IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

Lam Chi Kin
<Date>

Outline

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

Executive Summary

- Summary of methodologies
- Summary of all results

Introduction

- Space X
  - Advertise Falcon 9 rocket
    - Launch with cost of $62m
    - Compare with other providers: up to $165m
    - Mush of saving because of the reusage of first stage
- Determine
  - Successful rate of Falcon 9 first stage will land successfully
    - Find the cost of a launch

Section 1

Methodology

Methodology

Executive Summary

- Data collection methodology:
  - Download Falcon 9 and Falcon Heavy Launch data through
    - Space X API
    - Wikipedia
- Perform data wrangling
  - Using BeautifulSoup extract data from HTML
  - Using Pandas
  - Data preprocessing
  - Apply one-hot encoding method to 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
  - Apply Scikit-Learn
  - Classification:
    - K-Nearest Neighbors, Decision Tree, Support Vector Machine
    - Use GridSearchCV to find the best parameters
    - Evaluate by train dataset
      - Ratio of train-test size: 8:2

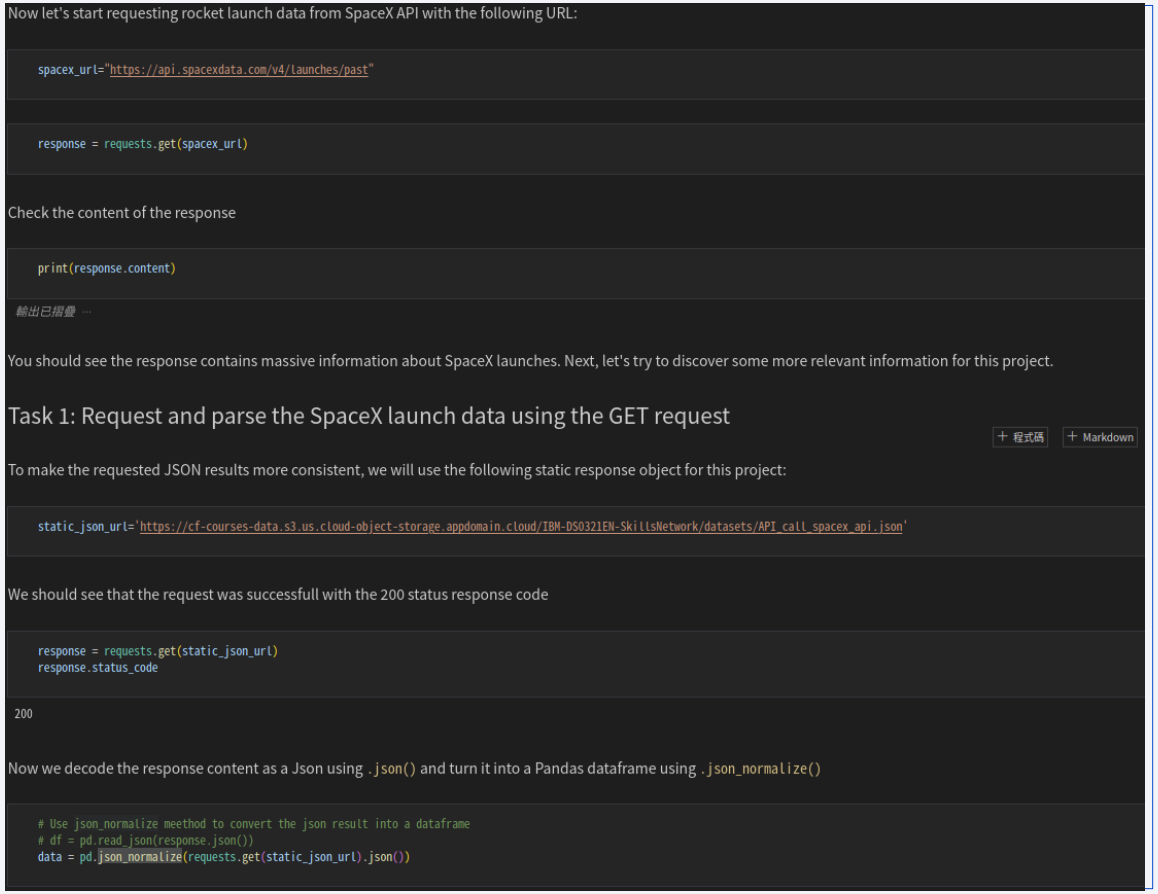
Data Collection

- Request data
  - From Space X API
    - requests.get()
    - -> json file
  - From Wikipedia
    - BeautifulSoup
- Use of Pandas
  - Convert json file from Space X API to dataframe
    - .json_normalize()
  - Convert HTML file from Wiki to dataframe
  - Data preprocessing
    - Extract necessary columns
    - Check and fill missing values

Data Collection – SpaceX API

- Space X API
  - requests.get
    - Get json data from api
  - Pandas
    - .json_normalize()
      - Convert json to Pandas dataframe

- Link:
  - https://github.com/CKLam33/IBM-Data-Science-Professional-Certificate/blob/main/Applied%20Data%20Science%20Capstone/jupyter-labs-spacex-data-collection-api.ipynb



Data Collection - Scraping

- Falcon 9 launch data
  - From Wikipedia
    - BeautifulSoup
    - Parse table & convert to Dataframe
      - With use of Pandas

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

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


# Use the find_all function in the BeautifulSoup object, with element type `table`
# Assign the result to a list called `html_tables`
html_tables = soup.find_all('table')
```

