



IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

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

Executive Summary

Cosmos Analytics leads the space race by leveraging Data Science to optimize missions, reduce costs, and enhance safety. Through predictive models, real-time analytics, and advanced algorithms, we improve trajectories, minimize risks, and accelerate innovation. Our approach positions us as pioneers in efficient and sustainable space exploration

Summary of methodologies

- Data Collection from API and Web scraping
- Data Wrangling
- Exploratory Data Analysis (EDA) using SQL, Pandas and Matplotlib
- Interactive Visual Analytics and Dashboard with Folium and Plotly Dash
- Predictive Analysis (Classification)

Summary of all results

- Parameters for Logistic Regression, SVM, KNN classifiers and Decision Trees
- Methods that performs best using test data

Introduction

Space exploration faces challenges like high costs, complex planning, and mission risks. Cosmos Analytics emerges in this context to harness Data Science as a transformative tool. By addressing key questions—how to optimize trajectories, reduce failures, and enhance efficiency—we aim to redefine the future of sustainable and safe space missions.

Section 1

Methodology

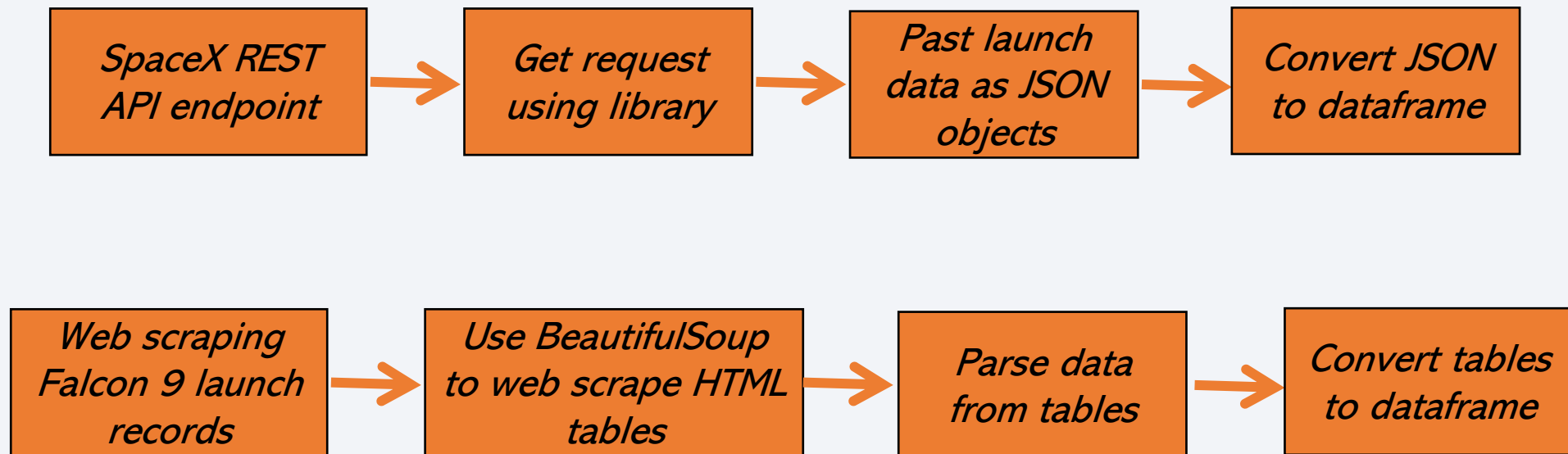
Methodology

Executive Summary

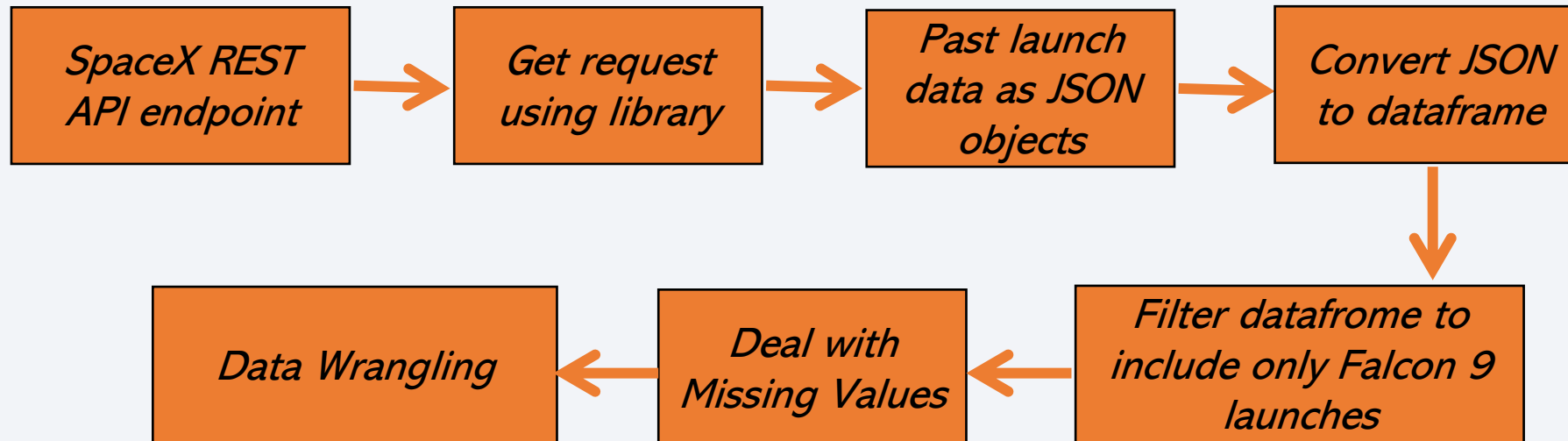
- Data collection methodology:
 - Data was collected from SpaceX REST API and Wiki Pages using web scraping
- Perform data wrangling
 - Data, in form of a JSON object and HTML tables, is converted into a Pandas dataframe for visualization and analysis
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
 - Machine learning was used to determine the success of the first stage of Falcon 9

