IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

Eric John Sulit
March 30, 2023

Outline

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

Executive Summary

- Summary of methodologies
  - Data Collection
  - Data Wrangling
  - EDA with Data Visualization
  - EDA with SQL
  - Building an interactive map with Folium
  - Building a dashboard with Plotly Dash
  - Predictive analysis (Classification)
- Summary of all results
  - EDA results
  - Interactive analysis
  - Predictive analysis

Introduction

- Project background and context
  - SpaceX 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 SpaceX can reuse the first stage.
- Problems you want to find answers
  - The project task is to predict if the first stage of the SpaceX Falcon 9 rocket will land successfully.

Section 1

Methodology

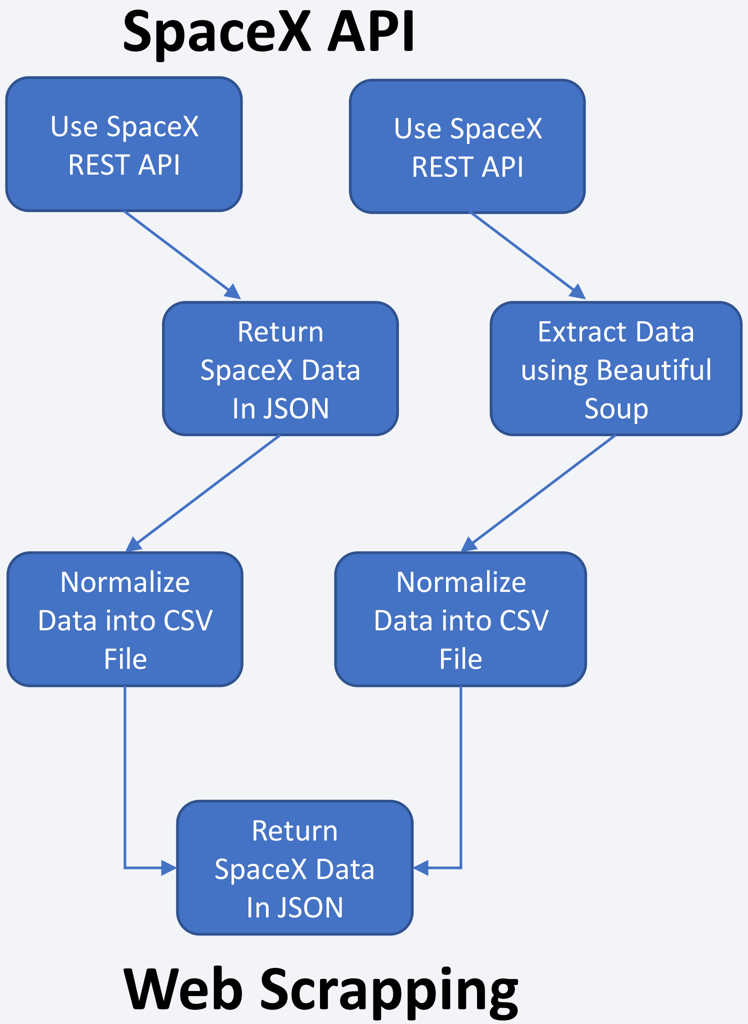
Methodology

Executive Summary

- Data collection methodology:
  - SpaceX Rest API
  - Web Scrapping from Wikipedia
- Perform data wrangling
  - One Hot Encoding data fields for Machine Learning and data cleaning of null values and irrelevant columns
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - LR, KNN, SVM, DT models have been built and evaluated for the best classifier

Data Collection

- The following datasets was collected:
  - SpaceX launch data that is gathered from the SpaceX REST API.
  - This API will give us data about launches, including information about the rocket used, payload delivered, launch specifications, landing specifications, and landing outcome.
  - The SpaceX REST API endpoints, or URL, starts with api.spacexdata.com/v4/.
  - Another popular data source for obtaining Falcon 9 Launch data is web scraping Wikipedia using BeautifulSoup.



Data Collection – SpaceX API

- Data collection with SpaceX REST calls

URL: https://github.com/ericjohn05/testrepo/blob/master/Final_Assignment.ipynb

1. Response From API

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

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

2. Getting Response to a JSON file

```
static_json_url='https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/API_call_spacex_api.json'
```

```
data = pd.json_normalize(response.json())
```

3. Apply Custom Function to Clean Data

```
getLaunchSite(data)      getCoreData(data)
getPayloadData(data)     getBoosterVersion(data)
```

4. Assign List to Dictionary then Dataframe

```
launch_dict = {'FlightNumber': list(data['flight_number']),
'Date': list(data['date']),
'BoosterVersion':BoosterVersion,
'PayloadMass':PayloadMass,
'Orbit':Orbit,
'LaunchSite':LaunchSite,
'GridFins':GridFins,
'Reused':Reused,
'Legs':Legs,
'LandingPad':LandingPad,
'Block':Block,
'ReusedCount':ReusedCount,
'Serial':Serial,
'Longitude': Longitude,
'Latitude': Latitude}
```

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

5. Filter Dataframe and Export to Flat File (.csv)

```
data_falcon9 = df[df['BoosterVersion']!='Falcon 1']
data_falcon9.to_csv('dataset_part_1.csv', index=False)
```

Data Collection - Scraping

- Web Scrapping From Wikipedia

URL: https://github.com/ericjohn05/testrepo/blob/master/jupyter-labs-webscraping%20(1).ipynb

1. Getting Response from HTML

```
page = requests.get(static_url)
```

2. Creating BeautifulSoup Object

```
soup = BeautifulSoup(page.text, 'html.parser')
```

3. Finding Tables

```
html_tables = soup.find_all('table')
```

4. Getting Column Names

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

5. Creation of Dictionary

```
# Let's initial the launch_dict with
launch_dict['Flight No.'] = []
launch_dict['Launch site'] = []
launch_dict['Payload'] = []
launch_dict['Payload mass'] = []
launch_dict['Orbit'] = []
launch_dict['Customer'] = []
launch_dict['Launch outcome'] = []
# Added some new columns
launch_dict['Version Booster']=[]
launch_dict['Booster landing']=[]
launch_dict['Date']=[]
launch_dict['Time']=[]
```

6. Appending Data to Keys

```
for table_number,table in enumerate(soup.find_all('table',"wikit
   # get table row
    for rows in table.find_all("tr"):
        #check to see if first table heading is as number corres
```

