DATA SCIENCE CAPSTONE PROJECT

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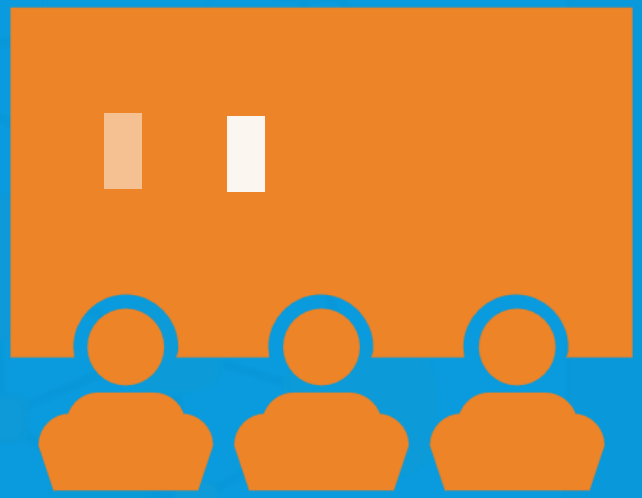
SKILLS NETWORK

OUTLINE

- Executive Summary
- Introduction
- Methodology
- Results
  - Visualization – Charts
  - Dashboard
- Discussion
  - Findings & Implications
- Conclusion
- Appendix



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EXECUTIVE SUMMARY

- Summary of Methodologies
  - Data Collection
  - Data Wrangling
  - Exploratory Data Analysis with SQL
  - Exploratory Data Analysis with Visualizations
  - Interactive Visualizations
  - Predictive Analytics

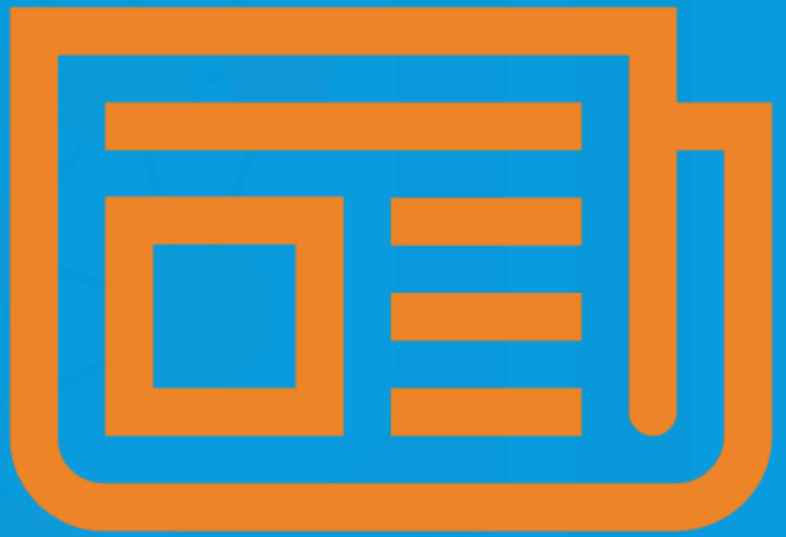
- Summary of Results
  - Exploratory Data Analysis results
  - Interactive Analytics demos in screenshot
  - Predictive analysis results

INTRODUCTION

- Project Background
  - The project's aim is to predict if Falcon 9 first stage will land successfully. SpaceX advertises Falcon rocket launches on its website with a cost of 62 million dollars. Other providers cost upwards of 165 million dollars. SpaceX provides the savings by reusing the first stage. If we can determine if the first stage will land, we can determine the cost of the launch. This information can be used by competing companies to bid against SpaceX for a rocket launch.
- Questions to be answered
  - How do variable influences such as payload mass, launch site, and orbits affect the success?
  - What is the effect of each relationship of variables on outcomes?
  - What are the conditions which will aid SpaceX to achieve the best results?

METHODOLOGY

- Data Collection Methodology
  - SpaceX Rest API
  - Web scrapping from Wiki
- Performed Data Wrangling (Transformed data for machine learning)
  - One Hot Encoding data fields for Machine learning and dropping irrelevant columns.
- Performed Exploration Data Analysis with visualization.
  - Plotting: Scatter and bar graphs to show relationship between variables and to show patterns of data.
- Performed Interactive Visual Analytics
  - Using Folium and Plotly Dash visualizations.
- Performed Predictive Analysis using Classification models
  - Build, tune, and evaluate classification models



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DATA COLLECTION

The data sets were gathered.

- I worked with SpaceX launch data that was gathered from SpaceX REST API.

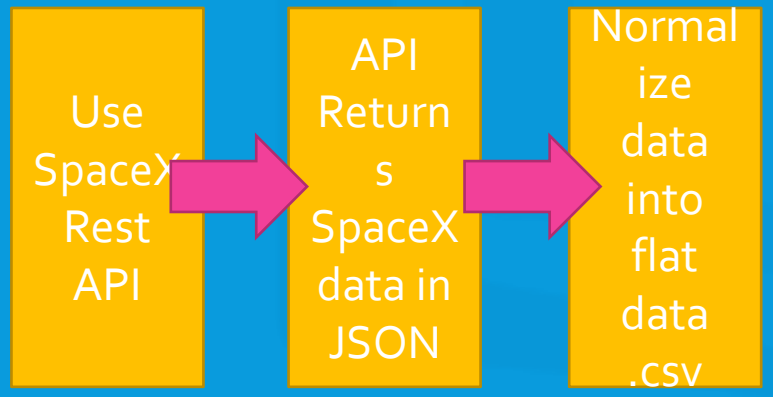
The API provided data related to launches, including information about the rocket uses, payload delivered, launch specs, landing specs, and landing outcomes.

The goal was to predict whether SpaceX will attempt to land a rockets.

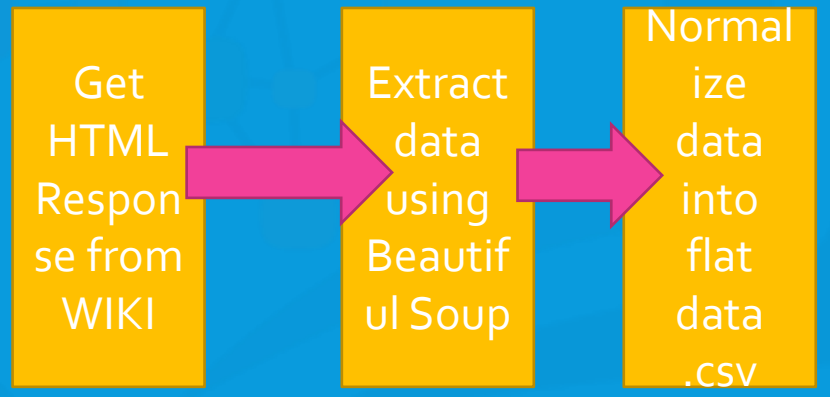
The SpaceX REST API URL starts with api.spacexdata.com/V4/

In addition, the other popular data source for obtaining Falcon 9 launch data is webs-craping Wikipedia using Beautiful Soup.

