Winning Space Race with Data Science

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Outline

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

Executive Summary

Summary of methodologies

- API Calls
- Webscraping

Summary of all results

- Missions with higher payloads at CCAFS SLC 40 and Orbit Type of LEO, ISS and PO are very likely to succeed
- The first stage of Falcon 9 is very likely to land successfully

Introduction

- Taking a role of a data scientist working for a new rocket for Space Y

- To gather useful insights to compete against Space X

- To determine the price of each launch

- To determine if the first stage of Falcon 9 will land successfully

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - Describe how data was collected
- Perform data wrangling
  - Describe how data was processed
- 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

SpaceX launch data will be gathered from the SpaceX REST API

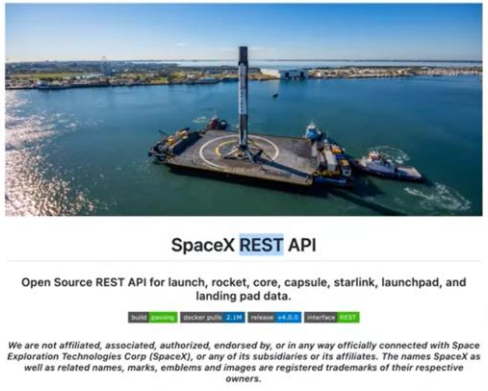
- Contains data on launches, including information about the rocket used, payload delivered, launch specifications, landing specifications, and landing outcome.
- Used to predict whether SpaceX will attempt to land a rocket or not

Webscraping HTML table

- Contains information on Falcon 9 launch records
- To address: Wrangling Data using an API, Sampling Data and Dealing with Nulls

Data Collection

Github URL:
https://github.com/mariotey/IBM_Coursera/blob/master/Week 1/jupyter-labs-spacex-data-collection-api.ipynb



https://api.spacexdata.com/v4/

...

api.spacexdata.com/v4/capsules

api.spacexdata.com/v4/cores

api.spacexdata.com/v4/launches/past

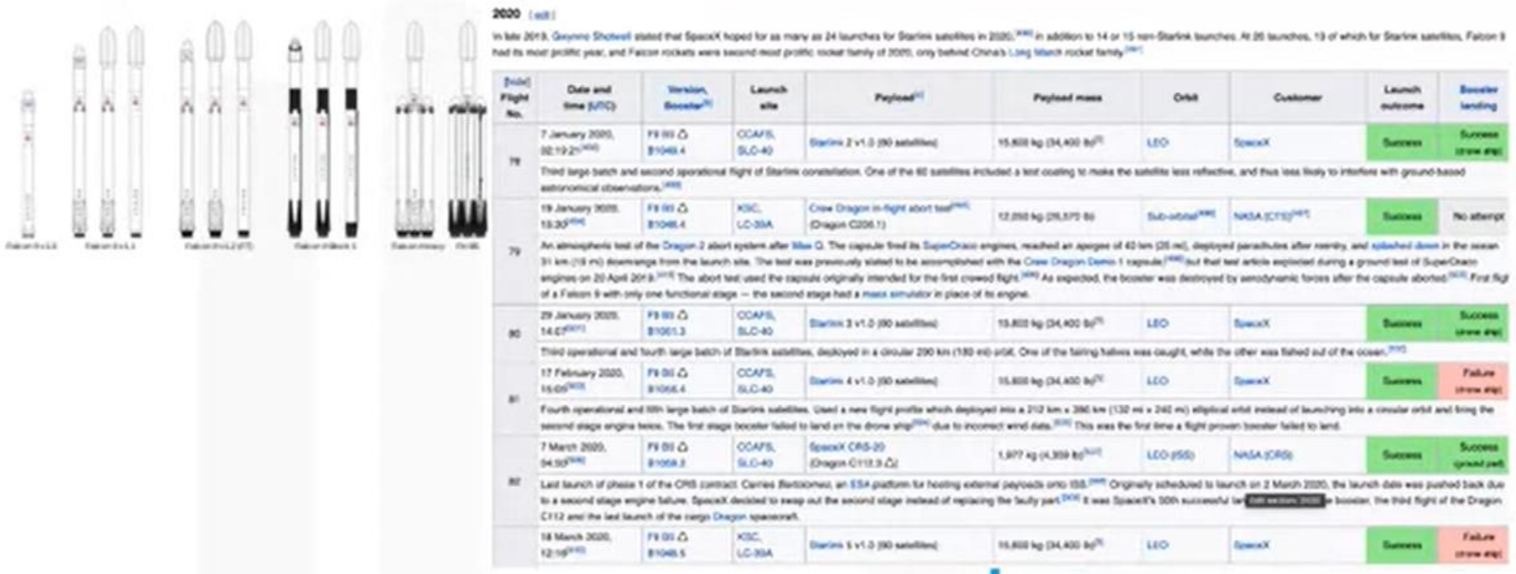
'[{"reuse_count":0,"water_landings":1,"land_landings":0,"last_update":"Hanging in atrium at SpaceX HQ in Hawthorne","launches":["5eb87cdeffd86e000604b330"],"serial":"C101","status":"retired","type":"Dragon 1.0","id":"5e9e2c5bf35918ed873b2664"},{"reuse_count":0,"water_landings":1,"land_

'[{"block":null,"reuse_count":0,"rtls_attempts":0,"rtls_landings":0,"asds_attempts":0,"asds_landings":0,"last_update":"Engine failure at T+33 seconds resulted in loss of vehicle","launches":["5eb87cd9ffd86e000604b32a"],"serial":"Merlin1A","status":"lost","id":"..

```
url = "https://api.spacexdata.com/v4/launches/past"
response = request.get(url)
response.json()
```

Data Collection

Github URL:
https://github.com/mariotey/IBM_Coursera/blob/master/Week 1/jupyter-labs-webscraping.ipynb



Web scraping with BeautifulSoup

	FlightNumber	Date	BoosterVersion	PayloadMass	Orbit	LaunchSite	Outcome	Flights	GridFins	Reused	Legs	LandingPad	Block	ReusedCount	Serial	Longitude	Latitude
0	1	2006-03-24	Falcon 1	20.0	LEO	Kwajalein Atoll	None None	1	False	False	False	None	NaN	0	Merlin1A	167.743129	9.047721
1	2	2007-03-21	Falcon 1	NaN	LEO	Kwajalein Atoll	None None	1	False	False	False	None	NaN	0	Merlin2A	167.743129	9.047721
2	4	2008-09-28	Falcon 1	165.0	LEO	Kwajalein Atoll	None None	1	False	False	False	None	NaN	0	Merlin2C	167.743129	9.047721
3	5	2009-07-13	Falcon 1	200.0	LEO	Kwajalein Atoll	None None	1	False	False	False	None	NaN	0	Merlin3C	167.743129	9.047721
4	6	2010-06-04	Falcon 9	NaN	LEO	CCAFS SLC 40	None None	1	False	False	False	None	1.0	0	B0003	-80.577366	28.561857

