IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

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

Executive Summary

In this project, a rival company to SpaceX (i.e., SpaceY) uses SpaceX Falcon 9 rocket data to determine the rocket first stage landing successes and the cost of a launch. A summary for the methodologies and results described in this report is outlined below.

Summary of methodologies

- Data Collection
- Data wrangling
- Exploratory data analysis with data visualization and SQL
- Building an interactive map with Folium
- Building Dashboard with Plotly Dash
- Predictive analysis (classification)

Summary of all results

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

Introduction

This capstone project is part of the IBM Data Science Professional Certificate. The goal of the project is to demonstrate proficiency in data science and machine learning techniques using a real-world data and to summarize the results in a report.

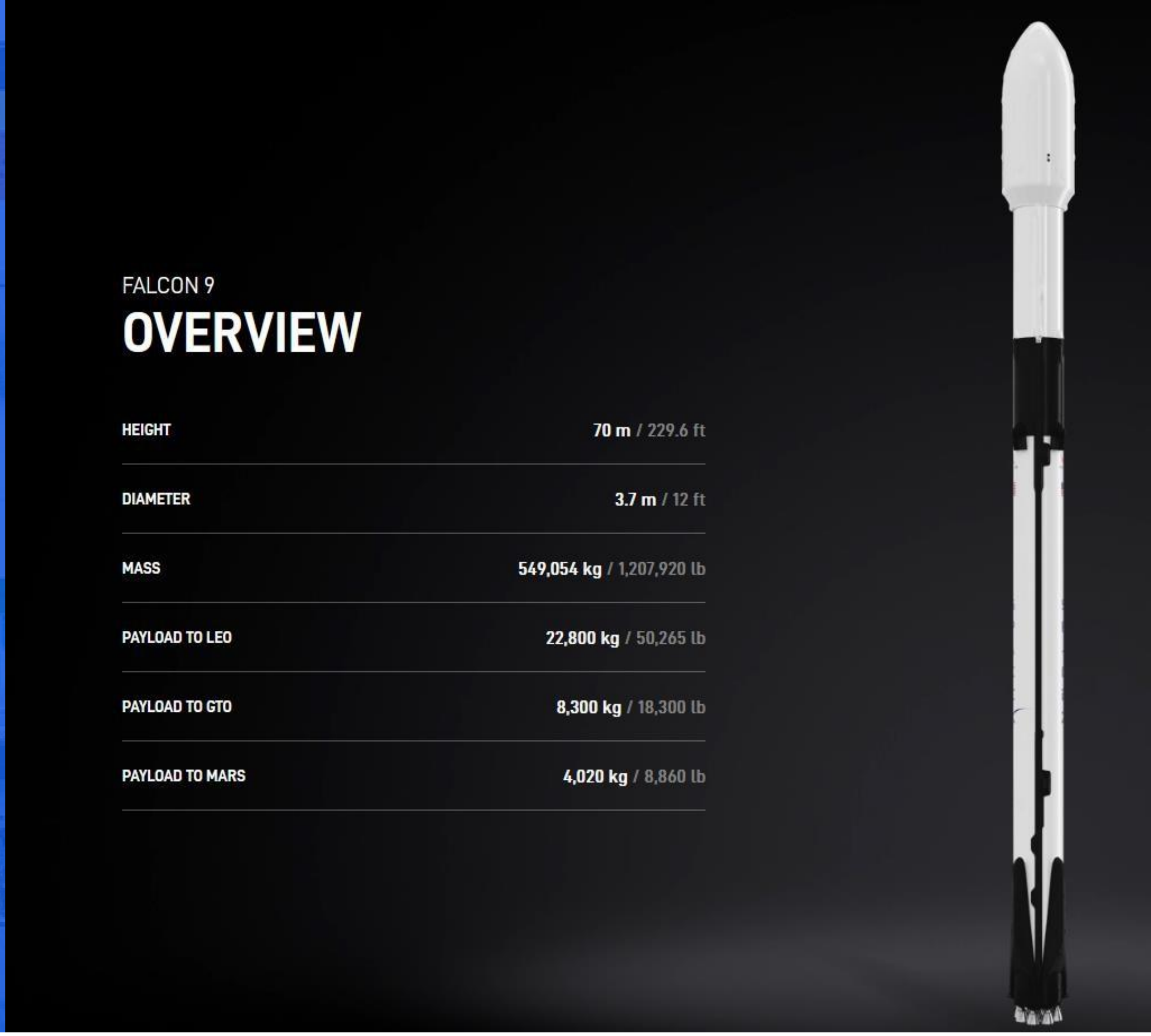
In this project, a rival company to SpaceX (i.e., SpaceY) uses SpaceX Falcon 9 rocket data to **determine the rocket first stage landing successes** and also uses the rocket data to **determine the cost of a launch**. Space Y uses the data to bid against SpaceX for a rocket launch. SpaceX advertises Falcon 9 rocket launch cost to be 62 million dollars. Whereas for other companies the cost of a rocket launch is more than 165 million dollars.

Throughout the project Python Jupyter note books are used to perform the data collection and analysis. These Jupyter note books and the final *.pdf report are saved in my GitHub repository webpage.

The major parts of this report include data collection methodology, data wrangling, exploratory data analysis (EDA), interactive data visualization, machine learning (ML) classification model development, and model evaluation. Finally, the accuracy of different ML algorithms are compared in predicting the future landing of the Falcon 9 first stage rocket.

Section 1

Methodology



Methodology

Data used in this project were collected from SpaceX Rest API and from Wikipedia launch table. The wrangling of the collected data included cleaning, preparation for visualization and information extraction for usage in ML predictive models such as logistic regression, support vector machine (SVM), decision tree, and K-nearest neighbors (KNN).

In addition, exploratory data analysis (EDA) was performed using visualization and SQL. Lastly, Folium and Plotly Dash Python libraries were use in data representation and in the interactive visual analytics of the data.

Finally, predictive analysis was performed using classification models

for predicting if the first stage of Falcon 9 rocket will land successfully using Skikit-learn and also the accuracy of the model was determined.

Data Collection: Overview

Data collection and visualization major steps:

Step # 1: Collect Data from SpaceX API and Convert data to .jason file → Step# 2: Scrap and filter data to include Falcon 9 data, assign data to dataf rame and dictionary, and export data to a csv file → Step 3: Plot and visualize the data

Portion of generated output data file: dataset_part1.csv

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
FlightNuml	Date	BoosterVe	PayloadMa	Orbit	LaunchSite	Outcome	Flights	GridFins	Reused	Legs	LandingPa	Block	ReusedCo	Serial	Longitude	Latitude
1	6/4/2010	Falcon 9	6123.548	LEO	CCSFS SLC	None Non	1	FALSE	FALSE	FALSE		1	0	B0003	-80.5774	28.56186
2	5/22/2012	Falcon 9	525	LEO	CCSFS SLC	None Non	1	FALSE	FALSE	FALSE		1	0	B0005	-80.5774	28.56186
3	3/1/2013	Falcon 9	677	ISS	CCSFS SLC	None Non	1	FALSE	FALSE	FALSE		1	0	B0007	-80.5774	28.56186
4	9/29/2013	Falcon 9	500	PO	VAFB SLC 4	False Ocea	1	FALSE	FALSE	FALSE		1	0	B1003	-120.611	34.63209
5	12/3/2013	Falcon 9	3170	GTO	CCSFS SLC	None Non	1	FALSE	FALSE	FALSE		1	0	B1004	-80.5774	28.56186
6	1/6/2014	Falcon 9	3325	GTO	CCSFS SLC	None Non	1	FALSE	FALSE	FALSE		1	0	B1005	-80.5774	28.56186
7	4/18/2014	Falcon 9	2296	ISS	CCSFS SLC	True Ocea	1	FALSE	FALSE	TRUE		1	0	B1006	-80.5774	28.56186
8	7/14/2014	Falcon 9	1316	LEO	CCSFS SLC	True Ocea	1	FALSE	FALSE	TRUE		1	0	B1007	-80.5774	28.56186
9	8/5/2014	Falcon 9	4535	GTO	CCSFS SLC	None Non	1	FALSE	FALSE	FALSE		1	0	B1008	-80.5774	28.56186
10	9/7/2014	Falcon 9	4428	GTO	CCSFS SLC	None Non	1	FALSE	FALSE	FALSE		1	0	B1011	-80.5774	28.56186

Data Collection: SpaceX API

Request response from SpaceX API using get request and covert data to .Jason file

↓

Use custom functions to clean data

↓

Clean data and assign data to dictionary and data frame

↓

Filter data to include only Falcon 9 launches and export data to a csv file: dataset_part1

```python
static_json_url='https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/API_call_spacex_api.json'
```

```python
# convert the json result into a dataframe using json_normalize method
data=pd.json normalize(response.json())
```

```python
# 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)]
```

Portion of output

```python
data_falcon9.head()
```

	FlightNumber	Date	BoosterVersion	PayloadMass	Orbit	LaunchSite	Outcome	Flights	GridFins	Reused	Legs	LandingPad	Block	ReusedCount	Serial	Longitude	Latitude
4	1	2010-06-04	Falcon 9	6123.547647	LEO	CCSFS SLC 40	None None	1	False	False	False	None	1.0	0	B0003	-80.577366	28.561857
5	2	2012-05-22	Falcon 9	525.000000	LEO	CCSFS SLC 40	None None	1	False	False	False	None	1.0	0	B0005	-80.577366	28.561857
6	3	2013-03-01	Falcon 9	677.000000	ISS	CCSFS SLC 40	None None	1	False	False	False	None	1.0	0	B0007	-80.577366	28.561857
7	4	2013-09-29	Falcon 9	500.000000	PO	VAFB SLC 4E	False Ocean	1	False	False	False	None	1.0	0	B1003	-120.610829	34.632093
8	5	2013-12-03	Falcon 9	3170.000000	GTO	CCSFS SLC 40	None None	1	False	False	False	None	1.0	0	B1004	-80.577366	28.561857

Data Collection: Scraping

Step 1: Perform HTTP get to request Falcon 9 HTML page and create Beautiful Soup object from HTML

Step 2: Extract all column/variable names from the HTML table header

Step3: Create a data frame by parsing the launch HTML tables

Step 4: export data into CSV file (spacex_web_scraped.csv)

```
[5]
# use requests.get() method with the provided static_url
# assign the response to a object
response = requests.get(static_url)
```

Create a `BeautifulSoup` object from the HTML `response`

```
[6]
# Use BeautifulSoup() to create a BeautifulSoup object from a response text content
soup = BeautifulSoup(response.content, 'html.parser')
```

Print the page title to verify if the `BeautifulSoup` object was created properly

```
[7]
# Use soup.title attribute
soup.title
```

```
<title>List of Falcon 9 and Falcon Heavy launches - Wikipedia</title>
```

