IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

Executive Summary

Summary of Methodologies

1. Data Acquisition: Retrieved SpaceX launch data through API calls via web scraping from Wikipedia.

2. Data Cleaning & Preparation:

- Processed and formatted the data to ensure consistency.
- Imported the data into a Db2 database and perfomed various SQL queries.
- Conducted exploratory analysis to uncover trends and patterns.

3. Feature Engineering: Developed new features and standardized the dataset for model building.

4. Interactive Visualizations:

- Created maps to display launch sites and success rates using the Folium Library.
- Developed and interactive dashboard using Plotly Dash to allow for dynamic visual analysis.

Executive Summary & Summary of Findings

5. Model Building & Evaluation:

- Built models using Support Vector Machines (SVM), Decision Trees and K-Nearest Neighbors (K-NN).
- Applied GridSearchCV for hyperparameter optimization.
- Assessed model perfomance based on accuracu from the test data.

6. Data Insights:

- Identified key factors influencing the success of Falcon 9 first stage landings.
- Mapped geographical patterns and success rates for clearer understanding.

7. Model Performance:

- SVM and K-Nearest Neighbors: 84.82% accuracy.
- Decision Tree:87.50% accuracy.

8. Key Findings:

- Launch site and payload mass impact landing success.
- Decision Tree model is the most effective predictor.

Introduction

Project Background and Context:

This capstone project focuses on predicting the successful landing of the Falcon 9 first stage. SpaceX offers rocket launches at a much lower cost than its competitors, primarily because they reuse the first stage of the rocket. By accurately forecasting landing success, we can estimate the cost of each launch and provide useful insights to companies competing with SpaceX.

Key Questions We Aim to Answer:

- What are the key factors that influence the success of the Falcon 9 first-stage landing?
- How can we leverage machine learning models to predict landing outcomes?
- Which machine learning model is the most accurate in prediction landing success?

Section 1

Methodology

Methodology

Executive Summary: This project takes a comprehensive approach to predicting the Falcon 9 first-stage landing success. It involves collecting data, preprocessing it, conducting exploratory analysis, creating interactive visualizations, and building predictive models.

Data Collection Approach: The data was gathered from the SpaceX API, which includes detailed records of Falcon 9 launches, such as launch dates, locations, payload details, and success outcomes.

Data Cleaning and Preparation: Data wrangling involved addressing missing values, standardizing formats, and ensuring data consistency. We also extracted relevant features and created new ones to enhance the dataset.

Perform Exploratory Data Analysis (EDA) Using Visualization and SQL:

- We visualized the success rates of launches, payload sizes, and launch sites using tools like Matplotlib and Seaborn.
- SQL queries were executed to explore specific insights and answer key questions about the dataset.

Methodology

Interactive Visual Analytics Using Folium and Plotly Dash:

- Folium was used to generate interactive maps to display launch sites and success outcomes.
- A Plotly Dash application was developed with interactive elements like dropdowns and sliders, allowing users to analyze launch success rates and payload weight distributions.

Perform Predictive Analysis Using Classification Models:

- A variety of classification models were built and evaluated, including Logistic Regression, Support Vector Machine (SVM), K-Nearest Neighbors (KNN), and Decision Trees.
- GridSearchCV was applied for hyperparameter optimization.
- Models were assessed based on accuracy, with the best model identified for predicting landing success.

Data Collection

- Step 1: SpaceX API Request

- Step 2: Web Scraping Wikipedia

- Step 3: Data Integration

Data Collection - SpaceX API

Step 1: Initiate API Request

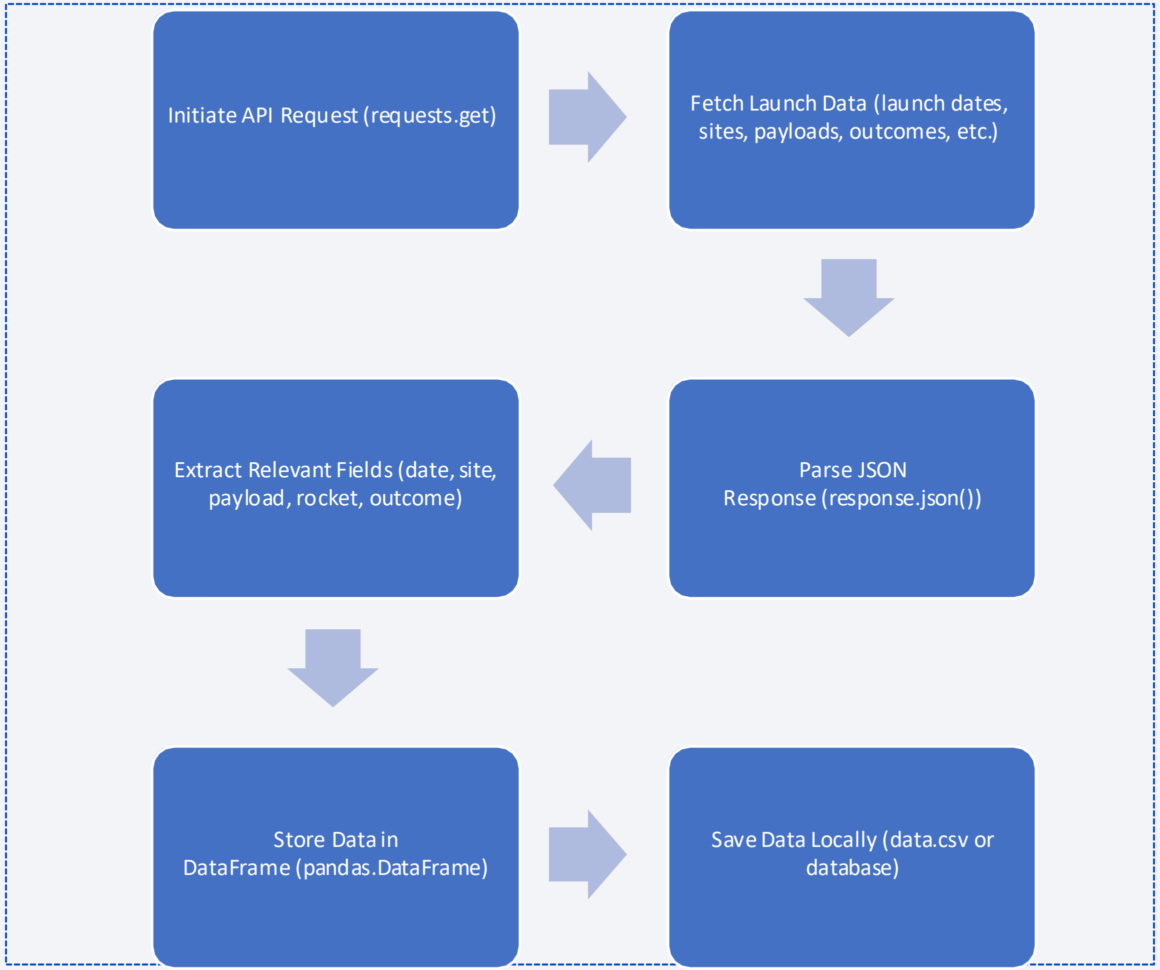
- Use Python's `requests` library to connect to the SpaceX API.
- Endpoint: `https://api.spacexdata.com/v4/launches`

Step 2: Parse API Response

- Convert API response from JSON to a Python dictionary.
- Extract relevant fields: launch date, launch site, payload mass, rocket type, outcome.

Step 3: Store Data Locally

- Save extracted data into a pandas DataFrame.
- Store the DataFrame locally for further processing.



Data Collection - Scraping

Step 1: Initiate Web Scraping

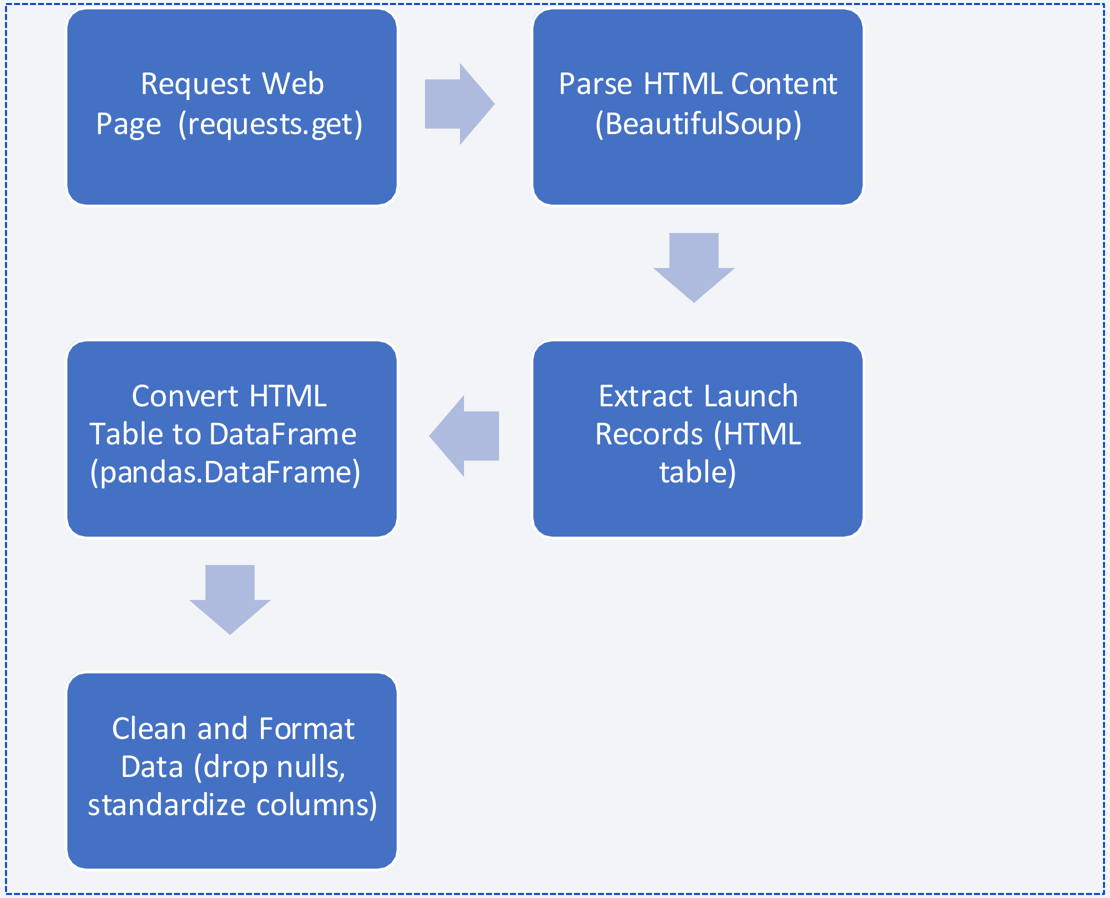
- Use Python's `requests` library to fetch the HTML content of the Wikipedia page.
- Target URL: `https://en.wikipedia.org/wiki/List_of_Falcon_9_and_Falcon_Heavy_launches`

Step 2: Parse HTML Content

- Use `BeautifulSoup` to parse the HTML content.
- Extract the HTML table containing Falcon 9 launch records.

