IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

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

- Summary of methodologies
  - Data Collection through API
  - Data Collection with Web Scraping
  - Data Wrangling
  - Exploratory Data Analysis with SQL
  - Exploratory Data Analysis with Data Visualization
  - Interactive Visual Analytics with Folium
  - Machine Learning Prediction
- Summary of all results
  - Exploratory Data Analysis result
  - Interactive analytics in screenshots
  - Predictive Analytics result

Introduction

- Project background and context

  Space X advertises Falcon 9 rocket launches on its website with a cost of 62 million dollars; other providers cost upward of 165 million dollars each, much of the savings is because Space X can reuse the first stage. Therefore, if we can determine if the first stage will land, we can determine the cost of a launch. This information can be used if an alternate company wants to bid against space X for a rocket launch. This goal of the project is to create a machine learning pipeline to predict if the first stage will land successfully.

- Problems you want to find answers

  - What factors determine if the rocket will land successfully?
  - The interaction amongst various features that determine the success rate of a successful landing.
  - What operating conditions needs to be in place to ensure a successful landing program.

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - Through SpaceX Rest API and Web scrapping from Wikipedia.
- Perform data wrangling
  - One-hot encoding was applied to categorical features and data fields for Machine Learning and data cleaning of null values and irrelevant 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
  - How to build, tune, evaluate classification models of Decision tree, K-nearest Neighbors, Logistic regression, Support Vector Machine to find the best classifier

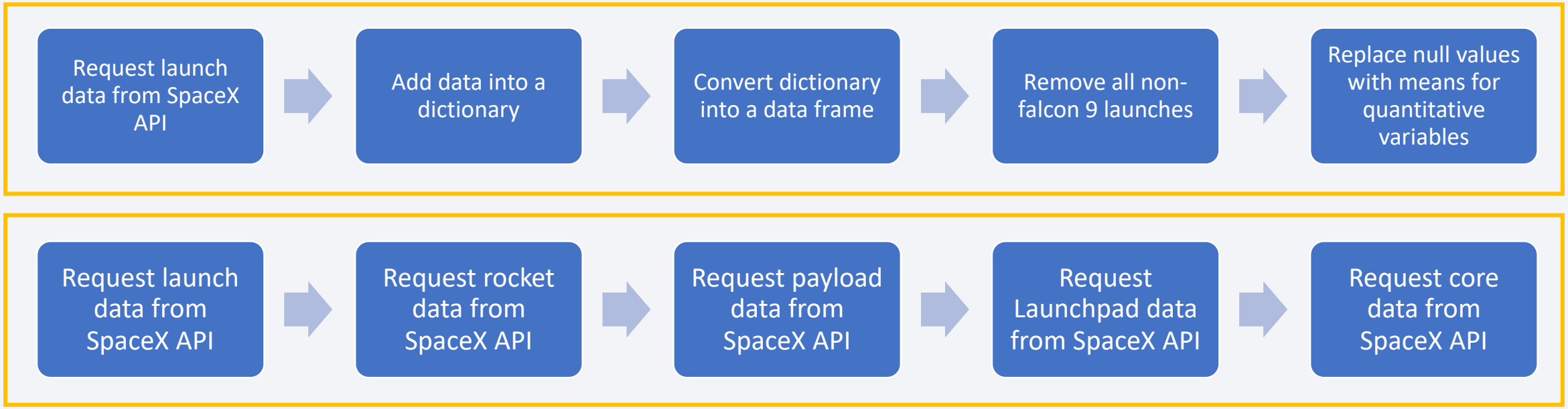
Data Collection

- The data was collected using various methods

	SpaceX API	Web Scraping
Source	Space X	Wikipedia
Step 1	Requested rocket launch data from SpaceX API	Extracted a Falcon 9 launch records HTML table from Wikipedia
Step 2	Decoded the response content as a Json using .json() and turned it into a Pandas data frame using .json_normalize()	Parsed the table and convert it into Pandas data frame using BeautifulSoup
Step 3	Performed data cleaning for missing values by replacing it with mean value of quantitative features	Extracted all column/variable names from the HTML table header

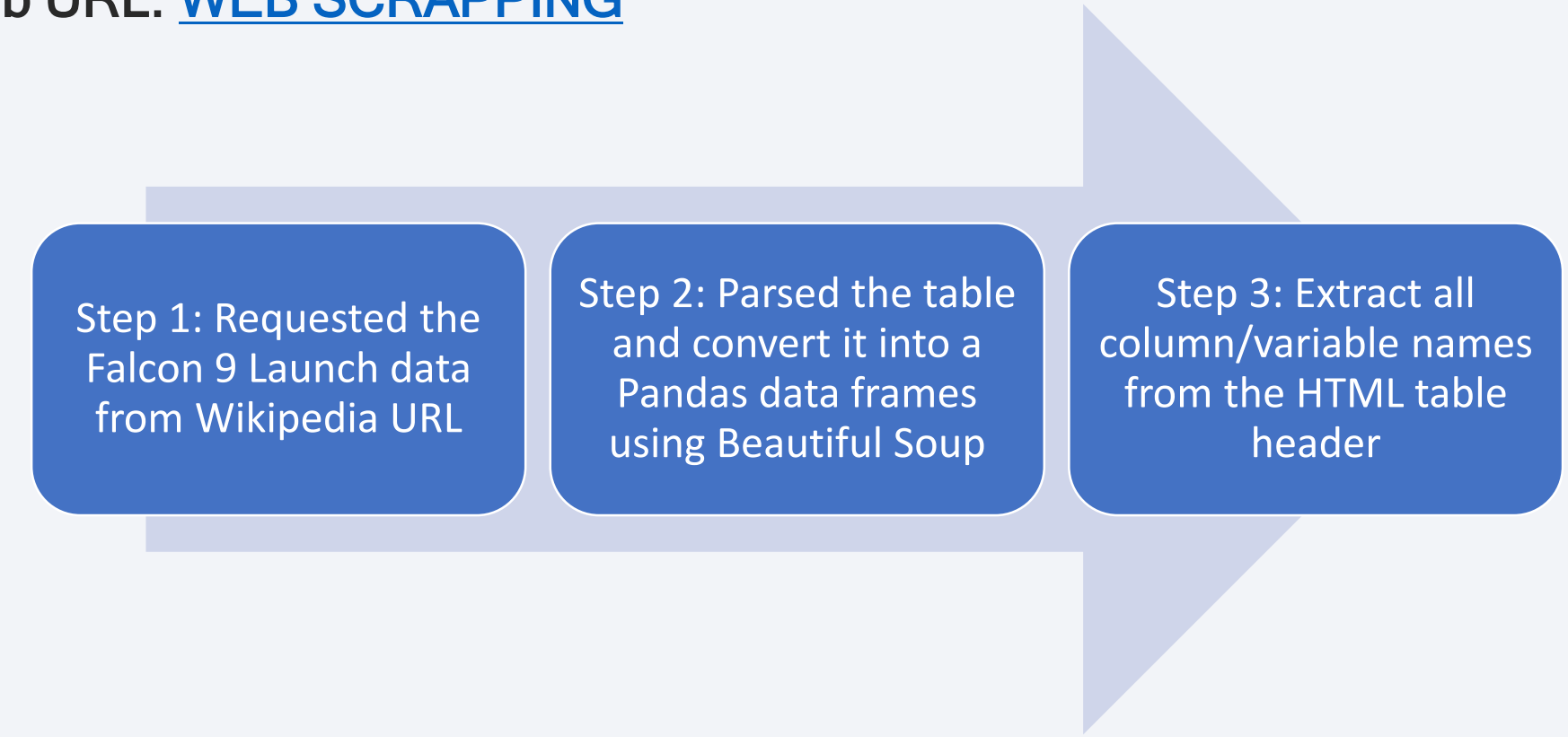
Data Collection - SpaceX API

- Present your web scraping process using key phrases and flowcharts
- [Github URL: Data Collection - SpaceX API]



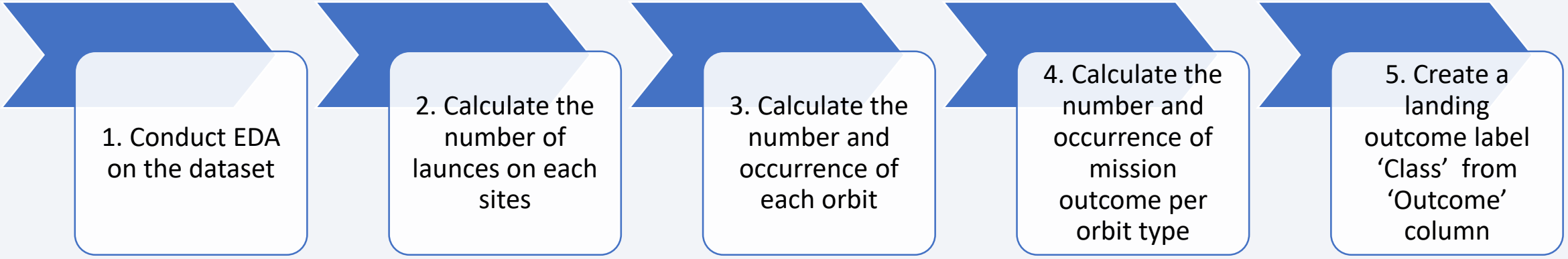
Data Collection - Scraping

- Present your web scraping process using key phrases and flowcharts
- **GitHub URL:** WEB SCRAPPING