	Flight No.	Launch site	Payload	Payload mass	Orbit	Customer	Launch outcome	Version Booster	Booster landing	Date	Time
0	1	CCAFS	Dragon Spacecraft Qualification Unit	0	LEO	[[SpaceX], \n]	Success\n	F9 v1.0B0003.1	Failure	4 June 2010	18:45
1	2	CCAFS	Dragon	0	LEO	[[.mw-parser-output .plainlist ol,.mw-parser-o...	Success	F9 v1.0B0004.1	Failure	8 December 2010	15:43
2	3	CCAFS	Dragon	525 kg	LEO	[[NASA], (, [COTS],)\n]	Success	F9 v1.0B0005.1	No attempt\n	22 May 2012	07:44
3	4	CCAFS	SpaceX CRS-1	4,700 kg	LEO	[[NASA], (, [CRS],)\n]	Success\n	F9 v1.0B0006.1	No attempt	8 October 2012	00:35
4	5	CCAFS	SpaceX CRS-2	4,877 kg	LEO	[[NASA], (, [CRS],)\n]	Success\n	F9 v1.0B0007.1	No attempt\n	1 March 2013	15:10

Next steps: Generate code with df View recommended plots

Portion of Output

Data Collection: Data Wrangling

Step 1: Load data from dataset_part1.csv file and calculate the number of launches on each site

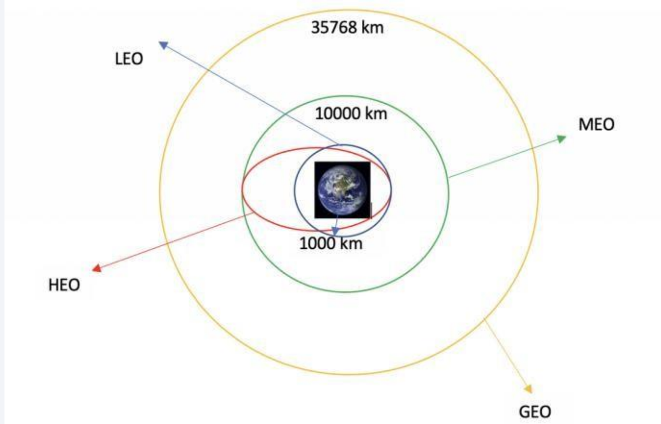
Step 2: Calculate the number and the occurrence of each orbit

Step3: Calculate the number and occurrence of mission outcome of the orbits

Step 4: Create a landing outcome label from outcome column and export data into dataset_part2.csv file

```
[5]
# Apply value_counts() on column LaunchSite
df['LaunchSite'].value_counts()
```

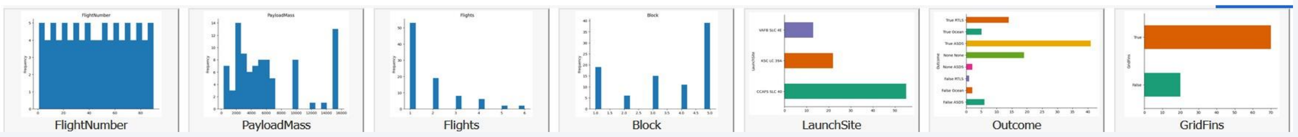
```
LaunchSite
CCAFS SLC 40    55
KSC LC 39A      22
VAFB SLC 4E     13
Name: count, dtype: int64
```




```
[12]
df.head(5)
```

	FlightNumber	Date	BoosterVersion	PayloadMass	Orbit	LaunchSite	Outcome	Flights	GridFins	Reused	Legs	LandingPad	Block	ReusedCount	Serial	Longitude	Latitude
0	1	2010-06-04	Falcon 9	6104.959412	LEO	CCAFS SLC 40	None None	1	False	False	False	NaN	1.0	0	B0003	-80.577366	28.561857
1	2	2012-05-22	Falcon 9	525.000000	LEO	CCAFS SLC 40	None None	1	False	False	False	NaN	1.0	0	B0005	-80.577366	28.561857
2	3	2013-03-01	Falcon 9	677.000000	ISS	CCAFS SLC 40	None None	1	False	False	False	NaN	1.0	0	B0007	-80.577366	28.561857
3	4	2013-09-29	Falcon 9	500.000000	PO	VAFB SLC 4E	False Ocean	1	False	False	False	NaN	1.0	0	B1003	-120.610829	34.632093
4	5	2013-12-03	Falcon 9	3170.000000	GTO	CCAFS SLC 40	None None	1	False	False	False	NaN	1.0	0	B1004	-80.577366	28.561857

Next steps: Generate code with df   View recommended plots



EDA and Data Visualization

Use Matplotlib and Seaborn for data visualization

Step 1: Visualize the relationship between flight number and launch site

Step 2: Visualize the relationship between payload and launch site

Step3: Visualize the relationship between success rate of each orbit type

Step 4: Visualize the relationship between flight number and orbit type

Step 5: Visualize the relationship between payload and orbit type

Step 6: Visualize the launch success yearly trend

Step 7: Create dummy variable to categorical columns

Step 8: Cast all numeric columns to float64

EDA with SQL

Step #1: Display the names of the unique launch sites in the space mission

Step 2: Display 5 records where launch sites begin with the string ‘CCA’

Step 3: Display average payload mass carried by booster launched by NASA (CRS)

Step 4: Display average payload mass carried by booster version F9 v1.1

Step 5: List the date when the first successful landing outcome in ground pad was achieved

Step 6: List the names of the boosters which have success in drone ship and mass > 4000 & <6000

Step 7: List the total number of successful and failure mission outcomes

Step 8: List the names of the booster_ve which have carried the max payload mass

Step 9: List the records which display the month, failure landing, booster version ..etc.

Step 10: Rank the count of landing outcomes or success

Build an Interactive Map with Folium

Step 1: Mark all launch sites on a map created using Folium by adding markers* with circle , popup label and text label to each site using its longitude and latitude coordinates to show the geographical location approximately to the equator

Step 2: Mark the success/failed launches for each site on the map using colored markers

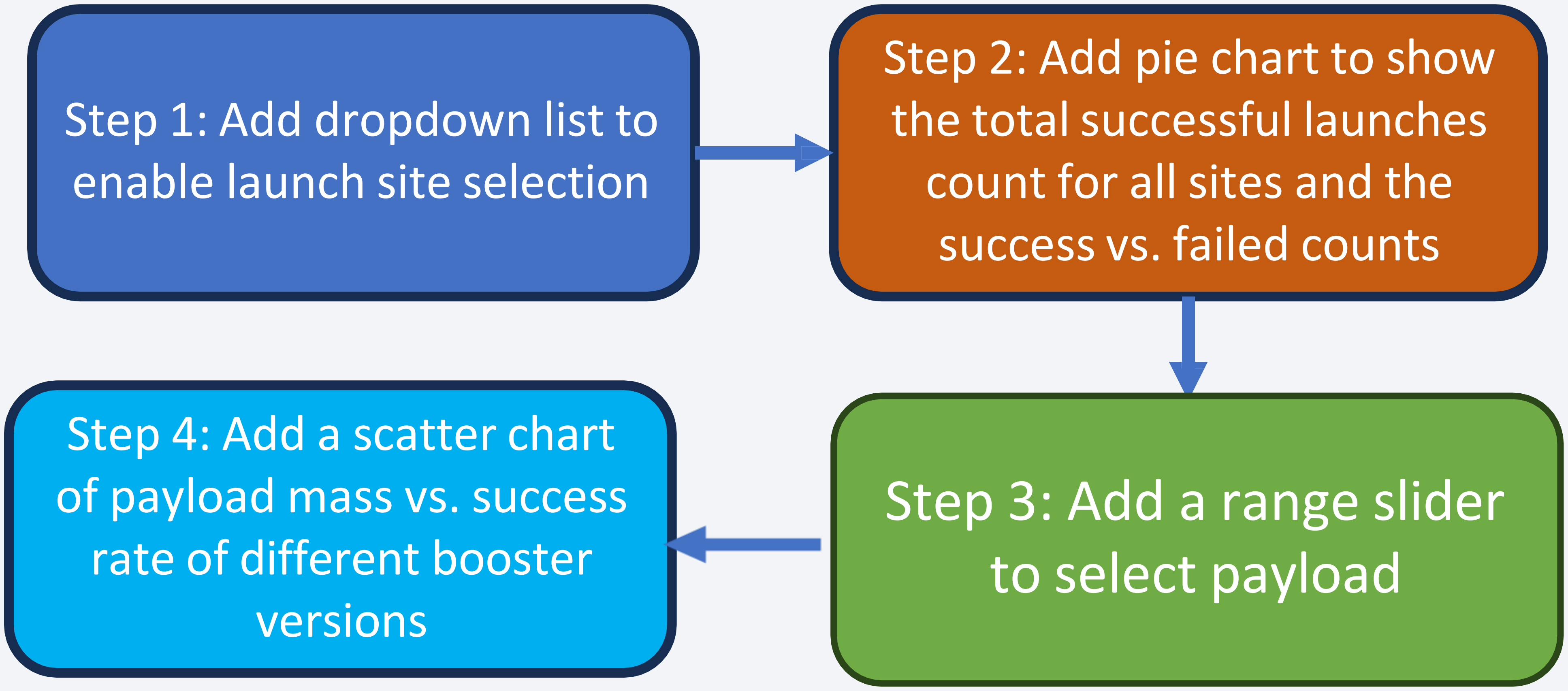
Step 3: Calculate the distance between a launch site to its proximities

*** Explanation:**

From the visual analysis of the launch site KSC LC-39A we can clearly see that it is:

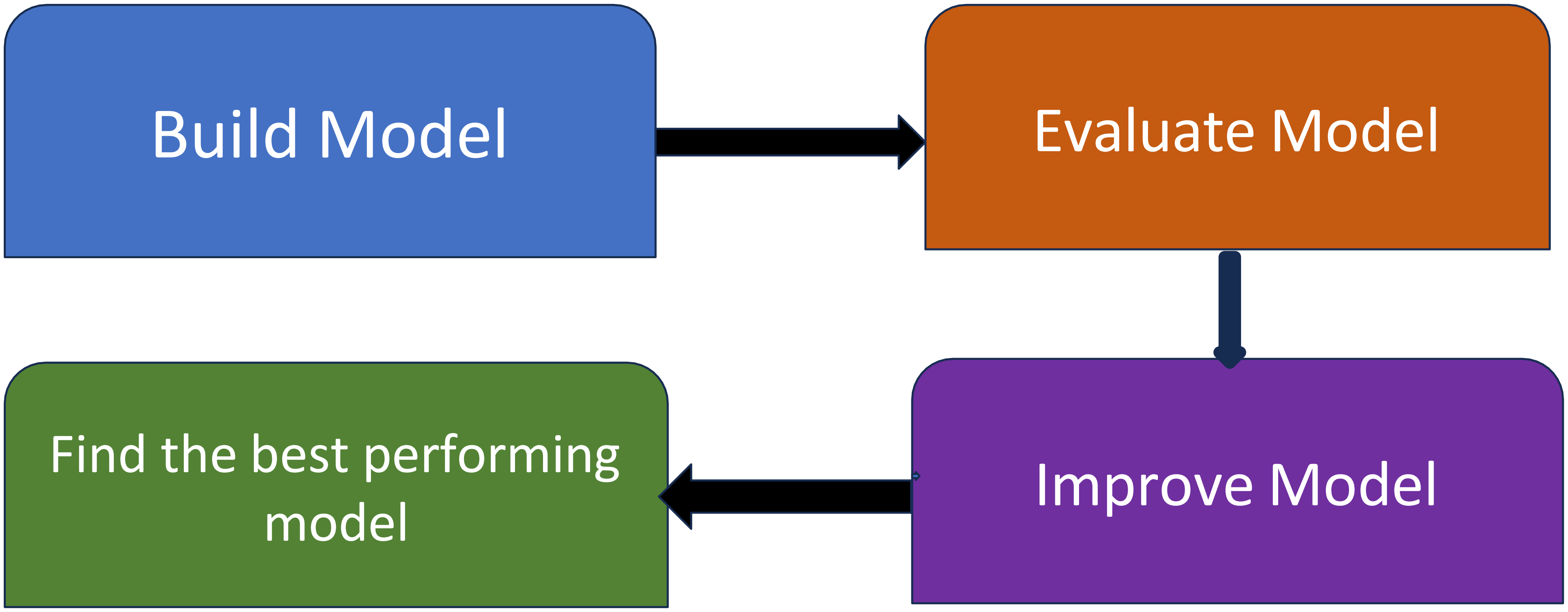
- **relative close to railway (15.23 km)**
- **relative close to highway (20.28 km)**
- **relative close to coastline (14.99 km)**
- **Also the launch site KSC LC-39A is relative close to its closest city Titusville (16.32 km).**
- **Failed rocket with its high speed can cover distances like 15-20 km in few seconds. It could be potentially dangerous to populated areas.**

