IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

Alice King
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Table of Contents / Outline

Executive Summary

- The purpose of this project is to determine whether we can predict—using data science—If the Falcon 9 first stage will land successfully. Determining whether the first stage will land is crucial in calculating the cost of a launch, and keeping SpaceX costs significantly lower than other providers.

- Summary of Methodology
  - Data was collected through API request website and webscraping.
  - Data cleaning and transformation—data wrangling—were performed.
  - Exploratory data analysis (EDA) was performed using visualization and SQL
  - Performed interactive visual analytics using Folium and Plotly Dash
  - Perform predictive analysis using classification models, machine learning pipelines with GridSearchCV.

- Summary of all results
  - Created a dataset using data collected through API request from SpaceX and webscraping from Wikipedia. Drilled down to specific F9 data, then transformed the data into a usable format for exploratory data analysis (data wrangling).
  - EDA with visualization and SQL revealed that launch site, payload mass, and orbit type, and booster type impacted successful outcomes. ES-L1, GEO, HEO, SSO/SO have the best success rates but few launches. VLEO and LEO have a higher number of launches and the next best success rates.
  - A Folium map revealed that sites in Florida—KSC LC 39A and CCAFS LC-40—have the most launches and are located closest to the equator. A Plotly dashboard revealed that KSC LC 39A has the highest success rate, followed by CCAFS LC-40. Both are located in Florida. The dashboard also revealed that the payload range with the most successful outcome is 1000 kg to 4000 kg.
  - With Predictive Analysis, we revealed that model accuracy and confusion matrix was the same for each method and that the classifiers correctly predicted that 12 first stages would land, which matched the true labels. The models do a good job predicting landings.

Introduction

- This project will determine if we can predict whether the Falcon 9 first stage will land successfully, using data science. Determining whether the first stage will land is crucial in calculating the cost of a launch, and keeping SpaceX costs significantly lower than other providers.
- Our analysis will answer the following questions:
  - What is the impact of site location?
  - What is the impact of payload?
  - What is the impact of orbit types?
  - What is the impact of booster type?
  - Overall success trend of launches
  - Can we predict whether SpaceX can reuse the first stage using a Machine Learning Model.

Section 1

Methodology

Methodology

Summary

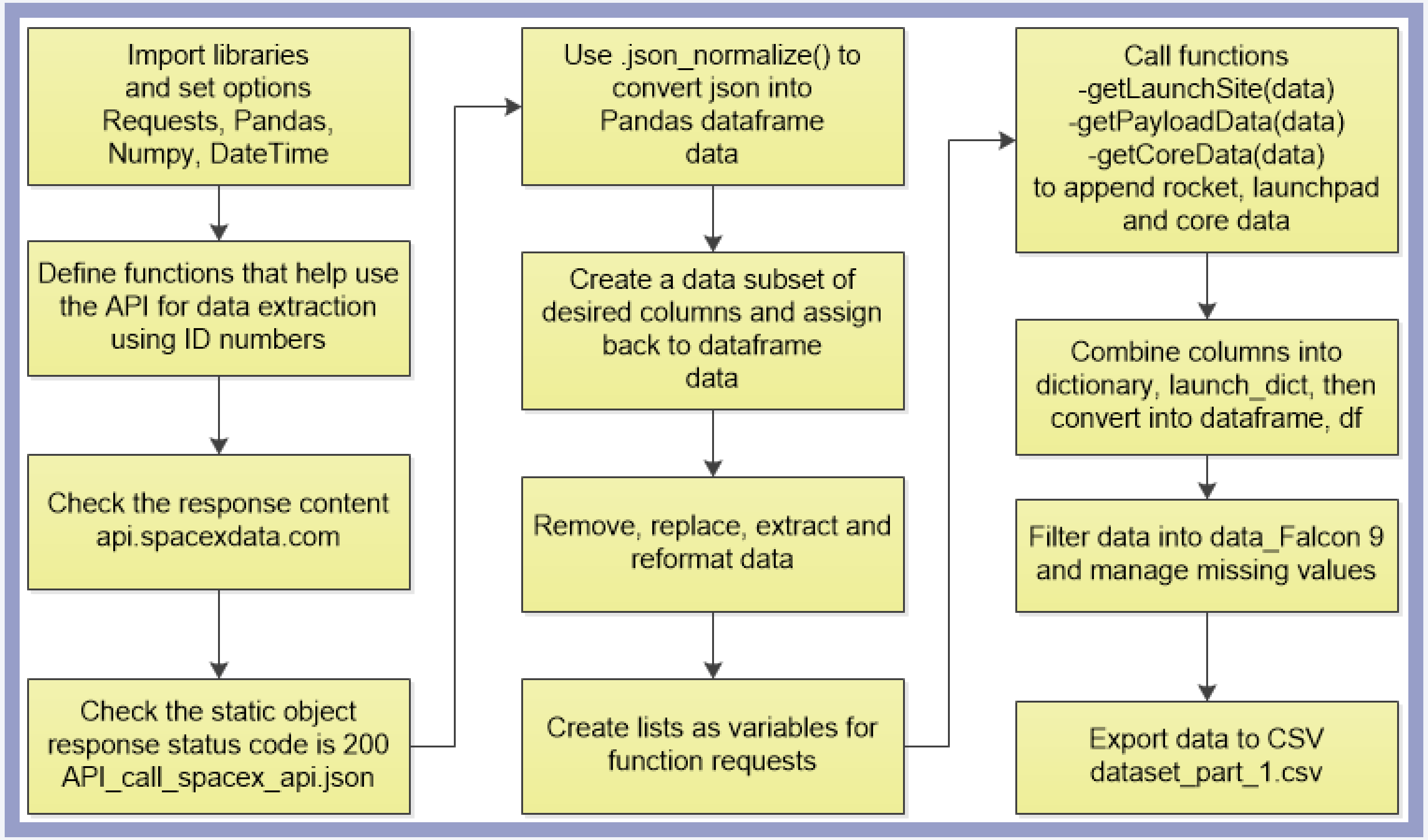
- Data collection methodology:
  - Data was collected through API request from SpaceX and webscraping from Wikepedia.
- Perform data wrangling
  - An initial analysis of dataframe structure and content were performed where F9 data was isolated and landing classes were identified for each launch.
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - A machine learning pipeline with GridSearchCV was used to find the optimal settings for maximum model performance, then compared model accuracies and confusion matrices to determine the best model

Data Collection

- Collected launch data from SpaceX API
  - Normalized the data then filtered on Falcon 9.
  - Ensured correct formatting in the resulting dataframe.
- Collected Falcon 9 historical landing data web scraped from Wikipedia.
  - Used Beautiful Soup to extract HTML tables.
  - Parsed the HTML tables into a dictionary, then converted it to a dataframe.
- Determined the training labels for supervised models.
  - Performed initial analysis on data collected; e.g., missing values and data types.
  - Identified launch sites and orbit codes with their occurrences, and mission outcomes.
  - Class column represents the mission outcomes with 1 (Success) or 0 (Fail).
- See Appendix, Note A for URLs used in data collection, as well as CSV Exports.

Data Collection – SpaceX API

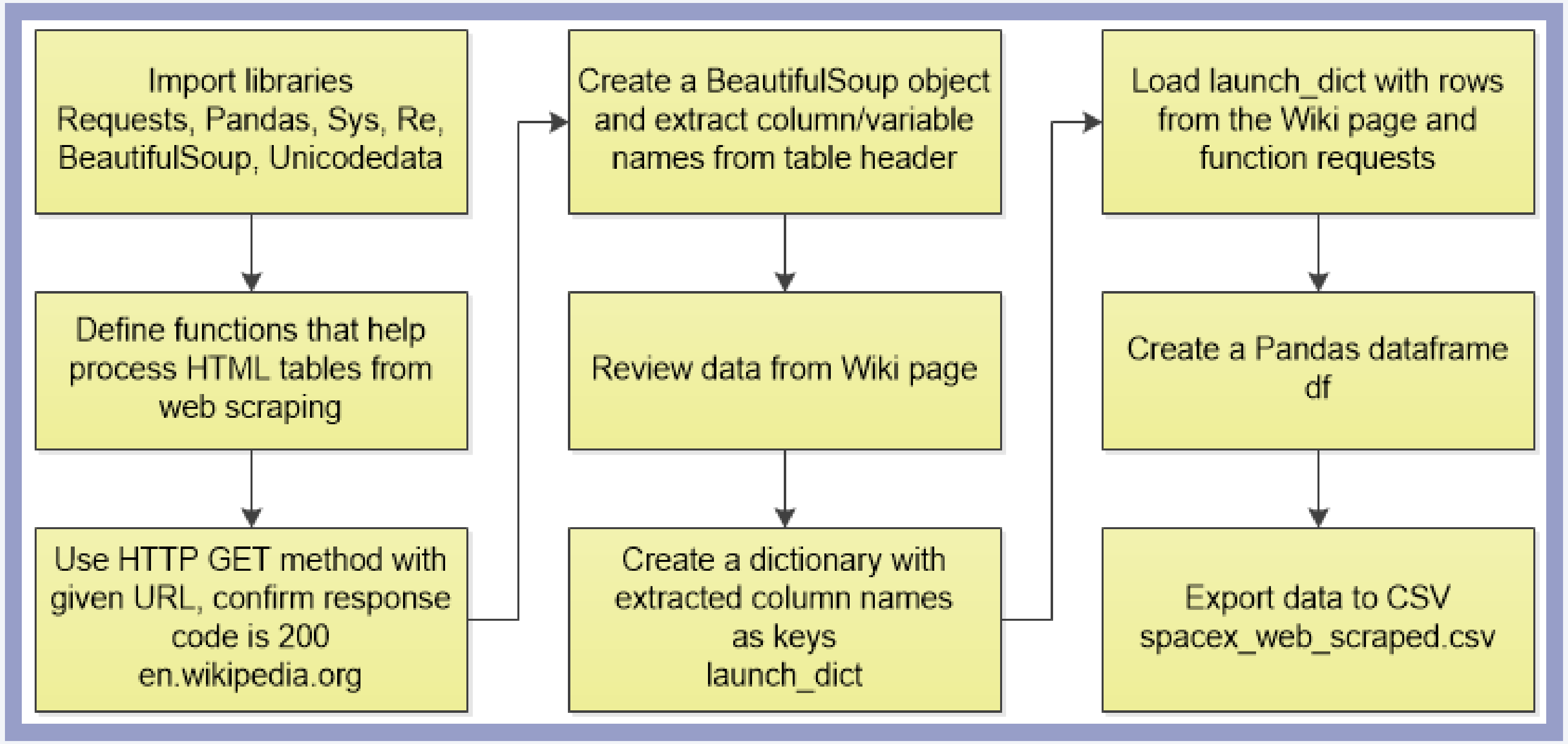
- Flowchart of the data collection process.
- https://github.com/GittiUpAFK/AKing-Capstone-Submission/blob/main/Mod1%20-%20jupyter-labs-spacex-data-collection-api.ipynb



Data Collection – Web Scraping

- Flowchart of the web scraping process.

