IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

Executive Summary

- Summary of methodologies
  - Data collection
  - Data wrangling
  - Exploratory Data Analysis with Data Visualization
  - Exploratory Data Analysis with SQL
  - Building an interactive map with Folium
  - Building a Dashboard with Plotly Dash
  - Predictive analysis (Classification)
- Summary of all results
  - Exploratory Data Analysis results
  - Interactive analytics demo in screenshots
  - Predictive analysis results

Introduction

- Project background and context
  - SpaceX has revolutionized commercial spaceflight by significantly reducing launch costs, largely due to its ability to reuse the first stage of its Falcon 9 rockets. While competitors charge over $165 million per launch, SpaceX offers launches for $62 million. This cost efficiency hinges on whether the first stage can be successfully recovered. In this project, we aim to predict the likelihood of first stage reuse using public data and machine learning techniques.
- Problems you want to find answers
  - In what ways do factors like payload mass, launch location, total number of flights, and orbital parameters influence the likelihood of a successful first stage landing?
  - Has there been a noticeable improvement in first stage landing success rates over time?
  - Which classification algorithm is most effective for predicting first stage landing outcomes in this context?

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - Accessing data through the SpaceX REST API and Extracting information via web scraping from Wikipedia
- Perform data wrangling
  - Refining the dataset by filtering
  - Handling incomplete or missing data entries
  - Applying One-Hot Encoding to format the data for binary classification analysis
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - Developing, optimizing, and assessing classification models to achieve optimal performance

Data Collection

- The data collection process combined API requests to the SpaceX REST API with web scraping from a launch table on SpaceX's Wikipedia page. Using both methods allowed us to gather comprehensive launch data necessary for a more in-depth analysis.

Data Collection – SpaceX API

Step 1: Acquire Launch Data

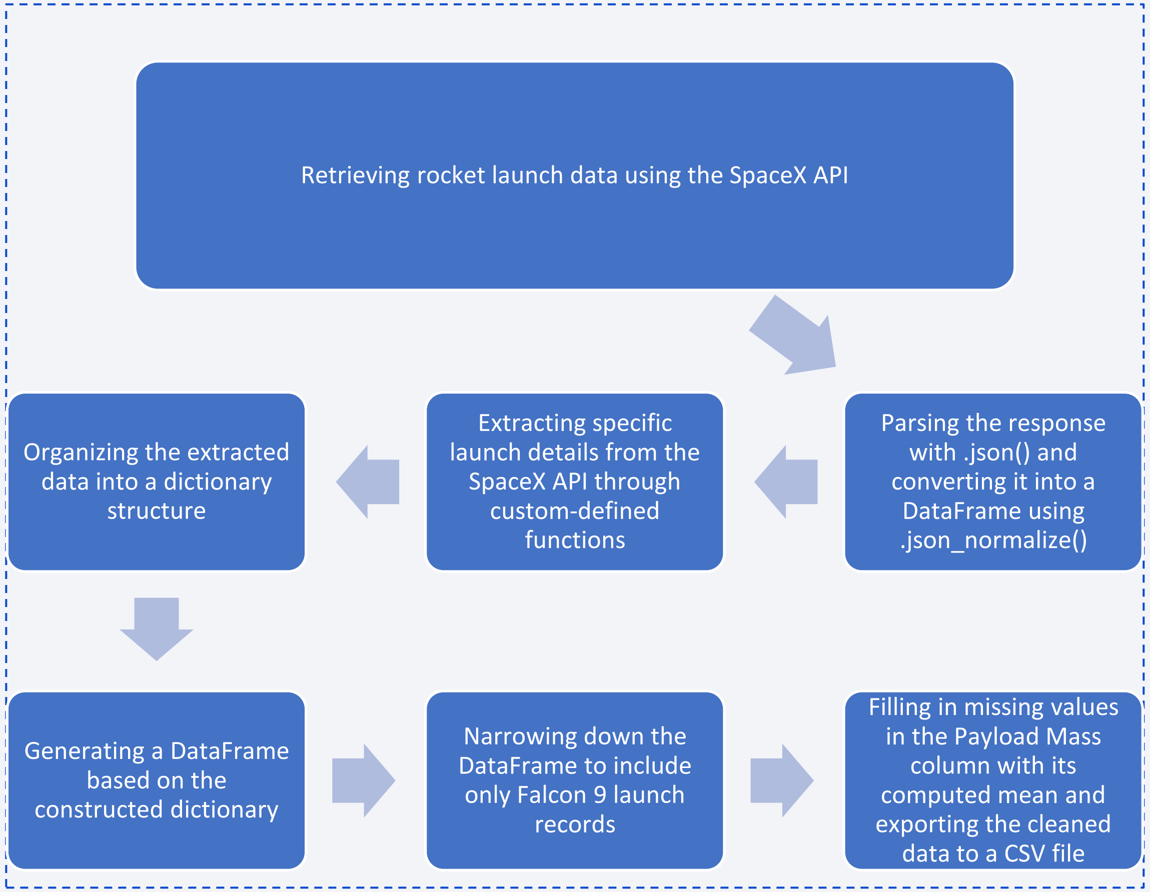
- Use Python's requests library to connect to the SpaceX REST API and request launch data.Use custom functions to target and extract specific information about each launch.

Step 2: Process API Response

- Decode the JSON response using .json() and flatten nested structures with json_normalize() for compatibility with pandas.Convert the dictionary into a pandas DataFrame. Filter the DataFrame to include only Falcon 9 launches for focused analysis.

Step 3: Clean and Export

- DataHandle missing values in the Payload Mass column by replacing them with the column's mean.Export the cleaned and filtered dataset to a CSV file for future modeling and analysis.



https://github.com/afnode/Rocket-Launch-Cost-Evaluation/blob/main/1_jupyter-labs-spacex-data-collection-api.ipynb

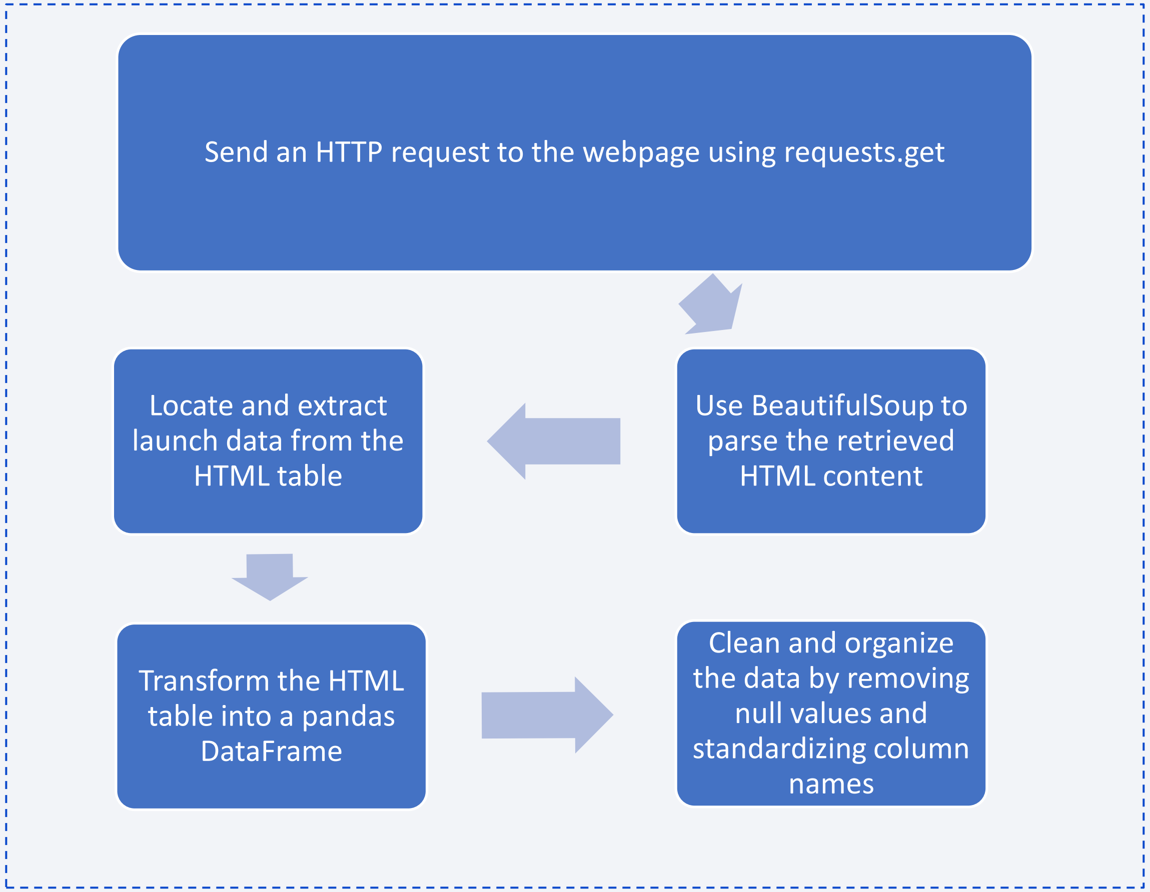
Data Collection - Scraping

Step 1: Retrieve and Extract Launch Table

- Use Python’s requests library to access the HTML content of the Wikipedia page containing SpaceX launch data.
- Parse the HTML using BeautifulSoup and extract the specific table listing Falcon 9 launches.

