IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

Nilesh Bharwad

January 24th 2025

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 Analytics
  - Predictive Analysis

Introduction

- Project background and context
  - SpaceX advertise Falcon 9 rocket launches on the website, with a cost of 62 million dollars; other provides cost upward of 165 million dollars each, much of the saving is due to reusable rockets in the first stage of launch.
- Problems you want to find answers
  - The project task is to predict weather the first stage of each launch of Falcon 9 rocket will land successfully or not.

Section 1

Methodology

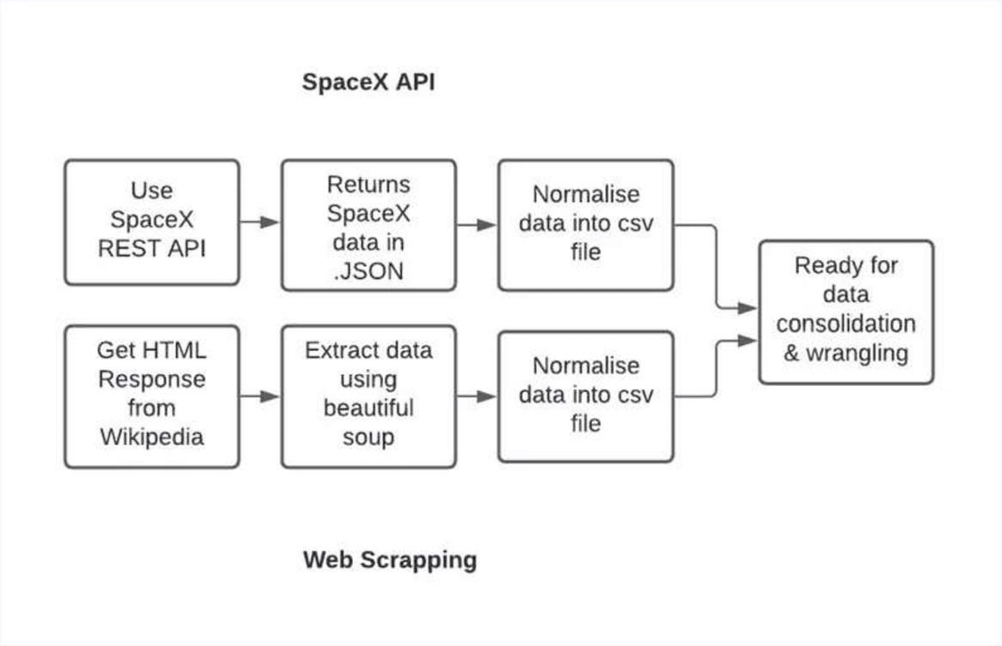
Methodology

Executive Summary

- Data collection methodology:
    - SpaceX Rest API
    - Web Scrapping from Wikipedia
- Perform data wrangling
    - One Hot Encoding data fields for Machine Learning data cleaning 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 and DT models have been built and evaluated for the best classifier

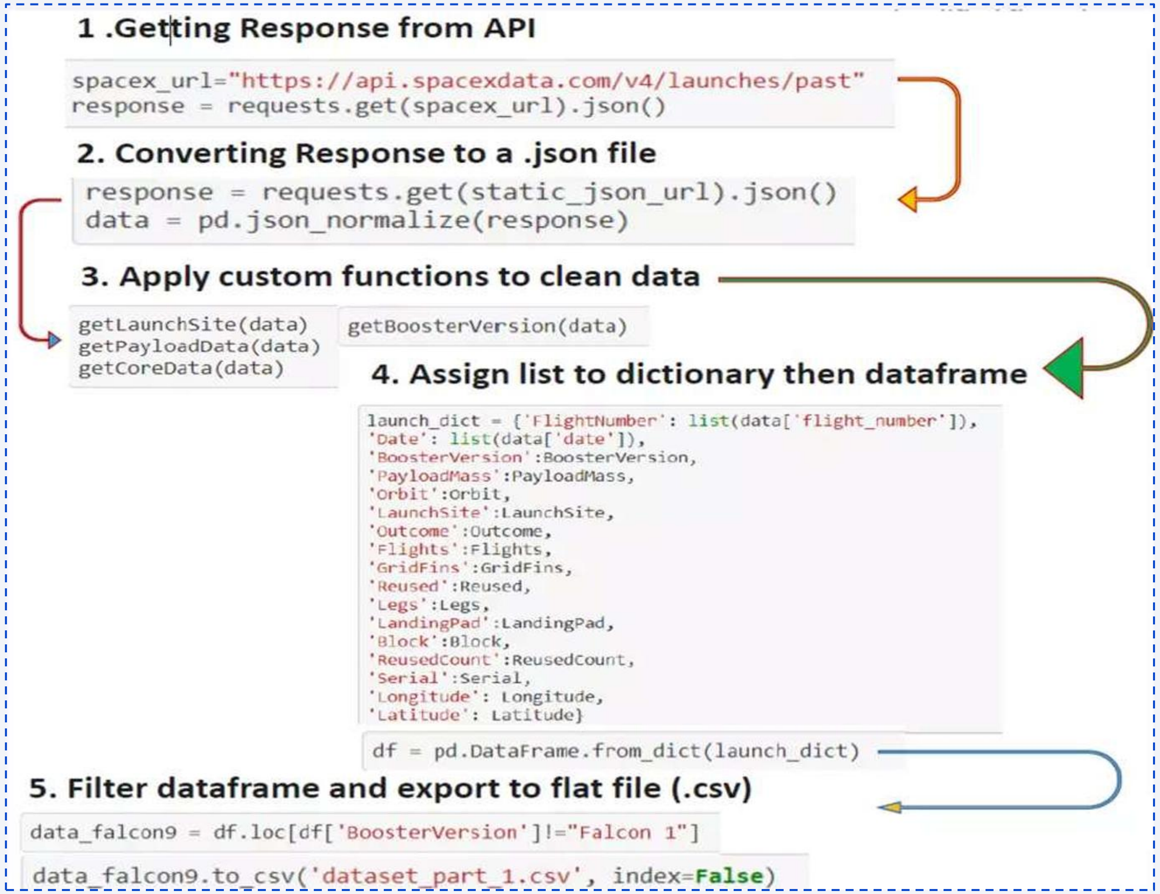
Data Collection

- The Following datasets were 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 outcomes.
  - The SpaceX REST APO endpoints, or URLs, starts with api.spacexdata.com/v4/.
  - Another Popular data course for obtaining Falcon 9 launch data is web scrapping from www.Wikipedia.com using BeautifulSoup method.



Data Collection – SpaceX API

- Data Collection with SpaceX Rest API calls.

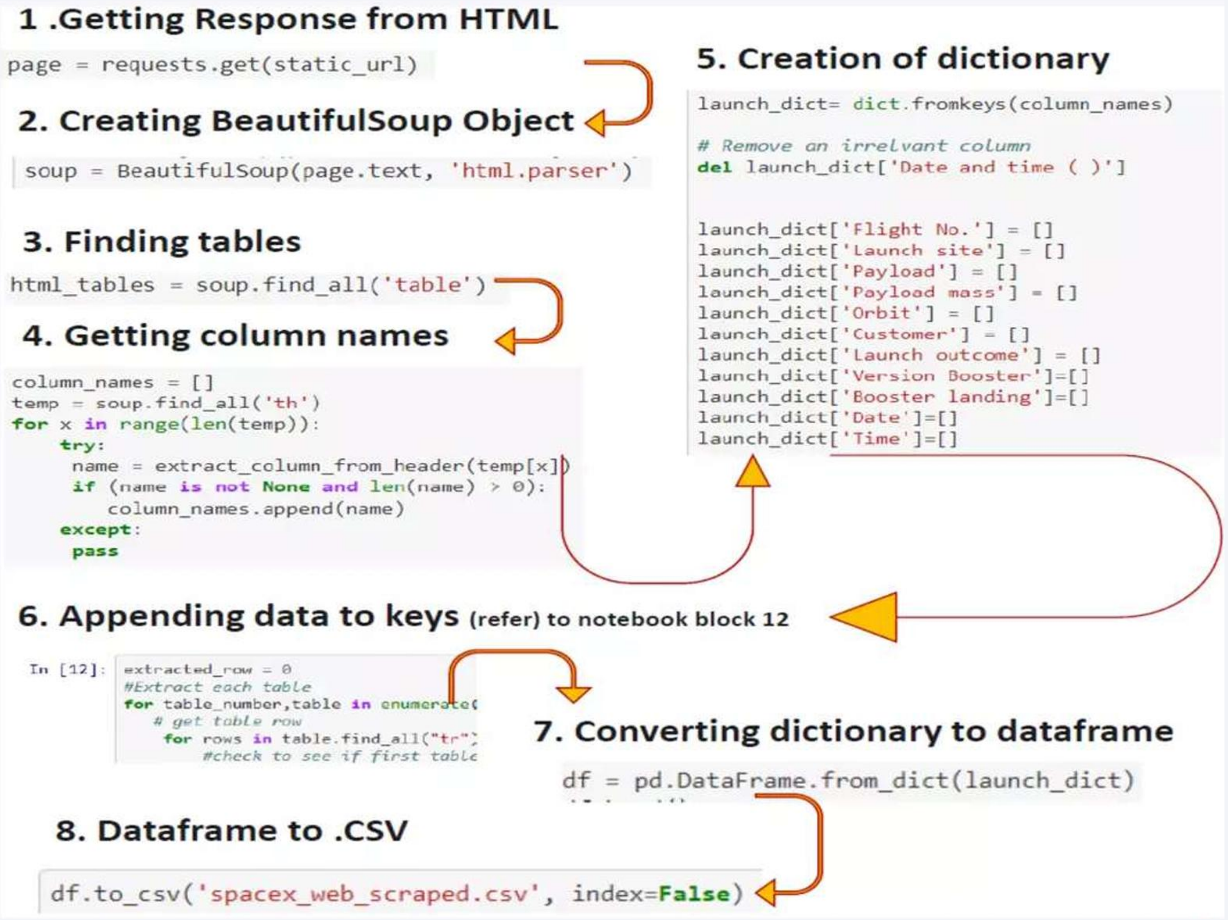


- nbharwad/IBM_Data_Science_Certificate: IBM Data Science Certificate.