```
# Let's print the third table and check its content
first_launch_table = html_tables[2]
print(first_launch_table)
```

- Link
  - https://github.com/CKLam33/IBM-Data-Science-Professional-Certificate/blob/main/Applied%20Data%20Science%20Capstone/jupyter-labs-webscraping.ipynb

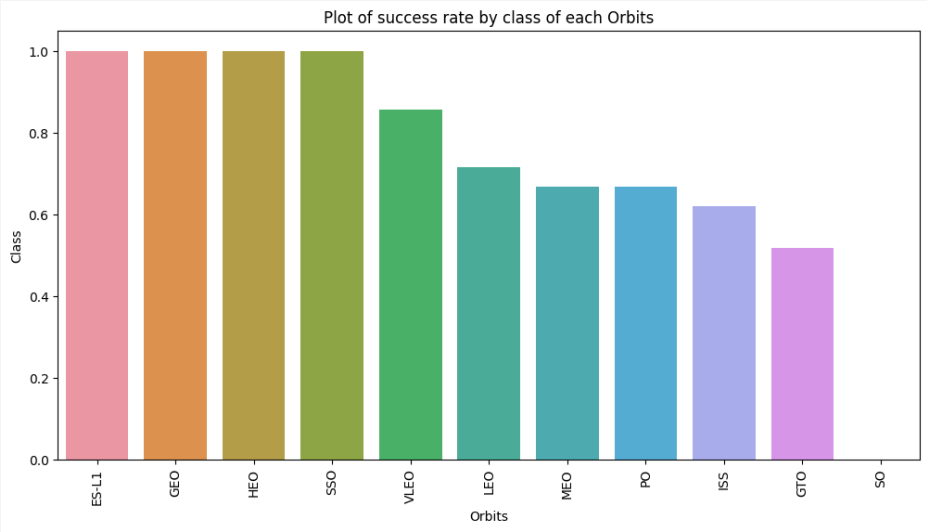
Data Wrangling

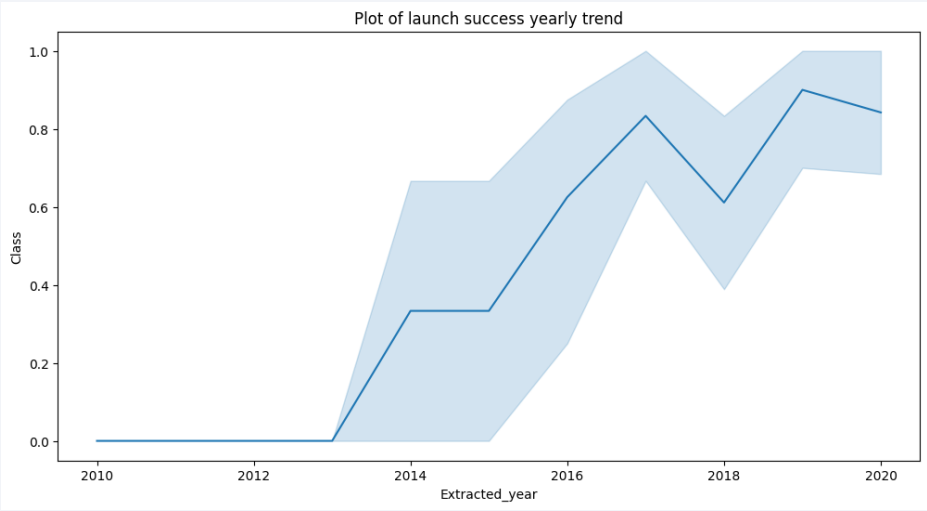
- Exploratory Data Analysis & Determine Training Labels
  - Calculate
    - number of launches on each site
    - number and occurrence of each orbit
    - number and occurence of mission outcome per orbit type
  - Create landing outcome label
    - From ‘Outcome’

- Link:
  - https://github.com/CKLam33/IBM-Data-Science-Professional-Certificate/blob/main/Applied%20Data%20Science%20Capstone/labs-jupyter-spacex-Data%20wrangling.ipynb

EDA with Data Visualization

- Use Matplotlib & Seaborn
  - Visualize
    - Launch sites vs Payload
    - Success rate by class of each Orbits
    - Launch success yearly trend
- Link:
  - https://github.com/CKLam33/IBM-Data-Science-Professional-Certificate/blob/main/Applied%20Data%20Science%20Capstone/jupyter-labs-eda-dataviz.ipynb





EDA with SQL

- Load csv file to database
  - SQLite
- Queries
  - Name of Launch site
  - Calculate average payload mass
  - Find 1st successful landing date
  - Find number of successful and failure landing outcomes
- Link:
  - https://github.com/CKLam33/IBM-Data-Science-Professional-Certificate/blob/main/Applied%20Data%20Science%20Capstone/jupyter-labs-eda-sql-coursera_sqllite.ipynb

