



# Will the Falcon 9 Succeed?

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October 18, 2023

# INTRODUCTION

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- Executive Summary
- Methodology
- Results
- Discussion
- Conclusion

# EXECUTIVE SUMMARY

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- Need to predict if first stage of Falcon 9, SpaceX will successfully land
  - Potentially be marginally cheaper launch than rival companies
- If successful, able to determine cost of entire launch
  - Information could be used if alternate company wants to bid against SpaceX for a rocket launch

# EXPLORATORY DATA ANALYSIS

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- SQL Querying
  - There are four launch sites:
    - CCAFS LC-40
    - VAFB SLC-4E
    - KSC LC-39A
    - CCAFS SLC-40



**Launch\_Site**

CCAFS LC-40

VAFB SLC-4E

KSC LC-39A

CCAFS SLC-40

# EXPLORATORY DATA ANALYSIS

- SQL Querying
  - Five records from launch sites starting with "CCA"

Date	Time (UTC)	Booster_Version	Launch_Site	Payload	PAYLOAD_MASS_KG	Orbit	Customer	Mission_Outcome	Landing_Outcome
2010-04-06	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX	Success	Failure (parachute)
2010-08-12	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
2012-08-10	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)	Success	No attempt
2013-01-03	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)	Success	No attempt

# EXPLORATORY DATA ANALYSIS

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- SQL Querying
  - Total payload mass carried by boosters launched by NASA



