IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

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

Executive Summary

- Summary of methodologies
  - Data Collection: Web Scraping, SpaceX API
  - EDA, Data Wrangling, Data Visulaization
  - ML Prediction
- Summary of all results
  - Identify the features that are useful for predictions with the ML
  - Using the data provided we can determine the best model to be used for this application

Introduction

- Project background and context
  - Objective is to determine if SpaceY can compete with SpaceX
- Problems you want to find answers
  - Predict if a landing will be successful which will directly determine the price of a launch ahead of time
  - The best location to land

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - SpaceX API & WebScraping
- Perform data wrangling
  - Fact Checking values & Replacing null with mean values
- 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, train/test split, fit 4 different models, evaluate each model with their accuracy

Data Collection

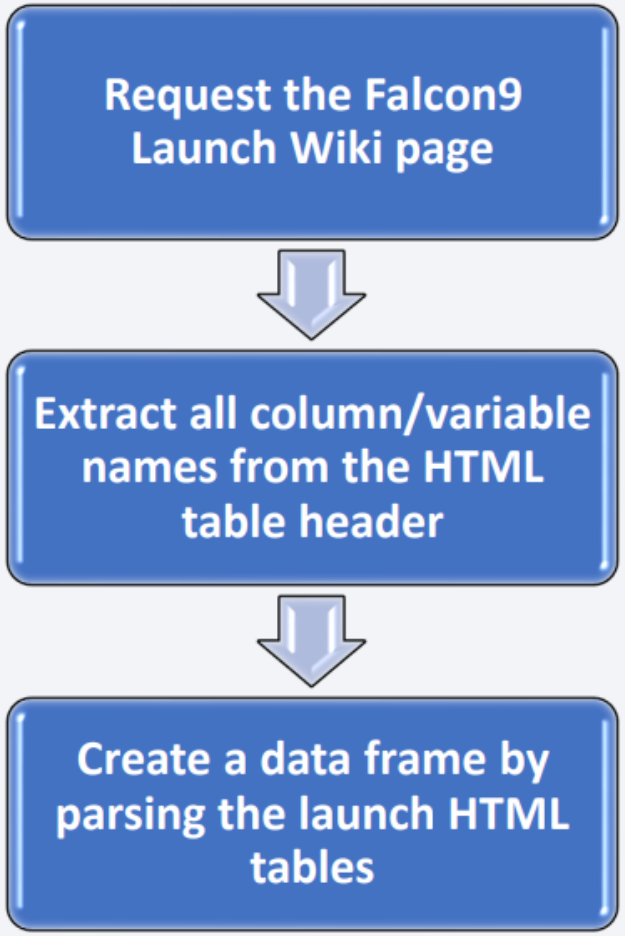
- Describe how data sets were collected.
- You need to present your data collection process use key phrases and flowcharts

Data Collection – SpaceX API

- SpaceX public API used to obtain the data used
- As shown by the flowchart the API is used then the data is saved
- https://github.com/JQ-C/Coursera/blob/master/data%20collection.ipynb

Data Collection - Scraping

- Wikipedia contains SpaceX launches data as well that can be web scrapped
- From Wikipedia the data is downloaded
- https://github.com/JQ-C/Coursera/blob/master/data%20collection%20web%20scrape%20.ipynb



Data Wrangling

- Check the values in the columns
- Calculate the mean value for columns with null value
- Replace null value with mean value
- https://github.com/JQ-C/Coursera/blob/master/data_wrangling.ipynb

EDA with Data Visualization

- Scatterplots & Barplots used to visualize the data.
- The data are mainly continuous data
- https://github.com/JQ-C/Coursera/blob/master/data_visual.ipynb

EDA with SQL

- Unique launch sites name
- Top 5 launch site with CCA
- Total payload mass carried by boosters launched by NASA (CRS)
- Average payload mass carried by booster version F9 v1.1
- Date when the first successful landing outcome in ground pad was achieved
- Names of the boosters which have success in drone ship and have payload mass between 4000 and 6000 kg
- Total number of successful and failure mission outcomes
- Names of the booster versions which have carried the maximum payload mass
- Failed landing outcomes in drone ship, their booster versions, and launch site names for in year 2015; and
- Rank of the count of landing outcomes (such as Failure (drone ship) or Success (ground pad)) between the date 2010-06-04 and 2017-03-20.
- https://github.com/JQ-C/Coursera/blob/master/EDA.ipynb

Build an Interactive Map with Folium

- Folium Maps in conjunction with markers, marker cluster, lines, and circles are used
  - Markers = launch sites
  - Marker clusters = groups of events in each coordinate, like launches in a launch site
  - Lines = distances between two coordinates.
  - Circles = highlighted areas around specific coordinates

- https://github.com/JQ-C/Coursera/blob/master/Interactive%20Visual%20Analytics%20with%20Folium%20lab.ipynb

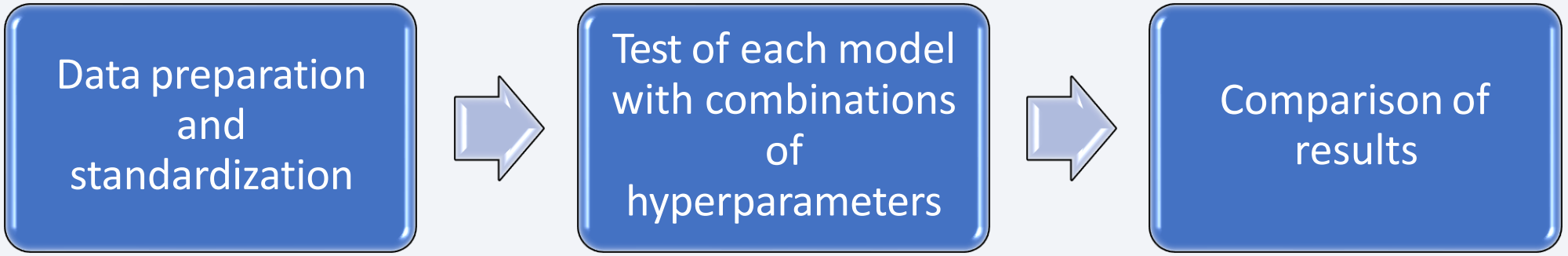
Build a Dashboard with Plotly Dash

- The Pay Load range and Percentage of Launches by site are the data that were visualize with the help of graphs and plots
- The relationship between payloads & launch sites can be quickly analysed to determine the best place for a successful launch

