



# IBM Capstone Project

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# OUTLINE

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- Executive Summary
- Introduction
- Recommendation
  - Findings & Implications
- Key results
- Methodology
  - EDA (SQL + Pandas)
  - Visualization – Charts
  - Dashboard
  - Predictive Analysis

# EXECUTIVE SUMMARY

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- The objective is to predict our Falcon 9 first stage landing success to support future bid decisions on projects.
- The recommendation is to bid lower prices in future rocket launch tenders, due to following findings from the data analysis:
  - The probability of launch failure is reducing with every Falcon 9 launch.
  - Payload masses are increasing, as the learning curve is growing. The payload masses are not correlating with the success or failure of the launch.
- The risk remains, that the call for tender is expecting to launch from a site and/or to an orbit with a low success rate leading to higher launch costs.
- In the next steps the individual orbit should be analyzed with the decision tree modelling to predict launch success individually with the highest possible accuracy.

# INTRODUCTION

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- The objective is to predict Falcon 9 first stage landing success in this capstone project.
- Cost Comparison: SpaceX's Falcon 9 launches cost \$62 million, significantly lower than competitors' launches priced at \$165 million, mainly due to the ability to reuse the first stage.
- Importance: Predicting first stage landing success is crucial for determining launch costs.

# RECOMMENDATION

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- The recommendation from the data analysis is to bid lower prices in future call for tenders for rocket launches, due to following reasons:
  - The probability of launch failure is reducing with every Falcon 9 launch.
  - Payload masses are increasing, as the learning curve is growing. The payload masses are not correlating with the success or failure of the launch.
- The risk remains, that the call for tender is expecting to launch from a site and/or to an orbit with a low success rate leading to higher launch costs.
- Next Steps: An assessment of the individual launch site and orbit for the specific call for tender.

# WHY

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- Launch failure decreased over time, leading to steadily lower launch cost over time. This is mainly due to learning curve growth.
- Payload masses are increasing, as learning curve is growing. The payload masses do not have an immediate impact on the success or failure of the launch.
- There are several launch sites and orbits of high failure and on the other side, high success. This is also applicable for the booster version.
  - Highest orbit success rate: ES-L1, GEO, HEO, SSO
  - Lowest orbit success rate: GTO, SO
  - KSC LC-39A with the highest success to failure rate.
  - CCAFS SLC-40 with the lowest success to failure rate.
- Predictions can be made with all models. However, decision tree modelling resulted in the highest accuracy. Confusion matrix probably has same values for all models, due to the low amount of samples and high euclidic distance between data points.

# METHODOLOGY & RESULTS: Overview

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- Collecting the data via APIs and Webscraping.
- Data pre-processing via data wrangling incl. one-hot encoding.
- Exploratory Data Analysis (EDA) for analysis of data.
- Graphical visualization via Folium and Dash to understand cause- and effect relationships.
- Creation of supervised, but also unsupervised models to predict the launch cost. This includes Logistic Regression, Decision Tree modelling, Supported Vector modelling, K-Nearest-Neighbour

# METHODOLOGY: Data collection (1/2)

## 1. Data collection: Getting Data via an API request.

To make the requested JSON results more consistent, we will use the following static response object for this project:

```
[9]: static_json_url='https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/API_call_spacex_api.json'
```

We should see that the request was successful with the 200 status response code

```
[10]: response.status_code
```

```
[10]: 200
```

Now we decode the response content as a Json using `.json()` and turn it into a Pandas dataframe using `.json_normalize()`

```
[13]: # Use json_normalize method to convert the json result into a dataframe
data = pd.json_normalize(response.json())
```

Using the dataframe `data` print the first 5 rows

```
[15]: # Get the head of the dataframe
data.head(3)
```

## 2. Filtering data via for the objects of interests.

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

## 3. Data wrangling: Filling out missing values.

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

# To CSV, landing pad rows will be removed afterwards
data_falcon9.to_csv('dataset_part_1.csv', index=False)
```



# METHODOLOGY: Data collection (2/2)

## 4. Webscraping: Getting further data via Wikipedia table.

First, let's perform an HTTP GET method to request the Falcon9 Launch HTML page, as an HTTP response.

```
[7]: # use requests.get() method with the provided static_url
# assign the response to a object
response = requests.get(static_url).text
```

Create a `BeautifulSoup` object from the HTML `response`

```
[8]: # Use BeautifulSoup() to create a BeautifulSoup object from a response text content
soup = BeautifulSoup(response)
```

Print the page title to verify if the `BeautifulSoup` object was created properly

```
[9]: # Use soup.title attribute
soup.title
```

```
[9]: <title>List of Falcon 9 and Falcon Heavy launches - Wikipedia</title>
```

--> Final Dataframe for analysis.

	FlightNumber	Date	BoosterVersion	PayloadMass	Orbit	LaunchSite	Outcome	Flights	GridFins	Reused	Legs	LandingPad
1	1	2010-06-04	Falcon 9	6123.547647058824	LEO	CCSFS SLC 40	None None	1	False	False	False	
2	2	2012-05-22	Falcon 9	525.0	LEO	CCSFS SLC 40	None None	1	False	False	False	
3	3	2013-03-01	Falcon 9	677.0	ISS	CCSFS SLC 40	None None	1	False	False	False	
4	4	2013-09-29	Falcon 9	500.0	PO	VAFB SLC 4E	False Ocean	1	False	False	False	
5	5	2013-12-03	Falcon 9	3170.0	GTO	CCSFS SLC 40	None None	1	False	False	False	
6	6	2014-01-06	Falcon 9	3325.0	GTO	CCSFS SLC 40	None None	1	False	False	False	
7	7	2014-04-18	Falcon 9	2296.0	ISS	CCSFS SLC 40	True Ocean	1	False	False	True	
8	8	2014-07-14	Falcon 9	1316.0	LEO	CCSFS SLC 40	True Ocean	1	False	False	True	
9	9	2014-08-05	Falcon 9	4535.0	GTO	CCSFS SLC 40	None None	1	False	False	False	
10	10	2014-09-07	Falcon 9	4428.0	GTO	CCSFS SLC 40	None None	1	False	False	False	
11	11	2014-09-21	Falcon 9	2216.0	ISS	CCSFS SLC 40	False Ocean	1	False	False	False	

## 5. Creating a Dataframe from Wikipedia table content.

We will create an empty dictionary with keys from the extracted column names in the previous task. Later, this dictionary will be converted into a Pandas dataframe

