# Launch Bids Ignition Space X with Data Science

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Last Updated: April 16th, 2024

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# Executive summary

## ➢ We use PACE framework

Data Analysis PACE Steps:

1. Plan/Prepare - import the relevant libraries and data

   Align project with business needs, requirements and contraints. Select an approriate machine learning model based on the problem and business context. KDD: Selection, Data Wrangling (Pre-processing and Transformation).

2. Analyze - Explarotary Data Analysis (EDA)

   Understanding data for accurate predictions, focus on the response variable (what the model predicts) and leverage exploratory data analysis to uncover patterns and address irregularities. KDD: Data Mining.

3. Construct - model

   Construct and evaluate model. KDD: Evaluation.

4. Execute - share

   Interpret model and share the story. KDD: Communicate to stakeholders.

## ➢ The recommended model

1. Random forest has the highest classification accuracy result
2. Next consider to explore other models

| | Model | Train Score | Test Score | Accuracy |
|---|---|---|---|---|
| 1 | KNN | 0.875000 | 0.944444 | 0.844444 |
| 3 | SVM | 0.861111 | 0.944444 | 0.822222 |
| 4 | Logistic Regression | 0.875000 | 0.944444 | 0.822222 |
| 2 | Decision Tree | 0.861111 | 0.888889 | 0.900000 |
| 0 | RF | 0.943576 | 0.861111 | 0.908333 |

# Introduction: Business case and Objective

# Business Case

Space X  offers competitive price since its first successful landing in 2015 by reusing the rocket, more than half of its competitors’ cost

## Opportunity/Problem Statement:

- Space x has been operating since 2010 and the landing success rate continue to increase
- Launch sites have an average success rate below 70%

## Goals

Improve the success rate of successful landings, currently averaging below 70%, to achieve a competitive bid proposal cost of $62 million compared to our competitors

**Project Objective:**

**Increase Revenue from Rocket Launch**

**KPI:**

**Successful landing launch rate (%)**

**Primary metric:**

- Improve **landing success rate** by 10% by identifying best launch site, orbit, pay load mass etc.

# Analytics Objective

Explore and compare **various machine learning models** and **find one** with **the best performance** to improve rockets landing

**Machine learning models:**

- Predict the best successful landing site.
- The best option for customers launching on the landing  site that offers the most value, considering factors such as from orbit, location etc.
- Determine the cost of the launch

**Hypothesis :**

**Machine learning models** delivers **more incremental value** of **landing success** relative to **the current systems**

# Section 1. Methodology

## PACE Framework

# Plan

Align project with business needs, requirements and contraints. Select an approriate machine learning model based on the problem and business context. KDD: Selection, Data Wrangling (Pre-processing and Transformation).

# Plan

**Selection - data collection**

- Takes the dataset and uses required features column to call the API and append the data to the list. https://api.spacexdata.com/v4/launches/past
- Request and parse the SpaceX launch data. https://.../API_call_spacex_api.json

**Link**

- Task008-P01-DS-SpaceX-Falcon-20240409 in Kaggle (The complete version with outcome and code cell)
- [01. jupyter-labs-spacex-data-collection-api.ipynb (github.com)]

# Data collection from API - Flowchart

Request and Parse to SpaceX API

Create a function, a list and apply the function

Create the dataframe

response

data

Keep the important features
Remove multiple rows
Correct the data type
Restrict the date etc.

requests.get (spacex_url)

pd.json_normalize (response.json())

*# Call getBoosterVersion*
getBoosterVersion(data)
BoosterVersion[0:5]

*# Call getLaunchSite*
getLaunchSite(data)

*# Call getPayloadData*
getPayloadData(data)

*# Call getCoreData*
getCoreData(data)

launch_dict

data_falcon9

Plan

# Data collection from API - Flowchart

**data_falcon9**
3 launch sites
Flight No. 90

| | FlightNumber | Date | BoosterVersion | PayloadMass | Orbit | LaunchSite | Outcome | Flights | GridFins | Reused | Legs | LandingPad | Block | ReusedCount | Serial | Longitude | Latitude |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4** | 1 | 2010-06-04 | Falcon 9 | NaN | 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 | 525.0 | 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 | 677.0 | 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 | 500.0 | 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 | 3170.0 | GTO | CCSFS SLC 40 | None None | 1 | False | False | False | None | 1.0 | 0 | B1004 | -80.577366 | 28.561857 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| **89** | 86 | 2020-09-03 | Falcon 9 | 15600.0 | VLEO | KSC LC 39A | True ASDS | 2 | True | True | True | 5e9e3032383ecb6bb234e7ca | 5.0 | 12 | B1060 | -80.603956 | 28.608058 |
| **90** | 87 | 2020-10-06 | Falcon 9 | 15600.0 | VLEO | KSC LC 39A | True ASDS | 3 | True | True | True | 5e9e3032383ecb6bb234e7ca | 5.0 | 13 | B1058 | -80.603956 | 28.608058 |
| **91** | 88 | 2020-10-18 | Falcon 9 | 15600.0 | VLEO | KSC LC 39A | True ASDS | 6 | True | True | True | 5e9e3032383ecb6bb234e7ca | 5.0 | 12 | B1051 | -80.603956 | 28.608058 |
| **92** | 89 | 2020-10-24 | Falcon 9 | 15600.0 | VLEO | CCSFS SLC 40 | True ASDS | 3 | True | True | True | 5e9e3033383ecbb9e534e7cc | 5.0 | 12 | B1060 | -80.577366 | 28.561857 |
| **93** | 90 | 2020-11-05 | Falcon 9 | 3681.0 | MEO | CCSFS SLC 40 | True ASDS | 1 | True | False | True | 5e9e3032383ecb6bb234e7ca | 5.0 | 8 | B1062 | -80.577366 | 28.561857 |

90 rows × 17 columns

Plan

Align project with business needs, requirements and contraints. Select an approriate machine learning model based on the problem and business context. KDD: Selection, Data Wrangling (Pre-processing and Transformation).

# Plan

**Data Scrapping**

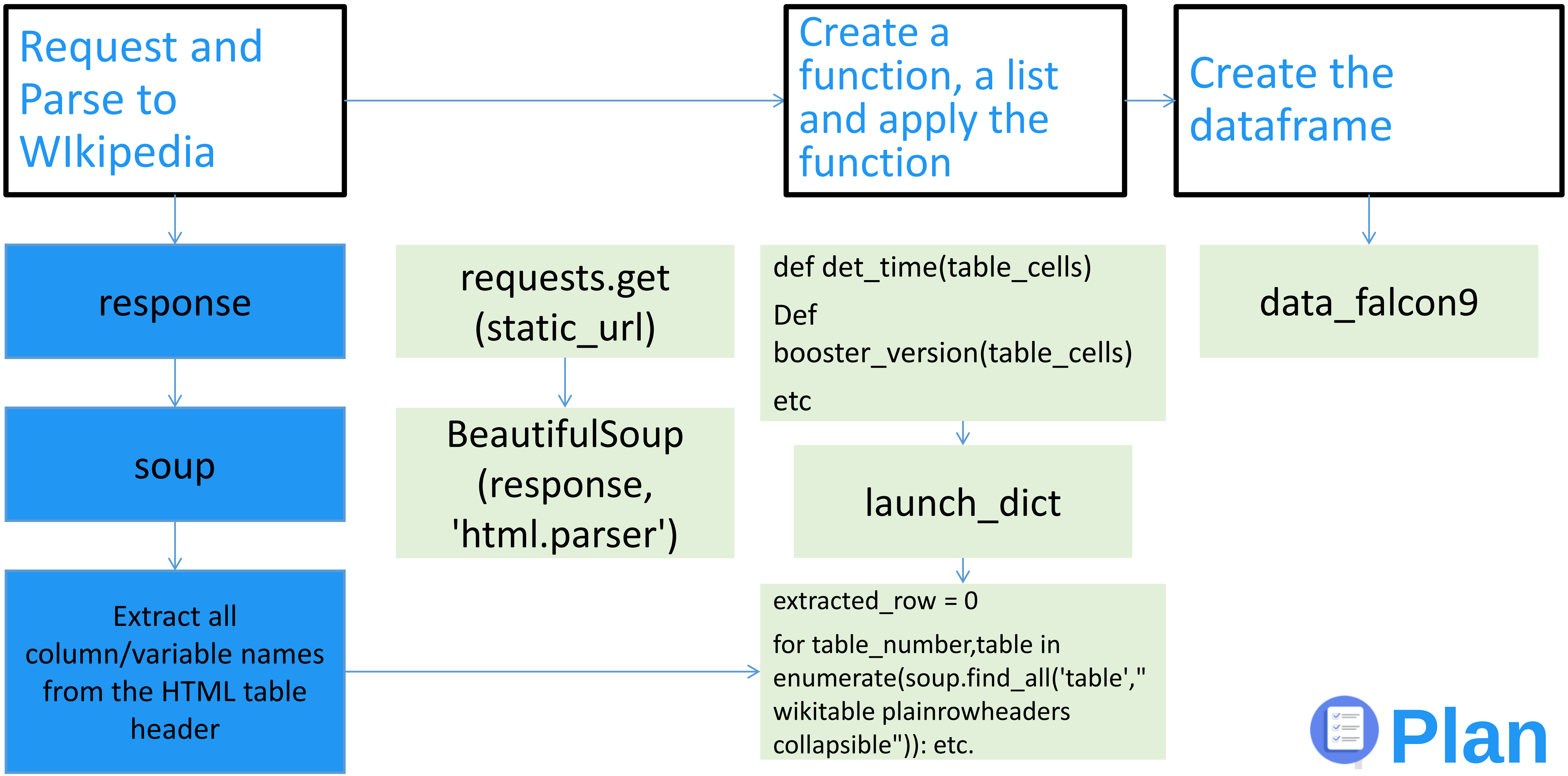
- Collect Falcon 9 historical launch records from wikipedia.

  https://en.wikipedia.org/wiki/List_of_Falcon_9_and_Falcon_Heavy_launches

**Link**

- Task008-P01-DS-SpaceX-Falcon-20240409 in Kaggle (The complete version with outcome and code cell)
- 02. jupyter-labs-webscraping.ipynb

# Scrapping from Wikipedia- Flowchart




Plan

# Data collection from Wikipedia- Flowchart

**data_falcon9**
5 launch sites
Flight No. 121

Data from the API differs from that on Wikipedia. We are adhering to the data outlined in the IBM capstone assignment.

| | 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 | Success\n | F9 v1.0B0003.1 | Failure | 4 June 2010 | 18:45 |
| **1** | 2 | CCAFS | Dragon | 0 | LEO | NASA | Success | F9 v1.0B0004.1 | Failure | 8 December 2010 | 15:43 |
| **2** | 3 | CCAFS | Dragon | 525 kg | LEO | NASA | Success | F9 v1.0B0005.1 | No attempt\n | 22 May 2012 | 07:44 |
| **3** | 4 | CCAFS | SpaceX CRS-1 | 4,700 kg | LEO | NASA | Success\n | F9 v1.0B0006.1 | No attempt | 8 October 2012 | 00:35 |
| **4** | 5 | CCAFS | SpaceX CRS-2 | 4,877 kg | LEO | NASA | Success\n | F9 v1.0B0007.1 | No attempt\n | 1 March 2013 | 15:10 |

| | Flight No. | Launch site | Payload | Payload mass | Orbit | Customer | Launch outcome | Version Booster | Booster landing | Date | Time |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **116** | 117 | CCSFS | Starlink | 15,600 kg | LEO | SpaceX | Success\n | F9 B5B1051.10 | Success | 9 May 2021 | 06:42 |
| **117** | 118 | KSC | Starlink | ~14,000 kg | LEO | SpaceX | Success\n | F9 B5B1058.8 | Success | 15 May 2021 | 22:56 |
| **118** | 119 | CCSFS | Starlink | 15,600 kg | LEO | SpaceX | Success\n | F9 B5B1063.2 | Success | 26 May 2021 | 18:59 |
| **119** | 120 | KSC | SpaceX CRS-22 | 3,328 kg | LEO | NASA | Success\n | F9 B5B1067.1 | Success | 3 June 2021 | 17:29 |
| **120** | 121 | CCSFS | SXM-8 | 7,000 kg | GTO | Sirius XM | Success\n | F9 B5 | Success | 6 June 2021 | 04:26 |

Plan

Align project with business needs, requirements and contraints. Select an approriate machine learning model based on the problem and business context. KDD: Selection, Data Wrangling (Pre-processing and Transformation).