Data Wrangling

- Describe how data were processed
- You need to present your data wrangling process using key phrases and flowcharts
- Github URL : Data Wrangling



EDA with Data Visualization

- Summarize what charts were plotted and why you used those charts
- Github URL: EDA with Data Visualization

No	Features	Type of Chart	Reason
1	Flight Number vs Launch Site	Scatterplot	To find relationship between these two numeric variables
2	Payload vs Launch Site		
3	FlightNumber vs Orbit type		
4	Payload vs Orbit type		
5	Success rate of each orbit type	Bar chart	To find the probability of success rate for each orbit type
6	Year vs Success rate	Line chart	To observe the trend of success rate across a period of time (years)

EDA with SQL

- Using bullet point format, summarize the SQL queries you performed
  - Launch site – unique, string 'CCA'
  - Payload Mass (kg) – total, average
  - Mission Outcome – total number of success and fail mission outcome
  - Booster version – carried the maximum payload mass
  - Date – 1st successful landing outcome in ground pad

- Github URL : EDA with SQL

Build an Interactive Map with Folium

- Summarize what map objects such as markers, circles, lines, etc. you created and added to a folium map
- Explain why you added those objects
- GitHub URL: Interactive Map with Folium

Add each site's location, label by using site's latitude & longitude coordinates and circle marker with name of launch sites, respectively

Visualize all launch sites into an interactive map

Mark the success/failed launches for each site on the map

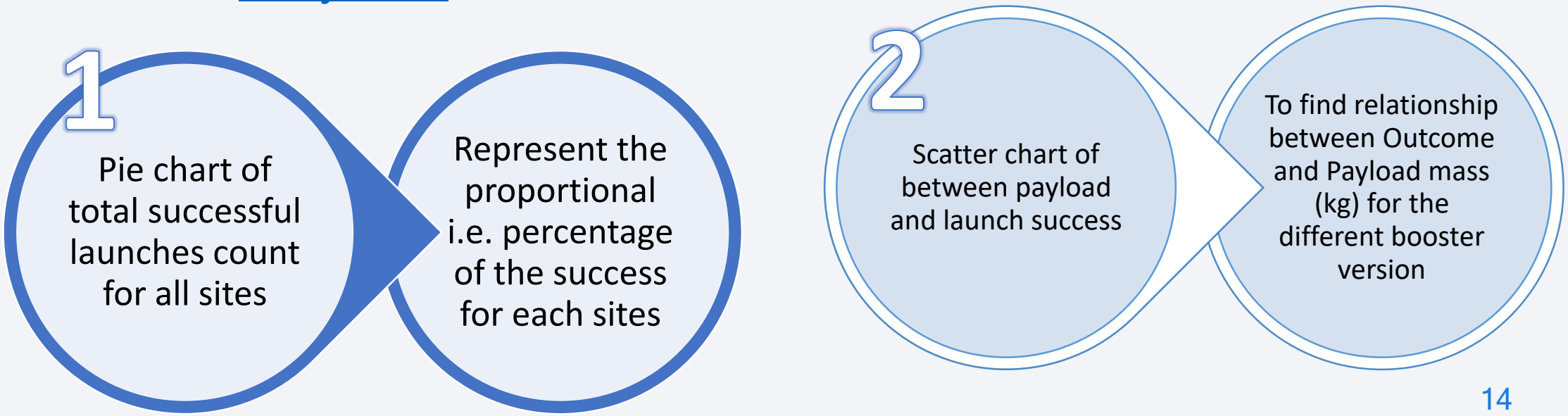
Assign feature of launch_outcomes with green marker for success launch site whereas red or failed launch site

Using Haversine's formula

Calculated distanced to the closest coastline, city, railway and highway, represented by a blue line on the map

Build a Dashboard with Plotly Dash

- Summarize what plots/graphs and interactions you have added to a dashboard
- Explain why you added those plots and interactions
- GitHub URL: Plotly Dash



Predictive Analysis (Classification)

- Summarize how you built, evaluated, improved, and found the best performing classification model
- You need present your model development process using key phrases and flowchart
- GitHub URL: Machine Learning Predictions

1. Loaded the data using numpy and pandas
2. Transformed the data
3. Split our data into training and testing
4. Decide which ML models to be deployed

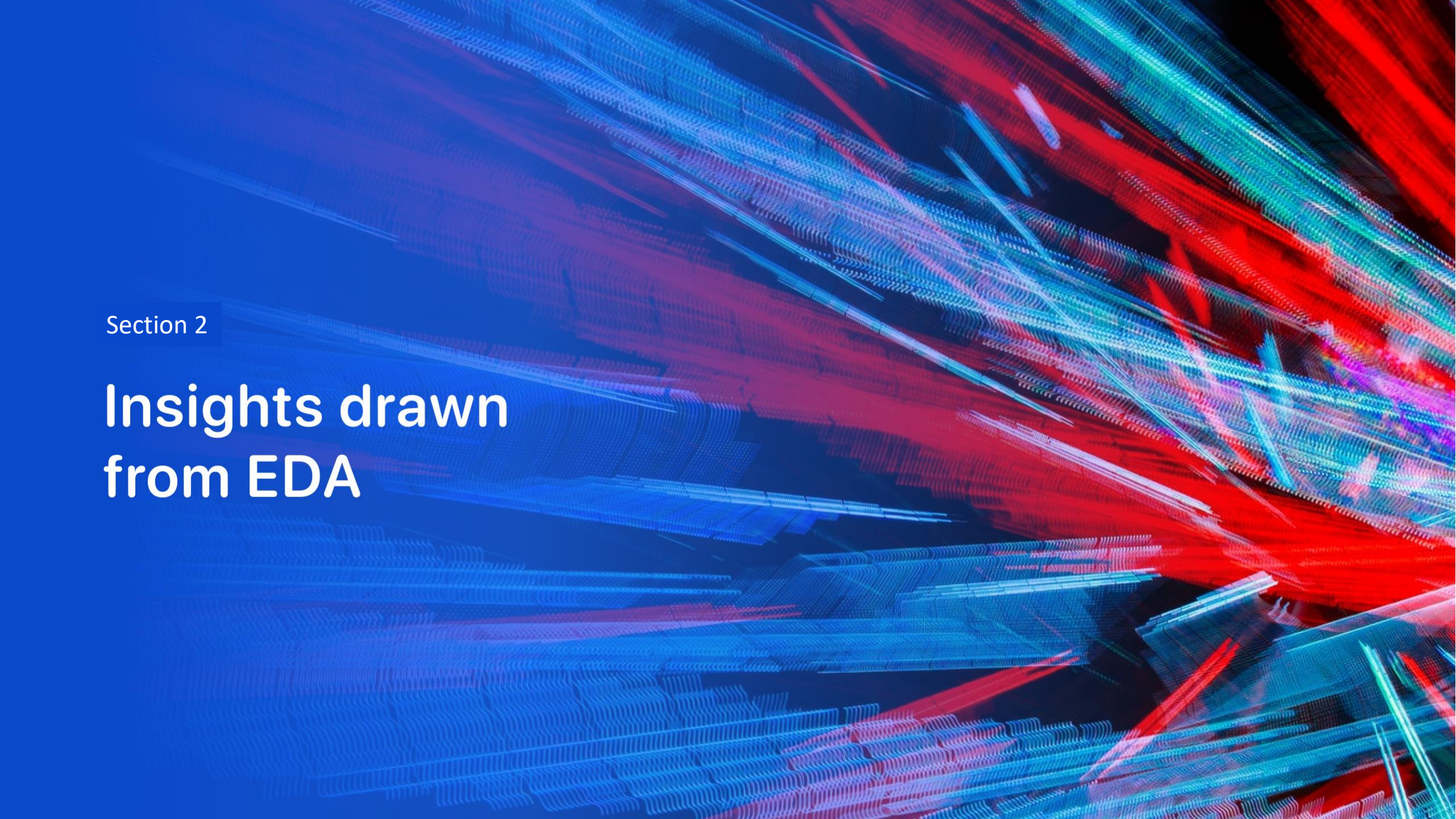
1. Build ML model
2. Check accuracy of each ML model
3. Tune different hyperparametes using GridSearchCV

