IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

Executive Summary

- **Summary of methodologies**
  - Data Collection
  - Data Wrangling
  - EDA with Data Visualization
  - EDA with SQL
  - Building an Interactive Map with Folium
  - Building a Dashboard with Plotly Dash
  - Predictive Analysis Classification
- **Summary of all results**
  - EDA Results
  - Interactive Analytics
  - Predictive Analysis

Introduction

- Project background and context

  SpaceX advertises Falcon 9 rocket launches on its website, with a cost of 62 million dollars; other providers cost upward of 165 million dollars each, much of the savings is because SpaceX can reuse the first stage. Therefore, if we can determine if the first stage will land, we can determine the cost of a launch.

- Problems you want to find answers

  The Project Task is to predict if the first stage of the SpaceX Falcon 9 will land successfully

Section 1

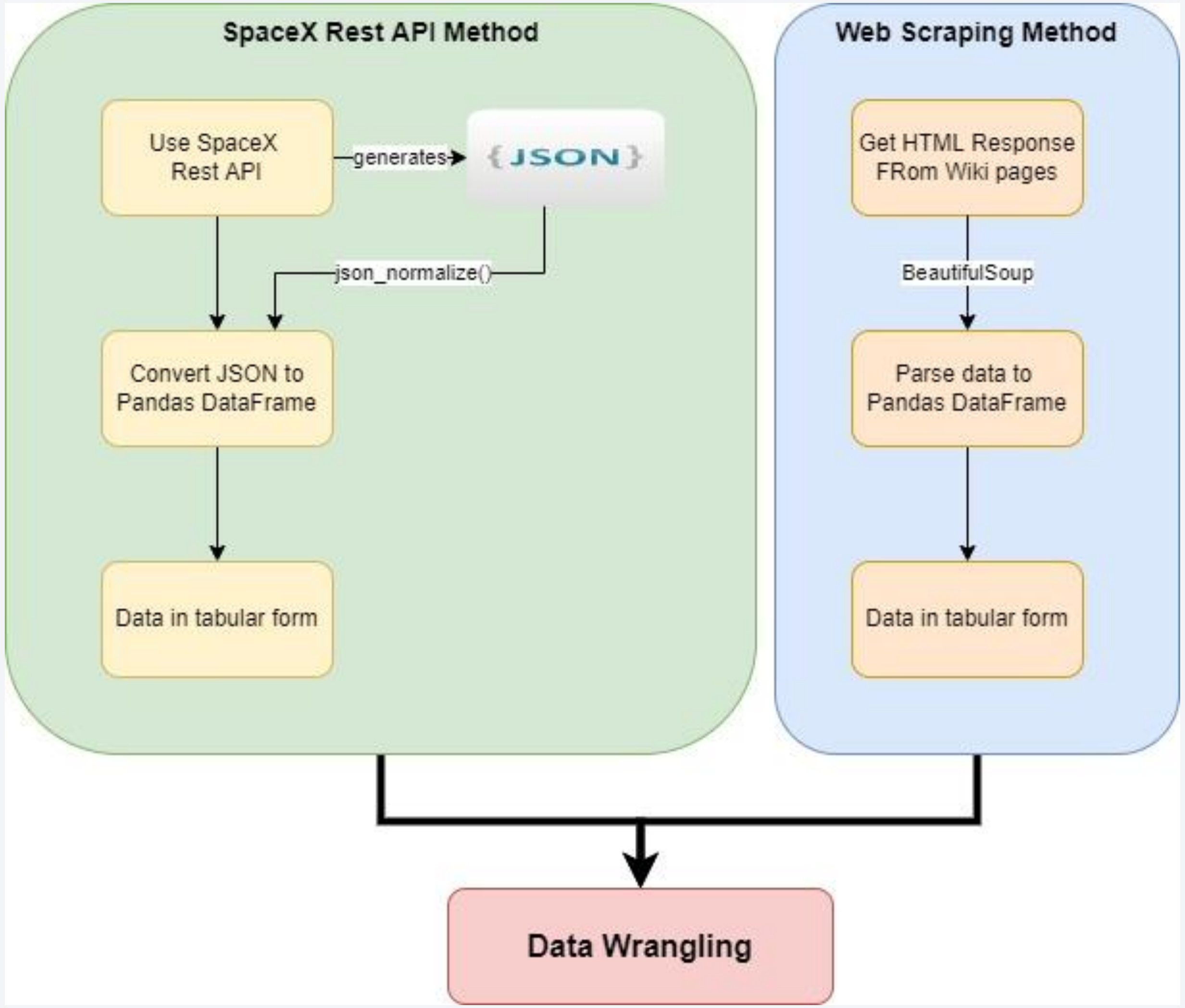
Methodology

Methodology

Executive Summary

- Data collection methodology:
  - SpaceX Rest API
  - Web Scraping from Wikipedia
- Perform data wrangling
  - One Hot Encoding fields for Machine Learning
  - Data cleaning – null values, irrelevant columns
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - Models built and evaluated : Linear Regression, KNN, SVM, Decision Tree
  - Best Classifier estimated

Data Collection



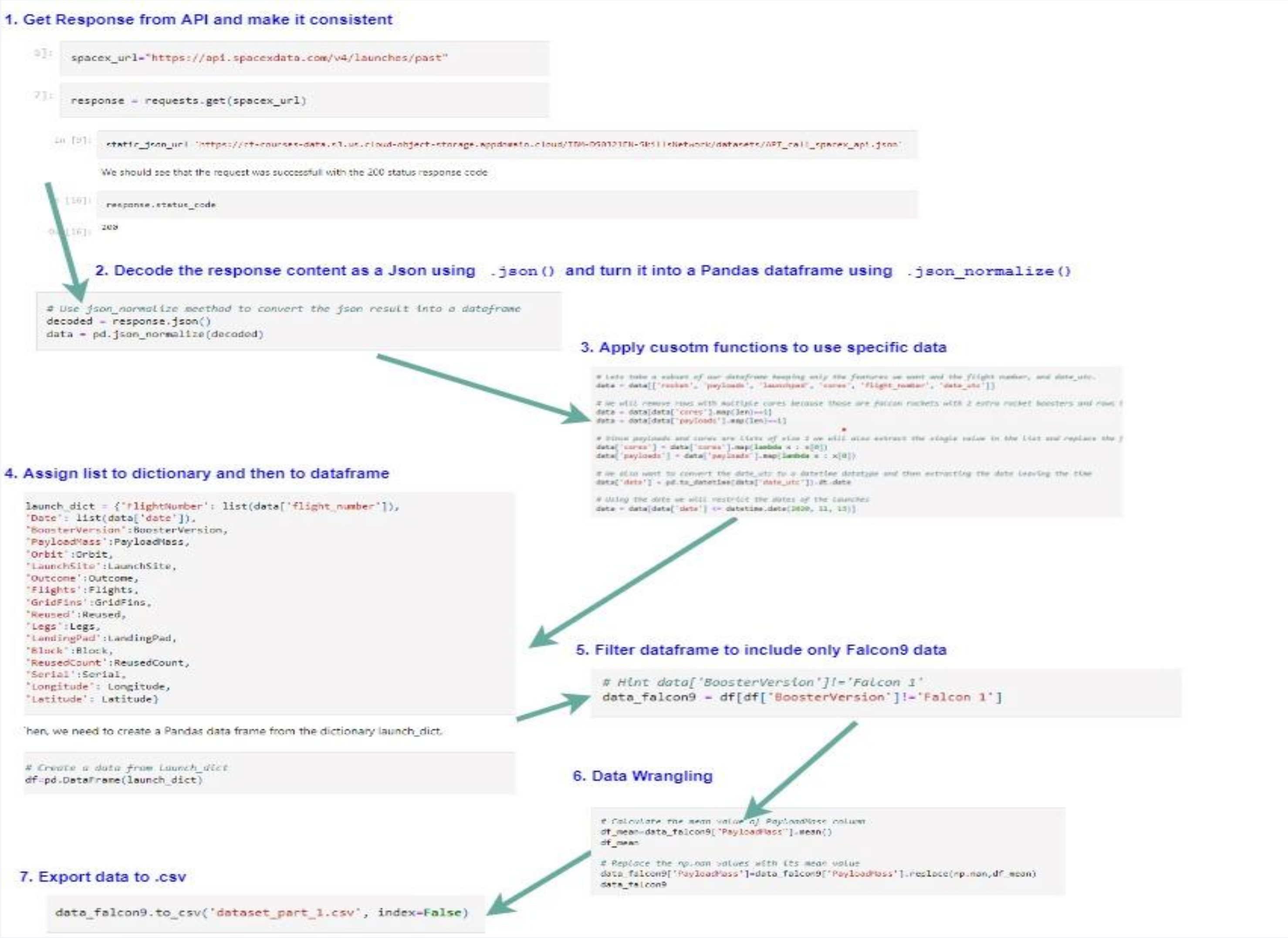
Two methods used for data collection :

- **From Space X API** – Specific endpoint to get the past launch data. Data obtained in json form is normalized to a flat table form
- **By Web Scraping related Wiki Pages** – web scrape some HTML tables that contain Falcon9 Launch records. Data is parsed into data frames for next steps.