Step 3: Convert to DataFrame

- Convert the extracted HTML table into a pandas DataFrame.
- Clean and format the DataFrame, ensuring data consistency.



Data Wrangling

Overview: Data wrangling involves cleaning, transforming, and organizing raw data into a structured format suitable for analysis.

- Step 1: Data Cleaning
  - Identify and fill or remove missing values in the dataset.
  - Use appropriate imputation techniques or drop rows/columns with excessive missing data.

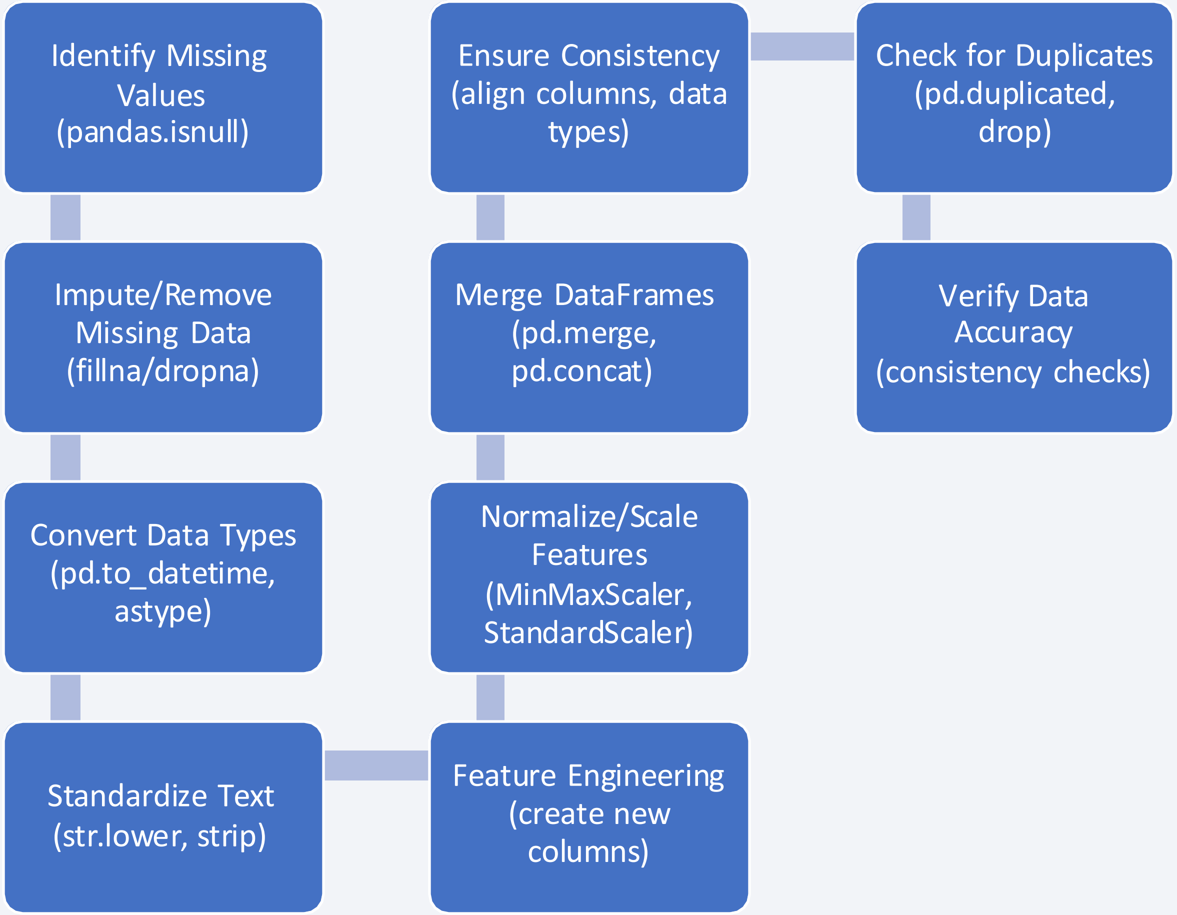
- Step 2: Data Transformation
  - Convert data types to appropriate formats (e.g., date-time, numerical).
  - Standardize text (e.g., lowercase, remove whitespace).
  - Create new features from existing data (e.g., extract year from date).
  - Normalize/scale numerical features to ensure consistency.

Data Wrangling

- Step 3: Data Integration
  - Merge datasets collected from different sources (API, web scraping) into a single cohesive dataset.
  - Ensure consistent column names and data formats across datasets.

- Step 4: Data Validation
  - Check for duplicate records and remove them.
  - Verify the accuracy and consistency of data entries.

Data Wrangling Flowchart



EDA with Data Visualization

Overview:

Exploratory Data Analysis (EDA) is the process of visually examining and summarizing a dataset's key characteristics. The primary goal is to understand the data's distribution, identify patterns, and discover relationships between variables.

Plots Generated:

1. Histograms:

- **Purpose:** to visualize the distribution of numerical variables, such as launch success rates, payload mass, and flight numbers.

- **Why:** Helps to understand the spread and central tendency of the data, identify outliers, and assess the skewness of the data.

2. Bar Charts:

- **Purpose**:Used to compare categorical variables like launch outcomes (success/failure) across different categories such as launch sites or rocket types.

- **Why**: Enables a clear comparison of frequencies or proportions within categorical data, highlighting any trends or patterns.

3. Line Charts:

- **Purpose:** To track trends over time, such as changes in the success rate of Falcon 9 launches across different years.

- **Why**: Helps to reveal temporal patterns, understanding performance trends or changes over time.

EDA with Data Visualization

4. Scatter Plots:

- **Purpose:** To explore relationships between two numerical variables, for example, payload mass versus launch success.
- **Why**: Identifies correlations or dependencies between variables, showing how one variable changes in relation to another.

5. Heatmaps:

- **Purpose:** Used to visualize correlation matrices between multiple numerical variables.
- **Why:** Helps in identifying strong correlations (positive or negative) between variables, aiding feature selection or understanding multicollinearity.

6. Box Plots:

- **Purpose:** To display the distribution of numerical data through quartiles.
- **Why:** Visualizes the spread and skewness of data, highlighting outliers and comparing distributions across different categories.

EDA with SQL

Aggregate Queries:

- Counted the total number of launches, successful launches, and failed launches.
- Calculated success rates by launch site and rocket type.

Join Queries:

- Linked tables to combine launch records with additional data, like rocket specifications.
- Merged datasets for a more comprehensive analysis.

Filtering Queries:

- Filtered data to focus on specific launch outcomes such as success or failure launches.
- Applied conditions to extract launches based on date or rocket configuration.

Sorting Queries:

- Sorted data to identify trends or outliers.
- Ordered launches by date or success rate for deeper analysis.

Subqueries:

- Used nested queries to calculate derived metrics, such as the average payload mass per launch site.
- Subqueries allowed for detailed analysis within larger datasets.

Build an Interactive Map with Folium

Map Objects Created

Markers:

- Placed markers on maps to indicate the geographic locations of launch sites.
- Each marker represents a specific launch site where SpaceX has conducted launches.

Circles:

- Added circles around launch sites to visually represent proximity zones.
- Circles help illustrate areas surrounding launch sites that might influence operational decisions.

Lines:

- Drew lines to connect launch sites with their proximity areas or other relevant locations.
- Lines provide spatial context, showing relationships between different locations related to launches.

Reasons for Adding Objects

Markers:

- Pinpoint launch locations for geographical reference, helping users identify where SpaceX launches occur.

Circles:

- Illustrate potential impact zones around launch sites, providing a visual understanding of safety perimeters and operational boundaries.

Lines:

- Show connections or relationships between launch sites and other key features, enhancing spatial understanding.

Build a Dashboard with Plotly Dash

Plots/Graphs Added

Success Pie Chart:

- Displays the distribution between successful and failed launches.
- Helps visualize the overall success rate and performance trends.

Success-Payload Scatter Plot:

- Shows the relationship between payload mass and launch success.
- Allows users to explore how payload mass affects mission outcomes.

Interactions Added

Launch Site Dropdown:

- Allows users to select specific launch sites for focused analysis.
- Facilitates the exploration of data based on geographical locations.

Range Slider for Payload:

- Lets users dynamically adjust payload mass ranges.
- Provides flexibility in examining how payload variations impact launch success rates.

Reasons for Adding Plots and Interactions

Success Pie Chart:

- Provides a quick overview of mission success rates.
- Essential for stakeholders to understand overall performance metrics at a glance.

Success-Payload Scatter Plot:

- Helps identify correlations between payload characteristics and launch outcomes.
- Supports decision-making processes related to payload planning and operational strategies.

Launch Site Dropdown:

- Enhances user experience by focusing analysis on specific launch locations.
- Allows for regional insights and comparisons across different launch sites.

Range Slider for Payload:

- Offers interactive exploration of how payload mass affects mission success.
- Enables detailed analysis and insights into payload-related performance factors.

Predictive Analysis (Classification)

1. Data Preprocessing:

- Standardized features to ensure all variables contribute equally.
- Split data into training and test sets for model validation.

2. Model Selection:

- Explored multiple classification algorithms: SVM, Decision Trees, and K-Nearest Neighbors (KNN).
- Chose algorithms suitable for binary classification tasks based on project requirements.

3. Hyperparameter Tuning:

- Used GridSearchCV to systematically search for optimal hyperparameters.
- Tuned parameters such as C (SVM), max_depth (Decision Trees), and n_neighbors (KNN).

4. Model Evaluation:

- Evaluated models using cross-validation techniques to ensure robustness and generalizability.
- Utilized metrics like accuracy, precision, recall, and F1-score to assess model performance.