DATA WRANGLING



WEB SCRAPING



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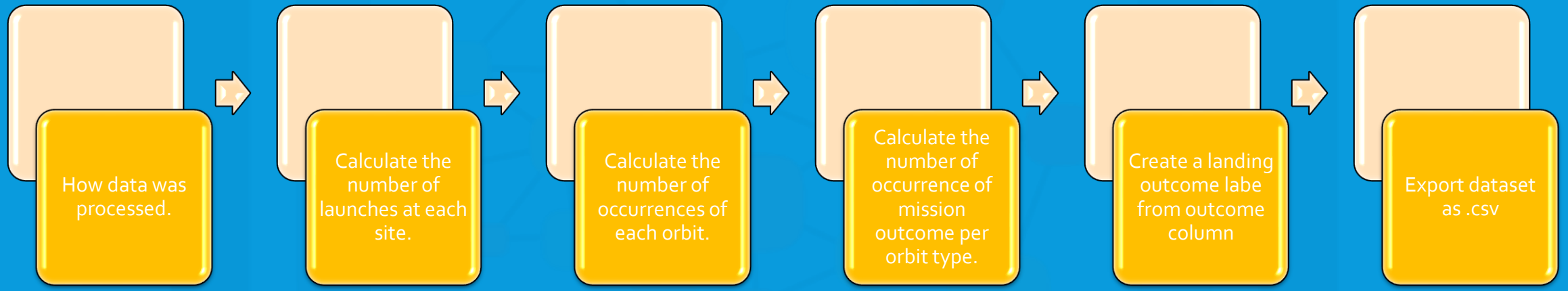
DATA COLLECTION – REST API

- Getting response from API
- Converting Response to a .json file.
- Apply custom functions to clean data.
- Assign a list to dictionary then a data frame.
- Filter the dataframe and export to a flat file (.csv)

GitHub Lab

Data Collection API – Lab 1

DATA WRANGLING



GitHub Lab

Data Wrangling – Lab 2

EDA WITH SQL

- Performed SQL queries:
- Displaying the names of the unique launch sites in the space mission.
- Displaying 5 records where launch sites begin with the string 'CCA'
- Displaying the total payload mass carried by boosters launched by NASA (CRS)
- Displaying 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 site names for the months in year 2015'
- Ranking the count of landing outcomes (such as Failure – drone ship or Success – ground pad between the date 2010-06-04 and 2017-03-20 in descending order.

GitHub Lab

EDA with SQL – Lab 3

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EDA AND INTERACTIVE VISUAL METHODOLOGY

- Charts were plotted.
  - Flight Number vs Payload Mass, Flight Number vs Launch Site, Payload Mass vs Launch Site, Orbit Type vs Success Rate, Flight Number vs Orbit Type, Payload Mass vs Orbit Type and Success Rate Yearly Trend
  - Scatter plots show the relationship between variables. If a relationship exists, they could be used in machine learning model.
  - Bar chart show comparisons among discrete categories. The goal is to show the relationship between the specific categories being compared and a measure value.
  - Line charts show trends in data over time (time series).

GitHub Lab

EDA with Visualization – Lab 4

BUILD AN INTERACTIVE MAP WITH FOLIUM

Git Hub Lab

Interactive Visualizations – Lab 5

- Markers of all Launch Sites:
  - Added Marker with Circle, Popup Label and Text Label of NASA Johnson Space Center using its latitude and longitude coordinates as a start location.
  - Add Markers with Circle Popup Label and Text Label of all Launch Sits using their latitude and longitude coordinates to show their geographical locations and proximity to Equator and coasts.
  - Coloured markers of the launch outcomes for each Launch Site:
    - Added coloured markers of success (Green) and failed (Red) launches using Maker Cluster to identify which launch sites have relatively high success rates.
  - Distances between a launch site to its proximities.

BUILD A DASHBOARD WITH PLOTLY DASH

- Launch Sites Dropdown List:
  - Add a dropdown list to enable Launch Site selection.
- Pie Chart showing Success Launches (All Sites/Certain Site):
  - Added a pie chart to show the total successful launches count for all sites and the Success vs. Failed counts for the site, if a specific Launch Site was selected.
- Slider of Payload Mass Range:
  - Added a slider to select Payload range.
- Scatter Chart of Payload Mass vs Success Rate for the different Booster Versions.

PREDICTIVE ANALYSIS METHODOLOGY

Building Model

Load the dataset into Numpy and Pandas

Transform data

Split the data into training and test data sets.

Check how many test samples there were.

Decide which type of matching learning algorithms to use.

Set the parameters and algorithms to GrdSearchCV

Evaluating Model

Check accuracy for each model.

Get tuned hyperparameters for each type of algorithms

Plot confusion matrix.

Improving Model

Feature Engineering

Algorithm tuning.

Finding the best performing classification model

The model with the best accuracy score winds the best performing model

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RESULTS

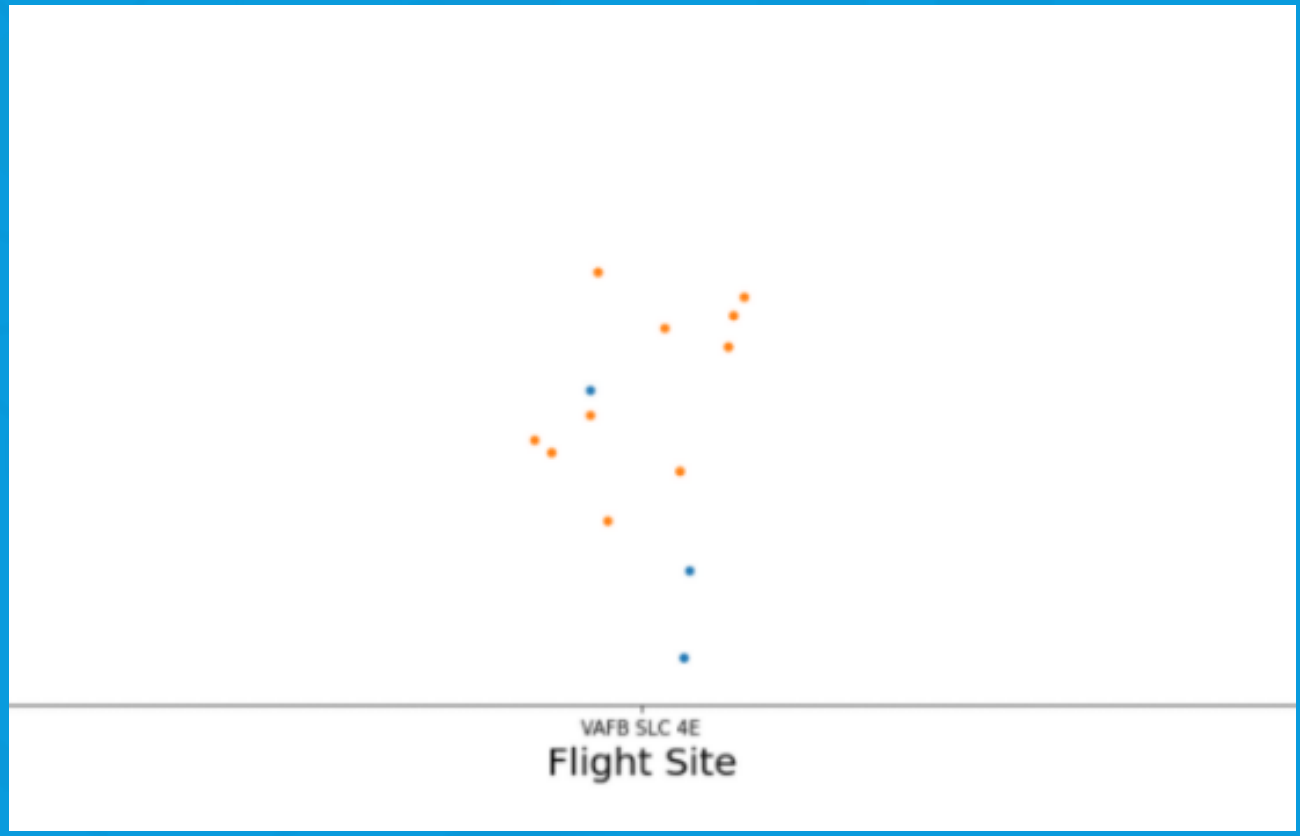
INTERACTIVE ANALYTICS DEMO IN SCREENSHOTS.

PREDICTIVE ANALYSIS RESULTS.