Data Collection – SpaceX API

- Data collection steps summary with SpaceX REST calls :

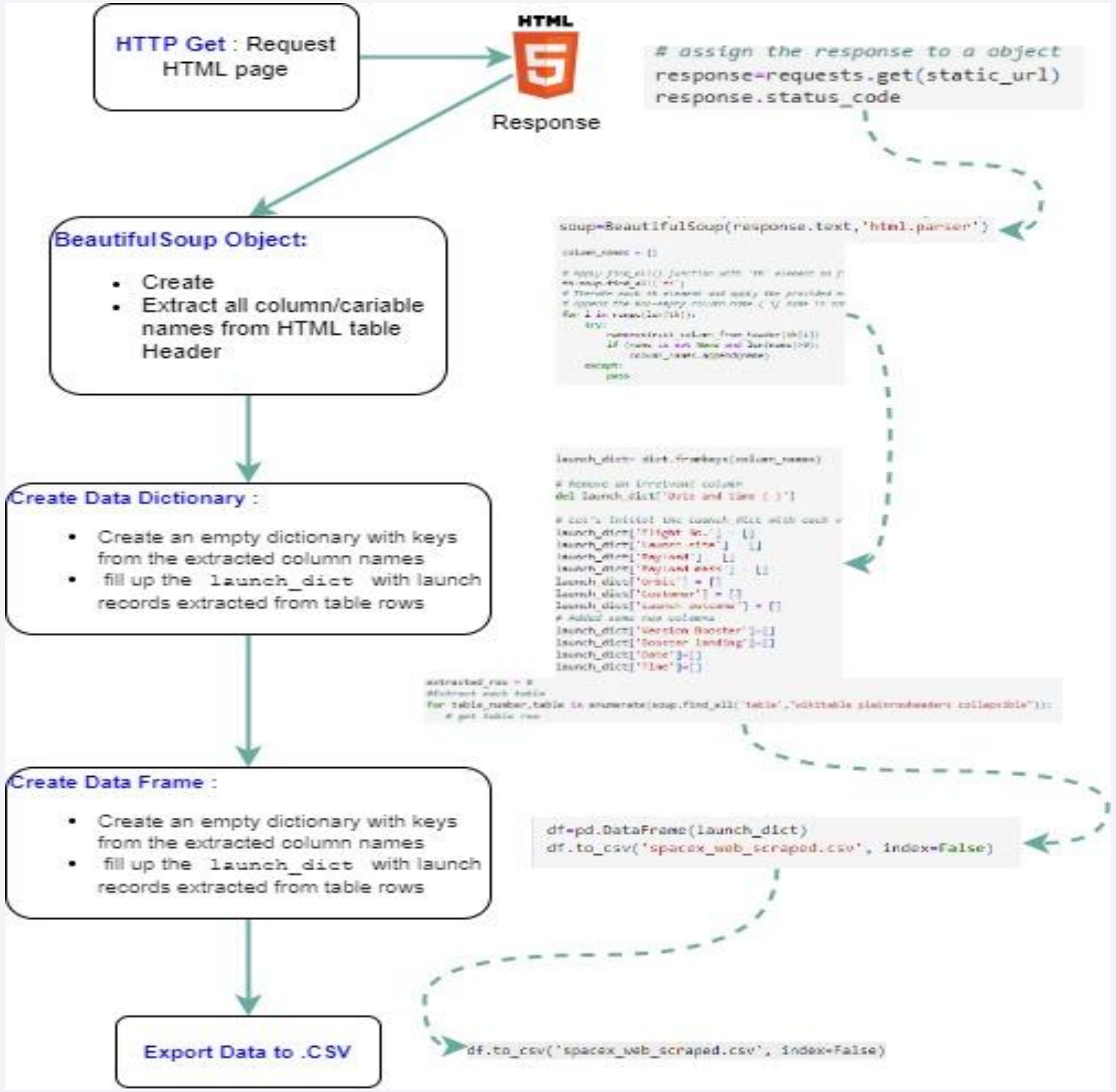
- GitHub URL for the complete code of SpaceX API calls https://github.com/sujasing/ds-ml-capstone-spacex/blob/main/01_DataCollectionAPI.ipynb



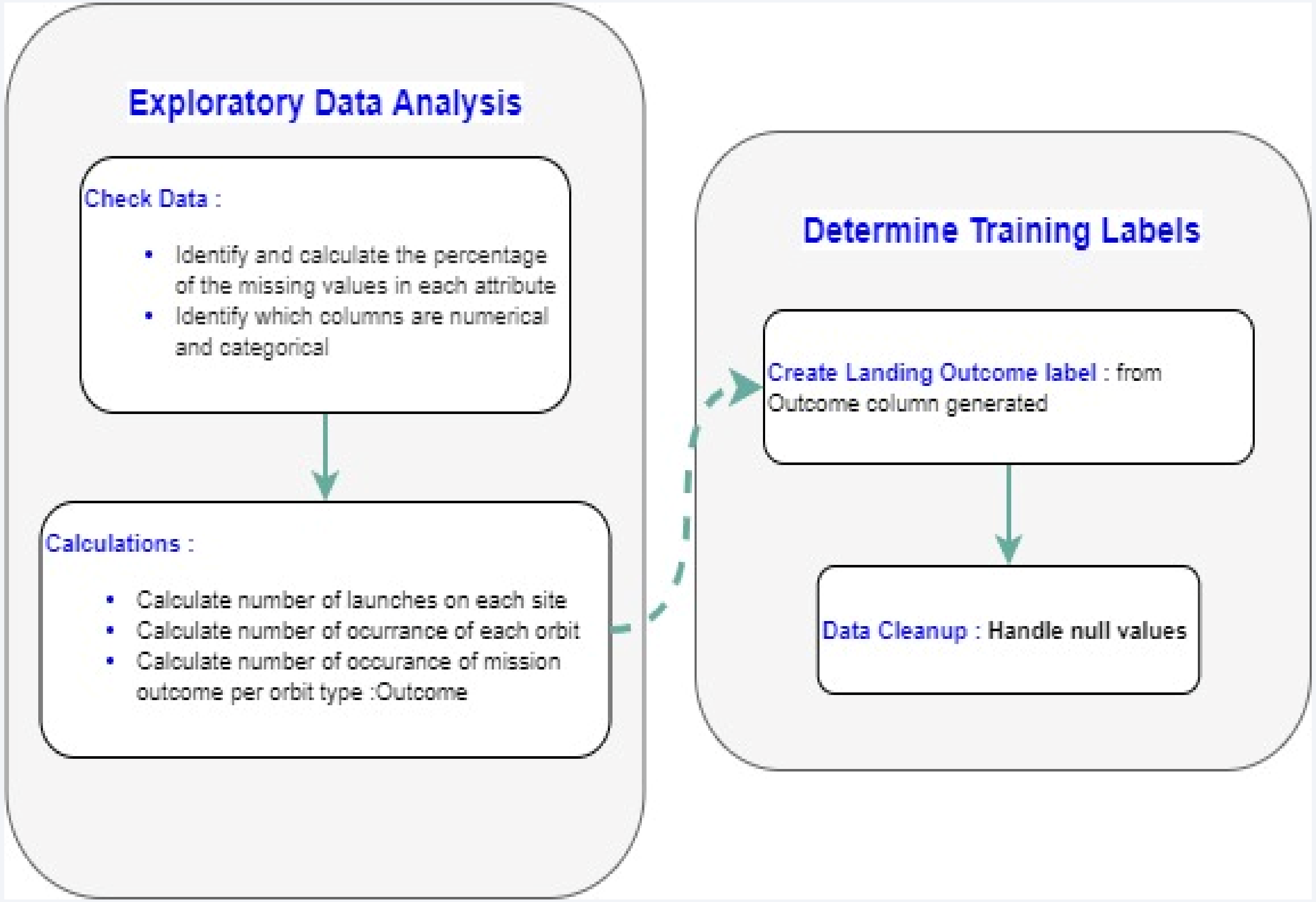
Data Collection Scraping

- Web Scraping from Wikipedia

- GitHub URL for the complete code of SpaceX Web Scraping https://github.com/sujasing/ds-ml-capstone-spacex/blob/main/02-DataCollectionWebScraping.ipynb

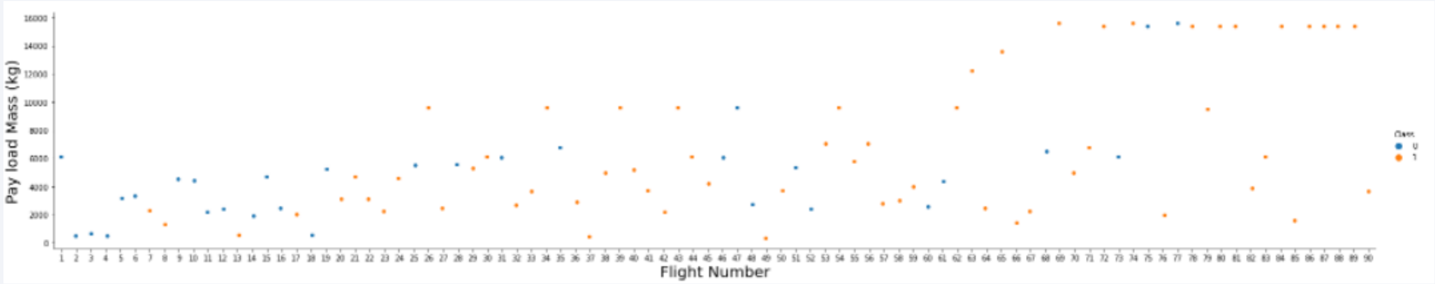


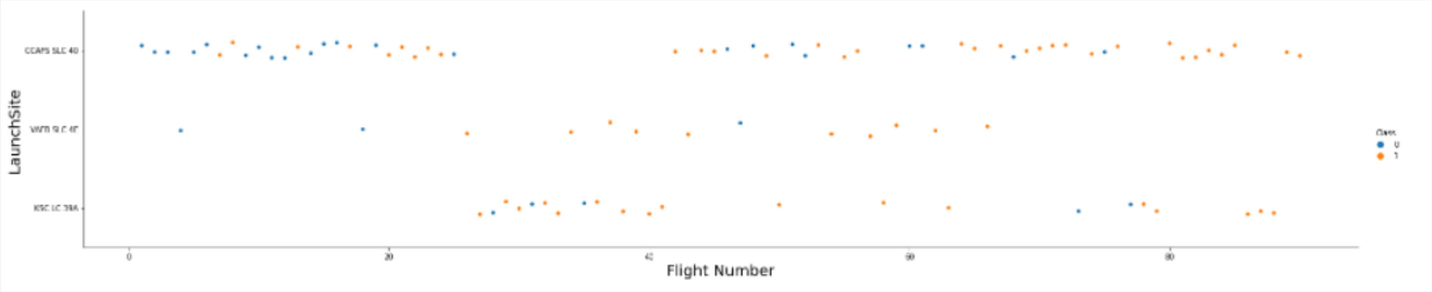
Data Wrangling

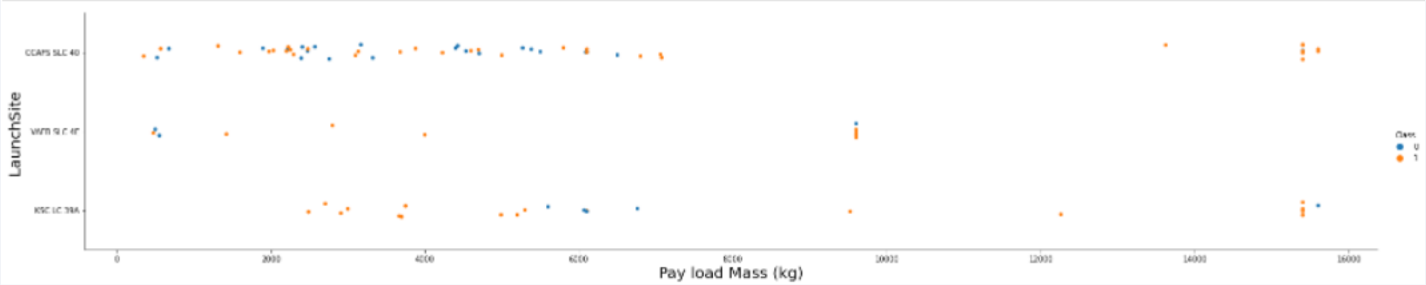


- Data Wrangling steps
- GitHub URL for the complete code of SpaceX Data Wrangling https://github.com/sujasing/ds-ml-capstone-spacex/blob/main/03-DataCollectionDataWrangling.ipynb