```
[14]: launch_dict= dict.fromkeys(column_names)

# Remove an irrelevant column
del launch_dict['date and time ( )']

# Let's initial the launch_dict with each value to be an empty list
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'] = []
# Add some new columns
launch_dict['Version Booster'] = []
launch_dict['Booster Landing'] = []
launch_dict['date'] = []
launch_dict['time'] = []
```

Next, we just need to fill up the `launch_dict` with launch records extracted from table rows.

Usually, HTML tables in Wiki pages are likely to contain unexpected annotations and other types of noises, such as reference links `[[B0004,118]]`, missing values `N/A` `[e]`, inconsistent formatting, etc.

To simplify the parsing process, we have provided an incomplete code snippet below to help you to fill up the `launch_dict`. Please complete the following code snippet with TODOs or you can choose to write your own logic to parse all launch tables:

```
[16]: 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 row is th:
            flight_numberrows,th=string,attr()
            flag(flight_number,table)

        else:
            flag=False
            #put table element
            row=rows.find_all("td")
            #if it is number save cells in a dictionary.
            if flag:
                extracted_row += 1
                # Flight Number value
                # TODO: Append the flight number into launch_dict with key 'Flight No.'.
                launch_dict['Flight No.'].append(flight_number)
                #print(flight_number)
                print(flight_number)
                #data=launch_dict[table_number]
```

Would you like to receive official Jupyter notebooks?

# METHODOLOGY: Data visualization (1/2)

1. Usage of Folium to create an interactive map for visualization purposes.

```
[1]: import piplite
      await piplite.install(['folium'])
      await piplite.install(['pandas'])

[2]: import folium
      import pandas as pd

[3]: # Import folium MarkerCluster plugin
      from folium.plugins import MarkerCluster
      # Import folium MousePosition plugin
      from folium.plugins import MousePosition
      # Import folium DivIcon plugin
      from folium.features import DivIcon
```

3. Usage of Folium Marker & Polyline to create lines and distance indication between points of interests.

```
orlando_lat= 28.53627
orlando_lon= -81.4
launch_site_lat= 28.562
launch_site_lon= -80.57717
distance_orlando = calculate_distance(launch_site_lat, launch_site_lon, orlando_lat, orlando_lon)

city_marker = folium.Marker(location = [28.53627, -81.4],
                             icon=DivIcon(icon_size = (20,20),
                                           icon_anchor = (0,0),
                                           html='<div style="font-size: 40; color:#d35400;"><b>%s</b></div>' % "{:10.2f}"
                                           )
                             )

lines=folium.PolyLine(locations=[[launch_site_lat, launch_site_lon], [orlando_lat, orlando_lon]], weight=1)
site_map.add_child(lines)
site_map.add_child(city_marker)
```

2. Usage of Folium objects to add markers to data points.

We could use `folium.Circle` to add a highlighted circle area with a text label on a specific coordinate. For example,

```
[7]: # Create a blue circle at NASA Johnson Space Center's coordinate with a popup label showing its name
      circle = folium.Circle(nasa_coordinate, radius=1000, color='#d35400', fill=True).add_child(folium.Popup('NASA Johnson Space Center'))
      # Create a blue circle at NASA Johnson Space Center's coordinate with a icon showing its name
      marker = folium.Marker(
          nasa_coordinate,
          # Create an icon as a text label
          icon=DivIcon(
              icon_size=(20,20),
              icon_anchor=(0,0),
              html='<div style="font-size: 12; color:#d35400;"><b>%s</b></div>' % 'NASA JSC',
          )
      )
      site_map.add_child(circle)
      site_map.add_child(marker)
```

# METHODOLOGY: Data visualization (2/2)

## 1. Addition of Dropdown menu to Dash

```
dcc.Dropdown(id='site-dropdown', options=[
    {'label': 'All Sites', 'value': 'ALL'},
    {'label': 'CCAFS LC-40', 'value': 'CCAFS LC-40'},
    {'label': 'VAFB SLC-4E', 'value': 'VAFB SLC-4E'},
    {'label': 'KSC LC-39A', 'value': 'KSC LC-39A'},
    {'label': 'CCAFS SLC-40', 'value': 'CCAFS SLC-40'}
],
             value='ALL',
             placeholder="SELECT",
             searchable=True,
             clearable=True
),
```

## 2. Creation of callback functions for pie chart.

```
@app.callback(Output(component_id='success-pie-chart', component_property='figure'),
              [Input(component_id='site-dropdown', component_property='value')])
def get_pie_chart(entered_site):
    filtered_df = spacex_df
    if entered_site == 'ALL':
        fig = px.pie(data_frame=filtered_df, values='class', names='Launch Site', title='Success/Failure per launch site')
    else:
        filtered_df = filtered_df[filtered_df['Launch Site'] == entered_site]
        grouped_df = filtered_df.groupby('class').size().reset_index(name='count')
        grouped_df['class'] = grouped_df['class'].astype(str)
        fig = px.pie(data_frame=grouped_df,
                    values='count', names='class',
                    title='Success/Failure per launch site')
    return fig
```

## 3. Addition of a range slider for visualization adjustment.

