IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Executive Summary

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Summary of all results:

Classification and visualization of various launch site specifications (success/failure, size/mass, orbit type, etc.)

Introduction

- Project background and context:
  - This project outlines the historical data captured from SpaceX launch site datasheets. SpaceX is a space exploration and discovery endeavor with a goal of affordable space expeditions. Analysis of various key variables (mass, orbit type, rocket type, launch location, success rates etc) are need to be performed to determine the optimal parameters for safe and affordable space travel.
- Problems you want to find answers:
  - How do the different variables stated above affect the success rate of expeditions?
  - Have optimization techniques been implemented to increase rate of success?
  - What is the best algorithm for classification of available data?

Section 1

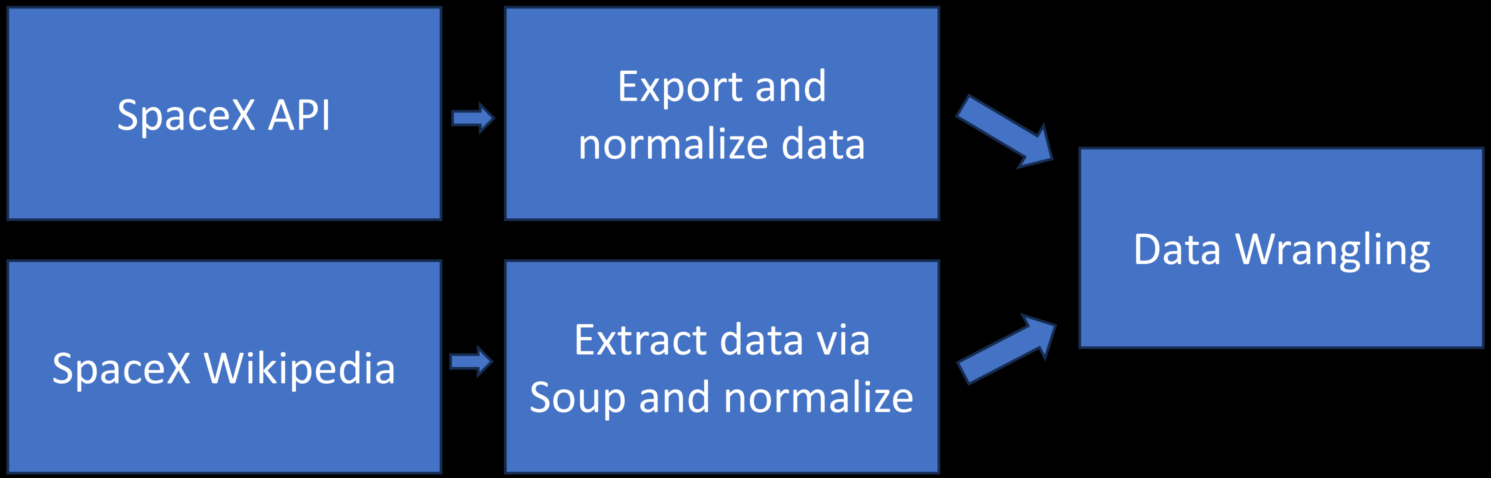
Methodology

Methodology

- Executive Summary
- Data collection methodology:
  - Data was collected from SpaceX API and web scraping from Wikipedia
- Perform data wrangling
  - One Hot Encoding and data cleaning (removal of null values and unnecessary data)
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - Utilize tools including K Nearest Neighbors, Logistic Regression, Tree Models and SVM’s.

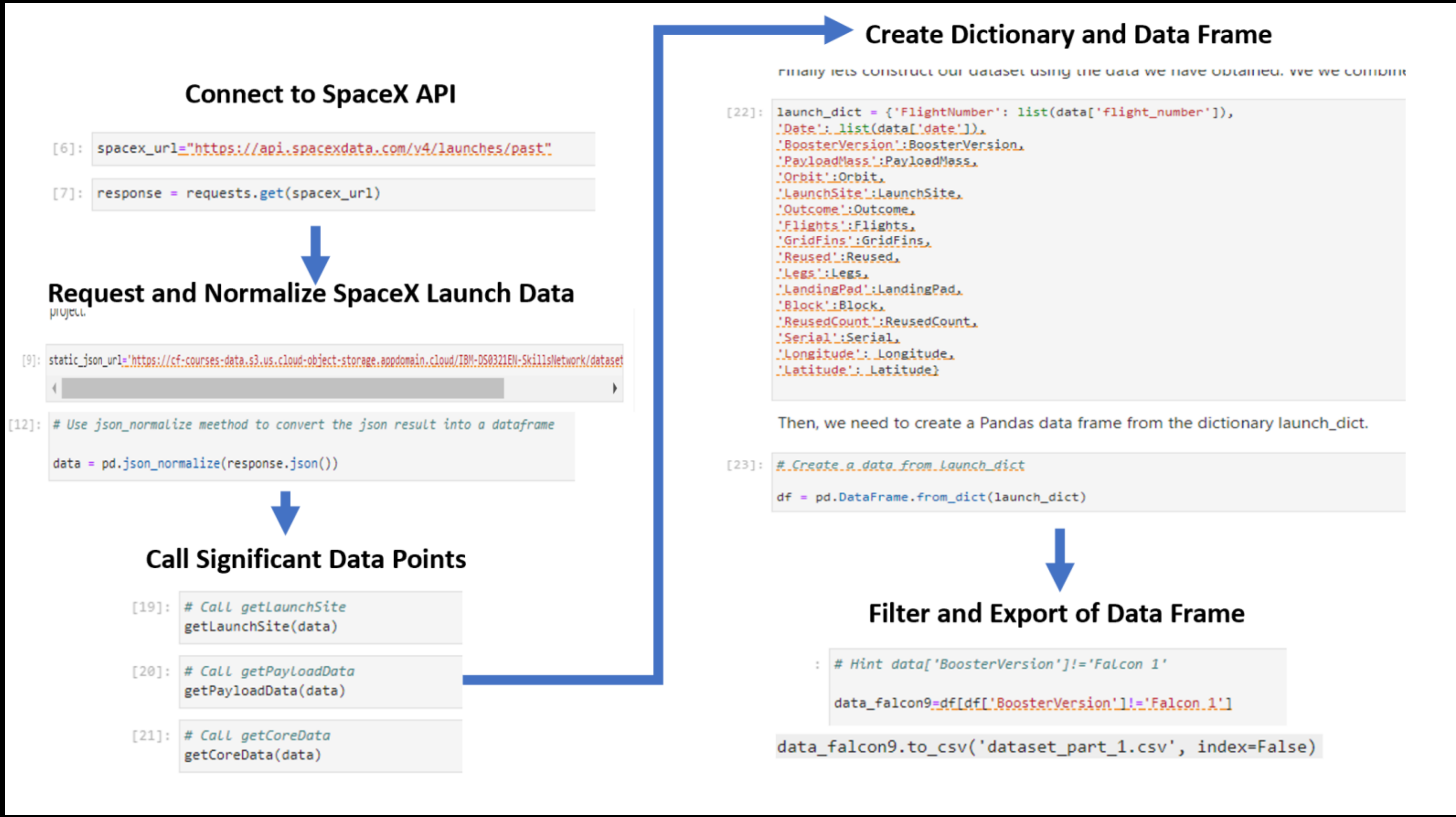
Data Collection

- Datasets were collecting utilizing SpaceX's API and web scraping Wikipedia via BeautifulSoup.
- The data exported included information including launch sites, date, payload delivery, landing outcome, rocket type, and more.
- Data had to be normalized be removal of null values, irrelevant columns, and entity manipulation (integer/float vs string, etc).



