



IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

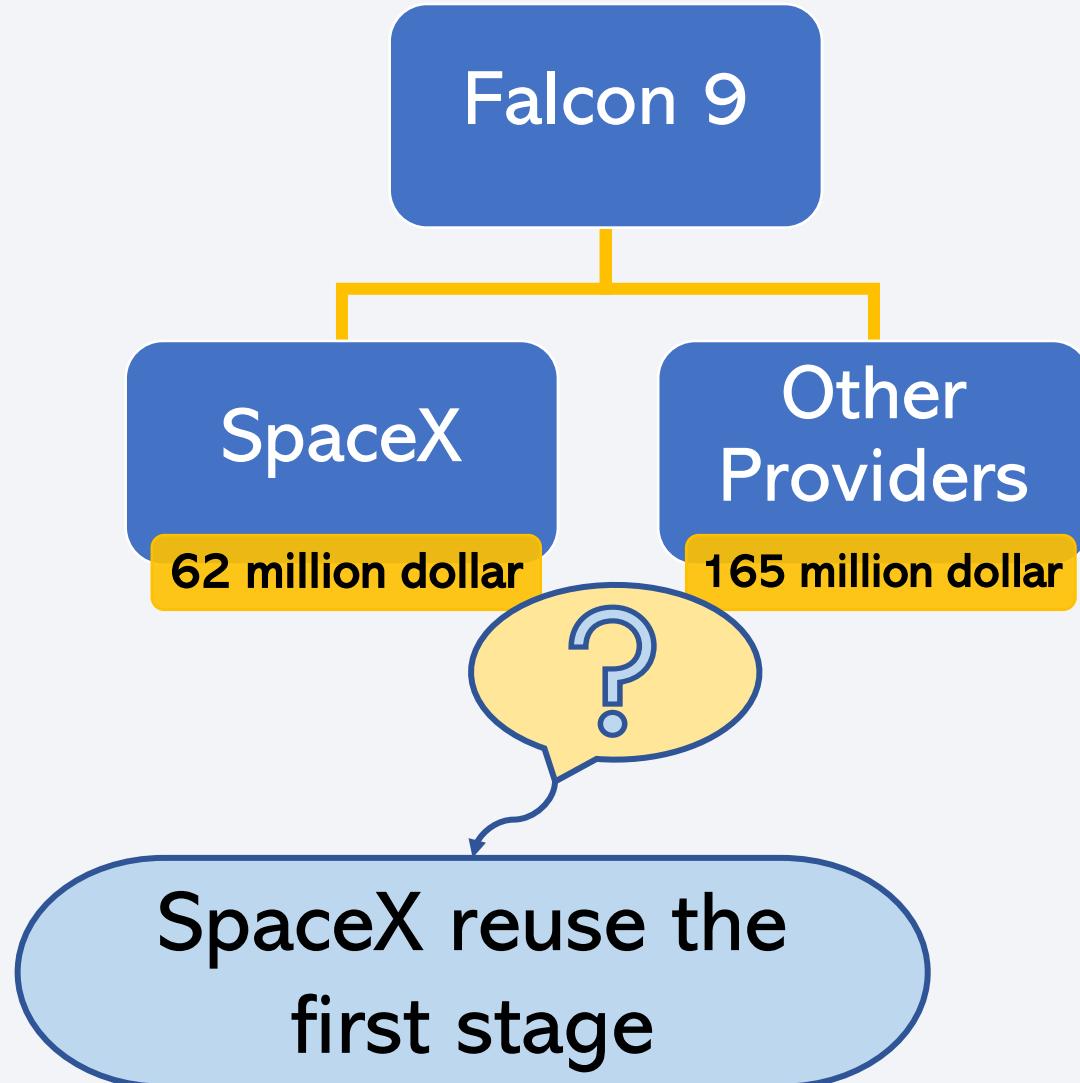


Executive Summary

At first, we use API and web scraping to collect a dataset of ‘Falcon 9’, create a data frame, modify it, and save it in CSV format. Exploratory data analysis (EDA) using visualization and SQL are next step. Then we create interactive visual analytics using Folium and Plotly Dash and finally perform predictive analysis by machine learning algorithms.

We use the above process, to understand the dataset and analyze it. We can optimize parameters and predict whether the result is successful or not. As a result of this work, costs are reduced

Introduction



determining Falcon 9 first stage landing status

determining the cost of a launch

Section 1

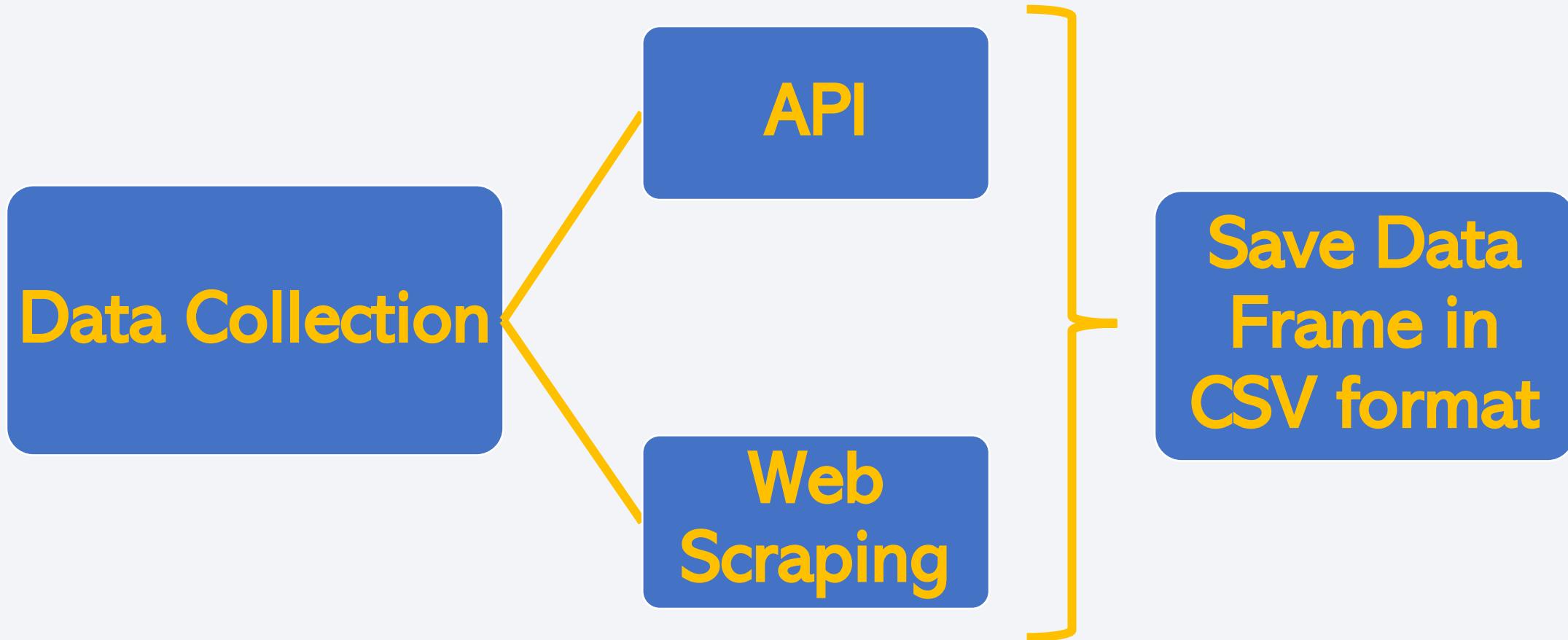
Methodology

Methodology

Executive Summary

- Data collection methodology:
 - With API and web scraping
- Perform data wrangling
 - Categorize and sort data
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
 - Using different algorithms of machine learning, modifying their parameters, comparing them together, and choosing the best

Data Collection



Data Collection – SpaceX API

Objectives:

- Requesting to the SpaceX API
- Cleaning the requested data
- [GitHub link of Data Collection](#)

