IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

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

Executive Summary

- Space X data was gathered, organized and analyzed using machine learning models which were evaluated for best use case.
- From the data analyzed the models all performed at the same level of predictive ability. The models were able to predict with high confidence if a particular launch is going to land the first stage or not.

Introduction

- The projects goal is to find out the factors that contribute most to the successful landing of the first stage of falcon9 rockets
- This data will help SpaceY to standardize their launches and minimize failures to land to ensure their costs remain competitive with SpaceX

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - Data was collected through a Database API as well as from webscraping tables from wikipedia
- Perform data wrangling
  - The data was processed using Python dataframes to determine success rates.
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - Tested multiple Classification models and tuned to most impactful hyperparameters with GridSearchCV. Compared accuracy scores to find best model.

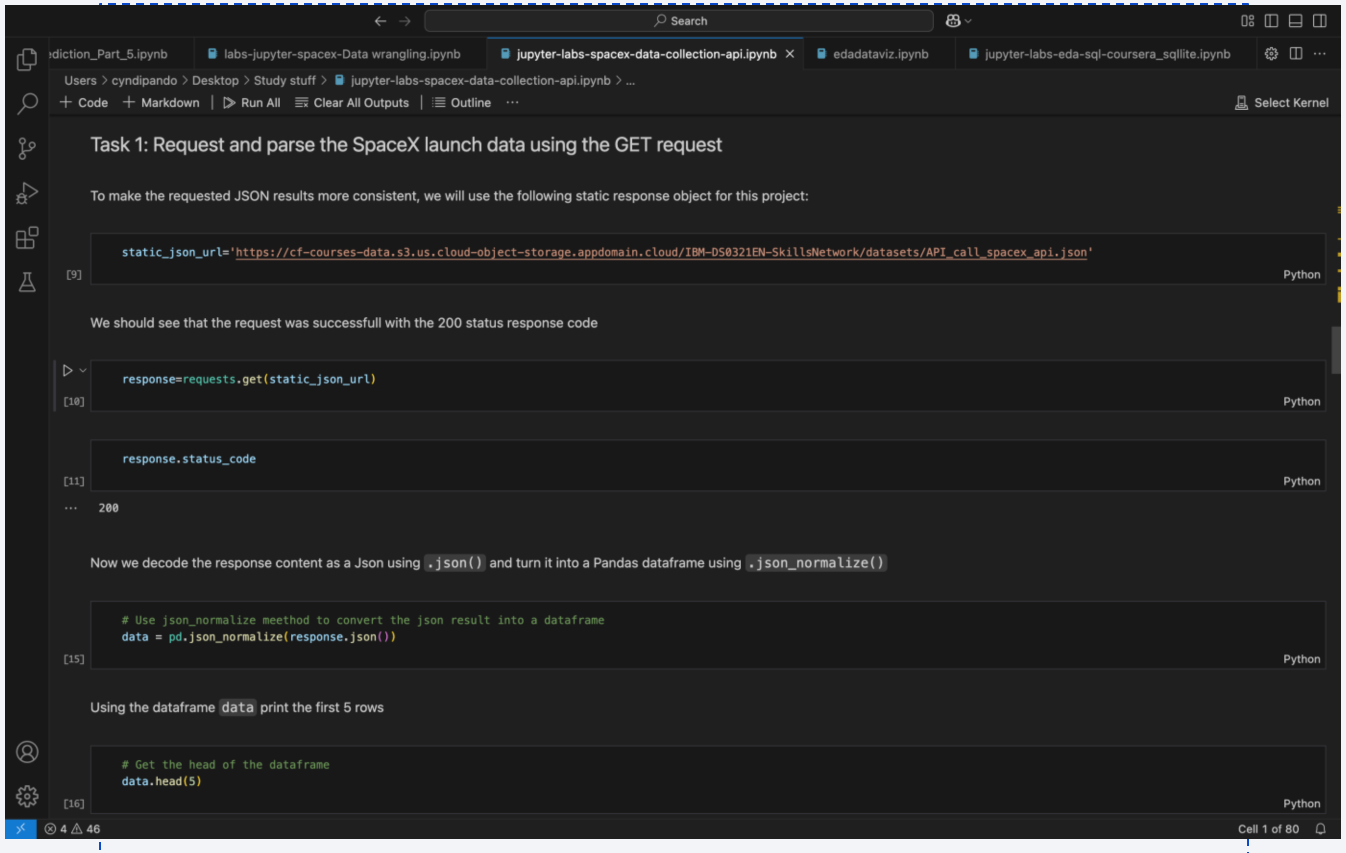
Data Collection

- The data was collected from two main sources.
  - Through a REST api connecting to a database with preconstructed tables
  - Through Webscrapping of the Wikipedia page tables to find relevant data
- Data had to be normalized as it enters as a JSON file so using the .json_normalize method allowed it to be transformed into a dataframe.
- BeautifulSoup was used for webscraping the html tables of the Wikipedia article.
- After loading data it had to be cleaned, and missing values had to either be filled, dropped, or ignored depending on the data missing.

Data Collection – SpaceX API

- To use the API we had to send a request to the server and await a response. This response was later transformed into the pandas dataframe.

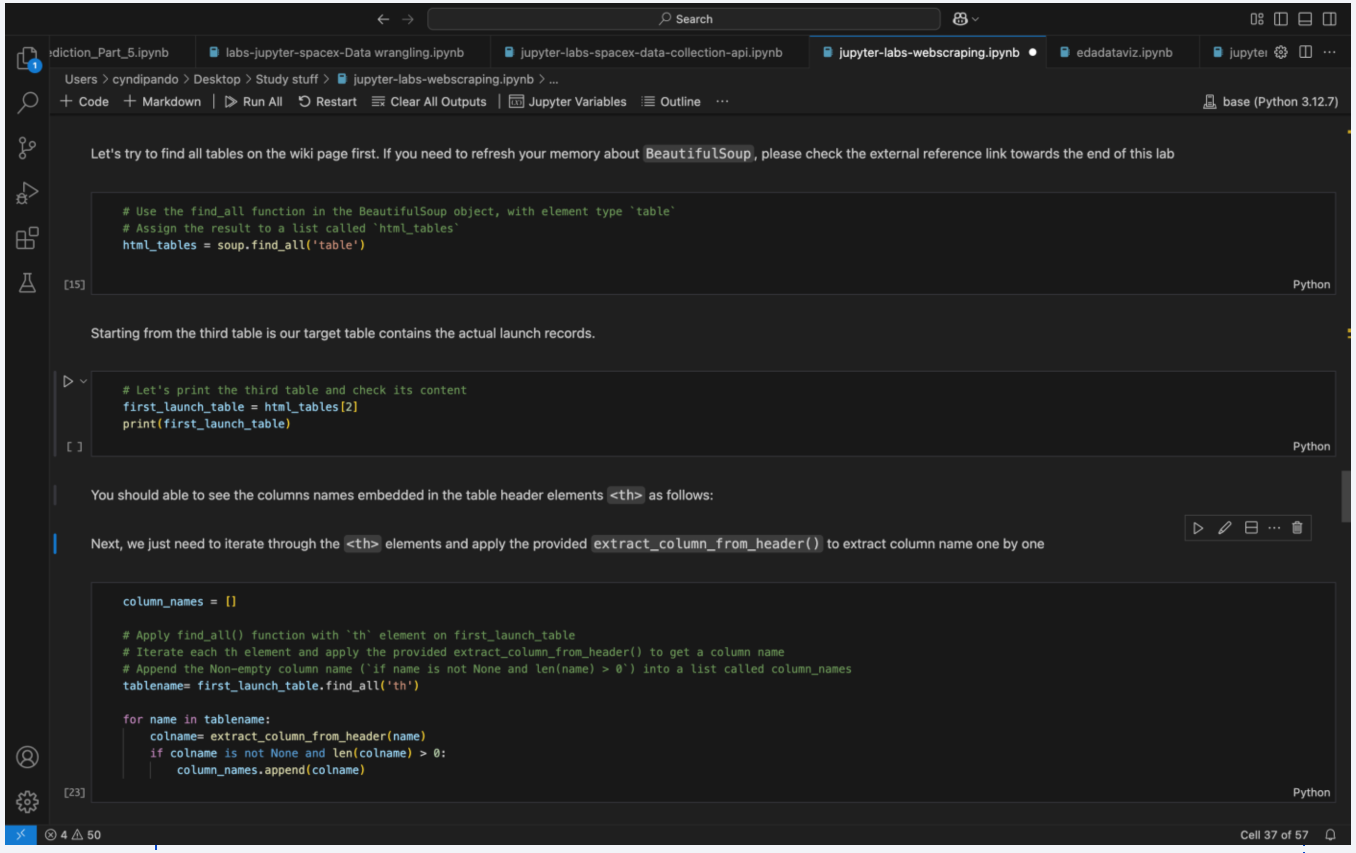
- https://github.com/Shane-Michael-git/IBMDataScienceCapstone/blob/main/jupyter-labs-spacex-data-collection-api.ipynb



