IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

Space Y

Data Scientist
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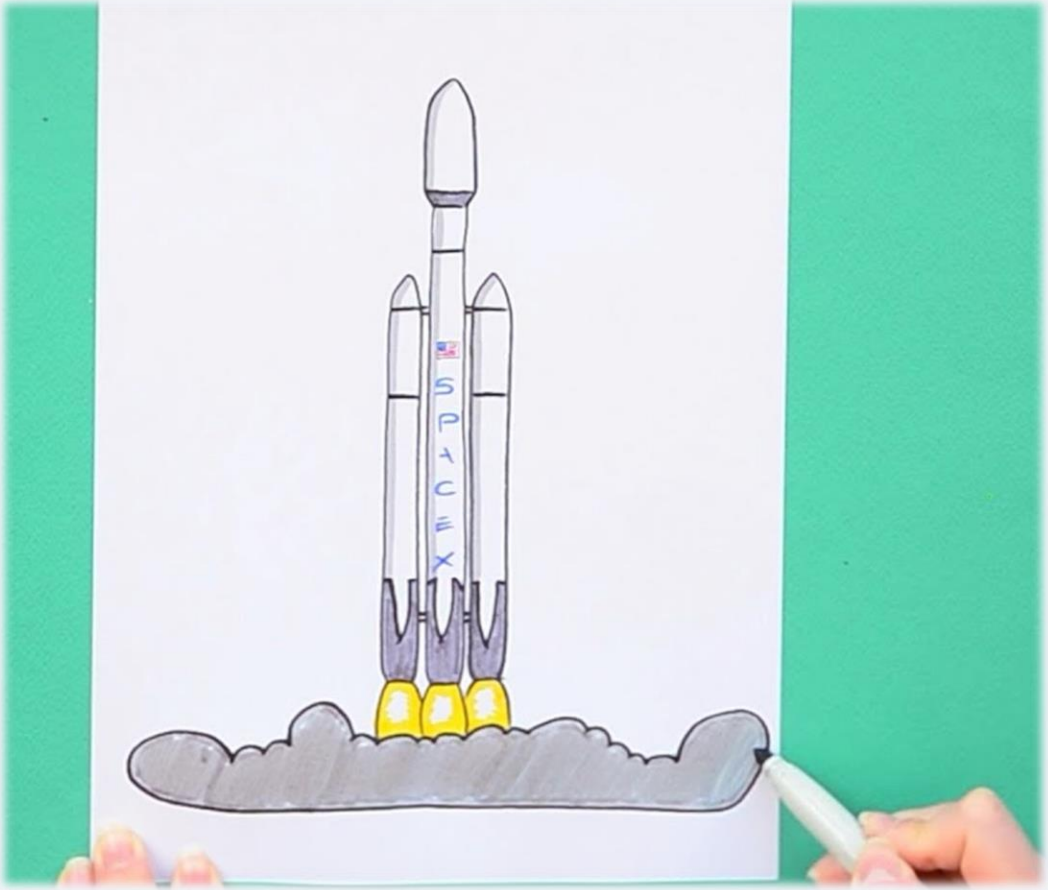
July 2022

Outline

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



Executive Summary

- **Summary Of Methodologies**
    - Data collection
    - Basic EDA and Data wrangling
    - EDA with data visualization
    - EDA with SQL
    - Building an interactive map with Folium
    - Building a Dashboard with Plotly Dash
    - Predictive analysis (Classification)

- **Summary Of All Results**
    - EDA results
    - Interactive analytics
    - Predictive analysis

Introduction

- **Project Background And Context**
    - SpaceX advertises Falcon 9 rocket launches on its website, with a cost of 62 million dollars; other providers cost upward of 165 million dollars each, much of the savings is because SpaceX can reuse the first stage.
    - Therefore, determining if the first stage will land can determine the cost of a launch.
    - This information can be used in our company, SpaceY wants to bid against SpaceX for a rocket launch.
- **Problems That Are Worth Solving**
    - What factors determine if the rocket will land successfully?
    - The interaction amongst various features (e.g. rocket variables) that determine the success rate of a successful landing.
    - What operating conditions need to be in place to ensure a successful landing program.

Elon Musk introduced SpaceX's new Dragon II spacecraft to the press.

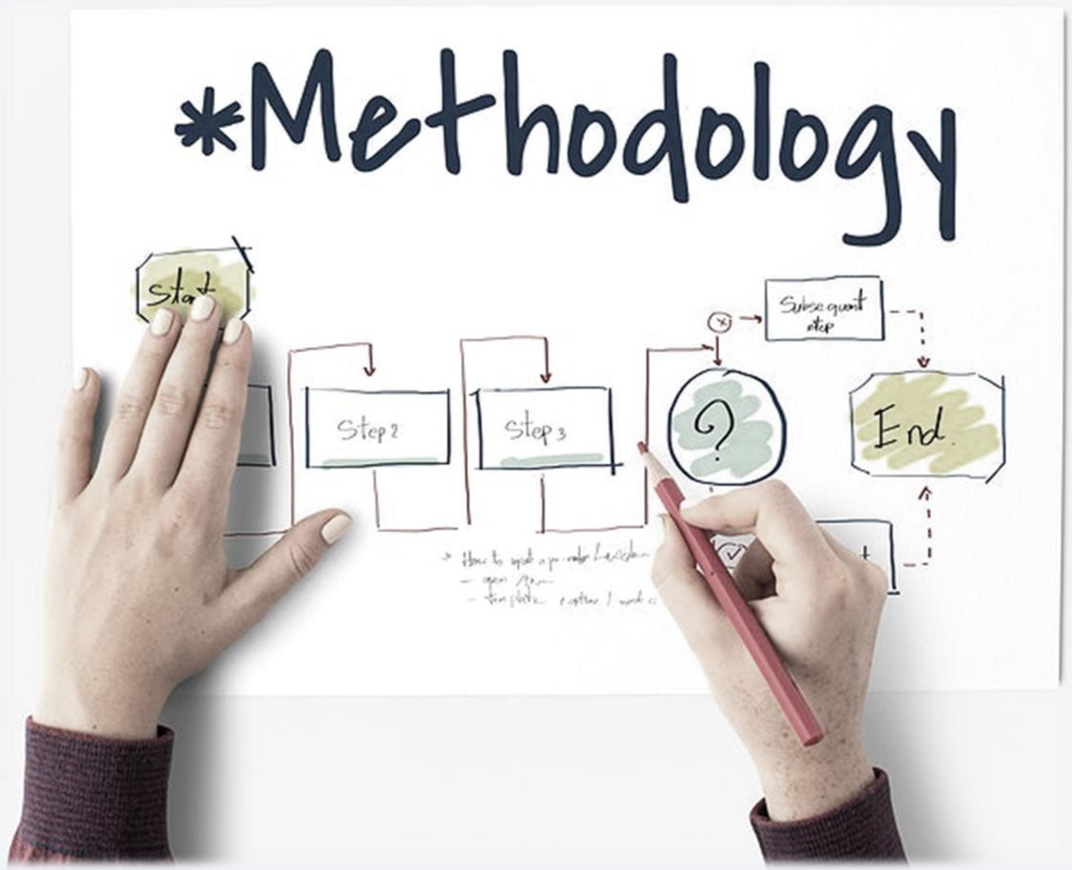
AP PHOTO/JAE C. HONG
Give space a chance.

Section 1

Methodology

Methodology – Executive Summary

- Data Collection Methodology:
  - SpaceX Rest API (received as .json file)
  - Web Scrapping from Wikipedia
- Perform Basic Exploratory Data Analysis (EDA) & Data Wrangling
  - Data cleaning of null values and irrelevant
  - Create training labels
- Perform Exploratory Data Analysis (EDA) Using Visualization And SQL
  - One Hot Encoding applied to categorical features
- Perform Interactive Visual Analytics Using Folium And Plotly Dash
- Perform Predictive Analysis Using Classification Models
  - Built various classification models (e.g. LR, KNN, SVM, DT)
  - Evaluated for the best classification model



Data Collection Overview

Goal of Data Collection:

To support the prediction of whether SpaceX will attempt to land a rocket or not.

Data Collection Methodology:

- SpaceX REST API
- Web Scrapping

SpaceX API	Web Scrapping
Use SpaceX REST API	Get HTML response from Wikipedia
Returns SpaceX data in .json file	Extract data using BeautifulSoup
Normalize data into .csv file	Normalize data into .csv file

Ready for data consolidation & data wrangling

Data Collection – SpaceX API

Key Phrases And Flowcharts:

1. Get a response from API
2. Convert response to a .json file
   (use 'static response object' for more consistency in this project instead)
3. Extract relevant data with custom functions
4. Create dictionary & dataframe
   (for Falcon 9 only)
5. Deal with missing values
6. Export to a .csv file

```
[29]: data_falcon9.to_csv('dataset_part_1.csv', index=False)
```

Click this icon for my notebook (API)

https://github.com/amoslimty/Applied-Data-Science-Capstone-Project-SpaceX/blob/main/1_jupyter-labs-spacex-data-collection-api%20(wk1-%20amos)%20-%20v2.ipynb

```
[6]: spacex_url="https://api.spacexdata.com/v4/launches/past"

[7]: response = requests.get(spacex_url)
```

```
[9]: static_json_url='https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/A
static_response = requests.get(static_json_url)

[11]: # Use json_normalize meethod to convert the json result into a dataframe
data = pd.json_normalize(static_response.json())
```

```
[16]: # Call getBoosterVersion
getBoosterVersion(data)

[18]: # Call getLaunchSite
getLaunchSite(data)

[19]: # Call getPayloadData
getPayloadData(data)

[20]: # Call getCoreData
getCoreData(data)
```

```
[21]: launch_dict = {'FlightNumber': list(data['flight_number']),
'Date': list(data['date']),
'BoosterVersion':BoosterVersion,
'PayloadMass':PayloadMass,
'Orbit':Orbit,
'LaunchSite':LaunchSite,
'Outcome':Outcome,
'Flights':Flights,
'GridFins':GridFins,
'Reused':Reused,
'Legs':Legs,
'LandingPad':LandingPad,
'Block':Block,
'ReusedCount':ReusedCount,
'Serial':Serial,
'Longitude': Longitude,
'Latitude': Latitude}

[22]: # Create a data from launch_dict
data = pd.DataFrame(launch_dict)

[24]: # Hint data['BoosterVersion']!='Falcon 1'
data_falcon9 = data[data.BoosterVersion == 'Falcon 9']
data_falcon9
```

```
[27]: # Calculate the mean value of PayloadMass column
Mean_PayloadMass = data_falcon9.PayloadMass.mean()
# Replace the np.nan values with its mean value
data_falcon9['PayloadMass'] = data_falcon9['PayloadMass'].replace(np.nan, Mean_PayloadMass)
```

