IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Executive Summary

Methodologies

Data Collection

- REST API
- Web Scraping

Data Wrangling

- Creation of binary Outcome Variable

Visualization

- Basic Graphs
- Maps using Folium
- Dashboard

Analysis

- Basic Analysis
- Predictive Models

Results

- Improved Success rate over the time
- KSC LC-39A is the most successful site
- ES-L1, GEO, HEO, and SSO have the highest success rate
- All sites are close to coastline
- Decision Trees model has the highest accuracy

Introduction

Project background and context

- SpaceX is a leader in the space industry. It has launched several missions in some of which first stage has been successful and unsuccessful in others. We need to analyze publicly available data for a competitor of SpaceX.

Specific questions

- How various factors (launch site, payload, orbit etc) affect success/failure of first stage landing?
- Is there any trend in success rate of first stage landings over time?
- What ML model best predicts success?

Section 1

Methodology

Methodology

Data collection:

Collected through REST API and Web Scraping

Perform data wrangling

Filtering, missing values handling, one hot endcode

Visualization and EDA with SQL

Visual analytics using Folium and Plotly Dash

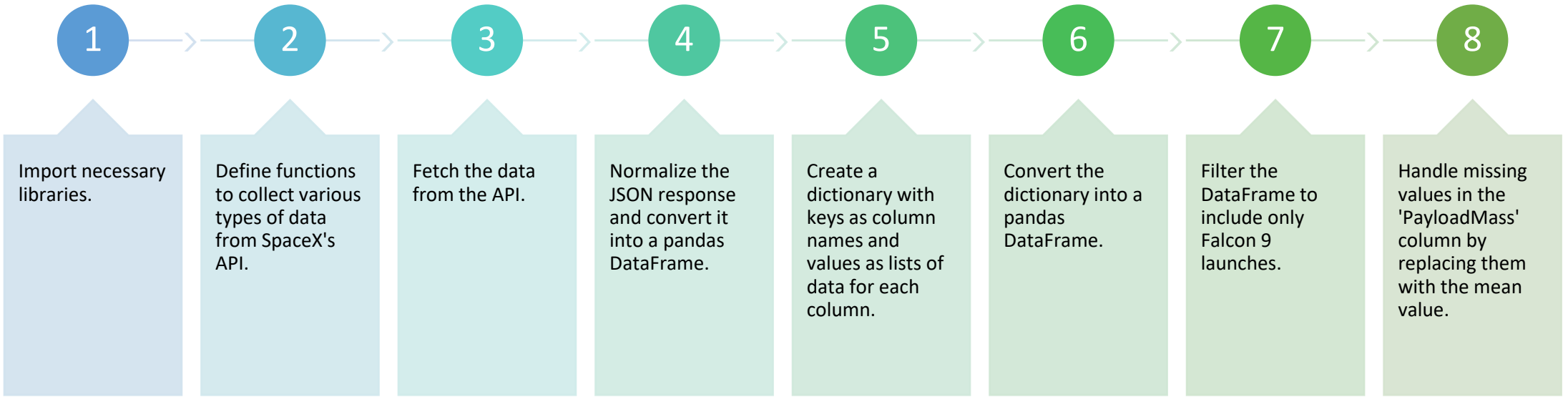
Predictive Analytics

Various classification models built and tested

Data Collection

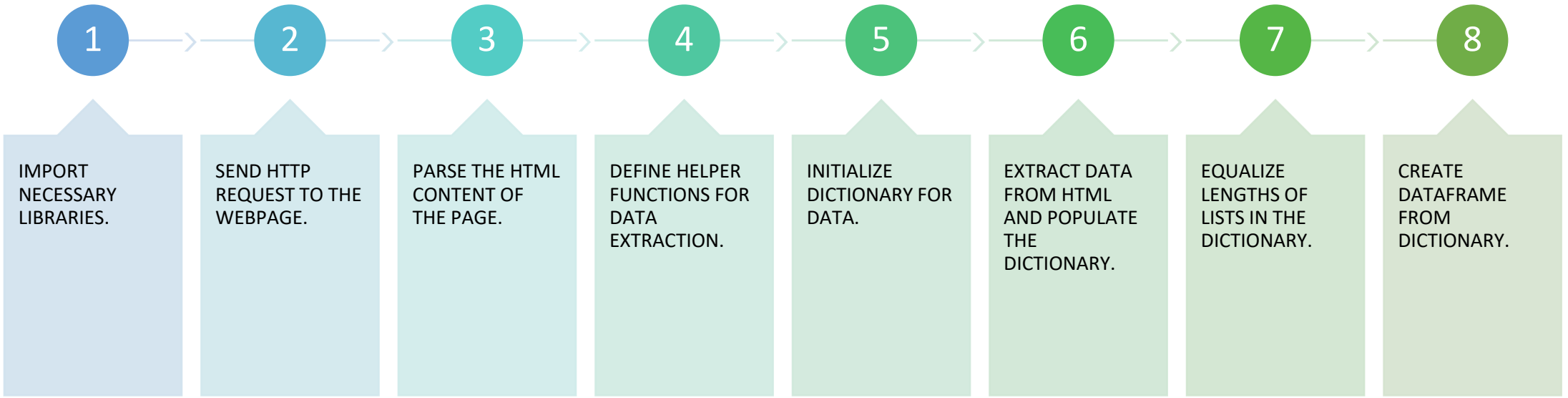
1. Request/Fetch Data
2. Convert to Data Frame
3. Filter Data
4. Replace missing values
5. Export to csv

Data Collection – SpaceX API



Github Link: https://github.com/Atifhussain40/data_science_capstone/blob/main/api%20collection.ipynb

Data Collection - Scraping



Github Link: https://github.com/Atifhussain40/data_science_capstone/blob/main/web%20scraping.ipynb

Data Wrangling

Import necessary libraries (**numpy**, **pandas**)

Load the dataset

Data analysis:

Missing values percentage

Column types

Calculations:

Number of launches on each site

Number and occurrence of each orbit

Number and occurrence of mission outcome per orbit type

New variable ‘Class’

Export the dataframe to a CSV file

Github Link: https://github.com/Atifhussain40/data_science_capstone/blob/main/data%20wrangling.ipynb

EDA with Data Visualization

Plot	Purpose
FlightNumber vs. PayloadMass	Investigate the impact of flight number and payload mass on landing success
FlightNumber vs. LaunchSite	Examine the influence of flight number and launch site on success rates
Payload vs. LaunchSite	Determine the relationship between payload mass and choice of launch site
Success Rate vs. Orbit Type	Identify which orbit types have higher success rates
FlightNumber vs. Orbit Type	Explore the correlation between flight number and orbit type
Payload vs. Orbit Type	Analyze how payload mass and orbit type affect landing success
Yearly Success Trend	Assess the trend of launch success rate over time

Github Link: https://github.com/Atifhussain40/data_science_capstone/blob/main/eda.ipynb

EDA with SQL 1/2

Select

Select distinct launch site names.

- Query: SELECT DISTINCT "Launch_Site" FROM SPACEXTABLE;

Display

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

- Query: %sql SELECT SUM(PAYLOAD_MASS_KG_) as Total_Payload_Mass FROM SPACEXTABLE WHERE Customer = 'NASA (CRS)';.