Build a Dashboard with Plotly Dash

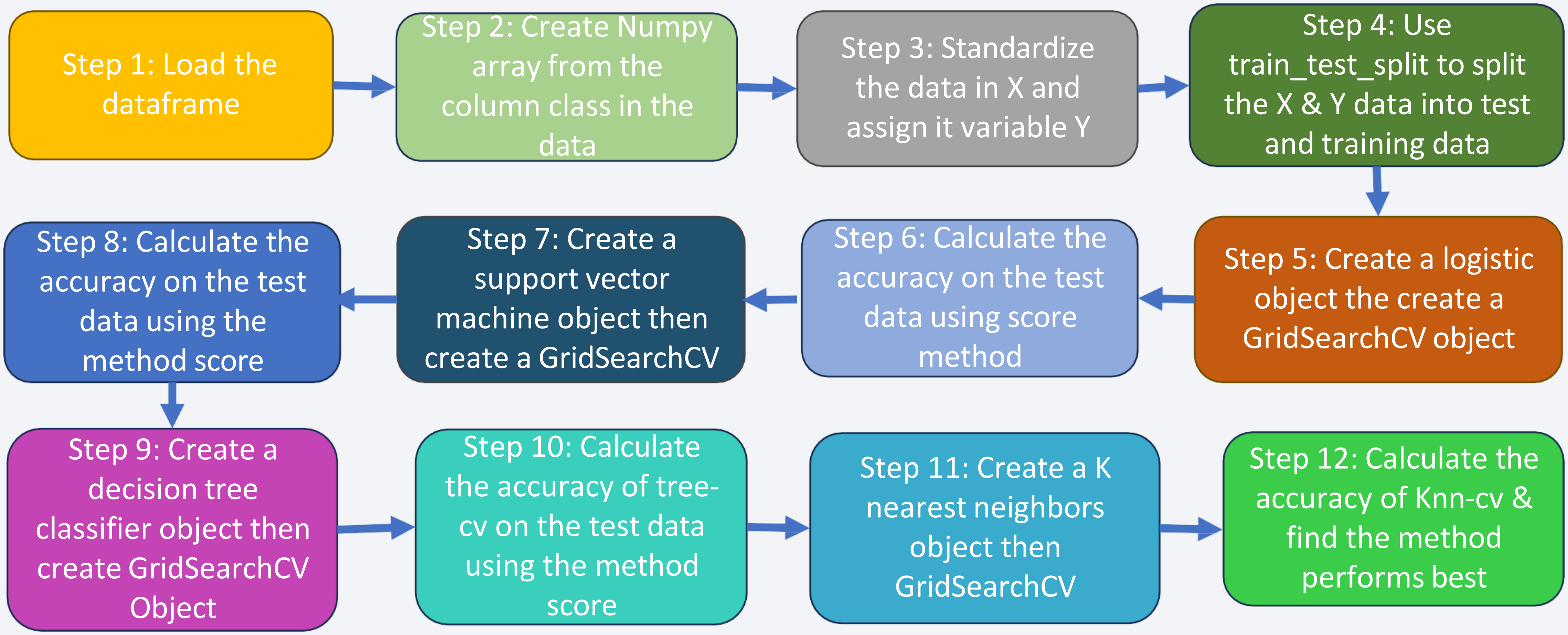


The dashboard is built using Dash web

Predictive Analysis (Classification): Overview



Predictive Analysis (Classification) Steps

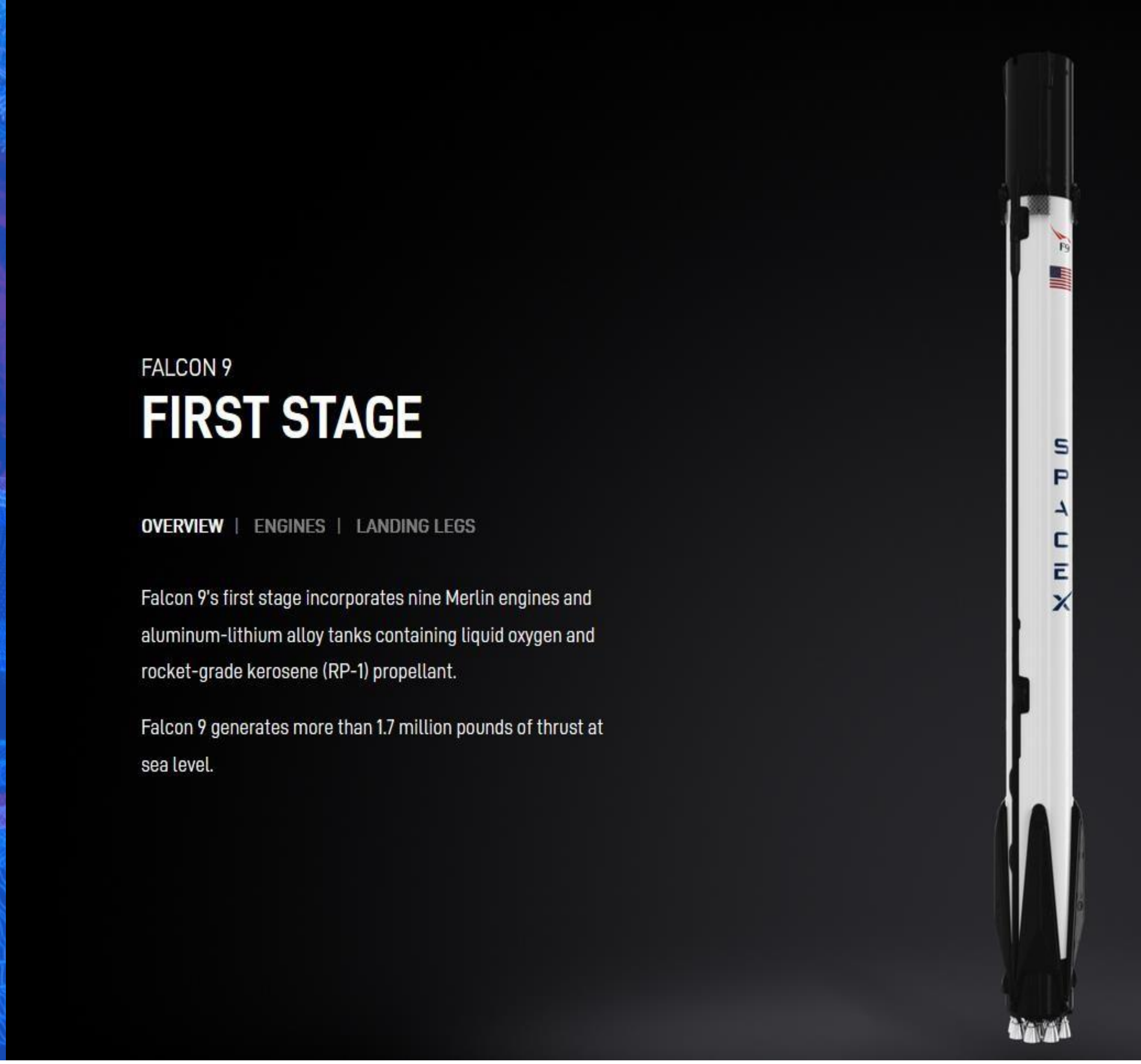


Results

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

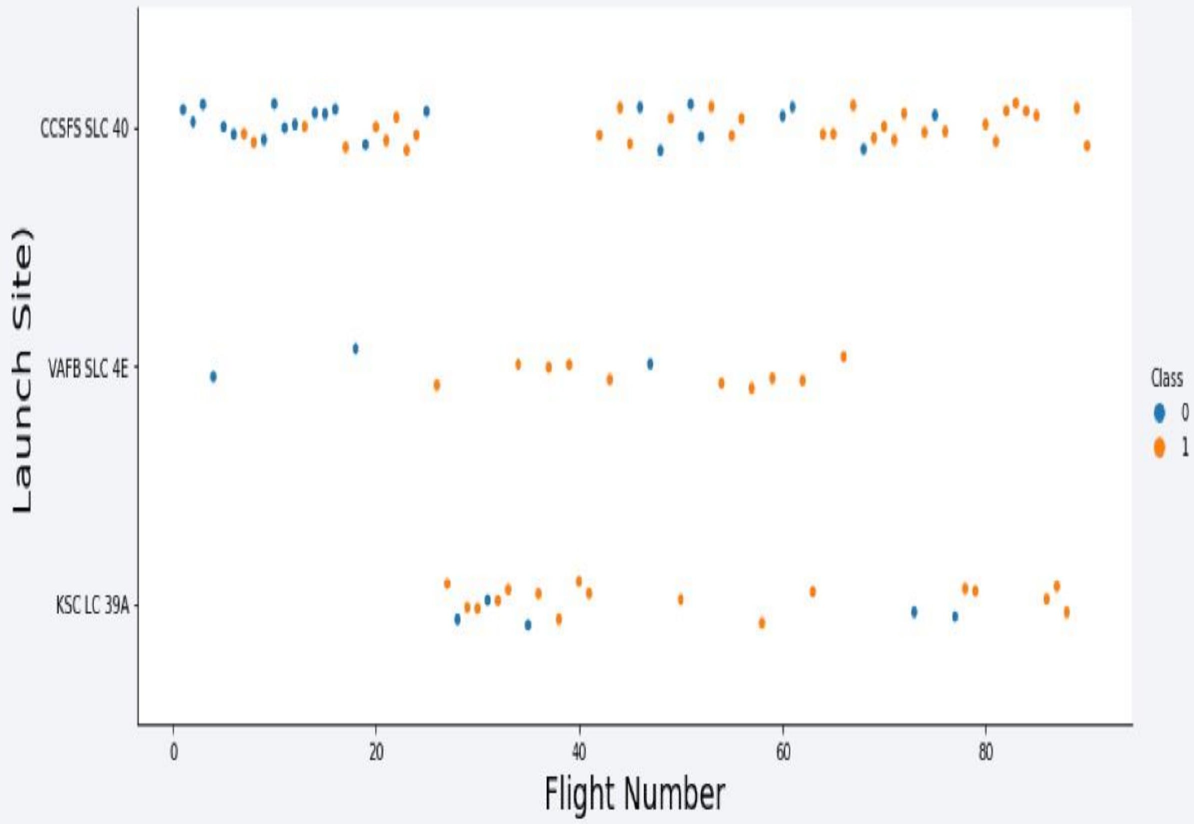
Section 2

Insights drawn from EDA



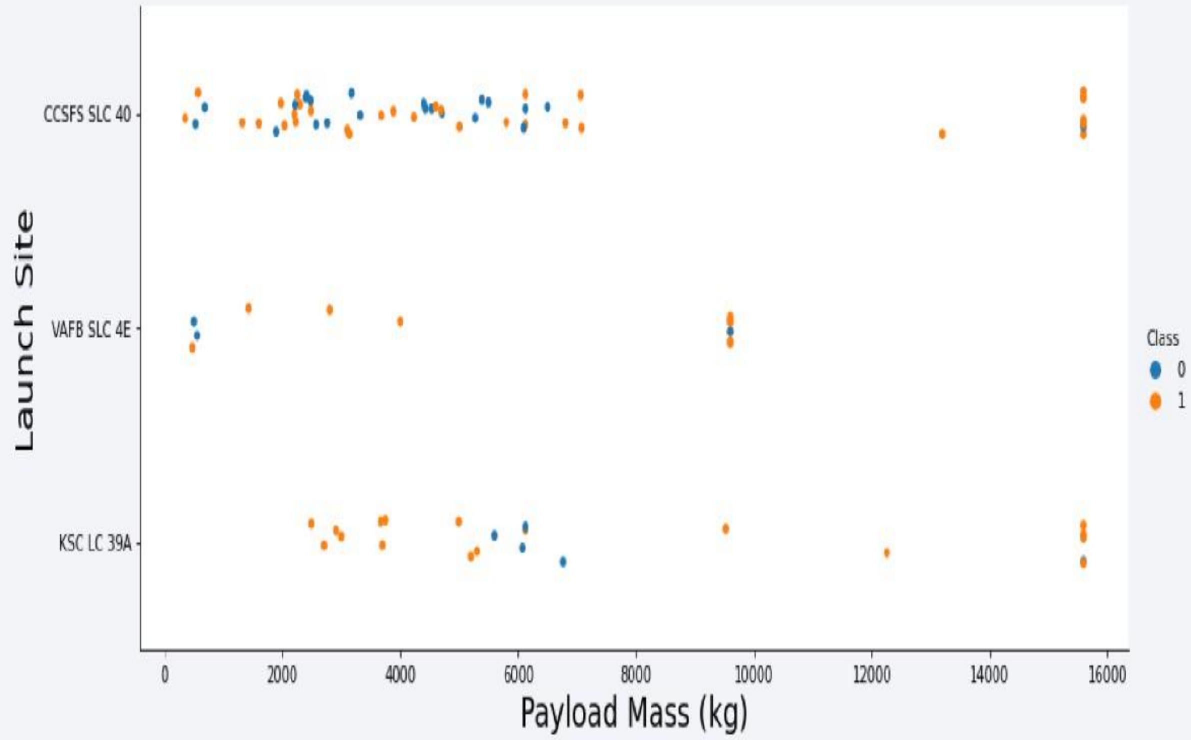
Flight Number vs. Launch Site

- The majority of the flights were launched from the CCAFS SLC 40 sites.
- The VAFB SLC 4E and KSC LC 39A sites have higher success rates than other sites.
