



IBM Developer  
SKILLS NETWORK

# 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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- 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

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- 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.
- Problems you want to find answers
  - The project task is to predicting if the first stage of the SpaceX Falcon 9 rocket will land successfully



Section 1

# Methodology

# Methodology

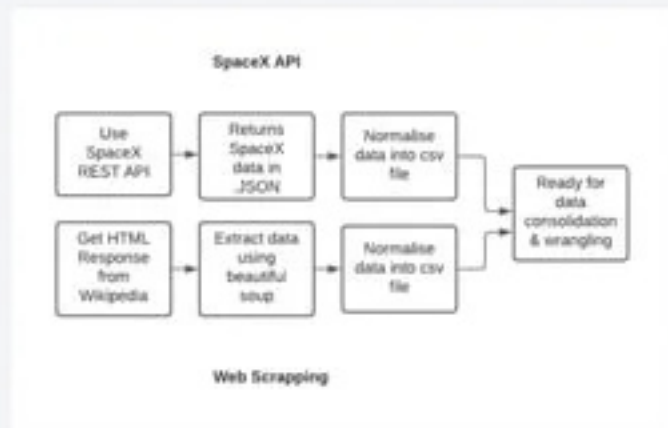
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## Executive Summary

- Data collection methodology:
  - SpaceX Rest API
  - Web Scrapping from Wikipedia
- Perform data wrangling
  - One Hot Encoding data fields for Machine Learning and data cleaning of null values and 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
  - LR, KNN, SVM, DT models have been built and evaluated for the best classifier

# Data Collection

- The following datasets was collected:
  - SpaceX launch data that is gathered from the SpaceX REST API.
  - This API will give us data about launches, including information about the rocket used, payload delivered, launch specifications, landing specifications, and landing outcome.
  - The SpaceX REST API endpoints, or URL, starts with `api.spacexdata.com/v4/`.
  - Another popular data source for obtaining Falcon 9 Launch data is web scraping Wikipedia using BeautifulSoup.



# Data Collection – SpaceX API

- Data collection with SpaceX REST calls

<https://github.com/initiative1972/data-science/blob/master/10-IBM%20Data%20Science%20Capstone%20project.ipynb>

## 1. Getting Response from API

```
spacex_url="https://api.spacexdata.com/v4/launches/past"
response = requests.get(spacex_url).json()
```

## 2. Converting Response to a .json file

```
response = requests.get(static_json_url).json()
data = pd.json_normalize(response)
```

## 3. Apply custom functions to clean data

```
getLaunchSite(data)
getPayloadData(data)
getCoreData(data)
```

```
getBoosterVersion(data)
```

## 4. Assign list to dictionary then dataframe

```
launch_dict = {'flightnumber': list(data['flight_number']),
               'date': list(data['date']),
               'boosterVersion': list(data['boosterVersion']),
               'payloadMass': list(data['payloadMass']),
               'core': list(data['core']),
               'launchSite': list(data['launchSite']),
               'outcome': list(data['outcome']),
               'flight': list(data['flight']),
               'orbit': list(data['orbit']),
               'reuse': list(data['reuse']),
               'stage': list(data['stage']),
               'landingPad': list(data['landingPad']),
               'clock': list(data['clock']),
               'reusability': list(data['reusability']),
               'serial': list(data['serial']),
               'longitude': list(data['longitude']),
               'latitude': list(data['latitude'])}
```

```
df = pd.DataFrame.from_dict(launch_dict)
```

## 5. Filter dataframe and export to flat file (.csv)

```
data_falcon = df.loc[df['boosterVersion'] != 'Falcon 1']
data_falcon.to_csv('dataset_part_1.csv', index=False)
```



# Data Collection - Scraping

- Web Scrapping from Wikipedia

## 1. Getting Response from HTML

```
page = requests.get(static_url)
```

## 2. Creating BeautifulSoup Object

```
soup = BeautifulSoup(page.text, 'html.parser')
```

## 3. Finding tables

```
html_tables = soup.find_all('table')
```

## 4. Getting column names

```
column_names = []  
temp = soup.find_all('th')  
for i in range(len(temp)):  
    key:  
    name = extract_column_from_header(temp[i])  
    if (name != '' and len(name) > 0):  
        column_names.append(name)  
except:  
    pass
```

## 5. Creation of dictionary

```
launch_dict = dict.fromkeys(column_names)  
  
# Remove an irrelevant column  
del launch_dict['Date and time ( )']  
  
launch_dict['Flight No.'] = []  
launch_dict['Launch site'] = []  
launch_dict['Payload'] = []  
launch_dict['Payload mass'] = []  
launch_dict['Orbit'] = []  
launch_dict['Customer'] = []  
launch_dict['Launch outcome'] = []  
launch_dict['Version Number'] = []  
launch_dict['Booster landing'] = []  
launch_dict['Data'] = []  
launch_dict['Time'] = []
```