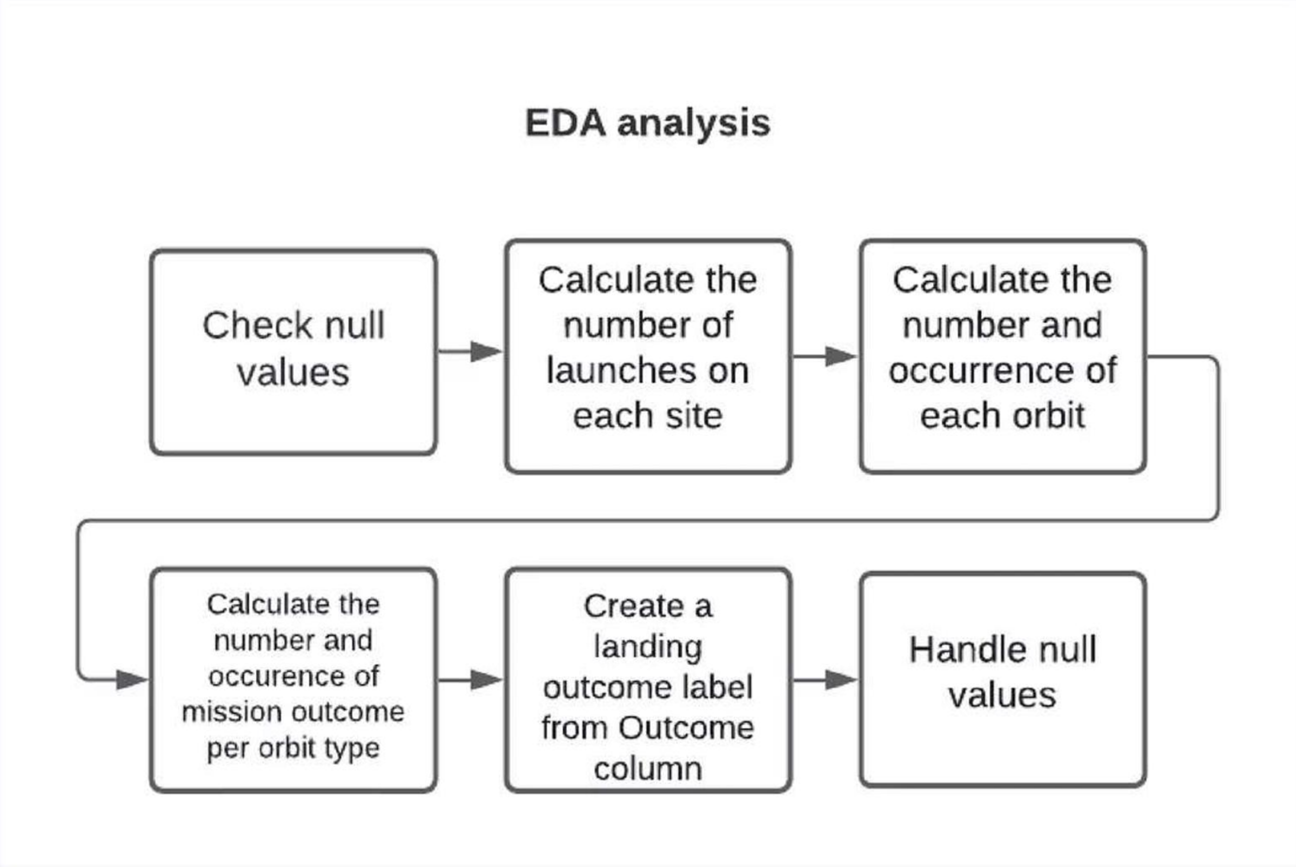
Data Collection - Scraping

- Web Scrapping from Wikipedia

- [IBM_Data_Science_Certificate/jupyter-labs-webscraping.ipynb at main · nbharwad/IBM_Data_Science_Certificate]

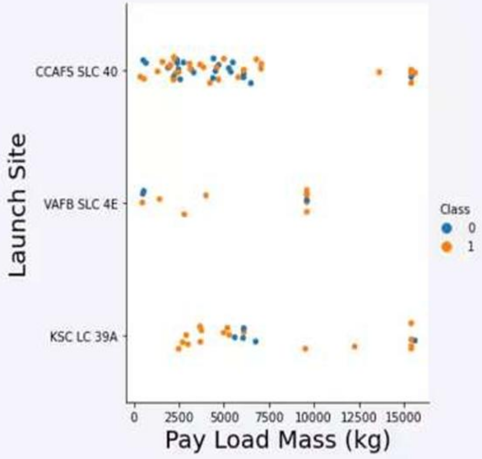


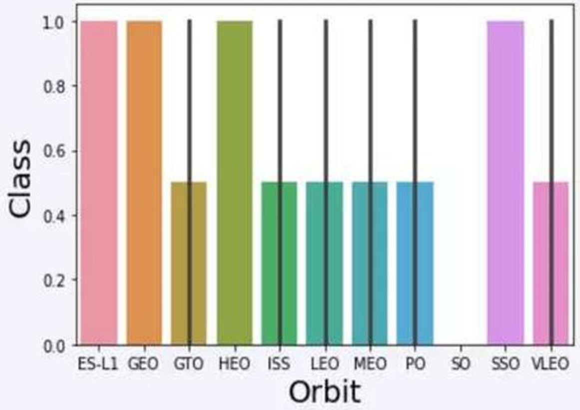
Data Wrangling

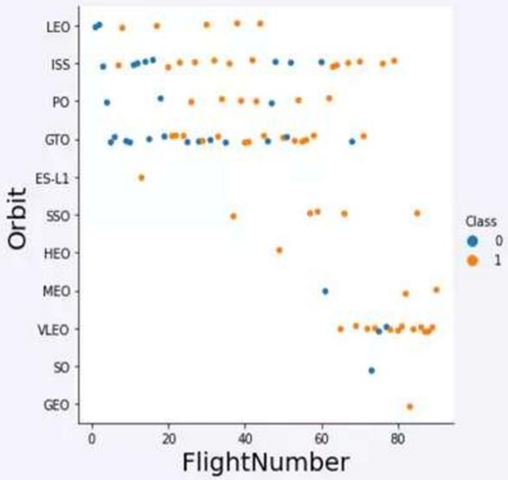


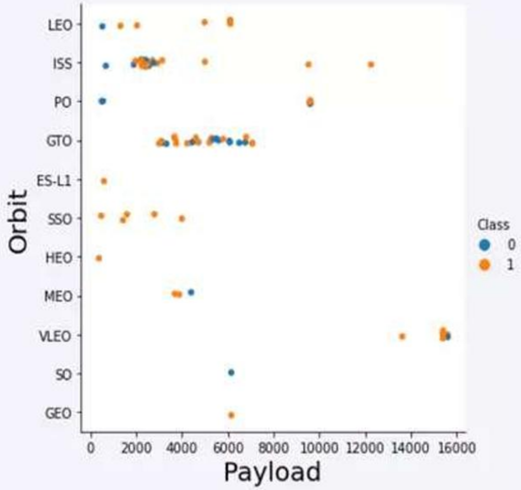
[IBM_Data_Science_Certificate/labs-jupyter-spacex-Data wrangling.ipynb at main · nbharwad/IBM_Data_Science_Certificate]