Requesting and
parsing the SpaceX
launch data using
the GET request

Filtering the data
frame to only
include “Falcon 9”
launches

Dealing with
Missing Values



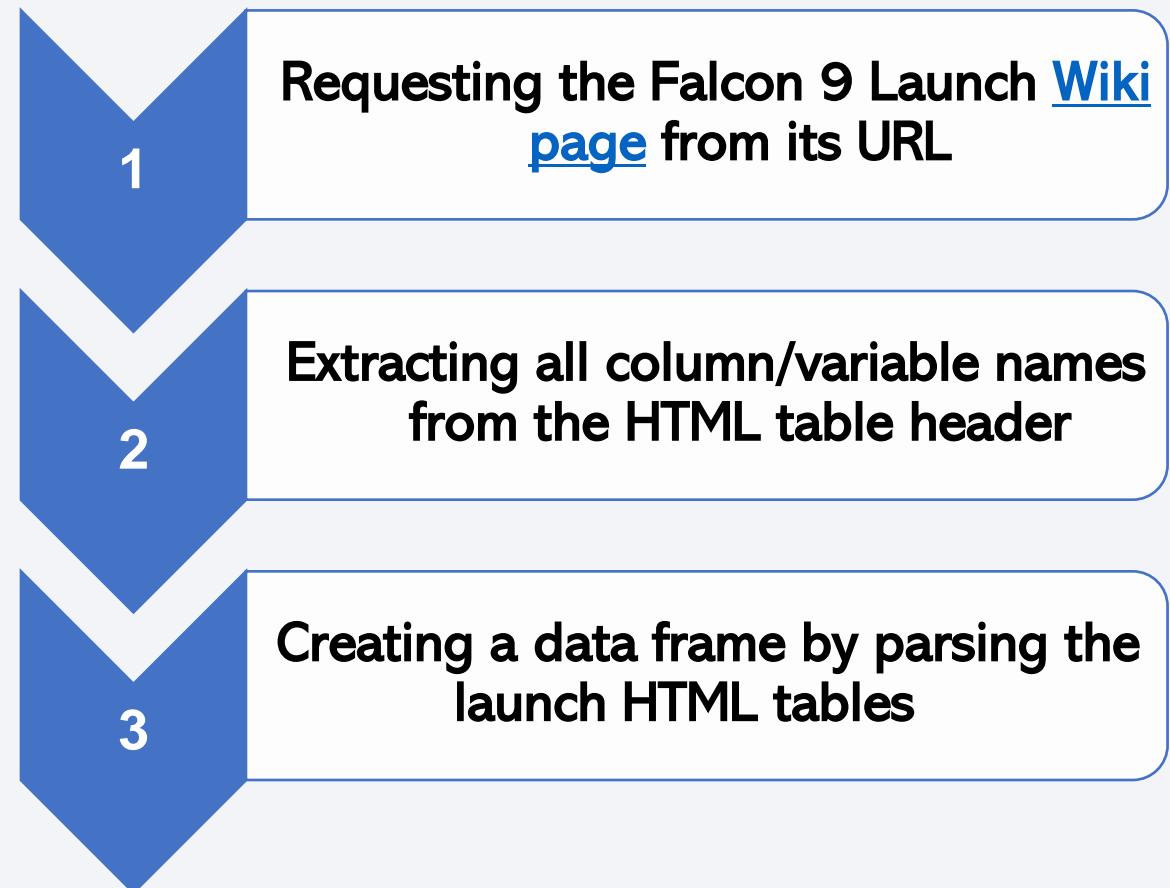
Data Collection with API - Dataset

index	FlightNumber	Date	BoosterVersion	PayloadMass	Orbit	LaunchSite	Outcome	Flights	GridFins	Reused	Legs	LandingPad	Block	ReusedCount	Serial	Longitude	Latitude
4	1	6/4/2010	Falcon 9	6123.547647	LEO	CCSFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B0003	-80.577366	28.5618571
5	2	5/22/2012	Falcon 9	525	LEO	CCSFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B0005	-80.577366	28.5618571
6	3	3/1/2013	Falcon 9	677	ISS	CCSFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B0007	-80.577366	28.5618571
7	4	9/29/2013	Falcon 9	500	PO	VAFB SLC 4E	False Ocean	1	FALSE	FALSE	FALSE		1	0	B1003	-120.610829	34.632093
8	5	12/3/2013	Falcon 9	3170	GTO	CCSFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B1004	-80.577366	28.5618571
9	6	1/6/2014	Falcon 9	3325	GTO	CCSFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B1005	-80.577366	28.5618571
10	7	4/18/2014	Falcon 9	2296	ISS	CCSFS SLC 40	True Ocean	1	FALSE	FALSE	TRUE		1	0	B1006	-80.577366	28.5618571
11	8	7/14/2014	Falcon 9	1316	LEO	CCSFS SLC 40	True Ocean	1	FALSE	FALSE	TRUE		1	0	B1007	-80.577366	28.5618571
12	9	8/5/2014	Falcon 9	4535	GTO	CCSFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B1008	-80.577366	28.5618571
13	10	9/7/2014	Falcon 9	4428	GTO	CCSFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B1011	-80.577366	28.5618571
14	11	9/21/2014	Falcon 9	2216	ISS	CCSFS SLC 40	False Ocean	1	FALSE	FALSE	FALSE		1	0	B1010	-80.577366	28.5618571
15	12	1/10/2015	Falcon 9	2395	ISS	CCSFS SLC 40	False ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb761634e7cb	1	0	B1012	-80.577366	28.5618571
16	13	2/11/2015	Falcon 9	570	ES-L1	CCSFS SLC 40	True Ocean	1	TRUE	FALSE	TRUE		1	0	B1013	-80.577366	28.5618571
17	14	4/14/2015	Falcon 9	1898	ISS	CCSFS SLC 40	False ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb761634e7cb	1	0	B1015	-80.577366	28.5618571
18	15	4/27/2015	Falcon 9	4707	GTO	CCSFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B1016	-80.577366	28.5618571
19	16	6/28/2015	Falcon 9	2477	ISS	CCSFS SLC 40	None ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	1	0	B1018	-80.577366	28.5618571
20	17	12/22/2015	Falcon 9	2034	LEO	CCSFS SLC 40	True RTLS	1	TRUE	FALSE	TRUE	5e9e3032383ecb267a34e7c7	1	0	B1019	-80.577366	28.5618571
21	18	1/17/2016	Falcon 9	553	PO	VAFB SLC 4E	False ASDS	1	TRUE	FALSE	TRUE	5e9e3033383ecbb9e534e7cc	1	0	B1017	-120.610829	34.632093
22	19	3/4/2016	Falcon 9	5271	GTO	CCSFS SLC 40	False ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	1	0	B1020	-80.577366	28.5618571
23	20	4/8/2016	Falcon 9	3136	ISS	CCSFS SLC 40	True ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	2	1	B1021	-80.577366	28.5618571
24	21	5/6/2016	Falcon 9	4696	GTO	CCSFS SLC 40	True ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	2	0	B1022	-80.577366	28.5618571
25	22	5/27/2016	Falcon 9	3100	GTO	CCSFS SLC 40	True ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	2	1	B1023	-80.577366	28.5618571
26	23	7/18/2016	Falcon 9	2257	ISS	CCSFS SLC 40	True RTLS	1	TRUE	FALSE	TRUE	5e9e3032383ecb267a34e7c7	2	1	B1025	-80.577366	28.5618571
27	24	8/14/2016	Falcon 9	4600	GTO	CCSFS SLC 40	True ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	2	0	B1026	-80.577366	28.5618571
28	25	9/1/2016	Falcon 9	5500	GTO	CCSFS SLC 40	None ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	3	0	B1028	-80.577366	28.5618571
29	26	1/14/2017	Falcon 9	9600	PO	VAFB SLC 4E	True ASDS	1	TRUE	FALSE	TRUE	5e9e3033383ecbb9e534e7cc	3	1	B1029	-120.610829	34.632093
30	27	2/19/2017	Falcon 9	2490	ISS	KSC LC 39A	True RTLS	1	TRUE	FALSE	TRUE	5e9e3032383ecb267a34e7c7	3	1	B1031	-80.6039558	28.6080585
31	28	3/16/2017	Falcon 9	5600	GTO	KSC LC 39A	None None	1	FALSE	FALSE	FALSE		3	0	B1030	-80.6039558	28.6080585
32	29	3/30/2017	Falcon 9	5300	GTO	KSC LC 39A	True ASDS	2	TRUE	TRUE	TRUE	5e9e3032383ecb6bb234e7ca	2	1	B1021	-80.6039558	28.6080585
33	30	5/1/2017	Falcon 9	6123.547647	LEO	KSC LC 39A	True RTLS	1	TRUE	FALSE	TRUE	5e9e3032383ecb267a34e7c7	3	1	B1032	-80.6039558	28.6080585
34	31	5/15/2017	Falcon 9	6070	GTO	KSC LC 39A	None None	1	FALSE	FALSE	FALSE		3	0	B1034	-80.6039558	28.6080585
35	32	6/3/2017	Falcon 9	2708	ISS	KSC LC 39A	True RTLS	1	TRUE	FALSE	TRUE	5e9e3032383ecb267a34e7c7	3	1	B1035	-80.6039558	28.6080585
36	33	6/23/2017	Falcon 9	3669	GTO	KSC LC 39A	True ASDS	2	TRUE	TRUE	TRUE	5e9e3032383ecb6bb234e7ca	3	1	B1029	-80.6039558	28.6080585
37	34	6/25/2017	Falcon 9	9600	PO	VAFB SLC 4E	True ASDS	1	TRUE	FALSE	TRUE	5e9e3033383ecbb9e534e7cc	3	1	B1036	-120.610829	34.632093
38	35	7/5/2017	Falcon 9	6761	GTO	KSC LC 39A	None None	1	FALSE	FALSE	FALSE		3	0	B1037	-80.6039558	28.6080585
39	36	8/14/2017	Falcon 9	2910	ISS	KSC LC 39A	True RTLS	1	TRUE	FALSE	TRUE	5e9e3032383ecb267a34e7c7	4	1	B1039	-80.6039558	28.6080585
40	37	8/24/2017	Falcon 9	475	SSO	VAFB SLC 4E	True ASDS	1	TRUE	FALSE	TRUE	5e9e3033383ecbb9e534e7cc	3	1	B1038	-120.610829	34.632093

Data Collection - Scraping

Objectives:

- Extracting a Falcon 9 launch records HTML table from Wikipedia
- Parsing the table and converting it into a Pandas data frame
- [GitHub link of Web Scraping](#)