```
html.P("Payload range (Kg):"),
dcc.RangeSlider(id='payload-slider', min=0, max=10000, step=1000, marks={0: '0', 100: '100'},
               value=[min_payload, max_payload]),
```

## 4. Creation of callback functions for scatter plotting.

```
@app.callback(Output(component_id='success-payload-scatter-chart', component_property='figure'),
              [Input(component_id='site-dropdown', component_property='value'),
               Input(component_id='payload-slider', component_property='value')])
def get_scatter(entered_site, payload_range):
    filtered_df = spacex_df
    min_payload, max_payload = payload_range
    if entered_site == 'ALL':
        scatter_fig = px.scatter(filtered_df[(filtered_df['Payload Mass (kg)'] >= min_payload) &
                                             (filtered_df['Payload Mass (kg)'] <= max_payload)],
                                x='Payload Mass (kg)', y='class',
                                color='Booster Version Category',
                                title='Relationship Payload Mass and success rate')
    else:
        scatter_fig = px.scatter(filtered_df[(filtered_df['Launch Site'] == entered_site) &
                                             (filtered_df['Payload Mass (kg)'] >= min_payload) &
                                             (filtered_df['Payload Mass (kg)'] <= max_payload)],
                                x='Payload Mass (kg)', y='class',
                                color='Booster Version Category',
                                title='Relationship Payload Mass and success rate')
    return scatter_fig
```

# METHODOLOGY: Predictive analytics

## 1. Defining the "class"/target variable.

```
[8]: Y = data['Class'].to_numpy()
Y
[8]: array([0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 1, 1, 1,
          1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1,
          1, 0, 0, 0, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1,
          1, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
          1, 1], dtype=int64)
```

## 2. Standardizing predictors.

```
[19]: # students get this
transform = preprocessing.StandardScaler()
X = transform.fit(X).transform(X.astype(float))
X
[19]: array([[ -1.71291154e+00, -1.34780356e-17, -6.53912840e-01, ...,
           -8.35531692e-01,  1.93309133e+00, -1.93309133e+00],
          [-1.67441914e+00, -1.19523159e+00, -6.53912840e-01, ...,
           -8.35531692e-01,  1.93309133e+00, -1.93309133e+00],
          [-1.63592675e+00, -1.16267307e+00, -6.53912840e-01, ...,
           -8.35531692e-01,  1.93309133e+00, -1.93309133e+00],
          ...,
          [ 1.63592675e+00,  1.99100483e+00,  3.49060516e+00, ...,
           1.19684269e+00, -5.17306132e-01,  5.17306132e-01],
          [ 1.67441914e+00,  1.99100483e+00,  1.00389436e+00, ...,
           1.19684269e+00, -5.17306132e-01,  5.17306132e-01],
          [ 1.71291154e+00, -5.19213966e-01, -6.53912840e-01, ...,
           -8.35531692e-01, -5.17306132e-01,  5.17306132e-01]])
```

## 3. Creation and fitting of several models. Finding of best model parameters with GridSearchCV.

```
[25]: parameters = {'C': [0.01, 0.1, 1],
                  'penalty': ['l2'],
                  'solver': ['lbfgs']}

[29]: parameters = {'C': [0.01, 0.1, 1], 'penalty': ['l2'], 'solver': ['lbfgs']} # l1 lasso l2 ridge
lr = LogisticRegression()
logreg_cv = GridSearchCV(lr, parameters, cv = 10)
logreg_cv.fit(X_train, Y_train)

[29]: > GridSearchCV
> estimator: LogisticRegression
> LogisticRegression
```

## 4. Evaluation of model accuracy via confusion matrix and R2-Score

```
]: yhat = knn_cv.predict(X_test)
plot_confusion_matrix(Y_test, yhat)
```

```
]: print("tuned hpyerparameters :(best parameters) ", knn_cv.best_params_)
print("accuracy :", knn_cv.best_score_)

tuned hpyerparameters :(best parameters) {'algorithm': 'auto', 'n_neighbors': 10, 'p': 1}
accuracy : 0.8482142857142858
```

# RESULTS: EDA (SQL)

## Task 1

//labs.cognitiveclass.ai/v2/tools/jupyterlab/?ulid=ulid-3b2a81d2238ed2815cf43e00243962e49176a464

12/24, 21:00

jupyter-labs-eda-sql-coursera\_sqlite

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

```
In [9]: %sql SELECT DISTINCT "Launch_Site" FROM SPACEXTABLE
```

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

```
Out[9]: Launch_Site
```

CCAFS LC-40

VAFB SLC-4E

KSC LC-39A

CCAFS SLC-40

Launch site overview

## Task 2

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

```
In [21]: %sql SELECT * FROM SPACEXTABLE WHERE "Launch_Site" LIKE 'CCA%' LIMIT 20
```

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

jupyter-labs-eda-sql-coursera\_sqlite

[21]:	Date	Time (UTC)	Booster_Version	Launch_Site	Payload	PAYLOAD_MASS_KG_	Orbit	Customer	Mission_Outcome	Landing
	2010-06-04	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit		0 LEO	SpaceX	Success	Failure
	2010-12-08	15:43:00	F9 v1.0 B0004	CCAFS LC-40	Dragon demo flight C1, two CubeSats, barrel of		0 LEO (ISS)	NASA (COTS) NRO	Success	Failure

## Task 3

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

```
In [20]: %sql SELECT SUM("PAYLOAD_MASS_KG_") as 'TOTAL PAYLOAD NASA' FROM SPACEXTABLE WHERE "Customer" LIKE 'NASA%'
```

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

```
Out[20]: TOTAL PAYLOAD NASA
```

99980

Total payload mass for NASA.

## Task 4

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

```
In [29]: %sql SELECT AVG("PAYLOAD_MASS_KG_") AS 'AVERAGE PAYLOAD F9 V1.1' FROM SPACEXTABLE WHERE "Booster_Version" LIKE 'F9
```

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

