PREDICTING THE SUCCESS RATE OF THE SPACE X FALCON 9 FIRST STAGE LANDING

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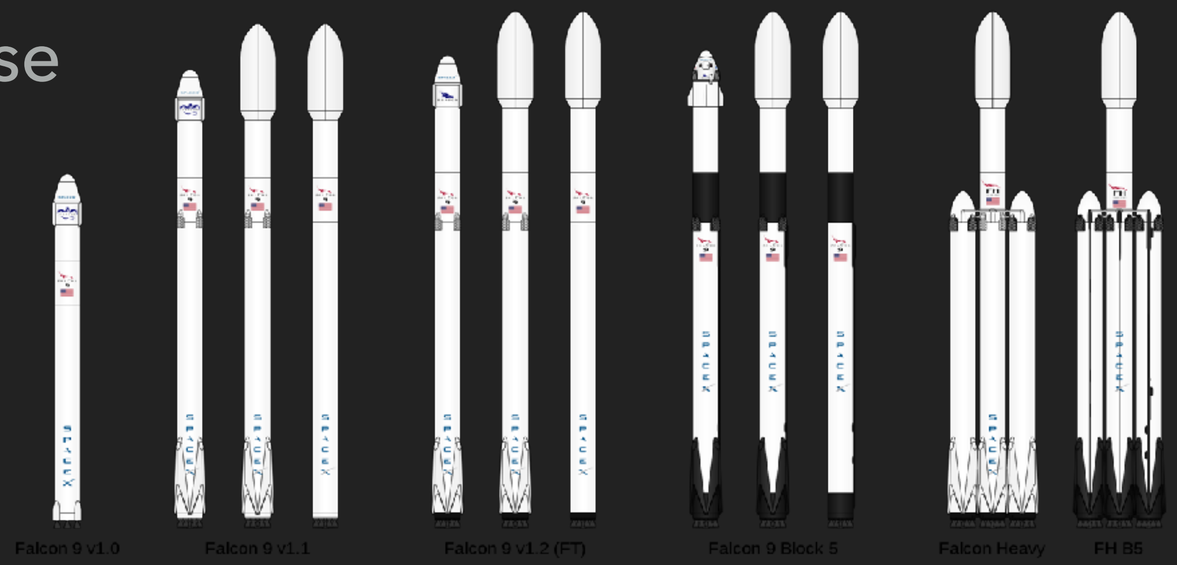
CONTENT

ABSTRACT

- Find out the which variables affect the success rate of Falcon 9 rocket
- Aim: Determine how to create the a more successful, reusable rocket to reduce the launching cost
- Provide illustrative graphs to show the relationship between different elements of the rocket and its success rate

WHY SPACE X FALCON 9

- Falcon 9 rocket launches cost ~100 million less than other rocket launches
- Reason of savings: Falcon 9 can reuse the first stage of landing
- Investigate Falcon 9 to apply its reusing technique in our rocket launches



Ref.: Wiki. Different Version of Falcon 9

METHODOLOGY: DATA WRANGLING

1. We use .json() to turn the data collected in the website into data frame
2. After we input the data into data frame, we use dataframe.isnull().sum() to find out how many missing values in each column
3. For pay load mass, we replace the missing value with the average of pay load mass
4. We convert all landing failure into class 0 and all successful landing into class 1

5. Apply OneHotEncoder to the column Orbits, LaunchSite, LandingPad, and Serial

METHODOLOGY

1. Collect the dataset from SpaceX API and Wikipedia
2. Graph the relationship between the independent variables and the success rate
3. Apply the algorithms to perform prediction:

- Dataset is split for training and testing purpose. 80% training, 20% testing
- Logistic Regression, Support Vector Machine (SVM), Decision Tree and K Nearest Neighbours Classification

DATA COLLECTION: PREDICTION

We believe the following elements will affect the success rate:

- Booster Version
- Pay Load Mass
- Orbit
- Launch Site
- Grid Fins, Reused Parts, Legs, Landing Pad, Block