Data Wrangling

- Wrangling Data using API → use *json_normalize* to convert the response object of the API call to a dataframe
- Incomplete information → utilize API to target other endpoints to gather specific data
- Filter only for data specific to Falcon 9
- Treatment of NULL values → replace NULL values with the mean of attribute / one hot encoding
- *"Outcome"* of the dataset needs to be converted to Classes y (either 0 or 1)

EDA with Data Visualization

- Scatter Point Chart
- Bar Chart
- Line Chart

Github URL:
https://github.com/mariotey/IBM_Coursera/blob/master/Week2/IBM-DS0321EN-SkillsNetwork_labs_module_2_jupyter-labs-eda-dataviz.ipynb.jupyterlite.ipynb

EDA with SQL

- Names of Unique Launch Sites in the Space Mission
- Records where Launch Sites begin with “CCA”
- Total Payload Mass carried by boosters launched by NASA (CRS)
- Average Payload Mass carried by booster ver F9 v1.1
- Date when the first successful landing outcome in the ground pad was achieved
- Names of boosters that have success in drone ships with 4000 <payload mass > 6000
- Total number of successful and failure mission outcomes
- Names of booster_versions that have carried the maximum payload mass
- Failure landing_outcomes in drone ship, booster versions, launch_site for the months in the year 2015.

Github URL: *https://github.com/mariotey/IBM_Coursera/blob/master/Week2/jupyter-labs-eda-sql-coursera_sqllite.ipynb*

Build an Interactive Map with Folium

- Folium.Circle → To mark the successful / failed launches for each site on the map
- Folium.Marker → To label the launch site names
- Folium.PolyLine → To label the calculated distances between a launch site to its proximities

Github URL: *https://github.com/mariotey/IBM_Coursera/blob/master/Week3/IBM-DS0321EN-SkillsNetwork_labs_module_3_lab_jupyter_launch_site_location.jupyterlite.ipynb*

Build a Dashboard with Plotly Dash

Input

- Dropdown List → To select Launch Sites
- Range Slider → To select the interested range of Payload Mass

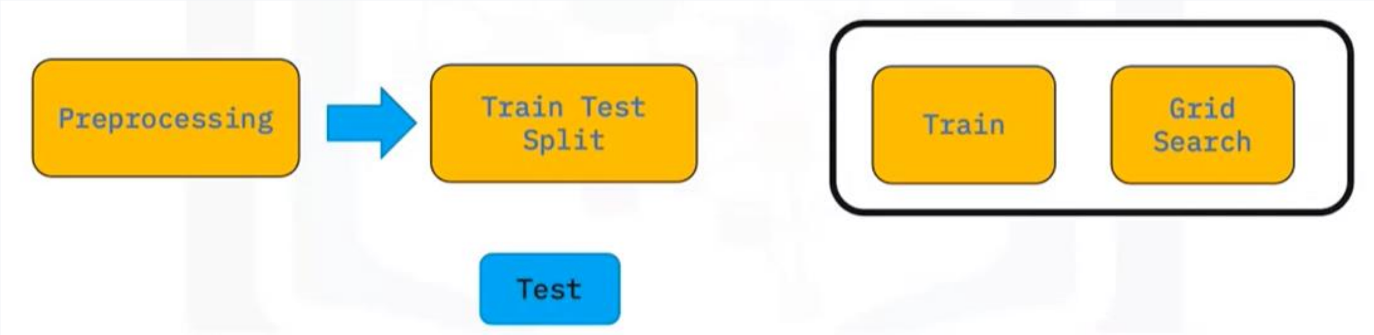
Output

- Piechart → To show the distribution of successful and failed missions at interested launch sites
- Scatterplot → To show the correlation between the interested range of Payload Mass and the Success at interested launch sites

Github URL: *https://github.com/mariotey/IBM_Coursera/blob/master/Week3/spacex_dash_app.py*

Predictive Analysis (Classification)

- Predict whether first stage of Falcon 9 will land successfully



- Determine the model with the best accuracy

Github URL: *https://github.com/mariotey/IBM_Coursera/blob/master/Week4/IBM-DS0321EN-SkillsNetwork_labs_module_4_SpaceX_Machine_Learning_Prediction_Part_5.jupyterlite.ipynb*