EDA WITH VISUALIZATIONS

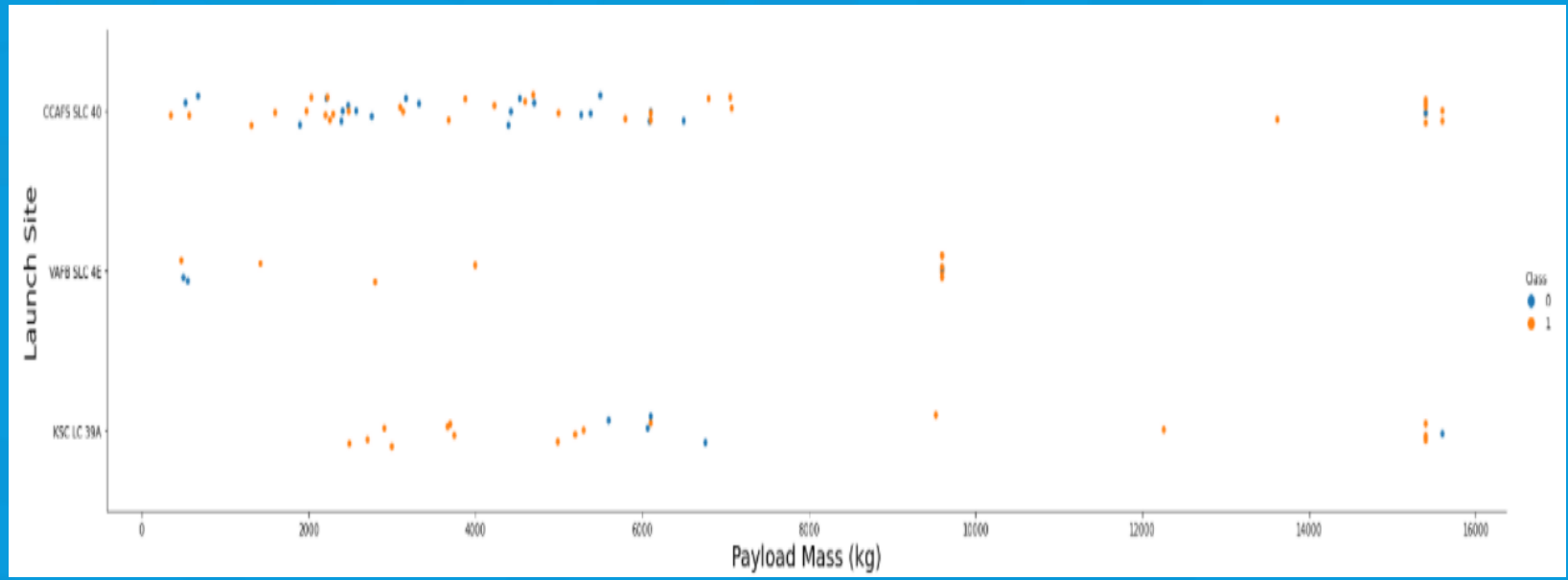
FLIGHT NUMBER VS. FLIGHT SITE

The more flights at a launch site the greater the success rate at a launch site.

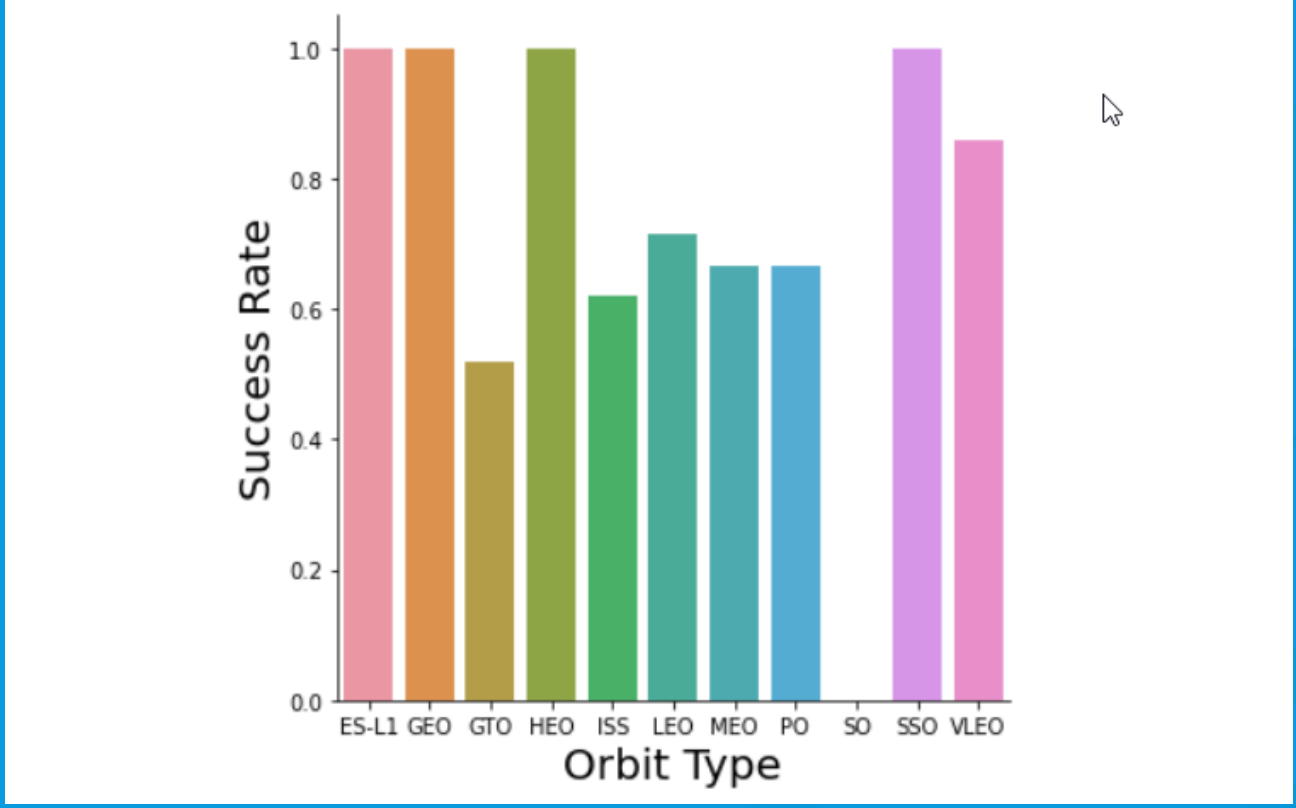


PAYLOAD VS LAUNCH SITE

The greater the payload mass for Launch Site CCAFS SLC 40 the higher the success rate for the Rocker. There is not quite a clear pattern to be found using this visualization to make a decision if the Launch Site is dependent on Pay Load Mass for a success launch.



SUCCESS RATE VS ORBIT TYPE



Explanation:

Orbits with 100% success rate:

ES-L1, GEO, HEO, SSO

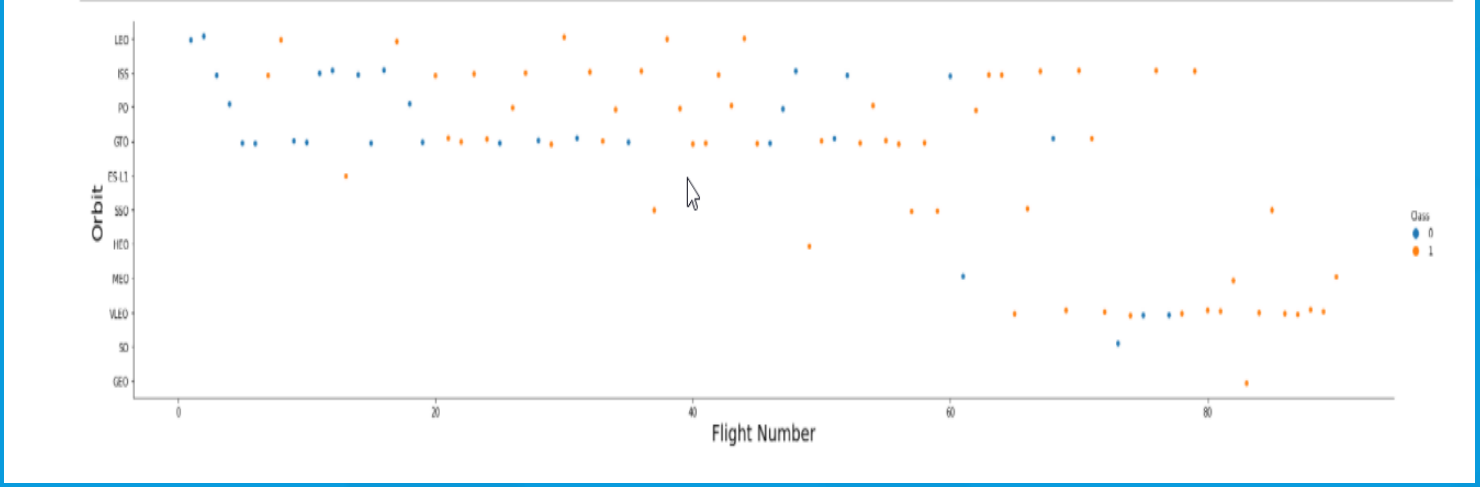
Orbits with 0% success rate:

SO

Orbits with success rate between 50% and 85%

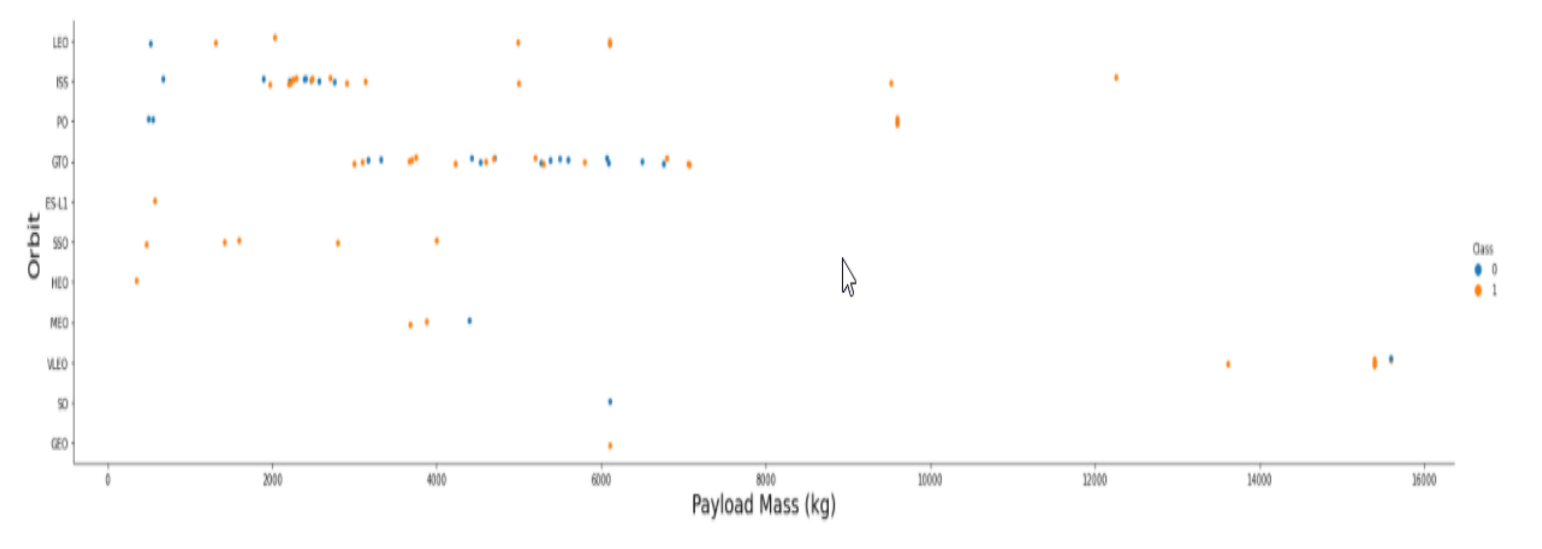
GTO, ISS,LEO,MEO,PO

FLIGHT NUMBER VS ORBIT TYPE



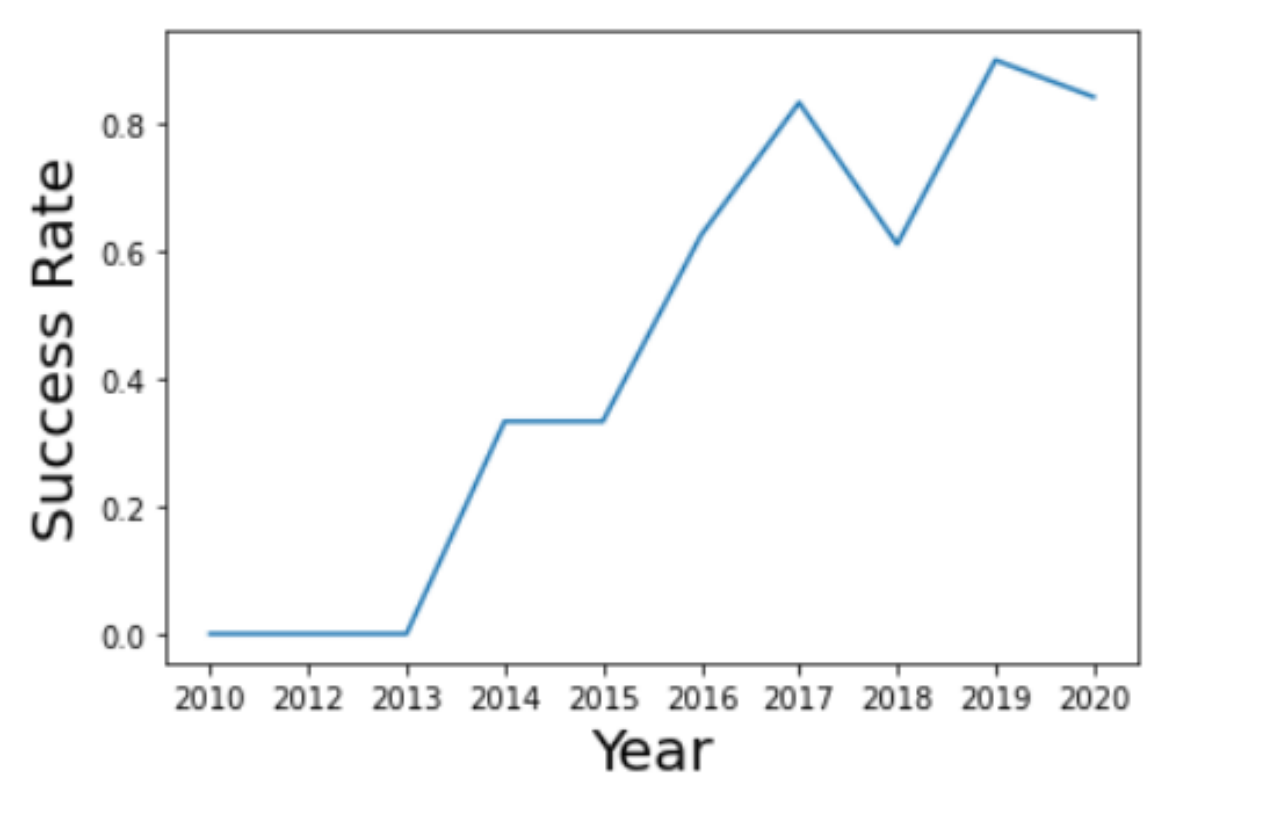
In the visualization you will see that in the LEO orbit the Success appears related to the number of flights. In addition there seems to be no relationship between flight number when in GTO orbit.

PAYLOAD MASS VS ORBIT TYPE



Heavy payloads have a negative influence on GTO orbits and positive on GTO and Polar LEO (ISS) orbits.

LAUNCH SUCCESS YEARLY TREND



The success rate since 2013 kept increasing till 2020.

EDA WITH SQL

ALL LAUNCH SITE NAMES

```
In [16]: %sql select distinct launch_site from SPACEXTBL;
 * ibm_db_sa://pkn91707:***@764264db-9824-4b7c-82df-40d1b13897c2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32536/bludb
Done.
```

Out[16]:

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

Using the work distinct in the query will pull the unique values for the launch site column from the table SPACEXTBL.