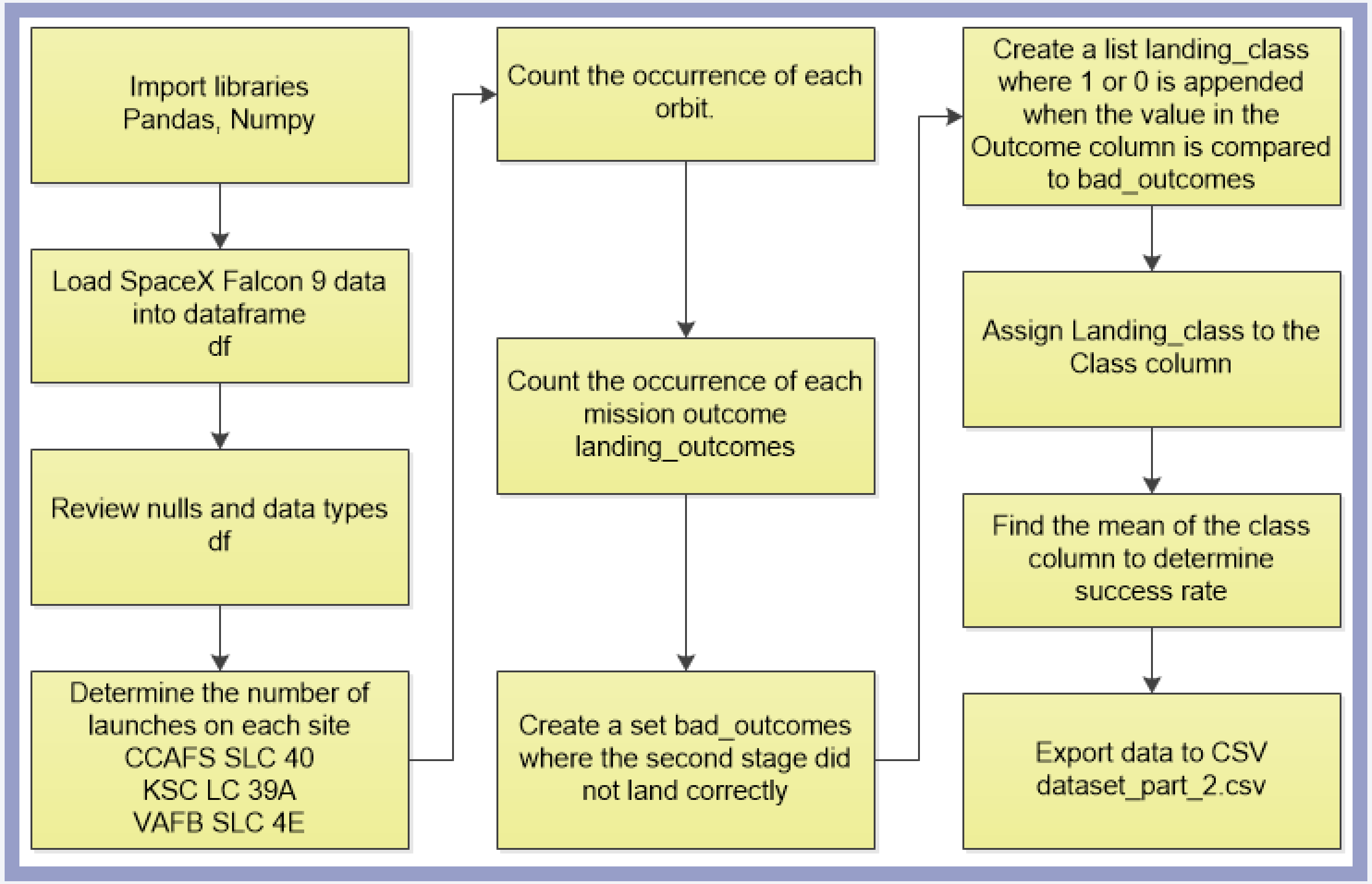
- https://github.com/GittiUpAFK/AKing-Capstone-Submission/blob/main/Mod1%20-%20jupyter-labs-webscraping.ipynb



Data Wrangling

- Flowchart of the data wrangling process.

- https://github.com/GittiUpAFK/AKing-Capstone-Submission/blob/main/Mod1%20-%20labs-jupyter-spacex-Data%20wrangling.ipynb



Section 2

Insights drawn from EDA

EDA with Data Visualization

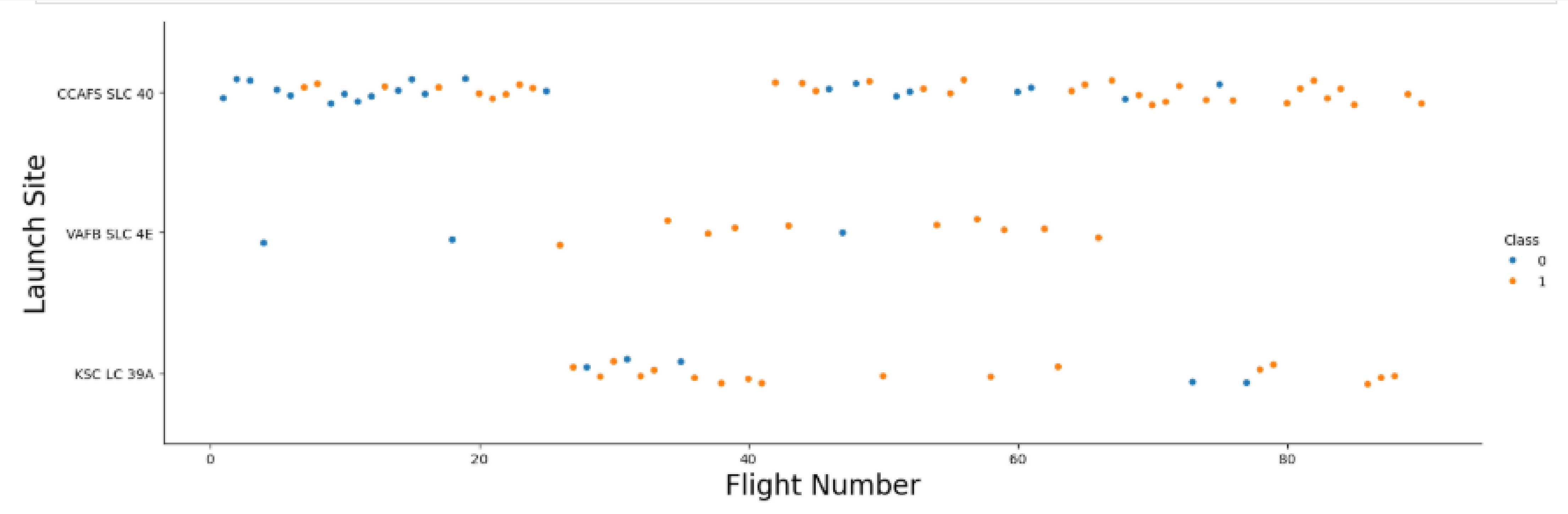
Performed Exploratory Data Analysis using Visualization to identify features that affect the success rate of the launch landings. See Appendix, Note B for launch site definitions.

Charts plotted:

- Flight Number vs. Launch Site
- Payload vs. Launch Site
- Success Rate vs. Orbit Type
- Flight Number vs. Orbit Type
- Payload vs. Orbit Type
- Launch Success Yearly Trend

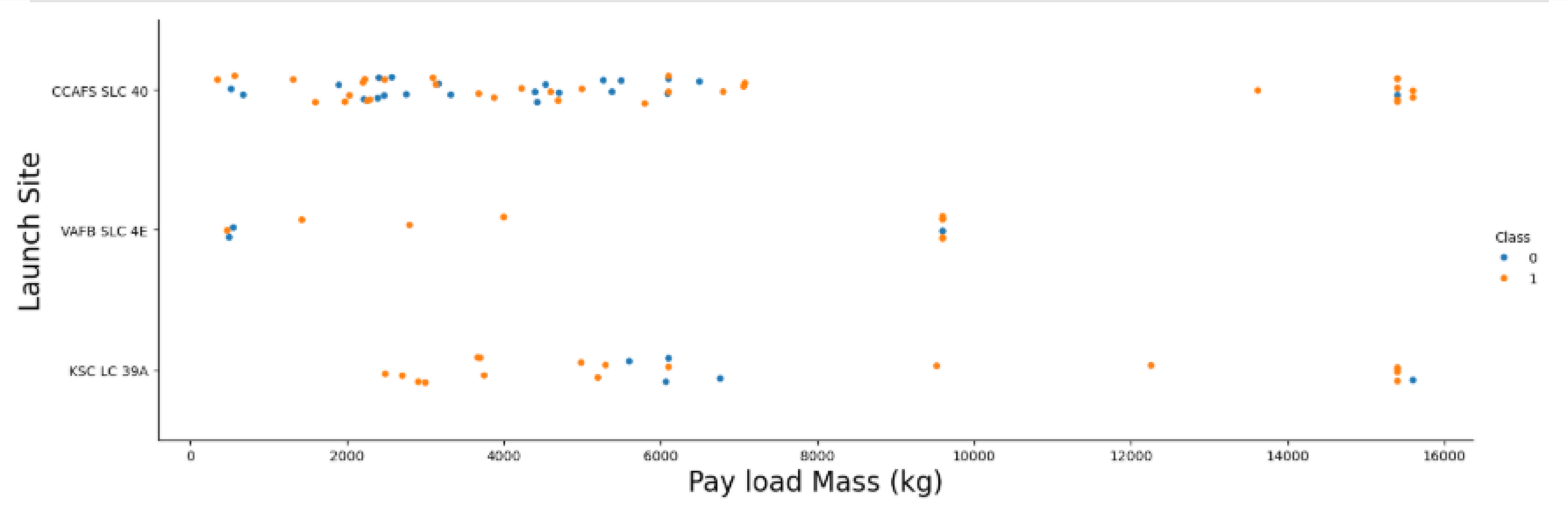
- https://github.com/GittiUpAFK/AKing-Capstone-Submission/blob/main/Mod2%20-%20edadataviz.ipynb

Flight Number vs. Launch Site



- CCAFS SLC 40 had the highest count of launches, however KSC LC 30A and VAFB SLC 4E had better success rates. Around flight 25 until flight 40, launches seem to have suspended in CCAFS SLC 40, then initialized at the same pace for KSC LC 39A. After around flight 70, launch success improves for CCAFS SLC 40.

