

# Winning Space Race with Data Science

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# Outline

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

# Executive Summary

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- SpaceX is one of the best companies over the world for space rockets launches. They are making space missions cheaper,.
- In this report, I made analysis, called Space Y that would like to do same work like SpaceX. my job is to use data science instead of rocket science to discover the possibility of competing with SpaceX. I have done data analytics, modeling ML algorithms and creating dashboards.

# Introduction

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- These missions require huge amounts of money where a launch of one space rocket costs in average 165 million dollars. SpaceX did this very less cost due to its unique and advanced technologies in returning the first stage of rocket structure.
- It come back in Earth the first stage of rockets return through a safe landing we will analysis the payload mass of rocket, launch location, rocket orbit, and more by analyzing and visualizing these information through the data science methodology provided by IBM

Section 1

# Methodology

# Methodology

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## Executive Summary

- Data collection methodology:
  - The data was collected using SpaceX rest API and Wikipedia webpages
- Perform data wrangling
  - The data was preprocessed using Pandas and NumPy, we use: standardization , OneHot encoding, unnecessary columns removal, data normalization and.
- Perform exploratory data analysis (EDA) using visualization and SQL
- Using libraries such as seaborn and matplotlib for visualization and SQL for data queries
- Perform interactive visual analytics using Folium and Plotly Dash
- Using the following libraries Folium and Plotly Dash
- Perform predictive analysis using classification models
  - Starting with splitting the data into train and test sets
  - Identifying the best algorithm and parameters through hyperparameters tuning using Grid Search
  - Adopting the best algorithm and parameters for the purpose of model deployment.

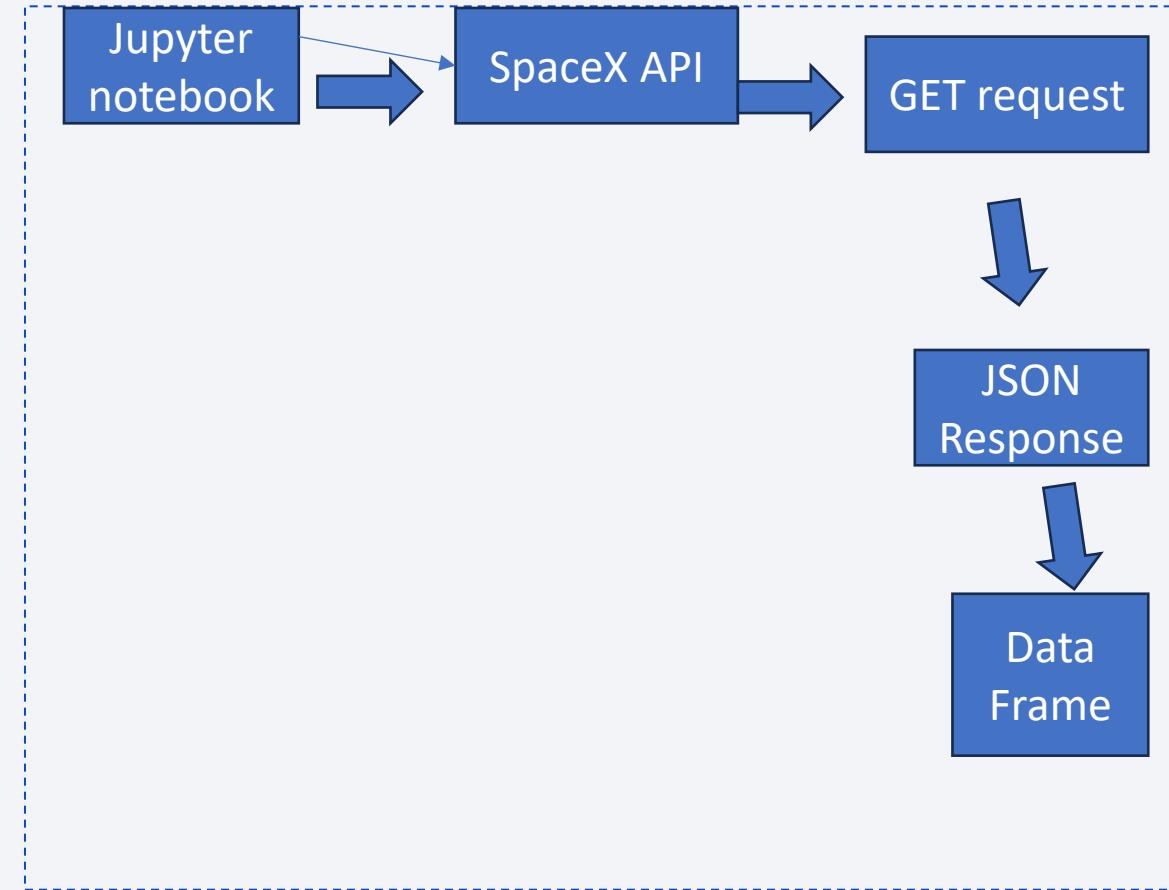
# Data Collection

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- Two sources:
- SpaceX API: REST API for launch, rocket, core, launchpad, and landing pad data.
- Wikipedia: Free online encyclopedia,