7. Converting Dictionary to Dataframe

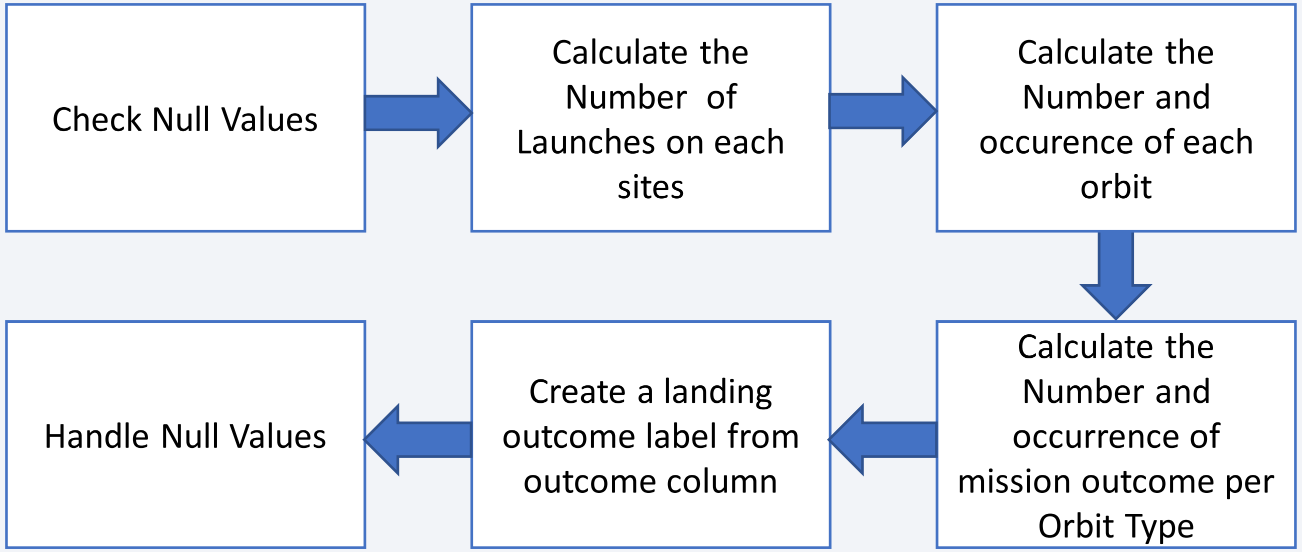
```
df=pd.DataFrame(launch_dict)
```

8. Dataframe to .CSV

```
df.to_csv('spacex_web_scraped.csv', index=False)
```

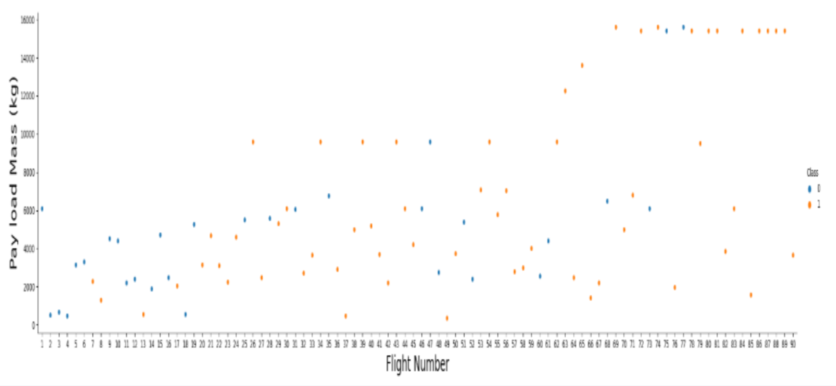
Data Wrangling

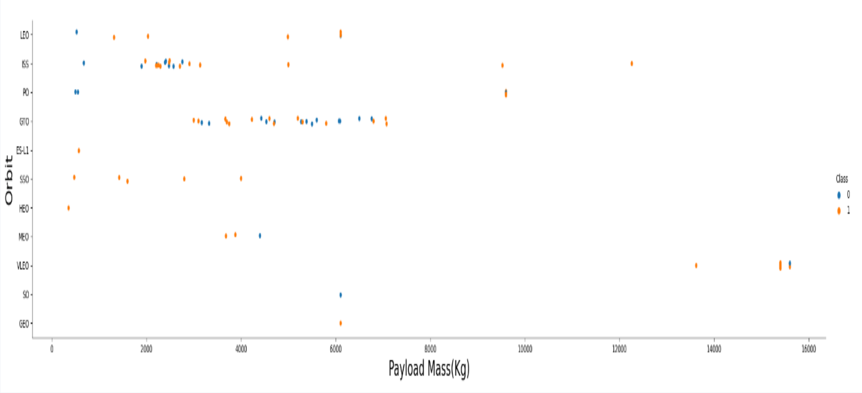
EDA Analysis

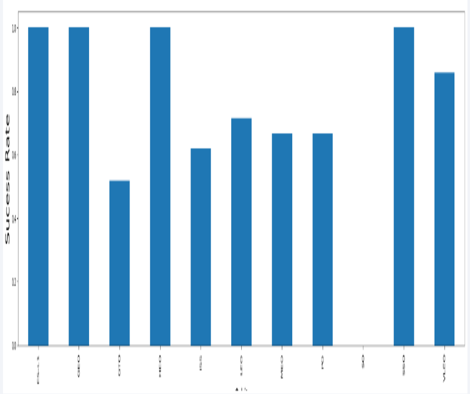


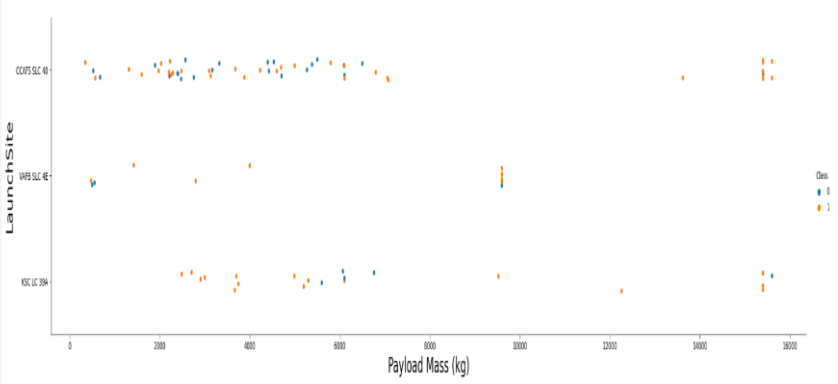
URL: https://github.com/ericjohn05/testrepo/blob/master/labs-jupyter-spacex-Data%20wrangling.ipynb

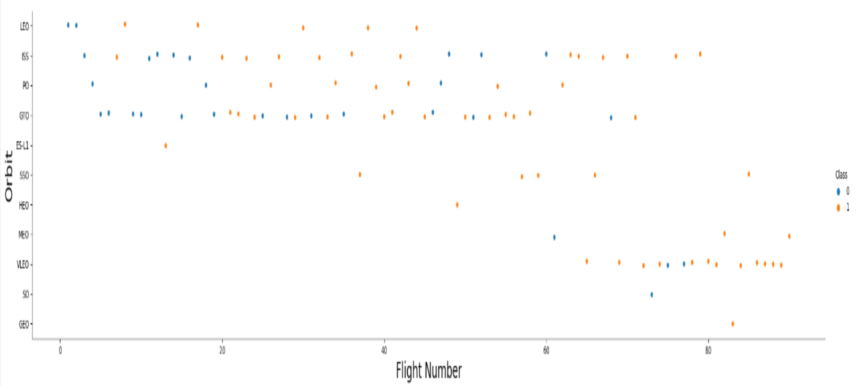
EDA with Data Visualization

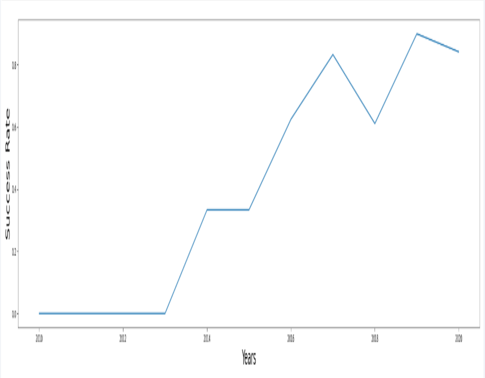












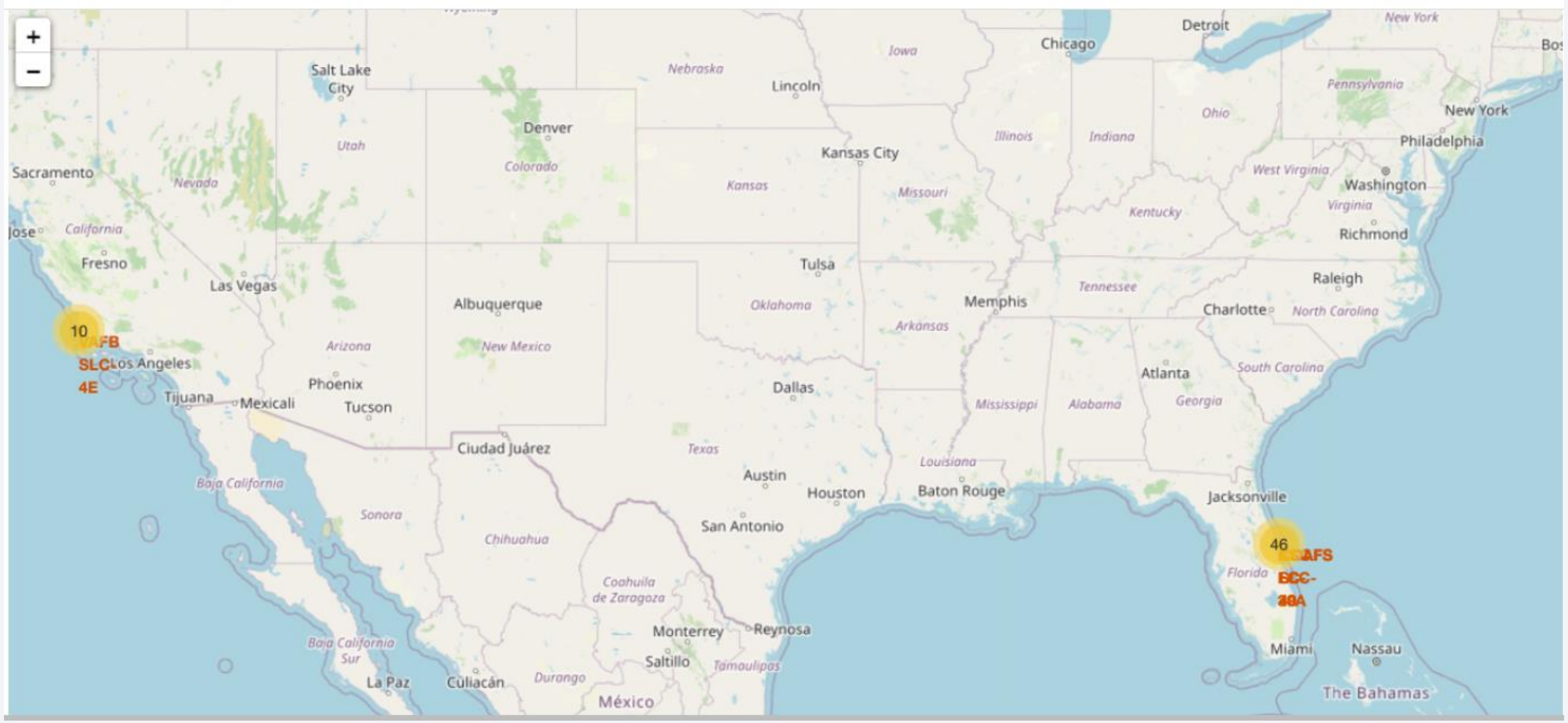
URL: https://github.com/ericjohn05/testrepo/blob/master/jupyter-labs-eda-sql-edx%20(1).ipynb