# Plan

**Data Wrangling (pre-processing and transformattion)**

- Convert outcomes training labels with 1 means the booster successfully landed, 0 means it failed

**Link**

- Task008-P01-DS-SpaceX-Falcon-20240409 in Kaggle (The complete version with outcome and code cell)
- 03. labs-jupyter-spacex-Data wrangling.ipynb (github.com)

# Wrangling- Flowchart

**df**
3 location sites
90 flight numbers

Calculate the number of launches on each site → Calculate the number and occurrence of each orbit → Calculate the number and occurrence of mission **outcomes** of the orbits → Assign to the variable landing_class

| Orbit | LaunchSite | Outcome | Flights | GridFins | Reused | Legs | LandingPad | Block | ReusedCount | Serial | Longitude | Latitude | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LEO | CCAFS SLC 40 | None None | 1 | False | False | False | NaN | 1.0 | 0 | B0003 | -80.577366 | 28.561857 | 0 |
| LEO | CCAFS SLC 40 | None None | 1 | False | False | False | NaN | 1.0 | 0 | B0005 | -80.577366 | 28.561857 | 0 |
| ISS | CCAFS SLC 40 | None None | 1 | False | False | False | NaN | 1.0 | 0 | B0007 | -80.577366 | 28.561857 | 0 |
| PO | VAFB SLC 4E | False Ocean | 1 | False | False | False | NaN | 1.0 | 0 | B1003 | -120.610829 | 34.632093 | 0 |
| GTO | CCAFS SLC 40 | None None | 1 | False | False | False | NaN | 1.0 | 0 | B1004 | -80.577366 | 28.561857 | 0 |

Plan

# Analyze

## Exploratory Data Analysis

Understanding data for accurate predictions, focus on the response variable (what the model predicts) and leverage exploratory data analysis to uncover patterns and address irregularities. KDD: Data Mining.

**df_1**
4 location sites
101 flight numbers

# Analyze

## SQL

- In this SQL data, 4 launch sites. **Unfortunately it differ from data in wrangling phase.**
- Lunch sites begin with the string 'CCA'
- There are 53 Customers
- Total payload mass carried by boosters launched by NASA (CRS)
- Average payload mass carried by booster version F9 v1.1
- The first successful landing outcome 22th Dec 2015
- List the total number of successful and failure mission outcomes
- 12 booster_versions which have carried the maximum payload mass.
- Rank the count of landing outcomes between the date 2010-06-04 and 2017-03-20
- List the failed landing_outcomes in drone ship, their booster versions, and launch site names for in year 2015

## Link

- Task008-P01-DS-SpaceX-Falcon-20240409 in Kaggle (The complete version with outcome and code cell)
- 04. jupyter-labs-eda-sql-coursera_sqllite.ipynb (github.com)

Understanding data for accurate predictions, focus on the response variable (what the model predicts) and leverage exploratory data analysis to uncover patterns and address irregularities. KDD: Data Mining.

**df**
3 location sites
90 flight numbers

# Analyze

## EDA Data Visualization

- Scatterplot to observe relationship between variables.
- Bar plot to visualize the success rate of each orbit.
- Line chart to track the trend of the success rate over each year.
- Pie chart to analyze the success rate of each launch site.

## Link

- Task008-P01-DS-SpaceX-Falcon-20240409 in Kaggle (The complete version with outcome and code cell)
- 05. edadataviz.ipynb (github.com)

Understanding data for accurate predictions, focus on the response variable (what the model predicts) and leverage exploratory data analysis to uncover patterns and address irregularities. KDD: Data Mining.

**df**
4 location sites
56 flight numbers

# Analyze

**Interactive Map with Folium**

- First, create a Folium Map object with an initial center location set to NASA Johnson Space Center in Houston, Texas
- Use folium.Circle to add a highlighted circle area
- Add marker using folium.Marker
- Mark each site using MarkerCluster()
- Add a MousePosition on the map to get coordinate for a mouse over a point on the map
- Calculate the distance and add distance marker
- Create lines using folium.Polyline

**Link**

- Task008-P01-DS-SpaceX-Falcon-20240409 in Kaggle (The complete version with outcome and code cell)
- 06. lab_jupyter_launch_site_location.ipynb (github.com)

Understanding data for accurate predictions, focus on the response variable (what the model predicts) and leverage exploratory data analysis to uncover patterns and address irregularities. KDD: Data Mining.

# Analyze

**df**
4 location sites
56 flight numbers

## Dashboard with Plotly Dash

- Add a dropdown list to enable Launch Site selection
- Create pie chart to show the total successful launches count for all sites
- Add a slider to select payload range
- Create a scatter chart to show the correlation between payload and launch success
- Add a callback function for `site-dropdown` as input, `success-pie-chart` as output
- Add a callback function for `site-dropdown` and `payload-slider` as inputs, `success-payload-scatter-chart` as output

## Link

- Task008-P01-DS-SpaceX-Falcon-20240409 in Kaggle (The complete version with outcome and code cell)
- [spacex_dash_app.py (github.com)]()

# Construct

Models and Findings

**df**
3 location sites
90 flight numbers

# Construct

## Predictive Analysis (Classification)

- Choose the relevant features
- Perform One hot encoding for the object or string values data
- Select the features (X) and label (y)
- Standardize the data in X and then reassign it to the variable X
- Utilize the function train_test_split to split in the data X and Y into training and test data. Set the parameter test_size to 0.2 and random_state to 2.
- Determine the parameter and apply the training and test datasets to logistic regression, SVM, Decision tree and KNN model
- Employ GridSearch with the model, cross-validation with a value of 10 and the parameter
- Display the results including accuracy, $R^2$ and confusion matrix

## Link

- Task008-P01-DS-SpaceX-Falcon-20240409 in Kaggle (The complete version with outcome and code cell)
- 07. SpaceX_Machine Learning Prediction_Part_5.ipynb (github.com)

# Predictive Analysis- Flowchart

**Select and utilize features (X) and label (y)**

- standardize and transform
- train, test and split function

scaler = StandardScaler()