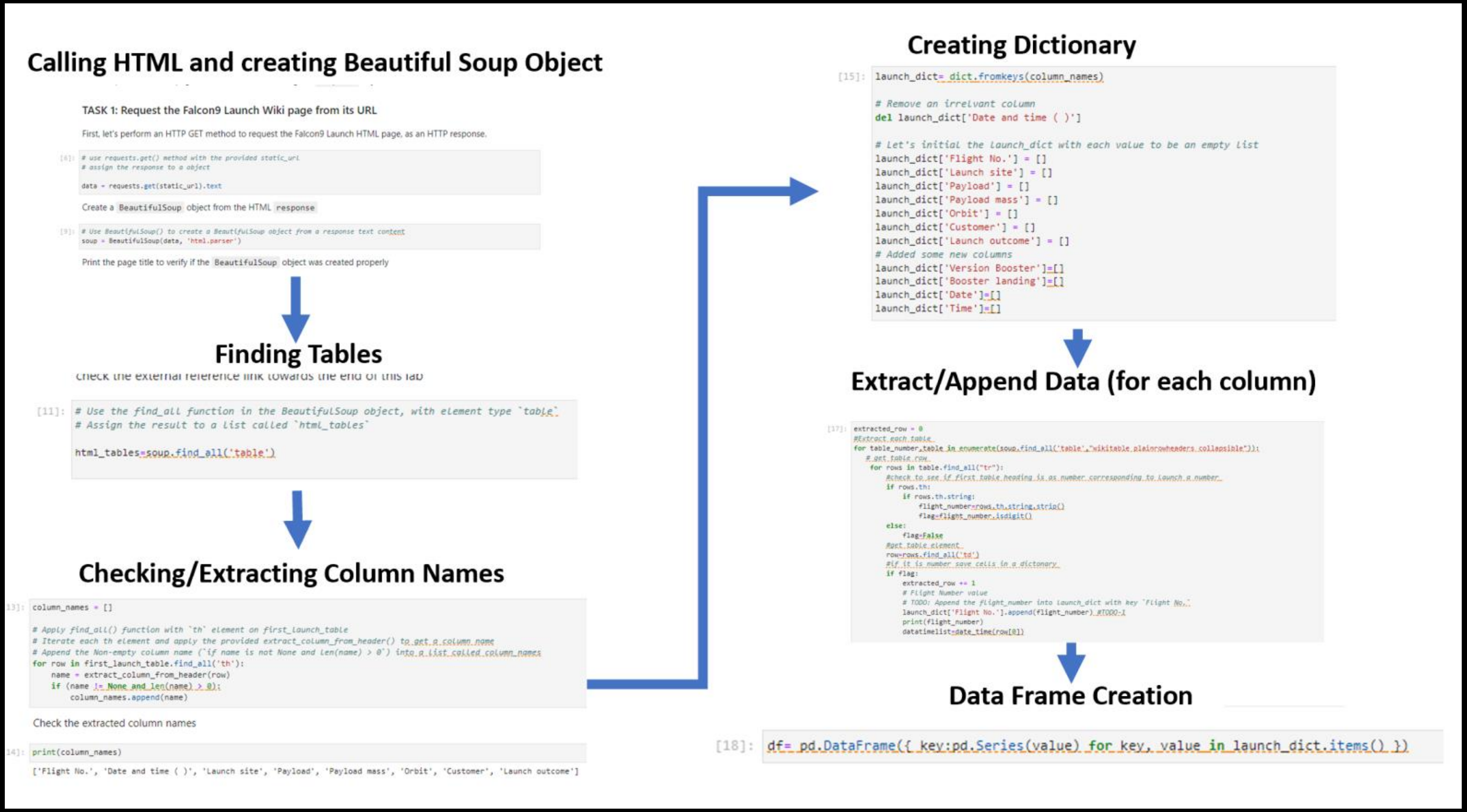
https://github.com/mgildner27/Capstone-Project/blob/main/jupyter-labs-spacex-data-collection-api.ipynb

Data Collection – SpaceX API



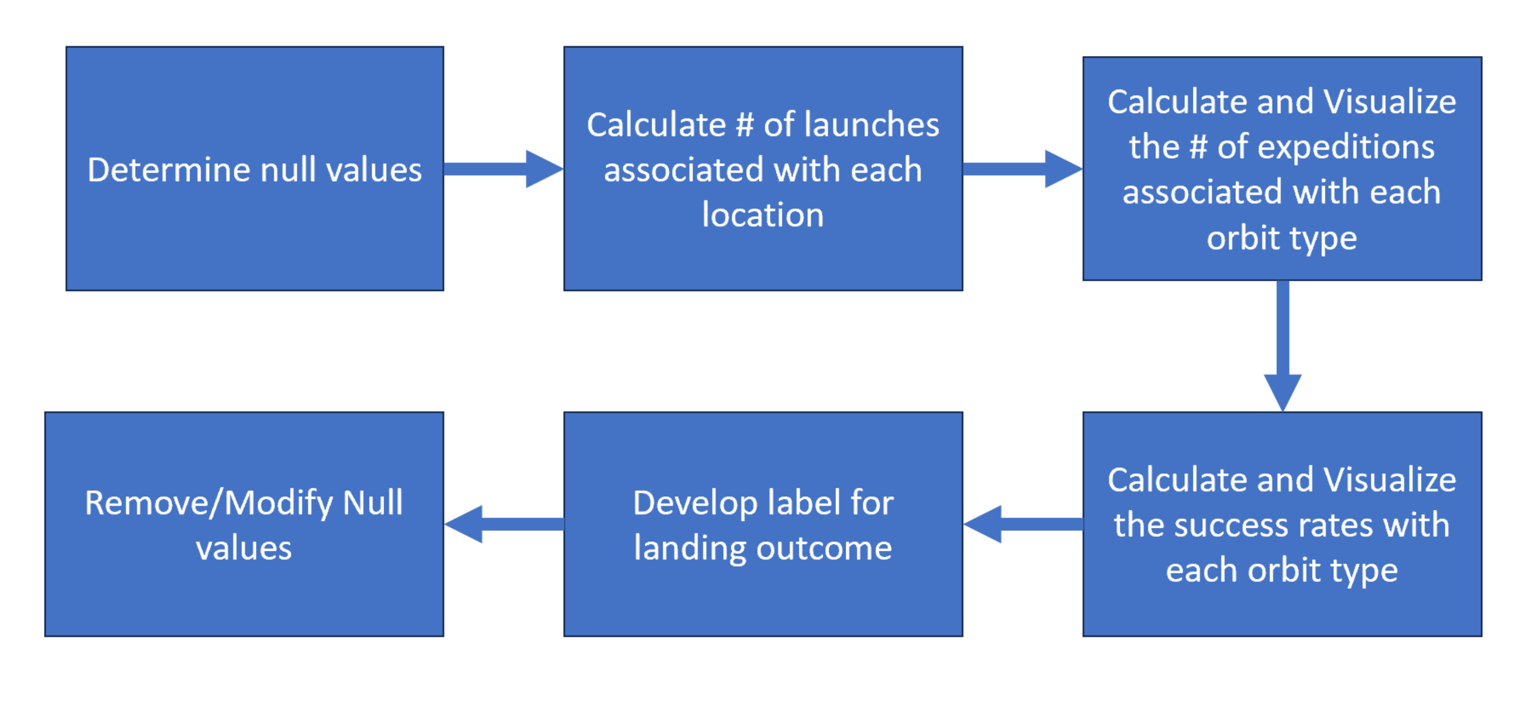
https://github.com/mgildner27/Capstone-Project/blob/main/jupyter-labs-spacex-data-collection-api.ipynb