Tables of dataset are saved for data analysis

RESULTS

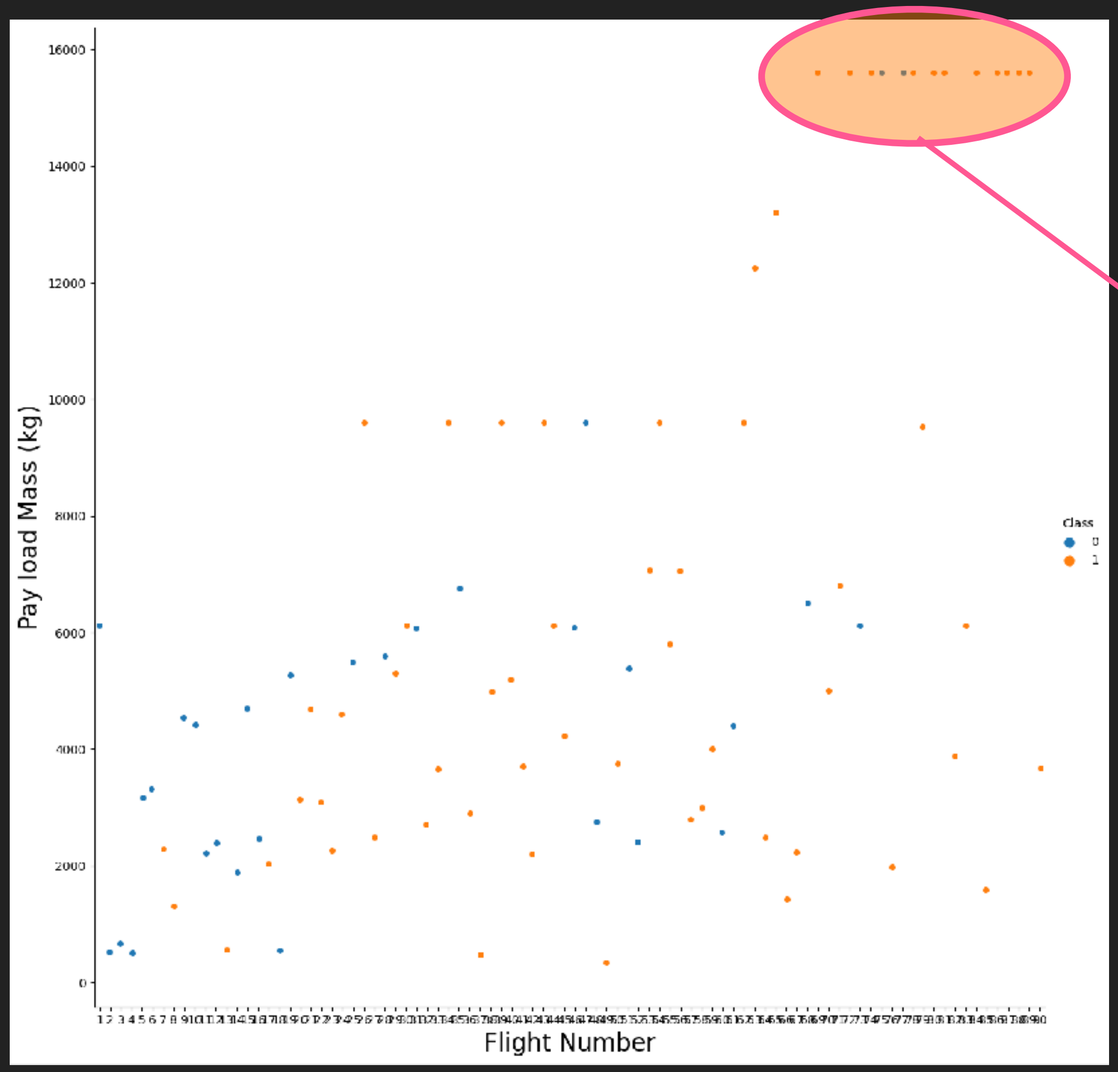


Fig.1 Pay load mass vs Flight Number Graph

PAY LOAD MASS VS FLIGHT NUMBER GRAPH

- Land Failure
- Land Success

Flight Number Increase
-> More likely to land successfully

RESULTS

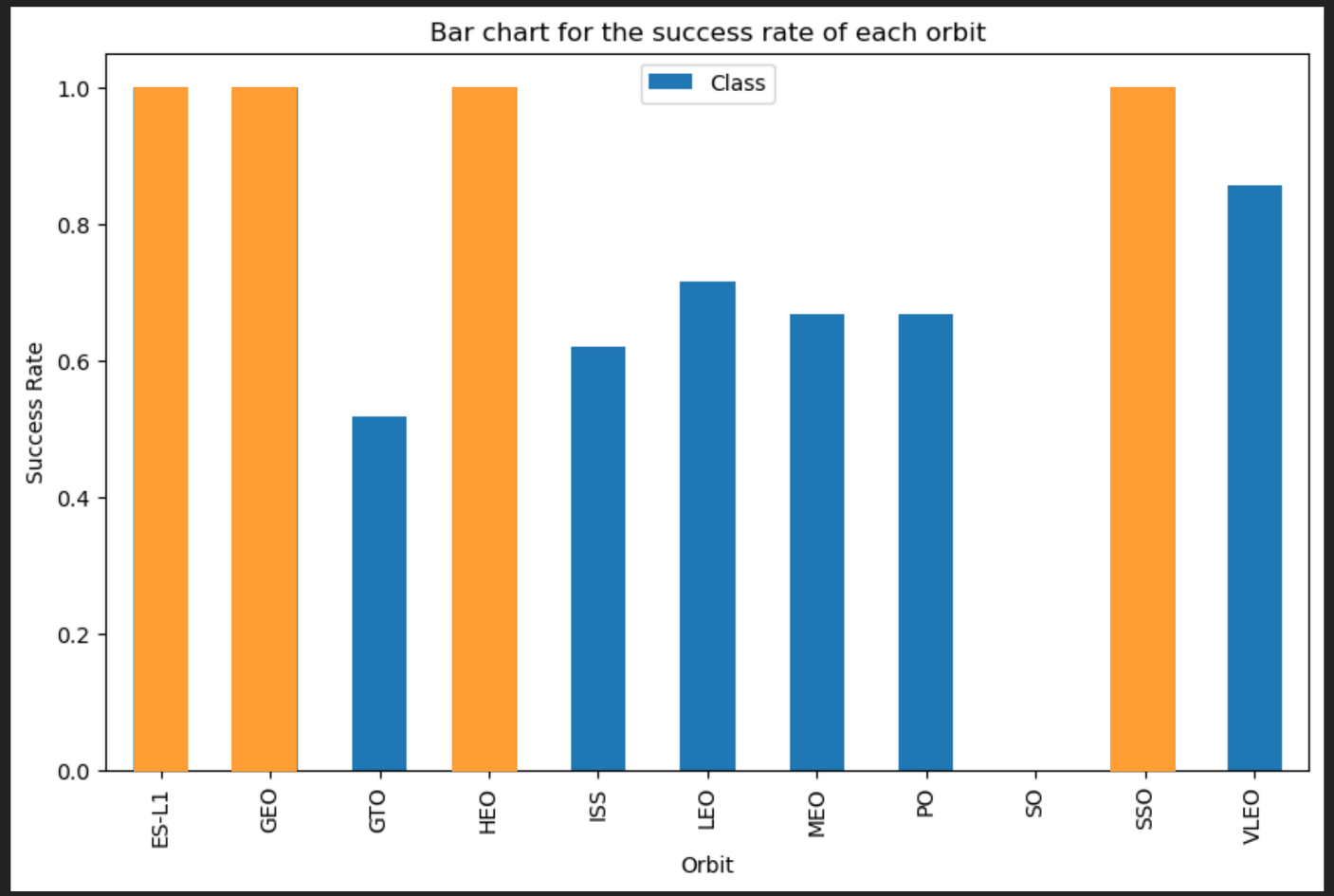


Fig 2. Bar chart for the success rate of each orbit

SUCCESS RATE OF EACH ORBIT

Most Success:

ES-L1

GEO

HEO

SSO

RESULTS

ORBIT VS PAY LOAD MASS GRAPH

Orbit: SSO with Pay Load Mass <6000kg
-> More likely to land successfully

Land Failure
Land Success

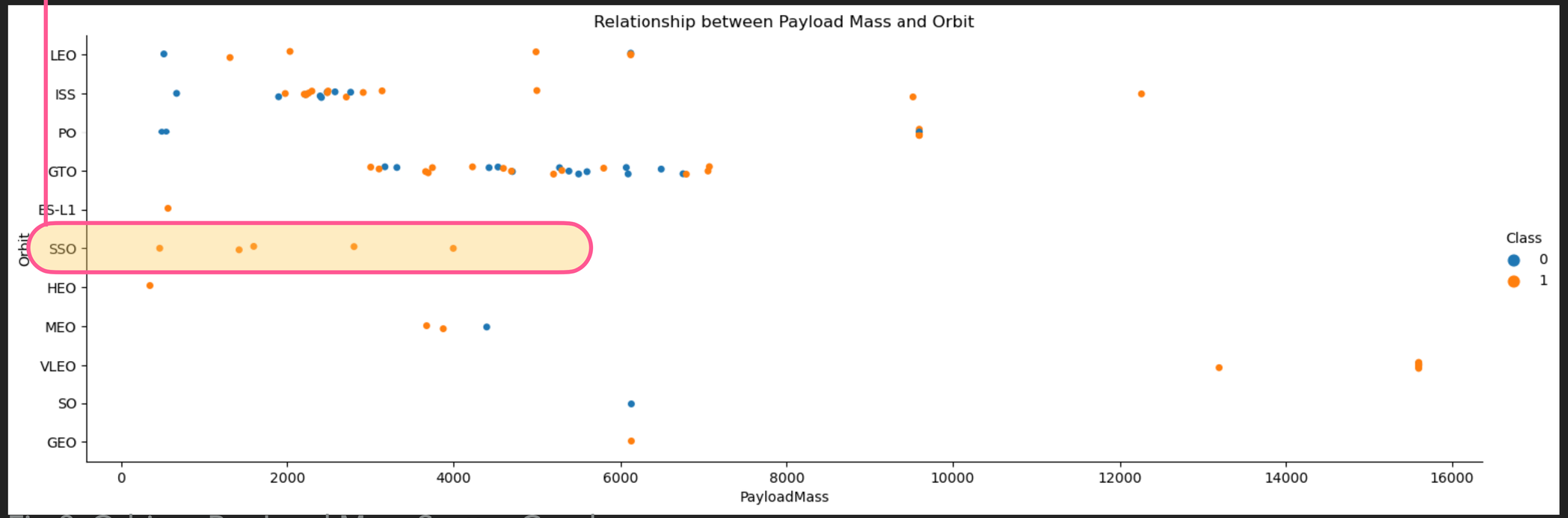


Fig 3. Orbit vs Pay Load Mass Scatter Graph

RESULTS

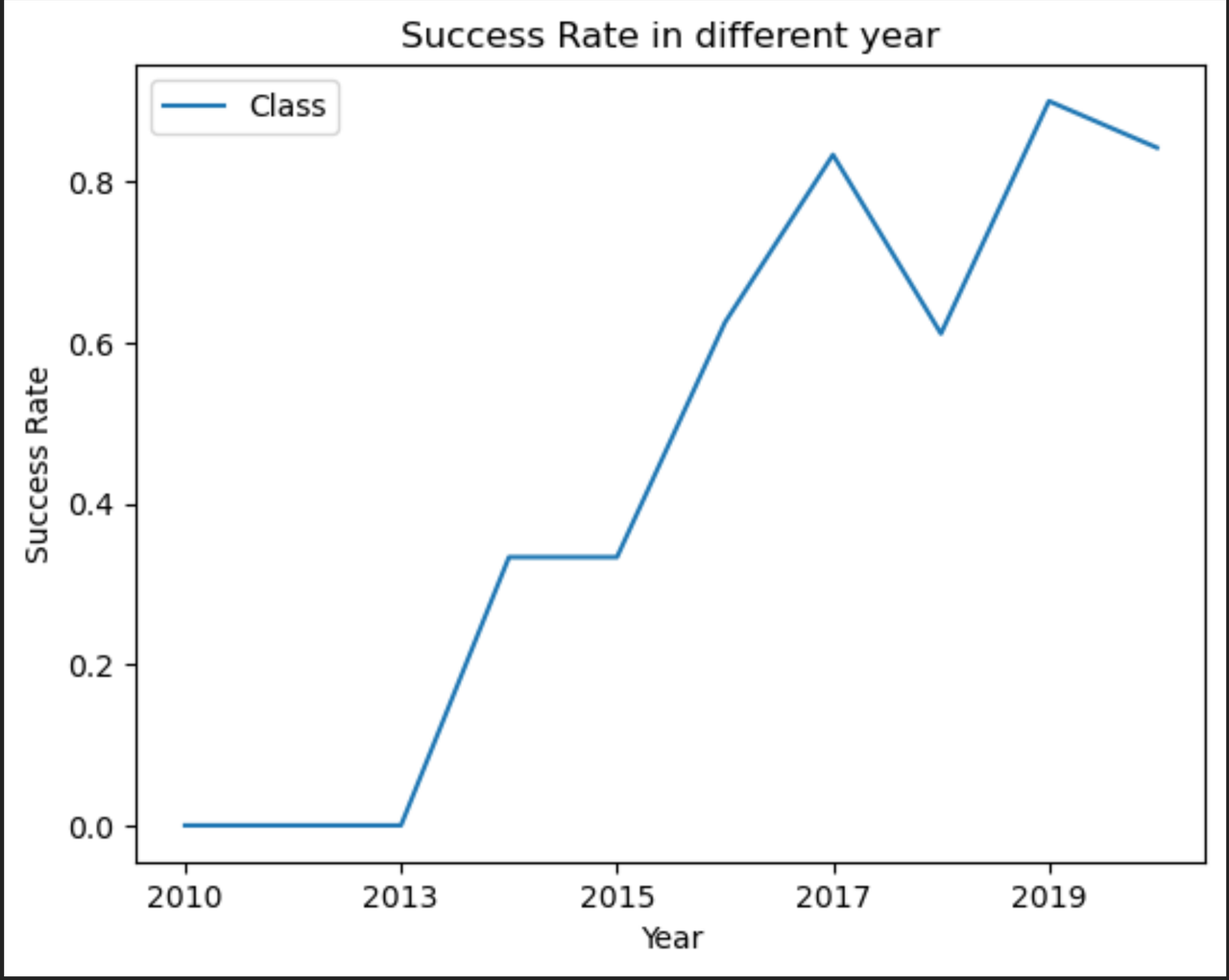


Fig 4. Line Graph of Success Rate in different Year

SUCCESS RATE IN DIFFERENT YEAR

Keep increasing after the year 2013

RESULTS

LAUNCH SITE VS FLIGHT NUMBER GRAPH

Launch Site: VAFB SLC4E, KSC LC 39A
-> More likely to land
successfully

Land Failure
Land Success

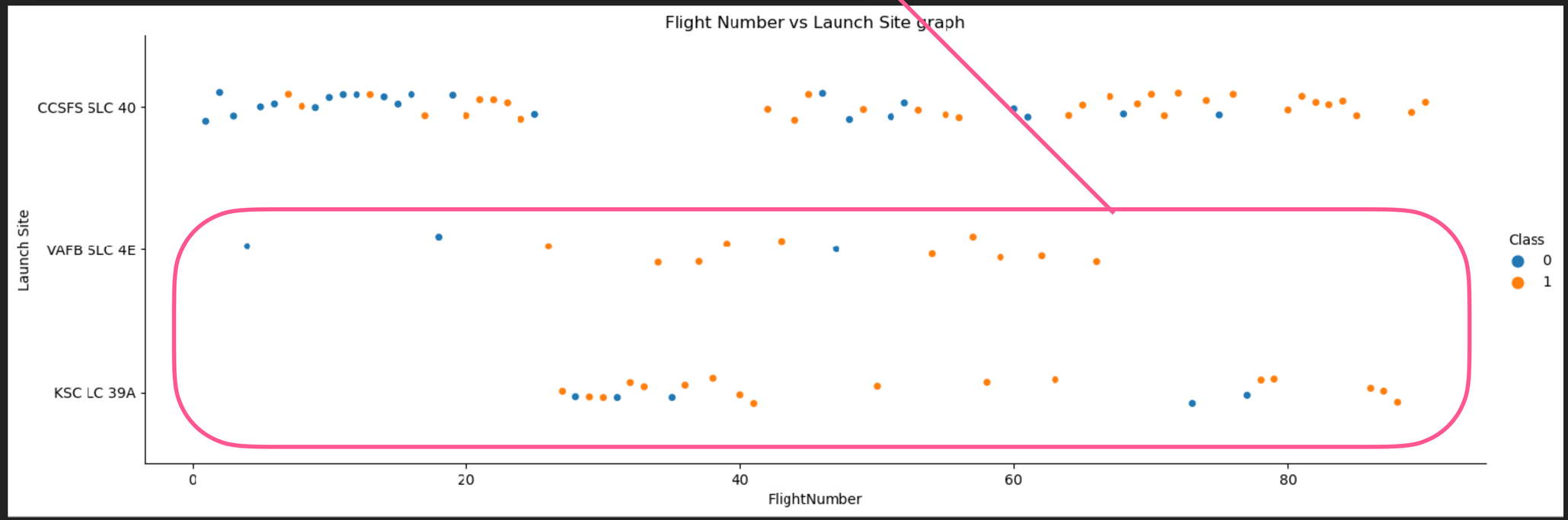


Fig 5. Launch Site vs Flight Number Graph

RESULTS

LAUNCH SITE VS PAY LOAD MASS GRAPH

Launch Site: CCSFS SLC40, KSC LC 39A
Pay Load Mass >10000kg
-> More likely to land successfully

Land Failure
Land Success

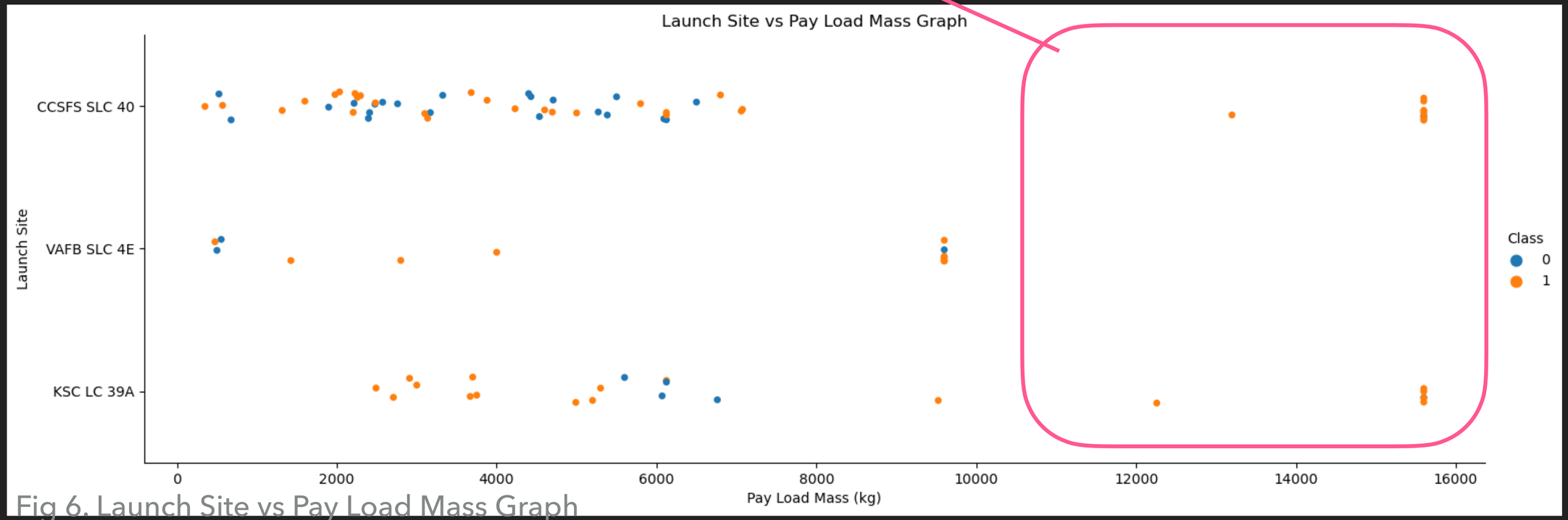


Fig 6. Launch Site vs Pay Load Mass Graph

WHERE ARE THE LAUNCH SITES?