test size = 0.2 , random state = 2

**Apply GridSearch cross-validation**

- parameter
- model
- cross-validation

**Display the results**

- Accuracy, R2 score, etc.
- Confusion matrix

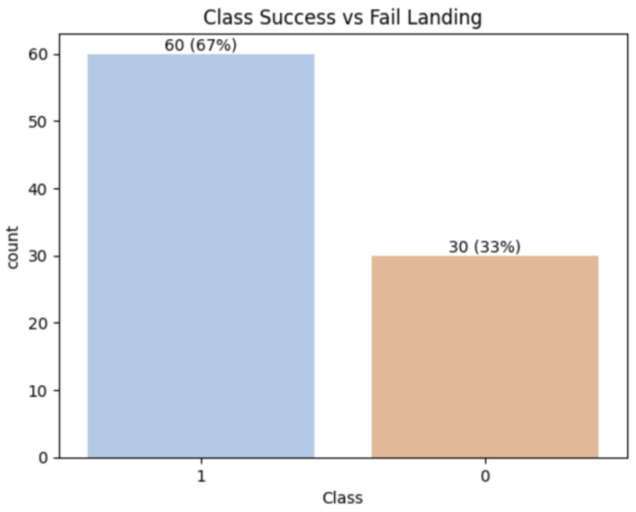
Construct


# Section 2. Insight Drawn from EDA

# Analyze

## EDA - Data Visualization

# The first landing





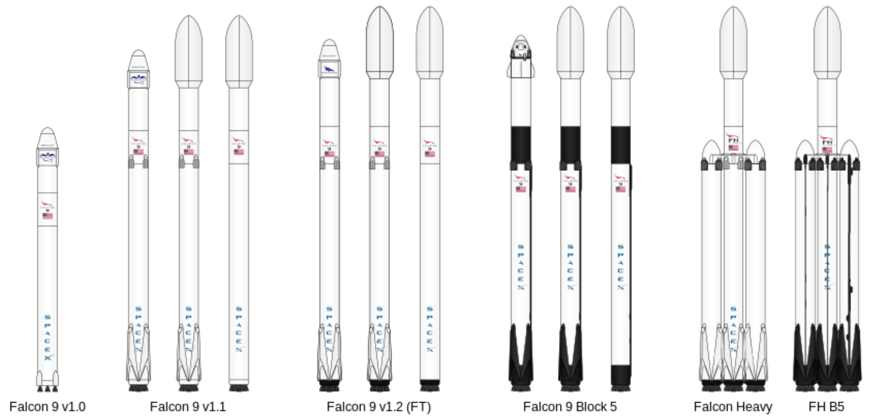

**Success**

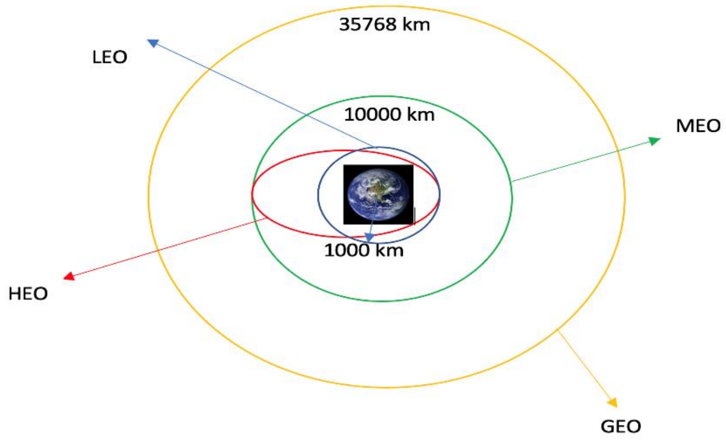
**(Class = 1)**

**Failure**

**(Class =0)**

# The rockets and orbits




Heavy Launch

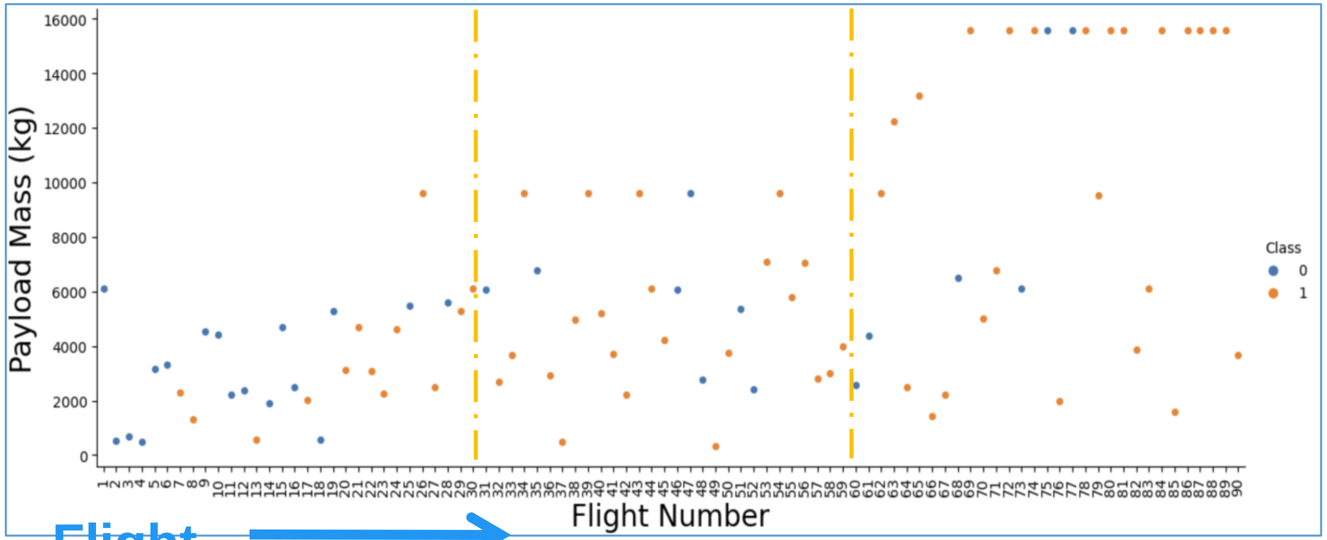
Orbit

# Flight number vs Payload mass

**From 2010 to 2020, we have had 90 flight numbers**

- Flight numbers increases, the first stage more likely land successfully

Payload Mass




Flight numbers

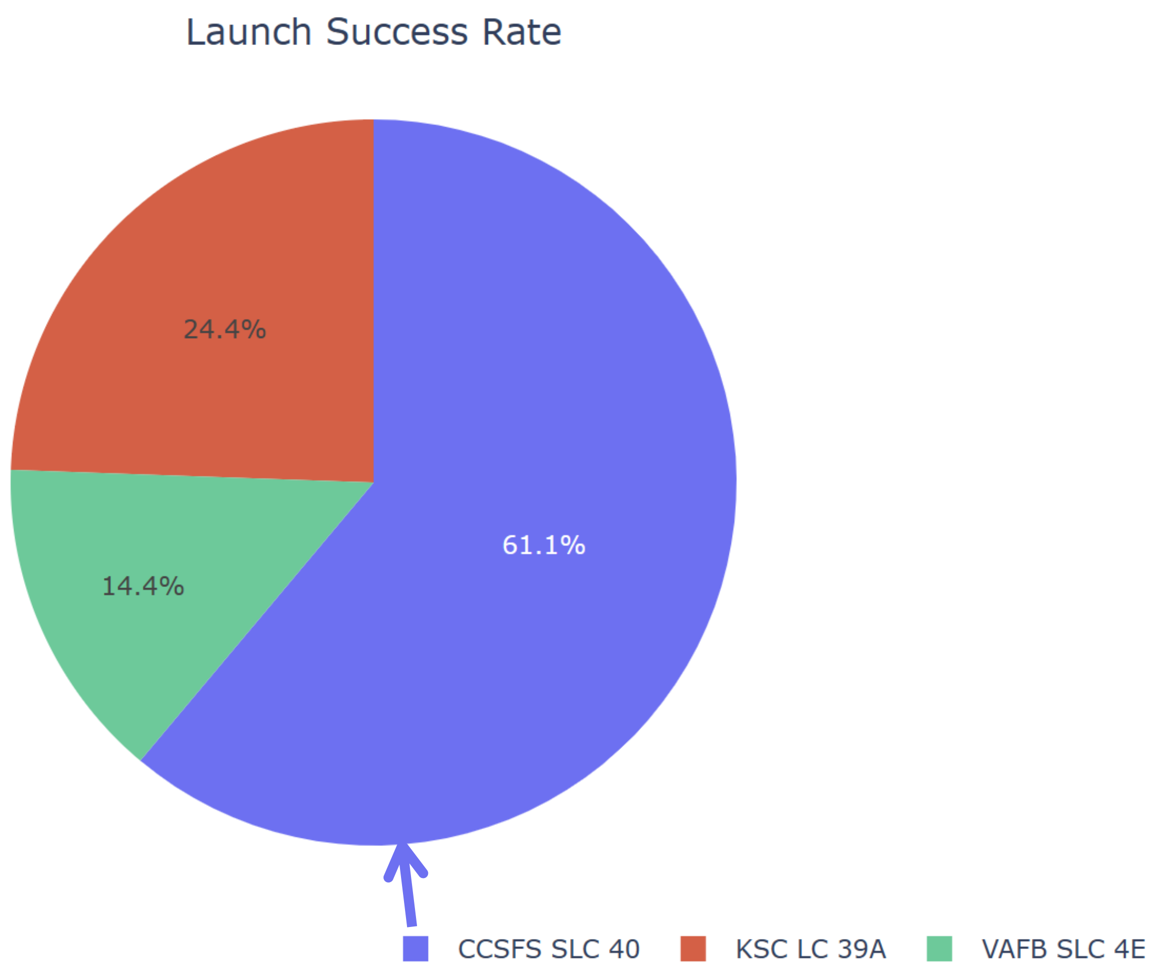
| df |
|---|
| 3 location sites |
| 90 flight numbers |

Analyze

# Launch Success Rate Contribution

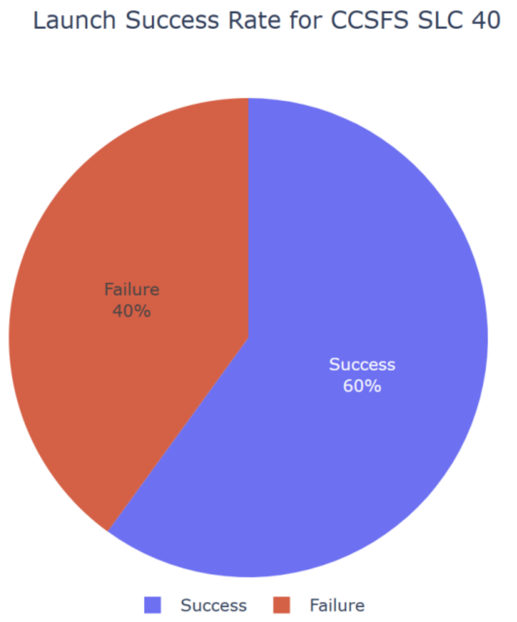
**2010 to 2020 we have to 90 flight numbers**

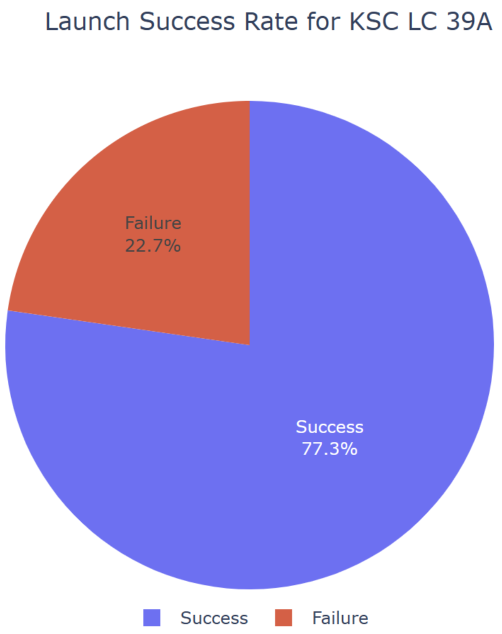
- `CCSFS SLC 40` contributed the highest launching success, more than 60% of total (its first launched in 2010)
- `KSC LC 39A` followed second place with nearly 25% of total. (launching in 2013)
- The youngest launch site in 2017, VAFB SLC 4E has less than 15% of the total launches.

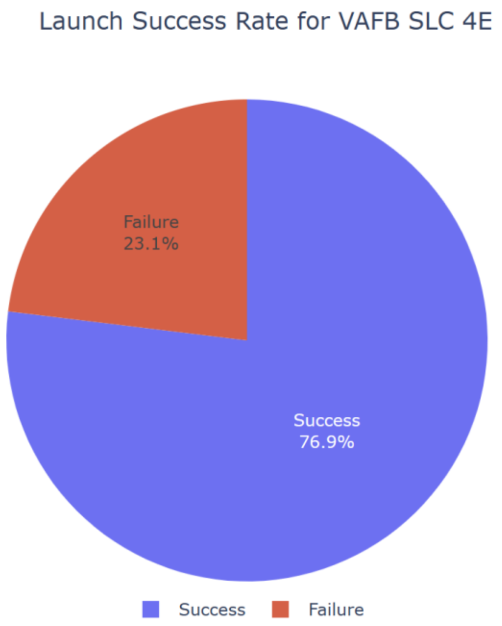



Analyze

# Launch Success Rate




**2010 to 2020 we have to 90 flight numbers**

- `KSC LC 39A` and `VAFB SLC 4E` has success rates of more than 75%
- `CCAFS SLC 40` has a success rate of 60% (the oldest launch site)

*It should be CCAFS instead of CCSFS

Analyze

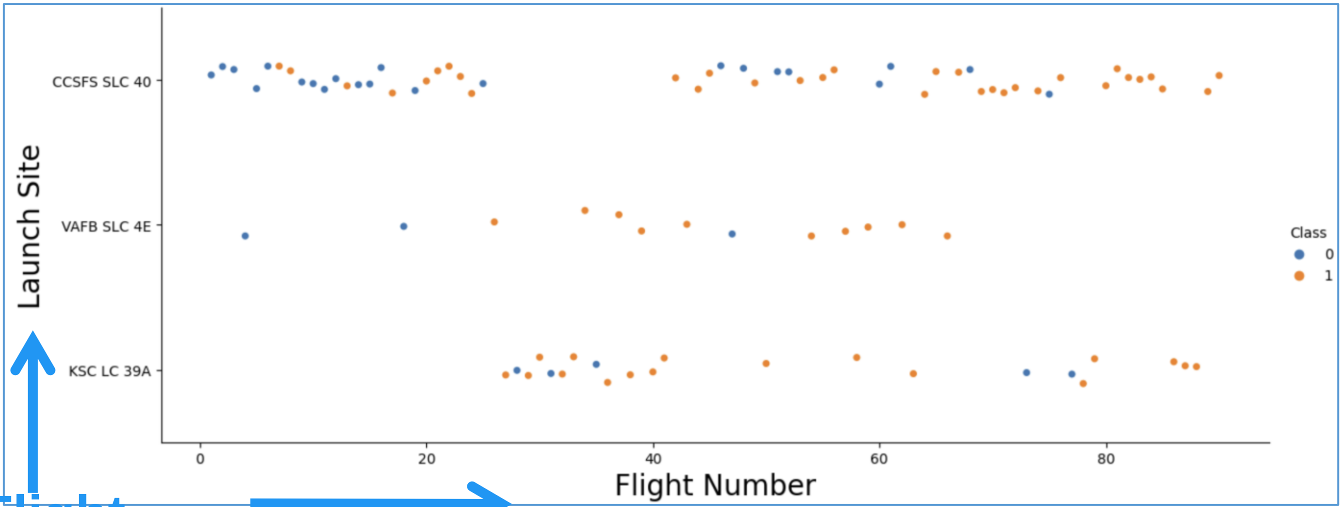
# Flight number vs Launch site

Analyze

**2010 to 2020 we have to 90 flight numbers**

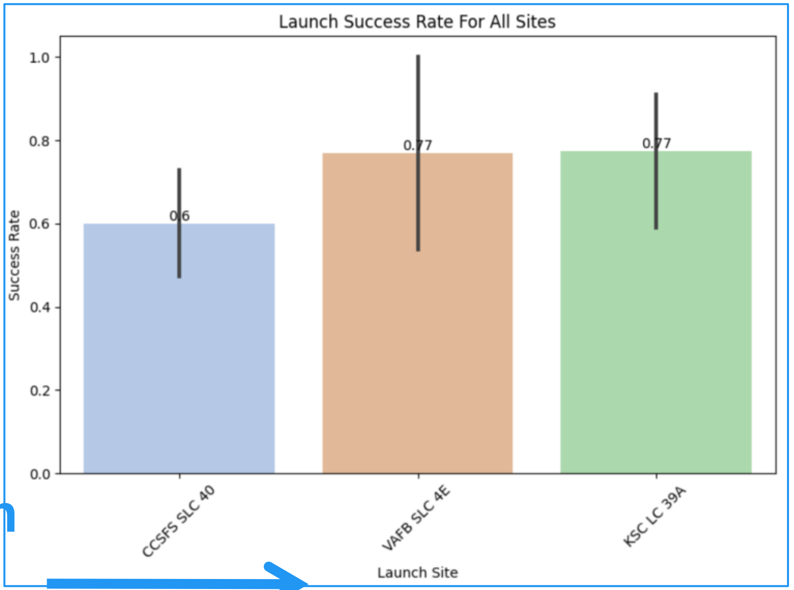
- As the flight number increases, the success rate of the first landing improves across all launch sites