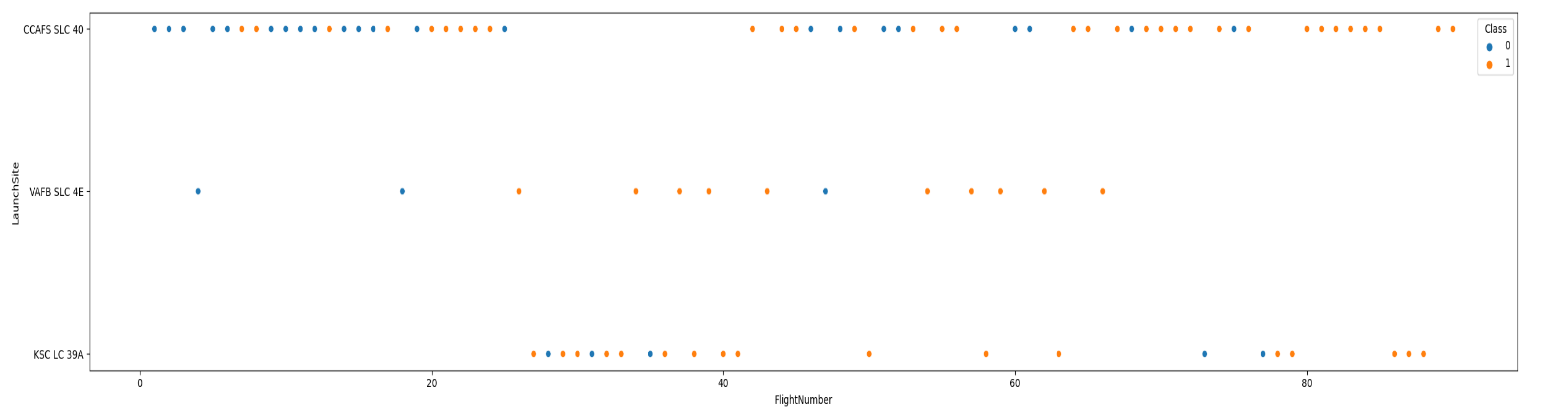
Results

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

Section 2

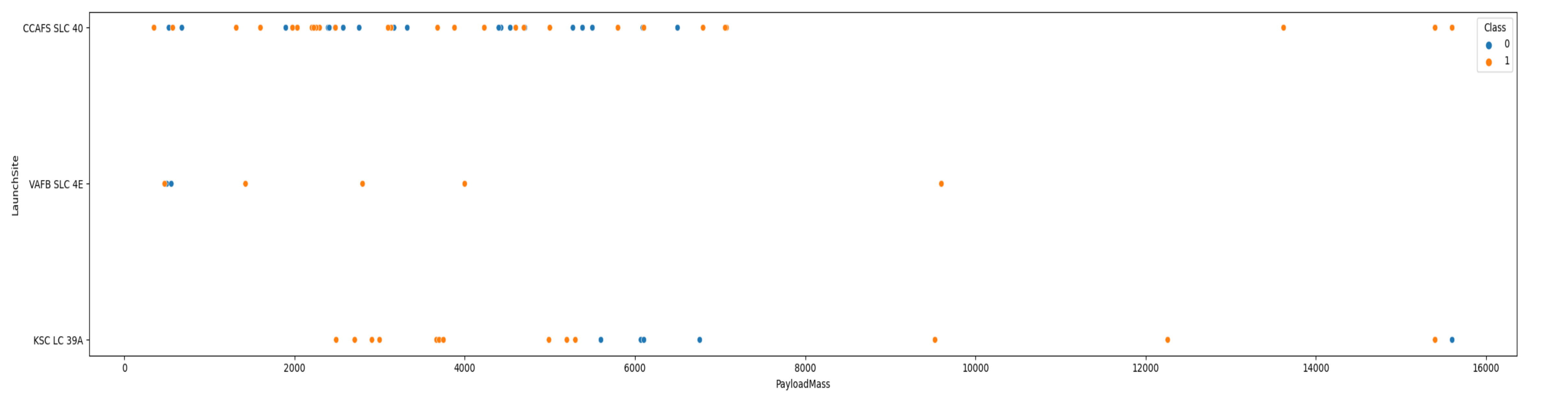
Insights drawn from EDA

Flight Number vs. Launch Site



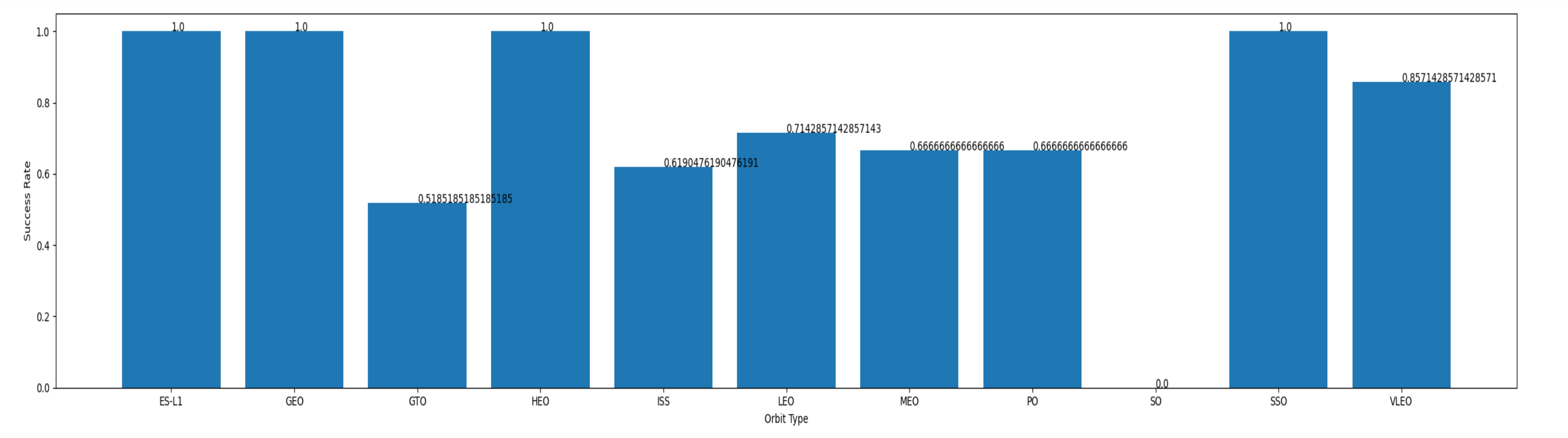
- For CCAFS SLC 40, flight numbers above 25 seem to be more successful than flight numbers below 25
- There are more missions conducted at CCAFS SLC 40 than VAFB SLC 4E and KSC LC39A
- There are too few missions conducted at VAFB SLC 4E and KSC LC39A to determine a trend

Payload vs. Launch Site



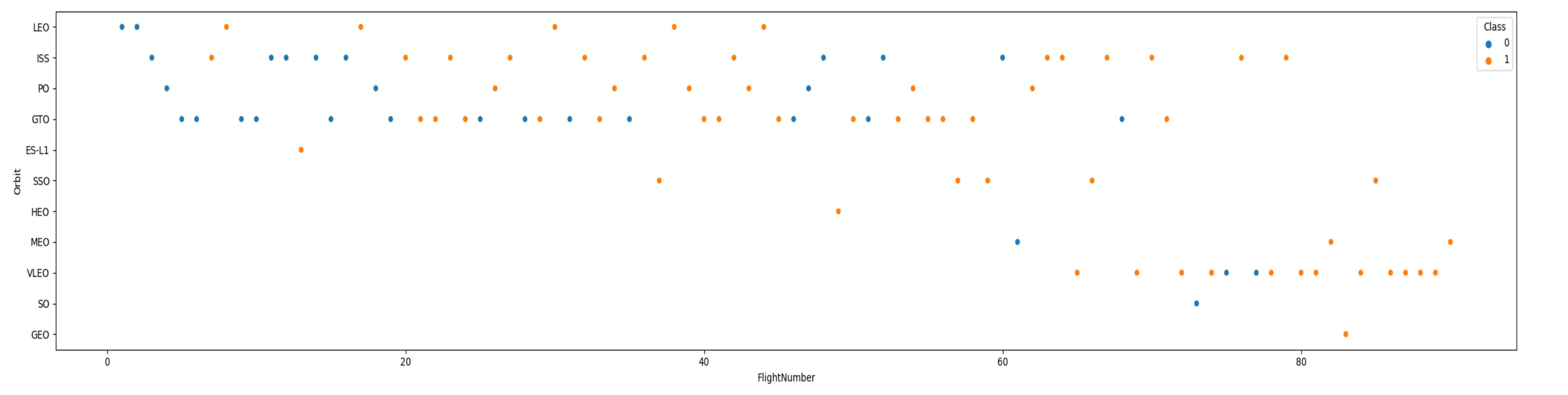
- Missions with payload below 8000kg were mostly held at CCAFS SLC 40. There does not seem to be any trend
- Missions are most successful when held at VAFB SLC 4E
- Missions held at KSC LC39A were mostly successful with the exception of payloads ranging between 5500 to 7000kg