LAUNCH SITE NAMES BEGIN WITH CCA

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

In [24]:
```
%sql select * from SPACEXTBL where launch_site like 'CCA%' limit 5;
```

```
 * ibm_db_sa://pkn91707:***@764264db-9824-4b7c-82df-40d1b13897c2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32536/bludb
Done.
```

Out[24]:

Date DD-MM-YYYY	time_utc_	booster_version	launch_site	payload	payload_mass_kg_	orbit	customer	mission_outcome	landing_outcome
2010-04-06	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
2010-08-12	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)
2012-08-10	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
2013-01-03	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attempt
2013-03-12	22:41:00	F9 v1.1	CCAFS LC-40	SES-8	3170	GTO	SES	Success	No attempt

Description: Using keyword "Limit 5" in the query will fetch 5 records from table SPACEX., condition LIKE keyword with wild card "CCA%". The percentage in the end suggest that the launch site name must start with CCA.

TOTAL PAYLOAD MASS

Using function SUM the total in the PAYLOAD_MASS_KG and the WHERE clause filters the dataset to only perform calculations on customer NASA

```
In [6]: %sql select sum(payload_mass__kg_) as total_payload_mass from SPACEXDATASET where customer = 'NASA (CRS)';
 * ibm_db_sa://wzf08322:***@0c77d6f2-5da9-48a9-81f8-86b520b87518.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31198/bludb
Done.
Out[6]:
```

total_payload_mass
45596

AVERAGE PAYLOAD MASS BY F9 V1.1

```
In [26]: %sql select avg(payload_mass__kg_) as average_payload_mass from SPACEXTBL  where booster_version like '%F9 v1.1%';
          * ibm_db_sa://pkn91707:***@764264db-9824-4b7c-82df-40d1b13897c2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32536/bludb
          Done.
```

Out[26]:

average_payload_mass
3226

Using the function AVG works out the average in the column PAYLOAD_MASS_KG.

The WHERE clause filters the dataset to only perform calculations on Booster_Version f9 v1.1.

FIRST SUCCESSFUL GROUND LANDING DATE

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

```
In [8]: %sql select min(date) as first_successful_landing from SPACEXDATASET where landing__outcome = 'Success (ground pad)';
 * ibm_db_sa://wzf08322:***@0c77d6f2-5da9-48a9-81f8-86b520b87518.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31198/bludb
Done.
Out[8]:
```

first_successful_landing
2015-12-22

SUCCESSFUL DRONE SHIP LANDING WITH PAYLOAD BETWEEN 4000 AND 6000

```
In [28]: %sql select booster_version from SPACEXTBL  where landing__outcome = 'Success (drone ship)' and payload_mass__kg_ between 4000 a
         nd 6000;
  * ibm_db_sa://pkn91707:***@764264db-9824-4b7c-82df-40d1b13897c2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32536/bludb
Done.
```

Out[28]:

booster_version
F9 FT B1022
F9 FT B1031.2

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

TOTAL NUMBER OF SUCCESSFUL AND FAILURE MISSION OUTCOMES.

Listing the total number of successful and failure mission outcomes.

```
In [10]: %sql select mission_outcome, count(*) as total_number from SPACEXDATASET group by mission_outcome;
 * ibm_db_sa://wzf08322:***@0c77d6f2-5da9-48a9-81f8-86b520b87518.bs2io90l08kqblod8lcg.databases.appdomain.cloud:31198/bludb
Done.
```

Out[10]:

mission_outcome	total_number
Failure (in flight)	1
Success	99
Success (payload status unclear)	1

BOOTERS CARRIED MAXIMUM PAYLOAD

Listing the names of the booster versions which have carried the maximum payload mass.

```
In [30]: %sql select booster_version from SPACEXTBL where payload_mass__kg_ = (select max(payload_mass__kg_) from SPACEXDATASET);
 * ibm_db_sa://pkn91707:***@764264db-9824-4b7c-82df-40d1b13897c2.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:32536/bludb
Done.
```

Out[30]:

booster_version
F9 B5 B1048.4
F9 B5 B1049.4
F9 B5 B1049.5
F9 B5 B1060.2
F9 B5 B1058.3

2015 LAUNCH RECORDS

Listing the failed landing outcomes in drone ship, their booster versions and launch site names for the month in year 2015.

```
In [12]: %%sql select monthname(date) as month, date, booster_version, launch_site, landing__outcome from SPACEXDATASET
             where landing__outcome = 'Failure (drone ship)' and year(date)=2015;

 * ibm_db_sa://wzf08322:***@0c77d6f2-5da9-48a9-81f8-86b520b87518.bs2io90108kqb1od8lcg.databases.appdomain.cloud:31198/bludb
Done.
```

Out[12]:

MONTH	DATE	booster_version	launch_site	landing__outcome
January	2015-01-10	F9 v1.1 B1012	CCAFS LC-40	Failure (drone ship)
April	2015-04-14	F9 v1.1 B1015	CCAFS LC-40	Failure (drone ship)

RANK SUCCESS COUNT BETWEEN 2016-06-04 AND 2017-03-20

```
In [13]: %%sql select landing__outcome, count(*) as count_outcomes from SPACEXDATASET
             where date between '2010-06-04' and '2017-03-20'
             group by landing__outcome
             order by count_outcomes desc;
 * ibm_db_sa://wzf08322:***@0c77d6f2-5da9-48a9-81f8-86b520b87518.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31198/bludb
Done.
```

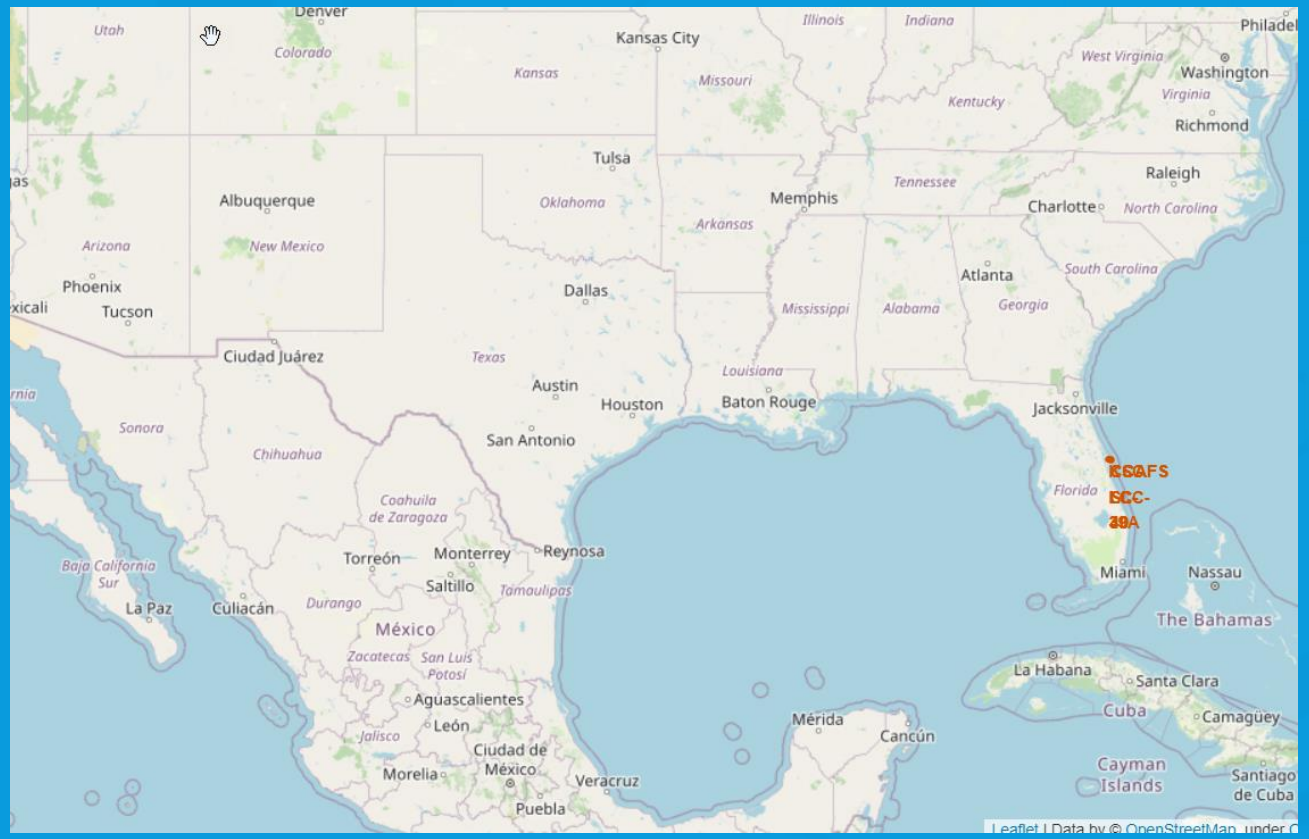
Out[13]:

landing__outcome	count_outcomes
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

Ranking the count of landing outcomes such as Failure = drone ship or Success - ground pad between the date 2010-06-04 and 2017-03-20 in desc order.