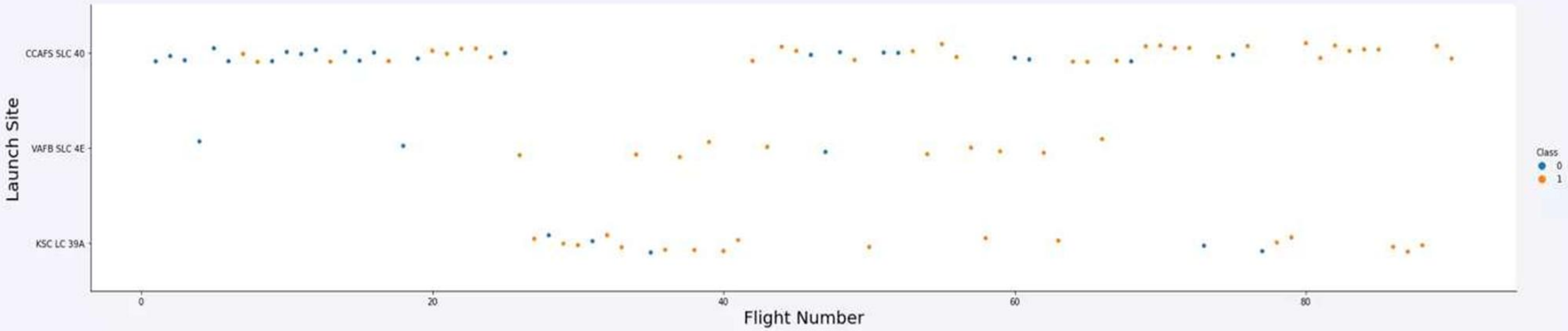
EDA with Data Visualization

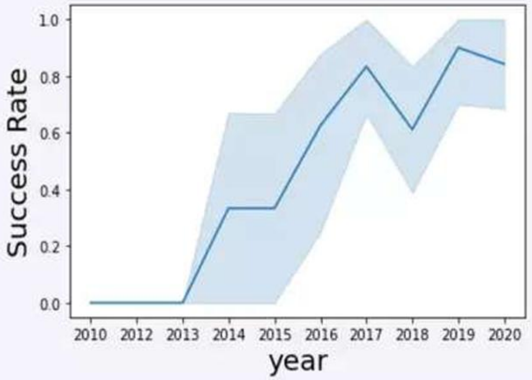










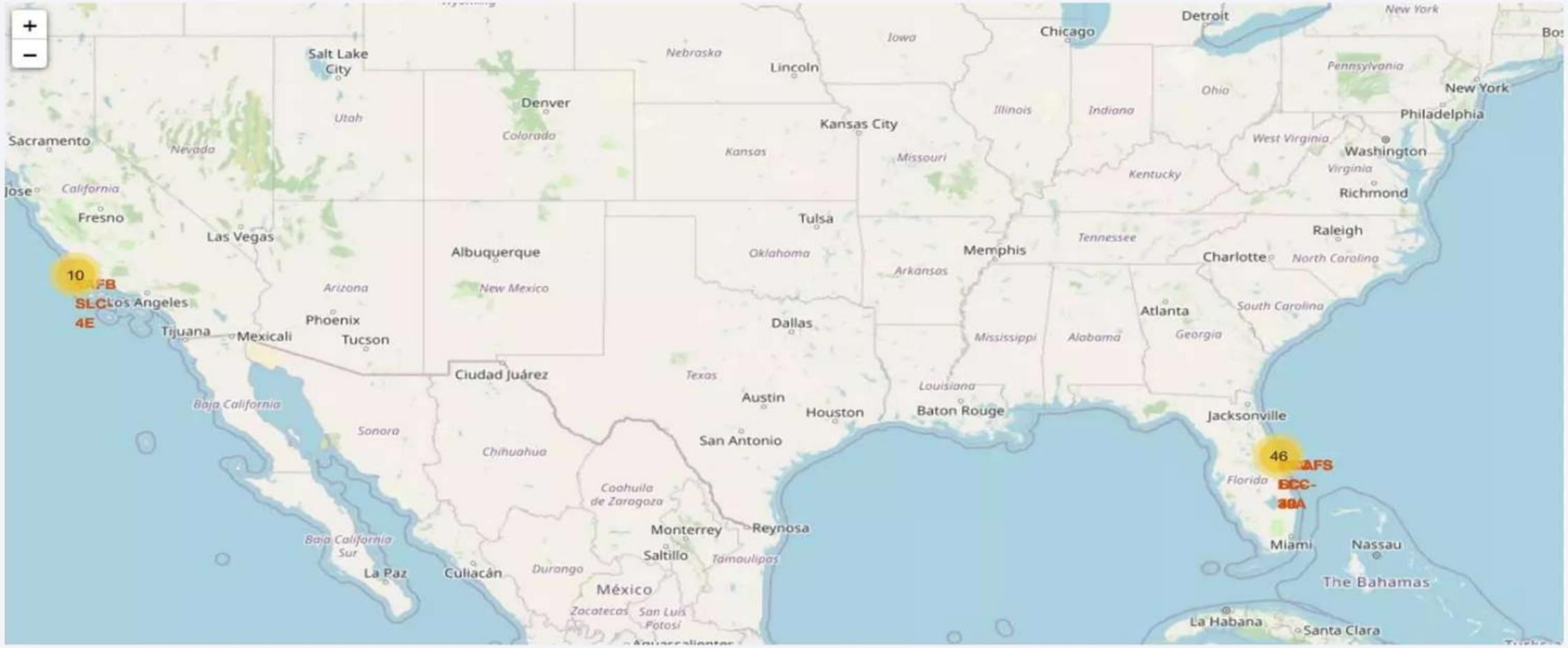


- [nbharwad/IBM_Data_Science_Certificate: IBM Data Science Certificate.]

EDA with SQL

- 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 between 4,000 and6,000
- Listing the total number of successful and failure mission outcomes
- Listing the names of the booster_versions which have carried the max. payload mass.
- Listing the records which will display the month names, successful landing outcomes in ground pad, booster versions, lannch site for the months in year 2017
- Ranking the count of successful landing outcomes between the dates 2010 and 2017.
- Link: IBM_Data_Science_Certificate/jupyter-labs-eda-sql-coursera_sqllite.ipynb at main · nbharwad/IBM_Data_Science_Certificate

Build an Interactive Map with Folium

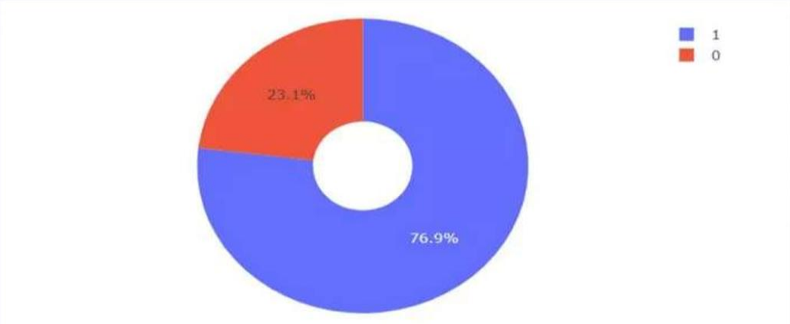


Map Markers have been added to the map with aim to finding an optimal location for building a launch site.

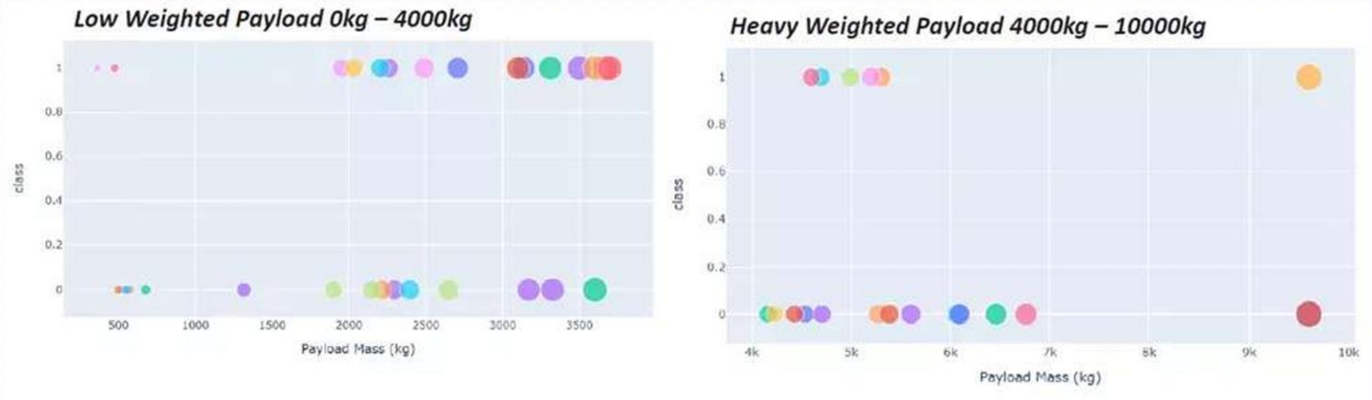
[IBM_Data_Science_Certificate/Interactive Visual Analytics with Folium.ipynb at main · nbharwad/IBM_Data_Science_Certificate]