Data Collection - Scraping

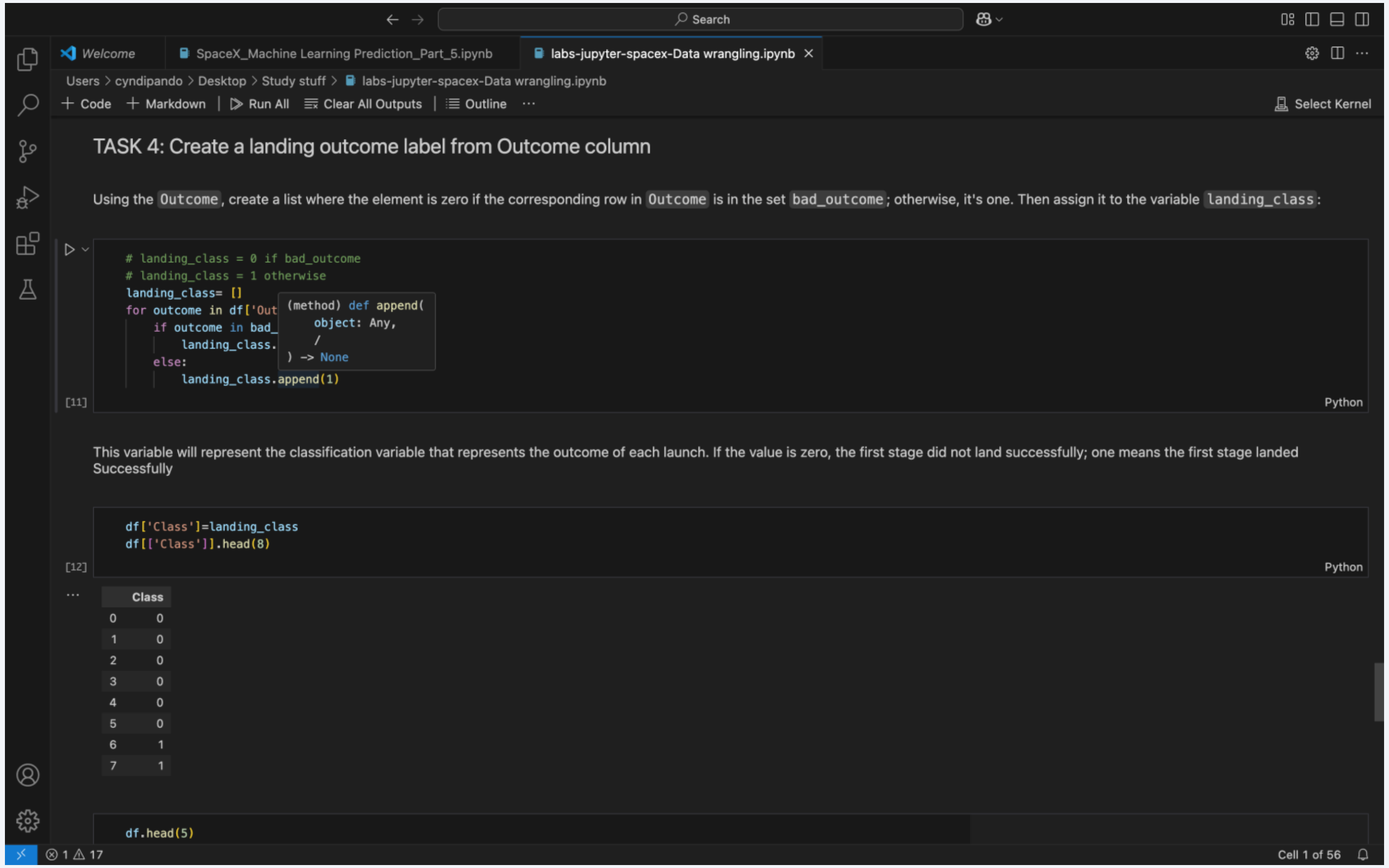
- To Webscrape for information a beautifulsoup object is created to parse the data of Falcon9 launches and eventually add the desired data to the dataframe.

- https://github.com/Shane-Michael-git/IBMDataScienceCapstone/blob/main/jupyter-labs-webscraping.ipynb



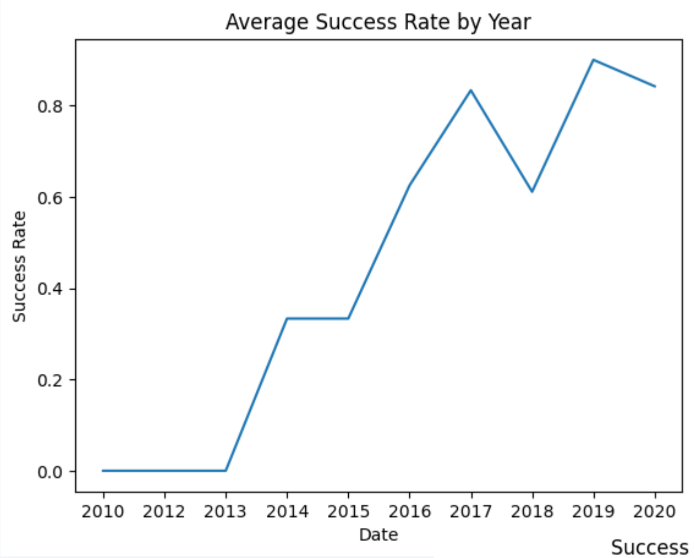
Data Wrangling

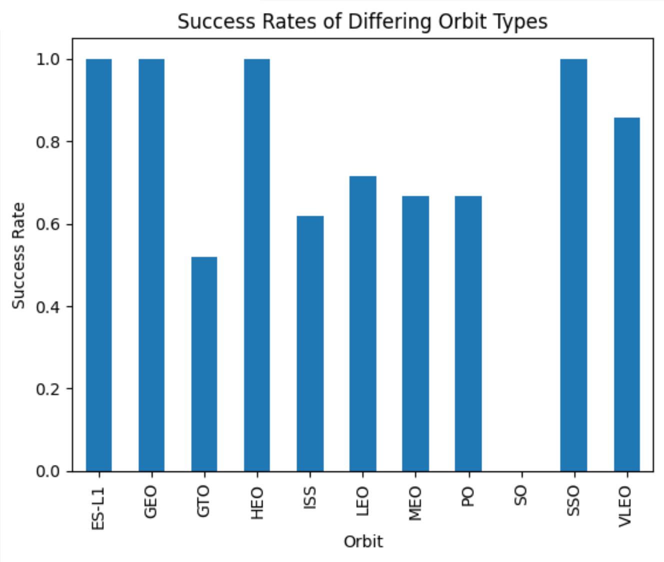
- To process this data further various metrics were calculated such as orbit type, launch site, and even the number of the launch itself to try to find relationships between these variables and the launch outcome.
- A landing outcome label was created to simplify the data as a number, 1 for successful landing, 0 for a failure.
- https://github.com/Shane-Michael-git/IBMDataScienceCapstone/blob/main/labs-jupyter-spacex-Data%20wrangling.ipynb



EDA with Data Visualization

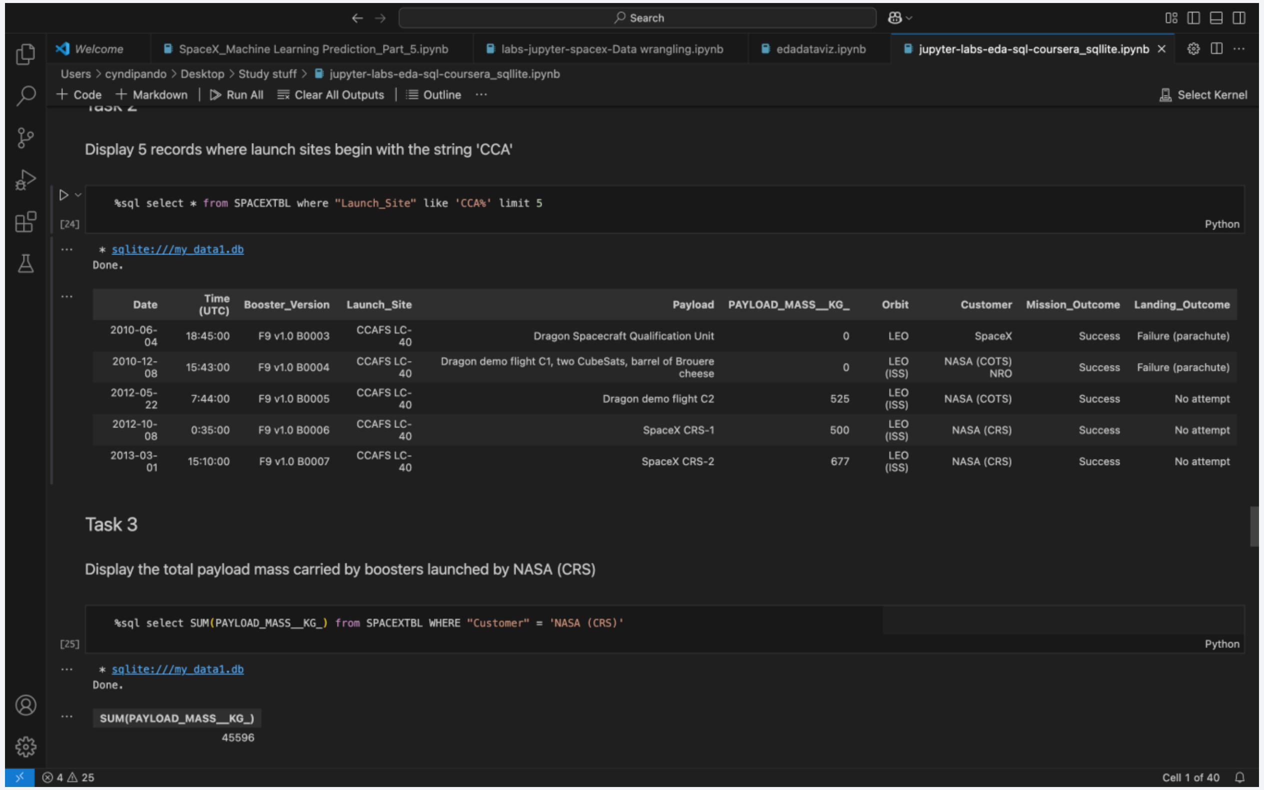
- During EDA relationships between variables were analyzed, flight number vs launch site, payload vs launch site, success rate of orbit types, flight number vs orbit type, and launch success rate by year. These charts help to visualize these relationships and determine the relevance of certain features.
- https://github.com/Shane-Michael-git/IBMDataScienceCapstone/blob/main/edadataviz.ipynb