Success Rate vs. Orbit Type



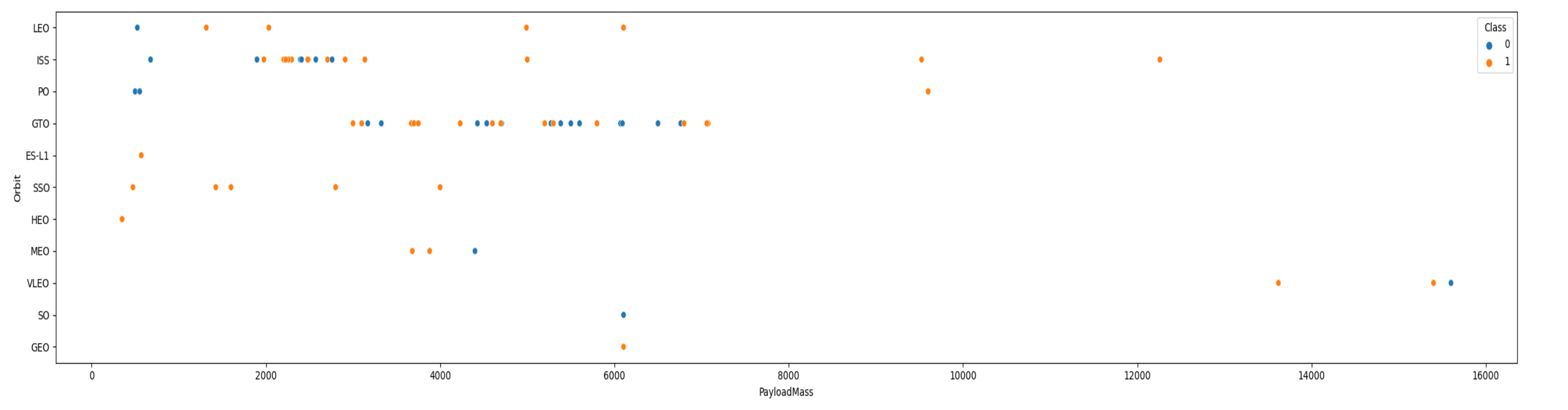
- Orbit Type of ES-L1, GEO, HEO and SSO had a success rate of 100%
- Orbit Type of SO had a success rate of 0%. Either all missions done in this orbit type failed or there are no missions done in this orbit type.

Flight Number vs. Orbit Type



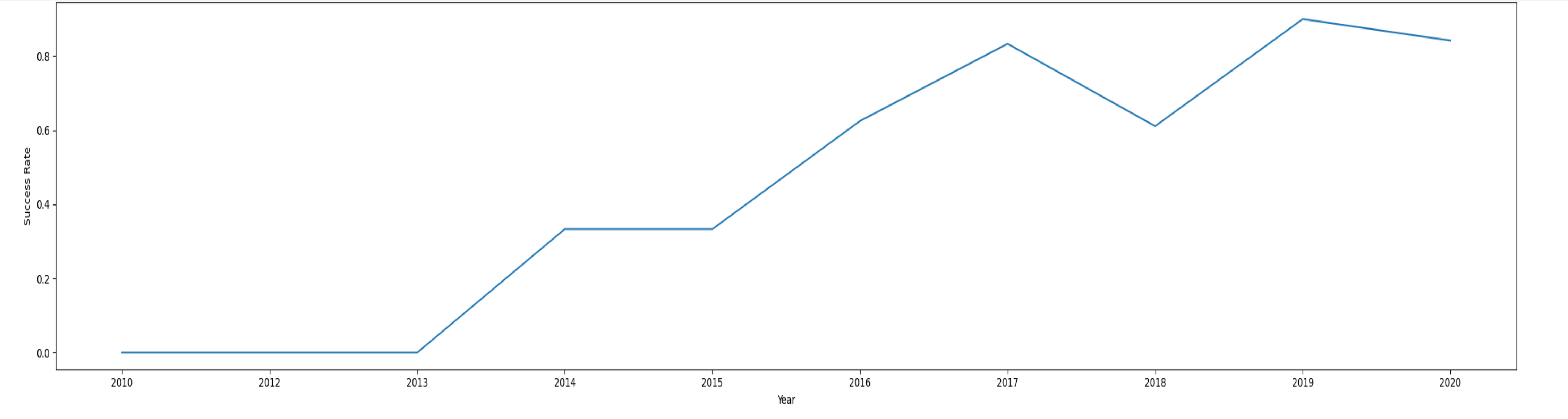
- Orbit Type LEO, ISS, PO, GTO and ES-L1 mostly handle flight numbers below 40
- Orbit Type SSO, HEO, MEO, VLEO, SO and GEO handle flight numbers above 40
- Orbit Type LEO successes appear to be related to the number of flights while GTO does not seem to exhibit any trend.

Payload vs. Orbit Type



- For Orbit type LEO, ISS and PO, they seem to have more successful missions when handling heavier payloads
- For Orbit type GTO, it has a mixture of successful and failed missions which makes the identification of a trend difficult.
- For for the rest of the Orbit types, they seemed rather consistent throughout various payloads

Launch Success Yearly Trend



- Launch missions from 2013 to 2020 mostly exhibit an increasing trend of success rate.
- In 2017 and 2019, the success rate of Launch Missions declined.

All Launch Site Names

```
In [14]: %sql SELECT DISTINCT(Launch_Site) FROM SPACEXTBL

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

Out[14]:

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

- Names of unique launches in the space mission

Launch Site Names Begin with 'CCA'

In [30]:

```
%sql SELECT * FROM SPACEXTBL \
    WHERE Launch_Site like "CCA%" LIMIT 5
```

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

Out[30]:

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

- 5 records where launch sites begin with the string “CCA”

Total Payload Mass

```
In [32]: %sql SELECT SUM(PAYLOAD_MASS__KG_) FROM SPACEXTBL \
            WHERE Customer like "NASA (CRS)"

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

Out[32]:

SUM(PAYLOAD_MASS__KG_)
45596

- Total payload mass carried by boosters launched by NASA (CRS)

Average Payload Mass by F9 v1.1

In [42]:
```
# %sql SELECT * FROM SPACEXTBL \
#     WHERE Booster_Version like "F9 v1.1"

%sql SELECT AVG(PAYLOAD_MASS__KG_) FROM SPACEXTBL \
    WHERE Booster_Version like "F9 v1.1"
```

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

Out[42]:

AVG(PAYLOAD_MASS__KG_)
2928.4

- Average payload mass carried by booster version F9 v1.1

First Successful Ground Landing Date

```
In [60]: %%sql SELECT min(Date) FROM SPACEXTBL
             WHERE "Landing _Outcome" like "Success%ground pad%"

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

Out[60]:

min(Date)
01-05-2017

- Date when the first successful landing outcome in the ground pad was achieved.
- The date shown in the output is in the format of DD-MM-YYYY

Successful Drone Ship Landing with Payload between 4000 and 6000

In [67]:
```
%%sql SELECT Booster_Version FROM SPACEXTBL
    WHERE "Landing _Outcome" like "Success%drone ship%"
    AND PAYLOAD_MASS__KG_ > 4000
    AND PAYLOAD_MASS__KG_ < 6000
```

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

Out[67]:

Booster_Version
F9 FT B1022
F9 FT B1026
F9 FT B1021.2
F9 FT B1031.2

- Names of the boosters which have success in drone ships and have payload mass greater than 4000 but less than 6000

Total Number of Successful and Failure Mission Outcomes