Build a Dashboard with Plotly Dash

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



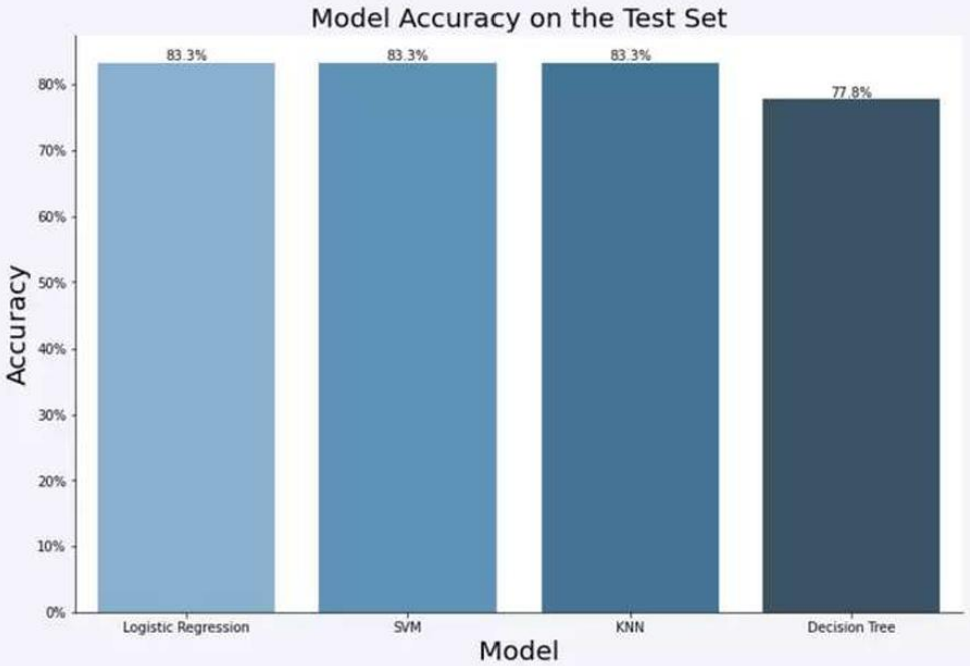
KSC LC-39A achieved a 76.9% success rate while getting a 23.1% failure rate

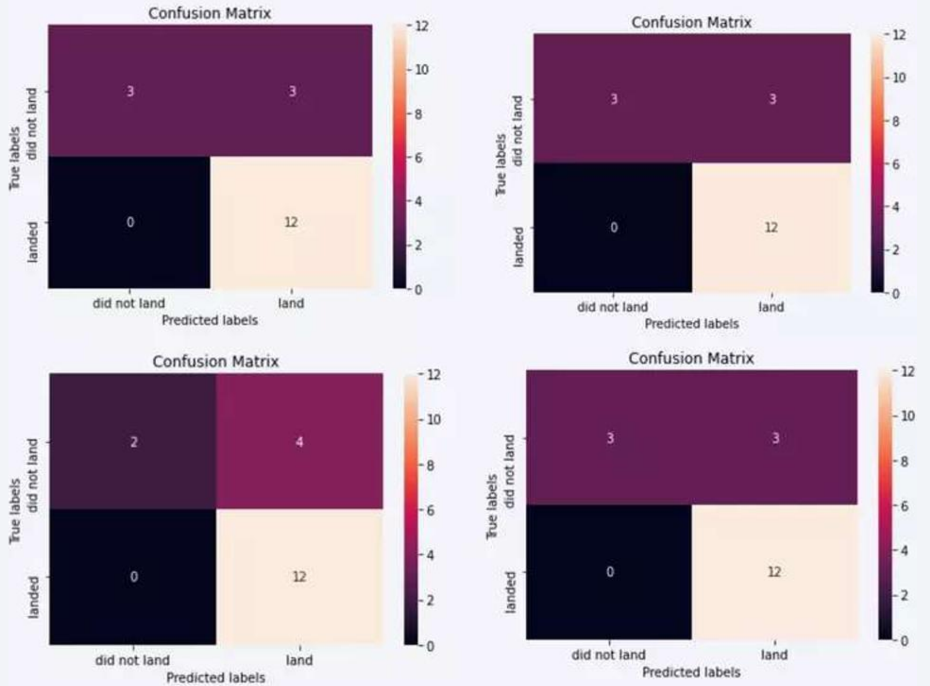


We can see the success rates for low weighted payloads is higher than the heavy weighted payloads

Predictive Analysis (Classification)

- The SVM, KNN, and LR model achieved the highest accuracy i.e. 83.3%, while the SVM performs the best in terms of Area Under the curve at 0.958





[IBM_Data_Science_Certificate/Machine Learning Prediction.ipynb at main · nbharwad/IBM_Data_Science_Certificate]

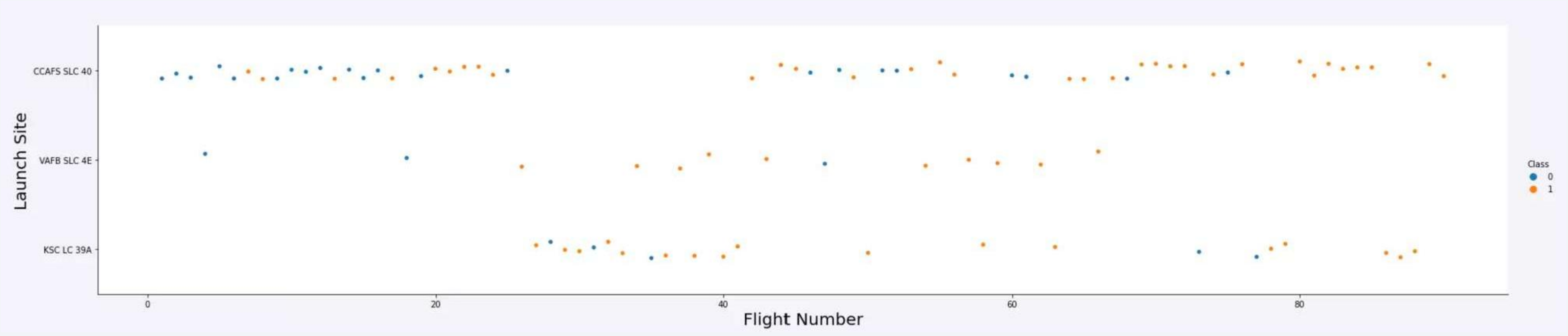
Results

- The SVM, KNN and LR models are the best in terms of prediction accuracy for this dataset.
- Low weighted payloads performs better than the heavier payloads
- The success rates for SPACEX launches is directly proportional time in years they will eventually perform 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

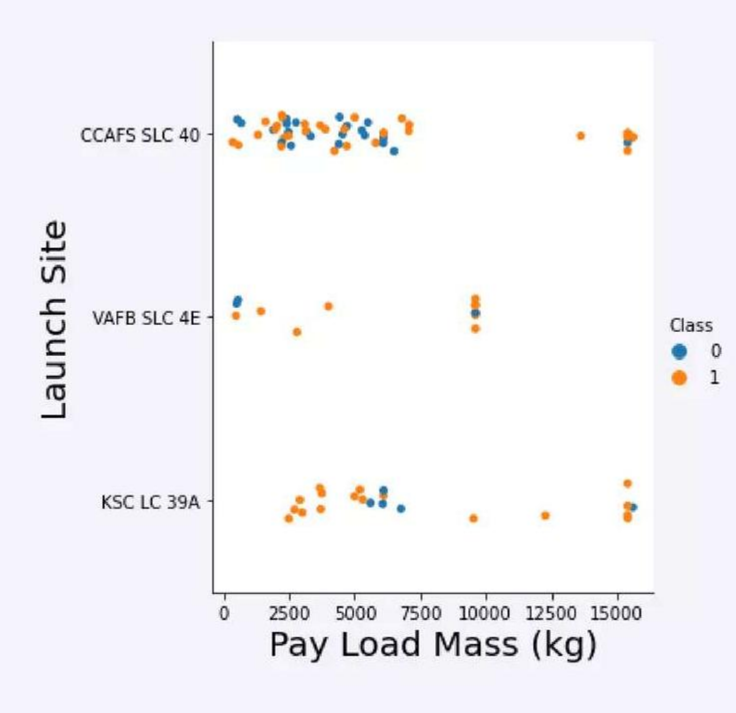
Flight Number vs. Launch Site



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

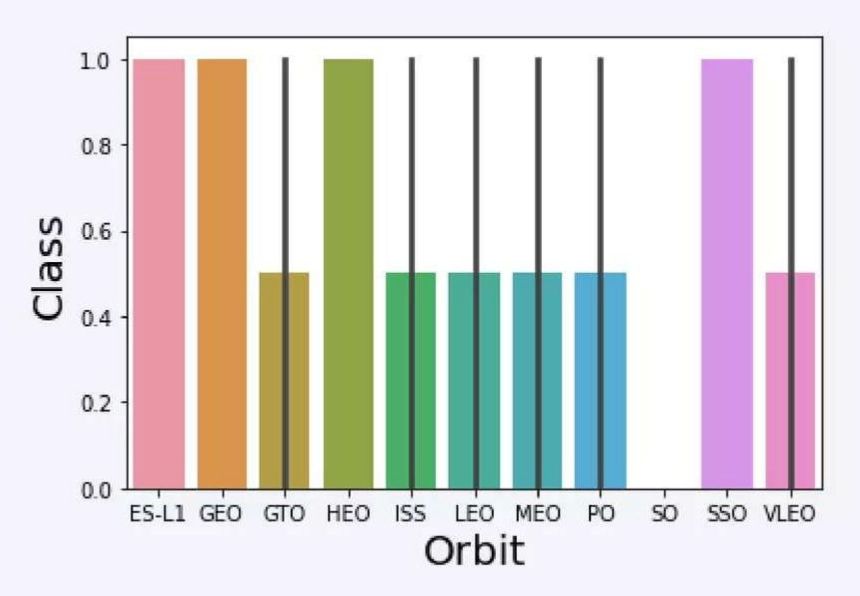
Payload vs. Launch Site

- The Majority of payloads with lower Mass have been launched from CCAFS SLC 40.