Display

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

- Query: SELECT SUM("PAYLOAD_MASS__KG_") as Total_Payload_Mass FROM SPACEXTABLE WHERE "Customer" = 'NASA (CRS)';

Display

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

- Query: SELECT AVG("PAYLOAD_MASS__KG_") as Average_Payload_Mass FROM SPACEXTABLE WHERE "Booster_Version" LIKE 'F9 v1.1%';

List

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

- Query: SELECT MIN("Date") as First_Successful_Landing FROM SPACEXTABLE WHERE "Landing_Outcome" LIKE 'Success%';

Github Link: https://github.com/Atifhussain40/data_science_capstone/blob/main/sql%20analysis.ipynb

EDA with SQL 2/2

List

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

- Query: SELECT DISTINCT "Payload" FROM SPACEXTABLE WHERE "Landing_Outcome" LIKE 'Success (drone ship)%' AND "PAYLOAD_MASS__KG_" > 4000 AND "PAYLOAD_MASS__KG_" < 6000;

List

List the total number of successful and failure mission outcomes.

- Query: SELECT SUM(CASE WHEN "Mission_Outcome" LIKE 'Success%' THEN 1 ELSE 0 END) AS Successful_Missions, SUM(CASE WHEN "Mission_Outcome" LIKE 'Failure%' THEN 1 ELSE 0 END) AS Failed_Missions FROM SPACEXTABLE;

List

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

- Query: SELECT "Booster_Version" FROM SPACEXTABLE WHERE "PAYLOAD_MASS__KG_" = (SELECT MAX("PAYLOAD_MASS__KG_") FROM SPACEXTABLE);

List

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

- Query: SELECT SUBSTR("Date", 4, 2) as Month, "Booster_Version", "Launch_Site", "Landing_Outcome" FROM SPACEXTABLE WHERE "Landing_Outcome" LIKE 'Failure (drone ship)%' AND SUBSTR("Date",7,4)='2015';

Rank

Rank the count of landing outcomes between the date 2010-06-04 and 2017-03-20, in descending order.

- Query: 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;

Github Link: https://github.com/Atifhussain40/data_science_capstone/blob/main/sql%20analysis.ipynb

Build an Interactive Map with Folium

Object Added	Purpose
folium.map.Marker	Mark the exact location of each launch site with a text label marker. The marker has the launch site name.
folium.PolyLine	Draw a line from the launch site to the coastline.
folium.PolyLine	Draw a line from a nearby city to the launch site and display the distance.
folium.PolyLine	Draw a line from a nearby railway to the launch site and display the distance.
folium.PolyLine	Draw a line from a nearby highway to the launch site and display the distance.

Github Link: https://github.com/Atifhussain40/data_science_capstone/blob/main/Folium.ipynb

Build a Dashboard with Plotly Dash

Chart	Purpose
Chart- Successful Launches by Site	To see which site has the highest share in the successful launches
Chart – KSC LC 39A Success Failure comparison	To see the percentage of successful launches from the site
Scatter Chart	To see correlation between payload and launch success

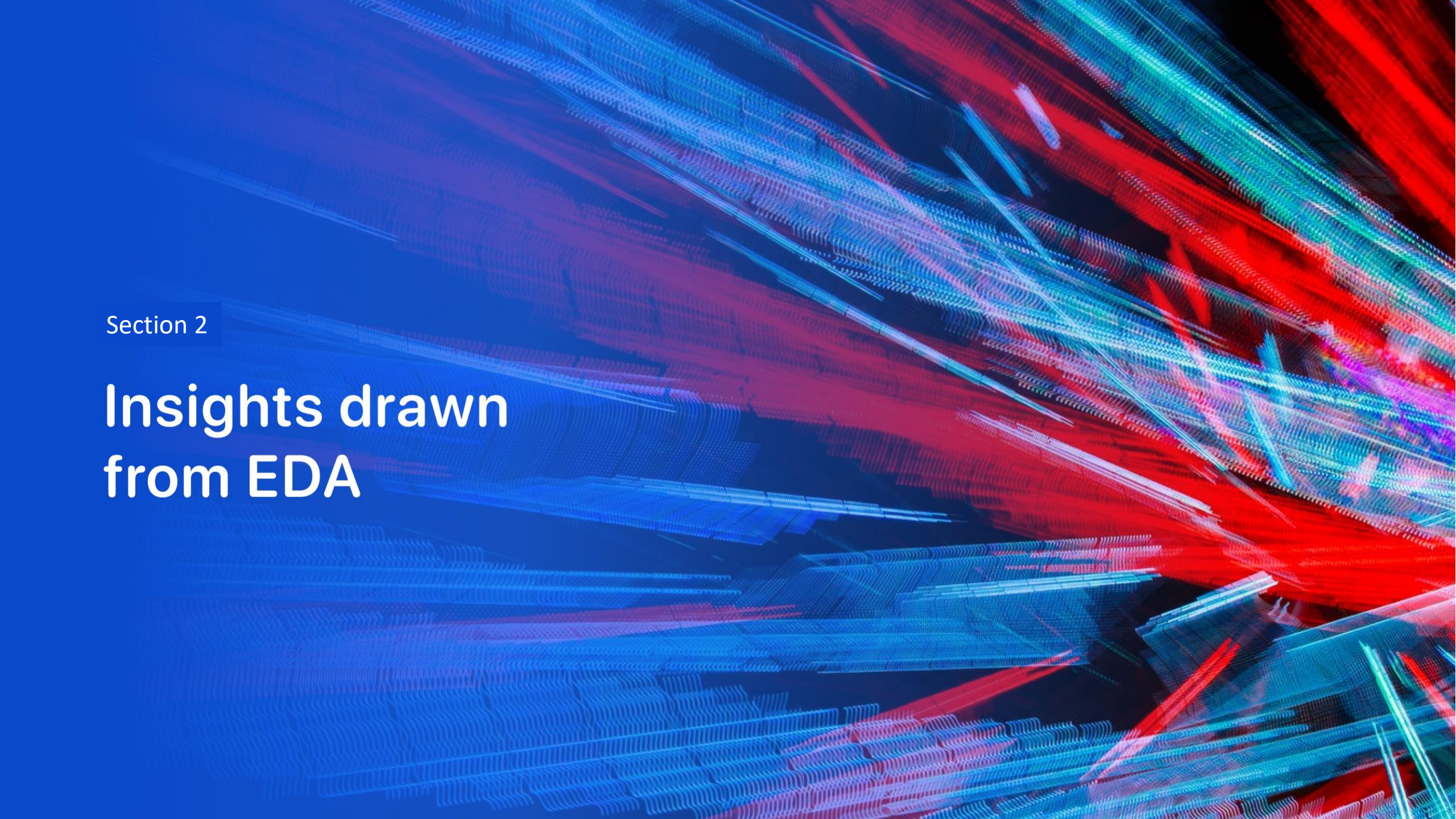
Predictive Analysis (Classification)