INTERACTIVE MAP WITH FOLIUM

ALL LAUNCH SITES LOCATION MARKERS ON A GLOBAL MAP.



Explanation

Most of launch sites are in proximity to the Equator line. The land is moving faster at the equator than any other place on the surface of the Earth.

All launch sites are in very close proximity to the coast, while launching rockets towards the ocean it minimizes the risk of hanving any debris dropping or exploding near people.

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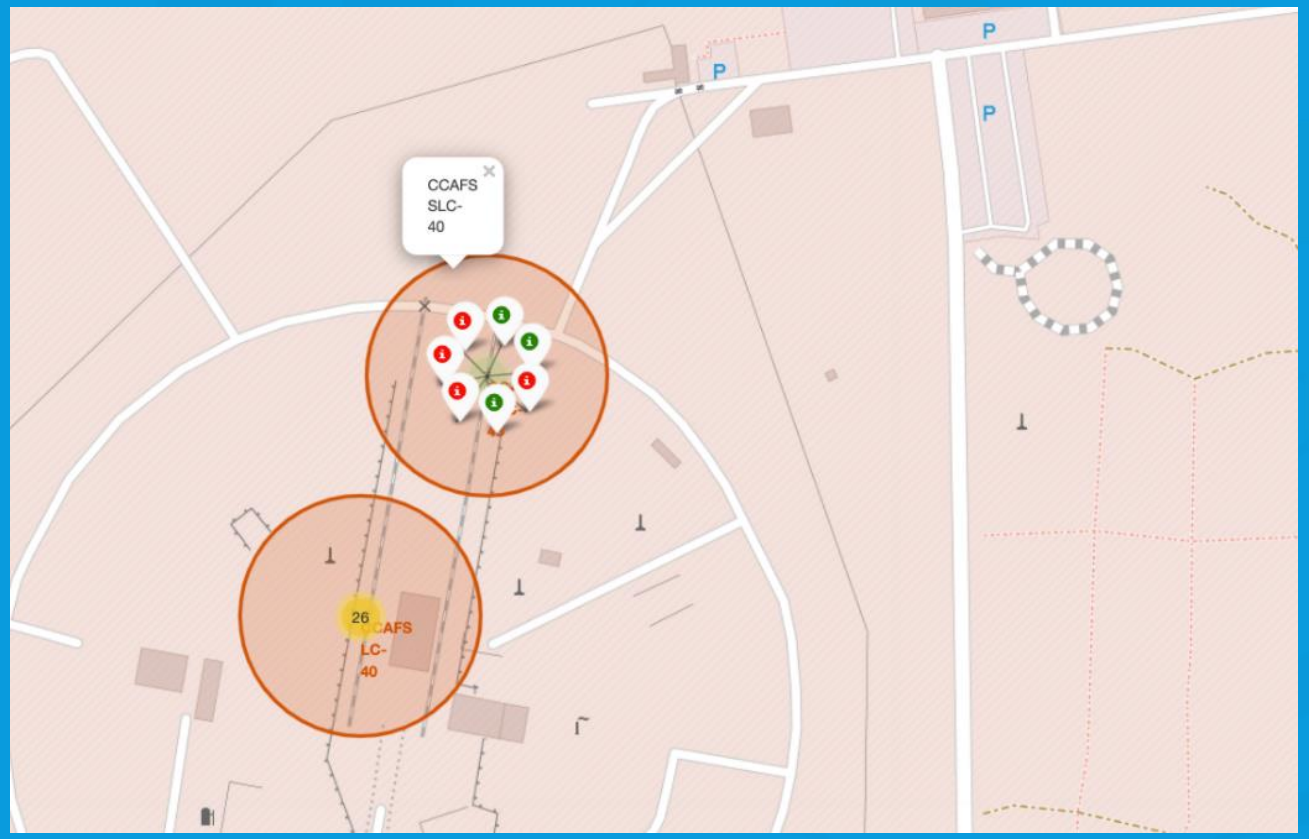
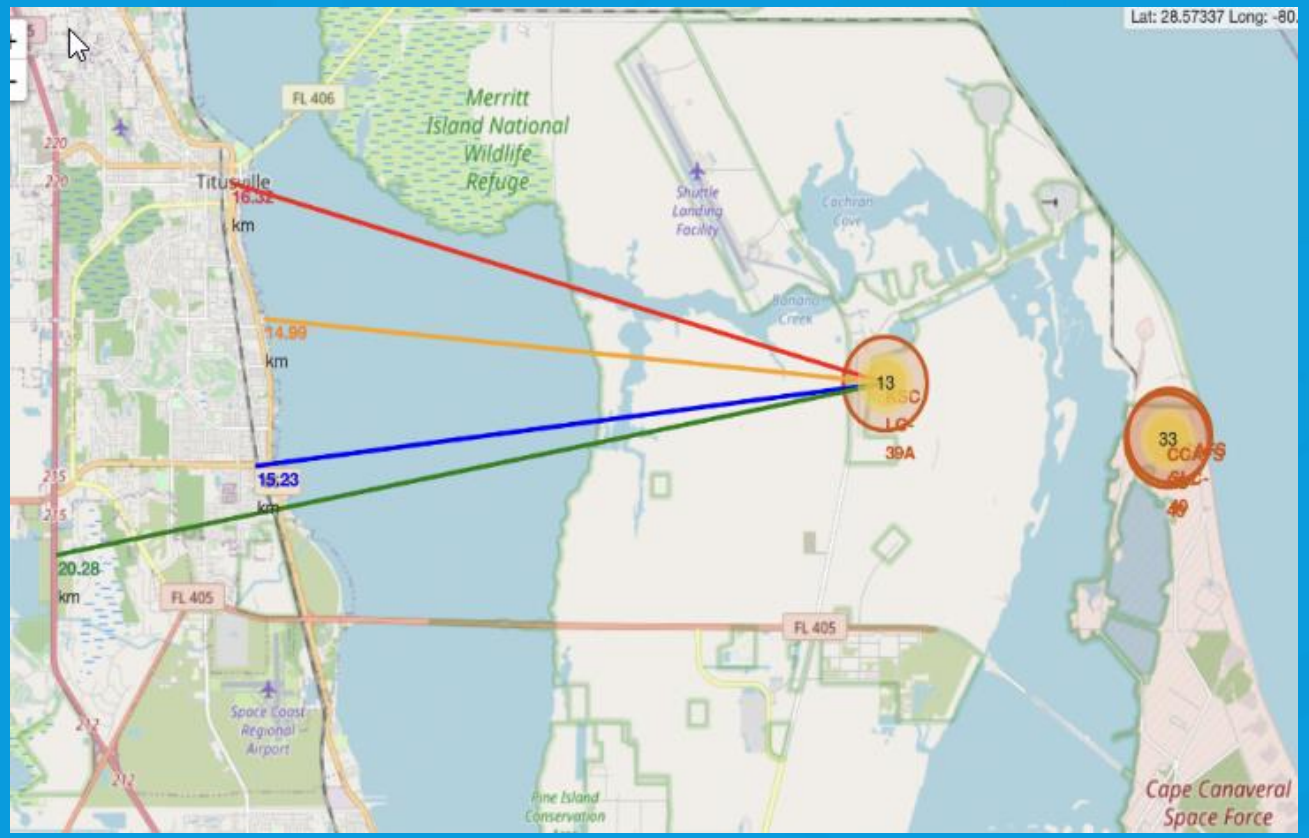
COLOUR LABELED LAUNCH RECORDS ON THE MAP



Explanation:

- From the colour labeled markers we should be able to easily identify which launch sites have relatively high success rates.
  - Green maker + successful launch
  - Red marker + failed launch
- Launch site KSC LC-39A has a very high success rate.