Launch Site




Flight numbers

Success Rate



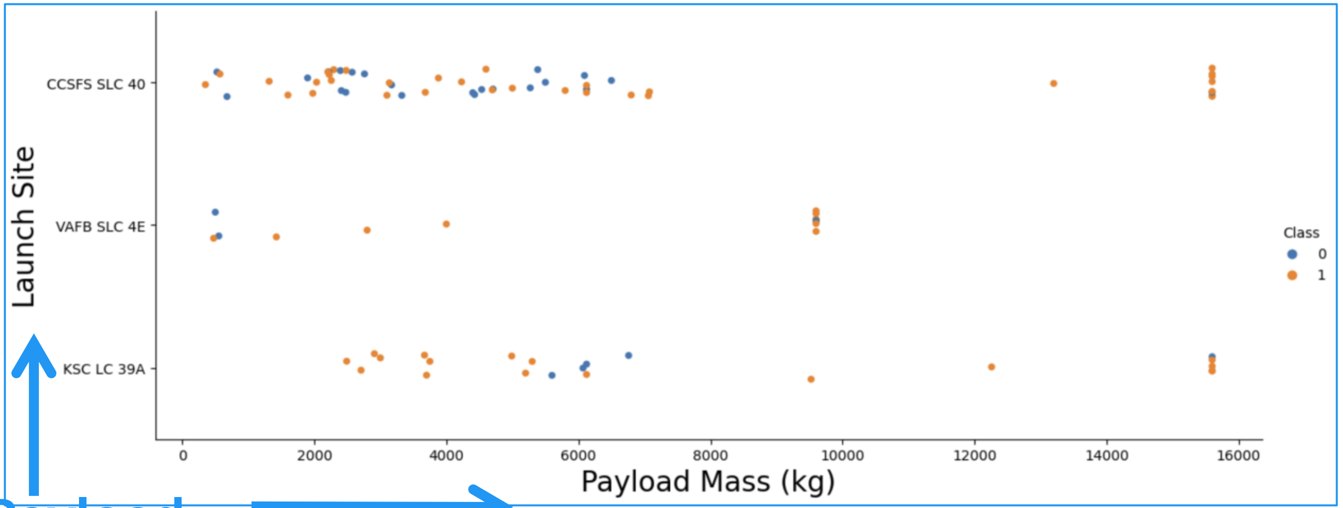

Launch Site

# Payload Mass vs Launch site

**2010 to 2020 we have to 90 flight numbers**

- As the flight number increases, the success rate of the first landing improves across all launch sites

Launch Site




Payload Mass

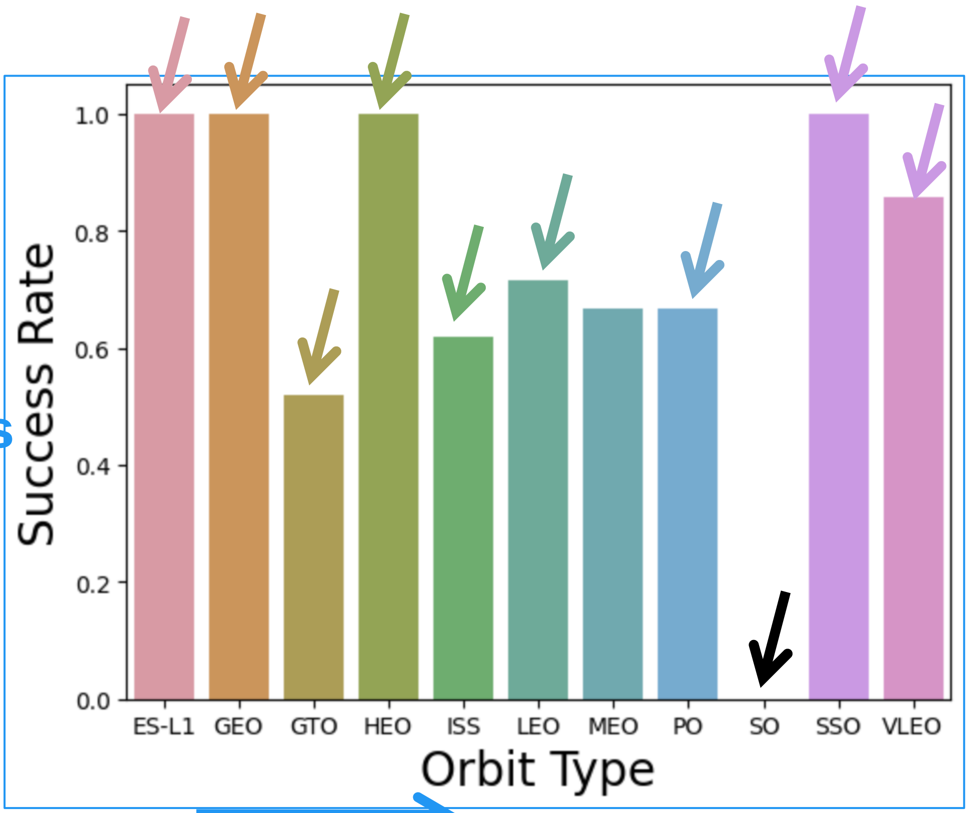
Analyze

# Success Rate vs Orbit Type

**2010 to 2020 we have to 90 flight numbers**

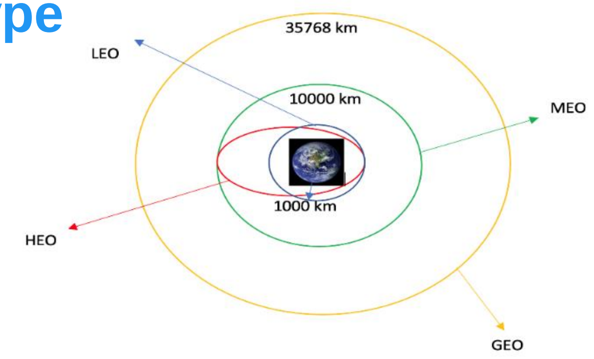
- The orbit which launches before 2015, with more than 2 launches have a success rate below 80%
- The orbit that has a 100% has only been launched once except for SO, which failed in the first launch
- SSO has 5 launches with 100% and VLEO has above 80% success rate

Success Rate




| Orbit | Min_Date |
|---|---|
| LEO | 2010-06-04 |
| ISS | 2013-03-01 |
| PO | 2013-09-29 |
| GTO | 2013-12-03 |
| ES-L1 | 2015-02-11 |
| SSO | 2017-08-24 |
| HEO | 2018-04-18 |
| MEO | 2018-12-23 |
| VLEO | 2019-05-24 |
| SO | 2020-01-19 |
| GEO | 2020-07-20 |

Orbit Type




| Orbit | |
|---|---|
| GTO | 27 |
| ISS | 21 |
| VLEO | 14 |
| PO | 9 |
| LEO | 7 |
| SSO | 5 |
| MEO | 3 |
| ES-L1 | 1 |
| HEO | 1 |
| SO | 1 |
| GEO | 1 |

Name: count 'int64

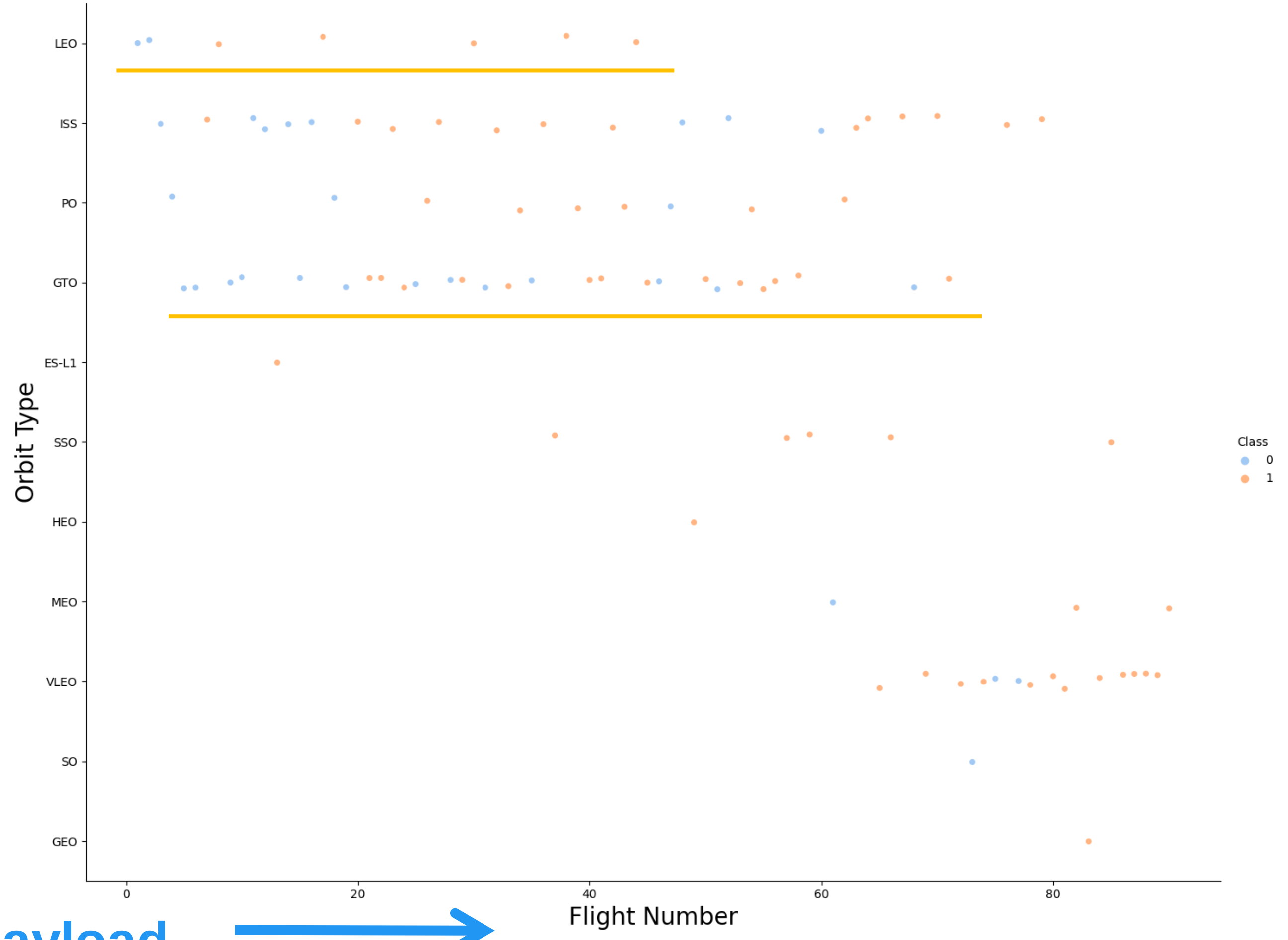
Analyze

# Flight Number vs Orbit Type

**2010 to 2020 we have to 90 flight numbers**

- the `LEO` orbit the Success appears related to the number of flights; on the other hand, there seems to be no relationship between flight number when in `GTO` orbit