```
Out[29]: AVERAGE PAYLOAD F9 V1.1
```

2534.6666666666665

Average payload mass.

# RESULTS: EDA (SQL)

## Task 5

List the date when the first succesful landing outcome in ground pad was acheived.

Hint: Use min function

ss.cognitiveclass.ai/v2/tools/jupyterlab/?id=ulid-362a81d2238ed2815cf3c00243962e49176a464

7/13

```
21:00 jupyter-labs-eda-sql-coursera_sqlite

In [35]: %sql SELECT MIN("Date") as "EARLIEST DATE FOR SUCCESSFUL LAUNCH" FROM SPACEXTABLE WHERE "Mission_Outcome" is "Succ
* sqlite:///my_data1.db
Done.
Out [35]: EARLIEST DATE FOR SUCCESSFUL LAUNCH
2010-06-04
```

First successful  
launch

## Task 6

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

```
In [55]: %sql SELECT Booster_Version, PAYLOAD_MASS_KG_ FROM SPACEXTABLE WHERE PAYLOAD_MASS_KG_ < 6000 AND PAYLOAD_MASS_KG_
* sqlite:///my_data1.db
Done.
```

```
Out[55]: Booster_Version  PAYLOAD_MASS_KG_
          F9 v1.1          4535
          F9 v1.1 B1011    4428
          F9 v1.1 B1014    4159
          F9 v1.1 B1016    4707
          F9 FT B1020      5271
          F9 FT B1022      4696
          F9 FT B1026      4600
          F9 FT B1030      5600
          F9 FT B1021.2    5300
          F9 FT B1032.1    5300
          F9 B4 B1040.1    4990
          F9 FT B1031.2    5200
          F9 B4 B1043.1    5000
          F9 FT B1032.2    4230
          F9 B4 B1040.2    5384
          F9 B5 B1046.2    5800
          F9 B5 B1047.2    5300
          F9 B5B1054       4400
          F9 B5 B1048.3    4850
          F9 B5 B1051.2    4200
          F9 B5B1060.1     4311
          F9 B5 B1058.2    5500
          F9 B5B1062.1     4311
```

Successful  
boosters versions with  
mass between 4000 –  
6000kg.

## Task 7

List the total number of successful and failure mission outcomes

```
In [76]: %sql SELECT "Mission_Outcome", COUNT(*) FROM SPACEXTABLE GROUP BY "Mission_Outcome"
* sqlite:///my_data1.db
Done.
Out[76]:
```

Mission_Outcome	COUNT(*)
Failure (in flight)	1
Success	98
Success	1
Success (payload status unclear)	1

Success/Failure  
overview

## Task 8

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

```
In [92]: %sql SELECT Booster_Version FROM SPACEXTABLE WHERE PAYLOAD_MASS_KG_ == (SELECT MAX(PAYLOAD_MASS_KG_) FROM SPACEXT
* sqlite:///my_data1.db
Done.
```

```
t[92]: 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
```

Maximum payload  
mass boosters.

# RESULTS: EDA (SQL)

## Task 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.

Note: SQLite does not support monthnames. So you need to use substr(Date, 6,2) as month to get the months and substr(Date,0,5)='2015' for year.

```
[95]: %sql SELECT substr(Date,6,2) AS "Month", "Landing_Outcome", "Booster_Version", "Launch_Site" FROM SPACEXTABLE WHERE
* sqlite:///my_data1.db
Done.
```

gnitvclass.ai/v2/tools/jupyterlab/?id=uid-3b2a81d2238ed2815cf43c00243962e49176a464

11/

0 jupyter-labs-eda-sql-coursera\_sqlite

```
t [95]:
```

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

## Task 10

Rank the count of landing outcomes (such as Failure (drone ship) or Success (ground pad)) between the date 2010-06-04 and 2017-03-20, in descending order.

```
[115]: %sql
SELECT COUNT(*), "Landing_Outcome", "Date"
FROM SPACEXTABLE
WHERE "Date" BETWEEN '2010-06-04' AND '2017-03-20' -- OR: WHERE "Date" >= '2010-06-04' AND "Date" <= '2017-03-20'
GROUP BY "Landing_Outcome"
ORDER BY COUNT(*) DESC
* sqlite:///my_data1.db
Done.
```

