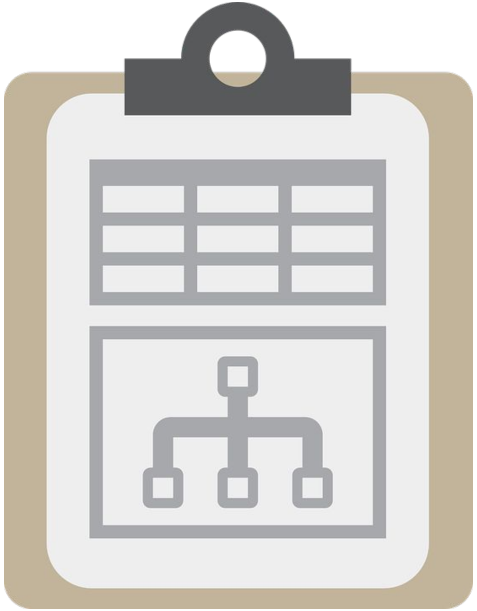
Data Science Capstone Project

-Hasmitha
-09/2021

Github link:
https://github.com/hasmithavasireddy/IBM-Data-Science-Professional-Certification

OUTLINE

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



Executive Summary

- Data collection is from a public API- SpaceX, which is basically a SpaceX Wikipedia page.
- I have created a column for labels called ‘class’ which classifies successful landings.
- Explored data using SQL, Data Visualization, Folium maps, and dashboards.
- Later have gathered relevant columns that has to be used as features.
- Then has changed all categorical variables to binary using one hot encoding.
- Standardized data and used GridSearchCV to find best parameters for machine learning models.
- Visualize accuracy score of all models.
- Specially Four machine learning models were produced:

    1)Logistic Regression

    2)Support Vector Machine and Decision Tree Classifier

    3)K Nearest Neighbors.
- Similar results were produced with an accuracy rate of around 83.33%.
- All the models were predicted successful landings.
- Extra amount of data is required for better model determination and accuracy.

INTRODUCTION & DELIVERABLES

Background data:

- Commercial Space Age is Here
- Space X has best pricing ($62 million vs. $165 million USD)
- Largely due to ability to recover part of rocket (Stage 1)
- Space Y wants to compete with Space X

Task & deliverables:

- Space Y tasks us to train a machine learning model to predict successful Stage 1 recovery

Methodology

1) Data collection methodology:
   - Combined data from SpaceX public API and SpaceX Wikipedia page
2) Perform data wrangling
   - Classifying true landings as successful and unsuccessful otherwise
3) Perform exploratory data analysis (EDA) using visualization and SQL
4) Perform interactive visual analytics using Folium and Plotly Dash.
5) Perform predictive analysis using classification models
   - Tuned models using GridSearchCV

Data Collection Overview

- Data collection process involved a combination of API requests from Space X public API and web scraping data from a table in Space X’s Wikipedia entry.
- The next slide will show the flowchart of data collection from API and the one after will show the flowchart of data collection from Webscraping.

Space X API Data Columns:

- FlightNumber, Date, BoosterVersion, PayloadMass, Orbit, LaunchSite, Outcome, Flights, GridFins,

Reused, Legs, LandingPad, Block, ReusedCount, Serial, Longitude, Latitude

Wikipedia Webscrape Data Columns:

- Flight No., Launch site, Payload, PayloadMass, Orbit, Customer, Launch outcome, Version Booster, Booster landing, Date, Time

Data collection- Space

Step-1

➔ Step-2

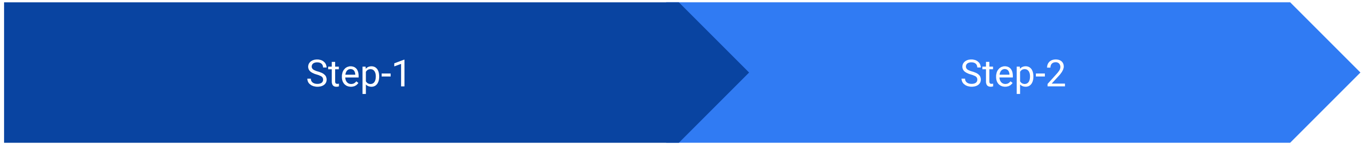
Step-33

- ➔ Request the space X API'S.
- ➔ .JSON file + Lists (Launch Site, Booster Version, Payload Data)
- ➔ Json_normalize to the DataFrame from JSON.

- ➔ Filter the data to only including the FALCON-9 launches.
- ➔ Cast the dictionary to a Data Frame.

- ➔ Retrieve the dictionary with relevant data.
- ➔ Impute missing PayloadMass values with its mean.

Data Collection- Web Scraping



Step-1

Step-2

- Request Wikipedia html
- BeautifulSoup html5lib Parser
- Find the launch information html table.

- Cast a dictionary to the DataFrame.
- Iterate through table cells to extract the data into the dictionary.
- Create a dictionary.

Data Wrangling

- Create a training label with landing outcomes where successful = 1 and failure = 0.
- Outcome column has two components:

  ‘Mission Outcome’

  ‘Landing Location’
- New training label column ‘class’ with a value of 1 if ‘Mission Outcome’ is True and 0 otherwise.
- Value Mapping:

  True ASDS, True RTLS, & True Ocean – set to -> 1

  None None, False ASDS, None ASDS, False Ocean, False RTLS – set to -> 0

EDA with SQL

- Loaded data set into IBM DB2 Database.
- Queried using SQL Python integration.
- Queries were made to get a better understanding of the dataset.
- Queried information about launch site names, mission outcomes, various pay load sizes of customers and booster versions, and landing outcomes.

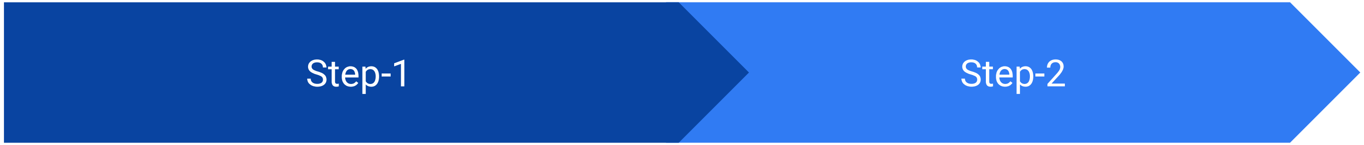
Build an interactive map with Folium

- Folium maps mark Launch Sites, successful and unsuccessful landings, and a proximity example to key locations: Railway, Highway, Coast, and City.
- This allows us to understand why launch sites may be located where they are. Also visualizes successful landings relative to location.

Build a Dashboard with Plotly Dash

- Dashboard includes a pie chart and a scatter plot.
- Pie chart can be selected to show distribution of successful landings across all launch sites and can be selected to show individual launch site success rates.
- Scatter plot takes two inputs: All sites or individual site and payload mass on a slider between 0 and 10000 kg.
- The pie chart is used to visualize launch site success rate.
- The scatter plot can help us see how success varies across launch sites, payload mass, and
- Booster version category.