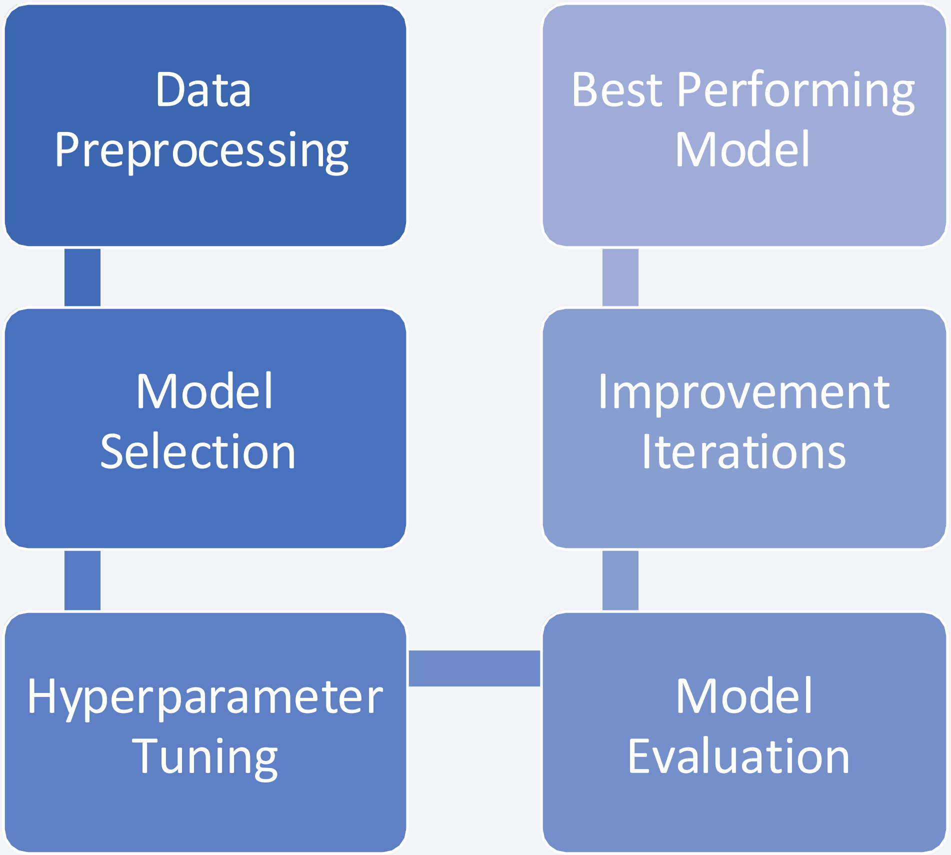
5. Improvement Iterations:

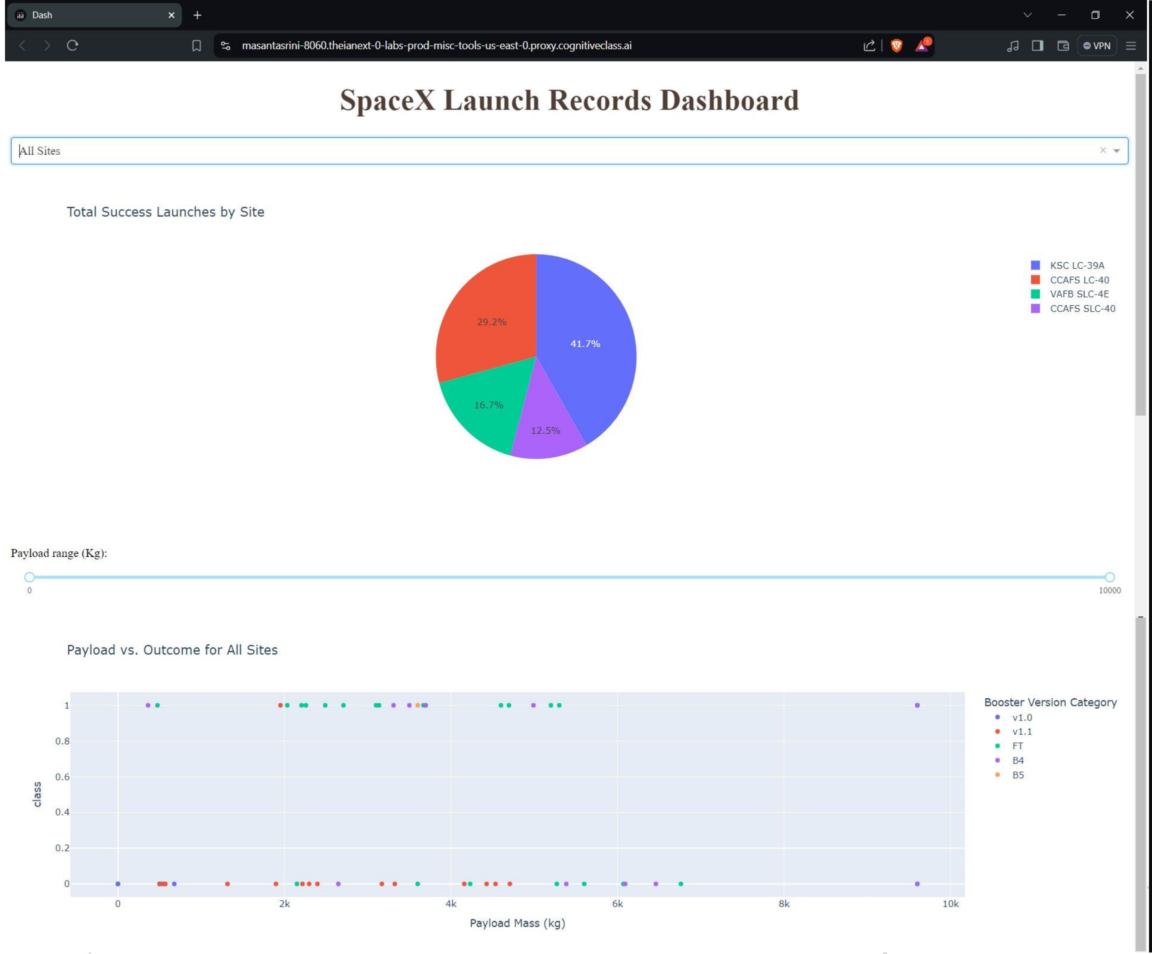
- Iteratively adjusted models based on insights from validation results.
- Fine-tuned hyperparameters to maximize predictive accuracy and reliability.

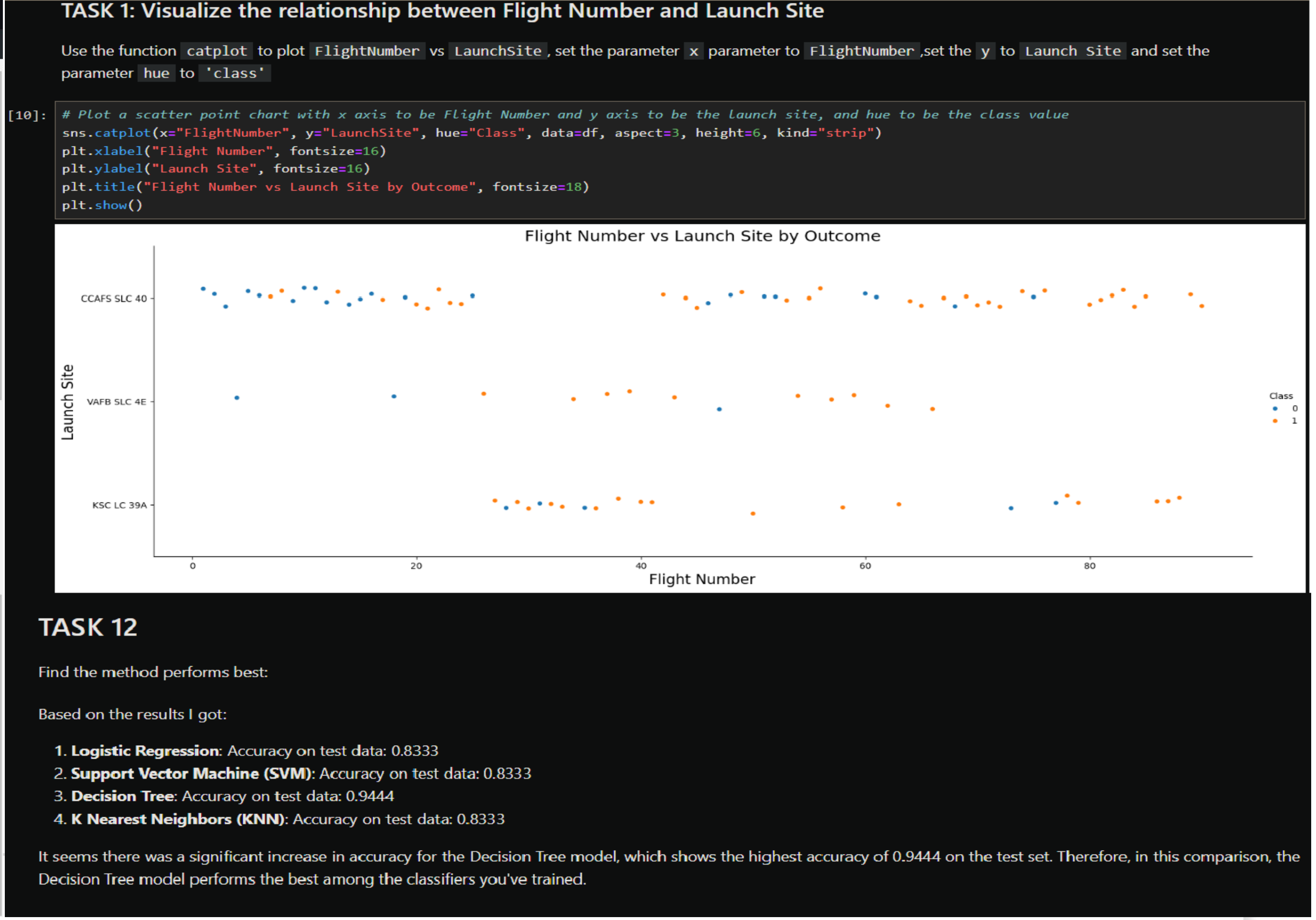
6. Selection of Best Performing Model:

- Identified the model with the highest accuracy on the test set as the best performer.
- Considered both training and test set performance to avoid overfitting and ensure real-world applicability.