```
t [115]:
```

COUNT(*)	Landing_Outcome	Date
10	No attempt	2012-05-22
5	Success (drone ship)	2016-04-08
5	Failure (drone ship)	2015-01-10
3	Success (ground pad)	2015-12-22
3	Controlled (ocean)	2014-04-18
2	Uncontrolled (ocean)	2013-09-29
2	Failure (parachute)	2010-06-04
1	Precluded (drone ship)	2015-06-28

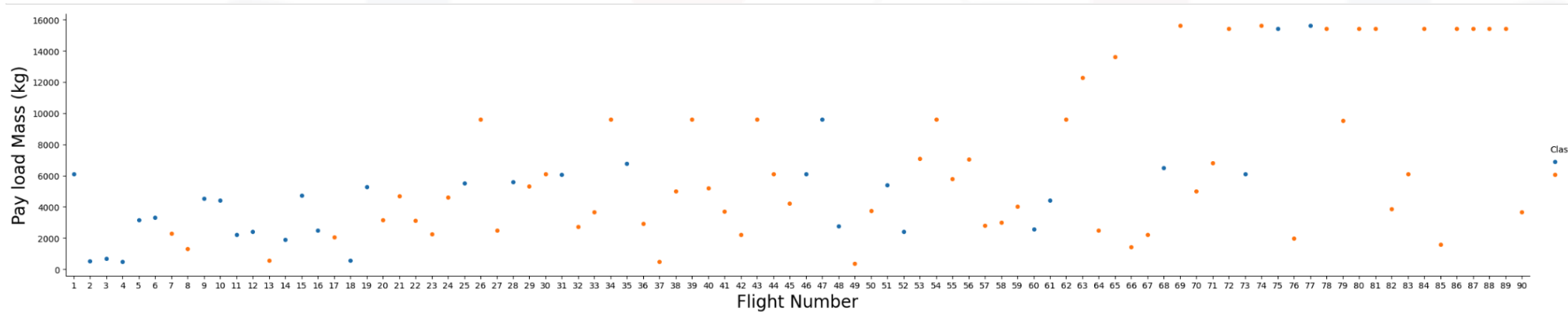
Landing outcomes for  
targeted date interval.

# Results: EDA (Pandas )

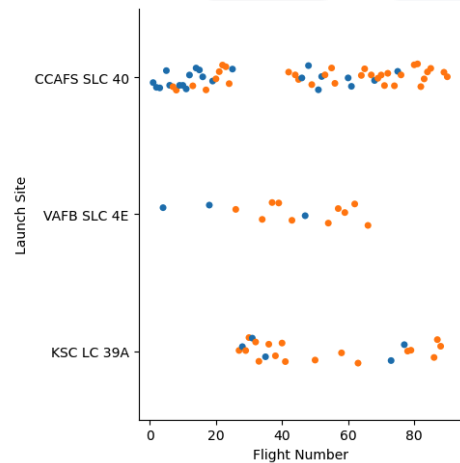
Amber: Success

Blue: Failed

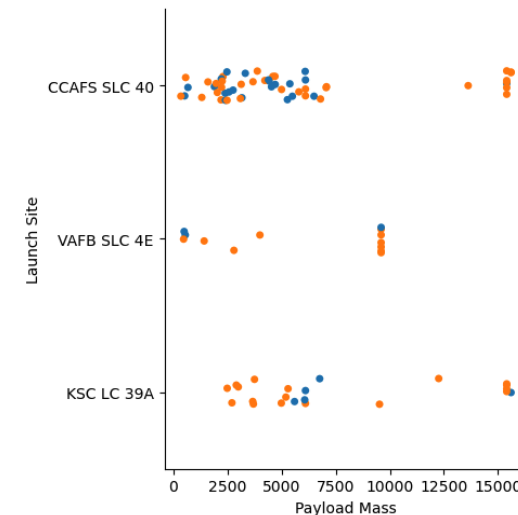
Flight Number over Pay-Load mass (kg) and Launch Site.



- Over time, success increased, failures decreased.



- KSC LC 39A started from 25th flight.
- Highest quantity of flights from CCAFS SLC 40
- First flights are rather unsuccessful.



- More low payload launches have failed that high payloads.



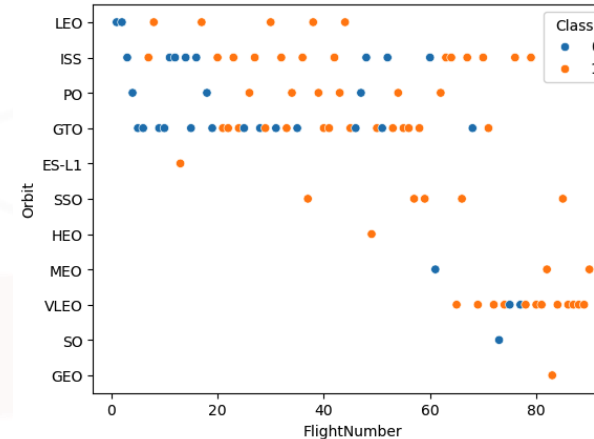
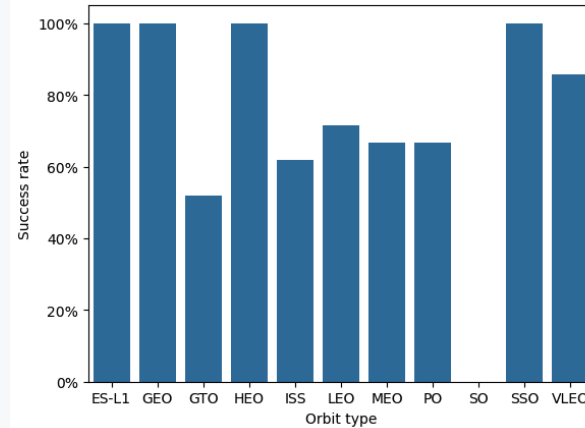
# Results: EDA (Pandas )

Amber: Success

