



IBM Developer  
SKILLS NETWORK

# Winning Space Race with Data Science

<Name>

<Date>



# Outline

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

# Executive Summary

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- Summary of methodologies
  - Data Collection with API
  - Data Collection with Web Scrapping
  - Data Wrangling
  - Exploratory Analysis with SQL
  - Exploratory Analysis with Visualization
  - Interactive Visualization with Folium
  - Machine Learning Prediction
- Summary of all results
  - Analysis Result
  - Prediction result from Machine Learning

# Introduction

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SpaceX is a revolutionary company who has disrupted the space industry by offering rocket launches specifically Falcon 9 as low as 62 million dollars; while other providers cost upward of 165 million dollars each. Most of this saving thanks to SpaceX's astounding idea to reuse the first stage of the launch by re-land the rocket to be used on the next mission. Repeating this process will make the price even lower. As a data scientist of a startup rivaling SpaceX, the goal of this project is to create the machine learning pipeline to predict the landing outcome of the first stage in the future. This project is crucial in identifying the right price to bid against SpaceX for a rocket launch.

The problems included:

- Identifying all factors that influence the landing outcome.
- The relationship between each variable and how it is affecting the outcome.
- The best condition needed to increase the probability of successful landing.



Section 1

# Methodology

# Methodology

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## Executive Summary

- Data collection methodology:
  - Data was collected using SpaceX REST API and web scrapping from Wikipedia
- Perform data wrangling
  - Data was processed using one-hot encoding for categorical features
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - How to build, tune, evaluate classification models

# Data Collection

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Data collection is the process of gathering and measuring information on targeted variables in an established system, which then enables one to answer relevant questions and evaluate outcomes.

As mentioned, the dataset was collected by REST API and Web Scrapping from Wikipedia.

For REST API, its started by using the get request. Then, we decoded the response content as Json and turn it into a pandas dataframe using `json_normalize()`. We then cleaned the data, checked for missing values and fill with whatever needed.

For web scrapping, we will use the BeautifulSoup to extract the launch records as HTML table, parse the table and convert it to a pandas dataframe for further analysis

# Data Collection – SpaceX API

Get request for rocket launch data using API

Use json\_normalize method to convert json result to dataframe

Performed data cleaning and filling the missing value

<https://github.com/ThLeroy61/SpaceX-Data-Science-Coursera/blob/main/Data%20Collection%20API.ipynb>

```
spacex_url="https://api.spacexdata.com/v4/launches/past"
```

```
response = requests.get(spacex_url)
```

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

```
# Lets take a subset of our dataframe keeping only the features we want and the flight number, and date_utc.  
data = data[['rocket', 'payloads', 'launchpad', 'cores', 'flight_number', 'date_utc']]
```

```
# We will remove rows with multiple cores because those are falcon rockets with 2 extra rocket boosters and rows that have multiple payloads in a single rocket.
```

```
data = data[data['cores'].map(len)==1]  
data = data[data['payloads'].map(len)==1]
```

```
# Since payloads and cores are lists of size 1 we will also extract the single value in the list and replace the feature.
```

```
data['cores'] = data['cores'].map(lambda x : x[0])  
data['payloads'] = data['payloads'].map(lambda x : x[0])
```

```
# We also want to convert the date_utc to a datetime datatype and then extracting the date leaving the time
```

```
data['date'] = pd.to_datetime(data['date_utc']).dt.date
```

```
# Using the date we will restrict the dates of the launches  
data = data[data['date'] <= datetime.date(2020, 11, 13)]
```



# Data Collection - Scraping

Request the Falcon9 Launch Wiki page  
from url

Create a BeautifulSoup from the HTML  
response

Extract all column/variable names  
from the HTML header

<https://github.com/ThLeroy61/SpaceX-Data-Science-Coursera/blob/main/Webscrapping.ipynb>

```
# use requests.get() method with the provided static_url
# assign the response to a object
data = requests.get(static_url).text
```

```
# Use BeautifulSoup() to create a BeautifulSoup object from a response text content
soup = BeautifulSoup(data, 'html.parser')
```

```
extracted_row = 0
#Extract each table
for table_number, table in enumerate(soup.find_all('table', "wikitable plainrowheaders collapsible")):
    # get table row
    for rows in table.find_all("tr"):
        #check to see if first table heading is as number corresponding to launch a number
        if rows.th:
            if rows.th.string:
                flight_number=rows.th.string.strip()
                flag=flight_number.isdigit()
            else:
                flag=False
```

# Data Wrangling

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Data Wrangling is the process of cleaning and unifying messy and complex data sets for easy access and Exploratory Data Analysis (EDA).

We will first calculate the number of launches on each site, then calculate the number and occurrence of mission outcome per orbit type. We then create a landing outcome label from the outcome column.

This will make it easier for further analysis, visualization, and ML. Lastly, we will export the result to a CSV.

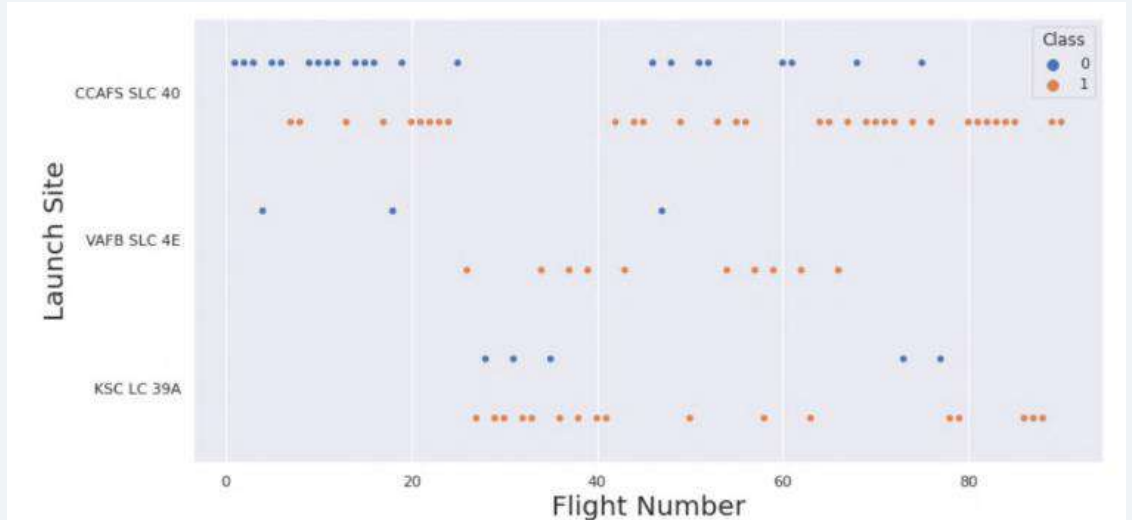
<https://github.com/ThLeroy61/SpaceX-Data-Science-Coursera/blob/main/Data%20Wrangling.ipynb>

# EDA with Data Visualization

We first started by using scatter graph to find the relationship between the attributes such as between:

- Payload and Flight Number.
- Flight Number and Launch Site.
- Payload and Launch Site.
- Flight Number and Orbit Type.
- Payload and Orbit Type.