Web Scraping - Dataset

Flight No.	Launch site	Payload mass	Orbit	Customer	Payload	Launch outcome	Version Booster	Booster landing	Date	Time
1	CCAFS	0	LEO	SpaceX	Dragon Spacecraft Qualification Unit	Success	F9 v1.0B0003.1	Failure	4-Jun-10	18:45
2	CCAFS	0	LEO		Dragon	Success	F9 v1.0B0004.1	Failure	8-Dec-10	15:43
3	CCAFS	525 kg	LEO	NASA	Dragon	Success	F9 v1.0B0005.1	Not attempted	#####	7:44
4	CCAFS	4,700 kg	LEO	NASA	SpaceX CRS-1	Success	F9 v1.0B0006.1	No attempt	8-Oct-12	0:35
5	CCAFS	4,877 kg	LEO	NASA	SpaceX CRS-2	Success	F9 v1.0B0007.1	Not attempted	1-Mar-13	15:10
6	VAFB	500 kg	Polar orbit	MDA	CASSIOPE	Success	F9 v1.1B1003	Uncontrolled	29-Sep-13	16:00
7	CCAFS	3,170 kg	GTO	SES	SES-8	Success	F9 v1.1	Not attempted	3-Dec-13	22:41
8	CCAFS	3,325 kg	GTO	Thaicom	Thaicom 6	Success	F9 v1.1	Not attempted	6-Jan-14	22:06
9	Cape Canaveral	2,296 kg	LEO	NASA	SpaceX CRS-3	Success	F9 v1.1	Controlled	18-Apr-14	19:25
10	Cape Canaveral	1,316 kg	LEO	Orbcomm	Orbcomm-OG2	Success	F9 v1.1	Controlled	14-Jul-14	15:15
11	Cape Canaveral	4,535 kg	GTO	AsiaSat	AsiaSat 8	Success	F9 v1.1	Not attempted	5-Aug-14	8:00
12	Cape Canaveral	4,428 kg	GTO	AsiaSat	AsiaSat 6	Success	F9 v1.1	Not attempted	7-Sep-14	5:00
13	Cape Canaveral	2,216 kg	LEO	NASA	SpaceX CRS-4	Success	F9 v1.1	Uncontrolled	21-Sep-14	5:52
14	Cape Canaveral	2,395 kg	LEO	NASA	SpaceX CRS-5	Success	F9 v1.1	Failure	10-Jan-15	9:47
15	Cape Canaveral	570 kg	HEO		DSCOVR	Success	F9 v1.1	Controlled	11-Feb-15	23:03
16	Cape Canaveral	4,159 kg	GTO		ABS-3A	Success	F9 v1.1	Not attempted	2-Mar-15	3:50
17	Cape Canaveral	1,898 kg	LEO	NASA	SpaceX CRS-6	Success	F9 v1.1	Failure	14-Apr-15	20:10
18	Cape Canaveral	4,707 kg	GTO	Turkmenistan National	Türkmenlem 52°E / MonacoSAT	Success	F9 v1.1	Not attempted	27-Apr-15	23:03
19	Cape Canaveral	1,952 kg	LEO	NASA	SpaceX CRS-7	Failure	F9 v1.1	Precluded	28-Jun-15	14:21
20	Cape Canaveral	2,034 kg	LEO	Orbcomm	Orbcomm-OG2	Success	F9 FT	Success	22-Dec-15	1:29
21	VAFB	553 kg	LEO		Jason-3	Success	F9 v1.1	Failure	17-Jan-16	18:42
22	Cape Canaveral	5,271 kg	GTO	SES	SES-9	Success	F9 FT	Failure	4-Mar-16	23:35
23	Cape Canaveral	3,136 kg	LEO	NASA	SpaceX CRS-8	Success	F9 FT	Success	8-Apr-16	20:43
24	Cape Canaveral	4,696 kg	GTO	SKY Perfect JSAT Group	JCSAT-14	Success	F9 FT	Success	6-May-16	5:21

Data Wrangling

Objectives:

- Exploratory Data Analysis
- Determining Training Labels
- [GitHub Link of Data Wrangling](#)

Calculating the number of launches on each site

Calculating the number and occurrence of each orbit

Calculating the number and occurrence of mission outcome of the orbits

Creating a landing outcome label from outcome column

Data Wrangling - Dataset

FlightNumber	Date	BoosterVersion	PayloadMass	Orbit	LaunchSite	Outcome	Flights	GridFins	Reused	Legs	LandingPad	Block	ReusedCount	Serial	Longitude	Latitude	Class
1	6/4/2010	Falcon 9	6104.95941	LEO	CCAFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B0003	-80.577366	28.561857	0
2	5/22/2012	Falcon 9	525	LEO	CCAFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B0005	-80.577366	28.561857	0
3	3/1/2013	Falcon 9	677	ISS	CCAFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B0007	-80.577366	28.561857	0
4	9/29/2013	Falcon 9	500*	PO	VAFB SLC 4E	False Ocean	1	FALSE	FALSE	FALSE		1	0	B1003	-120.61083	34.632093	0
5	12/3/2013	Falcon 9	3170	GTO	CCAFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B1004	-80.577366	28.561857	0
6	1/6/2014	Falcon 9	3325	GTO	CCAFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B1005	-80.577366	28.561857	0
7	4/18/2014	Falcon 9	2296	ISS	CCAFS SLC 40	True Ocean	1	FALSE	FALSE	TRUE		1	0	B1006	-80.577366	28.561857	1
8	7/14/2014	Falcon 9	1316	LEO	CCAFS SLC 40	True Ocean	1	FALSE	FALSE	TRUE		1	0	B1007	-80.577366	28.561857	1
9	8/5/2014	Falcon 9	4535	GTO	CCAFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B1008	-80.577366	28.561857	0
10	9/7/2014	Falcon 9	4428	GTO	CCAFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B1011	-80.577366	28.561857	0
11	9/21/2014	Falcon 9	2216	ISS	CCAFS SLC 40	False Ocean	1	FALSE	FALSE	FALSE		1	0	B1010	-80.577366	28.561857	0
12	1/10/2015	Falcon 9	2395	ISS	CCAFS SLC 40	False ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb761634e7cb	1	0	B1012	-80.577366	28.561857	0
13	2/11/2015	Falcon 9	570	ES-L1	CCAFS SLC 40	True Ocean	1	TRUE	FALSE	TRUE		1	0	B1013	-80.577366	28.561857	1
14	4/14/2015	Falcon 9	1898	ISS	CCAFS SLC 40	False ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb761634e7cb	1	0	B1015	-80.577366	28.561857	0
15	4/27/2015	Falcon 9	4707	GTO	CCAFS SLC 40	None None	1	FALSE	FALSE	FALSE		1	0	B1016	-80.577366	28.561857	0
16	6/28/2015	Falcon 9	2477	ISS	CCAFS SLC 40	None ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	1	0	B1018	-80.577366	28.561857	0
17	12/22/2015	Falcon 9	2034	LEO	CCAFS SLC 40	True RTLS	1	TRUE	FALSE	TRUE	5e9e3032383ecb267a34e7c7	1	0	B1019	-80.577366	28.561857	1
18	1/17/2016	Falcon 9	553	PO	VAFB SLC 4E	False ASDS	1	TRUE	FALSE	TRUE	5e9e3033383ecbb9e534e7cc	1	0	B1017	-120.61083	34.632093	0
19	3/4/2016	Falcon 9	5271	GTO	CCAFS SLC 40	False ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	1	0	B1020	-80.577366	28.561857	0
20	4/8/2016	Falcon 9	3136	ISS	CCAFS SLC 40	True ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	2	1	B1021	-80.577366	28.561857	1
21	5/6/2016	Falcon 9	4696	GTO	CCAFS SLC 40	True ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	2	0	B1022	-80.577366	28.561857	1
22	5/27/2016	Falcon 9	3100	GTO	CCAFS SLC 40	True ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	2	1	B1023	-80.577366	28.561857	1
23	7/18/2016	Falcon 9	2257	ISS	CCAFS SLC 40	True RTLS	1	TRUE	FALSE	TRUE	5e9e3032383ecb267a34e7c7	2	1	B1025	-80.577366	28.561857	1
24	8/14/2016	Falcon 9	4600	GTO	CCAFS SLC 40	True ASDS	1	TRUE	FALSE	TRUE	5e9e3032383ecb6bb234e7ca	2	0	B1026	-80.577366	28.561857	1

EDA with Data Visualization

Objectives:

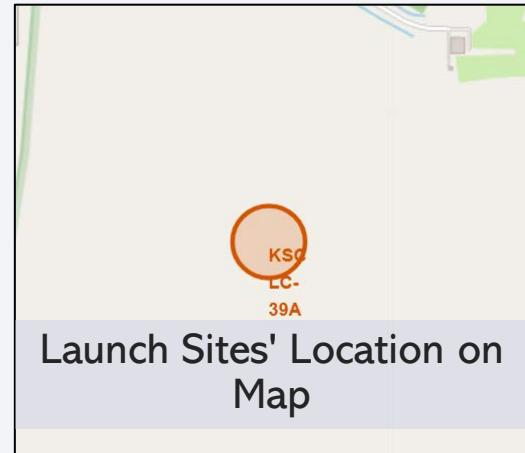
- Exploratory Data Analysis
- Preparing Data Feature Engineering
- [GitHub link of EDA with Data Visualization](#)

EDA with SQL

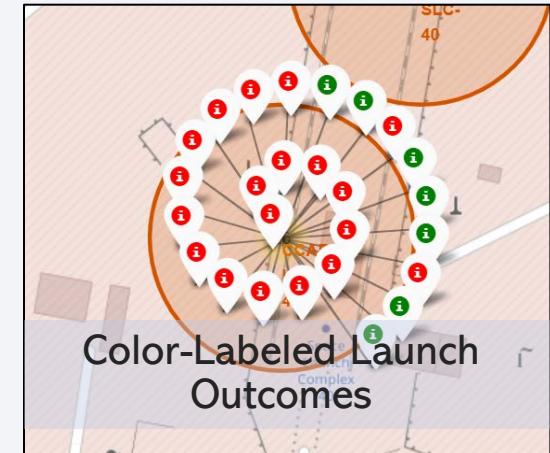
- Names of the unique launch sites in the space mission
- Launch sites begin with the string 'CCA'
- Total payload mass carried by boosters launched by NASA (CRS)
- Average payload mass carried by booster version F9 v1.1
- Date of the first successful landing outcome in ground pad
- Names of the boosters which have success in drone ship and have payload mass in [4000, 6000]
- Total number of successful and failure mission outcomes
- Names of the booster versions which have carried the maximum payload mass
- Month names, failure landing outcomes in drone ship ,booster versions, launch site in year 2015
- Count of landing outcomes between the date 2010-06-04 and 2017-03-20, in descending order
- [GitHub link of EDA with SQL](#)

Build an Interactive Map with Folium

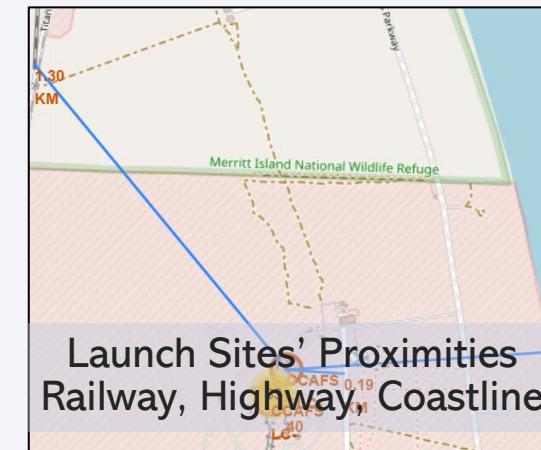
- Creating circles with markers to indicate launch sites' location on the map
- Adding colored markers to the map to show the landing outcome status
- Creating lines to display close proximities to railway, highway, and coastline to the selected launch site
- [GitHub link of Interactive Map](#)



Launch Sites' Location on Map



Color-Labeled Launch Outcomes



Launch Sites' Proximities
Railway, Highway, Coastline

Build a Dashboard with Plotly Dash



Pie chart of all launch sites' success rate and total success launch by site

Scatter plot of correlation between payload and success for all and each launch sites

