
# APPLIED DATA SCIENCE CAPSTONE PROJECT

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SKILLS NETWORK

# EXECUTIVE SUMMARY

- Build a data science pipeline to predict Falcon 9 first-stage landing success.
- Key Steps
  - Data collection, wrangling, and formatting
  - Exploratory data analysis and data visualization
  - Machine learning model for prediction
- Payload mass and launch site strongly influence success.
- Decision Tree & SVM provided best predictive performance.

# OUTLINE

- Executive Summary
- Introduction
- Methodology
- Results
  - Visualization – Charts
  - Dashboard
- Discussion
  - Findings & Implications
- Conclusion
- Appendix

# INTRODUCTION

- SpaceX Falcon 9 reusability significantly reduces launch costs
- Predicting first-stage landing success is critical for decision-making
- Project applies data science to analyze launch data and build models
- Scope includes data collection, wrangling, EDA, dashboard, and ML

-EDA identified key factors influencing landing success
-ML models were trained to predict outcomes based on features

# METHODOLOGY

- Data collected from SpaceX API, web scraping, and SQLite database
- Data wrangling performed to clean, merge, and preprocess feature
- Exploratory Data Analysis conducted using SQL queries and visualizations
- Machine Learning models applied including Logistic Regression, Decision Tree, SVM, and KNN
  - Hyperparameter tuning performed using GridSearchCV
  - Interactive dashboard created with Plotly Dash for data exploration

# EDA and Interactive Visual

Exploratory Data Analysis (EDA), using:

- SQL queries to summarize and explore launch outcomes
- Pandas and NumPy for data manipulation
- Identification of key factors such as payload mass, booster version, and launch site

Data visualization, using:

- Matplotlib and Seaborn for trend and distribution plots
- Folium for interactive geospatial mapping of launch sites
- Dash (Plotly) for building an interactive web-based dashboard with:
    - Launch site dropdown selector
    - Success/failure pie charts
    - Payload vs. outcome scatter plots
    - Payload range slider for filtering

# Predictive Analysis Methodology

Data preparation, using:

- Feature engineering from payload, booster version, launch site, and orbit
- Encoding categorical variables and scaling numerical features
- Train/test data split for model evaluation

Machine Learning models applied:

- Logistic Regression – baseline classifier
- Decision Tree – interpretable, rule-based model
- Support Vector Machine (SVM) – robust classifier for nonlinear boundaries
- K-Nearest Neighbors (KNN) – instance-based learning

Model optimization, using:

- Hyperparameter tuning with GridSearchCV
- 10-fold cross-validation to ensure generalization

# Evaluation and Key Insights

**Evaluation metrics:**

- Accuracy, precision, recall, and F1-score
- Comparison of models to identify the best performer