Data Collection – Web Scrapping

Key Phrases And Flowcharts:

1. Get a response from HTML and create BeautifulSoup Object
2. Find tables and extract column names
3. Create dictionary
4. Extract relevant data & append data with custom functions
   (Highlight is shown here. For full code refer to my notebook)
5. Convert to dataframe
6. Export to a .csv file

```
[5]:  data = requests.get(static_url).text
      # assign the response to a object
[6]:  soup = BeautifulSoup(data, "html.parser")
```

```
[8]:  html_tables = soup.find_all('table')
[10]: column_names = []
      for row in first_launch_table.find_all('th'):
          name = extract_column_from_header(row)
          if name != None and len(name) > 0:
              column_names.append(name)
```

```
[12]: launch_dict= dict.fromkeys(column_names)
      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 Booster']=[]
      launch_dict['Booster landing']=[]
      launch_dict['Date']=[]
      launch_dict['Time']=[]
```

```
[13]: extracted_row = 0
      #Extract each table
      for table_number,table in enumerate(soup.find_all('table',"wikitable plainrowheaders collapsible")):
         # get table row
          for rows in table.find_all("tr"):
              #check to see if first table heading is as number corresponding to launch a number
              if rows.th:
                  if rows.th.string:
                      flight_number=rows.th.string.strip()
                      flag=flight_number.isdigit()
              else:
                  flag=False
              #get table element
              row=rows.find_all('td')
```

```
[15]: df=pd.DataFrame(launch_dict)
```

```
[16]: df.to_csv('spacex_web_scraped.csv', index=False)
```

Click this icon for my notebook (web scrapping)

https://github.com/amoslimty/Applied-Data-Science-Capstone-Project-SpaceX/blob/main/2_jupyter-labs-spacex-webscraping%20(wk1-%20amos)%20-%20v2.ipynb

Basic EDA and Data Wrangling

Key Phrases And Flowcharts:

1. **Check** for **MISSING VALUES** in attributes & **understand DATA TYPES**
2. **Calculate** the number of launches on each **LAUNCH SITE**
3. **Calculate** the number and occurrence of each **ORBIT**
4. **Check** for **MISSING & NULL VALUES**
5. **Create** a **LANDING OUTCOME LABEL** (from the new OUTCOME column)
6. **Calculate** the number and occurrence of **MISSION OUTCOME PER ORBIT TYPE**
7. **Export** to a .csv file (dataset_part 2.csv)

Objectives of Data Wrangling:

- Exploratory Data Analysis
- Determine Training Labels

Data Source: Exported .csv file from SpaceX API (e.g. dataset_part_1.csv)

Click this icon for my notebook (data wrangling)

https://github.com/amoslimty/Applied-Data-Science-Capstone-Project-SpaceX/blob/main/3_jupyter-labs-spacex-Data%20wrangling%20%26%20EDA%20(wk1-%20amos)%20-%20v3.ipynb

EDA with Data Visualization

Objectives of EDA with Data Visualization:

- Exploratory Data Analysis
- Preparing for Feature Engineering

Click this icon for my notebook (data visualization)

WWW.

https://github.com/amoslimty/Applied-Data-Science-Capstone-Project-SpaceX/blob/main/5_jupyter-labs-spacex-eda-dataviz%20(wk2-%20amos)_v2.ipynb

Scatter Graphs Plotted:

- Flight Number vs. Payload Mass
- Flight Number vs. Launch Site
- Payload vs. Launch Site
- Flight Number vs. Orbit
- Payload vs. Orbit

Scatter graph shows the relationship (aka correlation) between two variables.

Bar Graph Plotted:

- Orbit vs. Class

Bar graph helps to compare sets of data between different category groups at a glance.

Line Graph Plotted:

- Success Rate vs. Year

Line graph shows data variables trends and helps prediction about future data not yet recorded

Data Source: Exported and updated .csv file from SpaceX API (e.g. dataset_part_2.csv)

EDA with SQL

Click this icon for my notebook (SQL)

https://github.com/amoslimty/Applied-Data-Science-Capstone-Project-SpaceX/blob/main/4_jupyter-labs-spacex-eda-sql%20(wk2-%20amos)_v2.ipynb

Data Source: Provided SpaceX Dataset in .csv format (extracted from Web scrapping method)

10 SQL Queries include:

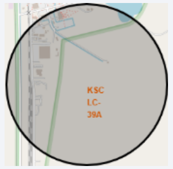
1. Display the names of the **unique launch sites** in the space mission
2. Display 5 records where **launch sites** begin with the string '**CCA**'
3. Display the **total payload mass** carried by boosters launched by **NASA (CRS)**
4. Display **average payload mass** carried by booster version **F9 v1.1**
5. List the **date** where the **first successful landing outcome** in **ground pad** was achieved.
6. List the **names of the boosters** which have **success in drone ship** have **payload mass** greater than 4000 but less than 6000
7. List the **total number** of **successful and failure mission outcomes**
8. List the **names of the booster_versions** which have carried the **maximum payload mass**.
9. List the **records** which will display the **month names**, **failure landing_outcomes** in **drone ship**, **booster versions**, **launch_site** for the **months** in **year 2015**
10. **Rank the count** of **successful landing_outcomes** between the date 4th Jun 2010 and 20th Mar 2017 in descending order.

Build an Interactive Map with Folium

Click this icon for my notebook (Folium)

https://github.com/amoslimty/Applied-Data-Science-Capstone-Project-SpaceX/blob/main/6_jupyter-labs-spacex-launch-site-location%20(wk3-%20Amos)_v2.ipynb

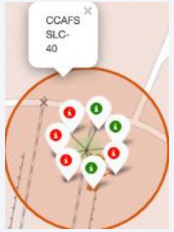
Data Source: Provided SpaceX Launch Geo Dataset in .csv format



Mark 'Launch Sites' with Circle and Label:

- NASA Johnson Space Center at Houston
- SpaceX Launch Sites: CCAFS LC-40, CCAFS SLC-40, KSC LC-39A, and VAFB SLC-4E.

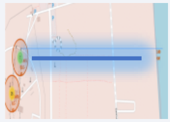
Ease of locating launch sites



Mark Color-labeled Markers in Marker Clusters (i.e., SpaceX Launch Sites):

- Red marker – Failed Launch
- Green marker – Successful Launch

Identify the Success rate of each launch sites (Geographical Patterns)

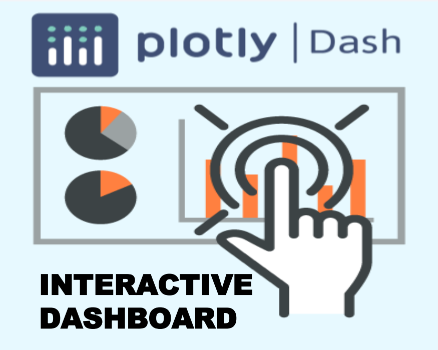


Mark Polylines between a Launch Site and to its Proximities:

- Selected coastline point
- Closest city
- Closest railway
- Closest highway

Calculate the distances between a launch site to its proximities for logistics, safety, etc.

Build a Dashboard with Plotly Dash



Click this icon for my notebook Plotly Dash App)

https://github.com/amoslimty/Appli
ed-Data-Science-Capstone-Project-
SpaceX/blob/main/7_spacex_dash_a
pp%20(wk3-%20amos).py

Interactive Inputs:

- **Dropdown Menu** – To select the launch site

- **Range Slider** – To select payload range

- Keep the number of inputs to a minimum.
- Two selected input choices are intuitive to most users.

Instant Rendering of Outputs:

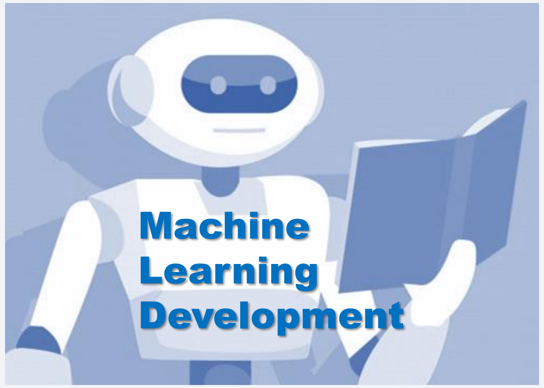
- **Pie Chart** – To display successful and failed launch counts for all sites

- **Scatter Graph** – To display the correlation between payload and launch success

- Two selected instant output choices also are relatable to users.
- The instant changes in the graphs allow users to understand the cause-and-effect.

Data Source: Provided SpaceX Launch Dash Dataset in .csv format

Predictive Analysis (Classification)