- By adding pie chart in dashboard, we can compare success rate of each launch site
- With the help of scatter plot we can perceive relation between payload and success for each site and for each range
- [GitHub link of Dashboard](#)

Predictive Analysis (Classification)

Standardizing the data

Splitting data into training data and test data (test size: 20%)

Finding the best hyperparameter for SVM, KNN, Classification Trees, and Logistic Regression

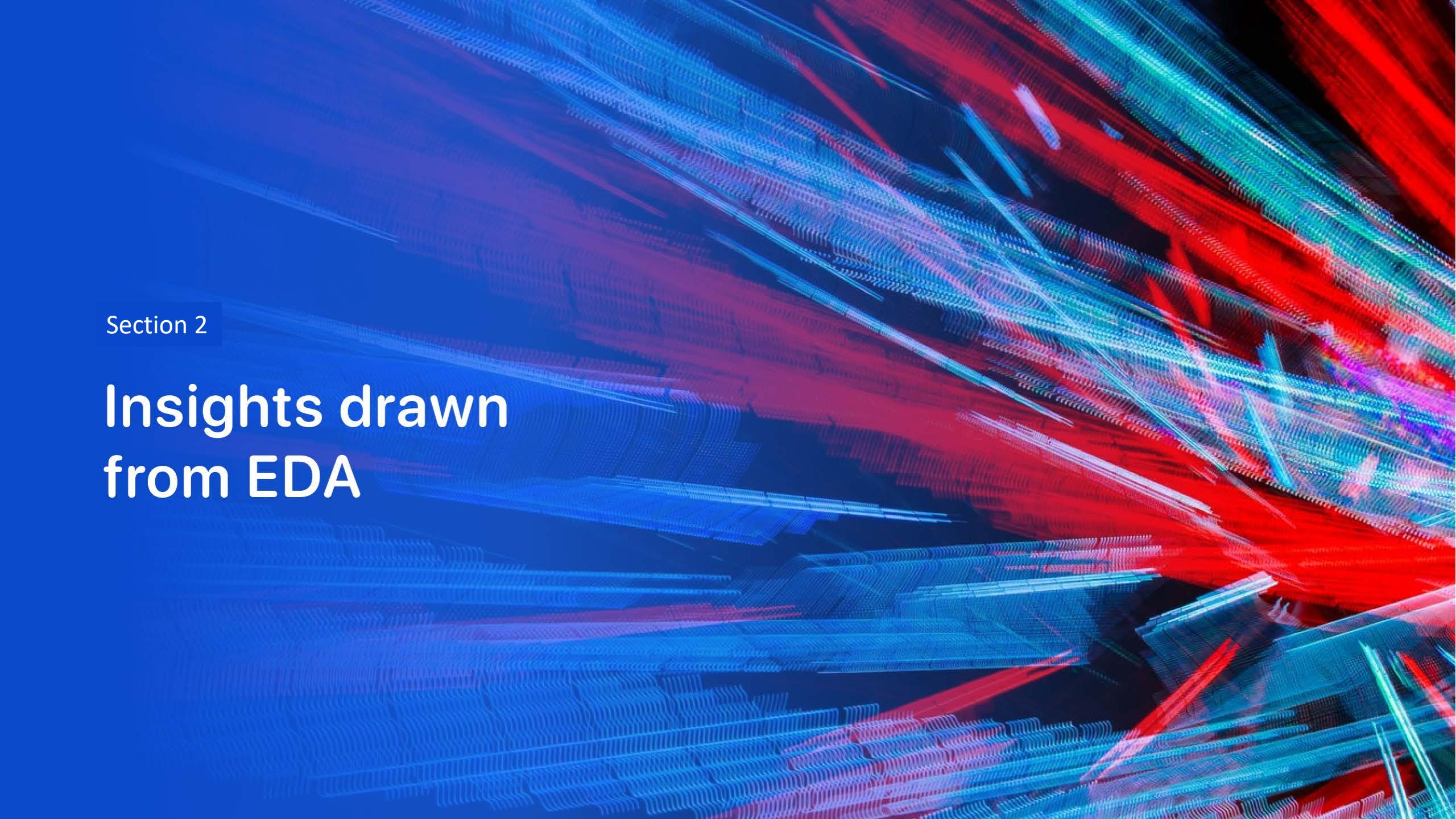
Using 3 method to calculate accuracy of model and finding the best algorithm to predict the model

- [GitHub link of Predictive Analysis](#)

Results

In the following slides, you can see the results of:

1. Visualizing the data with matplotlib and seaborn libraries
2. Creating queries with SQL
3. Displaying locations and markers on the map with Folium library
4. Creating a dashboard with dash library
5. Predicting data with machine learning algorithms

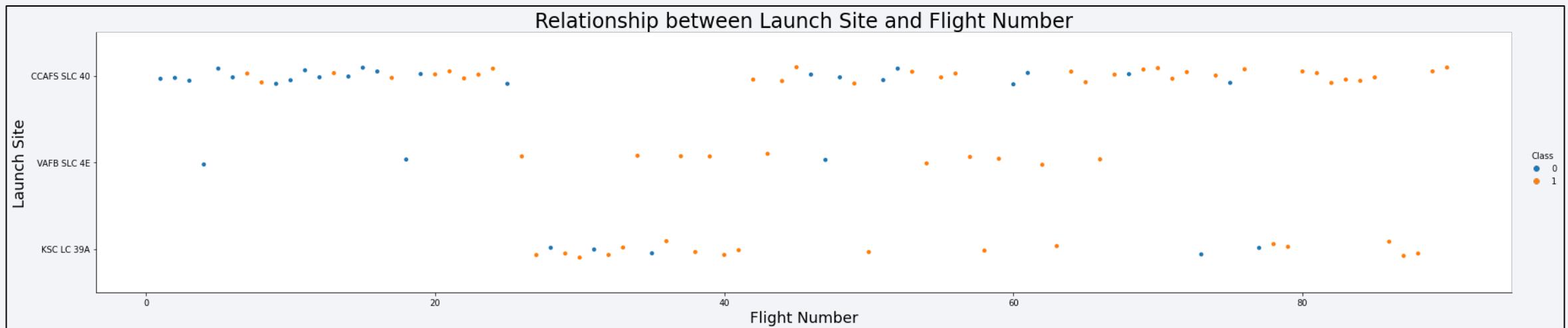
The background of the slide features a complex, abstract digital visualization. It consists of numerous thin, glowing lines that create a sense of depth and motion. The lines are primarily blue and red, with some green and white highlights. They form a grid-like structure that is more dense and vibrant towards the right side of the frame, while appearing more sparse and blue-tinted on the left. The overall effect is reminiscent of a high-energy particle simulation or a futuristic circuit board.

Section 2

Insights drawn from EDA

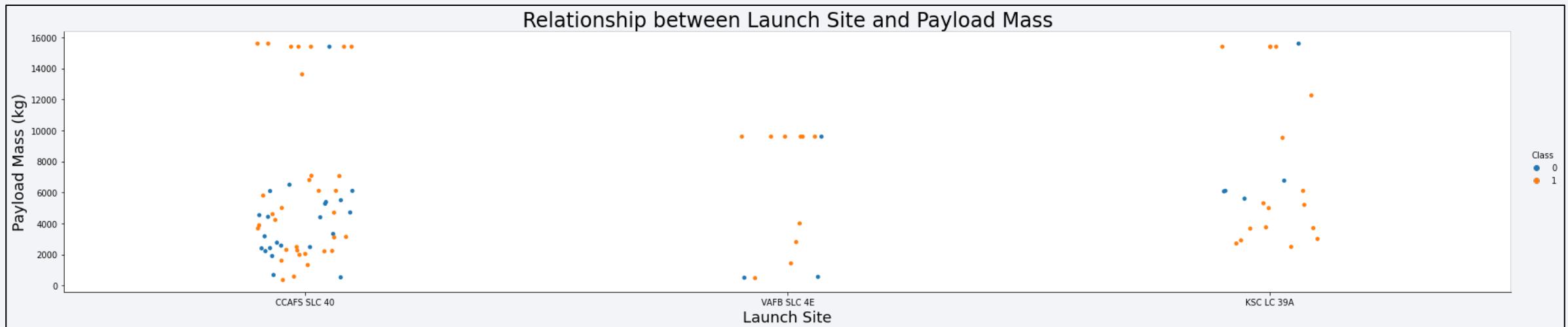
Flight Number vs. Launch Site

- As we move forward, the number of successful launches increases.
- Different launch sites have different success rates. CCAFS LC-40, has a success rate of 60 %, while KSC LC-39A and VAFB SLC 4E has a success rate of 77%.