- Newer flights have higher success rates than older flights.



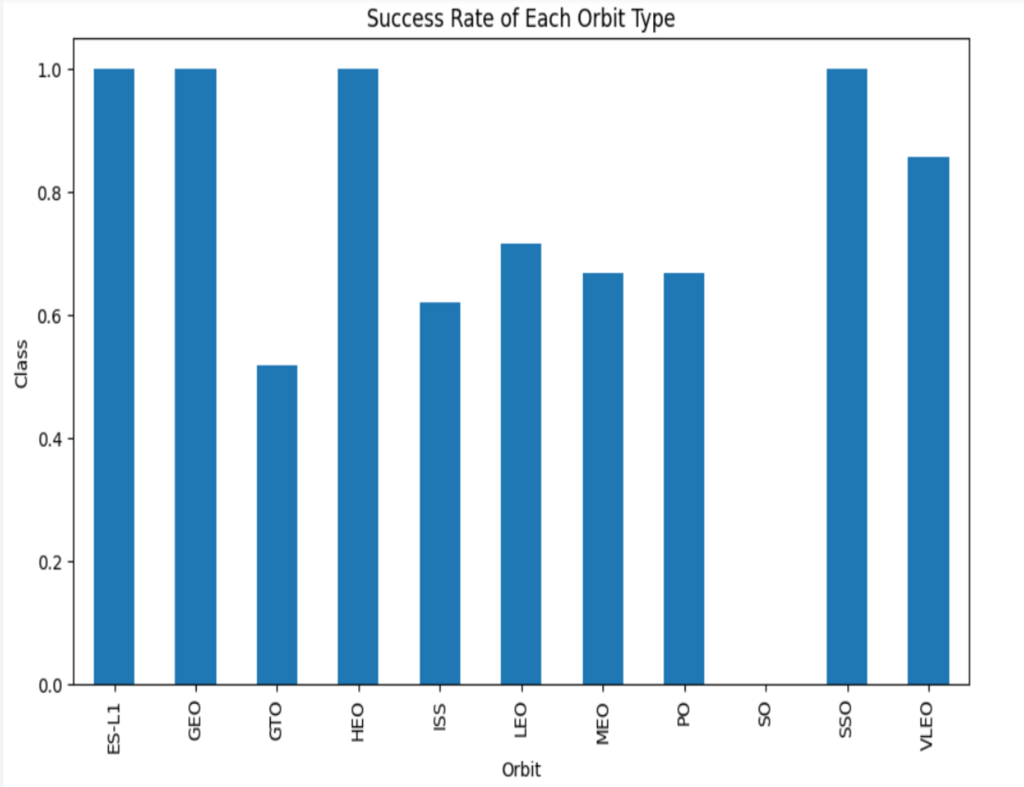
Payload Mass vs. Launch Site

- **The majority of the flights with payload mass above 7000 Kg were successful.**
- **KSC LC 39A success rate for payload mass under 5500 kg is 100%.**
- **For all launch sites the success rate is proportional to the payload mass.**



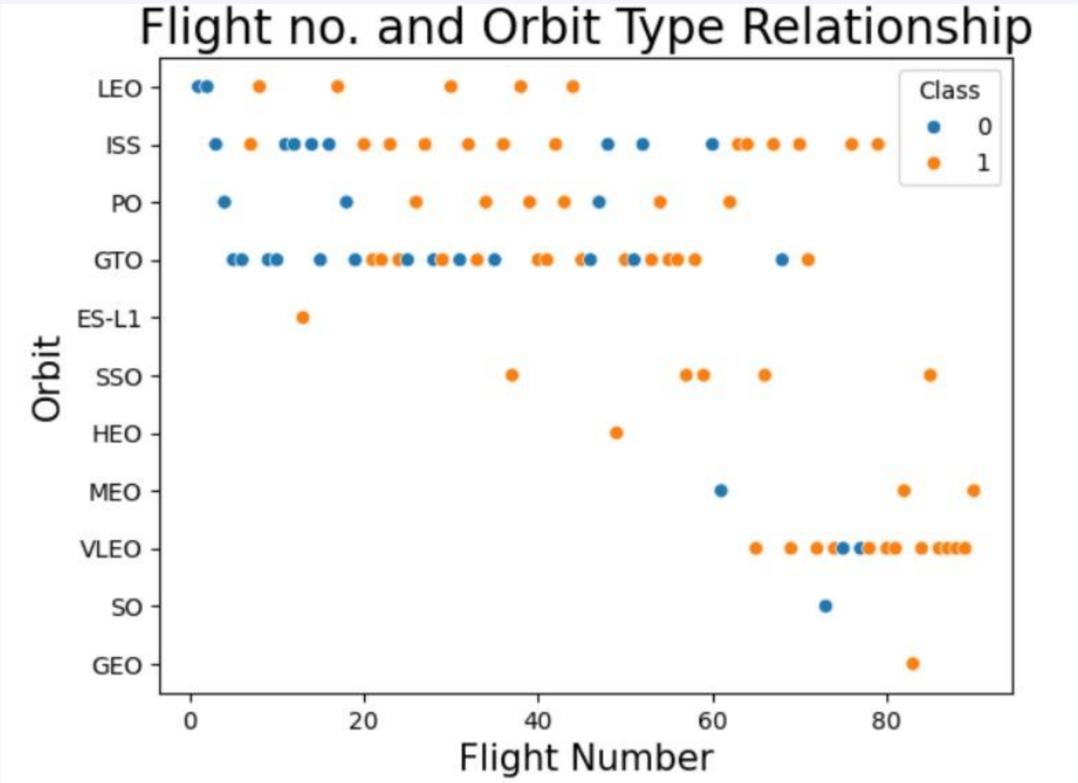
Success Rate vs. Orbit Type

- **The OS orbit has 0% success rate.**
- **The ELS-1, GEO, HEO and SSO orbits have 100% success rate.**
- **Orbits GTO, ISS, LEO, MEO and PO success rate is higher than 50% and less than 75%.**