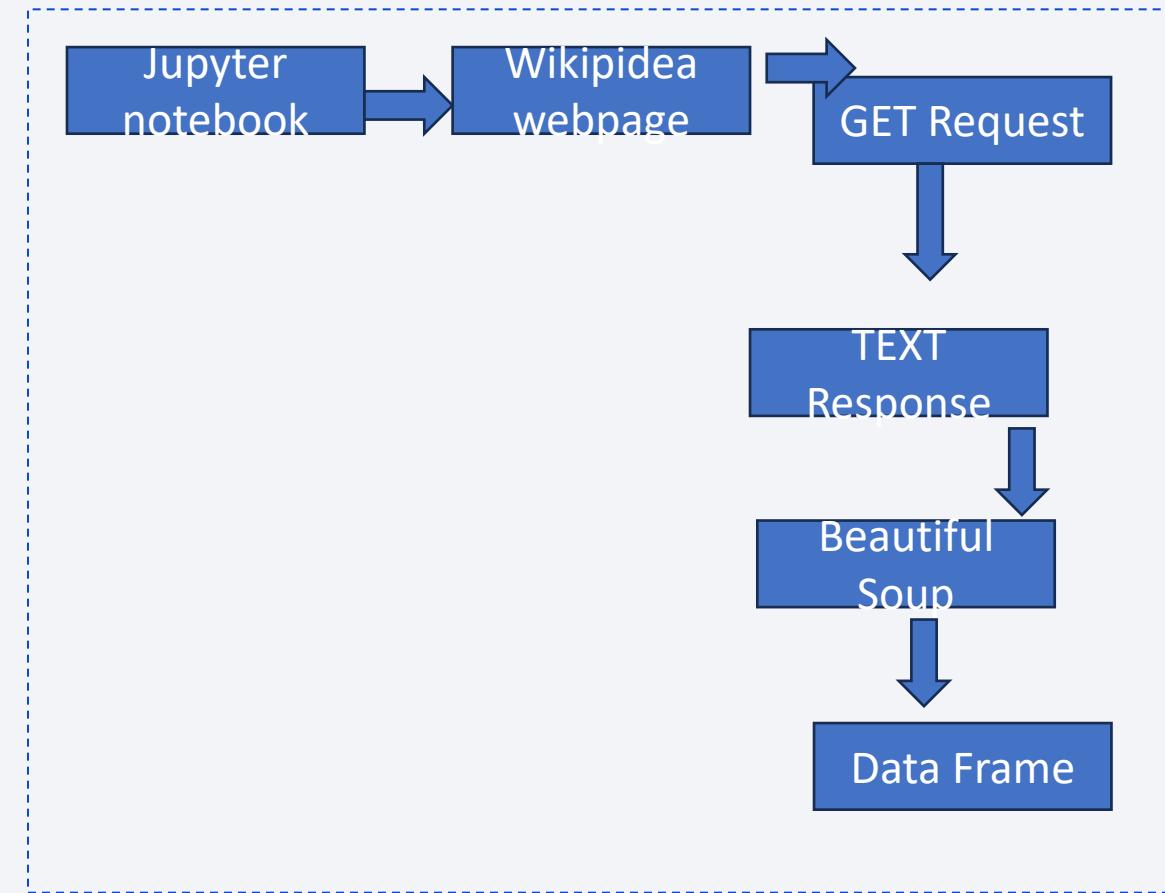
# Data Collection – SpaceX API

- importing the required libraries such as pandas, NumPy and Request, then we established a URL GET request, this request is raised as JSON file to be finally converted to a data frame GitHub URL of the completed SpaceX API calls notebook Click Here([https://github.com/arpanha/deritla-stack/test\\_arpan/blob/main / 01-Data Collection API Lab.ipynb](https://github.com/arpanha/deritla-stack/test_arpan/blob/main / 01-Data Collection API Lab.ipynb))



# Data Collection - Scraping

- Python libraries beautiful soup and request to perform a webpage on Wikipedia called “Space X Falcon 9 First Stage Landing Prediction” as a data source, then initialized an HTTP Get Request and the response was as a text format, then used the beautiful soup and later to a pandas' data frame
- GitHub URL of the completed web scrapping task notebook click [here](https://github.com/arpanhalderitla-stack/test_arpan/blob/main/ 02-Data Collection with Web Scraping lab.ipynb)([https://github.com/arpanhalderitla-stack/test\\_arpan/blob/main/ 02-Data Collection with Web Scraping lab.ipynb](https://github.com/arpanhalderitla-stack/test_arpan/blob/main/ 02-Data Collection with Web Scraping lab.ipynb))



# Data Wrangling

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- importing pandas and NumPy, loading our collected data in the previous stage to perform our exploratory data.
- - Loading the collected dataset > - Identifying and calculating the percentage of the missing values in each attribute> Identifying which columns are numerical and categorical > Calculating the number of launches on each site > - Calculating the number and occurrence of each orbit > Creating a landing outcome label from Outcome column > determining the success rate of returning the first stage of the rocket
- GitHub URL of the completed Data wrangling notebook Click Here([https://github.com/arpanhalderitla-stack/test\\_arpan/blob/main/03-Data Wrangling lab.ipynb](https://github.com/arpanhalderitla-stack/test_arpan/blob/main/03-Data%20Wrangling%20lab.ipynb))

# EDA with Data Visualization

- In this phase we completed our EDA process through finding the correlation between the features and the target using seaborn and matplotlib .
- GitHub URL of the completed EDA with data visualization notebook, Click Here ([https://github.com/arpanhalderitla-stack/test\\_arpan/blob/main/05-EDA with Visualization lab.ipynb](https://github.com/arpanhalderitla-stack/test_arpan/blob/main/05-EDA%20with%20Visualization%20lab.ipynb)

EDA with Data Visualization Stages

Visualize the relationship between Flight Number and Launch Site



Visualize the relationship between success rate of each orbit type



Visualize the relationship between Payload and Launch Site



Visualize the relationship between Flight Number and Orbit type



Visualize the relationship between Payload and Orbit type



Visualize the launch success yearly trend



# EDA with SQL

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- Display the names of the unique launch sites in the space mission.
- • Display 5 records where launch sites begin with the string 'CCA'.
- • Display the total payload mass carried by boosters launched by NASA (CRS). •
- List the date when the first successful landing outcome in ground pad was achieved. •
- List the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 6000. •
- List the total number of successful and failure mission outcomes. •
- GitHub URL of the completed EDA with SQL notebook, Click Here([https://github.com/arpanhalderitla-stack/test\\_arpan/blob/main/04-EDA with SQL.ipynb](https://github.com/arpanhalderitla-stack/test_arpan/blob/main/04-EDA%20with%20SQL.ipynb))

# Build an Interactive Map with Folium

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- In this stage we used folium library to represent our work as geospatial data by drawing markers circles and lines on an interactive map. •
- GitHub URL :, Click Here([https://github.com/arpanhalderitla-stack/test\\_arpan/blob/main/06-Interactive Visual Analytics with Folium.ipynb](https://github.com/arpanhalderitla-stack/test_arpan/blob/main/06-Interactive%20Visual%20Analytics%20with%20Folium.ipynb))

We started our interactive map by drawing 4 circles on 4 different sites belongs to Falcon 9 rockets lunches have the following information:

- launch Site Lat Long CCAFS LC-40 28.562302 -80.577356 CCAFS
- We started our interactive map by drawing 4 circles on 4 different sites belongs to Falcon 9 rockets lunches have the following information:
- We put markers to on the same sites to represent the successful/failed first stage of rockets return using marker objects :
- Finally, we calculated the distances between the launch site (CCAFS LC40) to its proximities 1-the closest city, 2-coastline, and 3-highway. Then we drew polylines to represent these distances using PolyLine object.
- We put markers to on the same sites to represent the successful/failed first stage of rockets return using marker objects :
- Finally, we calculated the distances between the launch site (CCAFS LC40) to its proximities 1-the closest city, 2-coastline, and 3-highway. Then we drew polylines to represent these distances using PolyLine object.