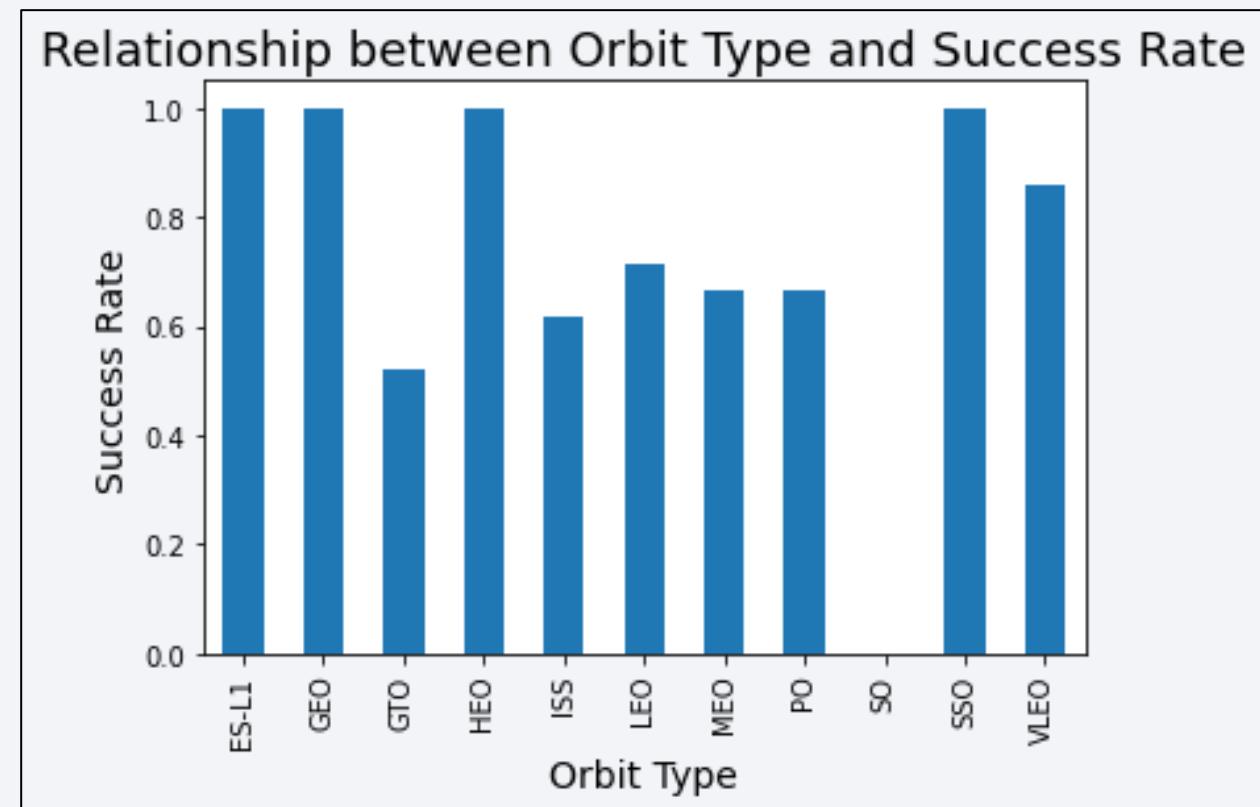
Payload vs. Launch Site

- Each site has different payload mass range.
- For the VAFB-SLC launch site there are no rockets launched for heavy payload mass (greater than 10000 kg).



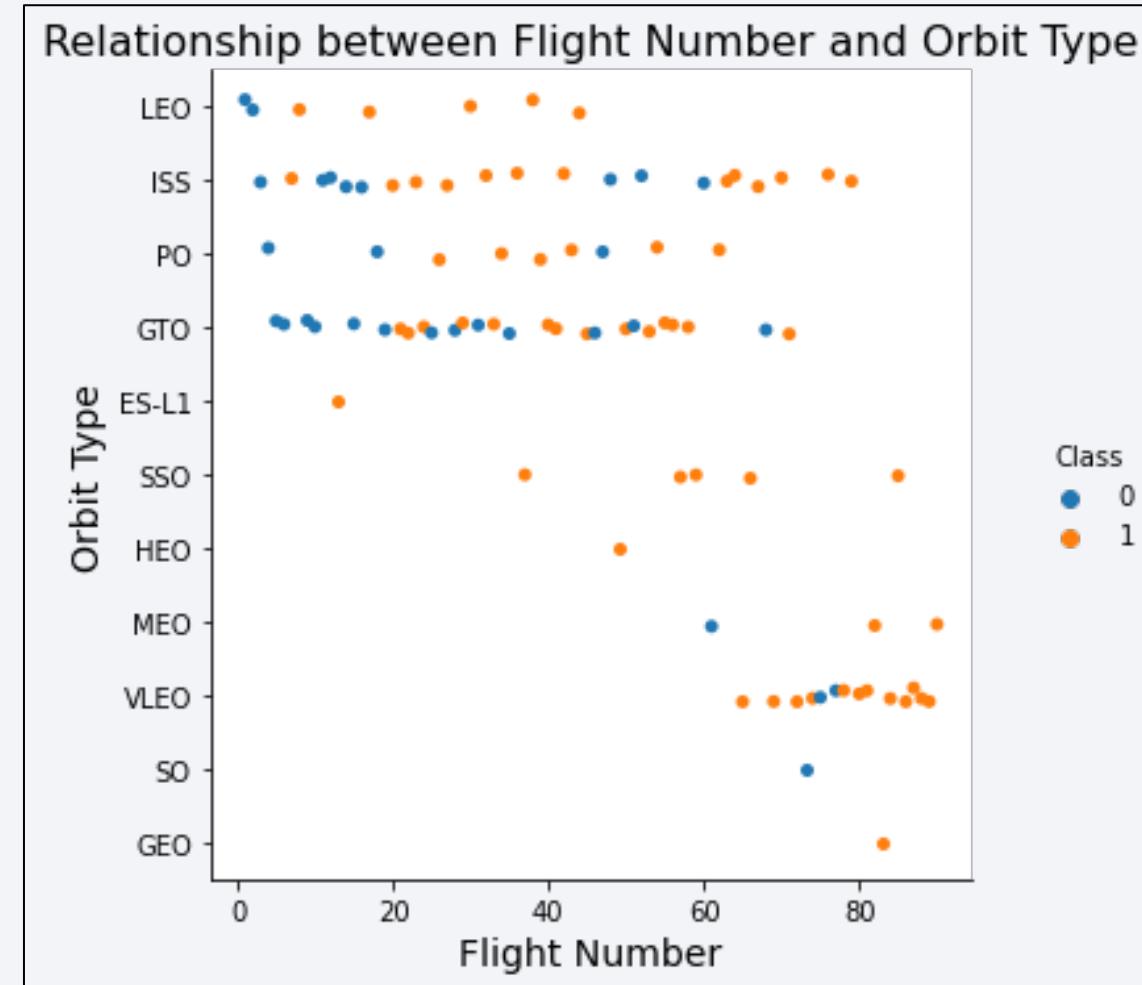
Success Rate vs. Orbit Type

- In ES-L1, GEO, HEO, and SSO orbit, there is not any failure.
- In SO orbit, the success rate is equal to zero, which means there is not any successful landing.

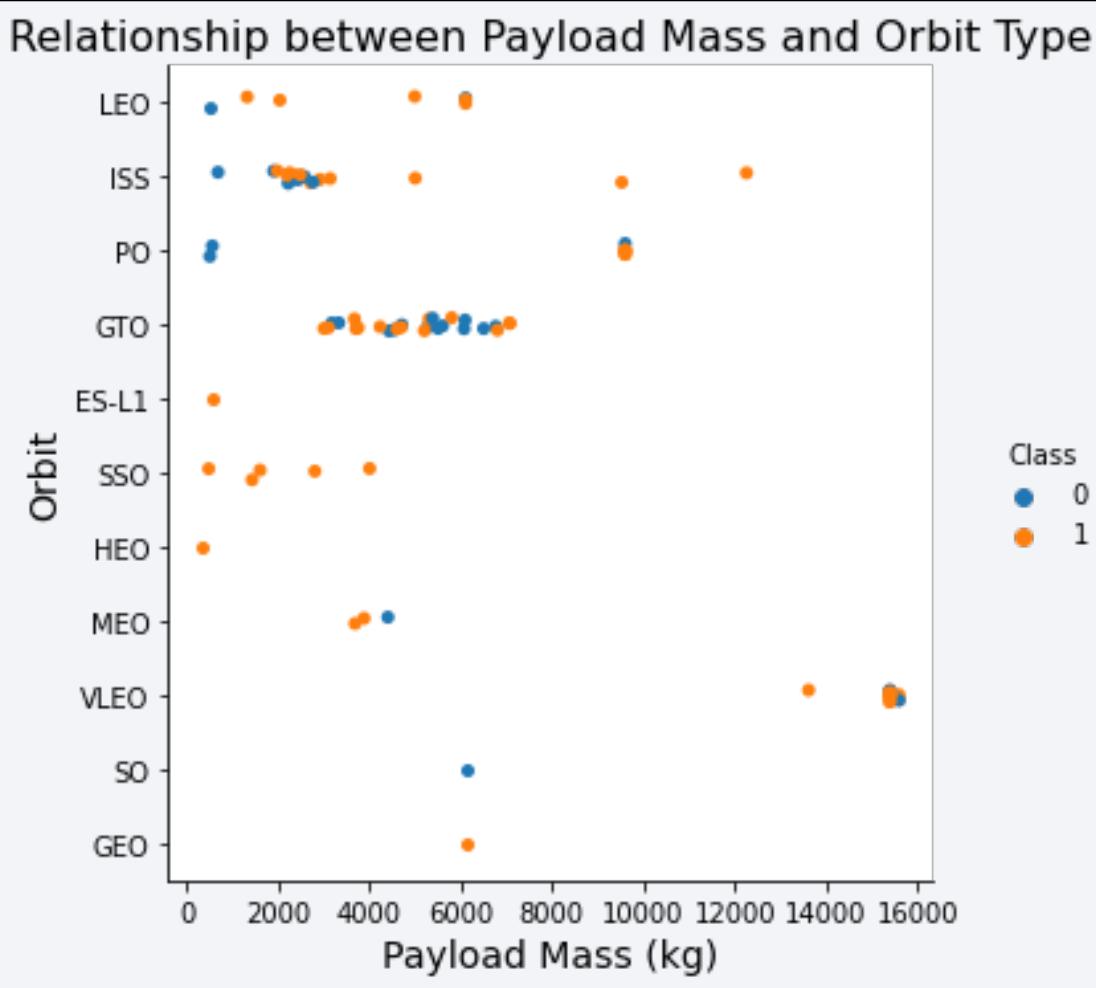


Flight Number vs. Orbit Type

- From flight number 62 onwards, the VLEO orbit began to be used and has been largely successful.
- In the LEO orbit the Success appears related to the number of flights.
- No relationship between flight number when in GTO orbit.