Data Collection - Scraping



https://github.com/mgildner27/Capstone-Project/blob/main/jupyter-labs-webscraping.ipynb

Data Wrangling



https://github.com/mgildner27/Capstone-Project/blob/main/labs-jupyter-spacex-data_wrangling_jupyterlite.jupyterlite.ipynb

EDA with Data Visualization

- Several different visualization tools/charts were used to depict SpaceX data:
  - Scatter plots were used to visualize several key relationships including: flight number vs launch site, flight number vs orbit, payload mass vs launch site, and payload vs orbit.
  - Bar charts were used to visualize the Orbit type and expedition outcome (Success or Failure)
  - A Line plot was used to visualize the increase in success rate over time.

- https://github.com/mgildner27/Capstone-Project

EDA with SQL

- SQL queries were used for the following outputs:
  - Names of distinct launch sites
  - Displaying 5 records were Launch Site included ‘KSC’
  - Calculating total payload mass of all expeditions combined
  - Calculating average payload mass of all expeditions
  - Listing dates of successful landing outome
  - Listing the names of boosters with successful landings on a Ground Pad with a weight of 4000-6000kg.
  - Total number of Failed vs Successful missions
  - Booster types that carried maximum payload
  - Ranking the counts of successful landings between 2010-06-04 and 2017-03-20
- https://github.com/mgildner27/Capstone-Project

Build an Interactive Map with Folium

- The Maps generated with Folium were utilized to visualize the location of the unique launch sites, the rates of successful and failed expeditions, as well as proximity to the nearest traintracks.

- https://github.com/mgildner27/Capstone-Project

Build a Dashboard with Plotly Dash

- The Plotly Dashboard that was generated was used to create an interactive visualization that allows for data to be deliberately selected for analysis. Drop downs were included that allowed filtering of data and, thus, affecting the charts/graphs/tools that were selected for data visualization. Scatter plots and Donut Charts were used for analysis and comparison.

- https://github.com/mgildner27/Capstone-Project

Predictive Analysis (Classification)

- Several predictive analysis tools (KNN, LR, SVM, and Tree Models) were used to evaluate the classification model that was generated. It was found that the highest accuracy found within the model was 83.3%.

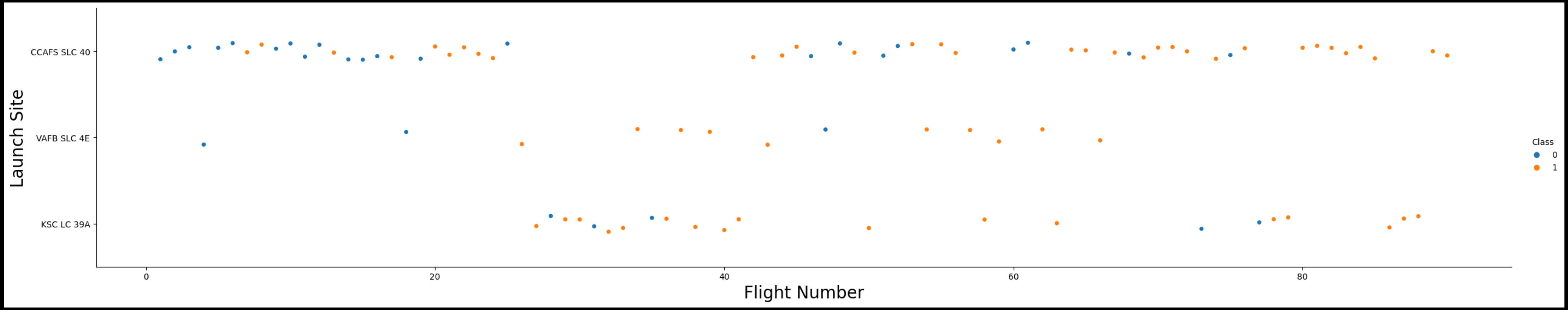
- https://github.com/mgildner27/Capstone-Project

Results

- Several different conclusions can be made from the exploratory data analysis performed including:
    - Success rates increased over time
    - Expeditions with lower payload mass had a higher success rate
    - GEO, HEO, SSO, and ES L1 orbits had the highest rates of success
    - The most successful launch site was KSC LC 39A.
    - The majority of SpaceX expeditions were conducted at CCAFS SLC 40.