## 6. Appending data to keys (refer) to notebook block 12

```
for i in range(12):  
    extracted_row = 0  
    # Extract each table  
    for table_number, table in enumerate:  
        if get_table_row:  
            for row in table.find_all('tr'):  
                # Append to one of flight table
```

## 7. Converting dictionary to dataframe

```
df = pd.DataFrame.from_dict(launch_dict)
```

## 8. Dataframe to .CSV

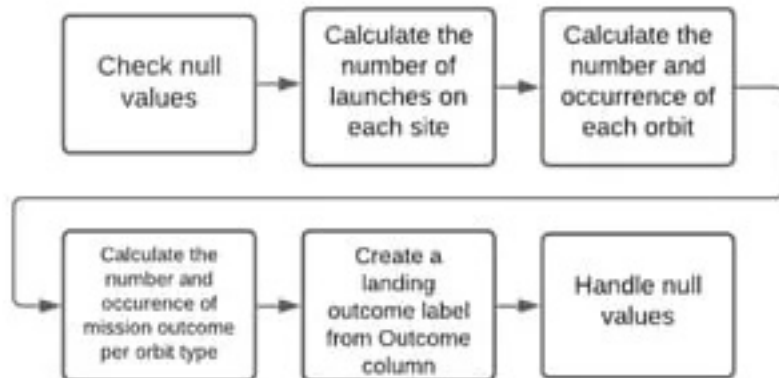
```
df.to_csv('spacex_web_scraped.csv', index=False)
```

<https://github.com/initiative1972/data-science/blob/master/10-IBM%20DS%20Capstone%20project-lab2-web%20scraping.ipynb>

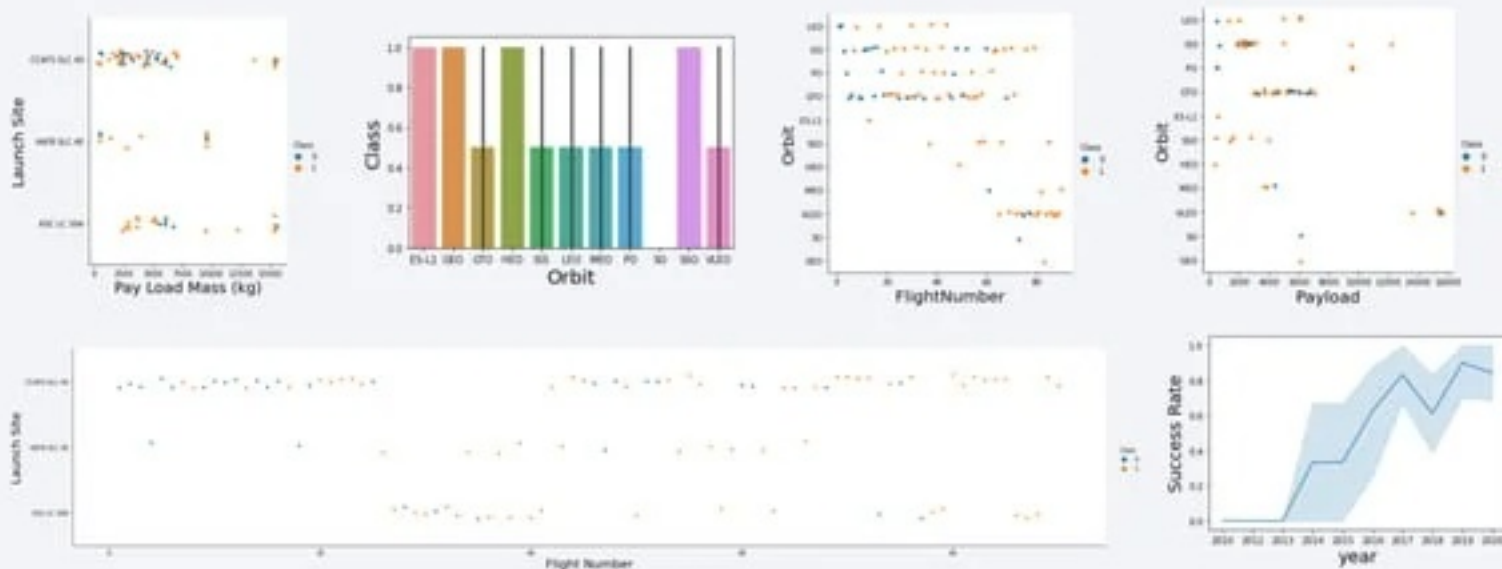
# Data Wrangling

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## EDA analysis



# EDA with Data Visualisation



# EDA with SQL

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- SQL queries performed include:
  - Displaying the names of the unique launch sites in the space mission
  - Displaying 5 records where launch sites begin with the string 'KSC'
  - Displaying the total payload mass carried by boosters launched by NASA (CRS)
  - Displaying average payload mass carried by booster version F9 v1.1
  - Listing the date where the successful landing outcome in drone ship was achieved.
  - Listing the names of the boosters which have success in ground pad and have payload mass greater than 4000 but less than 6000
  - Listing the total number of successful and failure mission outcomes
  - Listing the names of the booster\_versions which have carried the maximum payload mass.
  - Listing the records which will display the month names, successful landing\_outcomes in ground pad ,booster versions, launch\_site for the months in year 2017
  - Ranking the count of successful landing\_outcomes between the date 2010 06 04 and 2017 03 20 in descending order.