1. Feature engineering
2. Algorithm tuning

1. The best model will be chosen based on the best (highest) accuracy score

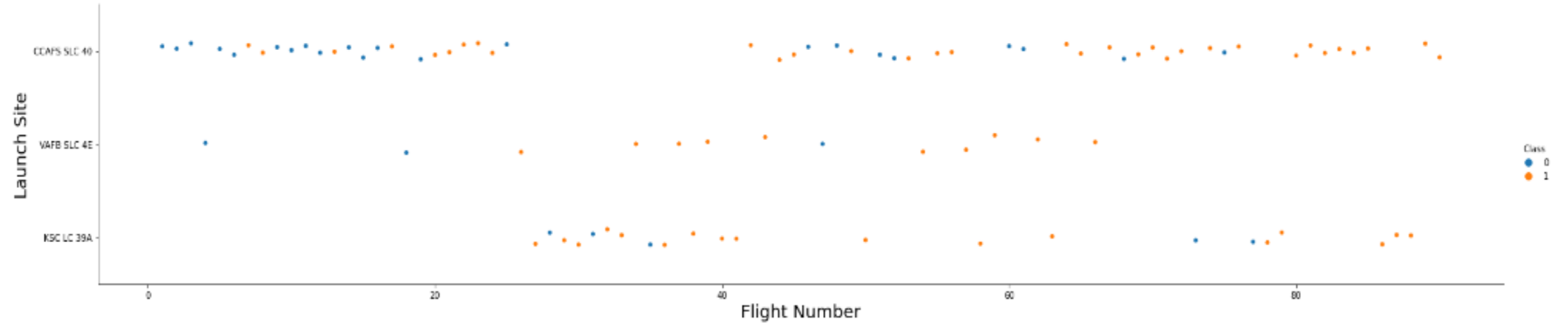
Results

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


Section 2
Insights drawn from EDA

Flight Number vs. Launch Site

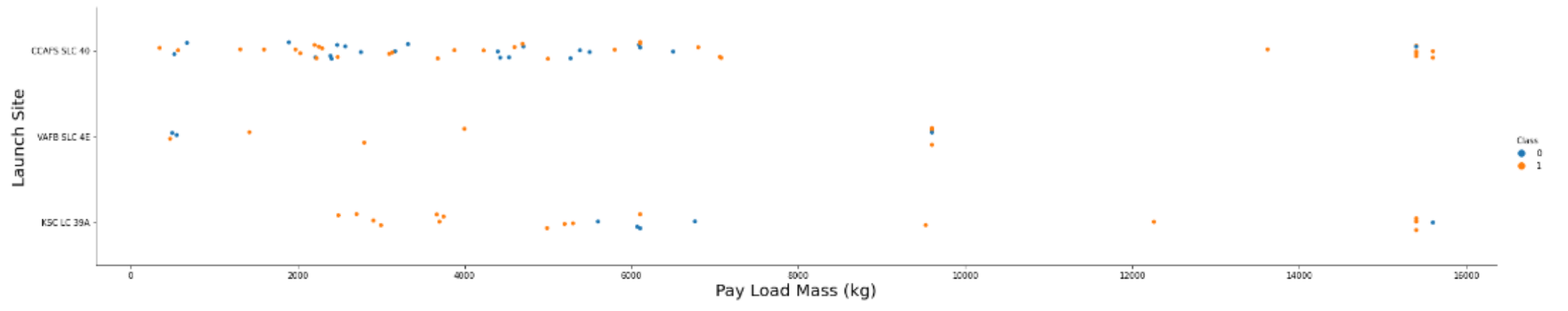
- Show a scatter plot of Flight Number vs. Launch Site
- Show the screenshot of the scatter plot with explanations



- **The larger amount of the flight number at the launch site, the greater the success rate at a launch site will be.**

Payload vs. Launch Site

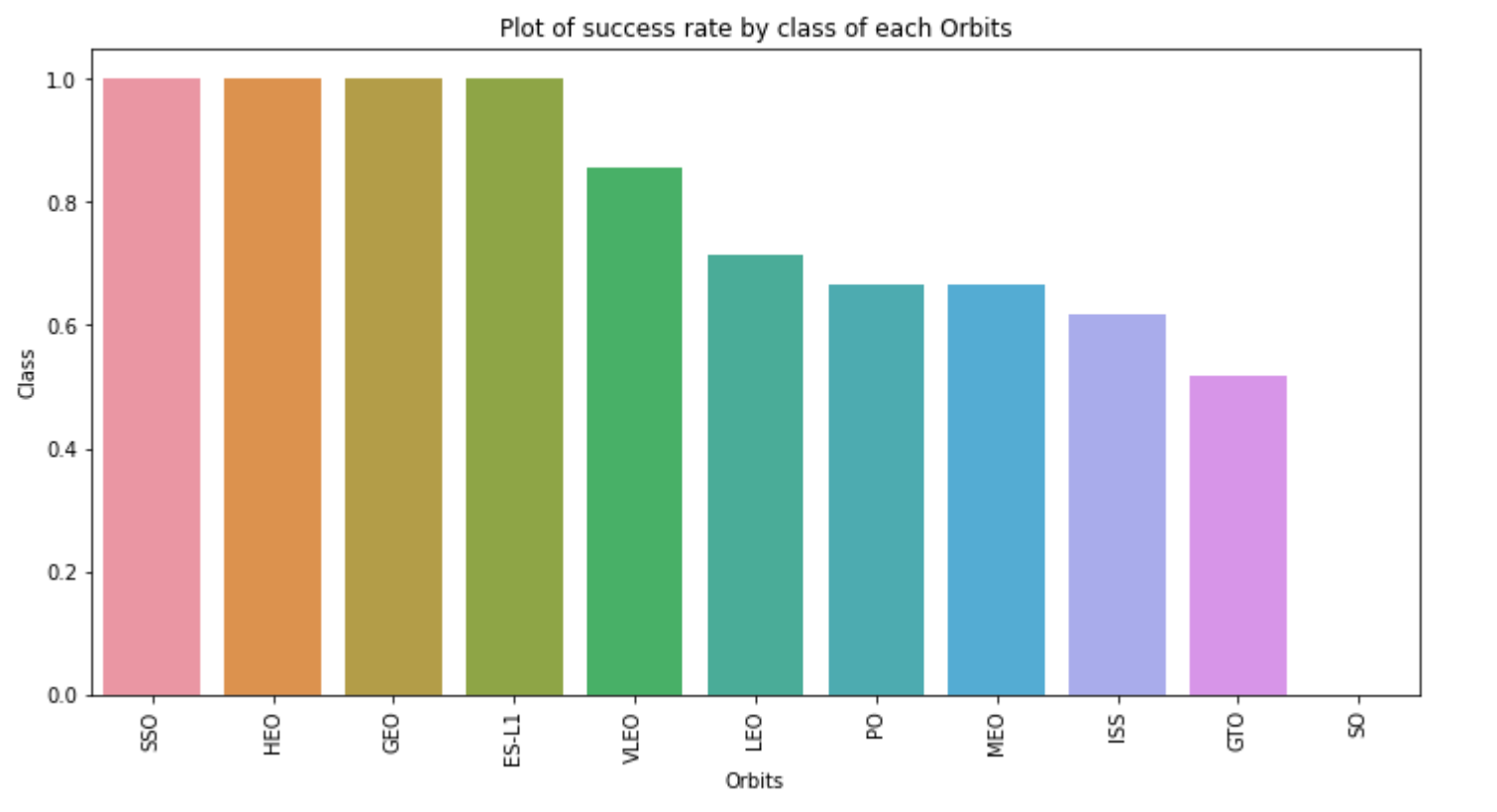
- Show a scatter plot of Payload vs. Launch Site
- Show the screenshot of the scatter plot with explanations



- CCAFS SLC 40: The greater the payload mass at the launch site, the higher the success rate for the Rocket.
- VAFB-SLC: No rockets launched for heavy payload mass (greater than 10,000 kg)