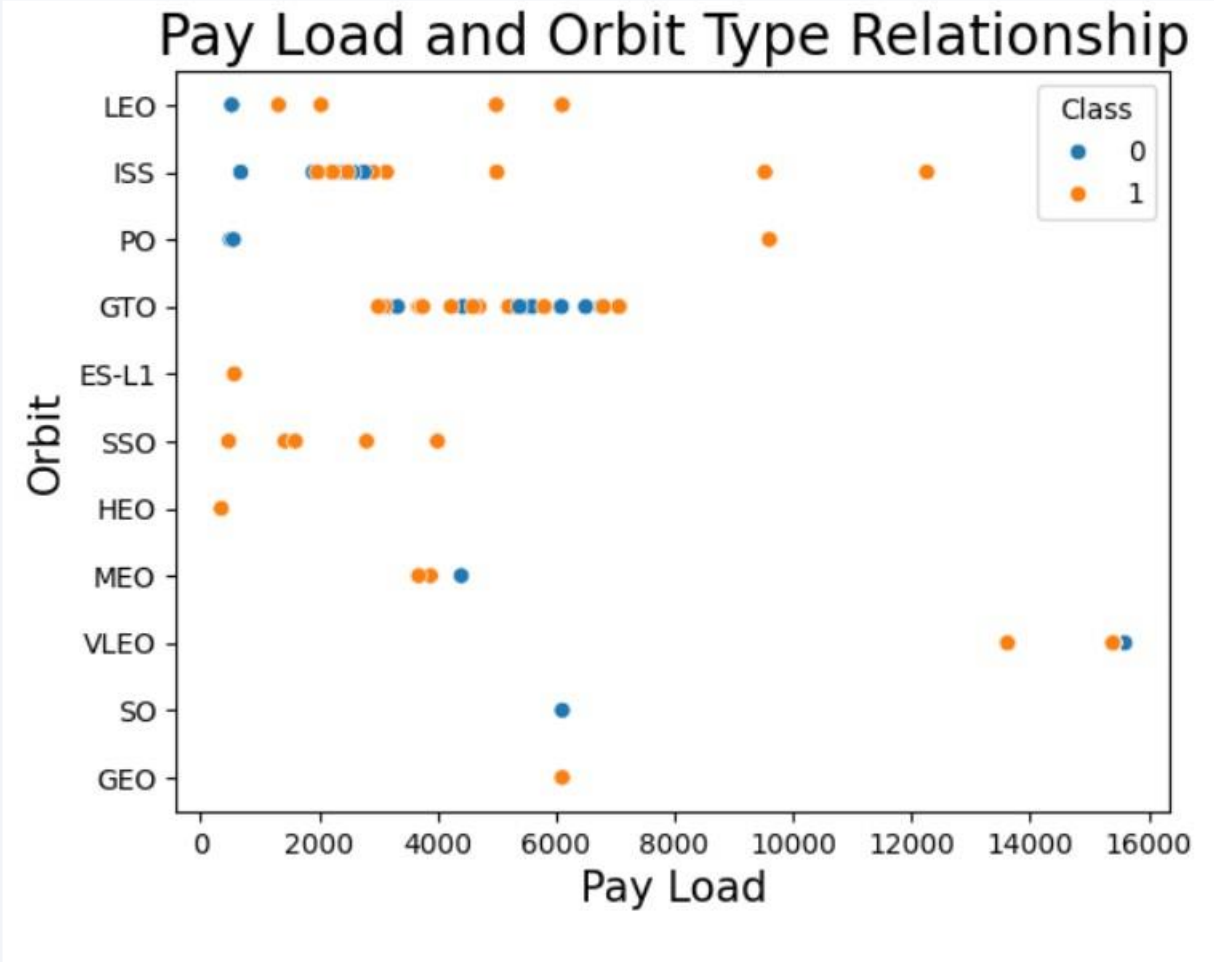
Flight Number vs. Orbit Type

- **The majority of the flights were launches to the ISS and GTO orbits.**
- **The data suggests that there is no relationship between the flight number and the orbit type.**



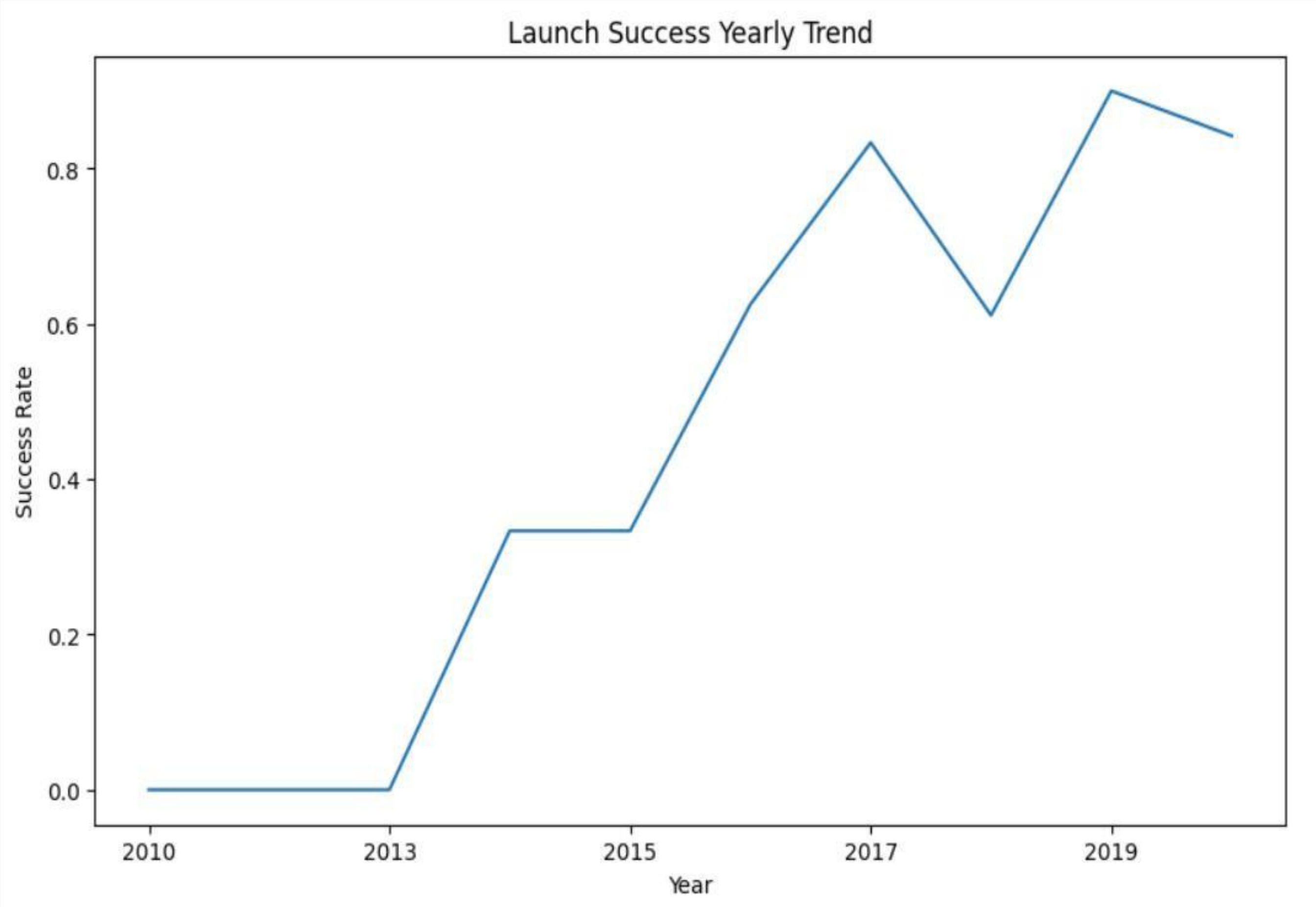
Payload Mass vs. Orbit Type

- **Payload masses above 10000 Kg were placed in PO, ISS and LEO orbits.**
- **Payload masses above 4000 and less than 8000 Kg were placed in the GTO orbit.**



Launch Success Yearly Trend

- The launches success rate increased steadily since 2013.
- The increase in the success rate between 2013 and 2017 was linear.
- During 2018 there was a drop in the launches success rate.



All Launch Site Names

The names of the unique launch sites and the query structure for obtaining these sites is shown below.

```
features= df[['LaunchSite']]
features.head()
```

	LaunchSite
0	CCAFS SLC 40
1	CCAFS SLC 40
2	CCAFS SLC 40
3	VAFB SLC 4E
4	CCAFS SLC 40

Launch Site Names Begin with 'CCA'

5 records for launch sites begin with the string 'CCA' and the query used for obtaining the information is shown below.

```
[ ]  1 %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

- **The calculated total payload mass carried by boosters from NASA site =45596 Kg.**
- **The query for obtaining the total payload mass is shown below.**

```
%sql select SUM(PAYLOAD_MASS__KG_) from SPACEXTABLE where "Customer" like 'NASA (CRS)%'
```

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

SUM(PAYLOAD_MASS__KG_)
48213

Average Payload Mass by F9 v1.1

- **The average payload mass carried by booster version F9 v1.1=2534.7 Kg.**
- **Furthermore, the query used to calculate the average payload mass carried by booster F9 v1.1 is shown below.**

```
%sql select AVG(PAYLOAD_MASS__KG_) from SPACEXTABLE where "Booster_Version" LIKE 'F9 v1.1%'
```

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

AVG(PAYLOAD_MASS__KG_)
2534.6666666666665

First Successful Ground Landing Date

- **The first successful landing outcome on a ground pad was in 2015-12-22.**
- **The query for obtaining this result is shown below.**

```
[ ]  1 %sql SELECT MIN(Date) AS first_successful_landing_date FROM SPACEXTABLE  WHERE landing_outcome = 'Success (ground pad)';
```

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

first_successful_landing_date
2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

- **List of boosters which have successfully landed on drone ship and had payload mass greater than 4000 but less than 6000 is shown below.**
- **The query used in obtaining this information is shown below.**

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

```
[ ]
%sql SELECT Booster_Version FROM SPACEXTABLE WHERE landing_outcome = 'Success (drone ship)' AND PAYLOAD_MASS__KG_ > 4000 AND PAYLOAD_MASS__KG_
```

```
 * 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

- **The total number of successful and failed missions is as follows:**
  - **Failure (in flight)= 1**
  - **Successful number of flights= 98**
- **The query result is shown below.**

```
[ ]  %sql SELECT mission_outcome, COUNT(*) AS total_count FROM SPACEXTABLE WHERE  mission_outcome IN ('Success', 'Failure (in flight)') GROUP BY mis
```

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

Mission_Outcome	total_count
Failure (in flight)	1
Success	98

Boosters Carried Maximum Payload

- **List of the boosters which have carried the maximum payload mass are shown below.**
- **The query used in obtaining the booster names is shown below.**

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

```
[ ]  %sql SELECT booster_version FROM SPACEXTABLE WHERE PAYLOAD_MASS__KG_ = (SELECT MAX (PAYLOAD_MASS__KG_) FROM SPACEXTABLE);
```

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

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

- List of the failed ”landing_outcomes” in drone ship, their booster version, and the launch site name during year 2015 is shown below.
- The query used in obtaining the information is shown below.

```
[ ]  %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' TH
```

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

month_name	Booster_Version	Launch_Site	Landing_Outcome
January	F9 v1.1 B1012	CCAFS LC-40	Failure (drone ship)
April	F9 v1.1 B1015	CCAFS LC-40	Failure (drone ship)