Data Collection

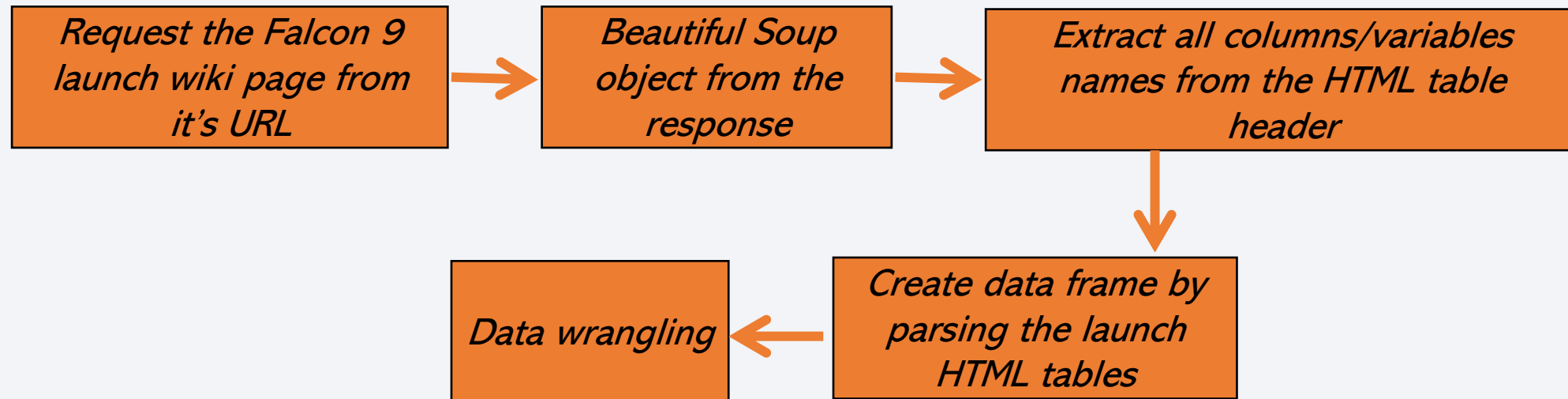
Data was collected from SpaceX REST API and Wiki Pages using web scraping



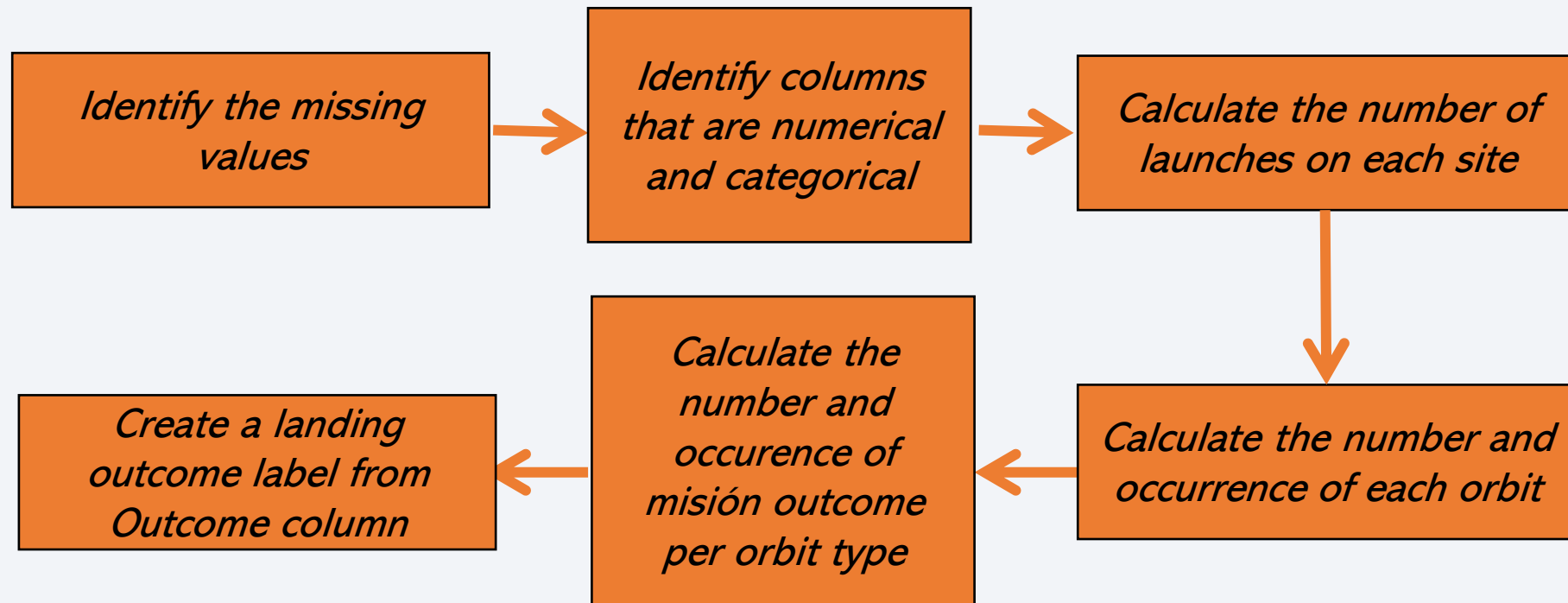
Data Collection – SpaceX API



Data Collection - Scraping



Data Wrangling



EDA with Data Visualization

- Summarize what charts were plotted:
 - Catplot for the relationship between Flight Number and Payload
 - Catplot for the relationship between Flight Number and Launch Site
 - Catplot for the relationship between Payload and Launch Site
 - Barchart for the relationship between Success Rate of each Orbit Type
 - Catplot for the relationship between Flight Number and Orbit Type
 - Catplot for the relationship between Payload and Orbit Type
 - Line chart to visualize the Launch Success Yearly Trend

EDA with SQL

- SpaceX dataset was loaded into a PostgreSQL database.
- EDA was applied with SQL to get insight from the data:
 - The names of unique launch sites in the space mission.
 - The total payload mass carried by boosters launched by NASA (CRS)
 - The average payload mass carried by booster version F9 v1.1
 - The total number of successful and failure mission outcomes
 - The failed landing outcomes in drone ship, their booster version and launch site names.

Build an Interactive Map with Folium

- We marked all launch sites, and added map objects such as markers, circles, lines to mark the success or failure of launches for each site on the folium map.
- We assigned the feature launch outcomes (failure or success) to class 0 and 1.i.e., 0 for failure, and 1 for success.
- Using the color-labeled marker clusters, we identified which launch sites have relatively high success rate.
- We calculated the distances between a launch site to its proximities. We answered some question for instance:
 - Are launch sites near railways, highways and coastlines.
 - Do launch sites keep certain distance away from cities.

Build a Dashboard with Plotly Dash

- We built an interactive dashboard with Plotly dash
- We plotted pie charts showing the total launches by a certain sites
- We plotted scatter graph showing the relationship with Outcome and Payload Mass (Kg) for the different booster version.

Predictive Analysis (Classification)

- We loaded the data using numpy and pandas, transformed the data, split our data into training and testing.
- We built different machine learning models and tune different hyperparameters using GridSearchCV.
- We used accuracy as the metric for our model, improved the model using feature engineering and algorithm tuning.
- We found the best performing classification model.