- https://github.com/JQ-C/Coursera/blob/master/spacex_dash_app.py

Predictive Analysis (Classification)

- Logistics Regression, Decision Tree, KNN, & SVM were compared



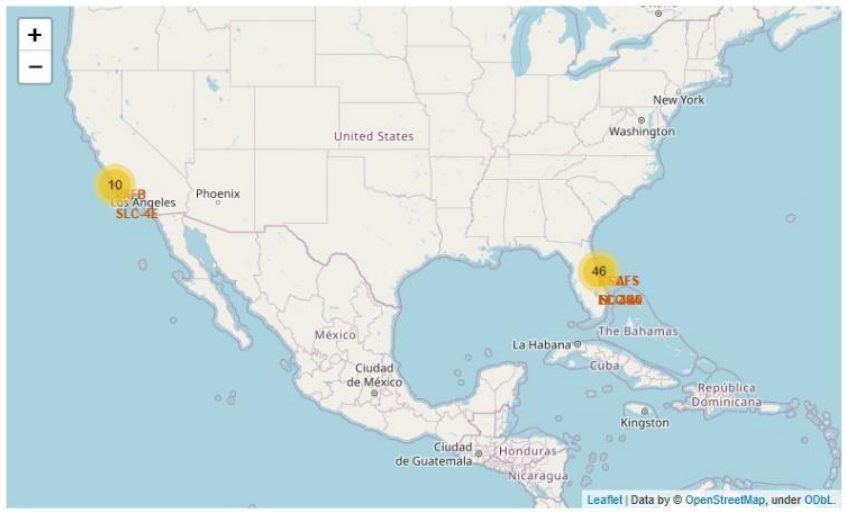
- https://github.com/JQ-C/Coursera/blob/master/Machine%20Learning%20Prediction.ipynb

Results

- Result of EDA:
  - 4 different launch sites were used by SpaceX;
  - The first launches were done to Space X itself and NASA;
  - The average payload of F9 v1.1 booster is 2,928 kg;
  - The first success landing outcome happened in 2015 fiver year after the first launch;
  - Many Falcon 9 booster versions were successful at landing in drone ships having payload above the average;
  - Almost 100% of mission outcomes were successful;
  - Two booster versions failed at landing in drone ships in 2015: F9 v1.1 B1012 and F9 v1.1 B1015;
  - The number of landing outcomes became as better as years passed.

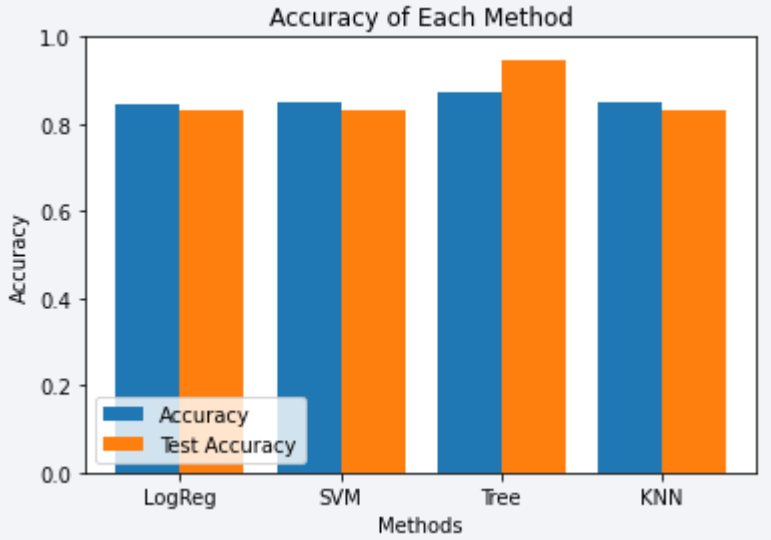
Results

- Using interactive analytics was possible to identify that launch sites use to be in safety places, near sea, for example and have a good logistic infrastructure around.
- Most launches happens at east cost launch sites.



Results

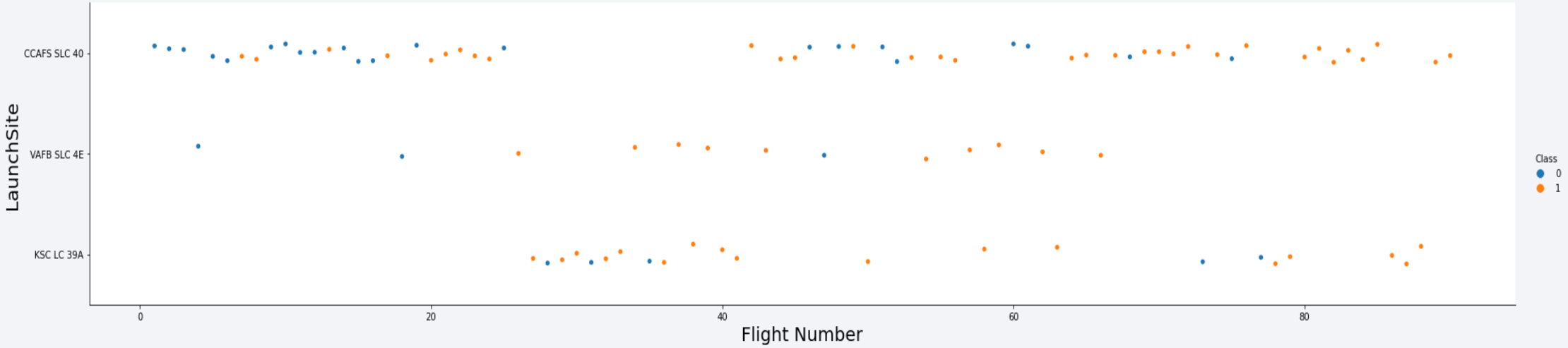
- Predictive Analysis showed that Decision Tree Classifier is the best model to predict successful landings, having accuracy over 87% and accuracy for test data over 94%.