# Build an Interactive Map with Folium

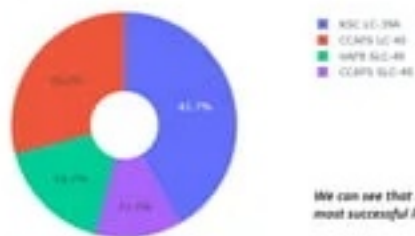


Map markers have been added to the map with aim to finding an optimal location for building a launch site

<https://github.com/initiative1972/data-science/blob/master/10-IBM%20DS%20Capstone-lab5-Folium.ipynb>

# Build a Dashboard with Plotly Dash

Total Success Launches By all sites

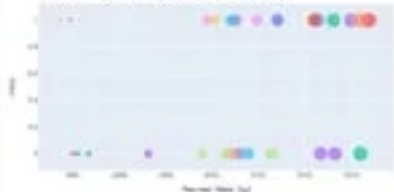


We can see that KSC LC-39A had the most successful launches from all the sites

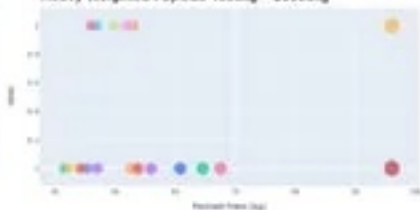


KSC LC-39A achieved a 76.9% success rate while getting a 23.1% failure rate

Low Weighted Payload Dlg - 4000kg



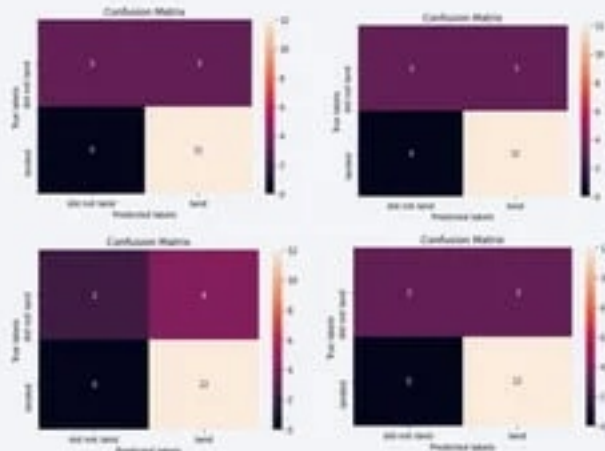
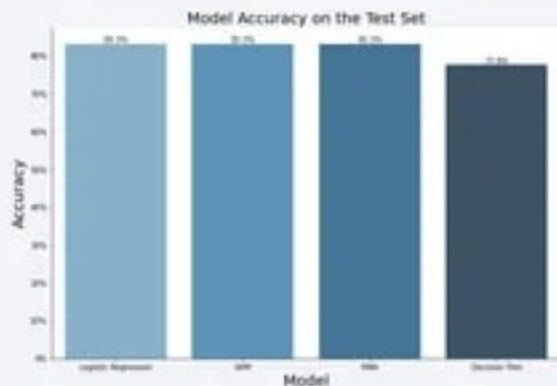
Heavy Weighted Payload 4000kg - 20000kg



We can see the success rates for low weighted payloads is higher than the heavy weighted payloads

# Predictive Analysis (Classification)

- The SVM, KNN, and Logistic Regression model achieved the highest accuracy at 83.3%, while the SVM performs the best in terms of Area Under the Curve at 0.958.





# Results

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- The SVM, KNN, and Logistic Regression models are the best in terms of prediction accuracy for this dataset.
- Low weighted payloads perform better than the heavier payloads.
- The success rates for SpaceX launches is directly proportional time in years they will eventually perfect the launches.
- KSC LC 39A had the most successful launches from all the sites.
- Orbit GEO,HEO,SSO,ES L1 has the best Success Rate.



The background of the slide is an abstract composition of vibrant blue and red streaks and brushstrokes. These strokes are dynamic and energetic, creating a sense of movement and depth. The blue strokes are more prevalent on the left side, while the red strokes are more concentrated on the right. The overall effect is a modern, high-tech aesthetic.