# Build a Dashboard with Plotly Dash

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- 1- We added a dropdown list to enable Launch Site selection including the following options: All Sites, CCAFS LC-40, CCAFS SLC-40, VAFB SLC-4E, KSC LC-39A
- 2- we added a slider to select payload which ranges from 0 -10000 4- finally we added a scatter chart to show the correlation between payload and launch success
- 3- we added a pie chart to show the total successful launches count for all sites
- GitHub URL of the completed Building an Interactive Dashboard with Plotly Dash notebook, Click Here([https://github.com/arpanhalderitla-stack/test\\_arpan/blob/main/06-Interactive Visual Analytics with Folium.ipynb](https://github.com/arpanhalderitla-stack/test_arpan/blob/main/06-Interactive%20Visual%20Analytics%20with%20Folium.ipynb))

# Predictive Analysis (Classification)

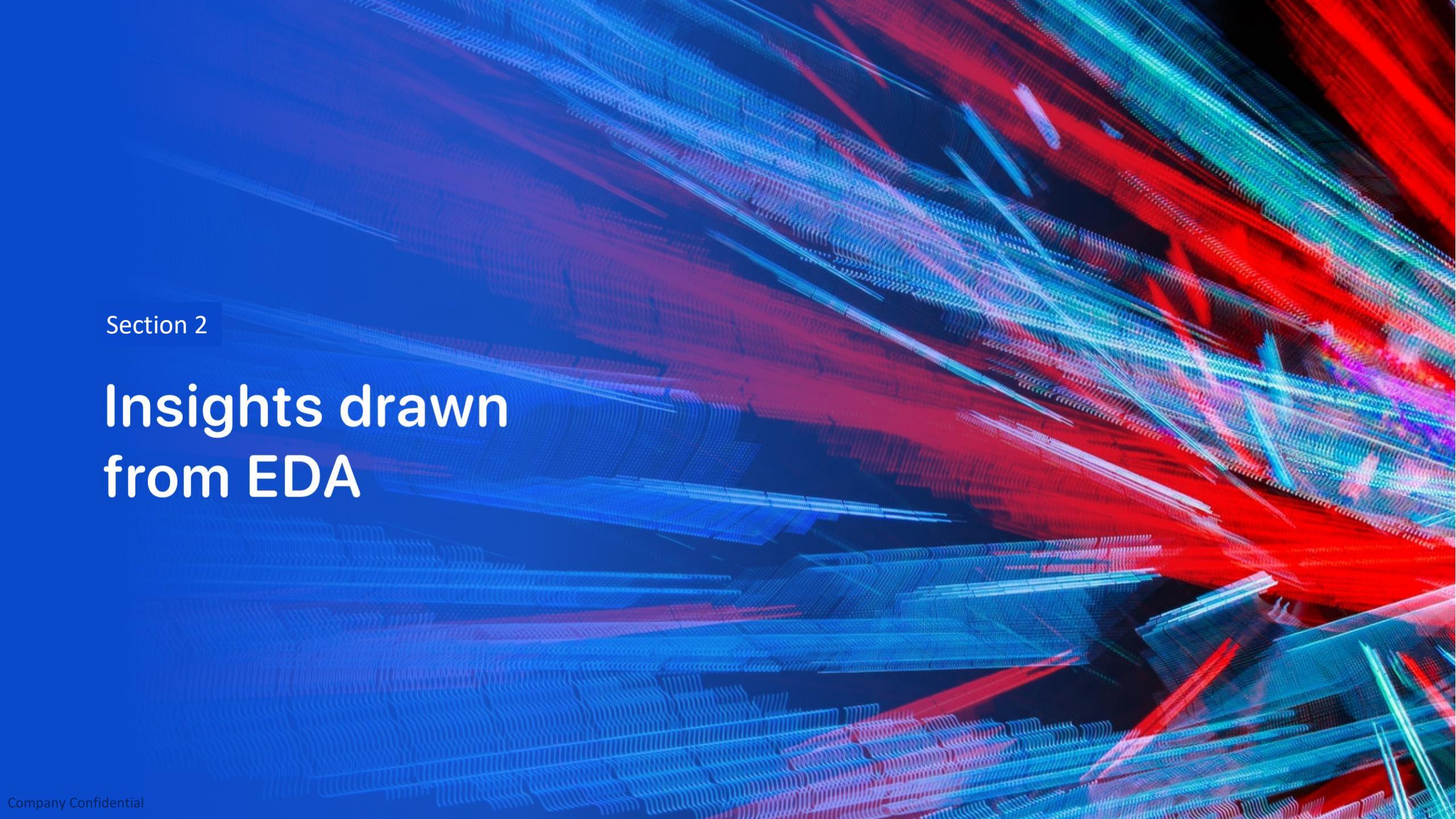
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- - Importing the required libraries.
- 2- Loading of cleaned data.
- 3- Standardizing the data to prevent the bias.
- 4- splitting the data into 20% for testing data and 80% training data.
- 5- Initializing 4 different classification algorithms:
  - Logistic Regression (LR)
  - Support Vector Machine (SVM)
  - Decision Tree (DT)
  - K nearest neighbors (KNN)
- 6- find parameters 7- Confusion matrix , F1 score, Jaccard Score for the purpose of using the best model among the algorithms above.
- Importing The Required Libraries > Loading the cleaned data > Standardizing the data > Using Grid Search technique > Initializing classification algorithms > Splitting the data into Test/Train sets > Using Evaluation techniques

# Results

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

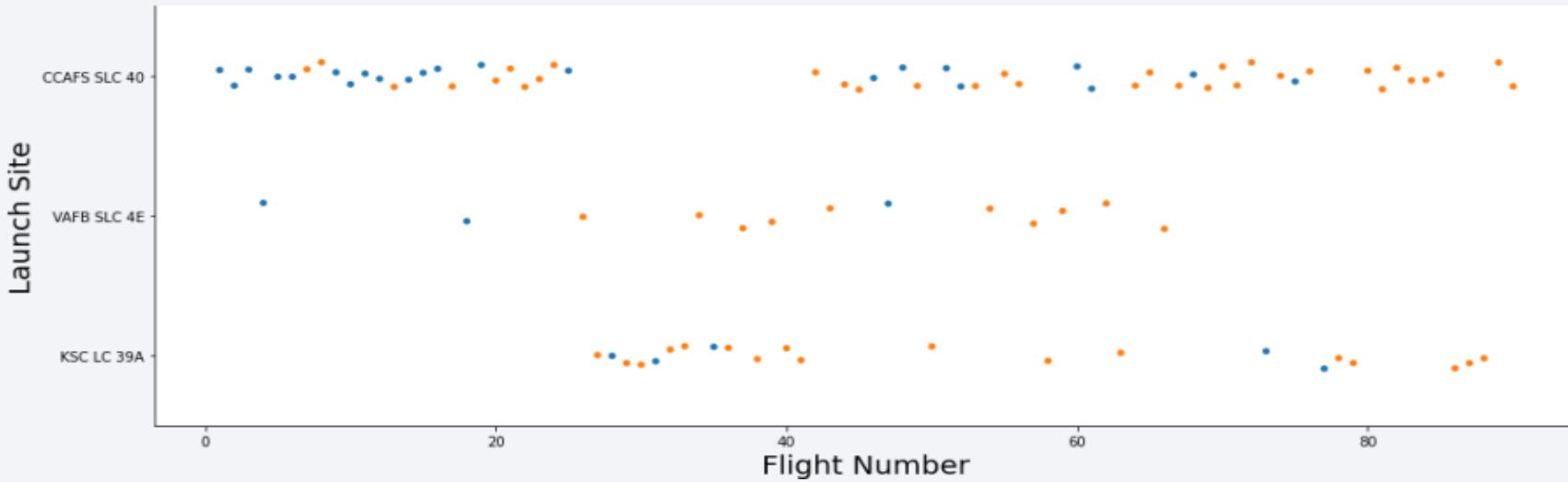
The background of the slide features a complex, abstract digital visualization. It consists of numerous thin, glowing lines that create a sense of depth and motion. The lines are primarily blue and red, with some green and purple highlights. They form a grid-like structure that curves and twists across the frame, resembling a three-dimensional space or a network of data points. The overall effect is futuristic and dynamic.