Section 2

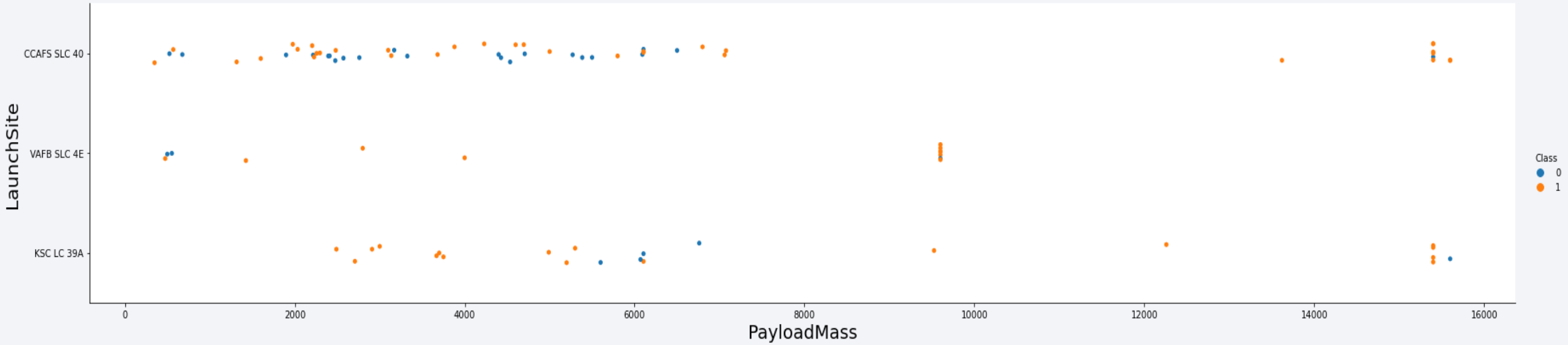
Insights drawn from EDA

Flight Number vs. Launch Site



- According to the plot above CCAF5 SLC 40 is verified to be the best launch sites, on another note most recent launches are successful;
- VAFB SLC 4E, 2nd Place; KSC LC 39A, 3rd Place;
- General successful rate predicted to improve over time.

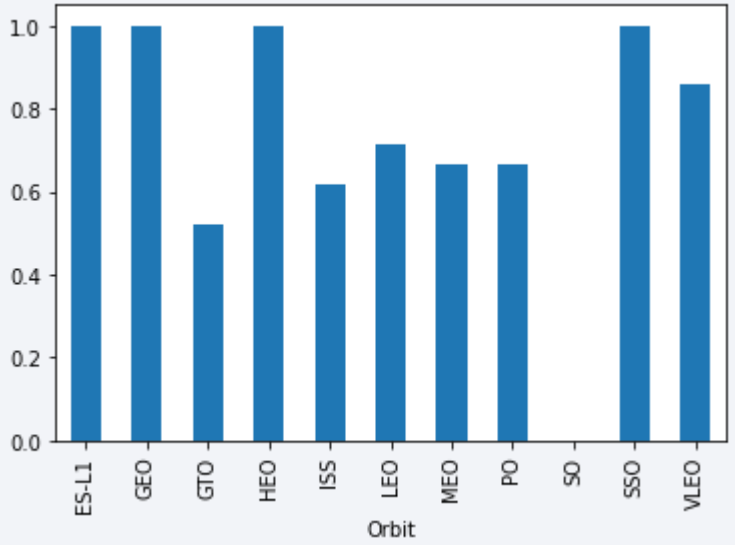
Payload vs. Launch Site



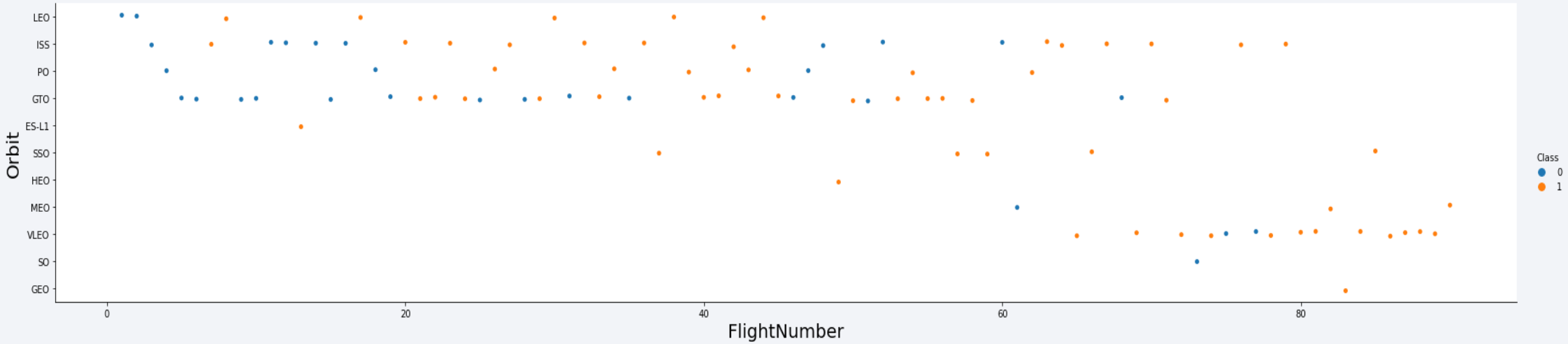
- Payloads over 9,000kg (about the weight of a school bus) have excellent success rate;
- Payloads over 12,000kg seems to be possible only on CCAFS SLC 40 and KSC LC 39A launch sites.