Section 2

## Insights drawn from EDA

## Flight Number vs. Launch Site

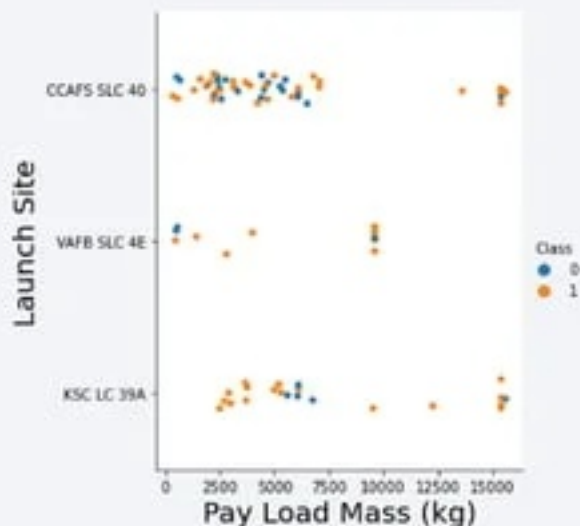
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- Launches from the site of CCAFS SLC 40 are significantly higher than launches from other sites.

## Payload vs. Launch Site

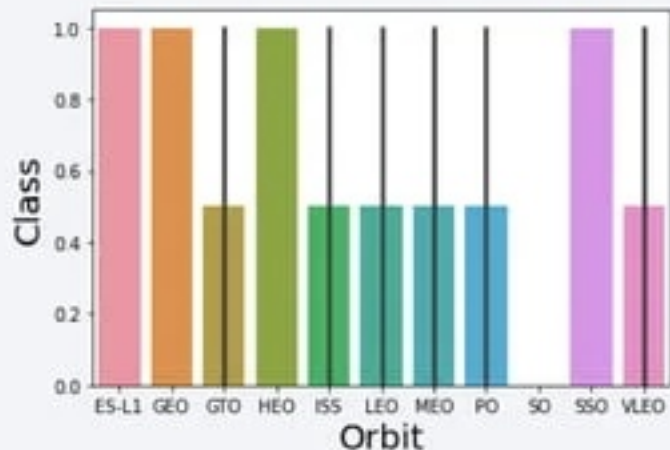
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- The majority of IPay Loads with lower Mass have been launched from CCAFS SLC 40.

## Success Rate vs. Orbit Type

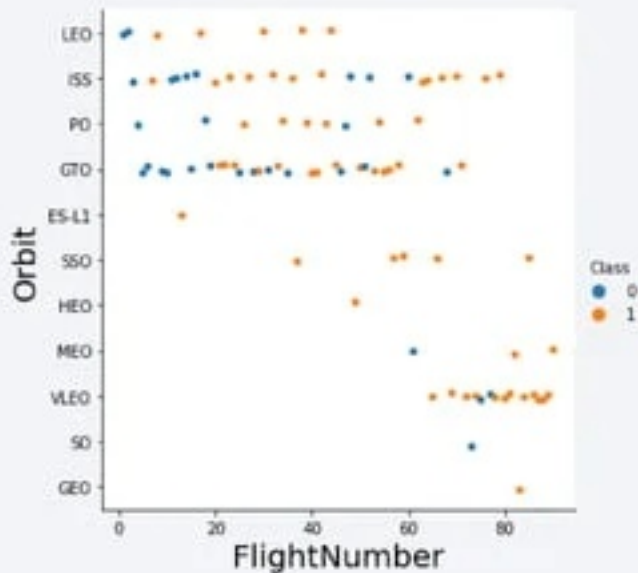
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- The orbit types of ES-L1, GEO, HEO, SSO are among the highest success rate.

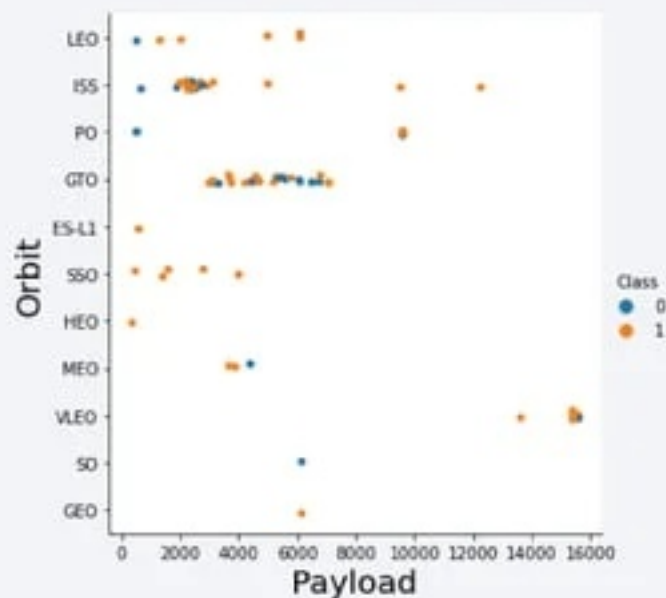
# Flight Number vs. Orbit Type

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- A trend can be observed of shifting to VLEO launches in recent years.