EDA with SQL

- SQL queries performed include:
  - Displaying the names of the unique launch sites in the space mission
  - Displaying 5 records where launch sites begin with the string 'KSC'
  - 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 ground pad and have payload mass greater than 4000 but less than 6000
  - Listing the total number of successful and failure mission outcomes
  - Listing the names of the booster_versions which have carried the maximum payload mass.
  - Listing the records which will display the month names, successful landing_outcomes in ground pad, booster
  - Versions, launch_site for the months in year 2017
  - Ranking the count of successful landing_outcomes between the date 2010 06 04 and 2017 03 20 in descending order.

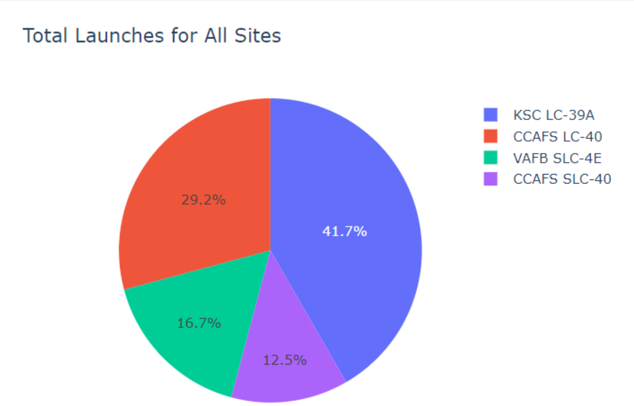
URL: https://github.com/ericjohn05/testrepo/blob/master/jupyter-labs-eda-sql-edx%20(4).ipynb

Build an Interactive Map with Folium

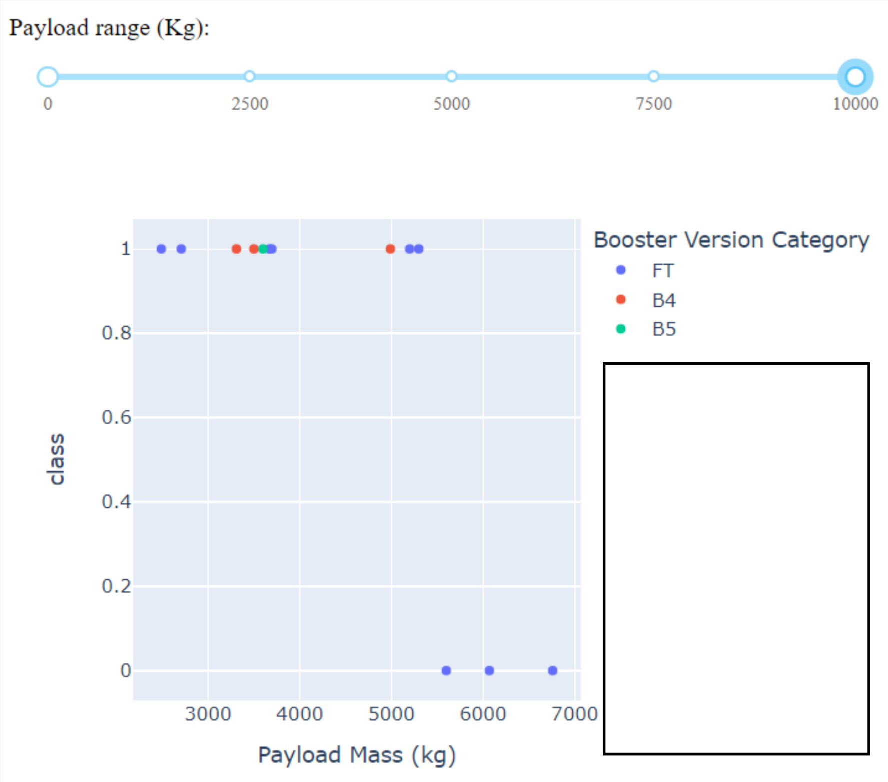


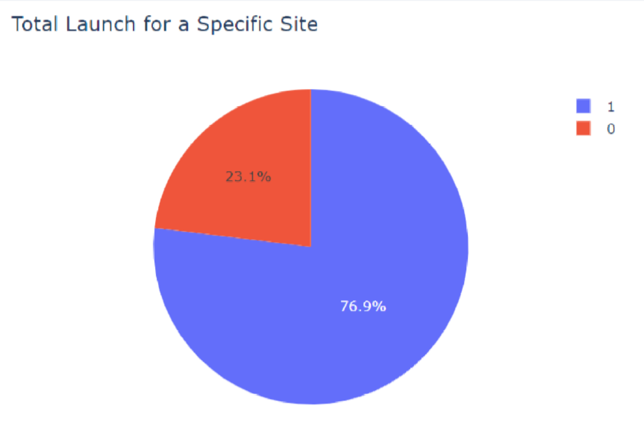
Map marker have been added to the map with aim to finding an optional location for building a launch site
URL: https://github.com/ericjohn05/testrepo/blob/master/IBM-DS0321EN-SkillsNetwork_labs_module_3_lab_jupyter_launch_site_location.jupyterlite%20(1).ipynb

Build a Dashboard with Plotly Dash



We can see that KSC LC-39A had the most successful launches from all the sites



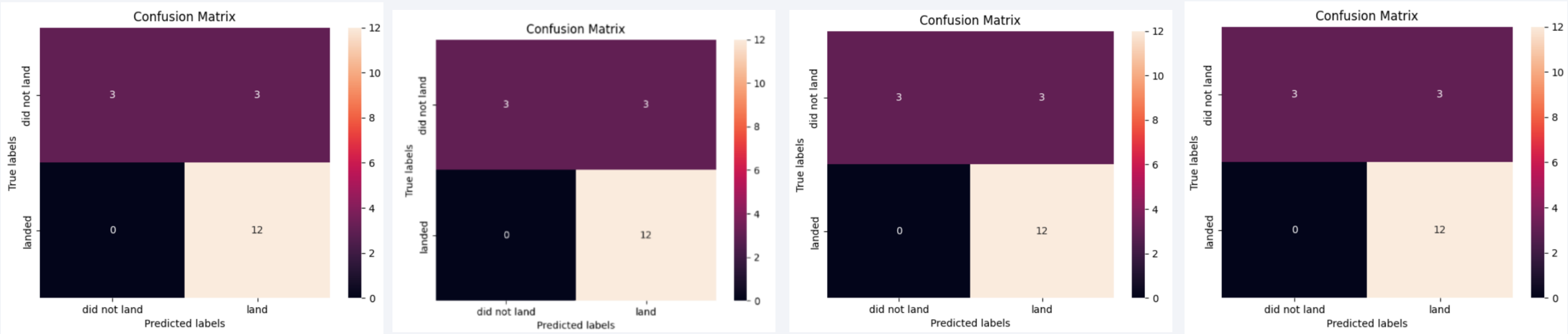


KSC LC-39A achieved a 76.9% success rate while getting a 23.1% failure rate

URL: https://github.com/ericjohn05/testrepo/blob/master/spacex_dash_app%20(1).py

Predictive Analysis (Classification)

- The SVM, KNN, and Logistic Regression model achieved the highest accuracy at 83.3% , while the SVM performs the best in terms of Area Under the Curve at 0.958.