Scatter plots show dependency of attributes on each other. Once a pattern is determined from the graphs. It's very easy to see which factors affecting the most to the success of the landing outcomes.



<https://github.com/ThLeroy61/SpaceX-Data-Science-Coursera/blob/main/EDA%20Data%20Viz.ipynb>

# EDA with Data Visualization

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Once we get a hint of the relationships using scatter plot. We will then use further visualization tools such as bar graph and line plots graph for further analysis.

Bar graphs is one of the easiest way to interpret the relationship between the attributes. In this case, we will use the bar graph to determine which orbits have the highest probability of success.

We then use the line graph to show a trends or pattern of the attribute over time which in this case, is used for see the launch success yearly trend.

We then use Feature Engineering to be used in success prediction in the future module by created the dummy variables to categorical columns.

<https://github.com/ThLeroy61/SpaceX-Data-Science-Coursera/blob/main/EDA%20Data%20Viz.ipynb>

# EDA with SQL

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Using SQL, we had performed many queries to get better understanding of the dataset, Ex:

- Displaying the names of the launch sites.
- Displaying 5 records where launch sites begin with the string 'CCA'.
- Displaying the total payload mass carried by booster launched by NASA (CRS).
- Displaying the average payload mass carried by booster version F9 v1.1.
- Listing the date when the first successful landing outcome in ground pad was achieved.
- Listing the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 6000.
- Listing the total number of successful and failure mission outcomes.
- Listing the names of the booster\_versions which have carried the maximum payload mass.
- Listing the failed landing\_outcomes in drone ship, their booster versions, and launch sites names for in year 2015.
- Rank the count of landing outcomes or success between the date 2010-06-04 and 2017-03-20, in descending order.

<https://github.com/ThLeroy61/SpaceX-Data-Science-Coursera/blob/main/EDA%20SQL.ipynb>



# Build an Interactive Map with Folium

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To visualize the launch data into an interactive map. We took the latitude and longitude coordinates at each launch site and added a circle marker around each launch site with a label of the name of the launch site.

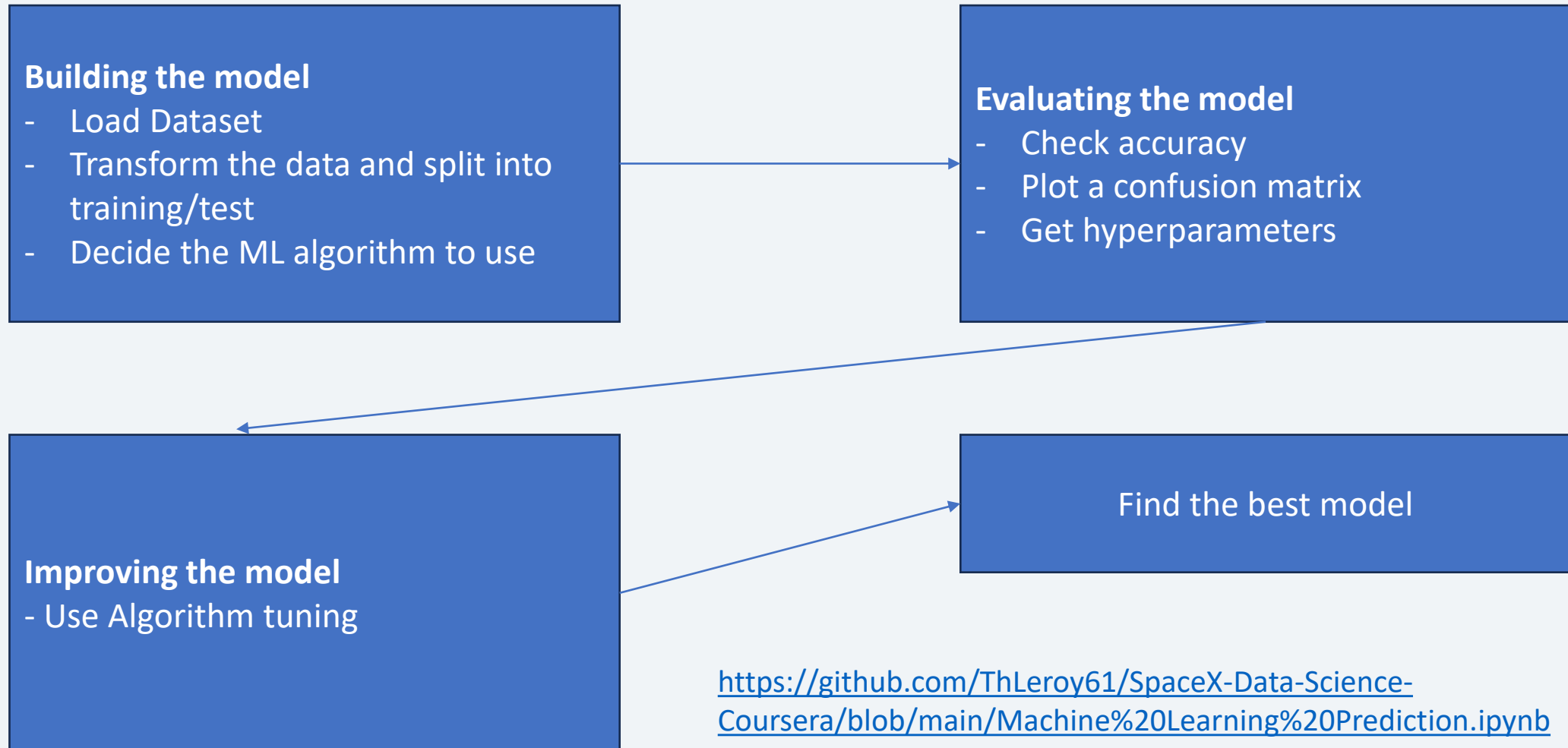
We then used the Haversine's formula to calculate the distance of the launch sites to various landmarks to find answers to the questions of:

- How close the launch sites with railways, highways and coastlines?
- How close the launch sites with nearby cities?