Success Rate vs. Orbit Type

- The biggest success rates happens to orbits:
  - ES-L1;
  - GEO;
  - HEO; and
  - SSO.
- Followed by:
  - VLEO (above 80%); and
  - LFO (above 70%).

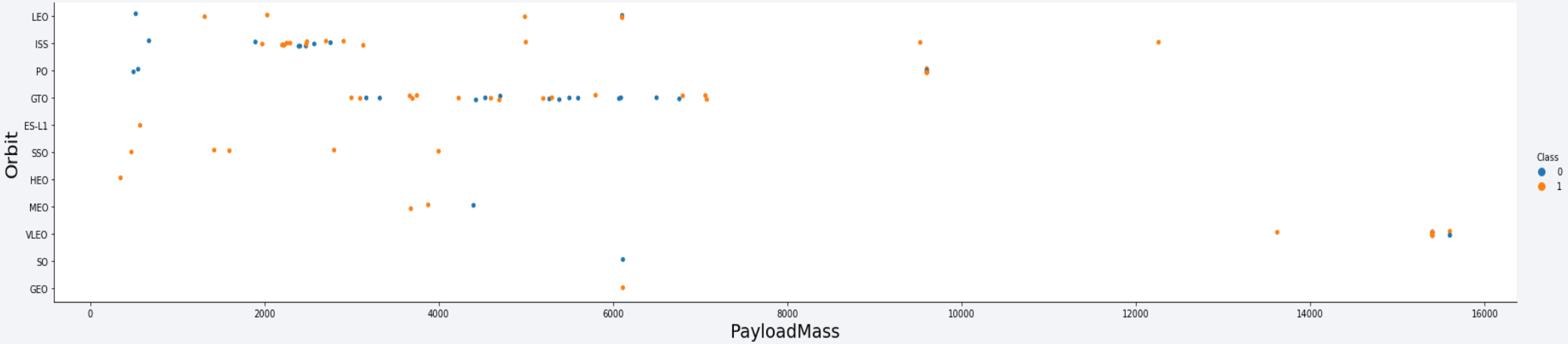


Flight Number vs. Orbit Type



- Apparently, success rate improved over time to all orbits;
- VLEO orbit seems a new business opportunity, due to recent increase of its frequency.

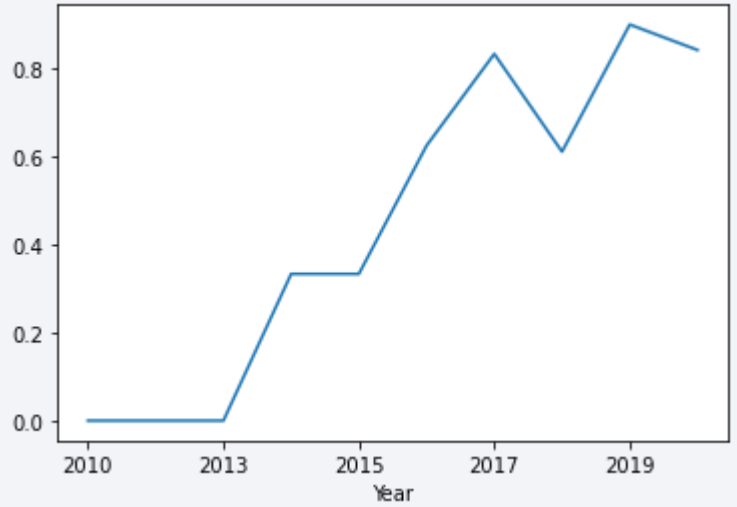
Payload vs. Orbit Type



- Apparently, there is no relation between payload and success rate to orbit GTO;
- ISS orbit has the widest range of payload and a good rate of success;
- There are few launches to the orbits SO and GEO.

Launch Success Yearly Trend

- Success rate started increasing in 2013 and kept until 2020;
- It seems that the first three years were a period of adjusts and improvement of technology.



All Launch Site Names

- According to data, there are four launch sites:

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

- They are obtained by selecting unique occurrences of “launch_site” values from the dataset.

Launch Site Names Begin with 'CCA'

- 5 records where launch sites 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	**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

- Here we can see five samples of Cape Canaveral launches.

Total Payload Mass

- Total payload carried by boosters from NASA:

Total Payload (kg)
111.268

- Total payload calculated above, by summing all payloads whose codes contain ‘CRS’, which corresponds to NASA.

Average Payload Mass by F9 v1.1

- Average payload mass carried by booster version F9 v1.1:

Avg Payload (kg)
2.928

- Filtering data by the booster version above and calculating the average payload mass we obtained the value of 2,928 kg.

First Successful Ground Landing Date

- First successful landing outcome on ground pad:

Min Date
2015-12-22

- By filtering data by successful landing outcome on ground pad and getting the minimum value for date it's possible to identify the first occurrence, that happened on 12/22/2015.

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

Booster Version
F9 FT B1021.2
F9 FT B1031.2
F9 FT B1022
F9 FT B1026

- Selecting distinct booster versions according to the filters above, these 4 are the result.

Total Number of Successful and Failure Mission Outcomes

- Number of successful and failure mission outcomes:

Mission Outcome	Occurrences
Success	99
Success (payload status unclear)	1
Failure (in flight)	1

- Grouping mission outcomes and counting records for each group led us to the summary above.