Results

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

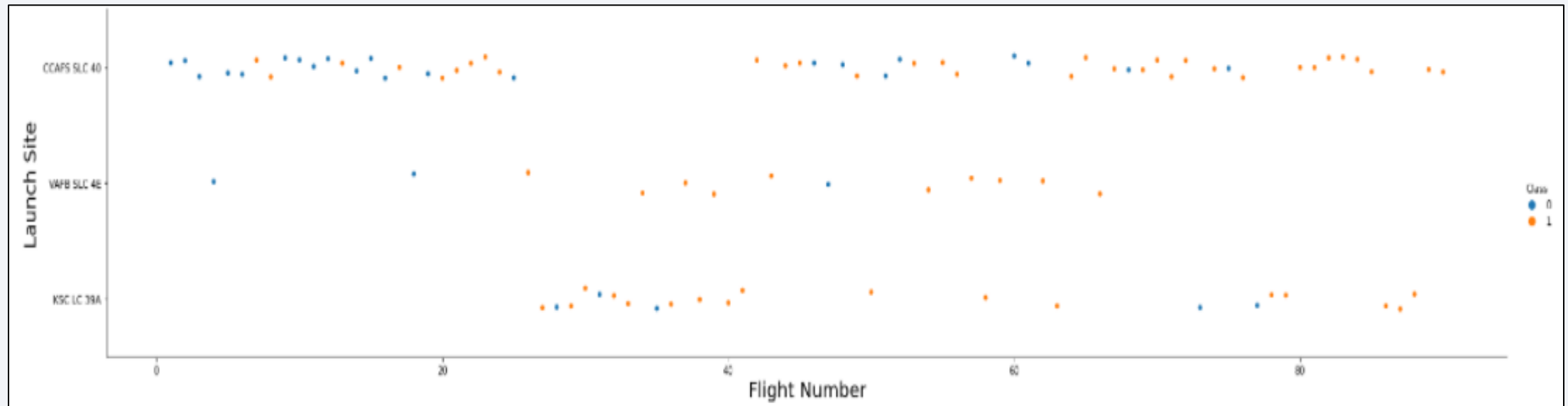
The background of the slide is an abstract composition. It features a dark blue base color. Overlaid on this are numerous diagonal streaks in shades of red and cyan. A faint, light blue grid pattern is also visible, particularly in the lower half of the image. The overall effect is dynamic and technological.

Section 2

Insights drawn from EDA

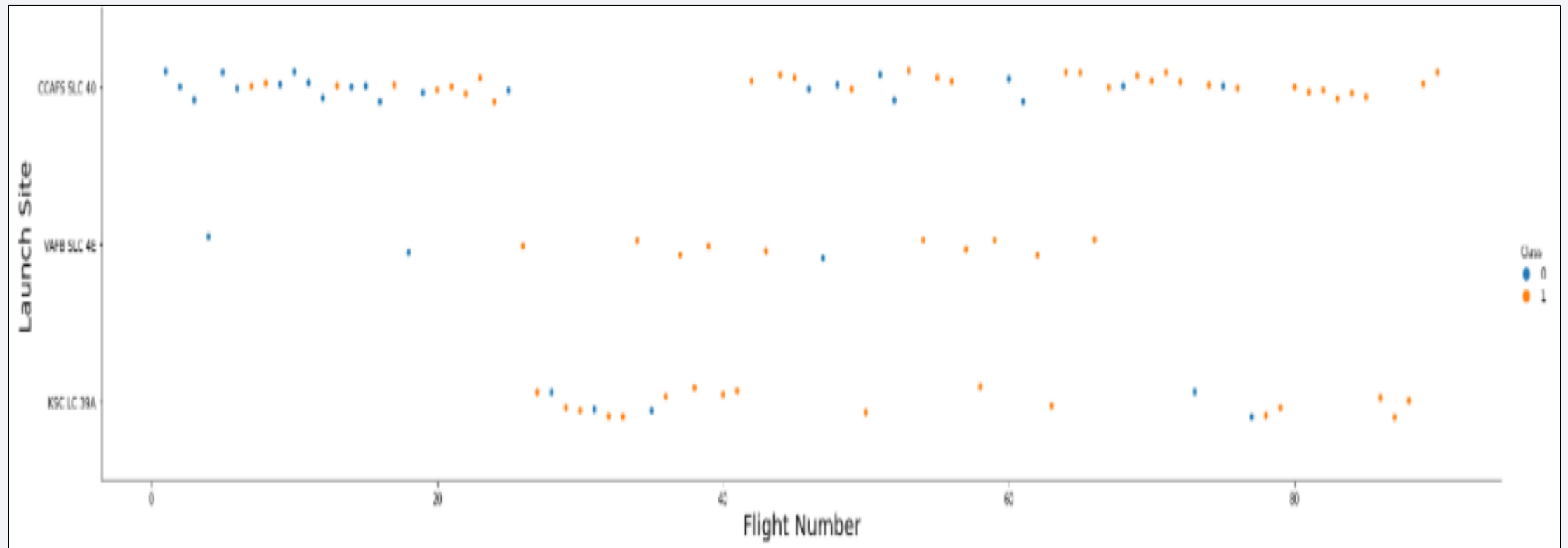
Flight Number vs. Launch Site

From the plot, we found that the larger the flight amount at a launch site, the greater the success rate at a launch site.