URL: https://github.com/ericjohn05/testrepo/blob/master/IBM-DS0321EN-SkillsNetwork_labs_module_4_SpaceX_Machine_Learning_Prediction_Part_5.jupyterlite.ipynb

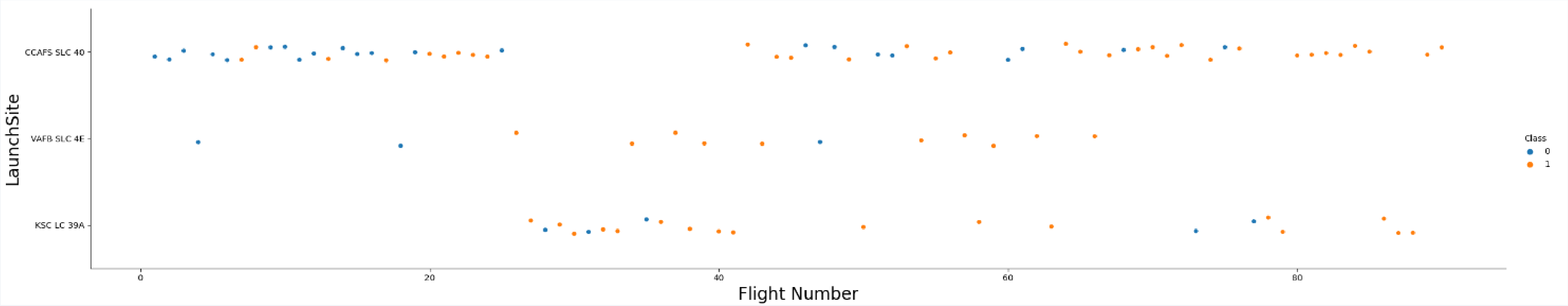
Results

- The SVM, KNN, and Logistic Regression models are the best in terms of prediction accuracy for this dataset.
- Low weighted payloads perform better than the heavier payloads.
- The success rates for SpaceX launches is directly proportional time in years they will eventually perfect the launches.
- KSC LC 39A had the most successful launches from all the sites.
- Orbit GEO,HEO,SSO,ES L1 has the best Success Rate.

Section 2

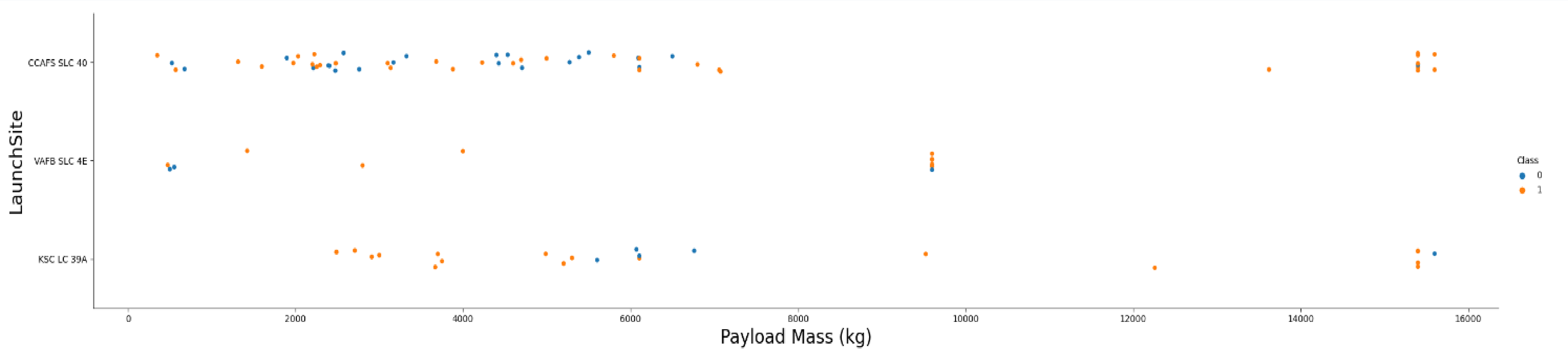
Insights drawn from EDA

Flight Number vs. Launch Site



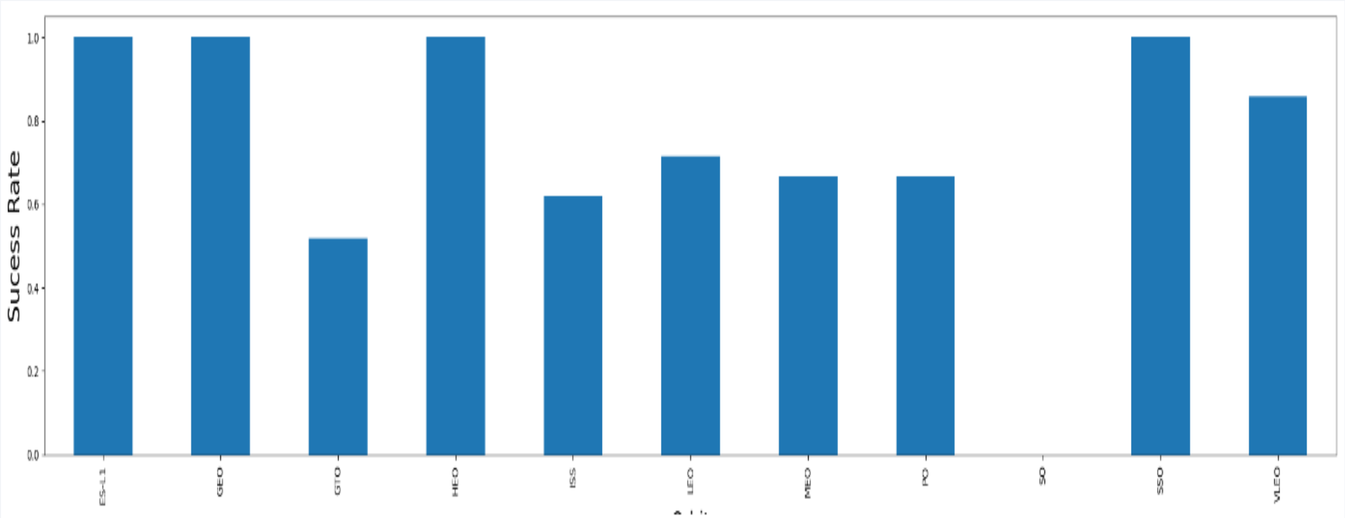
Launches from the site of CCAFS SLC 40 are significantly higher than launches from other sites

Payload vs. Launch Site



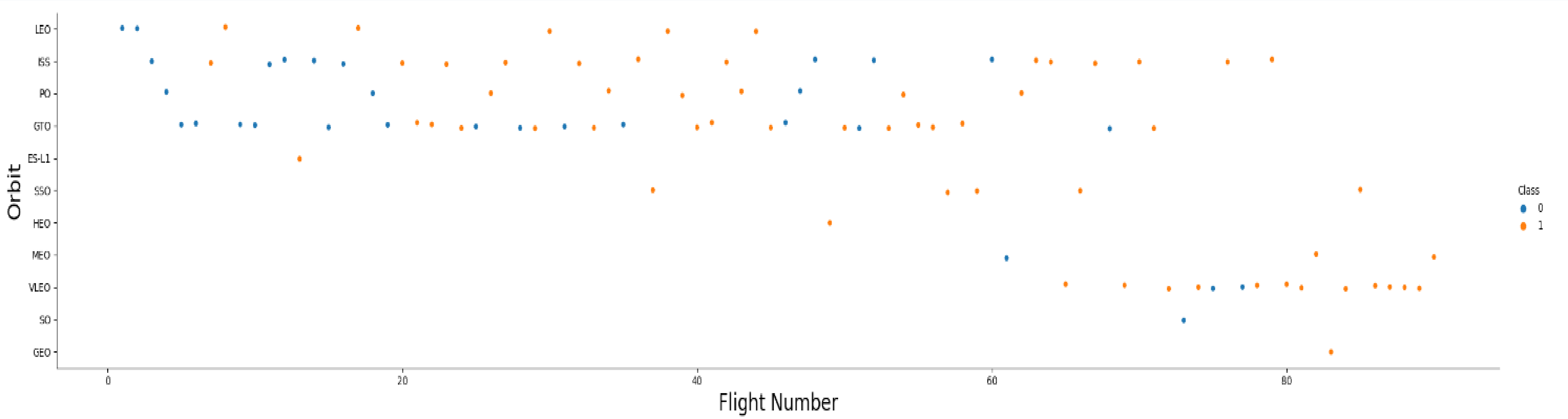
The majority of Pay Load with lower Mass have been launched from CCAFS SLC 40