Success Rate vs. Orbit Type

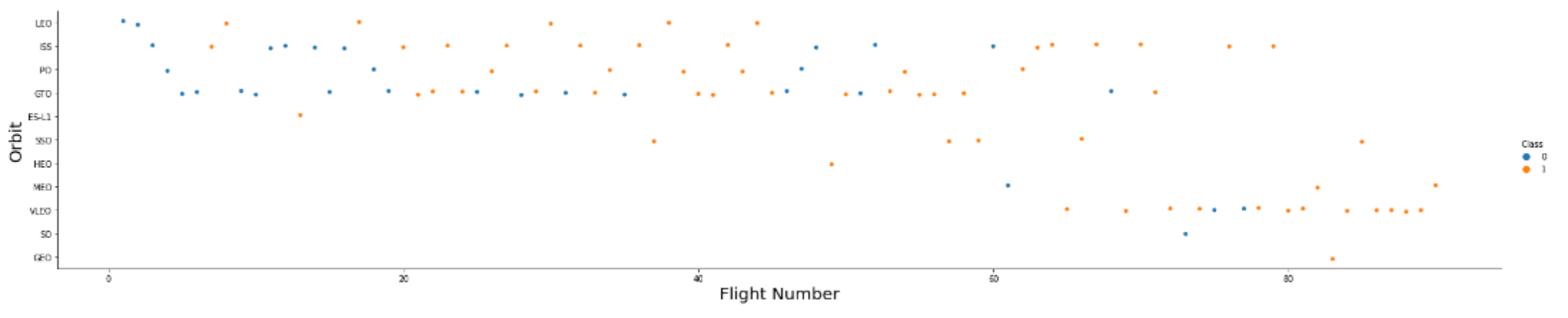
- Show a bar chart for the success rate of each orbit type
- Show the screenshot of the scatter plot with explanations



- **It shows that Orbit ES-L1, GEO, HEO and SSO have 100% success rate at the landing outcomes whereas Orbit SO recorded 0% of success rate at the landing outcome**

Flight Number vs. Orbit Type

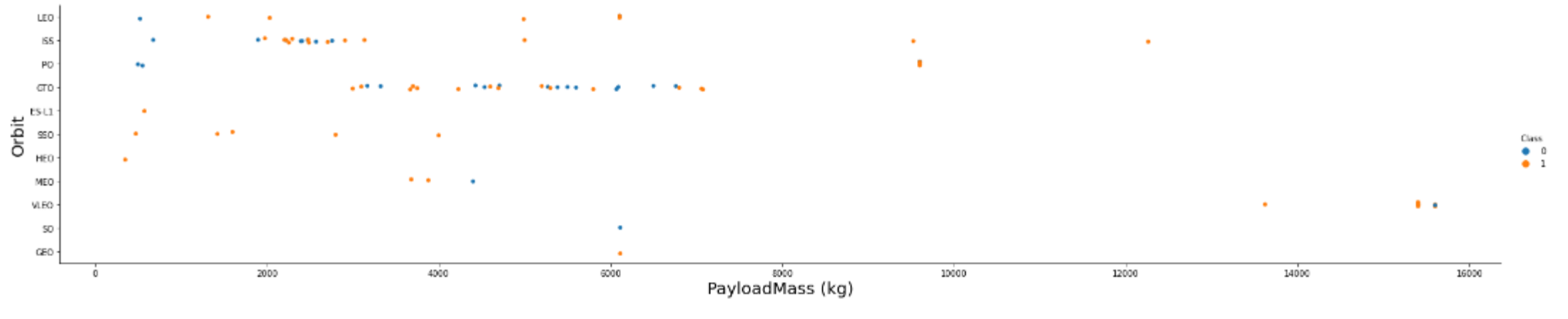
- Show a scatter point of Flight number vs. Orbit type
- Show the screenshot of the scatter plot with explanations



- **In LEO orbit, the Success appears related to the number of flights**
- **However, there exists no relationship between flight number when in GTO orbit**

Payload vs. Orbit Type

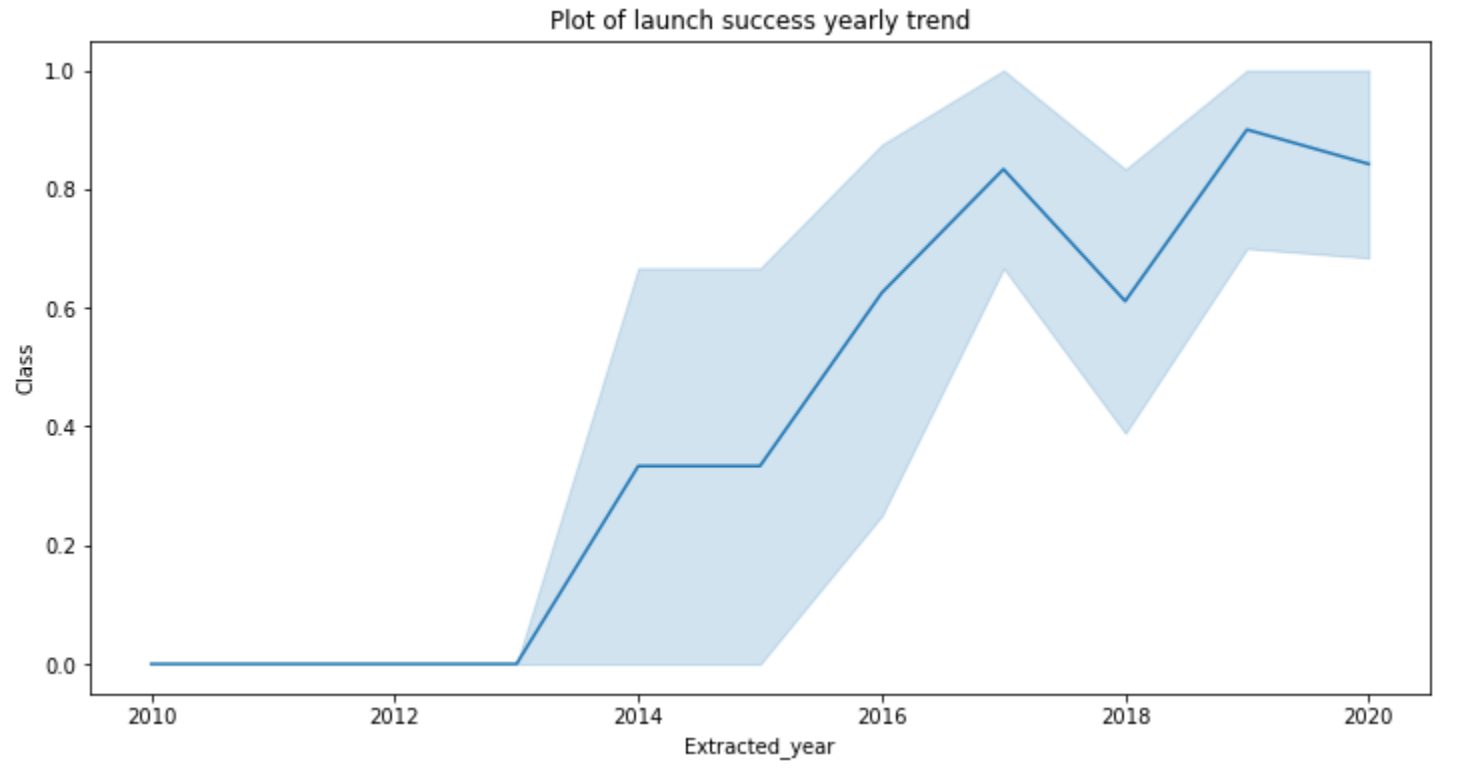
- Show a scatter point of payload vs. orbit type
- Show the screenshot of the scatter plot with explanations



- **Polar, LEO and ISS Orbit: Heavy payloads contributed to the successful landing**
- **GTO orbit: It seems like there exists no relationship between payloadmass and landing outcomes at the site**

Launch Success Yearly Trend

- Show a line chart of yearly average success rate
- Show the screenshot of the scatter plot with explanations



It is observed that the success rate is on an increasing trend, from 2013 to 2020

All Launch Site Names

- Find the names of the unique launch sites
- Present your query result with a short explanation here

```
%sql SELECT DISTINCT(LAUNCH_SITE) from SPACEXTBL order by LAUNCH_SITE ASC;
```

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

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

We used the key word DISTINCT to show only unique launch sites from the SpaceX data.