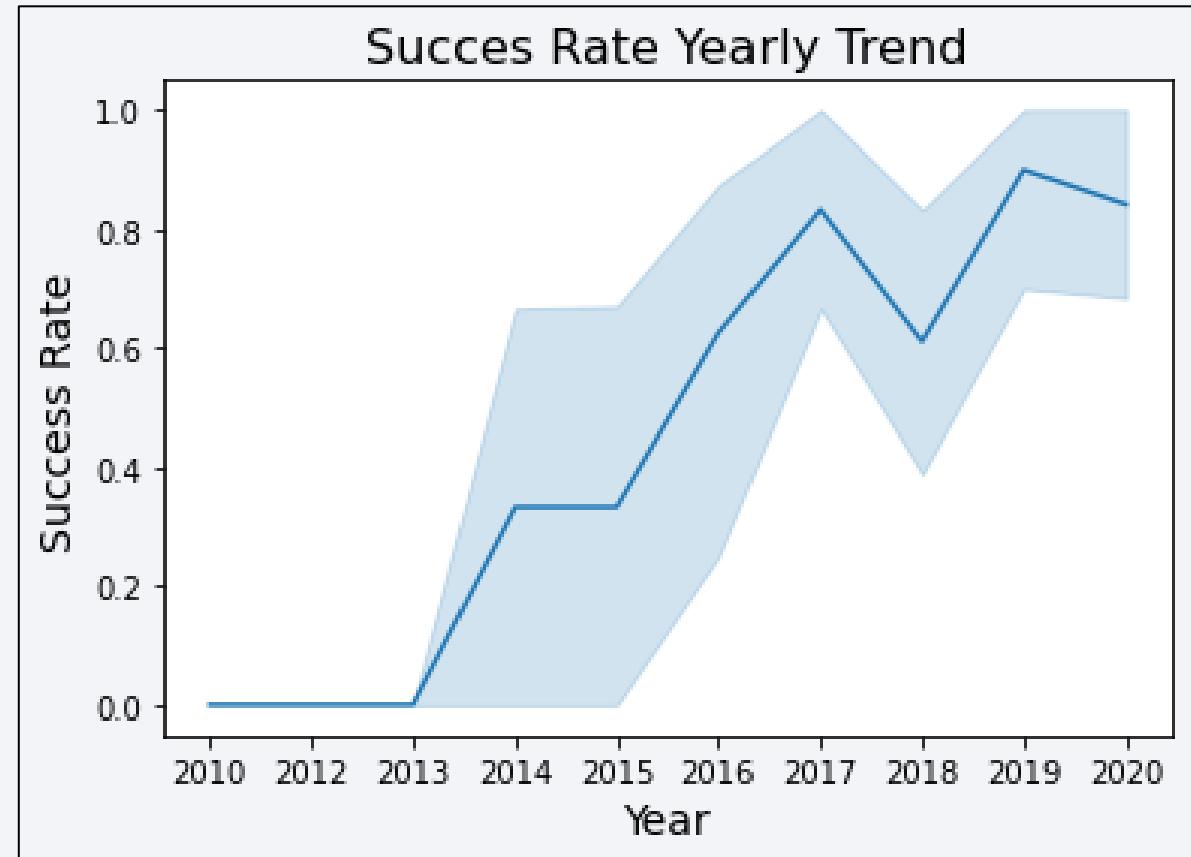
Payload vs. Orbit Type



- With heavy payloads, the successful landing or positive landing rate are more for Polar, LEO and ISS.
- It seems there is not any relationship between payload mass and success rate in GTO orbit.
- In the VLEO orbit, payload mass is very high (over than 13000 kg).

Launch Success Yearly Trend

- From 2010 to 2013, the success rate equal to zero.
- The success rate since 2013 kept increasing till 2020.
- In 2018, success rate decrease suddenly, in 2019 increase and compensated for the rate reduction.



All Launch Site Names

There are 4 Unique Launch Site:

1. CCAFS LC-40
2. VAFB SLC-4E
3. KSC LC-39A
4. CCAFS SLC-40

Launch Site
CCAFS LC-40
VAFB SLC-4E
KSC LC-39A
CCAFS SLC-40

Launch Site Names Begin with 'CCA'

- 5 Record of table that launch site names begin 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

Total Payload Mass

- Total payload mass is 45596 kg.

Total Payload Mass (kg)

45596

Average Payload Mass by F9 v1.1

- Average payload mass is 2928.4 kg.

Average Payload Mass (kg)

2928.4

First Successful Ground Landing Date

- First Successful ground landing date occurred in 22 December 2015.

First Successful Landing Date

2015-12-22

Successful Drone Ship Landing with Payload between 4000 and 6000

These boosters have successfully landed on drone ship and had payload mass greater than 4000 but less than 6000:

1. F9 FT B1022
2. F9 FT B1026
3. F9 FT B1021.2
4. F9 FT B1031.2

Booster Version	Payload Mass (kg)
F9 FT B1022	4696
F9 FT B1026	4600
F9 FT B1021.2	5300
F9 FT B1031.2	5200

Total Number of Successful and Failure Mission Outcomes

- Total number of successful mission outcomes: 100
- Total number of failure mission outcomes: 1

Mission Outcome	Number
Failure (in flight)	1
Success	98
Success	1
Success (payload status unclear)	1

Boosters Carried Maximum Payload

- Maximum payload is equal to 15600 kg.
- The names of the booster which have carried the maximum payload:

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

2015 Launch Records

- List of failed landing outcomes in drone ship, their booster versions, launch site names, and the month that landing occurred for in year 2015:

Month	Booster Version	Launch Site	Landing Outcome
10	F9 v1.1 B1012	CCAFS LC-40	Failure (drone ship)
04	F9 v1.1 B1015	CCAFS LC-40	Failure (drone ship)

Rank Landing Outcomes Between 2010-06-04 and 2017-03-20

- Rank of the count of landing outcomes between the date 2010-06-04 and 2017-03-20, in descending order:

Landing Outcome	Number
No attempt	21
Success (drone ship)	14
Success (ground pad)	9
Failure (drone ship)	5
Controlled (ocean)	5
Uncontrolled (ocean)	2
Precluded (drone ship)	1

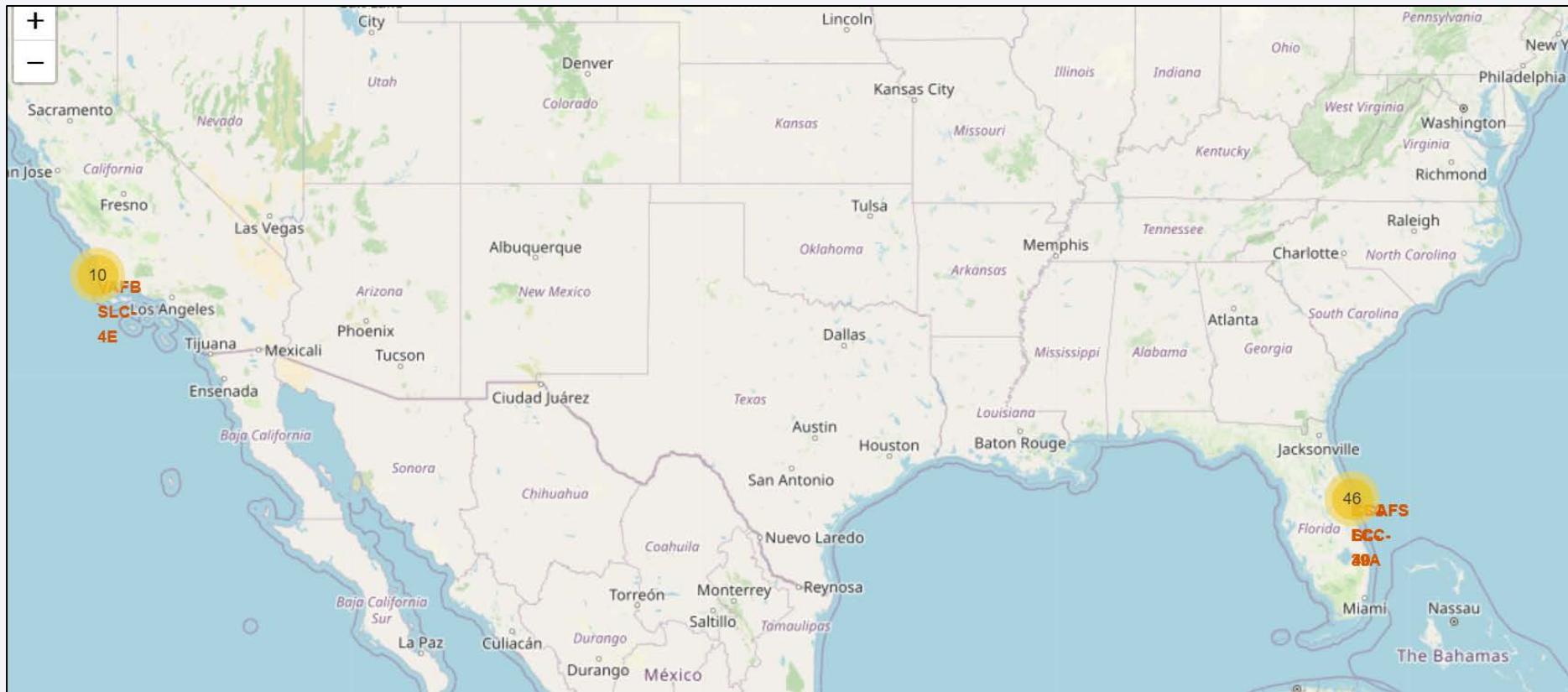
The background of the slide is a photograph taken from space at night. It shows the curvature of the Earth's horizon against a dark blue sky. Below, numerous city lights are visible as small white and yellow dots, with larger clusters indicating more populated areas. Some clouds are scattered across the lower half of the image.