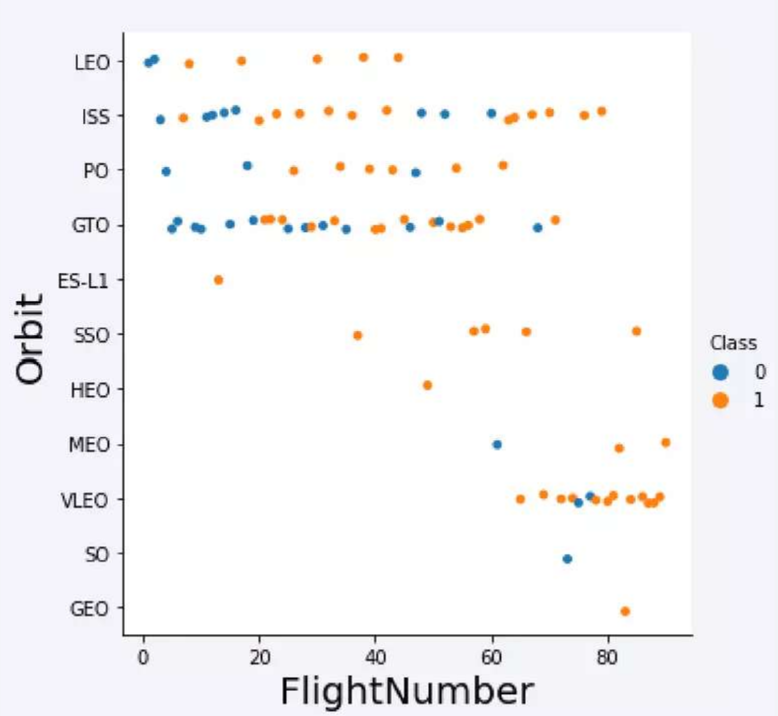
Success Rate vs. Orbit Type

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



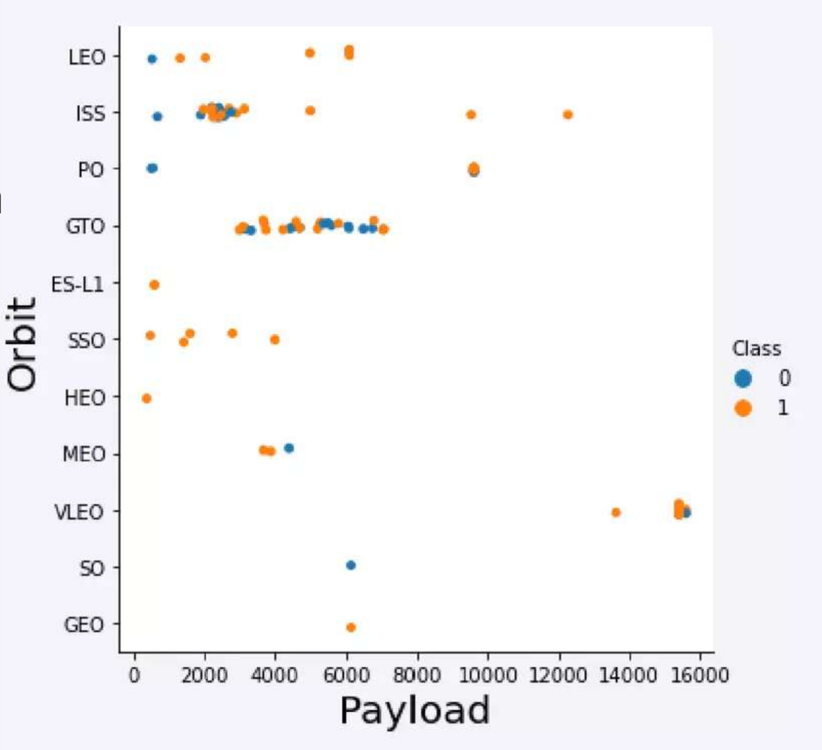
Flight Number vs. Orbit Type

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



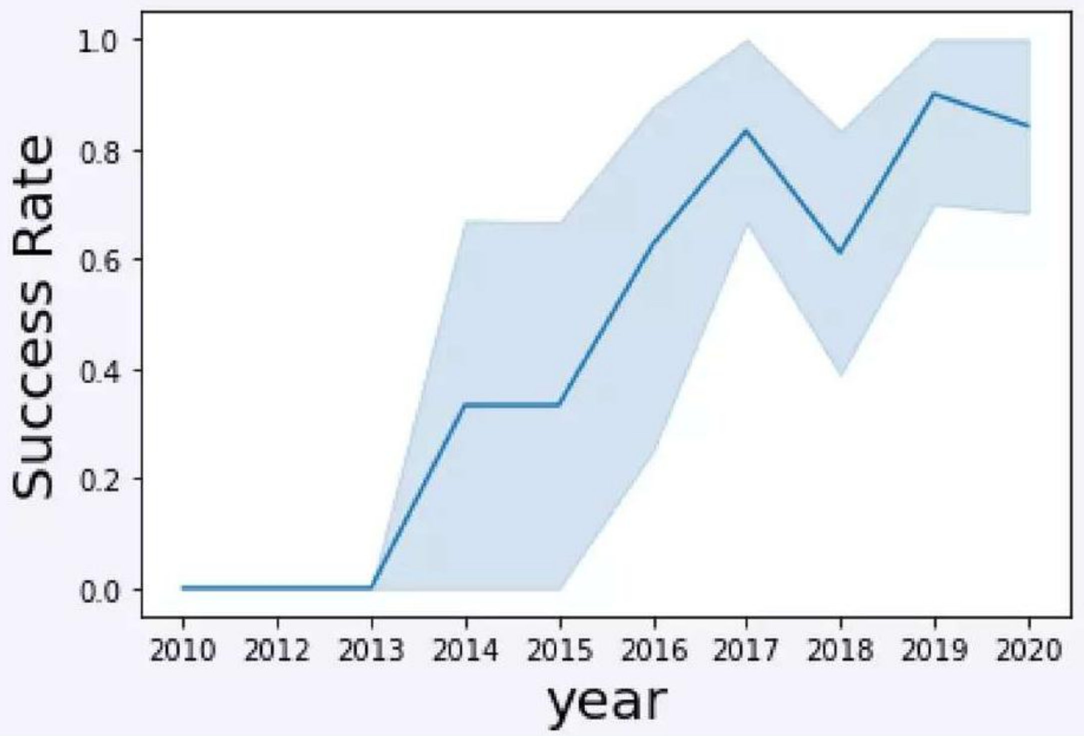
Payload vs. Orbit Type

- There are strong correlation between ISS and payload at the range around 2000, as well as between GTO an the range between 4,000 and 8,000.



Launch Success Yearly Trend

- Launch success rate has increased significantly since 2013 and has stabilised since 2010 and potentially due to advance in technology and lessons learned.



All Launch Site Names

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

Launch Site Names Begin with 'CCA'

DATE	time__utc_	booster_version	launch_site	payload	payload_mass__kg_	orbit	customer	mission_outcome	landing__outcome
2010-06-04	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
2010-12-08	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)
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
2012-10-08	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
2013-03-01	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attempt

- %sql select * from SPACEXTBL where LAUNCH_SITE like 'CCA%' limit 5

Total Payload Mass

- %sql select sum(PAYLOAD_MASS_KG) from SPACEXTBL where CUSTOMER = 'NASA (CRS)'

45596

Average Payload Mass by F9 v1.1

- %sql select avg(PAYLOAD_MASS_KG) from SPACEXTBL where BOOSTER_VERSION = 'F9V1,1'

2928.400000

First Successful Ground Landing Date

- %sql select min(DATE) from SPACEXTBL where Landing_Outcome = 'Success (ground pad)'

2015-12-22

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_ > 4000 and PAYLOAD MASS KG_ < 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 from SPACEXTBL where MISSION_OUTCOME = 'Success' or MISSION_OUTCOME = 'Failure (in flight)'

100

Boosters Carried Maximum Payload

- %sql select BOOSTER_VERSION from SPACEXTBL where PAYLOAD_MASS_ KG_ = (select max PAYLOAD_MASS_KG_) from SPACEXTBL)

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

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)
[illegible]	[illegible]	CCAFS LC-	[illegible]	[illegible]	[illegible]	SKY Perfect JSAT	[illegible]	[illegible]

