IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

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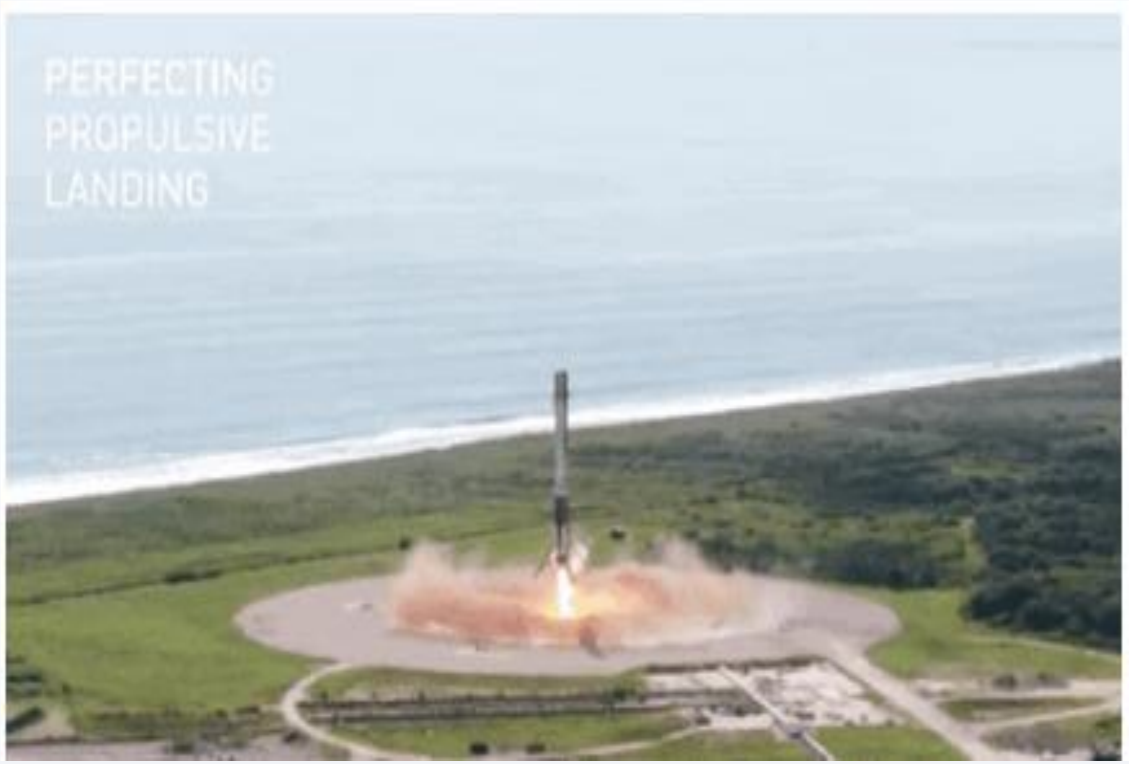
Executive Summary

- Summary of methodologies
  - SpaceX Data Collection using SpaceX API
  - SpaceX Data Collection with Web Scraping
  - SpaceX Data Wrangling
  - SpaceX Exploratory Data Analysis using SQL
  - Space-X EDA DataViz Using Python Pandas and Matplotlib
  - Space-X Launch Sites Analysis with Folium-Interactive Visual Analytics and Ploty Dash
  - SpaceX Machine Learning Landing Prediction
- Summary of all results
  - EDA results
  - Interactive Visual Analytics and Dashboards
  - Predictive Analysis(Classification)

Introduction



- Project background and context

  SpaceX advertises Falcon 9 launches at $62 million, while competitors charge over $165 million, largely due to SpaceX's first-stage reuse. Predicting first-stage landings allows cost estimation, crucial for competitors vying for launch contracts against SpaceX.

- Problems you want to find answers

  In this capstone, our aim is to forecast the successful landing of the Falcon 9 first stage, leveraging data from Falcon 9 rocket launches as advertised on SpaceX's website.

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - The data was collected by using Python to api into the different websites, or by using beautiful soup to parse out the data and return it.
- Perform data wrangling
  - After the data was collected it was cleaned by handling missing values correcting errors, and dealing with data inconsistencies.
- 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

Data Collection

- Description of how SpaceX Falcon9 data was collected.
  - Initially, data retrieval commenced through SpaceX's RESTful API, employing a series of auxiliary functions tailored to extract launch information via identification numbers. This involved issuing a GET request to the SpaceX API URL.
  - • Subsequently, the SpaceX launch data was acquired and formatted for consistency. JSON results from the GET request were parsed and decoded, then converted into a Pandas data frame.
  - • Additionally, web scraping was conducted to compile historical Falcon 9 launch records from a Wikipedia page titled "List of Falcon 9 and Falcon Heavy launches." The launch records, housed within an HTML table, were extracted using BeautifulSoup and the requests library. The table data was parsed and converted into a Pandas data frame for further analysis.

Data Collection – SpaceX API

- Data was gathered via the SpaceX API, utilizing a GET request to access the required information. The SpaceX launch data was then requested, parsed, and decoded from the response content into a JSON format. Subsequently, this JSON result was converted into a Pandas data frame for analysis.

- Here is the GitHub URL of the completed SpaceX API calls notebook https://github.com/Ganimal92/Data-Science-Capstone/blob/main/1.jupyter-labs-spacex-data-collection-api.ipynb

Task 1: Request and parse the SpaceX launch data using the GET request

To make the requested JSON results more consistent, we will use the following static response object for this project:

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

We should see that the request was successfull with the 200 status response code

```
response.status_code
```

```
200
```

Now we decode the response content as a Json using `.json()` and turn it into a Pandas dataframe using `.json_normalize()`

```
# Use json_normalize meethod to convert the json result into a dataframe
respjson = response.json()
data = pd.json_normalize(respjson)
```

Data Collection - WebScraping

- Conducted web scraping to retrieve historical Falcon 9 launch data from a Wikipedia page using BeautifulSoup and requests. Extracted Falcon 9 launch records from the HTML table on the Wikipedia page, and subsequently created a data frame by parsing the launch HTML.

- The GitHub URL of the completed web scraping notebook.

- https://github.com/Ganimal92/Data-Science-Capstone/blob/main/2.jupyter-labs-webscraping.ipynb

In [4]:
```
static_url = "https://en.wikipedia.org/w/index.php?title=List_of_Falcon_9_and_Falcon_Heavy_launches&oldid=1027686922"
```

Next, request the HTML page from the above URL and get a `response` object

TASK 1: Request the Falcon9 Launch Wiki page from its URL

First, let's perform an HTTP GET method to request the Falcon9 Launch HTML page, as an HTTP response.

In [5]:
```
# use requests.get() method with the provided static_url
# assign the response to a object
response = requests.get(static_url)
```

Create a `BeautifulSoup` object from the HTML `response`

In [6]:
```
# Use BeautifulSoup() to create a BeautifulSoup object from a response text content
soup = BeautifulSoup(response.content, 'html.parser')
```

Print the page title to verify if the `BeautifulSoup` object was created properly

In [7]:
```
# Use soup.title attribute
soup.title
```

Out[7]: `List of Falcon 9 and Falcon Heavy launches - Wikipedia`

TASK 2: Extract all column/variable names from the HTML table header

Next, we want to collect all relevant column names from the HTML table header

Let's try to find all tables on the wiki page first. If you need to refresh your memory about `BeautifulSoup`, please check the external re
this lab

In [10]:
```
# Use the find_all function in the BeautifulSoup object, with element type `table`
# Assign the result to a list called `html_tables`
```

Data Wrangling

- Once the data was obtained and a Pandas DataFrame was generated, filtering was applied based on the BoosterVersion column to retain only Falcon 9 launches. Subsequently, missing values in the LandingPad and PayloadMass columns were addressed. For PayloadMass, missing values were imputed using the mean value of the column.
- Additionally, Exploratory Data Analysis (EDA) was conducted to identify patterns within the data and determine the suitable label for training supervised models.
-
- The GitHub URL of the completed data wrangling related notebooks. https://github.com/Ganimal92/Data-Science-Capstone/blob/main/3.labs-jupyter-spacex-Data%20wrangling.ipynb

TASK 4: Create a landing outcome label from Outcome column

Using the `Outcome`, create a list where the element is zero if the corresponding row in `Outcome` is
variable `landing_class`:

```
# landing_class = 0 if bad_outcome
# landing_class = 1 otherwise
df['Class'] = df['Outcome'].apply(lambda x: 0 if x in bad_outcomes else 1)
df['Class'].value_counts()
```

```
1    60
0    30
Name: Class, dtype: int64
```

This variable will represent the classification variable that represents the outcome of each launch. If tl
first stage landed Successfully

```
landing_class=df['Class']
df[['Class']].head(8)
```