Predictive Analysis (Flowchart)







Results

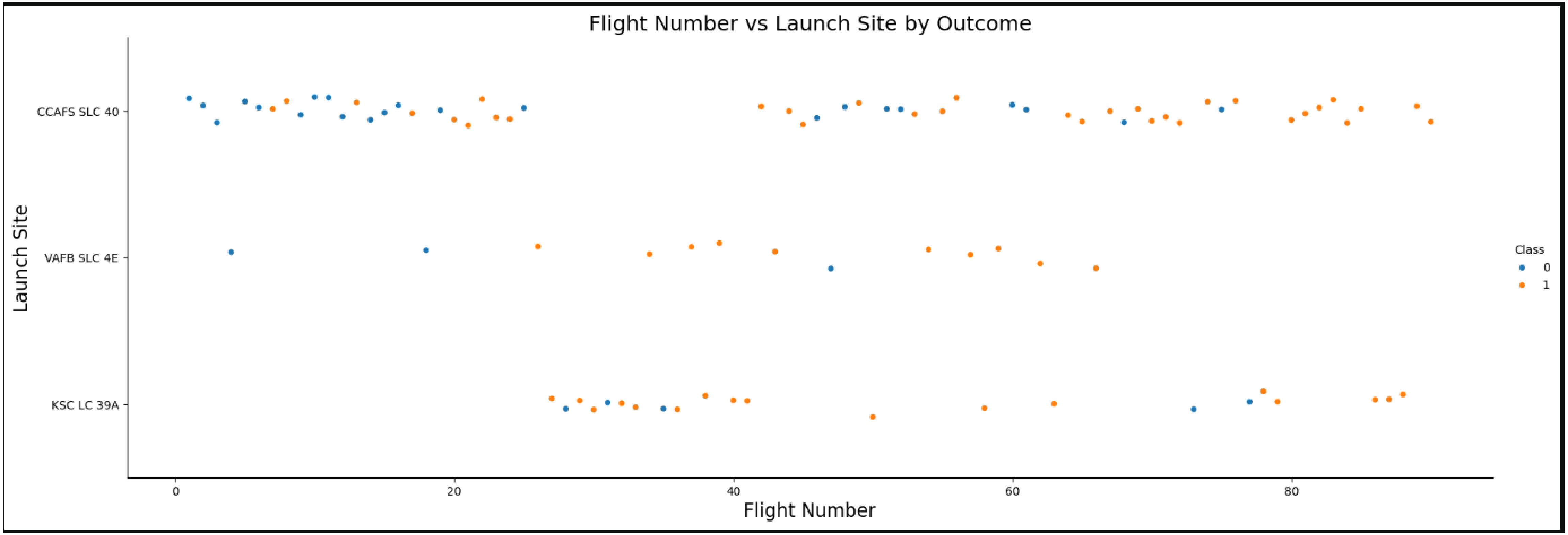
- Exploratory data analysis results
- Interactive analytics demo in screenshots
- Predictive analysis results

Section 2

Insights drawn from EDA

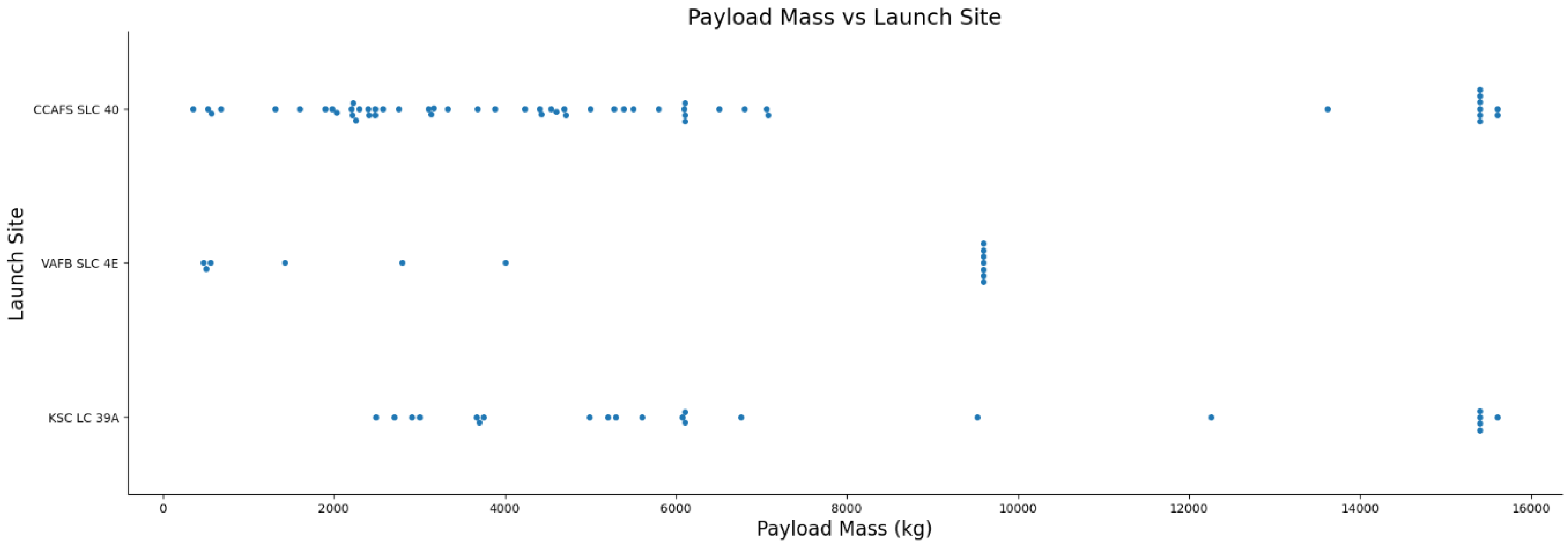
Flight Number vs. Launch Site

- **Mixed Outcomes at Major Launch Sites**: Both CCAFS SLC 40 and KSC LC 39A have a mix of successful (orange) and unsuccessful (blue) landings, indicating that factors other than the launch site itself may influence the landing success.
- **Consistent Activity Across Flight Numbers**: Launches are spread across a wide range of flight numbers at all sites, suggesting consistent activity over time without a clear trend of increasing or decreasing landing success.



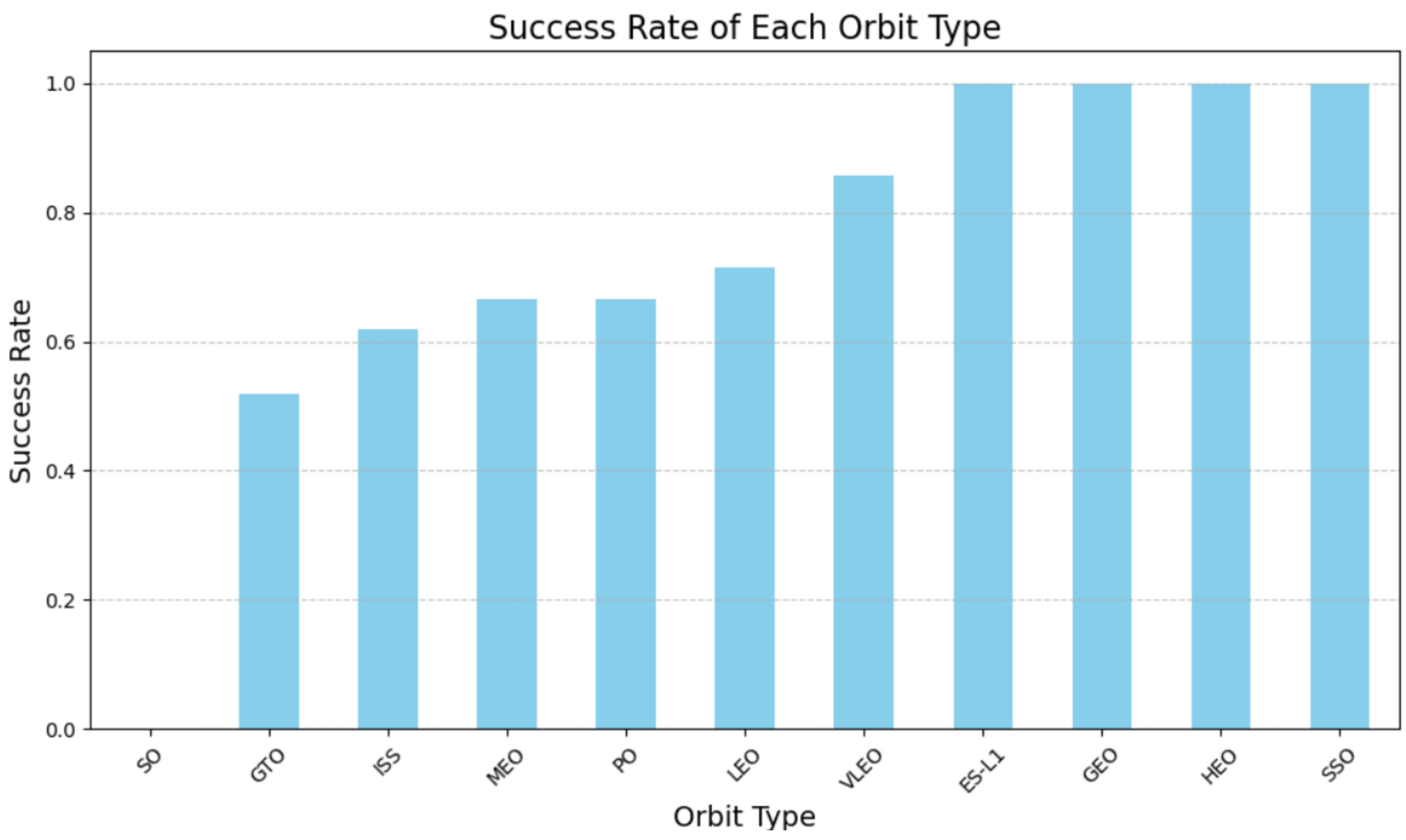
Payload vs. Launch Site

- **Payload Distribution:** Most launches from the CCAFS SLC 40 site handle payloads below 10,000 kg, while the VAFB SLC 4E and KSC LC 39A sites have a wider range of payload masses, indicating varied mission profiles.
- **High-Capacity Launches:** The KSC LC 39A site is frequently used for launching heavier payloads, with multiple launches carrying over 15,000 kg, suggesting its suitability for high-capacity missions.