Build an Interactive Map with Folium

- Folium with Map function
  - Circle
    - Mark launch site
  - Marker
    - Recognize success/failed launch for each site
    - Green: success
    - Red: fail
  - Calculate and draw distance
    - Launch site vs its proximities
- Link:
  - https://github.com/CKLam33/IBM-Data-Science-Professional-Certificate/blob/main/Applied%20Data%20Science%20Capstone/lab_jupyter_launch_site_location.ipynb

Build a Dashboard with Plotly Dash

- Pie chart
  - All launch site: successful rate compare to each site
  - Each site: display success and fail rate
- Scatter chart
  - Display payload mass of each booster
  - Range slider
    - For listener/user to limit the range of payload mass
    - Find out the success/fail rate of each booster in specific range
- Link:
  - https://github.com/CKLam33/IBM-Data-Science-Professional-Certificate/blob/main/Applied%20Data%20Science%20Capstone/spacex_dash_app.py

Predictive Analysis (Classification)

- Select ‘Class’ from train data as result label
  - Covert to array with numpy
- Scikit-Learn
  - Standardize: preprocessing.StandardScaler()
  - split train/test data: train_test_split()
- Search best parameter among classification methods
  - Logistic regression, Support Vector Machine, Decision Tree, kNN
  - With use of GridSearchCV
- Compare different classification methods
  - Find the best method
    - By compare accuracy score
- Link:
  - https://github.com/CKLam33/IBM-Data-Science-Professional-Certificate/blob/main/Applied%20Data%20Science%20Capstone/SpaceX_Machine%20Learning%20Prediction_Part_5.ipynb

Results

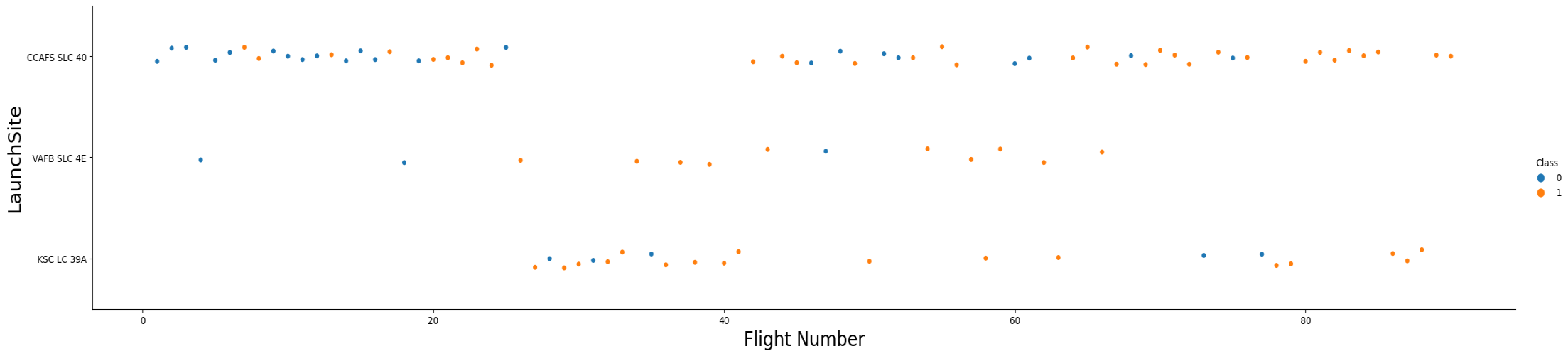
- Exploratory data analysis results
- Interactive analytics demo in screenshots
- Predictive analysis results

Section 2

Insights drawn from EDA

Flight Number vs. Launch Site

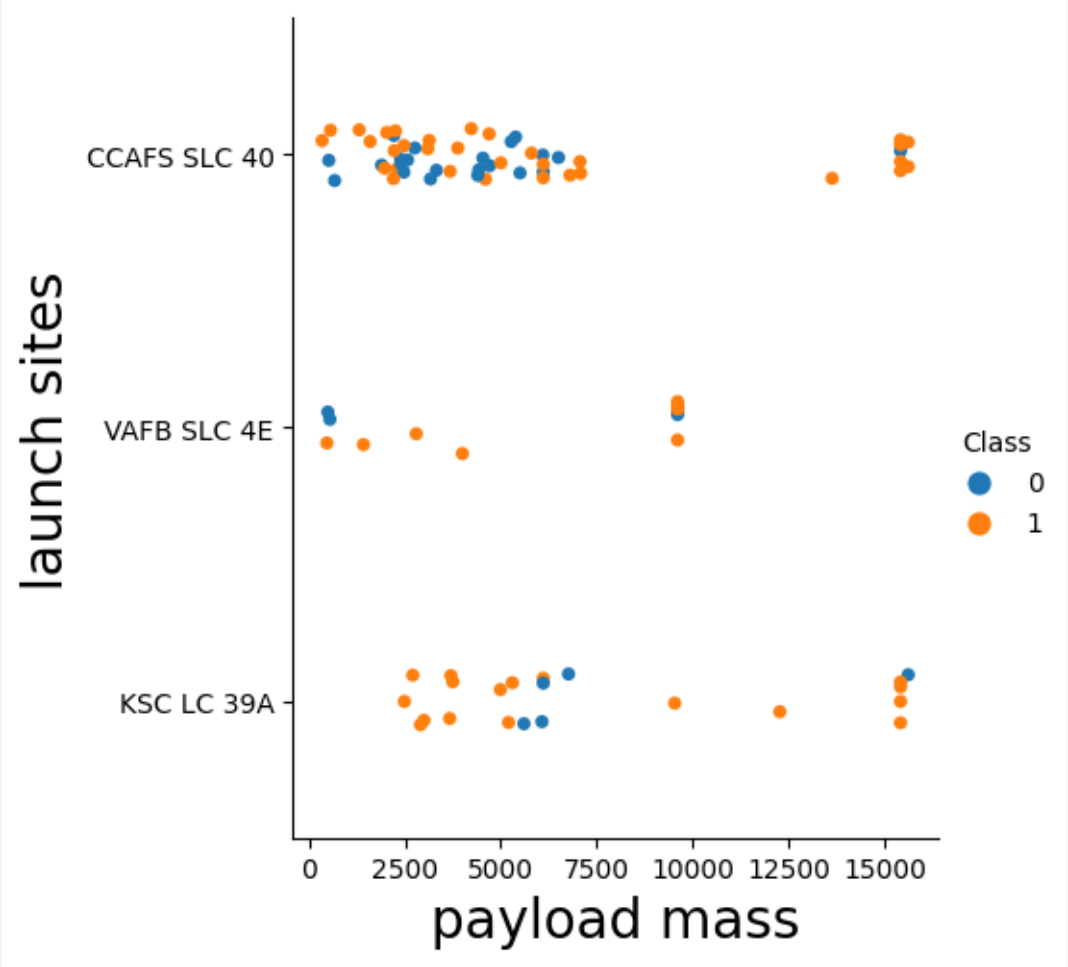
Scatter plot of Flight Number vs. Launch Site



- Most rockets are launched at CCAFS SLC 40
- Number of success outcome increase along the number of flight

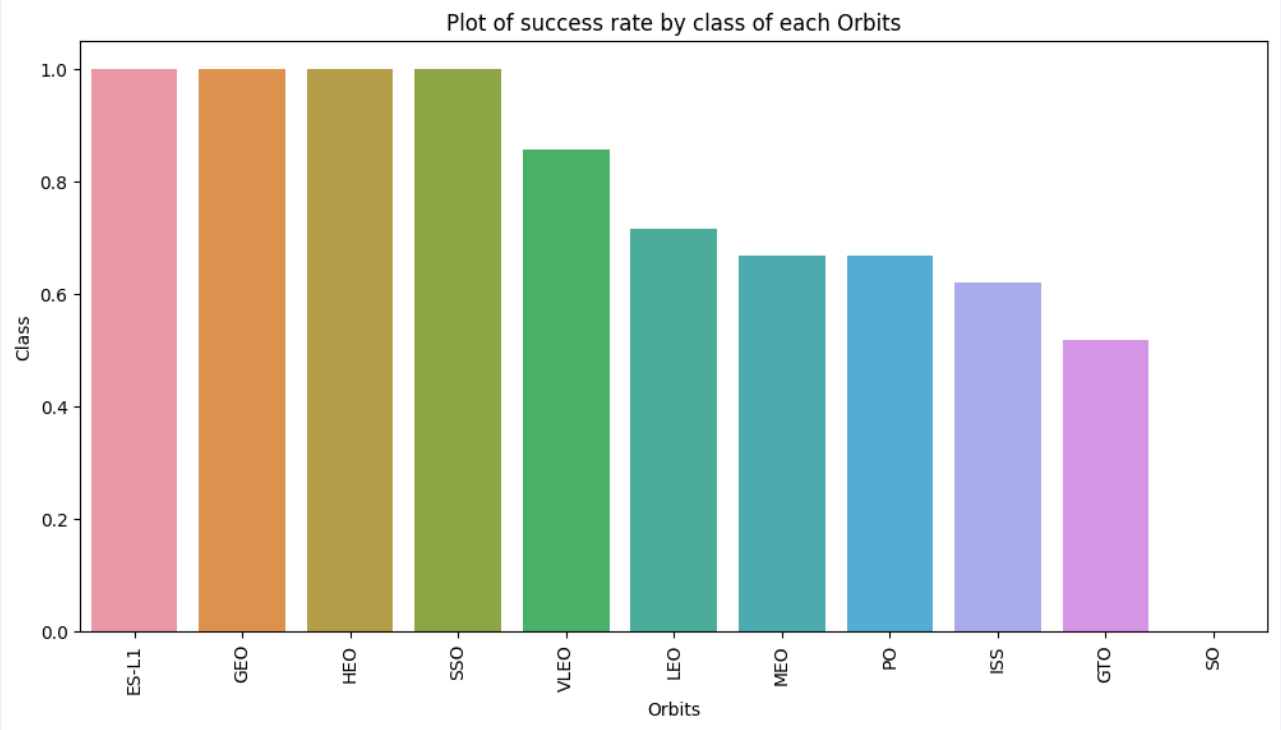
Payload vs. Launch Site

- Most Payload Mass of flights < 7500
- Few flights with Payload Mass between 7500 and 15000
- Only few flights use VAFB SLC 4E



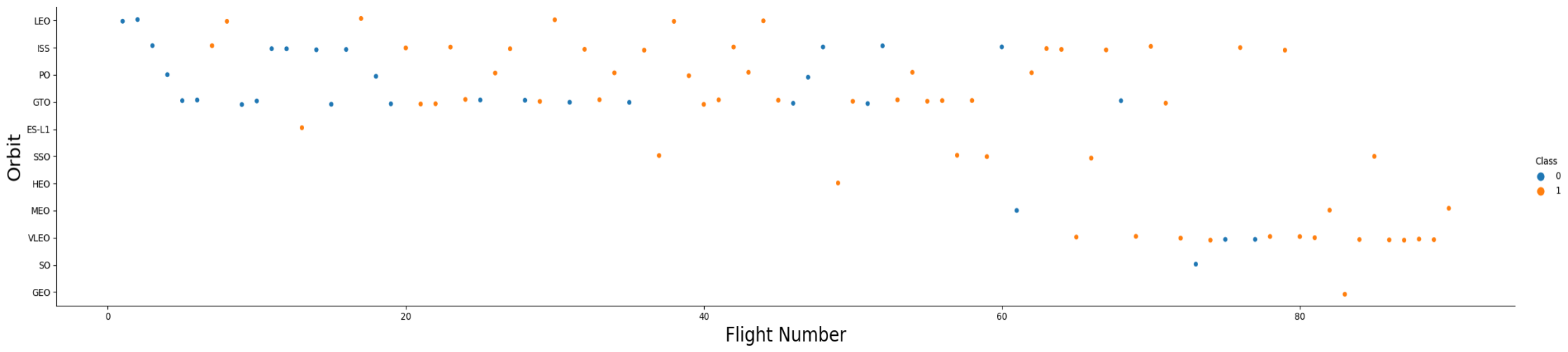
Success Rate vs. Orbit Type

- ES-L1, GEO, HEO, SSO
  - Greatest success rate among orbits
- VLEO
  - > 80% success rate

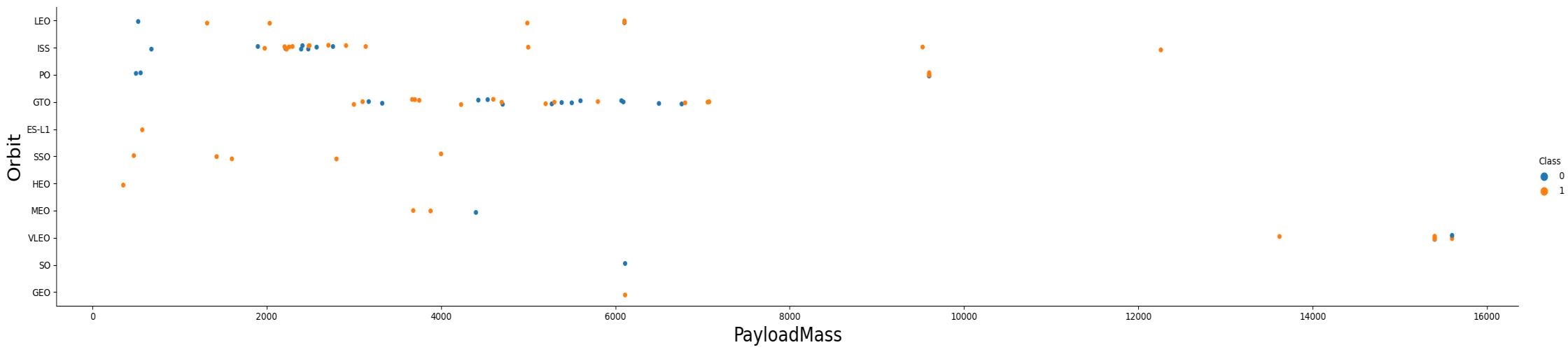


Flight Number vs. Orbit Type

- LEO, ISS, PO, GTO
  - Most used orbits in early time
- VLEO
  - Start to replace old orbit



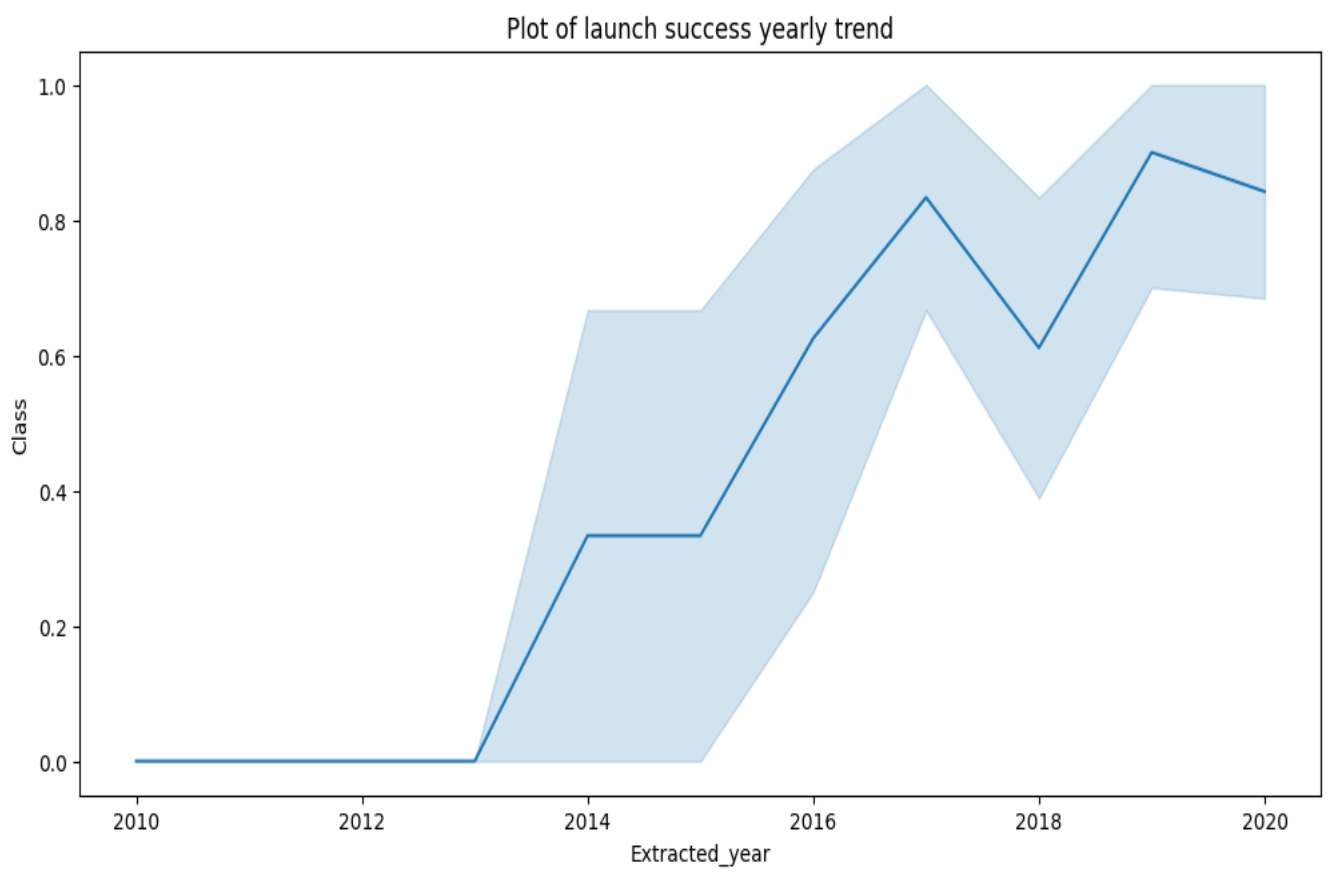
Payload vs. Orbit Type



- ISS & GTO
  - Mostly for payload mass < 8000
  - GTO -> high fail rate
- VLEO
  - For high payload mass

Launch Success Yearly Trend

- Overall success rate increase since 2013
  - Significant drop in 2018



All Launch Site Names

Find the names of the unique launch sites

Present your query result with a short explanation here

Launch Site Names Begin with 'CCA'