EDA with SQL

- Using SQL magics in jupyter notebooks we were able to take a look at specific data with SQL queries.
    - SQL queries are detailed further in the report but they allowed us to look at specific data in a more efficient manner than using pandas
- https://github.com/Shane-Michael-git/IBMDataScienceCapstone/blob/main/jupyter-labs-eda-sql-coursera_sqllite.ipynb



Build an Interactive Map with Folium

- Folium was used to visualize the launch site locations initially
- From there markers were added to show the success/fails of each launch site in a visual manner.
- Distance markers and lines were added to show the relative distance from a launch site to landmarks.
  - Coast
  - Highway
  - Railroad
  - City

- https://github.com/Shane-Michael-git/IBMDataScienceCapstone/blob/main/lab_jupyter_launch_site_location.ipynb

Build a Dashboard with Plotly Dash

- Dash was used to build an online dashboard app using Plotly graphs as visual displays
- A Pie chart was chosen to display success rate of all sites and then success/fail of each individual site
- A payload slider was added to show a scatter plot of payload vs success
    - Booster version was included in the marker color to distinguish boosters
- https://github.com/Shane-Michael-git/IBMDataScienceCapstone/blob/main/spacex_dash_app(1).py

Predictive Analysis (Classification)

- The data was loaded into two dataframes and transformed by StandardScaler. It was then split with train_test_split into training and testing datasets
- Models for Logistic Regression, SVM, Decision Tree, and KNN were created and inserted into a GridSearchCV object. The training data was fit to that object and the ideal hyperparameters were found.
- Confusion matrices and accuracy scores were taken for each classifier to compare and contrast results.
- https://github.com/Shane-Michael-git/IBMDataScienceCapstone/blob/main/SpaceX_Machine%20Learning%20Prediction_Part_5.ipynb

Results

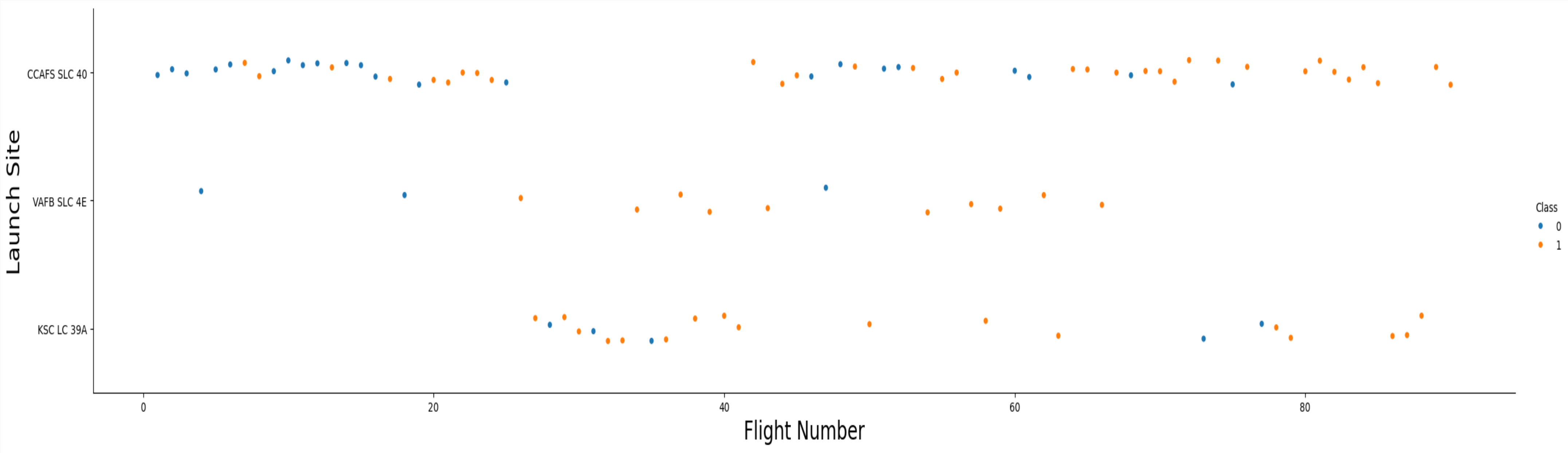
- Exploratory data analysis results
- Interactive analytics demo in screenshots
- Predictive analysis results

Section 2

Insights drawn from EDA

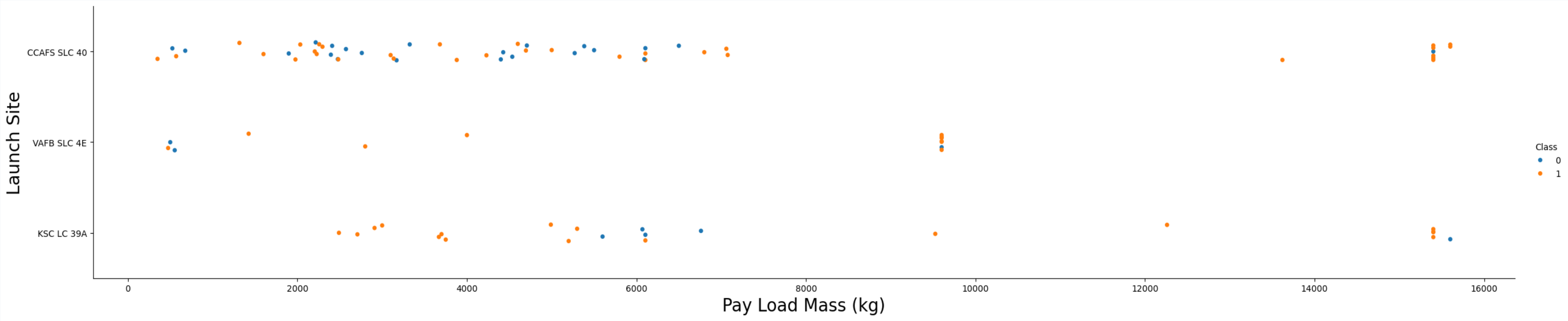
Flight Number vs. Launch Site

- The Scatter plot below shows that while it might be a very small difference there were more failures when there had been less flights. However there are strong diminishing returns.