Section 3

Launch Sites Proximities Analysis

Launch Sites' Location on Map

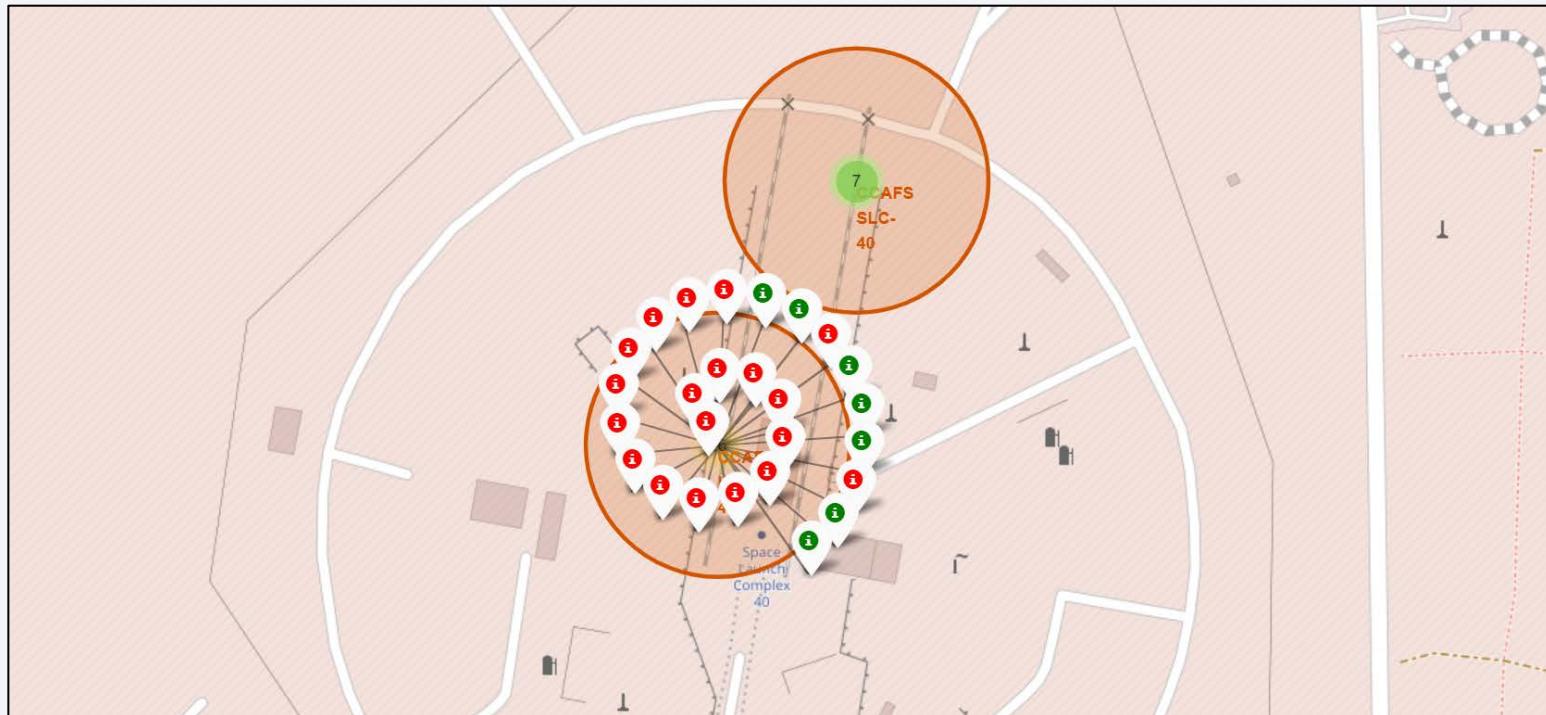
Generated folium map with all launch sites' location markers on a global map:



Color-Labeled Launch Outcomes

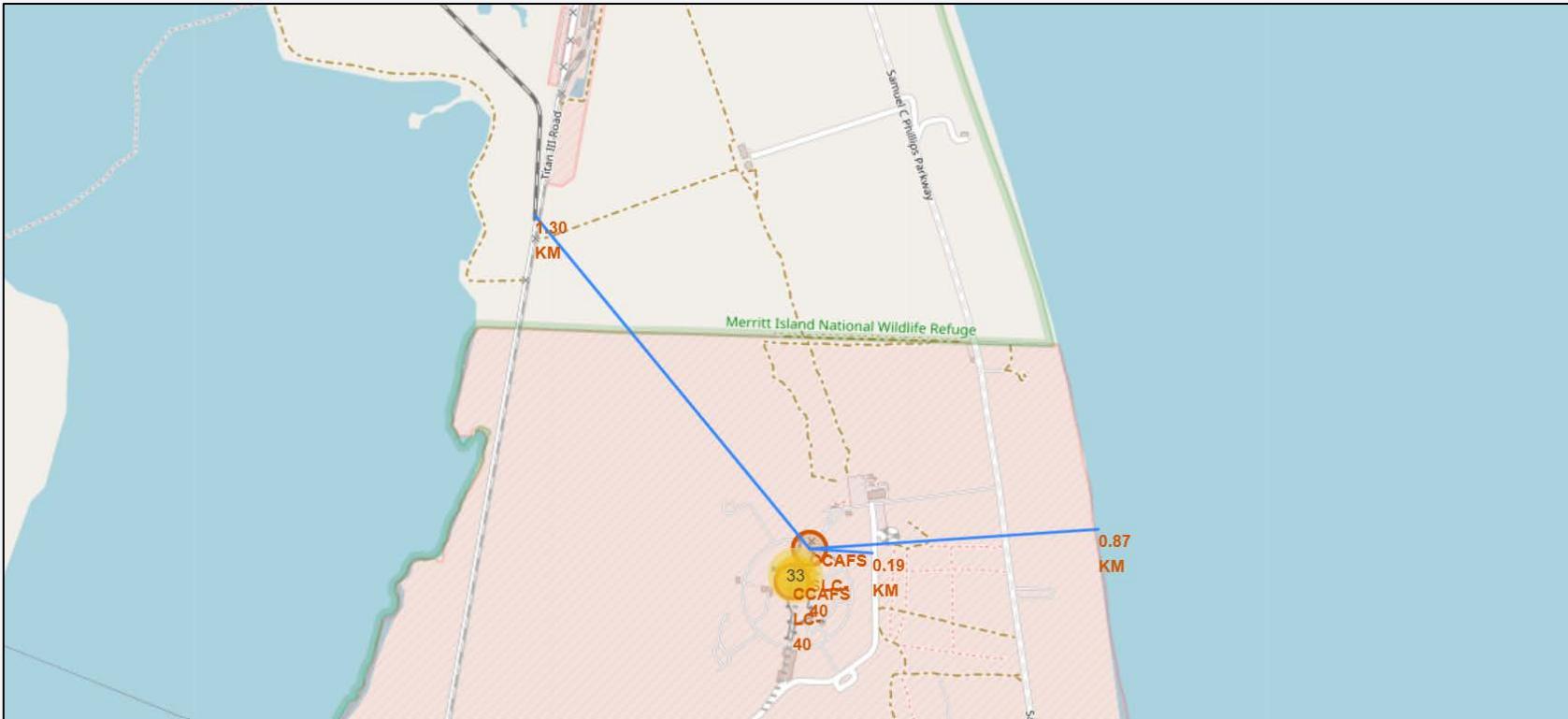
Folium map and the color-labeled launch outcomes on the map:

- The **Green** label means launch outcome is successful.
- The **red** label means failure launch outcome.



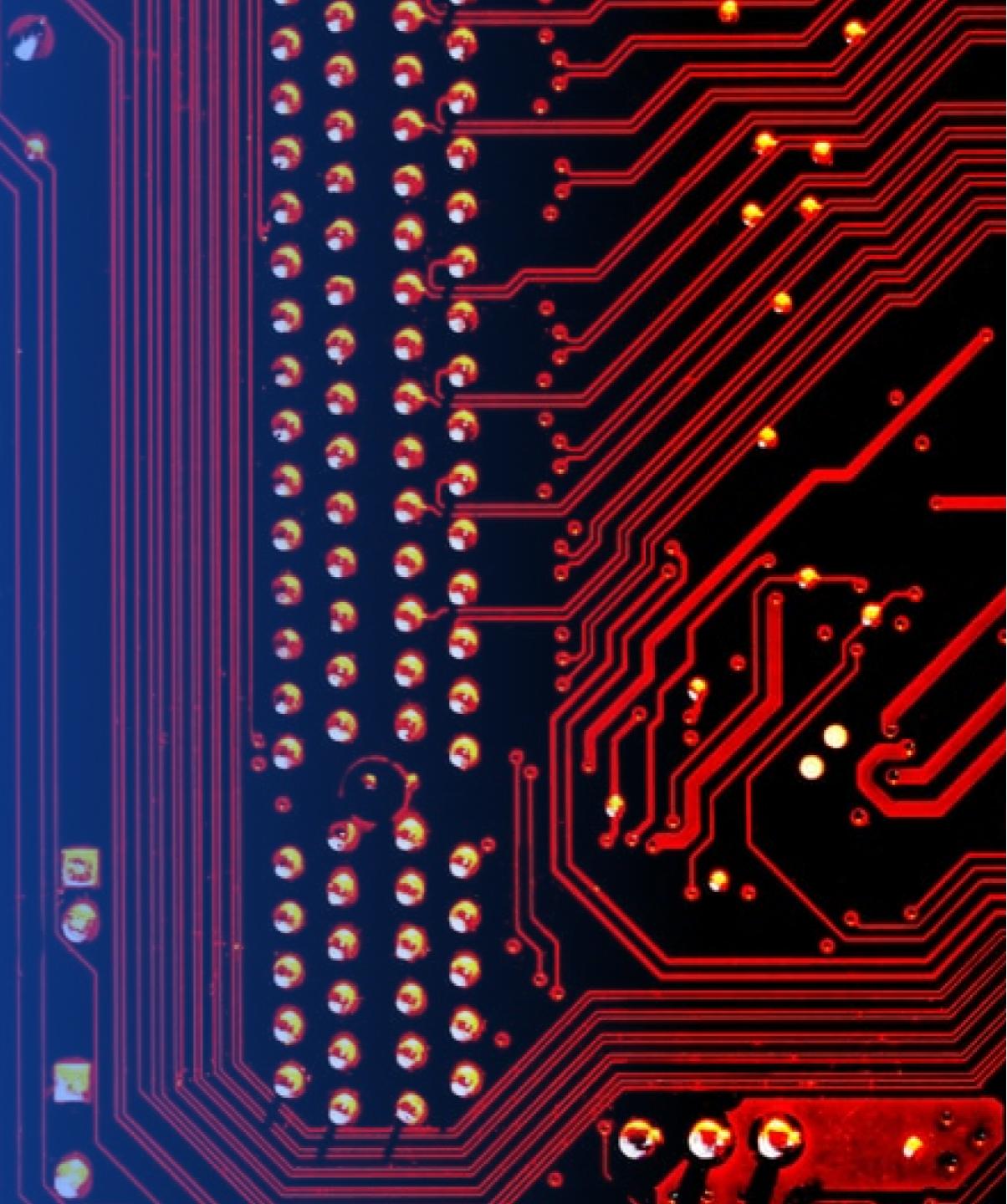
Launch Sites' Proximities Railway, Highway, Coastline

The selected launch site's (CCAFS SLC-40) proximity distance to railway, highway, and coastline is 1.3 km, 0.19 km, and 0.87 km.