EDA with Data Visualization



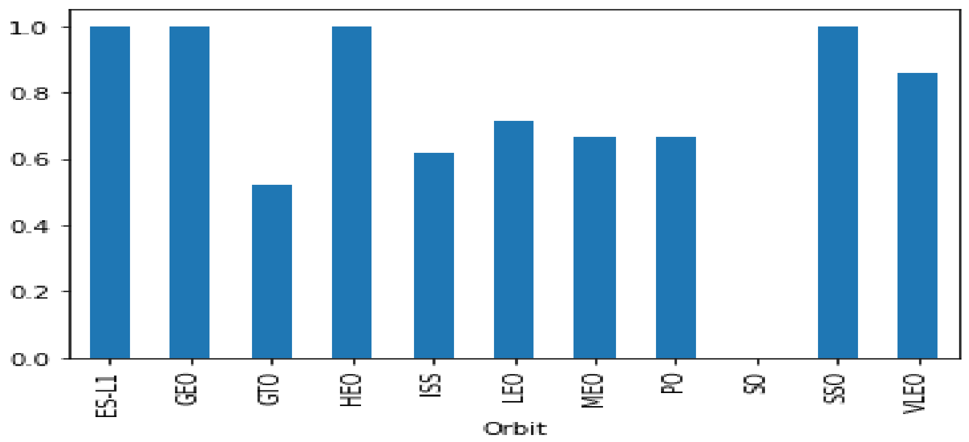


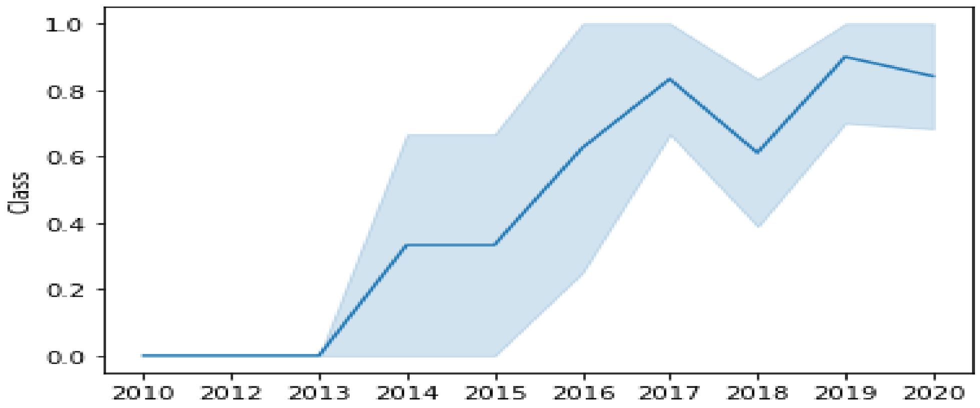


Scatter graph to find the relationship between the attributes such as between:

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

EDA with Data Visualization





Bar graph to determine which orbits have the highest probability of success

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.

Next, obtain some preliminary insights about impact on success rate by each important variable. This will help to select the features that will be used in success prediction.

GitHub URL for the complete code of Data Visualization supported EDA https://github.com/sujasing/ds-ml-capstone-spacex/blob/main/05-EDADataVisualization.ipynb

EDA with SQL

Using SQL to get better understanding of the dataset:

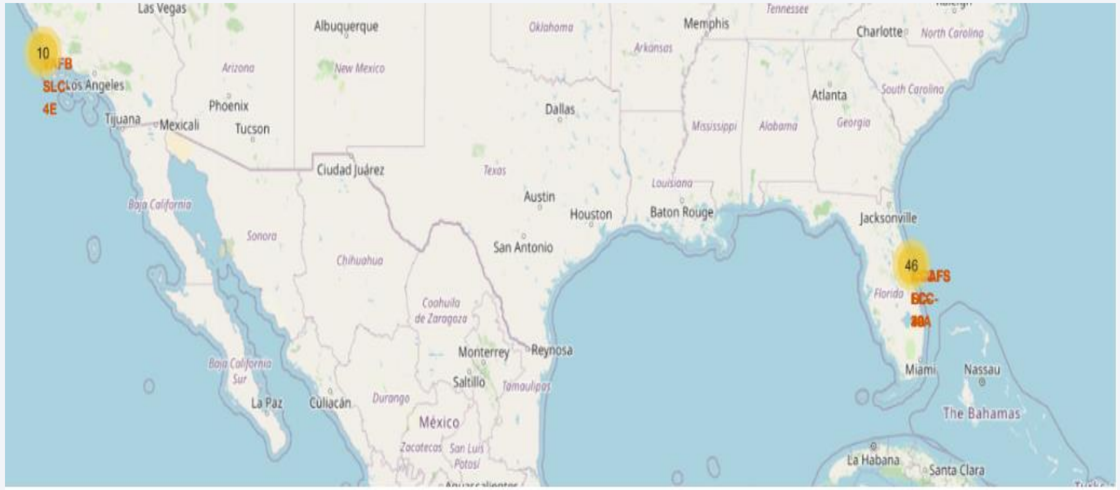
- Displaying the names of the launch sites.
- Displaying 5 records where launch sites begin with the string ‘KSC’.
- Displaying the total payload mass carried by booster launched by NASA (CRS).
- Displaying the average payload mass carried by booster version F9 v1.1.
- Listing the date when the first successful landing outcome in drone ship 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 leveraging subquery.
- List the records which will display the month names, succesful landing_outcomes in ground pad ,booster versions, launch_site for the months in year 2017.
- Rank the count of successful landing_outcomes between the date 2010-06-04 and 2017-03-20 in descending order.

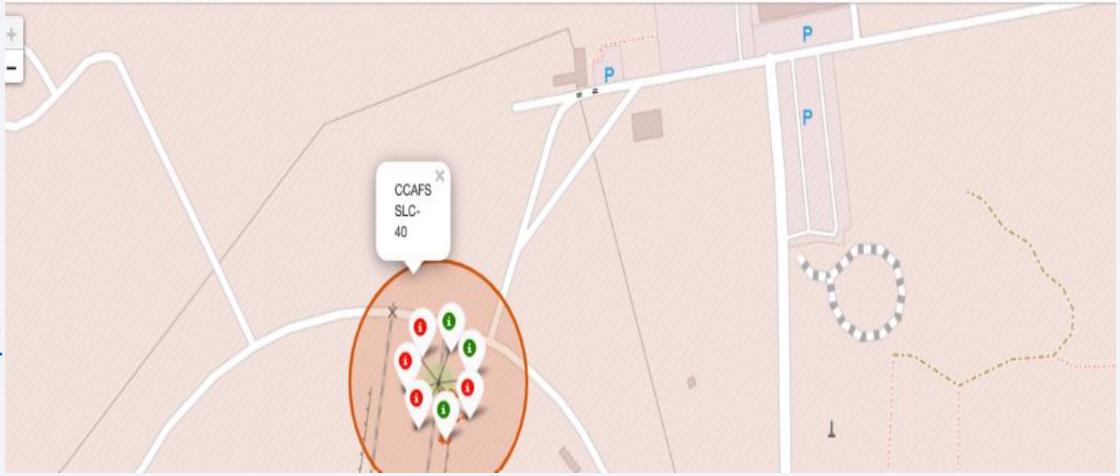
- GitHub URL for the complete code of SQL supported EDA

https://github.com/sujasing/ds-ml-capstone-spacex/blob/main/04-EDASQL.ipynb

Build an Interactive Map with Folium

- Circles and Markers were added for each launch site on the site map to highlight the launch sites
- The Launch Outcomes were added to the map with color coding to easily easily identify which launch sites have relatively high success rates
- Lines are drawn on maps to measure the distance to landmarks to find various trends as :
    - Are launch sites in close proximity to railways? No
    - Are launch sites in close proximity to highways? No
    - Are launch sites in close proximity to coastline? Yes
    - Do launch sites keep certain distance away from cities? Yes
- GitHub URL for the complete code for Interactive Map with Folium https://github.com/sujasing/ds-ml-capstone-spacex/blob/main/06-VisualAnalyticsFolium.ipynb



