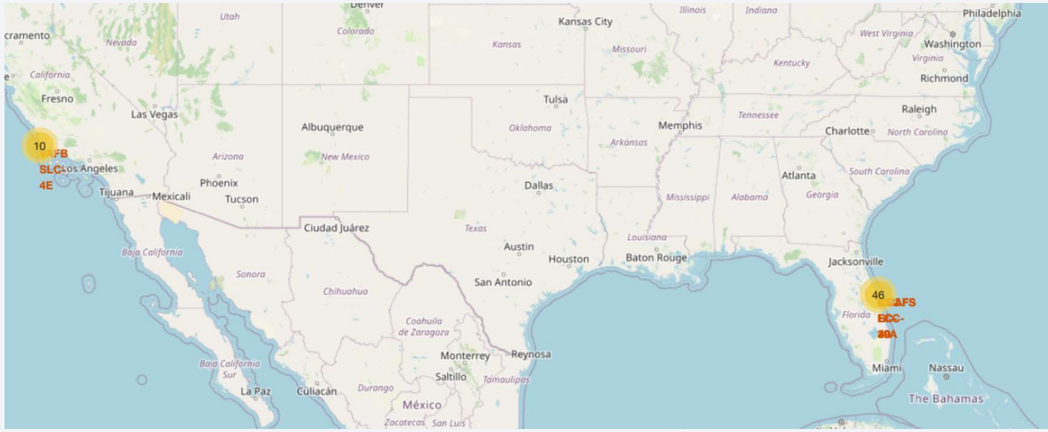
Launch Sites Proximities Analysis

<Folium Map Screenshot 1>

- Launch site's locations on the map



<Folium Map Screenshot 2>

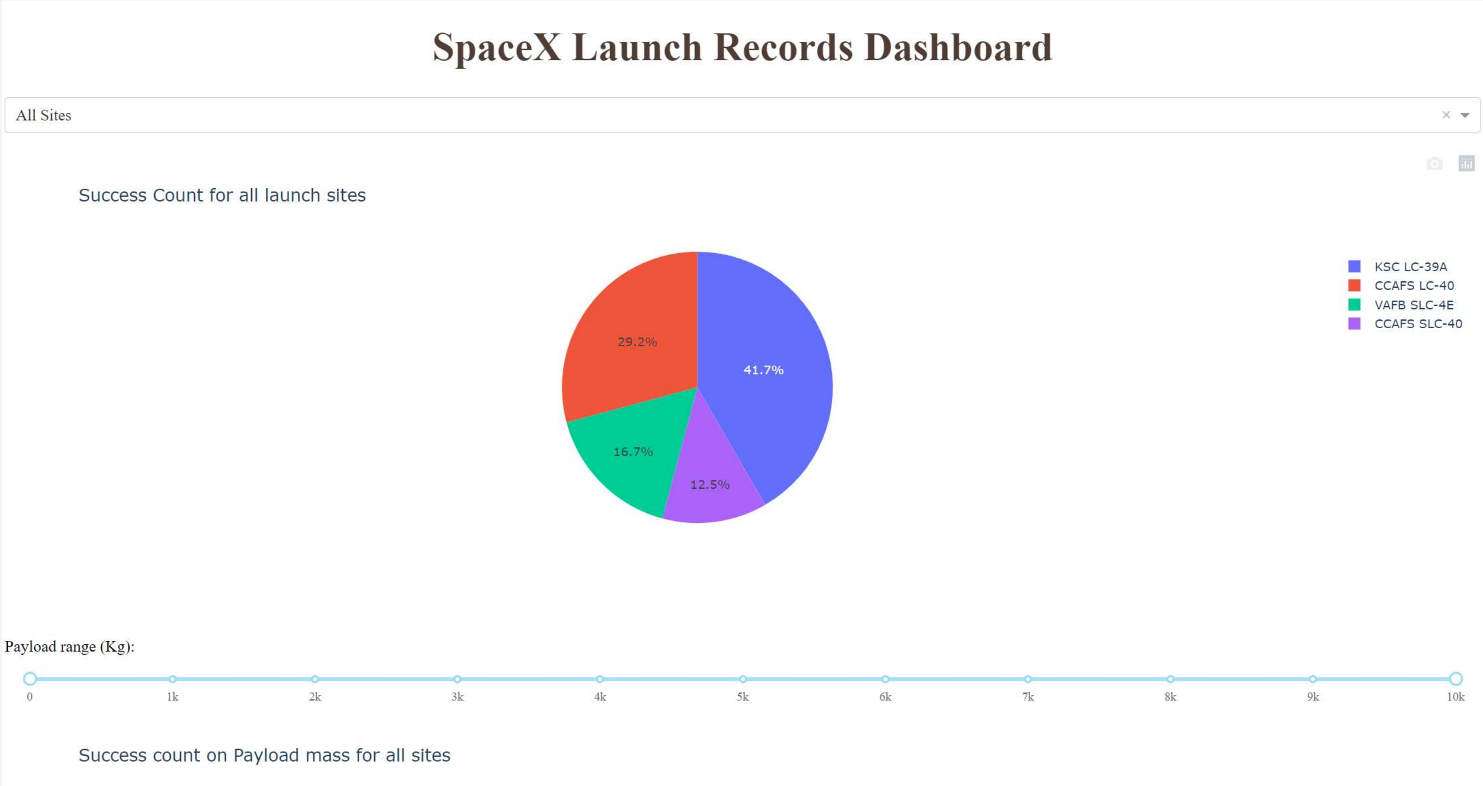