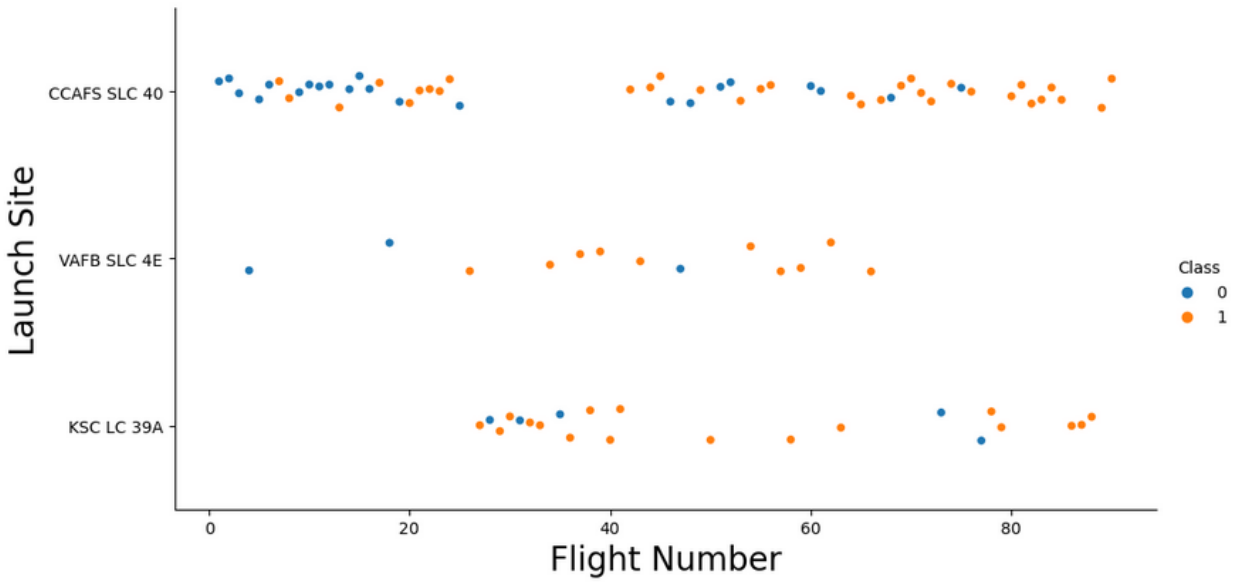
- Data Loaded
- Models Built
- Models tuned using GridSearchCV
- Models compared using accuracy score
- Best model selected

- Github Link: https://github.com/Atifhussain40/data_science_capstone/blob/main/Predictive.ipynb

Main Results

- Success rate has improved over the time
- KSC LC 39A has the best success rate
- Decision Trees based model performs best in predicting outcome

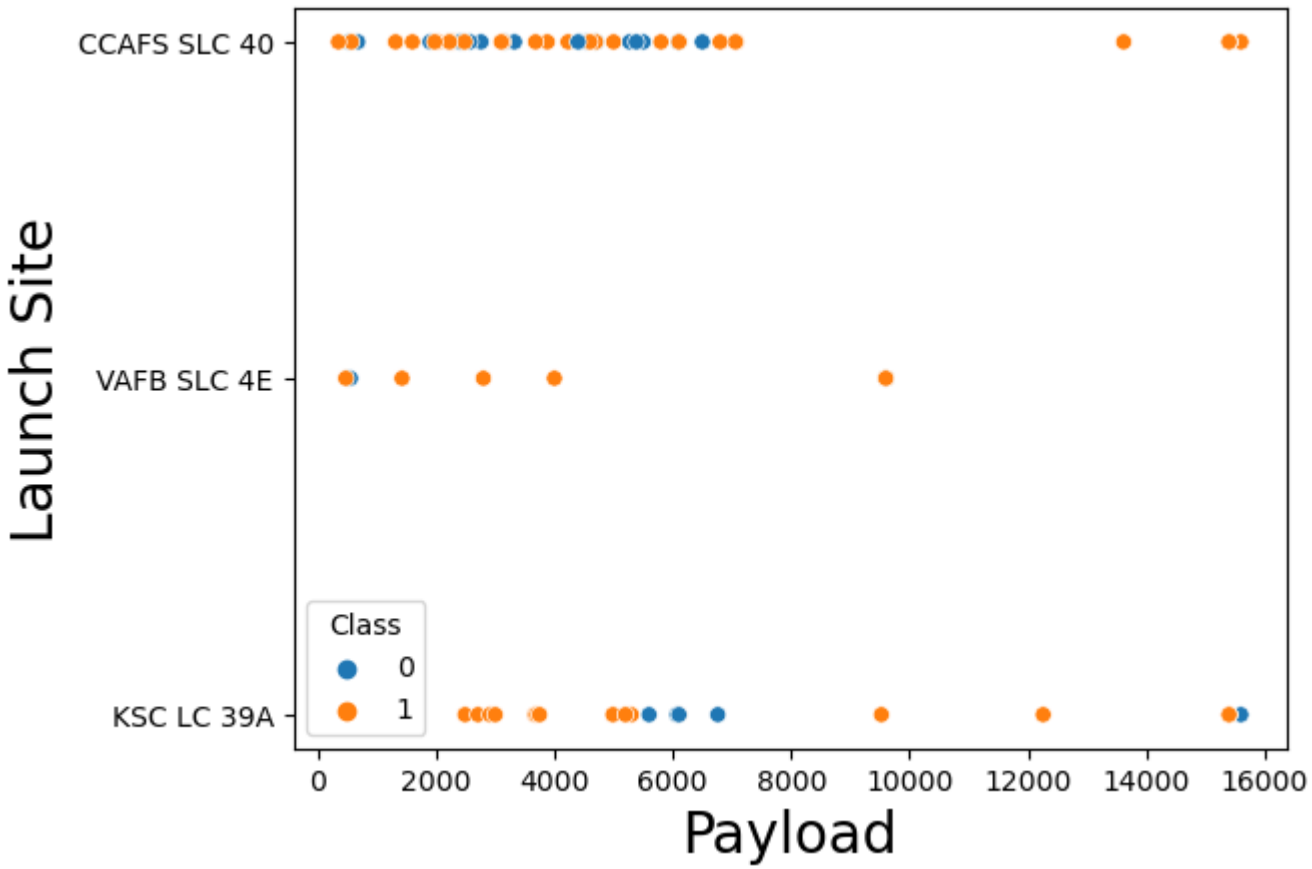

Section 2
Insights drawn from EDA



Flight Number vs. Launch Site

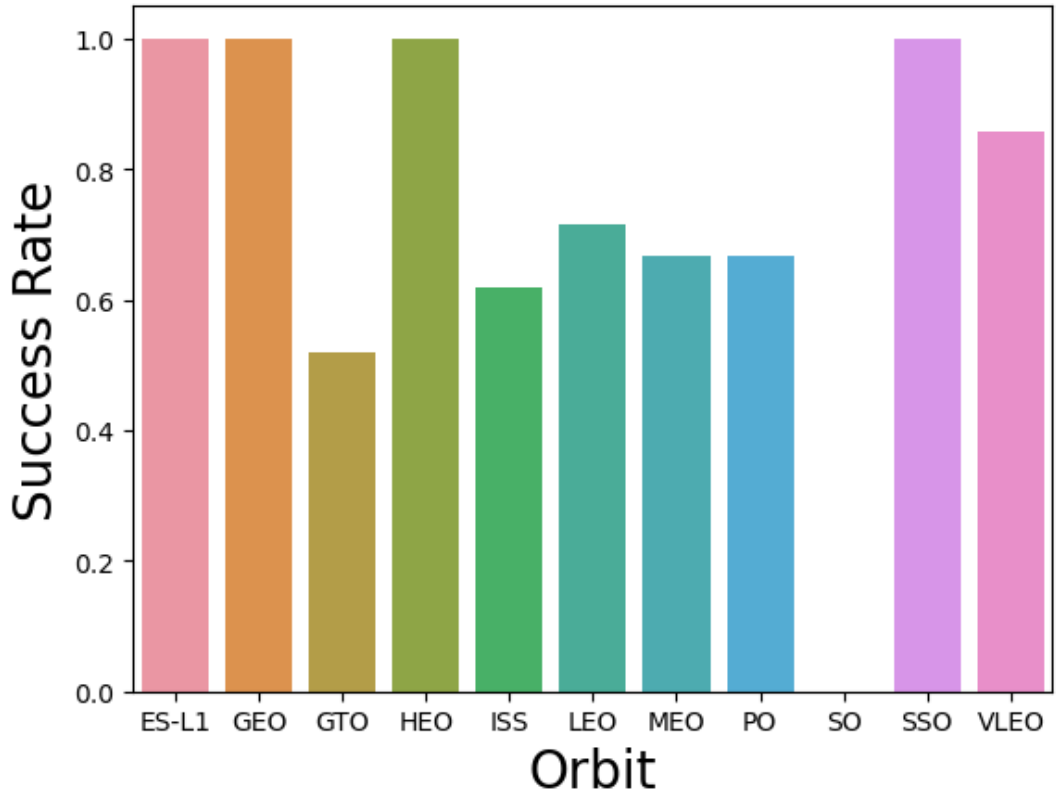
- CCAFS SLC 40 has the highest number of flights, however, many of those have been unsuccessful
- KSC LC 39A has very few unsuccessful flights