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sum(PAYLOAD_MASS_KG_)
```

45596

# EXPLORATORY DATA ANALYSIS

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- SQL Querying
  - Recorded date of the first successful landing outcome on ground pad



**min(Date)**

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2015-12-22

# EXPLORATORY DATA ANALYSIS

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- SQL Querying
  - Booster versions of launches which have success in drone ship and have a payload mass in between 4000 and 6000 kg

## Booster\_Version

F9 FT B1022

F9 FT B1026

F9 FT B1021.2

F9 FT B1031.2



# EXPLORATORY DATA ANALYSIS

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- SQL Querying
  - Number of successful and failed mission outcomes



Total Number of Successful Mission Outcomes	Total Number of Failed Mission Outcomes
98	0

# EXPLORATORY DATA ANALYSIS

- SQL Querying
  - List of booster versions that have carried the maximum payload mass of 15600 kg

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

# EXPLORATORY DATA ANALYSIS

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- SQL Querying
  - Booster versions and launch sites of launches in the year 2015 that have landing outcome 'Failure (drone ship)'

Year	Month	Landing_Outcome	Booster_Version	Launch_Site
2015	10	Failure (drone ship)	F9 v1.1 B1012	CCAFS LC-40
2015	04	Failure (drone ship)	F9 v1.1 B1015	CCAFS LC-40

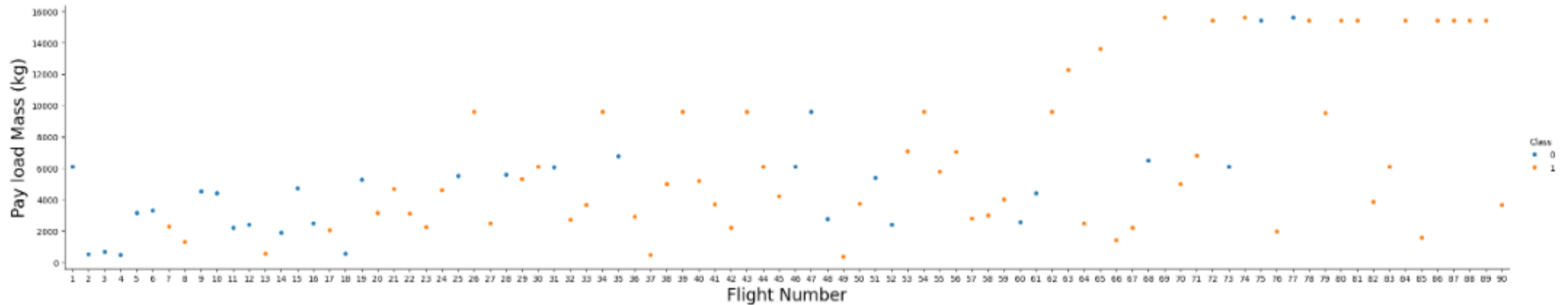
# EXPLORATORY DATA ANALYSIS

- SQL Querying
  - Ranked list of count of landing outcomes from June 4, 2010 to March 20, 2017

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

# EXPLORATORY DATA ANALYSIS

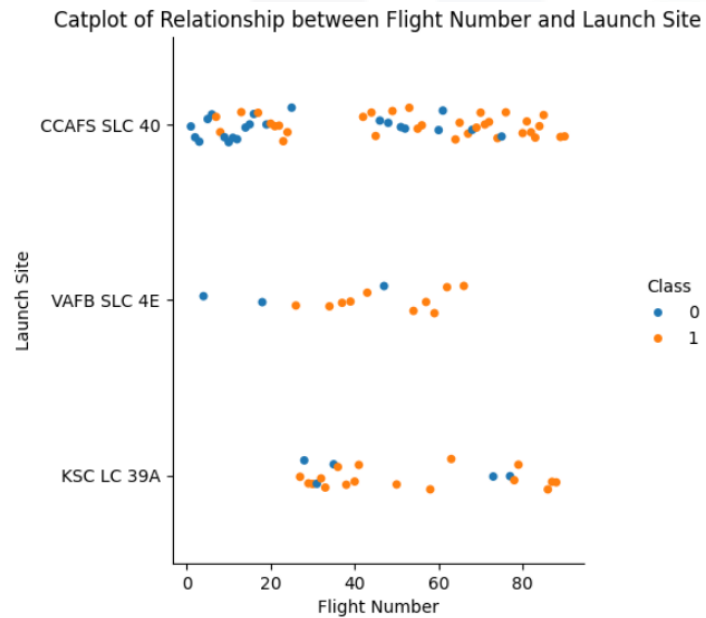
- Seaborn Plots
  - Payload Mass is correlative to the flight number, meaning that payload mass is increasing yearly
  - In addition, it seems that the heavier the payload mass, the more likely it will not succeed



# EXPLORATORY DATA ANALYSIS

- Seaborn Plots

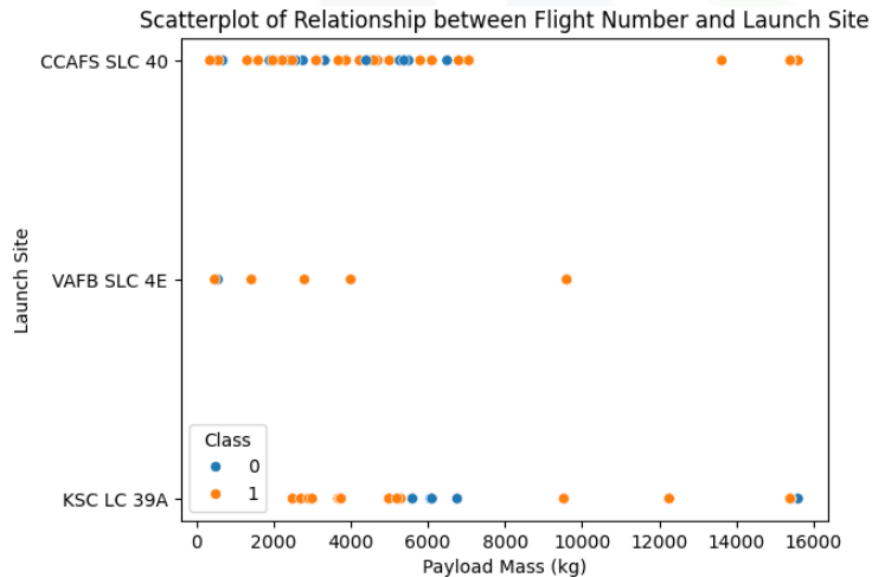
- For VAFB SLC 4E and KSC LC 39A, the more flights they had, the more likely a launch will be successful
- For CCAFS SLC 40, the relationship is not as strong



# EXPLORATORY DATA ANALYSIS

- Seaborn Plots

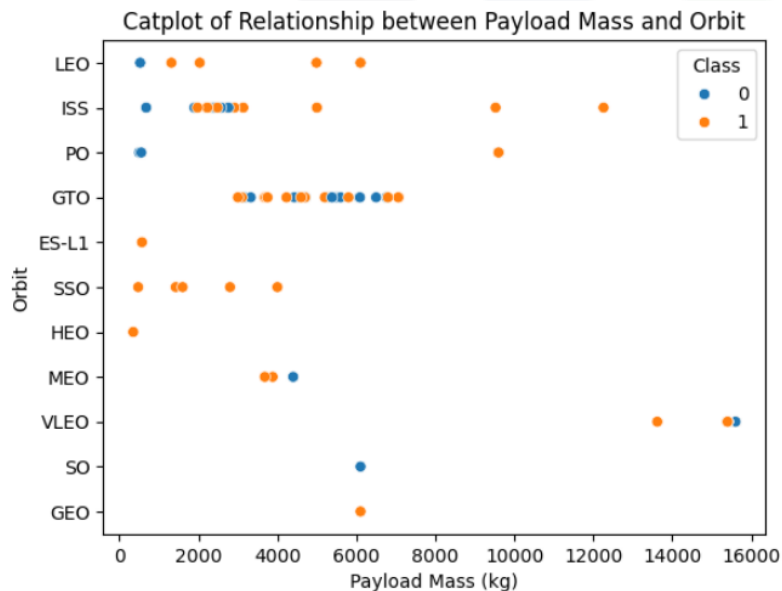
- For VAFB SLC 4E, all their launches have been successful for payload masses lighter than 10000 kg