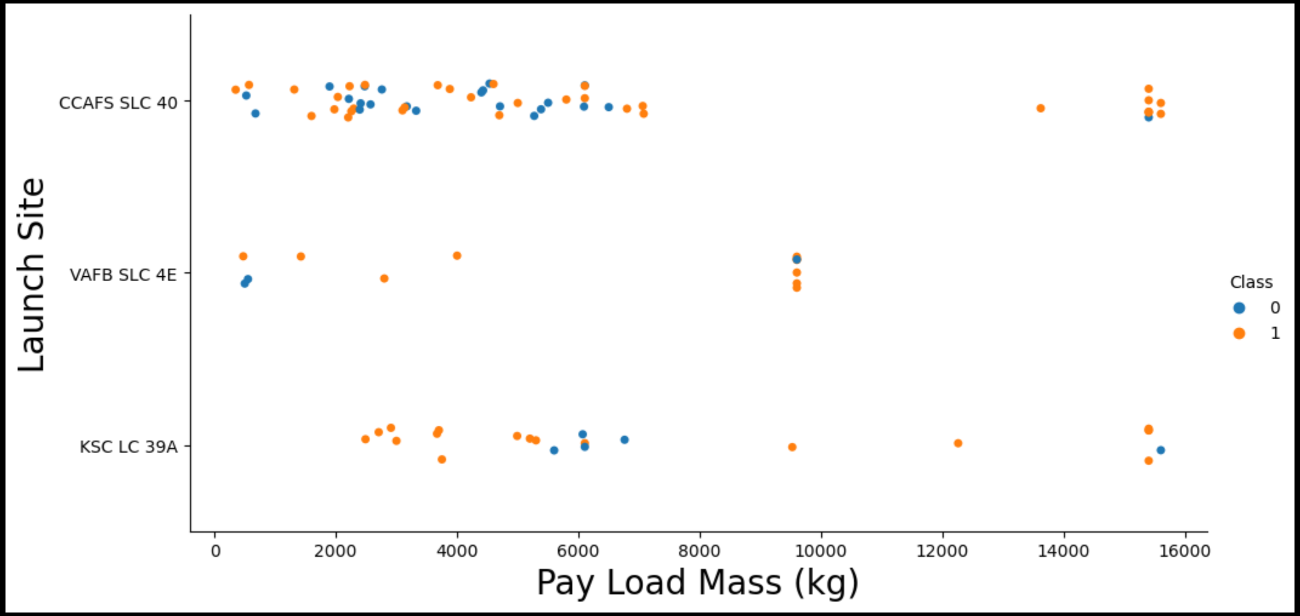
Section 2

Insights drawn from EDA



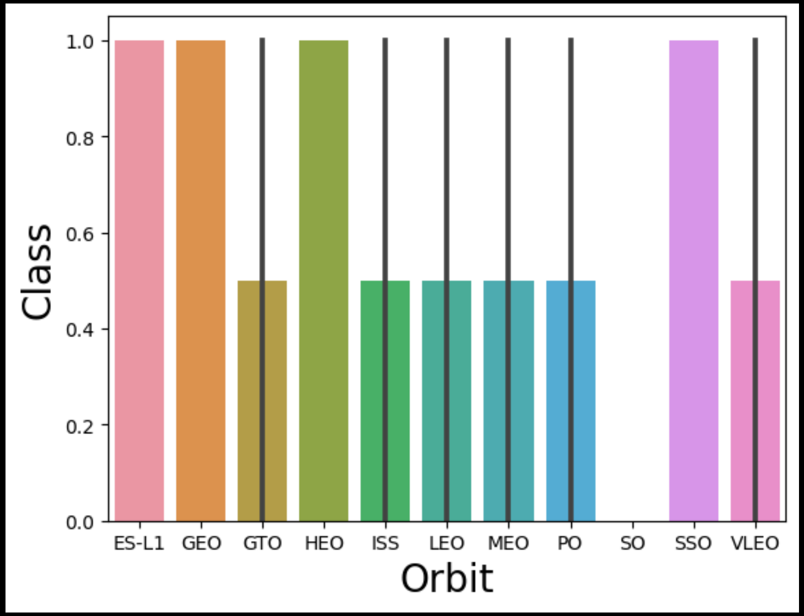
Flight Number vs. Launch Site

- This scatter plot depicts all SpaceX launches, organized by Launch site and Class.
- Plot is visualized using the flight number along the X-axis with the Launch Site (CCAFS SLC 40, VAFB SLC 4E, or KSC LC 39A).
- The hue variable was assigned based off the column “Class”, being assigned a 0 or 1 with the associated color scheme or blue or orange.



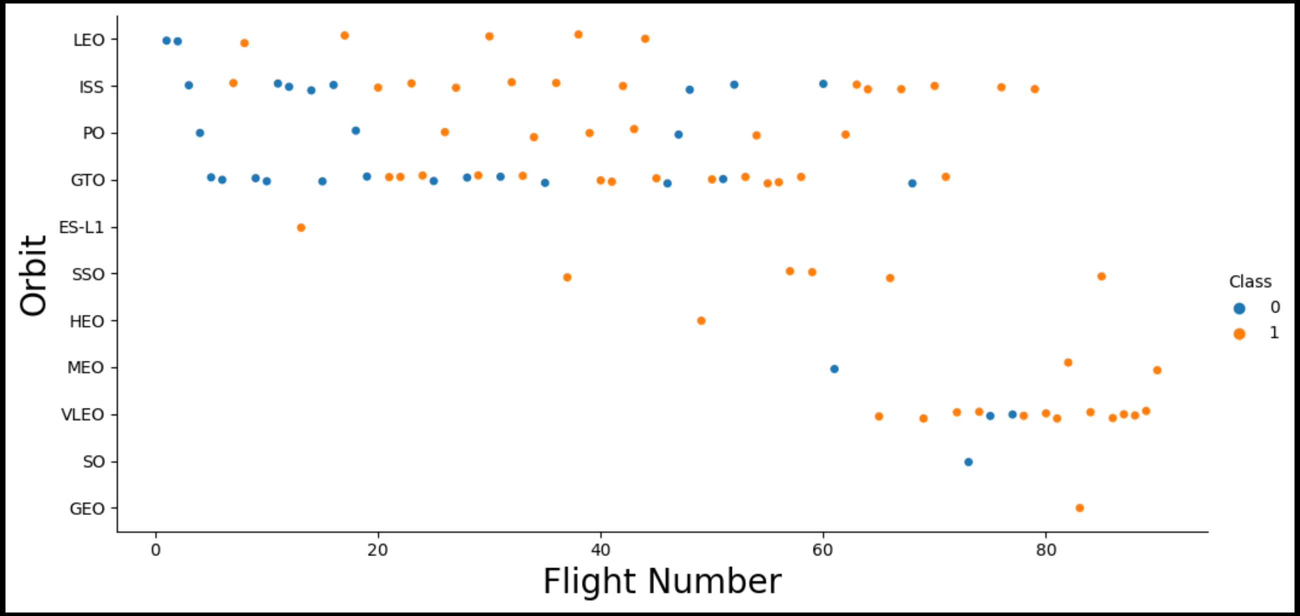
Payload vs. Launch Site

- The above scatter plot depicts all SpaceX launches, organized by pay load mass and launch site location, and further sorted by Class.
- Based off this data, most launches occurred at CCAFS SLC 40 and the fewest were performed at VAFB SLC 4E.



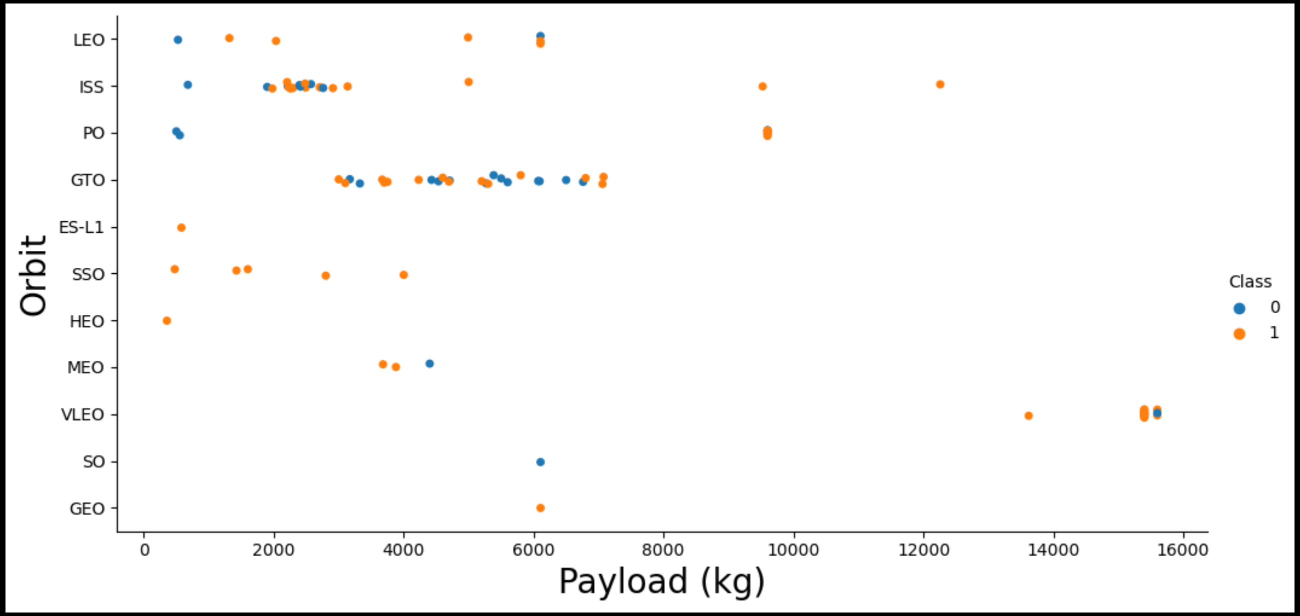
Success Rate vs. Orbit Type

- The bar chart above depicts the success rates based off the desired orbit destination and class.
- The success rates are depicted by the class type, indicating that ES-L1, GEO, and SSO orbits exhibit the highest rates of success.