```
[14]: %%sql

SELECT COUNT(Mission_Outcome) FROM SPACEXTBL
    WHERE Mission_Outcome like "Success%"

-- SELECT COUNT(Mission_Outcome) FROM SPACEXTBL
--     WHERE Mission_Outcome like "Fail%"

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

[14]:

COUNT(Mission_Outcome)
100

```
[15]: %%sql

-- SELECT COUNT(Mission_Outcome) FROM SPACEXTBL
--     WHERE Mission_Outcome like "Success%"

SELECT COUNT(Mission_Outcome) FROM SPACEXTBL
    WHERE Mission_Outcome like "Fail%"

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

[15]:

COUNT(Mission_Outcome)
1

- 100 successful missions and 1 failed mission

Boosters Carried Maximum Payload

In [80]:
```
%sql SELECT Booster_Version, MAX(PAYLOAD_MASS__KG_) FROM SPACEXTBL
```

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

Out[80]:

Booster_Version	MAX(PAYLOAD_MASS__KG_)
F9 B5 B1048.4	15600

- Name of the booster version that carried the maximum payload mass

2015 Launch Records

```
In [129…

%%sql

SELECT substr(Date, 4, 2) as Month, "Landing _Outcome", Booster_Version, Launch_Site FROM SPACEXTBL
    WHERE "Landing _Outcome" like "Fail%drone ship%"
    AND substr(Date, 7, 4) = '2015'

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

Out[129…

Month	Landing _Outcome	Booster_Version	Launch_Site
01	Failure (drone ship)	F9 v1.1 B1012	CCAFS LC-40
04	Failure (drone ship)	F9 v1.1 B1015	CCAFS LC-40

- Records that display the months, booster version and launch sites of failed missions in the year 2015