- For CCAFS SLC 40 and KSC LA 39A, they have had successful launches for payload masses near 16000 kg but KSC LA 39A has also had a failure



# EXPLORATORY DATA ANALYSIS

- Seaborn Plots

- For LEO, Polar, ISS, and GEO, they are better for heavier payload masses
- SSO, ES-L1, and HEO are good for lighter loads
- GTO, MEO, VLEO, and SO are orbits that are hard to come to conclusions about

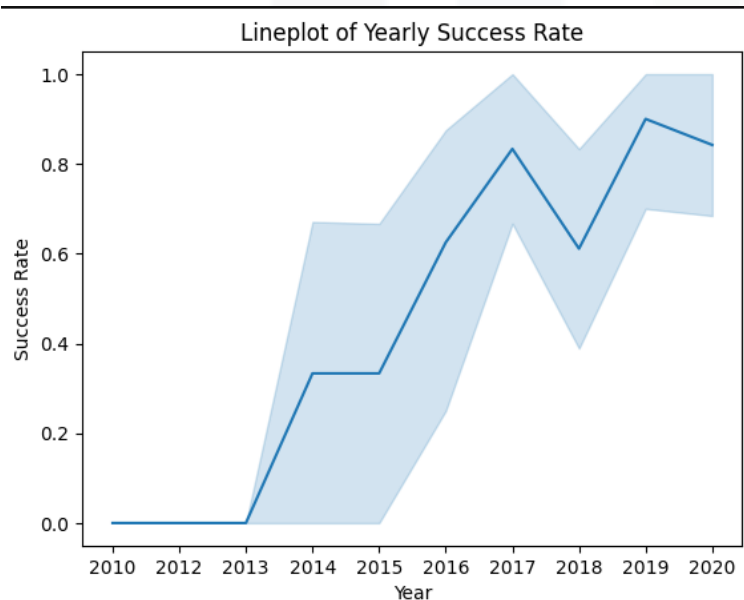




# EXPLORATORY DATA ANALYSIS

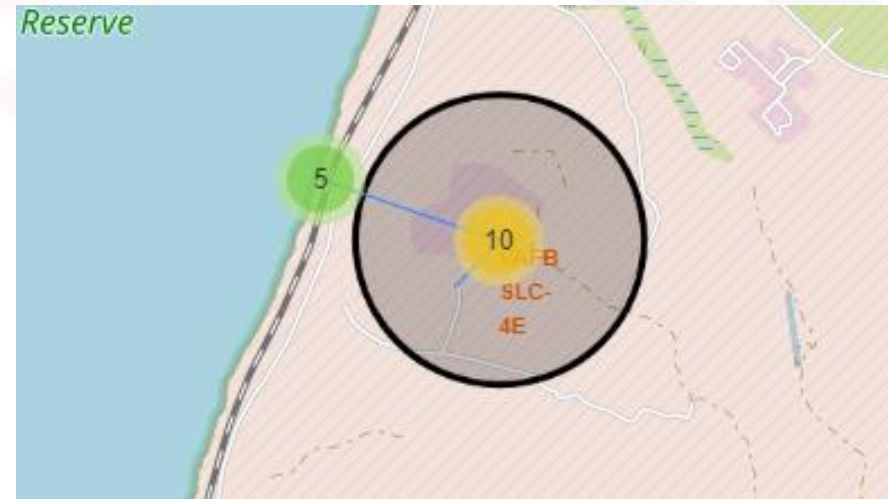
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- Seaborn Plots
  - We found that the year of the launch is proportional to the yearly success rate, meaning that launches are getting better



# EXPLORATORY DATA ANALYSIS

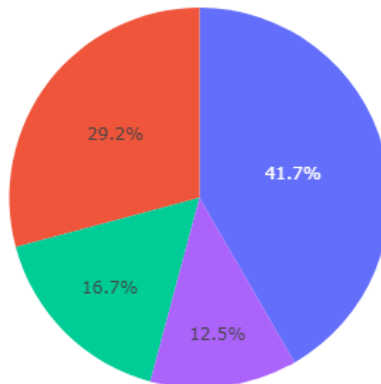
- Folium GeoMaps
  - We found that most launch sites are near roads and the coastlines but fairly far from cities



# EXPLORATORY DATA ANALYSIS

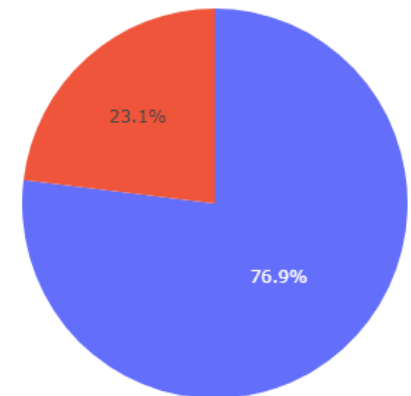
- Dash application
  - We found that the launch site KSC LC-39A is the launch site with the most successful landings
  - 41.7% of all successful launches were from KSC LC-39A
  - KSC LC-39A has an almost 77% successful launch rate

Total Success Launches by Site