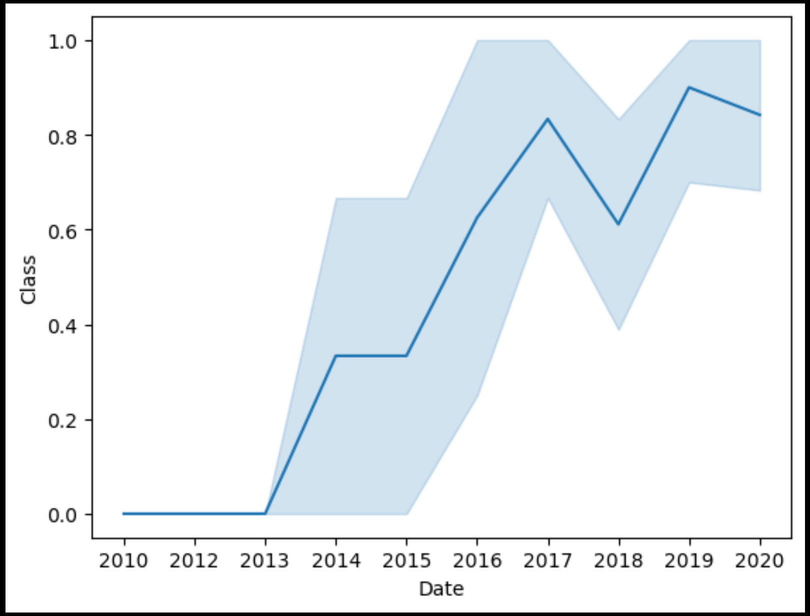
Flight Number vs. Orbit Type

- The scatter plot above visualizes the flight numbers, associated by Orbit type and Class/success rates.
- The earlier expeditions appear to have targeted LEO, ISS, PO, and GTO orbits primarily, whereas later launches were aiming for VLEO orbit.



Payload vs. Orbit Type

- The scatter plot above visualizes the SpaceX launches, arranged by payload mass along the X-axis and Orbit type along the Y-axis. The plot is further analyzed by investigating the class type.
- Most payloads are under 8000kg and target mostly ISS and GTO orbits.



Launch Success Yearly Trend

- The line chart above depicts the success rates of SpaceX expeditions over time.
- Between 2010 and 2020, there is stark evidence that success rates have increased.

All Launch Site Names

%sql SELECT distinct(Launch_Site) FROM SPACEXTBL:

Launch Site
CCAFS LC-40
CCAFS SLC-40
KSC LC-39A
VAFB SLC-4E

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

```
[9]: %sql SELECT LAUNCH_SITE FROM SPACEXTBL WHERE (LAUNCH_SITE) LIKE "KSC%" LIMIT 5

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

[9]:

Launch_Site
KSC LC-39A
KSC LC-39A
KSC LC-39A
KSC LC-39A
KSC LC-39A

Launch Site Names Begin with 'KSC'

- This line of code selects 5 distinct instances in which expeditions were conducted at Launch Site KSC LC-39A.

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

```
[10]: %sql SELECT SUM(PAYLOAD_MASS__KG_) AS PAYLOADMASS FROM SPACEXTBL

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

[10]:

PAYLOADMASS
619967

Total Payload Mass

- This Line of code takes the sum of the payload mass from all launch numbers in the SpaceX data frame.

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

```
[11]: %sql SELECT avg(PAYLOAD_MASS__KG_) FROM SPACEXTBL WHERE(Booster_Version) ='F9 v1.1'

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

[11]:

avg(PAYLOAD_MASS__KG_)
2928.4

Average Payload Mass by F9 v1.1

- This line of code takes the average payload mass from the SpaceX table where the booster version is F9 v1.1

```
[12]: %sql SELECT MIN(DATE) FROM SPACEXTBL WHERE(Mission_Outcome)='Success'

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

[12]:

MIN(DATE)
2010-04-06

First Successful Ground Landing Date

- This line of code finds the earliest date in which a successful expedition was performed by using the “MIN” function on the date column where “Mission Outcome”= Success.

List the names of the boosters which have success in ground pad and have payload mass greater than 4000 but less than 6000

[13]:
```
%sql SELECT BOOSTER_VERSION FROM SPACEXTBL WHERE(Landing_Outcome)='Success (ground pad)' and PAYLOAD_MASS__KG_ BETWEEN 4000 AND 6000
```

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

[13]:

Booster_Version
F9 FT B1032.1
F9 B4 B1040.1
F9 B4 B1043.1

Successful Drone Ship Landing with Payload between 4000 and 6000

- This line of code selects the booster version types from the SpaceX table where the landing outcome was successful in ground pad, with a payload mass between 4000-6000kg.
- The booster versions that succeeded during their expeditions were F9 FT B1032.1, F9 B4 B1040.1, and F9 B4 B1043.1

```
[14]: %sql SELECT COUNT(Mission_Outcome) AS MISSIONOUTCOMES FROM SPACEXTBL GROUP BY Mission_Outcome

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

[14]:

MISSIONOUTCOMES
1
98
1
1

Total Number of Successful and Failure Mission Outcomes

The line of code above groups the total number of expeditions by mission outcome.

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

[15]:
```
%sql SELECT Booster_Version AS BOOSTERVERSIONS FROM SPACEXTBL WHERE PAYLOAD_MASS__KG_=(SELECT MAX(PAYLOAD_MASS__KG_) FROM SPACEXTBL)
```

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

[15]:

BOOSTERVERSIONS
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

Boosters Carrying Maximum Load

The line of code above selects the booster version from the SpaceX table where payload mass is at the maximum value, via subquery.

```
[24]: %sql SELECT DATE AS MONTH, LANDING_OUTCOME, BOOSTER_VERSION, LAUNCH_SITE FROM SPACEXTBL WHERE LANDING_OUTCOME = 'Success (ground pad)' AND DATE LIKE '%2017%'

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

[24]:

MONTH	Landing_Outcome	Booster_Version	Launch_Site
2017-02-19	Success (ground pad)	F9 FT B1031.1	KSC LC-39A
2017-01-05	Success (ground pad)	F9 FT B1032.1	KSC LC-39A
2017-03-06	Success (ground pad)	F9 FT B1035.1	KSC LC-39A
2017-08-14	Success (ground pad)	F9 B4 B1039.1	KSC LC-39A
2017-07-09	Success (ground pad)	F9 B4 B1040.1	KSC LC-39A
2017-12-15	Success (ground pad)	F9 FT B1035.2	CCAFS SLC-40

2017 Launch Records

- The line of code above selects the date, landing outcome, booster version, and launch site of successful expeditions that occurred in 2017.