Payload vs. Launch Site



- CCAFS SLC 40 has more success with greater mass loads
- KSC LC 39A also has greater success with small mass loads

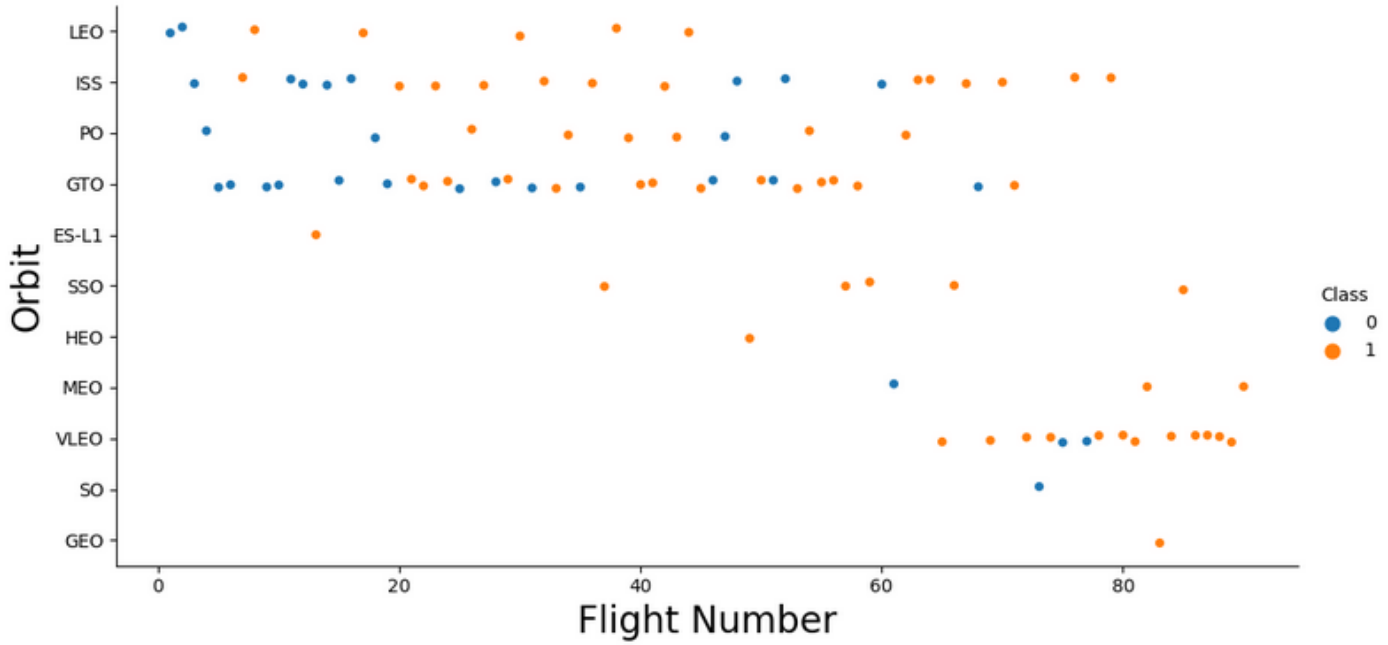
Success Rate vs. Orbit Type



- ES-L1, GEO, HEO and SSO have the highest success rates
- GTO orbit has the lowest success rate

