Winning Space Race with Data Science

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Outline

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

Executive Summary

- Methodologies used for data analysis:
  - Collection through SpaceX API
  - EDA, data wrangling, data visualization, interactive dashboard analytics
  - Machine Learning predictive analytics (supervised learning)
- Result Summary:
  - Machine learning prediction model had an accuracy of above 83%
  - EDA showed the right features for prediction of successful launches

Introduction

- The objective of this data science applied capstone is to see how good another company named Space Y is in terms of launch successes vs SpaceX
- Answers I looked for:
  - A reason why SpaceX does so well at a lower budget is because of successful landings, I want to estimate cost for launches through the success of rocket landings as an independent variable.
  - What geo-location ensures highest rate of launch landing success

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - Obtained through SpaceX API
  - WebScraping Wikipedia
- Perform data wrangling
  - Cleaned a few columns and finalized some datatype changes for certain 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
  - Normalized Data divided into training + test sets, evaluating with 4 different classification models, and finding the best one with > 87% accurate prediction.

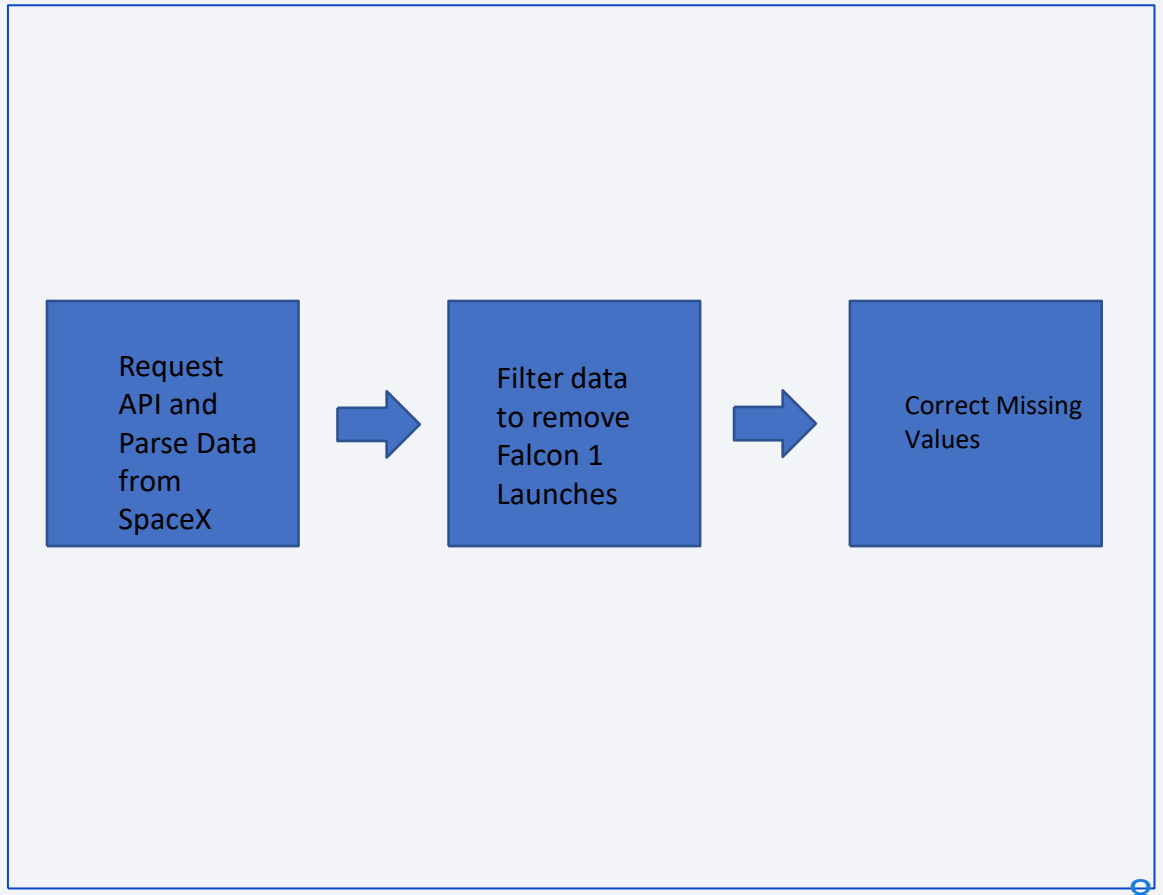
Data Collection

- Data was collected through SpaceX API (https://api.spacexdata.com/v4/)
- Data was collected through Wikipedia WebScraping (https://en.Wikipedia.org/wiki/List of falcon/ and Falcon Heavy Launches).

Data Collection – SpaceX API

- Please Refer to flowchart on right for data Collection process:

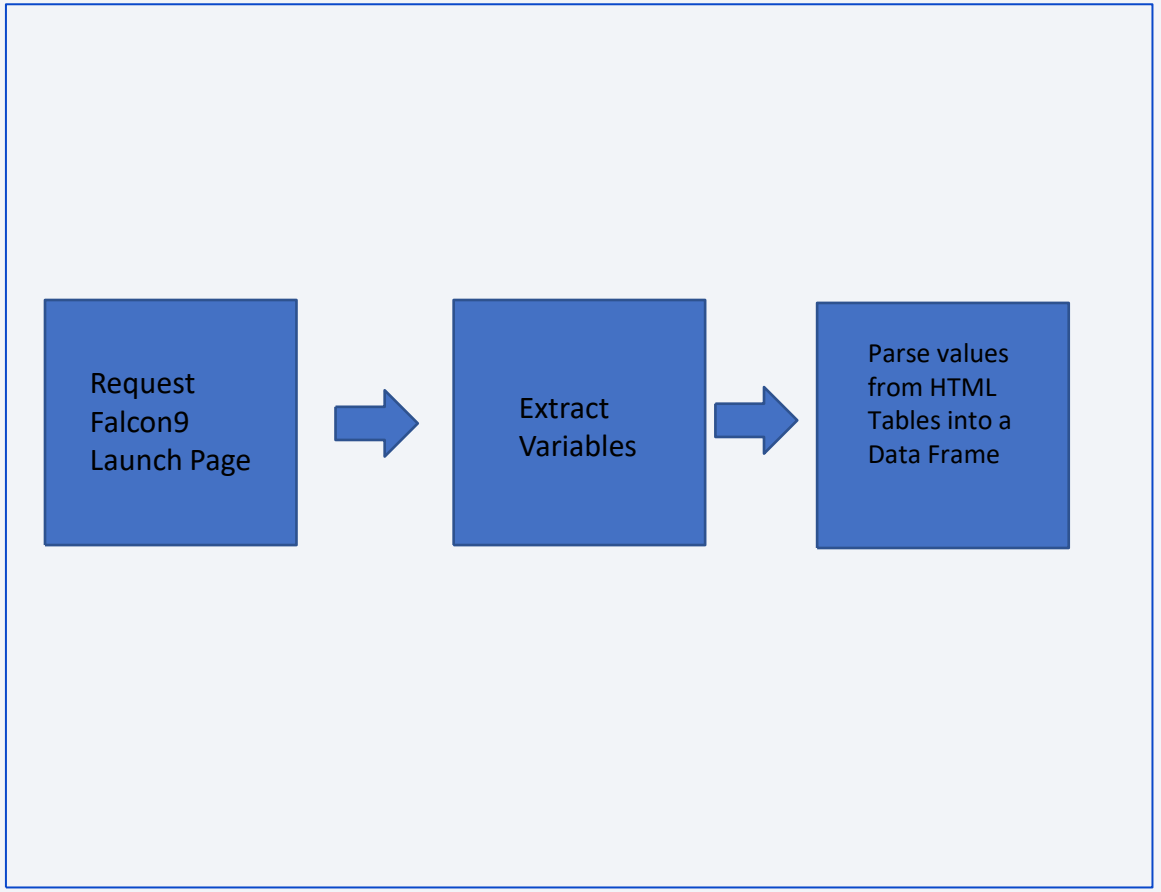
- Source: https://github.com/rohit/finalcapstone/blob/main/dataccollectionAPI.ipynb