Orbit Type




Payload Mass

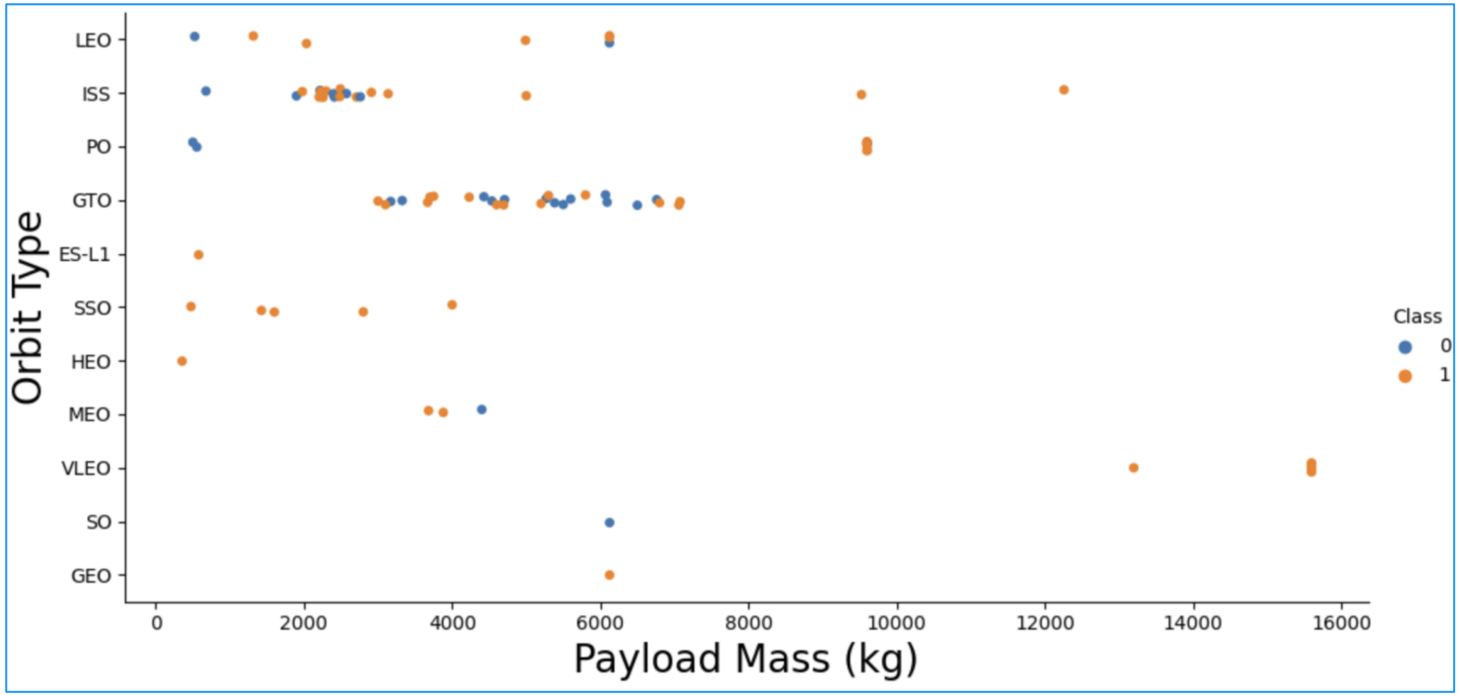
Analyze

# Payload vs Orbit Type

**2010 to 2020 we have to 90 flight numbers**

- With heavy payloads the successful landing or positive landing rate are more for `Polar`,`LEO` and `ISS`
- `GTO` we cannot distinguish this well as success and failure landing

Orbit Type




Payload Mass

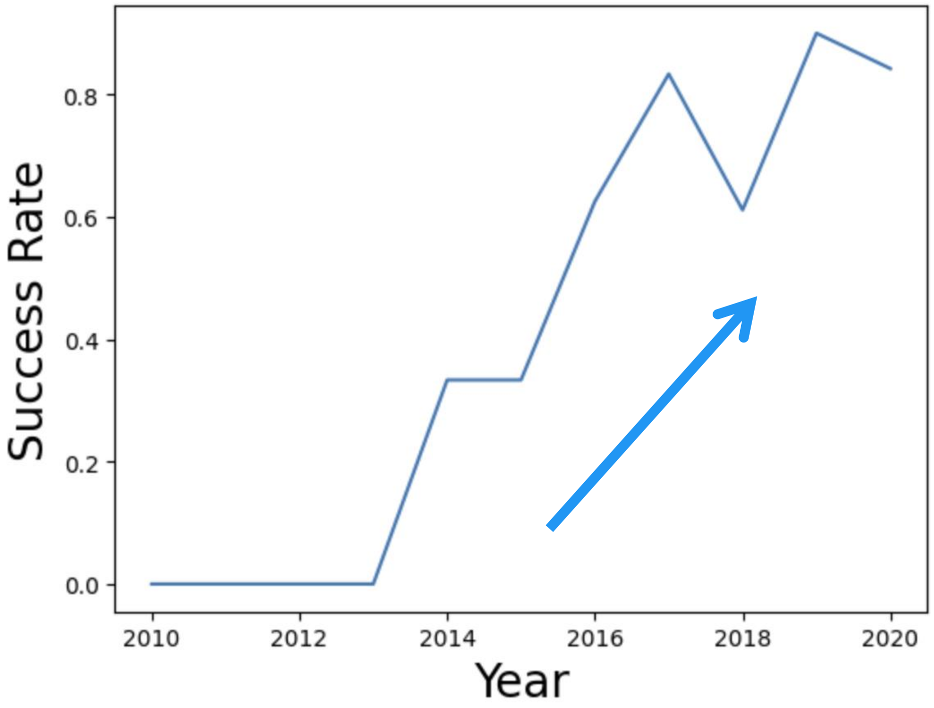
Analyze

# Launch Success Yearly Trend

**2010 to 2020 we have to 90 flight numbers**

- The success rate have been increasing since 2013 to 2020

Success Rate




Payload Mass

Analyze

# Analyze

## Analysis with SQL

# All Launch Site Names

**df_1**
4 location sites
101 flight numbers

| | Launch_Site |
|---|---|
| 0 | CCAFS LC-40 |
| 1 | VAFB SLC-4E |
| 2 | KSC LC-39A |
| 3 | CCAFS SLC-40 |

Kaggle

```
df_q = pd.read_sql('select distinct Launch_Site from spacexdata', conn)
df_q
```

SQL

```
%sql select distinct(LAUNCH_SITE) from SPACEXTBL
```

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

- Using SQL Data, we acquire 4 Launch Sites from spaceX data 2010 to 2020
- The data in SQL differ from data during wrangling phase. (following the assignment instructions)

Analyze

# Launch Site Names Begin with 'CCA'

SQL

Kaggle

```
%sql select * from SPACEXTBL where LAUNCH_SITE like 'CCA%' limit 5
```

```
df_q = pd.read_sql("select *  from spacexdata where Launch_Site like 'CCA%' limit 5", conn)
df_q
```

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

| | index | Date | Time_(UTC) | Booster_Version | Launch_Site | Payload | PAYLOAD_MASS__KG_ | Orbit | Customer | Mission_Outcome | Landing_Outcome |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 2010-06-04 00:00:00 | 18:45:00 | F9 v1.0 B0003 | CCAFS LC-40 | Dragon Spacecraft Qualification Unit | 0 | LEO | SpaceX | Success | Failure (parachute) |
| 1 | 1 | 2010-12-08 00:00:00 | 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) |
| 2 | 2 | 2012-05-22 00:00:00 | 7:44:00 | F9 v1.0 B0005 | CCAFS LC-40 | Dragon demo flight C2 | 525 | LEO (ISS) | NASA (COTS) | Success | No attempt |
| 3 | 3 | 2012-10-08 00:00:00 | 0:35:00 | F9 v1.0 B0006 | CCAFS LC-40 | SpaceX CRS-1 | 500 | LEO (ISS) | NASA (CRS) | Success | No attempt |
| 4 | 4 | 2013-03-01 00:00:00 | 15:10:00 | F9 v1.0 B0007 | CCAFS LC-40 | SpaceX CRS-2 | 677 | LEO (ISS) | NASA (CRS) | Success | No attempt |

- The 5 rockets launched from CCSFS LC-40 began their launches in June 2010. Two rockets were launched in 2010, and two were launched in 2012. The displayed data only shows 5 launches
- All 5 launches had a Low Earth Orbit (LEO) trajectory, and all of them were successful

Analyze

# Total Payload Mass

| | Customer | Total_Payload_Mass |
|---|---|---|
| 0 | NASA (CRS) | 45596 |

Kaggle

```
df_q = pd.read_sql("select Customer, sum(PAYLOAD_MASS__KG_) as Total_Payload_Mass from spacexdata where Customer='NASA (CRS)' group by Customer", conn)
df_q
```

SQL

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

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

- For NASA (CRS), the total payload was 45,596 kg

Analyze

# Average Payload Mass F9 v.1.1

| | Booster_Version | Avg_Payload_Mass |
|---|---|---|
| 0 | F9 v1.1 | 2928.4 |

Kaggle

```
df_q = pd.read_sql("select Booster_Version, avg(PAYLOAD_MASS__KG_) as Avg_Payload_Mass from spacexdata where Booster_Version='F9 v1.1' group by Booster_Versio
df_q
```

SQL

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

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

- The average payload mass served by F9 v.1.1 Booster was 2,928.4 kg

Analyze

# First Successful Ground Landing Date

| min(DATE) |
| --- |
| 2015-12-22 |

Kaggle

```
df_q = pd.read_sql("select *, min(Date) as min_date from spacexdata where Landing_Outcome='Success (ground pad)'", conn)
df_q
```

SQL

```
%sql select min(DATE) from SPACEXTBL where Landing_Outcome = 'Success (ground pad)'
```

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

- The first successful ground landing occurred in December 2015

Analyze

# Successful Drone Ship Landing with Payload between 4000 and 6000

| | Booster_Version |
|---|---|
| 0 | F9 FT B1022 |
| 1 | F9 FT B1026 |
| 2 | F9 FT B1021.2 |
| 3 | F9 FT B1031.2 |

Kaggle

```
df_q = pd.read_sql("select distinct Booster_Version from spacexdata where Landing_Outcome='Success (drone ship)' and PAYLOAD_MASS__KG_ between 4000 and 6000",
df_q
```

SQL

```
%sql select BOOSTER_VERSION from SPACEXTBL where Landing_Outcome = 'Success (drone ship)' and PAYLOAD_MASS__KG_ > 4000 and
```

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

- For payload masses between 4,000 and 6,000 kg, the Falcon 9 FT Booster with version B10 includes series of 22, 26, 21.2, and 31.2

Analyze

# Total Number of Successful and Failure Mission Outcomes

| | Mission_Outcome | count(*) |
|---|---|---|
| **0** | Failure | 1 |
| **1** | Success | 100 |

Kaggle

```
df_q = pd.read_sql("select substr(Mission_Outcome,1,7) as Mission_Outcome, count(*) from spacexdata  group by 1", conn)
df_q
```

SQL

```
%sql select case  when Mission_Outcome like 'Success%' then 'Success' else Mission_Outcome end as outcome,COUNT(*) as total_count from S
```

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

- Total Successful mission 100 and 1 is a failure mission

Analyze

# Booster Carried Maximum Payload

| 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 |

Kaggle

```
df_q = pd.read_sql("select distinct Booster_Version from spacexdata where PAYLOAD_MASS__KG_ = (select max(PAYLOAD_MASS__KG_) from spacexdata)", conn)
df_q
```

SQL

```
%sql select BOOSTER_VERSION from SPACEXTBL where PAYLOAD_MASS__KG_ = (select max(PAYLOAD_MASS__KG_) from SPACEXTBL)
```

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

- The Falcon 9 B5 Booster which carried maximum payload version B10 includes series of 48 to 60

Analyze

# 2015 Launch Records

| | Month | Landing_Outcome | Booster_Version | Launch_Site |
|---|---|---|---|---|
| **0** | 01 | Failure (drone ship) | F9 v1.1 B1012 | CCAFS LC-40 |
| **1** | 04 | Failure (drone ship) | F9 v1.1 B1015 | CCAFS LC-40 |

Kaggle

```
df_q = pd.read_sql("select distinct Landing_Outcome, Booster_Version, Launch_Site from spacexdata where Landing_Outcome='Failure (drone ship)'", conn)
df_q
```