Section 2

## Insights drawn from EDA

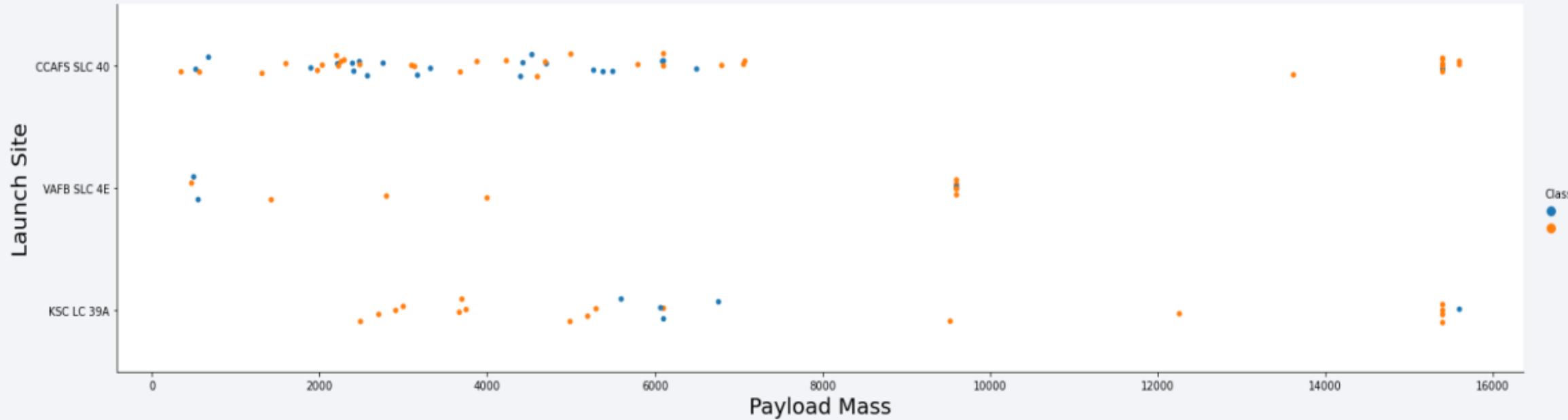
# Flight Number vs. Launch Site

- Show a scatter plot of Flight Number vs. Launch Site



1- CCAFS SLC 40 : is the most usable site for launching SpaceX's rockets and it has 55 trials, 33 of them are successful and 22 of them are failed # 60% success rate  
2- VAFB SLC 4E : is the least usable site for launching SpaceX's rockets and it has 13 trials, 10 of them are successful and 03 of them are failed # 77% success rate  
3- VAFB SLC 4E : is a moderate site in terms of launching SpaceX's rockets and it has 22 trials, 17 of them are successful and 05 of them are failed # 77% success rate

# Payload vs. Launch Site



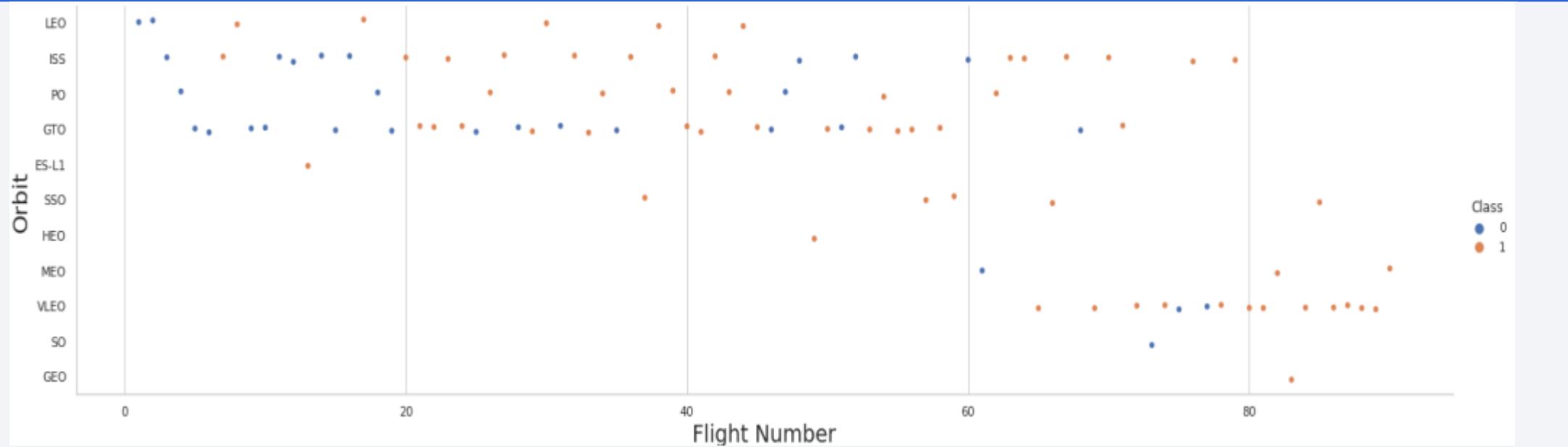
- We do not see any strong relationship between the payload mass and the success of first stage return

# Success Rate vs. Orbit Type

- According to the bar plot :  
The best orbits in terms of successful first stage returns are ['ES-L1', 'GEO', HEO, SSO] Where the worst orbit is 'GTO' , therefore we need to understand why it is the worst to avoid the failure of first stage return.