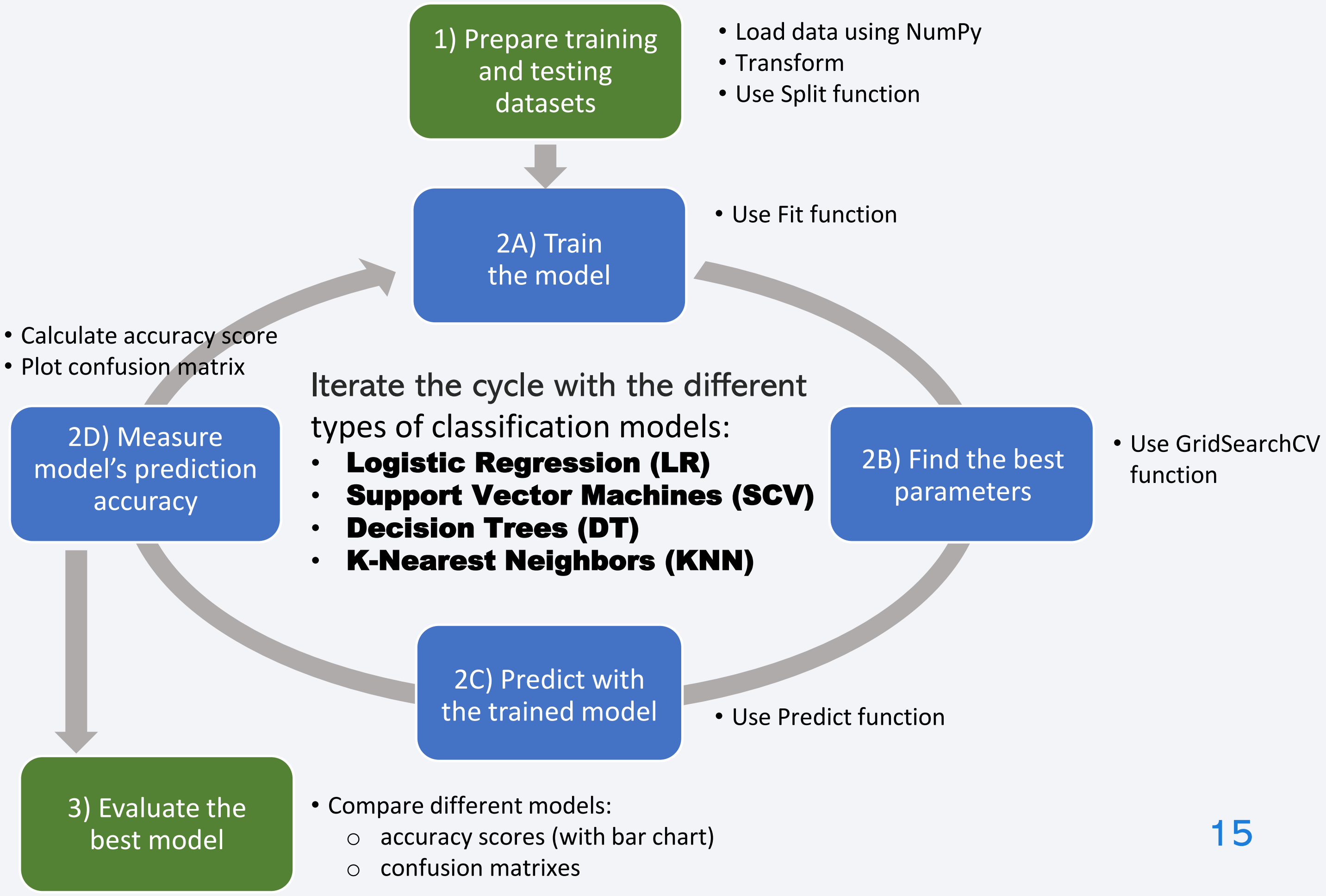


Click this icon for my notebook (Folium)

https://github.com/amoslimty/Applied-Data-Science-Capstone-Project-SpaceX/blob/main/8_jupyter-labs-spacex-machine%20learning%20prediction(wk4-%20amos)_v3.ipynb

Data Source: Exported and updated .csv file from SpaceX API (e.g. dataset_part_2.csv and dataset_part_3.csv)

Classification Model Development Process:



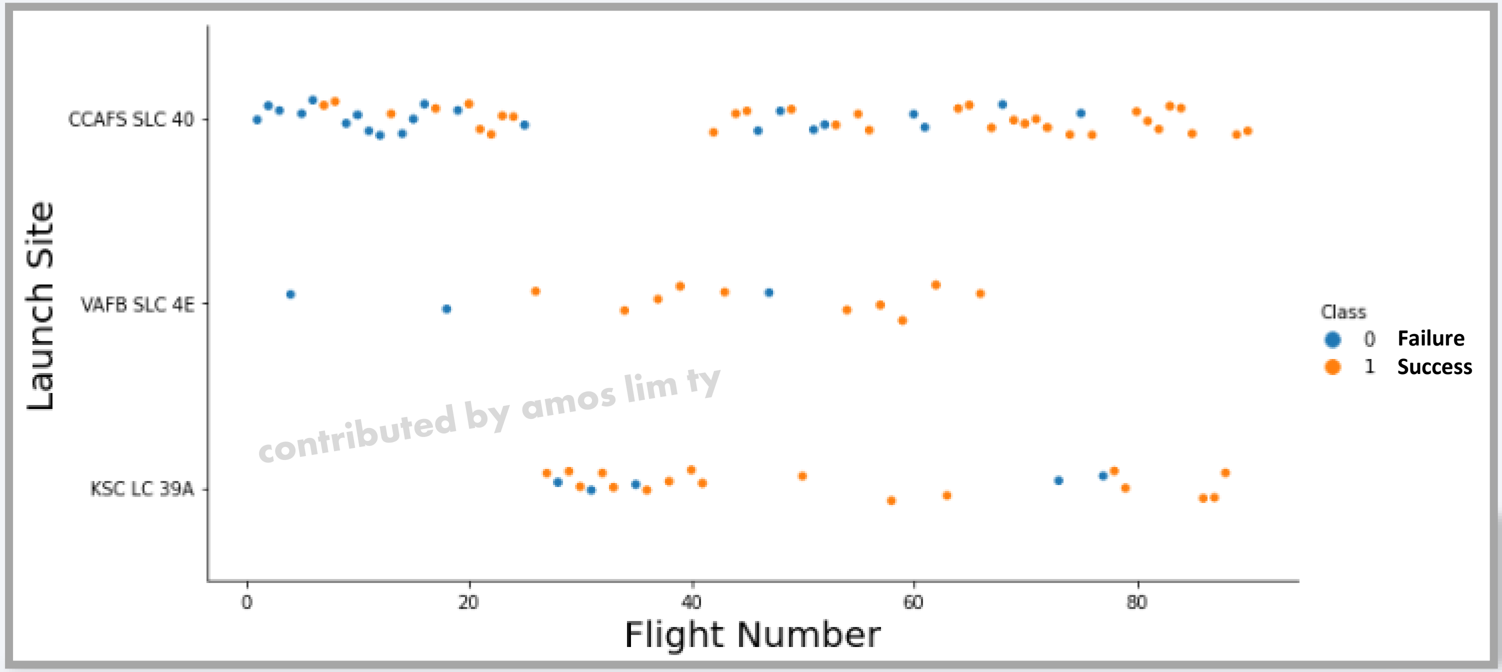
Key Results

- **Exploratory Data Analysis (EDA) Results**
  - Orbit types of **ES-L1**, **GEO**, **HEO**, and **SSO** are among the highest success rate.
  - The **larger the flight volume** at a launch site, the **greater the success rate** at the launch site over time. Space X has mastered the launch business and reached sustainable success from 2013 onwards.
- **Interactive Analytics Results**
  - **KSC LC-39A** site in **Florida** has the best success rate.
  - **Lighter payloads range** (particularly between 2,000Kg to 4,000Kg) has a better success rate.
- **Predictive Analysis Results**
  - The **K-Nearest Neighbour (KNN)** classification model is the best prediction algorithm for this assignment.

Section 2

Insights drawn from EDA

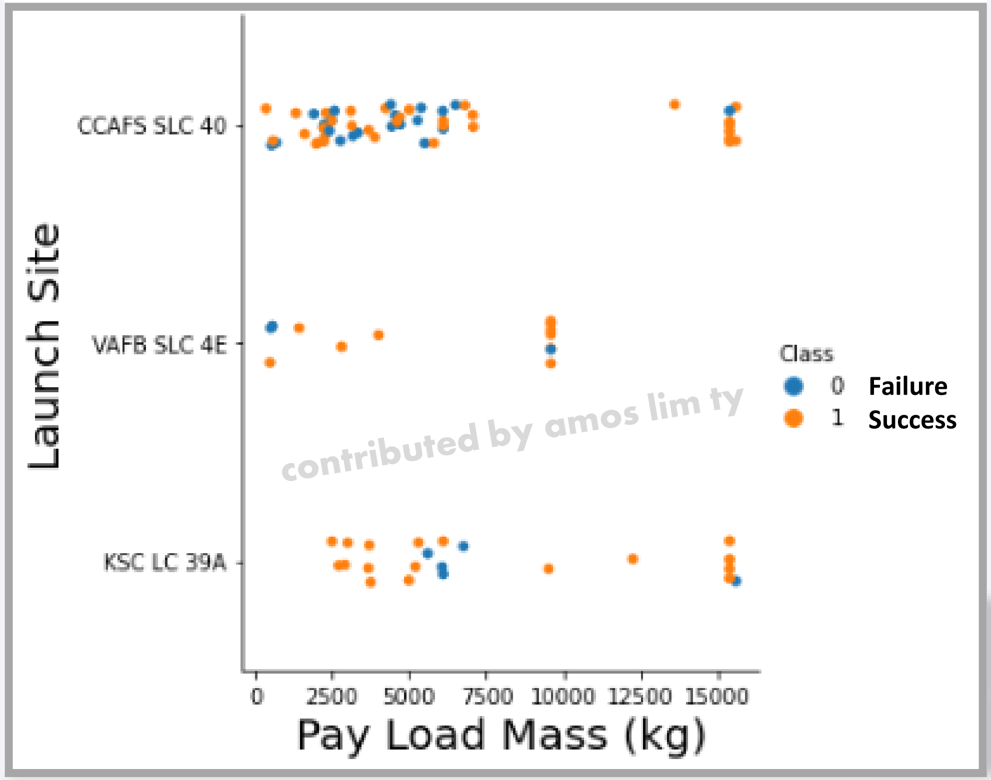
Flight Number vs. Launch Site



- From the scatter plot, as the flight volume increased gradually at any launch site, the success rate also increased at the launch site.
- Flight volume (aka launches) from the CCAFS SLC 40 site was significantly higher than other sites.