Launch Site Names Begin with 'CCA'

- Find 5 records where launch sites begin with `CCA`
- Present your query result with a short explanation here

- **We used the word like 'CCA%' to find the launch site begin with CCA**
- **We use the word limit (5) to only show 5 records from SpaceX data**

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

```
%sql select * from SPACEXTBL 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 _Outcome
04-06-2010	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
08-12-2010	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 (parachute)
22-05-2012	07:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)	Success	No attempt
08-10-2012	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
01-03-2013	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attempt

Total Payload Mass

- Calculate the total payload carried by boosters from NASA
- Present your query result with a short explanation here

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

```
%sql select sum (PAYLOAD_MASS__KG_) from SPACEXTBL where Customer ='NASA (CRS)';
```

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

sum (PAYLOAD_MASS__KG_)
45596

- **We use function of SUM to find the total in column PAYLOAD_MASS_KG_**
- **We use the WHERE clause to perform calculation for Customer NASA (CRS) from the SpaceX data**
- **The total payload carried by boosters from NASA is 45596kg as per query above**

Average Payload Mass by F9 v1.1

- Calculate the average payload mass carried by booster version F9 v1.1
- Present your query result with a short explanation here

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

```
%sql select avg(PAYLOAD_MASS__KG_) from SPACEXTBL where Booster_Version ='F9 v1.1';
```

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

avg(PAYLOAD_MASS__KG_)
2928.4

- **We use function of AVG to find the average in column PAYLOAD_MASS_KG_**
- **We use the WHERE clause to perform calculation for Booster Version F9 v1.1 from the SpaceX data**
- **The average payload mass carried by booster version F9 v1.1 is 2928.4 kg**

First Successful Ground Landing Date

- Find the dates of the first successful landing outcome on ground pad
- Present your query result with a short explanation here

```
%sql select min(Date) from SPACEXTBL where [Landing _Outcome] = 'Success (ground pad)';
```

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

min(Date)
01-05-2017

- **We use function of MIN to find the earliest date in column DATE**
- **We use the WHERE clause to find from column Landing Outcome = Success (ground pad)**
- **The first successful landing outcome on ground pad was on 01-05-2017**

Successful Drone Ship Landing with Payload between 4000 and 6000

- List the names of boosters which have successfully landed on drone ship and had payload mass greater than 4000 but less than 6000
- Present your query result with a short explanation here

```
%sql select Booster_Version from SPACEXTBL where [Landing _Outcome] = 'Success (drone ship)'
and PAYLOAD_MASS__KG_ > 4000 and PAYLOAD_MASS__KG_ <6000 order by Booster_Version ASC;
```

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

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

- **We used the WHERE clause to filter for boosters which have successfully landed on drone ship**
- **We used AND condition to find successful landing with payload mass greater than 4000 but less than 6000**

Total Number of Successful and Failure Mission Outcomes

- Calculate the total number of successful and failure mission outcomes
- Present your query result with a short explanation here

List the total number of successful and failure mission outcomes

```
%sql select count(Mission_Outcome) from SPACEXTBL where Mission_Outcome like '%Success%';
```

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

count(Mission_Outcome)
100

- **We used the COUNT function to count the number of failure and success in column Mission Outcomes**

```
%sql select count(Mission_Outcome) from SPACEXTBL where Mission_Outcome like'%Failure%';
```

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

count(Mission_Outcome)
1

- **We used wildcard like % to filter for WHERE Mission_Outcome was a success or failure**

Boosters Carried Maximum Payload

- List the names of the booster which have carried the maximum payload mass
- Present your query result with a short explanation here

```
%sql select Booster_Version from SPACEXTBL where PAYLOAD_MASS__KG_ = (select max (PAYLOAD_MASS__KG_) from SPACEXTBL) order by Booster_Version ASC;
```

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

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

- **We used WHERE clause and MAX function to find the booster have carried the maximum payload mass**

2015 Launch Records

- List the failed landing_outcomes in drone ship, their booster versions, and launch site names for in year 2015
- Present your query result with a short explanation here

List the failed landing_outcomes in drone ship, their booster versions, and launch site names for in year 2015

```
%sql select substr(Date, 4, 2) as Month , substr(Date, 7, 4) as Year, Date, Mission_Outcome, [Landing _Outcome], Booster_Version, Launch_Site from SPA
```

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

Month	Year	Date	Mission_Outcome	Landing _Outcome	Booster_Version	Launch_Site
01	2015	10-01-2015	Success	Failure (drone ship)	F9 v1.1 B1012	CCAFS LC-40
04	2015	14-04-2015	Success	Failure (drone ship)	F9 v1.1 B1015	CCAFS LC-40

- **We used WHERE clause to find the failed landing outcomes in drone ship in year 2015**

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

- 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
- Present your query result with a short explanation here

Rank the count of landing outcomes (such as Failure (drone ship