Boosters Carried Maximum Payload

- Boosters which have carried the maximum payload mass

Booster Version (...)
F9 B5 B1048.4
F9 B5 B1048.5
F9 B5 B1049.4
F9 B5 B1049.5
F9 B5 B1049.7
F9 B5 B1051.3

Booster Version
F9 B5 B1051.4
F9 B5 B1051.6
F9 B5 B1056.4
F9 B5 B1058.3
F9 B5 B1060.2
F9 B5 B1060.3

- These are the boosters which have carried the maximum payload mass registered in the dataset.

2015 Launch Records

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

Booster Version	Launch Site
F9 v1.1 B1012	CCAFS LC-40
F9 v1.1 B1015	CCAFS LC-40

- The list above has the only two occurrences.

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

- Ranking of all landing outcomes between the date 2010-06-04 and 2017-03-20:

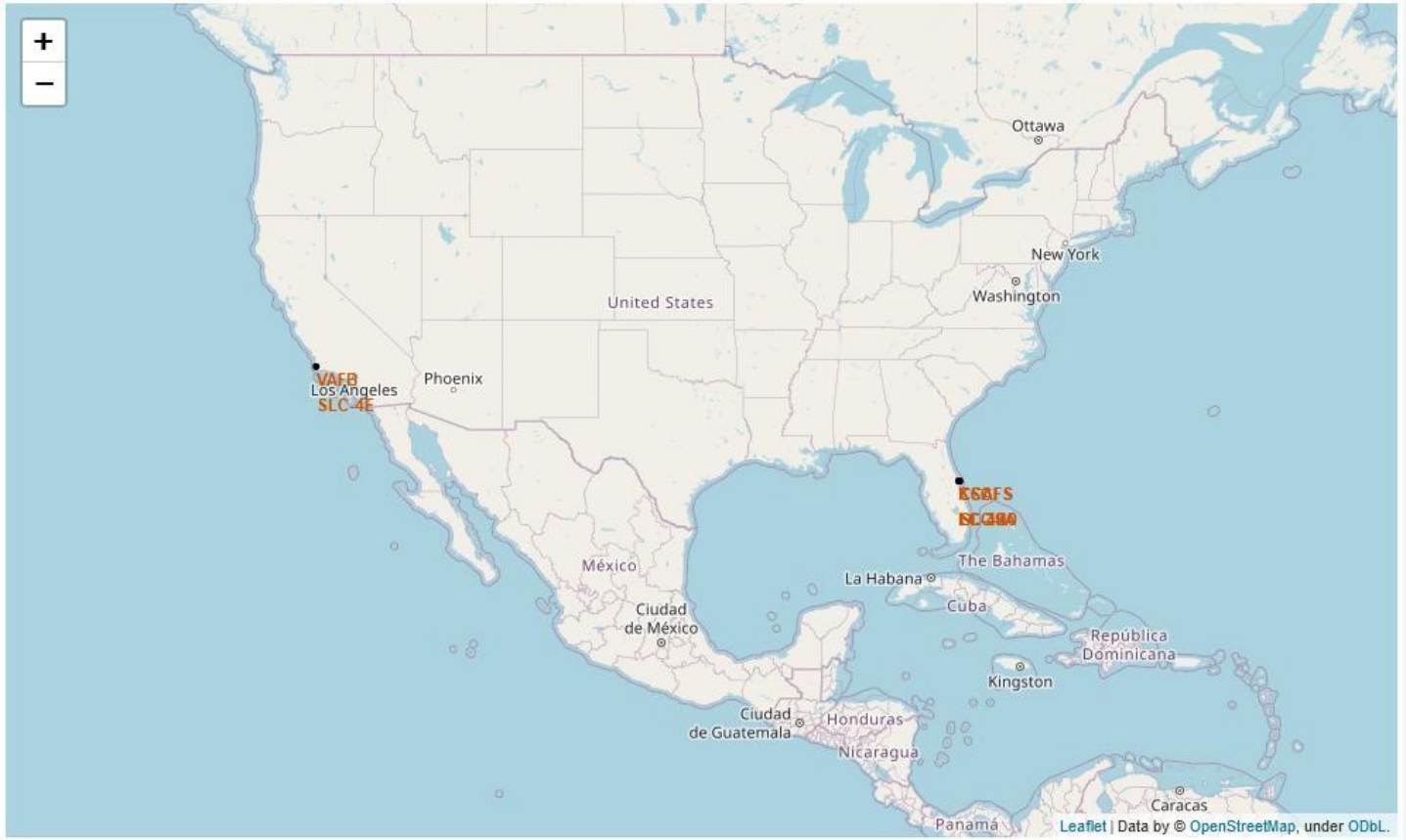
Landing Outcome	Occurrences
No attempt	10
Failure (drone ship)	5
Success (drone ship)	5
Controlled (ocean)	3
Success (ground pad)	3
Failure (parachute)	2
Uncontrolled (ocean)	2
Precluded (drone ship)	1

- This view of data alerts us that “No attempt” must be taken in account.