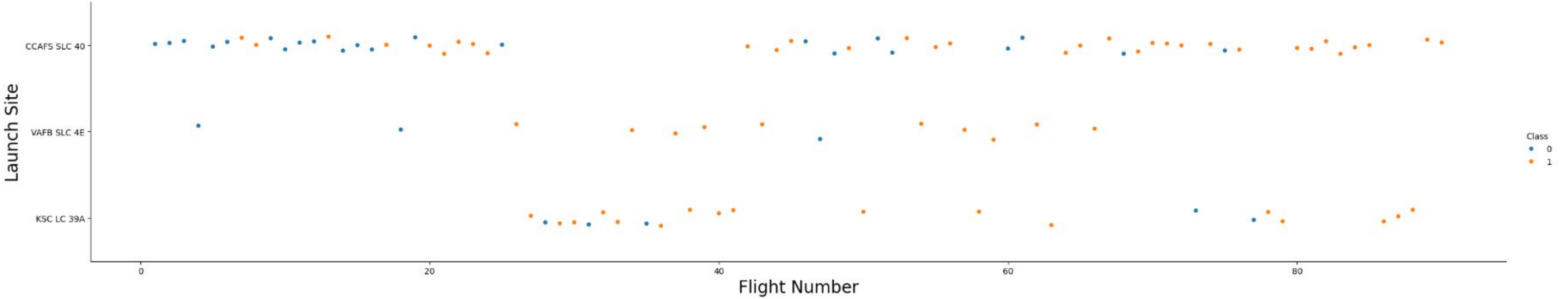
**Model performance:**

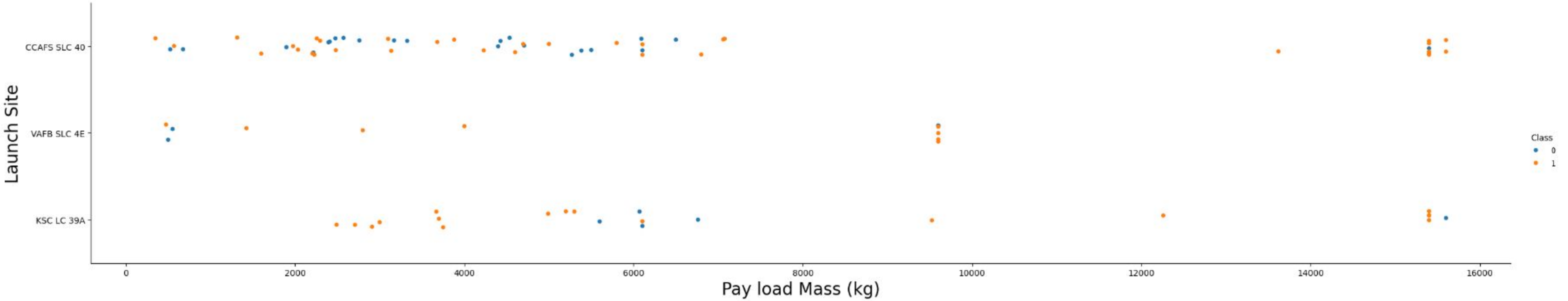
- Logistic Regression: ~83% accuracy
- Decision Tree: ~89% accuracy
- Support Vector Machine (SVM): ~89% accuracy
- K-Nearest Neighbors (KNN): ~83% accuracy

**Key insight:**

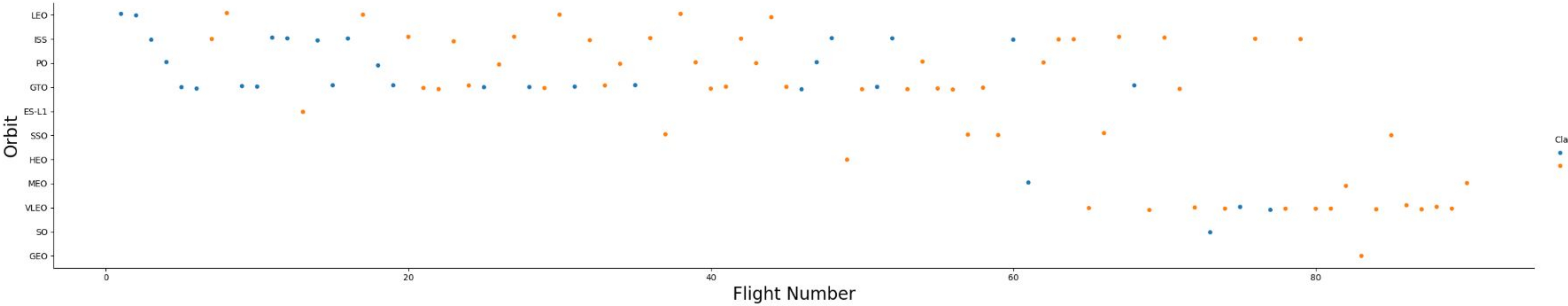
- Decision Tree and SVM achieved the best predictive accuracy for Falcon 9 landing success