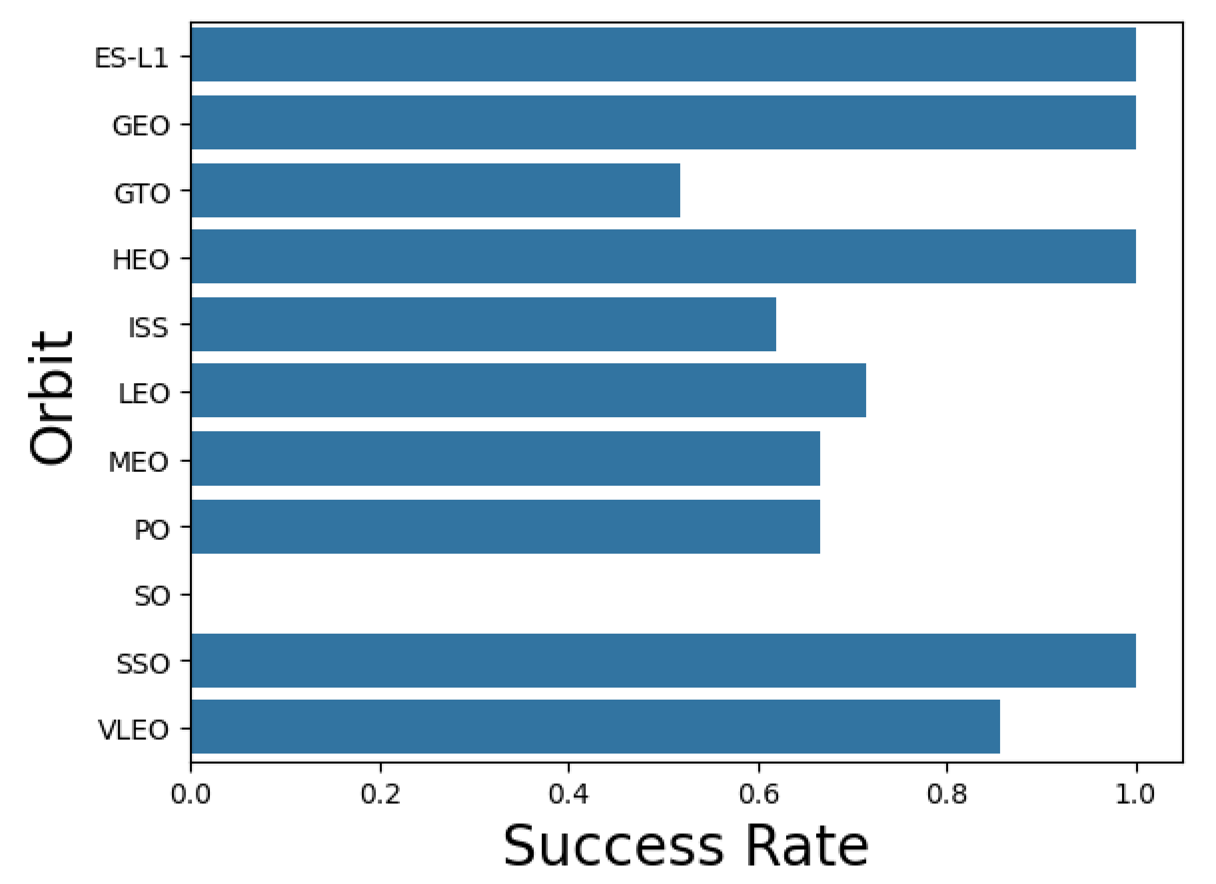
Payload vs. Launch Site



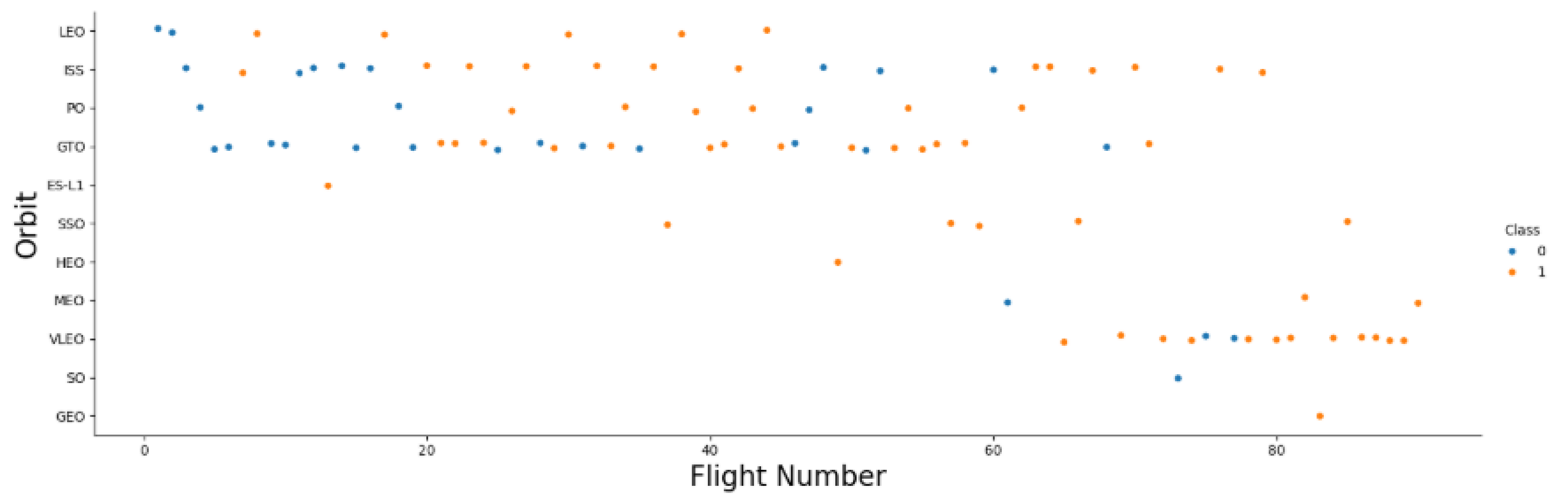
- The bulk of the launches had a payload of less than 8000 kg. Only sites CCAFS SLC 40 and KSC LC 39A had payloads over 10,000 kg, with launches mainly successful.

Success Rate vs. Orbit Type

- Orbits with the highest Success Rate:
    - ES-L1
    - GEO
    - HEO
    - SSO/SO
- VLEO and LEO have the next best success rates and also have a higher number of launches
- See Appendix, Note C for orbit definitions.

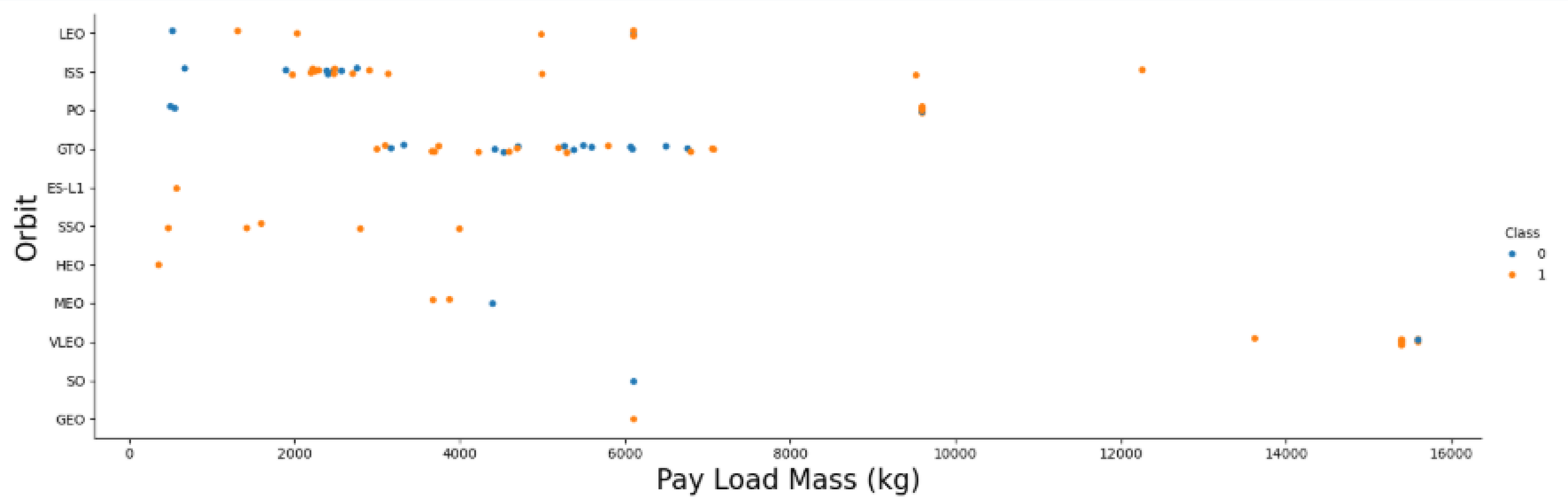


Flight Number vs. Orbit Type



- LEO and MEO are the only two orbits that appear to have a relationship with the number of flight. The remaining orbits do not appear to have a relationship with number of flights. Their successes do not remain constant as the flight numbers increase.