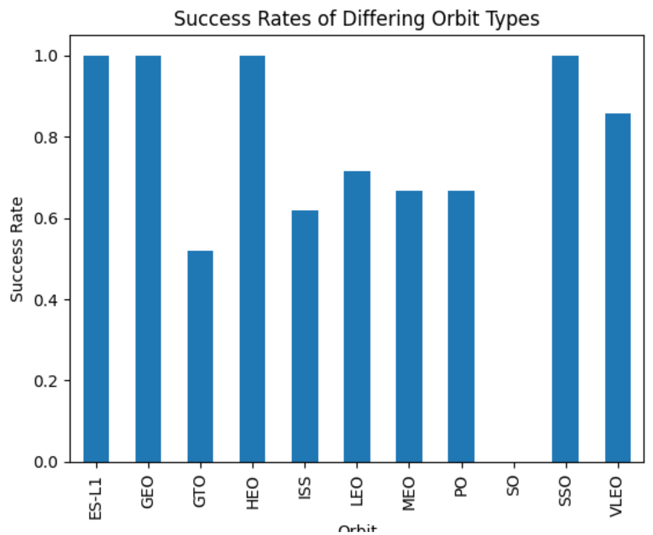
Payload vs. Launch Site

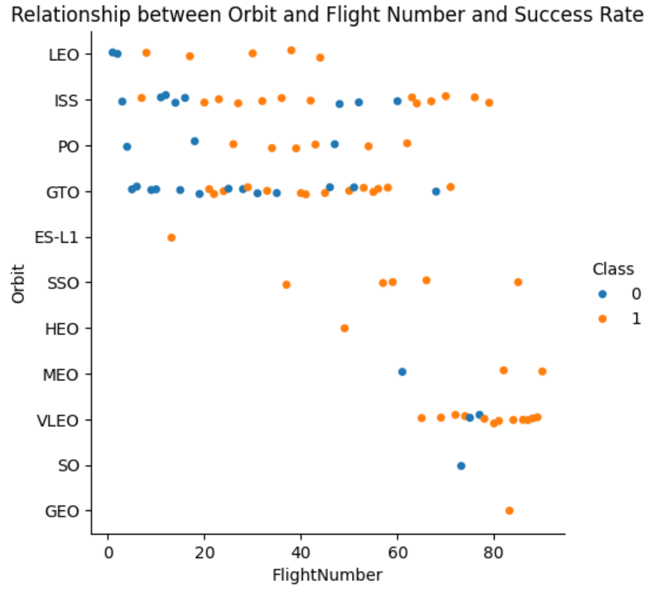
- From this data it can be surmised that the launch site VAFB SLC 4E does not launch rockets with a “heavy”(over 10,000kg) payloads.



Success Rate vs. Orbit Type

- Overall the riskiest orbit is GTO, although SO has a lower success rate there is simply not enough data to compare the two properly.
- ES-L1, GEO and HEO are poor examples of success as they are also singular instances.

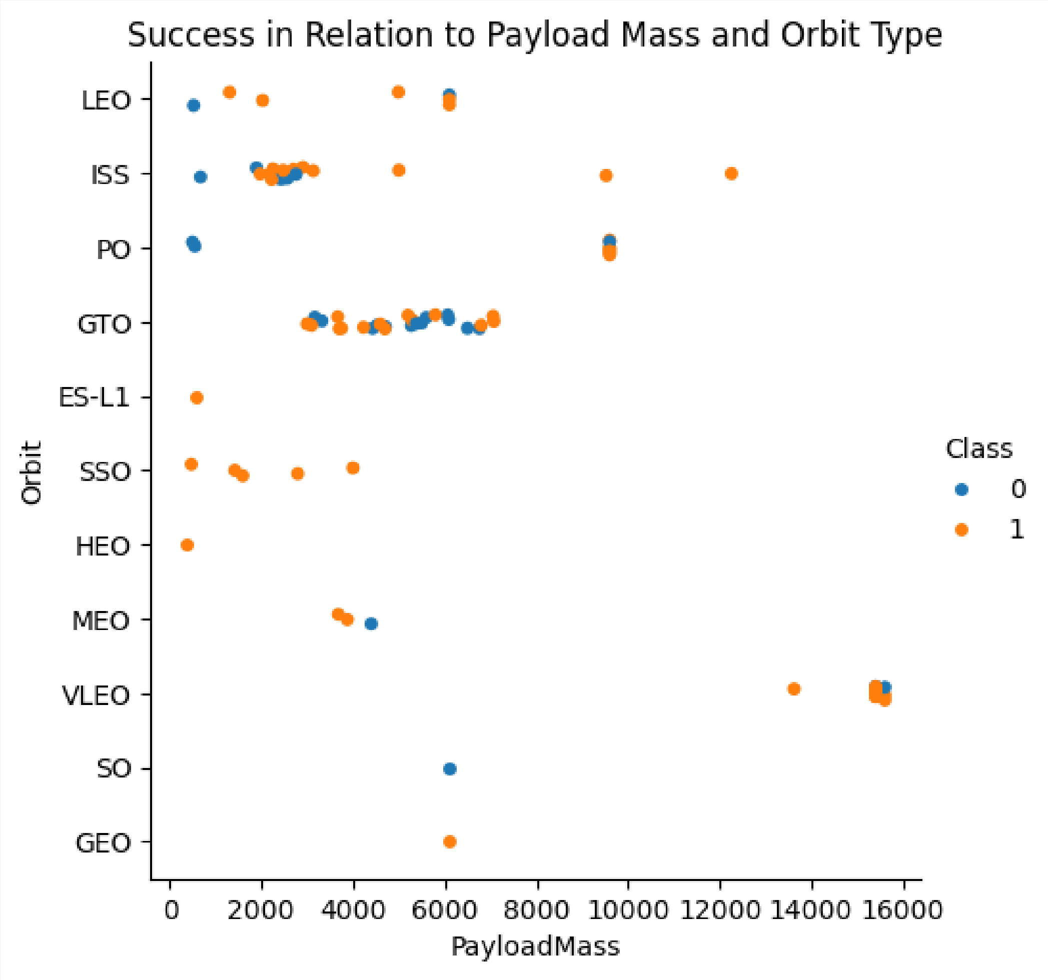




Payload vs. Orbit Type

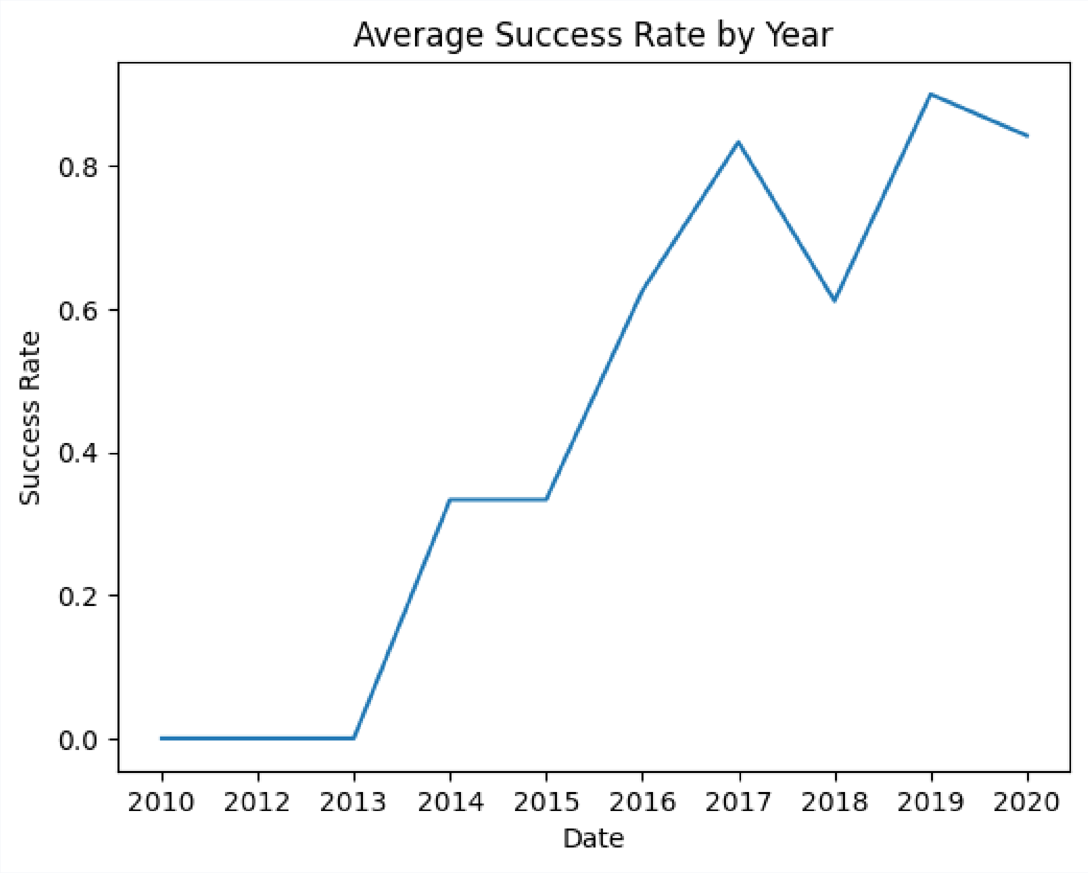
- The graph shows that payload mass is on average below 10,000 kg. This means very few orbit types carry heavy payloads

- Of the orbit types that carry heavy payloads VLEO has the highest number of successes while ISS and PO are not far behind.



Launch Success Yearly Trend

- The chart shows that while there are areas where things level off or even dip, in general success rates of the first stage landing have increased with time. This can be assumed to be an effect of fine tuning over time.



All Launch Site Names

- Four unique launch sites were found, their names are as follows; CCAFS LC-40, VAFB SLC-4E, KSC LC-39A, CCAFS SLC-40
- I was able to isolate these using the SQL query; select distinct "Launch_Site" from SPACEXTBL
- This query only returns the unique names found in the ”Launch_Site” column.