Predictive analysis (Classification)



Step-1

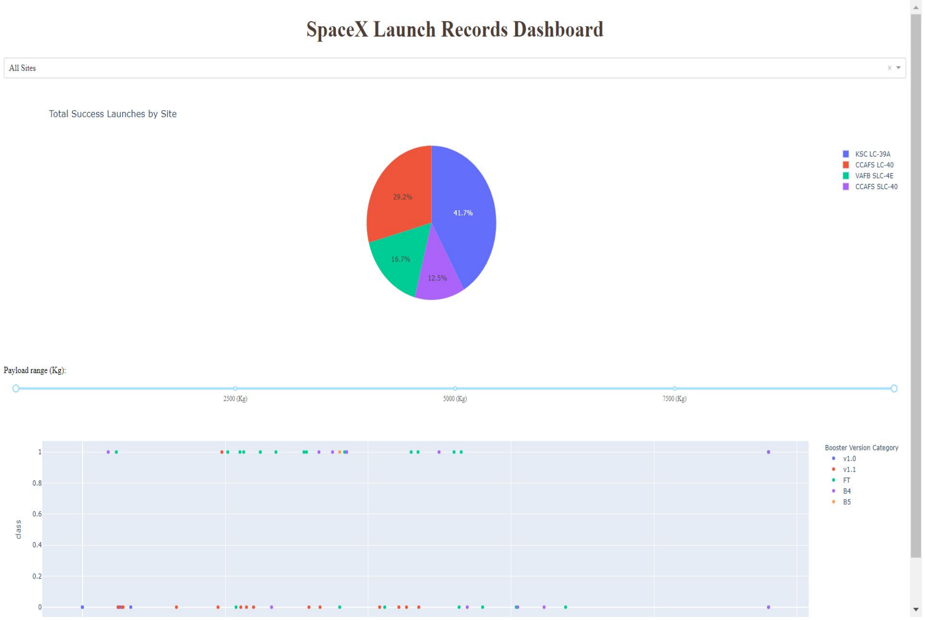
- Split label column ‘Class’ from dataset.
- Fit and Transform Standard Scaler
- Train_test_split data
- Score models on split test set

Step-2

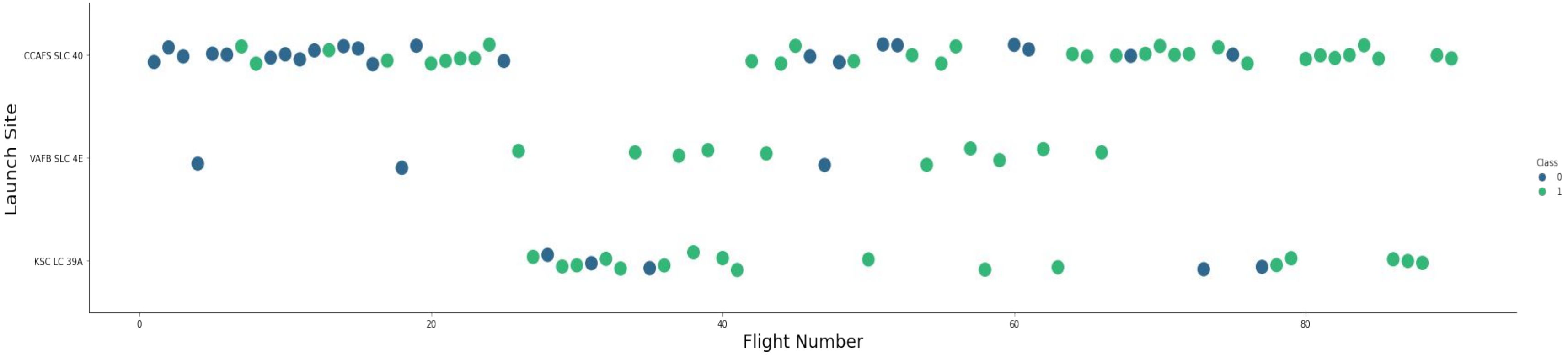
- Use GridSearchCV Decision Tree, and KNN models
- GridSearchCV (cv=10) to find optimal parameters
- Confusion Matrix for all models
- Barplot to compare scores of models

RESULTS

- This is a preview of the Plotly dashboard.
- The following sides will show the results of EDA with visualization, EDA with SQL, Interactive Map with Folium, and finally the results of our model with about 83% accuracy.

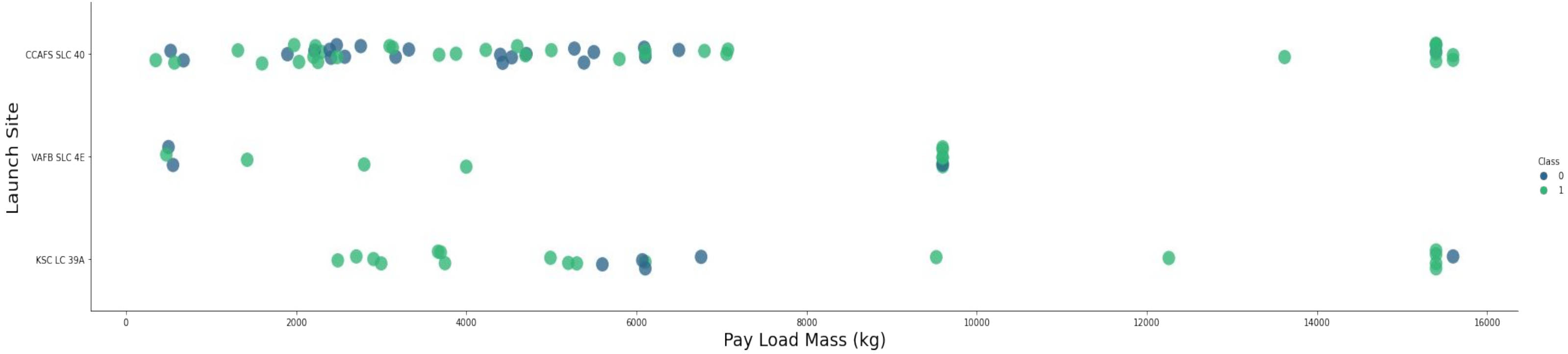


Flight Number vs Launch Site



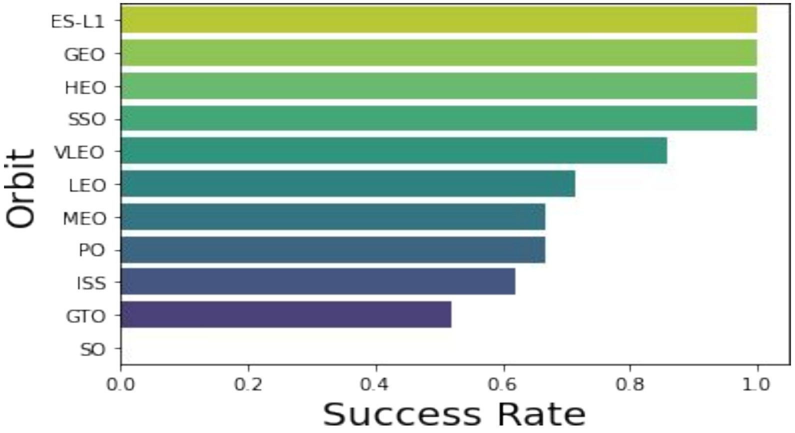
- ★ Green indicates successful launch; Purple indicates unsuccessful launch.
- ★ Graphic suggests an increase in success rate over time (indicated in Flight Number).
- ★ Likely a big breakthrough around flight 20 which significantly increased success rate.
- ★ CCAFS appears to be the main launch site as it has the most volume.