[https://github.com/ThLeroy61/SpaceX-Data-Science-Coursera/blob/main/lab\\_jupyter\\_launch\\_site\\_location.ipynb](https://github.com/ThLeroy61/SpaceX-Data-Science-Coursera/blob/main/lab_jupyter_launch_site_location.ipynb)

# Predictive Analysis (Classification)

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<https://github.com/ThLeroy61/SpaceX-Data-Science-Coursera/blob/main/Machine%20Learning%20Prediction.ipynb>



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 blue and red, creating a sense of motion or data flow. A faint, light blue grid pattern is also visible, particularly in the lower-left quadrant. The overall effect is high-tech and digital.

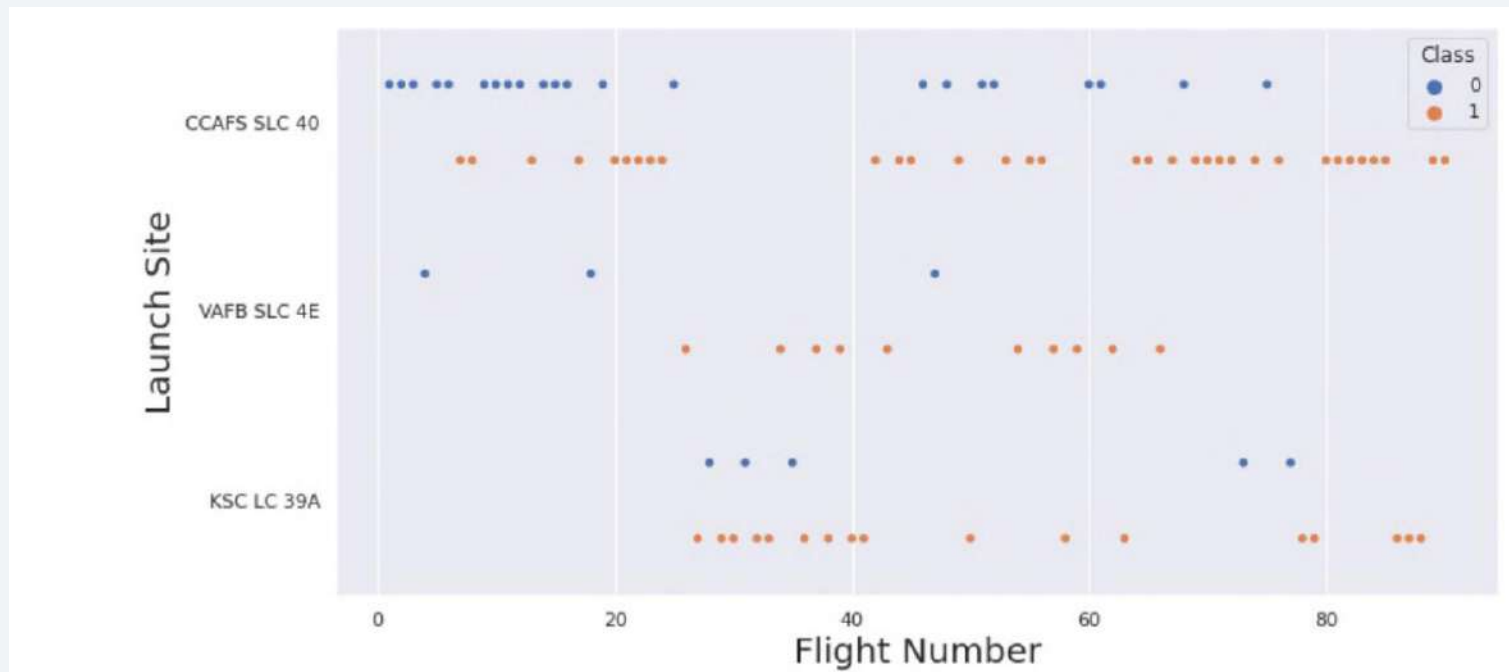
Section 2

# Insights drawn from EDA



# Flight Number vs. Launch Site

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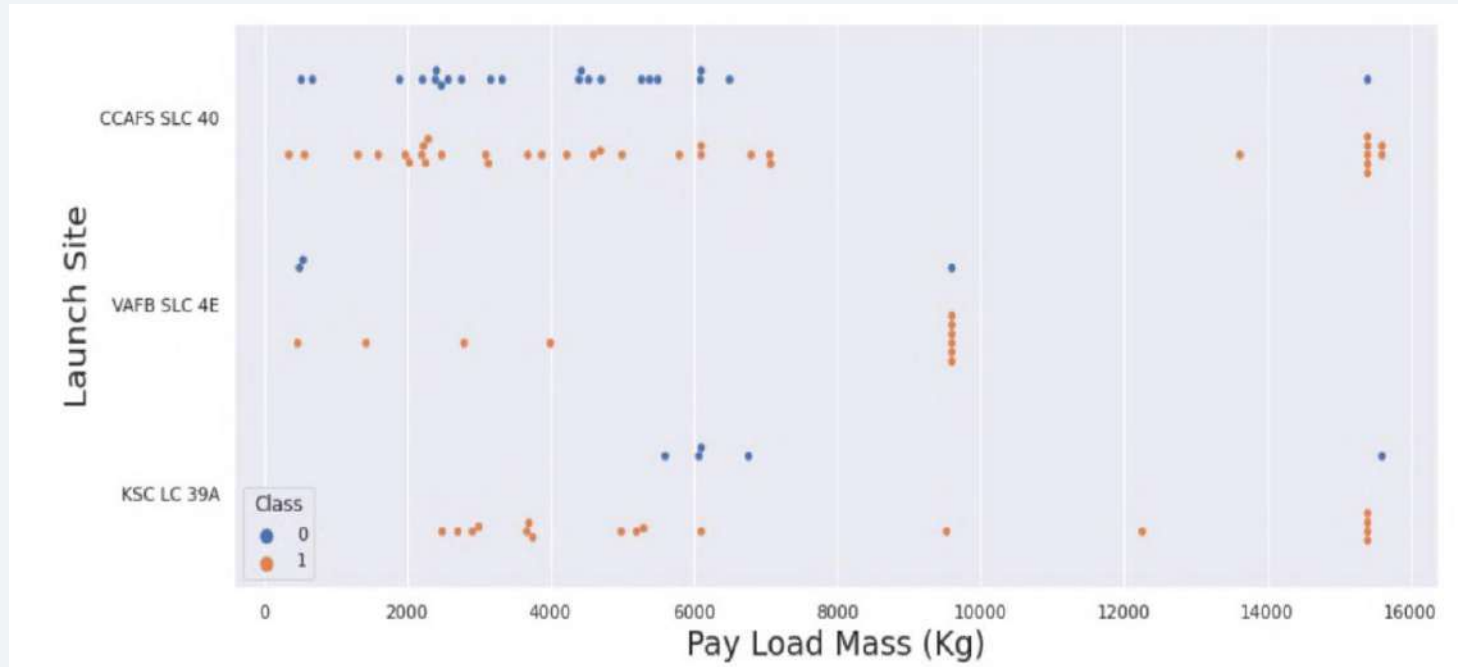