Data Collection - Scraping

- Please Refer to flowchart on right for data Collection process:

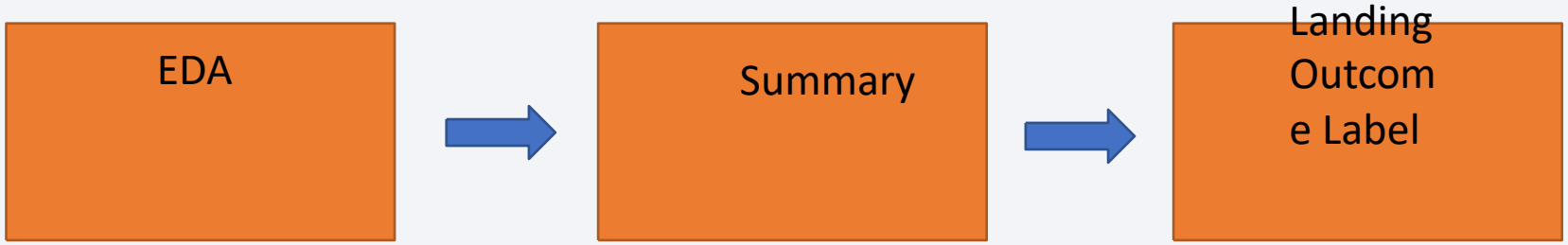
- Source: https://github.com/rohit23/finalcapstone/blob/main/WebScraping.ipynb



Data Wrangling

- EDA(Exploratory Data Analysis) was performed
- Please refer to the following flowchart

Source: https://github.com/roht/finalcapstone/blob/main/dataWrangling.ipynb



EDA with Data Visualization

- Scatterplots and Bar charts as well as Bar plots were the most used visuals for this lab as I had decided that they did their best job respectively to display the necessary insights on what data was being assessed.

- Source: https://github.com/rohit/finalcapstone/blob/main/EDAwithvisualization.ipynb

EDA with SQL

- What I did SQL Query Wise:
  - Names of unique launch sites
  - Top 5 launch sites beginning with ‘CCA’
  - Total payload mass on boosters launched by NASA CRS
  - Average payload mass carried by booster F9 1.1
  - Date of first successful landing
  - Names of boosters with success in droning AND payload mass = Between 4000-6000kg
  - Total # of successful missions
  - Total # of failure missions
  - Booster names with highest payload mass
  - Failed landing outcomes for 2015
  - Rank of landing outcomes between 2010-2017

Build an Interactive Map with Folium

- Markers/Circles/Lines/Marker Clusters used in Folium Maps:
  - Used because:
    - Markers: Good for launch site indication
    - Circles: Good for displaying NASA Johnson Space Center
    - Lines: Calculating distance between coordinates on a map
    - Marker Clusters: Groups of events occurring in each coordinate found.

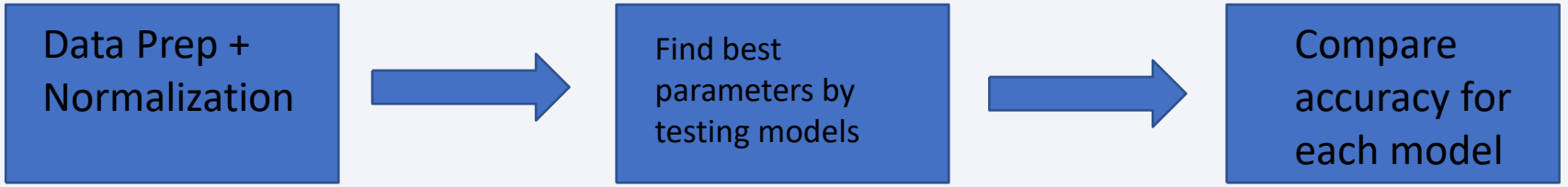
Source: https://github.com/roht/finalcapstone/blob/main/folium.ipynb

Build a Dashboard with Plotly Dash

- Graphs/Plots used in my dashboard:
  - Payload Range
  - Launches by site
- These were the best pair of variables to use to find best places for launches to occur
- Source: https://github.com/roht/finalcapstone/blob/main/spacexdashapp.py

Predictive Analysis (Classification)

- Classification is a supervised machine learning method:
  - I used the four methods of classifications taught: Regression, SVM, Decision Tree, KNN
    - Please refer to the flow chart below:



Source:

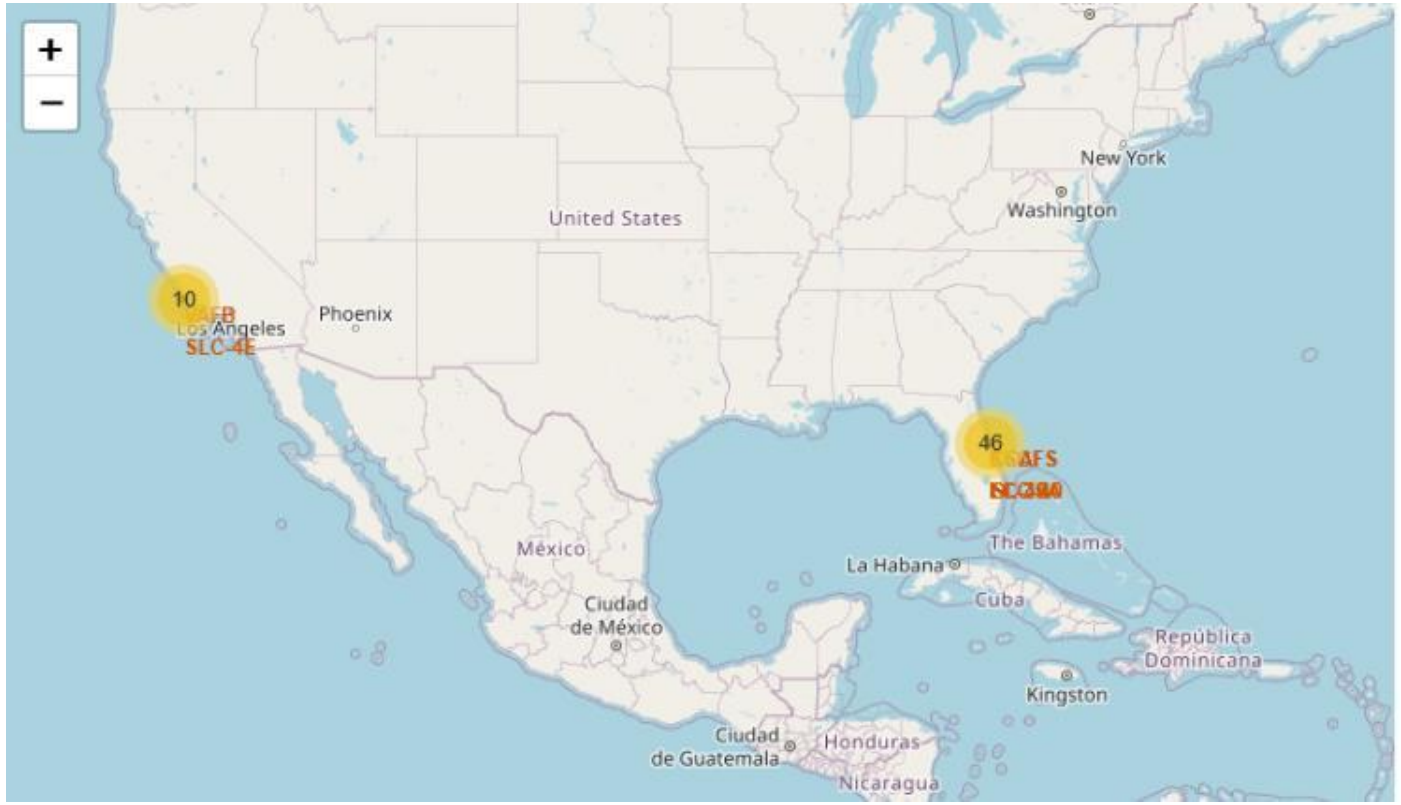
https://github.com/rohit/finalcapstone/blob/main/Machine%25Learning.ipynb

Results

- Data analysis results:
  - 4 different launch sites located
  - First launch was done to spaceX and NASA
  - First success landing occurred in 2015, 5 years after first launch
  - Falcon 9 booster versions still had good landing when above average payload having
  - Near 100% missions' outcomes were classified as successful
  - Two booster versions failed landing n 2015, f9 B1012 and f9 B1015
  - Linear increase in successful landing outcomes overtime

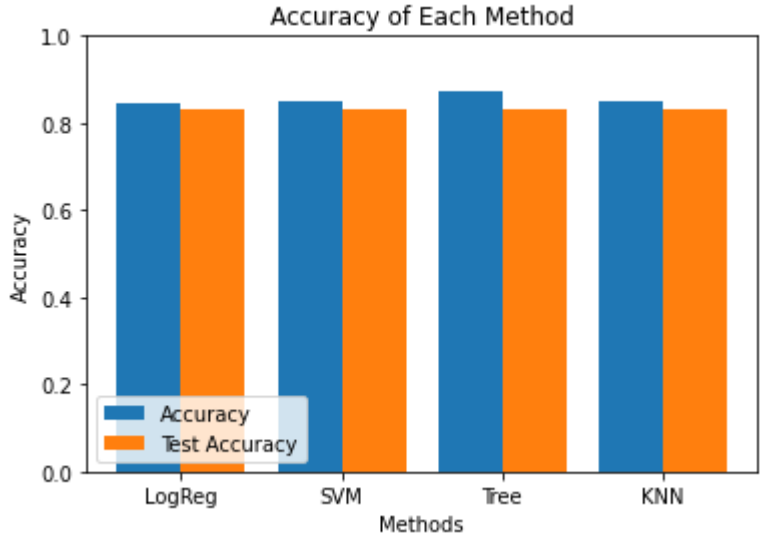
Results

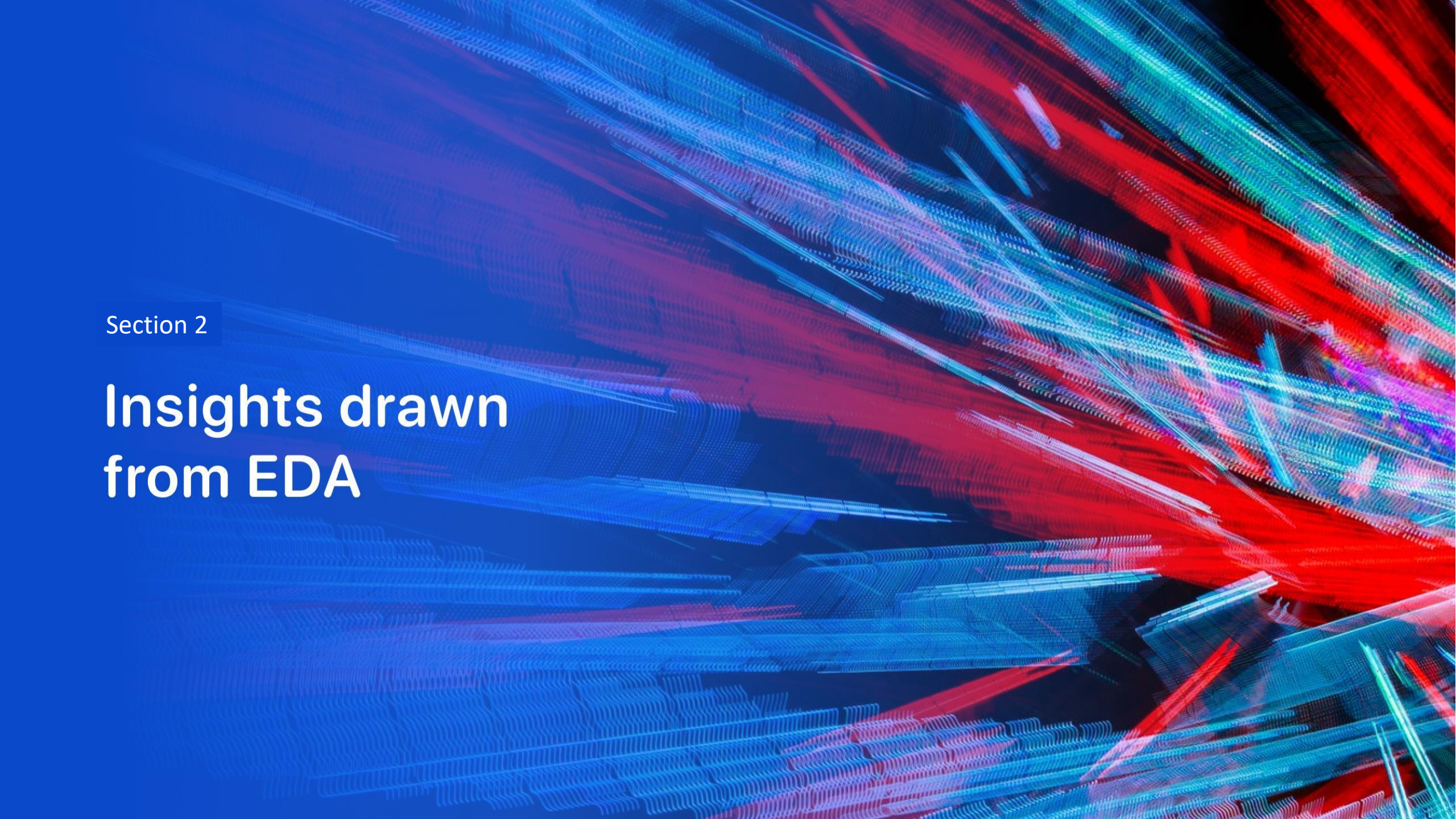
- According to interactive analytics, most launches occurred on east coast launch sites as shown below:



Results

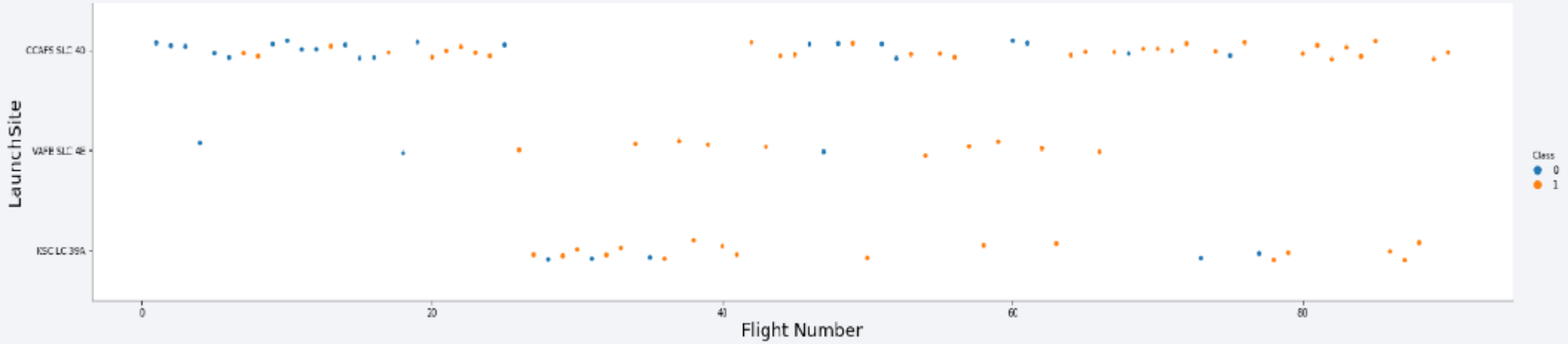
- Decision tree classification was best for prediction of successful landings:




Section 2
Insights drawn from EDA

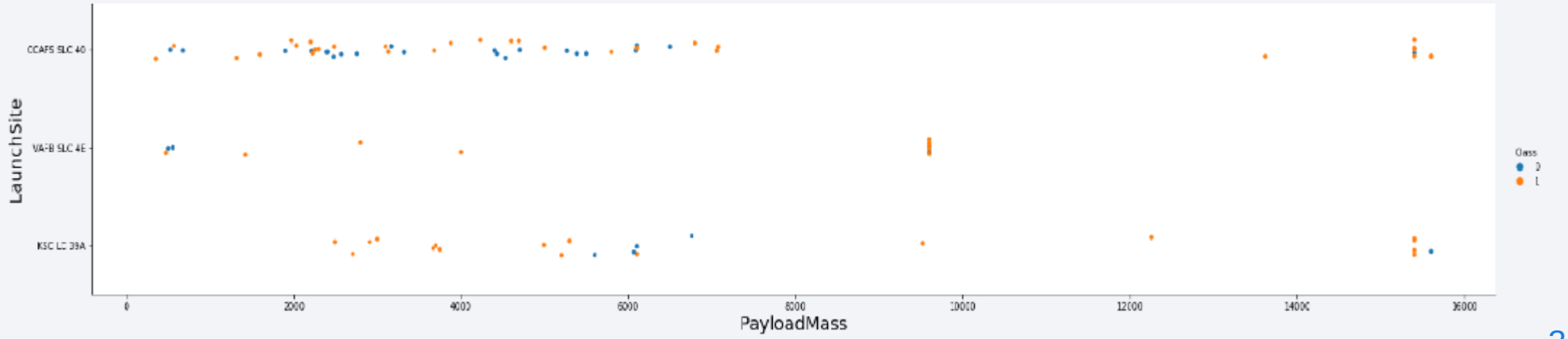
Flight Number vs. Launch Site

- As shown below on my scatter plot: safe conclusion is that best launch site is CCAF5 SLC40
- Overtime improvement in success rate is also displayed