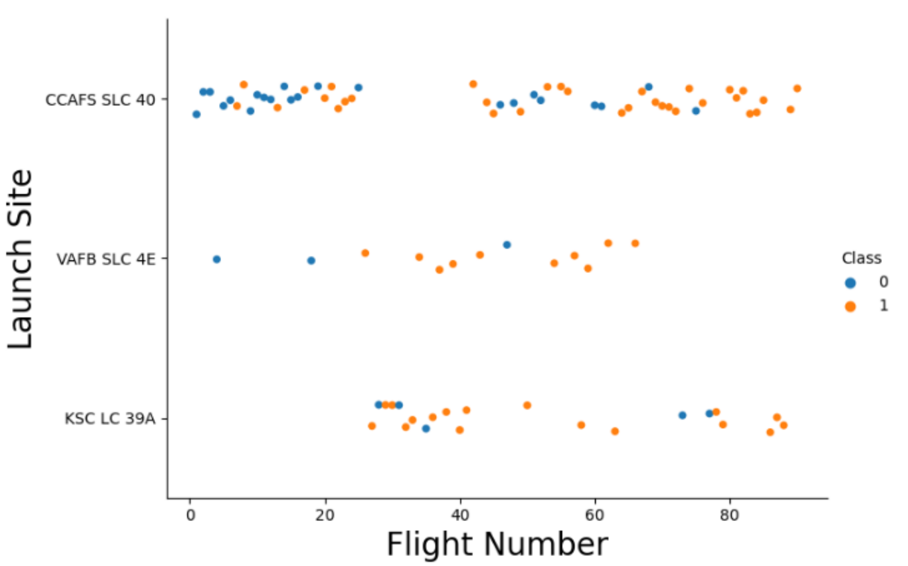
	Class
0	0
1	0
2	0
3	0
4	0
5	0
6	1
7	1

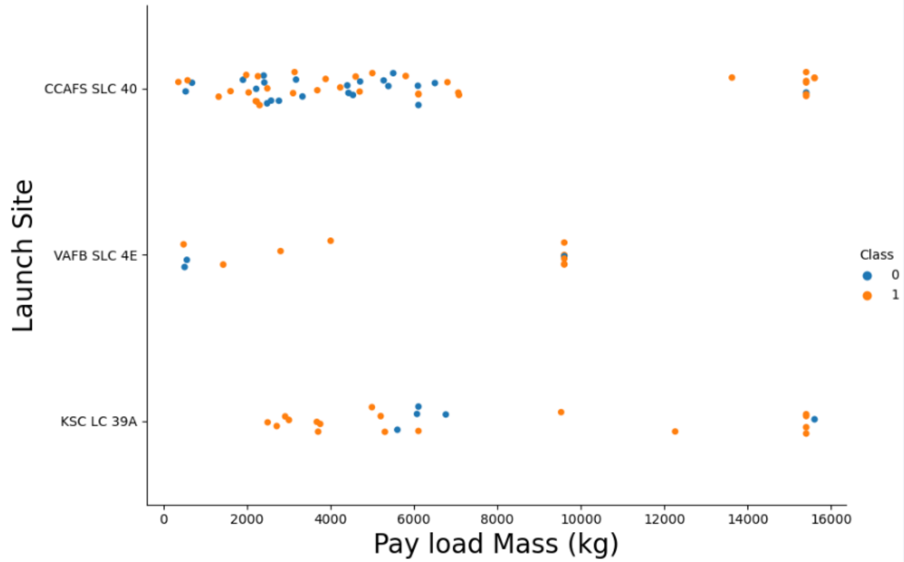
EDA with Data Visualization

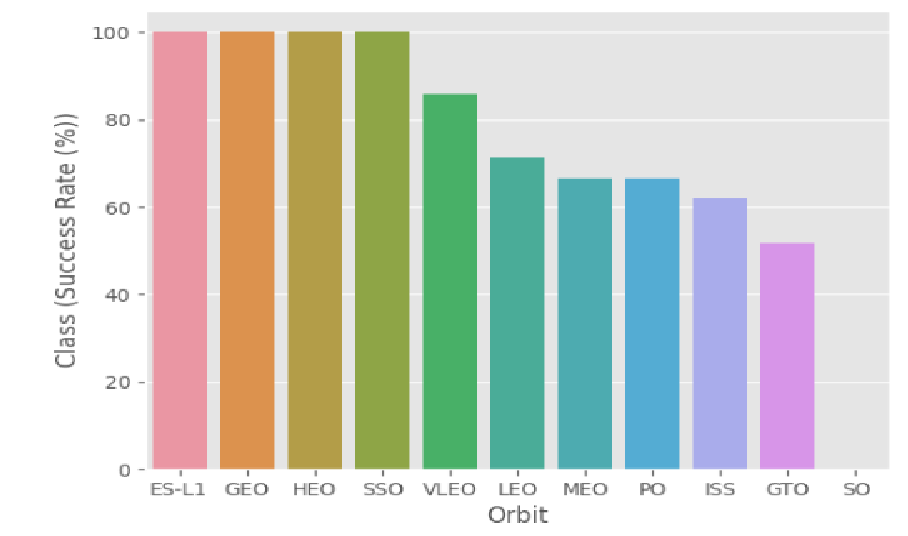
- Conducted data analysis and feature engineering using Pandas and Matplotlib,
  - Exploratory Data Analysis.
  - Preparing data through feature engineering.
  - Utilized scatter plots to visualize relationships between Flight Number and Launch Site, Payload and Launch Site, Flight Number and Orbit type, Payload and Orbit type.
  - Employed bar charts to visualize the relationship between success rates of each orbit type.
  - Used line plots to visualize the yearly trend in launch success.

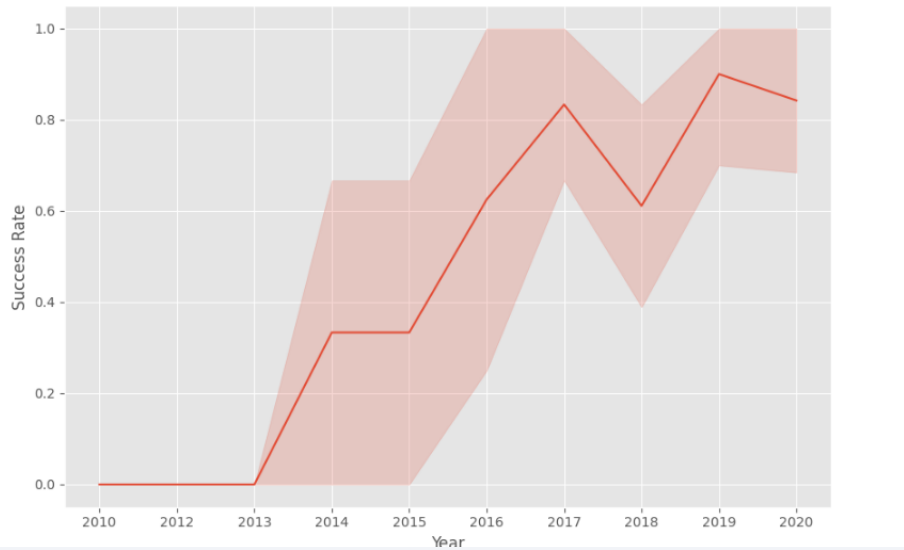
- The GitHub URL of your completed EDA with data visualization notebook https://github.com/Ganimal92/Data-Science-Capstone/blob/main/5.jupyter-labs-eda-dataviz.ipynb.jupyterlite.ipynb

EDA with Data Visualization (Plots Cont….)









EDA with SQL

- The following SQL queries were performed for EDA
  - Show the names of the distinct launch sites involved in the space

```
%sql SELECT DISTINCT LAUNCH_SITE as "Launch_Sites" FROM SPACEXTBL;
```

  - Show 5 records where launch sites start with the string 'CCA'.

```
%sql SELECT * FROM 'SPACEXTBL' WHERE Launch_Site LIKE 'CCA%' LIMIT 5;
```

  - Show the total payload mass transported by boosters launched under NASA's Commercial Resupply Services (CRS) program.

```
%sql SELECT SUM(PAYLOAD_MASS__KG_) as "Total Payload Mass(Kgs)", Customer FROM 'SPACEXTBL' WHERE Customer = 'NASA (CRS)';
```

  - Show the average payload mass transported by boosters of

```
%sql SELECT AVG(PAYLOAD_MASS__KG_) as "Payload Mass Kgs", Customer, Booster_Version FROM 'SPACEXTBL' WHERE Booster_Version LIKE 'F9 v1.1%';
```

EDA with SQL (Cont.…)

- List the date when the first successful landing outcome in ground pad was achieved

```
%sql SELECT MIN(DATE) FROM 'SPACEXTBL' WHERE "Landing _Outcome" = "Success (ground pad)";
```

- List the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 6000 *(%sql SELECT DISTINCT Booster_Version, Payload FROM SPACEXTBL WHERE "Landing _Outcome" = "Success (drone ship)" AND PAYLOAD_MASS__KG_ > 4000 AND PAYLOAD_MASS__KG_ < 6000;)*

- List the total number of successful and failure mission outcomes

```
%sql SELECT "Mission_Outcome", COUNT("Mission_Outcome") as Total FROM SPACEXTBL GROUP BY "Mission_Outcome";
```

- The GitHub URL of your completed EDA with SQL notebook https://github.com/Ganimal92/Data-Science-Capstone/blob/main/4.jupyter-labs-eda-sql-coursera_sqllite.ipynb

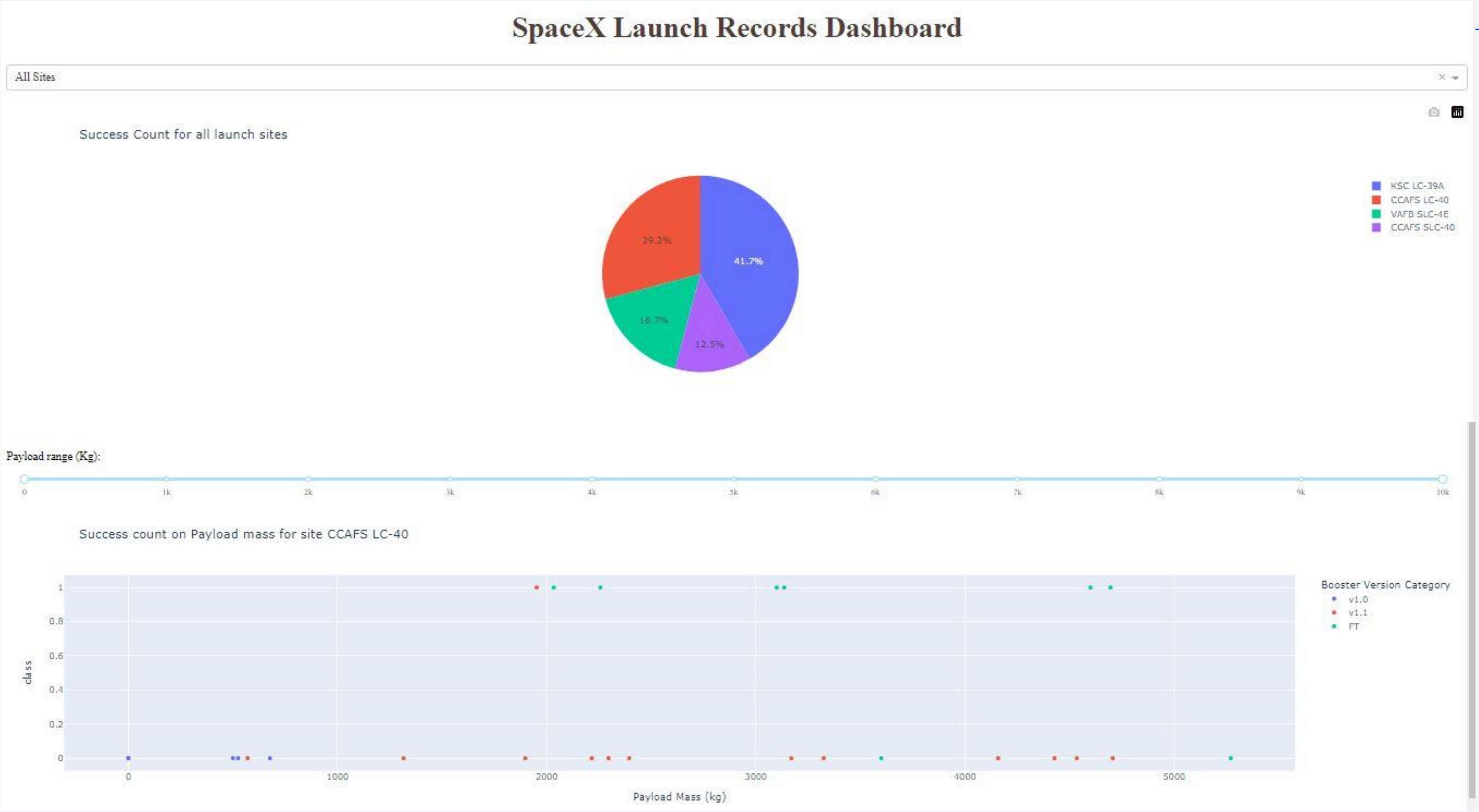
Build an Interactive Map with Folium

- Developed a Folium map to pinpoint all launch sites and generated map objects like markers, circles, and lines to denote the success or failure of launches at each site.
- Established launch outcomes as a binary set (failure=0 or success=1).
- The completed interactive map with Folium map, as an external reference and peer-review purpose https://github.com/Ganimal92/Data-Science-Capstone/blob/main/6.lab_jupyter_launch_site_location.jupyterlite.ipynb

Build a Dashboard with Plotly Dash

-
- • Constructed an interactive dashboard application using Plotly Dash by:
- - Incorporating a Launch Site Drop-down Input Component.
- - Implementing a callback function to display a success-pie-chart based on the selected site dropdown.
- - Integrating a Range Slider to facilitate Payload selection.
- - Implementing a callback function to render the success-payload-scatter-chart scatter plot.

SpaceX Dash App



Predictive Analysis (Classification)

- Overview of the process for building, evaluating, improving, and identifying the best-performing classification model:

- Upon loading the data into a Pandas DataFrame, the initial step involved conducting exploratory data analysis (EDA) to understand the dataset. The goal was to determine training labels.
- The column "Class" from the data was converted into a NumPy array using the to_numpy() method. This array, denoted as Y, served as the outcome variable.
- The feature dataset (X) was standardized by applying the preprocessing.StandardScaler() function from Sklearn.
- Subsequently, the data was split into training and testing sets using the train_test_split function from sklearn.model_selection. The test_size parameter was set to 0.2, and random_state was set to 2 to ensure reproducibility.

Predictive Analysis (Classification)

- In order to find the best ML model/ method that would performs best using the test data between SVM, Classification Trees, k nearest neighbors and Logistic Regression;
  - First created an object for each of the algorithms then created a GridSearchCV object and assigned them a set of parameters for each model.
  - For each of the models under evaluation, the GridsearchCV object was created with cv=10, then fit the training data into the GridSearch object for each to Find best Hyperparameter.
  - After fitting the training set, we output GridSearchCV object for each of the models, then displayed the best parameters using the data attribute best_params_ and the accuracy on the validation data using the data attribute best_score_.
  - Finally using the method score to calculate the accuracy on the test data for each model and plotted a confussion matrix for each using the test and predicted outcomes.