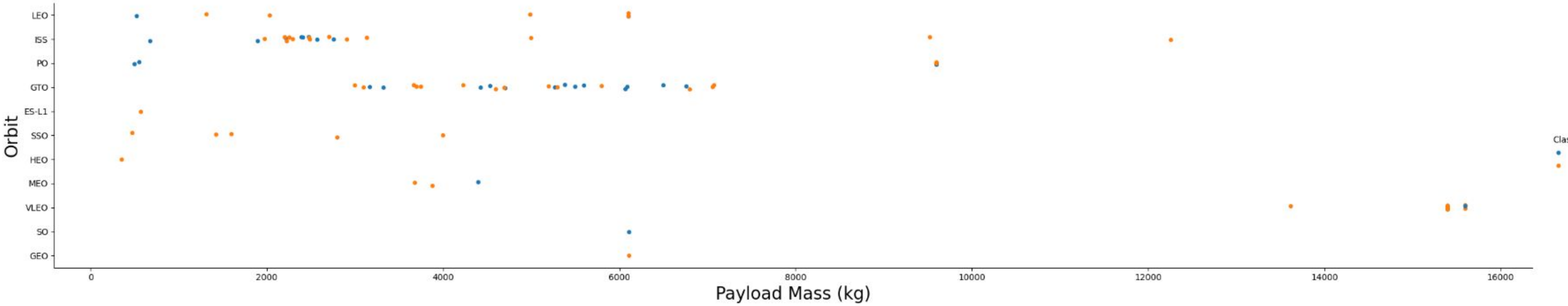
# EDA with Visualization results



# EDA with Visualization results



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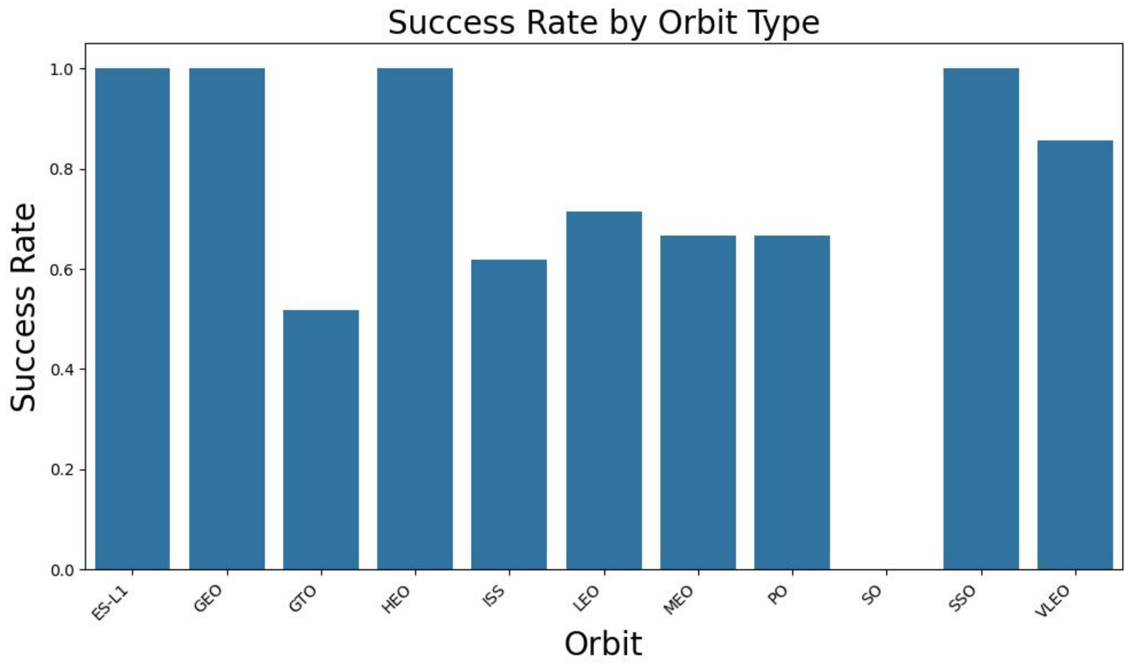
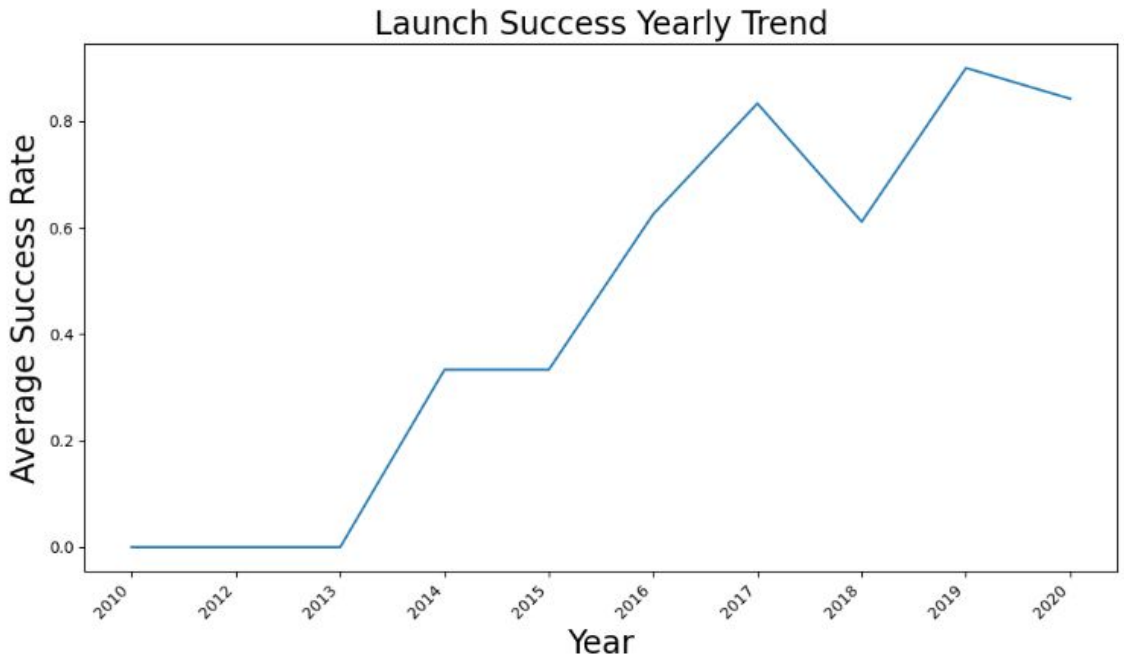


# EDA with SQL results

```
[ ] %sql SELECT DISTINCT "Launch_Site" FROM SPACEXTABLE;
```

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

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

```
[ ] %sql SELECT SUM(PAYLOAD_MASS__KG_) FROM SPACEXTABLE WHERE Customer = 'NASA (CRS)';
```

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

| SUM(PAYLOAD_MASS__KG_) |
|---|
| 45596 |

```
%sql SELECT * FROM SPACEXTABLE WHERE "Launch_Site" LIKE 'CCA%' LIMIT 5;
```

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

| 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 | 7:44:00 | F9 v1.0 B0005 | CCAFS LC-40 | Dragon demo flight C2 | 525 | LEO (ISS) | NASA (COTS) | Success | No attempt |
| 2012-10-08 | 0:35:00 | 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 |

# EDA with SQL results

```
%sql SELECT AVG(PAYLOAD_MASS__KG_) FROM SPACEXTABLE WHERE "Booster_Version" = 'F9 v1.1';
```

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

| AVG(PAYLOAD_MASS__KG_) |
|---|
| 2928.4 |

```
%sql SELECT MIN(Date) FROM SPACEXTABLE WHERE "Landing_Outcome" = 'Success (ground pad)';
```