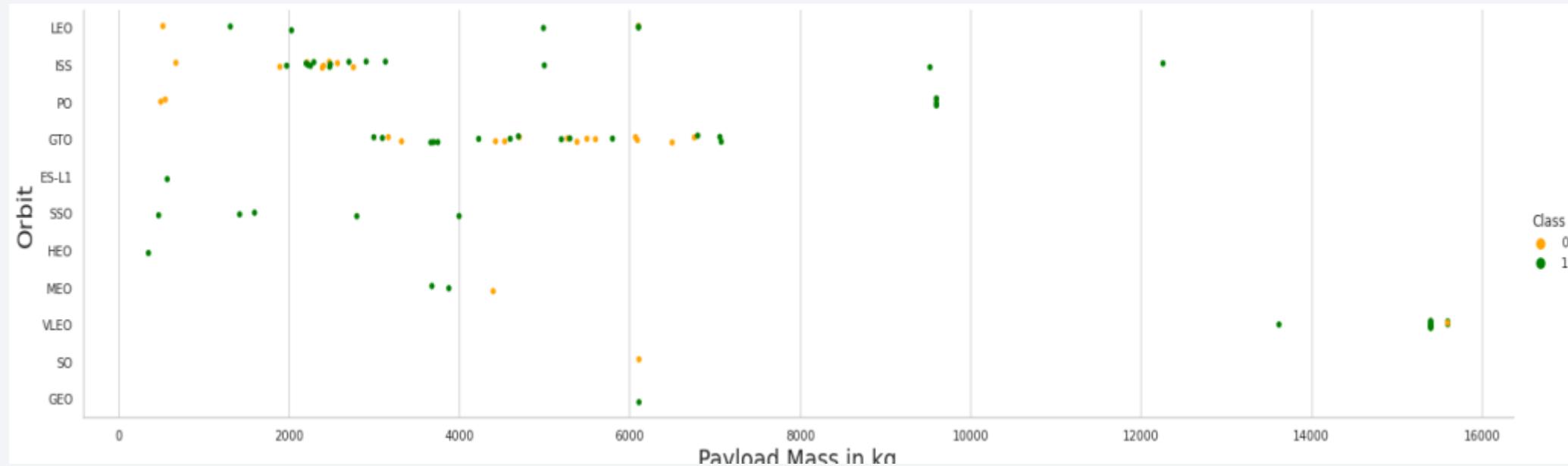


# Flight Number vs. Orbit Type



- We can see that in the LEO orbit the Success appears related to the number of flights;

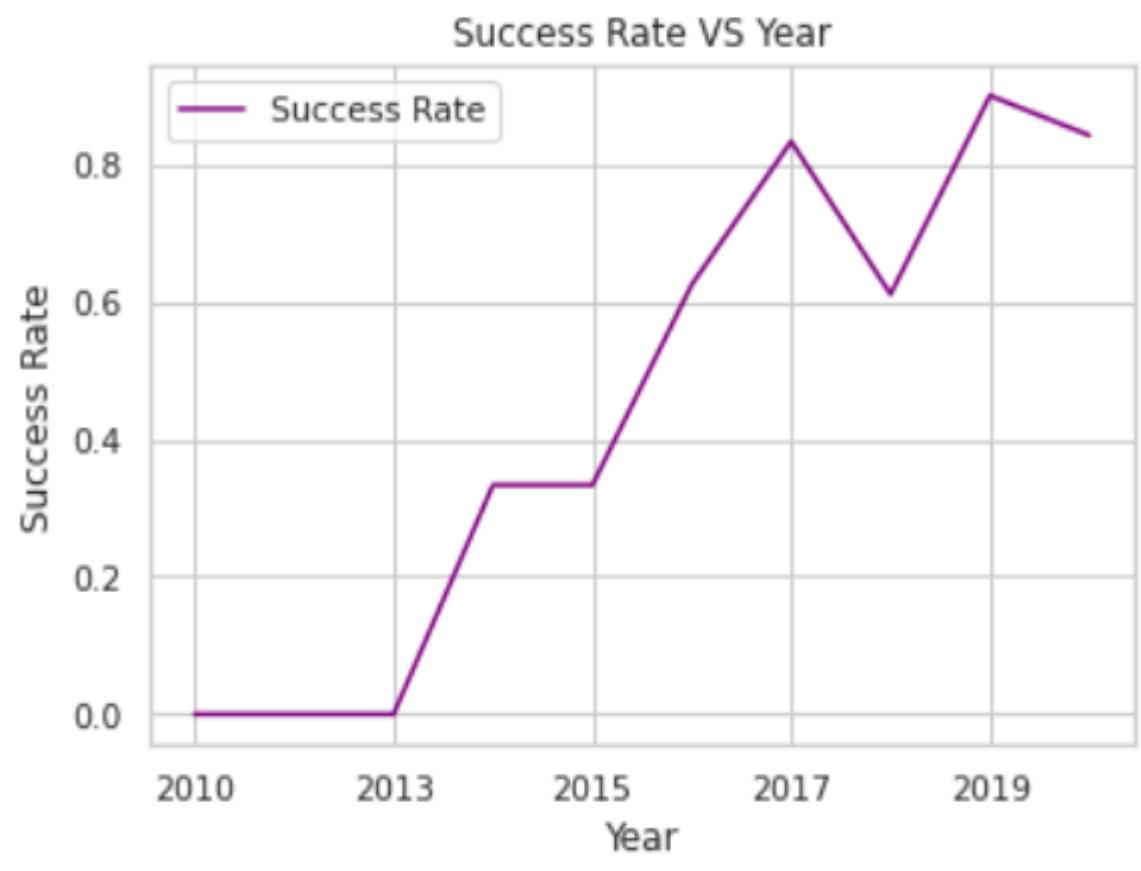
# Payload vs. Orbit Type



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

# Launch Success Yearly Trend

- We can observe that the success rate since 2013 and increasing till 2020



# All Launch Site Names

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- we have 4 distinct sites for rockets launches listed in the Table above.

*Display the names of the unique launch sites in the space mission*

```
*sql select distinct launch_site from SPACEXTBL
```

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

# Launch Site Names Begin with 'CCA'

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

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

DATE	time_utc	booster_version	launch_site	payload	payload_mass_kg	orbit	customer	mission_outcome	landing_outc
2010-06-04	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
2010-12-08	15:43:00	F9 v1.0 B0004	CCAFS LC-40	Dragon demo flight C1, two CubeSats, barrel of Brouere cheese	0	LEO (ISS)	NASA (COTS) NRO	Success	Failure (parachute)
2012-05-22	07:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)	Success	No attempt
2012-10-08	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
2013-03-01	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attempt

# Total Payload Mass

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- The total amount of payload that moved to the outer space by NASA through SpaceX rockets equals to 45596 Kg which is equal to 50.261 Us ton.