```
%%sql select [Landing _Outcome], COUNT (*)
FROM SPACEXTBL
WHERE DATE BETWEEN '04-06-2010' AND '20-03-2017'
group by [Landing _Outcome]
order by COUNT (*) DESC
```

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

Landing _Outcome	COUNT (*)
Success	20
No attempt	10
Success (drone ship)	8
Success (ground pad)	6
Failure (drone ship)	4
Failure	3
Controlled (ocean)	3
Failure (parachute)	2
No attempt	1

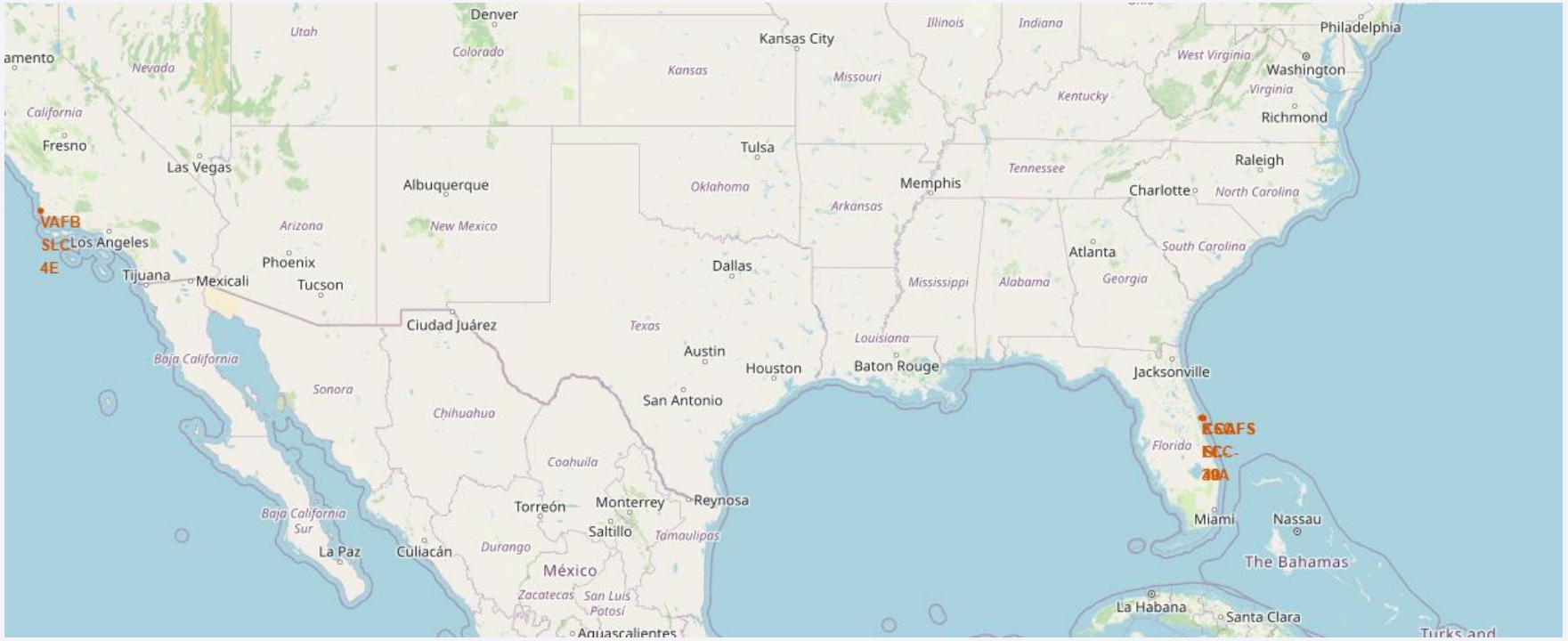
- **We used COUNT function to count the frequency for each landing outcomes**
- **We used WHERE clause to find the data between the mentioned data**
- **We used ORDER BY DESC function to sort the number of outcomes in descending order**

Section 3

Launch Sites Proximities Analysis

All launch sites global map markers

- Explore the generated folium map and make a proper screenshot to include all launch sites' location markers on a global map
- Explain the important elements and findings on the screenshot



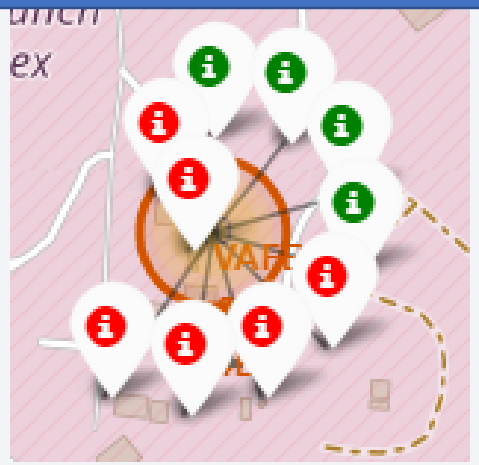
- **All SpaceX launch sites are in United States of America coasts, Florida and California**

Status of each launch sites by markers

- Explore the folium map and make a proper screenshot to show the color-labeled launch outcomes on the map
- Explain the important elements and findings on the screenshot

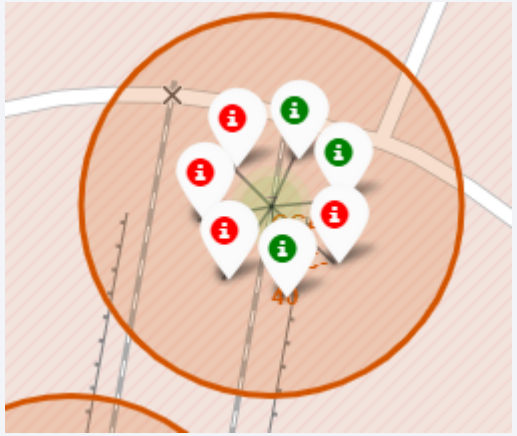
Green marker – Successful launches **Red marker** – Failed launched

FLORIDA LAUNCH SITES

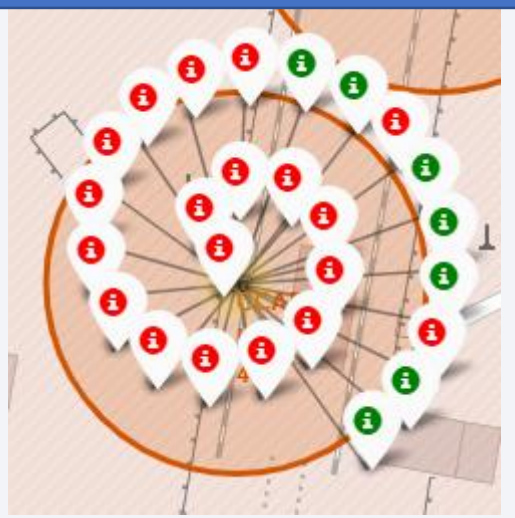


CCAFS LC 40

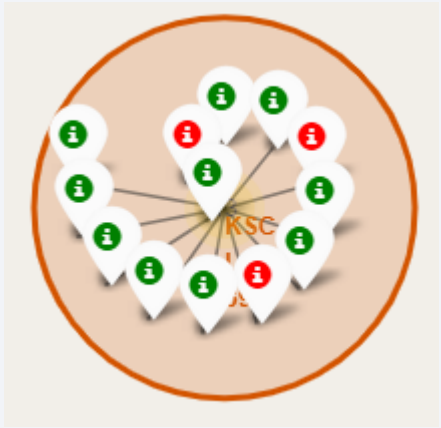
CALIFORNIA LAUNCH SITES



CCAFS SLC 40



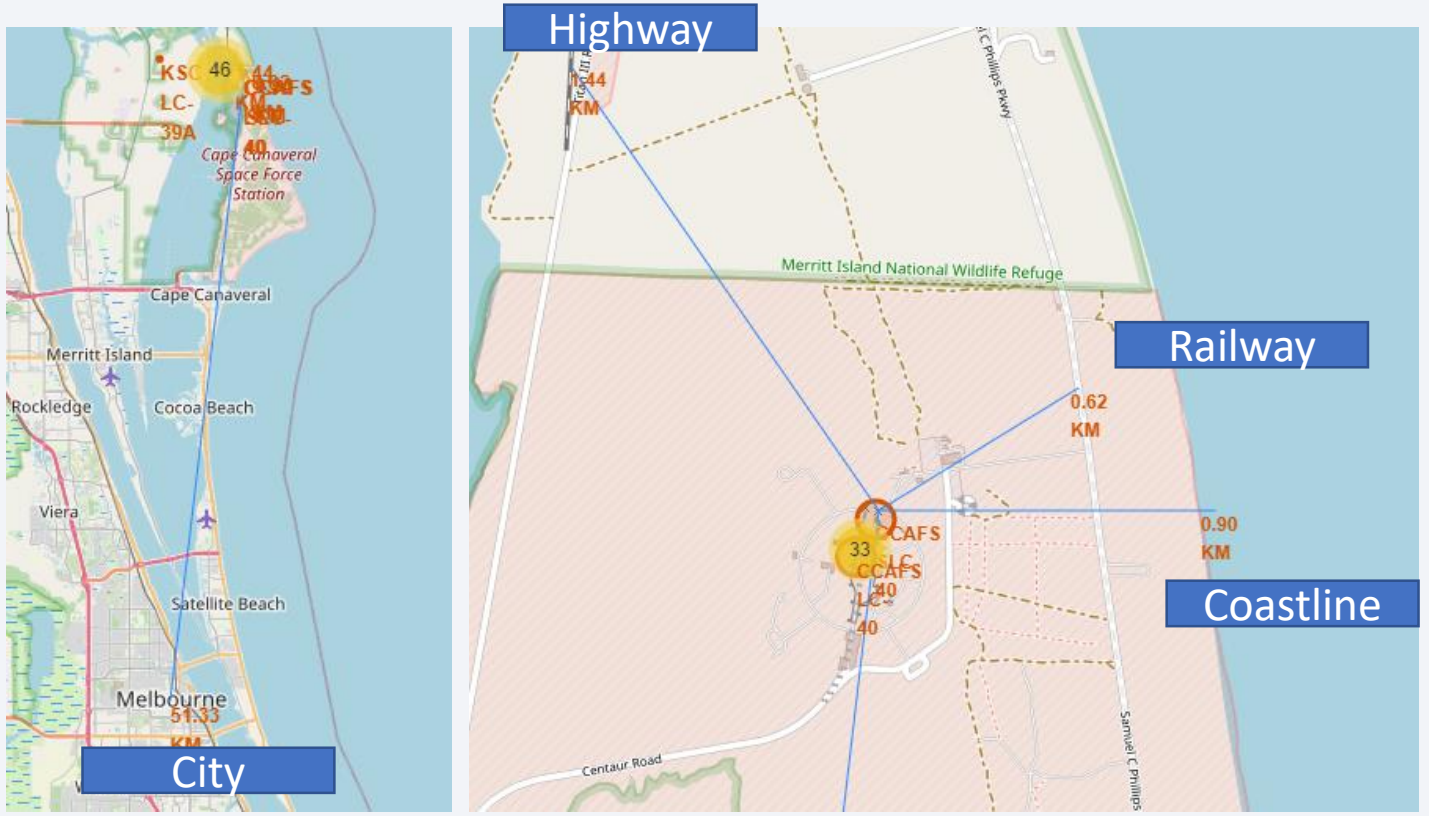
KSC LC 39



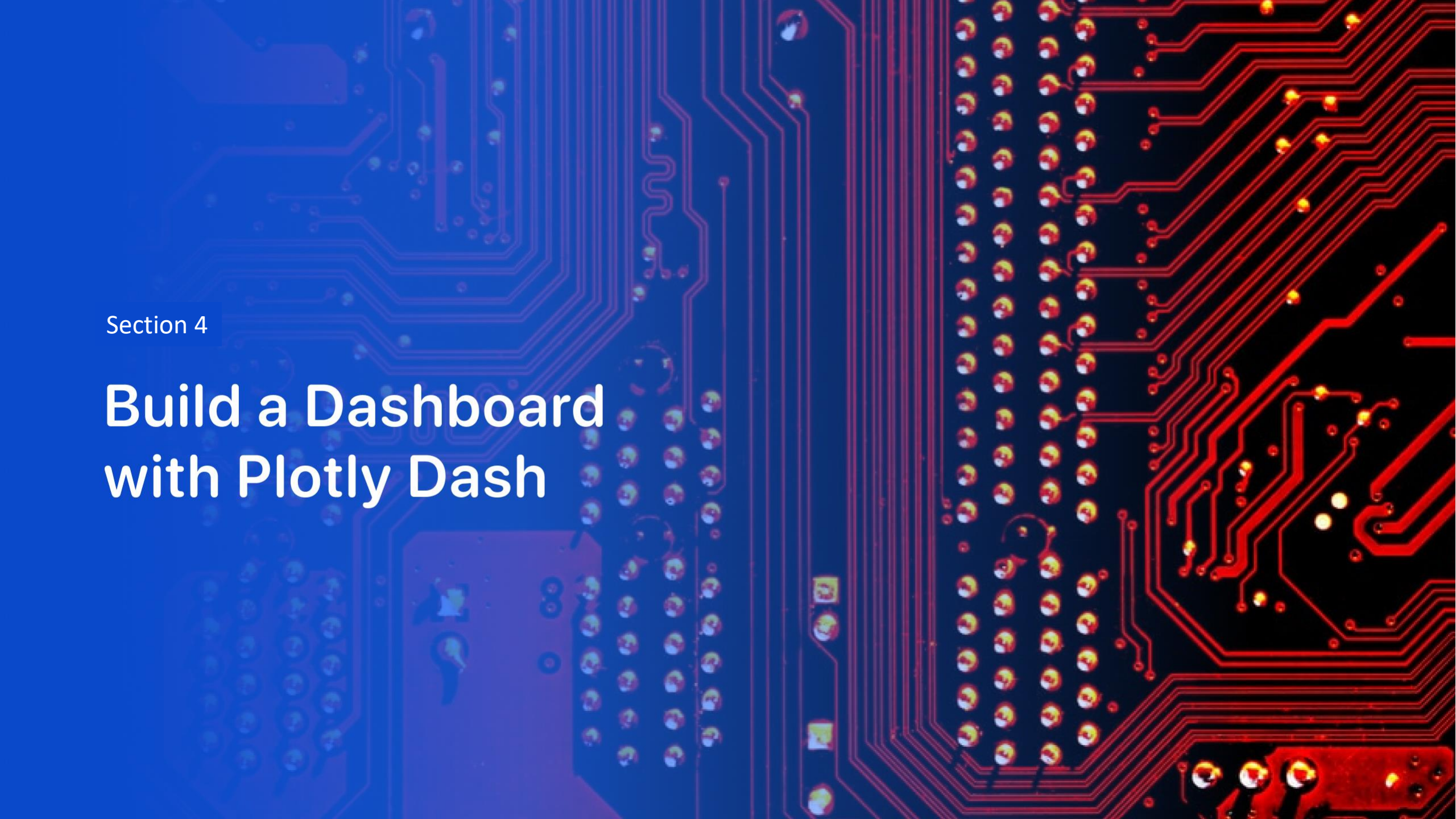
VAFB SLC 4E

Launch Site distance to its proximities

- Explore the generated folium map and show the screenshot of a selected launch site to its proximities such as railway, highway, coastline, with distance calculated and displayed