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

- **A rank of the count of landing outcomes (such as Failure (drone ship) or success (ground pad)) between the dates 2010-06-04 and 2017-03-20, in descending order is shown below.**
- **The query used to obtain the results is shown below.**

```
[ ] %sql SELECT landing_outcome, COUNT(*) AS outcome_count FROM SPACEXTABLE WHERE Date BETWEEN '2010-06-04' AND '2017-03-20' GROUP BY landing_outc
```

```
 * 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

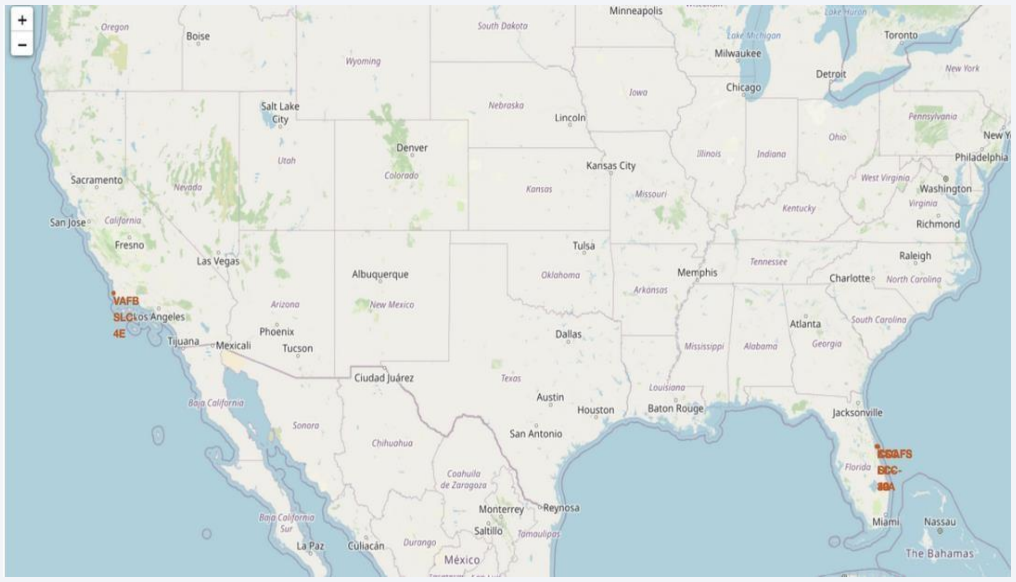
Section 3

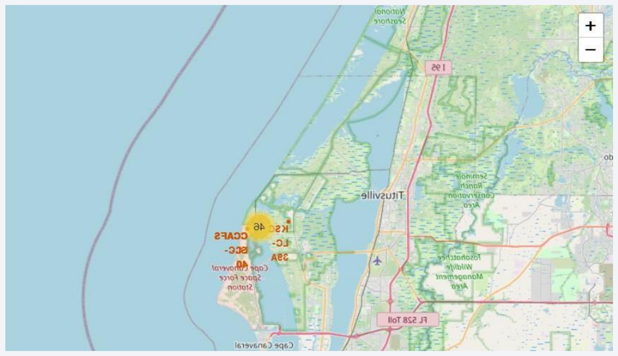
Launch Sites Proximities Analysis

USA Launch Sites in California and Florida

- Most of Launch sites considered in this project are in proximity to the Equator line. Launch sites are made at the closest point possible to Equator line, because anything on the surface of the Earth at the equator is already moving at the maximum speed (1670 kilometers per hour). For example launching from the equator makes the spacecraft move almost 500 km/hour faster once it is launched compared half way to north pole.

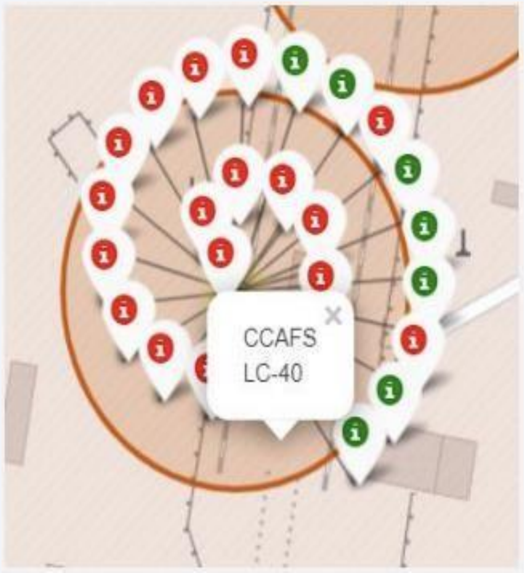
- All launch sites considered in this project are in very close proximity to the coast While starting rockets towards the ocean we minimize the risk of having any debris dropping or exploding near people.



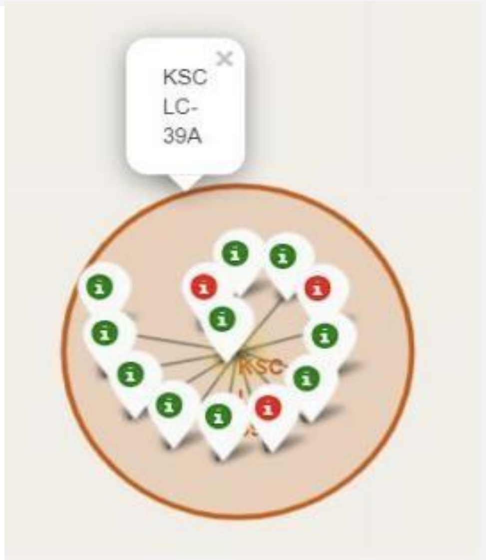


Color Labels Showing the Launch Sites on a Map

	Launch Site	Lat	Long	marker_color
0	CCAFS LC-40	28.562302	-80.577356	red
1	CCAFS LC-40	28.562302	-80.577356	red
2	CCAFS LC-40	28.562302	-80.577356	red
3	CCAFS LC-40	28.562302	-80.577356	red