DISTANCE FROM THE LAUNCH SITE



Explanation:

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

- Relative closest to railway
- Relative closest to highway
- Relative closest to coastline

Also the launch site KSC LC-39A is relative close to its closet city Titusville (16.32 km).

Failed rocket with its high speed can cover distances like 15-20 km in few seconds. IT could potentially dangerous to populated areas.

BUILD A DASHBOARD WITH PLOTLY DASH

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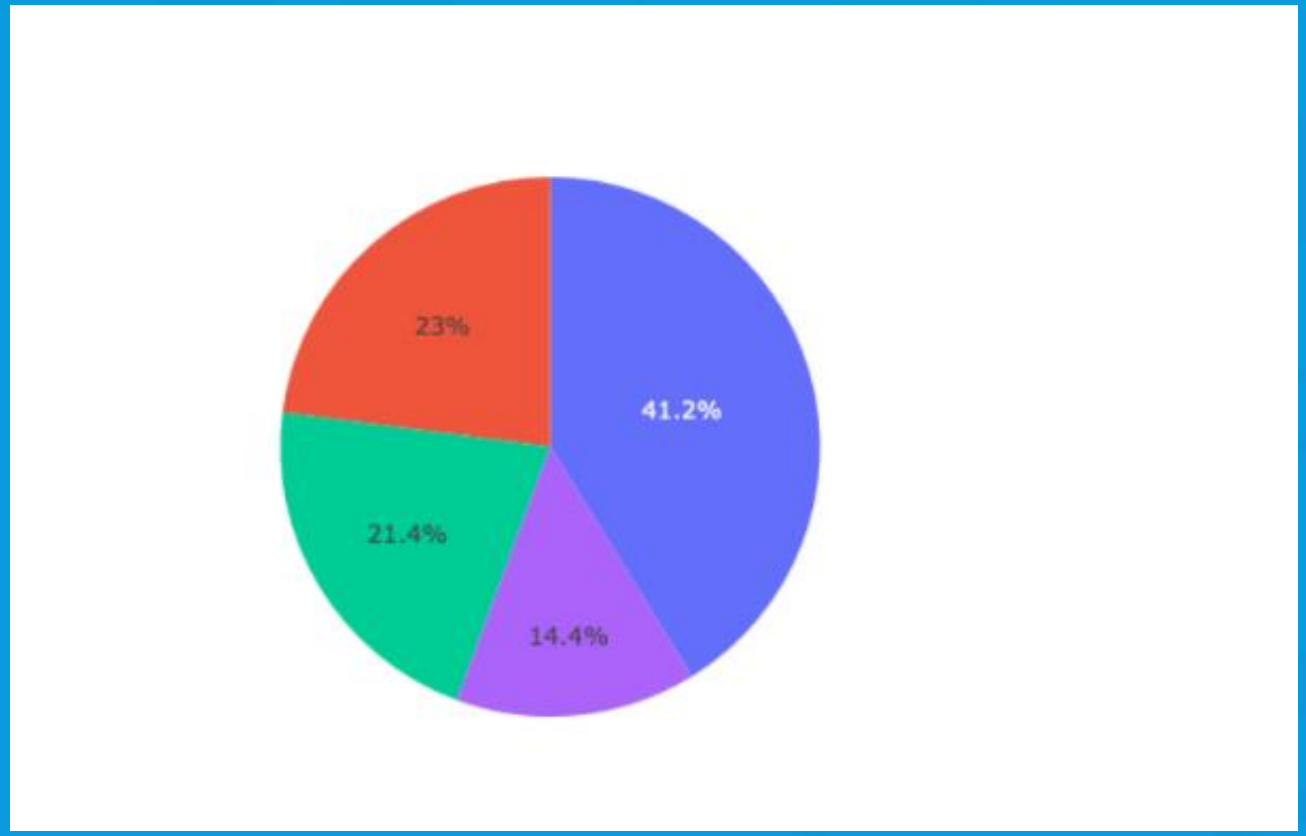
SKILLS NETWORK

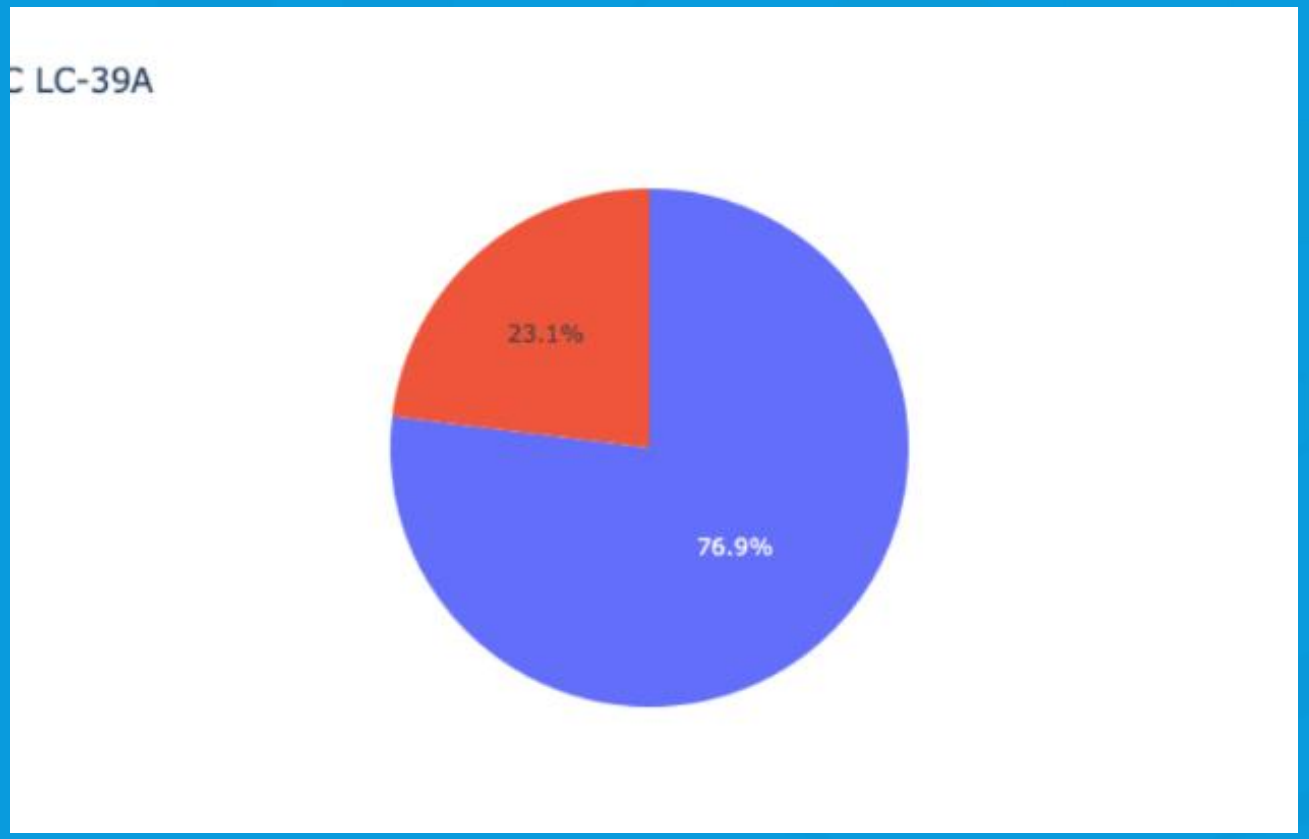
LAUNCH SUCCESS COUNT FOR ALL SITES



Explanation:

The chart clearly shows that from all the sites, KSC LC-39A has the most successful launches.