Payload vs Launch Site



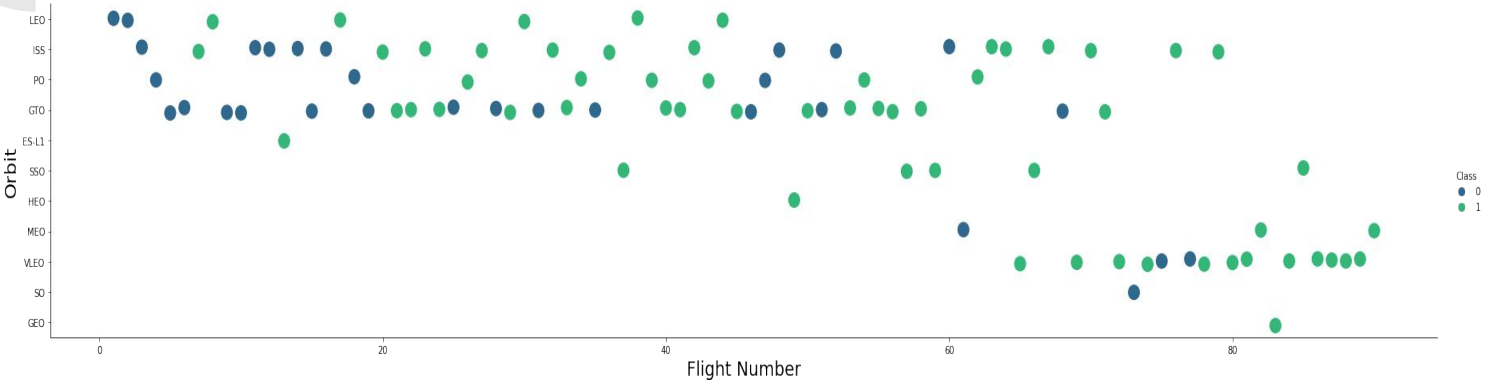
- ★ Green indicates successful launch; Purple indicates unsuccessful launch.
- ★ Payload mass appears to fall mostly between 0-6000 kg.
- ★ Different launch sites also seem to use different payload mass.

Success rate vs Orbit Type



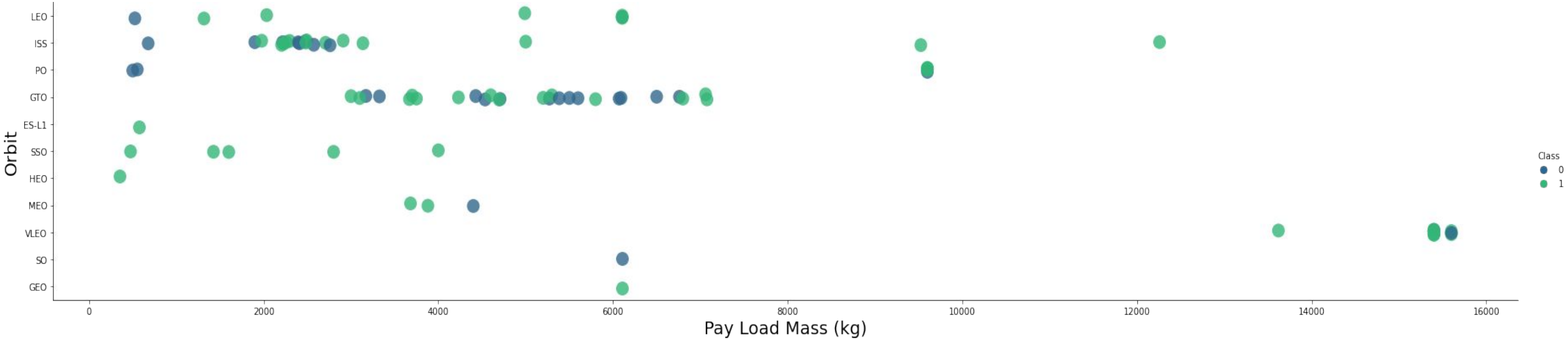
- ★ Success Rate Scale with 0 as 0% 0.6 as 60% 1 as 100%.
- ★ ES-L1 (1), GEO (1), HEO (1) have 100% success rate (sample sizes in parenthesis)
- ★ SSO (5) has 100% success rate
- ★ VLEO (14) has decent success rate and attempts SO (1) has 0% success rate
- ★ GTO (27) has the around 50% success rate but largest sample

Flight Number vs Orbit Type



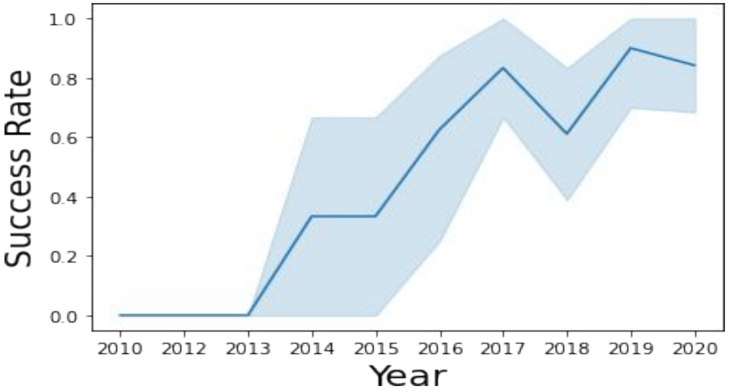
- ★ Green indicates successful launch; Purple indicates unsuccessful launch.
- ★ Launch Orbit preferences changed over Flight Number.
- ★ Launch Outcome seems to correlate with this preference.
- ★ SpaceX started with LEO orbits which saw moderate success LEO and returned to VLEO in recent launches SpaceX appears to perform better in lower orbits or Sun-synchronous orbits.

PayLoad vs. Orbit Type



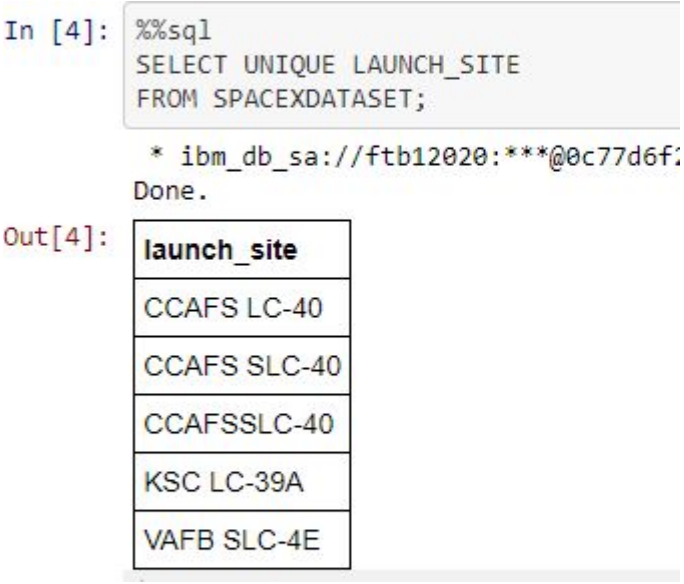
- ★ Green indicates successful launch; Purple indicates unsuccessful launch.
- ★ Payload mass seems to correlate with orbit LEO and SSO seem to have relatively low payload mass.
- ★ The other most successful orbit VLEO only has payload mass values in the higher end of the range

Launch Success Yearly Trend



- ★ 95% confidence interval (light blue shading)
- ★ Success generally increases over time since 2013 with a slight dip in 2018 Success in recent years at around 80%

All Launch Site Names



In [4]:

```
%%sql
SELECT UNIQUE LAUNCH_SITE
FROM SPACEXDATASET;
```

```
 * ibm_db_sa://ftb12020:***@0c77d6f
Done.
```

Out[4]:

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

★ Query unique launch site names from database.