<Folium Map Screenshot 3>

Section 4

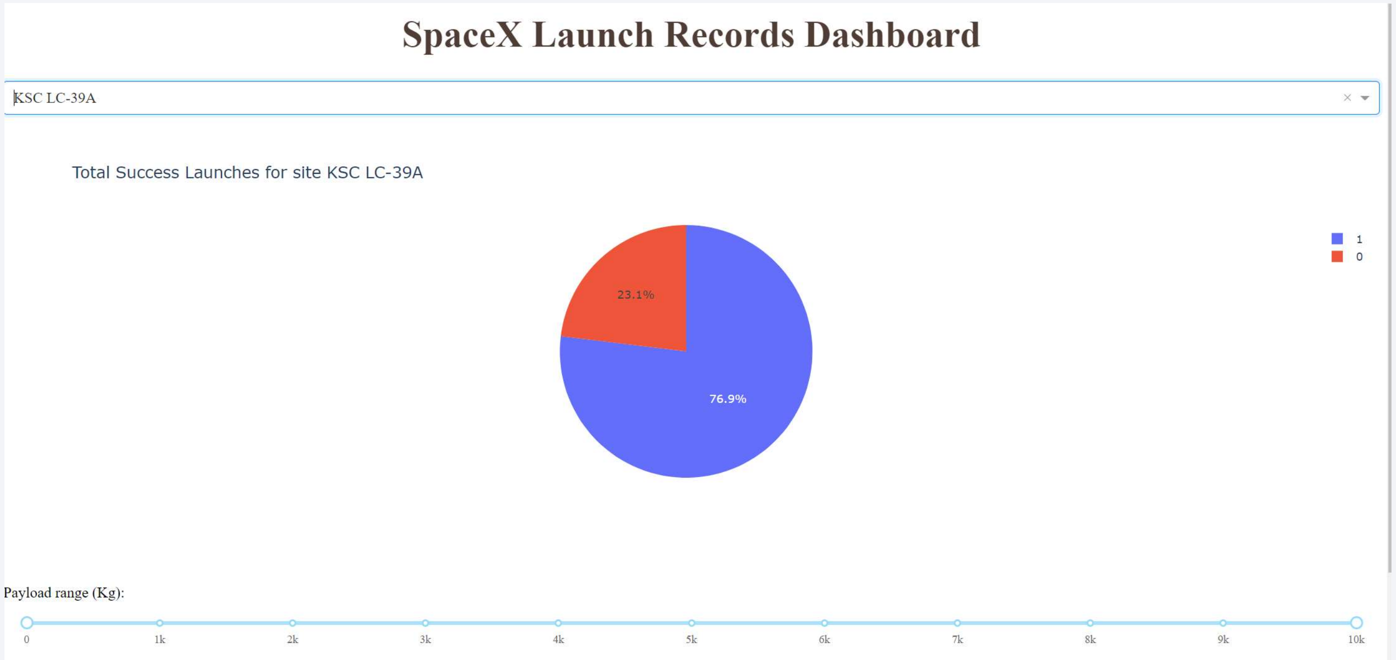
Build a Dashboard with Plotly Dash

<SpaceX Launch Records Dashboard>



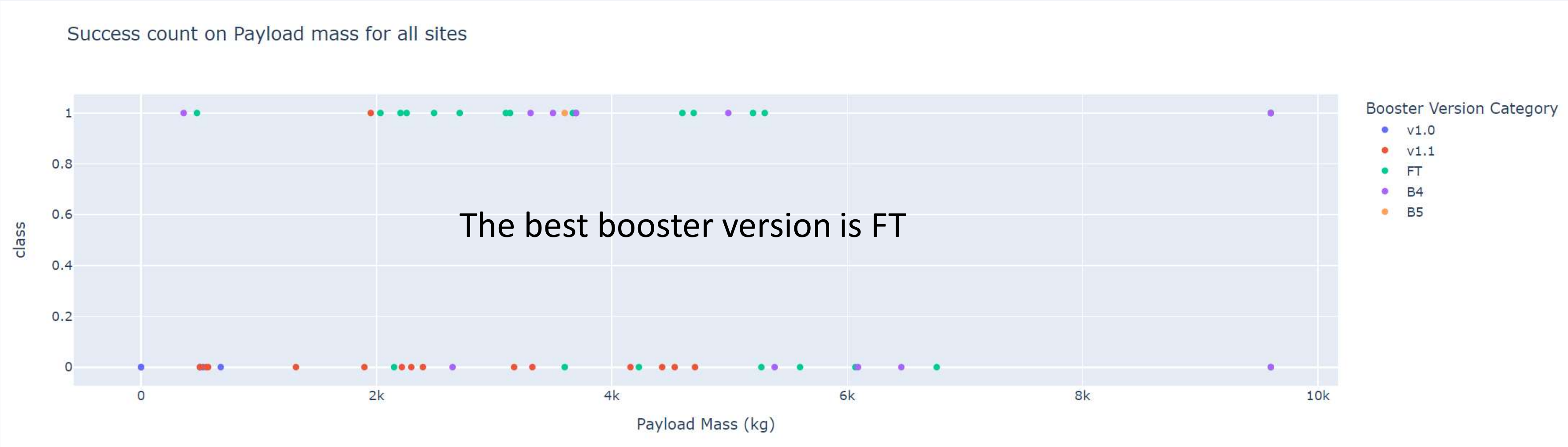
KSC LC-39A amount to the highest portion compared to other sites

<SpaceX Launch Records Dashboard Con>



- KSC LC-39A have about 77% success rate.

<SpaceX Launch Records Dashboard Con>



Section 5

Predictive Analysis (Classification)