***Display the total payload mass carried by boosters launched by NASA (CRS)***

```
%sql select sum(payload_mass__kg_) from SPACEXTBL where customer = 'NASA (CRS)';
```

1
45596

# Average Payload Mass by F9 v1.1

---

*Display average payload mass carried by booster version F9 v1.1*

```
%sql select avg(payload_mass_kg) as avg_mass_F9 from SPACEXTBL where booster_version = 'F9 v1.1'
```

avg_mass_f9
2928

The average payload mass carried by booster version F9 v1.1  
is : 2928 kg

# First Successful Ground Landing Date

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

*Hint: Use min function*

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

1
2015-12-22

# Successful Drone Ship Landing with Payload between 4000 and 6000

---

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

```
%sql select booster_version from SPACEXTBL\  
where (landing_outcome = 'Success (drone ship)' and (payload_mass_kg_ > 4000 and payload_mass_kg_ < 6000))
```

booster_version
F9 FT B1029.1
F9 FT B1036.1
F9 B4 B1041.1

# Total Number of Successful and Failure Mission Outcomes

*List the total number of successful and failure mission outcomes*

```
*sql select mission_outcome, count(mission_outcome) as counts from SPACEXTBL GROUP BY mission_outcome
```

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

# Boosters Carried Maximum Payload

*List the names of the booster\_versions which have carried the maximum payload mass. Use a subquery*

```
%sql select distinct booster_version from SPACEXTBL\\
where payload_mass_kg_ in (select max(payload_mass_kg_) from SPACEXTBL);
```

booster_version
F9 B5 B1048.4
F9 B5 B1048.5
F9 B5 B1049.4
F9 B5 B1049.5
F9 B5 B1049.7
F9 B5 B1051.3
F9 B5 B1051.4
F9 B5 B1051.6
F9 B5 B1056.4
F9 B5 B1058.3
F9 B5 B1060.2
F9 B5 B1060.3

# 2015 Launch Records

***List the failed landing\_outcomes in drone ship, their booster versions, and launch site names for in year 2015***

```
%sql select landing_outcome, booster_version, launch_site from SPACEXTBL\  
where (landing_outcome = 'Failure (drone ship)' and date like '2015%')
```

landing_outcome	booster_version	launch_site
Failure (drone ship)	F9 v1.1 B1012	CCAFS LC-40
Failure (drone ship)	F9 v1.1 B1015	CCAFS LC-40