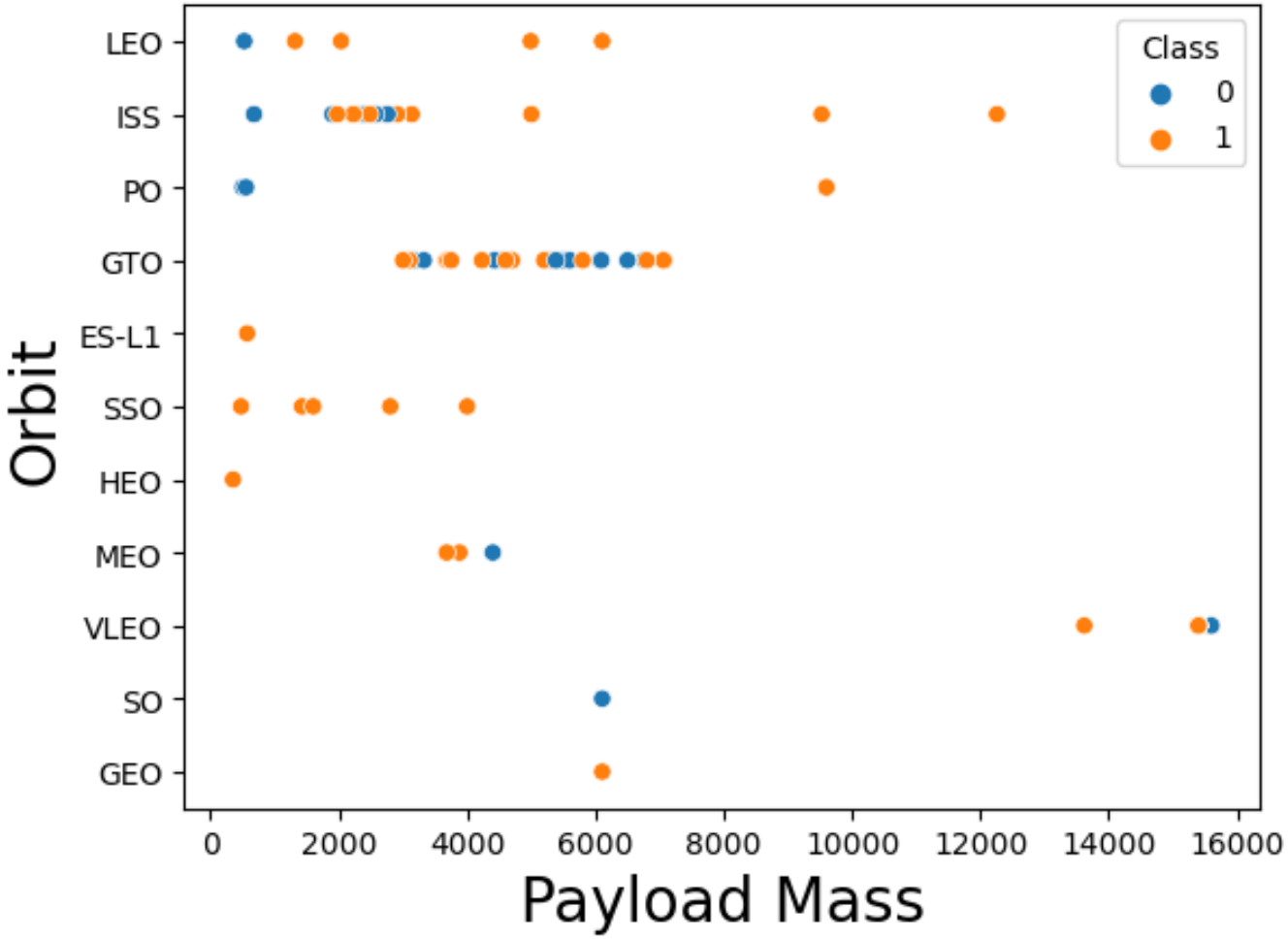
Flight Number vs. Orbit Type

- LEO orbit, success is related to the flight number whereas
- In the GTO orbit, there is no relationship between flight number and the success



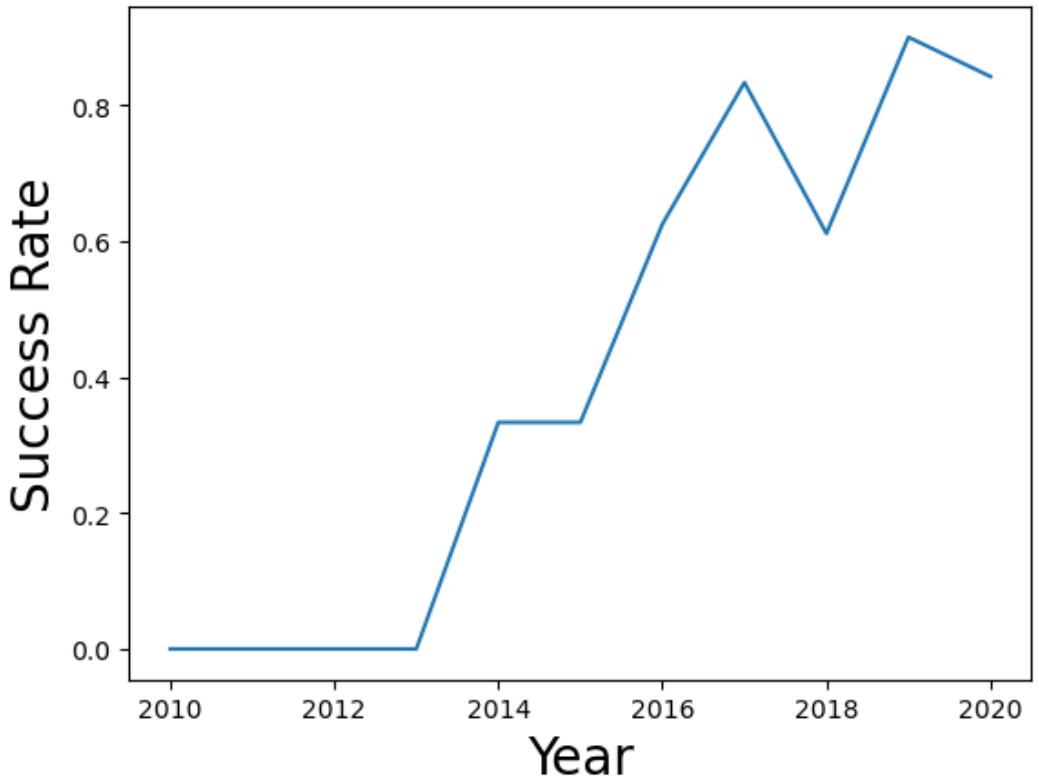
Payload vs. Orbit Type

In ISS orbit, success is associated with higher payloads



Launch Success Yearly Trend

Success rate has generally increased over the years.



All Launch Site Names

Query has selected distinct/unique launch site names from SPACEXTABLE

```
In [16]: %sql SELECT DISTINCT "Launch_Site" FROM SPACEXTABLE;
 * sqlite:///my_data1.db
Done.
```

Out[16]:

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

Launch Site Names Begin with 'CCA'

Selected records where launch sites began with `CCA` using LIKE

Date	Time (UTC)	Booster_Version	Launch_Site	Payload	PAYLOAD_MASS__KG_	Orbit	Customer	Mission
06/04/2010	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0.0	LEO	SpaceX	
12/08/2010	15:43:00	F9 v1.0 B0004	CCAFS LC-40	Dragon demo flight C1, two CubeSats, barrel of Brouere cheese	0.0	LEO (ISS)	NASA (COTS) NRO	
22/05/2012	7:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525.0	LEO (ISS)	NASA (COTS)	

Total Payload Mass

```
In [22]: %sql SELECT SUM("PAYLOAD_MASS__KG_") as Total_Payload_Mass FROM SPACEXTABLE WHERE "Customer" = 'NASA (CRS)';
 * sqlite:///my_data1.db
Done.
Out[22]:
```

Total_Payload_Mass
45596.0

Total payload carried by boosters from NASA is 45,596 Kgs

Average Payload Mass by F9 v1.1

In [12]:
```
%sql SELECT AVG("PAYLOAD_MASS__KG_") FROM SPACEXTABLE WHERE "Booster_Version" = 'F9 v1.1';
```

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

Out[12]:

AVG("PAYLOAD_MASS__KG_")
2928.4

Average Payload Mass carried by F9 v1.1 is 2534.67 Kgs

First Successful Ground Landing Date

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

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

MIN("Date")
01/08/2018

The first successful ground landing was on 01/07/2020

Successful Drone Ship Landing with Payload between 4000 and 6000

In [27]:
```
%sql SELECT DISTINCT "Payload" FROM SPACEXTABLE WHERE "Landing_Outcome" LIKE 'Success (drone ship)%' AND "PAY
```

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

Out[27]:

Payload
JCSAT-14
JCSAT-16
SES-10
SES-11 / EchoStar 105

Names of the boosters with payloads between 4000 and 6000 and successful landing are JCSAT-14, JCSAT-16, SES-10, SES-11/EchoStar 105

Total Number of Successful and Failure Mission Outcomes

List the total number of successful and failure mission outcomes

In [28]:
```
%sql SELECT SUM(CASE WHEN "Mission_Outcome" LIKE 'Success%' THEN 1 ELSE 0 END) AS Successful_Missions, SUM(CA
```

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

Out[28]:

Successful_Missions	Failed_Missions
100	1

100 missions have been successful and 1 unsuccessful

Boosters Carried Maximum Payload

In [15]:
```
%sql SELECT "Booster_Version", "PAYLOAD_MASS__KG_" FROM SPACEXTABLE WHERE "PAYLOAD_MASS__KG_" = (SELECT MAX("
```

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

Out[15]:

Booster_Version	PAYLOAD_MASS__KG_
F9 B5 B1048.4	15600.0
F9 B5 B1049.4	15600.0
F9 B5 B1051.3	15600.0
F9 B5 B1056.4	15600.0
F9 B5 B1048.5	15600.0
F9 B5 B1051.4	15600.0
F9 B5 B1049.5	15600.0
F9 B5 B1060.2	15600.0
F9 B5 B1058.3	15600.0
F9 B5 B1051.6	15600.0
F9 B5 B1060.3	15600.0
F9 B5 B1049.7	15600.0