This scatter plot shows that the larger the flights amount of the launch site, the greater the the success rate will be.

However, site CCAFS SLC40 shows the least pattern of this.

# Payload vs. Launch Site

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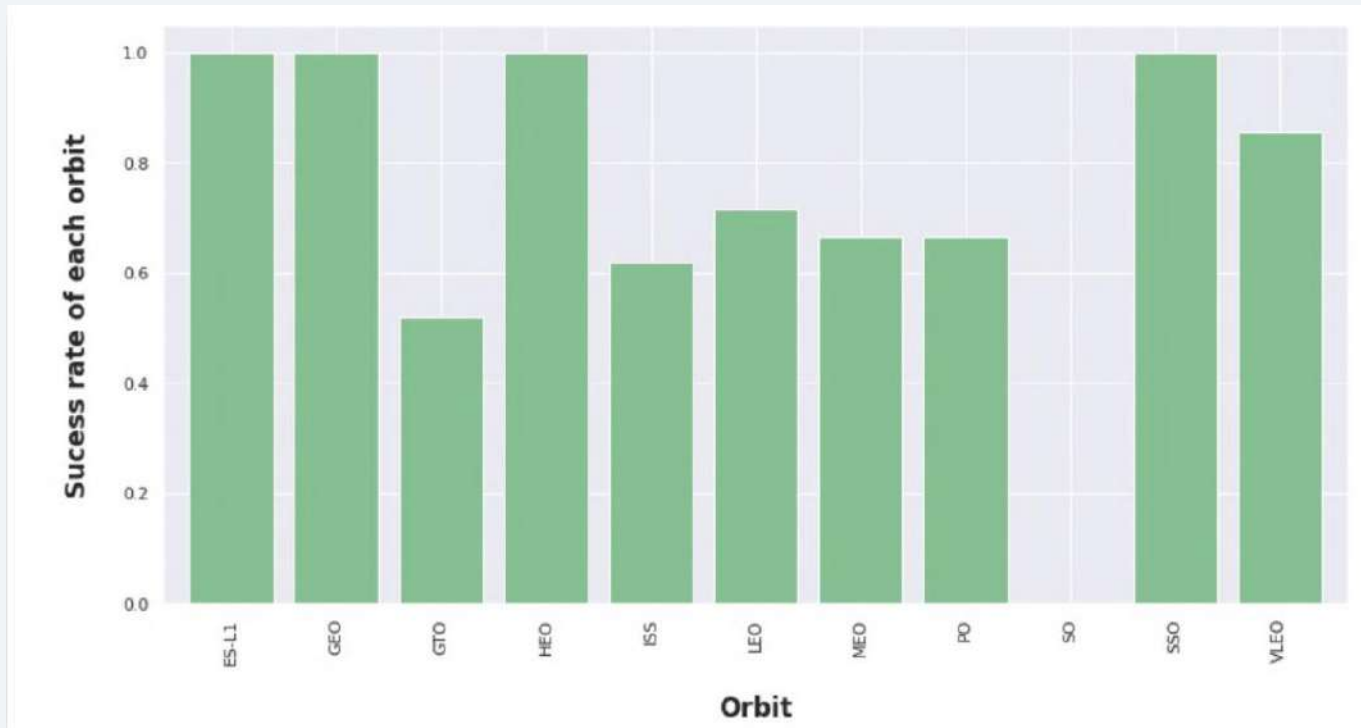


This scatter plot shows once the payload mass is greater than 7000kg, the probability of the success rate will be highly increased.

However, there is no clear pattern to say the launch site is dependent to the payload mass for the success rate.