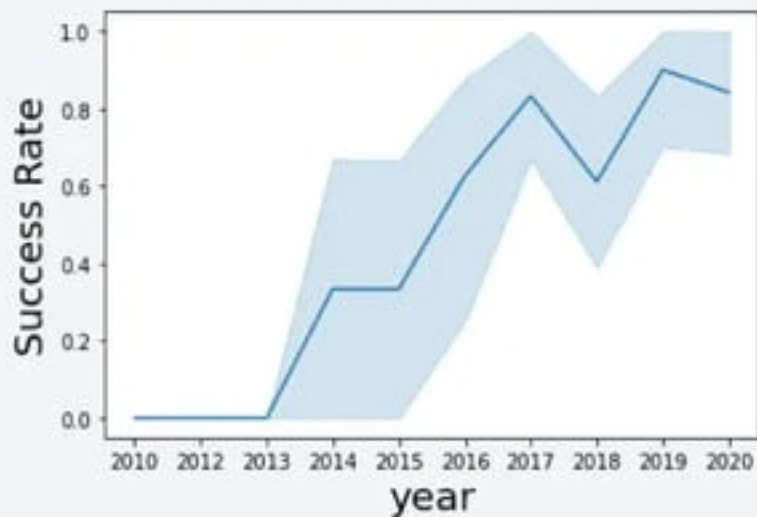
# Payload vs. Orbit Type



- There are strong correlation between ISS and Payload at the range around 2000, as well as between GTO and the range of 4000-8000.

## Launch Success Yearly Trend

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- Launch success rate has increased significantly since 2013 and has stabilised since 2019, potentially due to advance in technology and lessons learned.

## All Launch Site Names

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- %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'

- %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_outcome
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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- %sql select sum(PAYLOAD\_MASS\_\_KG\_) from SPACEXTBL where CUSTOMER = 'NASA (CRS)'

45596

## Average Payload Mass by F9 v1.1

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- %sql select avg(PAYLOAD\_MASS\_\_KG\_) from SPACEXTBL where BOOSTER\_VERSION = 'F9 v1.1'

2928.400000

## First Successful Ground Landing Date

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- %sql select min(DATE) from SPACEXTBL where Landing\_\_Outcome = 'Success (ground pad)'

2015-12-22

## Successful Drone Ship Landing with Payload between 4000 and 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 B1022
F9 FT B1026
F9 FT B1021.2
F9 FT B1031.2

## Total Number of Successful and Failure Mission Outcomes

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- %sql select count(MISSION\_OUTCOME) from SPACEXTBL where MISSION\_OUTCOME = 'Success' or MISSION\_OUTCOME = 'Failure (in flight)'

100

## Boosters Carried Maximum Payload

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- %sql select BOOSTER\_VERSION from SPACEXTBL where PAYLOAD\_MASS\_KG\_ = (select max(PAYLOAD\_MASS\_KG\_) from SPACEXTBL)

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 \* from SPACEXTBL where Landing\_\_Outcome like 'Success%' and (DATE between '2015-01-01' and '2015-12-31') order by date desc

time_utc	booster_version	launch_site	payload	payload_mass_kg	orbit	customer	mission_outcome	landing_outcome
14:39:00	F9 FT B1031.1	KSC LC-39A	SpaceX CRS-10	2490	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
17:54:00	F9 FT B1029.1	VAFB SLC-4E	Iridium NEXT 1	9600	Polar LEO	Iridium Communications	Success	Success (drone ship)
05:26:00	F9 FT B1026	CCAFS LC-40	JCSAT-16	4600	GTO	SKY Perfect JSAT Group	Success	Success (drone ship)
04:45:00	F9 FT B1025.1	CCAFS LC-40	SpaceX CRS-9	2257	LEO (ISS)	NASA (CRS)	Success	Success (ground pad)
21:39:00	F9 FT B1023.1	CCAFS LC-40	Thaicom 8	3100	GTO	Thaicom	Success	Success (drone ship)
06:00:00	F9 FT B1022.1	CCAFS LC-40	JCSAT-15	4600	GTO	SKY Perfect JSAT Group	Success	Success (drone ship)



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

---

- %sql select \* from SPACEXTBL where Landing\_\_Outcome like 'Success%' and (DATE between '2010-06-04' and '2017-03-20') order by date desc

2016-05-27	21:39:00	F9 FT B1023.1	CCAFS LC-40	Thaicom 8	3100	GTO	Thaicom	Success	Success (drone ship)
2016-05-06	05:21:00	F9 FT B1022	CCAFS LC-40	JCSAT-14	4896	GTO	SKY Perfect rSAT Group	Success	Success (drone ship)
2016-04-08	20:43:00	F9 FT B1021.1	CCAFS LC-40	SpaceX CRS-8	3136	LEO (ISS)	NASA (CRS)	Success	Success (drone ship)
2015-12-22	01:29:00	F9 FT B1019	CCAFS LC-40	OG2 Mission 2 11 Orbcomm-OG2 satellites	2034	LEO	Orbcomm	Success	Success (ground pad)

A satellite view of Earth from space, showing the curvature of the planet and city lights at night. The background is a deep blue gradient.