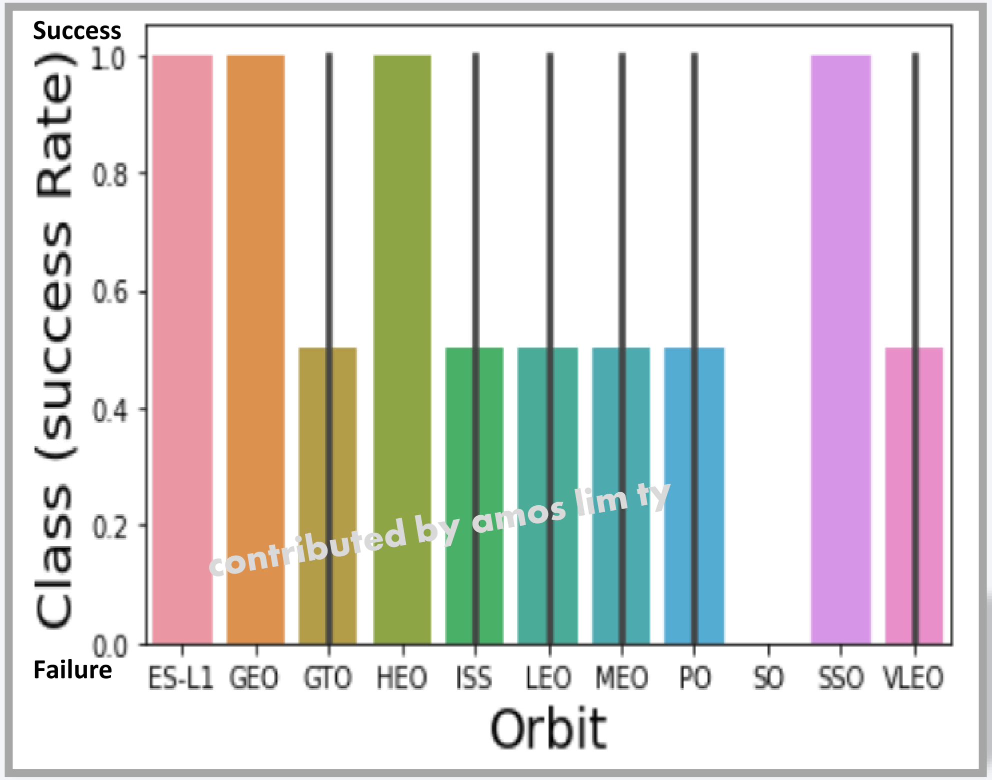
Payload vs. Launch Site

- Most launches with lower payloads (<7,500 kg) were from CCAFS SLC 40.
- The higher the payload mass, the higher the success rate for all launch sites. Particularly for payload mass >10,000 kg.
- For payload mass <7,500 kg, KSC LC39A site had better success rate than CCAFS SLC 40 site but KSC LC39A site had fewer launches than CCAFS SLC 40 site.



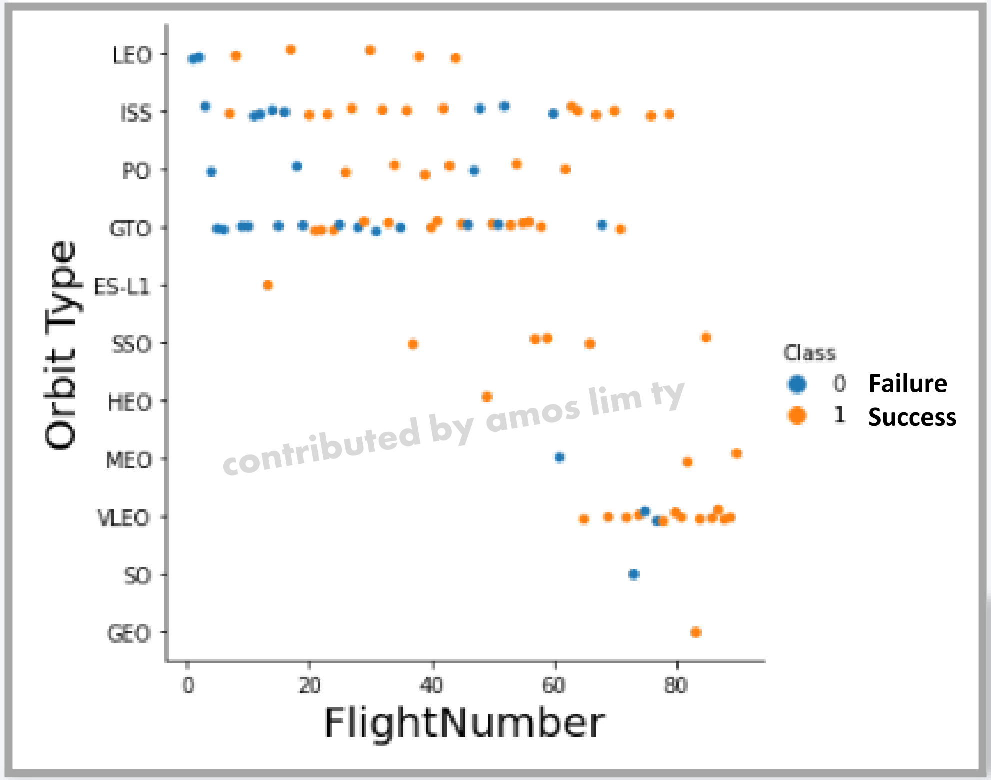
Success Rate vs. Orbit Type

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



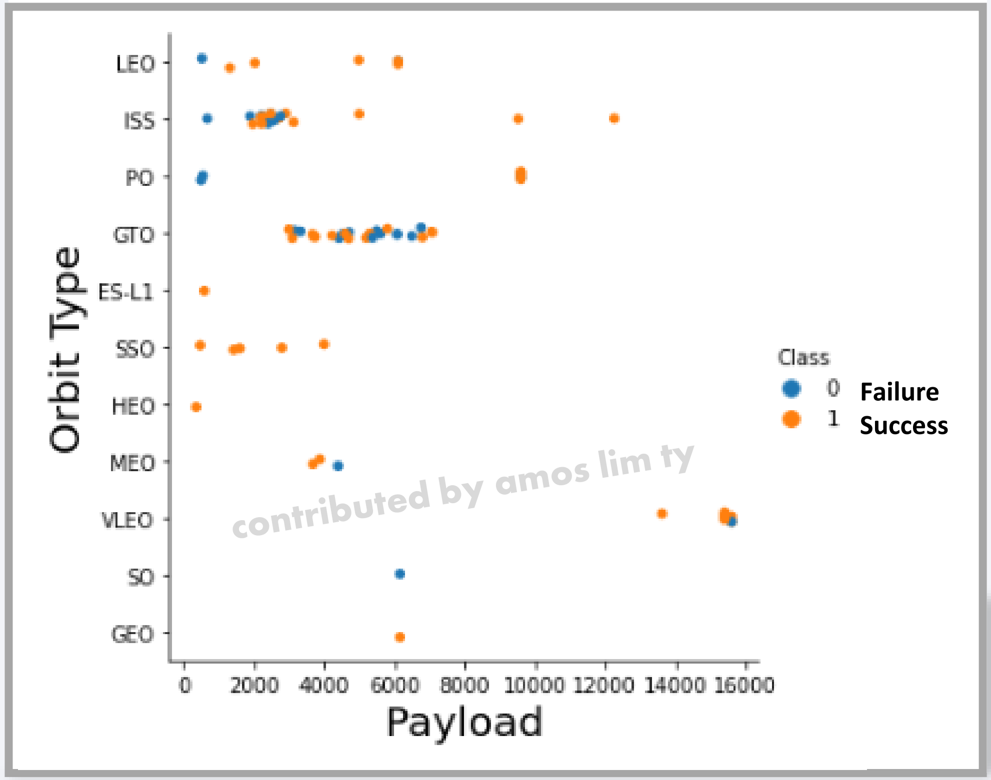
Flight Number vs. Orbit Type

- There are more successes, as the number of flights increases over time for LEO orbit.
- There seems to be no correlation between flight number and success rate for GTO orbit.
- There is a trend of more VLEO launches in recent times compared to GTO, LEO, ISS, & PO orbits launches.



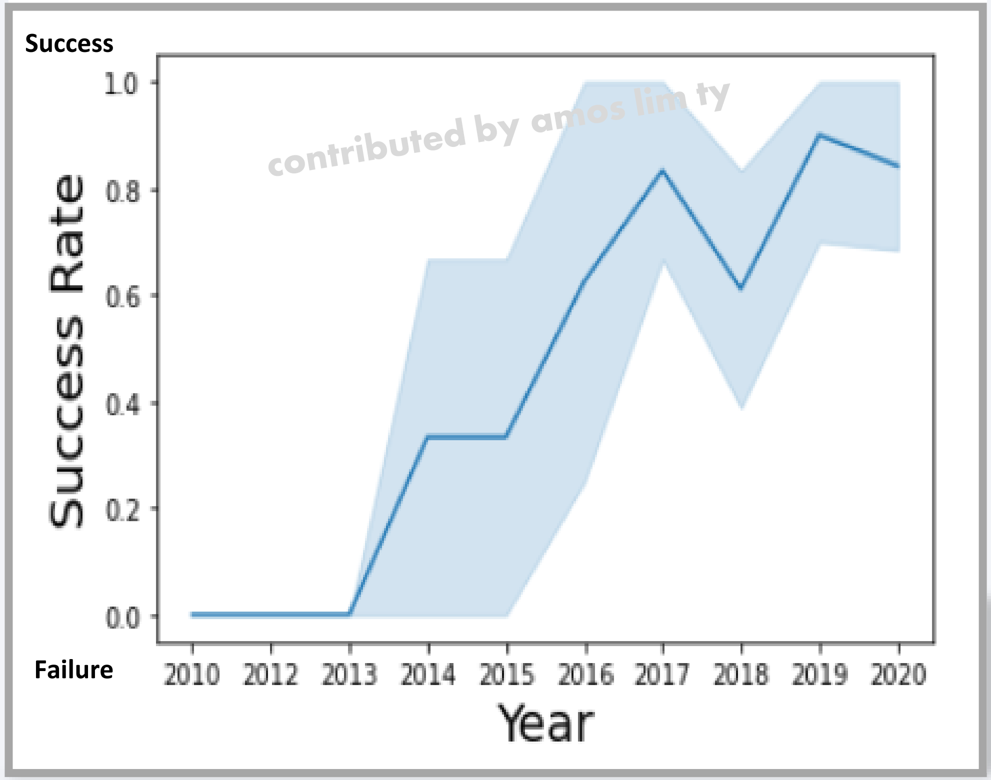
Payload vs. Orbit Type

- There is a high concentration of launches but no correlation of success rate.
  - **ISS orbit**: concentrated around 2,000 kg to 4,000 kg payload
  - **GTO orbit**: concentration around 3,000 kg to 7,000 kg payload
- For SSO orbit, regardless of the range of payload, it achieved 100% success so far.
- There is no failure after crossing a certain threshold of payload:
  - **LEO orbit:** > 1,000 kg payload
  - **ISS orbit:** > 4,000 kg payload
  - **PO orbit:** > 10,000 kg payload



Launch Success Yearly Trend

- From the line chart, it is observed that the success rate has increased significantly since 2013 and has stabilized since 2017, potentially due to advances in technology and lessons learned from failures.