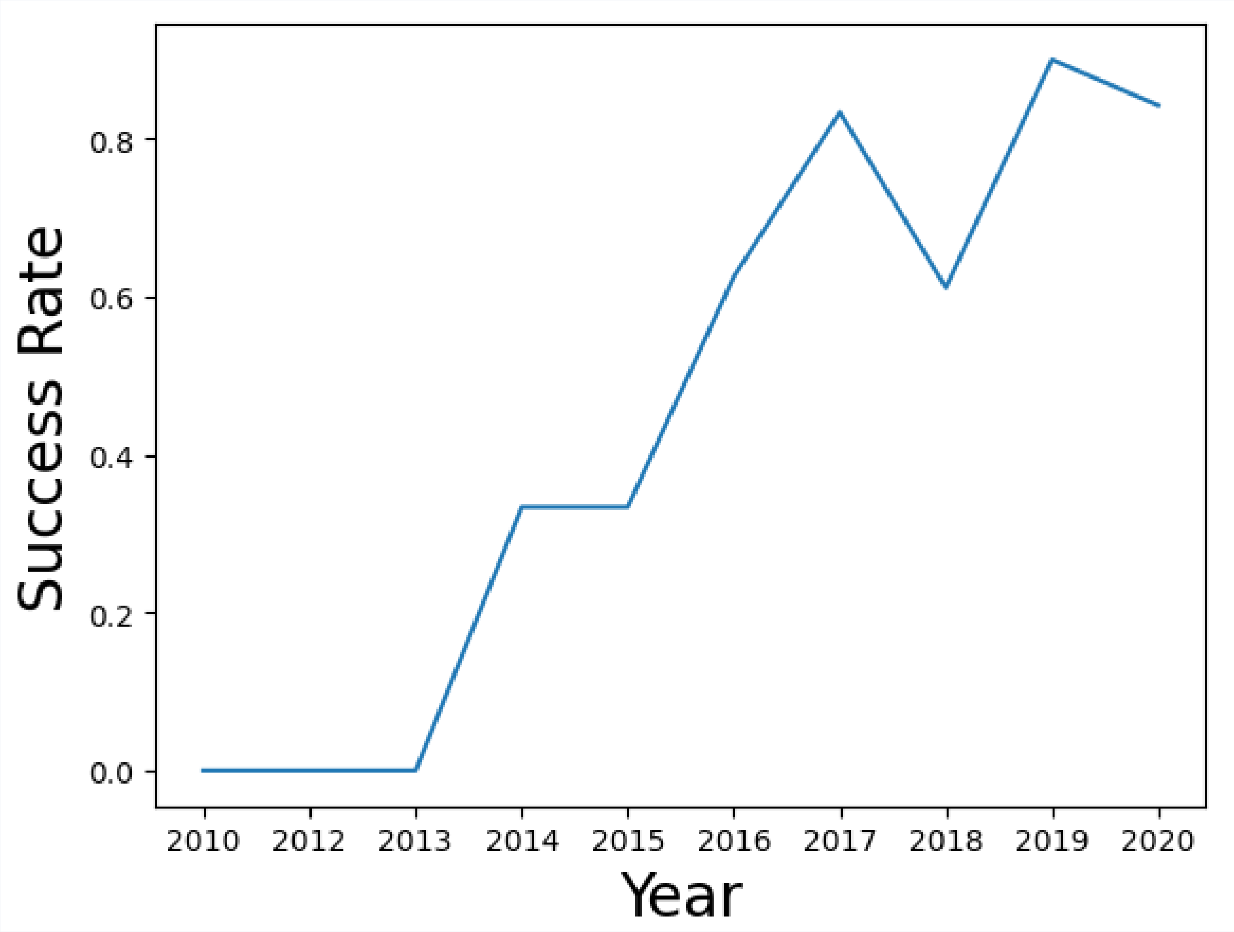
Payload vs. Orbit Type



- Orbits LEO, ISS, PO, GTO, SO, AND GEO are those which have payloads 6000 kg or greater. LEO, ISS, and PO orbits appear to have the best success rates. SSO has the best success rate for orbits 4000 kg or less.

Launch Success Yearly Trend

- The average success rate showed an overall increase from 2013 to 2020.
  - A decrease in the average success rate occurred in 2018.
  - 2019 showed a recovery and increase.
  - However, 2020 there was another decrease in average success rate.



EDA with SQL

Performed Exploratory Data Analysis with SQL, running the following queries to better understand the data:

- Unique launch site names.
- Five records where launch site begins with CCA.
- Total payload mass carried by boosters launched by NASA (CRS).
- Average payload mass carried by booster version F9 v1.1.
- Date of first successful landing outcome on a ground pad.
- Name of boosters which have success in drone ship and a payload mass between 4000 and 6000.
- Total number of successful and failure mission outcomes
- Names of booster versions which have carried the max payload.
- List of drone ship failures in the year 2015, displaying the booster version, month, year, and launch site.
- Rank the count of landing outcomes between 2010-06-04 and 2017-03-20.

- https://github.com/GittiUpAFK/AKing-Capstone-Submission/blob/main/Mod2%20-%20jupyter-labs-eda-sql-coursera_sqllite.ipynb

All Launch Site Names

- The query produced four DISTINCT launch site names.
  - CCAFS LC-40 and CCAFS SLC-40 are actually the same location.
  - CCAFS SLC-40 is the current designation.

```
%sql select DISTINCT Launch_Site from SPACEXTABLE
```

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

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

Launch Site Names Begin with 'CCA'

- Five records were returned using LIKE that begin with `CCA`.

```
%sql select * from SPACEXTABLE where Launch_Site like 'CCA%' limit 5
```

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

Date	Time (UTC)	Booster_Version	Launch_Site	Payload	PAYLOAD_MASS__KG_	Orbit	Customer	Mission_Outcome	Landing_Outc
2010-06-04	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parach
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 (parach
2012-05-22	7:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)	Success	No atte
2012-10-08	0:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No atte
2013-03-01	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No atte

Total Payload Mass

- Calculated the SUM of payload mass carried by boosters where Customer was “NASA (CRS)”.

```
%sql select SUM(PAYLOAD_MASS__KG_) from SPACEXTABLE where Customer = "NASA (CRS)"
```

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

SUM(PAYLOAD_MASS__KG_)
45596

Average Payload Mass by F9 v1.1

- Calculated the AVG of payload mass carried by booster version F9 v1.1.

```
%sql select AVG(PAYLOAD_MASS__KG_) from SPACEXTABLE where Booster_Version = "F9 v1.1"
```

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

AVG(PAYLOAD_MASS__KG_)
2928.4

First Successful Ground Landing Date

- Found the first date of a successful landing outcome on ground pad “Success (ground pad)”.

```
%sql select MIN(Date) from SPACEXTABLE where Landing_Outcome = "Success (ground pad)"
```

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

MIN(Date)
2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

- Listed the names of boosters which
  - had a successful landing outcome on drone ship “Success (drone ship)”, and
  - had payload mass greater than 4000 but less than 6000.
- Full SQL Query:
  - %sql select Booster_Version from SPACEXTABLE where Landing_Outcome = "Success (drone ship)" and PAYLOAD_MASS__KG_ between 4000 and 6000

```
%sql select Booster_Version from SPACEXTABLE where Landing_Outcome = "Success (drone ship)" and PAYLOAD_MASS__KG_ betwee
```

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

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

Total Number of Successful and Failure Mission Outcomes

- Counted the total number of successes and failures by DISTINCT Mission Outcomes.

```
%sql select DISTINCT Mission_Outcome, COUNT(*)  from SPACEXTABLE group by Mission_Outcome
```

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

Mission_Outcome	COUNT(*)
Failure (in flight)	1
Success	98
Success	1
Success (payload status unclear)	1

Boosters Carried Maximum Payload

- Found the maximum payload and determined which booster versions carried the maximum.

```
%sql select Booster_Version from SPACEXTABLE where PAYLOAD_MASS__KG_ = (select MAX(PAYLOAD_MASS__KG_) from SPACEXTABLE)
```

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

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

- Listed the Landing Outcomes in 2015 with a drone ship failure “Failure (drone ship)”.
- Full Query
  - %sql select Booster_Version, substr(Date, 6, 2) as "Month", substr(Date, 0,5) as "Year", Launch_Site,Landing_Outcome from SPACEXTABLE where Landing_Outcome = "Failure (drone ship)" AND substr(Date, 0, 5) = '2015'

```
%sql select Booster_Version, substr(Date, 6, 2) as "Month", substr(Date, 0,5) as "Year", Launch_Site,Landing_Outcome fro
```

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

Booster_Version	Month	Year	Launch_Site	Landing_Outcome
F9 v1.1 B1012	01	2015	CCAFS LC-40	Failure (drone ship)
F9 v1.1 B1015	04	2015	CCAFS LC-40	Failure (drone ship)

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

- Ranked the count of Landing Outcomes between the date 2010-06-04 and 2017-03-20, in descending order
- Full query:
  - %sql select DISTINCT Landing_Outcome, COUNT(*) as Total from SPACEXTABLE where Date between "2010-06-04" and "2017-03-10" group by Landing_Outcome order by Total DESC

```
%sql select DISTINCT Landing_Outcome, COUNT(*) as Total  from SPACEXTABLE where Date between "2010-06-04" and "2017-03-1
```

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

Landing_Outcome	Total
No attempt	9
Success (drone ship)	5
Failure (drone ship)	5
Success (ground pad)	3
Controlled (ocean)	3
Uncontrolled (ocean)	2
Failure (parachute)	2
Precluded (drone ship)	1