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

| MIN(Date) |
|---|
| 2015-12-22 |

```
%sql SELECT "Booster_Version" FROM SPACEXTABLE WHERE "Landing_Outcome" = 'Success (drone ship)' AND PAYLOAD_MASS__KG_ > 4000 AND PAYLOAD_MASS__KG_ < 6000;
```

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

| Booster_Version |
|---|
| F9 FT B1022 |
| F9 FT B1026 |
| F9 FT B1021.2 |
| F9 FT B1031.2 |

# EDA with SQL results

```
%sql SELECT "Mission_Outcome", COUNT(*) AS Total FROM SPACEXTABLE GROUP BY "Mission_Outcome";
```

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

| Mission_Outcome | Total |
|---|---|
| Failure (in flight) | 1 |
| Success | 98 |
| Success | 1 |
| Success (payload status unclear) | 1 |

```
%sql SELECT "Booster_Version" FROM SPACEXTABLE WHERE "PAYLOAD_MASS__KG_" = (SELECT MAX("PAYLOAD_MASS__KG_") FROM SPACEXTABLE);
```

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

| 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 |

# EDA with SQL results

```
%sql SELECT substr(Date, 6, 2) AS month, "Landing_Outcome", "Booster_Version", "Launch_Site" FROM SPACEXTABLE WHERE "Landing_Outcome" = 'Failure (drone ship)' AND substr(Date, 0, 5) = '2015';
```

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

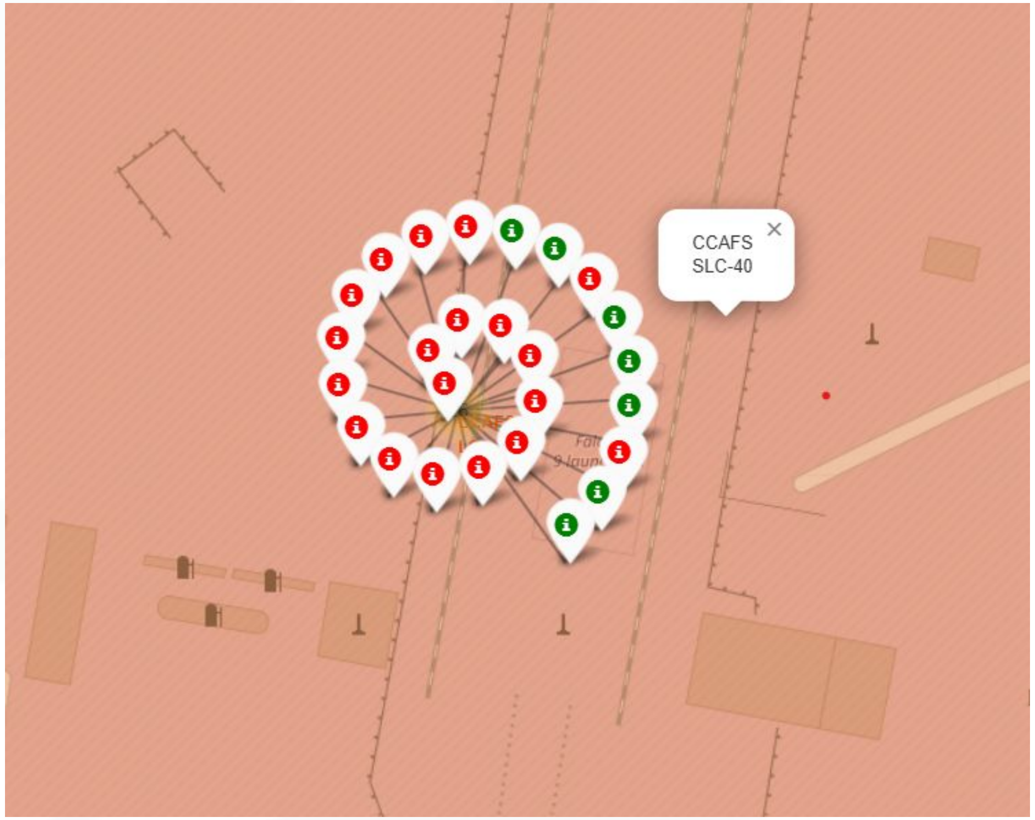
| month | Landing_Outcome | Booster_Version | Launch_Site |
|---|---|---|---|
| 01 | Failure (drone ship) | F9 v1.1 B1012 | CCAFS LC-40 |
| 04 | Failure (drone ship) | F9 v1.1 B1015 | CCAFS LC-40 |

```
%sql SELECT "Landing_Outcome", COUNT(*) AS count FROM SPACEXTABLE WHERE "Landing_Outcome" IN ('Failure (drone ship)', 'Success (ground pad)') AND Date BETWEEN '2010-06-04' AND '2017-03-20' GROUP BY "Landing_Outcome" ORDER BY count DESC;
```