All Launch Site Names

SQL Query

```
[6]: %sql select distinct(LAUNCH_SITE) from SPACEXTBL
```

[6]:

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

QUERY EXPLANATION

Using the word DISTINCT in the query means that it will only show Unique values in the Launch_Site column from tblSpaceX

Unique Launch Site	Location	Interesting Facts
Cape Canaveral Space Launch Complex 40 (CCAF SLC-40) • Previously Launch Complex 40 (LC-40)	Florida, U.S. 28.562106°N 80.577180°W	After 2007, the US Air Force leased the complex to SpaceX to launch the Falcon 9 rocket. As of May 2022, there have been 90 launches of the Falcon 9 from the complex.
Kennedy Space Center Launch Complex 39A (KSC LC-39A)	Florida, U.S. 28°36’30.2”N 80°36’15.6”W	In 2013, NASA announced that SpaceX as the new commercial tenant for 20-year exclusive lease. SpaceX will shift most of SpaceX's NASA launches to LC-39A, including commercial cargo and crew missions to the International Space Station.
Vandenberg Space Launch Complex 4 (VAFB SLC-4E)	California, U.S. 34.633°N 120.613°W	SpaceX refurbished SLC–4E for Falcon 9 launches in a 24-month process that began in early 2011.By late 2012, SpaceX scheduled the initial launch from the Vandenberg pad would be in 2013, with the larger variant Falcon 9 v1.1.

Source: www.wikipedia.org

Launch Site Names Begin with 'CCA'

SQL Query

```
[7]: %sql select * from SPACEXTBL where LAUNCH_SITE like 'CCA%' limit 5
```

QUERY EXPLANATION

Used the word LIMIT 5 in the query means that it will only show 5 records from tblSpaceX and LIKE keyword has a wild card with the words 'CCA%' the percentage, in the end, suggests that the Launch_Site name must start with CCA.

[7]:

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

The "Cape Canaveral Space Launch Complex 40" site had previously been renamed. However, the site has consistently labelled with the starting code "CCA". Therefore, this SQL query is useful to specifically search for records from "Cape Canaveral Space Launch Complex 40" site.

Source: https://en.wikipedia.org/wiki/Cape_Canaveral_Space_Launch_Complex_40

Total Payload Mass (by customer NASA (CRS))

SQL Query

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

[9]:	1
	45596

QUERY EXPLANATION

Using the function SUM summates the total in the column PAYLOAD_MASS_KG_. The WHERE clause filters the dataset to only perform calculations on Customer NASA (CRS)

Commercial Resupply Services (CRS) are a series of flights awarded by NASA to deliver cargo and supplies to the International Space Station (ISS) on a commercially operated spacecraft. The first CRS contracts were signed in 2008 and awarded $1.6 billion to SpaceX for twelve cargo Dragon and $1.9 billion to Orbital Sciences for eight Cygnus flights, covering deliveries to 2016. The Falcon 9 and Antares rockets were also developed under the CRS program to deliver cargo spacecraft to the ISS.

Source: https://en.wikipedia.org/wiki/Commercial_Resupply_Services

Average Payload Mass by F9 v1.1

SQL Query

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

[10]:

1
2928

QUERY EXPLANATION

Using the function AVG works out the average in the column PAYLOAD_MASS_KG_. The WHERE clause filters the dataset to only perform calculations on Booster_version F9 v1.1

Falcon 9 v1.1 was the second version of SpaceX's Falcon 9 orbital launch vehicle. The rocket was developed in 2011–2013, made its maiden launch in September 2013, and its final flight in January 2016. The Falcon 9 rocket was fully designed, manufactured, and operated by SpaceX. Following the second Commercial Resupply Services (CRS) launch, the initial version Falcon 9 v1.0 was retired from use and replaced by the v1.1 version.

Source: https://en.wikipedia.org/wiki/Falcon_9_v1.1

First Successful Ground Landing Date

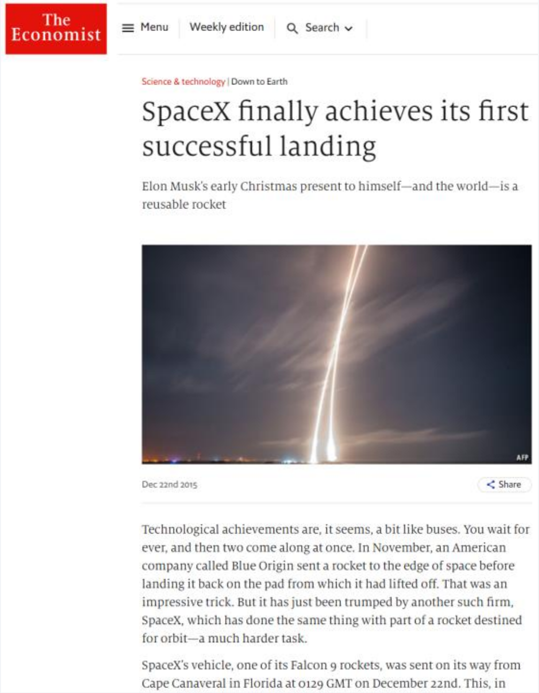
SQL Query

```
[11]: %sql select min(DATE) from SPACEXTBL where Landing__Outcome = 'Success (ground pad)'
```

[11]:	1
	2015-12-22

QUERY EXPLANATION

Using the function MIN works out the minimum date in the column Date. The WHERE clause filters the dataset to only perform calculations on Landing_Outcome Success (ground pad)



The Economist
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Science & technology | Down to Earth

SpaceX finally achieves its first successful landing

Elon Musk's early Christmas present to himself—and the world—is a reusable rocket

AFP

Dec 22nd 2015 | Share

Technological achievements are, it seems, a bit like buses. You wait for ever, and then two come along at once. In November, an American company called Blue Origin sent a rocket to the edge of space before landing it back on the pad from which it had lifted off. That was an impressive trick. But it has just been trumped by another such firm, SpaceX, which has done the same thing with part of a rocket destined for orbit—a much harder task.

SpaceX's vehicle, one of its Falcon 9 rockets, was sent on its way from Cape Canaveral in Florida at 0129 GMT on December 22nd. This, in

Source: https://www.economist.com/science-and-technology/2015/12/22/spacex-finally-achieves-its-first-successful-landing

Successful Drone Ship Landing with Payload between 4000 and 6000

SQL

SQL Query

```
[12]: %sql select distinct(BOOSTER_VERSION) from SPACEXTBL where LANDING__OUTCOME = 'Success (drone ship)'\
AND PAYLOAD_MASS__KG_ between 4000 and 6000
```

[12]: booster_version
F9 FT B1021.2
F9 FT B1031.2
F9 FT B1022
F9 FT B1026

QUERY EXPLANATION

Selecting only Booster Version. The WHERE clause filters the dataset to Landing_Outcome = Success (drone ship). The AND clause specifies additional filter conditions Payload_MASS_KG_ > 4000 AND Payload_MASS_KG_ < 6000

Of Course I Still Love You (OCISLY) is an **autonomous spaceport droneship (ASDS)** that is operated out of the Port of Long Beach, California. Of Course I Still Love You was previously based in Florida from 2015 to 2021.
Source: https://spacexfleet.com/of-course-i-still-love-you/

JCSAT-2B, known as JCSAT-14 before commissioning, is a geostationary communications satellite operated by SKY Perfect JSAT Group and designed and manufactured by SSL on the SSL 1300 platform. It had a **launch weight of 4,696.2 kg**, a power production capacity of 9 to 9.9 kW at end of life and a 15-year design life.
Source: https://en.wikipedia.org/wiki/JCSAT-2B

SES-10 is based on the three axis stabilised Eurostar-3000 satellite bus. It has a **mass of 5,282 kg**, produces 13 kW of power and has a design life of 15 years.
Source: https://en.wikipedia.org/wiki/SES-10

Source: https://en.wikipedia.org/wiki/List_of_Falcon_9_first-stage_boosters

S/N	Version	Launch date (UTC)[5]	Flight No.[a]	Turnaround	Payload[b]	Launch	Landing	Status
B1021	FT	8 April 2016	F9-023	—	Dragon C110 (CRS-8)[26]	Success (40)	Success (OCISLY)	Retired[27] To be displayed at Cape Canaveral[28] [dubious – discuss]
		30 March 2017	F9-032 △	356 days	SES-10[26]	Success (39A)	Success (OCISLY) [29][30]	
B1022	FT	6 May 2016	F9-024	—	JCSAT-14	Success (40)	Success (OCISLY)	Retired
B1026	FT	14 August 2016	F9-028	—	JCSAT-16	Success (40)	Success (OCISLY) [37]	Retired[33]
B1031	FT	19 February 2017	F9-030	—	Dragon C112 (CRS-10)[48]	Success (39A)	Success (LZ-1) [49]	Retired[33]
		11 October 2017	F9-043 △	234 days	SES-11[49]	Success (39A)	Success (OCISLY)	

Total Number of Successful and Failure Mission Outcomes

SQL Query

```
[13]: %sql select  MISSION_OUTCOME,count(*) as Counter from SPACEXTBL group by MISSION_OUTCOME
```

[13]:

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

QUERY EXPLANATION

To display the result set listing the outcome and its count of total number of outcome types found in dataset (i.e. failure (in flight), success, and success (payload status unclear), we add the "group by" clause to the select statement. The "group by" clause groups a result into subsets that has matching values for one or more columns.

Boosters Carried Maximum Payload

SQL Query

[14]:

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

[14]:

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

QUERY EXPLANATION

To determine the booster that has carried the maximum payload using a subquery in the WHERE clause and the MAX() function.

2015 Launch Records of Failure Drone Ship Landing

SQL Query

```
[19]:  %sql  select TO_CHAR ( TO_DATE ( MONTH ( "DATE“ ), 'MM' ), 'MONTH' ) as MONTH_NAME_IN_2015, \
          LANDING__OUTCOME,  BOOSTER_VERSION,  LAUNCH_SITE \
          from SPACEXTBL where LANDING__OUTCOME = 'Failure (drone ship)' AND DATE like '2015%'
```

[19]:

month_name_in_2015	landing__outcome	booster_version	launch_site
JANUARY	Failure (drone ship)	F9 v1.1 B1012	CCAFS LC-40
APRIL	Failure (drone ship)	F9 v1.1 B1015	CCAFS LC-40

QUERY EXPLANATION

To perform a series of conversions in order to extract the month in string format.

- The MONTH( ) function returns the month part for a given date (a number from 1 to 12).
- TO_DATE converts a formatted date string to a date integer.
- TO_CHAR performs the reverse operation; it converts a date integer to a formatted date string.

The WHERE clause filters the dataset to Landing_Outcome = Failure (drone ship). The AND clause specifies additional filter conditions with **LIKE** keyword has a wild card with the words '2015%' the percentage, in the end, suggests that the Date must start with the year 2015.