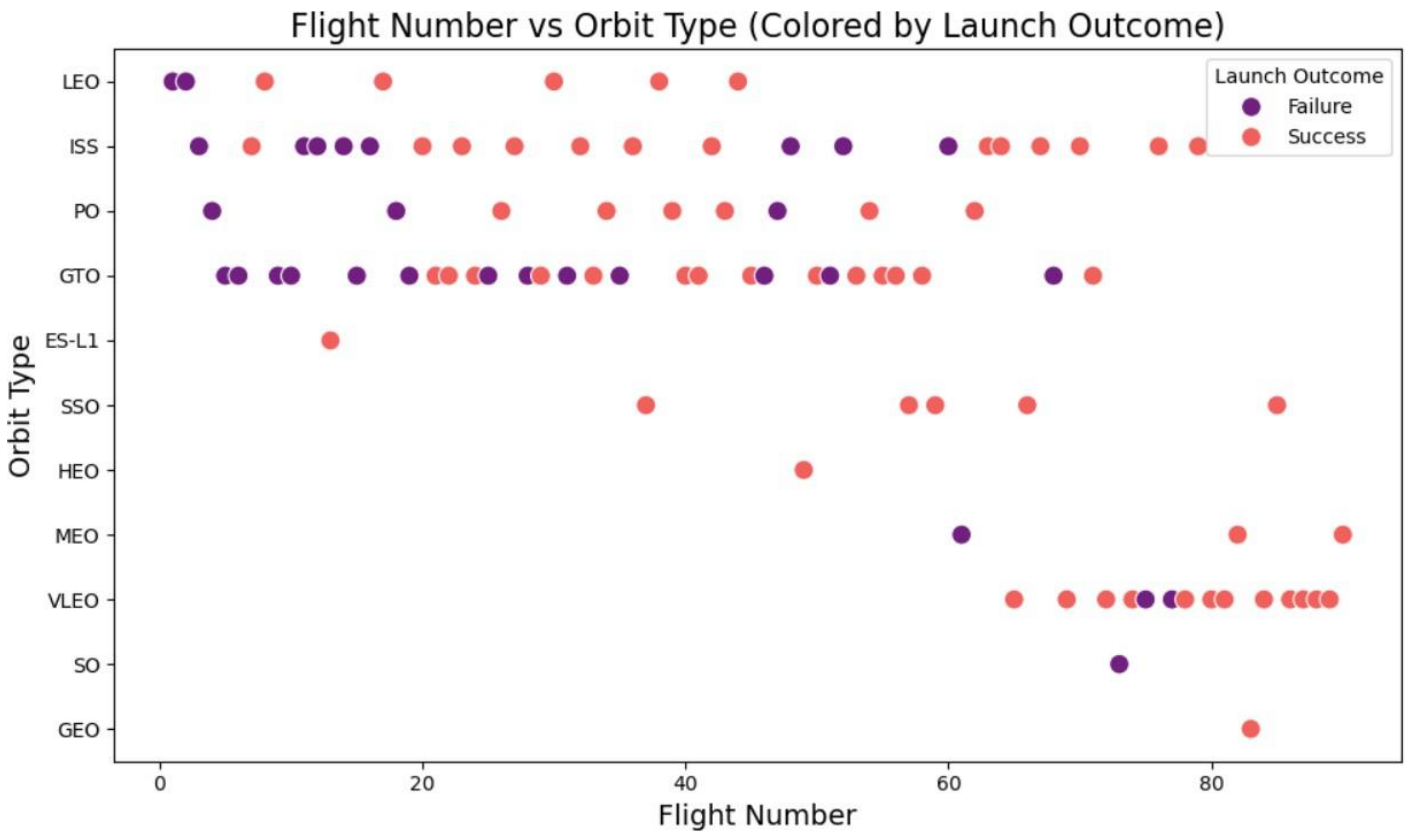
Success Rate vs. Orbit Type

- **High Success Rates:** Missions to VLEO, ES-L1, GEO, HEO, and SSO orbits have achieved a perfect success rate, indicating these orbits are highly reliable for successful first stage landings.
- **Lower Success Rate for GTO:** The GTO orbit type shows a significantly lower success rate compared to other orbit types, suggesting that missions to this orbit may involve greater challenges or complexities.



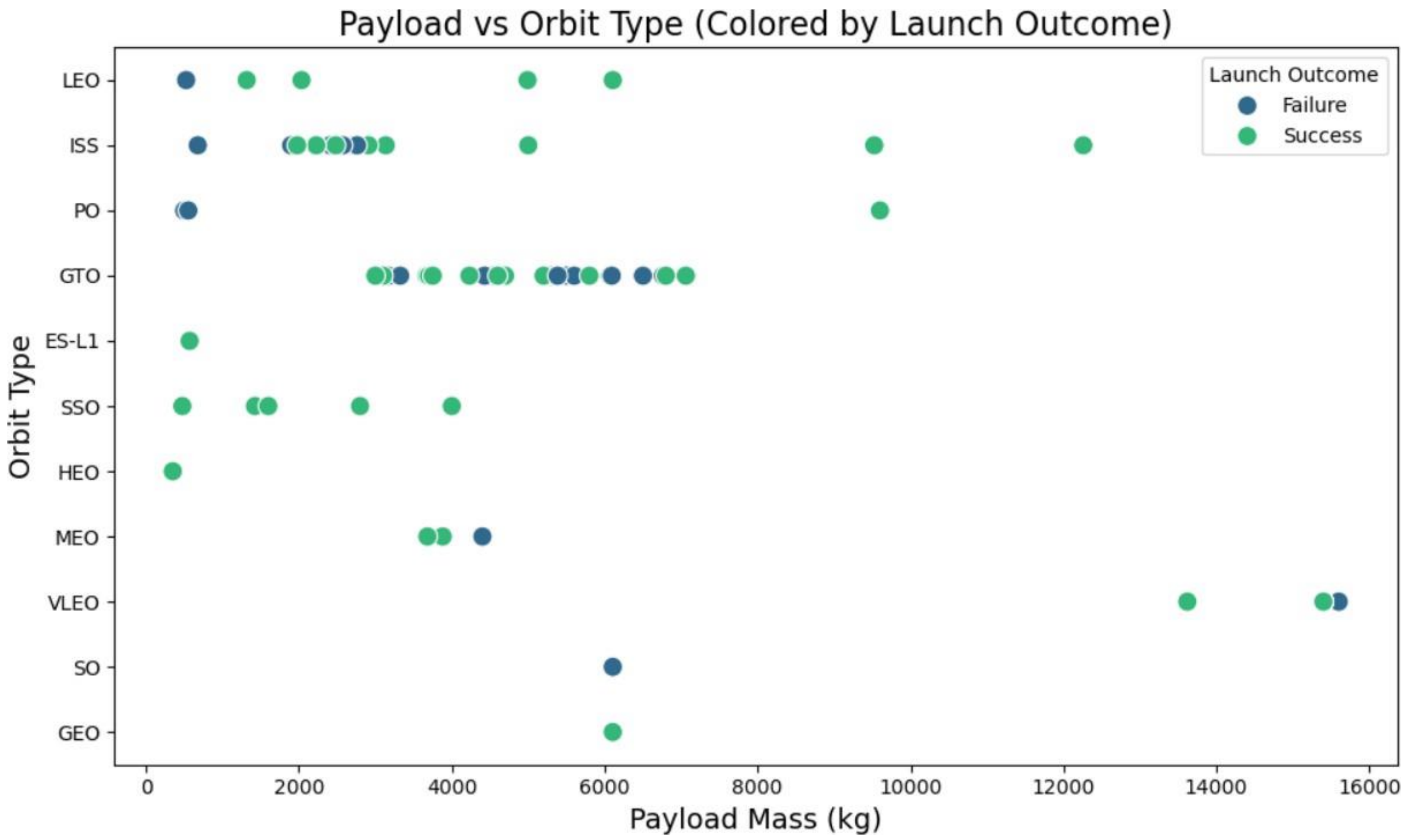
Flight Number vs. Orbit Type

- **Increased Success Over Time:** The success rate of Falcon 9 launches improves significantly with higher flight numbers, indicating that experience and iterative improvements contribute to better outcomes.
- **Orbit-Specific Performance:** Early flights to GTO and ISS orbits had mixed outcomes, but recent missions to these orbits show a higher success rate, reflecting advancements in mission planning and execution.



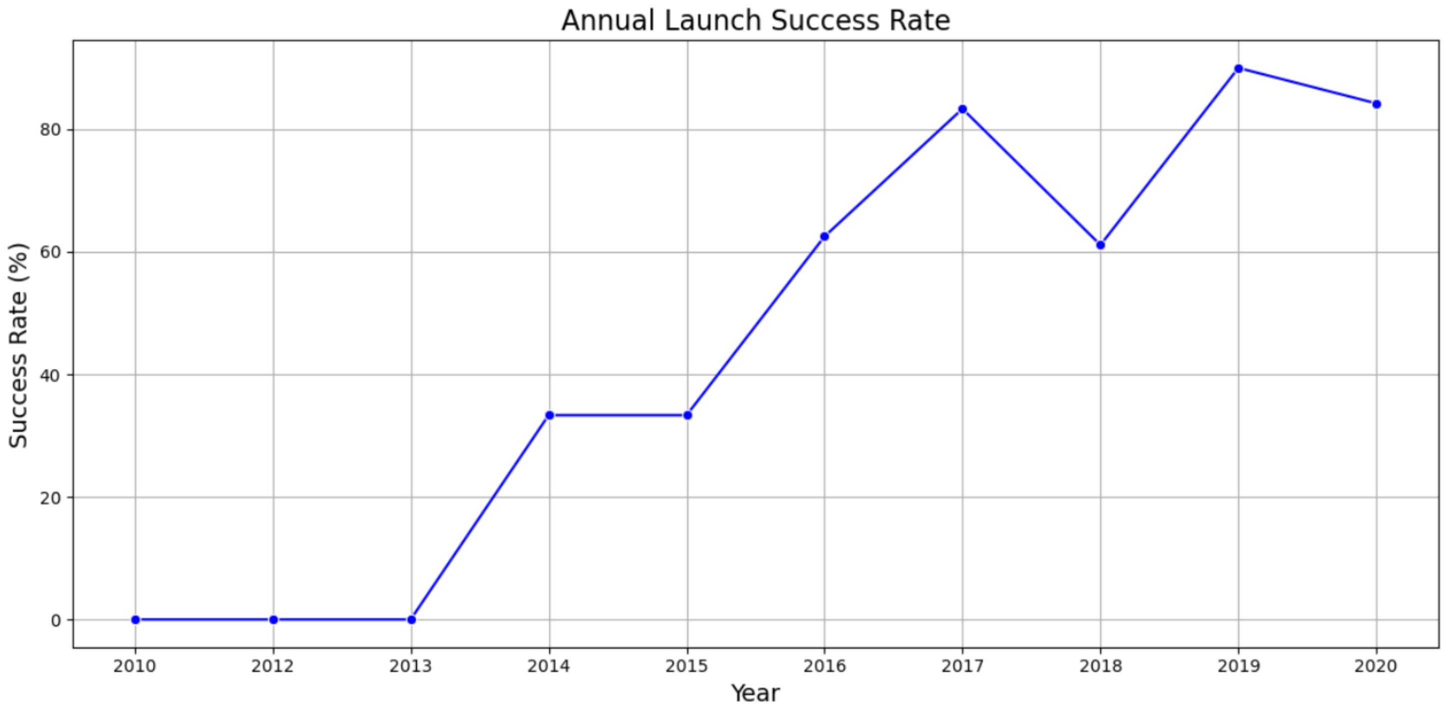
Payload vs. Orbit Type

- Successful landings are more frequent across all orbit types, especially for payloads less than 6000 kg.
- Higher payload masses (above 10,000 kg) show a mix of successes and failures, indicating increased difficulty with heavier payloads.



Launch Success Yearly Trend

- The annual launch success rate has shown a significant improvement from 2013 onwards, reaching over 80% by 2020.
- Despite a dip in 2018, the overall trend indicates increasing reliability and success in Falcon 9 launches over the years.