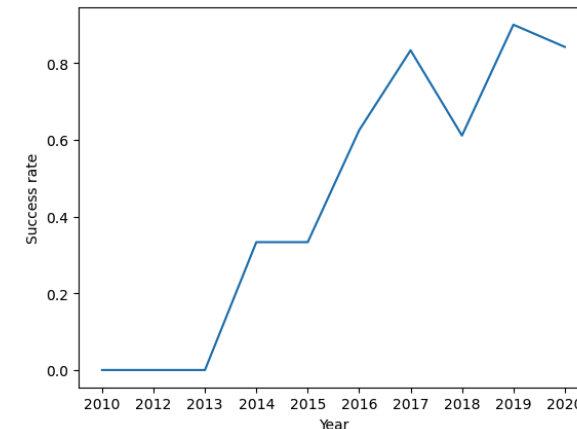
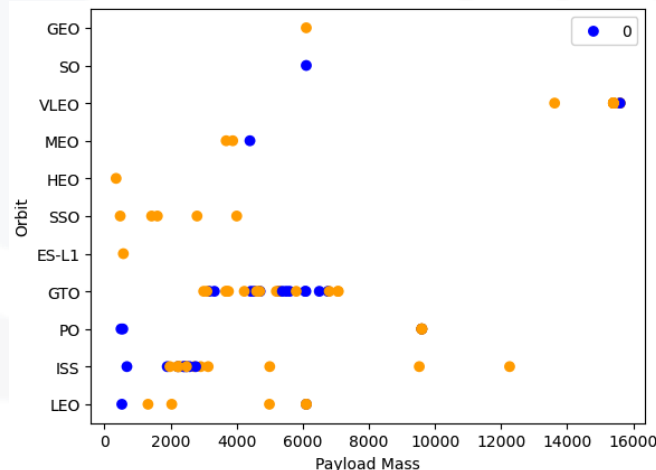
Blue: Failed

## Orbit vs. Success rate vs. Flight Number

- Highest success rate: ES-L1, GEO, HEO, SSO
- Lowest success rate: GTO, SO



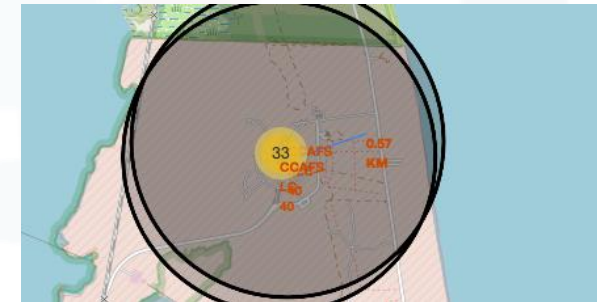
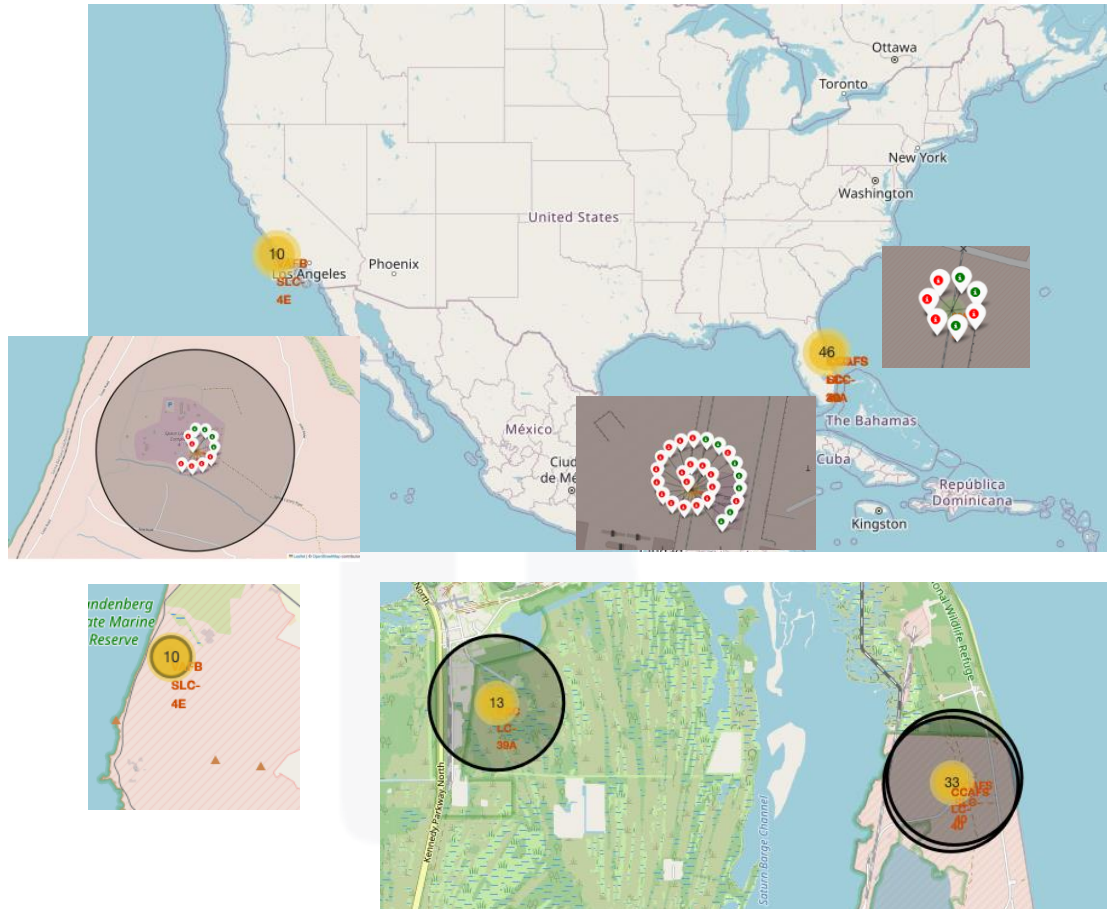
- Success rate increased with flight numbers.
- Top 5 Orbits are LEO, ISS, PO, GTO, VLEO



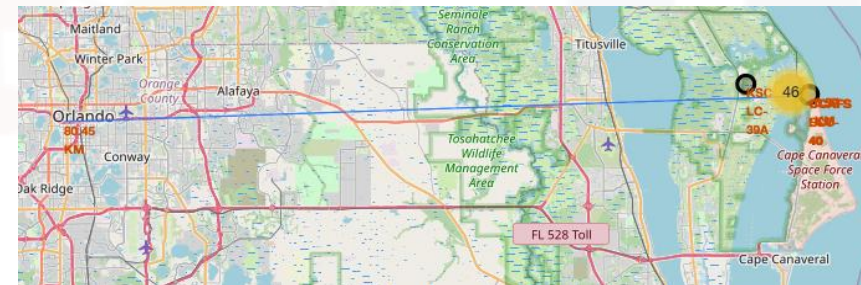
- Success rate increased steadily, except for a downward facing slope in 2017 and 2020.

# Results: Visualization with Folium

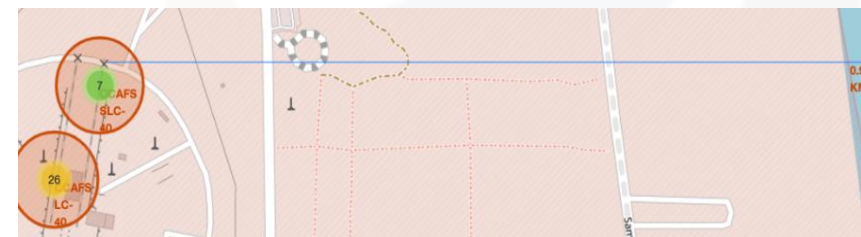
Marker location for successful and unsuccessful starts in US.



- Distance to nearest main street (0.6km).



- Distance to Orlando (80.45km)



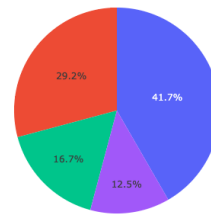
- Distance to ocean (0.9km).

# Results: Dashboard (1/5)

Pie chart and scatter plot analysis for all launch sites.

SpaceX Launch Records Dashboard

All Sites