Classification Accuracy

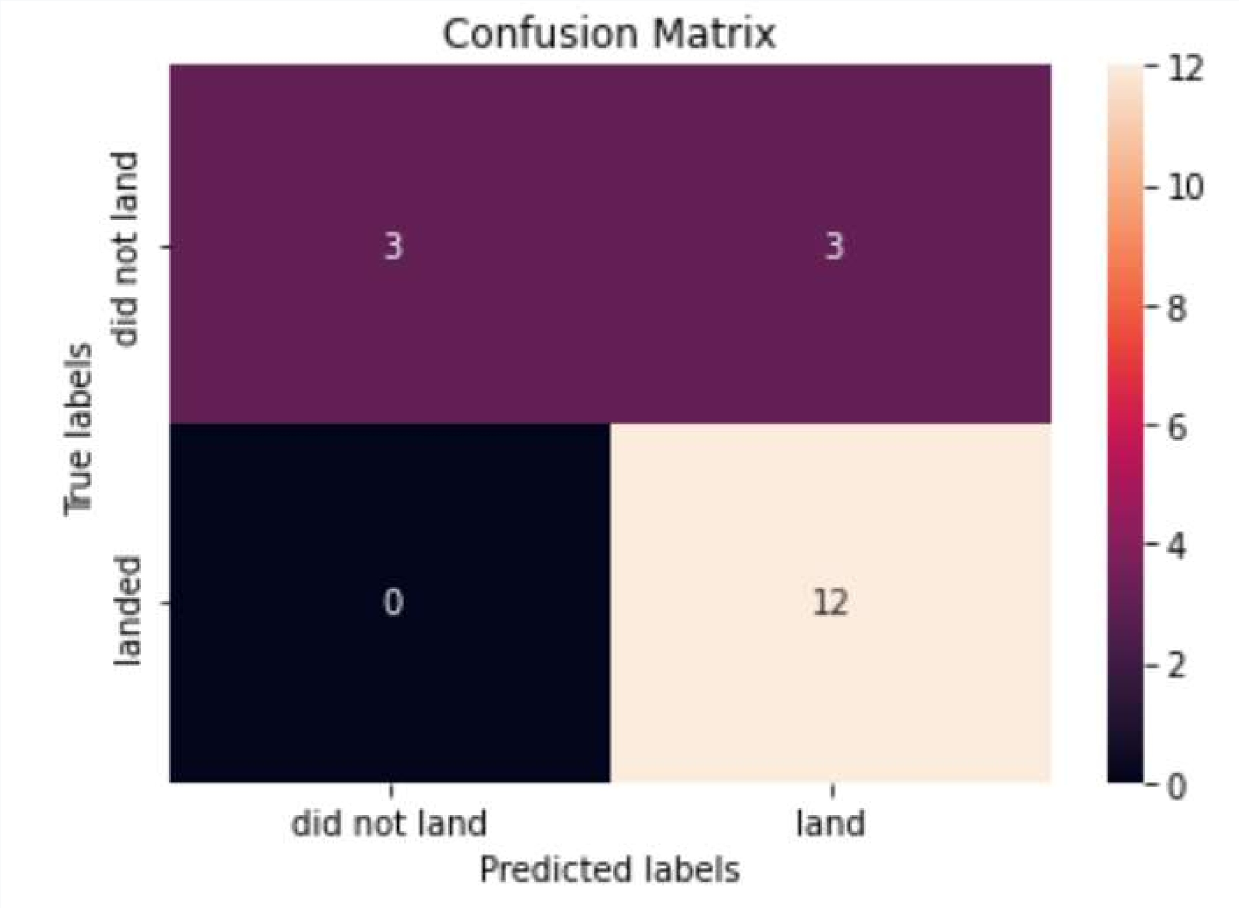
- For our case, all model presents equal accuracy, this may be due to split of training data set is random.

```
list_score = [knn_cv.score(X_test,Y_test), tree_cv.score(X_test,Y_test), svm_cv.score(X_test,Y_test), logreg_cv.score(X_test,

# Present the result
df = pd.DataFrame(list_score, index=['KNN','Decision Tree','SVM','Logistic Regression'])
df.columns = ['Score']

df
```

0]:

	Score
KNN	0.833333
Decision Tree	0.833333
SVM	0.833333
Logistic Regression	0.833333

Confusion Matrix



Examining the confusion matrix, we see that logistic regression can distinguish between the different classes. We see that the major problem is false positives.

Conclusions

- Success rate of rocket launches increases over time
- Model selection is objective, and accuracy is very dependent on the data set.
- Introduce MLR in further study will tell us the weight of each factor in determining the success rate of each launch.
- False feature can be a problem.


Thank you!