Predictive Analysis (Classification)

- Below is the table presenting the test data accuracy scores for each method, enabling comparison to identify the best performer among SVM, Classification Trees, K Nearest Neighbors, and Logistic Regression:

Out[68]:

	0
Method	Test Data Accuracy
Logistic_Reg	0.833333
SVM	0.833333
Decision Tree	0.833333
KNN	0.833333

- GitHub URL of the completed predictive analysis lab https://github.com/Ganimal92/Data-Science-Capstone/blob/main/8.SpaceX_Machine_Learning_Prediction_Part_5.jupyterlite.ipynb

Results

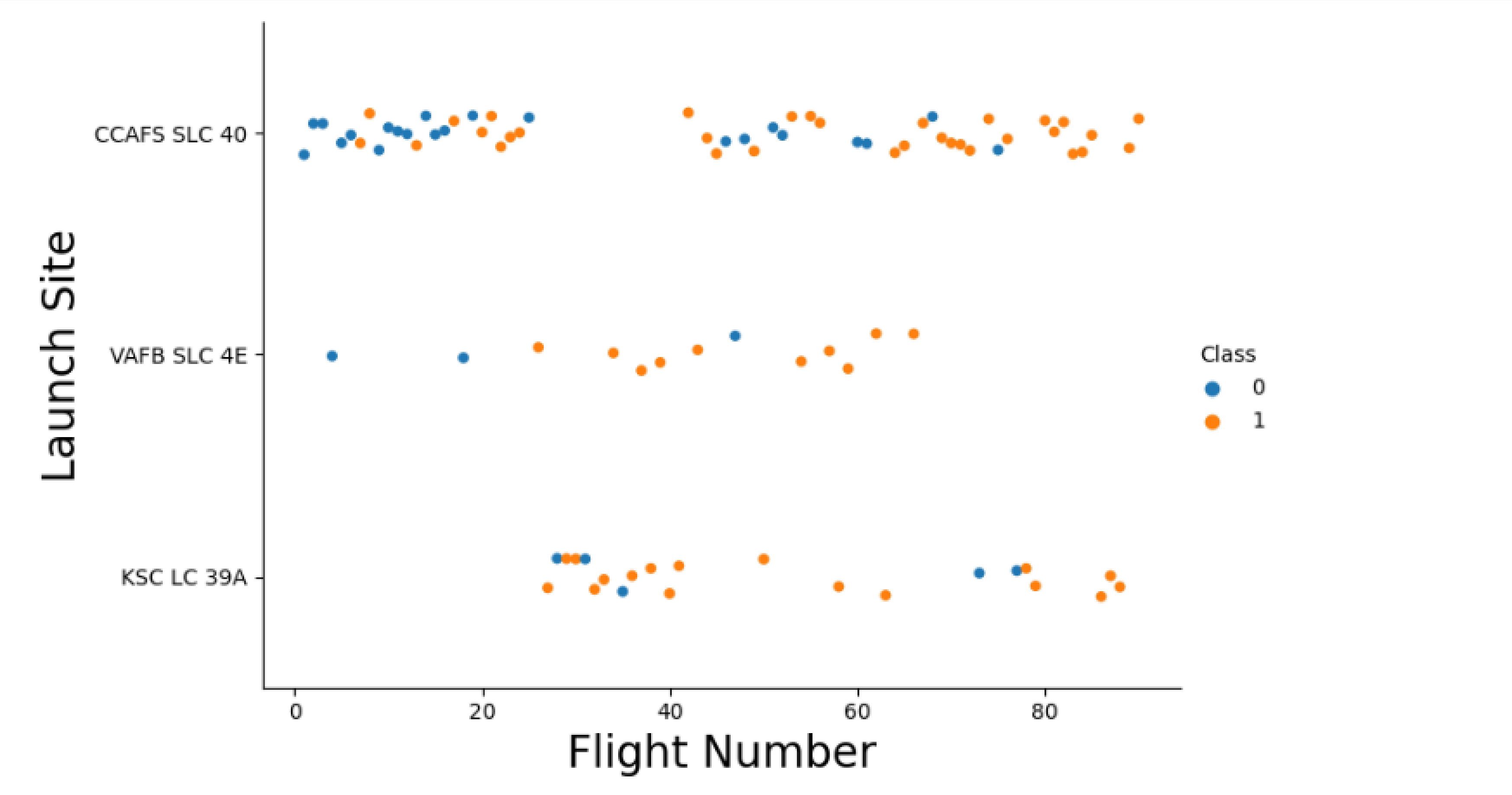
- Exploratory data analysis results
- Interactive analytics demo in screenshots
- Predictive analysis results

Section 2

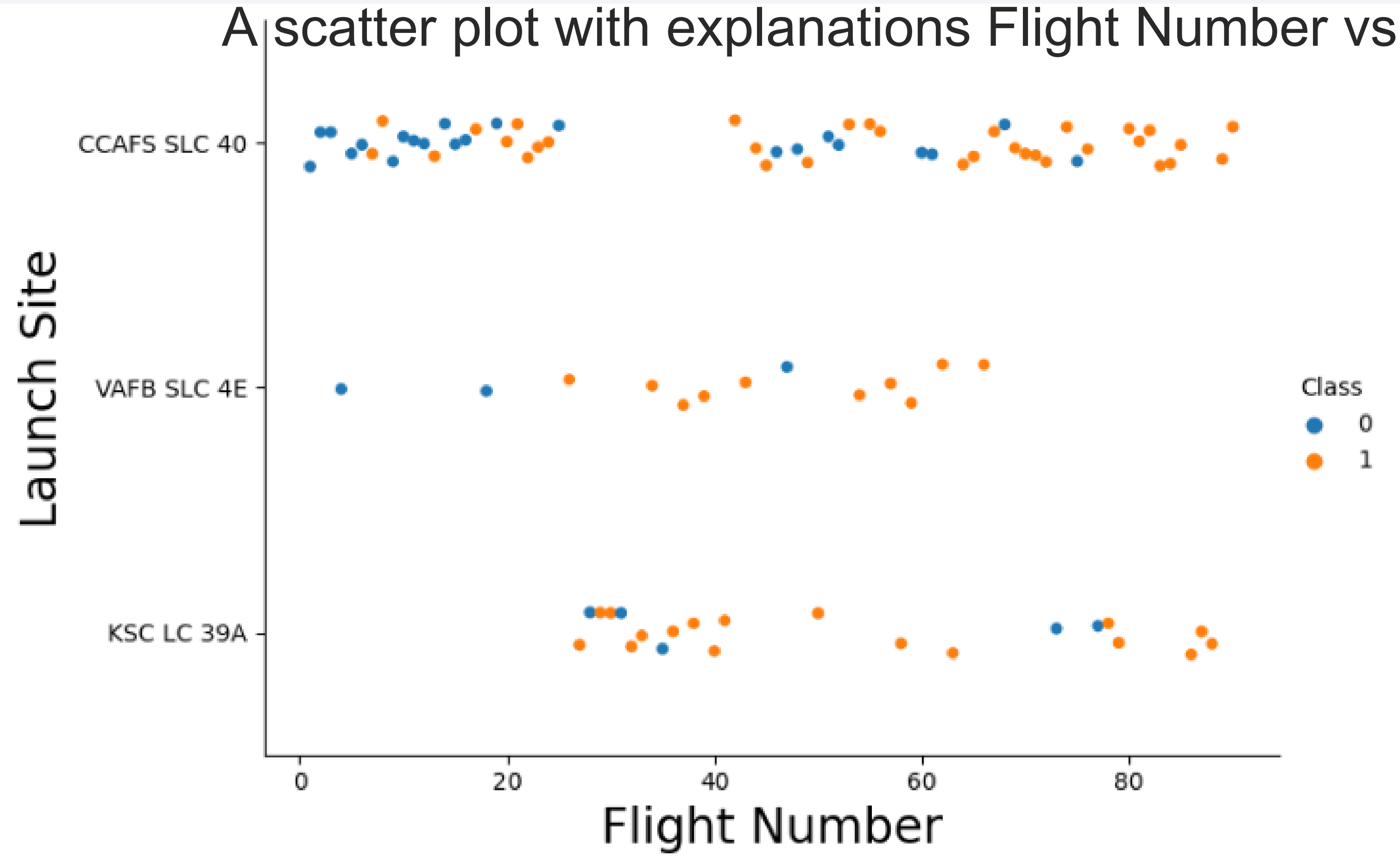
Insights drawn from EDA

Flight Number vs. Launch Site

A scatter plot of Flight Number vs. Launch Site



Flight Number vs. Launch Site with explanations

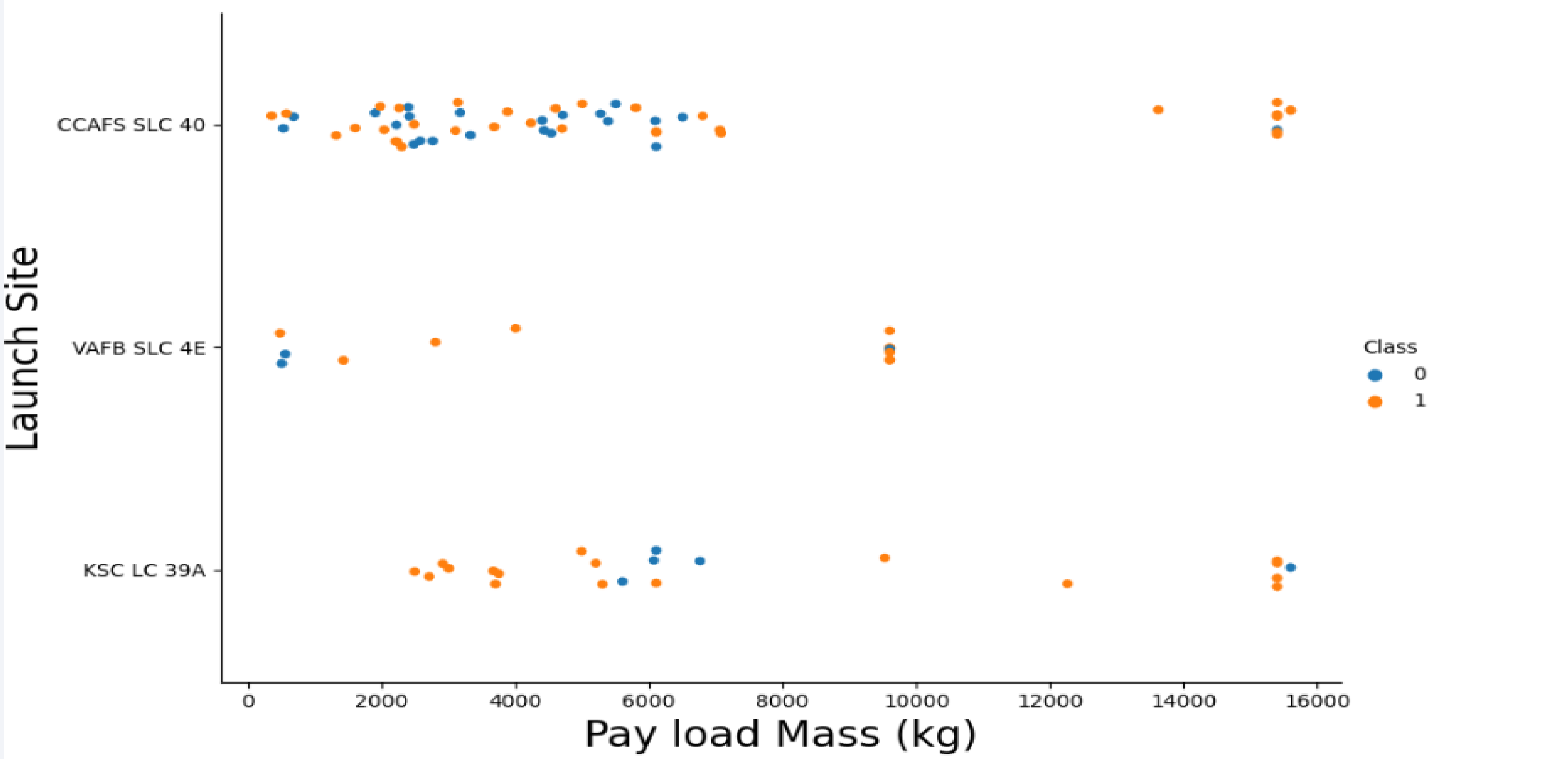


Now try to explain the patterns you found in the Flight Number vs. Launch Site scatter point plots.