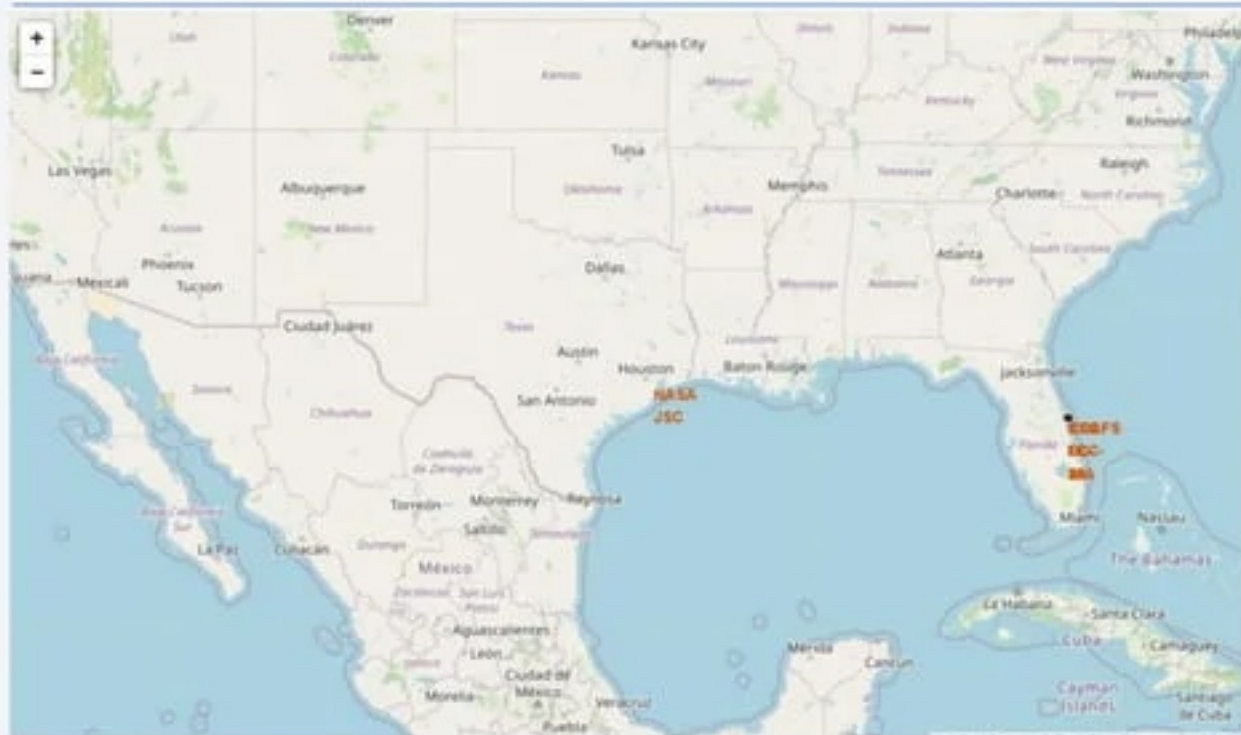
Section 4

# Launch Sites Proximities Analysis

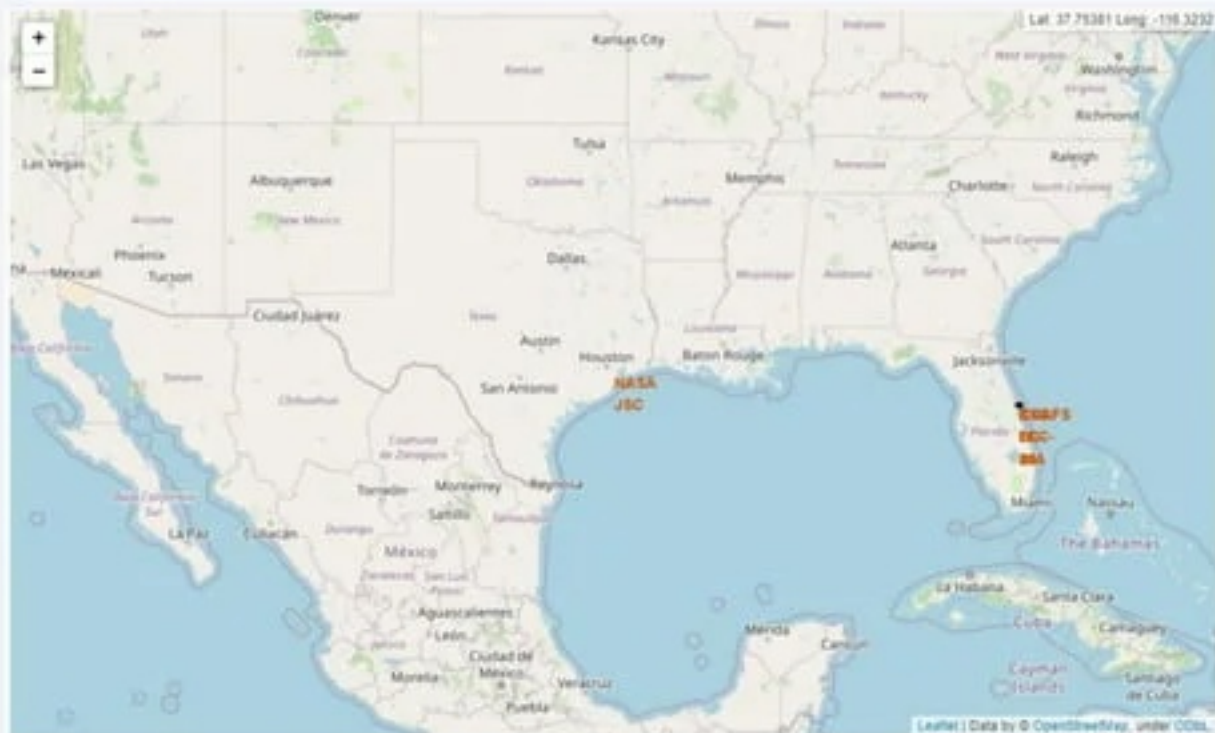
All launch sites marked on a map



## Success/failed launches marked on the map



# Distances between a launch site to its proximities







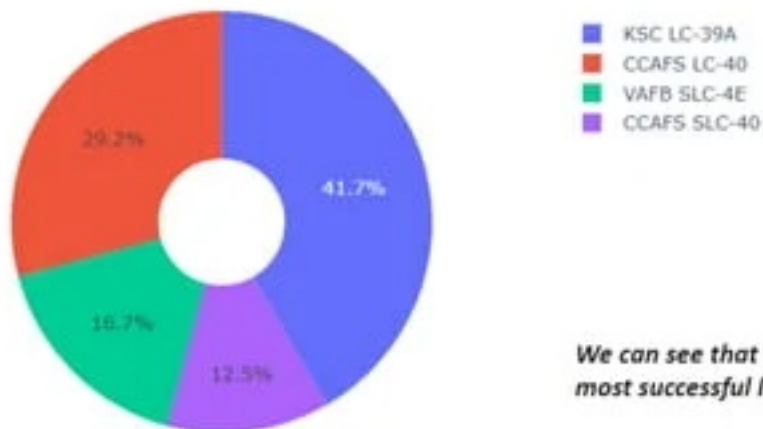
Section 5