Boosters carrying the maximum payload

2015 Launch Records

In [36]:
```
%sql SELECT SUBSTR("Date", 4, 2) as Month, "Booster_Version", "Launch_Site", "Landing_Outcome" FROM SPACEXTABL
```

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

Out[36]:

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

Two Boosters in 2015 failing in drone ship

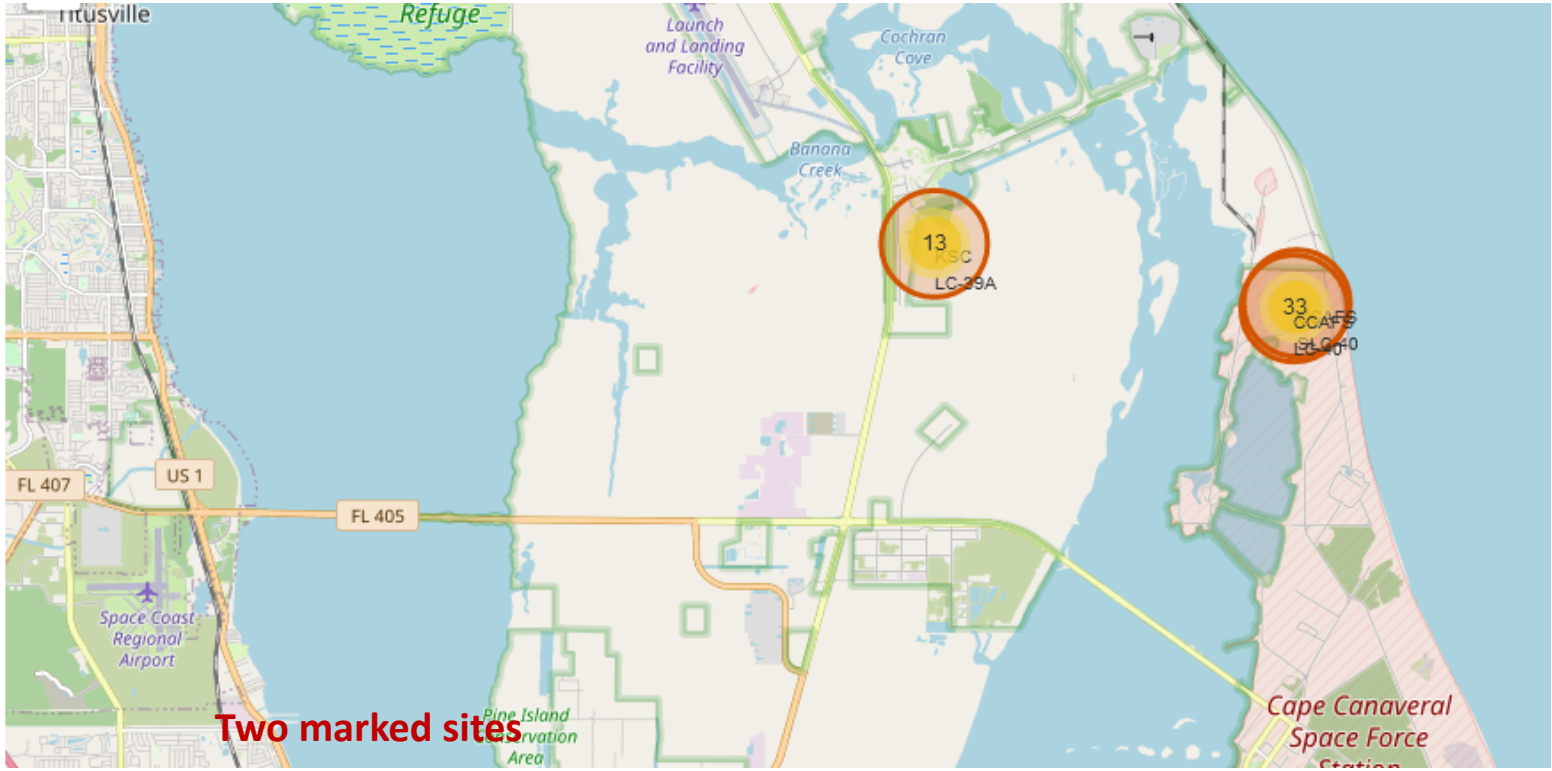
Section 3

Launch Sites Proximities Analysis

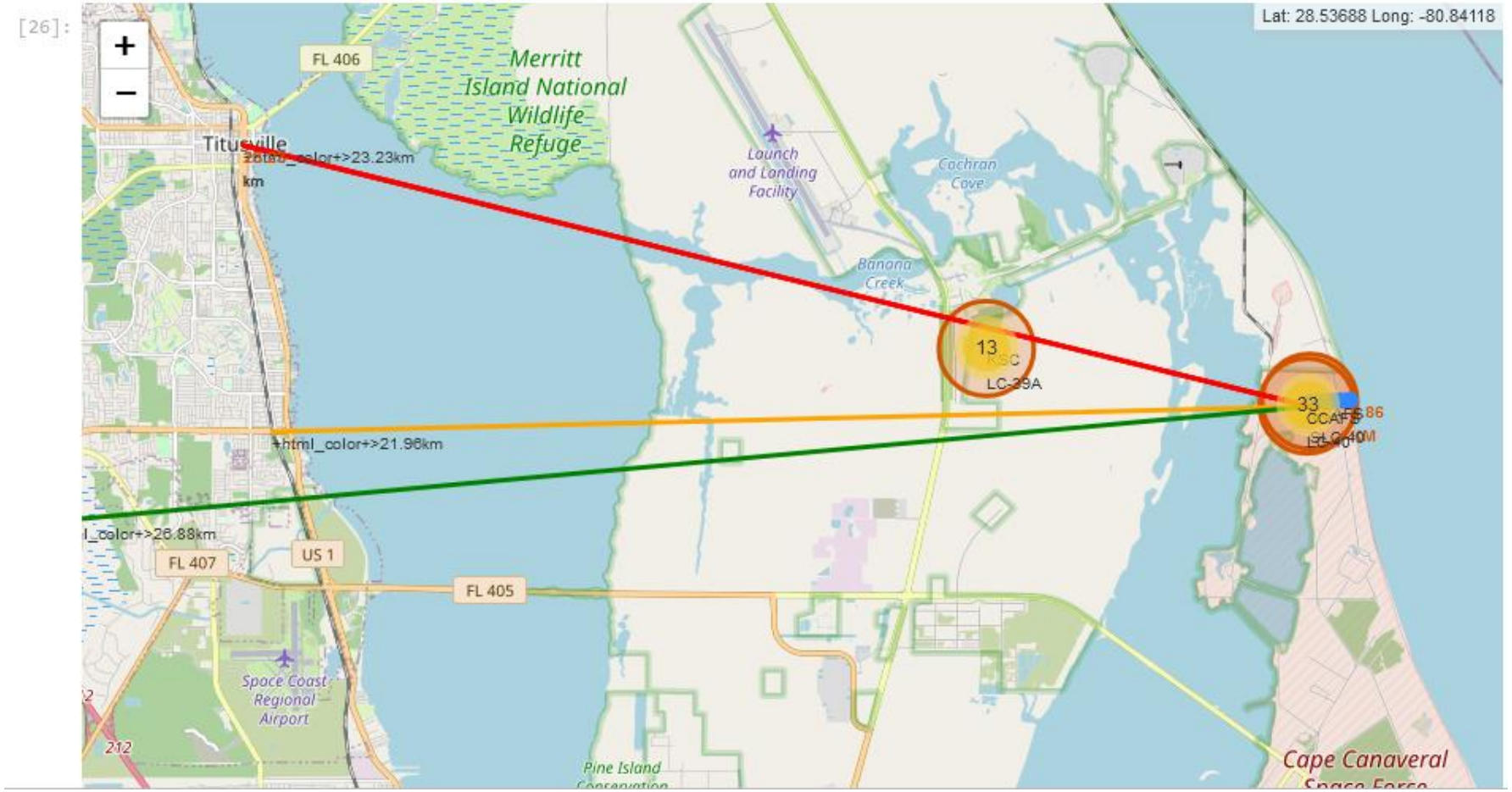