We can deduce that, as the flight number increases in each of the 3 launcg sites, so does the success rate. For instance, the success rate for the VAFB SLC 4E launch site is 100% after the Flight number 50. Both KSC LC 39A and CCAFS SLC 40 have a 100% success rates after 80th flight.

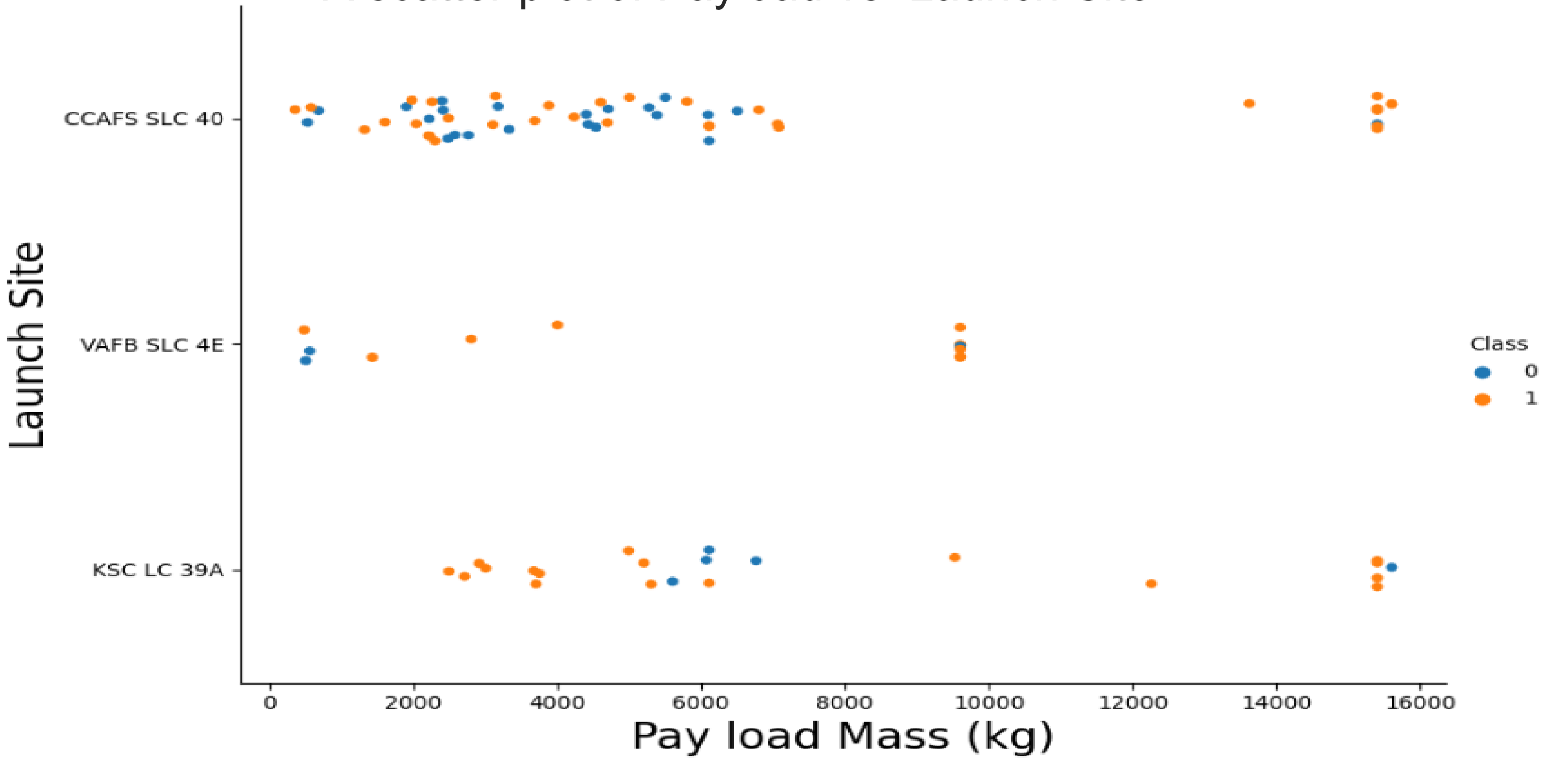
Payload vs. Launch Site

A scatter plot of Payload vs. Launch Site



Payload vs. Launch Site with explanations

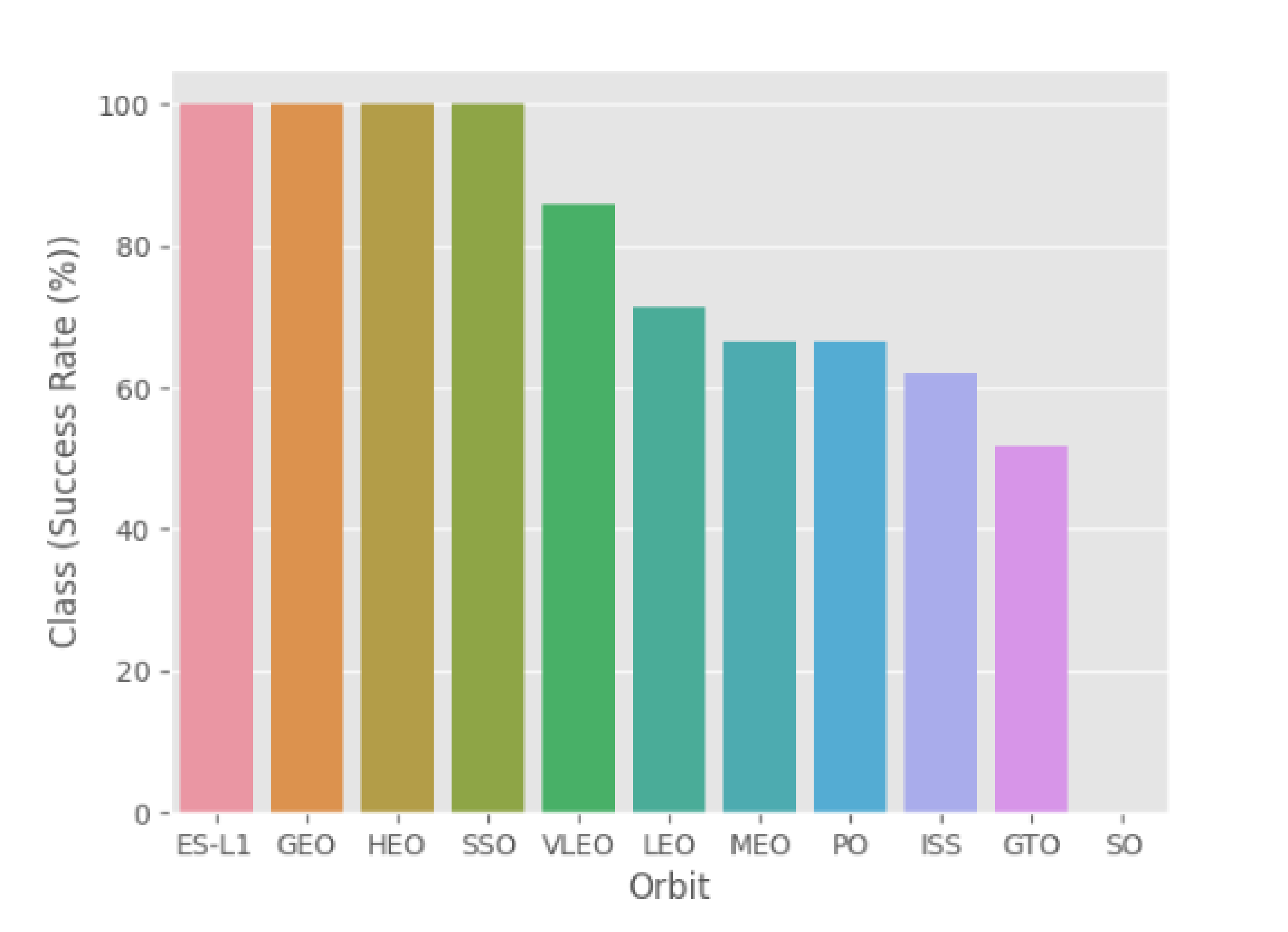
A scatter plot of Payload vs. Launch Site



Now if you observe Payload Vs. Launch Site scatter point chart you will find for the VAFB-SLC launchsite there are no rockets launched for heavypayload mass(greater than 10000).