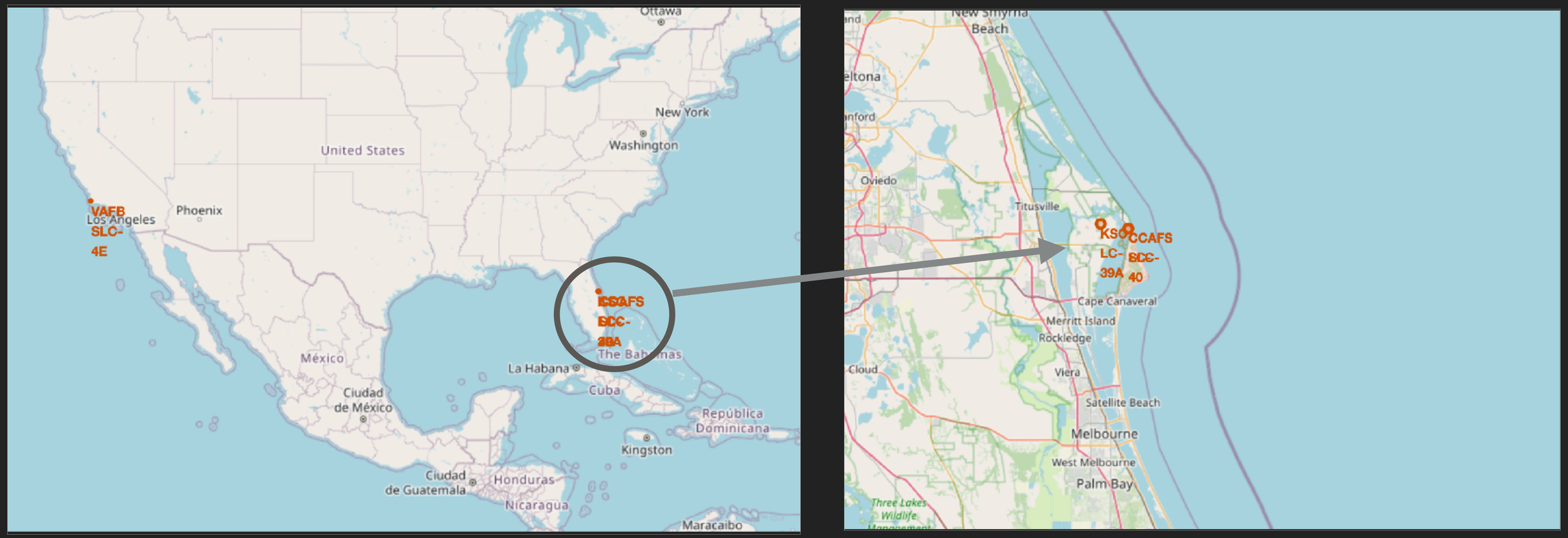


Fig 7. Map of the Launch Sites

ARE THEY NEAR THE COASTLINE?

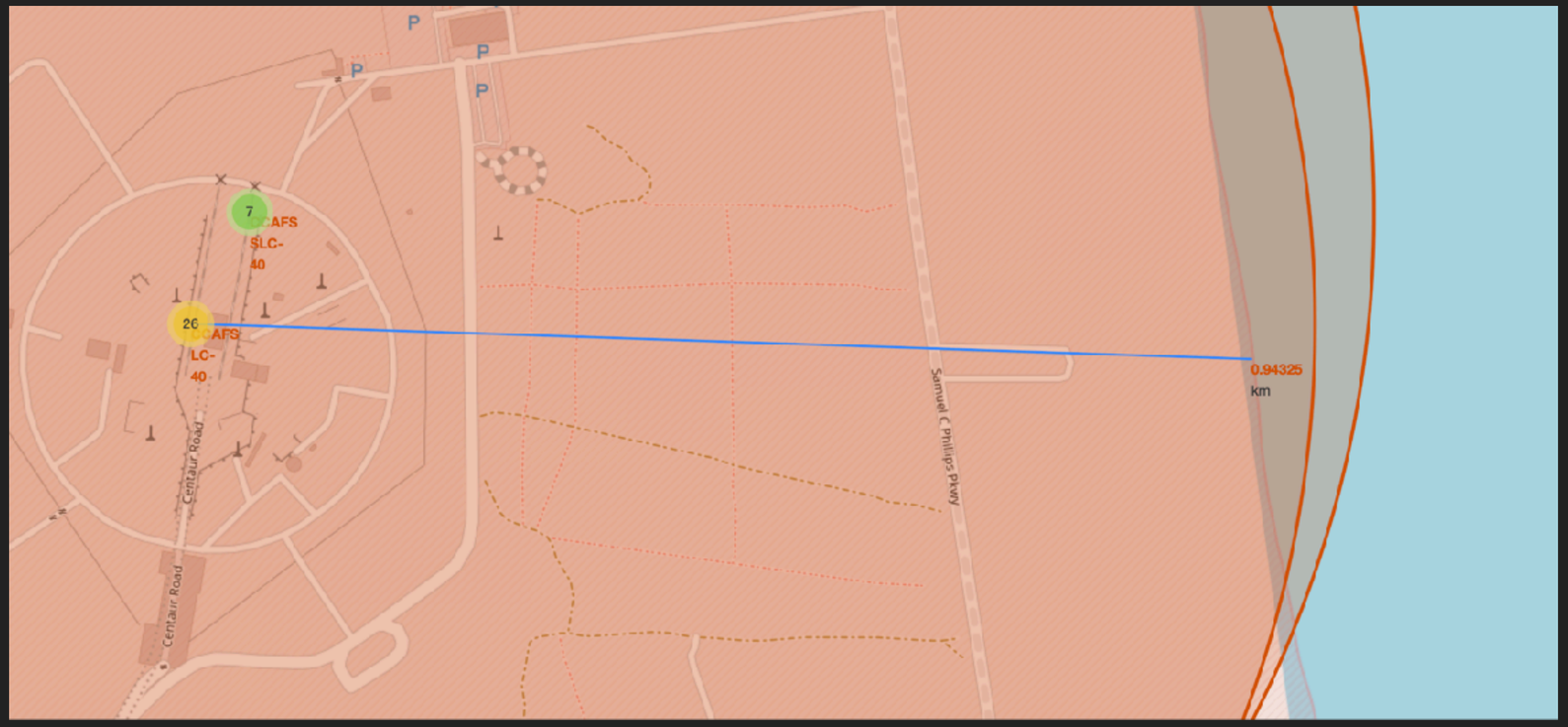
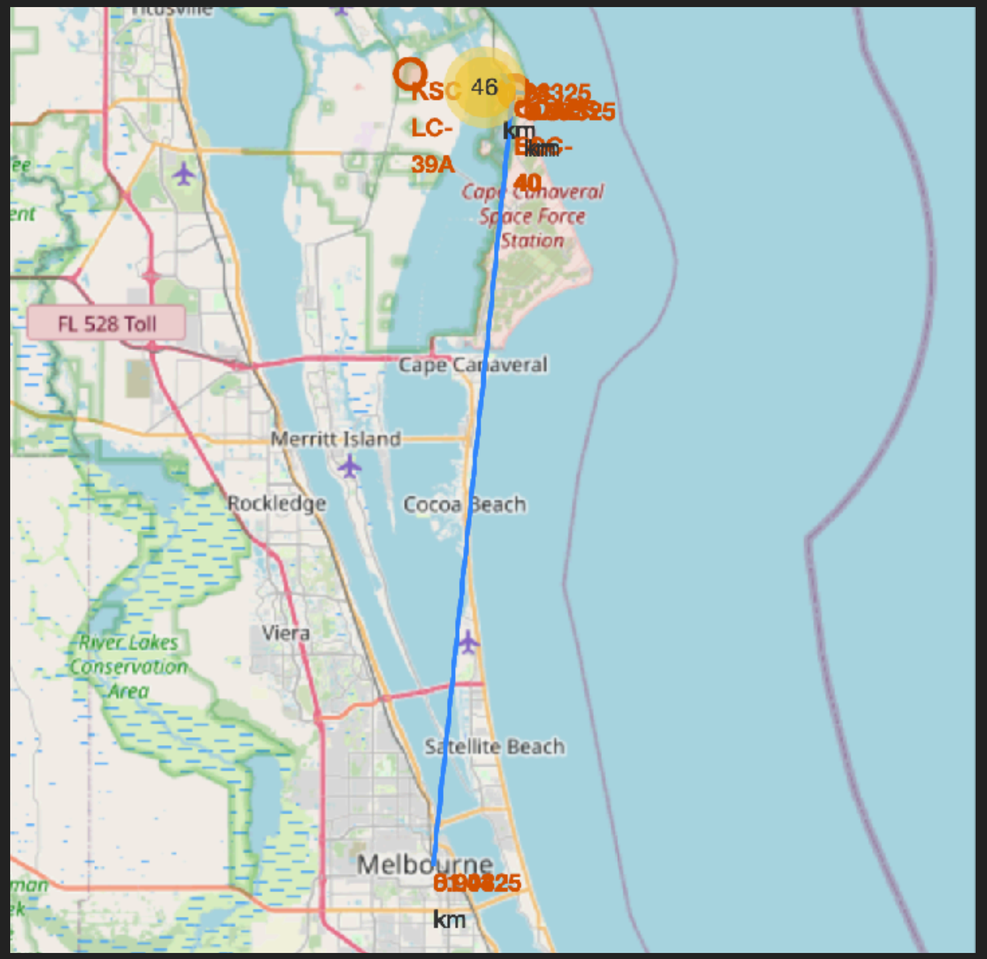