★ CCAFS SLC-40 and CCAFS SLC-40 likely all represent the same launch site with data entry errors.

★ CCAFS LC-40 was the previous name.

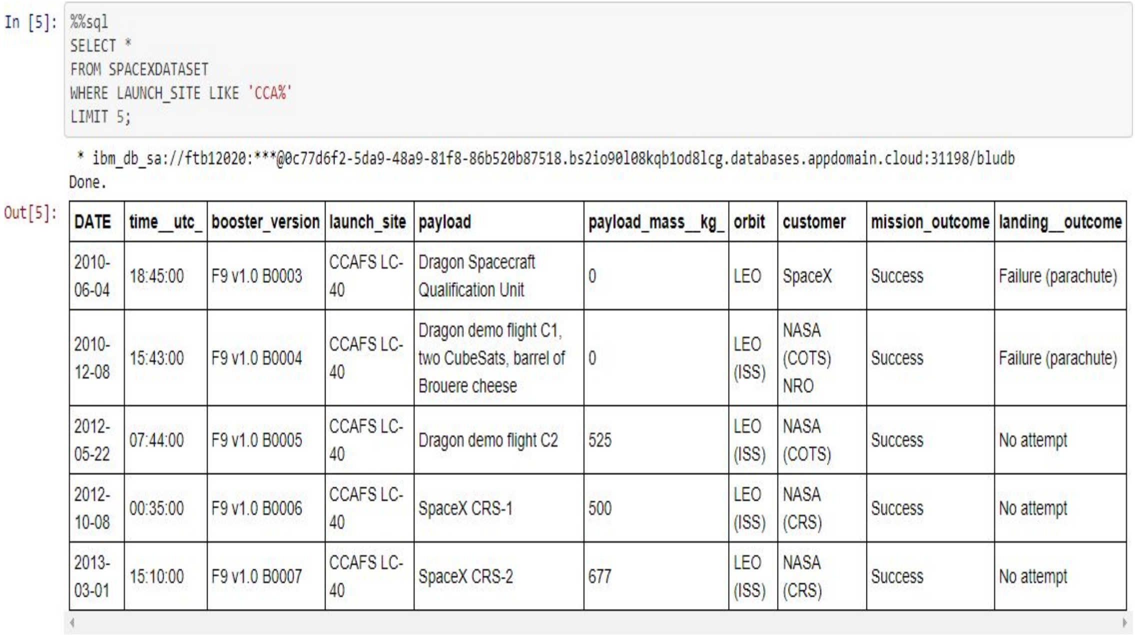
★ Likely only 3 unique launch_site values:

1) CCAFS SLC-40

2)KSC LC-39A

3)VAFB SLC-4E

Launch Site Names Beginning with `CCA`



```
In [5]: %%sql
        SELECT *
        FROM SPACEXDATASET
        WHERE LAUNCH_SITE LIKE 'CCA%'
        LIMIT 5;
```

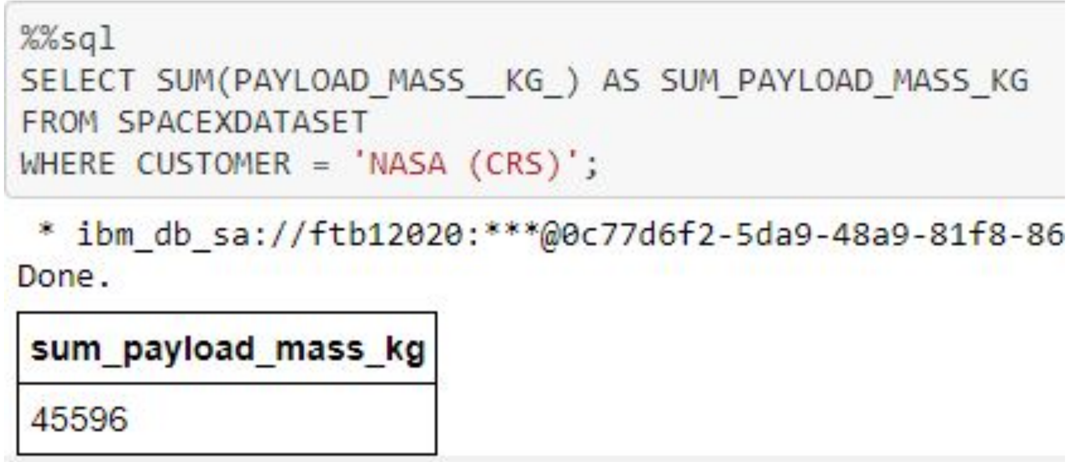
```
 * ibm_db_sa://ftb12020:***@0c77d6f2-5da9-48a9-81f8-86b520b87518.bs2io90l08kqb1od8lcg.databases.appdomain.cloud:31198/bludb
Done.
```

Out[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

First five entries in database with Launch Site name beginning with CCA.

Total Payload Mass from NASA



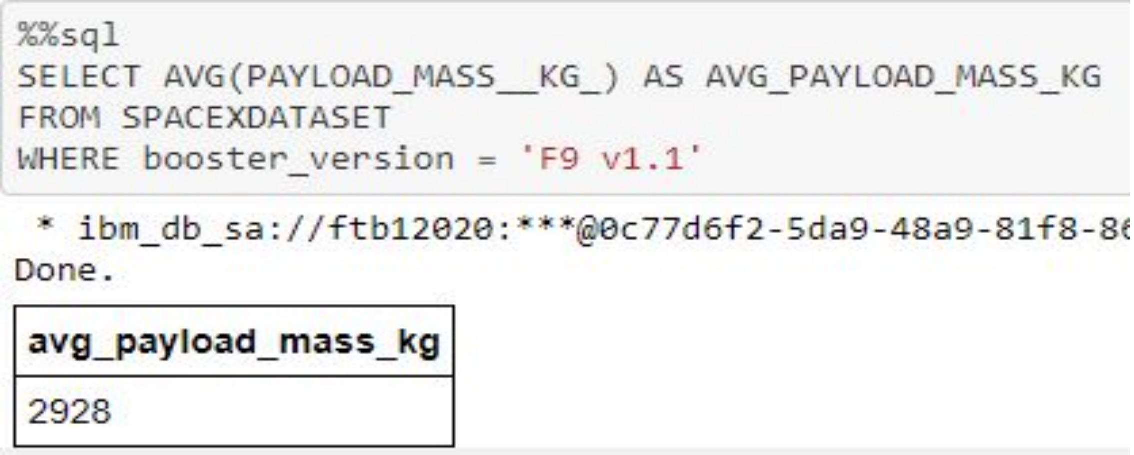
```
%%sql
SELECT SUM(PAYLOAD_MASS__KG_) AS SUM_PAYLOAD_MASS_KG
FROM SPACEXDATASET
WHERE CUSTOMER = 'NASA (CRS)';
```

```
 * ibm_db_sa://ftb12020:***@0c77d6f2-5da9-48a9-81f8-86
Done.
```

sum_payload_mass_kg
45596

This query sums the total payload mass in kg where NASA was the customer. CRS stands for Commercial Resupply Services which indicates that these payloads were sent to the International Space Station (ISS).