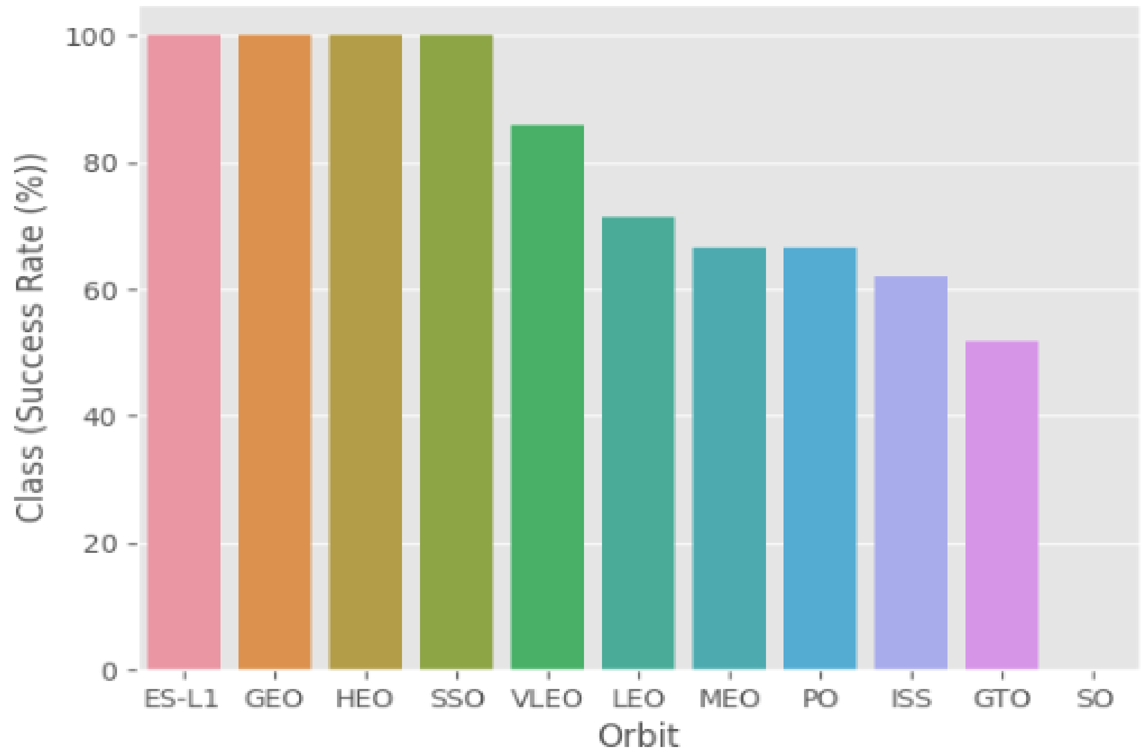
Success Rate vs. Orbit Type

- Show a bar chart for the success rate of each orbit type



Success Rate vs. Orbit Type with explanations

- Show the screenshot of the bar chart with explanations

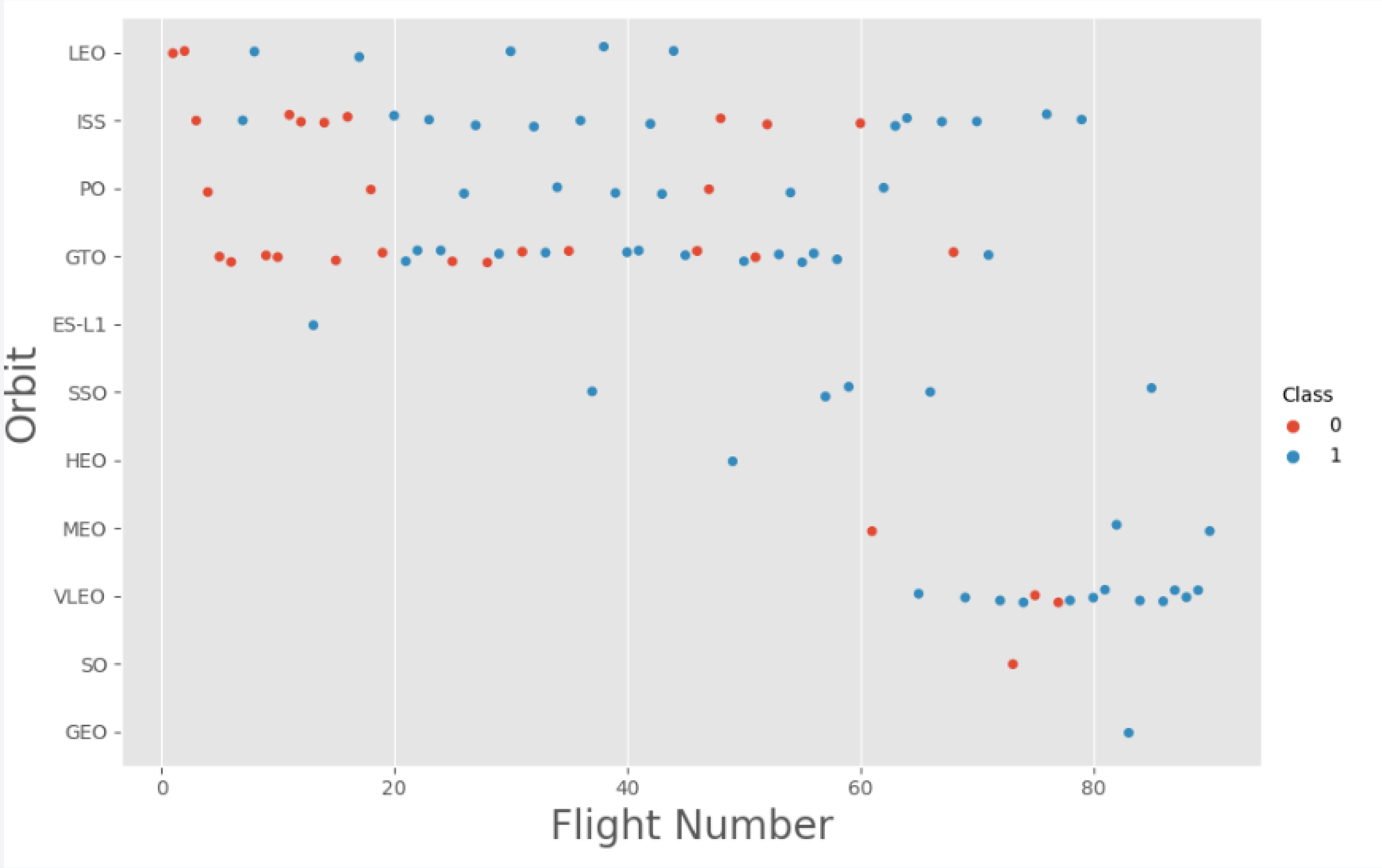


Analyze the ploted bar chart try to find which orbits have high sucess rate.

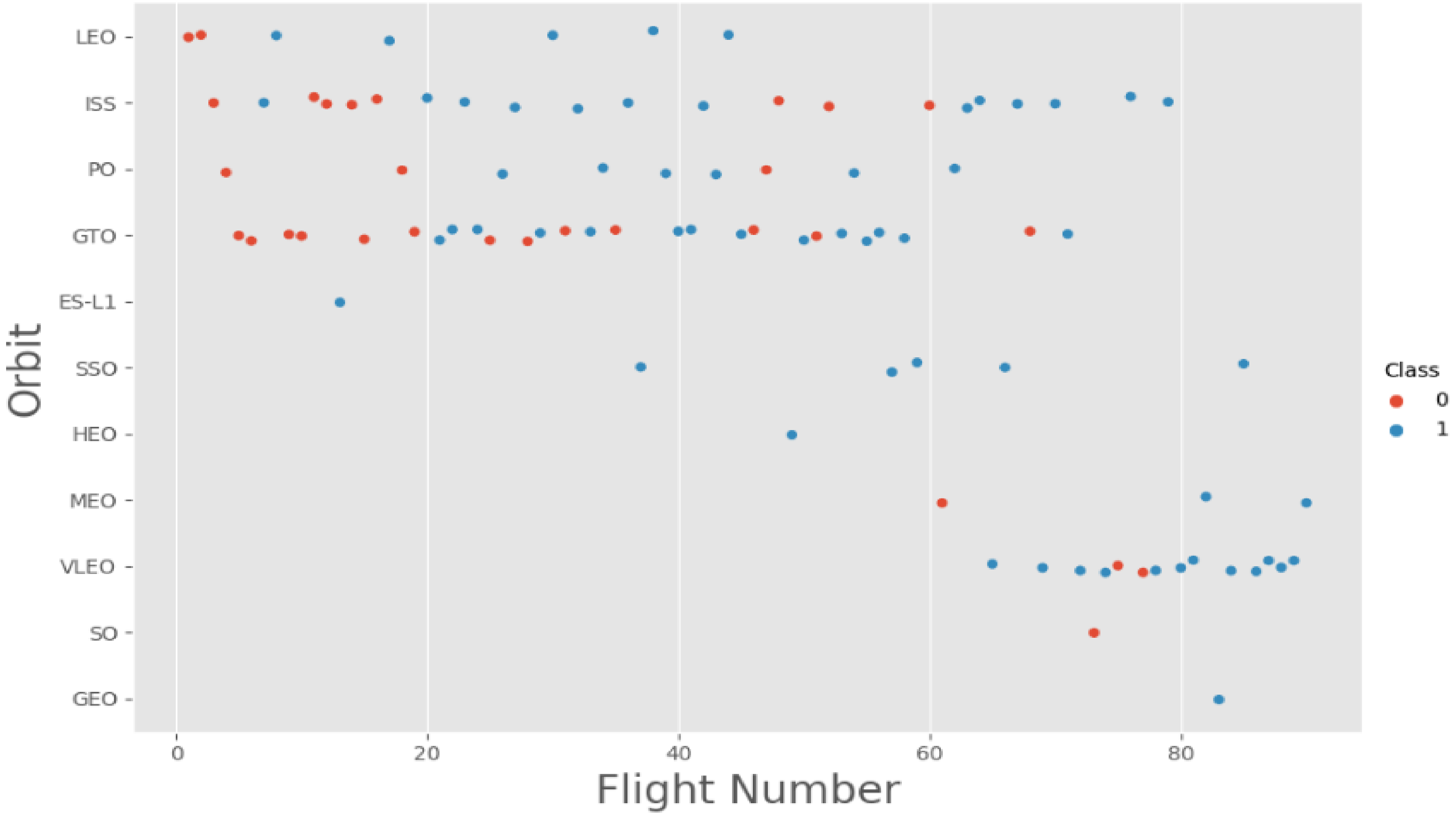
Orbits ES-L1, GEO, HEO & SSO have the highest success rates at 100%, with SO orbit having the lowest success rate at ~50%. Orbit SO has 0% success rate.

Flight Number vs. Orbit Type

- A scatter point of Flight number vs. Orbit type



Flight Number vs. Orbit Typewith explanations



You should see that in the LEO orbit the Success appears related to the number of flights; on the other hand, there seems to be no relationship between flight number when in GTO orbit.

Payload vs. Orbit Type

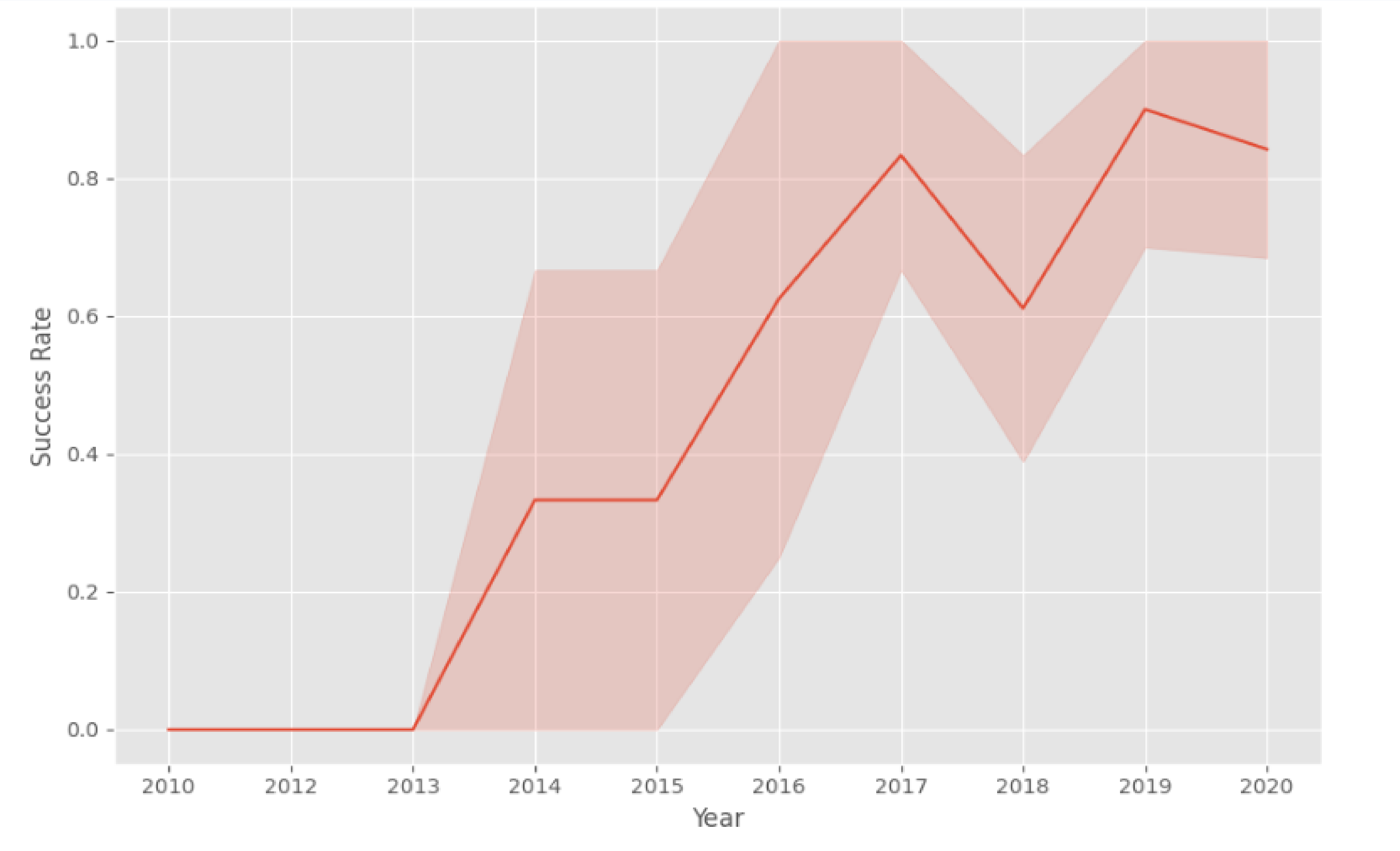
l When dealing with heavy payloads, we observe a higher rate of successful or positive landings for Polar, Low Earth Orbit (LEO), and International Space Station (ISS) missions.