Section 4

Launch Sites Proximities Analysis

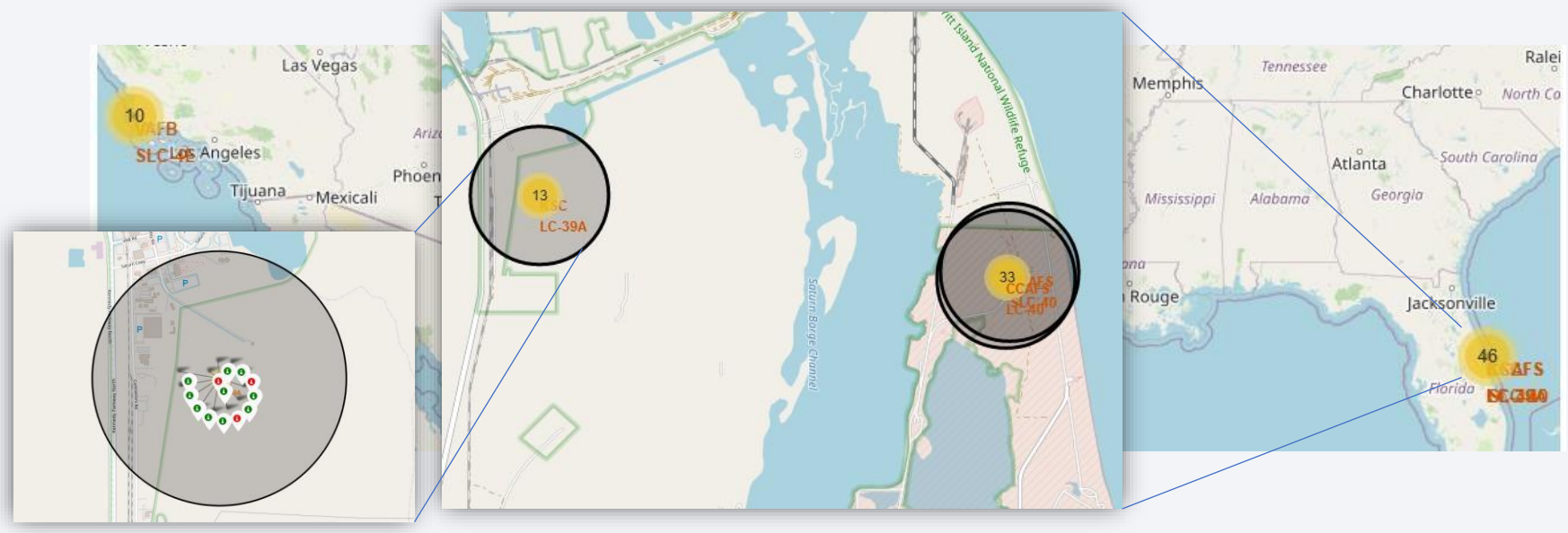
All launch sites



- Launch sites are near sea, probably by safety, but not too far from roads and railroads.