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

KSC-LC-39A  
with highest overall share  
of successful launches

Payload range (Kg):



Relationship Payload Mass and success rate



Most payloads are  
within 2-6k (kg)

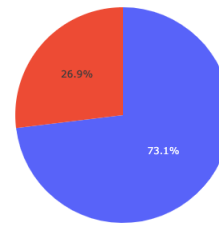
# Results: Dashboard (2/5)

Pie chart and scatter plot analysis for CCAPS LC-40.

SpaceX Launch Records Dashboard

CCAPS LC-40

Success/Failure per launch site



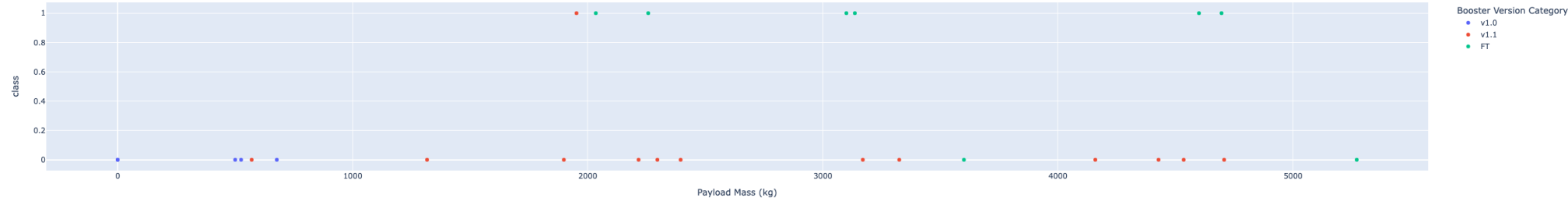
0  
1

CCAPS LC-40 with second highest success to failure rate.

Payload range (Kg):

0 100

Relationship Payload Mass and success rate



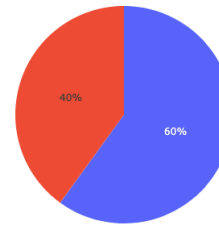
# Results: Dashboard (3/5)

Pie chart and scatter plot analysis for VAFB SLLC-4E.

## SpaceX Launch Records Dashboard

VAFB SLC-4E

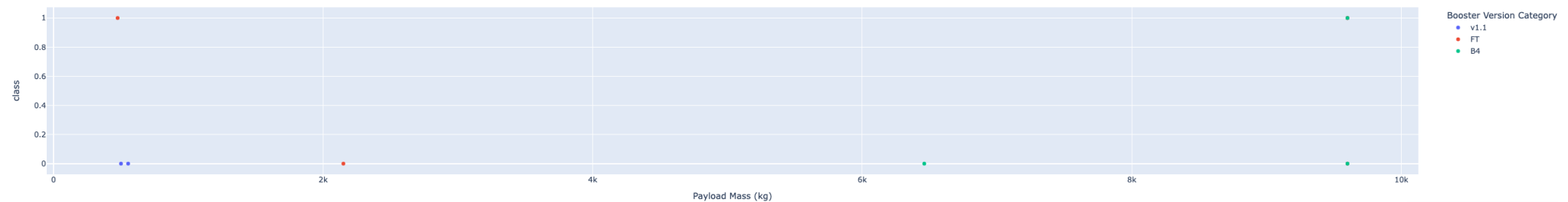
Success/Failure per launch site



Payload range (Kg):

0 100

Relationship Payload Mass and success rate



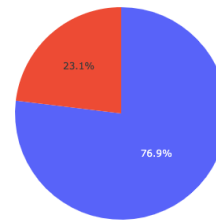