Success Rate vs. Orbit Type



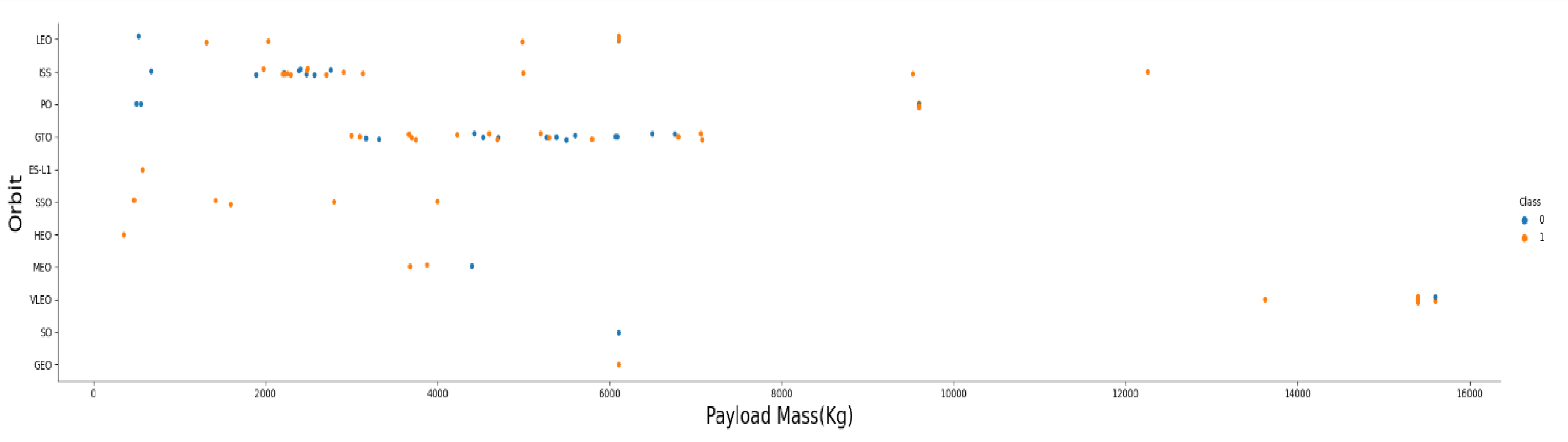
The orbit types of ES-L1, GEO, HEO, SSO are among the highest success rate.

Flight Number vs. Orbit Type



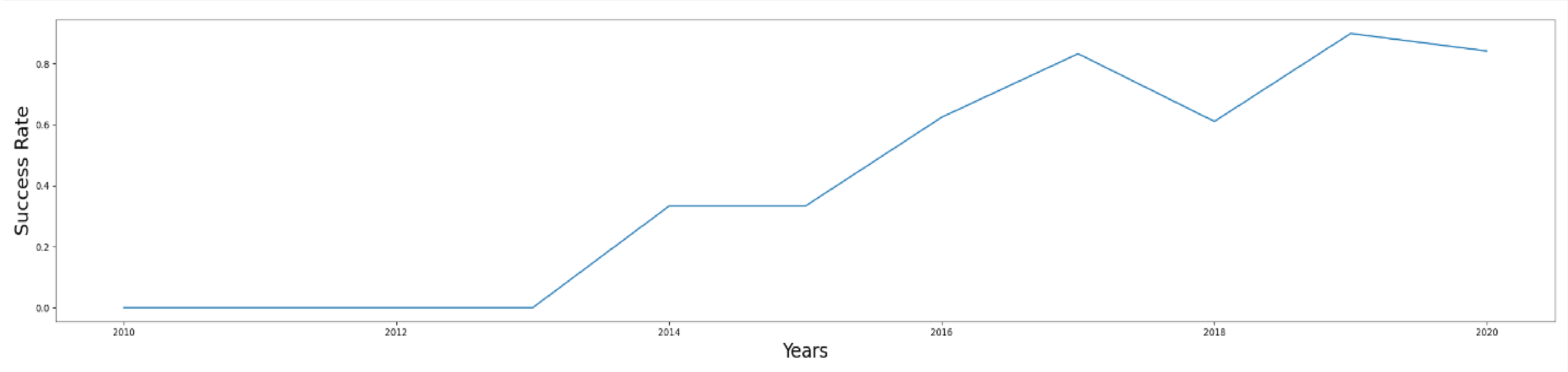
A trend can be observed of shifting to VLEO launches in recent years.

Payload vs. Orbit Type



There are strong correlation between ISS and Payload at the range around 2000, as well as between GTO and the range of 4000-8000.

Launch Success Yearly Trend



Launches success rate has increased significantly since 2013 and has stablised since 2019, potentially due to advance in technology and lesson learned.

All Launch Site Names

%sql select Unique(LAUNCH_SITE) from SPACEXTBL

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

Launch Site Names Begin with 'KSC'

%sql SELECT * from SPACEXTBL where (LAUNCH_SITE) LIKE 'KSC%' LIMIT 5

id	DATE	time__utc_	booster_version	launch_site	payload	payload_mass__kg_	orbit	customer	mission_outcome	landing__outcome
30	2019-02-20	14:39:00	F9 FT B1031.1	KSC LC-39A	SpaceX CRS-10	2490	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
31	2016-03-20	06:00:00	F9 FT B1030	KSC LC-39A	EchoStar 23	5600	GTO	EchoStar	Success	No attempt
32	2030-03-20	22:27:00	F9 FT B1021.2	KSC LC-39A	SES-10	5300	GTO	SES	Success	Success (drone ship)
33	2001-05-20	11:15:00	F9 FT B1032.1	KSC LC-39A	NROL-76	5300	LEO	NRO	Success	Success (ground pad)
34	2015-05-20	23:21:00	F9 FT B1034	KSC LC-39A	Inmarsat-5 F4	6070	GTO	Inmarsat	Success	No attempt

Total Payload Mass

```
%sql select sum(PAYLOAD_MASS__KG_) as payloadmass from SPACEXTBL
```

payloadmass
45596

Average Payload Mass by F9 v1.1

```
%sql select avg(PAYLOAD_MASS__KG_) as payloadmass from SPACEXTBL
WHERE BOOSTER_VERSION = 'F9 v1.1’
```

payloadmass
2928

First Successful Ground Landing Date

%sql select min(DATE) from SPACEXTBL WHERE Landing__Outcome = 'Success (ground pad)’

1
2001-05-20

Successful Drone Ship Landing with Payload between 4000 and 6000

%sql select BOOSTER_VERSION from SPACEXTBL where LANDING__OUTCOME='Success (drone ship)' and PAYLOAD_MASS__KG_ BETWEEN 4000 and 6000

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

Total Number of Successful and Failure Mission Outcomes

%sql select count(MISSION_OUTCOME) as missionoutcomes from SPACEXTBL WHERE MISSION_OUTCOME = 'Success' or MISSION_OUTCOME = 'Failure (in flight)’

missionoutcomes
100

Boosters Carried Maximum Payload

%sql select BOOSTER_VERSION as boosterversion from SPACEXTBL where PAYLOAD_MASS__KG_=(select max(PAYLOAD_MASS__KG_) from SPACEXTBL)

boosterversion
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

2015 Launch Records

%sql SELECT * FROM SPACEXTBL WHERE Landing__Outcome like ‘Success%’ and (DATE between ‘2015-01-01’ and ‘2015-12-31’ Order By DATE Desc;

time__utc_	booster_version	launch_site	payload	payload_mass__kg_	orbit	customer	mission_outcome	landing__outcome
14:39:00	F9 FT B1031.1	KSC LC-39A	SpaceX CRS-10	2490	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
17:54:00	F9 FT B1029.1	VAFB SLC-4E	Iridium NEXT 1	9600	Polar LEO	Iridium Communications	Success	Success (drone ship)
05:26:00	F9 FT B1026	CCAFS LC-40	JCSAT-16	4600	GTO	SKY Perfect JSAT Group	Success	Success (drone ship)
04:45:00	F9 FT B1025.1	CCAFS LC-40	SpaceX CRS-9	2257	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
21:39:00	F9 FT B1023.1	CCAFS LC-40	Thaicom 8	3100	GTO	Thaicom	Success	Success (drone ship)
		CCAFS LC-				SKY Perfect JSAT		