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

| Landing_Outcome | count |
|---|---|
| Failure (drone ship) | 5 |
| Success (ground pad) | 3 |

# Interactive map with Folium

# Interactive map with Folium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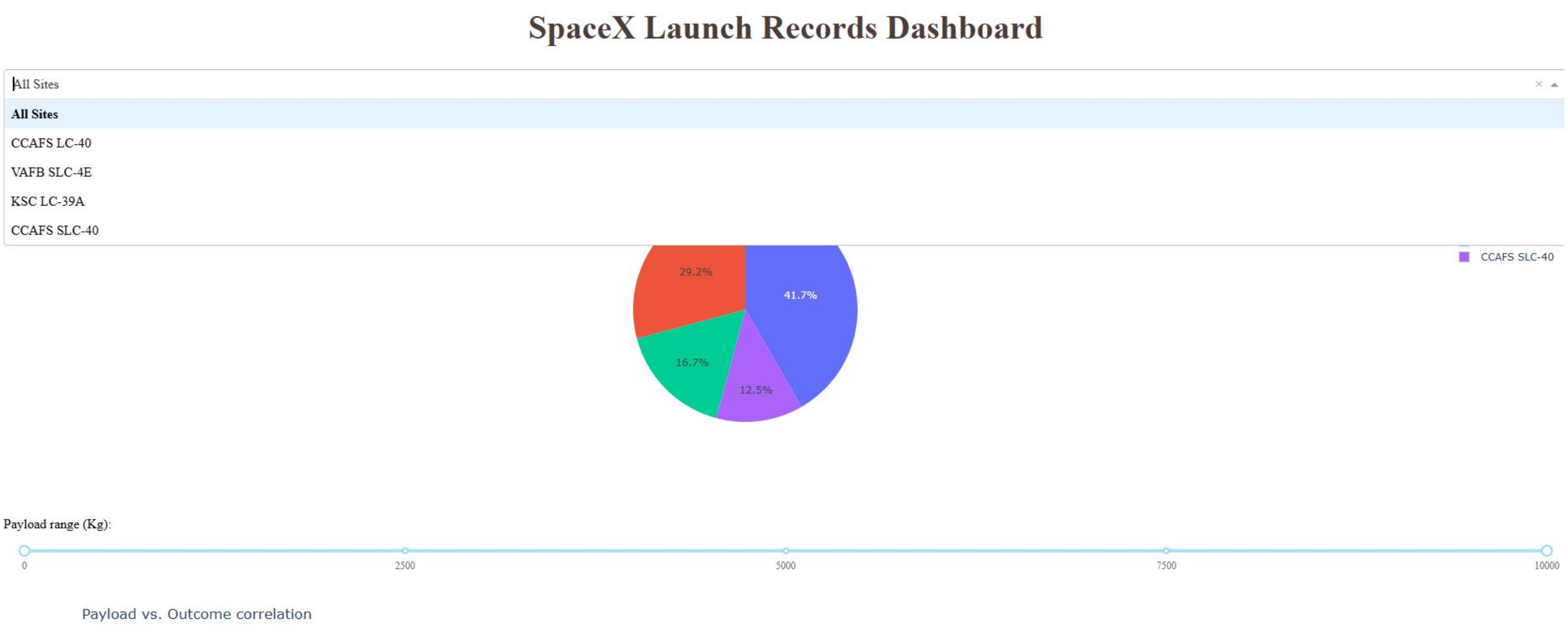
# Plotly Dash Dashboard