Section 3

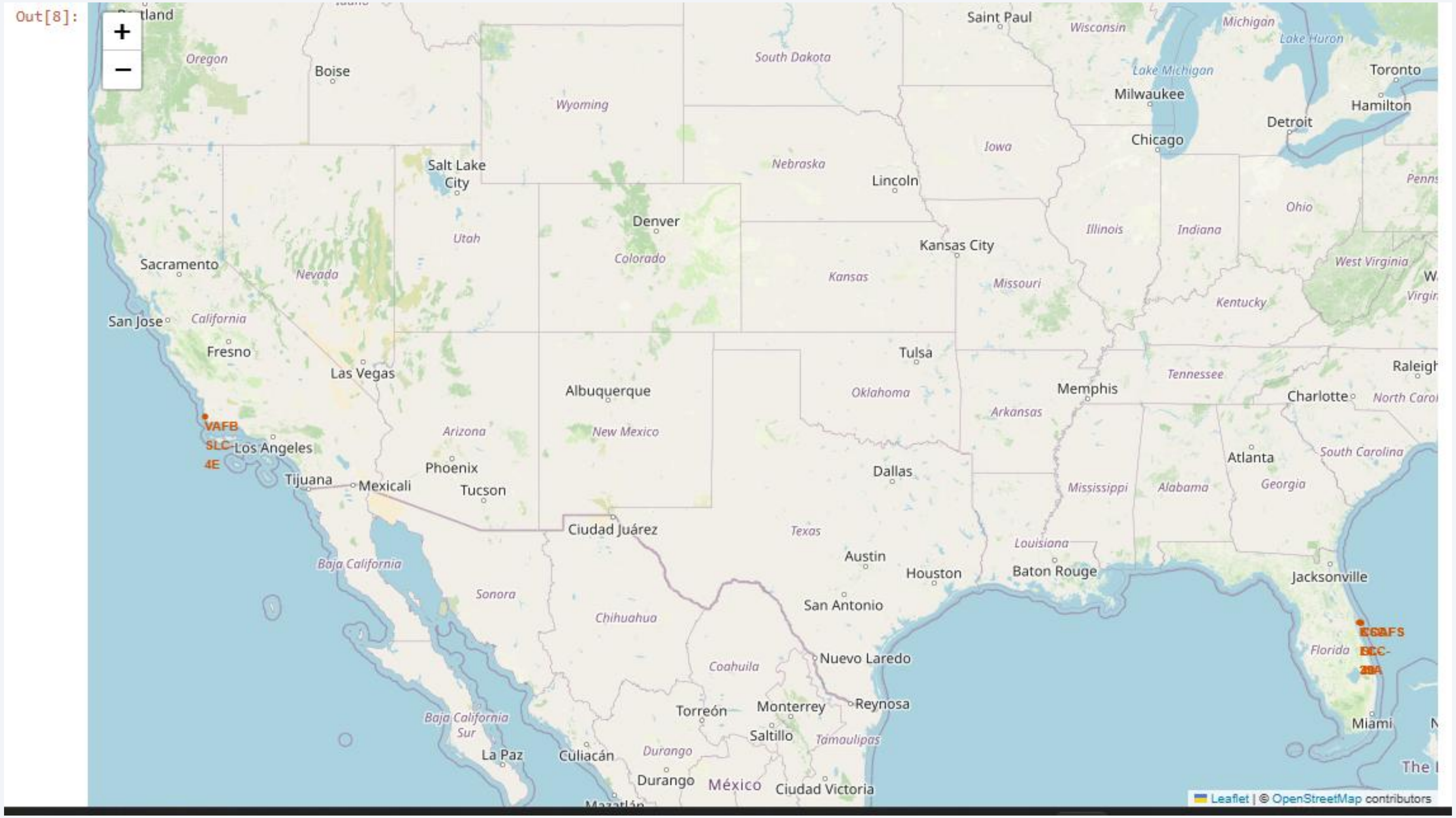
Launch Sites Proximities Analysis

Interactive Map with Folium

- Created an interactive map with Folium to identify launch sites and launch results using markers, circles and lines.
- Additional details were added to the VAFB SLC 4E site to explore points in its proximity.
- Exploring the launch sites and their proximities can aid in finding features that contribute to successful landings.
- https://nbviewer.org/github/GittiUpAFK/AKing-Capstone-Submission/blob/main/Mod2%20-%20lab_jupyter_launch_site_location.ipynb

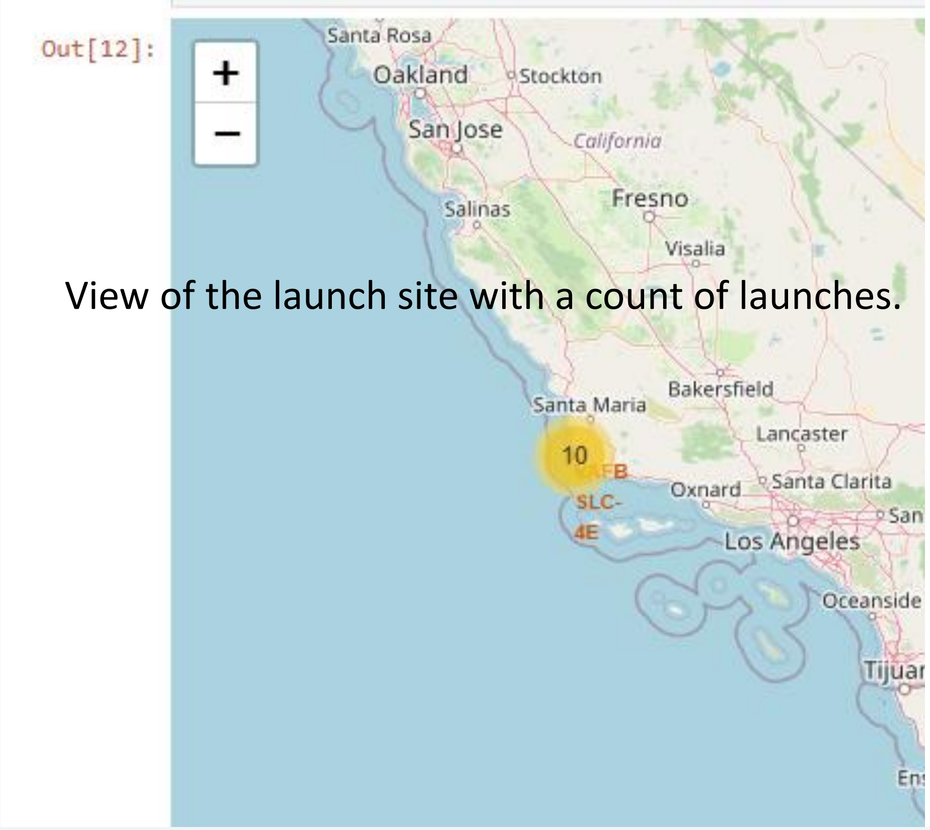
Folium Map – All Launch Sites

- Map displays the location markers for all sites.
  - One launch site is in CA while all others are in FL.
  - All sites are in close proximity to a coast.
  - Sites in FL are closest to the equator.

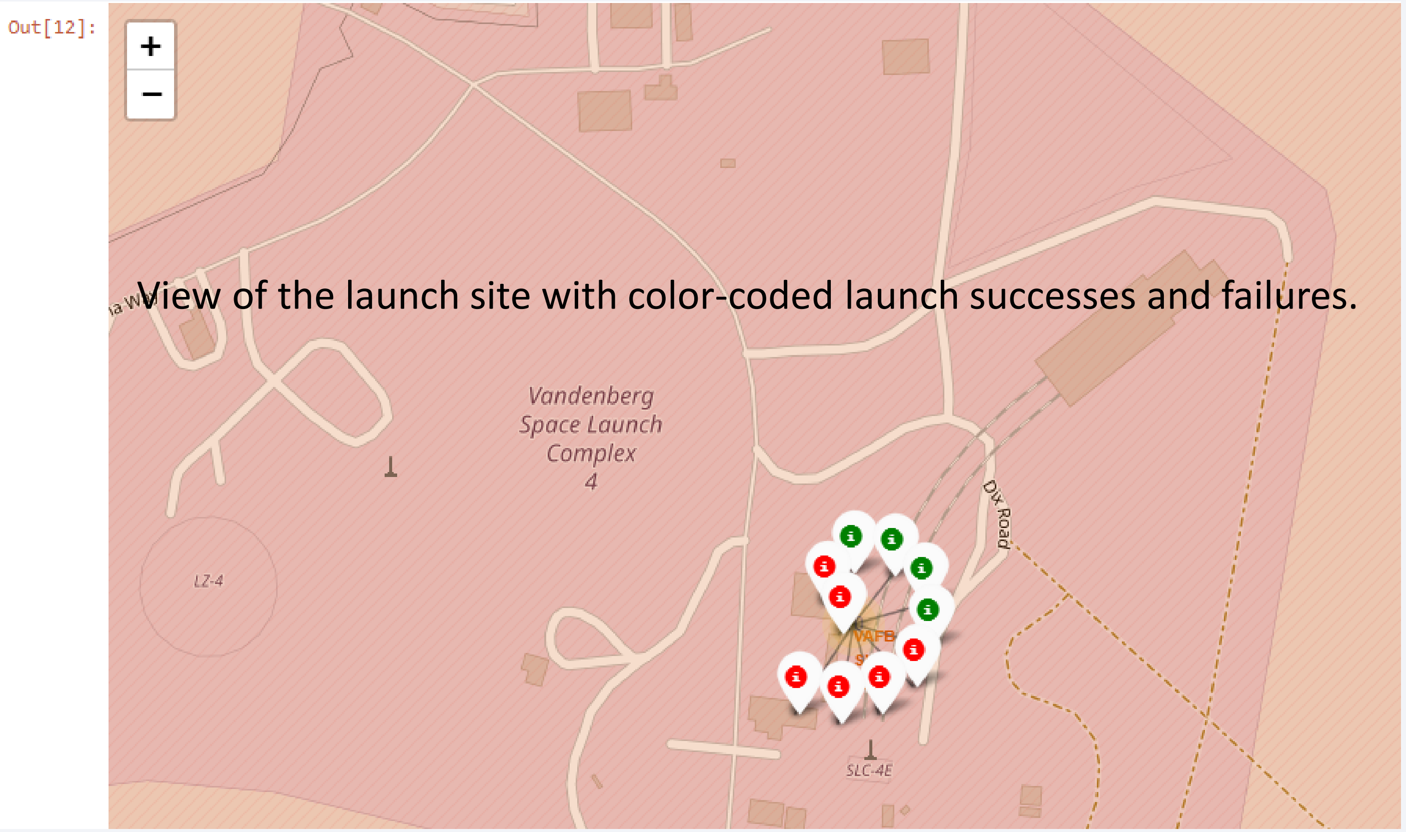


Folium Map – Color-Labeled Launch Outcomes

- VAFB SLC 4E is featured in the below maps.