Average Payload Mass by F9 v1.1



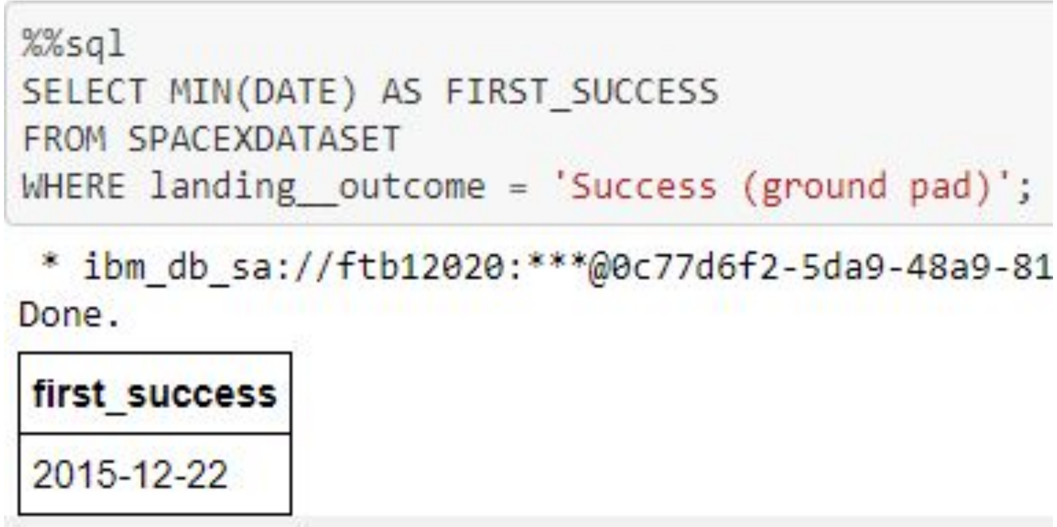
```
%%sql
SELECT AVG(PAYLOAD_MASS__KG_) AS AVG_PAYLOAD_MASS_KG
FROM SPACEXDATASET
WHERE booster_version = 'F9 v1.1'
```

```
 * ibm_db_sa://ftb12020:***@0c77d6f2-5da9-48a9-81f8-86
Done.
```

avg_payload_mass_kg
2928

This query calculates the average payload mass or launches which used booster version F9 v1.1
Average payload mass of F9 1.1 is on the low end of our payload mass range

First Successful Ground Pad Landing Date



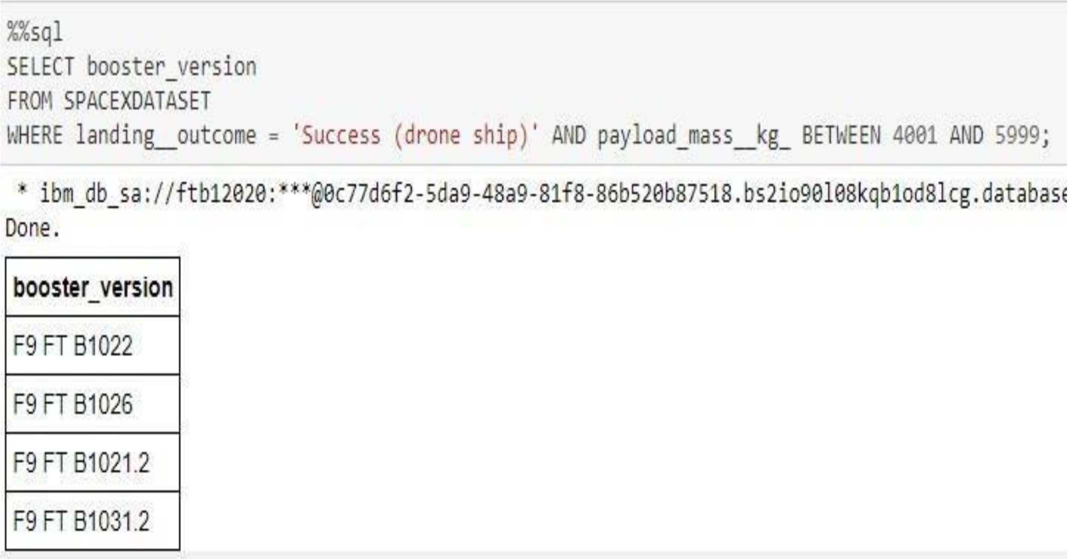
```
%%sql
SELECT MIN(DATE) AS FIRST_SUCCESS
FROM SPACEXDATASET
WHERE landing__outcome = 'Success (ground pad)';
```

```
 * ibm_db_sa://ftb12020:***@0c77d6f2-5da9-48a9-81
Done.
```

first_success
2015-12-22

This query returns the first successful ground pad landing date. First ground pad landing wasn’t until the end of 2015. Successful landings in general appear starting 2014.

Successful Drone Ship Landing with Payload Between 4000 and 6000



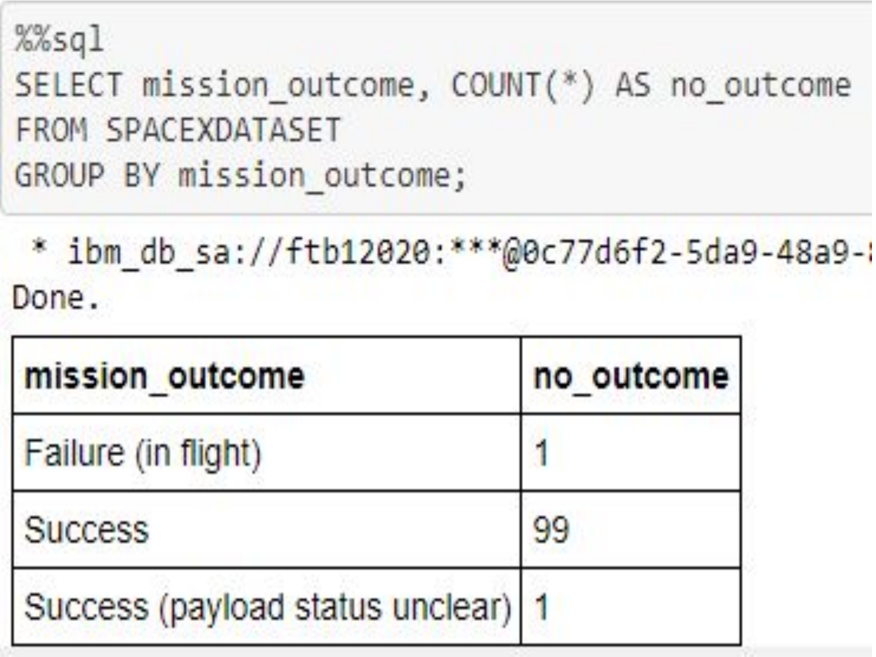
```
%%sql
SELECT booster_version
FROM SPACEXDATASET
WHERE landing__outcome = 'Success (drone ship)' AND payload_mass__kg_ BETWEEN 4001 AND 5999;
```

```
 * ibm_db_sa://ftb12020:***@0c77d6f2-5da9-48a9-81f8-86b520b87518.bs2io90l08kqb1od8lcg.database
Done.
```

booster_version
F9 FT B1022
F9 FT B1026
F9 FT B1021.2
F9 FT B1031.2

This query returns the four booster versions that had successful drone ship landings and a payload mass between 4000 and 6000 non-inclusively.