Source: https://en.wikipedia.org/wiki/List_of_Falcon_9_first-stage_boosters

S/N[a]	Version	Launch date (UTC)[5]	Flight No.	Payload[b]	Launch	Landing	Status
B1012	v1.1	10 January 2015	F9-014	Dragon C107 (CRS-5)	Success (40)	Failure	Destroyed
B1013	v1.1	11 February 2015	F9-015	DSCOVR	Success (40)	Controlled (ocean)	Expended
B1014	v1.1	2 March 2015	F9-016	ABS-3A / Eutelsat 115 West B	Success (40)	No attempt[18]	Expended
B1015	v1.1	14 April 2015	F9-017	Dragon C108 (CRS-6)	Success (40)	Failure	Destroyed
B1016	v1.1	27 April 2015	F9-018	TürkmenÄlem 52°E / MonacoSAT	Success (40)	No attempt[18]	Expended

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

SQL Query

```
[16]: %sql  select LANDING__OUTCOME,  count(*) as counter_btw_2010Jun04_to_2017Mar20 from SPACEXTBL \
       where DATE between '2010-06-04' and '2017-03-20' \
       group by LANDING__OUTCOME order by counter_btw_2010Jun04_to_2017Mar20 desc
```

[16]:

landing__outcome	counter_btw_2010jun04_to_2017mar20
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

QUERY EXPLANATION

Selected Landing outcomes and the COUNT of landing outcomes from the data and used the WHERE clause to filter for landing outcomes BETWEEN 2010-06-04 to 2010-03-20. Also applied the GROUP BY clause to group the landing outcomes and the ORDER BY clause to order the grouped landing outcome in DESCENDING ORDER.

Section 3

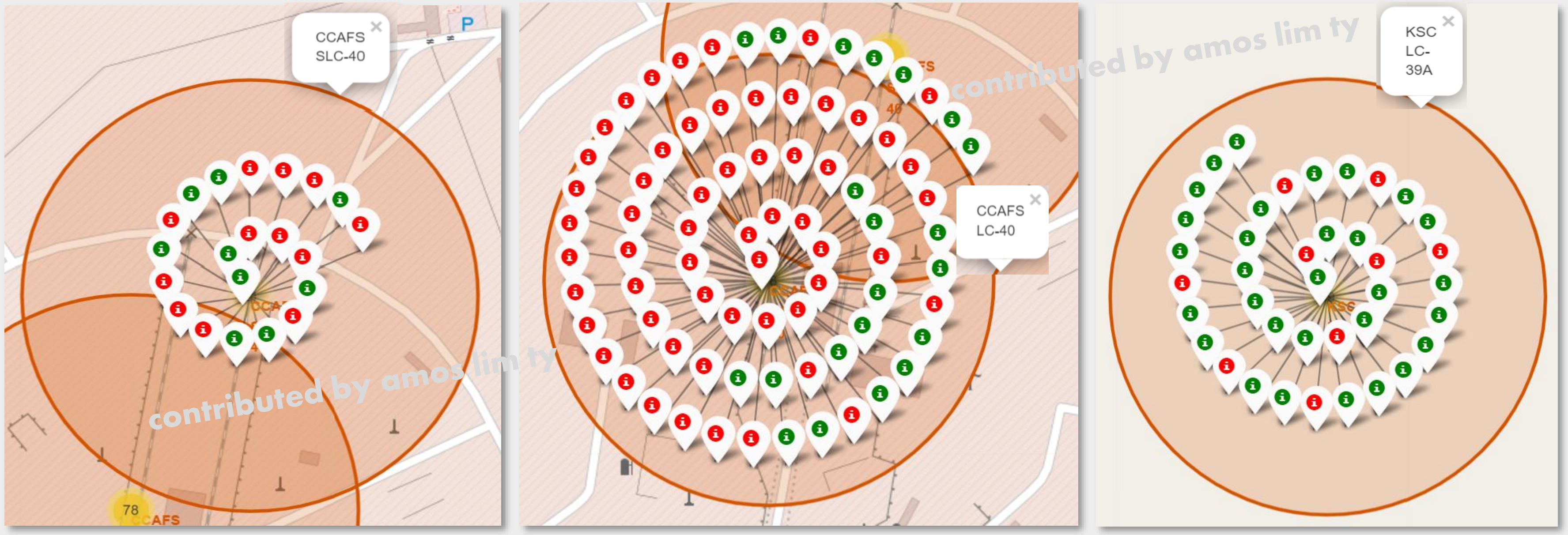
Launch Sites Proximities Analysis

Global Locations Of All Space X Launch Sites

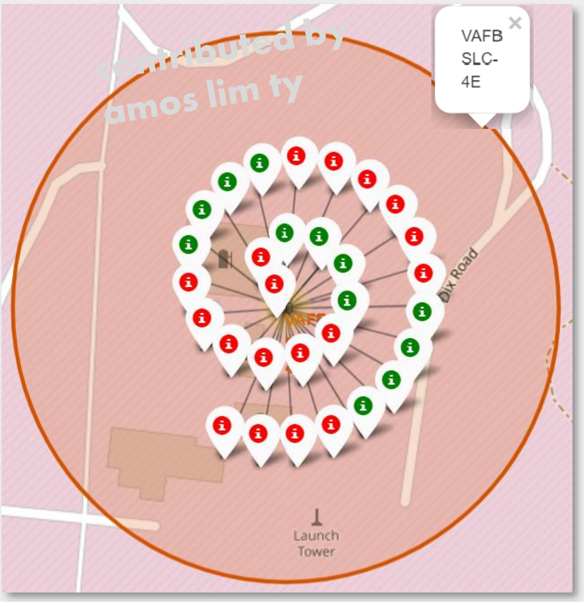
SpaceX launch sites are found on both sides of the United States of America coasts. All the sites are located in either **Florida** or **California**.

Launch Success Rate Analysis by Sites

Florida Launch Sites



California Launch Site



- **CCAFS LC-40** had the **worst** success rate, but it also clocked the **most** launches.
- **KSC LC-39A** has the **best** success rate.