Step 2: Convert and Clean Data

- Transform the extracted HTML table into a pandas DataFrame for analysis.
- Clean the dataset by handling missing values, standardizing column names, and ensuring consistent formatting.



https://github.com/afnode/Rocket-Launch-Cost-Evaluation/blob/main/2_jupyter-labs-webscraping%20(1).ipynb

Data Wrangling

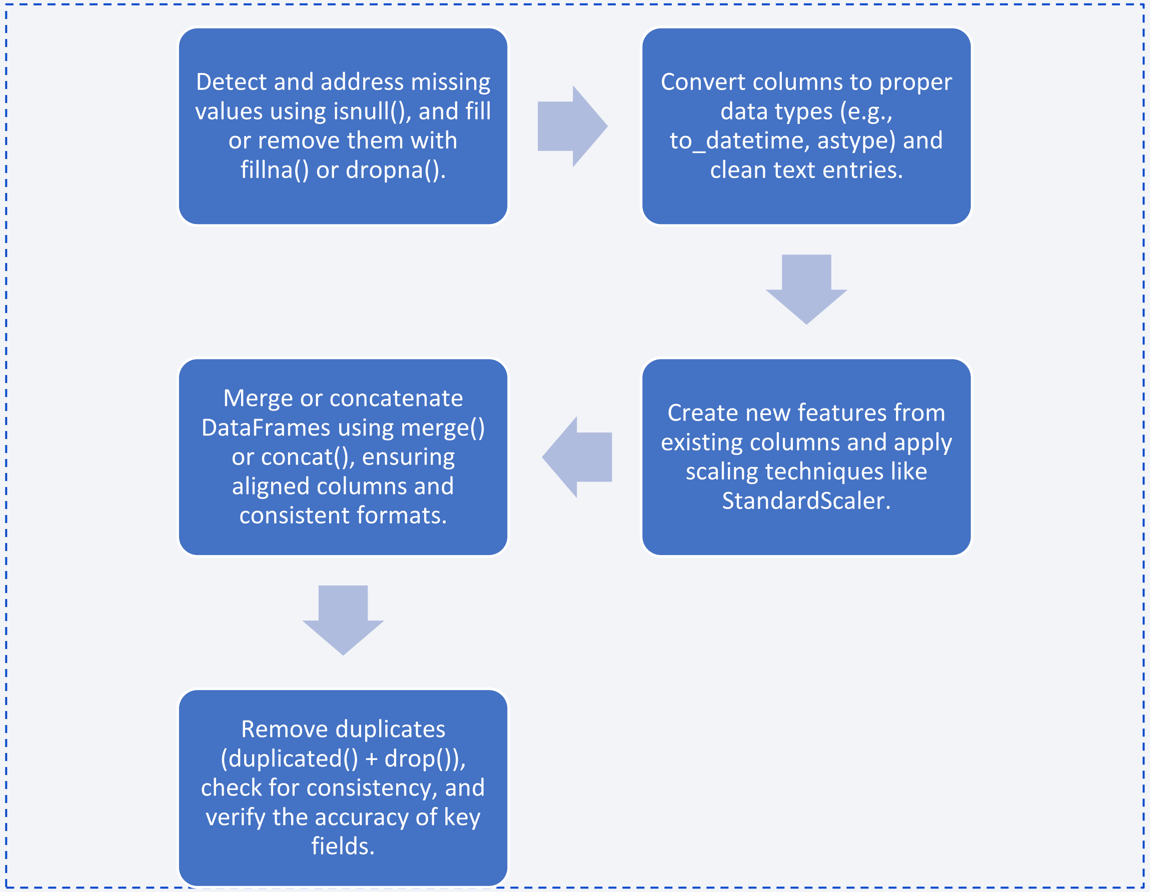
Step 1: Handle Missing Data
- Detect and address missing values within the dataset.
- Apply suitable imputation methods (e.g., mean, median) or remove rows/columns with excessive gaps.

Step 2: Transform Data Formats
- Convert data types into appropriate formats, such as changing strings to datetime or numeric types.
- Standardize text entries by making them lowercase, stripping whitespace, or correcting inconsistencies.

Step 3: Feature Engineering
- Generate new variables from existing data (e.g., extracting year from a date or categorizing payload mass).
- Normalize or scale numerical features to bring them onto a common range for modeling.

Step 4: Combine Multiple Data Sources
- Integrate datasets gathered from various sources (e.g., SpaceX API and Wikipedia) into a unified dataset.
- Align column names, formats, and data structures to ensure smooth merging.

Step 5: Validate and Finalize Dataset
- Remove duplicate records to prevent data skew.
- Check for inconsistencies or errors in values and confirm data integrity before modeling.



https://github.com/afnode/Rocket-Launch-Cost-Evaluation/blob/main/3_labs-jupyter-spacex-Data%20wrangling.ipynb

EDA with Data Visualization

1. Scatter Plots
   - Visualizes the relationship between two numerical variables
   - Useful for spotting correlations or patterns (e.g., Payload Mass vs. Launch Success)
   - Each point represents an individual launch, allowing comparison and trend recognition

2. Bar Charts
   - Used to compare categorical data, such as rocket types or launch sites
   - Specifically highlights the relationship between success rate and orbit type
   - Makes it easy to see how performance varies across different orbital destinations
   - Clearly displays frequencies or proportions of successful vs. failed launches by category

3. Line Charts
   - Shows how metrics change over time, shown as the yearly success rates from 2010 to 2020
   - Great for analyzing performance trends across months or years
   - Smoothly connects data points to reveal upward or downward trajectories

https://github.com/afnode/Rocket-Launch-Cost-Evaluation/blob/main/5_edadataviz.ipynb

EDA with SQL

Filtering Queries: Filtered records using WHERE clauses to isolate specific conditions such as rocket types, mission outcomes, or dates.

- Retrieved records of launches with payload mass between 4000 and 6000 kg.
- Isolated missions with a successful landing outcome on a drone ship.
- Filtered data to include only specific launch sites or booster versions.

Aggregate Queries: Used GROUP BY and aggregation functions like AVG() and COUNT() to calculate summary statistics.

- Listed names of boosters that had successful drone ship landings with payloads between 4000 and 6000 kg.
- Calculated the average payload mass carried by each booster version category.
- Counted total records for launches that met multiple filtering conditions.

Summary and Distinct Queries: Counted unique values using DISTINCT and COUNT to understand the diversity of launch sites and mission outcomes.

- Counted the number of distinct launch sites used across the dataset.
- Determined the number of unique booster version categories.
- Identified the total number of launches present in the dataset.

https://github.com/afnode/Rocket-Launch-Cost-Evaluation/blob/main/4_jupyter-labs-eda-sql-coursera_sqllite%20(2).ipynb

Build an Interactive Map with Folium

Markers:

- Plotted markers to represent SpaceX launch sites on the map.
- Each marker corresponds to a precise geographic location of a launch.
- Enables users to visually locate where SpaceX missions have originated.
- Provides spatial awareness of launch activity across different regions.

Circles:

- Added circular overlays around launch sites to indicate zones of influence.
- Visually depicts areas that may be relevant for operational or safety planning.
- Highlights proximity buffers surrounding launch locations.
- Useful for understanding safety boundaries or environmental impact zones.

Lines:

- Drew connecting lines between launch sites and nearby zones or features.
- Shows spatial links and directional relationships between key points.
- Helps illustrate connections between launch infrastructure and surrounding areas.
- Adds clarity to the geographic layout and spatial interactions of launch-related elements.

https://github.com/afnode/Rocket-Launch-Cost-Evaluation/blob/main/6_lab_jupyter_launch_site_location.ipynb

Build a Dashboard with Plotly Dash

Success Rate Pie Chart
• Visualizes the proportion of successful vs. failed launches.
• Provides a quick snapshot of overall mission performance.
• Useful for understanding SpaceX's launch reliability at a glance.