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

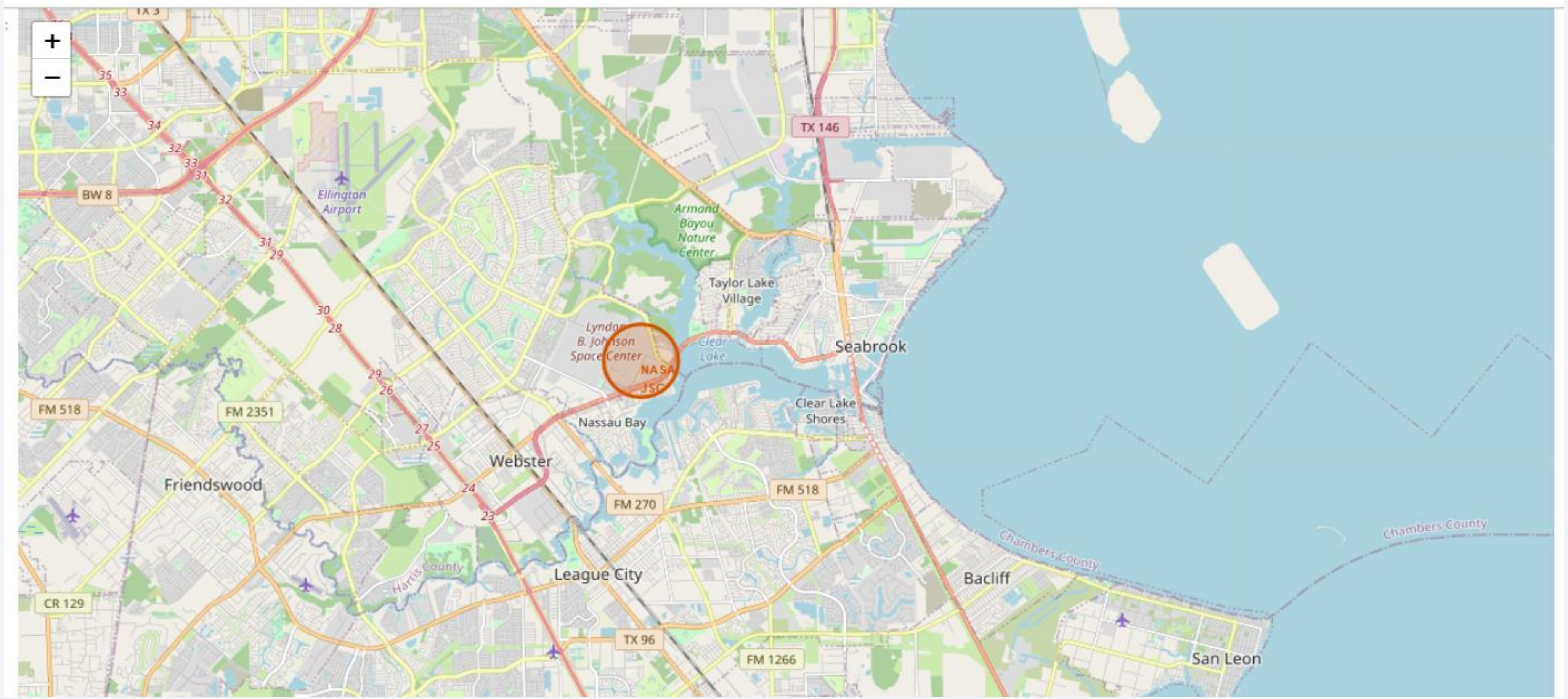
%sql SELECT * FROM SPACEX WHERE Landing__Outcome Like 'Success%' and (DATE BETWEEN '2010-06-04' AND '2017-03-20') ORDER BY date DESC;

2016-05-27	21:39:00	F9 FT B1023.1	CCAFS LC-40	Thaicom 8	3100	GTO	Thaicom	Success	Success (drone ship)
2016-05-06	05:21:00	F9 FT B1022	CCAFS LC-40	JCSAT-14	4696	GTO	SKY Perfect JSAT Group	Success	Success (drone ship)
2016-04-08	20:43:00	F9 FT B1021.1	CCAFS LC-40	SpaceX CRS-8	3136	LEO (ISS)	NASA (CRS)	Success	Success (drone ship)
2015-12-22	01:29:00	F9 FT B1019	CCAFS LC-40	OG2 Mission 2 11 Orbcomm-OG2 satellites	2034	LEO	Orbcomm	Success	Success (ground pad)