4	CCAFS LC-40	28.562302	-80.577356	red
5	CCAFS LC-40	28.562302	-80.577356	red
6	CCAFS LC-40	28.562302	-80.577356	red
7	CCAFS LC-40	28.562302	-80.577356	red
8	CCAFS LC-40	28.562302	-80.577356	red
9	CCAFS LC-40	28.562302	-80.577356	red
10	CCAFS LC-40	28.562302	-80.577356	red
11	CCAFS LC-40	28.562302	-80.577356	red
12	CCAFS LC-40	28.562302	-80.577356	red
13	CCAFS LC-40	28.562302	-80.577356	red
14	CCAFS LC-40	28.562302	-80.577356	red
15	CCAFS LC-40	28.562302	-80.577356	red
16	CCAFS LC-40	28.562302	-80.577356	red
17	CCAFS LC-40	28.562302	-80.577356	green
18	CCAFS LC-40	28.562302	-80.577356	green
19	CCAFS LC-40	28.562302	-80.577356	red
20	CCAFS LC-40	28.562302	-80.577356	green



36	KSC LC-39A	28.573255	-80.646895	green
37	KSC LC-39A	28.573255	-80.646895	red
38	KSC LC-39A	28.573255	-80.646895	green
39	KSC LC-39A	28.573255	-80.646895	green
40	KSC LC-39A	28.573255	-80.646895	red
41	KSC LC-39A	28.573255	-80.646895	green
42	KSC LC-39A	28.573255	-80.646895	green
43	KSC LC-39A	28.573255	-80.646895	red
44	KSC LC-39A	28.573255	-80.646895	green
45	KSC LC-39A	28.573255	-80.646895	green
46	KSC LC-39A	28.573255	-80.646895	green
47	KSC LC-39A	28.573255	-80.646895	green
48	KSC LC-39A	28.573255	-80.646895	green



Green= Successful Launch

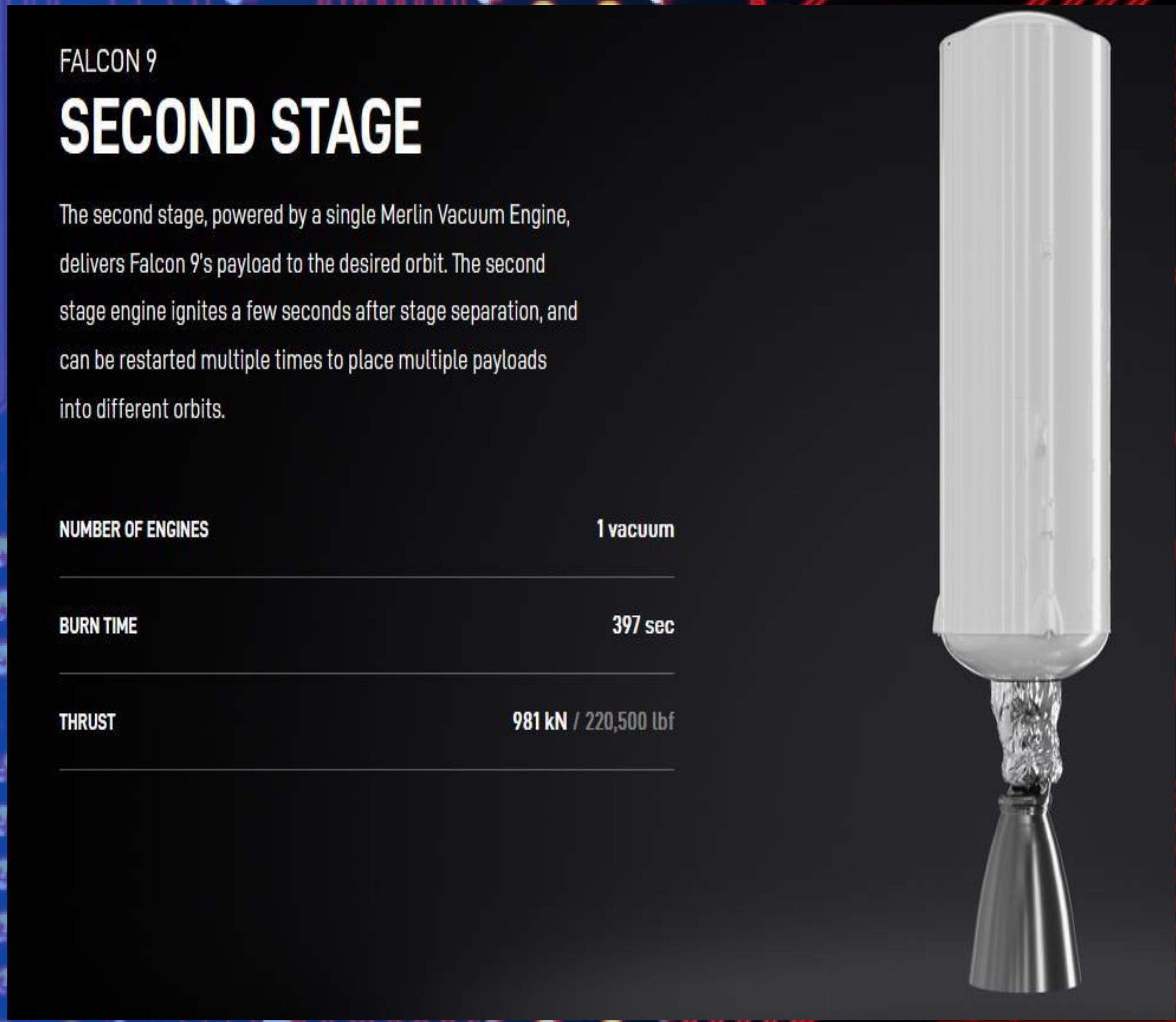
Red= Failed Launch

Safe Distance to Launch Site

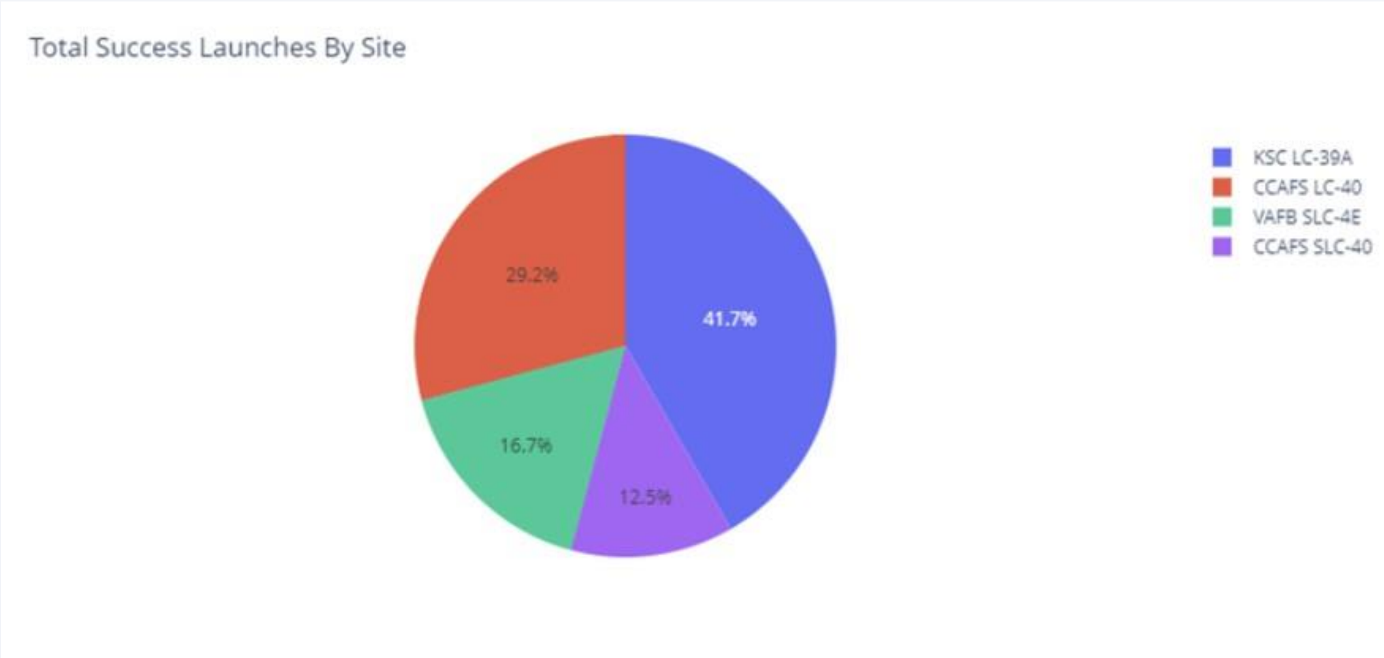
The obtained results indicate that all launch sites are at safe distance from railway lines and cities.

Section 4

Build a Dashboard with Plotly Dash



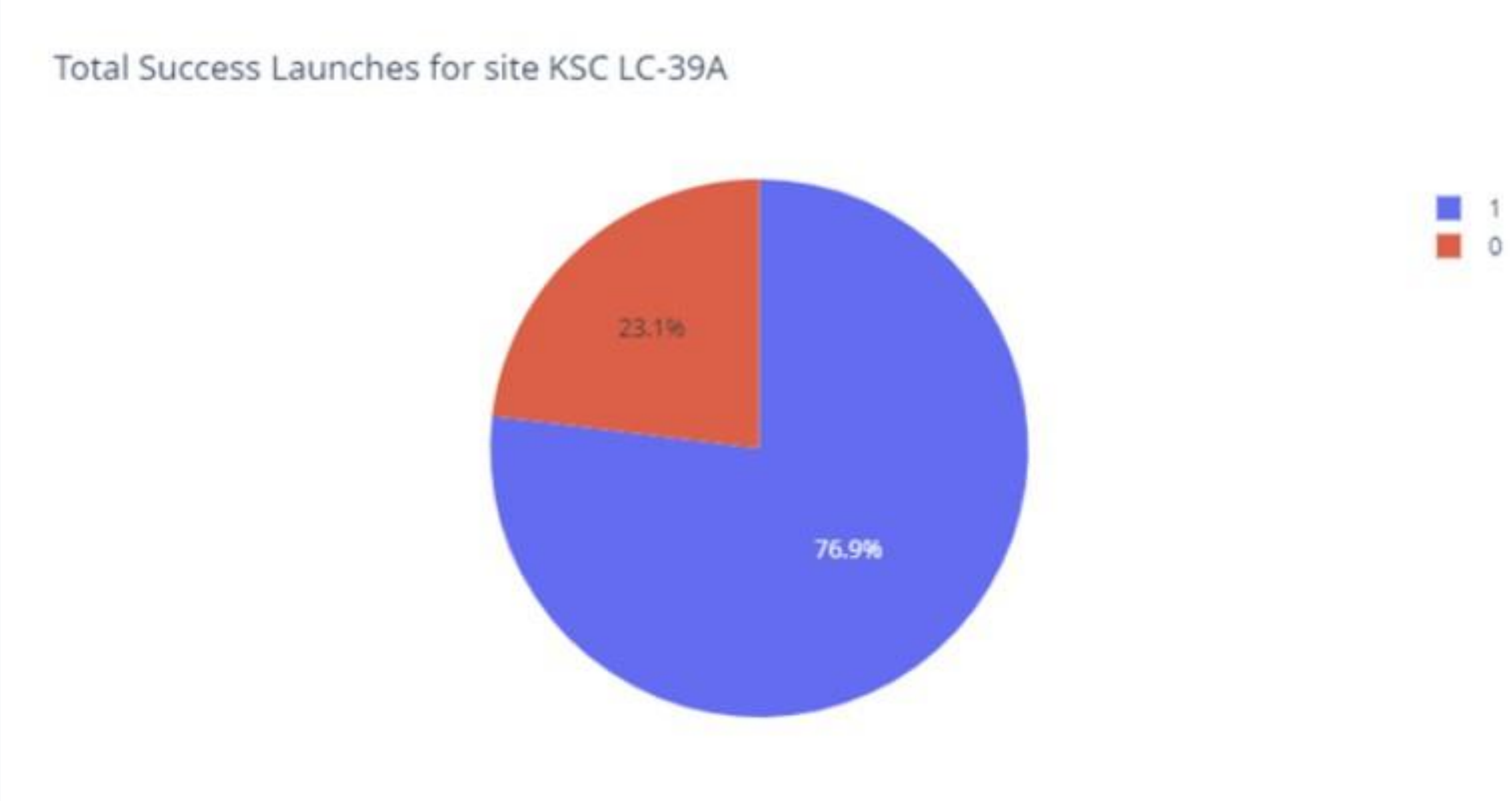
Total Launch Success for All Sites