Fig 8. Map showing the distance between a specific launch site and coastline

Distance between Launch site and Coastline:

0.943km

ARE THEY NEAR THE CITY?

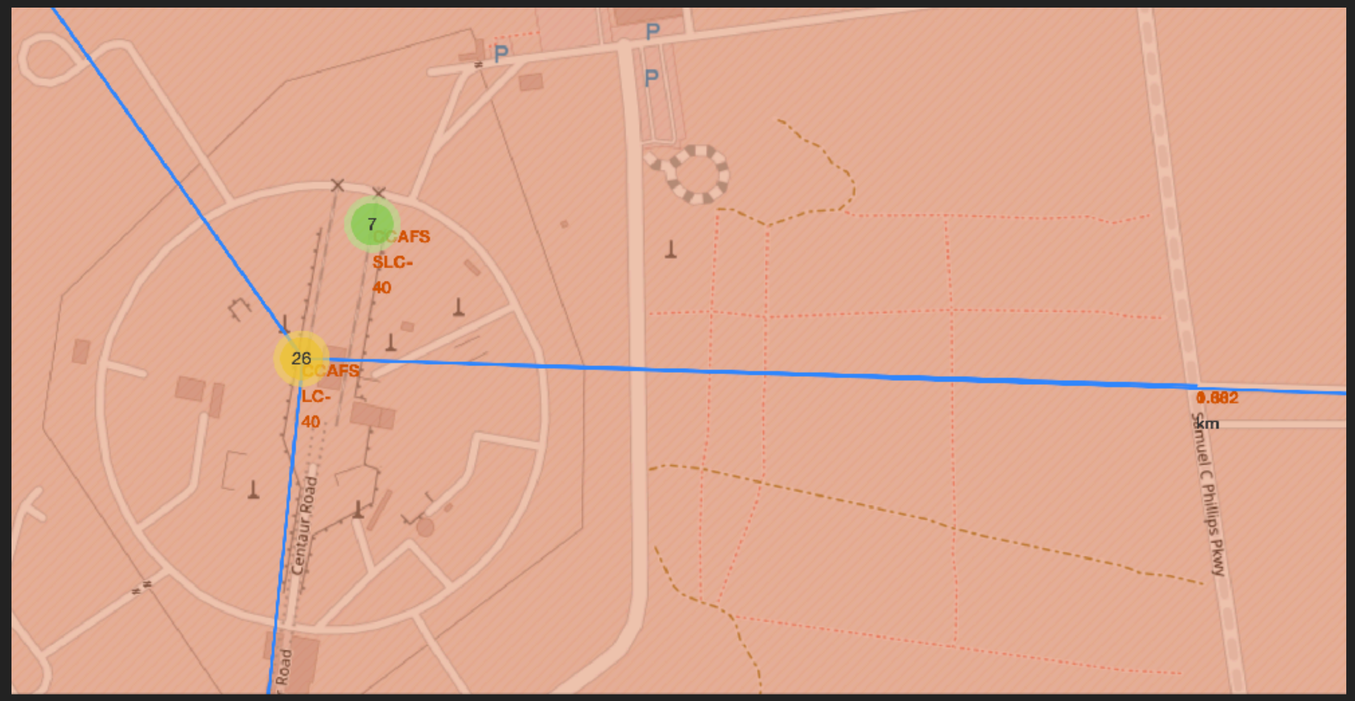


Distance between Launch site and the Nearest City Melbourne:

51.04km

Fig 9. Map showing the distance between a specific launch site and the nearest city

ARE THEY NEAR THE HIGHWAY?