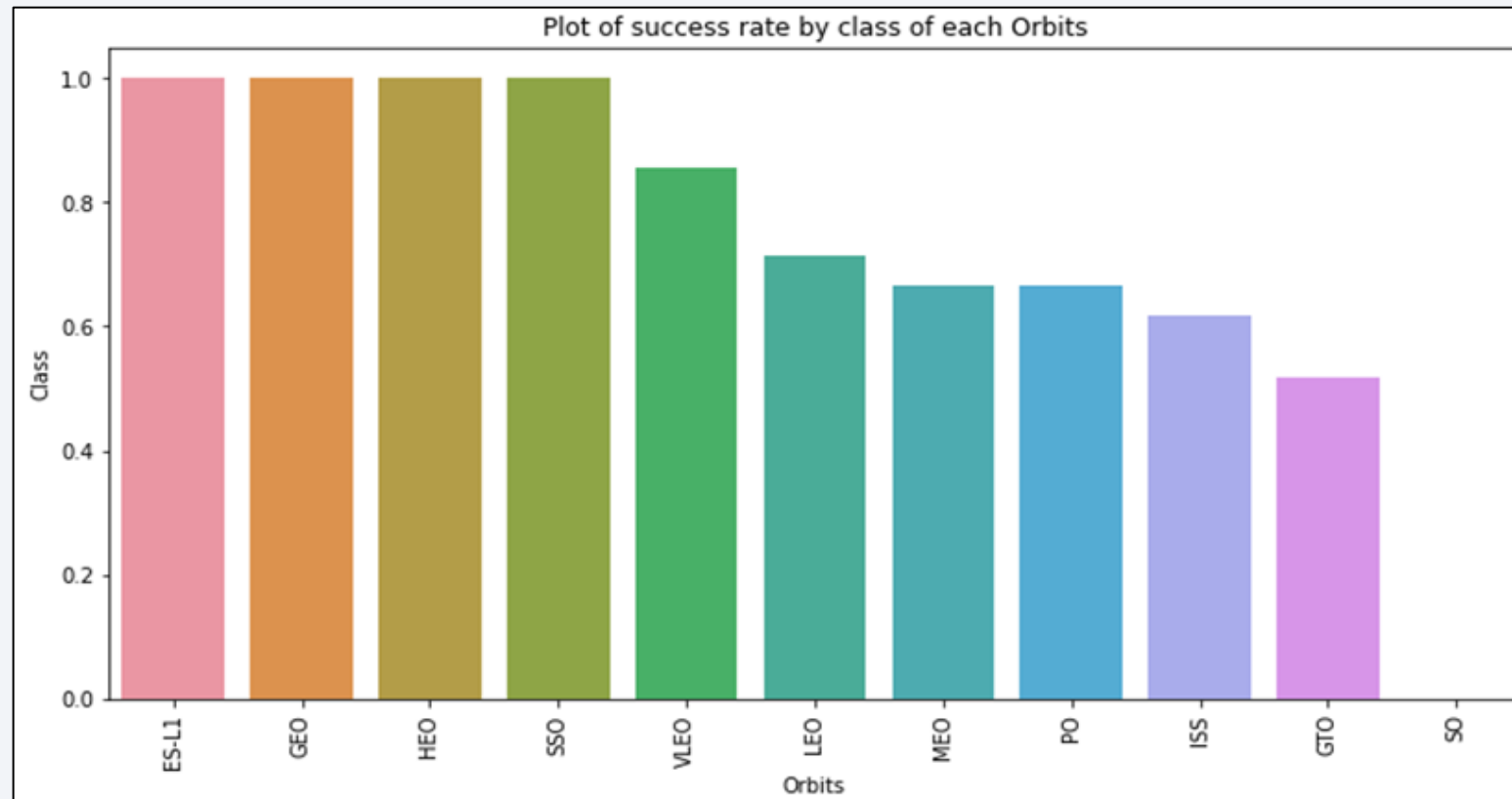
Payload vs. Launch Site

We found that the greater the payload mass for launch site CCAFS SLC 40, the higher the success rate for the rocket



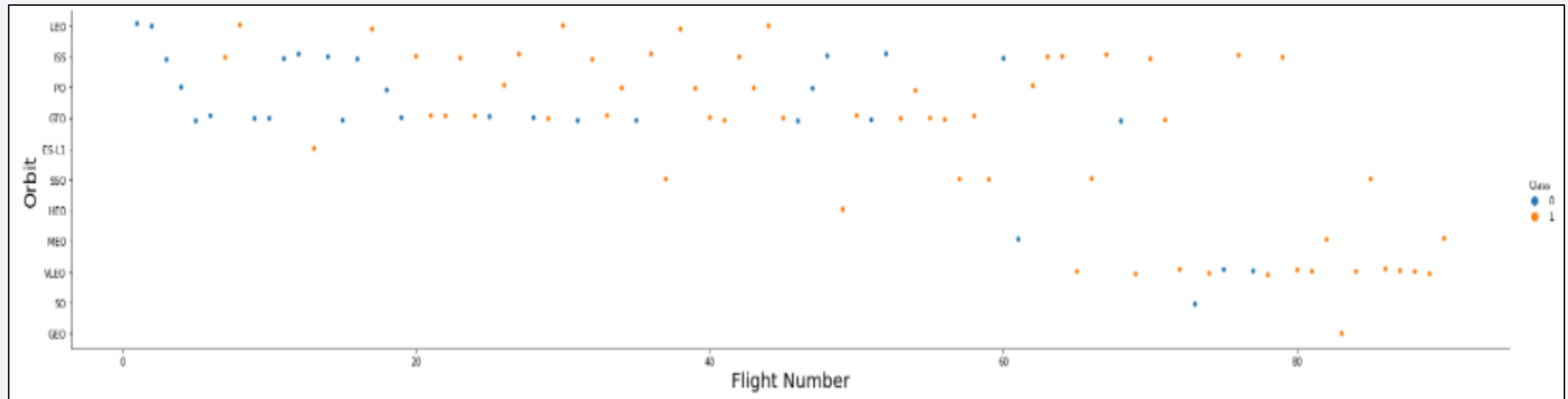
Success Rate vs. Orbit Type

From the plot, we can see that ES-L1, GEO, HEO, SSO, VLEO had the most success rate.



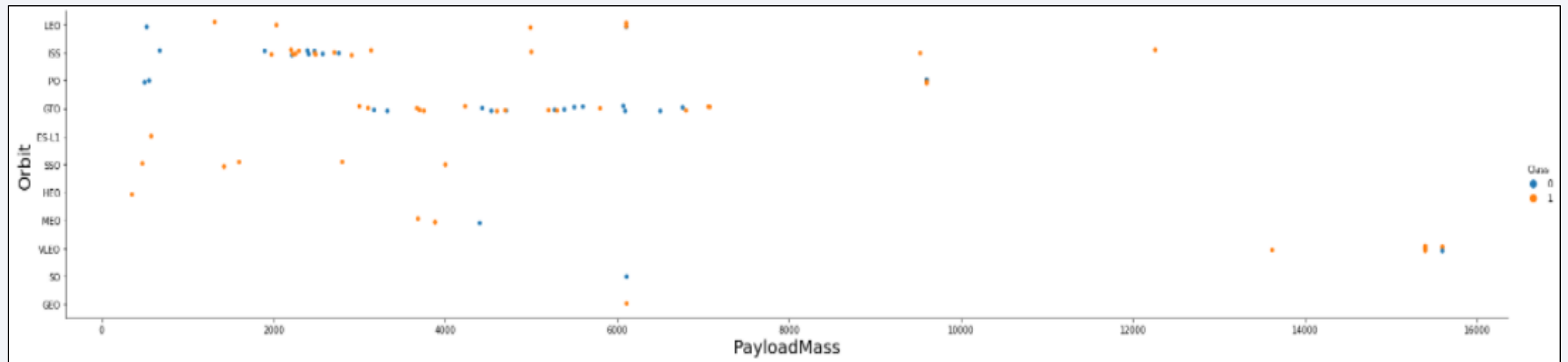
Flight Number vs. Orbit Type

The plot below shows the Flight Number vs. Orbit type. We observe that in the LEO orbit, success is related to the number of flights whereas in the GTO orbit, there is no relationship between flight number and the orbit.