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

```
[22]: %%sql

SELECT substr(Date, 7, 4) as Year, COUNT(*) as Count FROM SPACEXTBL
    WHERE "Landing _Outcome" like "Success%"
    AND CAST(substr(Date, 7, 4) as int) < 2018
    AND CAST(substr(Date, 7, 4) as int) > 2010
    GROUP By CAST(substr(Date, 7, 4) as int)
    ORDER By COUNT(*) DESC

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

[22]:

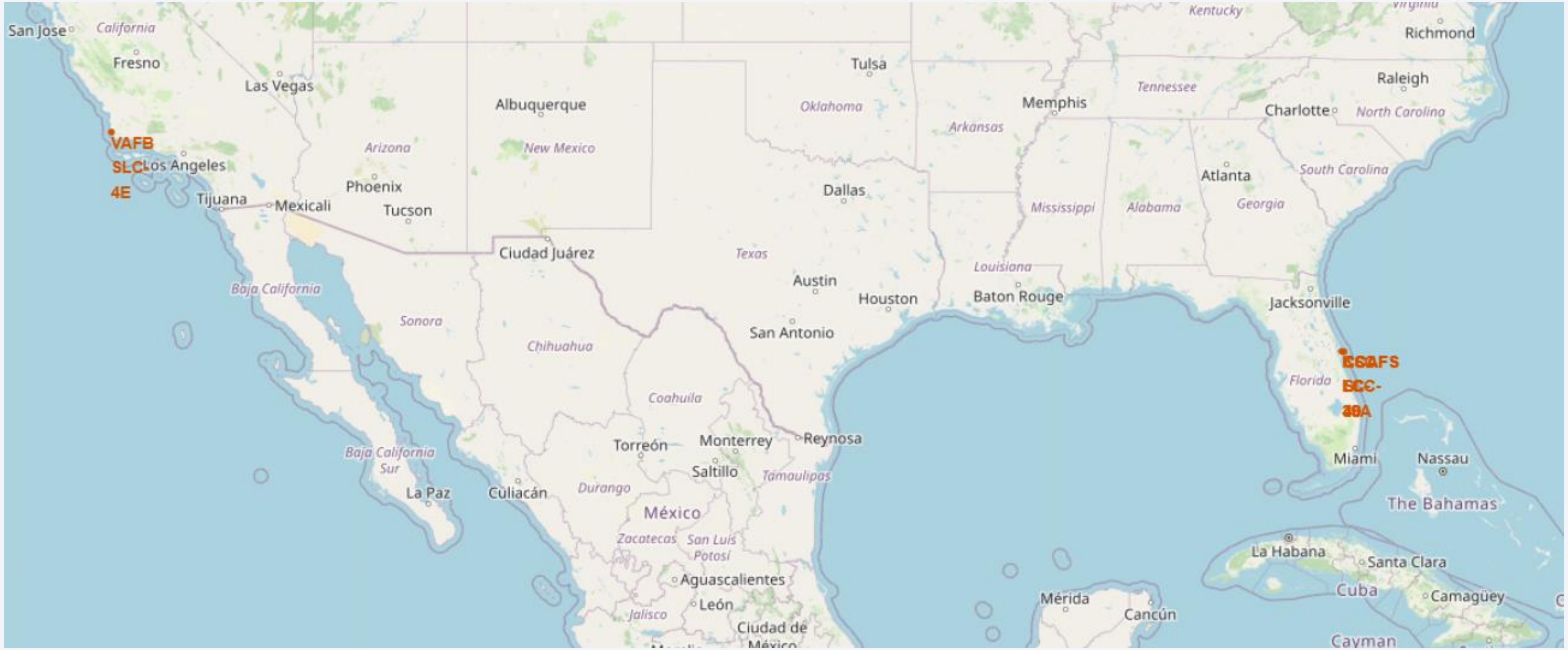
Year	Count
2017	14
2016	5
2015	1

- Count of successful land outcomes between 2010-06-04 and 2017-03-20 in descending order

Section 3

Launch Sites Proximities Analysis

Location of Launch Sites

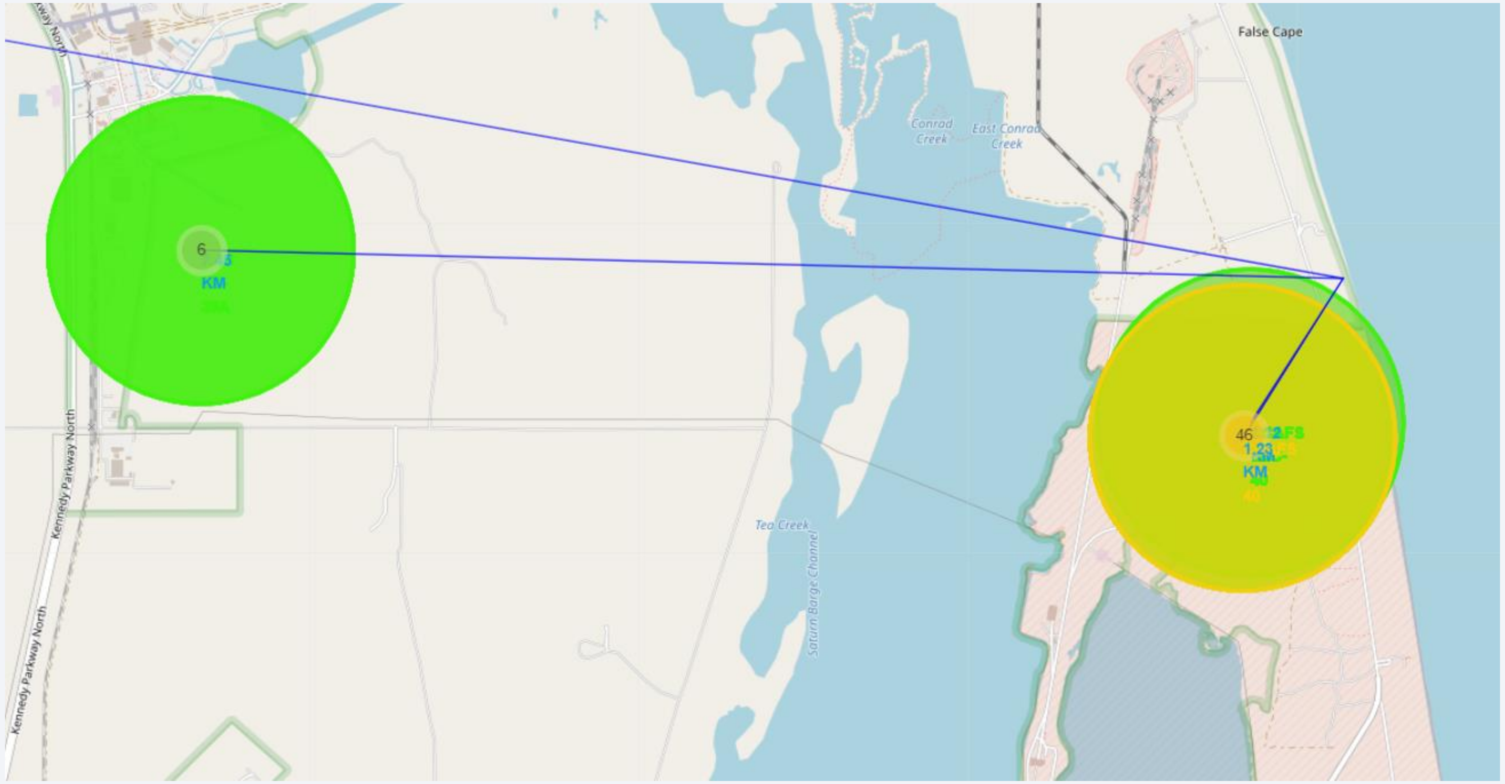


- Locations are identified in the red dot and labelled with the names of the launch sites

Locations of Launch Sites with Successful / Failed Missions

- Launch Sites with Successful missions are in Green