Payload Range Slider
• Lets users interactively set a custom payload mass range.
• Helps isolate launches within specific mass thresholds.
• Enables focused analysis of performance across different payload sizes.

Success vs. Payload Scatter Plot
• Plots each launch based on its payload mass and success outcome.
• Reveals trends or patterns between payload size and mission results.
• Allows users to identify potential payload thresholds affecting success rates.

Launch Site Dropdown Filter
• Lets users choose individual launch sites for targeted analysis.
• Simplifies geographic filtering and comparison across locations.
• Supports exploration of how outcomes vary by site.

https://github.com/afnode/Rocket-Launch-Cost-Evaluation/blob/main/7_spacex-dash-app.py

Predictive Analysis (Classification)

1. Data Loading

- Imported launch data from an external CSV file using a fetch() call.
- Loaded the dataset into a pandas DataFrame for analysis and preprocessing.

2. Feature Scaling

- Applied StandardScaler() to normalize feature values.
- Ensured that all numerical features contributed equally during model training.

3. Model Selection

- Explored several classification algorithms:
  – Logistic Regression
  – Support Vector Machines (SVM)
  – Decision Trees
  – K-Nearest Neighbors (KNN)
- Chose algorithms well-suited for binary classification problems.

4. Hyperparameter Tuning

• Used GridSearchCV to perform an exhaustive search for optimal hyperparameters.

• Tuned model-specific parameters (e.g., regularization strength, max depth, neighbors) for better accuracy.

5. Model Evaluation

• Evaluated performance using cross-validation to ensure generalization.

• Assessed accuracy scores on both training and test datasets to detect overfitting.

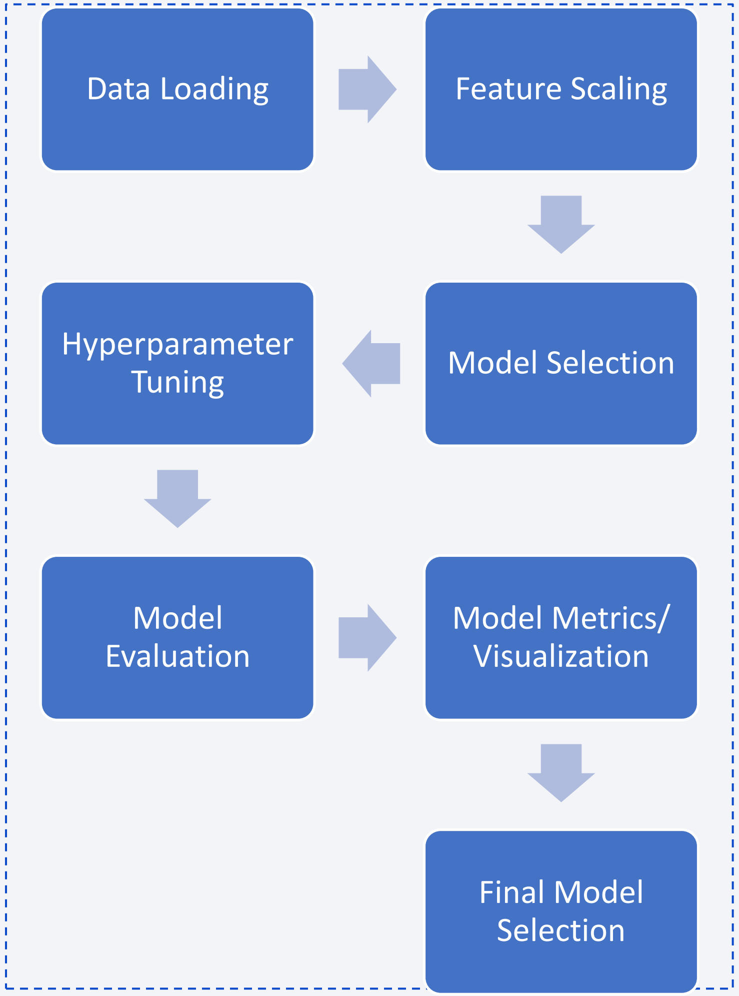
6. Model Metrics & Visualization

• Visualized confusion matrices for each model using seaborn heatmaps.

• Measured accuracy for a comprehensive performance review.

7. Final Model Selection

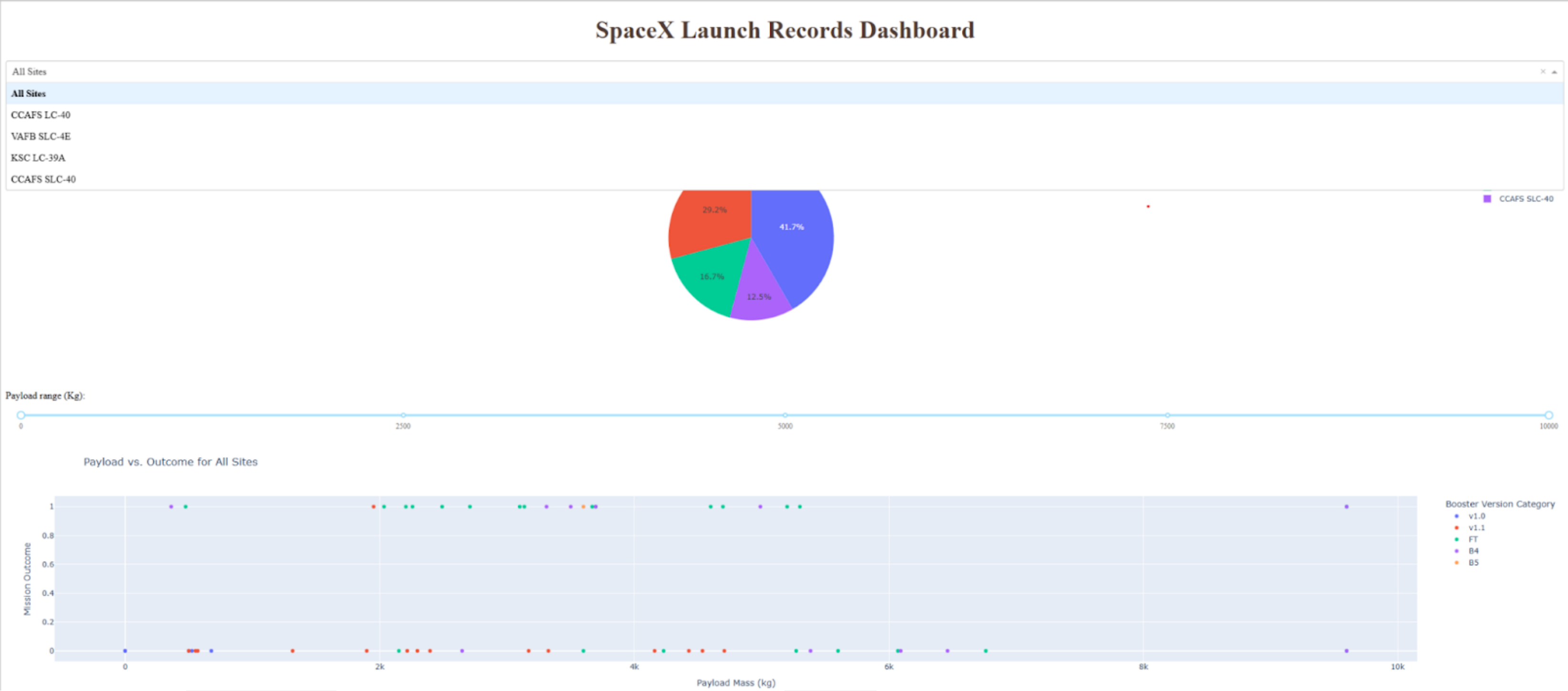
• Selected the best-performing model based on highest accuracy on the test set.



https://github.com/afnode/Rocket-Launch-Cost-Evaluation/blob/main/8.1_SpaceX_Machine%20Learning%20Prediction_Part_5.ipynb