# Build a Dashboard with Plotly Dash

## Total success launches by all sites

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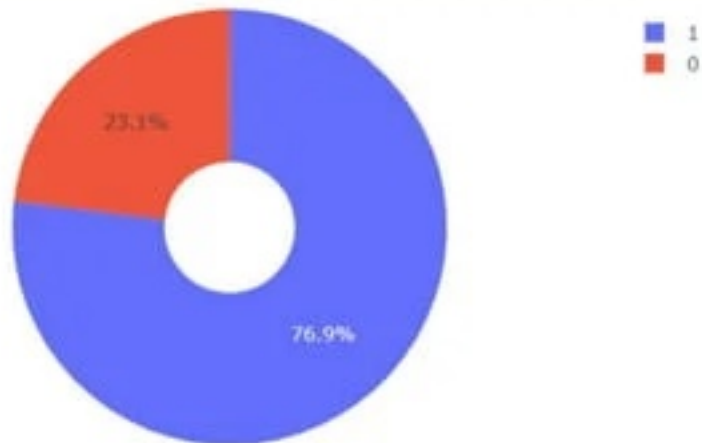
Total Success Launches By all sites



*We can see that KSC LC-39A had the most successful launches from all the sites*

## Success rate by site

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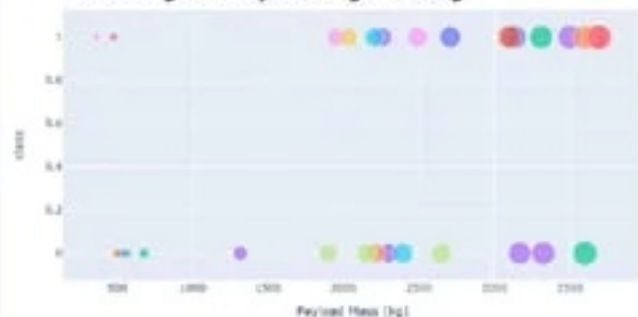