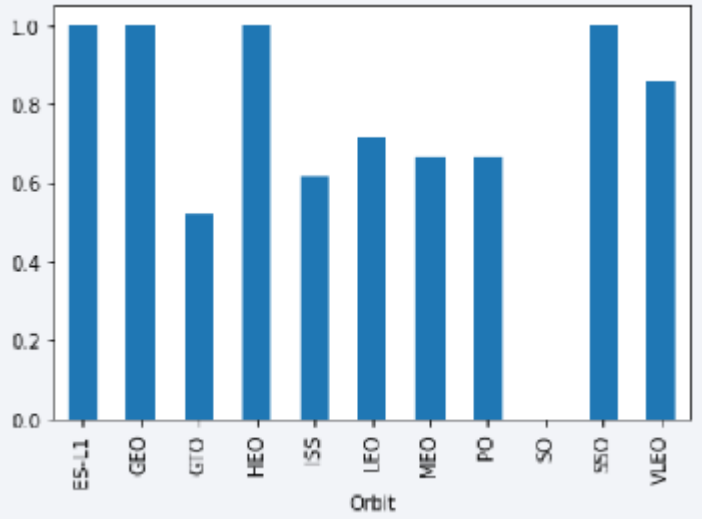
Payload vs. Launch Site

- Good success rate = payloads > 9000 kg



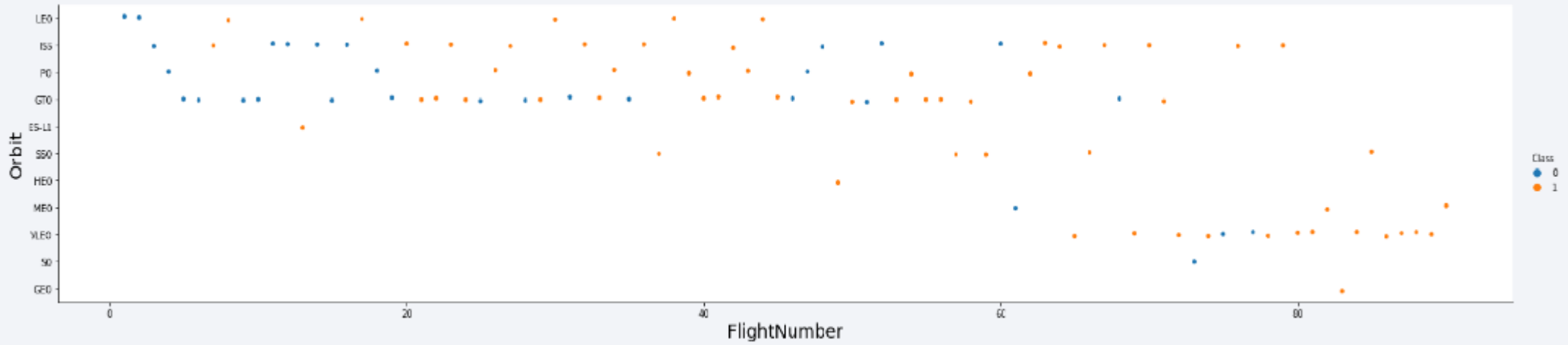
Success Rate vs. Orbit Type

- Best success rate: ES-L1
- Worst success rate: GTO



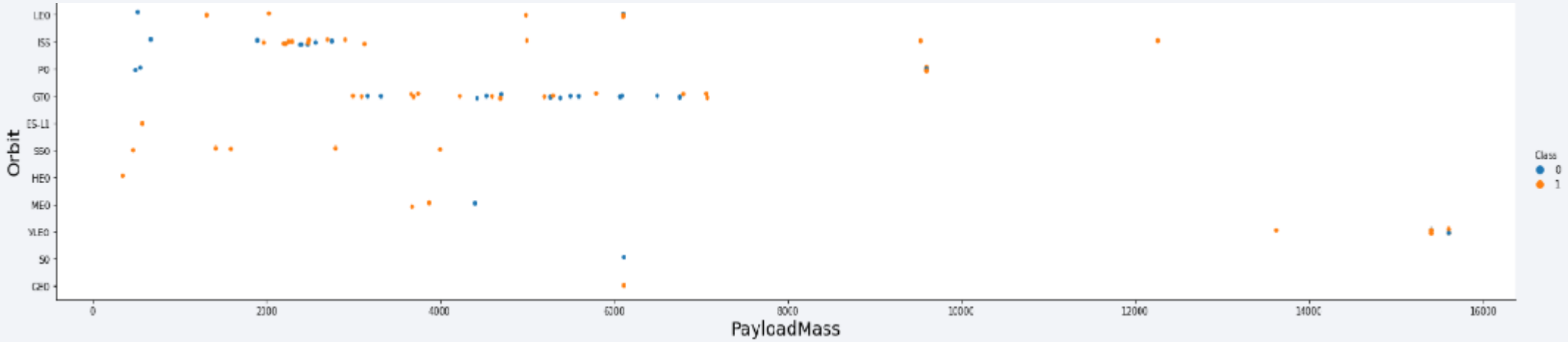
Flight Number vs. Orbit Type

- Linear increase overtime in success rates across all orbit variables



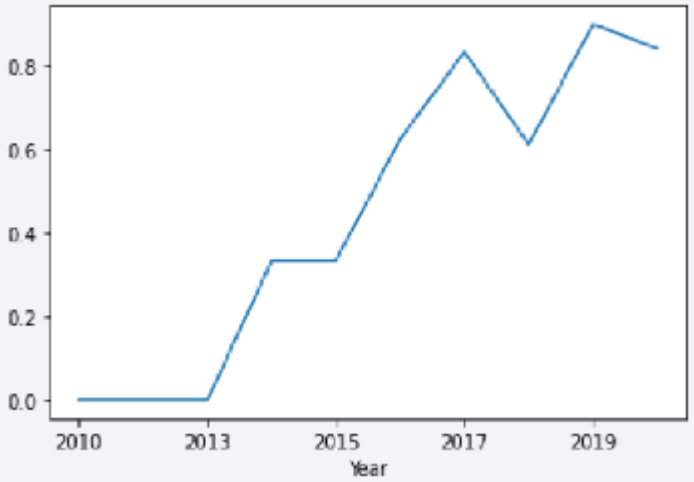
Payload vs. Orbit Type

- Hard to find connection between two axis, however ISS seems promising



Launch Success Yearly Trend

- Huge increase in success rate from 2013 to 2017.



All Launch Site Names

- All launch site names:
  - CCAFS LC-40
  - CCAFS SLC-40
  - KSC LC-39A
  - VAFB SLC-4E

  - Obtained through querying unique rows with launch site values from dataset

Launch Site Names Begin with 'CCA'

- As shown below, we see the CCA tag in bold in the dataset.

2010-06-04	18:45:00	F9 v1.0 B0003	**CCA**FS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
2010-12-08	15:43:00	F9 v1.0 B0004	**CCA**FS 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	**CCA**FS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)	Success	No attempt
2012-10-08	00:35:00	F9 v1.0 B0006	**CCA**FS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
2013-03-01	15:10:00	F9 v1.0 B0007	**CCA**FS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attemp

Total Payload Mass

- Total payload carried by boosters from NASA:
  - 111,268kg
  - Calculated using simple mathematics summing all payloads with CRS in their code respectively.

Average Payload Mass by F9 v1.1

- Avg payload mass carried by booster F9 v1.1:
  - 2,928kg
  - Data acquired through the filtering of booster versions and using math to calculate the average.

First Successful Ground Landing Date

- First successful landing outcome:
  - December 22nd, 2015
  - To get this data I filtered the data set by successful landing and queried the minimum possible value on the date column

Successful Drone Ship Landing with Payload between 4000 and 6000

- Boosters which have successfully landed on drone ship and had payload mass greater than 4000 but less than 6000
  - F9 BT B1021.2
  - F9 FT B1031.2
  - F9 FT B1022
  - F9 FT B1026

  - Selecting distinct booster versions and using a between statement was used to query this information

Total Number of Successful and Failure Mission Outcomes

- Ratio of successful missions to failed missions:
  - 99 occurrences to 1 occurrence
  - Groupby statement used on mission outcomes lead to the obtainability of this dataset

Boosters Carried Maximum Payload

- Boosters that carried max payload mass:
  - F9 B5 B1048.4 AND .5
  - F9 B5 B1049.4 AND .5 AND .7
  - F9 B5 B1051.3 AND .4 AND .6
  - F9 B5 B1056.4
  - F9 B5 B1058.3
  - F9 B5 B1060.2 AND .3

2015 Launch Records

- Failed landing_outcomes in drone ship, their booster versions, and launch site names for in year 2015