```
%sql select * from SPACEXTBL 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
04-06-2010	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
08-12-2010	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)
22-05-2012	07:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)	Success	No attempt
08-10-2012	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
01-03-2013	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attempt

- All mission outcomes were success
- First 2 records were qualification test
  - Fail to land to parachute
- Did not let booster land to any place after first 2 attempt

Total Payload Mass

- Total payload mass from NASA was 45596kg

```
%sql select sum(PAYLOAD_MASS__KG_) from SPACEXTBL where Customer = 'NASA (CRS)'
```

```
 * sqlite:///my_data1.db
Done.
 sum(PAYLOAD_MASS__KG_)
                  45596
```

Average Payload Mass by F9 v1.1

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

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

AvgPayload_Mass
2928.4

- Average payload mass by F9 v1.1 was 2928.4kg

First Successful Ground Landing Date

```
%sql select MIN(Date) as FirstSuccessfull_landing_date from SPACEXTBL where Landing_Outcome like 'Success (ground pad)'
```

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

FirstSuccessfull_landing_date
2015-12-22 00:00:00

- 1st successful landing to ground pad
  - 22nd Dec 2015

Successful Drone Ship Landing with Payload between 4000 and 6000

- Boosters that land to drone ship successfully with Payload between 4000 and 6000:

```
%sql select Booster_Version from SPACEXTBL where Landing_Outcome like 'Success (drone ship)' and PAYLOAD_MASS__KG_ > 4000 and PAYLOAD_MASS__KG_ < 6000
```

```
 * 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

- Most missions are success
- Only 1 failed

```
successful = %sql select count(Mission_Outcome) as SuccessfulOutcome from SPACEXTBL where Mission_Outcome like 'Success%'
print(successful)

failure = %sql select count(Mission_Outcome) as FailureOutcome from SPACEXTBL where Mission_Outcome like 'Failure%'
print(failure)
```

```
 * sqlite:///my_data1.db
Done.
+------------------+
| SuccessfulOutcome |
+------------------+
|        100       |
+------------------+
 * sqlite:///my_data1.db
Done.
+----------------+
| FailureOutcome |
+----------------+
|       1        |
+----------------+
```

Boosters Carried Maximum Payload

- F9 B5 series has the most payload mass with 15600kg

```
tk8 = %sql select Booster_Version, PAYLOAD_MASS__KG_ from SPACEXTBL where PAYLOAD_MASS__KG_ = (select max(PAYLOAD_MASS__KG_) from SPACEXTBL) order by Booster_Version
tk8
```

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

Booster_Version	PAYLOAD_MASS__KG_
F9 B5 B1048.4	15600
F9 B5 B1048.5	15600
F9 B5 B1049.4	15600
F9 B5 B1049.5	15600
F9 B5 B1049.7	15600
F9 B5 B1051.3	15600
F9 B5 B1051.4	15600
F9 B5 B1051.6	15600
F9 B5 B1056.4	15600
F9 B5 B1058.3	15600
F9 B5 B1060.2	15600
F9 B5 B1060.3	15600

2015 Launch Records

- In year 2015, 2 failure in landing drone ship
  - Both were F9 v1.1 in May

```
tk9 = %sql select Landing_Outcome, Booster_Version, Launch_Site, substr(Date,4,2) as Month from SPACEXTBL where Landing_Outcome like 'Failure (drone ship)' and Date like '2015%'
tk9
```

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

Landing_Outcome	Booster_Version	Launch_Site	Month
Failure (drone ship)	F9 v1.1 B1012	CCAFS LC-40	5-
Failure (drone ship)	F9 v1.1 B1015	CCAFS LC-40	5-

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