•Conversely, distinguishing successful landings from unsuccessful ones, particularly in Geostationary Transfer Orbit (GTO), proves challenging. Here, both positive and negative landing outcomes have nearly equal probabilities.

Launch Success Yearly Trend

- The success rate has consistently increased since 2013, steadily climbing until the year 2020.

A line chart of yearly average success rate



All Launch Site Names

- Find the names of the unique launch sites

- Used 'SELECT DISTINCT' statement to return only the unique launch sites from the 'LAUNCH_SITE' column of the SPACEXTBL table

Task 1

Display the names of the unique launch sites in the space mission

In [31]:

```
%sql SELECT DISTINCT LAUNCH_SITE as "Launch_Sites" FROM SPACEXTBL;
```

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

Out[31]:

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

Launch Site Names Begin with 'CCA'

- Find 5 records where launch sites begin with `CCA`

Task 2

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

In [72]:

```
%sql SELECT * FROM 'SPACEXTBL' WHERE Launch_Site LIKE 'CCA%' LIMIT 5;
```

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

Out[72]:

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

- Used ‘LIKE’ command with ‘%’ wildcard in ‘WHERE’ clause to select and dispay a table of all records where **launch sites begin with the string 'CCA'**

Total Payload Mass

- Calculate and Display the total payload carried by boosters from NASA

Task 3

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

In [17]:

```
%sql SELECT SUM(PAYLOAD_MASS__KG_) as "Total Payload Mass(Kgs)", Customer FROM 'SPACEXTBL' WHERE Customer = 'NASA (CRS)';
```

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

Out[17]:

Total Payload Mass(Kgs)	Customer
45596	NASA (CRS)

- Used the 'SUM()' function to return and dispaly the total sum of '**PAYLOAD_MASS_KG**' column for Customer '**NASA(CRS**'

Average Payload Mass by F9 v1.1

- Calculate the average payload mass carried by booster version F9 v1.1

Task 4

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

```
%sql SELECT AVG(PAYLOAD_MASS__KG_) as "Payload Mass Kgs", Customer, Booster_Version FROM 'SPACEXTBL' WHERE Booster_Version LIKE 'F9 v1.1%';
```

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

Payload Mass Kgs	Customer	Booster_Version
2534.6666666666665	MDA	F9 v1.1 B1003

- Used the ‘AVG()’ function to return and dispaly the average payload mass carried by booster version F9 v1.1

First Successful Ground Landing Date

- Find the dates of the first successful landing outcome on ground pad

Task 5

List the date when the first succesful landing outcome in ground pad was acheived.

Hint:Use min function

```
%sql SELECT MIN(DATE) FROM 'SPACEXTBL' WHERE "Landing _Outcome" = "Success (ground pad)";
```

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

MIN(DATE)
01-05-2017

- Used the ‘MIN()’ function to return and dispaly the first (oldest) date when first successful landing outcome on ground pad ‘***Success (ground pad)***’ happened.

Successful Drone Ship Landing with Payload between 4000 and 6000

- List of Boosters which have successfully landed on drone ship and had payload mass greater than 4000 but less than 6000

Task 6

List the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 6000

```
]: # %sql SELECT * FROM 'SPACEXTBL'
```

```
]: %sql SELECT DISTINCT Booster_Version, Payload FROM SPACEXTBL WHERE "Landing _Outcome" = "Success (drone ship)" AND PAYLOAD_MASS__KG_ > 4000 AND PAYLOA
```

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

]:

Booster_Version	Payload
F9 FT B1022	JCSAT-14
F9 FT B1026	JCSAT-16
F9 FT B1021.2	SES-10
F9 FT B1031.2	SES-11 / EchoStar 105

- Used 'Select Distinct' statement to return and list the 'unique' names of boosters with operators >4000 and <6000 to only list booster with payloads btween 4000-6000 with landing outcome of 'Success (drone ship)'.

Total Number of Successful and Failure Mission Outcomes

- Calculate the total number of successful and failure mission outcomes

Task 7

List the total number of successful and failure mission outcomes

```
%sql SELECT "Mission_Outcome", COUNT("Mission_Outcome") as Total FROM SPACEXTBL GROUP BY "Mission_Outcome";
```

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

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

- Used the 'COUNT()' together with the 'GROUP BY' statement to return total number of missions outcomes

Boosters Carried Maximum Payload

- List of the boosters which have carried the maximum payload mass

```
%sql SELECT "Booster_Version",Payload, "PAYLOAD_MASS__KG_" FROM SPACEXTBL WHERE "PAYLOAD_MASS__KG_" = (SELECT MAX("PAYLOAD_MASS__KG_") FROM SPACEXTBL)
```

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

Booster_Version	Payload	PAYLOAD_MASS__KG_
F9 B5 B1048.4	Starlink 1 v1.0, SpaceX CRS-19	15600
F9 B5 B1049.4	Starlink 2 v1.0, Crew Dragon in-flight abort test	15600
F9 B5 B1051.3	Starlink 3 v1.0, Starlink 4 v1.0	15600
F9 B5 B1056.4	Starlink 4 v1.0, SpaceX CRS-20	15600
F9 B5 B1048.5	Starlink 5 v1.0, Starlink 6 v1.0	15600
F9 B5 B1051.4	Starlink 6 v1.0, Crew Dragon Demo-2	15600
F9 B5 B1049.5	Starlink 7 v1.0, Starlink 8 v1.0	15600
F9 B5 B1060.2	Starlink 11 v1.0, Starlink 12 v1.0	15600
F9 B5 B1058.3	Starlink 12 v1.0, Starlink 13 v1.0	15600
F9 B5 B1051.6	Starlink 13 v1.0, Starlink 14 v1.0	15600
F9 B5 B1060.3	Starlink 14 v1.0, GPS III-04	15600
F9 B5 B1049.7	Starlink 15 v1.0, SpaceX CRS-21	15600

- Using a Subquerry to return and pass the Max payload and used it list all the boosters that have carried the Max payload of 15600kgs

2015 Launch Records

- List of failed landing outcomes in drone ship, with their booster versions, and launch site names in 2015

Task 9

List the records which will display the month names, failure landing_outcomes in drone ship ,booster versions, launch_site for the months in year 2015.

```
%sql SELECT substr(Date,7,4), substr(Date, 4, 2),"Booster_Version", "Launch_Site", Payload, "PAYLOAD_MASS__KG_", "Mission_Outcome", "Landing _Outcome"
```

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

substr(Date,7,4)	substr(Date, 4, 2)	Booster_Version	Launch_Site	Payload	PAYLOAD_MASS__KG_	Mission_Outcome	Landing _Outcome
2015	01	F9 v1.1 B1012	CCAFS LC-40	SpaceX CRS-5	2395	Success	Failure (drone ship)
2015	04	F9 v1.1 B1015	CCAFS LC-40	SpaceX CRS-6	1898	Success	Failure (drone ship)

- Used the ‘subsrt()’ in the select statement to get the month and year from the date column where substr(Date,7,4)='2015' for year and Landing_outcome was ‘Failure (drone ship’) and return the records nmatching the filter.

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

Task 10

Rank the count of successful landing_outcomes between the date 04-06-2010 and 20-03-2017 in descending order.

```
%sql SELECT * FROM SPACEXTBL WHERE "Landing _Outcome" LIKE 'Success%' AND (Date BETWEEN '04-06-2010' AND '20-03-2017') ORDER BY Date DESC;
```

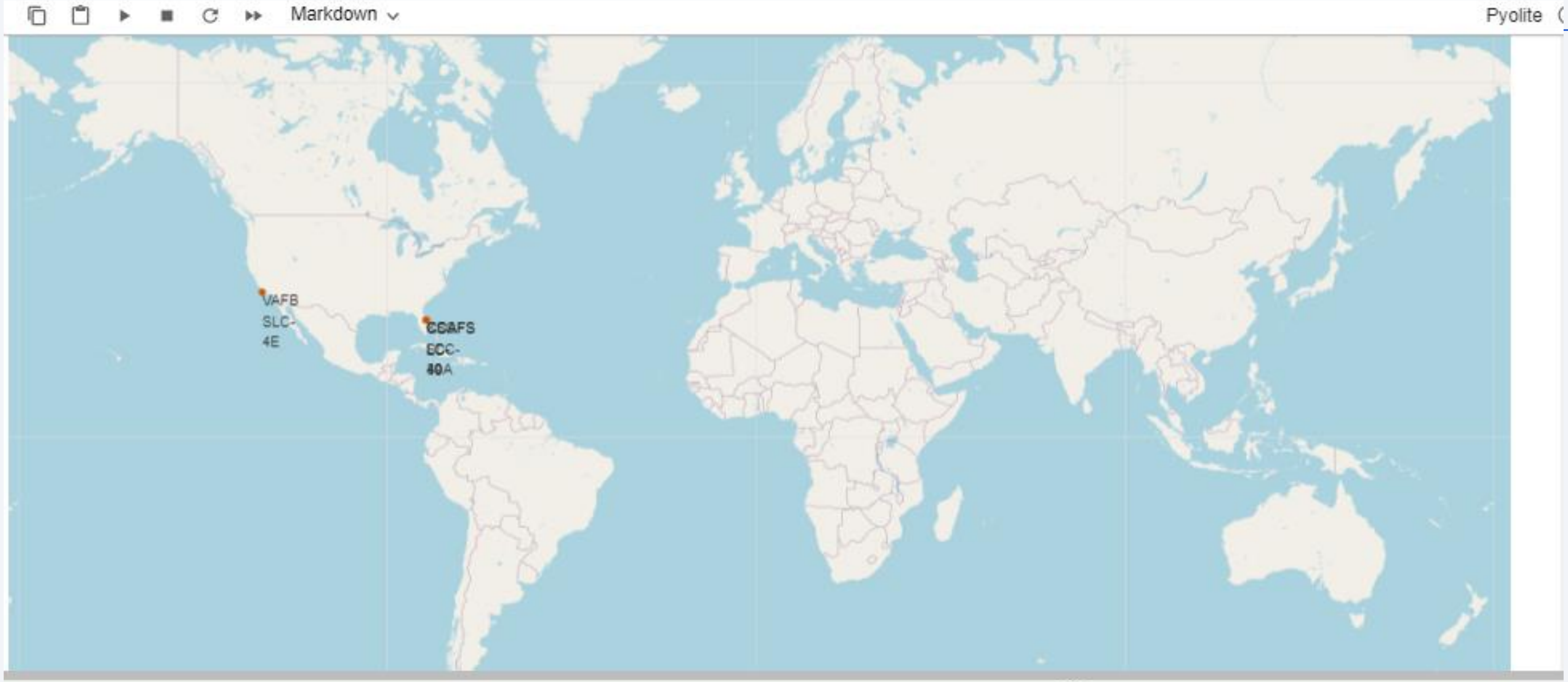
```
 * sqlite:///my_data1.db
Done.
```

Date	Time (UTC)	Booster_Version	Launch_Site	Payload	PAYLOAD_MASS__KG_	Orbit	Customer	Mission_Outcome	Landing _Outcome
19-02-2017	14:39:00	F9 FT B1031.1	KSC LC-39A	SpaceX CRS-10	2490	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
18-10-2020	12:25:57	F9 B5 B1051.6	KSC LC-39A	Starlink 13 v1.0, Starlink 14 v1.0	15600	LEO	SpaceX	Success	Success
18-08-2020	14:31:00	F9 B5 B1049.6	CCAFS SLC-40	Starlink 10 v1.0, SkySat-19, -20, -21, SAOCOM 1B	15440	LEO	SpaceX, Planet Labs, PlanetIQ	Success	Success
18-07-2016	04:45:00	F9 FT B1025.1	CCAFS LC-40	SpaceX CRS-9	2257	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
18-04-2018	22:51:00	F9 B4 B1045.1	CCAFS SLC-40	Transiting Exoplanet Survey Satellite (TESS)	362	HEO	NASA (LSP)	Success	Success (drone ship)