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

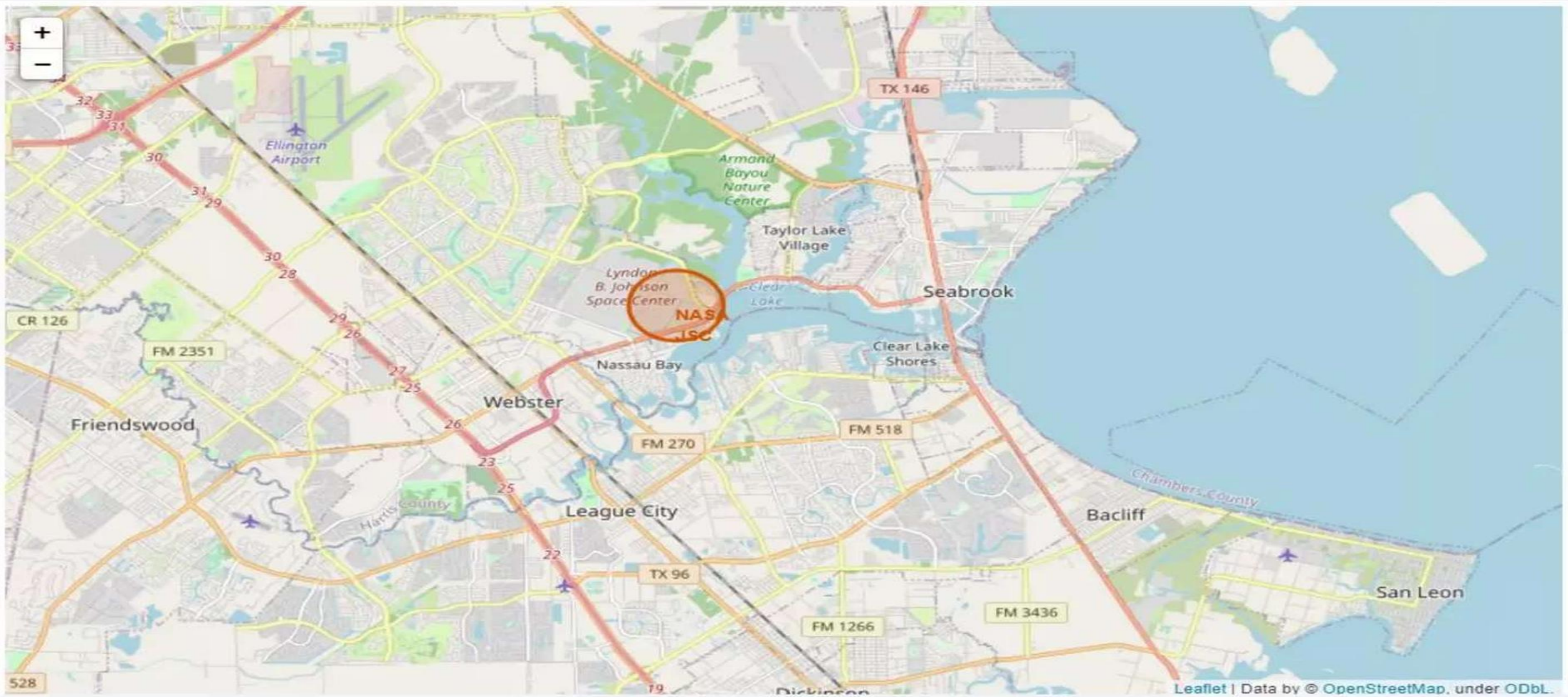
- %sql select from SPACEXTBL where Landing Outcome like 'Success%' and (DATE between '2010-06-04' and '2017-03-20') order by date desc

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)

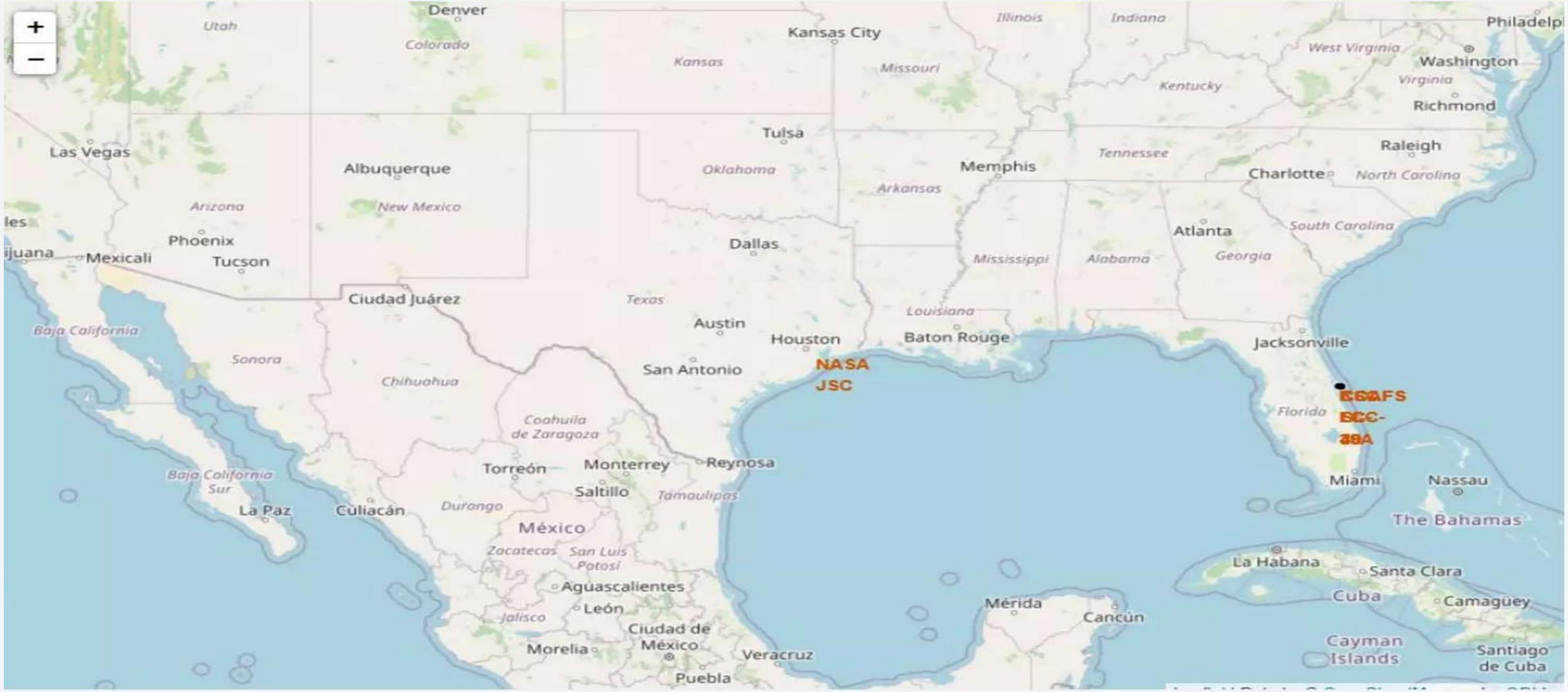
Section 3

Launch Sites Proximities Analysis

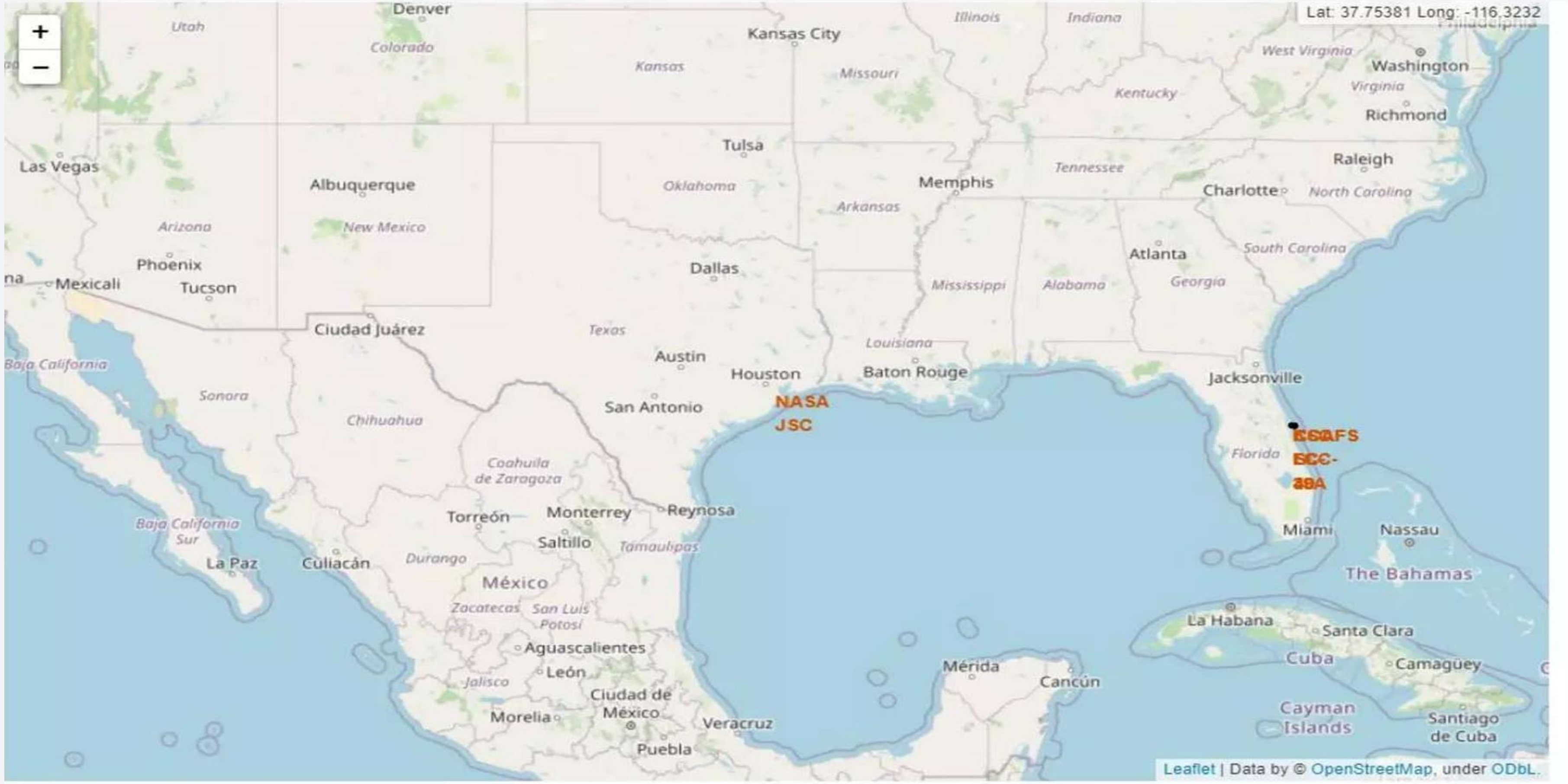
Marked launch sites on map!