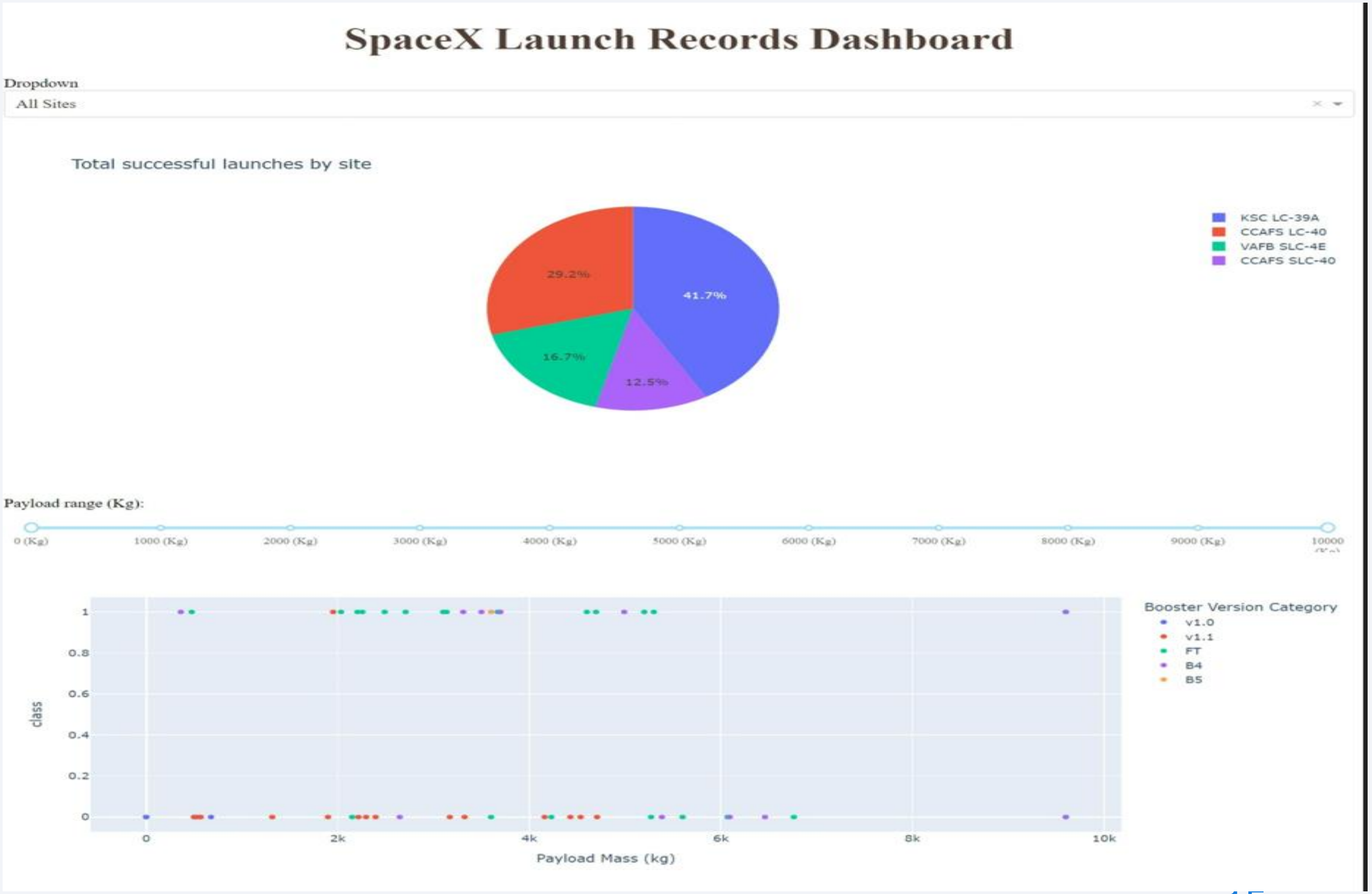


Build a Dashboard with Plotly Dash

- A pie chart to show the total successful launches count for all sites. If a specific launch site was selected, show the Success vs. Failed counts for the site.

- A callback function for `site-dropdown` and `payload-slider` as inputs, `success-payload-scatter-chart` as output

- GitHub URL for the complete code for Plotly Dasbboard https://github.com/sujasing/ds-ml-capstone-spacex/blob/main/07-InteractiveDashboardPlotly_app.py

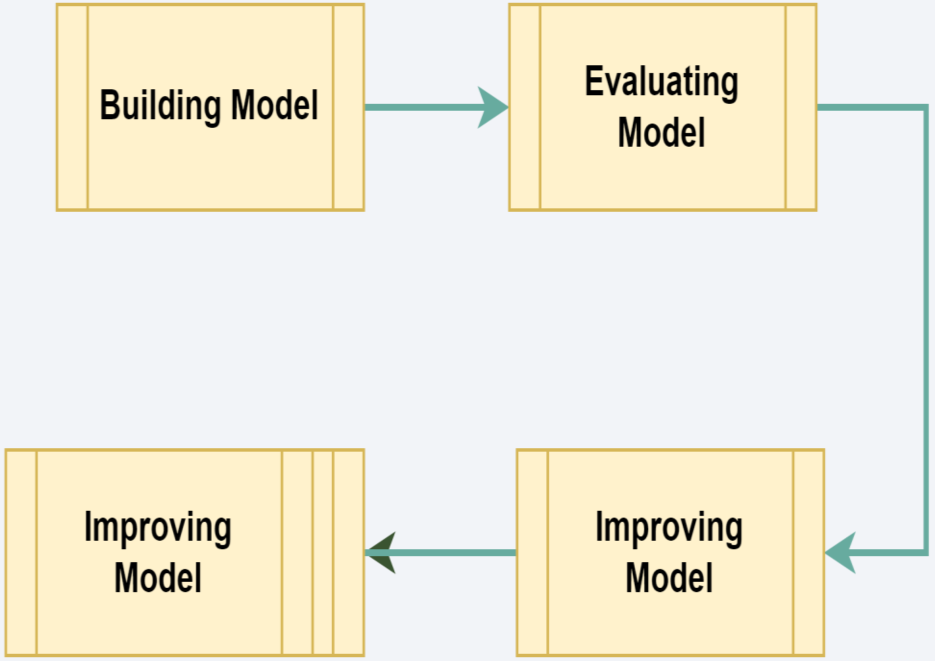


Predictive Analysis (Classification)

Using the best hyperparameter values, the model with the best accuracy using the training data is determined.

The following tests are done : Logistic Regression, Support Vector machines, Decision Tree Classifier, and K-nearest neighbors. Finally, the confusion matrix is produced.

- GitHub URL for the complete code for Classification https://github.com/sujasing/ds-ml-capstone-spacex/blob/main/08-MLPredictiveAnalysisClassification.ipynb



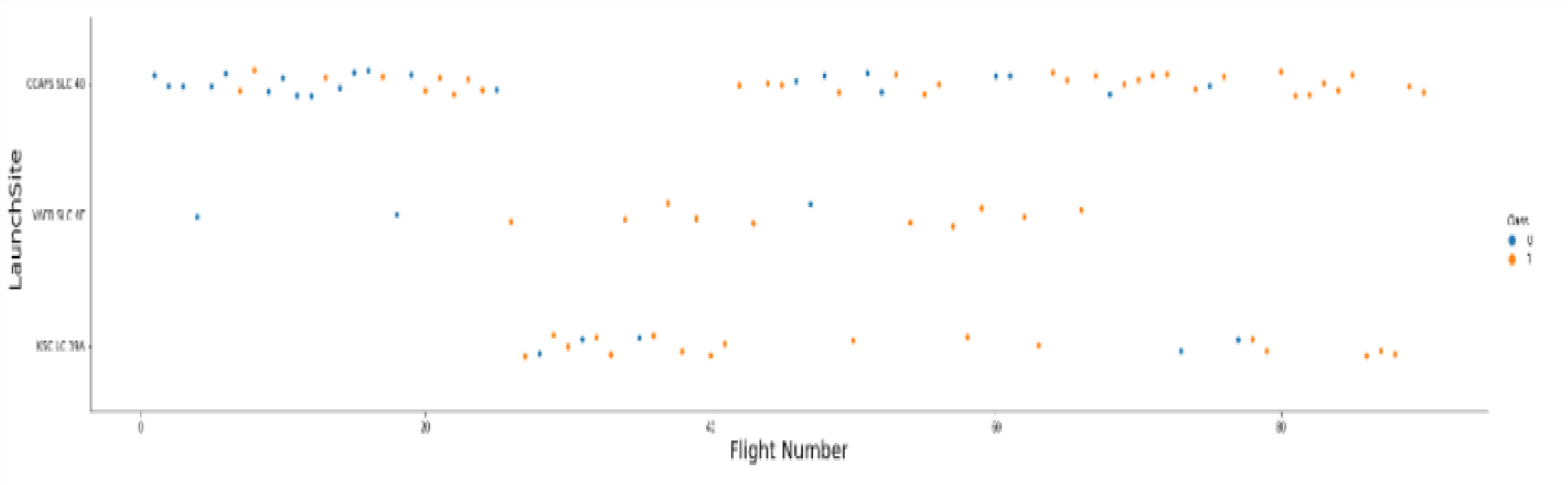
Results

- SVM, KNN and Logistic Regression models are the best for prediction accuracy for this dataset
- Low weighted payloads perform better than the heavier payloads
- KSC LC 39A has the most successes from all sites
- Orbit GEO, HEO, SSO , ES L1 has the best success rates