Results

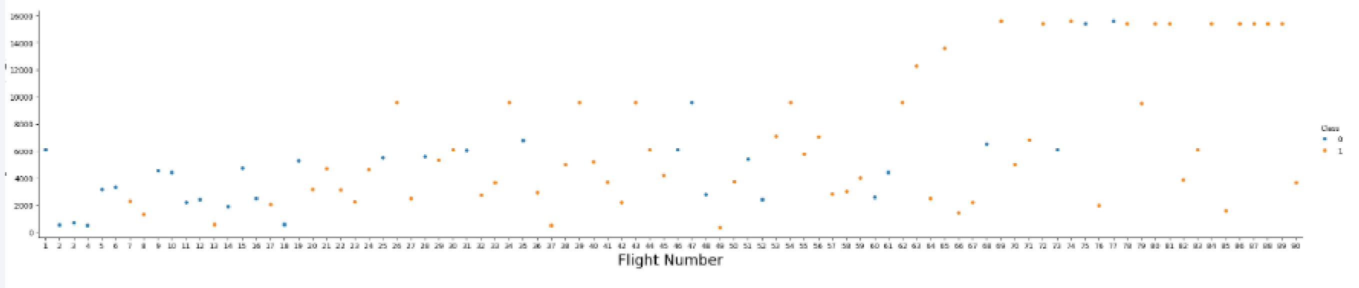
- Exploratory data analysis results
- Interactive analytics demo in screenshots
- Predictive analysis results



First, let's try to see how the `FlightNumber` (indicating the continuous launch attempts.) and `Payload` variables would affect the launch outcome.

We can plot out the `FlightNumber` vs. `PayloadMass` and overlay the outcome of the launch. We see that as the flight number increases, the first stage is more likely to land successfully. The payload mass also appears to be a factor; even with more massive payloads, the first stage often returns successfully.

```
sns.catplot(y="PayloadMass", x="FlightNumber", hue="Class", data=df, aspect = 5)
plt.xlabel("Flight Number",fontsize=20)
plt.ylabel("Pay load Mass (kg)",fontsize=20)
plt.show()
```



Find the method performs best:

```
print(test_accuracy)
print(svm_test_accuracy)
print(tree_test_accuracy)
print(knn_test_accuracy)
```

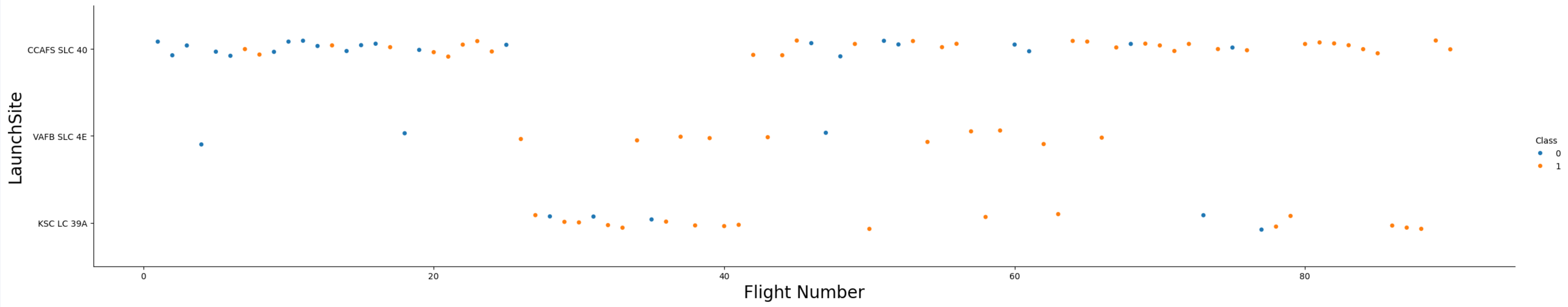
```
0.8333333333333334
0.8333333333333334
0.8888888888888888
0.8333333333333334
```

Section 2

Insights drawn from EDA

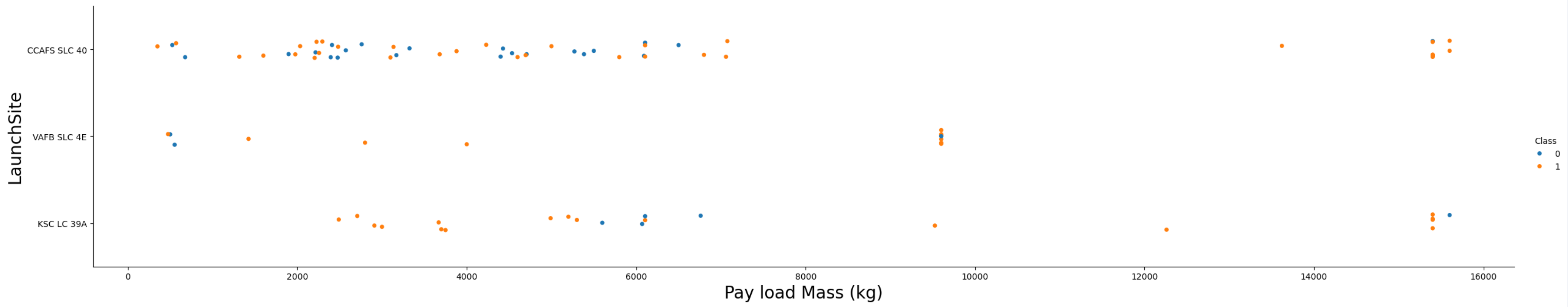
Flight Number vs. Launch Site

- Diverse Outcomes at CCAFS SLC 40: This site shows a combination of successful (orange) and failed (blue) landings, reflecting variability in mission results.
- Diverse Outcomes at KSC LC 39A: Similar to CCAFS, this site also experiences mixed landing outcomes, suggesting that success may depend on more than just the launch location.
- Stable Launch Frequency Over Time: Launches are distributed across a broad range of flight numbers at all sites, indicating sustained activity without a clear trend in success rates.



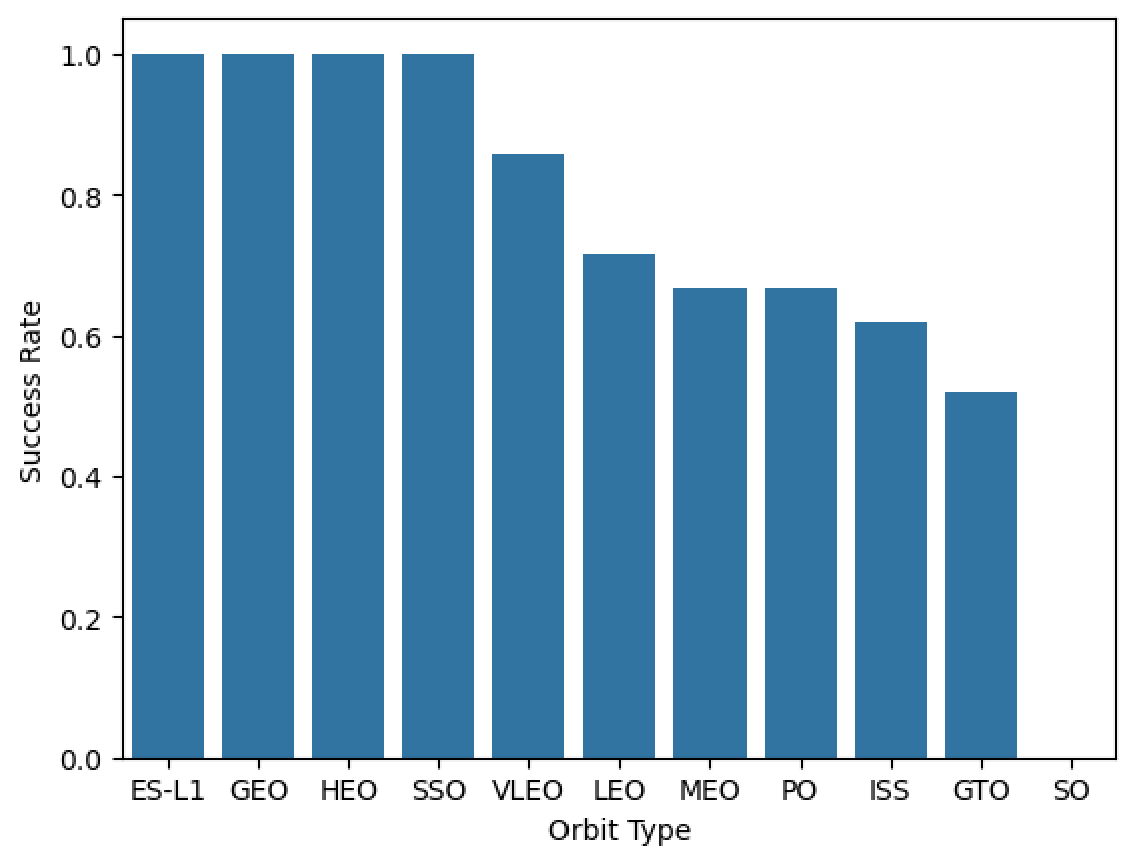
Payload vs. Launch Site

- CCAFS SLC 40 Payload Trend: Most launches from this site carry payloads under 10,000 kg, indicating a focus on lighter missions.
- Wider Payload Range at Other Sites: VAFB SLC 4E and KSC LC 39A accommodate a broader spectrum of payload masses, reflecting more diverse mission types.
- Heavy Lift Capability at KSC LC 39A: This site regularly supports launches exceeding 15,000 kg, highlighting its role in high-capacity missions.