Rank the count of landing outcomes (such as Failure (drone ship) or Success (ground pad)) between the date 2010-06-04 and 2017-03-20, in descending order

```
[19]: %sql SELECT * from SPACEXTBL where Landing_Outcome like 'Success%' and (Date Between '2010-06-04' and '2017-03-20') order by date desc
```

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

[19]:

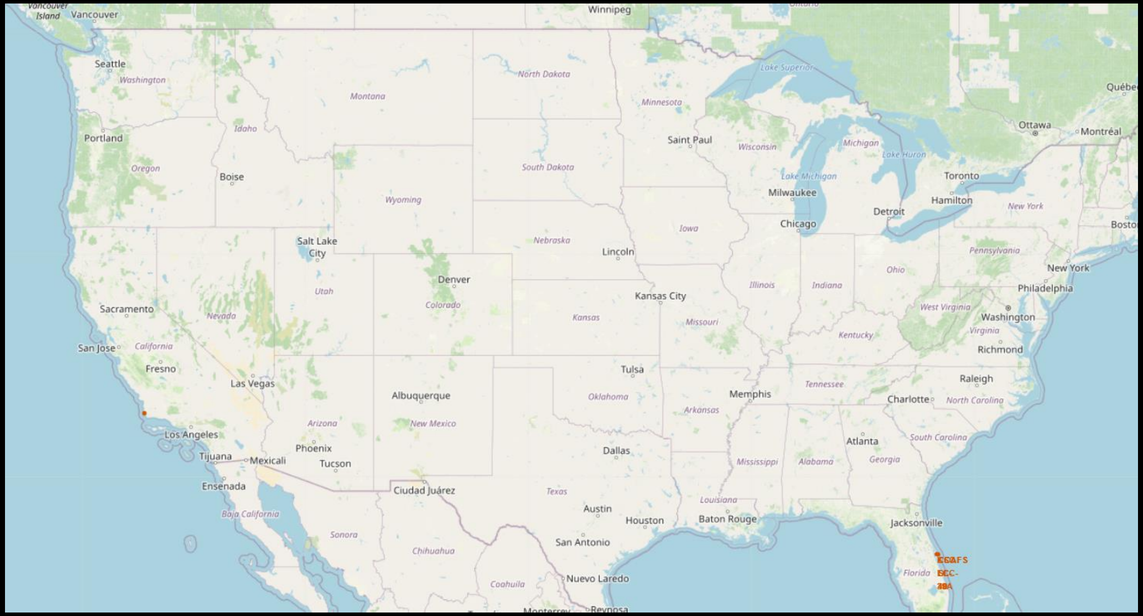
Date	Time (UTC)	Booster_Version	Launch_Site	Payload	PAYLOAD_MASS__KG_	Orbit	Customer	Mission_Outcome	Landing_Outcome
2017-02-19	14:39:00	F9 FT B1031.1	KSC LC-39A	SpaceX CRS-10	2490	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
2017-01-14	17:54:00	F9 FT B1029.1	VAFB SLC-4E	Iridium NEXT 1	9600	Polar LEO	Iridium Communications	Success	Success (drone ship)
2016-08-14	5:26:00	F9 FT B1026	CCAFS LC-40	JCSAT-16	4600	GTO	SKY Perfect JSAT Group	Success	Success (drone ship)
2016-07-18	4:45:00	F9 FT B1025.1	CCAFS LC-40	SpaceX CRS-9	2257	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
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	5:21:00	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	1:29:00	F9 FT B1019	CCAFS LC-40	OG2 Mission 2 11 Orbcomm-OG2 satellites	2034	LEO	Orbcomm	Success	Success (ground pad)

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

- The output from the code above selects the expeditions based off of successful landing outcomes between the dates of 2010-06-04 and 2017-03-20, ordered by descending date.