- Explain the important elements and findings on the screenshot

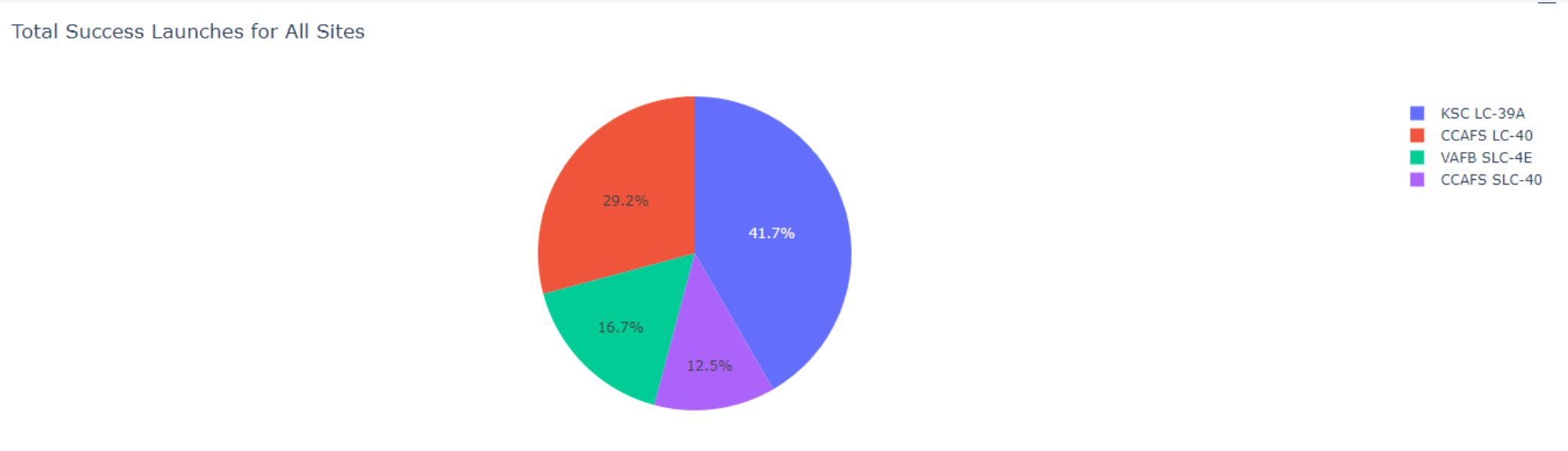


Questions	Answer
Are launch sites in close proximity to railways?	Yes
Are launch site in close proximity to highways?	No
Are launch sites in close proximity to coastline	Yes
Do launch sites keep certain distance away from cities?	Yes


Section 4
Build a Dashboard with Plotly Dash

Launch success count for all sites

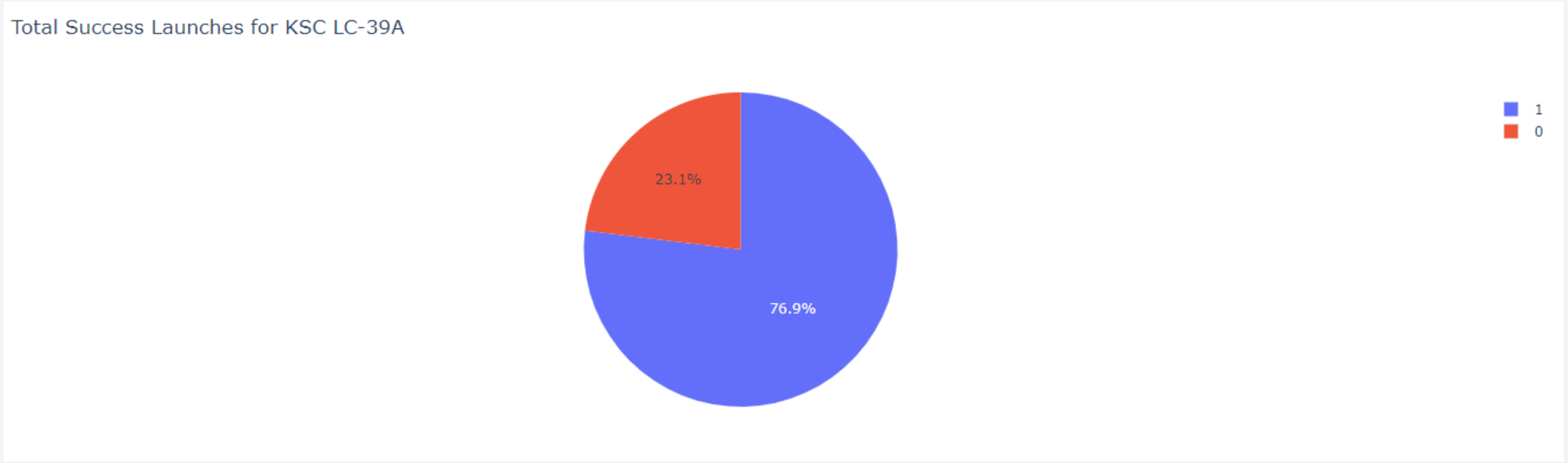
- Show the screenshot of launch success count for all sites, in a piechart
- Explain the important elements and findings on the screenshot



- **KSC LC-39A was the site with highest success rate (41.7%)**
- **The remaining 3 launch sites success rate were below 30%**

Launch site with highest success rate: KSC LC-39A

- Show the screenshot of the piechart for the launch site with highest launch success ratio
- Explain the important elements and findings on the screenshot

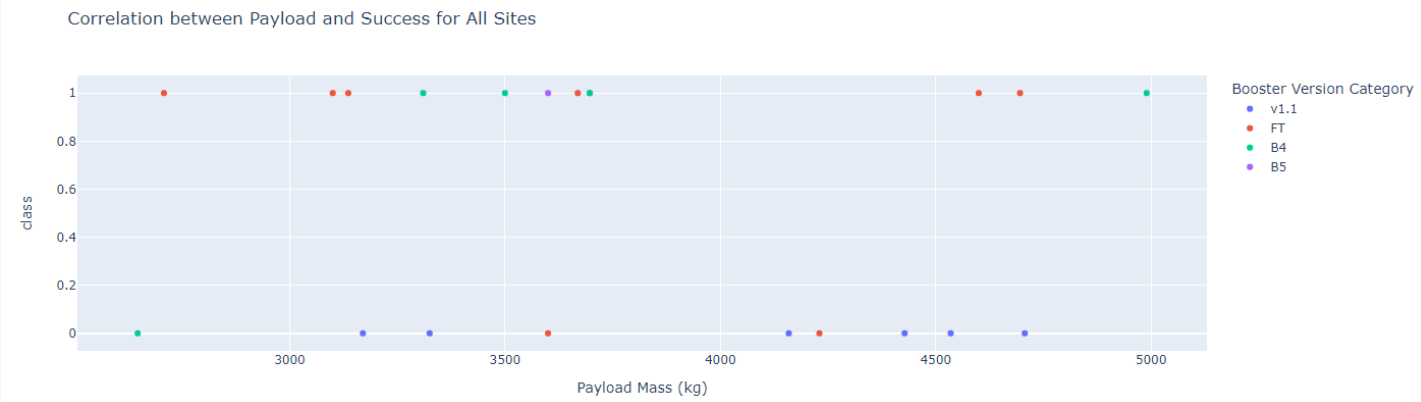


- **KSC LC-39A has a record of 76.9% of success rate whereas failure rate at 23.1%**

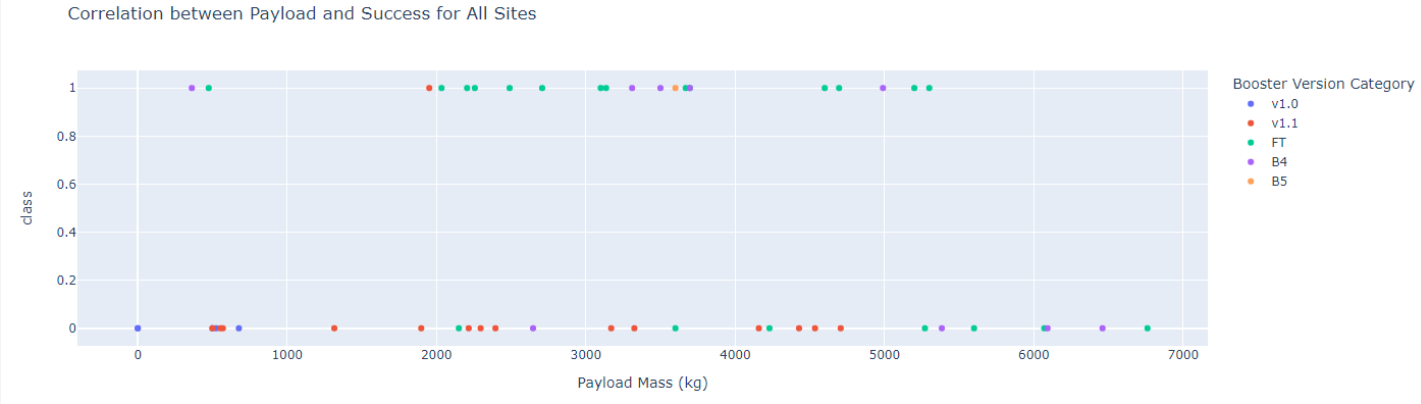
Payload Mass (kg) vs Success rate for all sites

- Show screenshots of Payload vs. Launch Outcome scatter plot for all sites, with different payload selected in the range slider
- Explain the important elements and findings on the screenshot, such as which payload range or booster version have the largest success rate, etc.

2500 – 7500 kg



0 – 7500 kg



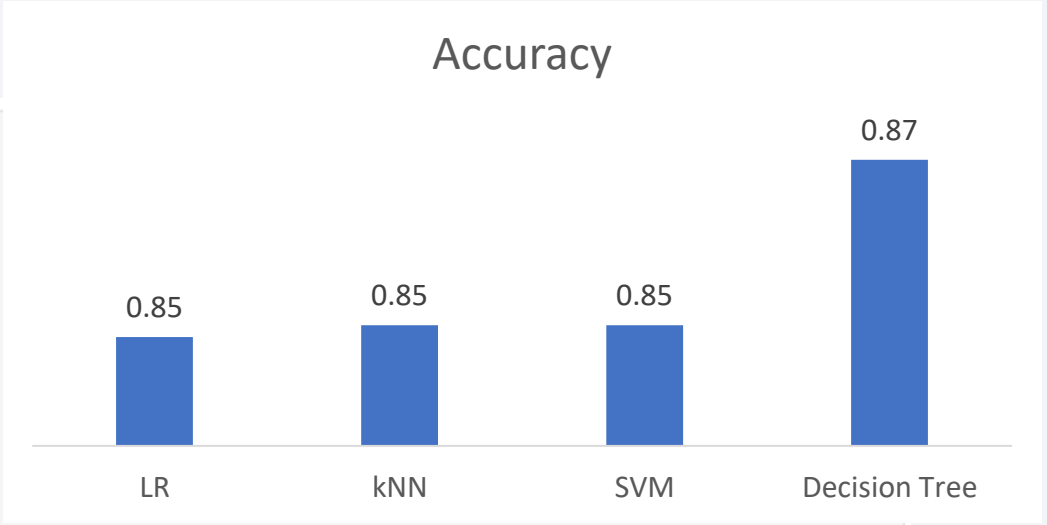
It is observed that low weighted payload mass have largest success rate as compared to high weighted payload mass.

Section 5

Predictive Analysis (Classification)

Classification Accuracy

- Visualize the built model accuracy for all built classification models, in a bar chart
- Find which model has the highest classification accuracy



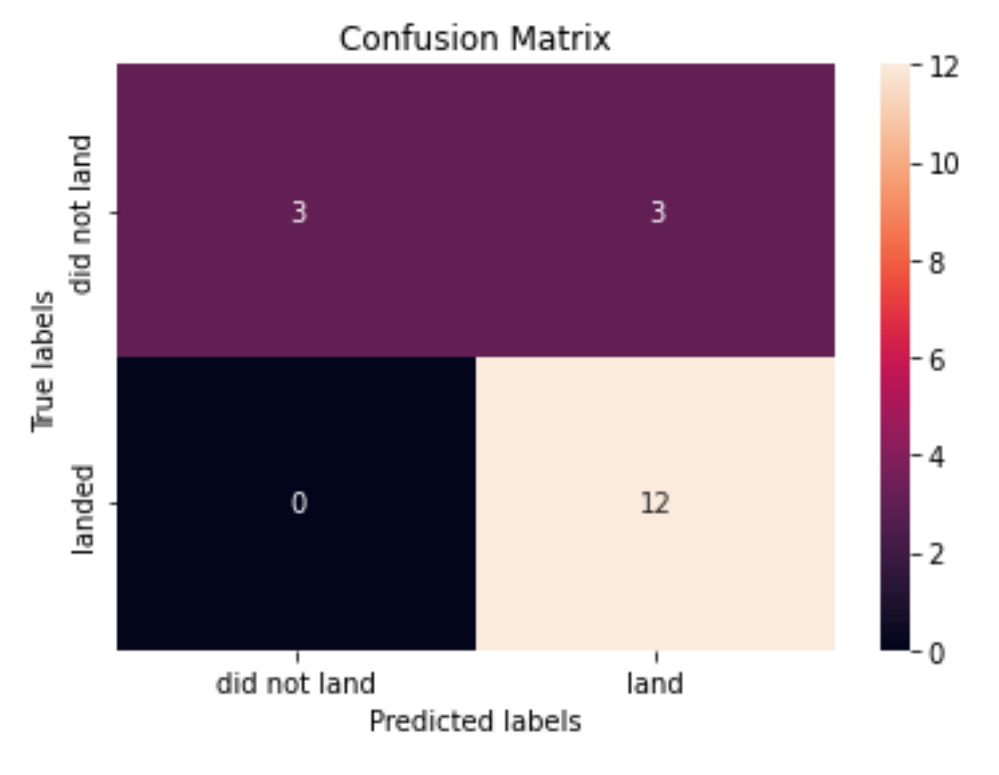