Section 2

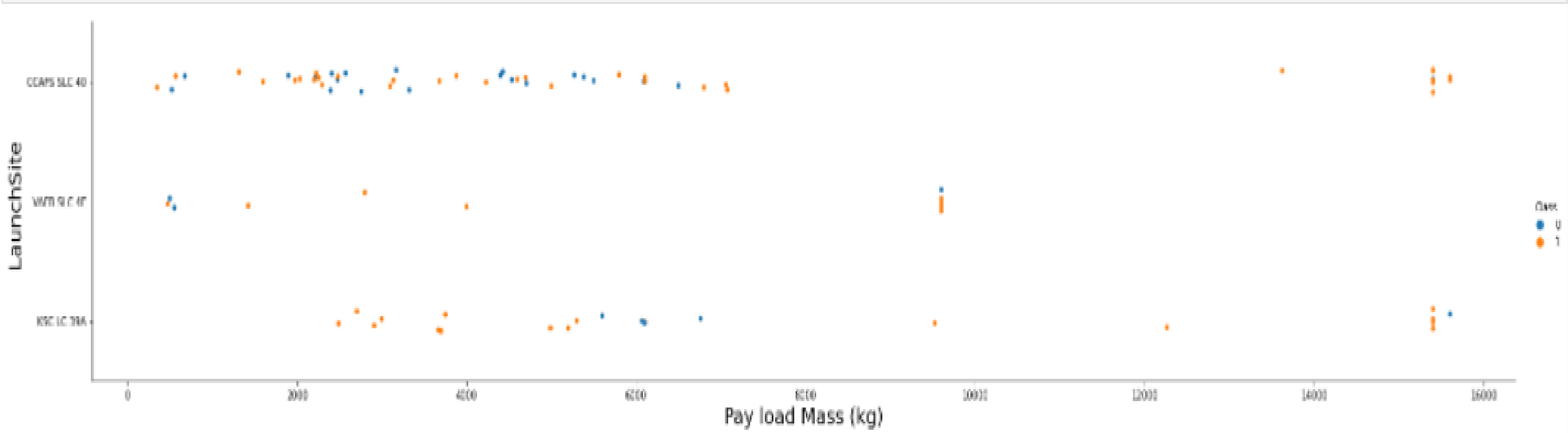
Insights drawn from EDA

Flight Number vs. Launch Site



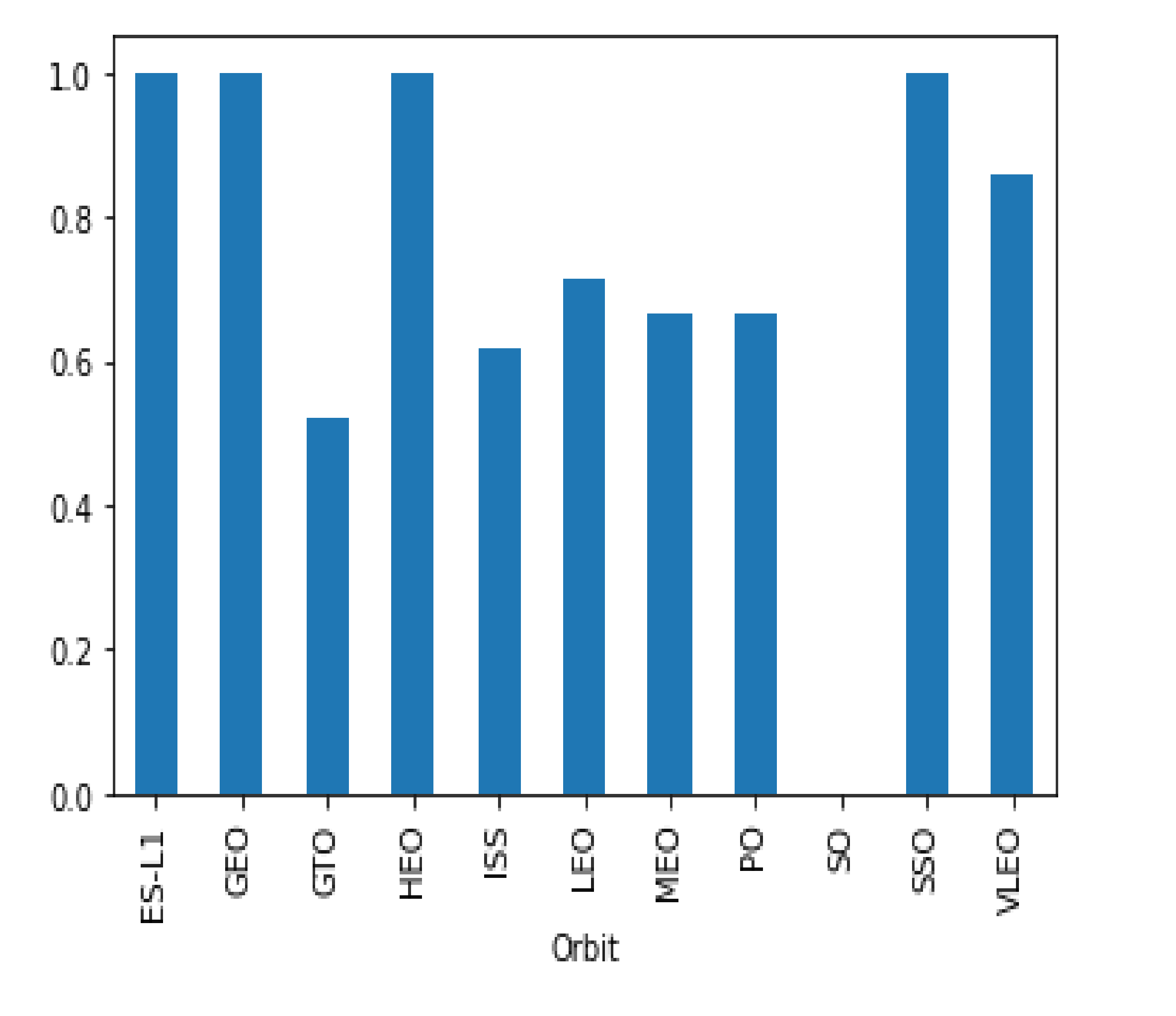
- Launches from the site CCAFS SLC 40 are slightly higher than other sites

Payload vs. Launch Site



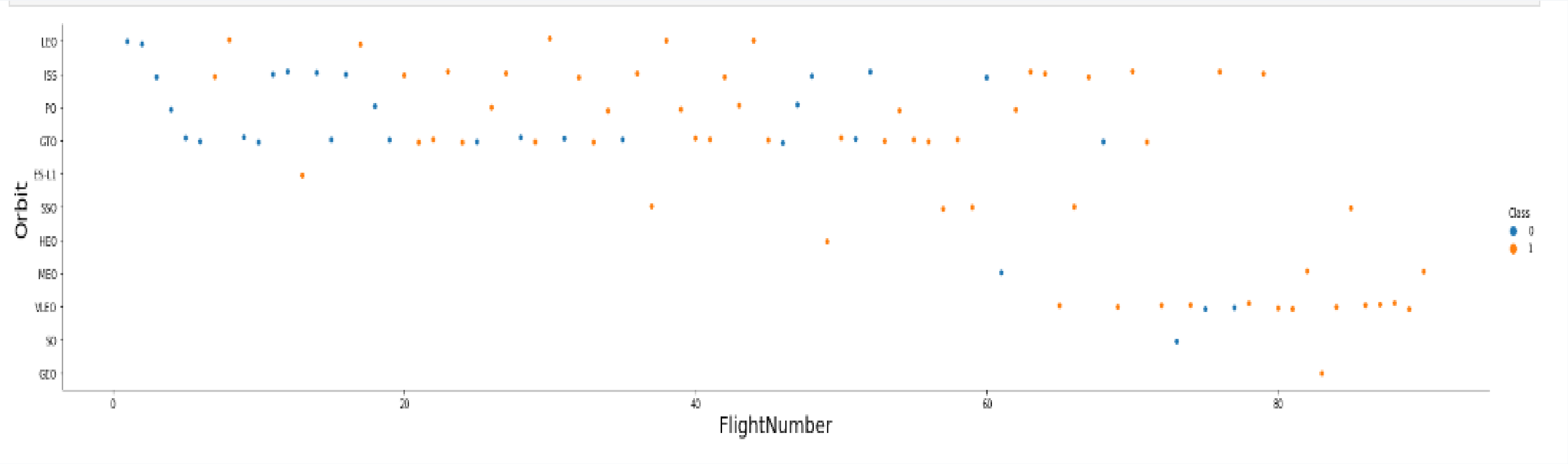
- Mostly lower mass Payloads have been lunched from CCAFS SLC 40

Success Rate vs. Orbit Type



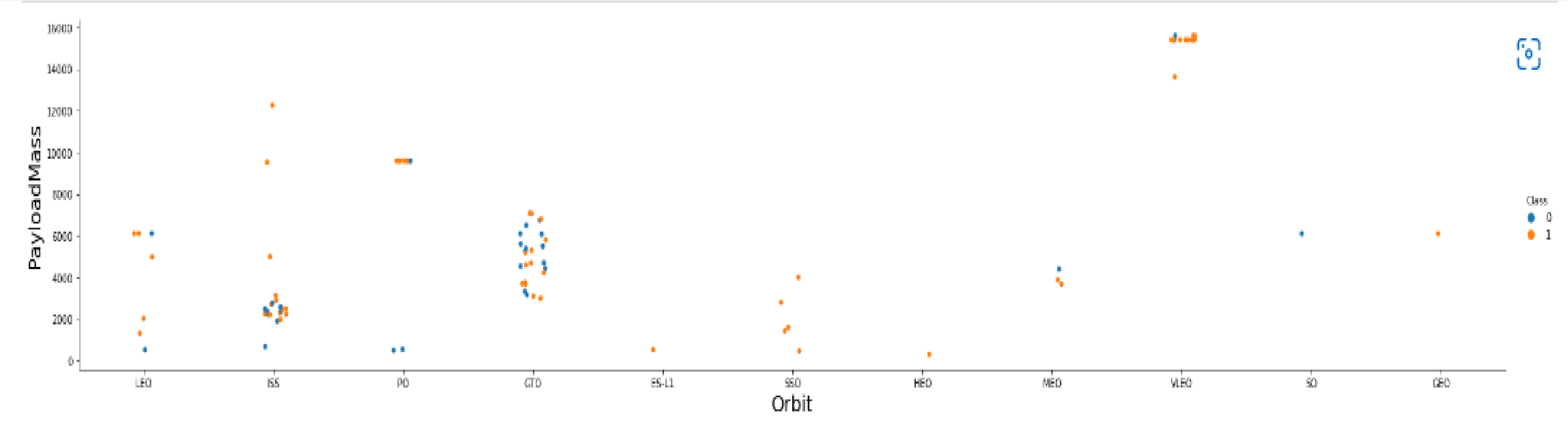
- Highest success rates are for orbit types of ES-L1, GEO, HEO, SSO