Launch Site Names Begin with 'CCA'

- Using the SQL query; select * from SPACEXTBL where "Launch_Site" like 'CCA%' limit 5
- This query shows the first 5 results it finds where the first letters of the value of “Launch_Site” will be ”CCA”

Total Payload Mass

- The Total Payload Mass can be found with the query; select SUM(PAYLOAD_MASS__KG_) from SPACEXTBL WHERE "Customer" = 'NASA (CRS)'
- This query gives the answer “45,596” meaning the Total of all payload masses is 45,596kg.

Average Payload Mass by F9 v1.1

- The average Payload Mass for the F9 v1.1 booster can be found using the query; select avg(PAYLOAD_MASS__KG_) from SPACEXTBL where "Booster_Version" = 'F9 v1.1’
- This query only returns the average of 2928.4 kg.

First Successful Ground Landing Date

- To find the first ground landing date use the following query; select min(date) from SPACEXTBL where "Landing_Outcome" = 'Success (ground pad)'
- This filter the date to the lowest and ensures its looking only for successful ground pad landing outcomes. This gives a single value of 2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

- To find successful drone ship landings with payloads over between 4-6 thousand kg use the query; select "Booster_Version" from SPACEXTBL where "Landing_Outcome" = 'Success (drone ship)' and PAYLOAD_MASS__KG_ between 4000 and 6000
- This query returns the names of boosters that have succesfuly landed on a drone ship while specifically carrying between 4000 and 6000 kg of payload. Their names are;
  - F9 FT B1022
  - F9 FT B1026
  - F9 FT B1021.2
  - F9 FT B1031.2

Total Number of Successful and Failure Mission Outcomes

- To calculate the total count of mission outcomes use the query; select count("Mission_Outcome") from SPACEXTBL
- This query counts the total non empty rows in the “Mission_Outcome” column and returns the number 101 which is a combined total between successes and failures.

Boosters Carried Maximum Payload

- To find boosters that have carried the maximum payload use the query; select "Booster_Version" from SPACEXTBL where PAYLOAD_MASS__KG_ = (SELECT MAX(PAYLOAD_MASS__KG_) FROM SPACEXTBL)
- This query uses a subquery to specifically find the values that carried the highest payload. The booster versions are as follows: 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

- To get the failed landings on a drone ship for 2015 and display the month you use the query; select substr(Date, 6,2), "Landing_Outcome", "Booster_Version", "Launch_Site" from SPACEXTBL where "Landing_Outcome" = 'Failure (drone ship)' and substr(Date,0,5)='2015’
- This query specifies that the only rows we are interested in include the landing outcome of “Failure (drone ship)” and from the year 2015. There are two rows displayed.

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

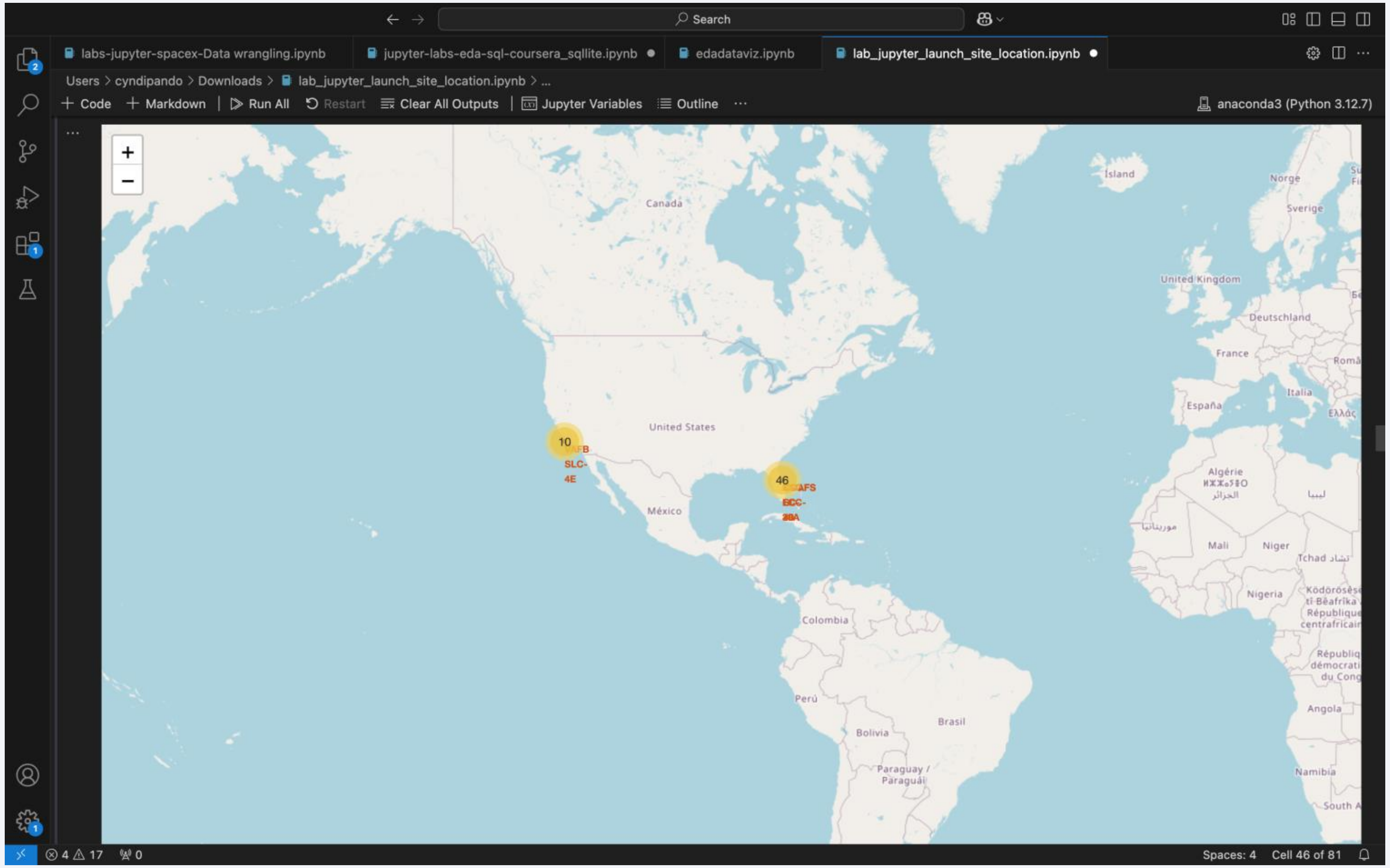
- To rank landing outcomes in a specific date range use the query; select count("Landing_Outcome"), "Landing_Outcome" from SPACEXTBL where "Date" between '2010-06-04' and '2017-03-20' group by "Landing_Outcome" order by count("Landing_Outcome") DESC
- This query will order the results from highest number of instances to lowest. It shows that no attempts are most common, followed by a tie in successes and failures to land on drone ships, followed again by a tie of success on a ground pad and controlled into the ocean. Next is uncontrolled into the ocean which ties with failure with parachute. Last is precluded drone ship.