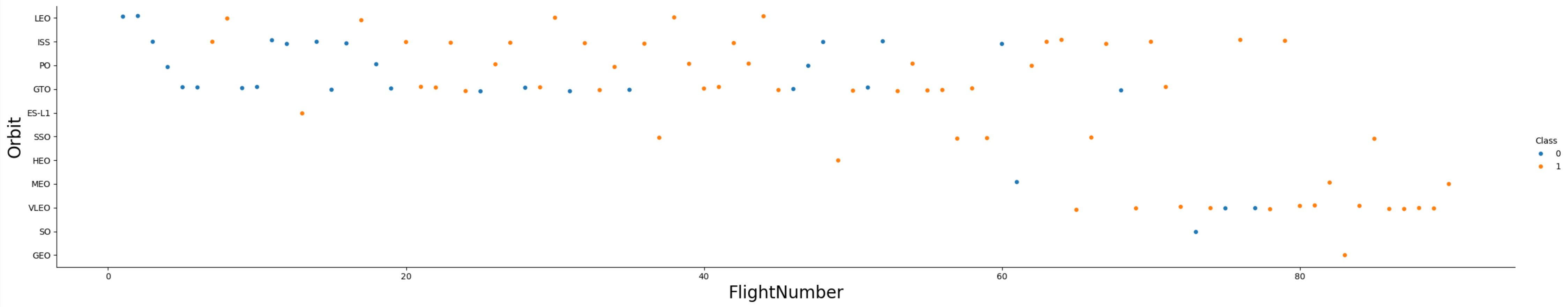
Success Rate vs. Orbit Type

- Perfect Success in Select Orbits: Missions targeting HEO, SSO, ES-L1, and GEO orbits have demonstrated 100% landing success.
- Consistent Results for HEO and SSO: Launches to HEO and SSO orbits have also maintained flawless first stage landing outcomes, reflecting strong reliability.
- Challenges with GTO Missions: Launches to GTO have a notably lower success rate, pointing to increased difficulty or complexity associated with this orbit type.



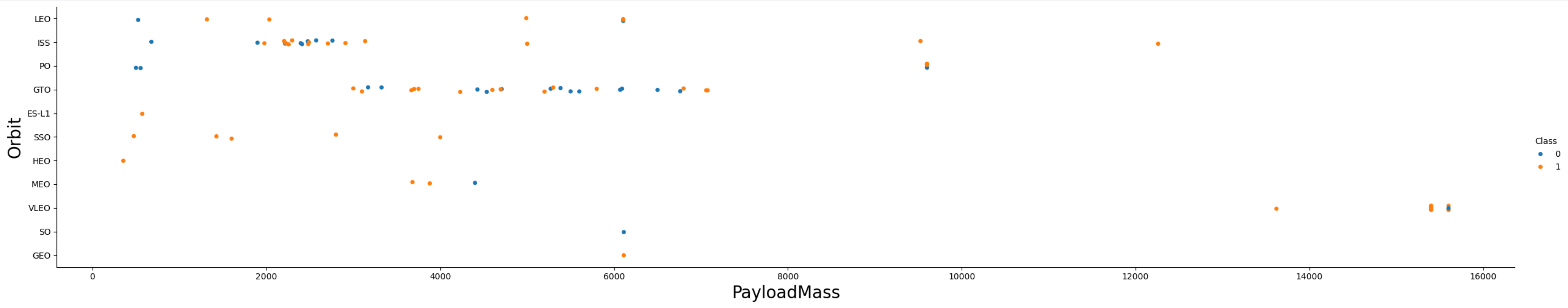
Flight Number vs. Orbit Type

- Improved Performance with Experience: Falcon 9 missions show a clear increase in success rate as flight numbers rise.
- Ongoing Enhancements Over Time: This upward trend suggests that accumulated experience and technical refinements have led to more reliable landings.
- Orbit-Specific Progress: Initial missions to GTO and ISS experienced varied results, but more recent launches to these destinations show improved consistency and higher success rates.



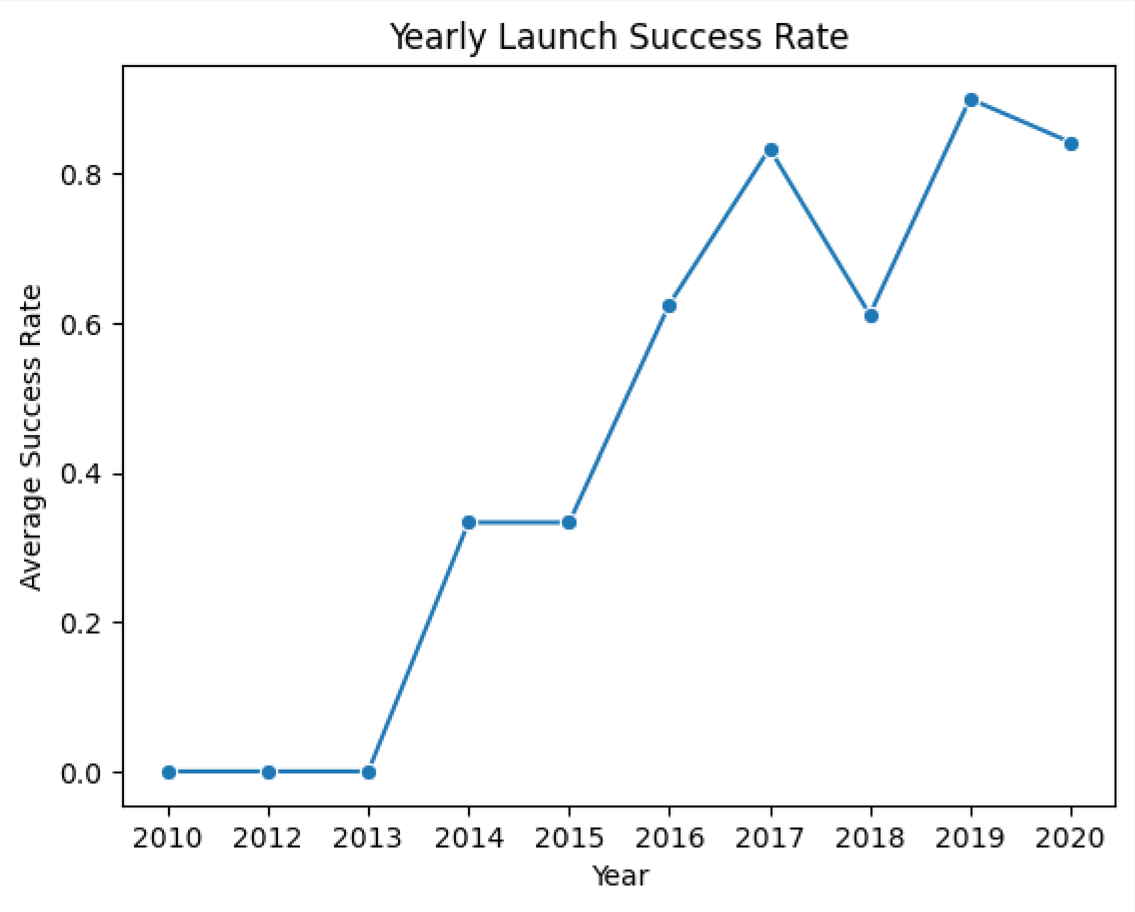
Payload vs. Orbit Type

- Frequent Success Across Orbits: All orbit types demonstrate a high frequency of successful landings.
- Greater Reliability with Lighter Payloads: Missions carrying payloads under 6000 kg tend to achieve more consistent landing success.
- Mixed Outcomes for Heavy Payloads: Launches involving payloads over 10,000 kg are lower frequency, suggesting increased challenges with heavier missions.