SQL

```
%sql select substr(Date, 6, 2) as Month, substr(Date, 0, 5) as Year, Landing_Outcome, Booster_Version, Launch_Site from SPA(
```

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

- In 2015 there was two failure (drone ship) launches, both in CCAFS LC-40 with booster version v1.1 B10 serie 12 and 15

Analyze

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

| | Landing_Outcome | count(*) |
|---|---|---|
| 0 | No attempt | 10 |
| 1 | Success (drone ship) | 5 |
| 2 | Failure (drone ship) | 5 |
| 3 | Success (ground pad) | 3 |
| 4 | Controlled (ocean) | 3 |
| 5 | Uncontrolled (ocean) | 2 |
| 6 | Precluded (drone ship) | 1 |

Kaggle

```
df_q = pd.read_sql("select Landing_Outcome, count(*) from spacexdata where Date between '2011-06-04' and '2017-03-20' group by Landing_Outcome order by 2 desc
df_q
```

SQL

```
%sql select Landing_Outcome, count(*) from SPACEXTBL  where Date between '2011-06-04' and '2017-03-20' group by Landing_Out
```

- The most landing outcome occurance of 10 due to no attempt
- Drone ship has success and failure tied in 5 times
- Success landed in ground pad also draw to Controlled in ocean with 3 times

Analyze

# Section 3. Map

## Launch Sites Proximity Analysis

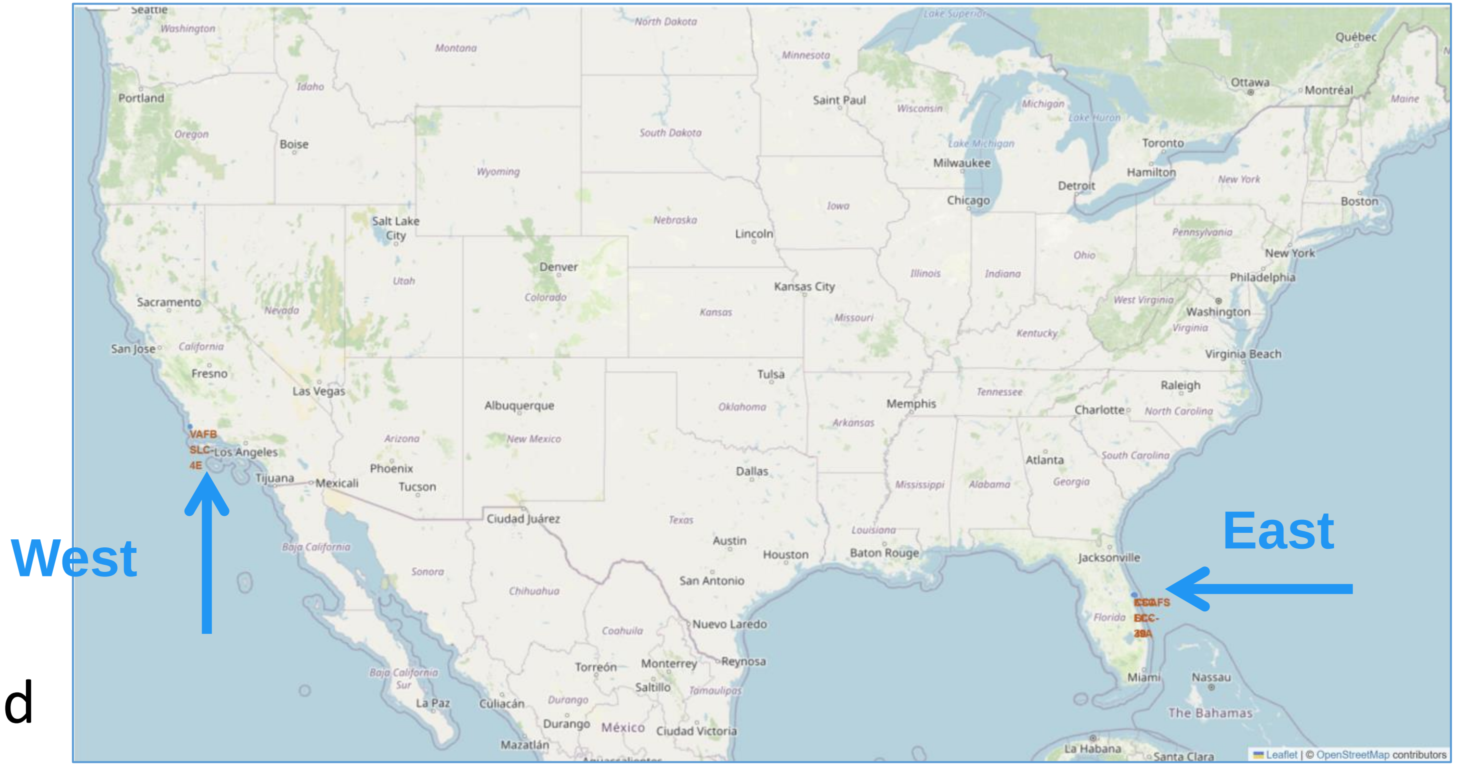
# Analyze

## Map Visualization

# Launch Site Map

**We identify 2 Launch Area**

- West, VAFB SLC-4E on Vanderberg State
- East, KSC LC-39A on Kennedy and the CCAFS SLC-40 and CCAFS LC-40 on Cape Canaveral




**df**
4 location sites
56 flight numbers

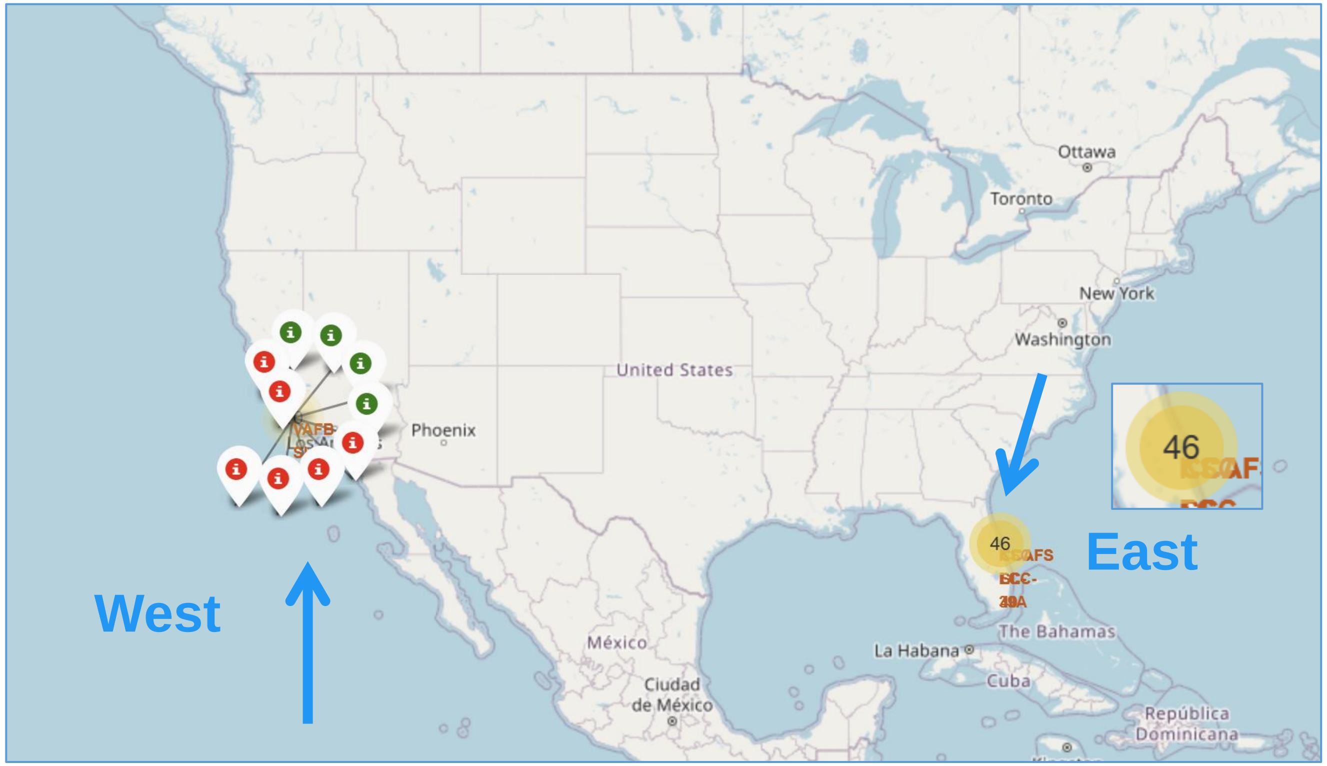
Analyze

# West Launch Site Map

**In the West Area (VAFB SLC-4E )**

- The map shows there is 10 launches
- 4 successful first landing or 40% success rate