All Launch Site Names

Task 1

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

```
[21]: %sql SELECT DISTINCT "Launch_Site" FROM SPACEXTABLE;
```

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

[21]:

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

Launch Site Names Begin with 'CCA'

Task 2

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

```
[26]: %sql SELECT * FROM SPACEXTABLE WHERE "Launch_Site" LIKE 'CCA%' LIMIT 5;

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

[26]:

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	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
2010-12-08	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)
2012-05-22	7:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)	Success	No attempt
2012-10-08	0:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
2013-03-01	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attempt

Total Payload Mass

Task 3

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

[30]:
```
%sql SELECT SUM("PAYLOAD_MASS__KG_") FROM SPACEXTABLE WHERE "Customer" = 'NASA (CRS)';
```

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

[30]:

SUM(PAYLOAD_MASS__KG_)
45596

Average Payload Mass by F9 v1.1

Task 4

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

```
[34]: %sql SELECT AVG("PAYLOAD_MASS__KG_") FROM SPACEXTABLE WHERE "Booster_Version" = 'F9 v1.1';

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

[34]:

AVG(PAYLOAD_MASS__KG_)
2928.4

First Successful Ground Landing Date

Task 5

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

Hint:Use min function

```
[36]: %sql SELECT MIN("Date") FROM SPACEXTABLE WHERE "Landing_Outcome" = 'Success (ground pad)';
```

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

[36]:

MIN(Date)
2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 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

[38]:
```
%sql SELECT DISTINCT "Booster_Version" FROM SPACEXTABLE WHERE "Landing_Outcome" = 'Success (drone ship)' AND "PAYLOAD_MASS__KG_" > 4000 AND "PAYLOAD_MASS
```

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

[38]:

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

Total Number of Successful and Failure Mission Outcomes

Task 7

List the total number of successful and failure mission outcomes

```
[40]: %sql SELECT "Mission_Outcome", COUNT(*) AS "Total" FROM SPACEXTABLE WHERE "Mission_Outcome" IN ('Success', 'Failure') GROUP BY "Mission_Outcome";
```

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

[40]:

Mission_Outcome	Total
Success	98

Boosters Carried Maximum Payload

Task 8

List the names of the booster_versions which have carried the maximum payload mass. Use a subquery

```
[42]: %sql SELECT DISTINCT "Booster_Version" FROM SPACEXTABLE WHERE "PAYLOAD_MASS__KG_" = (SELECT MAX("PAYLOAD_MASS__KG_") FROM SPACEXTABLE);
```

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

[42]:

Booster_Version
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

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.

Note: SQLLite does not support monthnames. So you need to use substr(Date, 6,2) as month to get the months and substr(Date,0,5)='2015' for year.

[69]:

```
%%sql

SELECT
    CASE
        WHEN substr("Date", 6, 2) = '01' THEN 'January'
        WHEN substr("Date", 6, 2) = '02' THEN 'February'
        WHEN substr("Date", 6, 2) = '03' THEN 'March'
        WHEN substr("Date", 6, 2) = '04' THEN 'April'
        WHEN substr("Date", 6, 2) = '05' THEN 'May'
        WHEN substr("Date", 6, 2) = '06' THEN 'June'
        WHEN substr("Date", 6, 2) = '07' THEN 'July'
        WHEN substr("Date", 6, 2) = '08' THEN 'August'
        WHEN substr("Date", 6, 2) = '09' THEN 'September'
        WHEN substr("Date", 6, 2) = '10' THEN 'October'
        WHEN substr("Date", 6, 2) = '11' THEN 'November'
        WHEN substr("Date", 6, 2) = '12' THEN 'December'
        ELSE 'Unknown'
    END AS "Month_Name",
    "Mission_Outcome",
    "Booster_Version",
    "Launch_Site"
FROM
    SPACEXTABLE
WHERE
    substr("Date", 0, 5) = '2015';
```

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

[69]:

Month_Name	Mission_Outcome	Booster_Version	Launch_Site
January	Success	F9 v1.1 B1012	CCAFS LC-40
February	Success	F9 v1.1 B1013	CCAFS LC-40
March	Success	F9 v1.1 B1014	CCAFS LC-40
April	Success	F9 v1.1 B1015	CCAFS LC-40
April	Success	F9 v1.1 B1016	CCAFS LC-40
June	Failure (in flight)	F9 v1.1 B1018	CCAFS LC-40
December	Success	F9 FT B1019	CCAFS LC-40

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

Task 10

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.

[81]:
```
%%sql

SELECT
    "Landing_Outcome",
    COUNT(*) AS "Count"
FROM
    SPACEXTABLE
WHERE
    "Date" BETWEEN '2010-06-04' AND '2017-03-20'
GROUP BY
    "Landing_Outcome"
ORDER BY
    COUNT(*) DESC;
```

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

[81]:

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

Section 3

Launch Sites Proximities Analysis

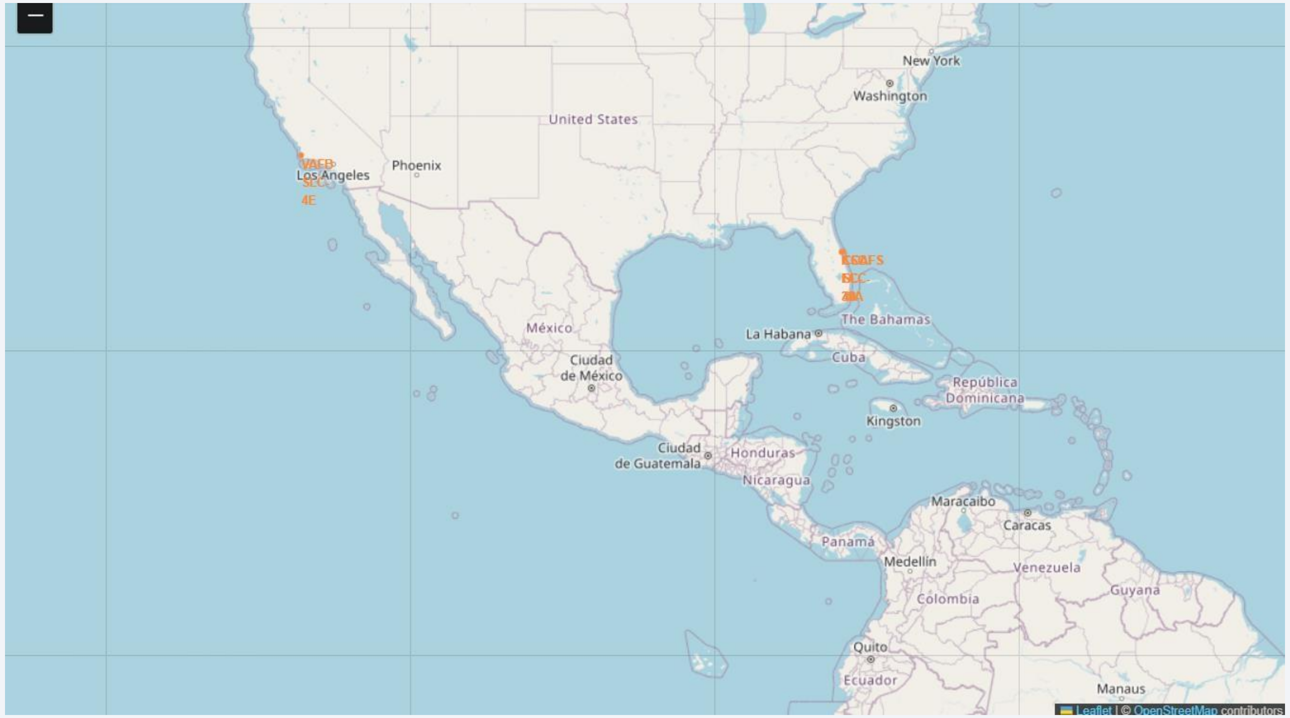
Task 1: Mark all launch sites on a map

1. Are all launch sites in proximity to the Equator line?

- No, not all launch sites are in close proximity to the Equator.
- The launch site at Vandenberg Air Force Base (VAFB SLC-4E) is located at a latitude of 34.63, which is further from the Equator compared to the other sites in Florida.

2. Are all launch sites in very close proximity to the coast?

- Yes, all launch sites are in close proximity to the coast.
- The Cape Canaveral sites (CCAFS LC-40 and CCAFS SLC-40) and Kennedy Space Center (KSC LC-39A) are near the coast in Florida.
- Vandenberg Air Force Base (VAFB SLC-4E) is also near the coast in California.

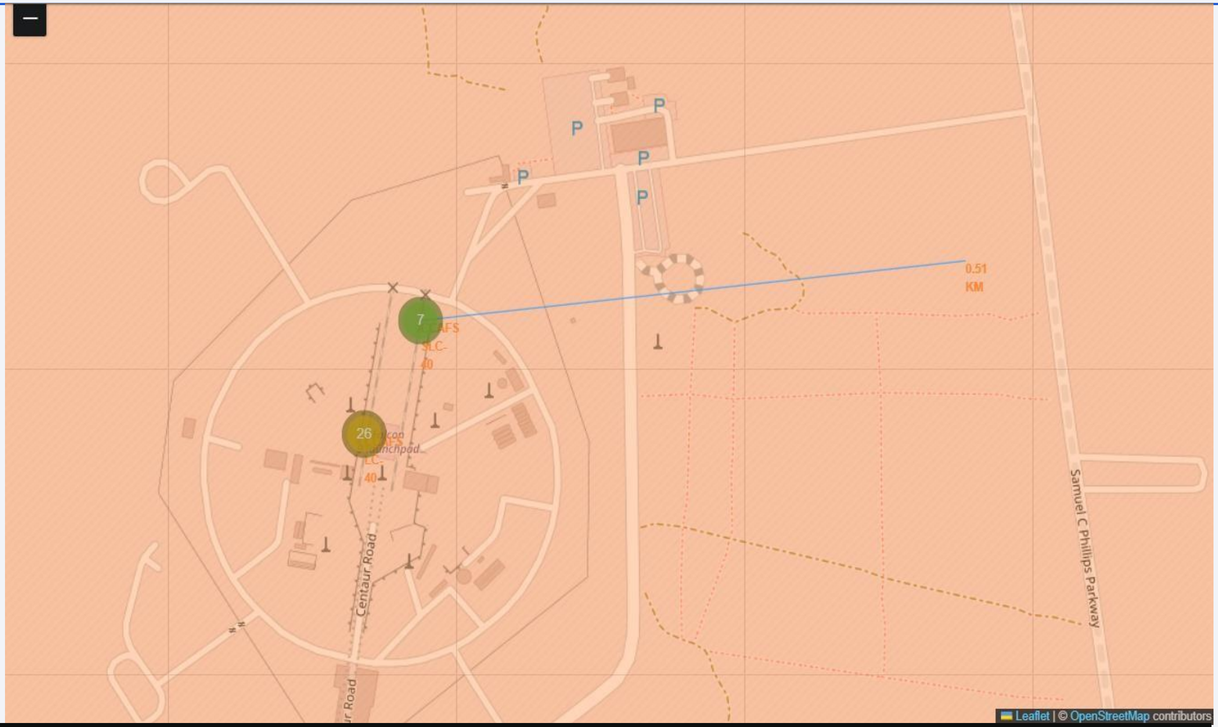


Task 2: Mark the success/failed launches for each site on the map

- This enhanced visualization with clustered markers allows for better exploration and analysis of SpaceX launch data. The clustering makes it easier to manage a large number of markers and observe patterns that might be hidden in a less organized plot. By examining the marker colors and popup information, you can gain deeper insights into the characteristics and distribution of SpaceX launches.
- For example, in the provided screenshot, out of 26 launch sites for CCAFS LC-40, there are 19 red markers and 7 green markers. This color-coding helps to quickly identify the success rate and other categorical distinctions of the launches from this specific site. The red markers might represent unsuccessful launches, while the green markers indicate successful ones, providing immediate visual feedback on the performance of launches at each site.