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

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```
%sql select landing_outcome, count(*) as counts_of_landing_outcomes from SPACEXTBL\  
where DATE between '2010-06-04' and '2017-03-20' group by landing_outcome\  
order by count(landing_outcome) desc
```

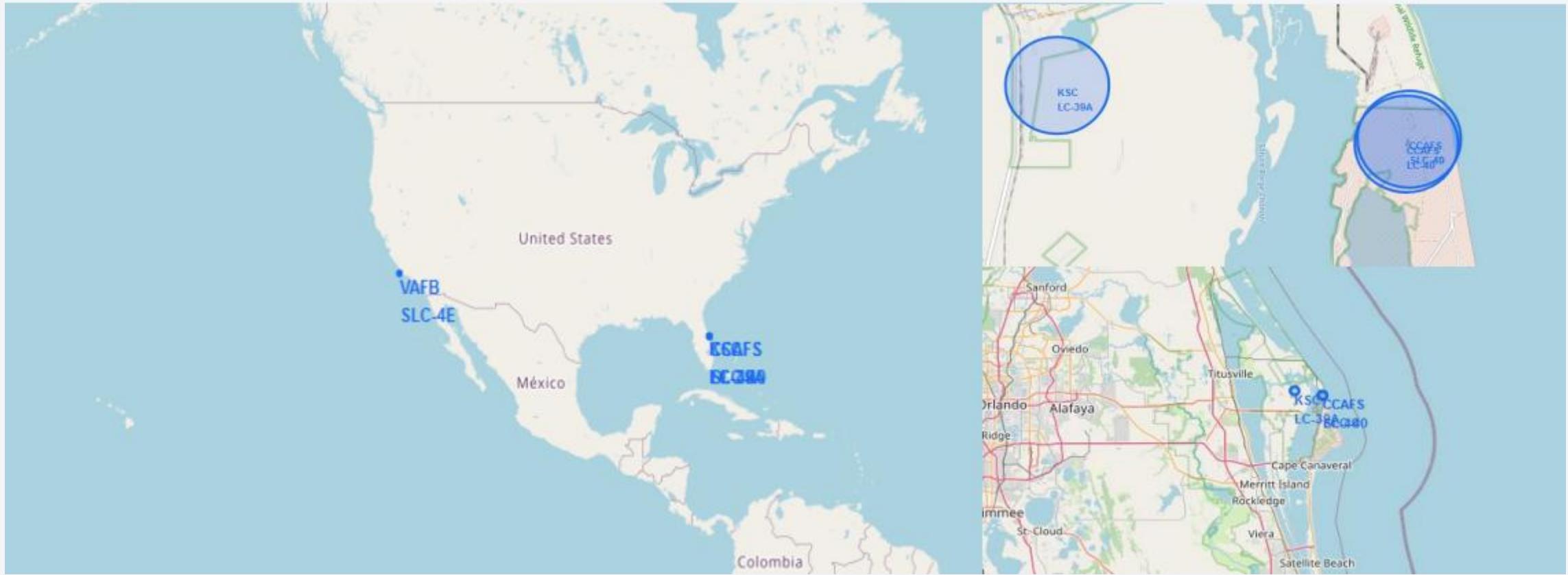
landing_outcome	counts_of_landing_outcomes
No attempt	10
Failure (drone ship)	5
Success (drone ship)	5
Controlled (ocean)	3
Success (ground pad)	3
Failure (parachute)	2
Uncontrolled (ocean)	2
Precluded (drone ship)	1

The background of the slide is a photograph taken from space at night. It shows the curvature of the Earth against a dark blue-black void of space. City lights are visible as numerous small white and yellow dots, primarily concentrated in the lower right quadrant where the United States appears. There are also larger clusters of lights in South America and Europe. The atmosphere of the Earth is visible as a thin blue line, and the horizon shows the transition from the dark void to the planet's surface.

Section 3

# Launch Sites Proximities Analysis

# <Folium Map Launch Sites >

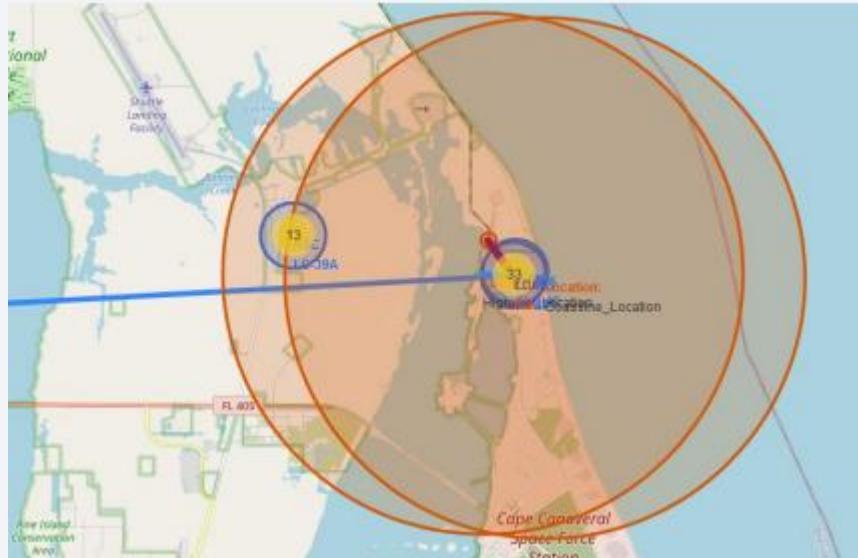


- All site locations are near the coast and Equator line, SpaceX focuses on locations that are close to water

## <Folium Map Success rate for each launch location >



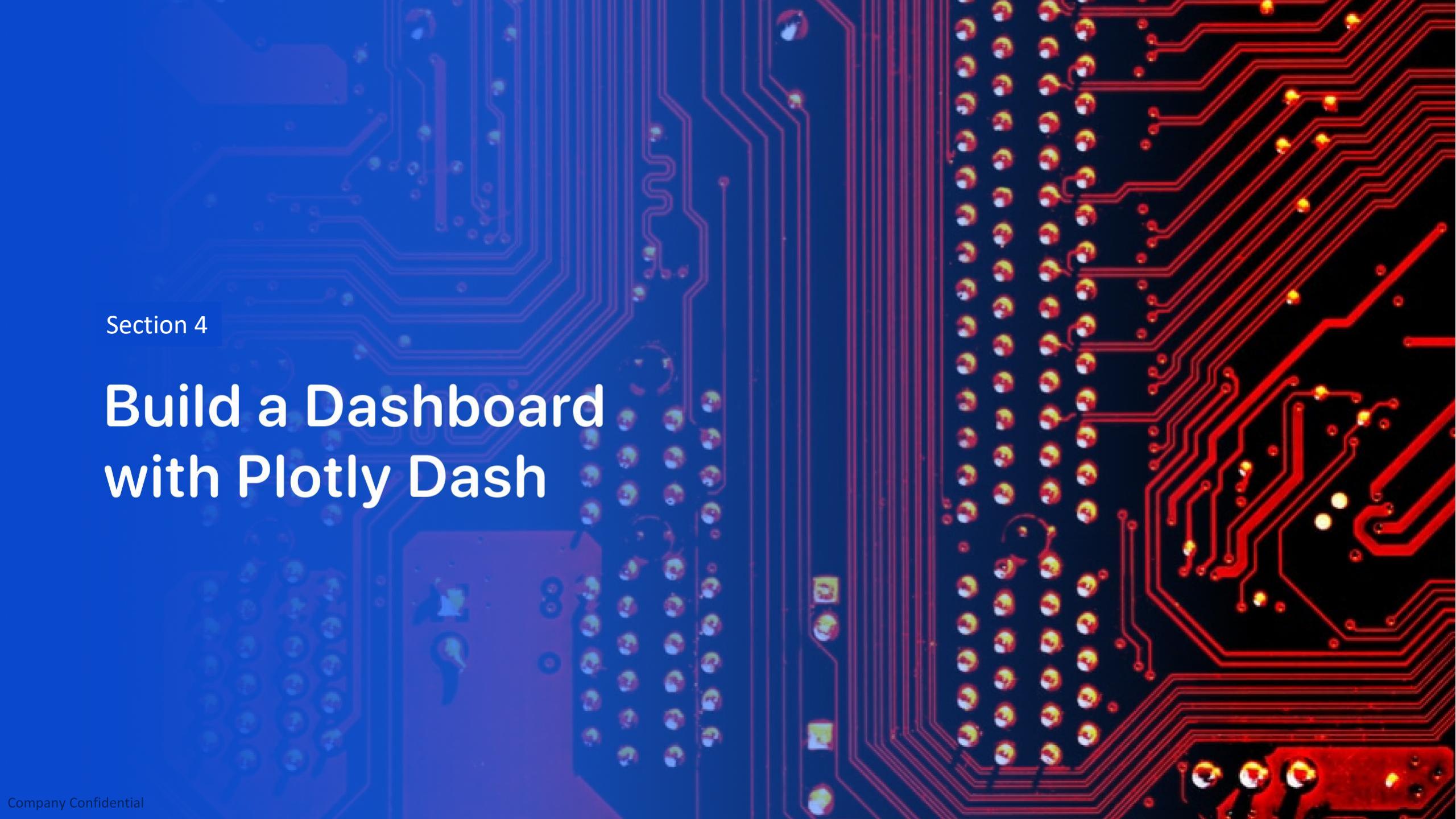
# <Folium Map Closest Proximities to CCAFS LC-40 >



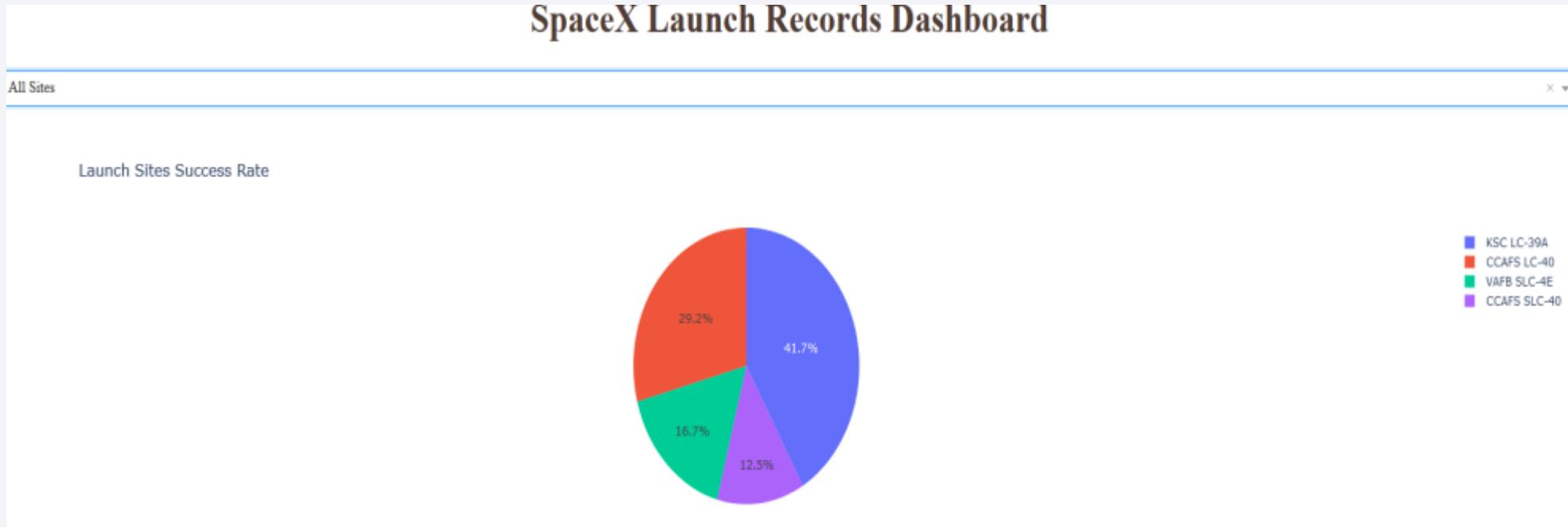
	Location	Lat	Long
0	Orlando_Location	28.52300	-81.38260
1	Coastline_Location	28.56146	-80.56746
2	Highway_Location	28.56270	-80.58703

Section 4

# Build a Dashboard with Plotly Dash

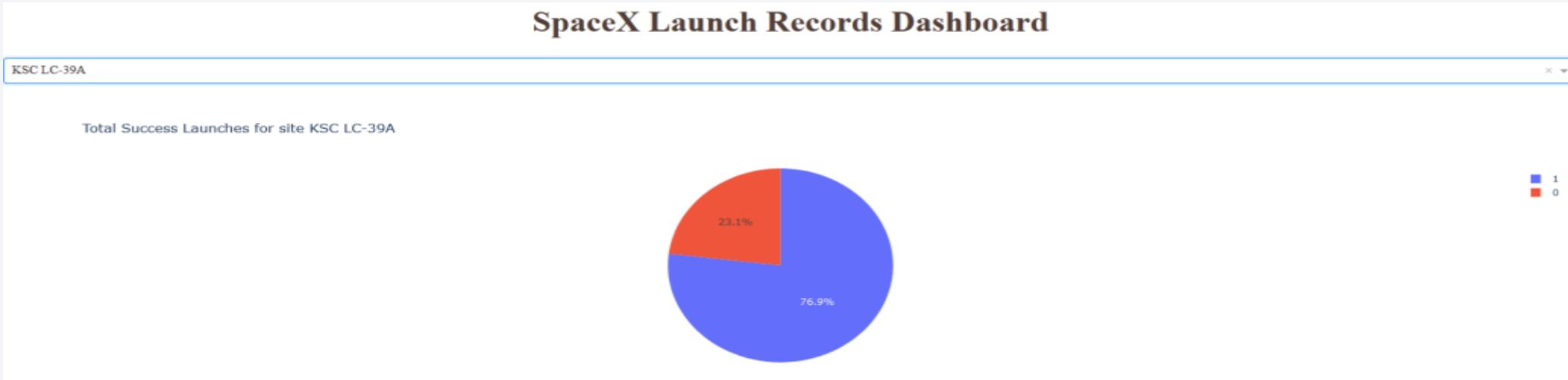


# <Dashboard Launch success count for all sites >



- The graph shows the success percentage for every single site in terms of first stage return:
  - The best site is KSC LC-39A with 41.7%. of total successful rocket launch among all sites
  - The least site for successful rocket launch: CCAFS SLC-40 with only 12.5%.