It shows 46 launches occurred in East Area

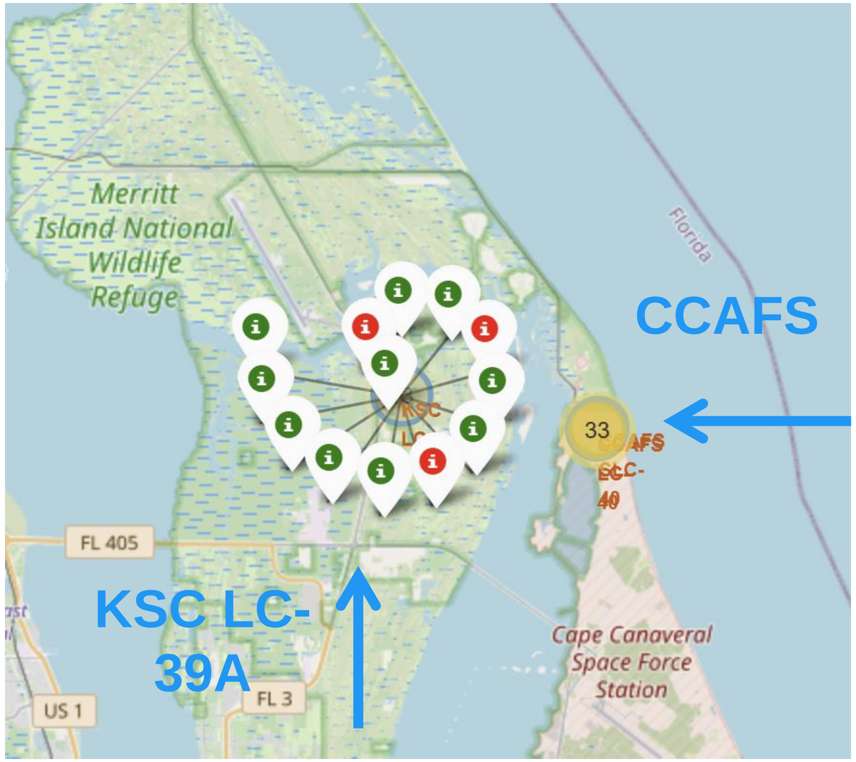



Analyze

# East Launch Site Map

**In the East Area (KSC LC-39A )**

- 10 successful first landing or more than 70% success rate




Analyze

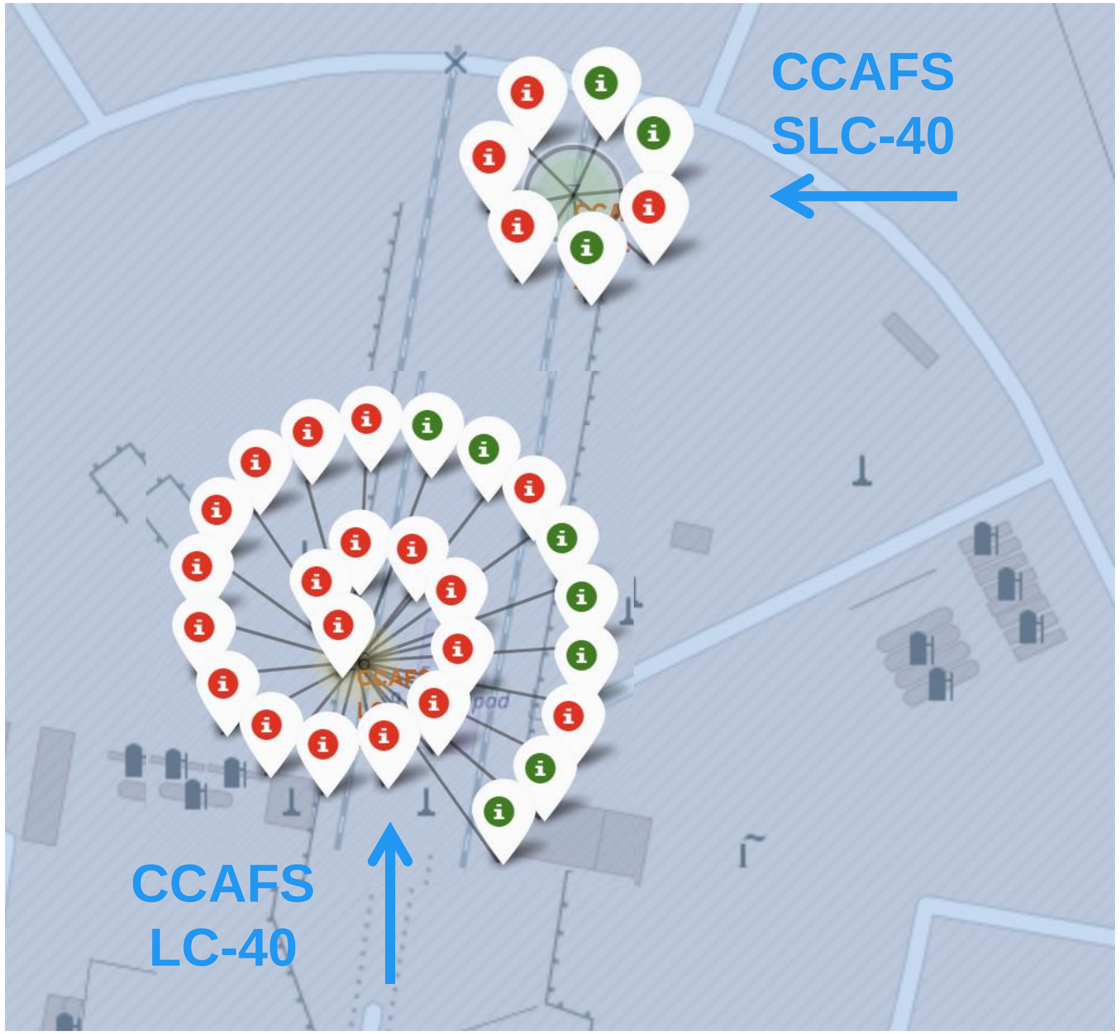
# East Launch Site Map

**In the East Area (CAFS LC-40 )**

- 7 successful first landing or less than 30% success rate

**In the East Area (CAFS SLC-40 )**

- 3 successful first landing or less than 50% success rate




Analyze

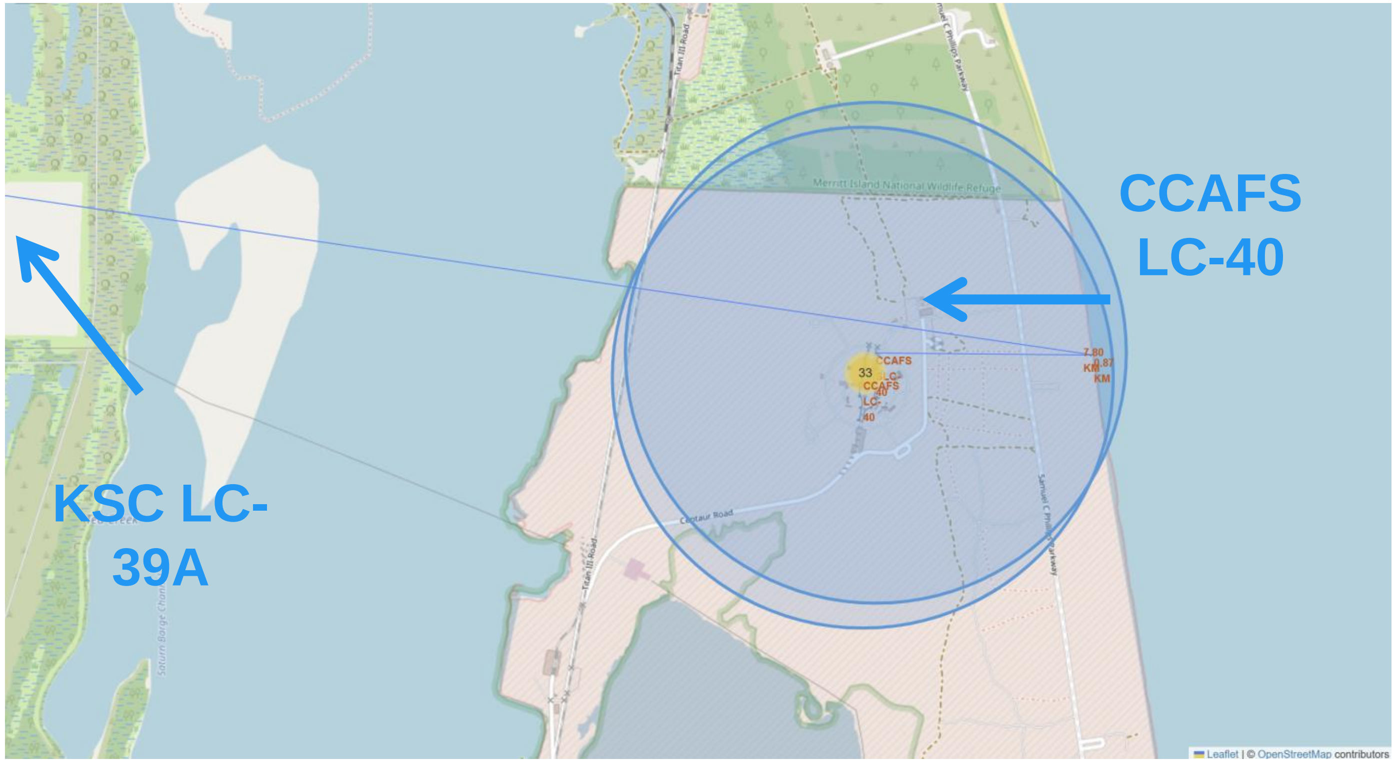
# East Launch Site Map

**In the East Area (KSC LC-39A )**

- The distance 7,8 km to the CAFS SLC-40 nearest Coastline

**In the East Area (CAFS SLC-40 )**

- The distance 0,87 km to its nearest coastline

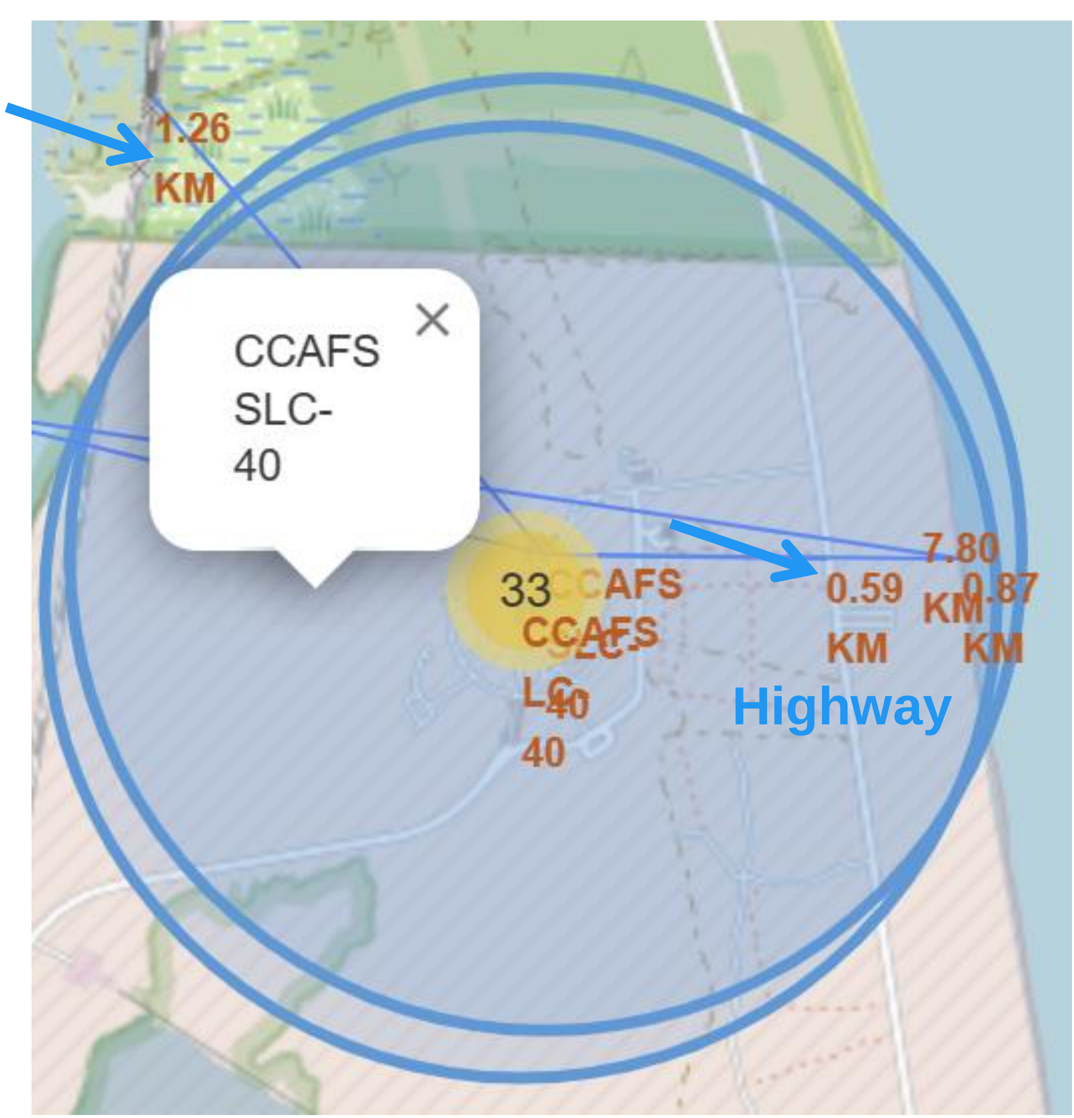



Analyze

# CCAFS LC-40 Launch Site Map

**In the East Area (CAFS SLC-40 )**

- The distance 1,26 km to its nearest **railway**, 0,59km to its nearest **highway** and 23,47 km to its nearest **city**