Section 3

Launch Sites Proximities Analysis

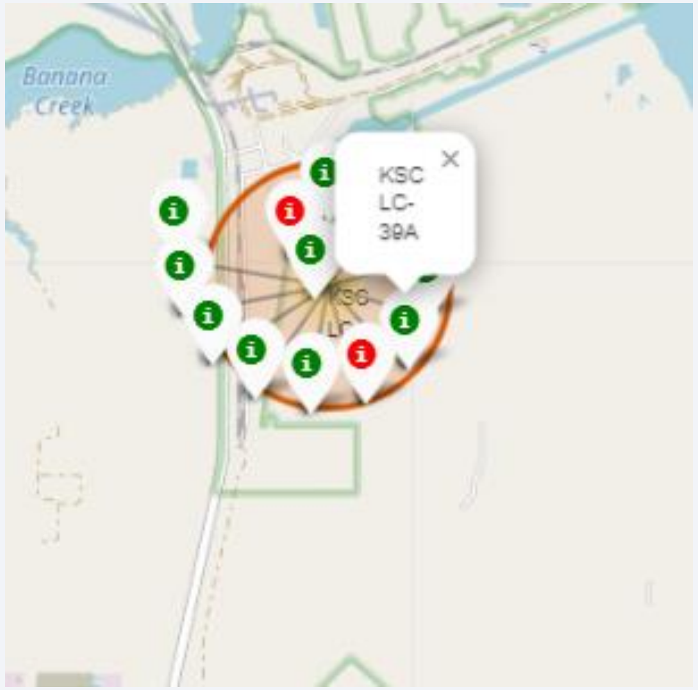
Markers of all launch sites on global map



- All launch sites are in proximity to the Equator, (located southwards of the US map). Also all the laumch sites are in very close proximity to the coast.

Launch outcomes for each site on the map With Color Markers

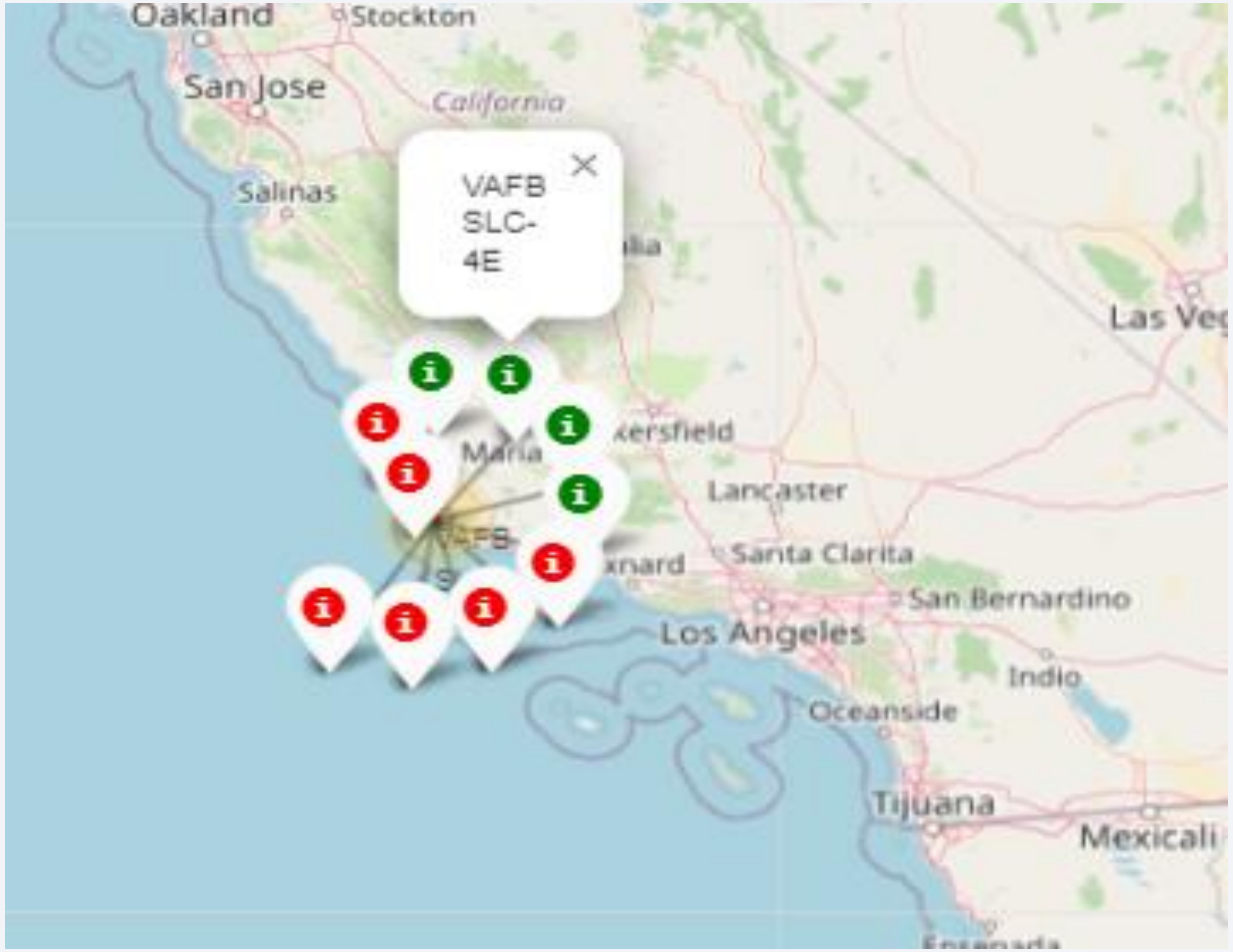
Florida Sites



- On the Eastern coast in Florida, the launch site KSC LC-39A exhibits relatively high success rates compared to both CCAFS SLC-40 and CCAFS LC-40.

Launch outcomes for each site on the map With Color Markers

West Coast/ Carlifonia

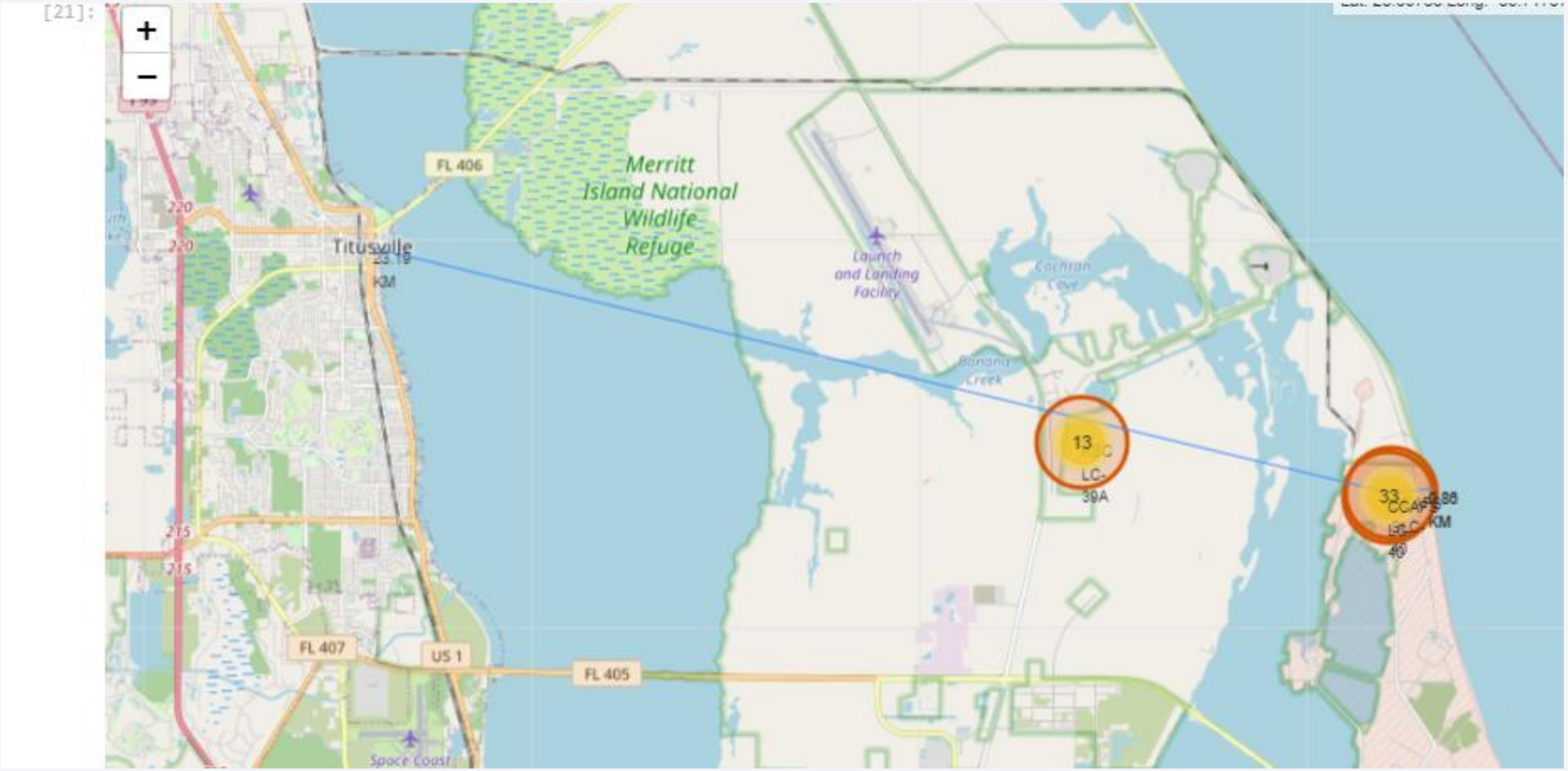


- At the West Coast launch site, VAFB SLC-4E in California, the success rate stands at 4 out of 10, relatively lower when compared to the KSC LC-39A launch site located on the Eastern Coast of Florida.

Distances between a launch site to its proximities

- The launch site CCAFS SLC-40 is located approximately 0.86 kilometers from the coastline.

Distances between a launch site to its proximities

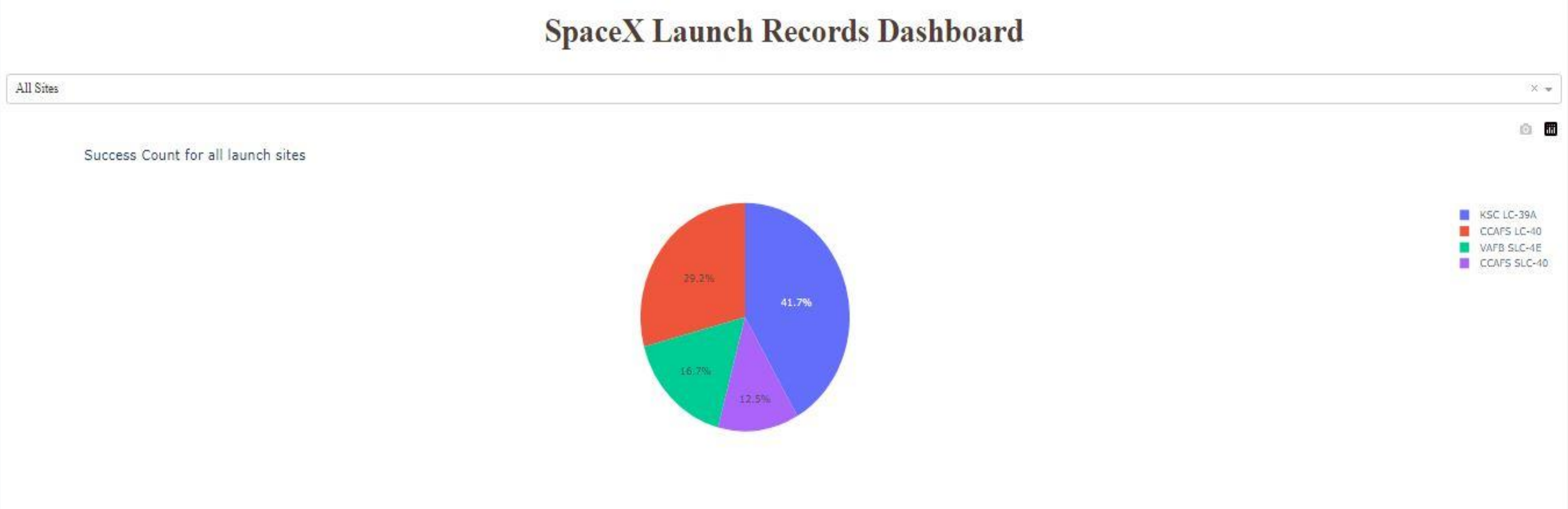


- The launch site CCAFS SLC-40 is situated approximately 23.19 kilometers from the nearest highway, Washington Avenue.