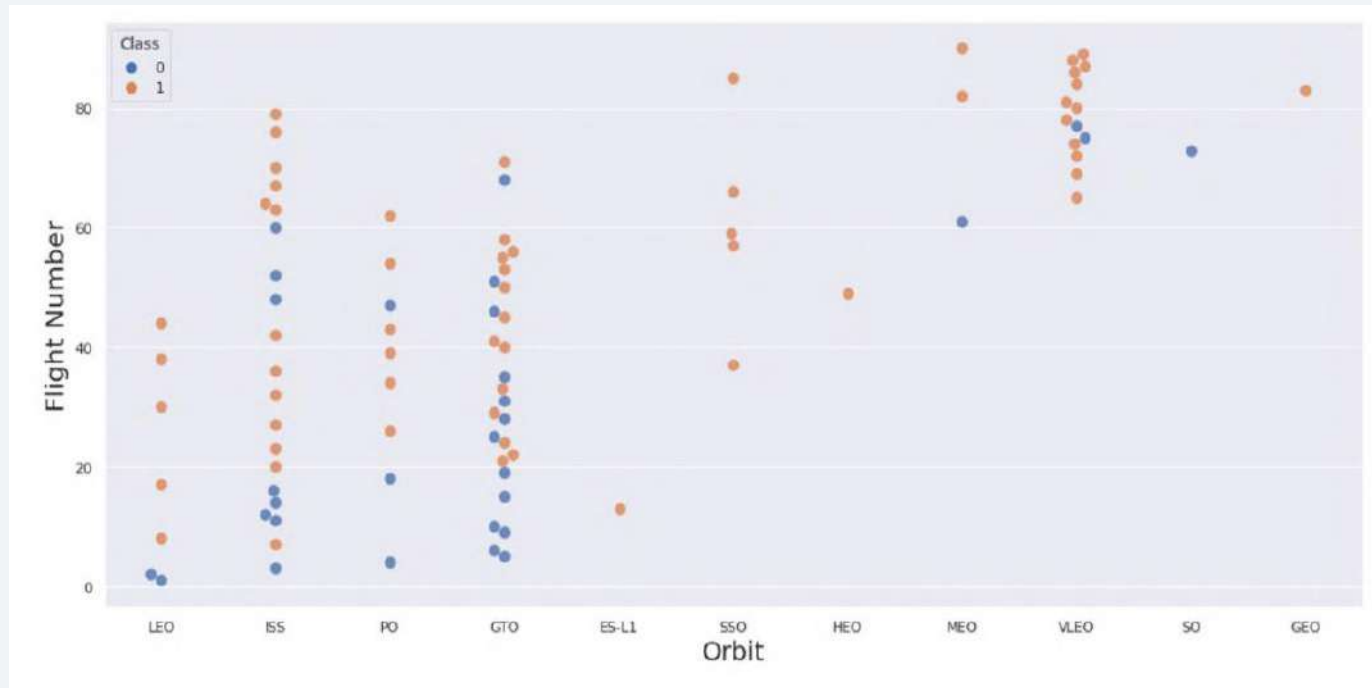
# Success Rate vs. Orbit Type



This figure depicted the possibility of the orbits to influences the landing outcomes as some orbits has 100% success rate such as SSO, HEO, GEO AND ES-L1 while SO orbit produced 0% rate of success.

However, deeper analysis show that some of this orbits has only 1 occurrence such as GEO, SO, HEO and ES-L1 which mean this data need more dataset to see pattern or trend before we draw any conclusion.

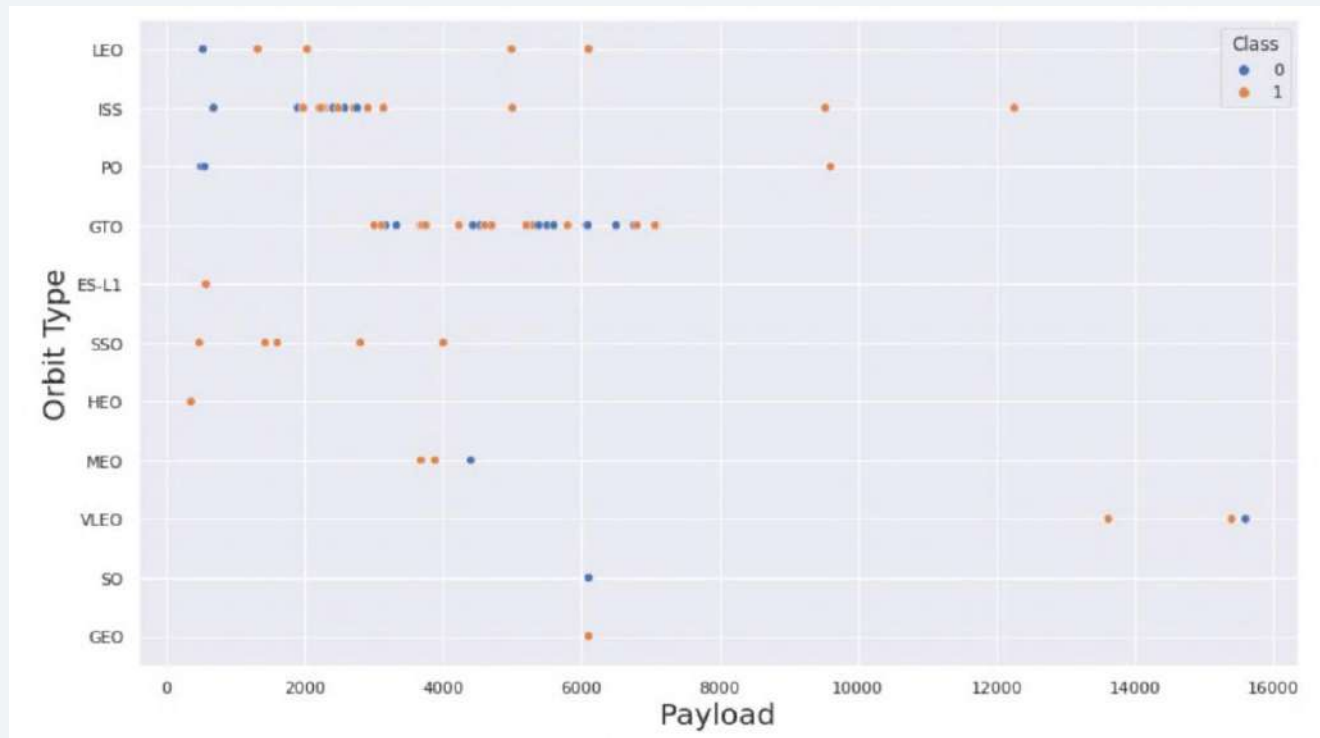
# Flight Number vs. Orbit Type



This scatter plot shows that generally, the larger the flight number on each orbits, the greater the success rate (especially LEO orbit) except for GTO orbit which depicts no relationship between both attributes.

Orbit that only has 1 occurrence should also be excluded from above statement as it's needed more dataset.