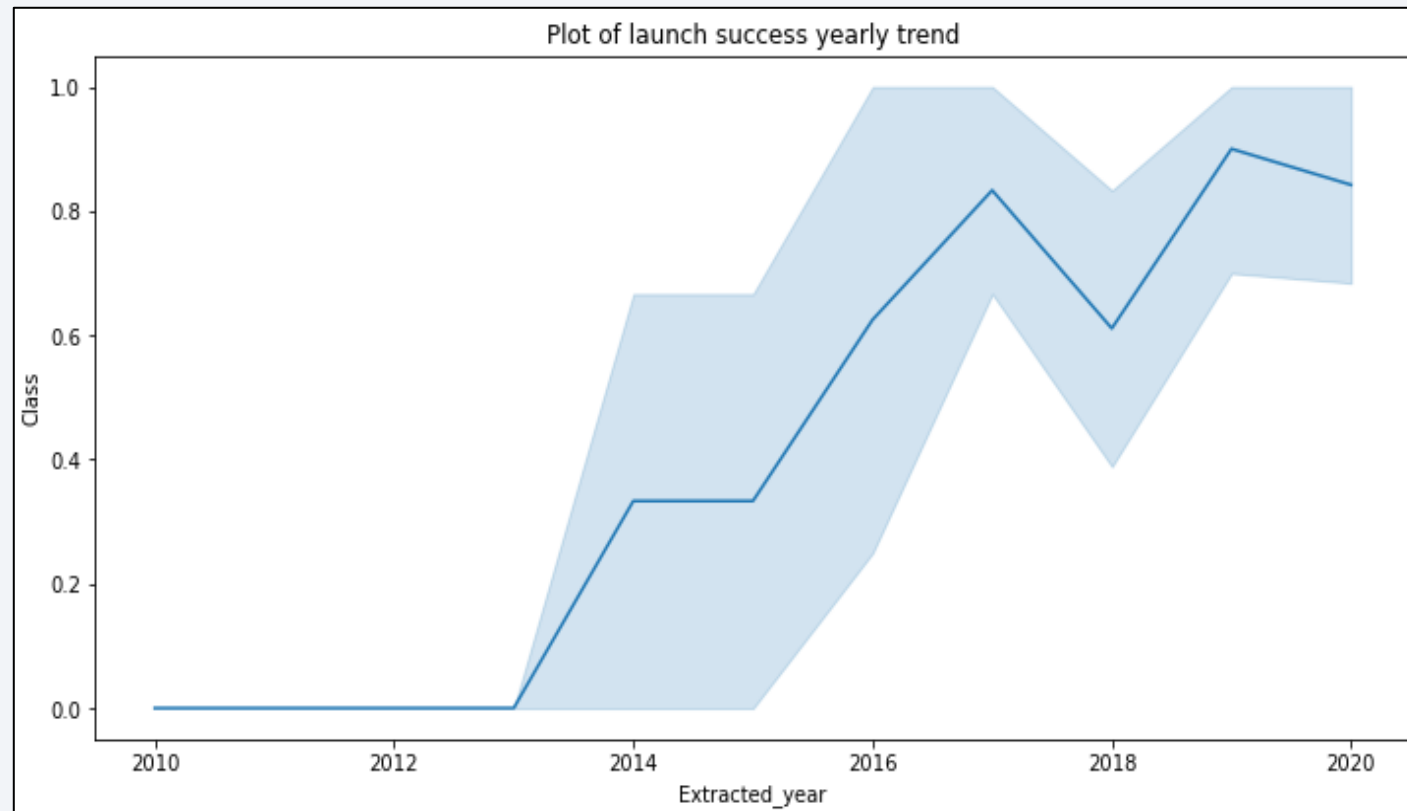
Payload vs. Orbit Type

We can observe that with heavy payloads, the successful landing are more for PO, LEO and ISS orbits



Launch Success Yearly Trend

From the plot, we can observe that success rate since 2013 kept on increasing till 2020.



All Launch Site Names

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

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

In [10]: task_1 = '''
          SELECT DISTINCT LaunchSite
          FROM SpaceX
          ...
          create_pandas_df(task_1, database=conn)

Out[10]:
```

	launchsite
0	KSC LC-39A
1	CCAFS LC-40
2	CCAFS SLC-40
3	VAFB SLC-4E

Launch Site Names Begin with 'CCA'

We used the query above to display 5 records where launch sites begin with 'CCA'

Display 5 records where launch sites begin with the string 'CCA'											
In [11]: <pre>task_2 = ''' SELECT * FROM SpaceX WHERE LaunchSite LIKE 'CCA%' LIMIT 5 ''' create_pandas_df(task_2, database=conn)</pre>											
Out[11]:											
	date	time	boosterversion	launchsite	payload	payloadmasskg	orbit	customer	missionoutcome	landingoutcome	
0	2010-04-06	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)	
1	2010-08-12	15:43:00	F9 v1.0 B0004	CCAFS LC-40	Dragon demo flight C1, two CubeSats, barrel of...	0	LEO (ISS)	NASA (COTS) NRO	Success	Failure (parachute)	
2	2012-05-22	07:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)	Success	No attempt	
3	2012-08-10	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt	
4	2013-01-03	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attempt	

Total Payload Mass

We calculated the total payload carried by boosters from NASA as 45596 using the query below

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

In [12]: task_3 = '''
          SELECT SUM(PayloadMassKG) AS Total_PayloadMass
          FROM SpaceX
          WHERE Customer LIKE 'NASA (CRS)'
          '''
          create_pandas_df(task_3, database=conn)

Out[12]:
```

	total_payloadmass
0	45596

Average Payload Mass by F9 v1.1

We calculated the average payload mass carried by booster version F9 v1.1 as 2928.4

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

In [13]: task_4 = '''
          SELECT AVG(PayloadMassKG) AS Avg_PayloadMass
          FROM SpaceX
          WHERE BoosterVersion = 'F9 v1.1'
          '''
          create_pandas_df(task_4, database=conn)

Out[13]:
```

	avg_payloadmass
0	2928.4

First Successful Ground Landing Date

We observed that the dates of the first successful landing outcome on ground pad was 22nd December 2015

```
In [14]: task_5 = '''
          SELECT MIN(Date) AS FirstSuccessfull_landing_date
          FROM SpaceX
          WHERE LandingOutcome LIKE 'Success (ground pad)'
          '''
          create_pandas_df(task_5, database=conn)
```

```
Out[14]:
```

	firstsuccessfull_landing_date
0	2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

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

```
In [15]: task_6 = '''
          SELECT BoosterVersion
          FROM SpaceX
          WHERE LandingOutcome = 'Success (drone ship)'
             AND PayloadMassKG > 4000
             AND PayloadMassKG < 6000
          ...
          create_pandas_df(task_6, database=conn)
```

```
Out[15]:
```

	boosterversion
0	F9 FT B1022
1	F9 FT B1026
2	F9 FT B1021.2
3	F9 FT B1031.2

Total Number of Successful and Failure Mission Outcomes

We used wildcard like '%' to filter for WHERE MissionOutcome was a success or a failure.

```
List the total number of successful and failure mission outcomes

In [16]: task_7a = '''
          SELECT COUNT(MissionOutcome) AS SuccessOutcome
          FROM SpaceX
          WHERE MissionOutcome LIKE 'Success%'
          '''

          task_7b = '''
          SELECT COUNT(MissionOutcome) AS FailureOutcome
          FROM SpaceX
          WHERE MissionOutcome LIKE 'Failure%'
          '''

          print('The total number of successful mission outcome is:')
          display(create_pandas_df(task_7a, database=conn))
          print()
          print('The total number of failed mission outcome is:')
          create_pandas_df(task_7b, database=conn)

The total number of successful mission outcome is:
  successoutcome
0              100

The total number of failed mission outcome is:
Out[16]:  failureoutcome
0              1
```

Boosters Carried Maximum Payload

We determined the booster that have carried the maximum payload using a subquery in the WHERE clause and the MAX() function.

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

In [17]: task_8 = '''
          SELECT BoosterVersion, PayloadMassKG
          FROM SpaceX
          WHERE PayloadMassKG = (
                                SELECT MAX(PayloadMassKG)
                                FROM SpaceX
                              )
          ORDER BY BoosterVersion
          '''
          create_pandas_df(task_8, database=conn)

Out[17]:
```

	boosterversion	payloadmasskg
0	F9 B5 B1048.4	15600
1	F9 B5 B1048.5	15600
2	F9 B5 B1049.4	15600
3	F9 B5 B1049.5	15600
4	F9 B5 B1049.7	15600
5	F9 B5 B1051.3	15600
6	F9 B5 B1051.4	15600
7	F9 B5 B1051.6	15600
8	F9 B5 B1056.4	15600
9	F9 B5 B1058.3	15600
10	F9 B5 B1060.2	15600
11	F9 B5 B1060.3	15600