Total Number of Each Mission Outcome



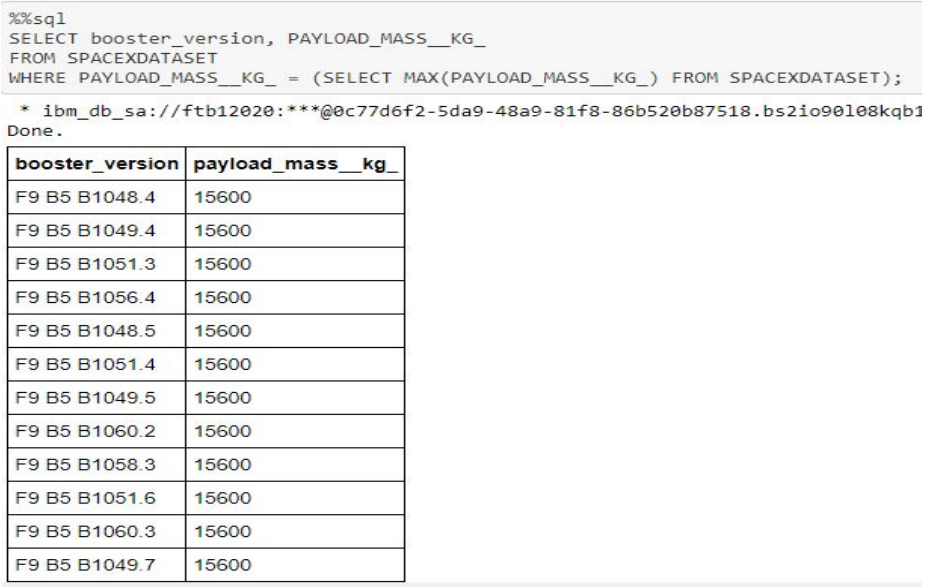
```
%%sql
SELECT mission_outcome, COUNT(*) AS no_outcome
FROM SPACEXDATASET
GROUP BY mission_outcome;
```

```
 * ibm_db_sa://ftb12020:***@0c77d6f2-5da9-48a9-
Done.
```

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

- ★ This query returns a count of each mission outcome.
- ★ SpaceX appears to achieve its mission outcome nearly 99% of the time.
- ★ This means that most of the landing failures are intended.
- ★ Interestingly, one launch has an unclear payload status and unfortunately one failed in flight.

Boosters that Carried Maximum Payload



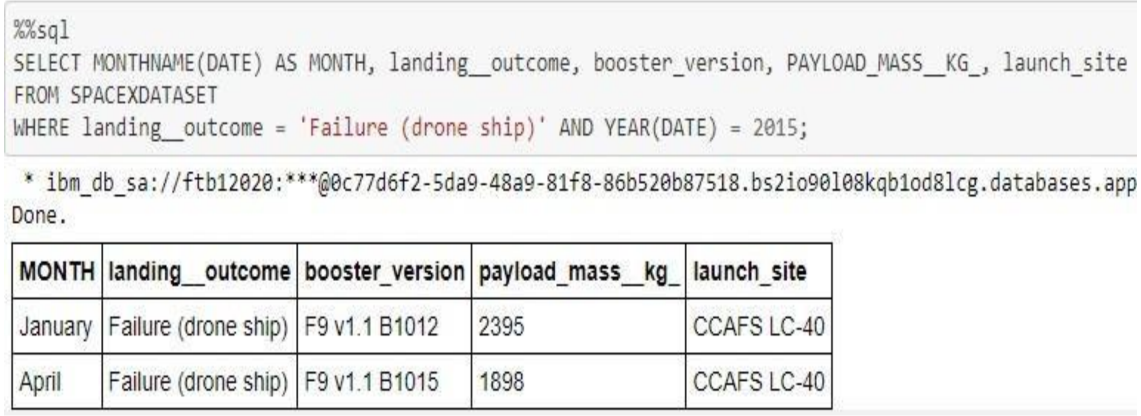
```
%%sql
SELECT booster_version, PAYLOAD_MASS__KG_
FROM SPACEXDATASET
WHERE PAYLOAD_MASS__KG_ = (SELECT MAX(PAYLOAD_MASS__KG_) FROM SPACEXDATASET);
```

```
 * ibm_db_sa://ftb12020:***@0c77d6f2-5da9-48a9-81f8-86b520b87518.bs2io90l08kqb1
Done.
```

booster_version	payload_mass__kg_
F9 B5 B1048.4	15600
F9 B5 B1049.4	15600
F9 B5 B1051.3	15600
F9 B5 B1056.4	15600
F9 B5 B1048.5	15600
F9 B5 B1051.4	15600
F9 B5 B1049.5	15600
F9 B5 B1060.2	15600
F9 B5 B1058.3	15600
F9 B5 B1051.6	15600
F9 B5 B1060.3	15600
F9 B5 B1049.7	15600

- ★ This query returns the booster versions that carried the highest payload mass of 15600 kg.
- ★ These booster versions are very similar and all are of the F9 B5 B10xx.x variety.
- ★ This likely indicates payload mass correlates with the booster version that is used.

2015 Failed Drone Ship Landing Records



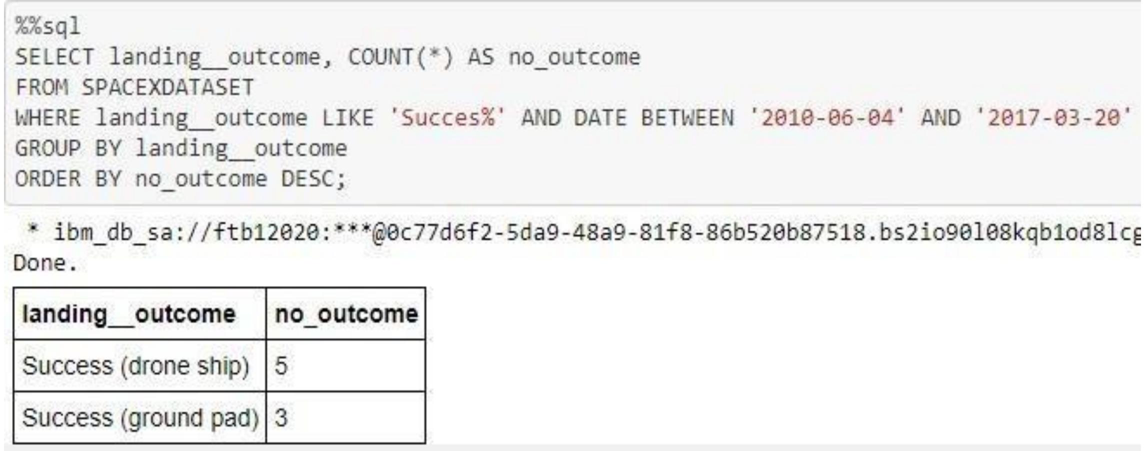
```
%%sql
SELECT MONTHNAME(DATE) AS MONTH, landing__outcome, booster_version, PAYLOAD_MASS__KG_, launch_site
FROM SPACEXDATASET
WHERE landing__outcome = 'Failure (drone ship)' AND YEAR(DATE) = 2015;
```

```
 * ibm_db_sa://ftb12020:***@0c77d6f2-5da9-48a9-81f8-86b520b87518.bs2io90l08kqb1od8lcg.databases.app
Done.
```