# Payload vs. Orbit Type



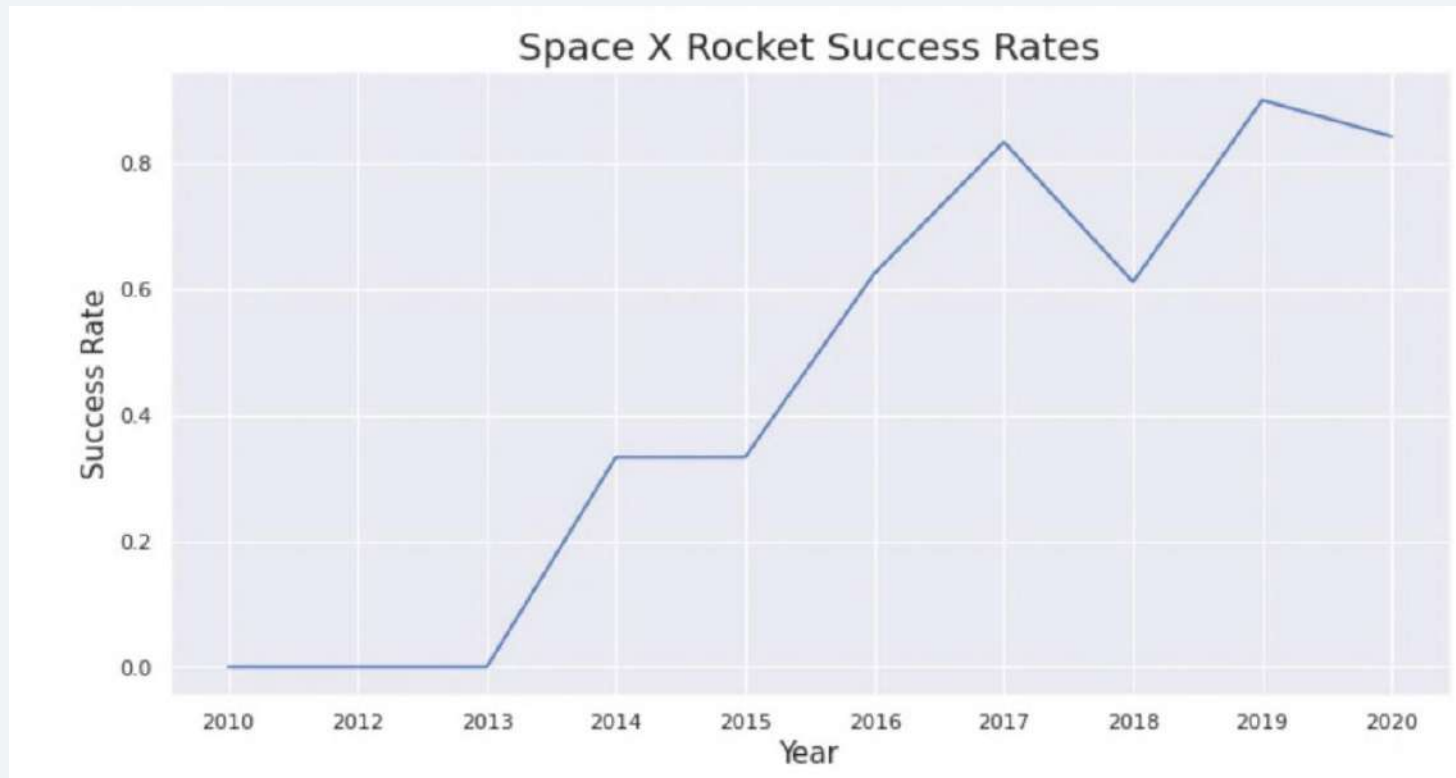
Heavier payload has positive impact on LEO, ISS and PO orbit. However, it has negative impact on MEO and VLEO orbit.

GTO orbit seem to depict no relation between the attributes.

Meanwhile, again, SO, GEO and HEO orbit need more dataset to see any pattern or trend.

# Launch Success Yearly Trend

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This figures clearly depicted and increasing trend from the year 2013 until 2020.

If this trend continue for the next year onward, the success rate will steadily increase until reaching 1% success rate.

# All Launch Site Names

---

In [5]:

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

```
* ibm_db_sa://zpw86771:***@fbd88901-ebdb-4a4f-a32e-9822b9fb237b.clogj3  
sd0tgtu0lqde00.databases.appdomain.cloud:32731/bludb  
Done.
```

Out [5]:

**Launch\_Sites**

CCAFS LC-40

CCAFS SLC-40

KSC LC-39A

VAFB SLC-4E



# Launch Site Names Begin with 'CCA'

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

In [11]:

```
task_2 = '''
SELECT *
FROM SpaceX
WHERE LaunchSite LIKE 'CCA%'
LIMIT 5
'''

create_pandas_df(task_2, database=conn)
```

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

---

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

```
%sql SELECT SUM(PAYLOAD_MASS__KG_) AS "Total Payload Mass by NASA (CRS)"
```

```
* ibm_db_sa://zpw86771:***@fbd88901-ebdb-4a4f-a32e-9822b9fb237b.clogj3  
sd0tgtu0lqde00.databases.appdomain.cloud:32731/bludb  
Done.
```

**Total Payload Mass by NASA (CRS)**

---

45596

# Average Payload Mass by F9 v1.1

---

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

```
%sql SELECT AVG(PAYLOAD_MASS__KG_) AS "Average Payload Mass by Booster  
WHERE BOOSTER_VERSION = 'F9 v1.1';
```

```
* ibm_db_sa://zpw86771:***@fbd88901-ebdb-4a4f-a32e-9822b9fb237b.clogj3  
sd0tgtu0lqde00.databases.appdomain.cloud:32731/bludb  
Done.
```

**Average Payload Mass by Booster Version F9 v1.1**

---

2928

# First Successful Ground Landing Date

---

```
%sql SELECT MIN(DATE) AS "First Successful Landing Outcome in Ground Pad  
WHERE LANDING__OUTCOME = 'Success (ground pad)';
```

```
* ibm_db_sa://zpw86771:***@fbd88901-ebdb-4a4f-a32e-9822b9fb237b.clogj3  
sd0tgtu0lqde00.databases.appdomain.cloud:32731/bludb  
Done.
```

**First Successful Landing Outcome in Ground Pad**

---

2015-12-22

# Successful Drone Ship Landing with Payload between 4000 and 6000

---

```
%sql SELECT BOOSTER_VERSION FROM SPACEX WHERE LANDING__OUTCOME = 'Success (drone ship)' \
AND PAYLOAD_MASS__KG_ > 4000 AND PAYLOAD_MASS__KG_ < 6000;
```

```
* ibm_db_sa://zpw86771:***@fbd88901-ebdb-4a4f-a32e-9822b9fb237b.clogj3sd0tgtu0lqde00.databases.appdomain.cloud:32731/bludb
```