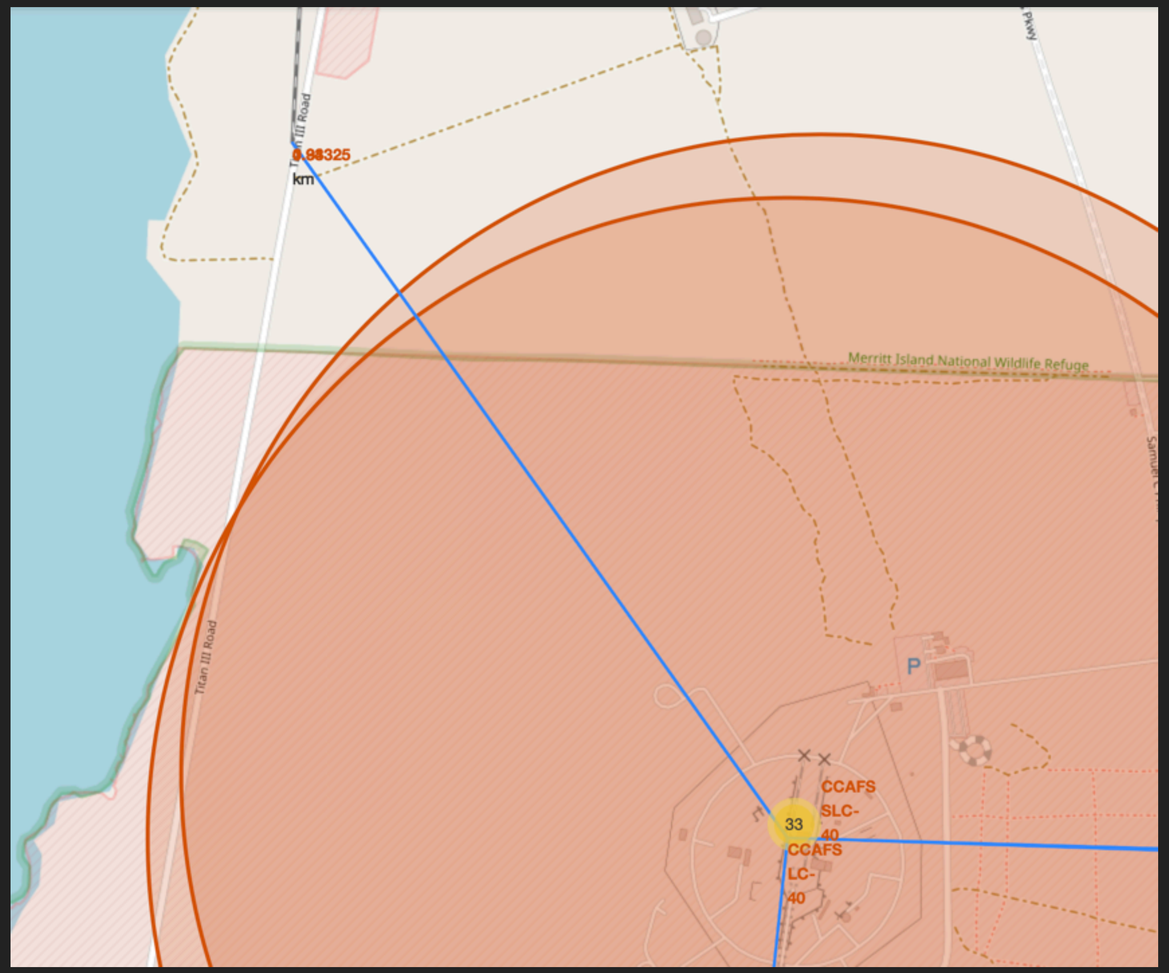


Distance between Launch site and the Nearest Highway:

0.66km

Fig 10. Map showing the distance between a specific launch site and the nearest highway

ARE THEY NEAR THE RAILWAY?



Distance between Launch site and the Nearest Railway:

1.33km

Fig 11. Map showing the distance between a specific launch site and the nearest railway

DASHBOARD

Jasmine Lam

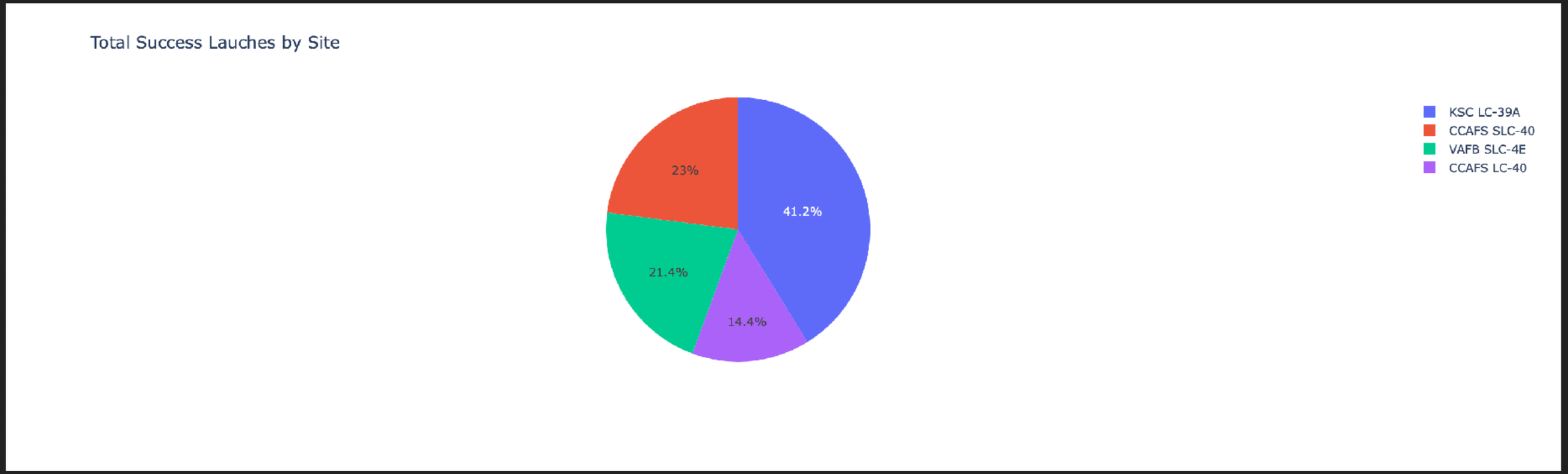


Fig 12. Pie chart of the Total Success Launches by Site

The Launch Site KSC LC-39A has the highest success rate

DASHBOARD

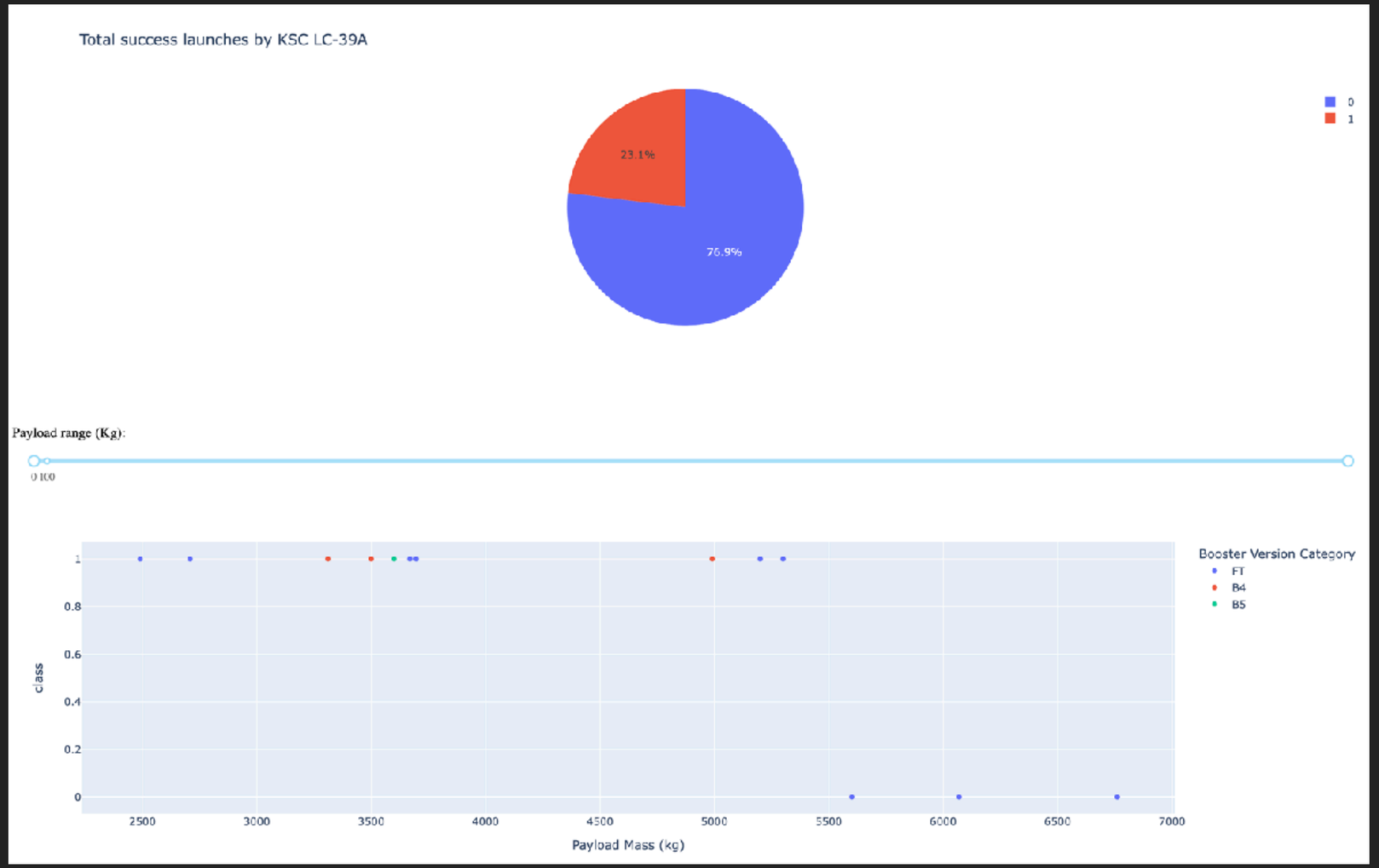
Jasmine Lam

Fig 13. Class vs Pay Load Mass Graph

Pay Load Mass between 2000-4000kg is most likely to success with Booster Version FT