Launch Sites in USA

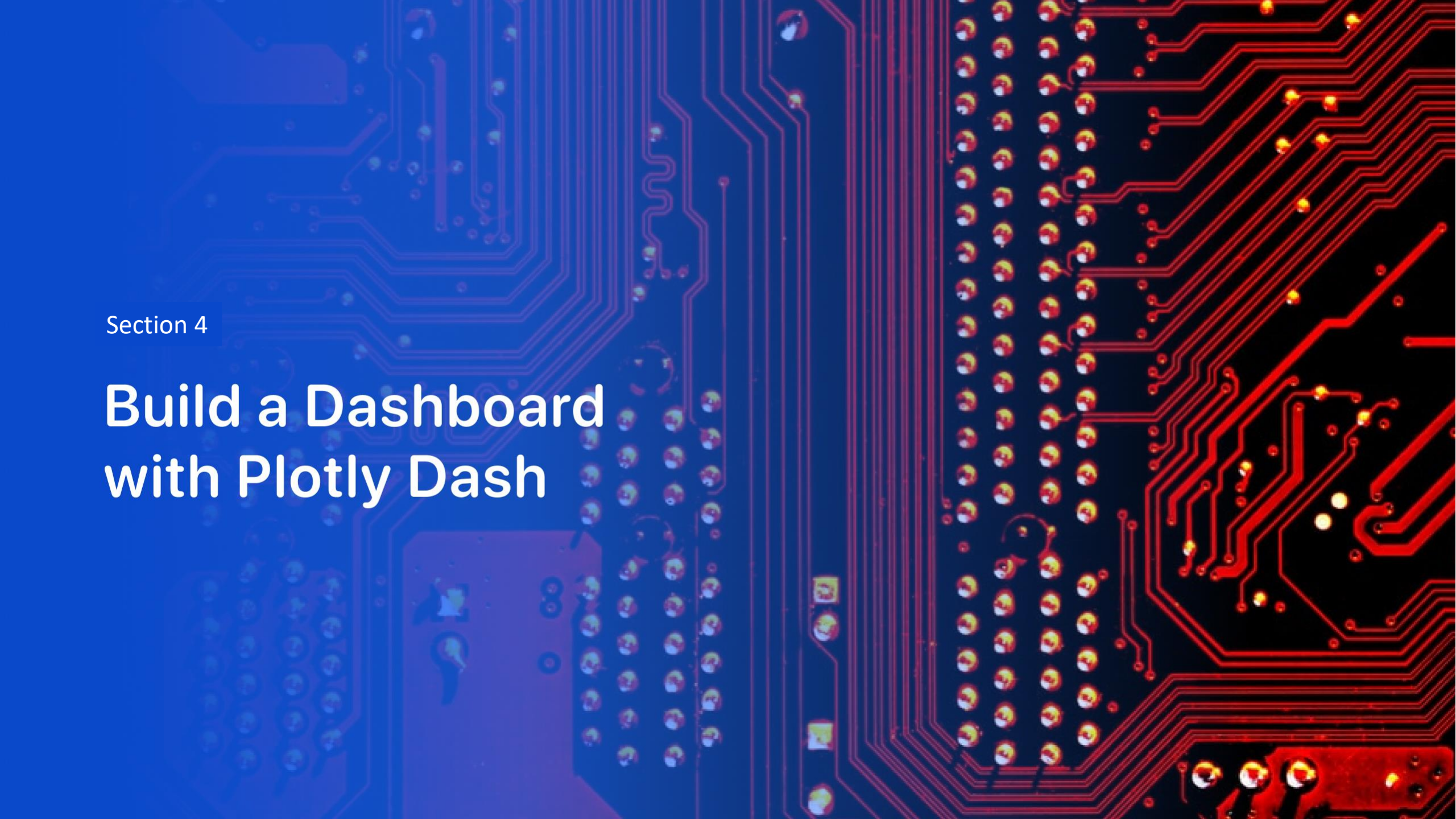
Launch sites in USA

Marked Sites

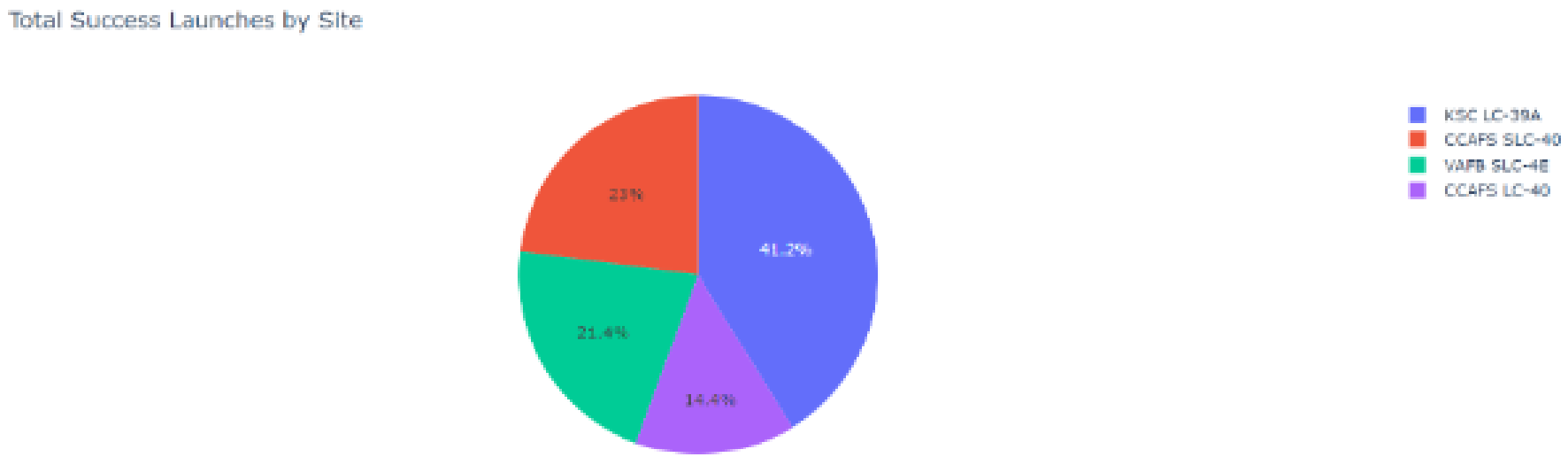


Distances from city, railway, and highway



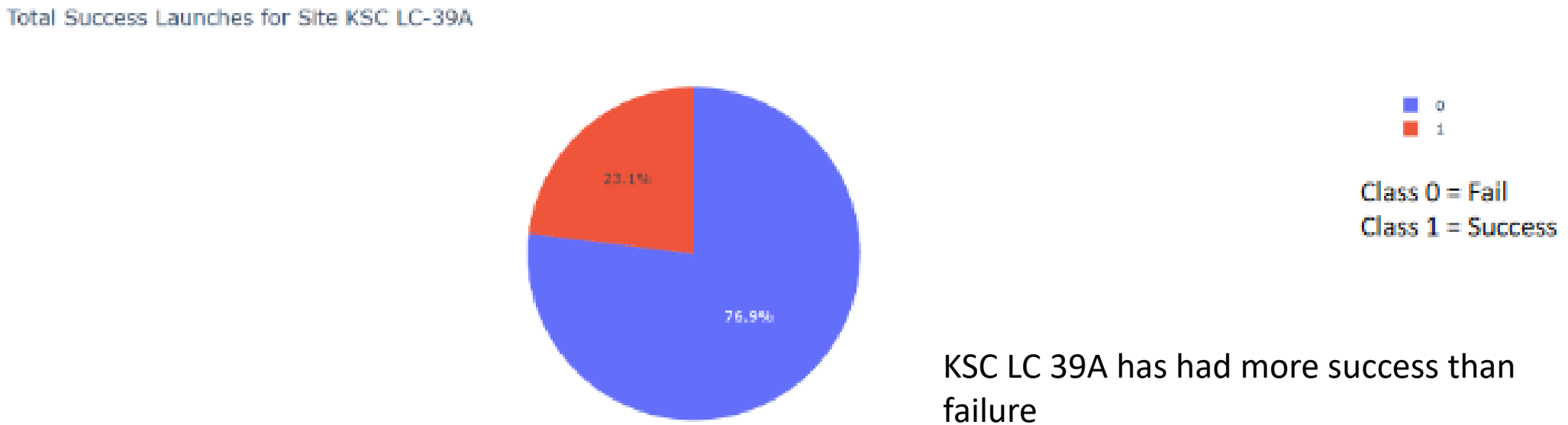

Section 4
Build a Dashboard with Plotly Dash

Successful Launches by site



KSC LC 39A has the highest successful launches

KSC LC 39A Success vs Failure

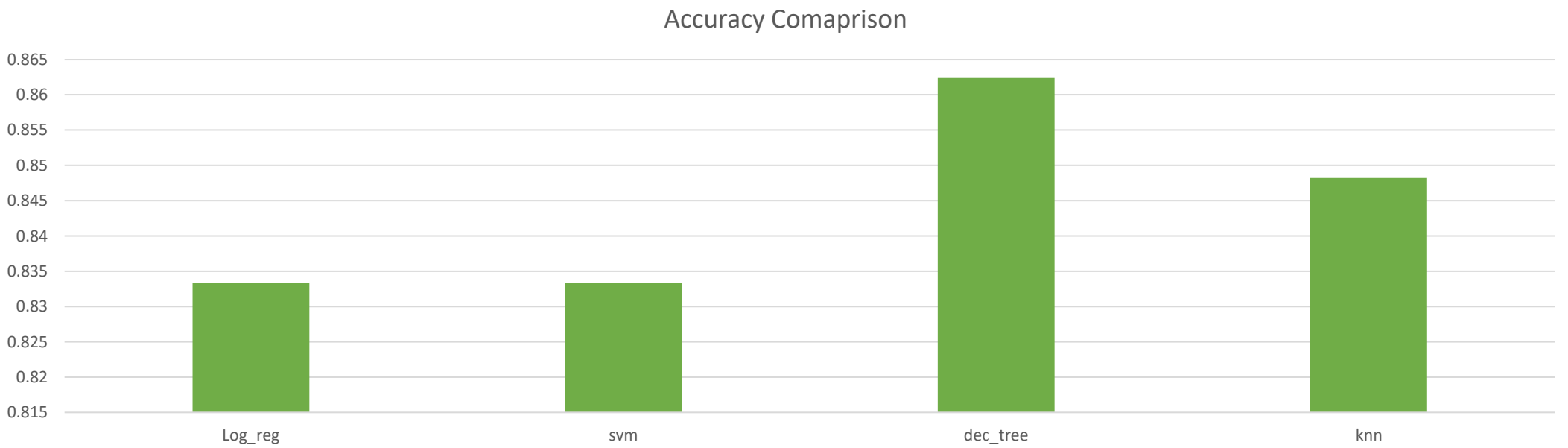


KSC LC 39A has had more success than failure