Flight Number vs. Orbit Type



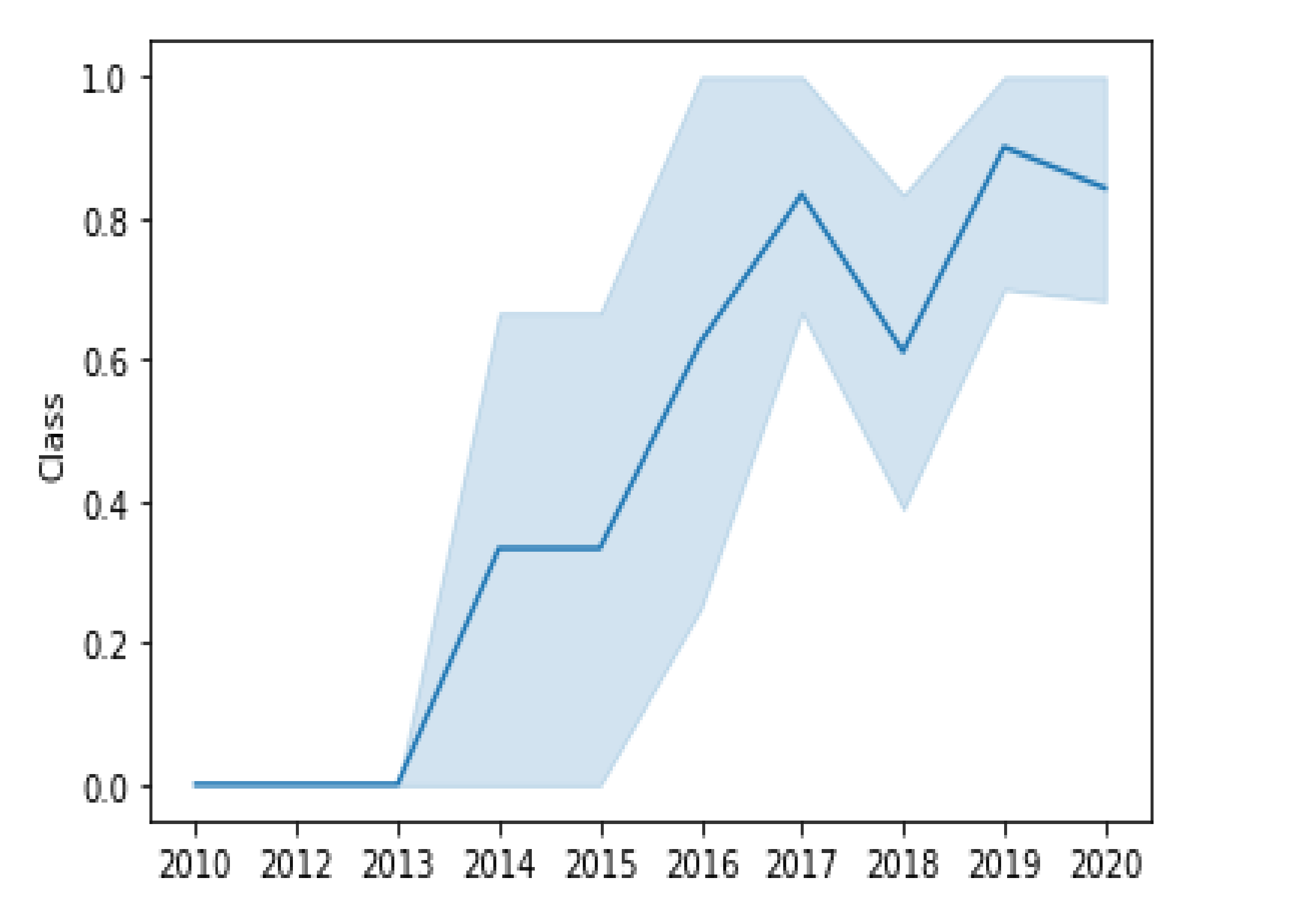
- In the LEO orbit the Success appears related to the number of flights; where as , there seems to be no relationship between flight number when in GTO orbit.

Payload vs. Orbit Type



- With heavy payloads the successful landing or positive landing rate are more for Polar, LEO and ISS.
- However, for GTO we cannot distinguish this well as both positive landing rate and negative landing(unsuccessful mission) are both there here.

Launch Success Yearly Trend



- The success rate since 2013 kept increasing till 2020

All Launch Site Names

```
%sql select distinct(launch_site) from spacex
```

```
 * ibm_db_sa://ygn69416:***@125f9f61-9715-46f9-9399-c8177b21803b.c1ogj3sd0tgtu0lqde00.databases.appdomain.cloud:30426/bludb
Done.
```

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

Launch Site Names Begin with 'KSC'

```
%sql select * from spacex where launch_site like 'KSC%' limit 5
```

```
 * ibm_db_sa://ygn69416:***@125f9f61-9715-46f9-9399-c8177b21803b.c1ogj3sd0tgtu0lqde00.databases.appdomain.cloud:30426/bludb
Done.
```

DATE	time_utc_	booster_version	launch site	payload	payload_mass_kg_	orbit	customer	mission_outcome	landing_outcome
2017-02-19	14:39:00	F9 FT B1031.1	KSC LC-39A	SpaceX CRS-10	2490	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
2017-03-16	06:00:00	F9 FT B1030	KSC LC-39A	EchoStar 23	5600	GTO	EchoStar	Success	No attempt
2017-03-30	22:27:00	F9 FT B1021.2	KSC LC-39A	SES-10	5300	GTO	SES	Success	Success (drone ship)
2017-05-01	11:15:00	F9 FT B1032.1	KSC LC-39A	NROL-76	5300	LEO	NRO	Success	Success (ground pad)
2017-05-15	23:21:00	F9 FT B1034	KSC LC-39A	Inmarsat-5 F4	6070	GTO	Inmarsat	Success	No attempt

Total Payload Mass

```
%sql select sum(PAYLOAD_MASS__KG_) from spacex where customer='NASA (CRS)'

 * ibm_db_sa://ygn69416:***@125f9f61-9715-46f9-9399-c8177b21803b.c1ogj3sd0tgtu0lqde00.databases.appdomain.cloud:30426/bludb
Done.

    1
45596
```

Average Payload Mass by F9 v1.1

```
%sql select avg(PAYLOAD_MASS__KG_) from spacex where Booster_Version='F9 v1.1'
```

```
 * ibm_db_sa://ygn69416:***@125f9f61-9715-46f9-9399-c8177b21803b.c1ogj3sd0tgtu0lqde00.databases.appdomain.cloud:30426/bludb
Done.
```

1
2928

First Successful Drone Ship Landing Date

```
%sql select min(date) from spacex where Landing__Outcome='Success (drone ship)'
```

```
 * ibm_db_sa://ygn69416:***@125f9f61-9715-46f9-9399-c8177b21803b.c1ogj3sd0tgtu0lqde00.databases.appdomain.cloud:30426/bludb
Done.
```

1
2016-04-08

Successful Ground Pad Boosters with Payload between 4000 and 6000

```
%sql select Booster_Version from spacex where Landing__Outcome='Success (ground pad)' and PAYLOAD_MASS__KG_>4000 and PAYLOAD_MASS__KG_<6000
```

```
 * ibm_db_sa://ygn69416:***@125f9f61-9715-46f9-9399-c8177b21803b.c1ogj3sd0tgtu0lqde00.databases.appdomain.cloud:30426/bludb
Done.
```

booster_version
F9 FT B1032.1
F9 B4 B1040.1
F9 B4 B1043.1

Total Number of Successful and Failure Mission Outcomes

```
%sql select Mission_Outcome, count(1) from spacex group by Mission_Outcome
```

```
 * ibm_db_sa://ygn69416:***@125f9f61-9715-46f9-9399-c8177b21803b.c1ogj3sd0tgtu0lqde00.databases.appdomain.cloud:30426/bludb
Done.
```

mission_outcome	2
Failure (in flight)	1
Success	99
Success (payload status unclear)	1

Boosters Carried Maximum Payload

```
%sql select booster_version from spacex where PAYLOAD_MASS__KG_ = ( select max(PAYLOAD_MASS__KG_) from spacex )
```

```
 * ibm_db_sa://ygn69416:***@125f9f61-9715-46f9-9399-c8177b21803b.c1ogj3sd0tgtu0lqde00.databases.appdomain.cloud:30426/bludb
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

%sql select monthname(date),landing__outcome,booster_version,Launch_site from spacex where year(date)='2017' and landing__outcome ='Success (ground pad)'

```
* ibm_db_sa://ygn69416:***@125f9f61-9715-46f9-9399-c8177b21803b.c1ogj3sd0tgtu0lqde00.databases.appdomain.cloud:30426/bludb
Done.
```

1	landing__outcome	booster_version	launch_site
February	Success (ground pad)	F9 FT B1031.1	KSC LC-39A
May	Success (ground pad)	F9 FT B1032.1	KSC LC-39A
June	Success (ground pad)	F9 FT B1035.1	KSC LC-39A
August	Success (ground pad)	F9 B4 B1039.1	KSC LC-39A
September	Success (ground pad)	F9 B4 B1040.1	KSC LC-39A
December	Success (ground pad)	F9 FT B1035.2	CCAFS SLC-40

Rank Landing Outcomes Between 20100604 and 20170320

```
%sql select landing__outcome, count(1) cnt from spacex where landing__outcome like 'Success%' and date between '2010-06-04'and'2017-03-20' group by landing__outcome
```