  - F9 v1.1 B1012 on CCAFS LC-40
  - F9 v1.1 b1015 on CCAFS LC-40

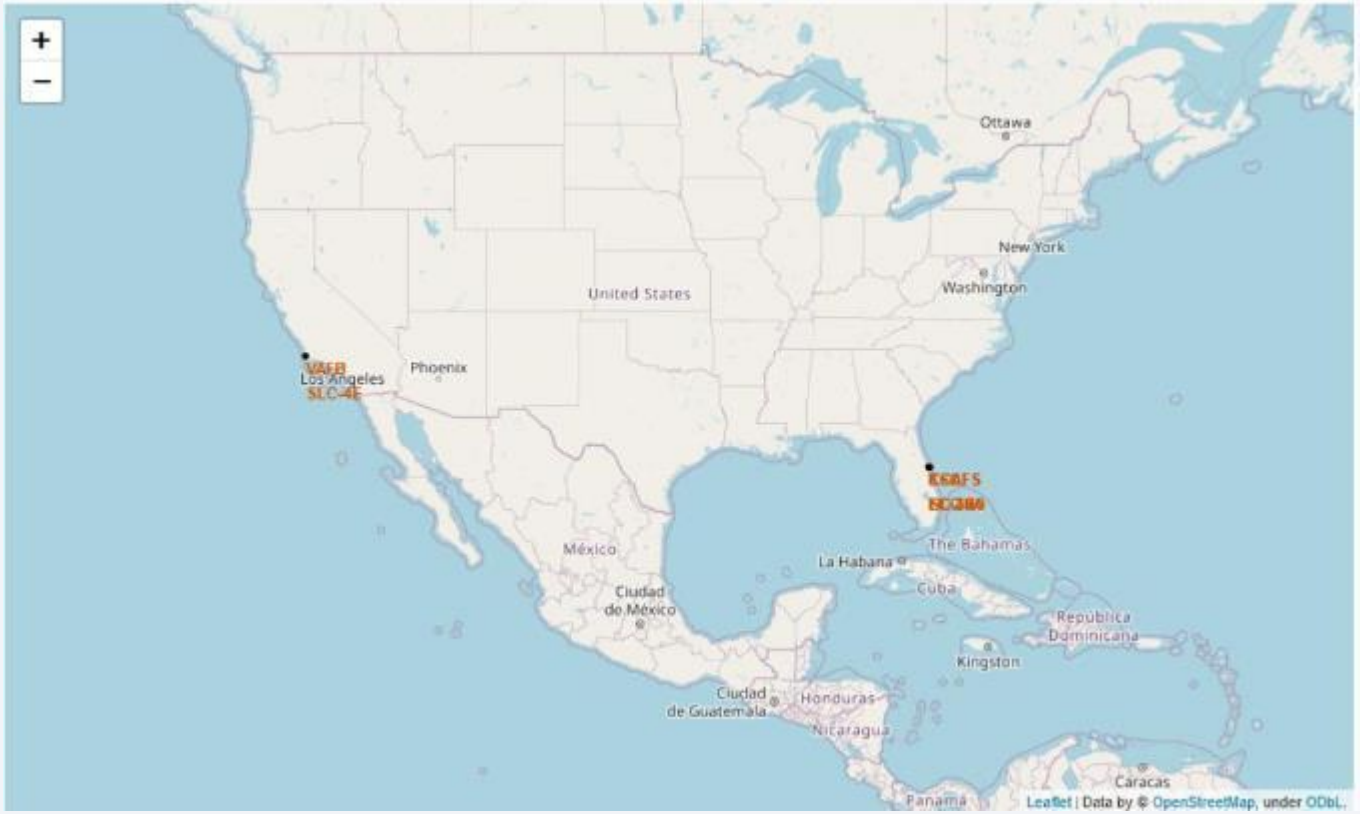
Rank Landing Outcomes Between 2010-06-04 and 2017-03-20

- Please examine the table on the right hand side for this information.

Landing Outcome	Occurrences
No attempt	10
Failure (drone ship)	5
Success (drone ship)	5
Controlled (ocean)	3
Success (ground pad)	3
Failure (parachute)	2
Uncontrolled (ocean)	2
Precluded (drone ship)	1


Section 3
Launch Sites
Proximities Analysis

All Launch Site Locations



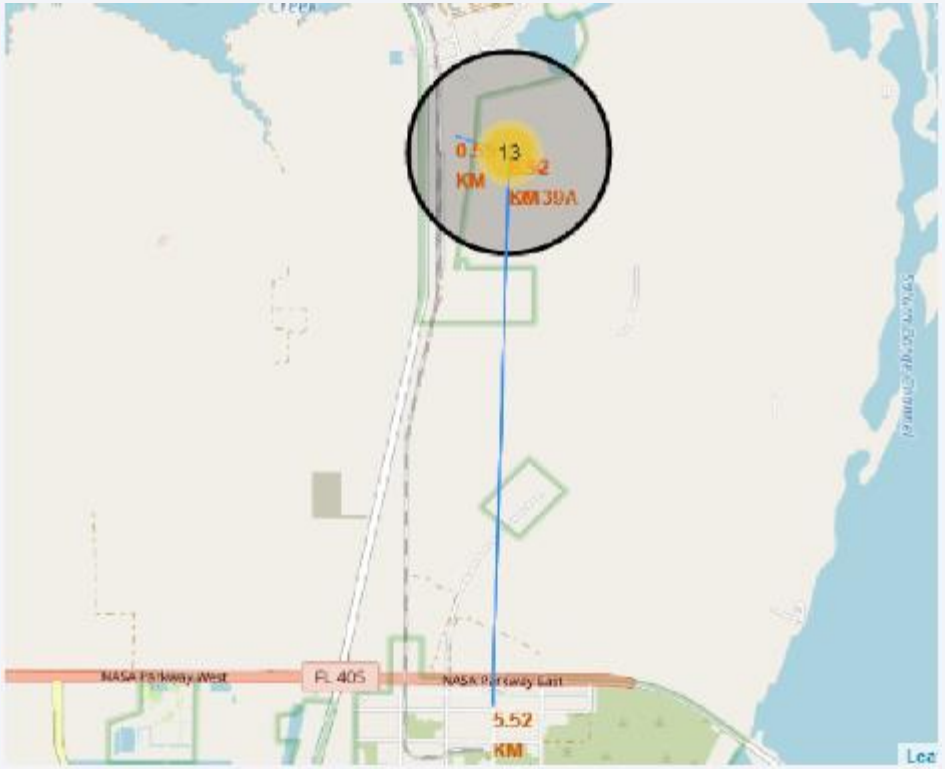
- Most launch sites were located on east coast