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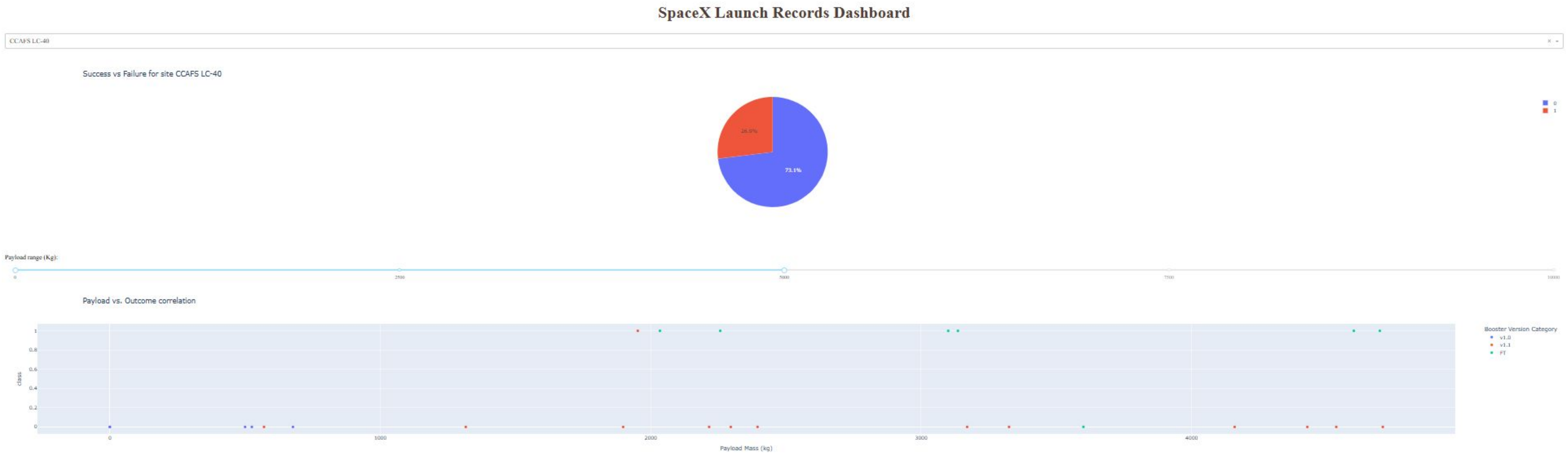
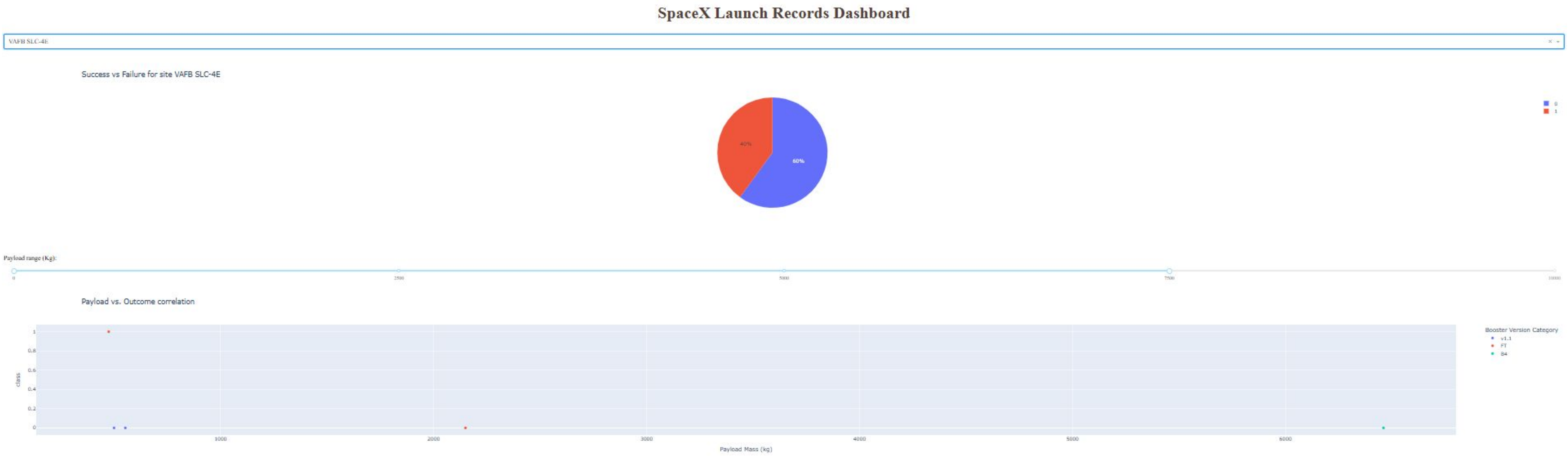
# Plotly Dash Dashboard