```
 * ibm_db_sa://ygn69416:***@125f9f61-9715-46f9-9399-c8177b21803b.c1ogj3sd0tgtu0lqde00.databases.appdomain.cloud:30426/bludb
Done.
```

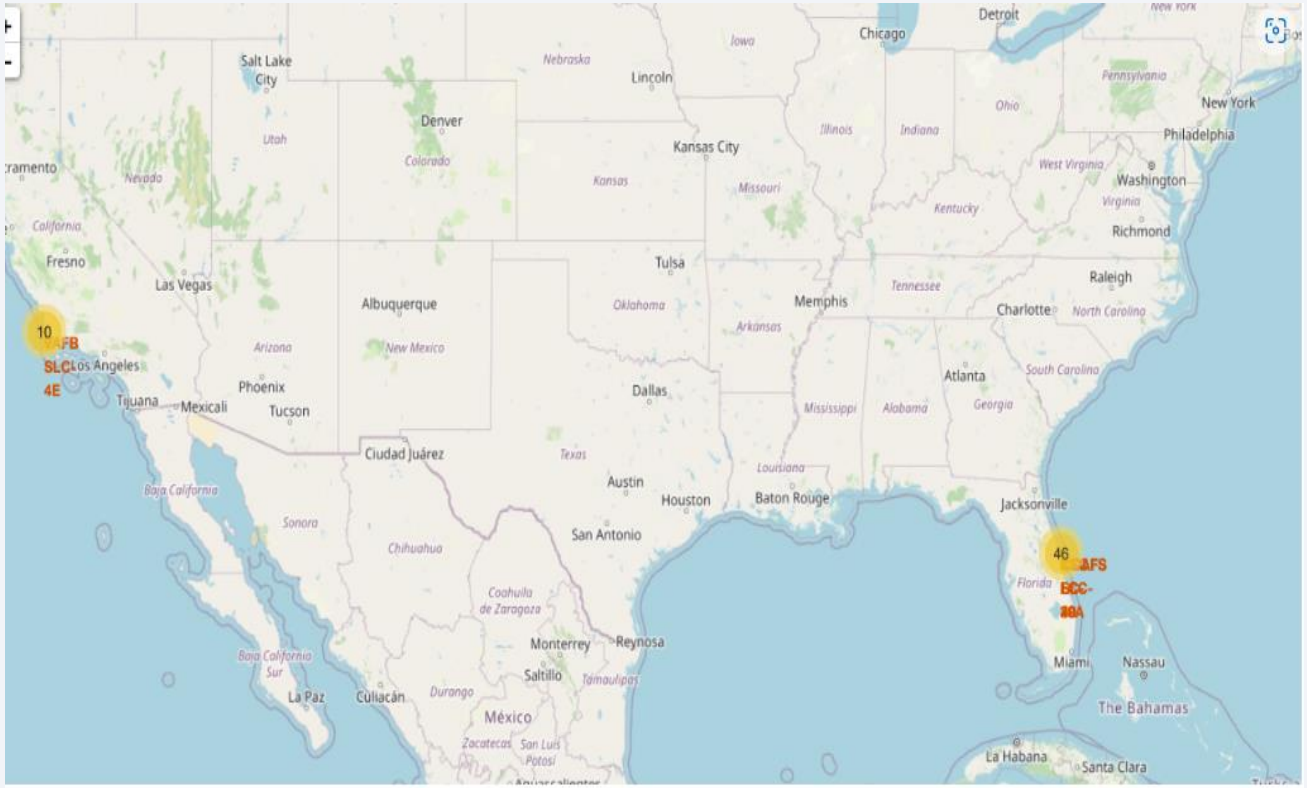
landing_outcome	cnt
Success (drone ship)	5
Success (ground pad)	3

Section 3

Launch Sites Proximities Analysis

Launch Sited Marked On A Map

Success/Failed Launches for Each Site on the Map



From the color-labeled markers in marker clusters, one can easily identify which launch sites have relatively high success rates.

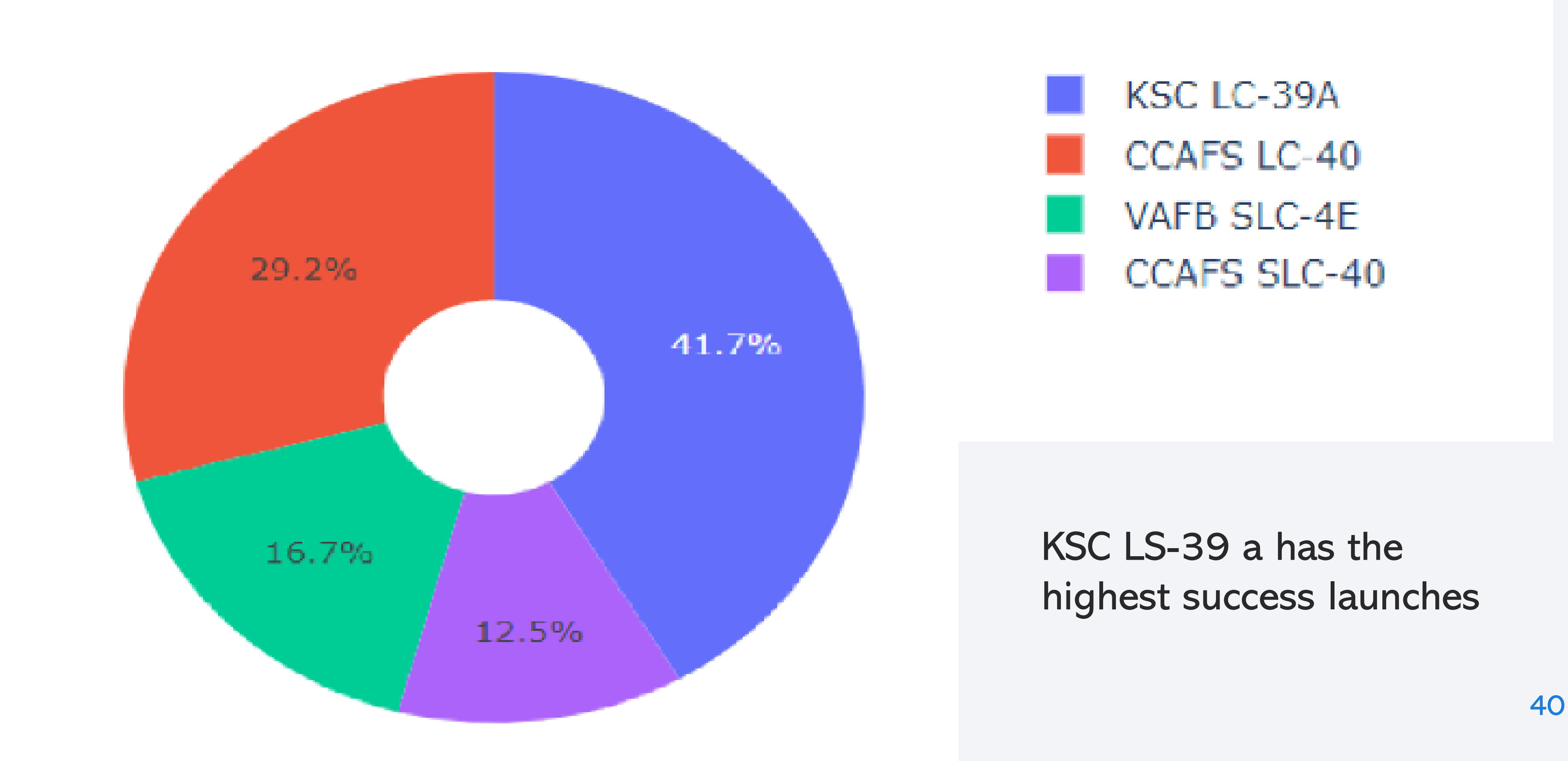
Distances Between a Launch Site to its Proximities

Map with distance line

Section 4

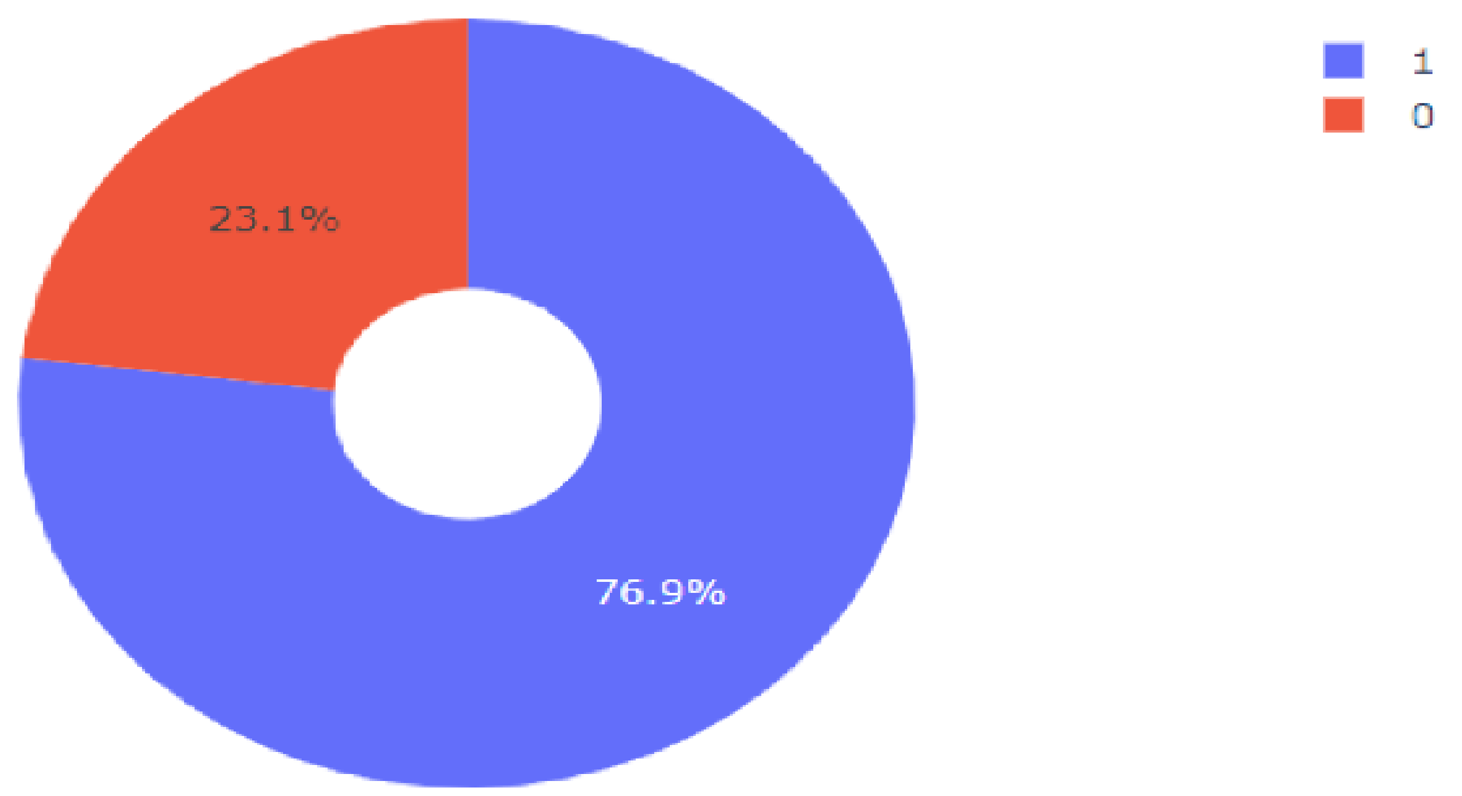
Build a Dashboard with Plotly Dash

Total Success Launches Site Wise



KSC LS-39 a has the highest success launches

Launch Site with highest Success Ratio



KSC LC-39A achieved a 76.9% success rate while getting a 23.1% failure rate

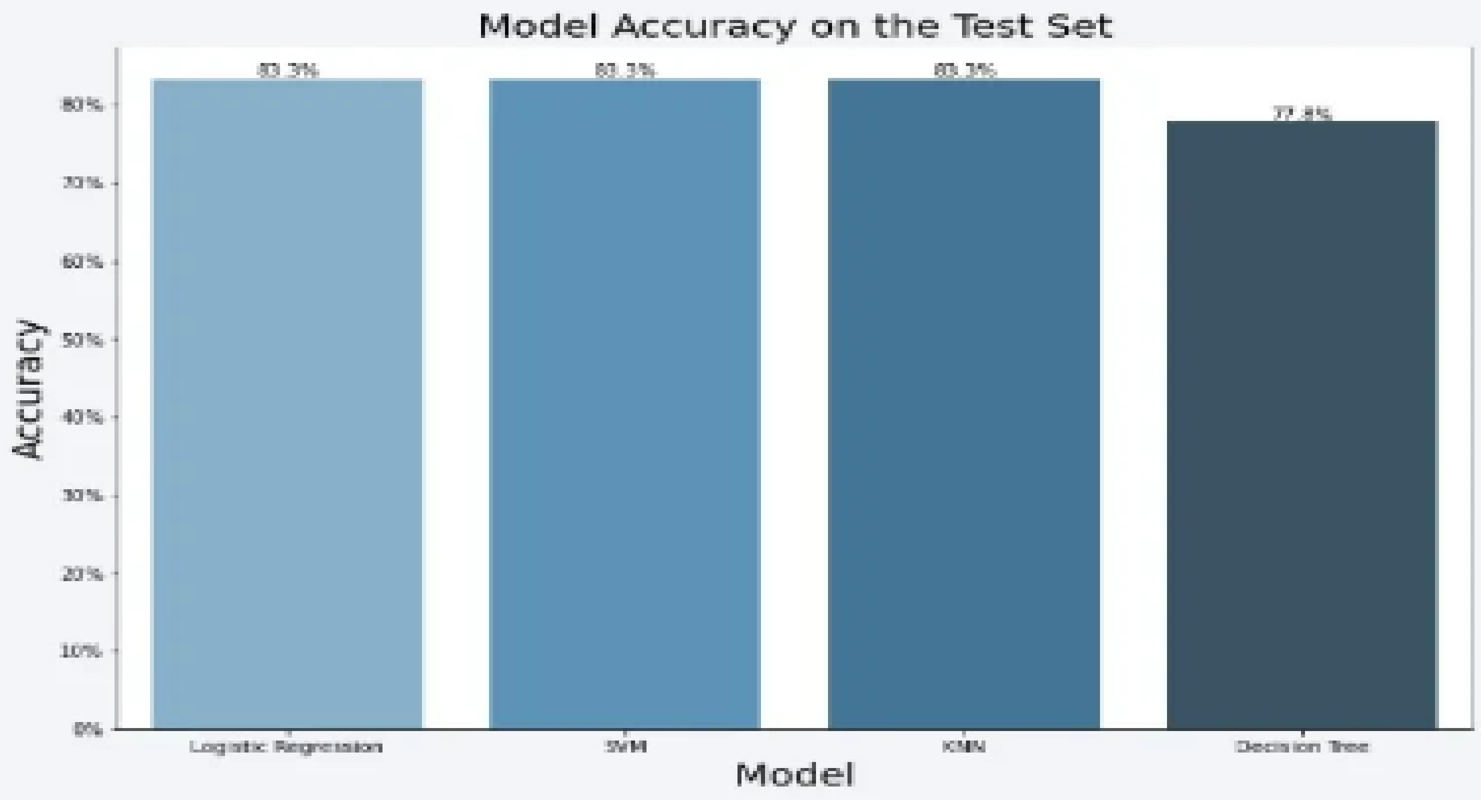
<Dashboard Screenshot 3>

Low weighted payloads have higher success rates

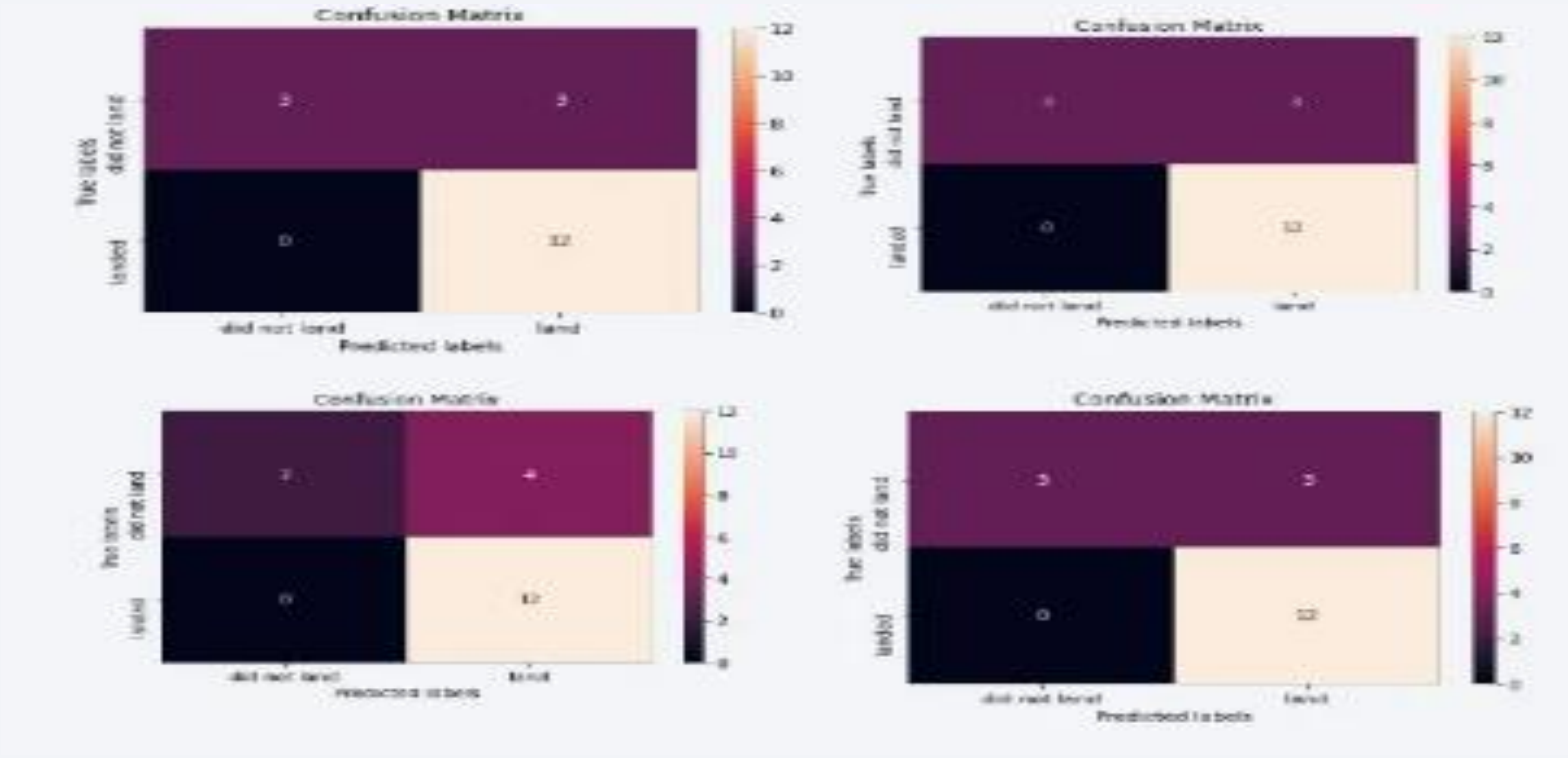
Section 5

Predictive Analysis (Classification)

Classification Accuracy



Confusion Matrix



Conclusions

- Decision Tree Algorithm is the best for this dataset for prediction
- Low weighted payloads have higher success rates than the heavy payloads