2015 Launch Records

We used a combinations of the WHERE clause, LIKE, AND, and BETWEEN conditions to filter for failed landing outcomes in drone ship, their booster versions, and launch site names for year 2015

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

In [18]: task_9 = '''
          SELECT BoosterVersion, LaunchSite, LandingOutcome
          FROM SpaceX
          WHERE LandingOutcome LIKE 'Failure (drone ship)'
             AND Date BETWEEN '2015-01-01' AND '2015-12-31'
          ...
          create_pandas_df(task_9, database=conn)

Out[18]:
```

	boosterversion	launchsite	landingoutcome
0	F9 v1.1 B1012	CCAFS LC-40	Failure (drone ship)
1	F9 v1.1 B1015	CCAFS LC-40	Failure (drone ship)

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

We selected Landing outcomes and the COUNT of landing outcomes from the data and used the WHERE clause to filter for landing outcomes BETWEEN 2010-06-04 to 2010-03-20; then we applied the GROUP BY clause to group the landing outcomes and the ORDER BY clause to order the grouped landing outcome in descending order.

```
Rank the count of landing outcomes (such as Failure (drone ship) or Success (ground pad))

In [19]: task_10 = '''
          SELECT LandingOutcome, COUNT(LandingOutcome)
          FROM SpaceX
          WHERE DATE BETWEEN '2010-06-04' AND '2017-03-20'
          GROUP BY LandingOutcome
          ORDER BY COUNT(LandingOutcome) DESC
          '''

          create_pandas_df(task_10, database=conn)