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

---

List the total number of successful and failure mission outcomes

```
%sql SELECT COUNT(MISSION_OUTCOME) AS "Successful Mission" FROM SPACEX WHERE MISSION_OUTCOME LIKE 'Success%';
```

```
* ibm_db_sa://zpw86771:***@fbd88901-ebdb-4a4f-a32e-9822b9fb237b.clogj3sd0tgtu0lqde00.databases.appdomain.cloud:32731/bludb
Done.
```

Successful Mission
--------------------

100
-----

```
%sql SELECT COUNT(MISSION_OUTCOME) AS "Failure Mission" FROM SPACEX WHERE MISSION_OUTCOME LIKE 'Failure%';
```

```
* ibm_db_sa://zpw86771:***@fbd88901-ebdb-4a4f-a32e-9822b9fb237b.clogj3sd0tgtu0lqde00.databases.appdomain.clou
d:32731/bludb
Done.
```

Failure Mission
-----------------

1
---

# Boosters Carried Maximum Payload

```
%sql SELECT DISTINCT BOOSTER_VERSION AS "Booster Versions which carried the Maximum Payload Mass" FROM SPACEX  
WHERE PAYLOAD_MASS_KG_ =(SELECT MAX(PAYLOAD_MASS_KG_) FROM SPACEX);
```

```
* ibm_db_sa://zpw86771:***@fbd88901-ebdb-4a4f-a32e-9822b9fb237b.clogj3sd0tgtu0lqde00.databases.appdomain.clou  
d:32731/bludb
```

Done.

**Booster Versions which carried the Maximum Payload Mass**

F9 B5 B1048.4

F9 B5 B1048.5

F9 B5 B1049.4

F9 B5 B1049.5

F9 B5 B1049.7

F9 B5 B1051.3

F9 B5 B1051.4

F9 B5 B1051.6

F9 B5 B1056.4

F9 B5 B1058.3

F9 B5 B1060.2

F9 B5 B1060.3

# 2015 Launch Records

---

```
%sql SELECT BOOSTER_VERSION, LAUNCH_SITE FROM SPACEX WHERE DATE LIKE '2015-%' AND \
LANDING__OUTCOME = 'Failure (drone ship)';
```

```
* ibm_db_sa://zpw86771:***@fbd88901-ebdb-4a4f-a32e-9822b9fb237b.clogj3sd0tgtu0lqde00.
databases.appdomain.cloud:32731/bludb
Done.
```

booster_version	launch_site
-----------------	-------------

F9 v1.1 B1012	CCAFS LC-40
---------------	-------------

F9 v1.1 B1015	CCAFS LC-40
---------------	-------------

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

---

```
%sql SELECT LANDING__OUTCOME as "Landing Outcome", COUNT(LANDING__OUTCOME) AS "Total Count" FROM SPACEX \
WHERE DATE BETWEEN '2010-06-04' AND '2017-03-20' \
GROUP BY LANDING__OUTCOME \
ORDER BY COUNT(LANDING__OUTCOME) DESC ;
```

```
* ibm_db_sa://zpw86771:***@fbd88901-ebdb-4a4f-a32e-9822b9fb237b.clogj3sd0tgu01qde00.databases.appdomain.c
loud:32731/bludb
Done.
```

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

A satellite view of Earth from space, showing the curvature of the planet and city lights at night. The image is a composite of a dark blue sky with stars and a view of the Earth's surface from space. The Earth's surface is mostly dark, with a thin layer of white clouds and a dense network of yellow and orange lights representing city lights at night. The lights are concentrated in the lower right portion of the image, forming a complex pattern of interconnected lines and dots. The horizon of the Earth is visible as a curved line separating the dark surface from the black sky.

Section 3

# Launch Sites Proximities Analysis

# <Folium Map Screenshot 1>

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- Replace <Folium map screenshot 1> title with an appropriate title
- Explore the generated folium map and make a proper screenshot to include all launch sites' location markers on a global map
- Explain the important elements and findings on the screenshot

## <Folium Map Screenshot 2>

---

- Replace <Folium map screenshot 2> title with an appropriate title
- Explore the folium map and make a proper screenshot to show the color-labeled launch outcomes on the map
- Explain the important elements and findings on the screenshot



# <Folium Map Screenshot 3>

---

- Replace <Folium map screenshot 3> title with an appropriate title
- Explore the generated folium map and show the screenshot of a selected launch site to its proximities such as railway, highway, coastline, with distance calculated and displayed
- Explain the important elements and findings on the screenshot



Section 4

# Build a Dashboard with Plotly Dash

# <Dashboard Screenshot 1>

---

- Replace <Dashboard screenshot 1> title with an appropriate title
- Show the screenshot of launch success count for all sites, in a piechart
- Explain the important elements and findings on the screenshot

## <Dashboard Screenshot 2>

---

- Replace <Dashboard screenshot 2> title with an appropriate title
- Show the screenshot of the piechart for the launch site with highest launch success ratio
- Explain the important elements and findings on the screenshot

## <Dashboard Screenshot 3>

---

- Replace <Dashboard screenshot 3> title with an appropriate title
- Show screenshots of Payload vs. Launch Outcome scatter plot for all sites, with different payload selected in the range slider
- Explain the important elements and findings on the screenshot, such as which payload range or booster version have the largest success rate, etc.



Section 5

# Predictive Analysis (Classification)



# Classification Accuracy

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As we can see, by using the code as below: we could identify that the best algorithm to be the Tree Algorithm which have the highest classification accuracy.