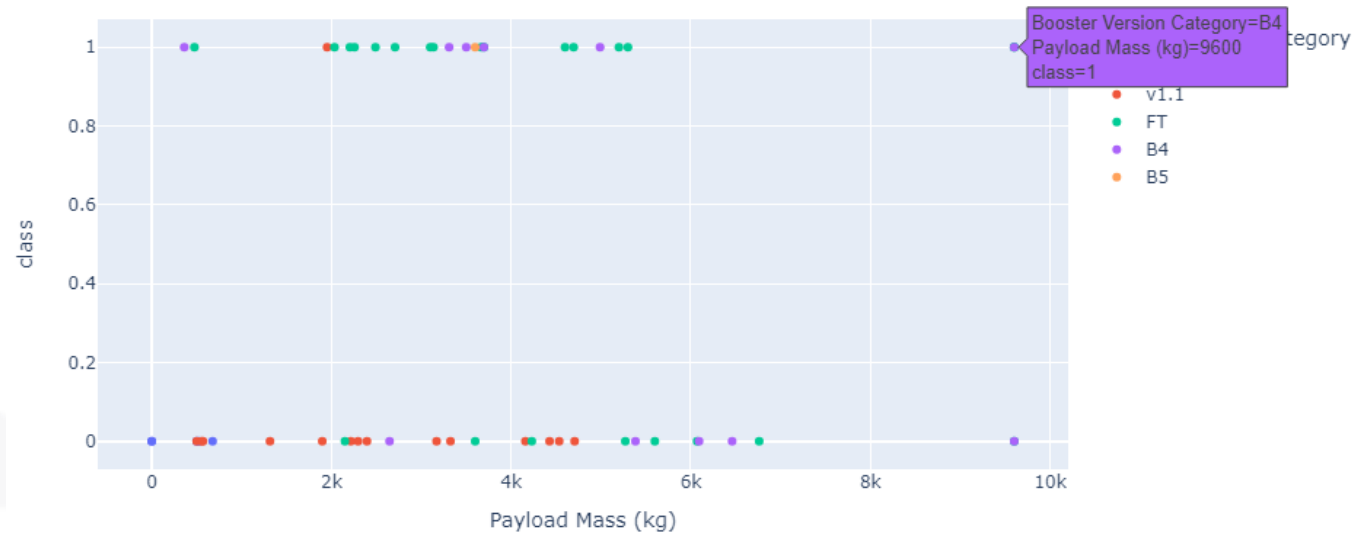
■ KSC LC-39A  
■ CCAFS LC-40  
■ VAFB SLC-4E  
■ CCAFS SLC-40

Total Success Launches for site KSC LC-39A

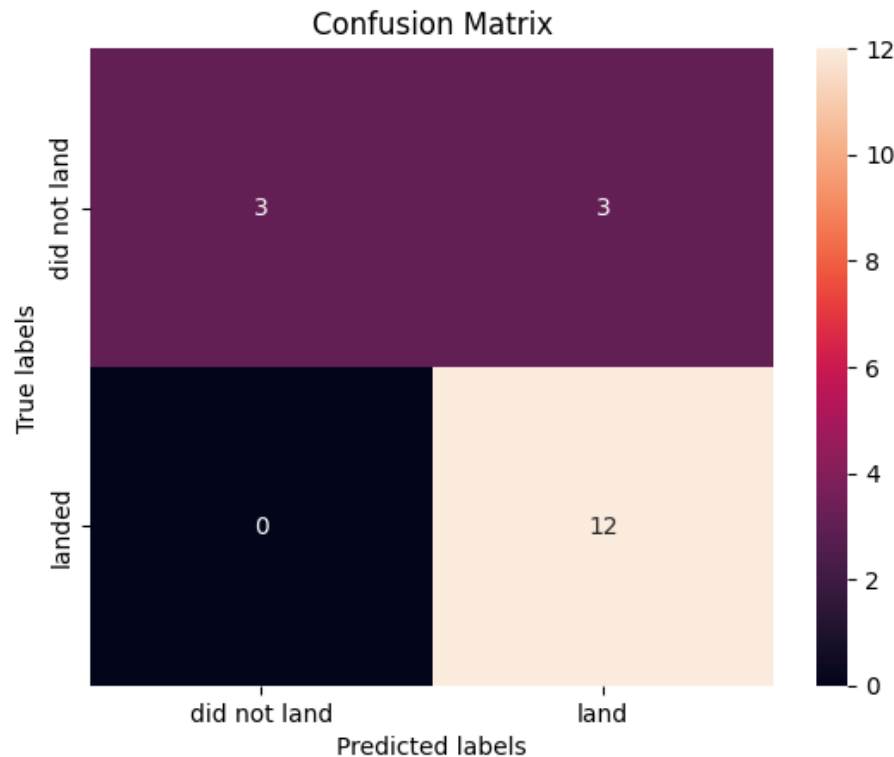


# EXPLORATORY DATA ANALYSIS

- Dash application
  - We also found that the successful landing with the heaviest payload mass was 9600 kg and was Booster Version B4



# RESULTS



- Predictive Model

- We found that the Decision Tree model was the best for predicting whether or not the first launch would be successful
- Training score: 0.83334
- Best score: 0.903
- Best parameters: shown below

0.8333333333333333

```
tuned hyperparameters :(best parameters) {'criterion': 'gini', 'max_depth': 4, 'max_features': 'sqrt', 'min_samples_leaf': 1, 'min_samples_split': 5, 'splitter': 'random'}  
accuracy : 0.9035714285714287
```

# CONCLUSION

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- Best Model: Decision Tree
- Launches in general have gotten better over the years
  - Launch Site KSC LC-39A has the best successful launch rate as well as the highest number of successful launches of all launch sites
  - Highest successful launch payload mass is 9600 kg with booster version 4B