Out[19]:
```

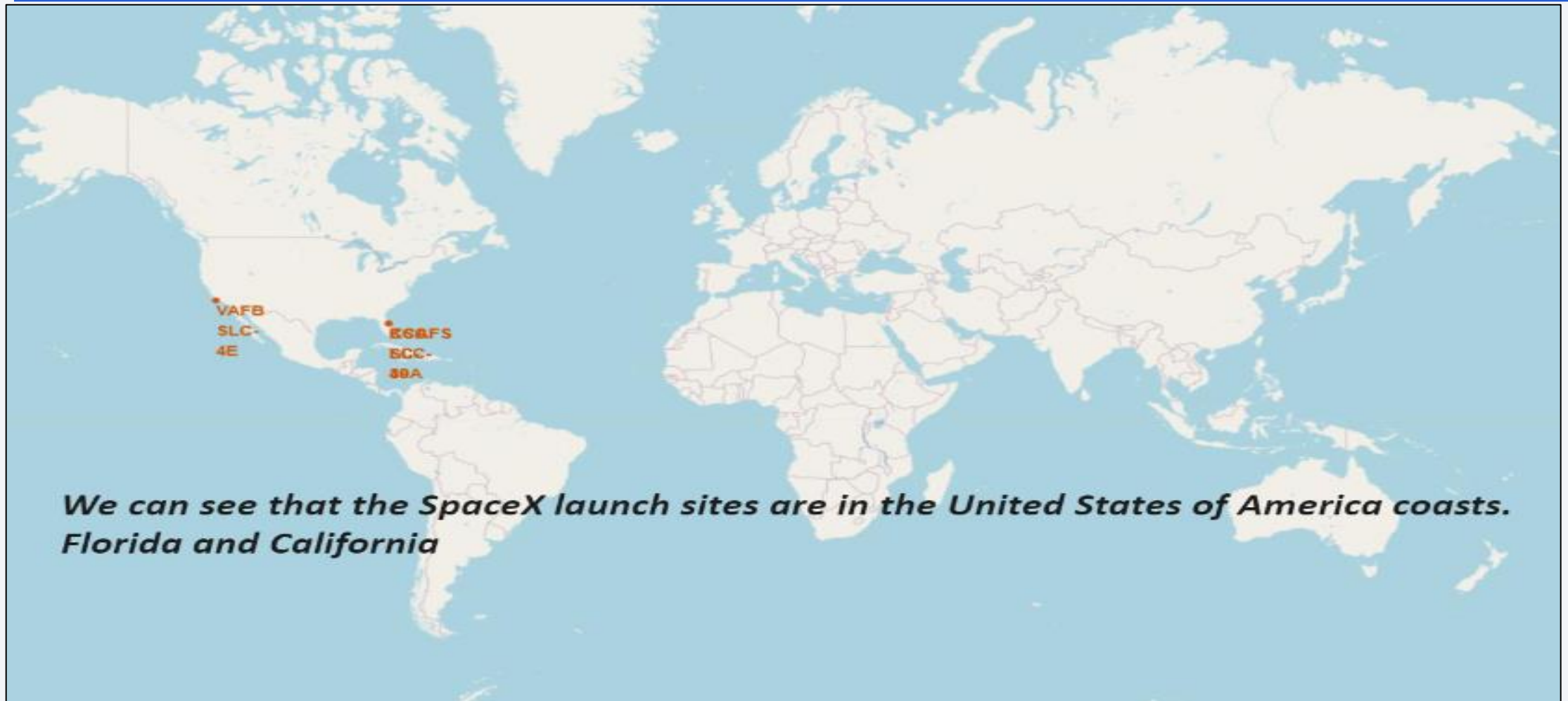
	landingoutcome	count
0	No attempt	10
1	Success (drone ship)	6
2	Failure (drone ship)	5
3	Success (ground pad)	5
4	Controlled (ocean)	3
5	Uncontrolled (ocean)	2
6	Precluded (drone ship)	1
7	Failure (parachute)	1

A satellite view of Earth from space, showing the curvature of the planet and city lights at night. The background is a deep blue gradient.

Section 3

Launch Sites Proximities Analysis

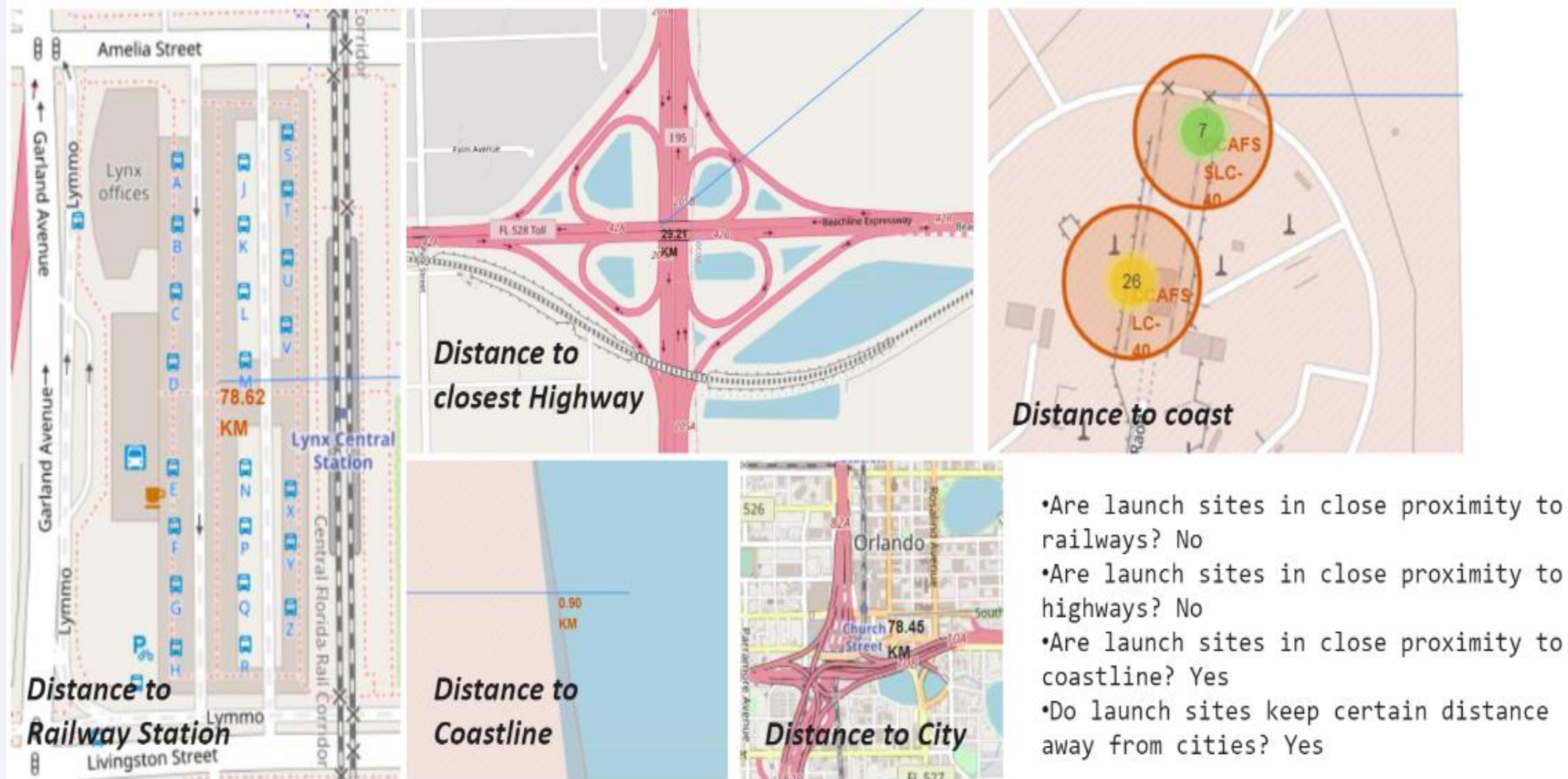
All launch sites with global map markers



Markers showing launch sites using color labels



Launch Site distance to landmarks



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

The background of the slide is a close-up, artistic photograph of a printed circuit board (PCB). The board is dark, and the intricate circuit traces are highlighted in a vibrant, glowing red. Numerous small, circular components, likely solder joints or micro-components, are visible along the traces, some of which also appear to be glowing. The overall effect is a high-tech, digital aesthetic.

Section 4

Build a Dashboard with Plotly Dash

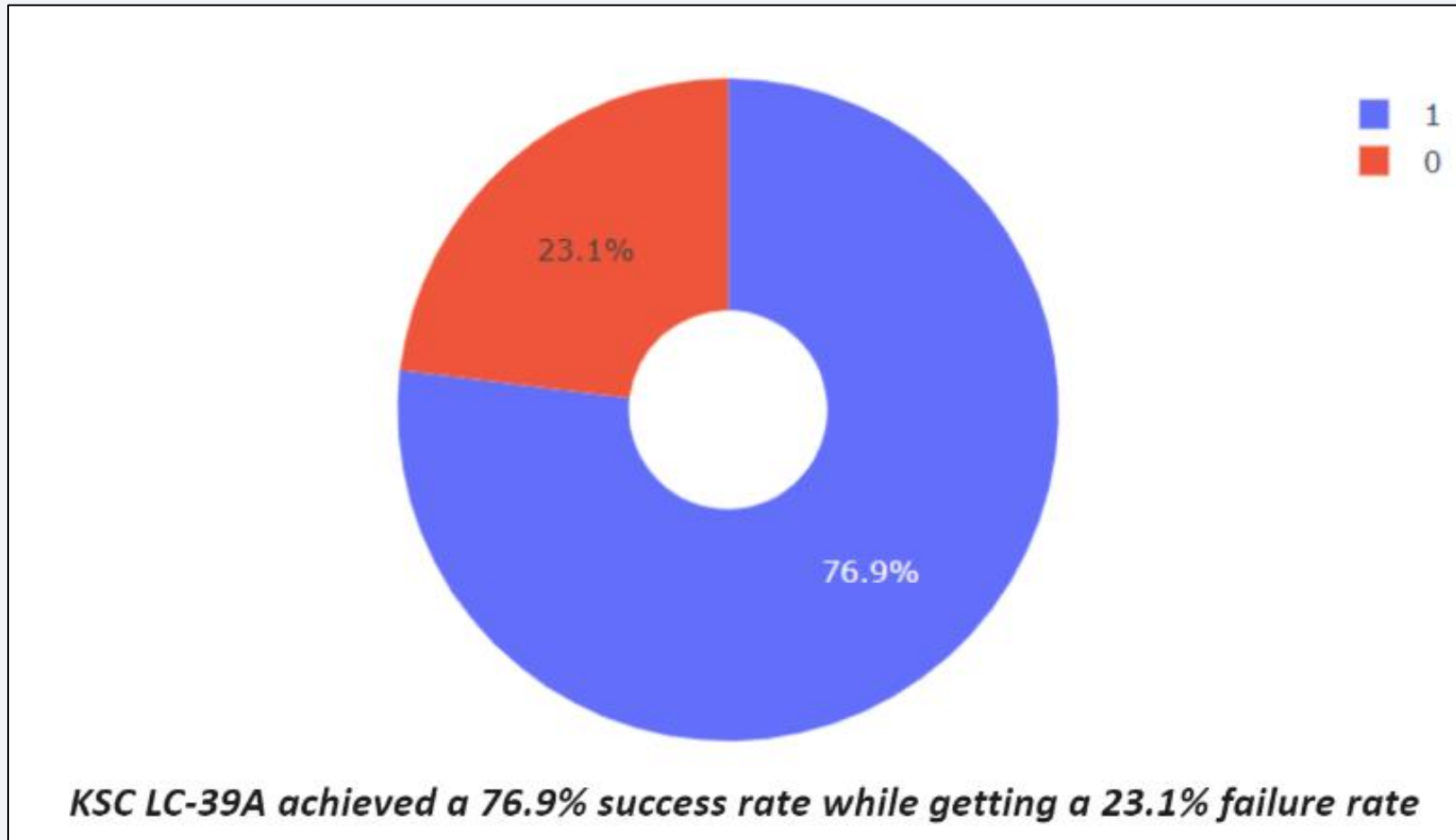
Pie chart showing the success percentage achieved by each launch site

Total Success Launches By all sites

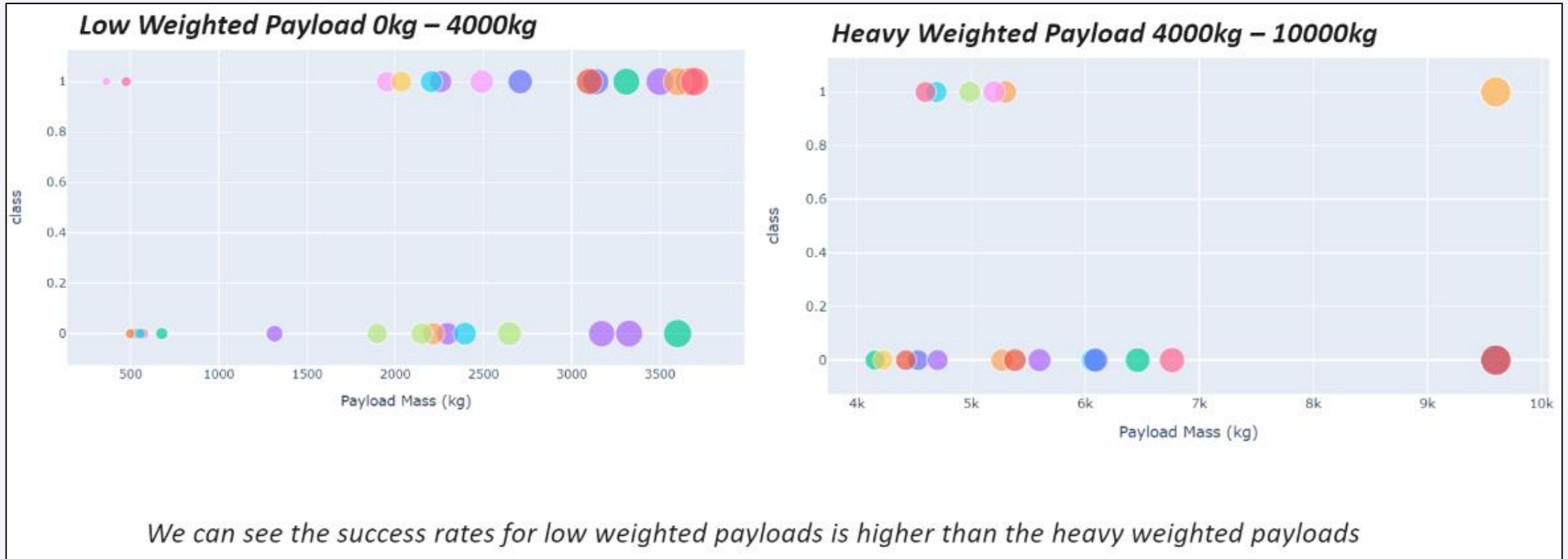


We can see that KSC LC-39A had the most successful launches from all the sites

Pie chart showing the Launch site with the highest launch success ratio



Scatter plot of Payload vs Launch Outcome for all sites, with different payload selected in the range slider