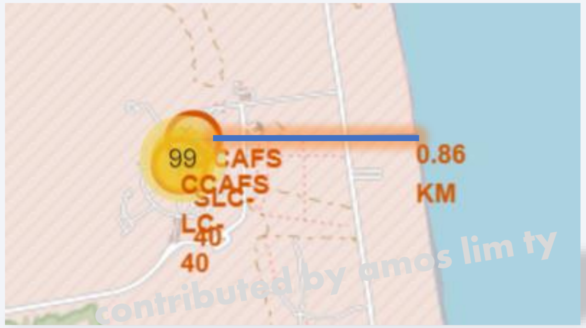
Color Maker Legend

Success

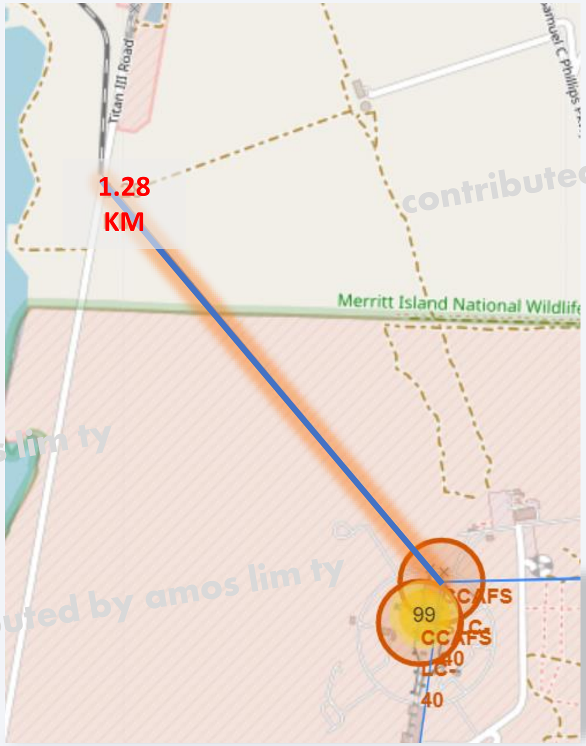
Failure

Proximities Analysis - CCAFS SLC-40 Site Only

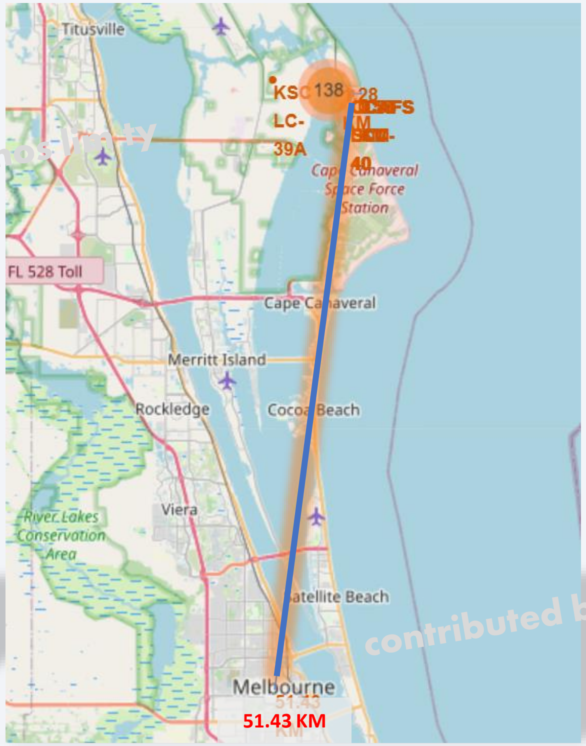
Distance to
Closest **Coastline**



Distance to
Closest **Highway**



Distance to
Closest **Railway**



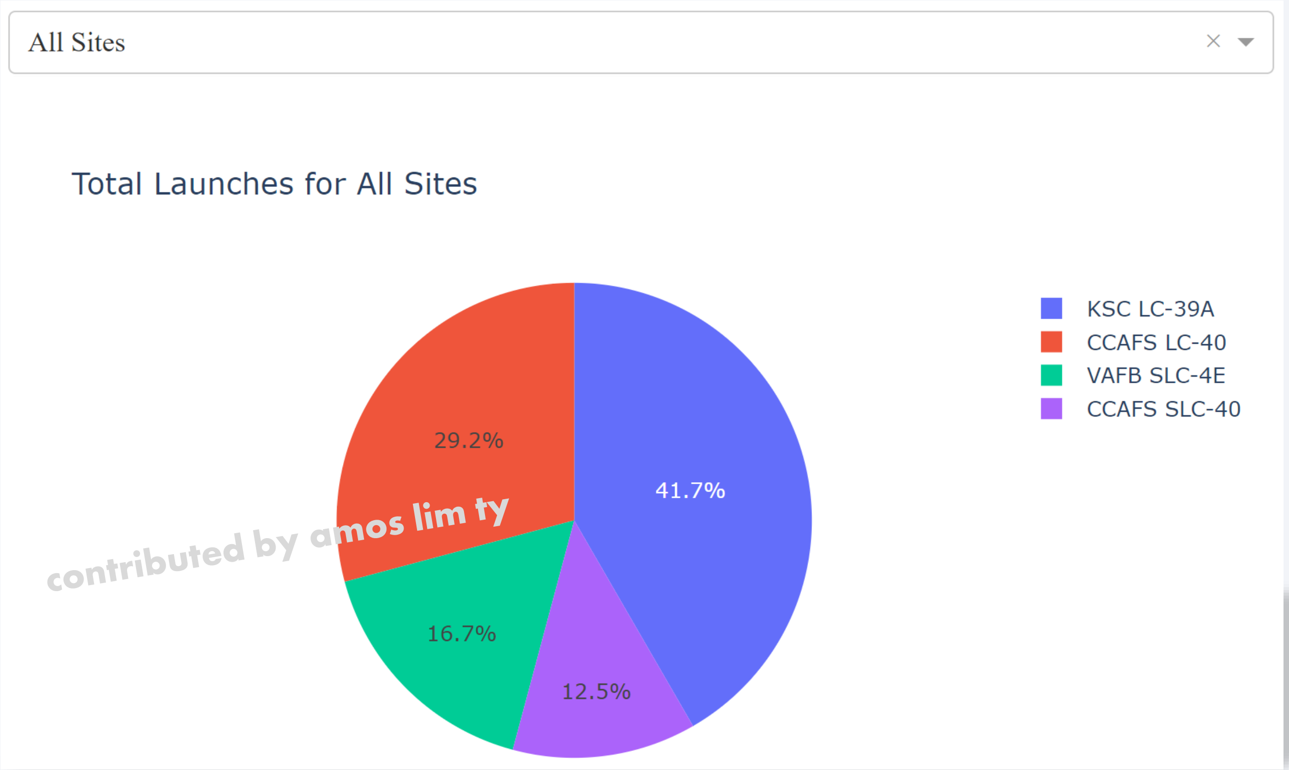
Distance to
Closest **City**

- Observed that the transport infrastructures (e.g. highway, railway, etc) are accessible to the site, which is typically < 1.5km in proximity. It is believed for better logistic efficiency.
- Site is far (>50 km) from the closest city, which supports the safety reason.
- All the site proximities consideraten is necessary requirements but might not contribute to the launch success rate directly

Section 4

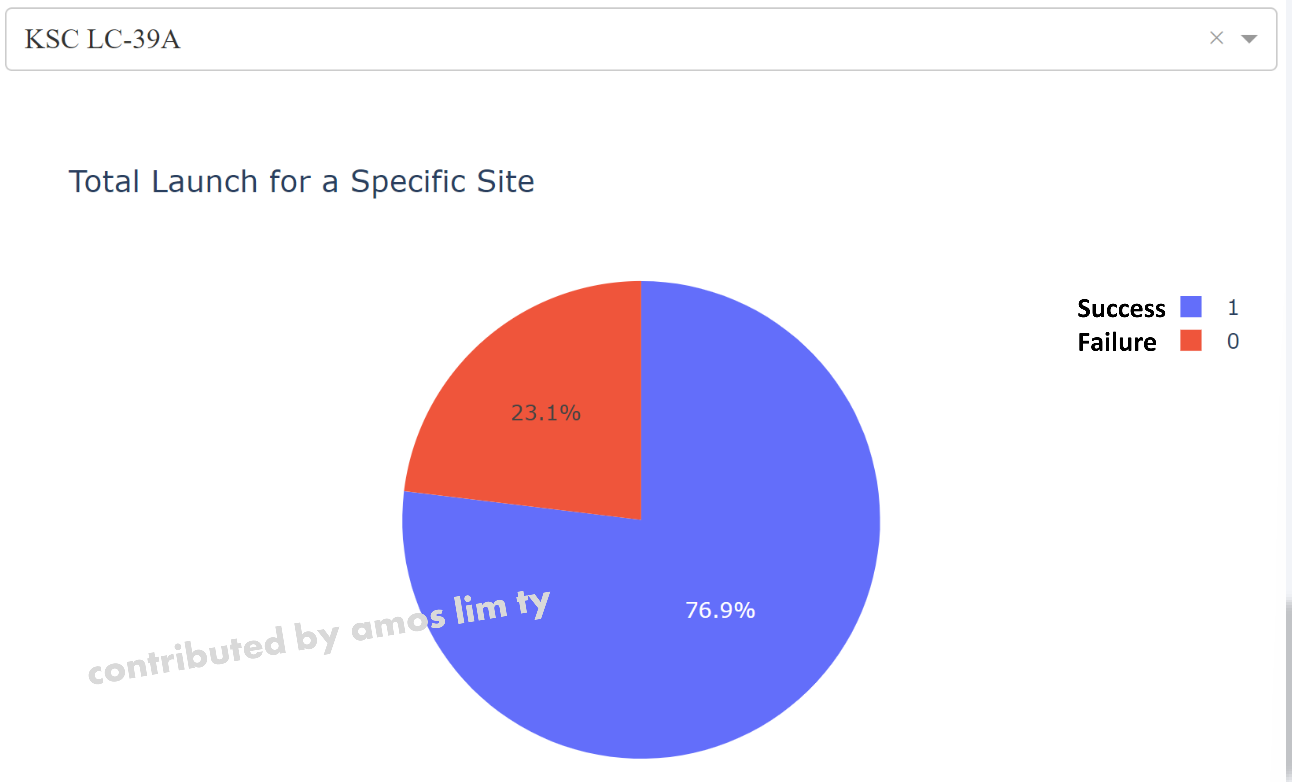
Build a Dashboard with Plotly Dash

Overall Sites' Successful Launches Contribution



- **KSC LC-39A** had the highest contribution (**41.7%**) to successful launches when compared to all sites.

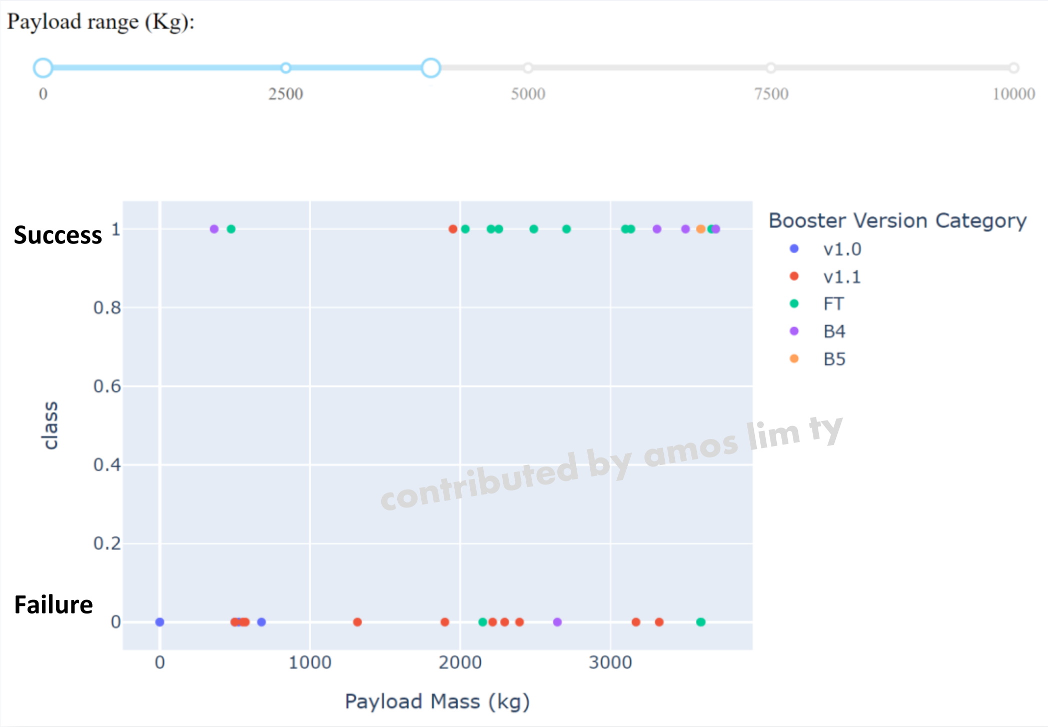
Success Rate of Site With the Overall Highest Successful Launches Contribution



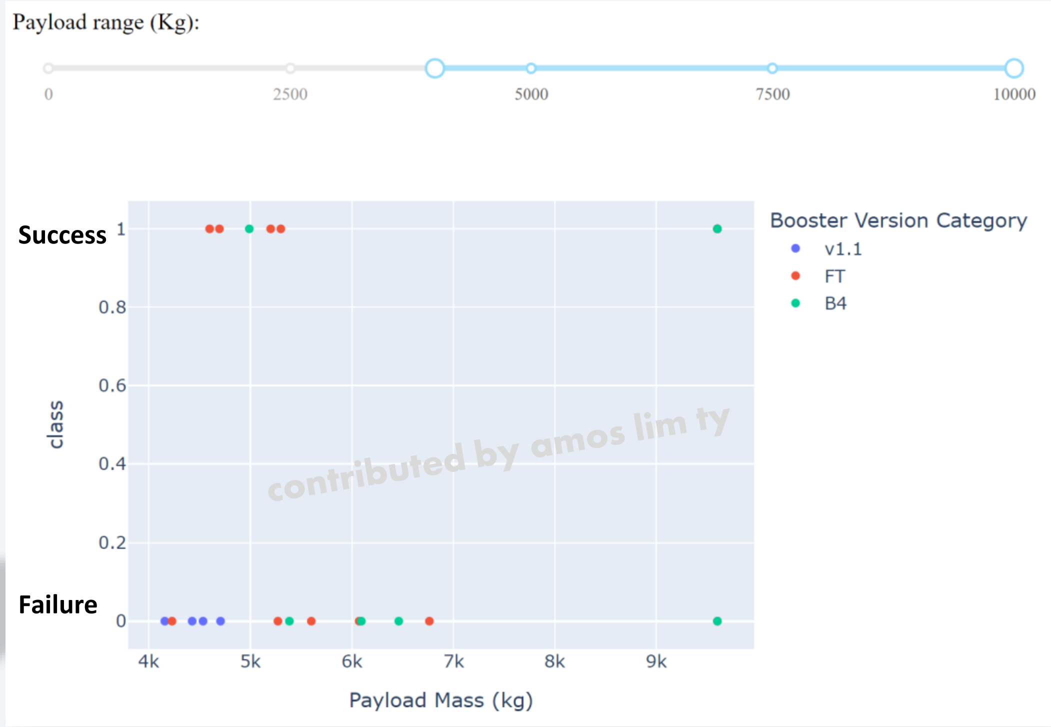
- **KSC LC-39A** site itself had achieved **76.9%** successful launches and **23.1%** of failed launches.