Analyze

# Section 4. Dashboard

## Build a Dashboard with Plotly Dash

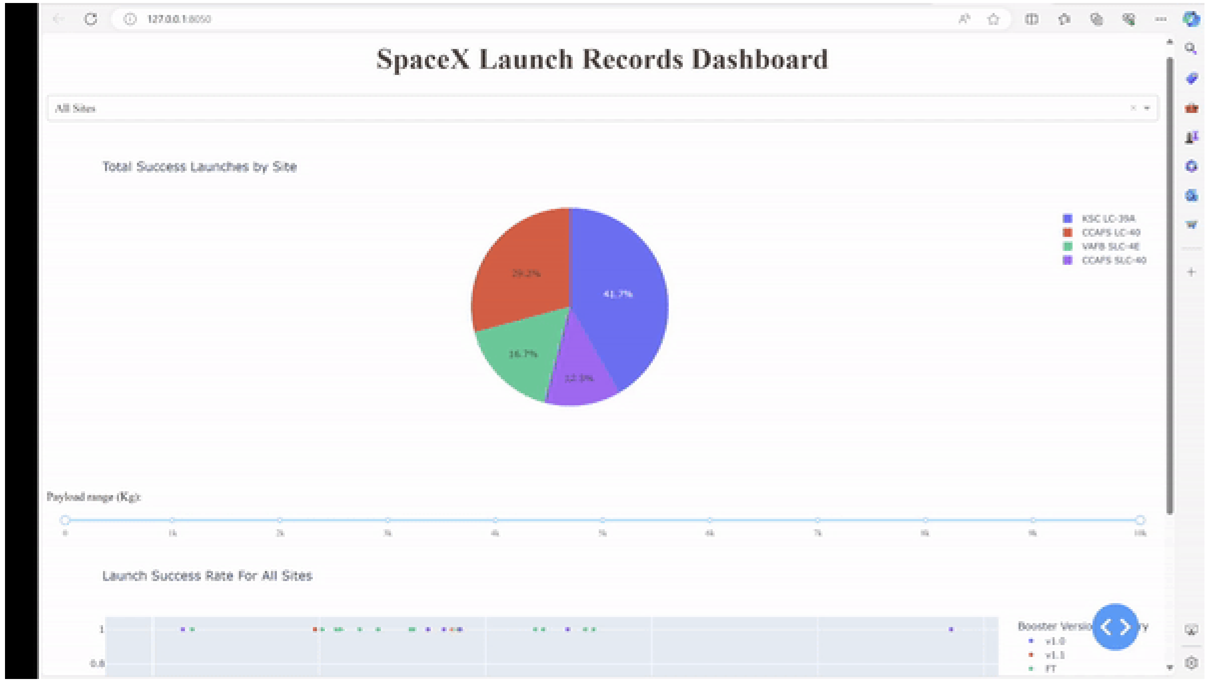
# Analyze

## Interactive Dashboard

# All Site Success Launches

**Total Success Launches by Site**

- KSC LC-39A has the highest success  40% of total launches compare the others



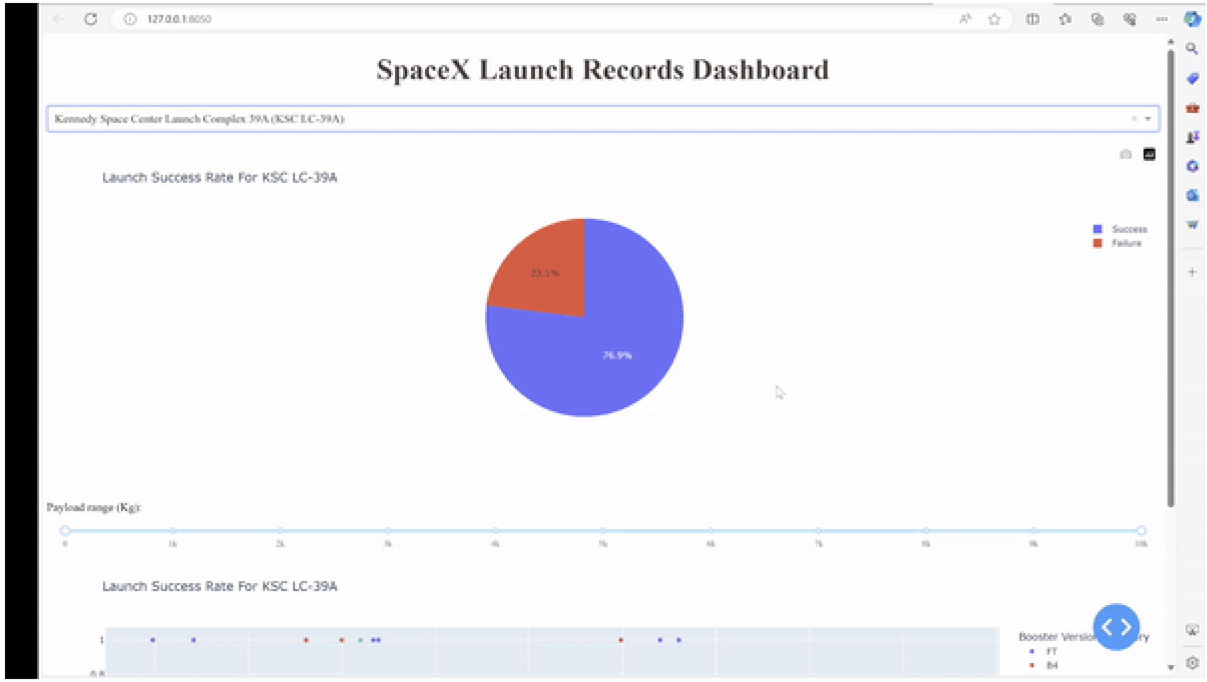

**df**
4 location sites
56 flight numbers

Analyze

# The Highest Success Launches

**Total Success Launches by Site**

- KSC LC-39A has the highest success rate of 70%




Analyze

# Payload vs Launch Outcome

**In regards to payload mass**

- FT and B4 have more successful landing
- Range from 0 to 6K and above 8K, the number of successful landing and failure is almost equal.
- Between 6k to 8k, 3 fail launches.
- No correlation to landing success




Analyze

# Section 5. Model

## Predictive Analysis (Classification)

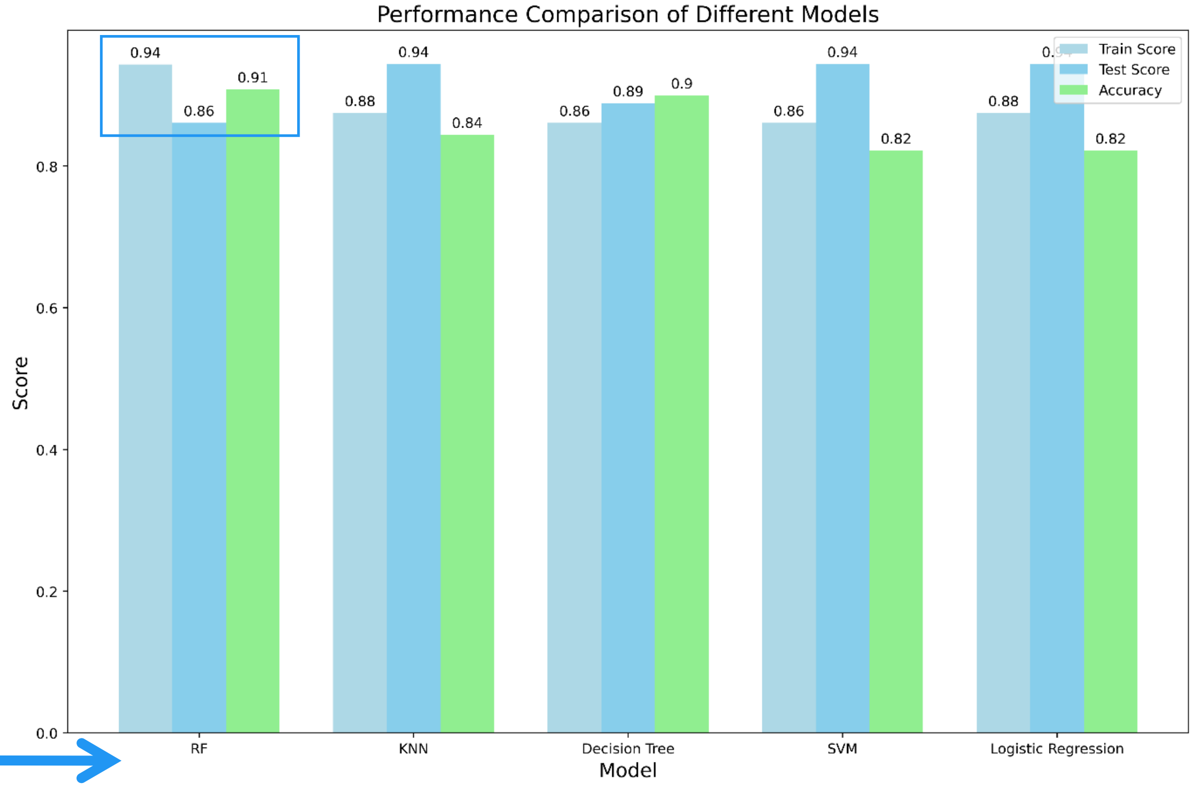
# Models and Findings

# Classification Accuracy

**df**
3 location sites
90 flight numbers

Score

Model

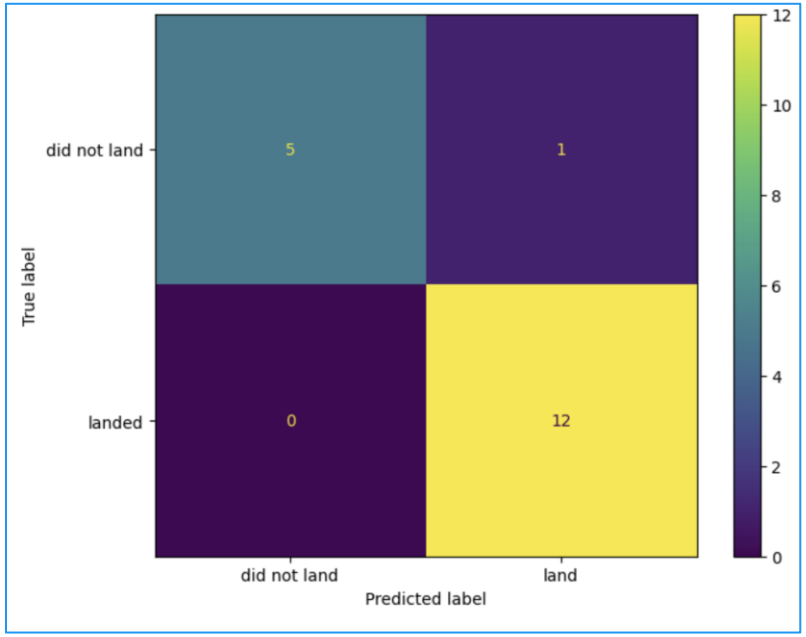



1. KNN, SVM and Logistic Regression performs reasonably well on the test set with a high score. However, the accuracy is slightly lower compared to some other models.
2. KNN, SVM and Logistic Regression have high test scores but may be overfitting.
3. Decision Tree and Random Forest have balanced performance.

Analyze

# Confusion Matrix

**df**
3 location sites
90 flight numbers




```
              precision    recall  f1-score   support

did not land       1.00      0.50      0.67         6
        land       0.80      1.00      0.89        12

    accuracy                           0.83        18
   macro avg       0.90      0.75      0.78        18
weighted avg       0.87      0.83      0.81        18

[[ 3  3]
 [ 0 12]]


Accuracy Score: 0.83
Mean Cross-Validation Accuracy: 0.82
ROC AUC: 0.87
```

**Confusion Matrix:**

- In this case, there are 3 instances of "did not land" correctly classified as such, 3 instances incorrectly classified as "land,"
- 12 instances of "land" correctly classified as such, with 0 instances incorrectly classified as "did not land.“

Overall, a good performance with high precision and recall for the “land” class and slightly lower performance for the did not “land class”

**Evaluation Metrics:**

1. The accuracy 83% of instances were correctly classified
2. 82% suggesting consistent performance across subset data
3. Good discrimination between positive and negative classes to 87%

The model performs well overall and generalizes effectively to unseen data.

Analyze

# Conclusion

# Conclussion

We decided to choose **Random forest** which performs well on the test set 94% with the highest accuracy 91% score among all models. The feature importance of the Random forrest as follows:

1. Reused count
2. Legs
3. Grid fins
4. Flight number
5. Payload mass
6. Block
7. Orbit GTO
8. Landing pad with last 3 numbers or letters 7ca

Next Steps

- Considering XGBoost and Kmeans
- Analyze the feature importance from random forest further
- Review the hyperparameter tuning

# Appendix

# Appendix

Documents:

- https://www.kaggle.com/code/wahyuardhitama/Task008-P01-DS-SpaceX-Falcon-20240409
- https://github.com/whyzie/Task008-P01-DS-SpaceX-Falcon-20240409