DASHBOARD

Jasmine Lam



- 76.9% OF SUCCESS RATE IN KSC LC-39A
- PAY LOAD MASS BETWEEN 2500-4000KG ARE MORE LIKELY TO SUCCESS

Fig 14. Dashboard showing Total Success Launches by KSC LC-39A

PREDICTION

	LogReg	SVM	Tree	KNN
Accuracy	0.833333	0.833333	0.944444	0.777778
f1_score	0.814815	0.814815	0.943030	0.738095
Jaccard Score	0.700000	0.700000	0.893162	0.611111

Table 1. Accuracy and Scores of predicting the test data

	LogReg	SVM	Tree	KNN
Accuracy	0.833333	0.833333	0.944444	0.777778
f1_score	0.943030	0.882051	0.988841	0.804456
Jaccard Score	0.893162	0.793651	0.977960	0.685735

Table 2. Accuracy and Scores of all dataset

- Aim: Input the input variables, the classification algorithms will predict whether the first stage landing is success or not
- From both table, we can see that the accuracy and scores of Tree Diagram prediction are the highest

COMPARE THE CONFUSION MATRIX

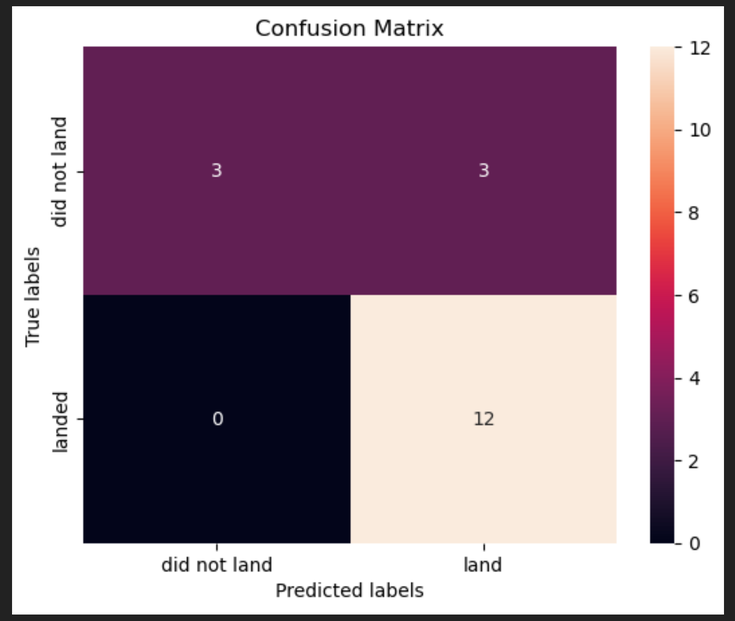


Figure 15. Confusion Matrix of Logistic Regression

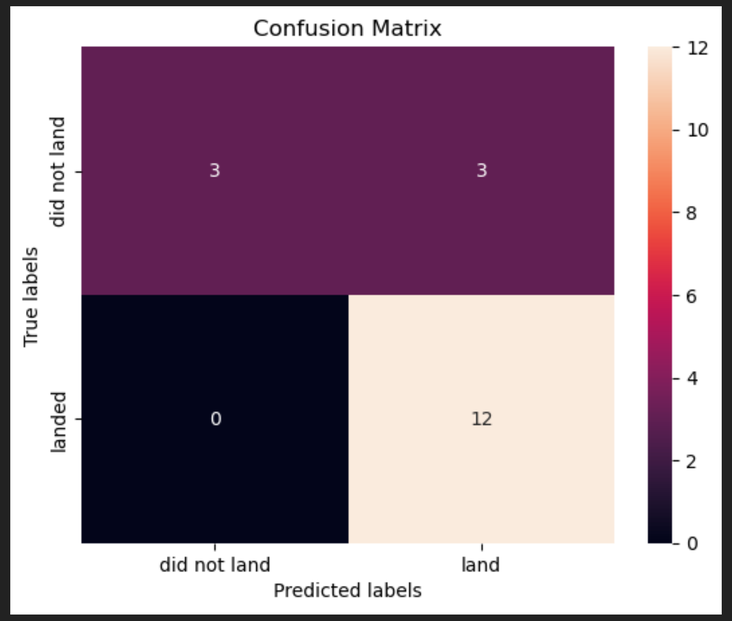


Figure 16. Confusion Matrix of SVM

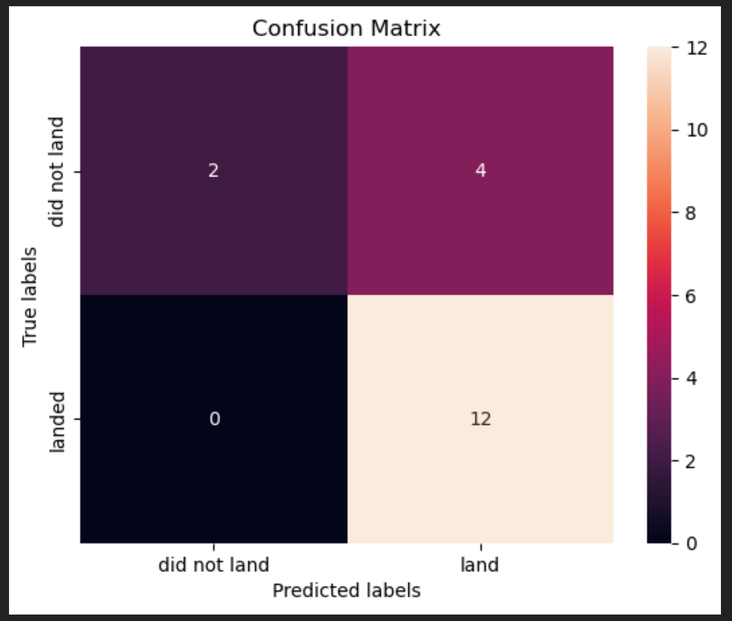


Figure 17. Confusion Matrix of KNN

Compare to Logistic Regression and SVM, KNN has less accuracy in predicting the failure of first stage landing.