- Launches with Failed missions are in Yellow

Proximity of Launch Sites to Specific Location

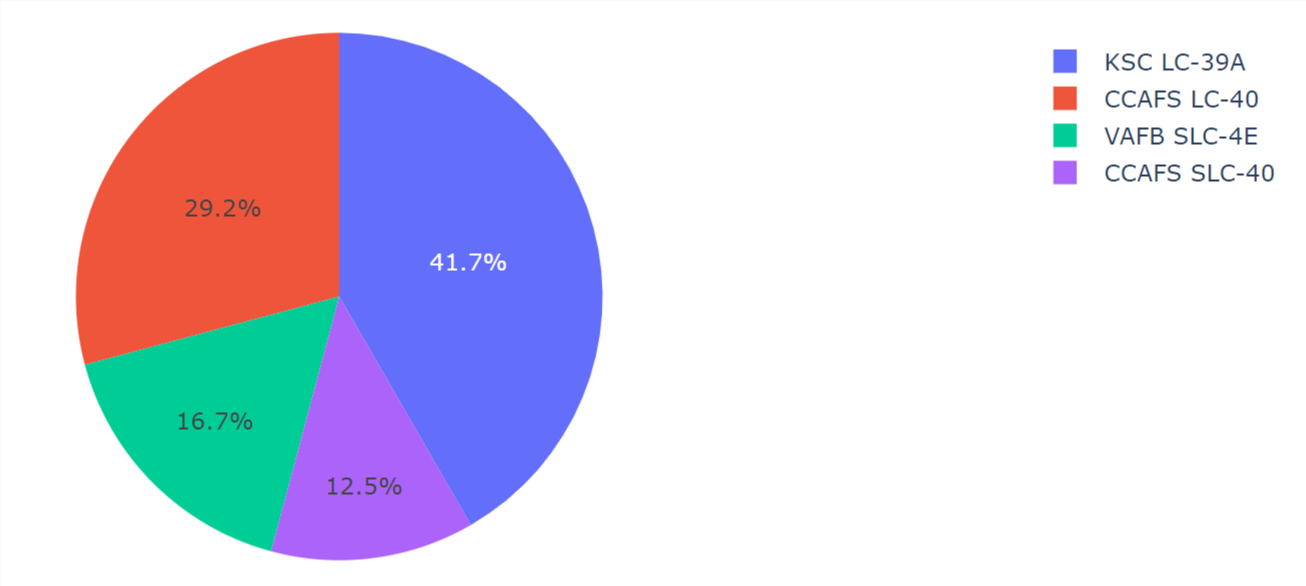


- Determining the proximity of launch sites to [28.57164, -80.57064]
- The longer the blue the further the launch sites are from the point of interest

Section 4

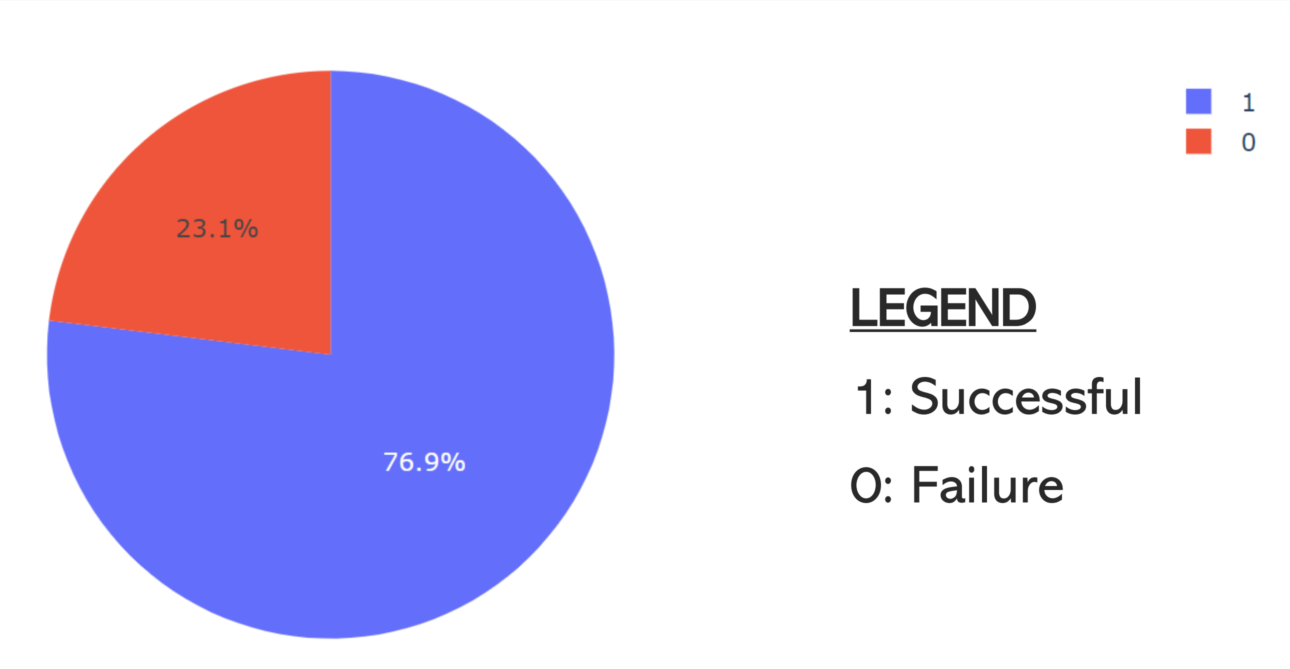
Build a Dashboard with Plotly Dash

Total Successful Launches by Launch Sites



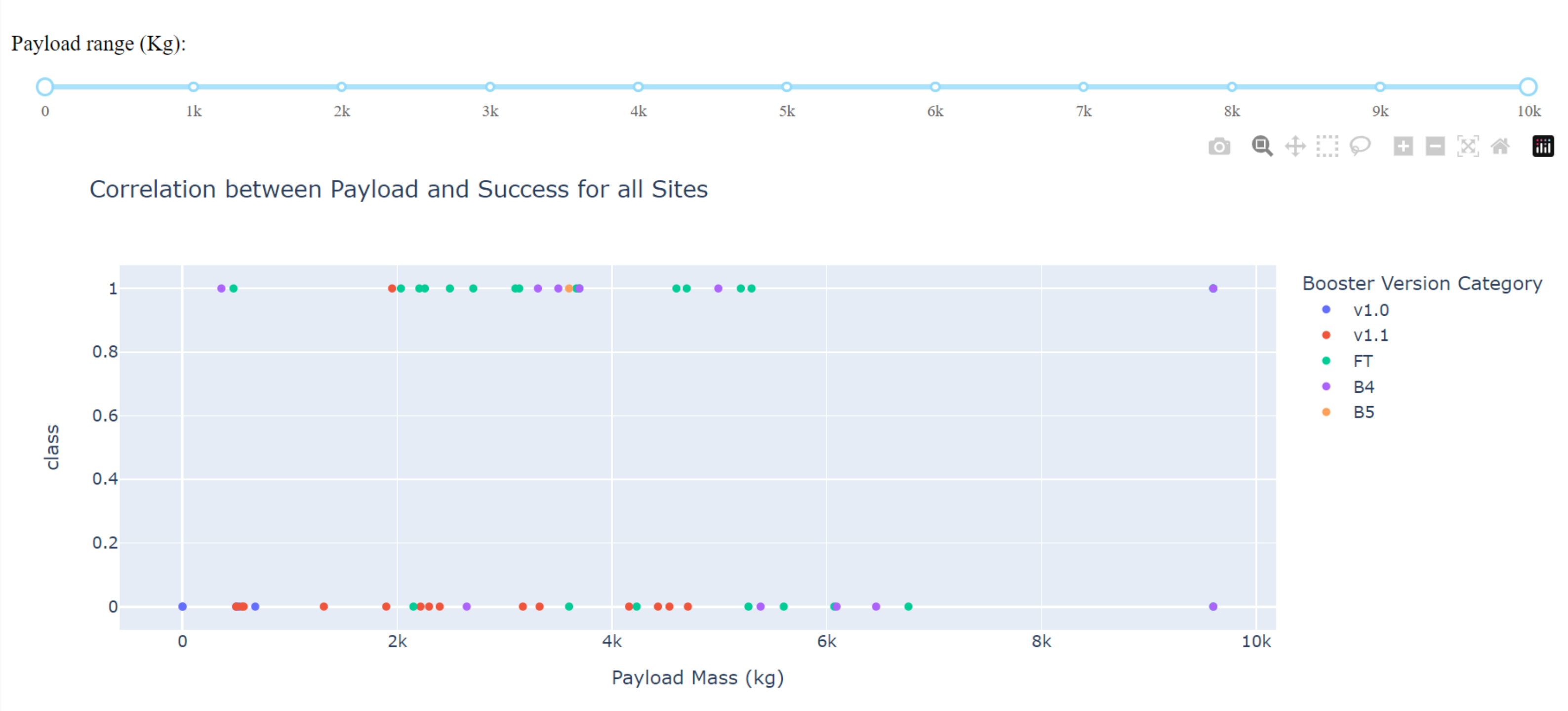
- KSC LC-39A contributes the most to successful launches while CCADS SLC-40 contributes the least to successful launches

Distribution of Successful Launches at KSC LC-39A



- Majority of the launches are successful

Payload vs. Launch Outcome for all Sites, with Different Payloads

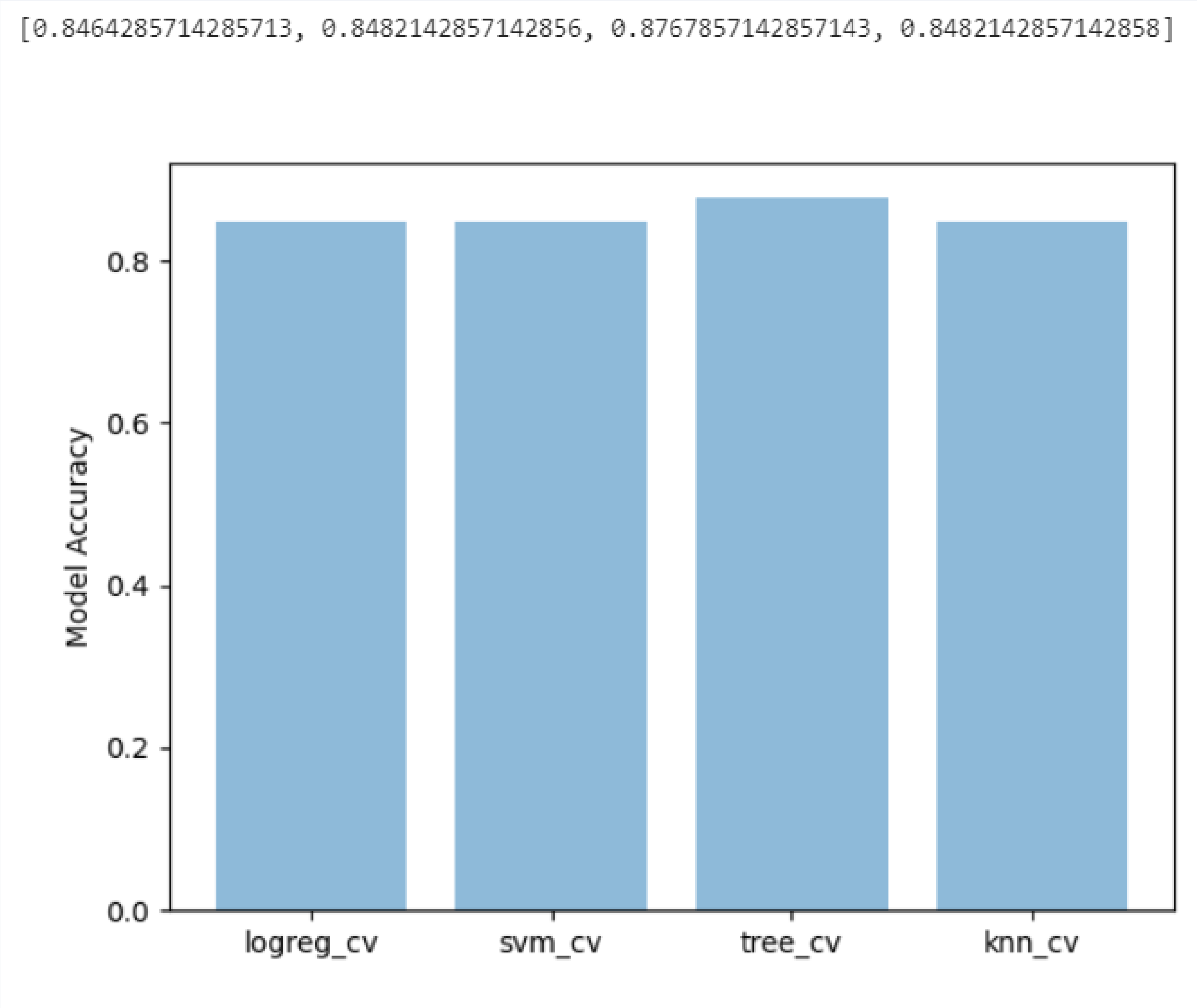


- FT Booster seems to be very reliable; being mostly successful across various payloads