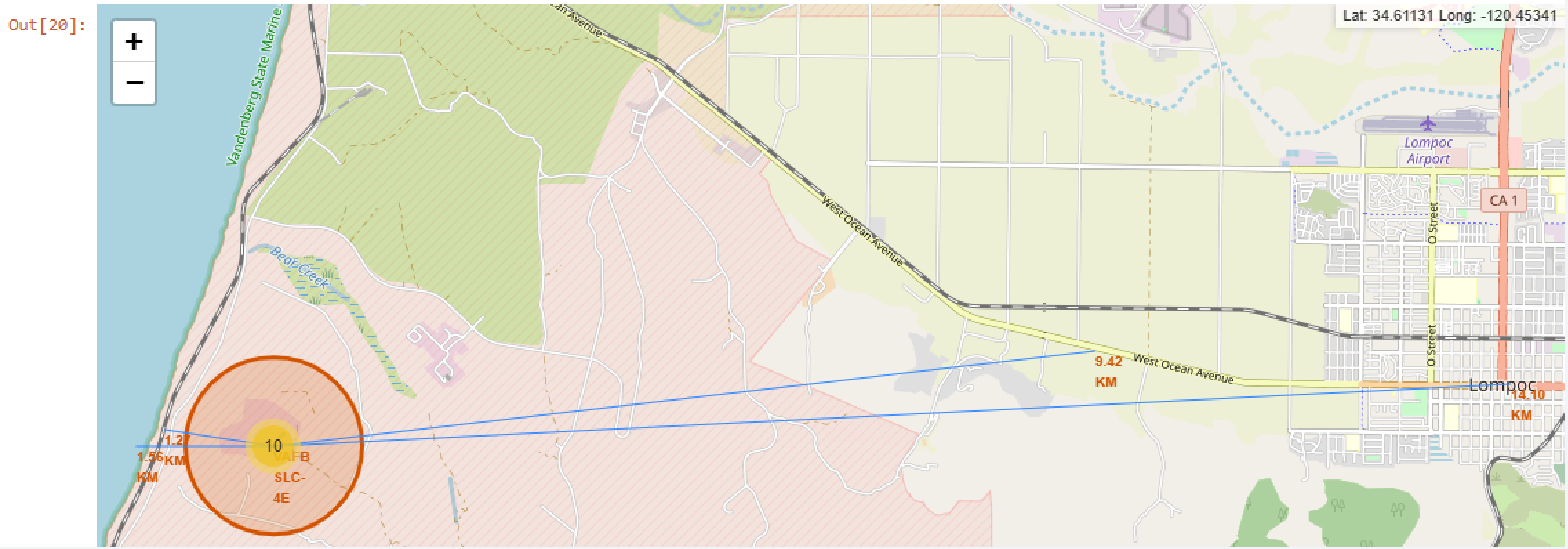
View of the launch site with a count of launches.



View of the launch site with color-coded launch successes and failures.

Folium Map – Proximities to Landmarks

- VAFB SLC 4E is less than 2 km to the ocean and railway. The main road and nearest town are greater than 9 km away.



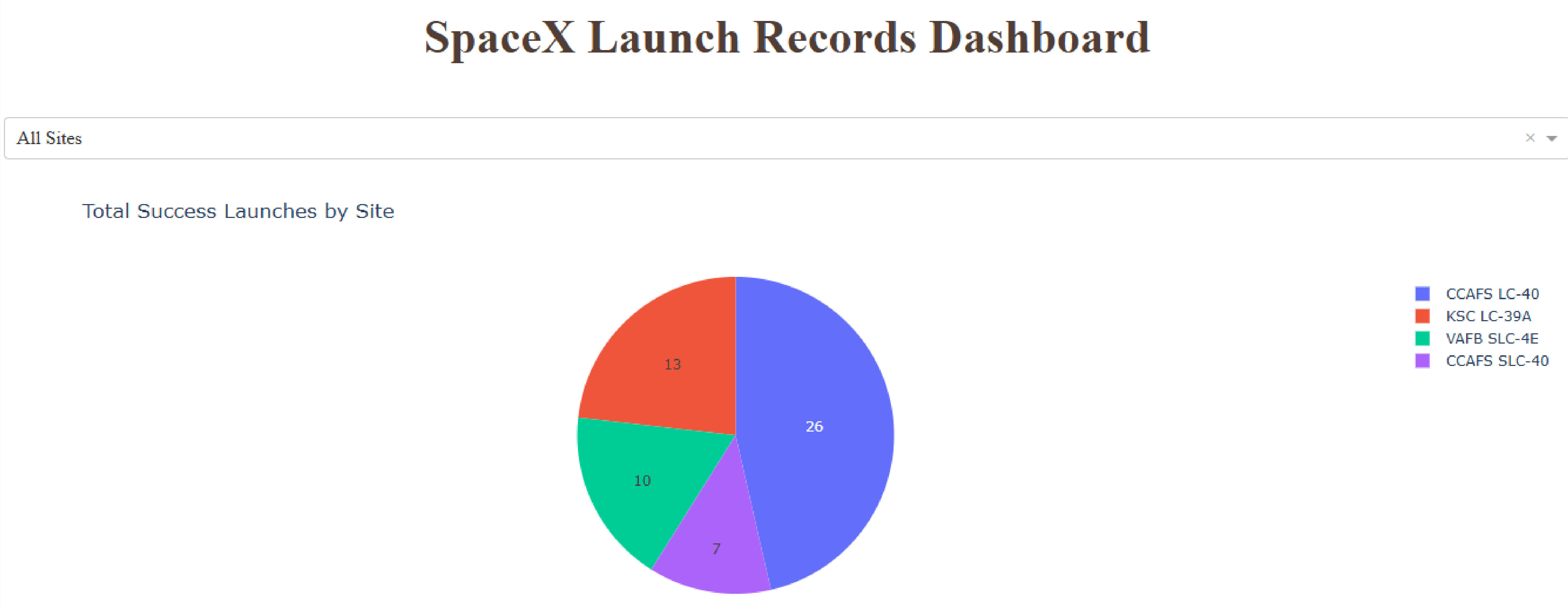
Section 4

Build a Dashboard with Plotly Dash

Dashboard with Plotly Dash

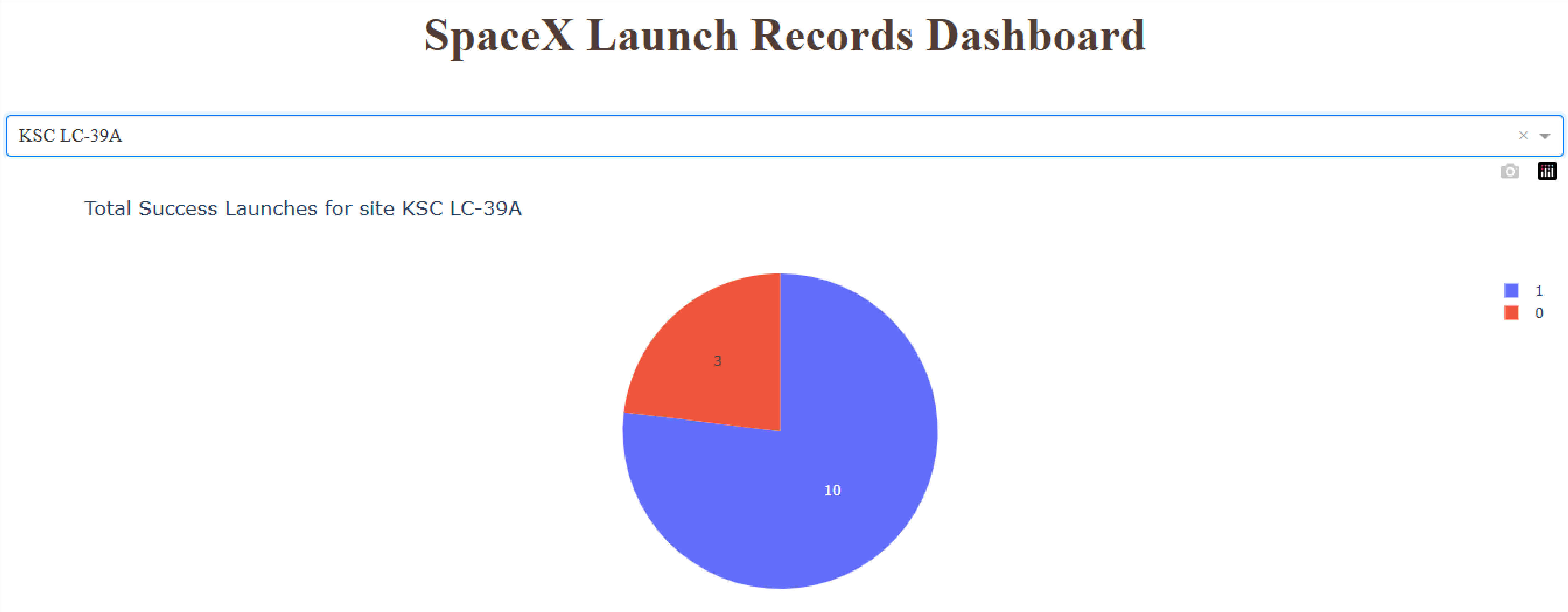
- Plotly dashboard has two parts
  - Pie chart to visualize the count of successful launches, for all sites or by individual site.
  - Scatter plot to visualize launch outcome results for selected site, with a slider to drill down to specific payload rages.
- The most successful launch and landing sites, payload ranges, and booster types can be determined visually using the dashboard.
- https://github.com/GittiUpAFK/AKing-Capstone-Submission/blob/main/Mod3%20-%20spacex_dash_app.py

Dashboard – Launch Success Count for All Sites



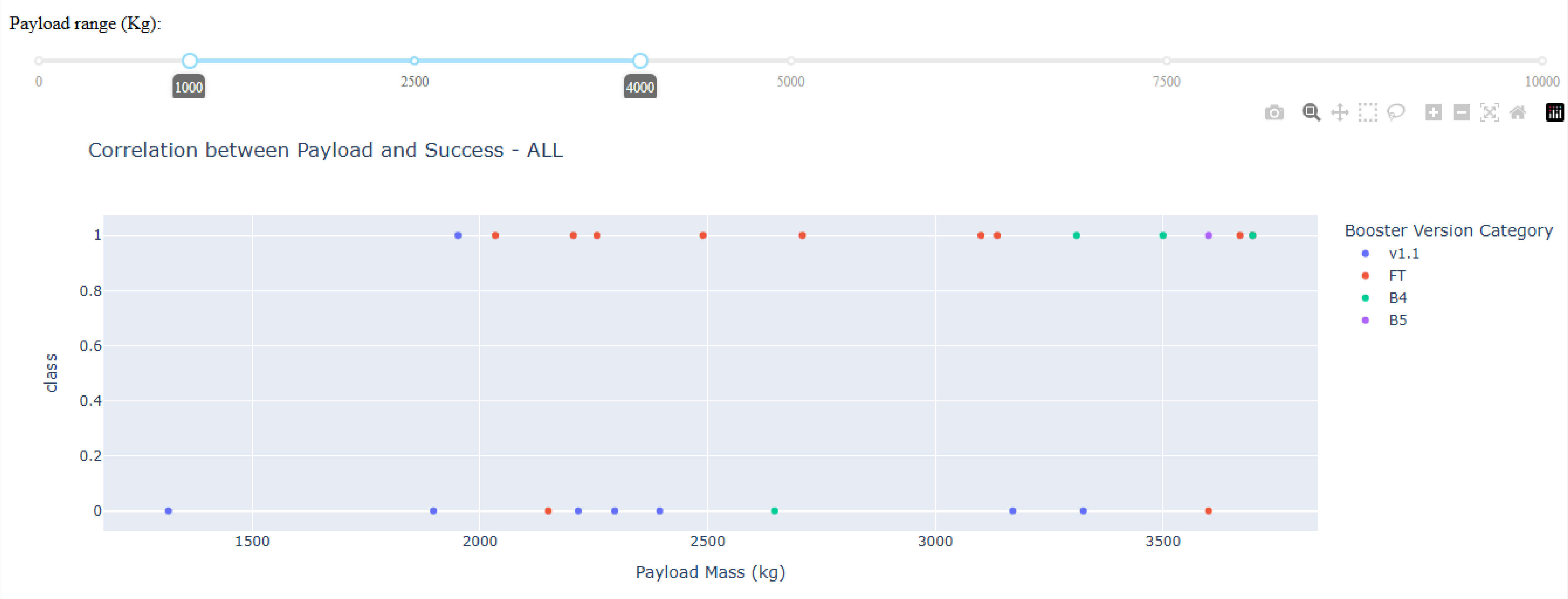
- Pie chart displaying launch success count for all sites revealed that CCAFS LC-40 had the largest count of successful launches.