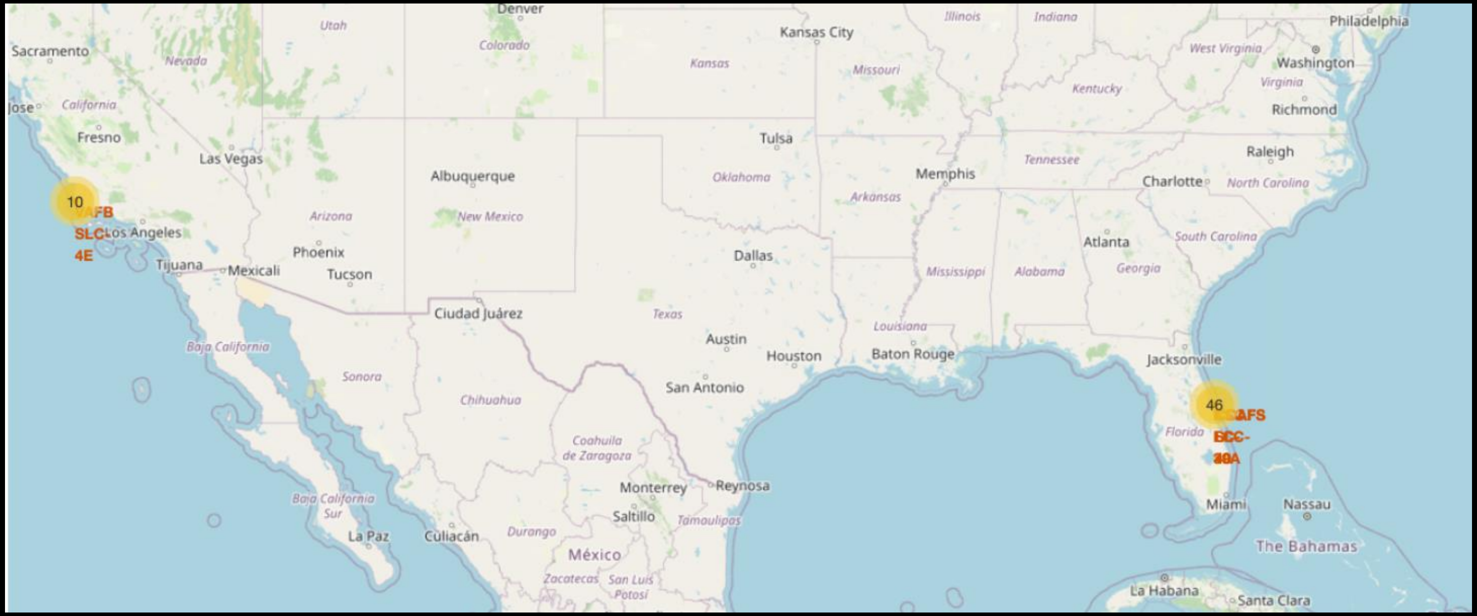
Section 3

Launch Sites Proximities Analysis



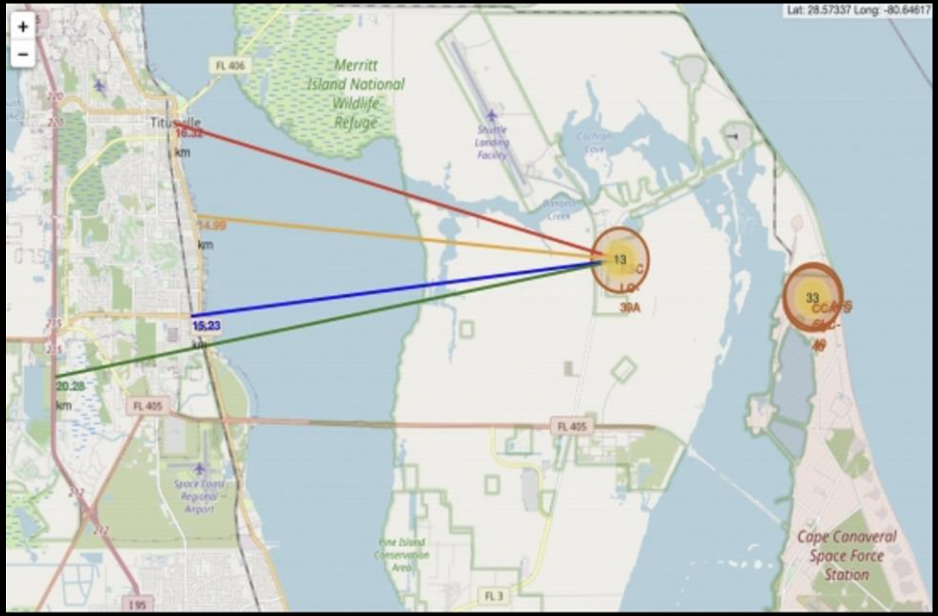
Map of Launch Site Locations

- The folium map above depicts the location of all 3 SpaceX locations with VAFB SLC-4E in southern California and KSC LC-39A, CCAFS SLC-40, and CCAFS LC-40 on the eastern coast of Florida.



Map of Color-Labeled Launch Outcomes

- The map above visualizes the launch locations and their respective success/failure outcomes.

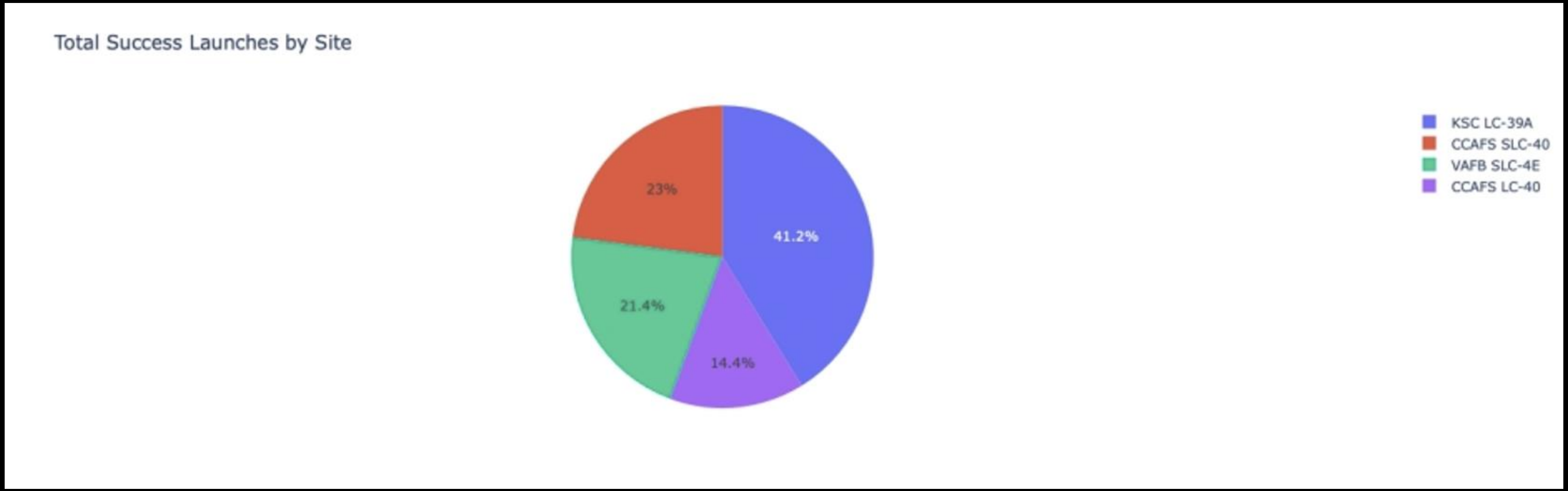


Map Visualizing Distance/Proximity

- Based off the Folium map, it an be determined that Launch Site KSC LC-39A is approximately 20.28km from the nearest highway, 15.23 nearest railroad, and 14.99 to the nearest coastline.

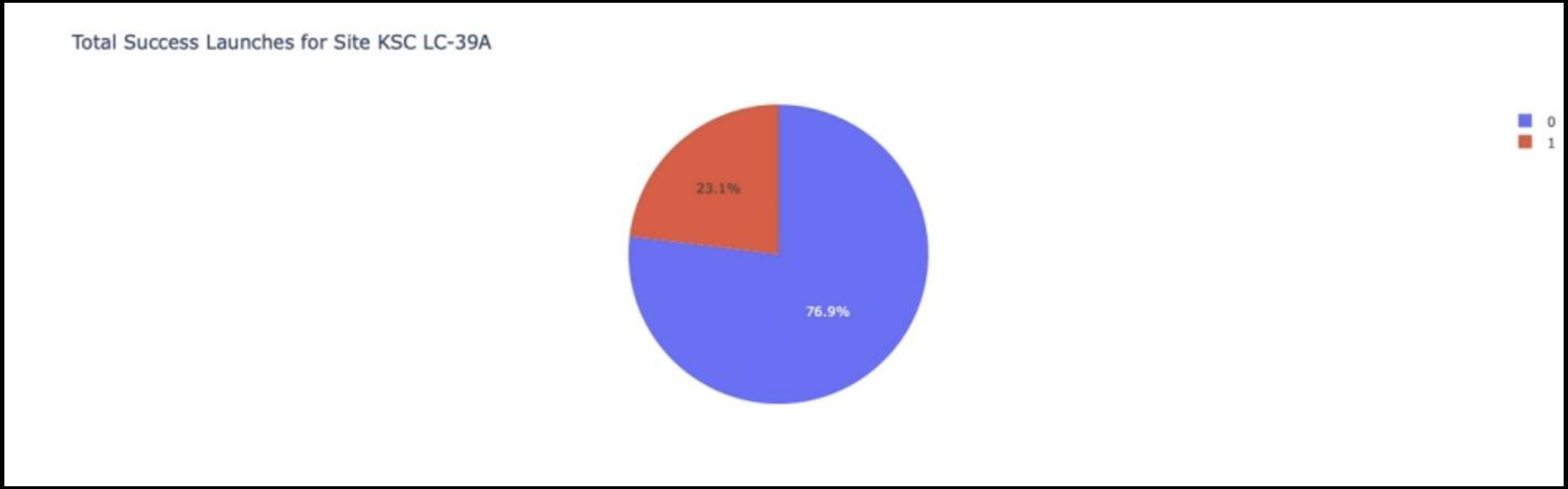
Section 4

Build a Dashboard with Plotly Dash



Successful Launches (All Sites)