MONTH	landing__outcome	booster_version	payload_mass__kg_	launch_site
January	Failure (drone ship)	F9 v1.1 B1012	2395	CCAFS LC-40
April	Failure (drone ship)	F9 v1.1 B1015	1898	CCAFS LC-40

- ★ This query returns the Month, Landing Outcome, Booster Version, Payload Mass (kg), and Launch site of 2015 launches where stage 1 failed to land on a drone ship.
- ★ There were two such occurrences.

Ranking Counts of Successful Landings Between 2010-06-04 and 2017-03-20



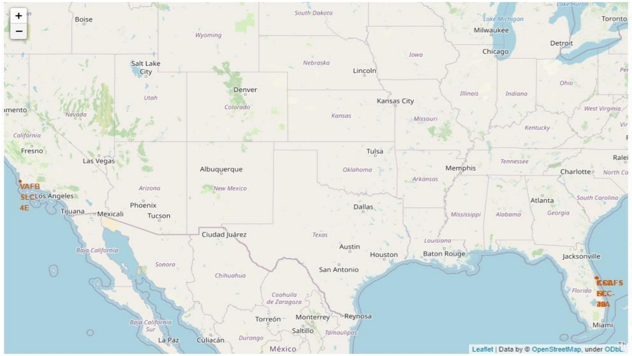
```
%%sql
SELECT landing__outcome, COUNT(*) AS no_outcome
FROM SPACEXDATASET
WHERE landing__outcome LIKE 'Succes%' AND DATE BETWEEN '2010-06-04' AND '2017-03-20'
GROUP BY landing__outcome
ORDER BY no_outcome DESC;
```

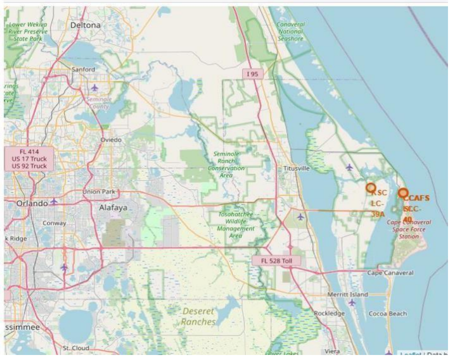
```
 * ibm_db_sa://ftb12020:***@0c77d6f2-5da9-48a9-81f8-86b520b87518.bs2io90l08kqb1od8lcg
Done.
```

landing__outcome	no_outcome
Success (drone ship)	5
Success (ground pad)	3

- ★ This query returns a list of successful landings and between 2010-06-04 and 2017-03-20 inclusively.
- ★ There are two types of successful landing outcomes: drone ship and ground pad landings.
- ★ There were 8 successful landings in total during this time period.

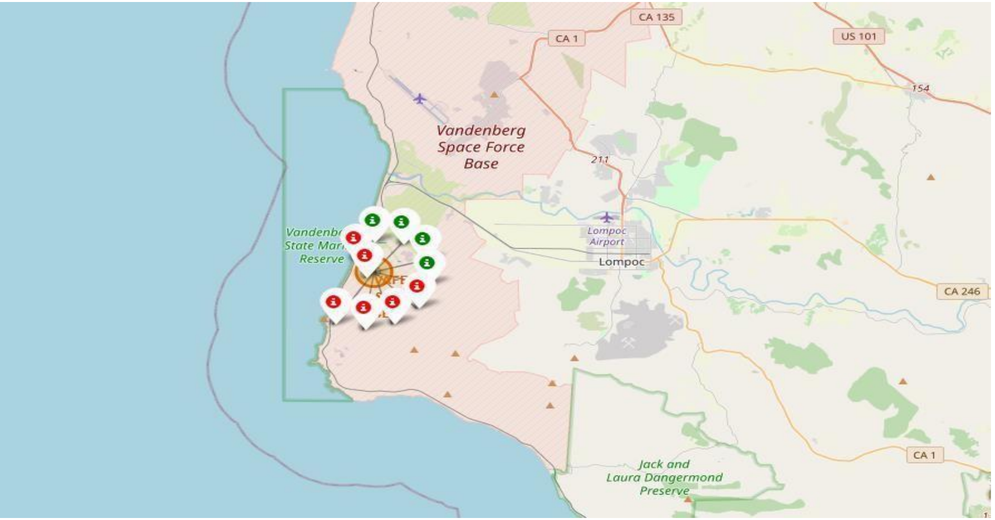
Interactive Map with Folium
Launch Site Locations





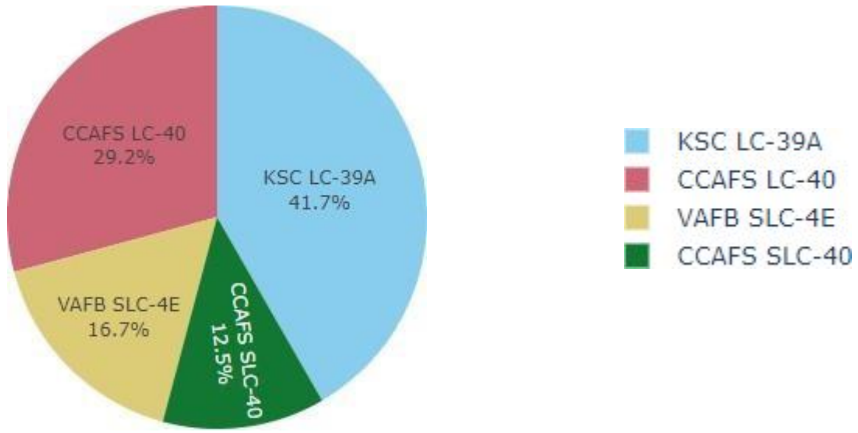
- ★ The left map shows all launch sites relative US map.
- ★ The right map shows the two Florida launch sites since they are very close to each other.
- ★ All launch sites are near the ocean.

Color-Coded Launch Markers


CA 135
CA 1
US 101
154
Vandenberg Space Force Base
211
Vandenberg State Marine Reserve
Lompoc Airport
Lompoc
CA 246
CA 1
Jack and Laura Dangermond Preserve

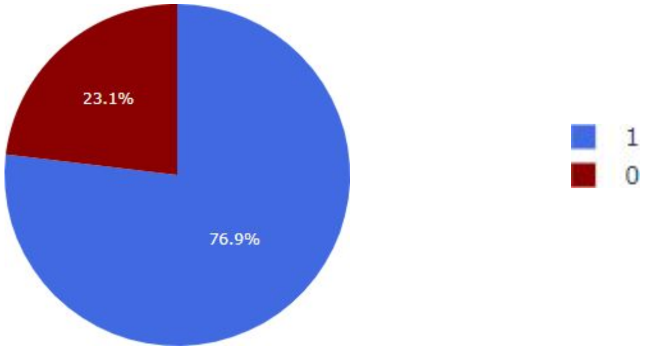
- ★ Clusters on Folium map can be clicked on to display each successful landing (green icon) and failed landing (red icon).
- ★ In this example VAFB SLC-4E shows 4 successful landings and 6 failed landings.