Dashboard – Launch Site with Highest Success Ratio



- KSC LC-39A was the site with the highest success ratio, only slightly higher than the success ratio for CCAFS LC-40 where most launches took place.

Dashboard – Payload vs Launch Outcome



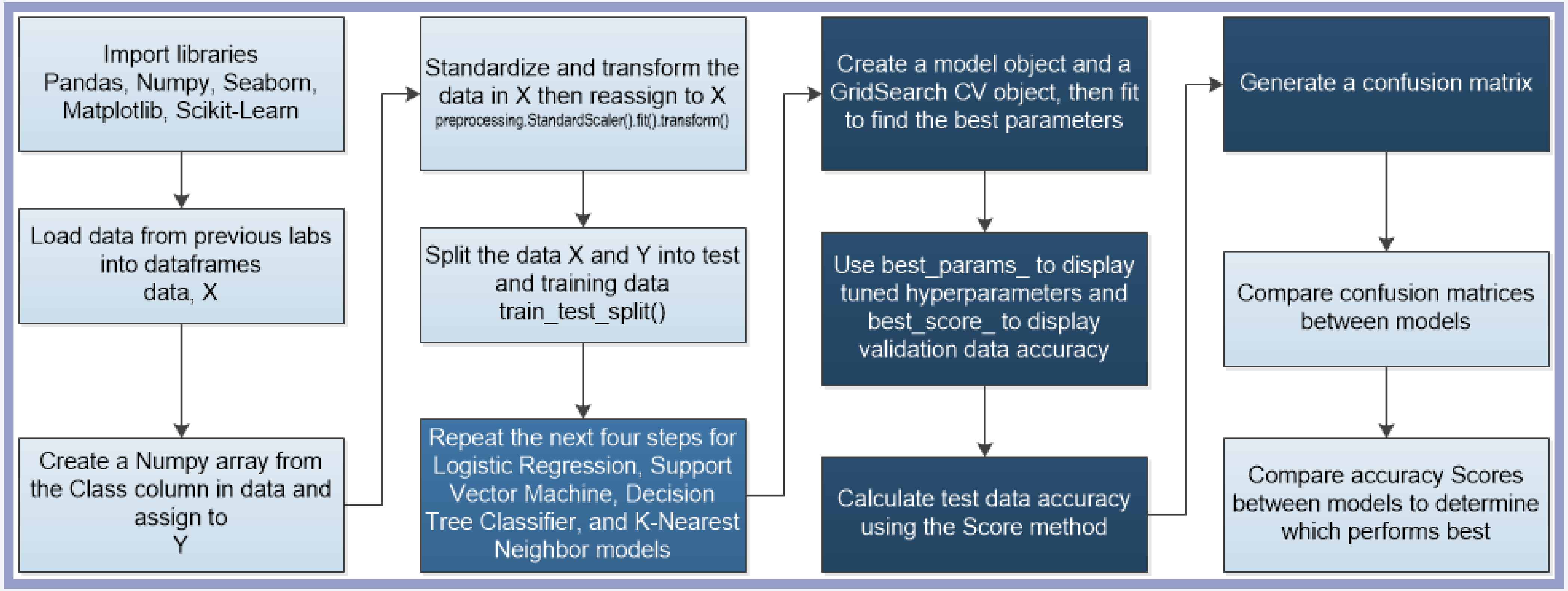
- Payload range from 1000 kg to 4000 kg appears to have the highest success rate, with the FT booster having the largest success in that range.

Section 5

Predictive Analysis (Classification)

Predictive Analysis (Classification)

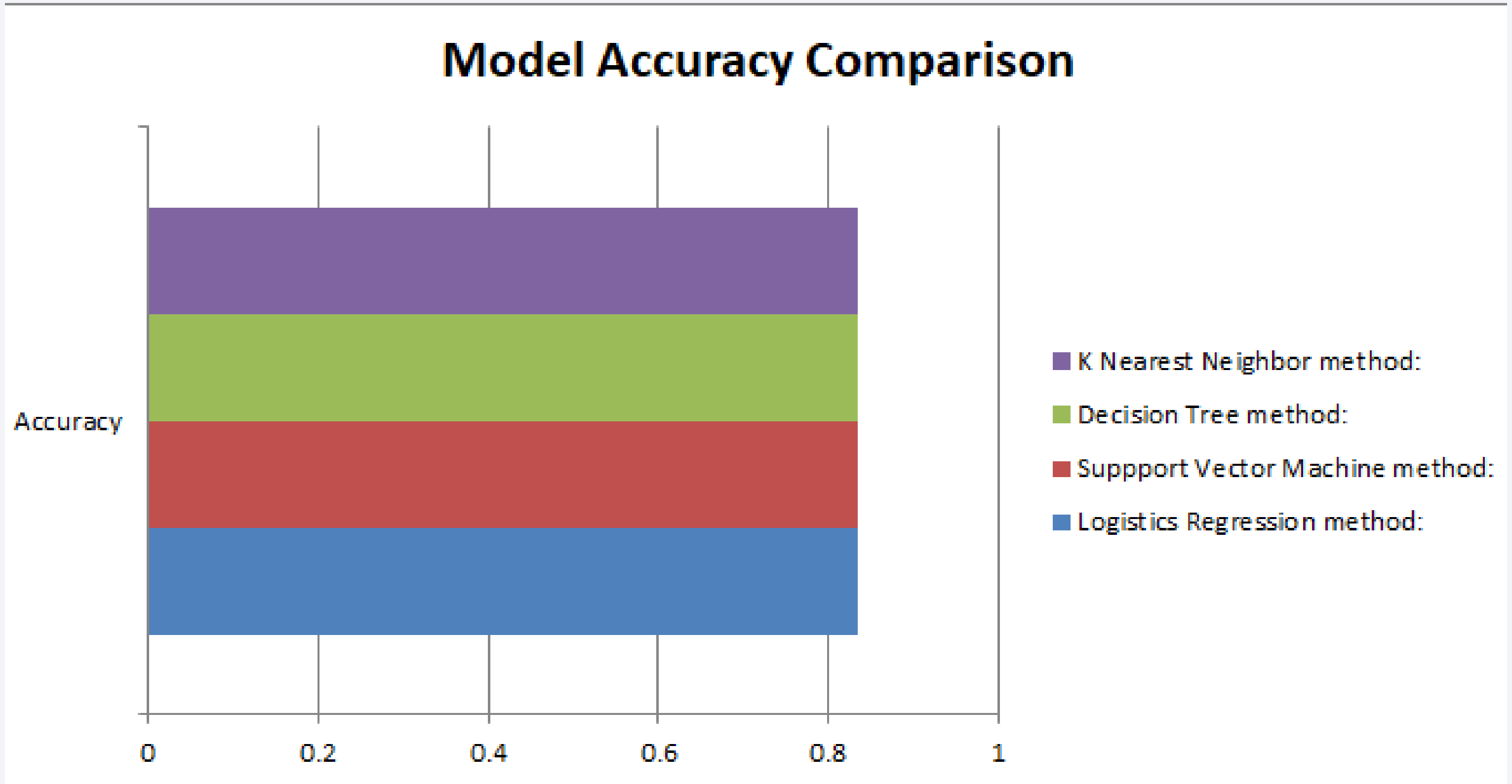
- Used a machine learning pipeline with GridSearchCV to find the optimal settings for maximum model performance, then compared model accuracies and confusion matrices to determine the best model that predicts whether the first stage will land.



- https://nbviewer.org/github/GittiUpAFK/AKing-Capstone-Submission/blob/main/Mod4%20-%20SpaceX_Machine%20Learning%20Prediction_Part_5.ipynb