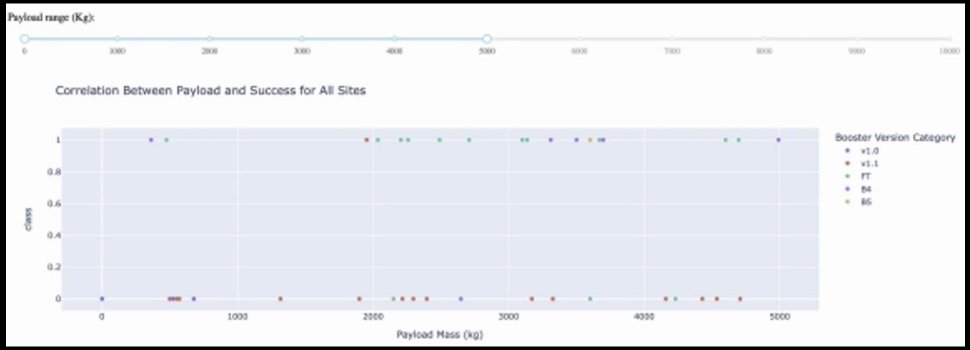
- The chart above displays the percentage of each launch site relative to the total number of successful launches.
  - KSC LC39A constitutes for 41.2% of the total number of SpaceX successes, followed by CCAFS SLC-40 (23%), VAFB SLC-4E (21.4%), CCAFS LC-40 (14.4%)

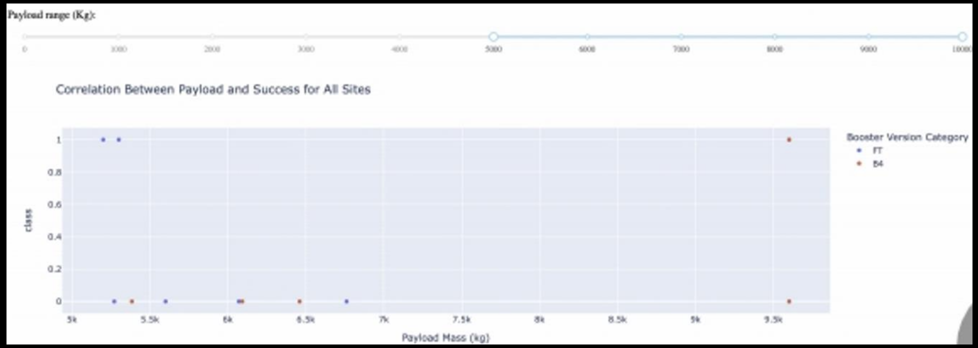


High Launch Site Success Rates (KSC LC-39A)

- Launch Site KSC LC-39A had the highest success rate out of all sites, with a rate of 76.9%.

Payload Mass vs Success Rate





- Based off the vizualizaiton tools, these charts depict that payload masses between 2000-5000kg have the highest success rates.
- Booster type v1.1 also seems to positively affect success rates.

Section 5

Predictive Analysis (Classification)

Classification Accuracy

Test:

[109]:	LogReg	SVM	Tree	KNN
Jaccard_Score	0.800000	0.800000	0.800000	0.800000
F1_Score	0.888889	0.888889	0.888889	0.888889
Accuracy	0.833333	0.833333	0.833333	0.833333

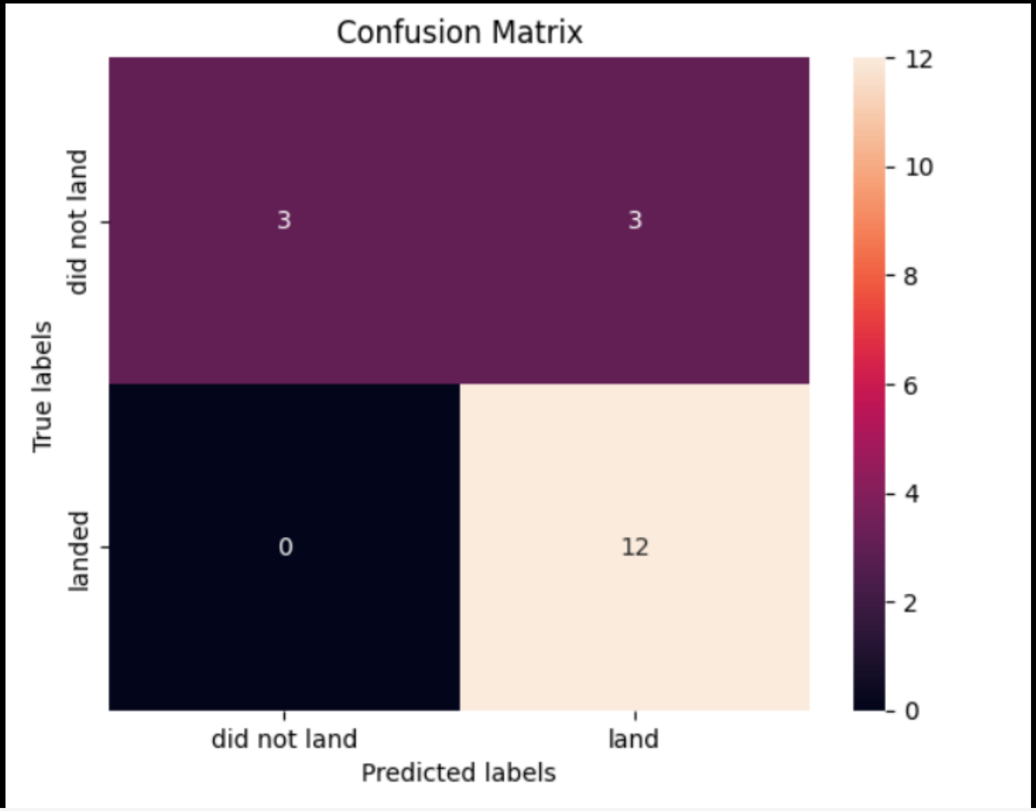
Entire Dataset:

	LogReg	SVM	Tree	KNN
Jaccard_Score	0.833333	0.845070	0.882353	0.819444
F1_Score	0.909091	0.916031	0.937500	0.900763
Accuracy	0.866667	0.877778	0.911111	0.855556

Based off the test model, the optimal classification algorithm cannot be determined due to shared values across the board.

When incorporating the entire dataset, it can bee concluded that the Decision tree claissifer is the best of this data set as it has the highest jaccard, f1, and accuracy scores.

Confusion Matrix




```
Best model is DecisionTree with a score of 0.875
Best params is : {'criterion': 'entropy', 'max_depth': 4, 'max_features': 'sqrt', 'min_samples_leaf': 1, 'min_samples_split': 10, 'splitter': 'best'}
```

Conclusions

- Many conclusions can be drawn from this data analysis including:
  - KSC LC-39A had the highest success rate out of all launch sites
  - Success rates for all launch sites have increased over years
  - Launches with a lower payload mass tend to be more successful
  - The decision tree model is the ideal algorithm for classification.
  - ES-L1, GEO, and SSO orbits exhibit the highest rates of success

Thank you!