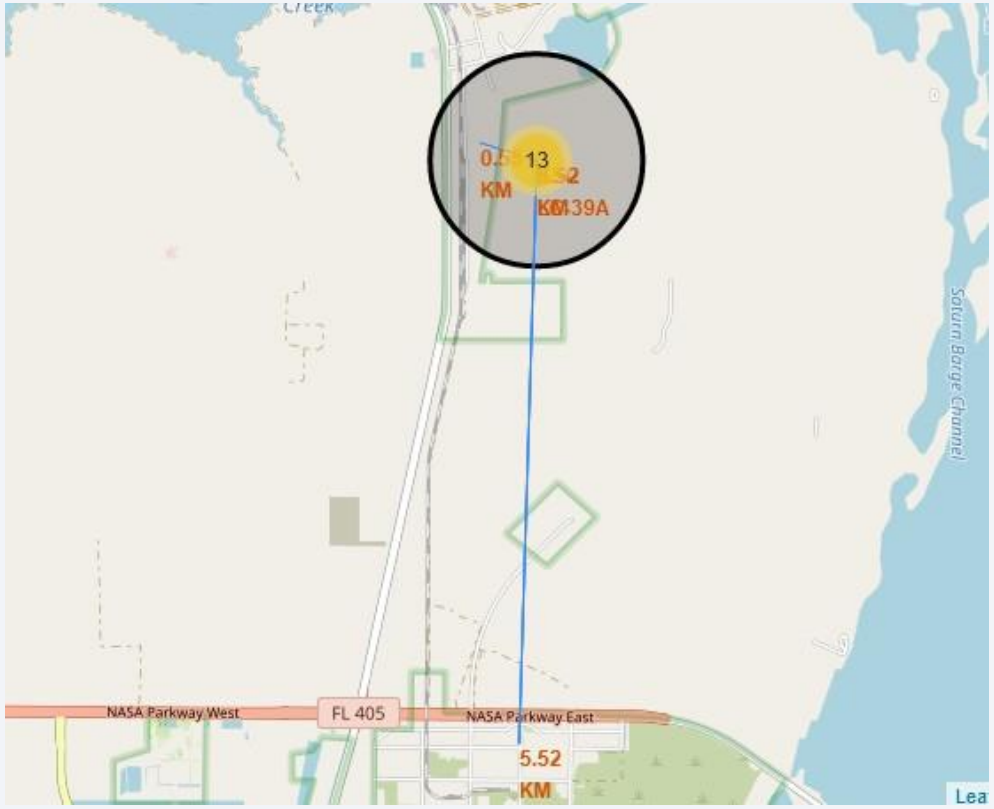
Launch Outcomes by Site

- Example of KSC LC-39A launch site launch outcomes

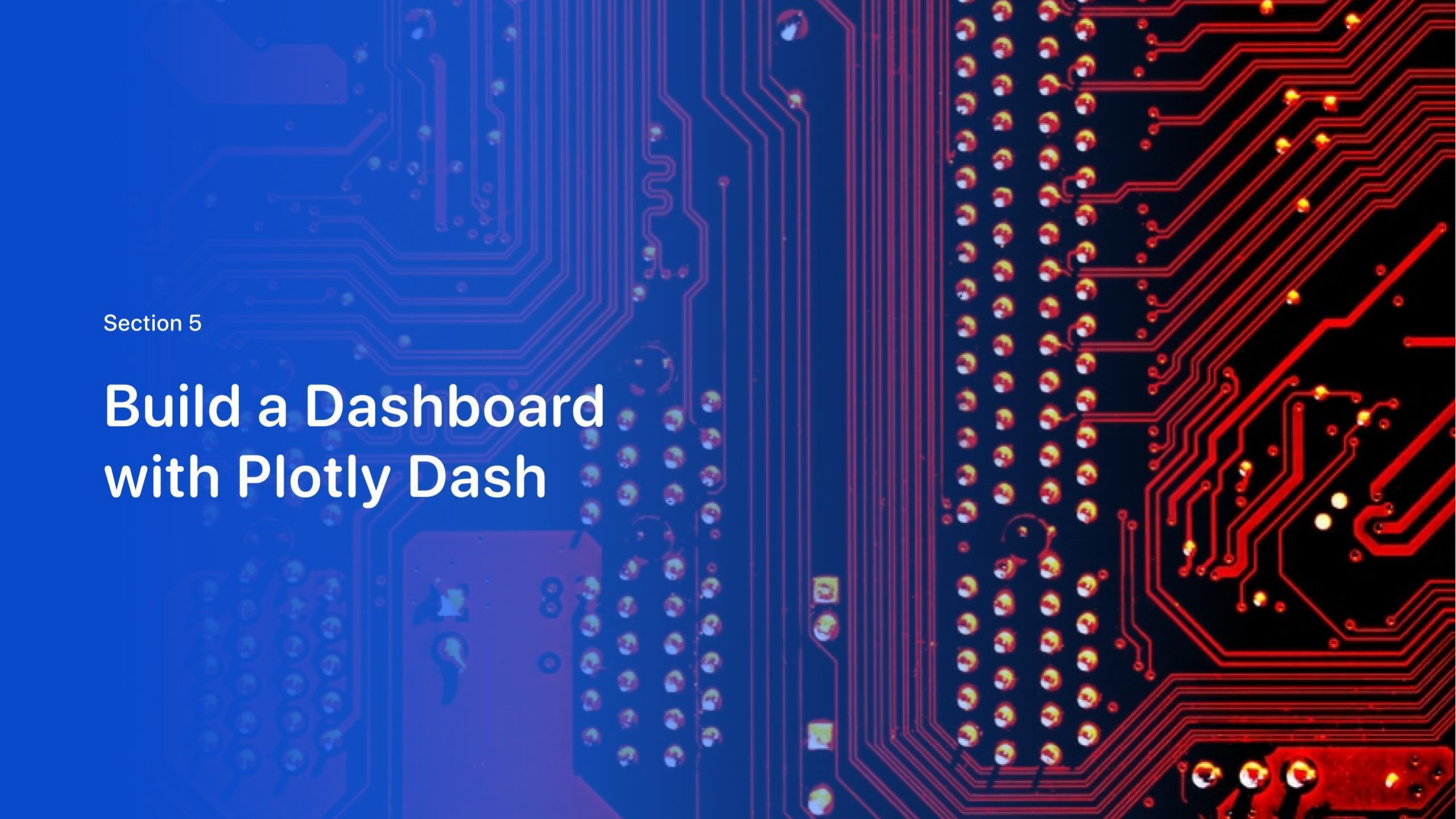


- Green markers indicate successful and red ones indicate failure.

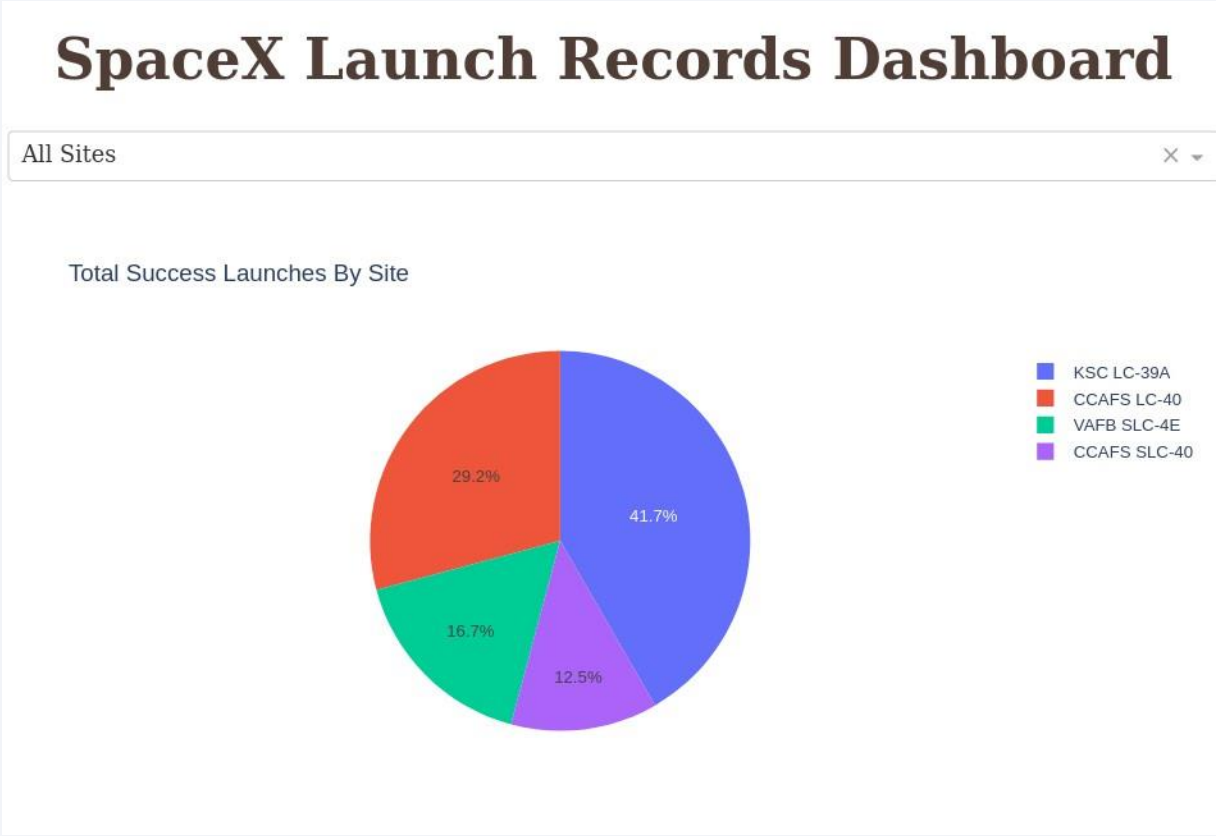
Logistics and Safety



- Launch site KSC LC-39A has good logistics aspects, being near railroad and road and relatively far from inhabited areas.