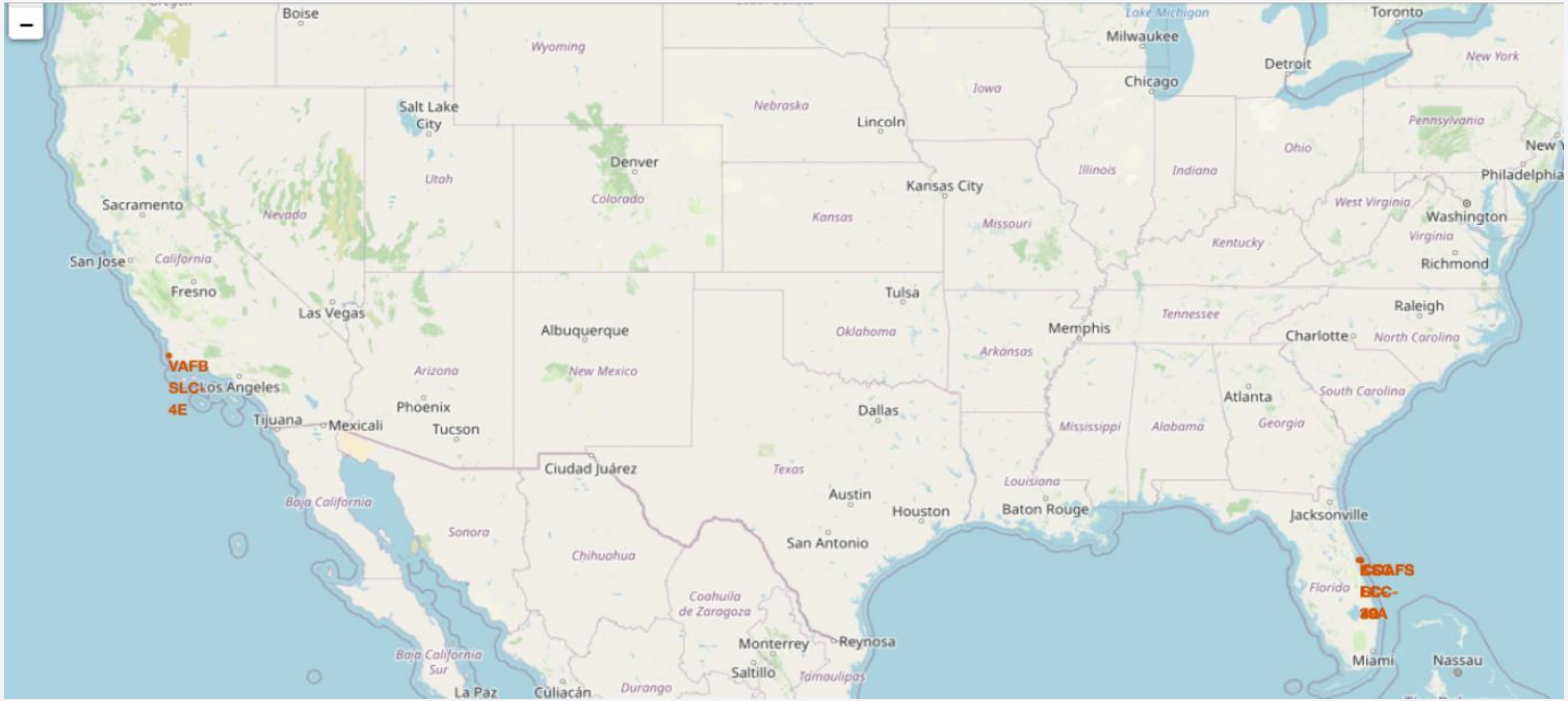
Section 3

Launch Sites Proximities Analysis

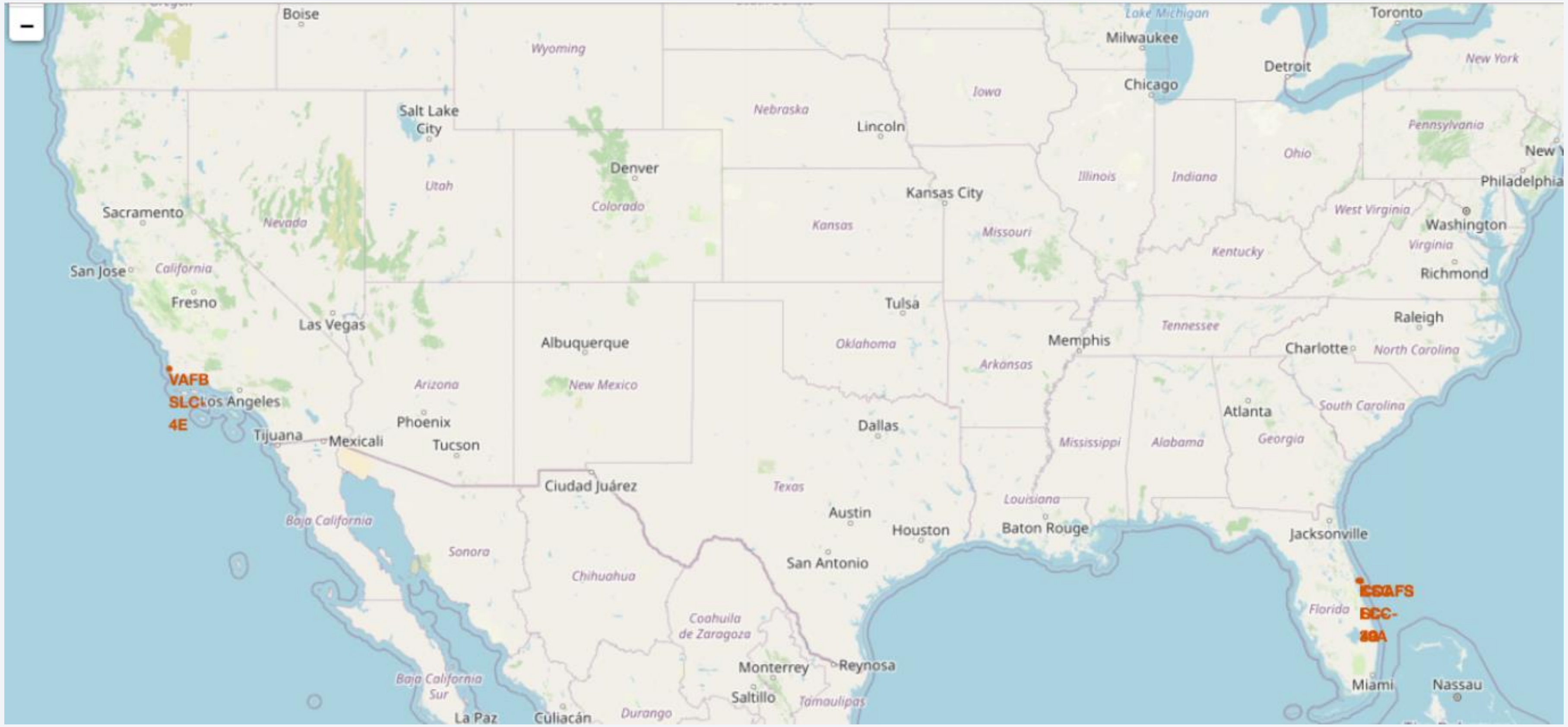
All launch sites marked on a map



Success/Failed Launches marked on the Map



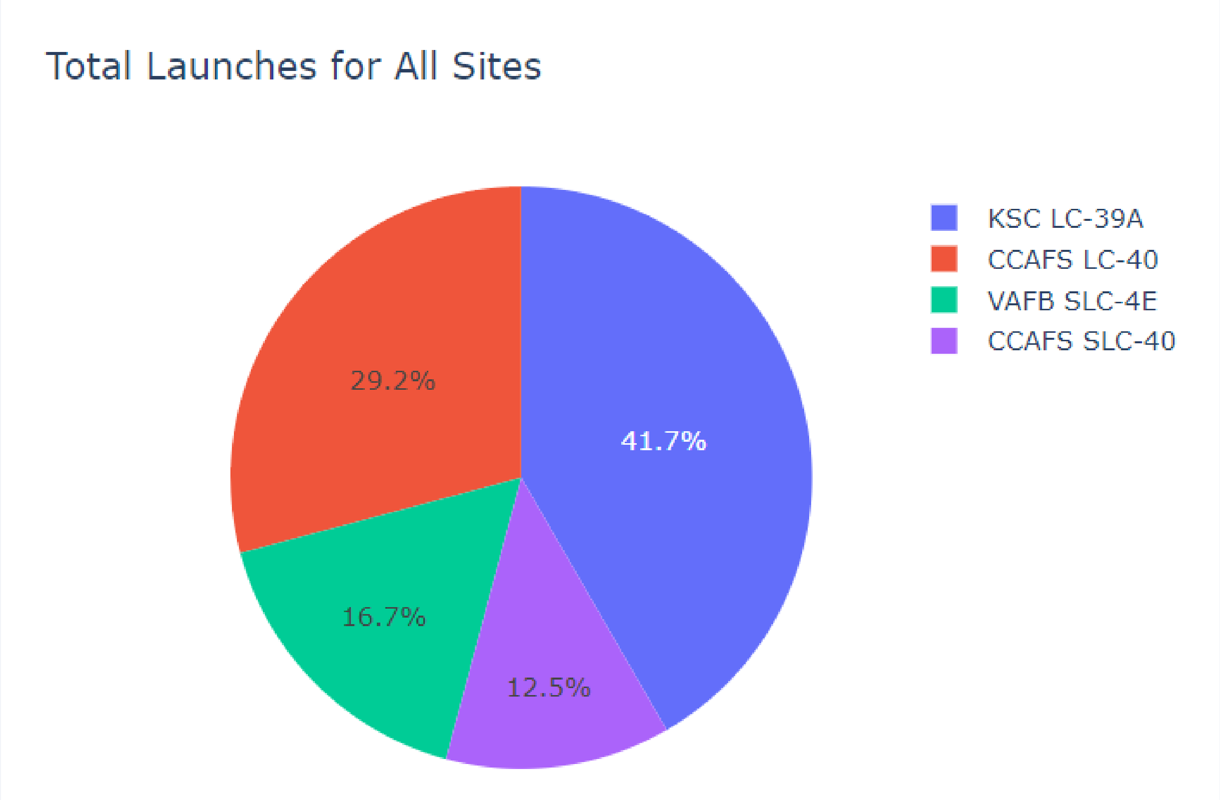
Distance between a launch site to its Proximities