Launch Success Yearly Trend

- Improved Success Rates Since 2013: Starting in 2013, Falcon 9 launches began to show noticeable gains in reliability.
- Peak Performance by 2020: By 2020, the annual success rate had climbed to over 80%, reflecting major advancements in launch technology and operations.
- Temporary Decline in 2018: Although there was a slight drop in success in 2018, the overall trend points to steady improvements in mission outcomes over time.



All Launch Site Names

- Displays the names of the unique launch sites in the space mission

```
%sql SELECT DISTINCT Launch_Site FROM SPACEXTABLE;
```

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

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

Launch Site Names Begin with 'CCA'

- This query returns the first five launch records from the SpaceX dataset where the launch site name starts with "CCA", specifically CCAFS LC-40. The results show that all these early Falcon 9 launches (from 2010–2013) were successful missions to LEO or LEO (ISS) orbits, but none had a successful first stage landing—either due to failure (e.g., parachute issues) or no landing attempt at all, reflecting the early development phase before reusable landings were implemented.

```
%sql SELECT * FROM SPACEXTABLE 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
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

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

```
%sql SELECT SUM(Payload_Mass__kg_) AS total_payload_mass FROM SPACEXTABLE WHERE Customer = 'NASA (CRS)';
```

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

total_payload_mass
45596

Average Payload Mass by F9 v1.1

- This query calculates the average payload mass carried by the F9 v1.1 booster version, which is approximately 2928.4 kg. This suggests that missions using the F9 v1.1 typically launched medium-weight payloads, reflecting its capabilities during its operational period.

```
%sql SELECT AVG(Payload_Mass__kg_) AS average_payload_mass FROM SPACEXTABLE WHERE Booster_Version = 'F9 v1.1';
```

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

average_payload_mass
2928.4

First Successful Ground Landing Date

- This query identifies the earliest date of a successful ground pad landing, which was December 22, 2015. This marks a major milestone for SpaceX, as it was the first time they successfully landed a Falcon 9 first stage on land, demonstrating the viability of reusable rockets.

```
%sql SELECT MIN(Date) AS first_success_ground FROM SPACEXTABLE WHERE Landing_Outcome = 'Success (ground pad)';
```

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

first_success_ground
2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

- This query returns the names of boosters that successfully landed on a drone ship and carried payloads weighing between 4000 and 6000 kg. The result shows that four Falcon 9 Full Thrust (F9 FT) boosters—B1022, B1026, B1021.2, and B1031.2—met these criteria, highlighting their ability to handle mid-weight payloads while achieving successful sea landings.

```
%sql SELECT Booster_Version FROM SPACEXTABLE WHERE Landing_Outcome = 'Success (drone ship)' AND Payload_Mass__kg_ BETWEEN 40
```

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

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

Total Number of Successful and Failure Mission Outcomes

- This query groups and counts the total number of mission outcomes. It shows that there were 98 clear mission successes, along with 1 in-flight failure, 1 success with unclear payload status, and 1 additional 'Success' entry—suggesting a possible data duplication or formatting inconsistency between the two "Success" labels.

```
%sql SELECT Mission_Outcome, COUNT(*) AS total FROM SPACEXTABLE 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

Boosters Carried Maximum Payload

- This query identifies all booster versions that carried the maximum recorded payload mass of 15,600 kg. The results show that multiple boosters from the F9 B5 series achieved this, highlighting the high-capacity performance and reusability of the Falcon 9 B5 version across different missions.

```
%%sql
SELECT Booster_Version, Payload_Mass__kg_
FROM SPACEXTABLE
WHERE Payload_Mass__kg_ = (
    SELECT MAX(Payload_Mass__kg_)
    FROM SPACEXTABLE
);
```

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

Booster_Version	PAYLOAD_MASS__KG_
F9 B5 B1048.4	15600
F9 B5 B1049.4	15600
F9 B5 B1051.3	15600
F9 B5 B1056.4	15600
F9 B5 B1048.5	15600
F9 B5 B1051.4	15600
F9 B5 B1049.5	15600
F9 B5 B1060.2	15600
F9 B5 B1058.3	15600
F9 B5 B1051.6	15600
F9 B5 B1060.3	15600
F9 B5 B1049.7	15600

2015 Launch Records

- This query retrieves records of drone ship landing failures that occurred in 2015, along with the month, booster version, and launch site. The results show that two such failures happened in January and April, both involving F9 v1.1 boosters launched from CCAFS LC-40, indicating challenges with sea landings during early 2015

```
%%sql
SELECT substr(Date, 6, 2) AS month, Landing_Outcome, Booster_Version, Launch_Site
FROM SPACEXTABLE
WHERE Landing_Outcome = 'Failure (drone ship)'
  AND substr(Date, 0, 5) = '2015';
```

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

month	Landing_Outcome	Booster_Version	Launch_Site
01	Failure (drone ship)	F9 v1.1 B1012	CCAFS LC-40
04	Failure (drone ship)	F9 v1.1 B1015	CCAFS LC-40

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

- This query ranks the frequency of landing outcomes between June 4, 2010, and March 20, 2017, in descending order. The most common outcome was "No attempt" (10 times), followed by equal counts of successful and failed drone ship landings (5 each), and fewer instances of ground pad successes, ocean landings, and parachute failures—reflecting SpaceX’s early experimentation and gradual improvement in landing technology during this period.

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

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

Landing_Outcome	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

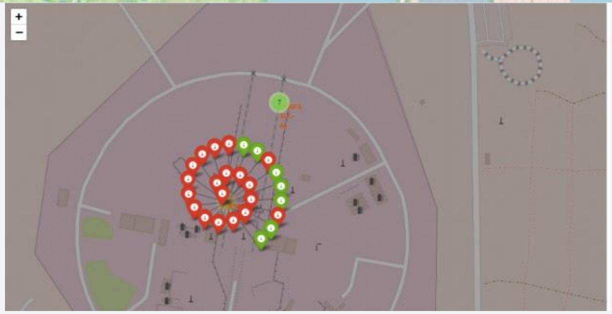
Launch Sites Proximities Analysis

All Launch Sites

- Launch sites vary in latitude, with Vandenberg Air Force Base (VAFB SLC-4E) being farther from the Equator than Florida-based sites.
- All SpaceX launch sites are situated near coastlines, allowing for safer launch and landing trajectories.
- CCAFS LC-40, CCAFS SLC-40, and KSC LC-39A are positioned on Florida's east coast.
- VAFB SLC-4E is located on the California coast, maintaining coastal proximity like its Florida counterparts.

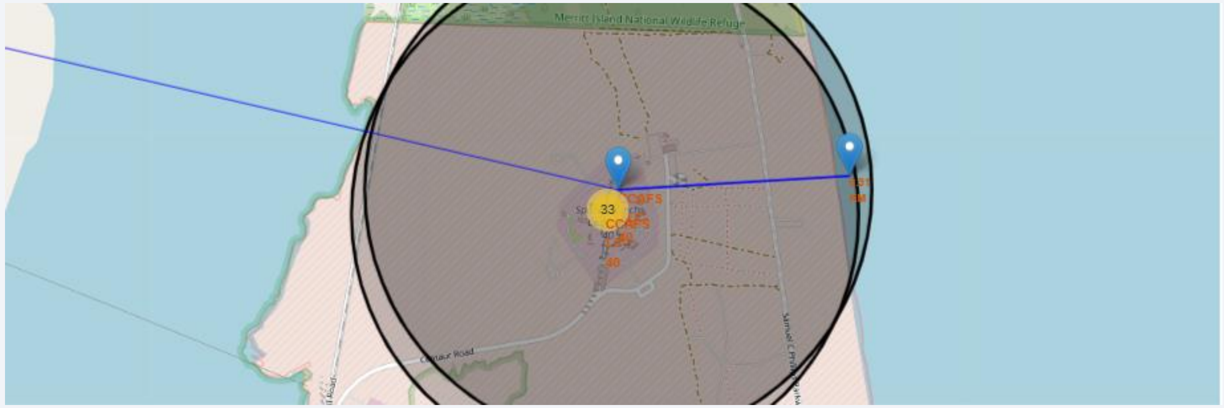
Launch Outcomes

- Clustered markers improve readability: Grouping markers together allows for clearer visualization when dealing with a large number of launch records.
- Efficient pattern recognition: Clustering helps uncover trends and patterns that could be overlooked in a densely populated map.
- Color-coded markers enhance interpretation: In the example, CCAFS LC-40 displays 19 red markers and 7 green ones, visually indicating launch outcomes.
- Instant performance insights: Red markers likely denote failed launches, while green markers suggest successful ones, enabling quick evaluation of launch site performance.