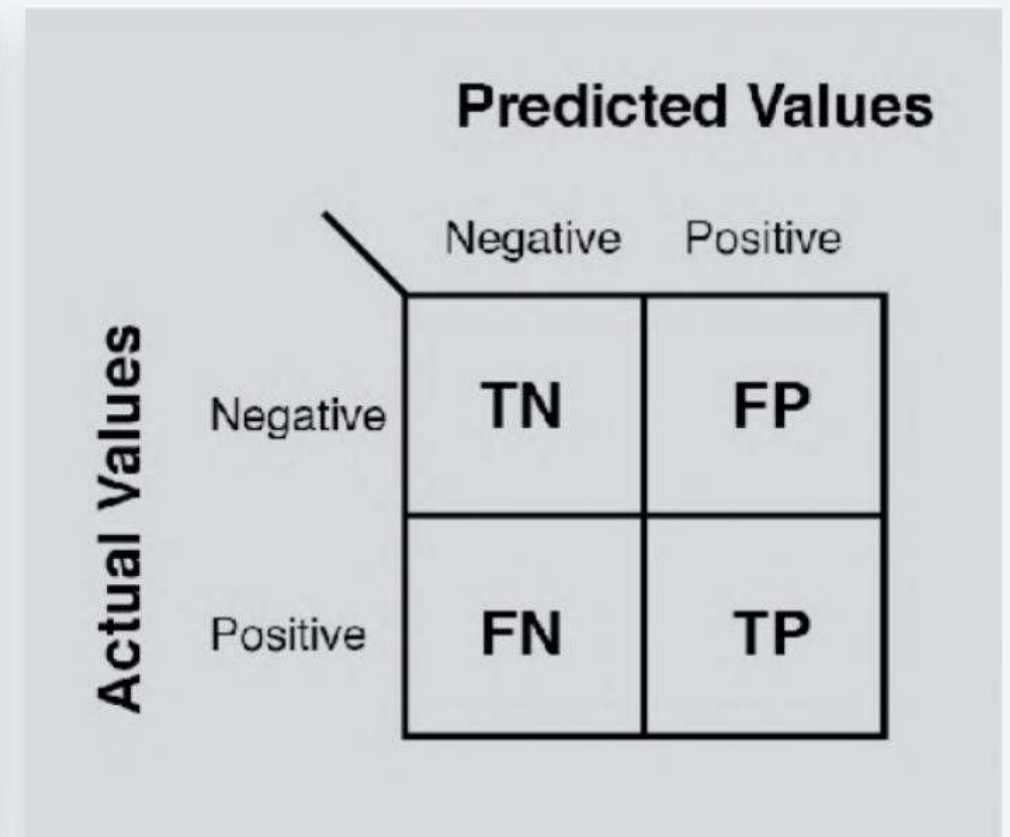
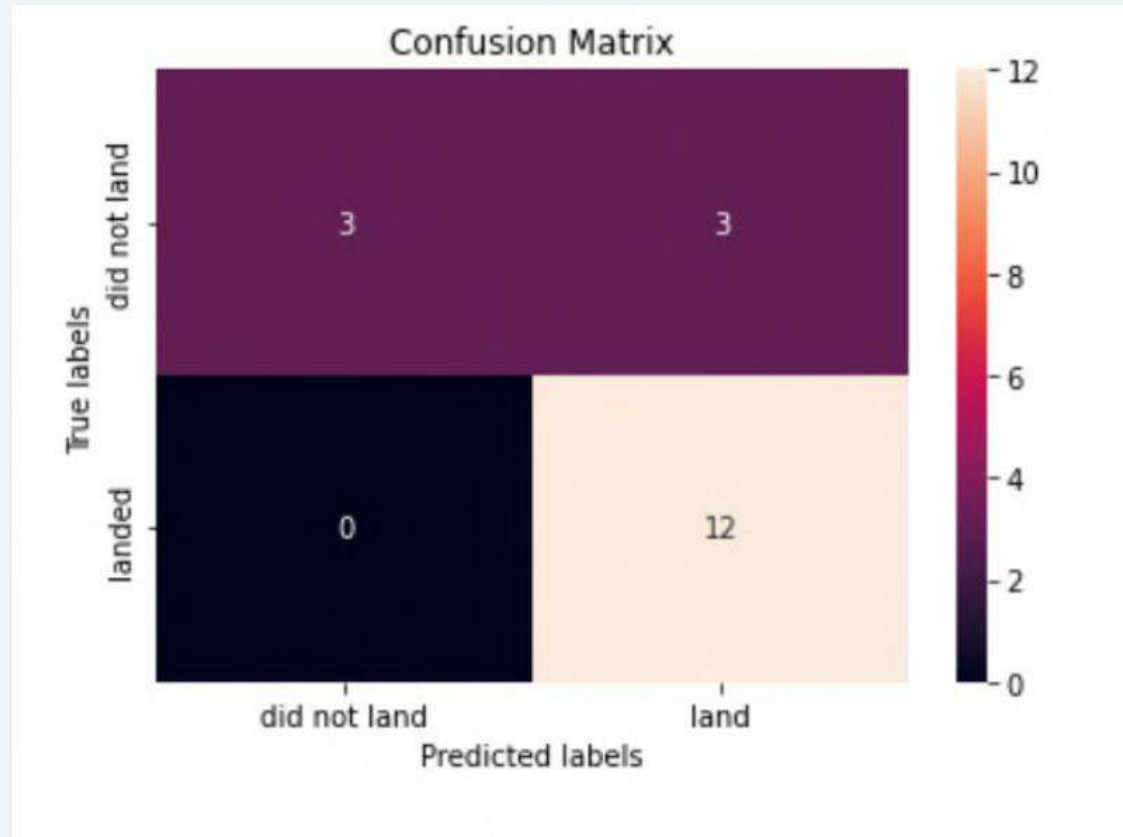
```
algorithms = {'KNN':knn_cv.best_score_, 'Tree':tree_cv.best_score_, 'LogisticRegression':logreg_cv.best_score_}
bestalgorithm = max(algorithms, key=algorithms.get)
print('Best Algorithm is',bestalgorithm,'with a score of',algorithms[bestalgorithm])
if bestalgorithm == 'Tree':
    print('Best Params is :',tree_cv.best_params_)
if bestalgorithm == 'KNN':
    print('Best Params is :',knn_cv.best_params_)
if bestalgorithm == 'LogisticRegression':
    print('Best Params is :',logreg_cv.best_params_)
```

Best Algorithm is Tree with a score of 0.9017857142857142

Best Params is : {'criterion': 'entropy', 'max\_depth': 10, 'max\_features': 'auto', 'min\_samples\_leaf': 2, 'min\_samples\_split': 10, 'splitter': 'random'}



# Confusion Matrix



# Conclusions

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We can conclude that:

- The Tree Classifier Algorithm is the best Machine Learning approach for this dataset.
- The low weighted payloads (which define as 4000kg and below) performed better than the heavy weighted payloads.
- Starting from the year 2013, the success rate for SpaceX launches is increased, directly proportional time in years to 2020, which it will eventually perfect the launches in the future.
- KSC LC-39A have the most successful launches of any sites; 76.9%
- SSO orbit have the most success rate; 100% and more than 1 occurrence.

# Appendix

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- Include any relevant assets like Python code snippets, SQL queries, charts, Notebook outputs, or data sets that you may have created during this project

Thank you!