```
tk10 = %sql SELECT Landing_Outcome, COUNT(Landing_Outcome) FROM SPACEXTBL WHERE Date BETWEEN '2010-06-04' AND '2017-03-20' GROUP BY Landing_Outcome ORDER BY COUNT(Landing_Outcome) DESC
tk10
```

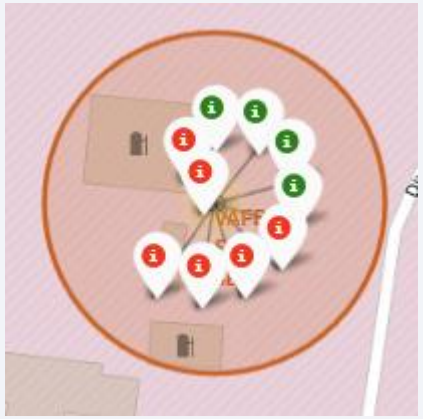
```
 * sqlite:///my_data1.db
Done.
```

Landing_Outcome	COUNT(Landing_Outcome)
No attempt	10
Success (ground pad)	5
Success (drone ship)	5
Failure (drone ship)	5
Controlled (ocean)	3
Uncontrolled (ocean)	2
Precluded (drone ship)	1
Failure (parachute)	1

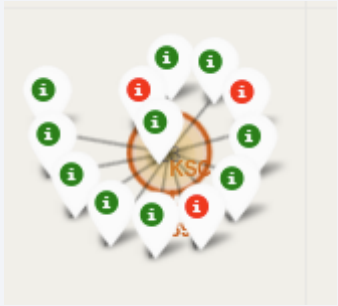

Section 3
Launch Sites
Proximities Analysis

Launch site of Space X in global map

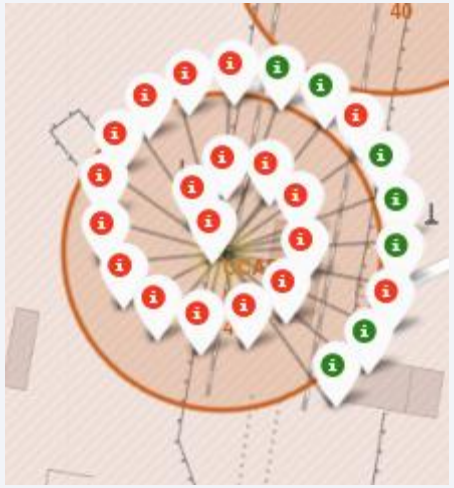
Color-labeled launched outcomes on map



VAFB SLC-4E



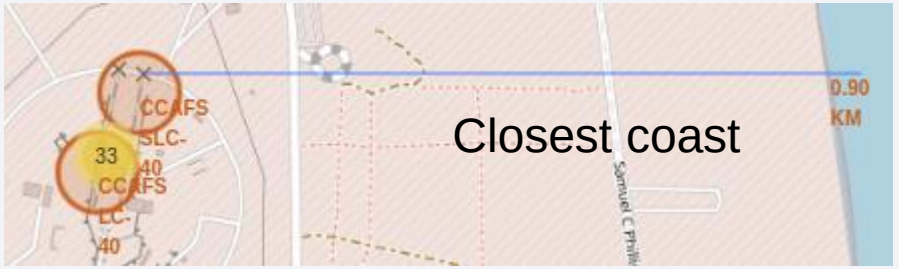
KSC LC-39A

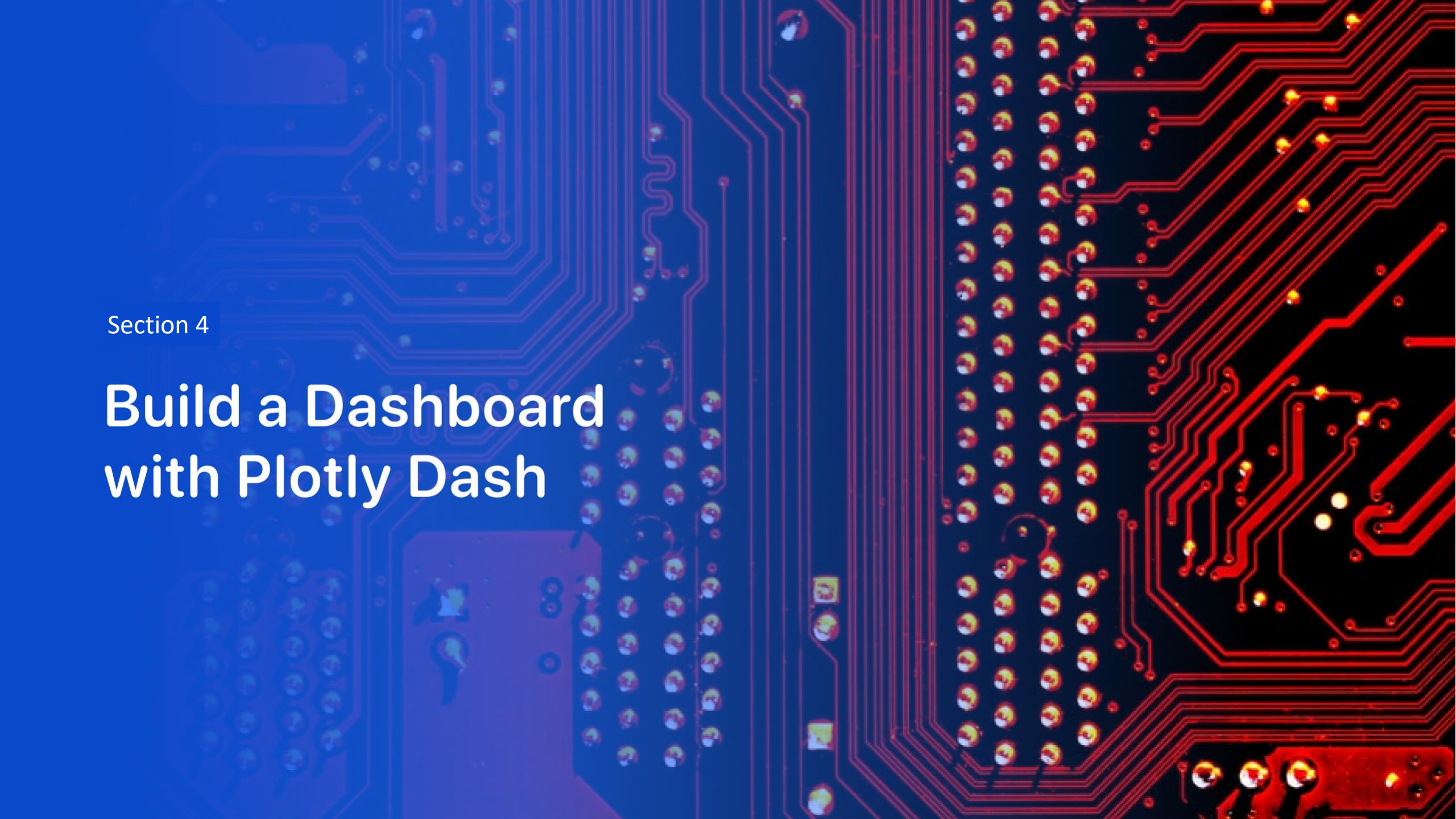


CCAFS LC-40

CCAFS SLC-40

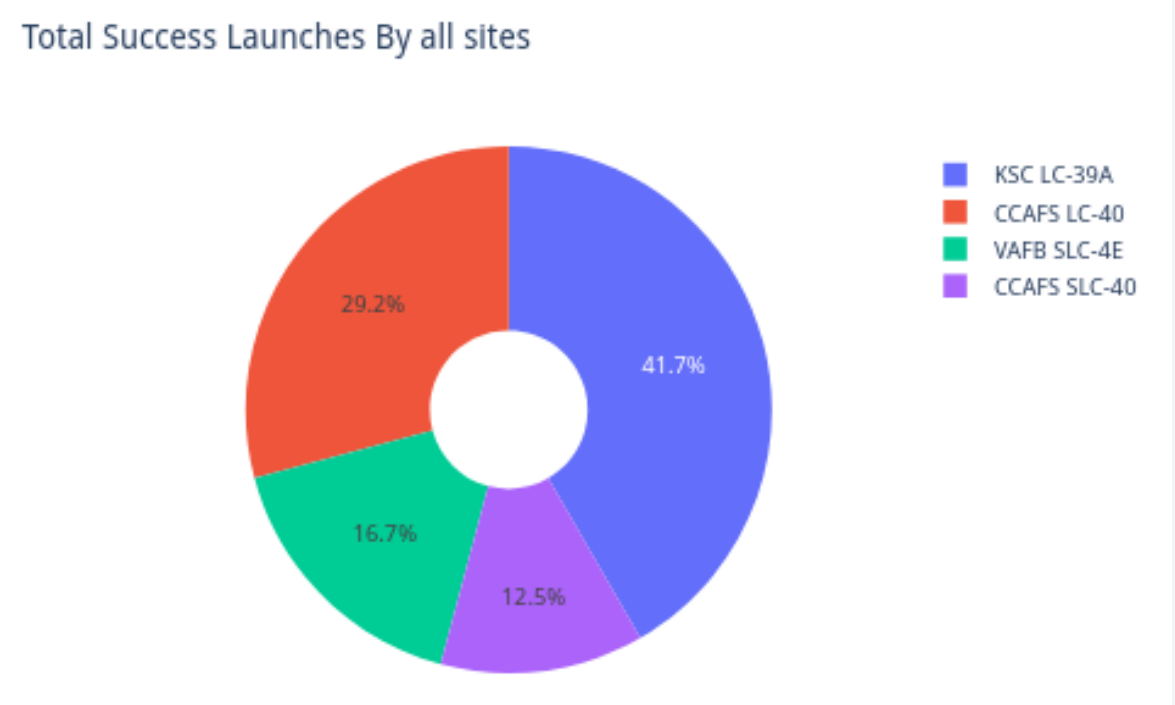
Launch site distance to landmarks in Florida




Section 4
Build a Dashboard with Plotly Dash