```
models = {'KNeighbors':knn_cv.best_score_,
              'DecisionTree':tree_cv.best_score_,
              'LogisticRegression':logreg_cv.best_score_,
              'SupportVector': svm_cv.best_score_}

bestalgorithm = max(models, key=models.get)
print('Best model is', bestalgorithm,'with a score of', models[bestalgorithm])
if bestalgorithm == 'DecisionTree':
    print('Best params is :', tree_cv.best_params_)
if bestalgorithm == 'KNeighbors':
    print('Best params is :', knn_cv.best_params_)
if bestalgorithm == 'LogisticRegression':
    print('Best params is :', logreg_cv.best_params_)
if bestalgorithm == 'SupportVector':
    print('Best params is :', svm_cv.best_params_)
```

```
Best model is DecisionTree with a score of 0.8732142857142856
Best params is : {'criterion': 'gini', 'max_depth': 6, 'max_features': 'auto', 'min_samples_leaf': 2, 'min_samples_split': 5, 'splitter': 'random'}
```

- **Best model: Decision tree with the highest classification accuracy**

Confusion Matrix

- Show the confusion matrix of the best performing model with an explanation



- **The confusion matrix for the decision tree classifier shows that the classifier can distinguish between the different classes.**
- **Problem:**
  - **False positive i.e. unsuccessful landing marked as successful landing by the classifier.**
  - **False negative i.e. successful landing marked as unsuccessful landing by classifier**

Conclusions

- The larger amount of the flight number at the launch site, the greater the success rate at a launch site will be.
- Orbit ES-L1, GEO, HEO and SSO have 100% success rate at the landing outcomes.
- Success rate is on an increasing trend from 2013 till 2020.
- Low weighted payload mass have largest success rate as compared to high weighted payload mass.
- KSC LC-39A had the most successful launches of any sites.
- The Decision tree classifier is the best machine learning algorithm for this project.

Appendix

- Include any relevant assets like Python code snippets, SQL queries, charts, Notebook outputs, or data sets that you may have created during this project

Thank you!