Section 3

Launch Sites Proximities Analysis

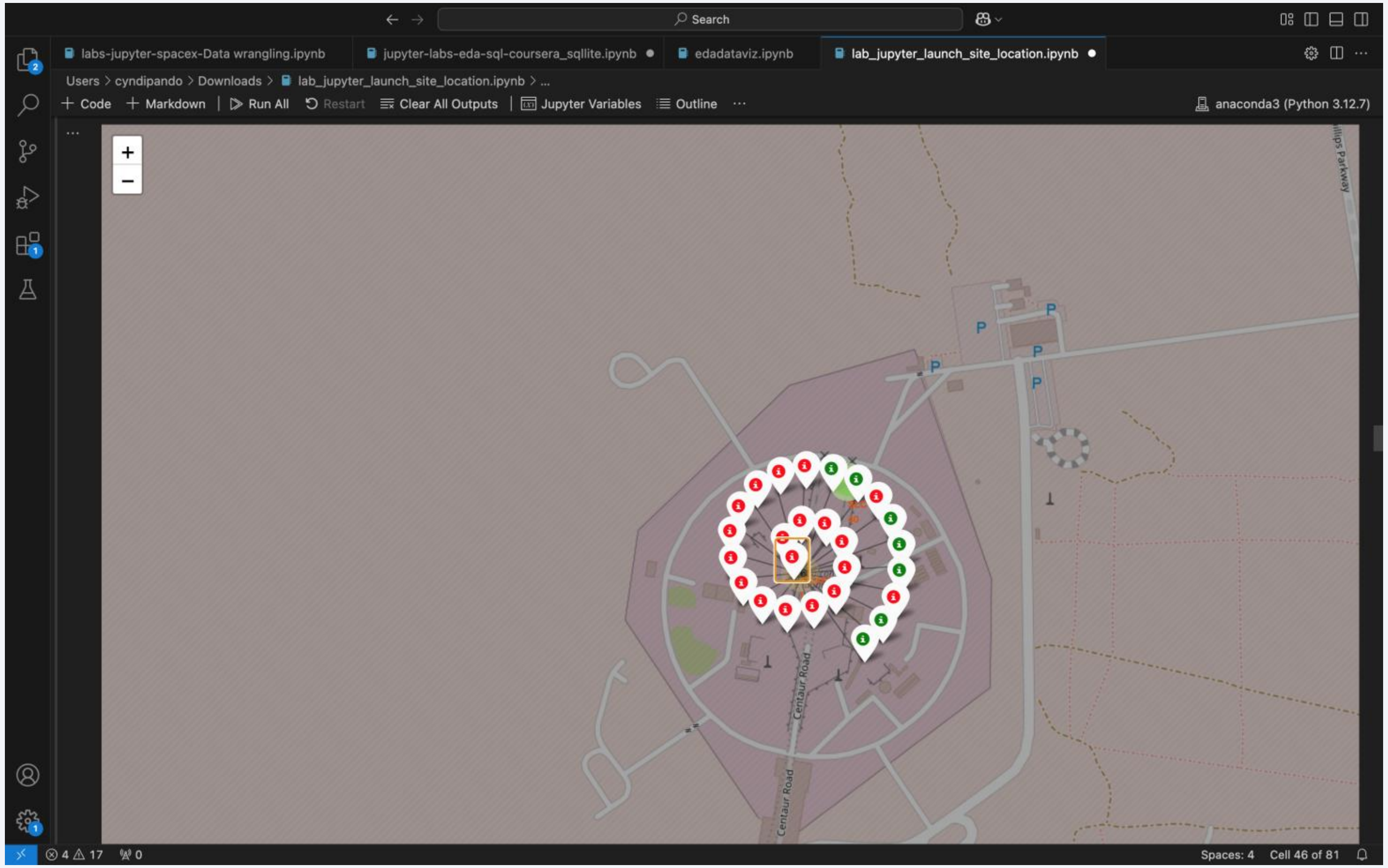
Global Position of launch sites

- This map displays the launch sites, which can be found closer to the coast, and their number of launches. By further hovering and zooming in more info can be discovered.

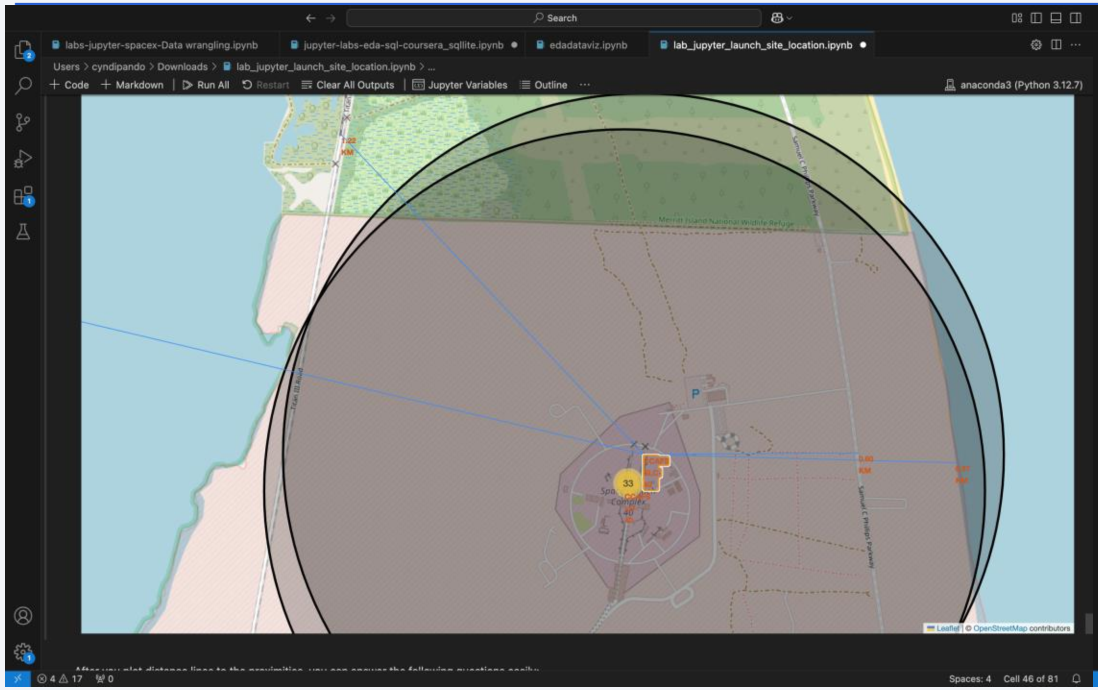


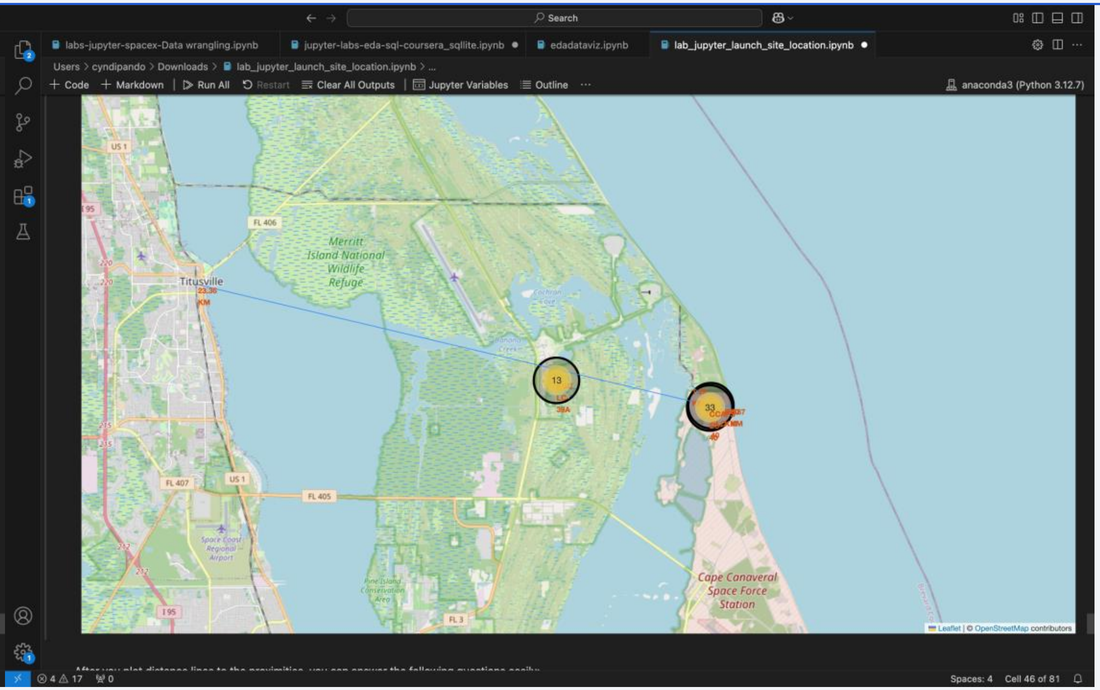
Success/Failure markers

- This screenshot shows a marker cluster for a particular launch site, the successful stage 1 landing marked in green and the failures marked in red. This gives a visual representation of the success/failure ratio of each launch site.