# <Dashboard Launch success for KSC LC 39A >



- Total Success Launches for site KSC LC-39 • KSC LC-39A with 76.9% successful missions • KSC LC-39A with 23.1% Failed missions

## <Dashboard Payload vs. Launch Outcome scatter plot >



- This interactive scatter plot shows the launch outcome based on the relationship between the payload mass and the final outcomes as we can infer that the success rate per booster version for example, the payload mass  $< 4000$  kg more likely to be successful.

The background of the slide features a dynamic, abstract design. It consists of several thick, curved lines in shades of blue and yellow, creating a sense of motion and depth. The lines curve from the bottom left towards the top right, with some lines being more prominent than others. The overall effect is reminiscent of a tunnel or a high-speed train track.

Section 5

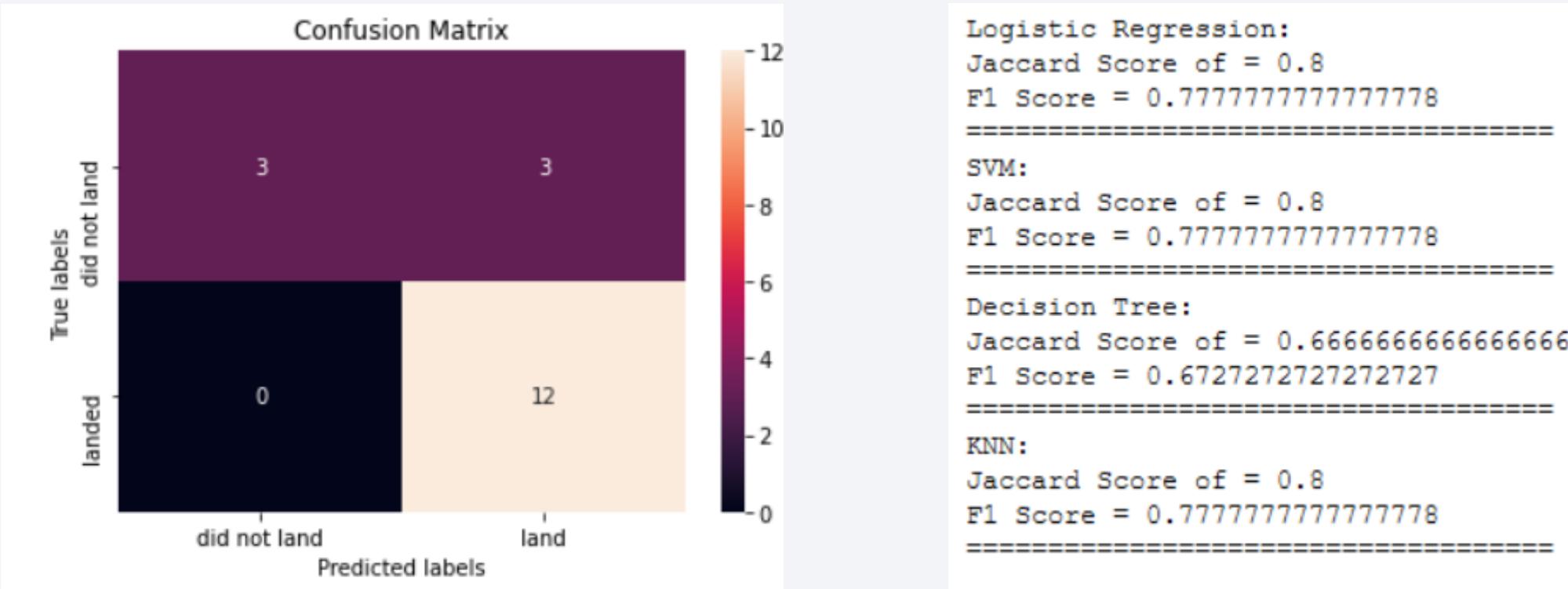
# Predictive Analysis (Classification)

# Classification Accuracy

- Logistic Regression , SVM and KNN has the same performance where the Jaccard Score is same : 0.8 Where Decision Tree has the worst performance compared to other models.



# Confusion Matrix



- Logistic Regression , SVM and KNN have the same confusion matrix and results:
  - True Positive = 12
  - False Positive = 0
  - True Negative = 3
  - False Negative = 3

# Conclusions

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- a successful first stage return, leads to huge savings in terms of rockets lunches cost
- A wide range of attributes affects the possibility of a successful first stage return. In our model there were 83 attributes were taken into consideration.
- SpaceX Falcon9 launch sites were all close to a highway, railway, and coastline proximities, which aimed in transportation cost-reduction
- insight requires further investigation. SpaceX success rate increased with years, KSC LC – 39A site is the highest in success rate

# Appendix

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- All data are collected using SpaceX API and Wikipedia

Thank you!