Success/Failed Launch Sites Marked on the Map!



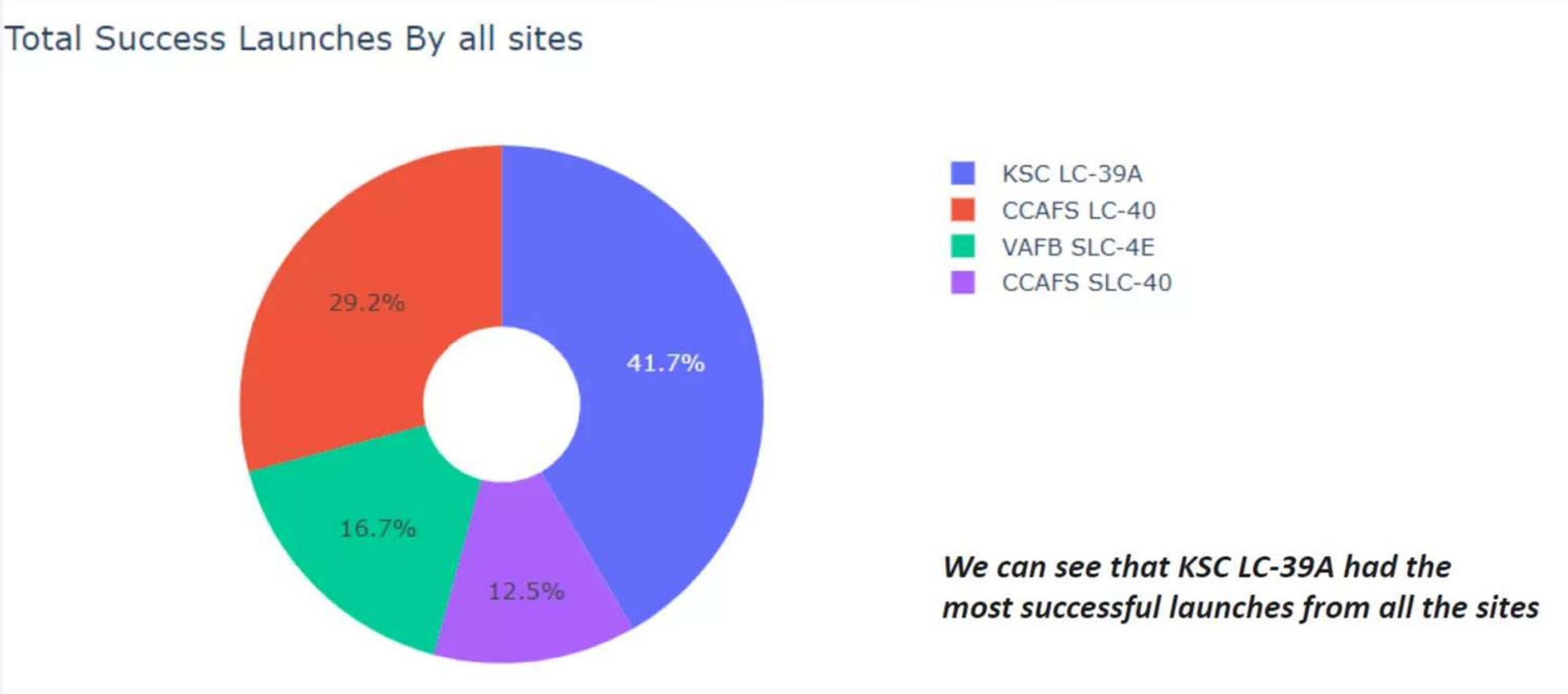
Distance between launch sites to it’s proximity



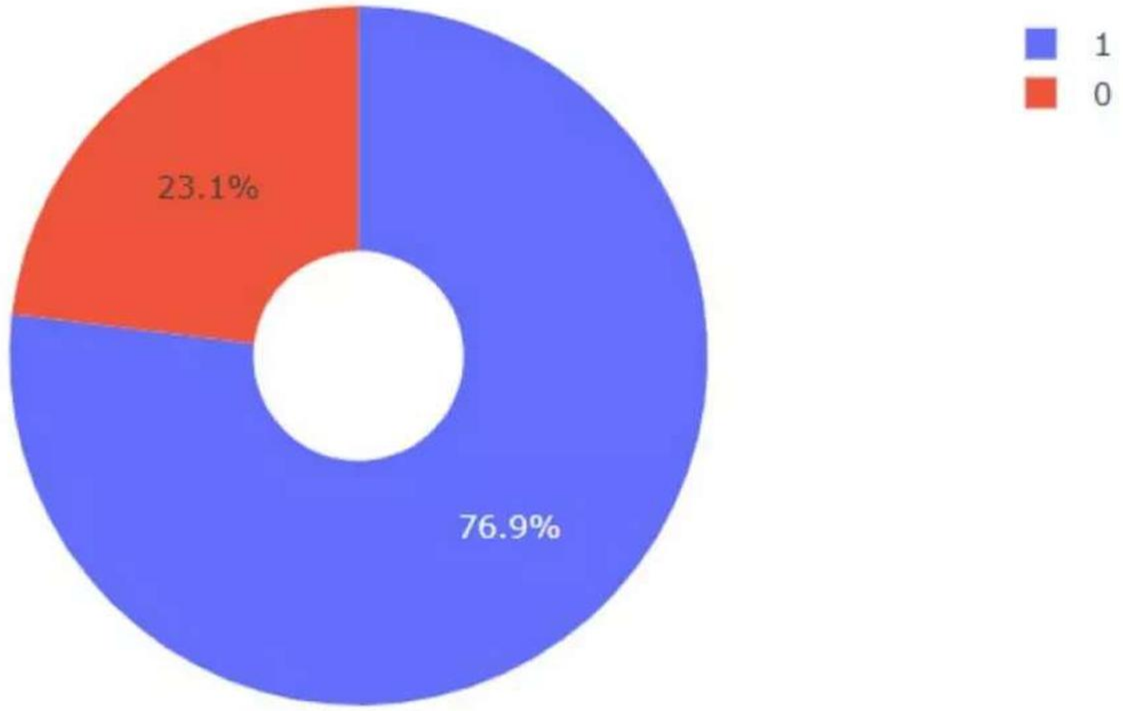
Section 4

Build a Dashboard with Plotly Dash

Total Success Launches by all sites!

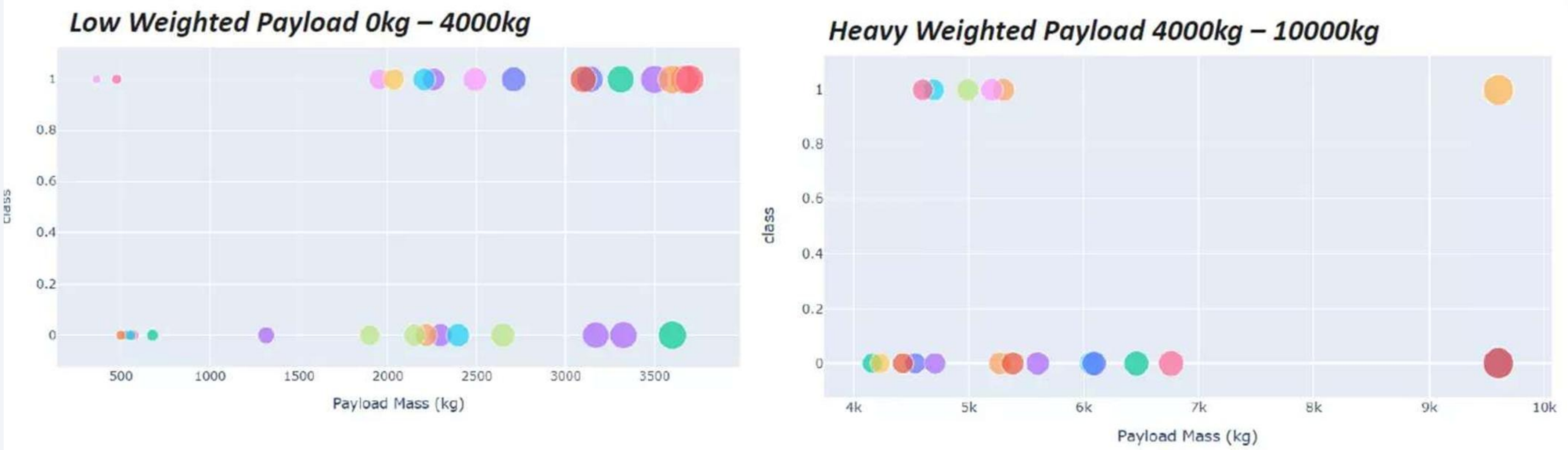


Success rate by site!