- V1.1 seems to be unreliable with the least successful launches and contributing the most to failed missions across various payloads

Section 5

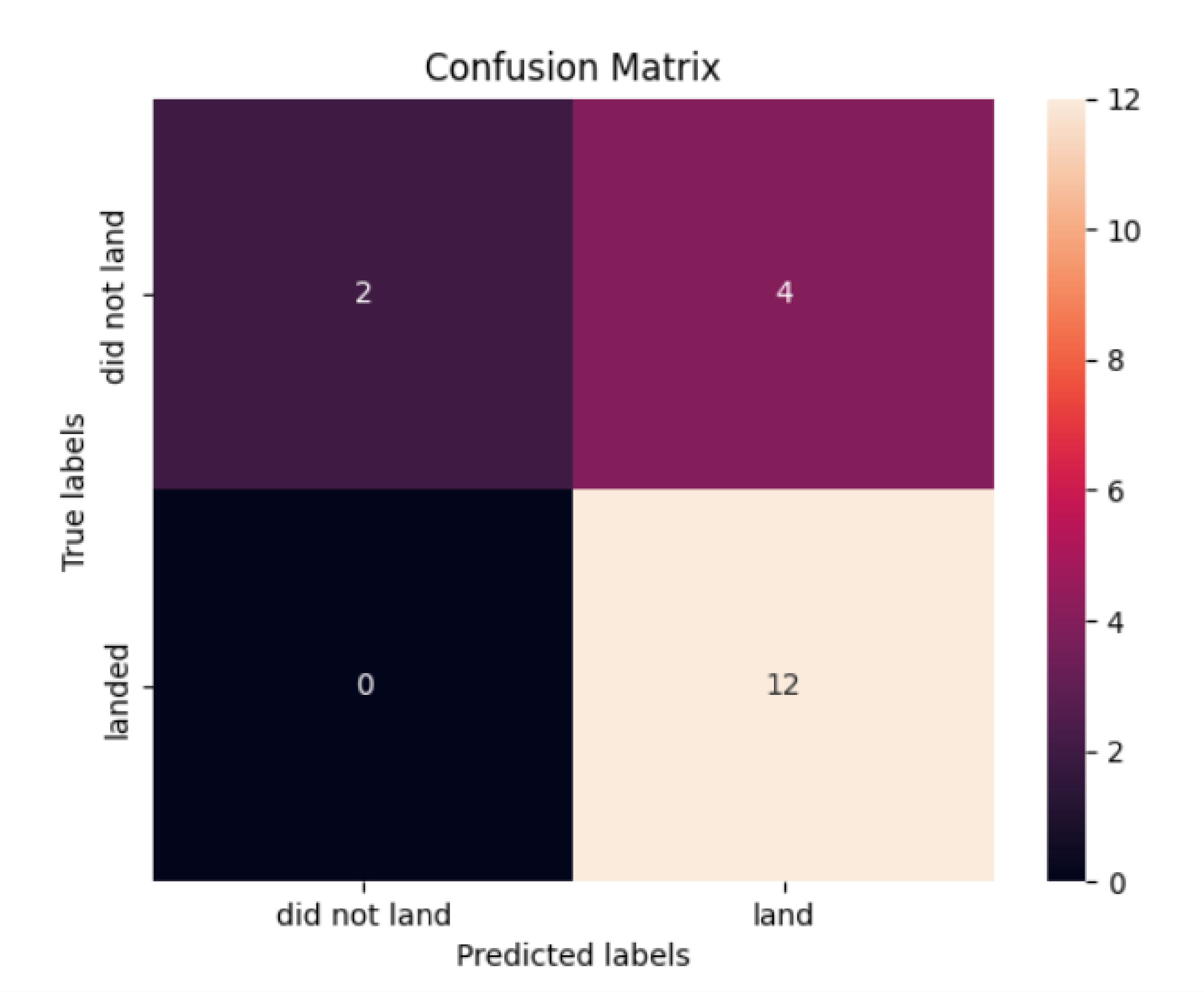
Predictive Analysis (Classification)

Classification Accuracy



- Decision tree classifier has the highest accuracy of 87.7%
- Log Regression classifier has the lowest accuracy of 84.6%

Confusion Matrix



- Uses a decision tree classifier object
- Selected best model is relatively accurate in predicting and has a test error count of 4

Conclusions

- Missions with higher payloads at CCAFS SLC 40 are very likely to succeed
- Missions with Orbit Type LEO, ISS and PO are very likely to succeed
- Majority of the missions are held near Florida
- Booster v1.1 needs to be reviewed for its reliability
- The first stage of Falcon 9 is very likely to land successfully

Thank you!