Section 4

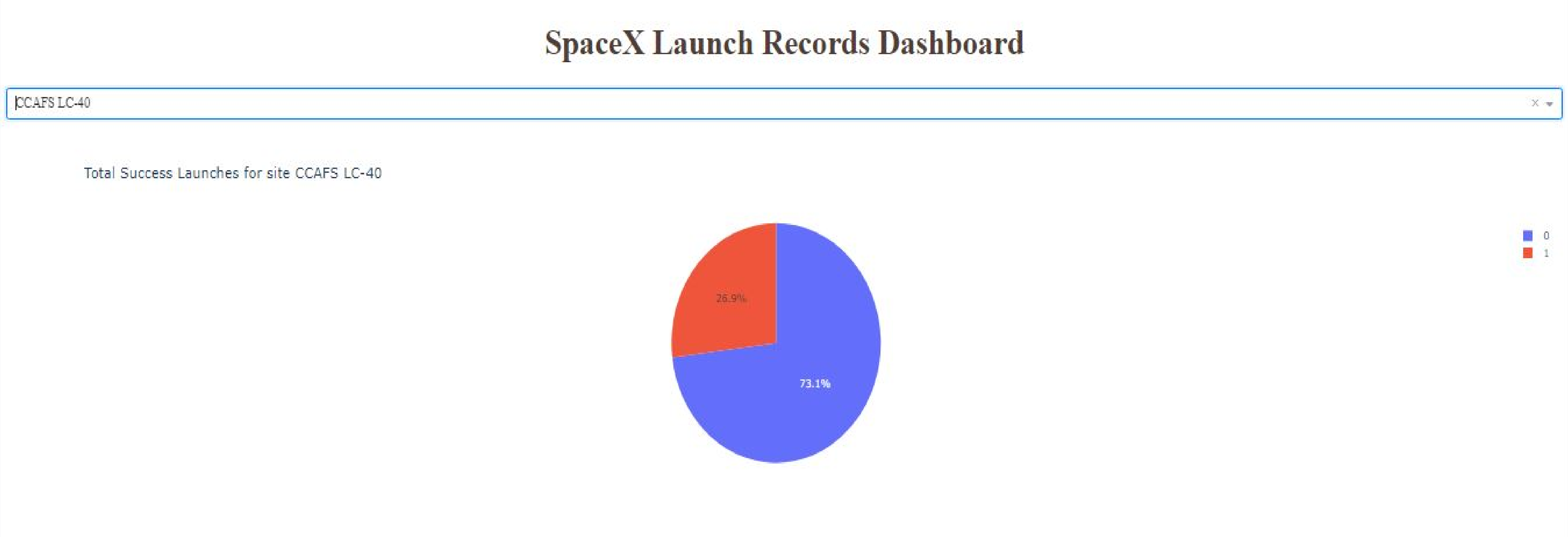
Build a Dashboard with Plotly Dash

Pie-Chart for launch success count for all sites



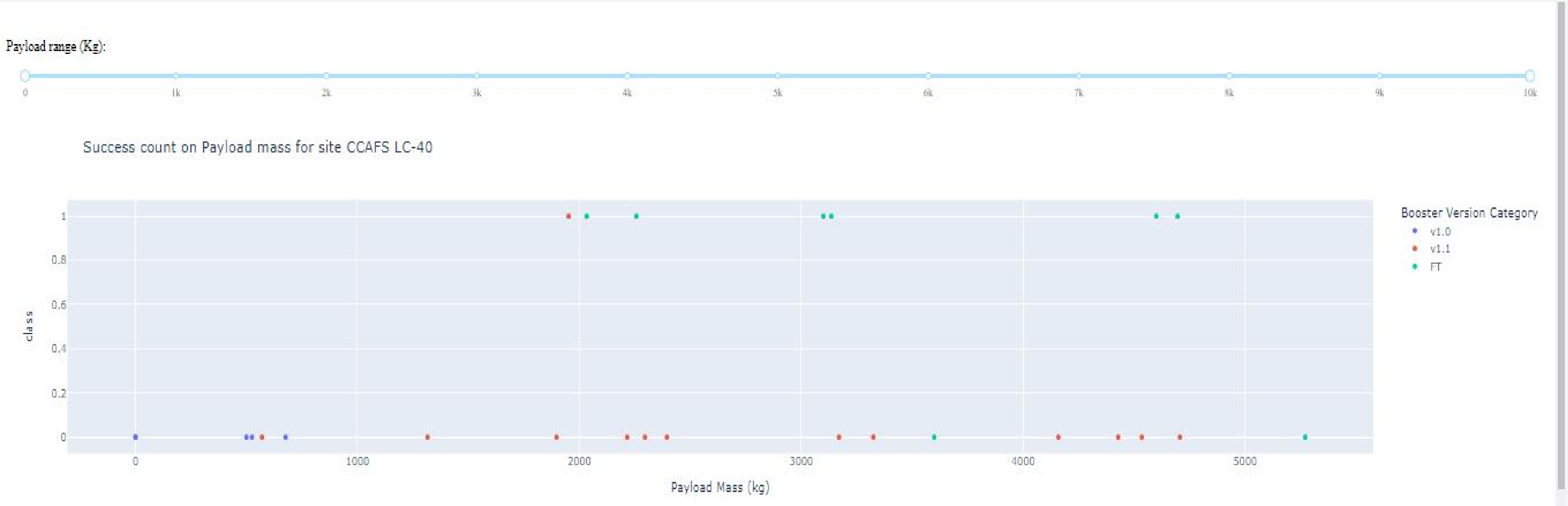
- The launch site KSC LC-39A boasts the highest launch success rate at 42%, followed by CCAFS LC-40 at 29%. VAFB SLC-4E stands at 17%, while CCAFS SLC-40 has the lowest success rate of 13%.

Pie chart for the launch site with 2nd highest launch success ratio



- The launch site CCAFS LC-40 achieved the second-highest success ratio with 73% successful launches and 27% failed launches.

Payload vs. Launch Outcome scatter plot for all sites



- For Launch site CCAFS LC-40 the booster version FT has the largest success rate from a payload mass of >2000kg

Section 5

Predictive Analysis (Classification)

Classification Models Accuracy

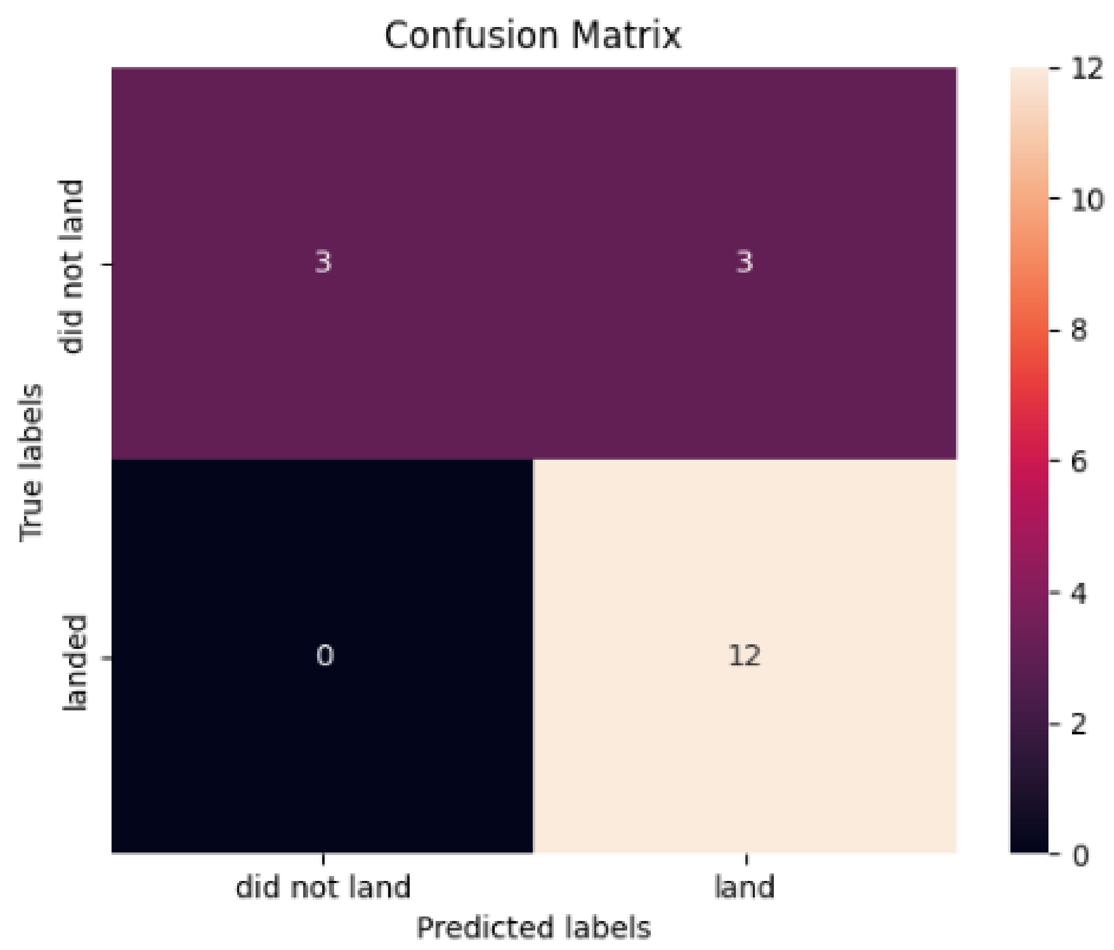
Out[68]:

	0
Method	Test Data Accuracy
Logistic_Reg	0.833333
SVM	0.833333
Decision Tree	0.833333
KNN	0.833333

All the methods perform equally on the test data: i.e. They all have the same accuracy of 0.833333 on the test Data

Confusion Matrix

- All four classification models exhibited identical confusion matrices and effectively distinguished between the various classes. However, a notable issue across all models is the occurrence of false positives.



Conclusions

- Different launch sites exhibit varying success rates. CCAFS LC-40 boasts a 60% success rate, while both KSC LC-39A and VAFB SLC 4E have higher success rates of 77%.
- It's notable that as the flight number increases at each launch site, the success rate also rises. For example, the success rate at VAFB SLC 4E reaches 100% after Flight number 50. Similarly, both KSC LC 39A and CCAFS SLC 40 achieve a 100% success rate after the 80th flight.
- Upon observing the scatter point chart for Payload vs. Launch Site, it's evident that there are no rockets launched for heavy payload masses (greater than 10000) at the VAFB-SLC launch site.
- Orbits ES-L1, GEO, HEO, and SSO exhibit the highest success rates at 100%, while SO orbit demonstrates the lowest success rate at approximately 50%. Notably, Orbit SO has a 0% success rate.
- Regarding LEO orbit, success appears to be correlated with the number of flights. Conversely, in GTO orbit, there seems to be no discernible relationship between flight number and success rate.

Conclusions Cont….

- The success rate has consistently increased from 2013 to 2020. Additionally, heavier payloads tend to have higher success rates for Polar, LEO, and ISS missions, whereas distinguishing success rates for GTO missions is challenging due to a mix of positive and negative landing outcomes.

Thank you!