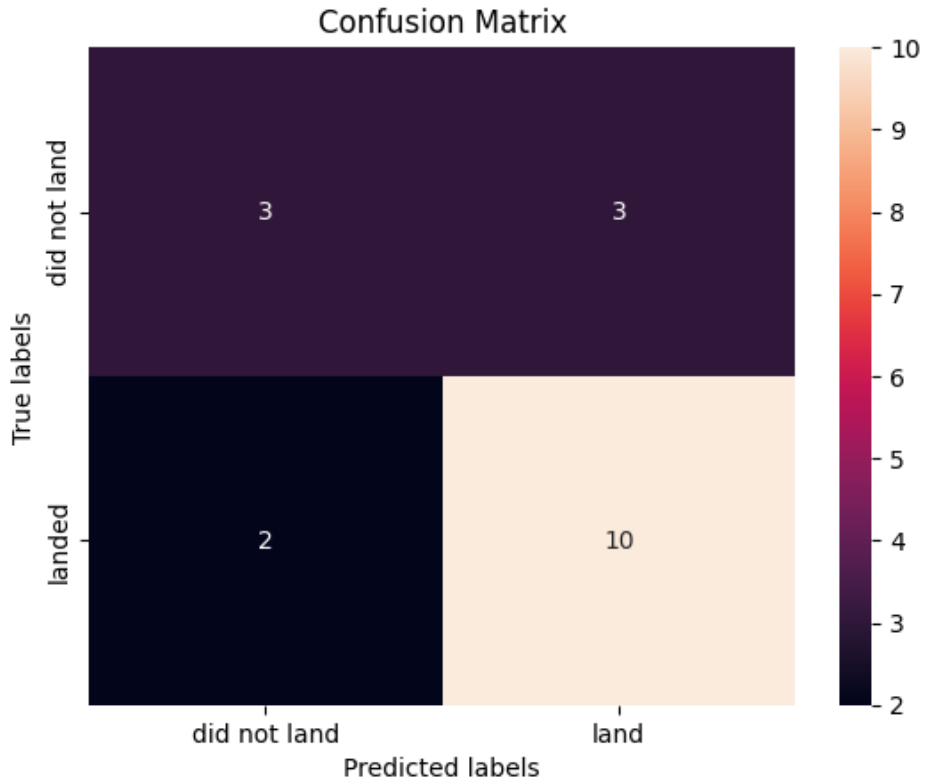
Section 5

Predictive Analysis (Classification)

Classification Accuracy



Confusion Matrix of Decision Tree



The matrix shows that the classifier misclassified 3 failed landings as successful

Conclusions

Launch success rate has generally increased over the time.

Orbits ES-L1, GEO, HEO, SSO, VLEO had the most success

KSC LC-39A has enjoyed the most success.

The Decision tree classifier is the best classifier in the current context

Thank you!