Section 4

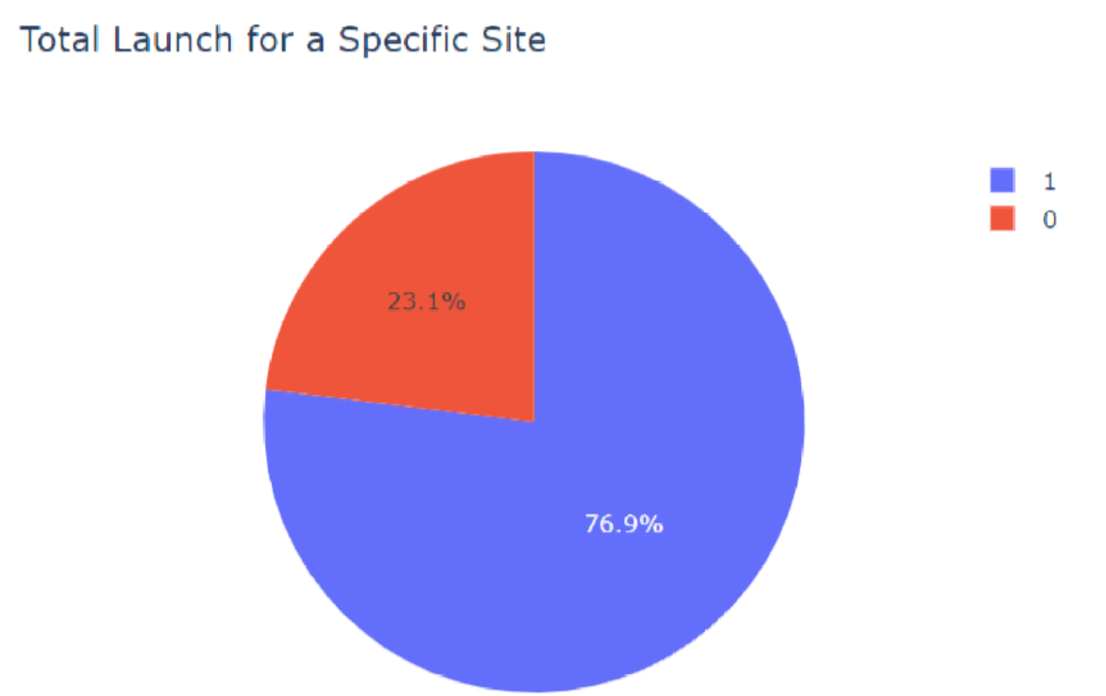
Build a Dashboard with Plotly Dash

Total Success Launches by all Sites



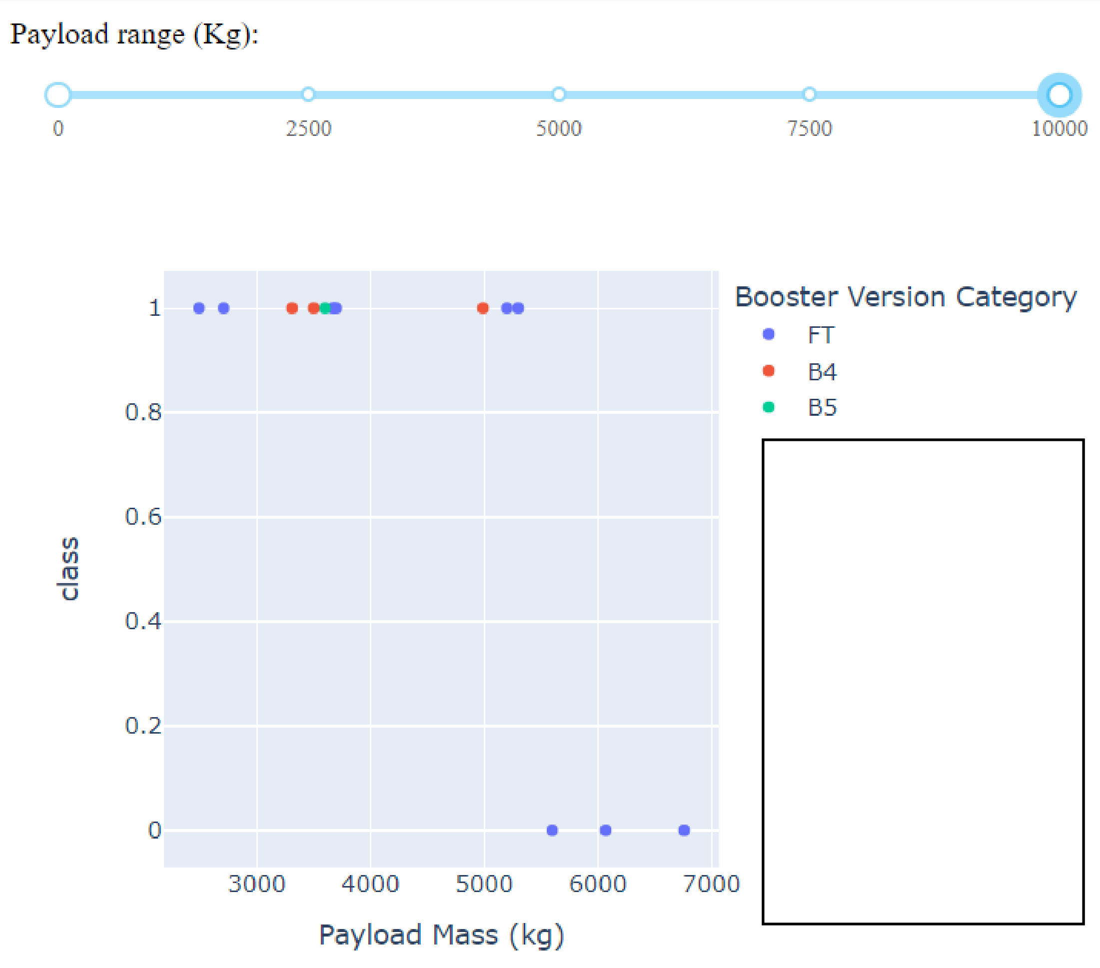
We can see that KSC LC-39A had the most successful launches from all the sites

Success Rate by Site



KSC LC-39A achieved a 76.9% success rate while getting a 23.1% failure rate

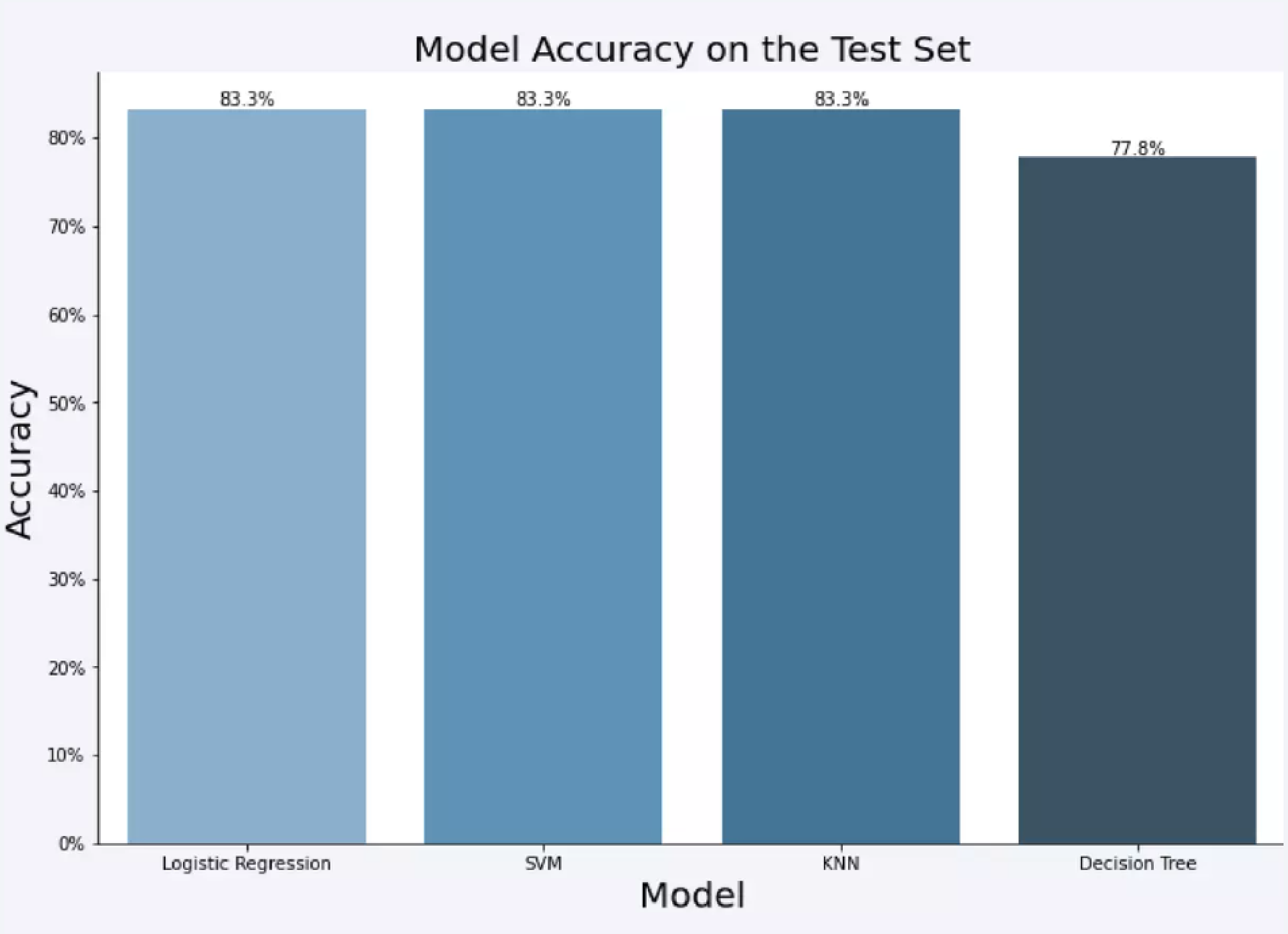
Payload


Payload range (Kg):
0
2500
5000
7500
10000
class
1
0.8
0.6
0.4
0.2
0
3000
4000
5000
6000
7000
Payload Mass (kg)
Booster Version Category
FT
B4
B5

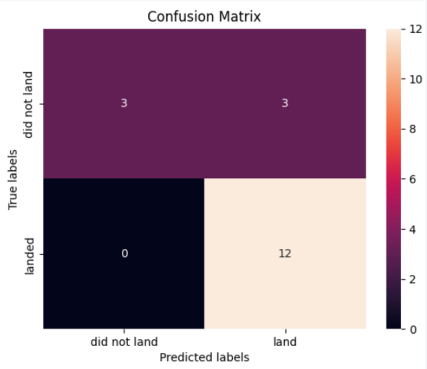
Section 5

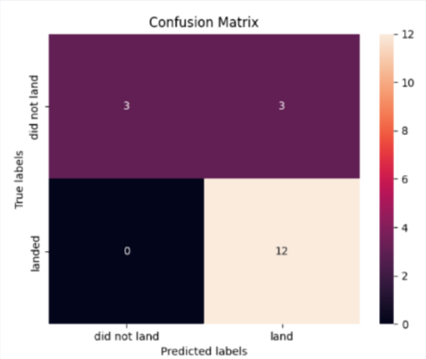
Predictive Analysis (Classification)

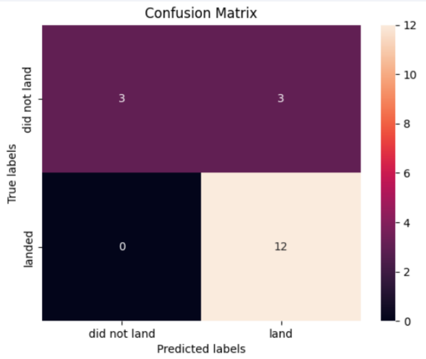
Classification Accuracy

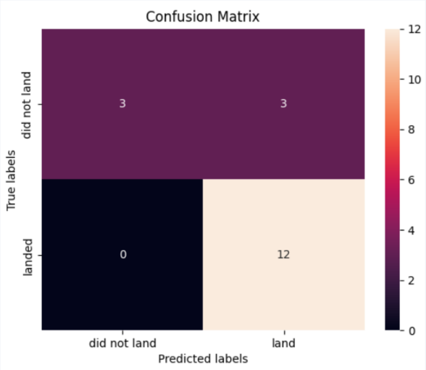


Confusion Matrix









Conclusions

- The SVM, KNN, and Logistic Regression models are the best in terms of prediction accuracy for this dataset.
- Low weighted payloads perform better than the heavier payloads.
- The success rates for SpaceX launches is directly proportional time in years they will eventually perfect the launches.
- KSC LC 39A had the most successful launches from all the sites.
- Orbit GEO,HEO,SSO,ES L1 has the best Success Rate.

Thank you!