Different Payload Vs. Launch Outcome For All Sites

Lighter Payload: 0KG to 4,000KG



Heavier Payload: 4,001KG to 10,000KG

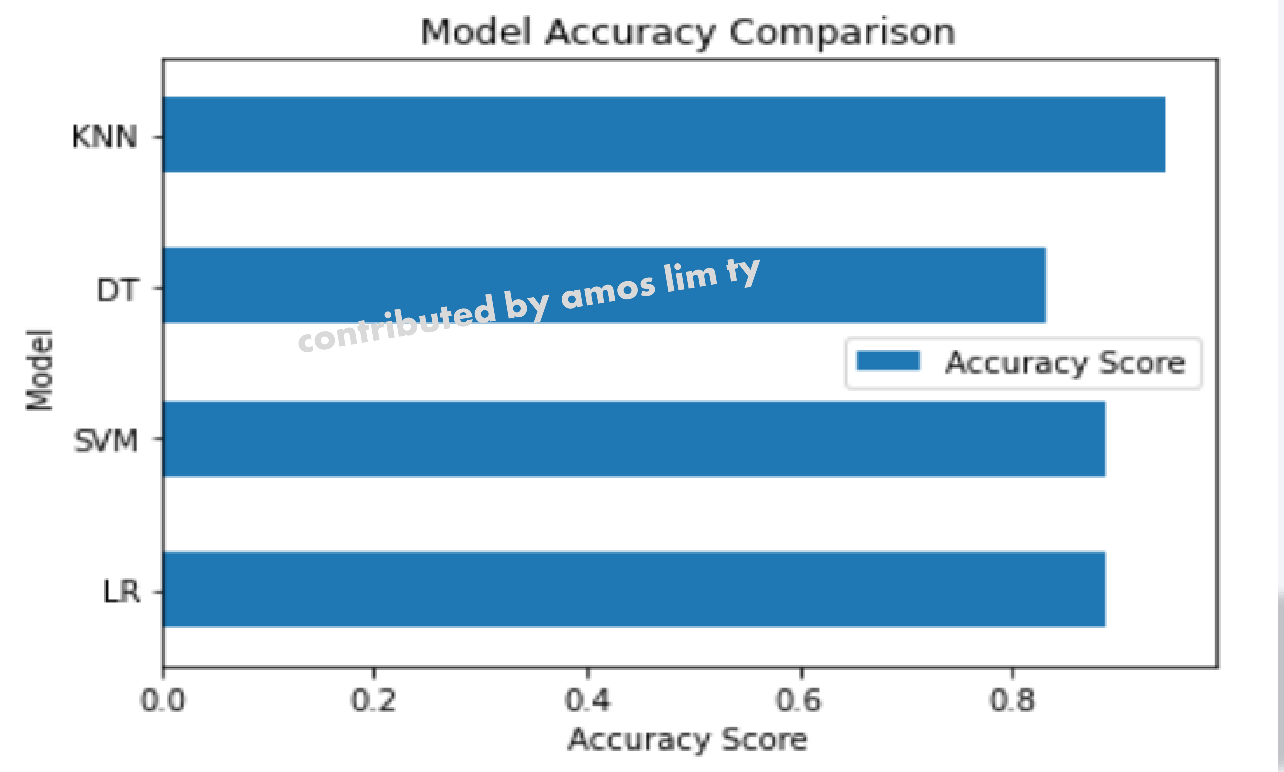


- There were more successful launches with lighter payloads, particularly between 2,000Kg to 4,000Kg.
- There were more Booster Version Categories for lighter payloads.

Section 5

Predictive Analysis (Classification)

Classification Accuracy Comparison

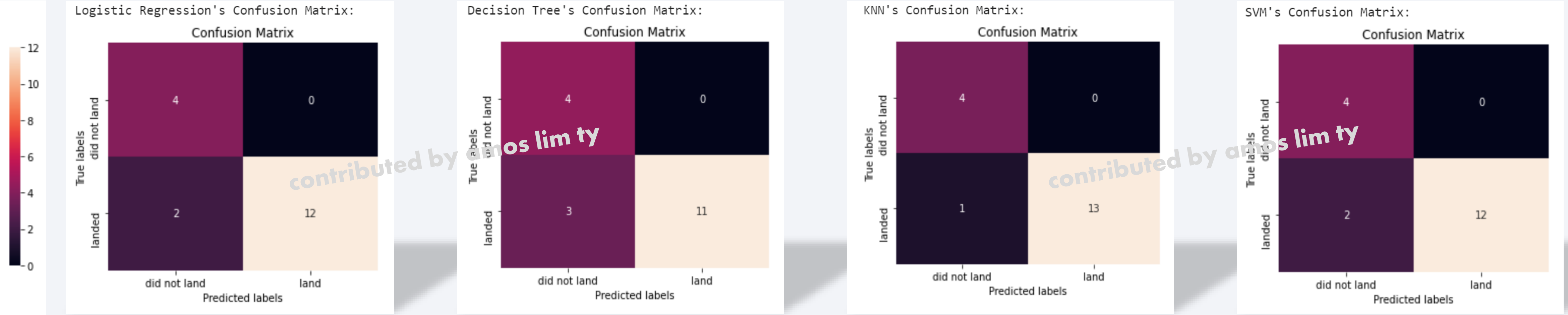


[32]:

	Model	Accuracy Score
0	LR	0.888889
1	SVM	0.888889
2	DT	0.833333
3	KNN	0.944444

- **K-Nearest Neighbour** (KNN) is the best classification model for achieving **94.44% accuracy** on the test data.

Confusion Matrix Comparison



- The confusion matrix for the **K-Nearest Neighbour** (KNN) classification model shows the <u>highest of '**True Positive**'</u>(i.e. 13) and the <u>lowest of '**False Negative**'</u> (i.e. 1).

Actual Values \ Predicted Values	Negative	Positive
Negative	TN	FP
Positive	FN	TP

Conclusions

- SpaceY could bid against SpaceX for a rocket launch because of our ability to predict the first-stage landing outcomes.
- Each successful first stage landing is worth about 100 million dollars. This is a significant opportunity cost for every launch.
- We discovered there are 10-15 factors that could help to build the prediction model and there are strong correlations among them.
- We also observed that Elon Musk increased his chances of success through failure. While we can shorten the process by learning about his failures, “Failure is still truly life’s greatest teacher”.

Thank you!

Appendix

- https://github.com/amoslimty/Applied-Data-Science-Capstone-Project-SpaceX

Wk1 – 10.1.9 (Collect data via API)

```
[6]: spacex_url="https://api.spacexdata.com/v4/l
```

https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/API_call_spacex_api.json

```
[26]: FlightNumber
      Date
      BoosterVersion
      PayloadMass
      Orbit
      LaunchSite
      Outcome
      Flights
      GridFins
      Reused
      Legs
      LandingPad
      Block
      ReusedCount
      Serial
      Longitude
      Latitude
```

```
data_falcon9.to_csv('dataset_part_1.csv', index=False)
```

Wk1 – 10.1.11 (Collect data via Web scrapping)

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

Static URL:
https://en.wikipedia.org/w/index.php?title=List_of_Falcon_9_and_Falcon_Heavy_launches&oldid=1027686922

```
['Flight No.'] = []
['Launch site'] = []
['Payload'] = []
['Payload mass'] = []
['Orbit'] = []
['Customer'] = []
['Launch outcome'] = []

['Version Booster']=[]
['Booster landing']=[]
['Date']=[]
['Time']=[]
```

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

Wk1 – 10.1.13 (Data Wrangling & EDA)

https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/dataset_part_1.csv

		#	Column	Dtype
		---	------	-----
FlightNumber	int64	0	FlightNumber	int64
Date	object	1	Date	object
BoosterVersion	object	2	BoosterVersion	object
PayloadMass	float64	3	PayloadMass	float64
Orbit	object	4	Orbit	object
LaunchSite	object	5	LaunchSite	object
Outcome	object	6	Outcome	int64
Flights	int64	7	Flights	int64
GridFins	bool	8	GridFins	bool
Reused	bool	9	Reused	bool
Legs	bool	10	Legs	bool
LandingPad	object	11	LandingPad	object
Block	float64	12	Block	float64
ReusedCount	int64	13	ReusedCount	int64
Serial	object	14	Serial	object
Longitude	float64	15	Longitude	float64
Latitude	float64	16	Latitude	float64

```
df.to_csv("dataset_part_2.csv", index=False)
```

From web scraping (Wikipedia)

Wk2 – 10.2.2 (EDA with SQL)

https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/labs/module_2/data/Spacex.csv

Wk2 – 10.2.4 (EDA with Data Viz & Feature engineering)

https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/dataset_part_2.csv

```
features = df[['FlightNumber', 'PayloadMass', 'Orbit',
'LaunchSite', 'Flights',\
'GridFins', 'Reused', 'Legs', 'LandingPad',
'Block', 'ReusedCount', 'Serial'
```

```
features_one_hot.to_csv('dataset_part_3.csv', index=False)
```

Wk3 – 10.3.2 (Launch site location analysis with Folium)

https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/spacex_launch_geo.csv

- **TASK 1:** Mark all launch sites on a map
- **TASK 2:** Mark the success/failed launches for each site on the map
- **TASK 3:** Calculate the distances between a launch site to its proximities

Wk3 – 10.3.3 (Dashboard Application with Plotly Dash)

https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/spacex_launch_dash.csv

Building a Plotly Dash application for users to perform interactive visual analytics on SpaceX launch data in real-time

1. Which site has the largest successful launches?
2. Which site has the highest launch success rate?
3. Which payload range(s) has the highest launch success rate?
4. Which payload range(s) has the lowest launch success rate?
5. Which F9 Booster version (v1.0, v1.1, FT, B4, B5, etc.) has the highest launch success rate?

Wk4 – 10.4.2
(ML Prediction)

https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/dataset_part_2.csv

Y (Actual value with outcome)

https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/dataset_part_3.csv

X (independent Variable, Predictor)