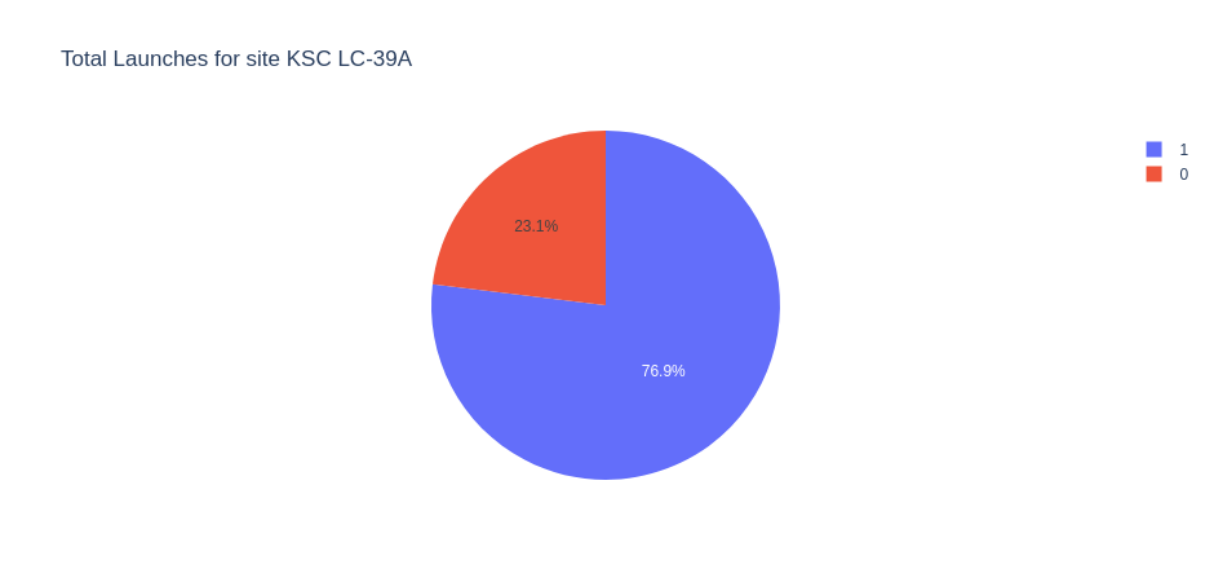

Section 5
Build a Dashboard with Plotly Dash

Successful Launches by Site



- The place from where launches are done seems to be a very important factor of success of missions.

Launch Success Ratio for KSC LC-39A



- 76.9% of launches are successful in this site.

Payload vs. Launch Outcome

- Payloads under 6,000kg and FT boosters are the most successful combination.

Payload vs. Launch Outcome

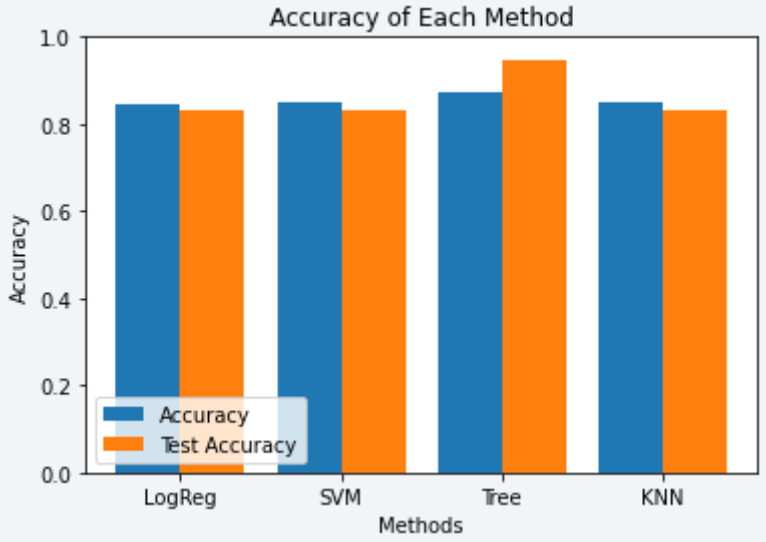
- There’s not enough data to estimate risk of launches over 7,000kg

Section 6

Predictive Analysis (Classification)

Classification Accuracy

- Four classification models were tested, and their accuracies are plotted beside;
- The model with the highest classification accuracy is Decision Tree Classifier, which has accuracies over than 87%.



Confusion Matrix of Decision Tree Classifier

- Confusion matrix of Decision Tree Classifier proves its accuracy by showing the big numbers of true positive and true negative compared to the false ones.

Conclusions

- Different data sources were analyzed, refining conclusions along the process;
- The best launch site is KSC LC-39A;
- Launches above 7,000kg are less risky;
- Although most of mission outcomes are successful, successful landing outcomes seem to improve over time, according the evolution of processes and rockets;
- Decision Tree Classifier can be used to predict successful landings and increase profits.

Appendix

- As an improvement for model tests, it's important to set a value to `np.random.seed` variable;
- Folium didn't show maps on Github, so I took screenshots.

Thank you!