DISCUSSION: LAUNCH SITE

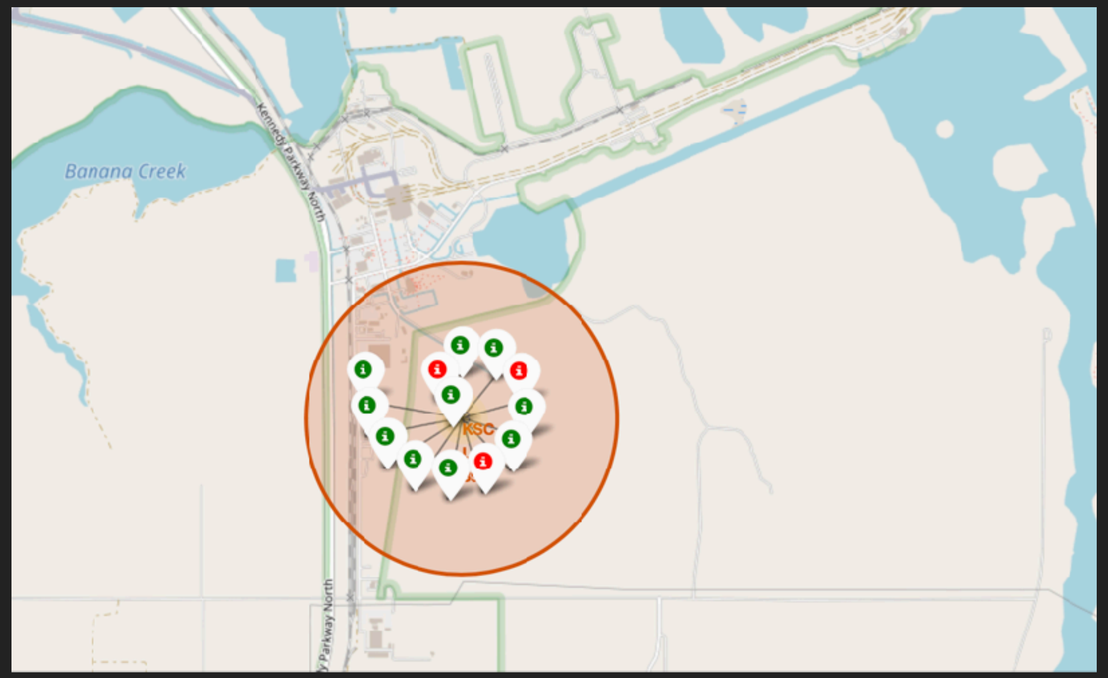
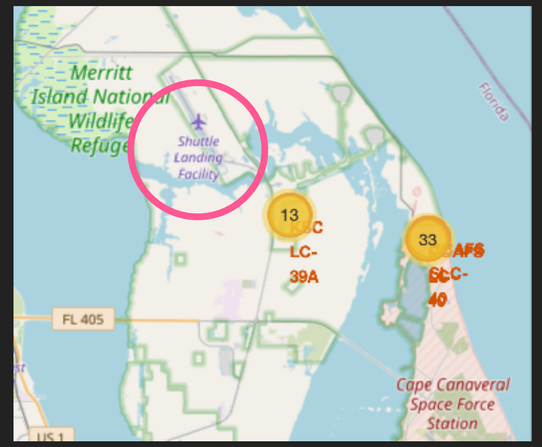
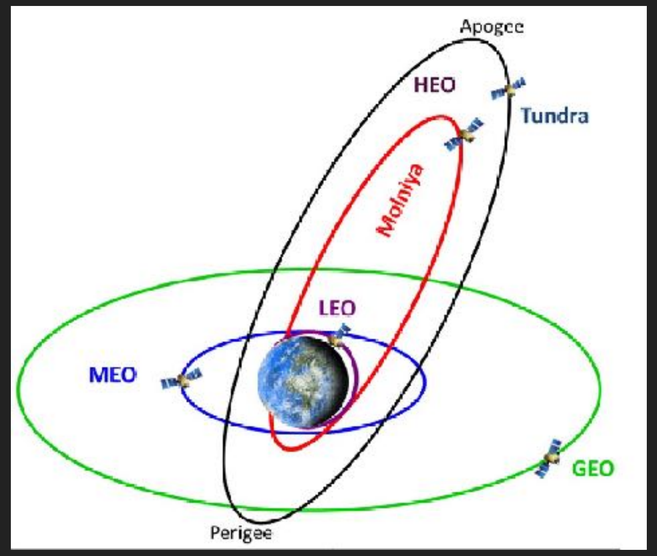


Fig 18. Map indicating the number of success in KSC LC-39A

- KSC LC-39A has the highest success rate
- The launch site isn't nearest to the coastline, while it seems to be closer to the railway
- The launch site is closer to the shuttle landing facility. It may indicate that the launch site has more accessible resources compare to other launch sites



DISCUSSION: ORBIT



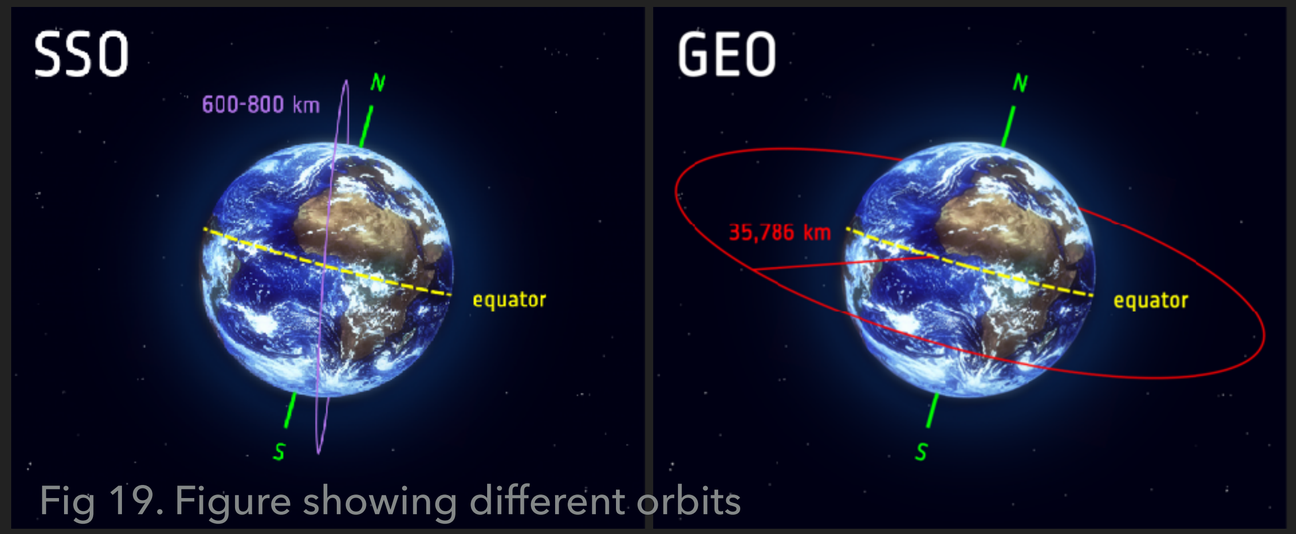


Fig 19. Figure showing different orbits

- ES-L1,GEO,HEO,SSO have more successful landing
- Same amount of trials are not used for testing. Bias may existed. More data are need to understand whether the success rate depends on the distance of the orbit from the Earth
- However, SSO with Pay Load Mass <6000kg is observed to have highest success rate

DISCUSSION: ORBIT

- In general, rocket with pay load mass >10000kg are more likely to land successfully
- Booster Version FT : Pay Load Mass between 2000-4000kg is more likely to success
- Orbit SSO : Pay Load Mass <6000kg is more likely to success

CONCLUSION

Aim of our Project: Determine how to create the a more successful, reusable rocket to reduce the launching cost

Prediction: Tree Diagram will be used as our algorithm to predict whether the landing will be success in the future

We should focus our landing investigation on:

1. Launch Site KSC LC-39A with pay load mass 2500-4000kg
2. Orbit: ES-L1,GEO,HEO,SSO

APPENDIX. DATA ANALYSIS WITH SQL

Find out each launch site:

```
%sql select distinct(LAUNCH_SITE) FROM SPACEX
```

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

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

Find out the total number of successful and failure mission outcomes:

List the total number of successful and failure mission outcomes

```
%sql SELECT MISSION_OUTCOME,COUNT(MISSION_OUTCOME) FROM SPACEX GROUP BY MISSION_OUTCOME
```

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

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

APPENDIX. DATA ANALYSIS WITH SQL

Find out the average pay load mass of Falcon 9:

```
%sql SELECT AVG(PAYLOAD_MASS__KG_) FROM SPACEX WHERE BOOSTER_VERSION LIKE 'F9 v1.1%'
```

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

AVG(PAYLOAD_MASS__KG_)
2534.6666666666665

Special Thanks to

COSERA

IBM