Proximity to infrastructure





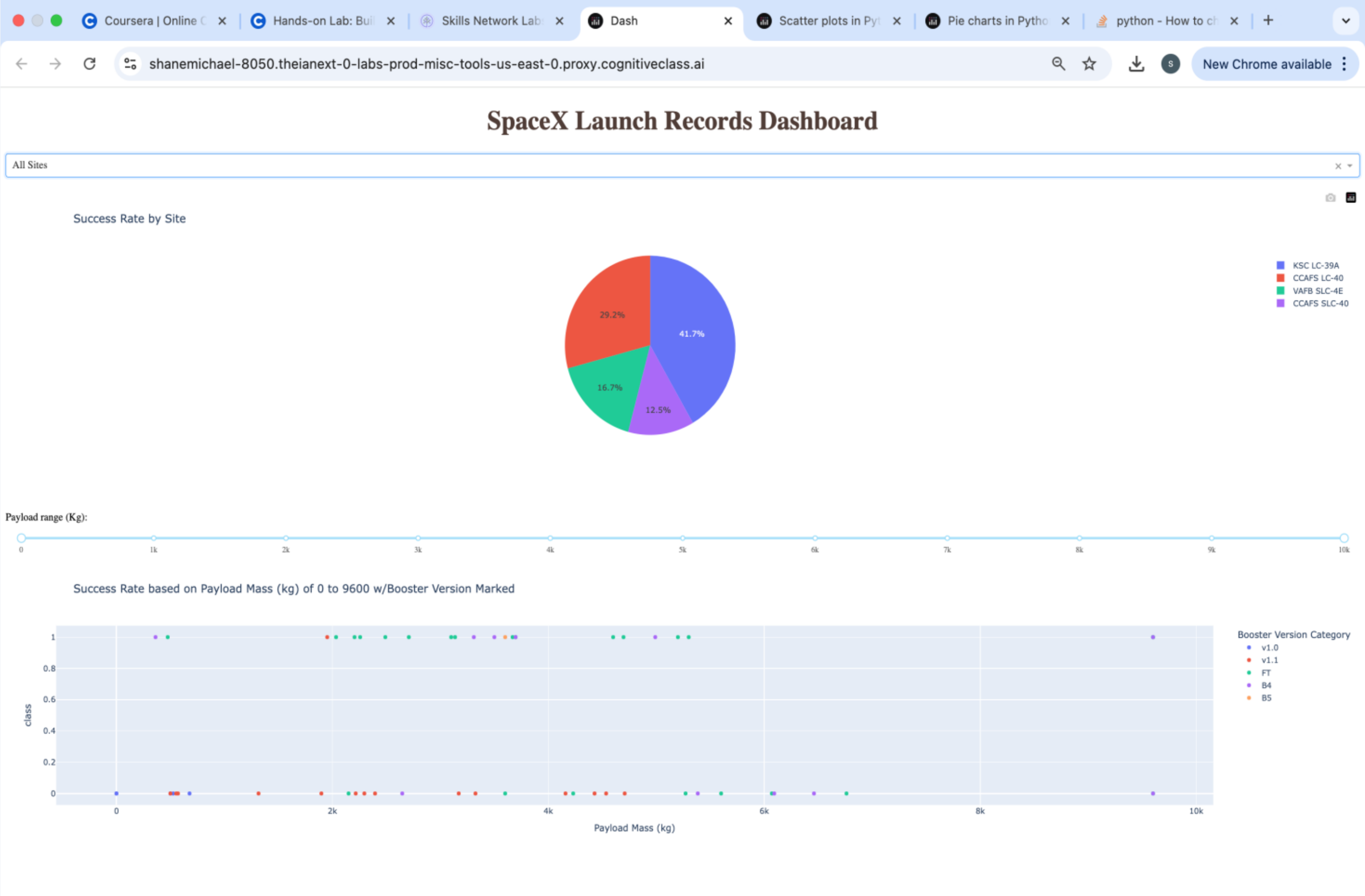
- The above screenshots show the proximity of one launch site to the coast, nearby highways, nearby railroads, and in the second screenshot, nearby cities. As shown by the maps launch sites are in close proximity to railroads, coasts, and highways, but not very close to cities. This should be accounted for when choosing launch site locations.

Section 4

Build a Dashboard with Plotly Dash

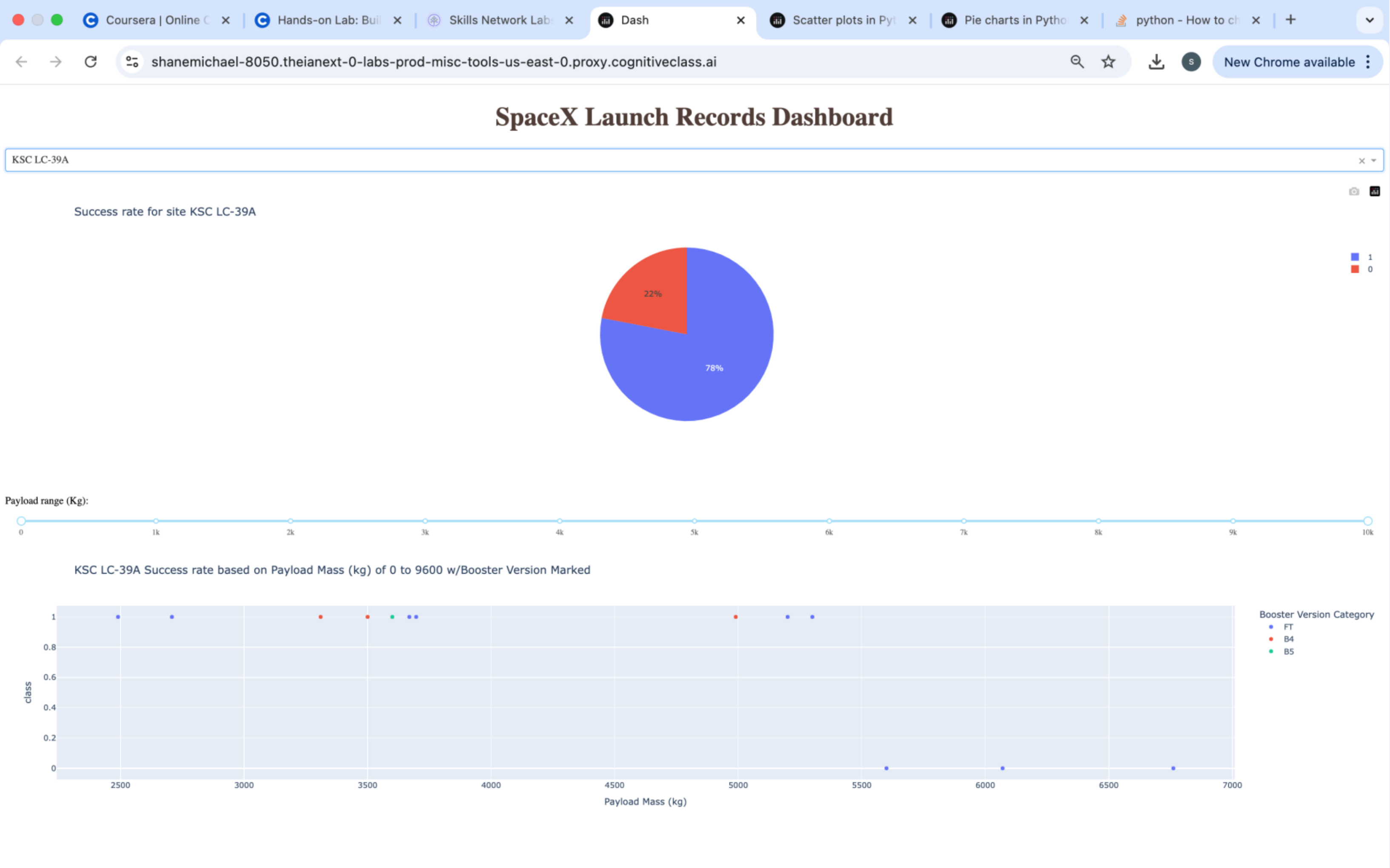
Launch Sites proportion of success

- The accompanying pie chart shows the successes by site. Each slice is a proportion of the total successes that can be attributed to a specific launch site.



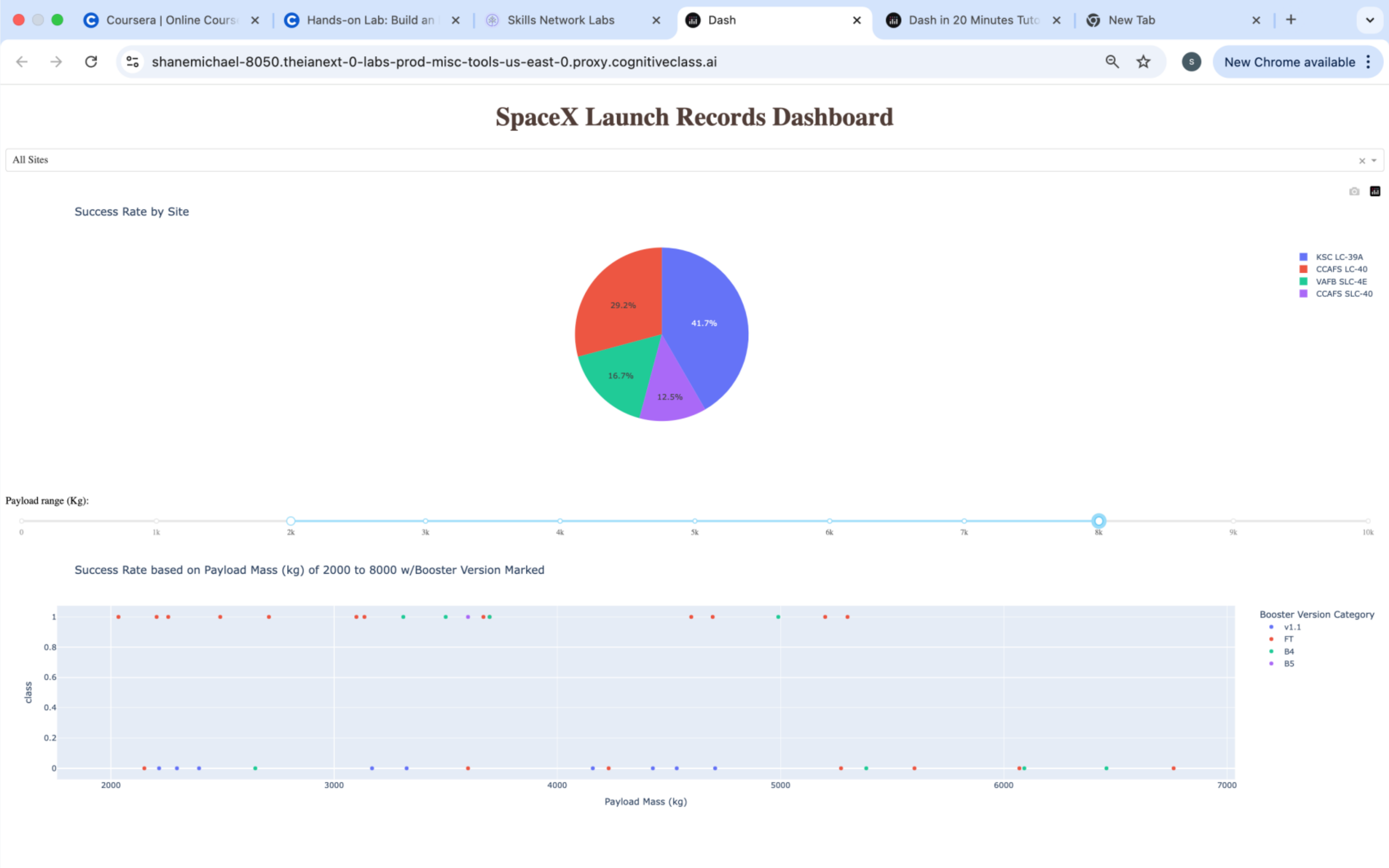
Highest success rate Launch Site

- Shown in the accompanying graphic is the highest success rate launch site. Site KSC LC-39A had the highest rate of successful launches at 78%.