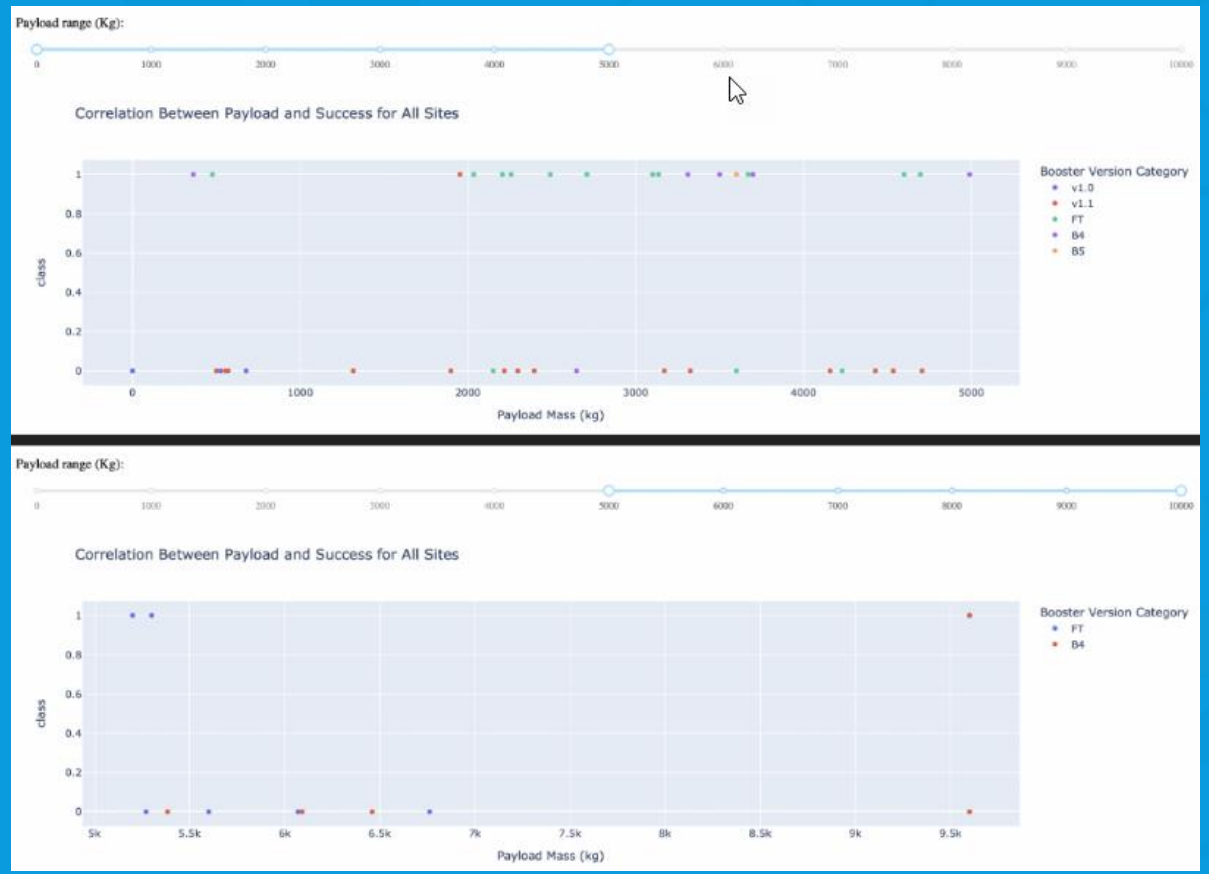
LAUNCH SITE WITH HIGHEST LAUNCH SUCCESS RATION



Explanation:

KSC LC-39A has the highest launch success rate (76.9%) with 10 successful and only 3 failed landings.

PAYLOAD MASS VS LAUNCH OUTCOME FOR ALL SITES



Explanation:

The charts show that payloads between 2000 and 5500 kg have the highest success rate.

PREDICTIVE ANALYSIS (CLASSIFICATION)

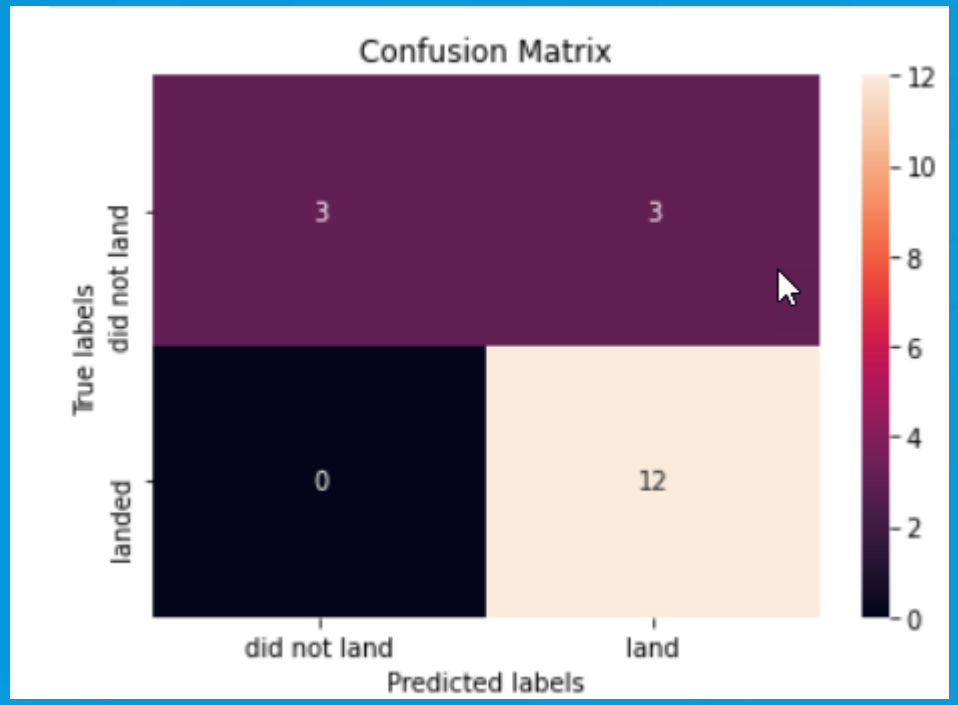
CLASSIFICATION ACCURACY

- Explanation:
  - Based on the score of the Test set, we can not confirm which method performs best.
  - Same Test Set scores may be due to the small test sample size (18 samples) , Therefore, we tested all methods based on the whole dataset.
  - The scores of the whole Dataset confirm that the best model is the Decision Tree model. This model has not only higher scores, but also the highest accuracy.

	LogReg	SVM	Tree	KNN
Jaccard_Score	0.800000	0.800000	0.800000	0.800000
F1_Score	0.888889	0.888889	0.888889	0.888889
Accuracy	0.833333	0.833333	0.833333	0.833333

	LogReg	SVM	Tree	KNN
Jaccard_Score	0.833333	0.845070	0.882353	0.819444
F1_Score	0.909091	0.916031	0.937500	0.900763
Accuracy	0.866667	0.877778	0.911111	0.855556

CONFUSION MATRIX



Explanation

Examining the confusion matrix, we see that logistic regression can distinguish between the different classes, WE see that the major problem is false positives.

CONCLUSION

- The decision tree model is the best algorithm for this dataset.
- The low weighted payloads perform better than heavier payloads.
- Success rates for SpaceX launches are directly proportional to time and eventually launches will be perfected
- KSC LC-39A had the most successful launches
- Orbits ES-L1, GEO,HEO, and SSO have 100% success rates

APPENDIX

- IBM Coursera