- With increasing years, success rates has increased. With more years, they will perfect the launches
- KSC LC – 39A has the best success launches
- Orbits with best success rates are – GEO, HEO, SSO, ES-L1

Appendix

- Sample dataset_part_3.csv created for predictions : https://github.com/sujasing/ds-ml-capstone-spacex/blob/main/dataset_part_3.csv

FlightNum	PayloadM	Flights	GridFins	Reused	Legs	Block	ReusedCo	Orbit_ES-l	Orbit_GEC	Orbit_GTC	Orbit_HEC	Orbit_ISS	Orbit_LEO	Orbit_ME(	Orbit_PO	Orbit_SO	Orbit_SSO	Orbit_VLE(
1	6104.959	1	FALSE	FALSE	FALSE	1	0	0	0	0	0	0	1	0	0	0	0	0
2	525	1	FALSE	FALSE	FALSE	1	0	0	0	0	0	0	1	0	0	0	0	0
3	677	1	FALSE	FALSE	FALSE	1	0	0	0	0	0	1	0	0	0	0	0	0
4	500	1	FALSE	FALSE	FALSE	1	0	0	0	0	0	0	0	0	1	0	0	0
5	3170	1	FALSE	FALSE	FALSE	1	0	0	0	1	0	0	0	0	0	0	0	0
6	3325	1	FALSE	FALSE	FALSE	1	0	0	0	1	0	0	0	0	0	0	0	0
7	2296	1	FALSE	FALSE	TRUE	1	0	0	0	0	0	1	0	0	0	0	0	0
8	1316	1	FALSE	FALSE	TRUE	1	0	0	0	0	0	0	1	0	0	0	0	0
9	4535	1	FALSE	FALSE	FALSE	1	0	0	0	1	0	0	0	0	0	0	0	0
10	4428	1	FALSE	FALSE	FALSE	1	0	0	0	1	0	0	0	0	0	0	0	0
11	2216	1	FALSE	FALSE	FALSE	1	0	0	0	0	0	1	0	0	0	0	0	0
12	2395	1	TRUE	FALSE	TRUE	1	0	0	0	0	0	1	0	0	0	0	0	0
13	570	1	TRUE	FALSE	TRUE	1	0	1	0	0	0	0	0	0	0	0	0	0
14	1898	1	TRUE	FALSE	TRUE	1	0	0	0	0	0	1	0	0	0	0	0	0

- Project Code Repository : https://github.com/sujasing/ds-ml-capstone-spacex

Thank you!