Payload effect on Success rate

- The Screenshot included shows a range slider for payload adjusted to different ranges to hone in on differing payload success rates. It seems that as payload increases there is some decrease in successes. Some booster versions perform better than others at differing payloads. Such as FT performing very well with low to mid range payloads compared to the 1.1 which fails more often.

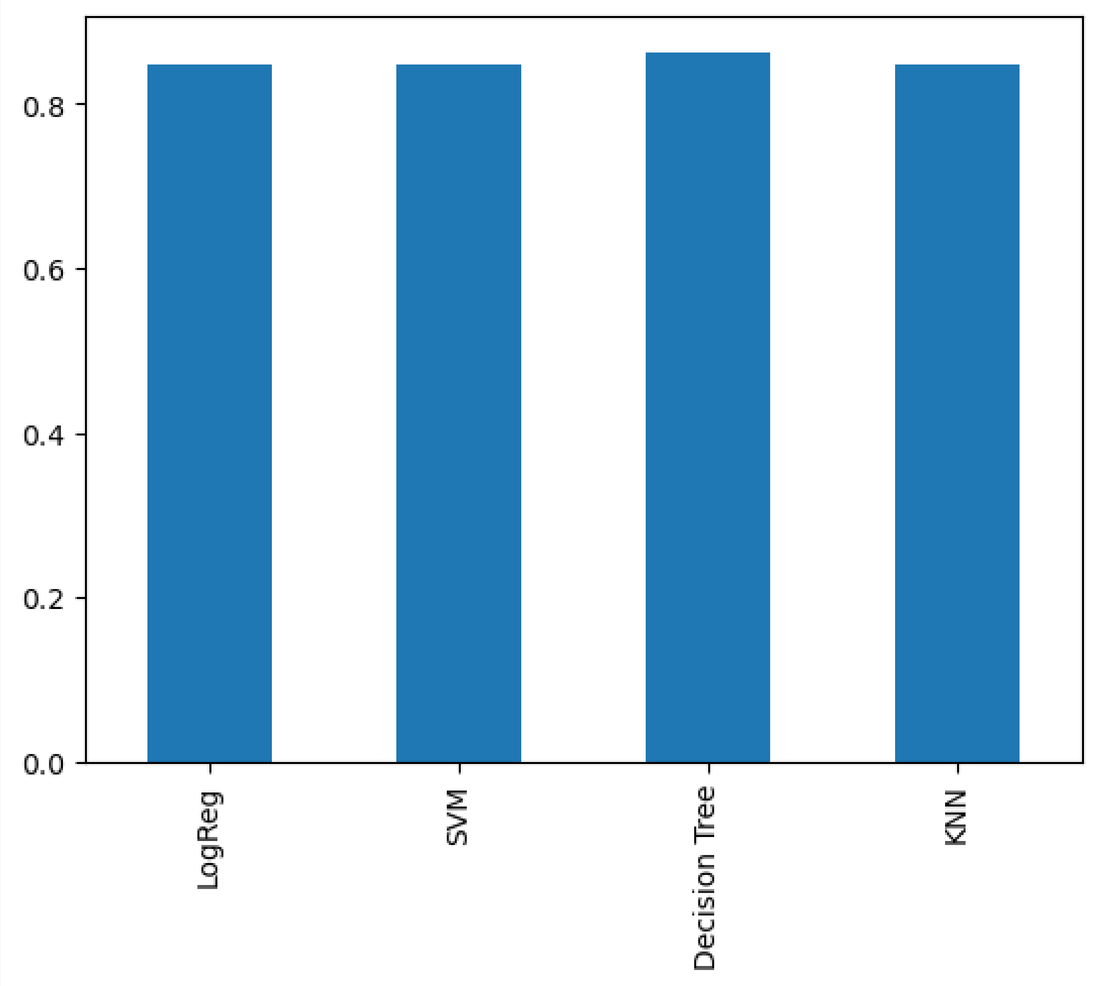


Section 5

Predictive Analysis (Classification)

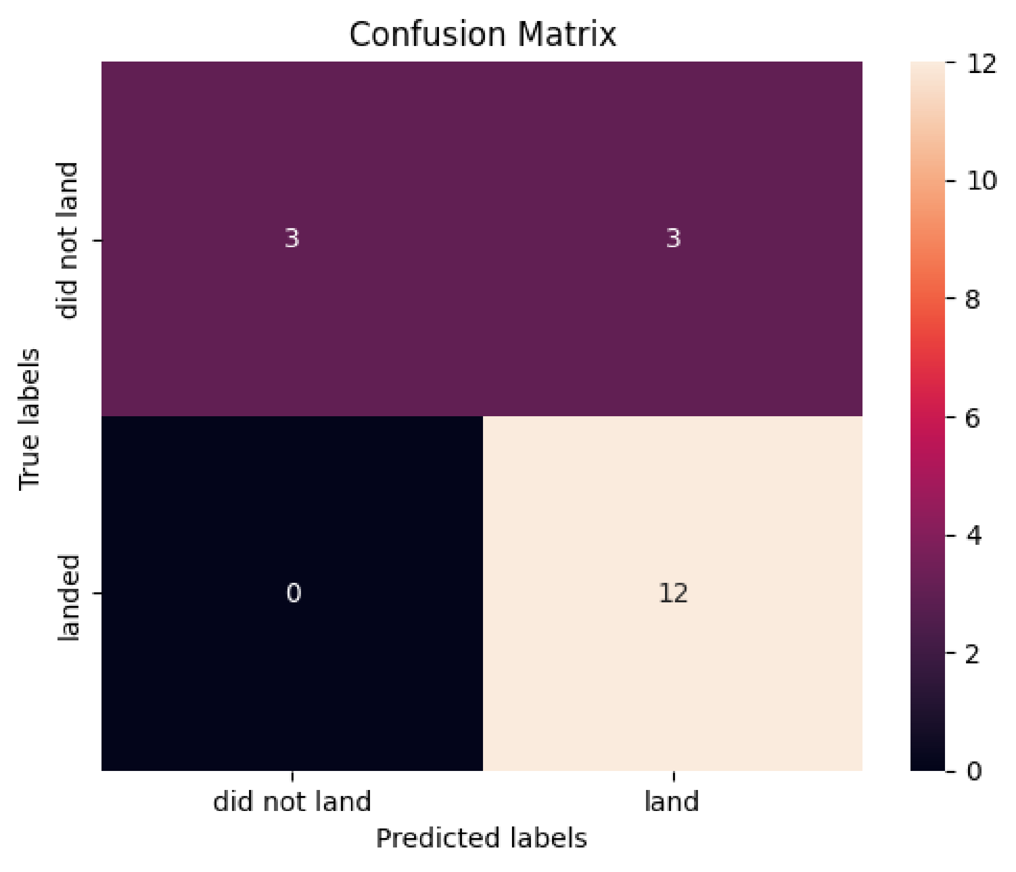
Classification Accuracy

- From the predictive analysis four methods were chosen to attempt to find the best method for classification.
- The best score of the four models came from the decision tree which slightly outperformed the other three trees, however their .score was identical for each.



Confusion Matrix

- All the confusion matrices are identical so I provided one. Overall they correctly predict 15 of the result and only mislabel 3 that did not land as would land.
- Although their confusion matrices are identical the decision tree ranked highest on the .best_score_ compared to the other three.



Conclusions

- The data showed many things, the Decision tree seems to be the most accurate although all four confusion matrices are identical.
- The locations proximity is important to keep in mind as it provides criteria for choosing potential launch site locations.
- Of the orbit types SSO has the highest confidence for success and GTO the lowest.

Appendix

- To examine anything else please refer to my GITHUB repository
- https://github.com/Shane-Michael-git/IBMDataScienceCapstone.git

Thank you!