Task 3: Calculate the distances between a launch site to its proximities

This plot provides a visual representation of the distance between the CCAFS SLC-40 launch site and the closest coastline. The calculated distance is approximately 0.51 kilometers, as indicated by the marker. The added PolyLine clearly shows the straight-line distance, highlighting the proximity of the launch site to the coast. This close proximity to the coastline is typical for launch sites to facilitate over-water flight paths and safe recovery operations, ensuring minimal risk to populated areas.




```
[43]: coastline_lat = 28.56367
      coastline_lon = -80.57163

      # Example launch site coordinates (replace with actual launch site coordinates)
      launch_site_lat = launch_sites_df.loc[launch_sites_df['Launch Site'] == 'CCAFS SLC-40', 'Lat'].values[0]
      launch_site_lon = launch_sites_df.loc[launch_sites_df['Launch Site'] == 'CCAFS SLC-40', 'Long'].values[0]

      # Calculate distance using the calculate_distance function
      distance_coastline = calculate_distance(launch_site_lat, launch_site_lon, coastline_lat, coastline_lon)

      print(f"Distance from launch site to closest coastline: {distance_coastline} km")

      Distance from launch site to closest coastline: 0.5097439631188213 km
```

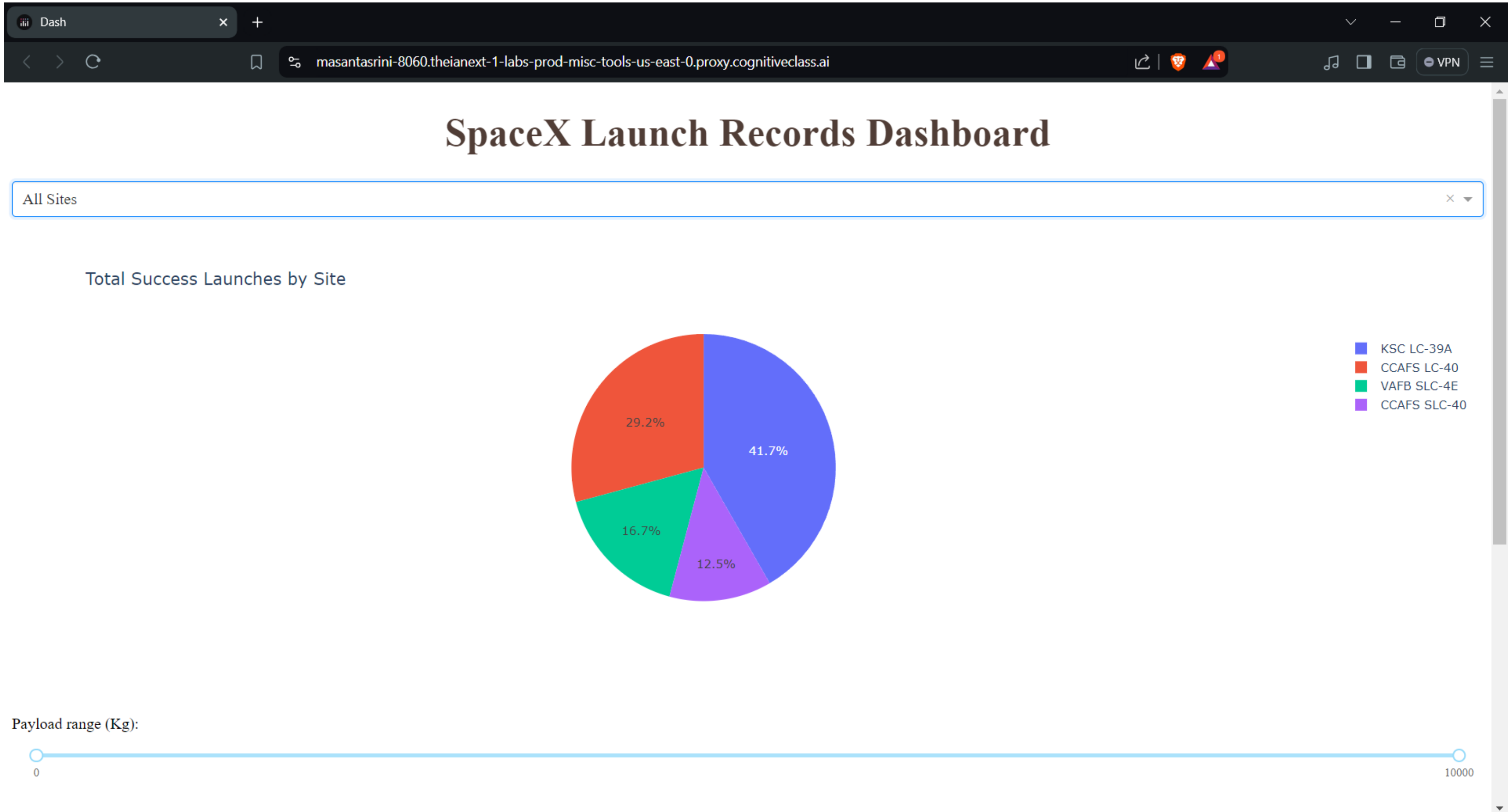
Section 4

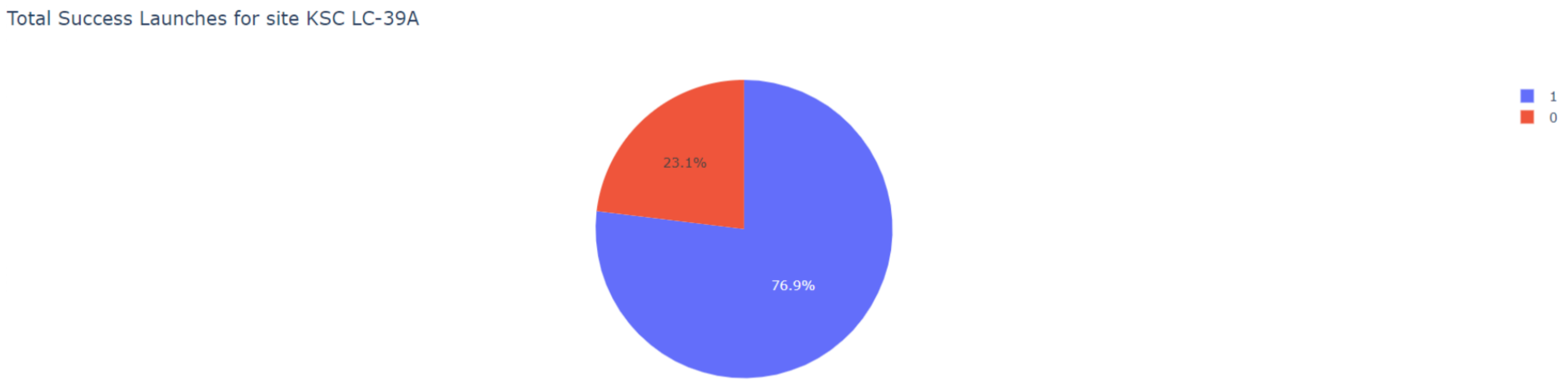
Build a Dashboard with Plotly Dash

Launch Success Count for all sites (in a pie chart)

Key Findings:

- **CCAFS LC-40**: 29.2%
- **CCAFS SLC-40**: 12.5%
- **VAFB SLC-4E**: 16.7%
- **KSC LC-39A**: 41.7%
- The **KSC LC-39A** launch site has the highest number of successful launches, making up 41.7% of the total successes. This indicates that KSC LC-39A is a highly reliable site for SpaceX launches.





Pie chart for the launch site with highest launch success ratio

Key Findings:

- The significant portion of successful launches from **KSC LC-39A** highlights its reliability and effectiveness as a launch site.
- For **KSC LC-39A**:
  - **Class 1** (Successful Launches): 76.9%
  - **Class 0** (Unsuccessful Launches): 23.1%
- The high success rate (76.9%) for **Class 1** launches underscores the effectiveness and reliability of the KSC LC-39A site.