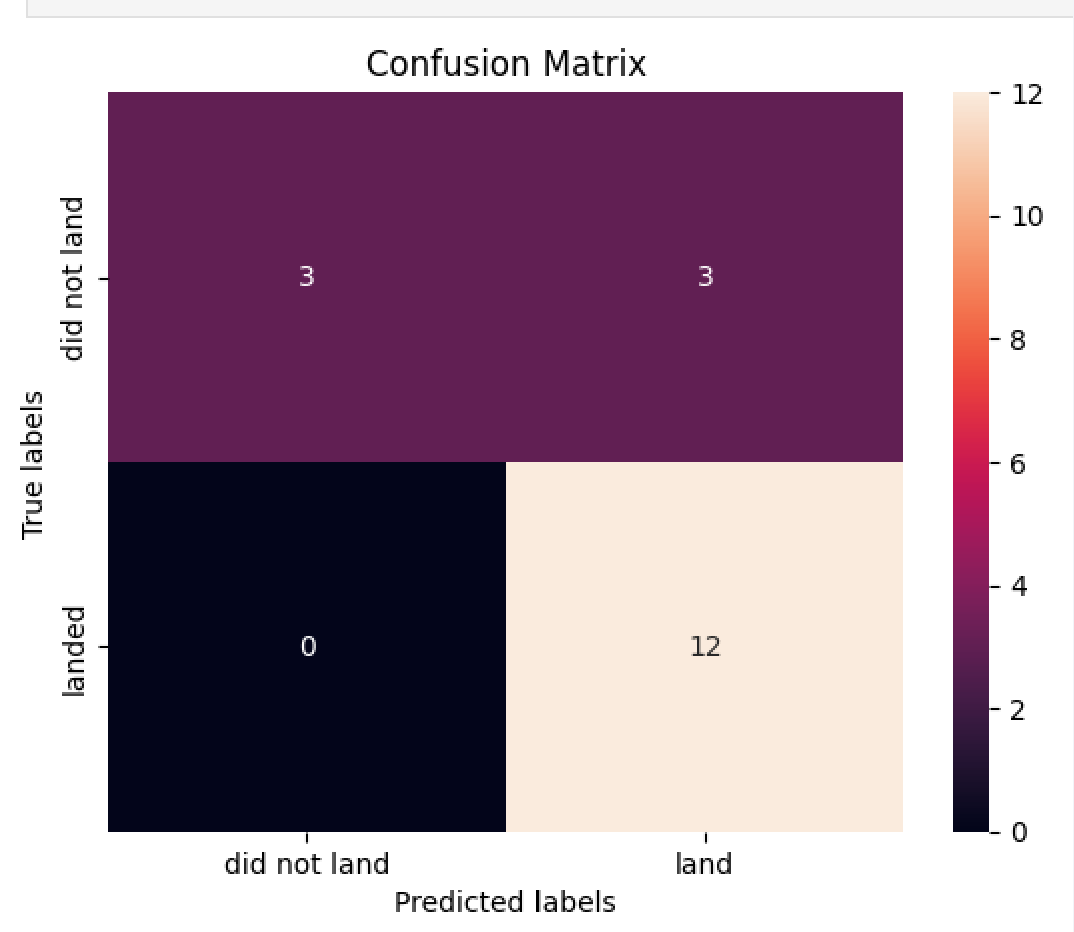
Classification Accuracy

- Using the Score method, the test data accuracy was the same for each model: 0.8333333333333334.
- See Appendix, Note D for tuned (best) hyperparameters and Note E for validation data accuracy results.



Confusion Matrix

- The Confusion Matrix was the same for all four classification models.
    - 12 True Positive – True label is land and Predicted label is land. The classifiers correctly predicted that 12 first stages would land, which matched the true labels. The models do a good job predicting landings.
    - 3 False Positive – True label is did not land and Predicted label is land. Out of six true labels, the classifiers correctly predicted that three first stages would not land and incorrectly predicted that three would land.



Section 6

Results

Results

- Created a dataset using data collected through API request from SpaceX and webscraping from Wikipedia. Drilled down to specific F9 data, then transformed the data into a usable format for exploratory data analysis (data wrangling).
- EDA with visualization and SQL revealed that launch site, payload mass, and orbit type, and booster type impacted successful outcomes.
- ES-L1, GEO, HEO, SSO/SO have the best success rates but few launches. VLEO and LEO have a higher number of launches and the next best success rates.
- A Folium map revealed that sites in Florida—KSC LC 39A and CCAFS LC-40—have the most launches and are located closest to the equator.
- A Plotly dashboard revealed that KSC LC 39A has the highest success rate, followed by CCAFS LC-40. Both are located in Florida. The dashboard also revealed that the payload range with the most successful outcome is 1000 kg to 4000 kg.
- With Predictive Analysis, we revealed that model accuracy and confusion matrix was the same for each method and that the classifiers correctly predicted that 12 first stages would land, which matched the true labels. The models do a good job predicting landings.

Section 7

Conclusions

Conclusions

- What is the impact of site location?
  - Florida sites appear to have the best outcome. KSC LC 39A has the highest success rate, followed closely by CCAFS LC-40 which has the highest number of launches.
- What is the impact of payload?
  - Payloads between 1000 kg and 4000 kg appear to have the highest success rates. KSC LC 39A launches were most successful at heavy and lighter payloads.
- What is the impact of orbit types?
  - Success rates are highest for ES-L1, GEO, HEO, and SSO/SO orbits. GTO has the lowest success rate.
- What is the impact of booster type?
  - FT booster type appears to have the highest success rate for payloads between 1000 kg and 4000 kg.

Conclusions

- Overall success trend of launches
  - Reviewing data from 2010 to 2020, the average success rate showed an overall increase from 2013 to 2020. There was a decrease in the average success rate in 2018, followed by a recovery in 2019 and another decrease in 2020
- Can we predict whether SpaceX can reuse the first stage using a Machine Learning Model.
  - Reuse of the first stage can be predicted using a Machine Learning Model. The models reviewed (K-Nearest Neighbor, Decision Tree Classifier, Logistic Regression, Support Vector Machine) showed equal accuracy and performed well at predicting landings. They did not predict landing failures well.

Section 8

Appendix

Appendix

Note A – Datasets and Exports

- SpaceX API URL:

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

- SpaceX API, Skills Network Static JSON URL:

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

- List of Falcon 9 and Falcon Heavy Launches Wikipedia URL:

    https://en.wikipedia.org/wiki/List_of_Falcon_9_and_Falcon_Heavy_launches

- 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

Appendix

Note A – Datasets and Exports (Continued)

- Data Collection Lab CSV Export:

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

- Web Scraping Lab CSV Export:

  https://github.com/GittiUpAFK/AKing-Capstone-Submission/blob/main/Mod1%20-%20spacex_web_scraped.csv

- Data Wrangling Lab CSV Export:

  https://github.com/GittiUpAFK/AKing-Capstone-Submission/blob/main/Mod1%20-%20dataset_part_2.csv

- EDA with Visualization CSV Export:

  https://github.com/GittiUpAFK/AKing-Capstone-Submission/blob/main/Mod2%20-%20dataset_part_3.csv

- Complete GitHub Repository:
  - https://github.com/GittiUpAFK/AKing-Capstone-Submission/tree/main

Appendix

Note B – Launch Site Definitions (Source: Space X Falcon 9 First Stage Landing Prediction – Lab 2 Data Wrangling)

- CCAFS LC 40 - Cape Canaveral Launch Complex 40. The original designation of CCAFS SLC 40.
- CCAFS SLC 40 - Cape Canaveral Space Launch Complex 40; leased by SpaceX.
- VAFB SLC 4E - Vandenberg Air Force Base Space Launch Complex 4E.
- KSC LC 39A - Kennedy Space Center Launch Complex 39A.

Note C – Orbit Definitions (Source: Skills Network Space X Falcon 9 First Stage Landing Prediction – Data Wrangling Lab)

- LEO: Low Earth Orbit – an Earth-centered orbit with an altitude of 2,000 km (1,200 mi) or less (approximately one-third of the radius of Earth),[1] or with at least 11.25 periods per day (an orbital period of 128 minutes or less) and an eccentricity less than 0.25.[2] Most of the manmade objects in outer space are in LEO [1].
- VLEO: Very Low Earth Orbit – defined as the orbits with a mean altitude below 450 km. Operating in these orbits can provide a number of benefits to Earth observation spacecraft as the spacecraft operates closer to the observation[2].

Appendix

Note C – Orbit Definitions (Continued)

- GTO: Geosynchronous Transfer Orbit - A geosynchronous orbit is a high Earth orbit that allows satellites to match Earth's rotation. Located at 22,236 miles (35,786 kilometers) above Earth's equator, this position is a valuable spot for monitoring weather, communications and surveillance. Because the satellite orbits at the same speed that the Earth is turning, the satellite seems to stay in place over a single longitude, though it may drift north to south," NASA wrote on its Earth Observatory website [3] .
- SSO (or SO): Sun-synchronous Orbit - Also called a heliosynchronous orbit, it is a nearly polar orbit around a planet, in which the satellite passes over any given point of the planet's surface at the same local mean solar time [4] .
- ES-L1 : Sun-Earth L1 Lagrange Point Orbit - At the Lagrange point the gravitational forces of the two large bodies cancel out in such a way that a small object placed in orbit there is in equilibrium relative to the center of mass of the large bodies. L1 is one such point between the sun and the earth [5] .
- HEO: Highly Elliptical Orbit - A highly elliptical orbit is an elliptic orbit with high eccentricity, usually referring to one around Earth [6].

Appendix

Note C – Orbit Definitions (Continued)

- ISS: International Space Station - A modular space station (habitable artificial satellite) in low Earth orbit. It is a multinational collaborative project between five participating space agencies: NASA (United States), Roscosmos (Russia), JAXA (Japan), ESA (Europe), and CSA (Canada) [7]
- MEO: Medium Earth Orbit - Geocentric orbits ranging in altitude from 2,000 km (1,200 mi) to just below geosynchronous orbit at 35,786 kilometers (22,236 mi). Also known as an intermediate circular orbit. These are most commonly at 20,200 kilometers (12,600 mi), or 20,650 kilometers (12,830 mi), with an orbital period of 12 hours [8]
- HEO: High Earth Orbit - Geocentric orbits above the altitude of geosynchronous orbit (35,786 km or 22,236 mi) [9]
- GEO: Geostationary Orbit - A circular geosynchronous orbit 35,786 kilometres (22,236 miles) above Earth's equator and following the direction of Earth's rotation [10]
- PO: Polar Orbiting Satellite - It is one type of satellites in which a satellite passes above or nearly above both poles of the body being orbited (usually a planet such as the Earth [11]

Appendix

Note D – Tuned/ Best Hyperparameters (Source: (Source: Space X Falcon 9 First Stage Landing Prediction – Machine Learning Prediction Lab)

- K-Nearest Neighbor (KNN) – {‘algorithm’: ‘auto’, ‘n_neighbors’: 10, ‘p’: 1}
- Decision Tree Classifier (DT) - {'criterion': 'entropy', 'max_depth': 10, 'max_features': 'log2', 'min_samples_leaf': 2, 'min_samples_split': 10, 'splitter': 'random'}
- Support Vector Machine (SVM) - {'C': 1.0, 'gamma': 0.03162277660168379, 'kernel': 'sigmoid'}
- Logistic Regression (LR) - {'C': 0.01, 'penalty': 'l2', 'solver': 'lbfgs'}

Note E –Validation Data Accuracy Using best_score_ (Source: (Source: Space X Falcon 9 First Stage Landing Prediction – Machine Learning Prediction Lab)

- KNN – 0.8482142857142858
- DT – 0.8767857142857143
- SVM – 0.8482142857142856
- LR – 0.8464285714285713

Thank you!