The highest success launch rates were recorded at these sites :

1. KSC LC-39A (41.7%)
2. CCAFS LC-40 (29.2%)

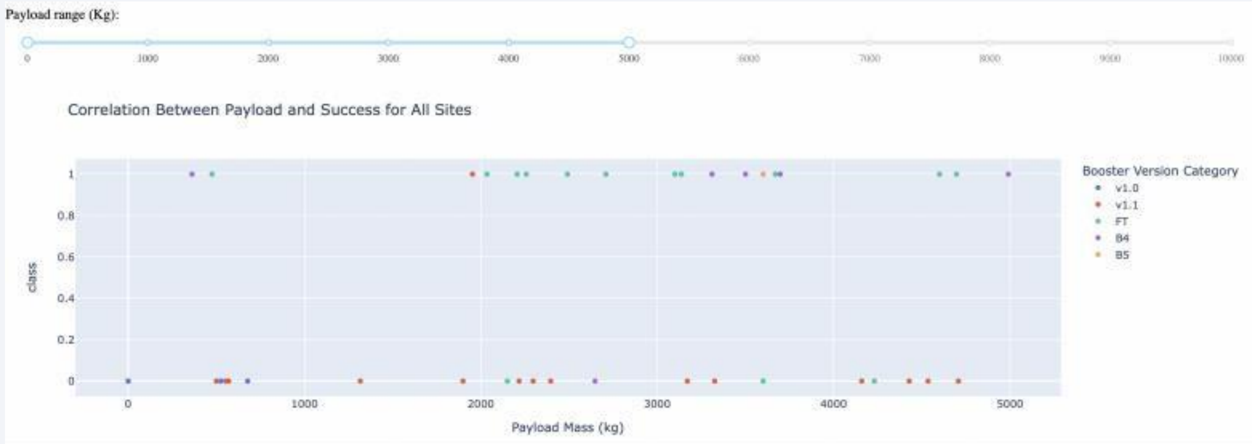
KSC LC-39 Launch Site Success Rate

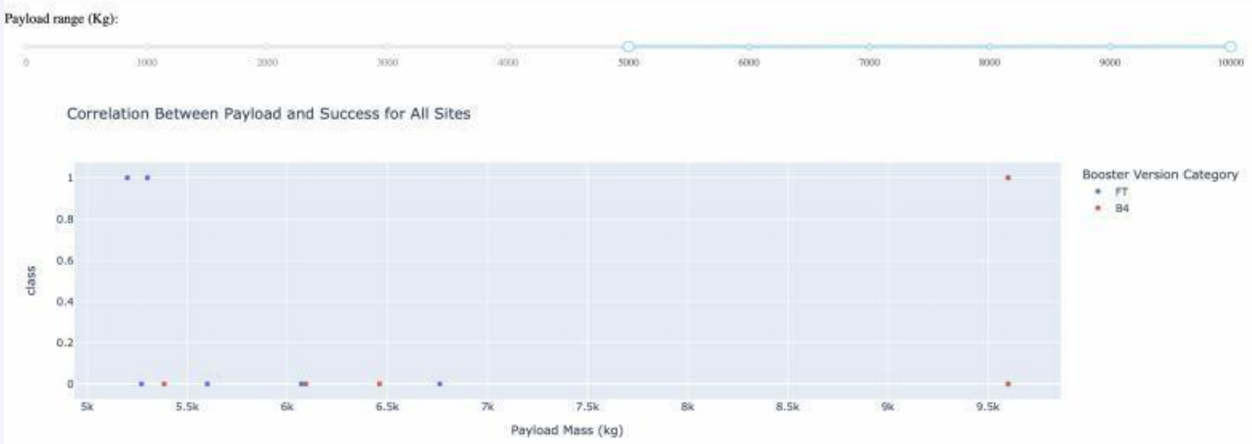


Site KSC LC-39 success rate is 76.9%

Payload vs. Launch Outcome for All Sites

Highest success rate for payloads is between 2000 and 5500 Kgs

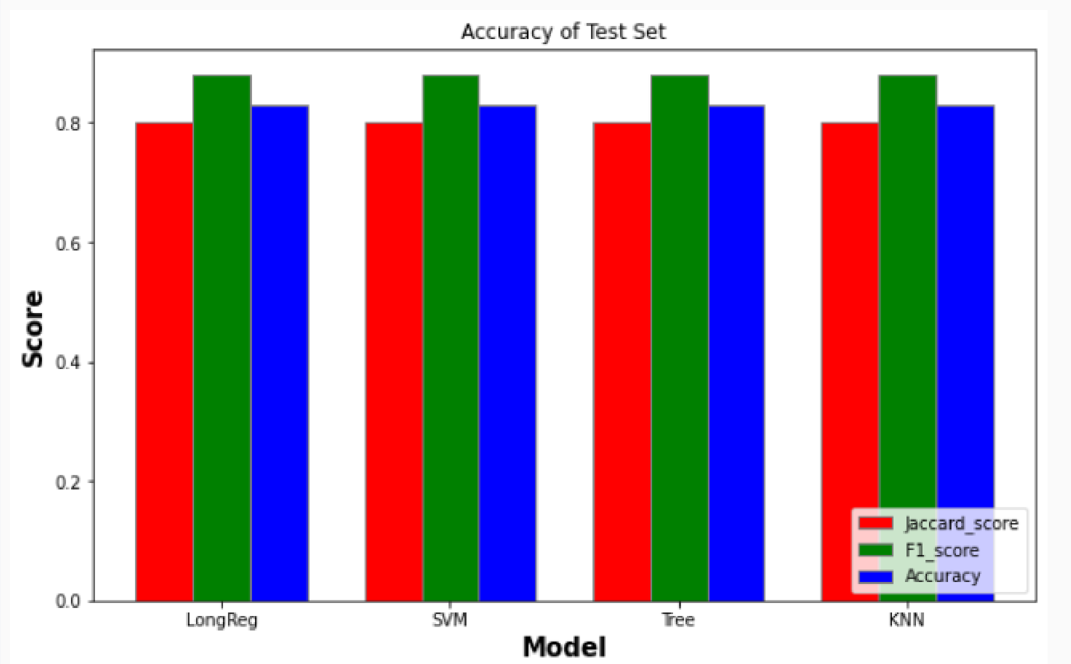


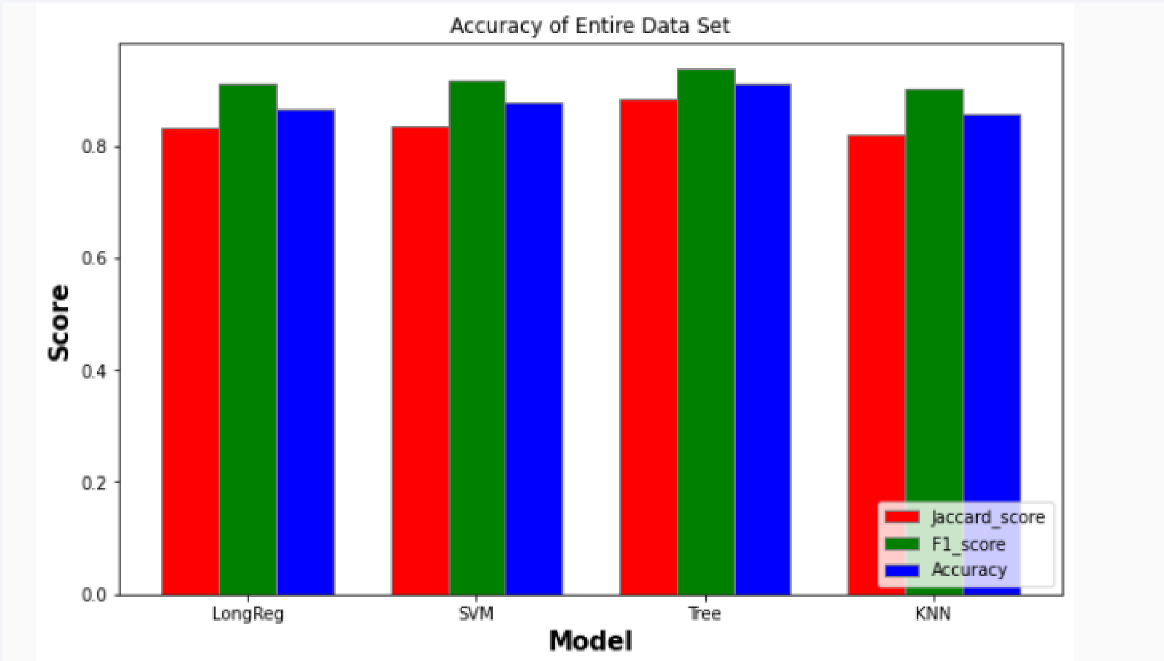


Section 5

Predictive Analysis (Classification)

Classification Accuracy

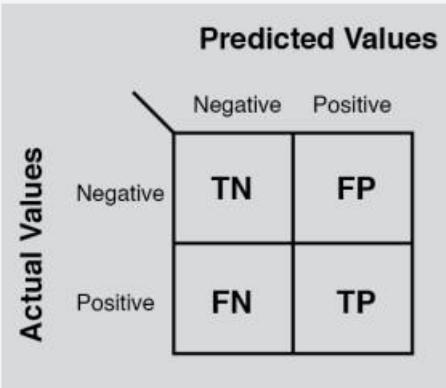


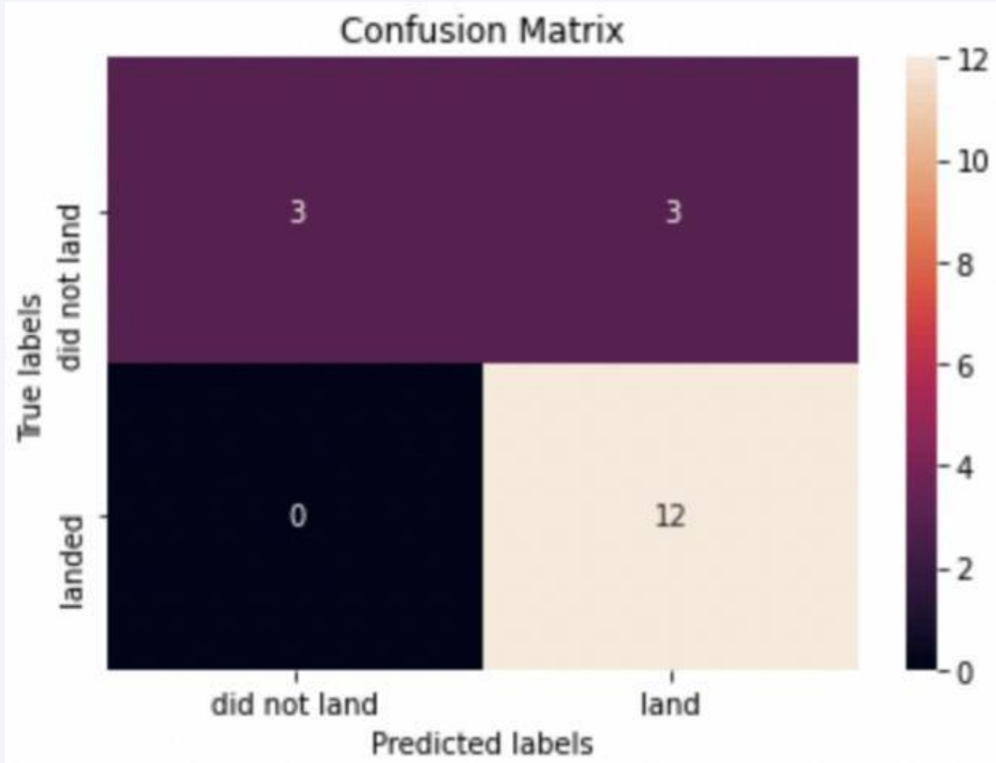


- **Using the test set the same accuracy results were obtained from the four models.**
- **The Tree Model provided the best accuracy results for the entire data set.**

Confusion Matrix

- The confusion matrix analysis suggests that the best performing model is the Logistic Regression model.
- The confusion matrix predicts 13 true positives, 3 false positives, 3 true positive, and 0 false negative.

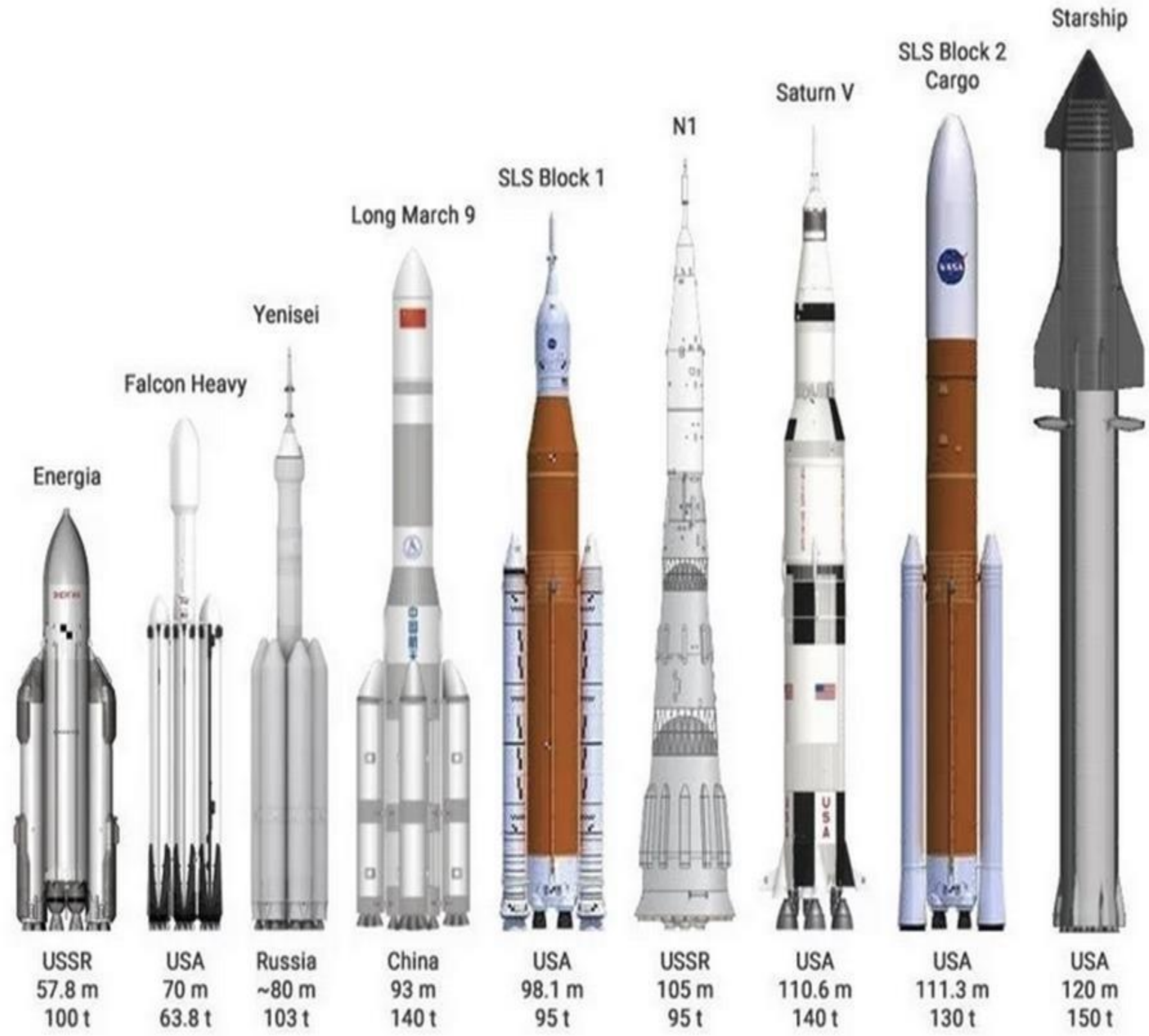




Conclusions

- The success rate for the rocket launches increased after 2013.
- Orbits GEO, HEO, ES-L1 and SSO have 100% launch success rate.
- Launch site KSC LC-39A has the highest success rate.
- The Decision Tree model is the best ML algorithm for analyzing the SpaceX data set and provided the best accuracy results.

Thank you!


Starship
SLS Block 2 Cargo
Saturn V
N1
SLS Block 1
Long March 9
Yenisei
Falcon Heavy
Energia
USSR 57.8 m 100 t
USA 70 m 63.8 t
Russia ~80 m 103 t
China 93 m 140 t
USA 98.1 m 95 t
USSR 105 m 95 t
USA 110.6 m 140 t
USA 111.3 m 130 t
USA 120 m 150 t