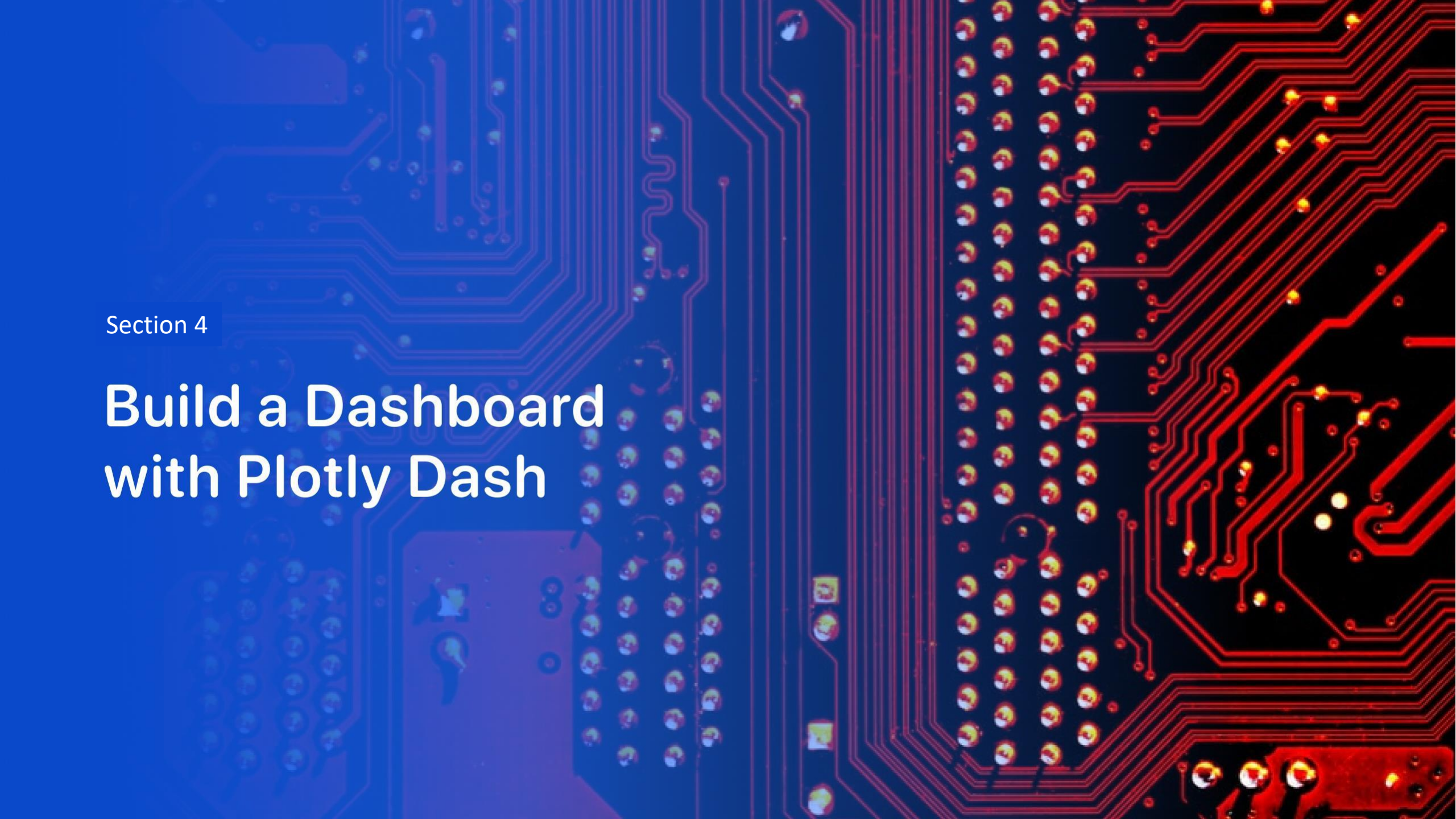
Launch Outcomes by Site

- Green markers label successful attempts, and red markers label failed attempts.

Safety of launch sites by GeoLocation

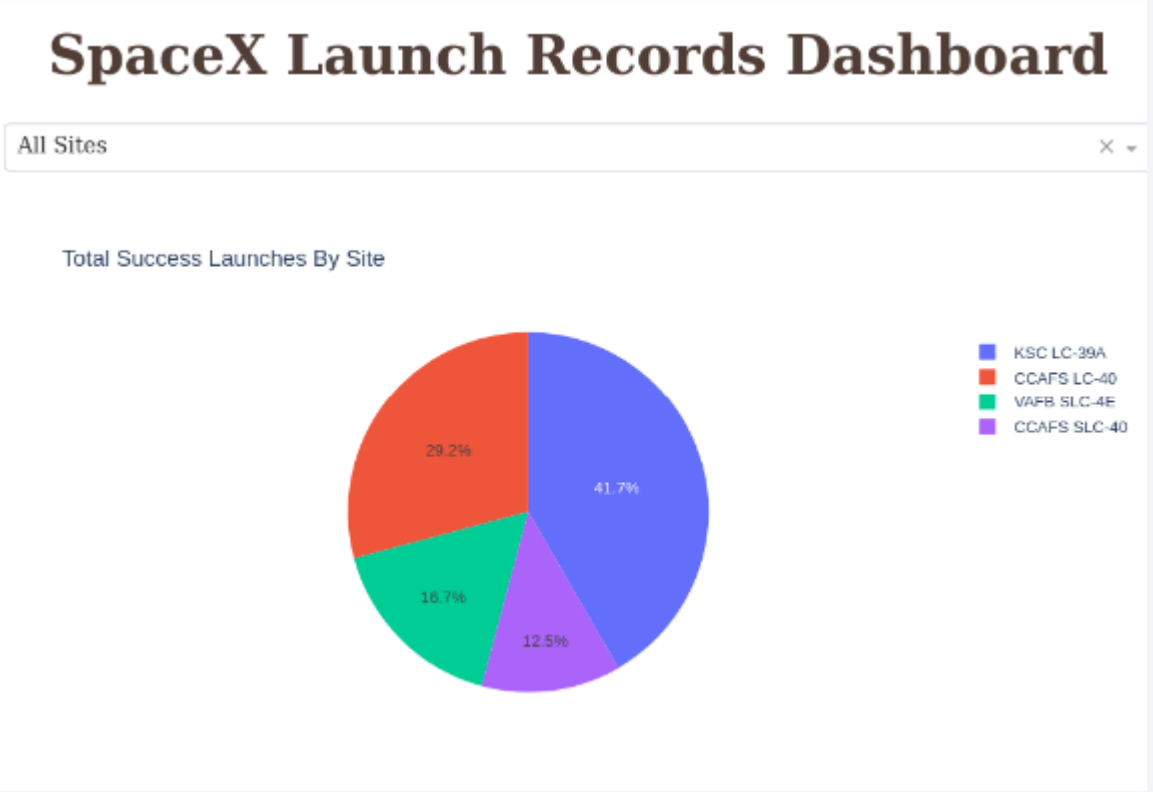
- As shown on the right, launch site KSC LC-39A being 5.52 km from pathway.