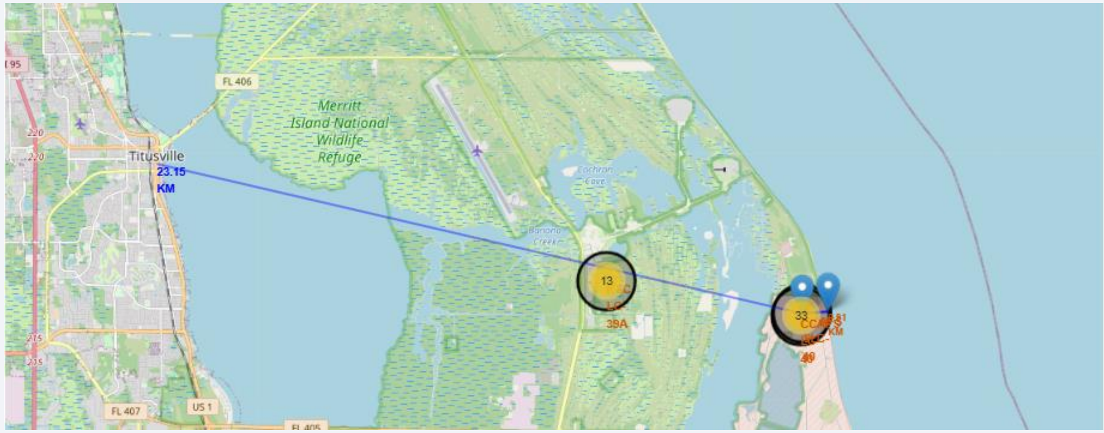


Launch site distance to its proximities

- This plot visually illustrates the distance between the CCAFS SLC-40 launch site and the nearest coastline, marked at approximately 0.91 kilometers. A PolyLine connects the site to the coast.



- This plot visually illustrates the distance between the CCAFS SLC-40 launch site and the nearest City (Titusville), marked at approximately 23.15 kilometers. A PolyLine connects the site to the city.

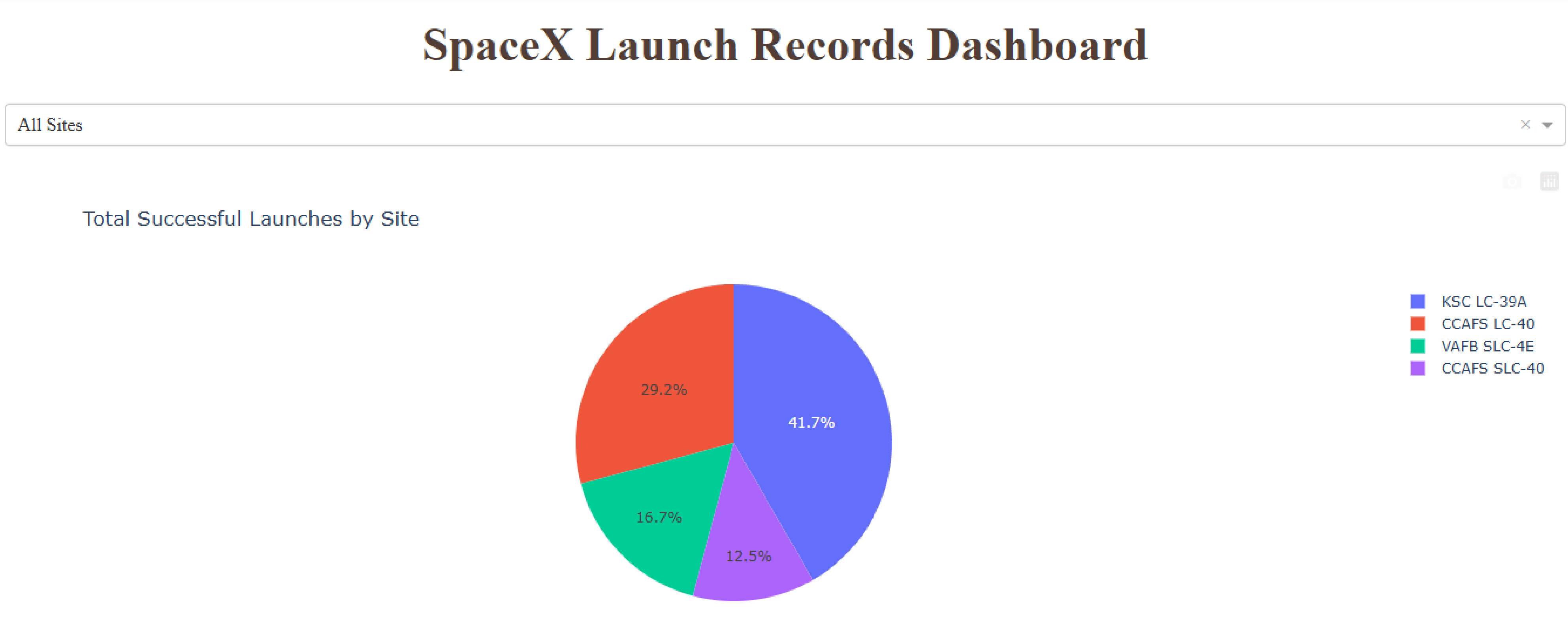


Section 4

Build a Dashboard with Plotly Dash

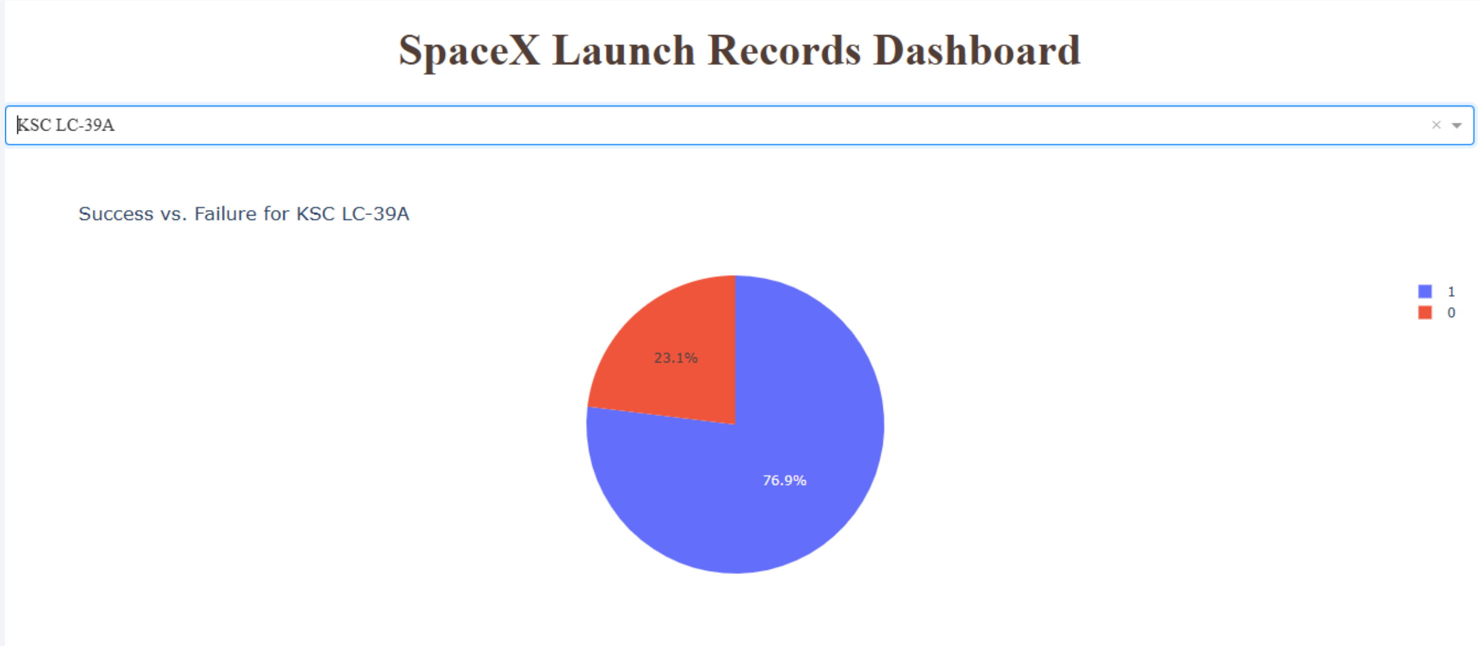
Pie chart launch success count

- KSC LC-39A accounts for the highest proportion of successful launches at 41.7%, followed by CCAFS LC-40 (29.2%), VAFB SLC-4E (16.7%), and CCAFS SLC-40 (12.5%)—highlighting KSC LC-39A as SpaceX's most reliable and frequently successful launch site.