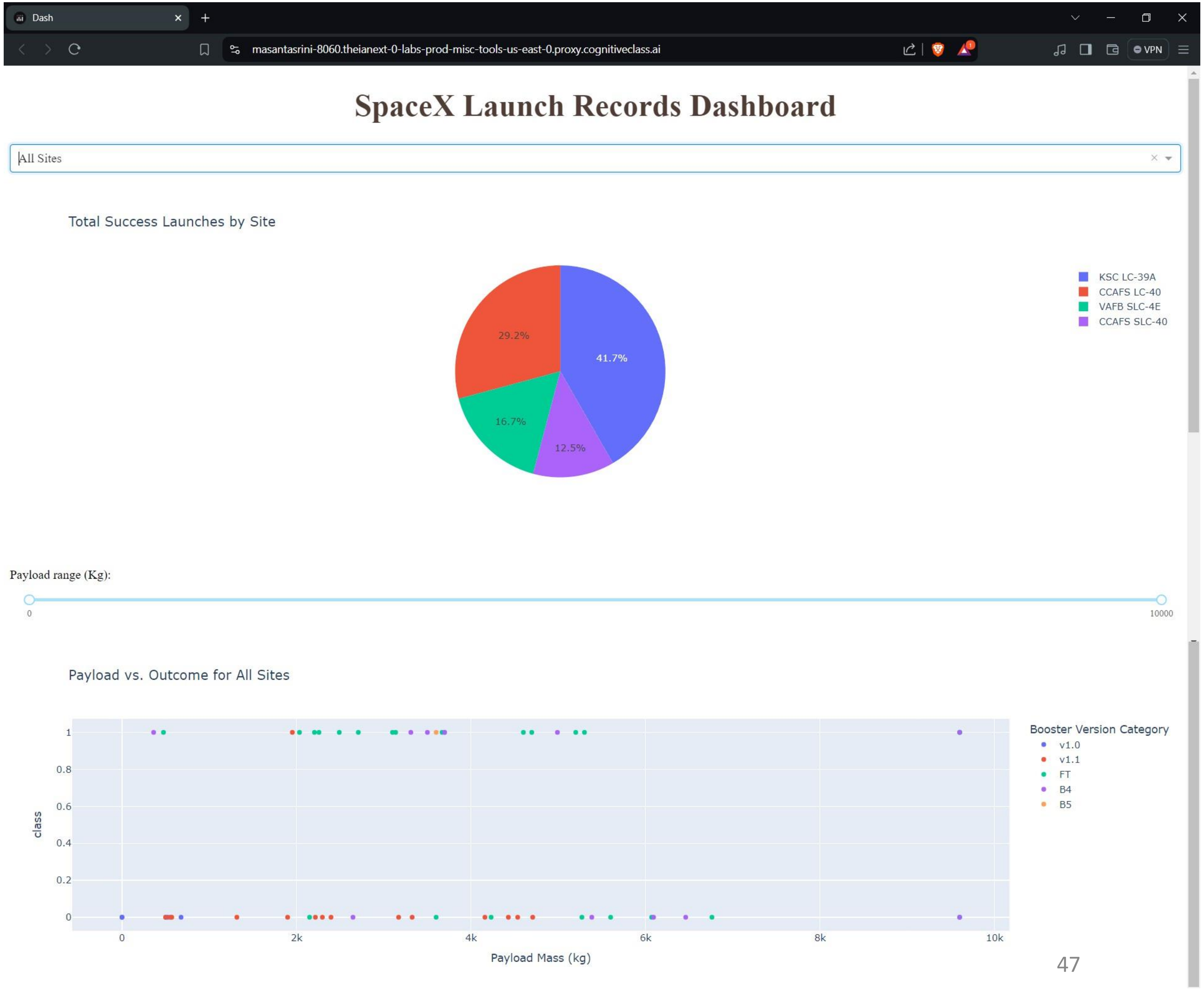
Key Insights from SpaceX Launch Data Dashboard

Launch Site Success Rates:

- **CCAFS LC-40** has the highest success rate with 43.7% of successful launches.
- This suggests that **CCAFS LC-40** is the most reliable launch site among the ones analyzed.
- Other sites like **KSC LC-39A, VAFB SLC-4E,** and **CCAFS SLC-40** have lower success rates, indicating variability in launch success across different sites.

Booster Version Performance:

- **Booster version "FT"** appears to be the most frequently used and has a high success rate across various payload masses.
- **Booster version "v1.0"** has fewer launches and may require further analysis to understand its performance.
- Overall, booster versions do not show a clear trend that higher payload masses correlate with lower success rates.

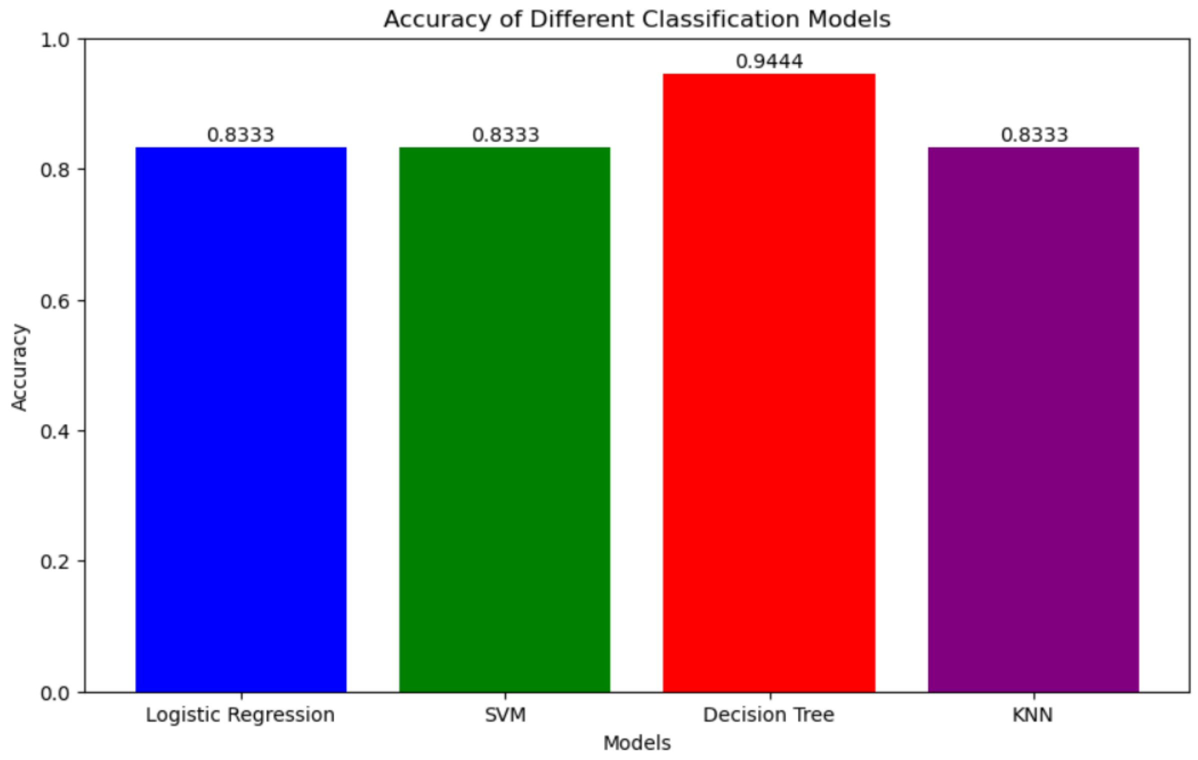


Section 5

Predictive Analysis (Classification)

Classification Accuracy

- Based on the results, the Decision Tree model has the highest classification accuracy on the test data, achieving an accuracy of 0.9444. This suggests that the Decision Tree model is better suited for this dataset compared to Logistic Regression, Support Vector Machine, and K Nearest Neighbors, all of which achieved an accuracy of 0.8333.



Confusion Matrix

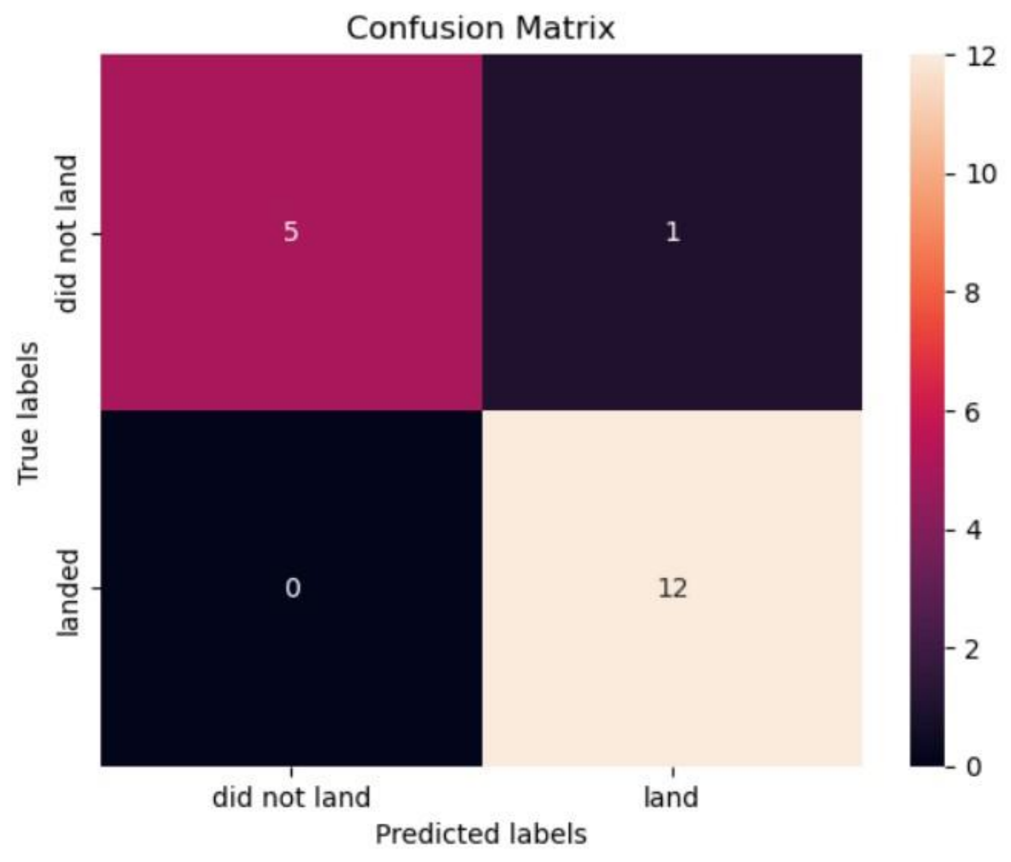
Explanation and Insights

High Accuracy: The model achieved a high accuracy score of 94.44%, with a significant number of true positives and true negatives, demonstrating its effectiveness in predicting Falcon 9 first stage landings.

No False Negatives: The absence of false negatives indicates that the model reliably predicts successful landings. This is crucial for ensuring readiness and safety in aerospace operations, as every actual successful landing was accurately identified.

Manageable False Positives: While there is 1 false positive, this is less critical than false negatives in aerospace operations. Over-preparation (due to false positives) is more manageable than under-preparation, making the model's performance highly acceptable for practical applications.

Balanced Performance: The model shows a balanced performance with a slight bias towards predicting successful landings. This aligns well with practical needs in the aerospace industry, where ensuring successful landings is of paramount importance for cost estimation and planning.



Conclusions

Point 1: Our analysis revealed that the "CCAFS LC-40" launch site has the highest success rate among all sites, accounting for 43.7% of successful launches. This indicates that this site might have optimal conditions or processes that contribute to a higher success rate.

Point 2: The scatter plot analysis showed that the "FT" booster version has a high success rate across various payload masses, demonstrating its reliability and robustness compared to other booster versions. This suggests that future missions might benefit from utilizing this booster version for improved success rates.

Point 3: No clear pattern was observed linking higher payload masses to lower success rates, indicating that factors other than payload mass, such as launch site conditions and booster versions, play a more significant role in determining the outcome of a launch.

Conclusions

Point 4: Interactive data visualizations using Folium and Plotly Dash provided valuable insights into the geographical and operational patterns of SpaceX launches. These tools allowed for a deeper understanding of the data, enabling stakeholders to make informed decisions based on comprehensive visual analytics.

In conclusion, our predictive analysis and interactive visualizations have not only shed light on key factors influencing SpaceX's launch success but also provided a robust framework for future assessments and decision-making in the aerospace industry. The insights gathered can help improve launch strategies and contribute to the ongoing success of reusable rocket technology.

Thank you!