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

Payload vs Launch outcome!



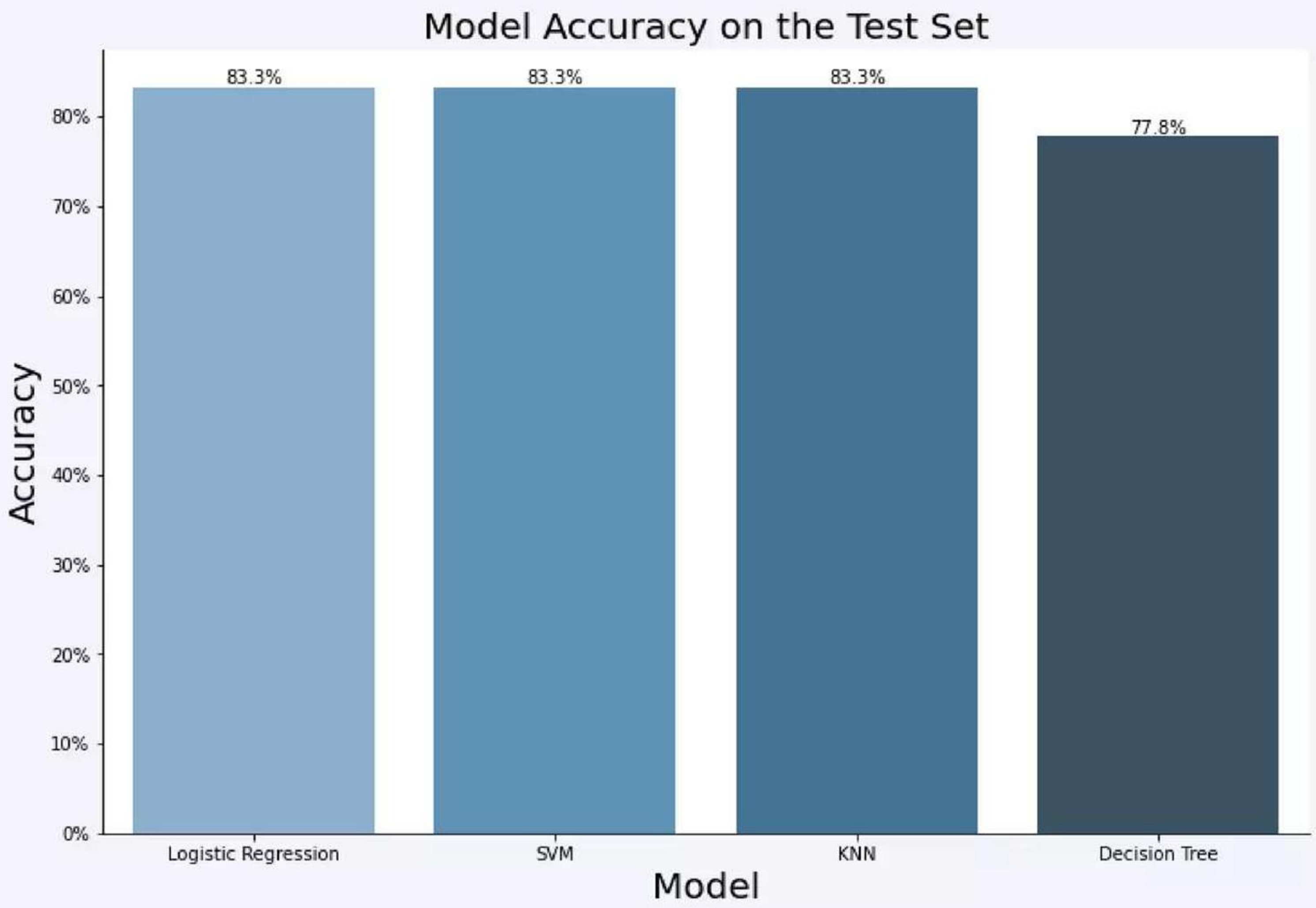
We can see the success rates for low weighted payloads is higher than the heavy weighted payloads

Section 5

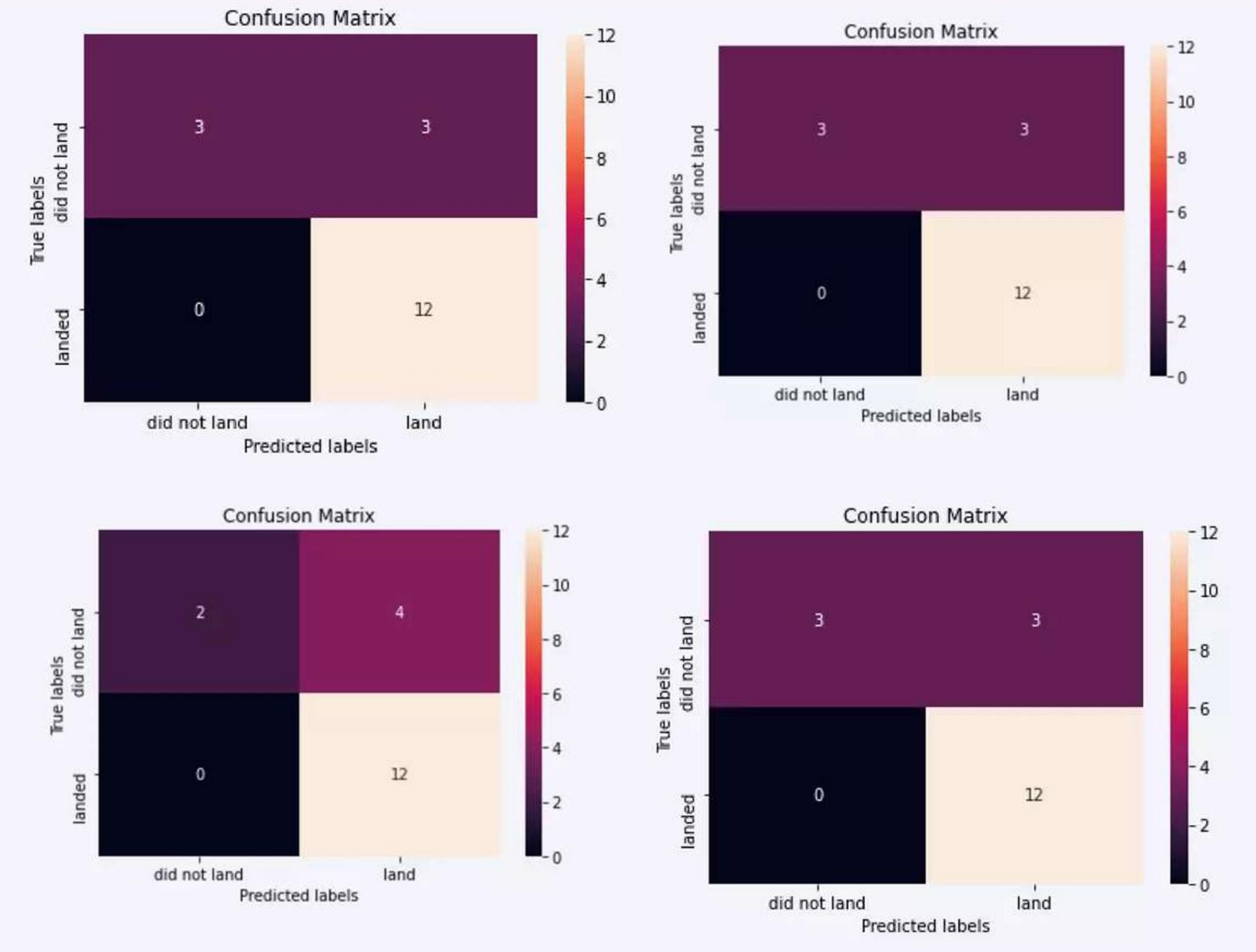
Predictive Analysis (Classification)

Classification Accuracy

Model Accuracy!



Confusion Matrix



Conclusions

- The SVM, KNN, and Logistic Regression models are the best in terms of predction 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.

Appendix

- nbharwad/IBM_Data_Science_Certificate: IBM Data Science Certificate.

Thank you!