*KSC LC-39A achieved a 76.9% success rate while getting a 23.1% failure rate*



# Payload vs launch outcome

*Low Weighted Payload 0kg – 4000kg*



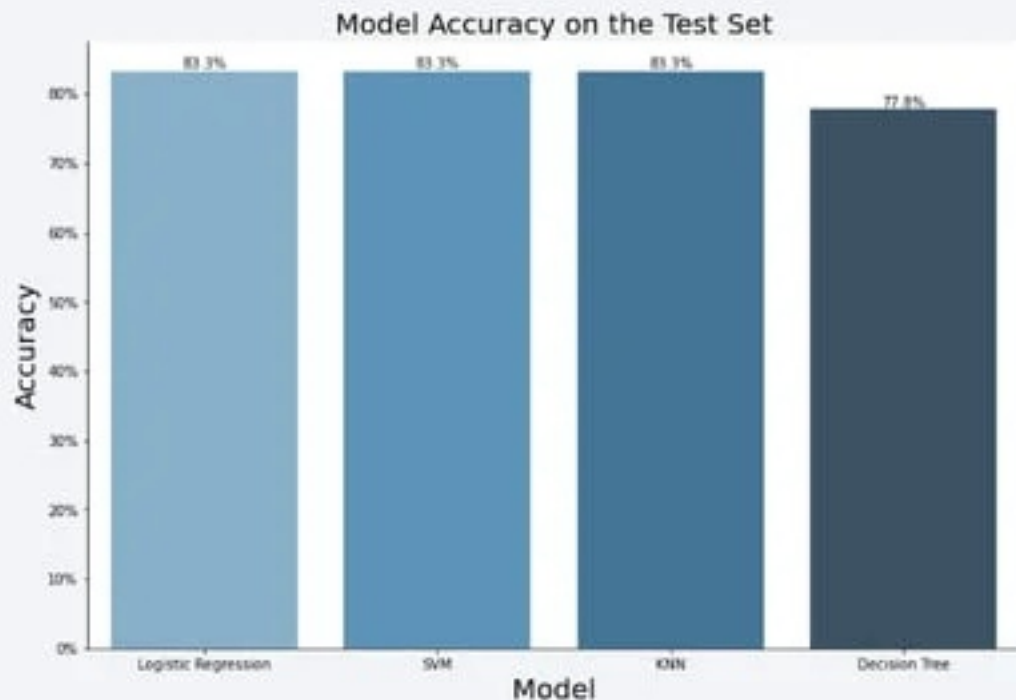
The background of the slide is an abstract composition of flowing, curved lines in shades of blue and white, creating a sense of motion and depth. The lines appear to originate from the right side and curve towards the left, with some lines being more prominent than others. The overall effect is a dynamic and modern aesthetic.

Section 6

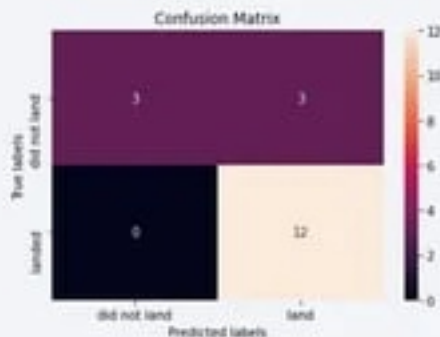
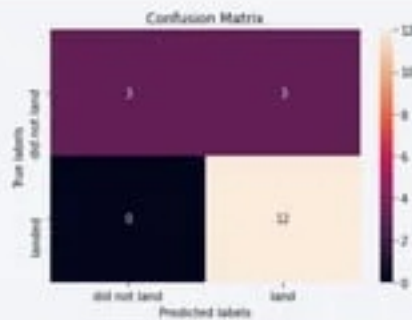
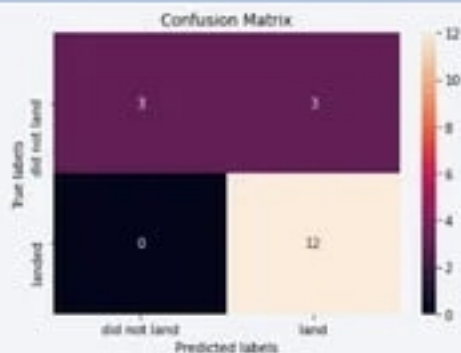
## Predictive Analysis (Classification)

# Classification Accuracy

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# Confusion Matrix



## Conclusions

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- The SVM, KNN, and Logistic Regression models are the best in terms of prediction accuracy for this dataset.
- Low weighted payloads perform better than the heavier payloads.
- The success rates for SpaceX launches is directly proportional time in years they will eventually perfect the launches.
- KSC LC 39A had the most successful launches from all the sites.
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Thank you!