Pie chart for the launch site with highest launch success ratio

- KSC LC-39A demonstrates strong reliability with a high success rate—76.9% of its launches were successful (Class 1), while only 23.1% were unsuccessful (Class 0)—showing its effectiveness as one of SpaceX's most dependable launch sites.



Payload vs. Launch Outcome scatter plot

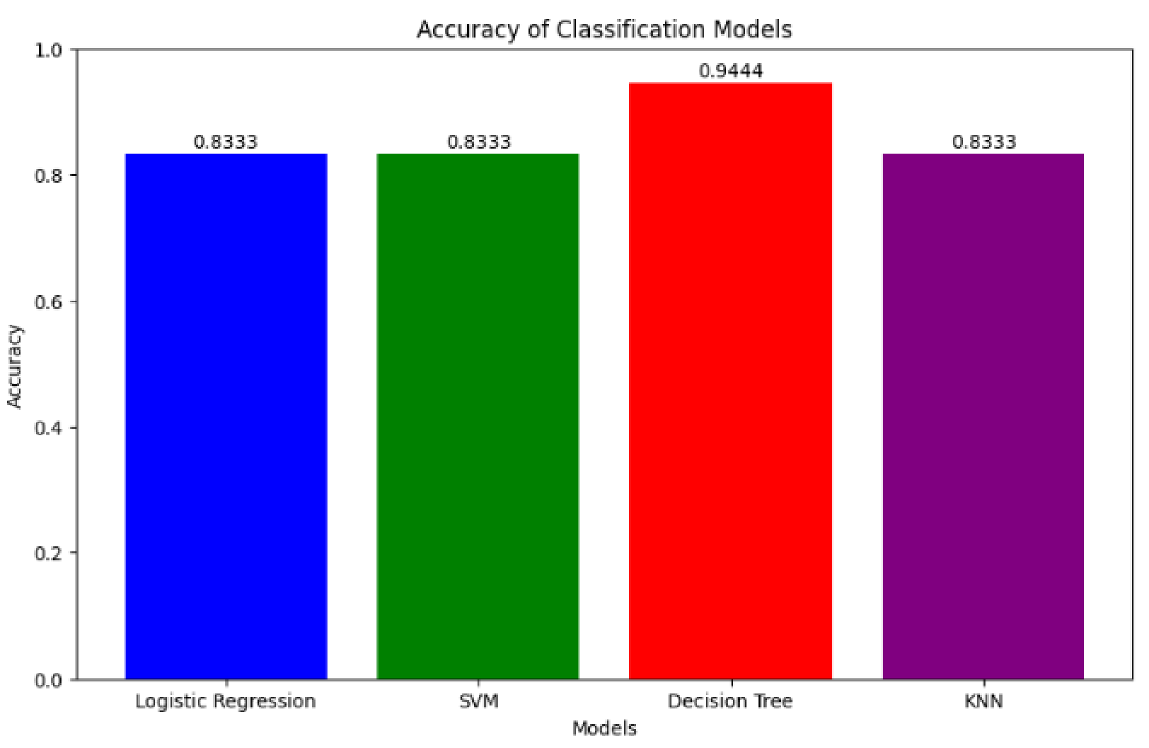
- The “FT” booster version is the most frequently used and consistently successful across a range of payload masses, while the older “v1.0” version had fewer launches and warrants further analysis; overall, there is no clear trend indicating that higher payload masses lead to lower success rates across booster versions.
- Most payloads that succeeded were in the range of 2000kg to 6000kg.

Section 5

Predictive Analysis (Classification)

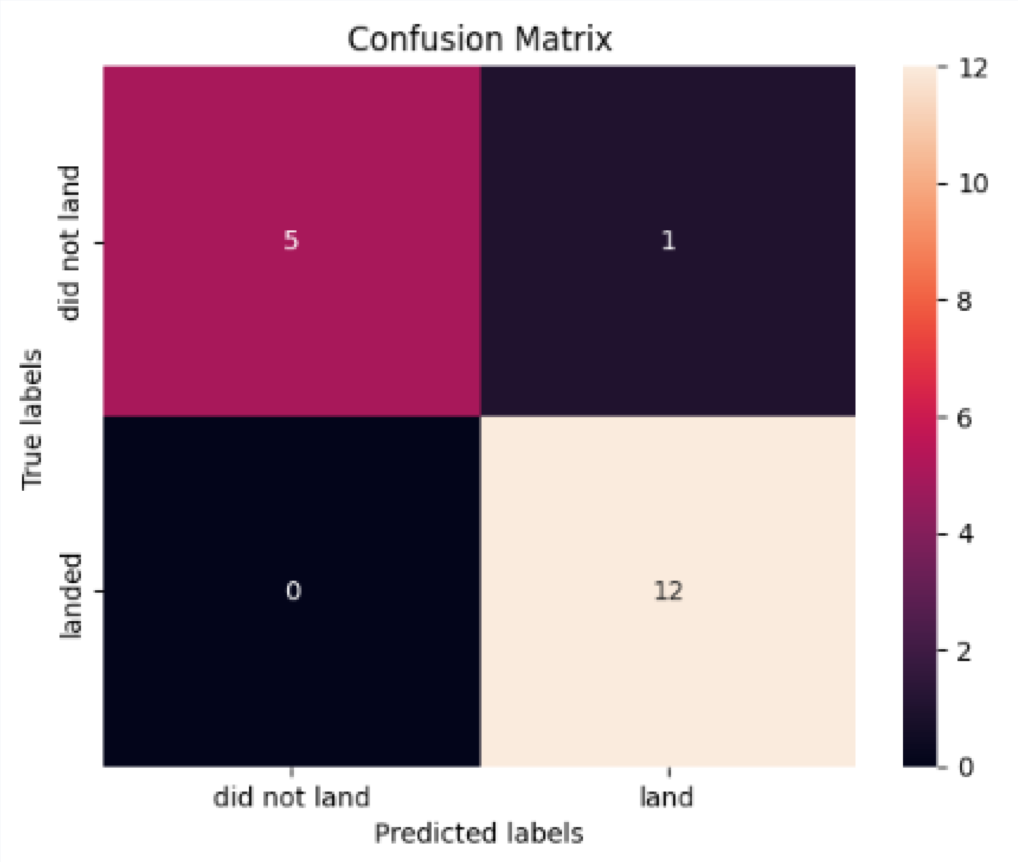
Classification Accuracy

- The Decision Tree model achieved the highest accuracy on the test data at 0.9444, outperforming the other classification models.
- This result indicates that the Decision Tree is better suited to the dataset compared to Logistic Regression, Support Vector Machine, and K-Nearest Neighbors, which each reached an accuracy of 0.8333.



Confusion Matrix

- High Accuracy and Balanced Results: The model achieved a strong accuracy of 94.44%, with high true positive and true negative counts, showing effective and reliable performance in predicting Falcon 9 first stage landings.
- Acceptable False Positives: With only one false positive, the model leans slightly toward over-predicting success, which is considered manageable and preferable in aerospace contexts, where over-preparation is safer than missed landings.
- Zero False Negatives: The model had no false negatives, meaning all actual successful landings were correctly identified—an essential trait for operational safety and mission readiness in aerospace.



Conclusions

- CCAFS LC-40 leads in success rate: This launch site accounts for 43.7% of all successful missions, suggesting it may benefit from optimal conditions or efficient operational procedures that enhance launch outcomes.
- Payload mass not a primary factor in success: No clear correlation was found between heavier payloads and lower success rates, implying that booster type and launch site have a more significant impact on mission success.
- FT booster version proves most reliable: The FT booster consistently achieved high success rates across various payload masses, indicating it is a dependable choice for future missions aiming to improve reliability.
- Interactive visualizations provide deeper insight: Tools like Folium and Plotly Dash helped uncover geographic and operational patterns, offering a clearer understanding of SpaceX launch behavior and performance.
- This analysis not only highlighted key factors affecting SpaceX's launch success but also provided a strong framework for future assessments, strategy optimization, and technological advancement in reusable rocket missions.

Thank you!