# Results: Dashboard (4/5)

Pie chart and scatter plot analysis for KSC LC-39A.

## SpaceX Launch Records Dashboard

KSC LC-39A

Success/Failure per launch site



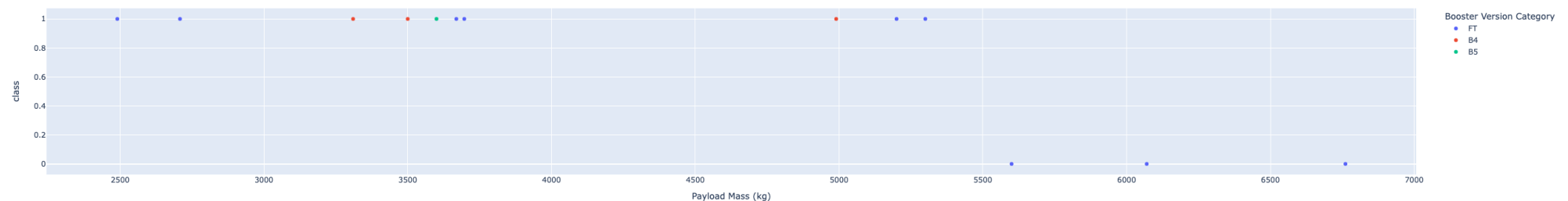
1  
0

KSC LC-39A with highest success to failure rate.

Payload range (Kg):

0 100

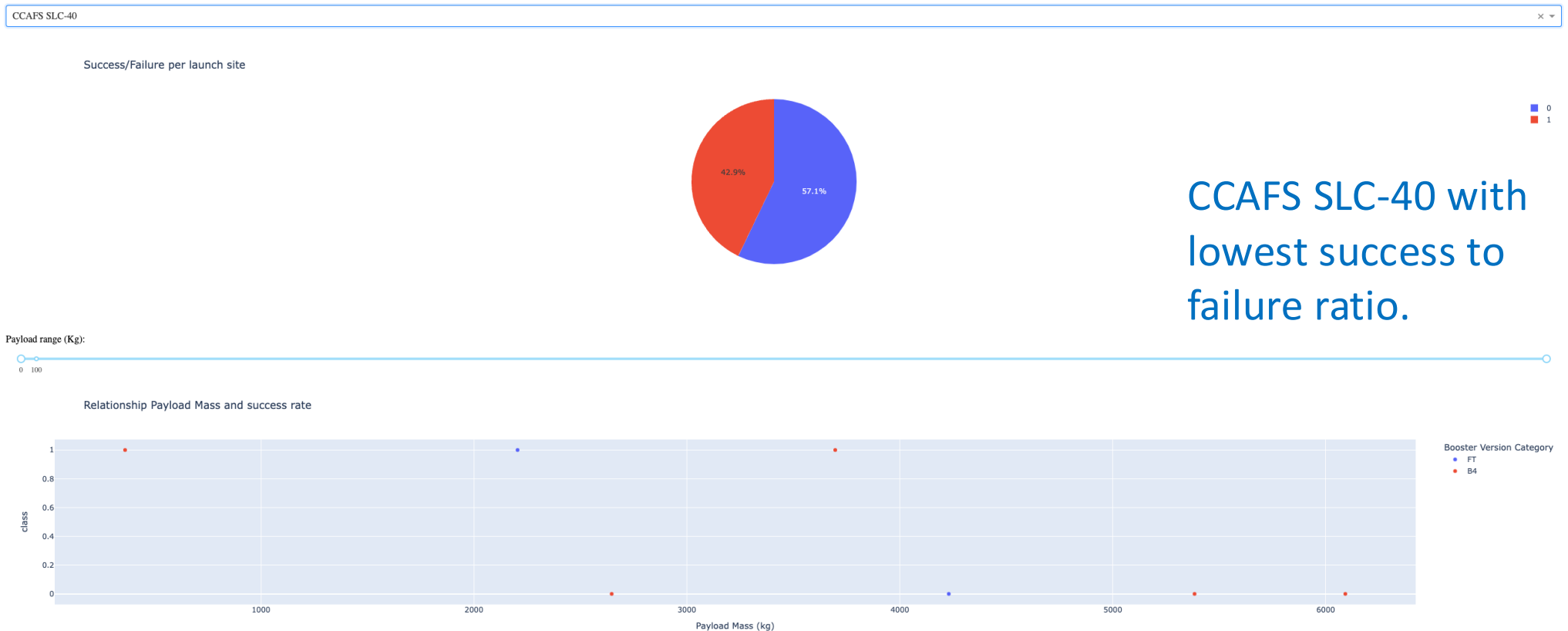
Relationship Payload Mass and success rate



# Results: Dashboard (5/5)

Pie chart and scatter plot analysis for KSC LC-39A.

SpaceX Launch Records Dashboard

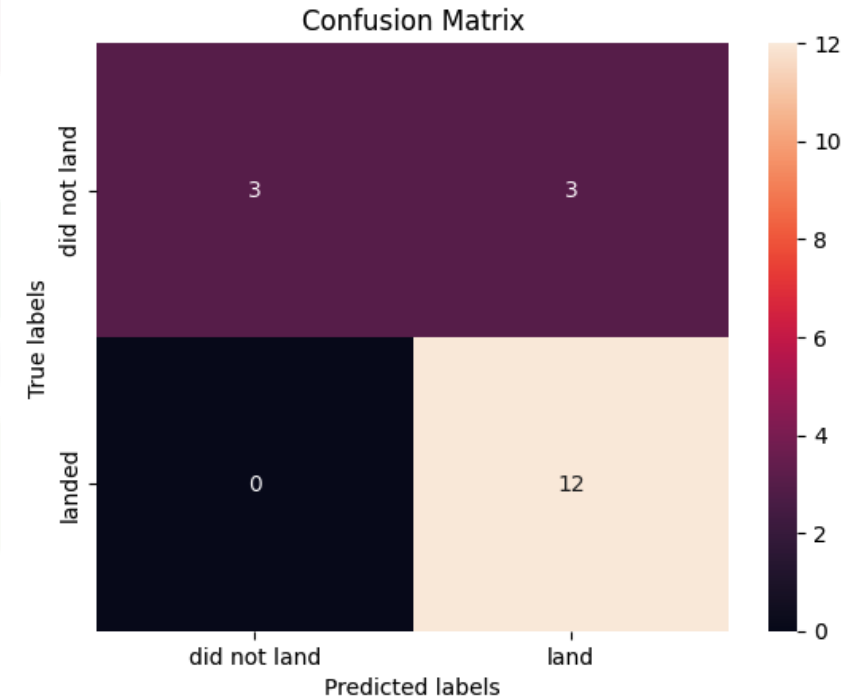


# Results: Predictive Analysis

Overview of model accuracy including confusion matrix\*

Model	R2 Score	Accuracy
Logistic Regression	0.83	0.846429
Supported Vector Model	0.83	0.848214
<b>Decision Tree</b>	<b>0.83</b>	<b>0.875</b>
KNN	0.83	0.848214

Decision tree model resulted in highest accuracy. Models are optimized with GridSearchCV for highest accuracy. Out of sample accuracy is relatively high.



\*identical confusion matrix values resulted for all models.