Build a Dashboard with Plotly Dash
Successful Launches Across Launch Sites



- ★ This is the distribution of successful landings across all launch sites.
- ★ CCAFS LC-40 is the old name of CCAFS SLC-40 so CCAFS and KSC have the same amount of successful landings, but a majority of the successful landings were performed before the name change.
- ★ VAFB has the smallest share of successful landings. This may be due to smaller sample and increase in difficulty of launching in the west coast.

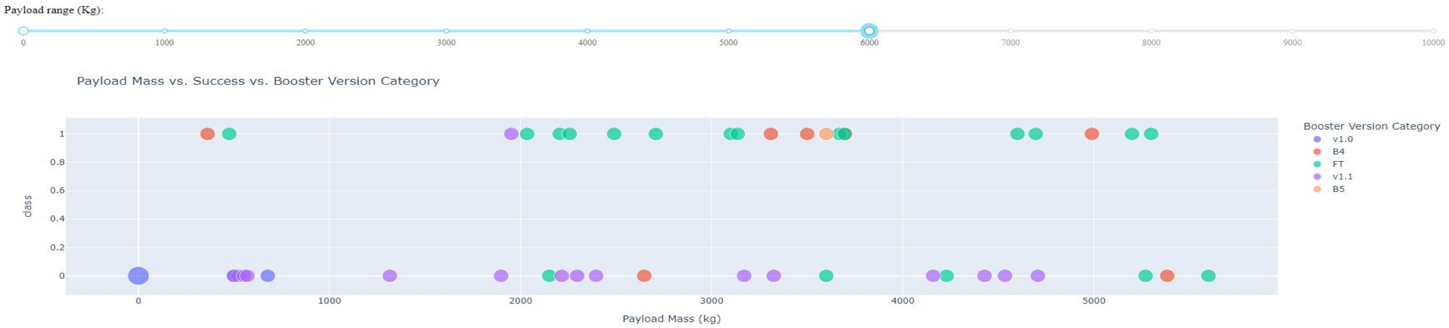
Highest Success Rate Launch Site



KSC LC-39A Success Rate (blue=success)

KSC LC-39A has the highest success rate with 10 successful landings and 3 failed landings.

Payload Mass vs. Success vs. Booster Version Category



- ★ Plotly dashboard has a Payload range selector.
- ★ However, this is set from 0-10000 instead of the max Payload of 15600.
- ★ Class indicates 1 for successful landing and 0 for failure.
- ★ Scatter plot also accounts for booster version category in color and number of launches in point size.
- ★ In this particular range of 0-6000, interestingly there are two failed landings with payloads of zero kg.

Predictive Analysis (Classification)

GRIDSEARCHCV(CV=10)

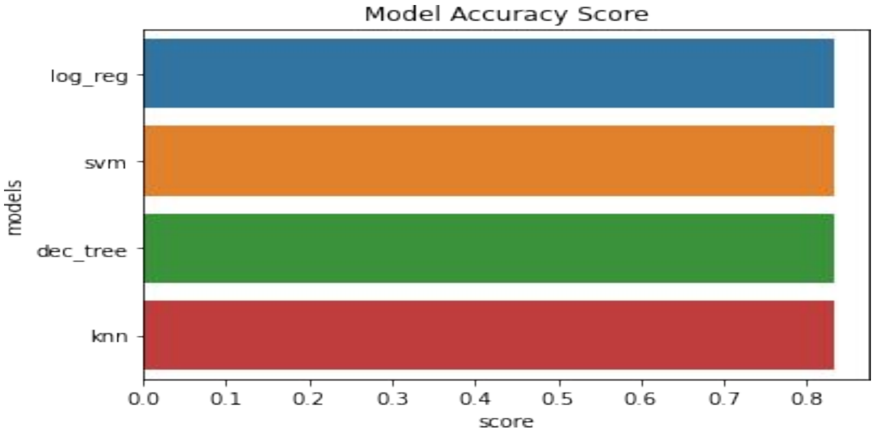
ON LOGISTIC REGRESSION

SVM

DECISION TREE

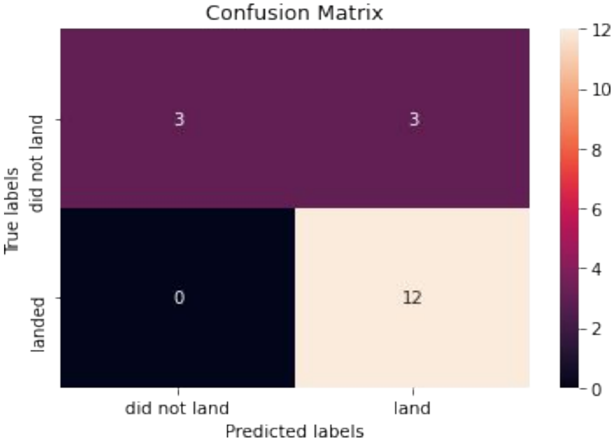
KNN

Classification Accuracy



- ★ All models had virtually the same accuracy on the test set at 83.33% accuracy.
- ★ It should be noted that test size is small at only sample size of 18.
- ★ This can cause large variance in accuracy results, such as those in Decision Tree Classifier model in repeated runs.
- ★ We likely need more data to determine the best model.

Confusion Matrix



- ★ Correct predictions are on a diagonal from top left to bottom right.
- ★ Since all models performed the same for the test set, the confusion matrix is the same across all models.
- ★ The models predicted 12 successful landings when the true label was successful landing.
- ★ The models predicted 3 unsuccessful landings when the true label was unsuccessful landing.
- ★ The models predicted 3 successful landings when the true label was unsuccessful landings (false positives).
- ★ Our models over predict successful landings.

CONCLUSION

- ★ Our task: to develop a machine learning model for Space Y who wants to bid against SpaceX
- ★ The goal of model is to predict when Stage 1 will successfully land to save ~$100 million USD.
- ★ Used data from a public SpaceX API and web scraping SpaceX Wikipedia page.
- ★ Created data labels and stored data into a DB2 SQL database Created a dashboard for visualization.
- ★ We created a machine learning model with an accuracy of 83%.
- ★ Allon Mask of SpaceY can use this model to predict with relatively high accuracy whether a launch will have a successful Stage 1 landing before launch to determine whether the launch should be made or not.
- ★ If possible more data should be collected to better determine the best machine learning model and improve accuracy.

APPENDIX

GitHub repository url:
https://github.com/hasmithavasireddy/IBM-Data-Science-Professional-Certification

Instructors: Rav Ahuja, Alex Aklson, Aije Egwaikhide, Svetlana Levitan, Romeo Kienzler, Polong Lin, Joseph Santarcangelo, Azim Hirjani, Hima Vasudevan, Sai Shruthi Swaminathan, Saeed Aghabozorgi, Yan Luo

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