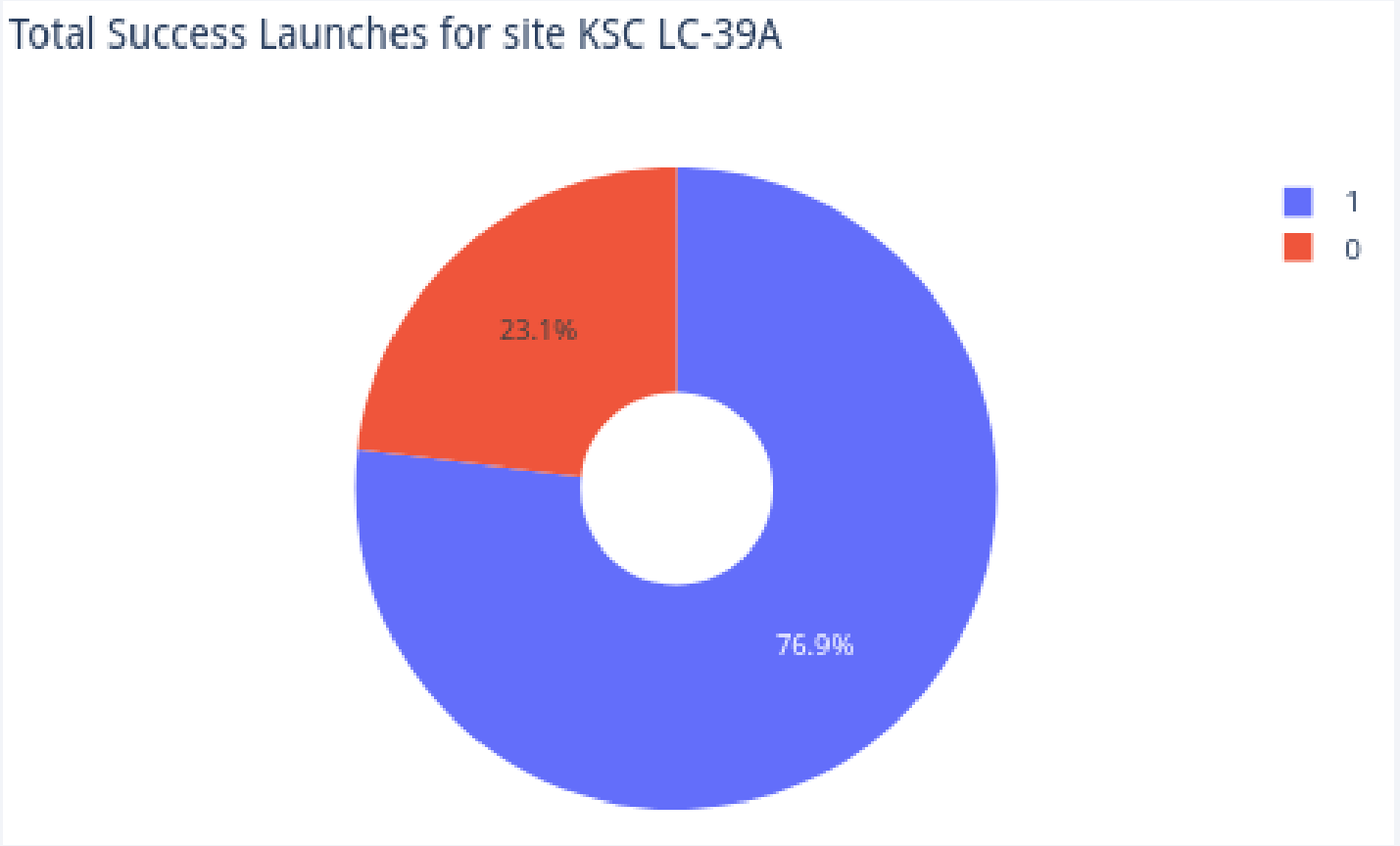
Pie chart of success launches by all sites

- KSC LC-39A
  - Has most success launches in all site
- CCAFS SLC-40
  - The least success launches in all site

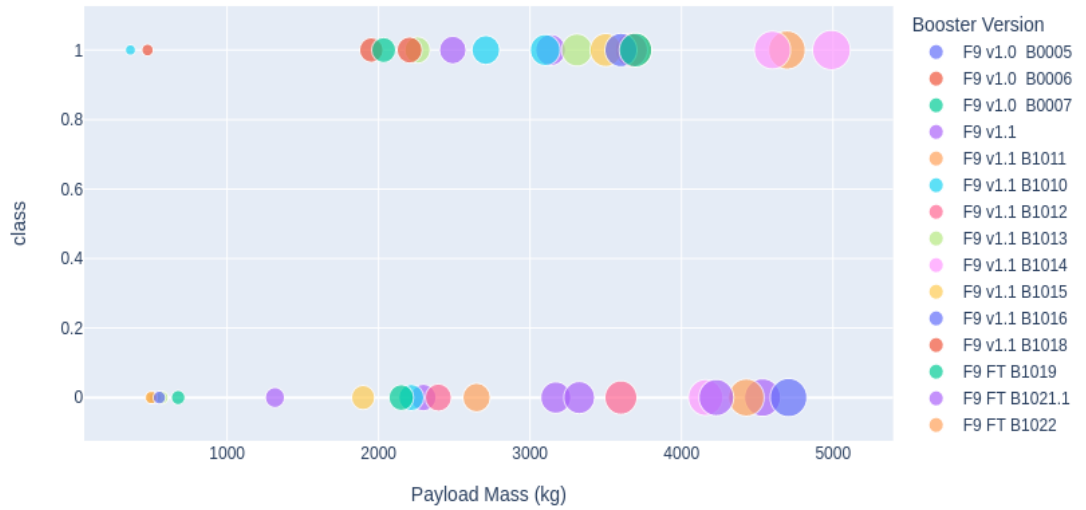


Pie chart of total success launches in KSC LC-39A

- 76.9% of successful rate
- 23.1% of failure rate

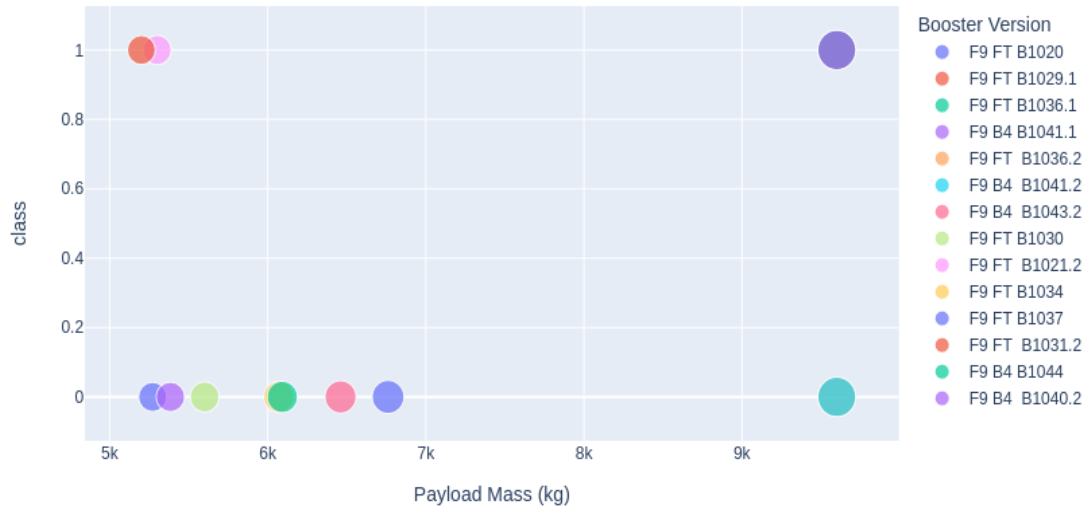


Payload vs Launch Outcome scatter plot for all sites



Payload vs Launch Outcome

(0 – 5000kg)



Payload vs Launch Outcome

(5000kg – 10000kg)

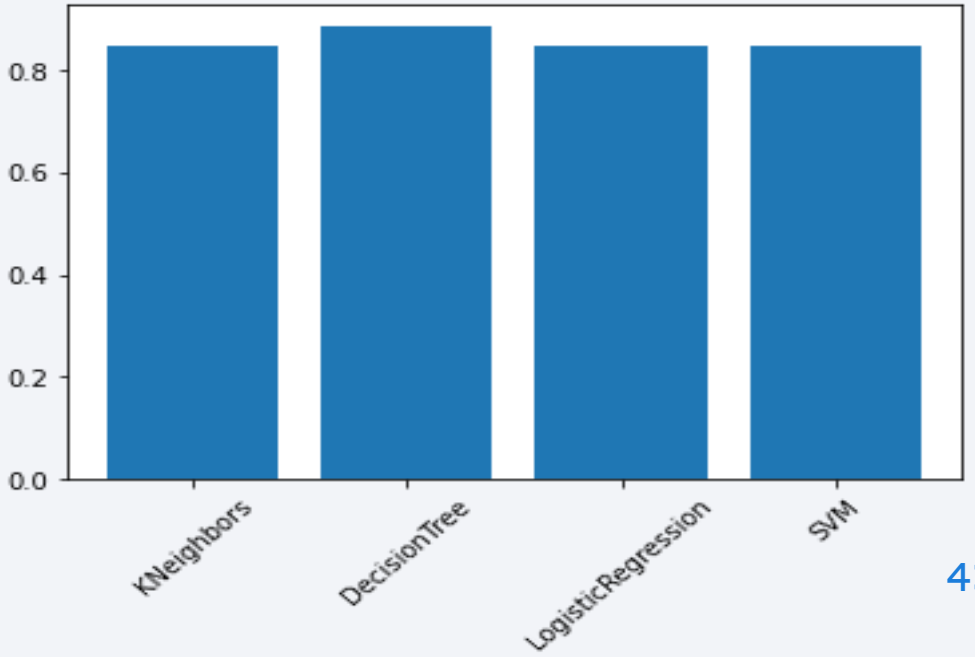
Section 5

Predictive Analysis (Classification)

Classification Accuracy

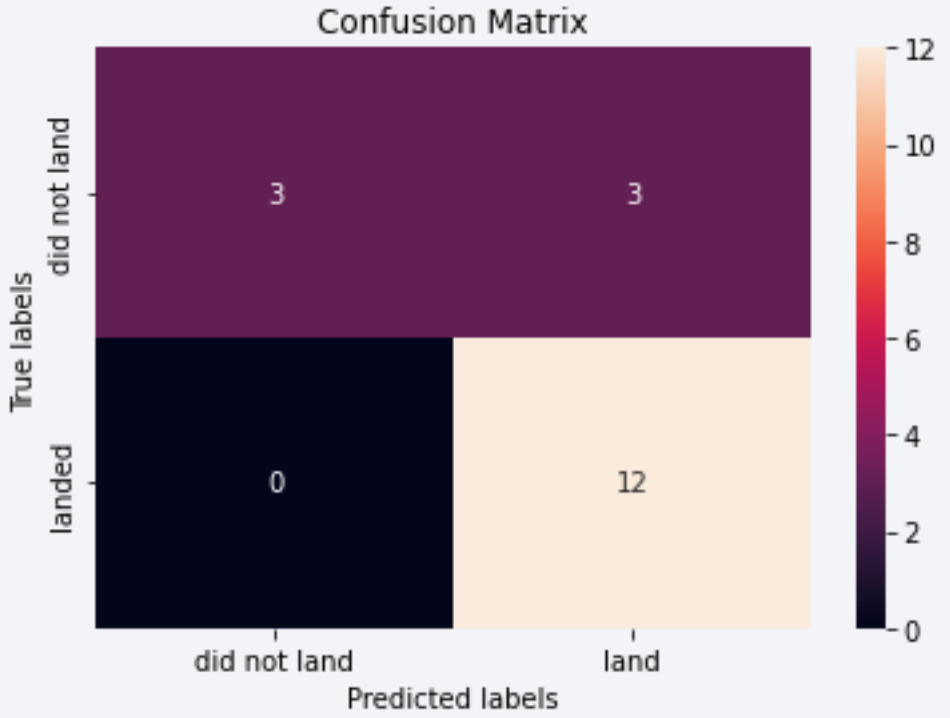
```
models = {'KNeighbors':knn_cv.best_score_, 'DecisionTree':tree_cv.best_score_, 'LogisticRegression':logreg_cv.best_score_, 'SupportVector': svm_cv.best_score_}

bestalgorithm = max(models, key=models.get)
print('Best model is', bestalgorithm,'with a score of', models[bestalgorithm])
if bestalgorithm == 'DecisionTree':
    print('Best params is :', tree_cv.best_params_)
if bestalgorithm == 'KNeighbors':
    print('Best params is :', knn_cv.best_params_)
if bestalgorithm == 'LogisticRegression':
    print('Best params is :', logreg_cv.best_params_)
if bestalgorithm == 'SupportVector':
    print('Best params is :', svm_cv.best_params_)
```

```
Best model is DecisionTree with a score of 0.9035714285714287
Best params is : {'criterion': 'gini', 'max_depth': 18, 'max_features': 'sqrt', 'min_samples_leaf': 1, 'min_samples_split': 10, 'splitter': 'random'}
```



Confusion Matrix

- Confusion Matric of prediction with Decision Tree
  - Can handle most cases
  - But it has a probability that mark unsuccessful landing as success



Conclusions

- Launch success rate increase since 2013
- CCAFS SLC-40 is the best launch site
- ISS & GTO
  - For payload mass < 8000
- VLEO
  - For higher payload mass
- Decision Tree
  - Best classification method to predict successful launch and landing

Thank you!