Section 5

Predictive Analysis (Classification)

Classification Accuracy

The decision tree classifier is the model with the highest classification accuracy

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

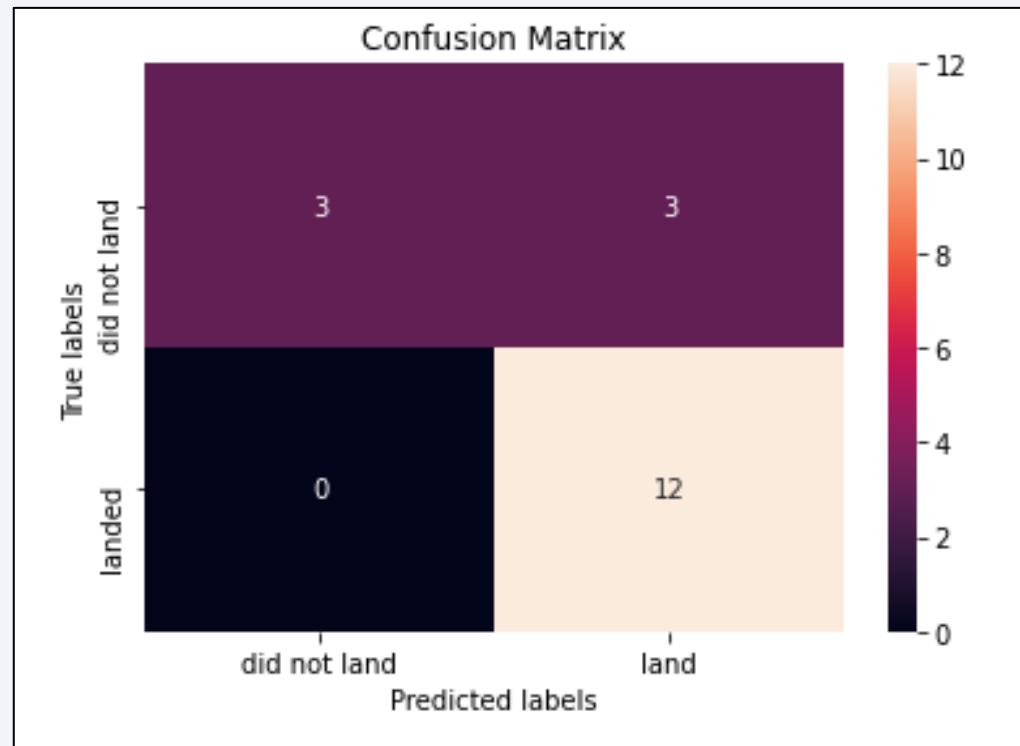
bestalgorithm = max(models, key=models.get)
print('Best model is', bestalgorithm,'with a score of', models[bestalgorithm])
if bestalgorithm == 'DecisionTree':
    print('Best params is :', tree_cv.best_params_)
if bestalgorithm == 'KNeighbors':
    print('Best params is :', knn_cv.best_params_)
if bestalgorithm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

Best model is DecisionTree with a score of 0.8732142857142856

Best params is : {'criterion': 'gini', 'max_depth': 6, 'max_features': 'auto', 'min_samples_leaf': 2, 'min_samples_split': 5, 'splitter': 'random'}

Confusion Matrix

The confusion matrix for the decision tree classifier shows that the classifier can distinguish between the different classes. The major problem is the false positives .i.e., unsuccessful landing marked as successful landing by the classifier.



Conclusions

- The larger the flight amount at a launch site, the greater the success rate at a launch site.
- Launch success rate started to increase in 2013 till 2020.
- Orbits ES-L1, GEO, HEO, SSO, VLEO had the most success rate.
- KSC LC-39A had the most successful launches of any sites.
- The Decision tree classifier is the best machine learning algorithm for this task.

Thank you!