Section 4
Build a Dashboard with Plotly Dash

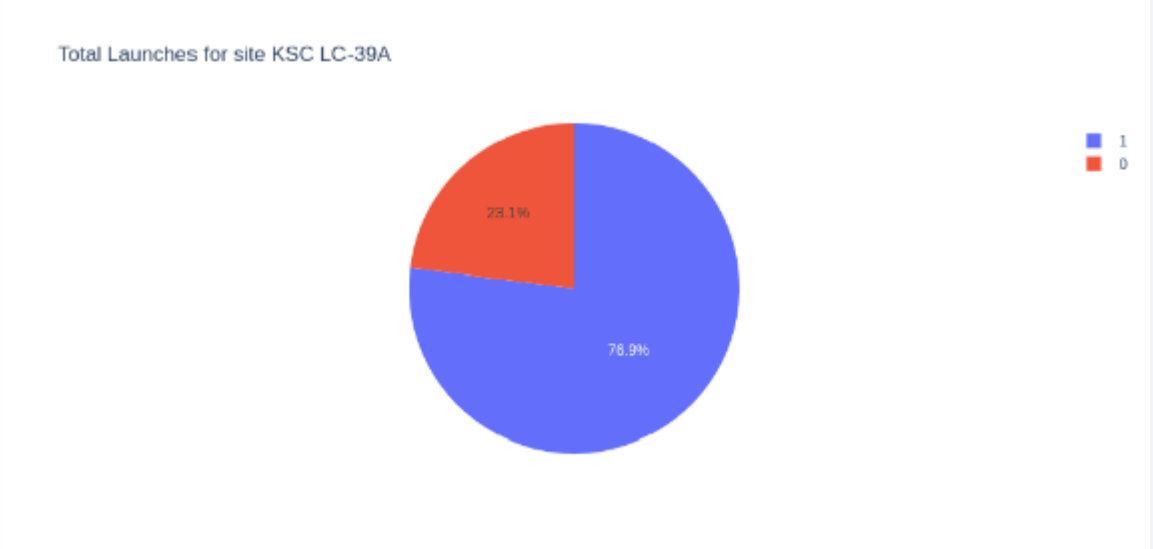
Successful launch count per site

- As shown on pie chart: 41.7% of successful launches occurred on KSC LC-39A



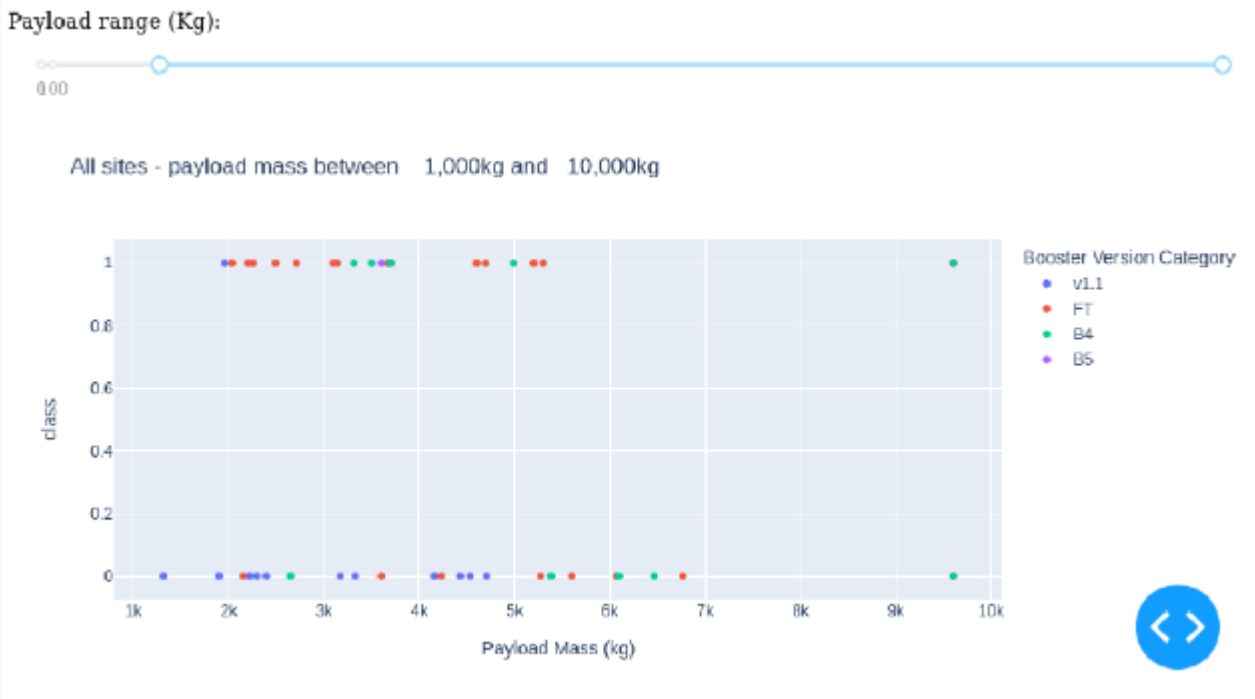
Diving deeper into KSC LC-39A’s success

- KSC LC-39A represents a 76.9% success rate



Payload vs Launch Outcome for all sites

- Highest success combination:
  - Payloads < 6000kg
  - Booster version set to: FT

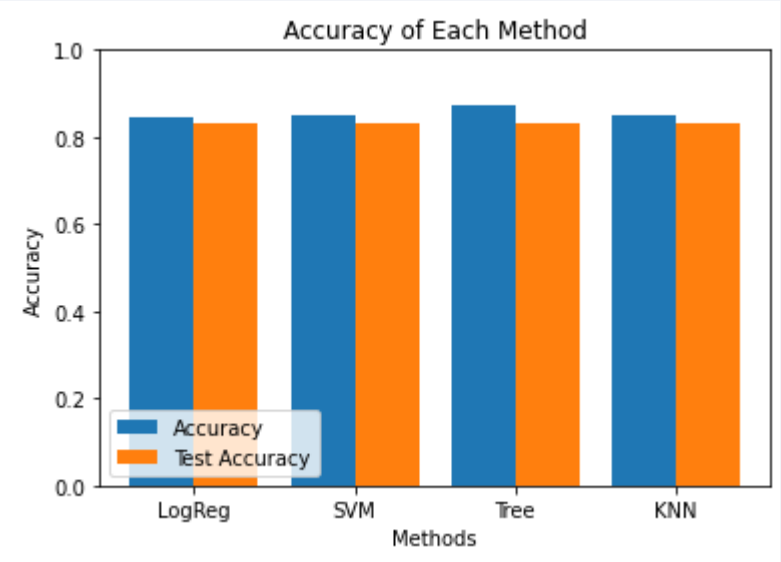


Section 5

Predictive Analysis (Classification)

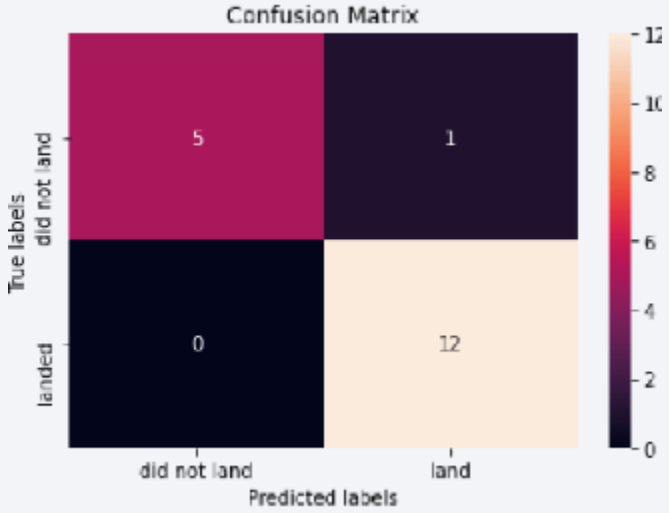
Classification Accuracy

- As seen by the orange bars on the right, the highest reaching one was the decision tree model, reaching above 83%.



Confusion Matrix

- Confusion matrix performed for decision tree model showed high levels of true positives and true negatives.



Conclusions

- The best launch site was found to be KSC LC-39A
- Launches above 6000-7000kg are safer
- Decision Tree classifier is a safe classification method to use for this analysis

Appendix

- Had some issues on github for some reason, so everything that I was not able to upload there, I have uploaded here as screenshots

Thank you!