# Plotly Dash Dashboard



# Predictive Analysis Results

Machine Learning model performance:

- Logistic Regression: Provided baseline accuracy (~75–80%)
- Decision Tree: Strong performance with tuned parameters (~83–85%)
- Support Vector Machine (SVM): Comparable to Decision Tree (~84–85%)
- K-Nearest Neighbors (KNN): Moderate accuracy (~78–80%)

Key takeaway:

- Decision Tree and SVM models performed best for predicting Falcon 9 first-stage landing success

# Discussion:

-Payload mass shows a strong correlation with landing success: heavier payloads reduce probability of success

-Launch site analysis revealed that some sites (e.g., KSC LC-39A) achieved higher success rates than others

-Booster version category significantly impacts landing outcomes, with newer boosters performing better

-Machine Learning predictions validate insights from EDA and provide a reliable method for forecasting launch outcomes

# CONCLUSION

- Machine Learning models were applied and tuned; Decision Tree and SVM achieved the best predictive accuracy (~89%)
- The dashboard allowed stakeholders to explore launch outcomes interactively and gain business insights
- This project demonstrates how data-driven approaches can support decision-making in aerospace and space exploration

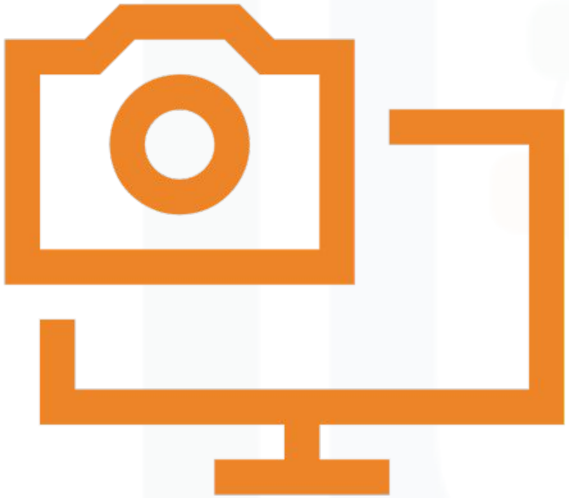
# Future work:

-Incorporate additional features such as weather conditions and launch time

-Explore ensemble models for improved predictive performance

-Deploy the prediction model as a real-time web service for broader accessibility

# APPENDIX



**Machine Learning details**

- Confusion matrices for Decision Tree, SVM, and other models
- ROC curves comparing model performance
- Hyperparameter tuning tables (GridSearchCV results)