Section 4

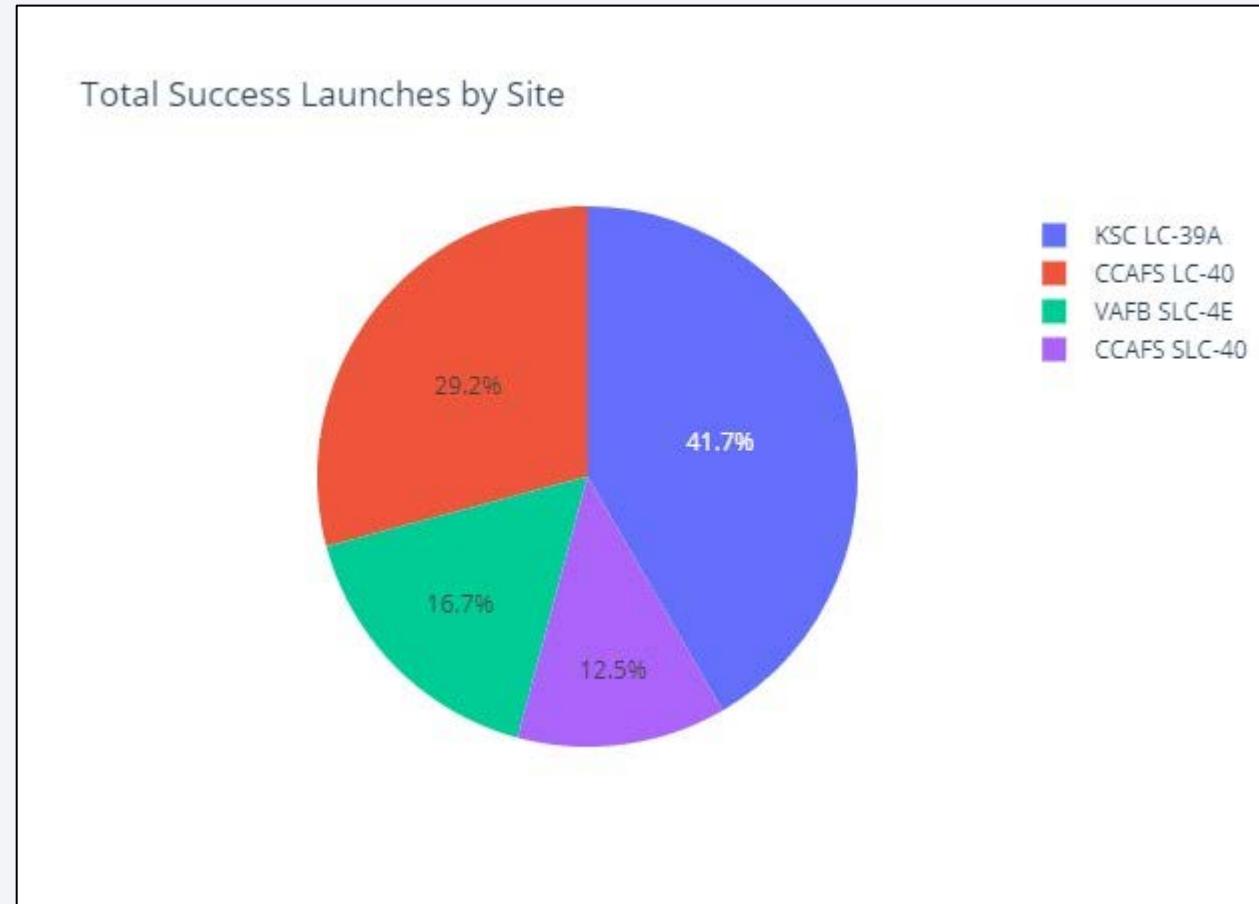
Build a Dashboard with Plotly Dash



Pie Chart of Launch Success for All Sites

The pie chart indicates the total success launches by site:

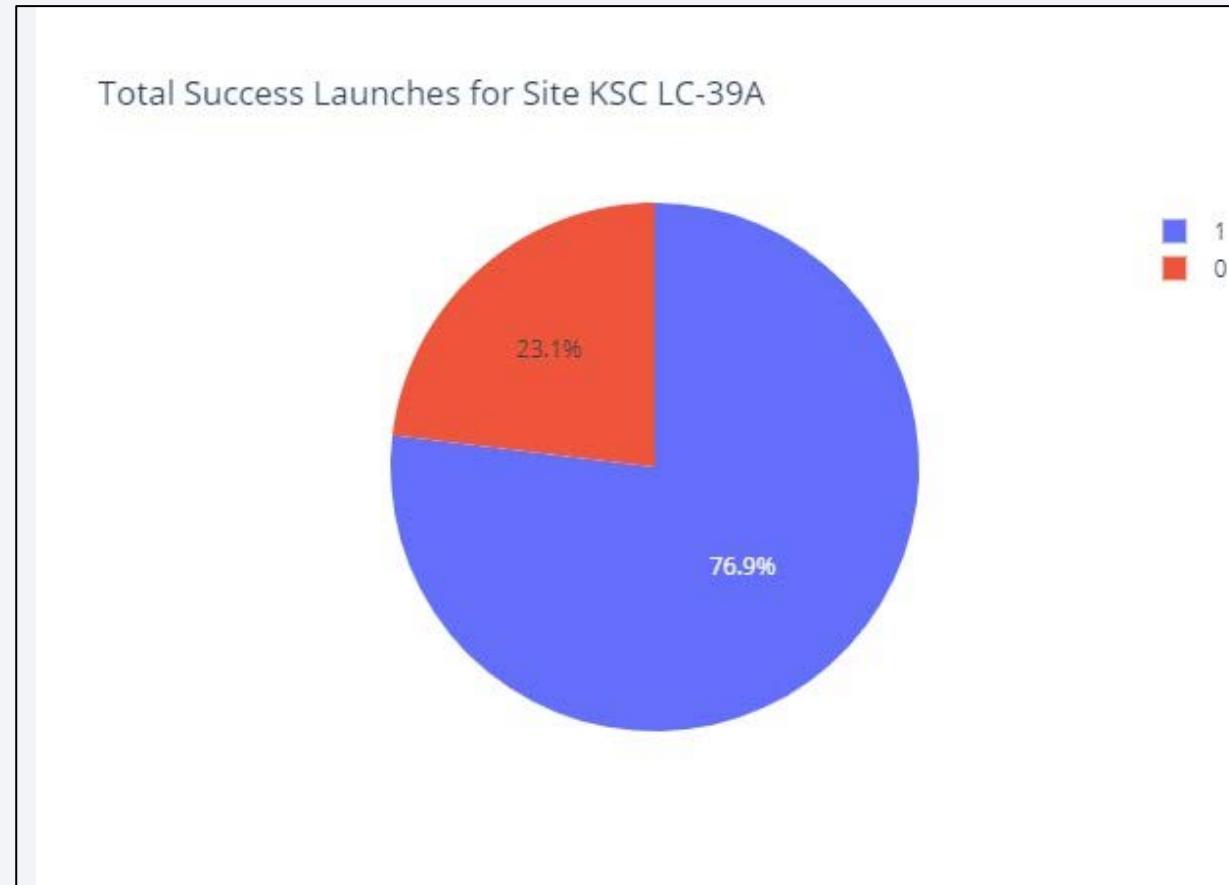
- KSC LC-39A: 41.7%
- CCAFS LC-40: 29.2%
- VAFB SLC-4E: 16.7%
- CCAFS SLC-40: 12.5%



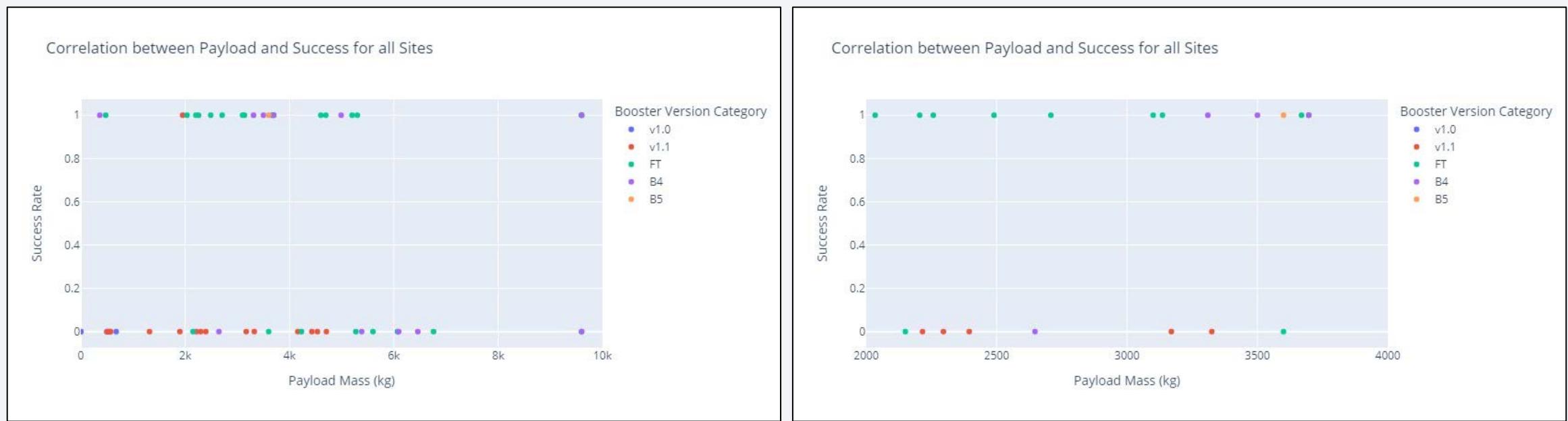
Pie Chart of Launch Success for Site KSC LC-39A

The pie chart indicates the total success launches for site KSC LC-39A:

- 76.9% Success
- 23.1% Failure



Scatter Plot of Payload vs Launch Outcome for All Site



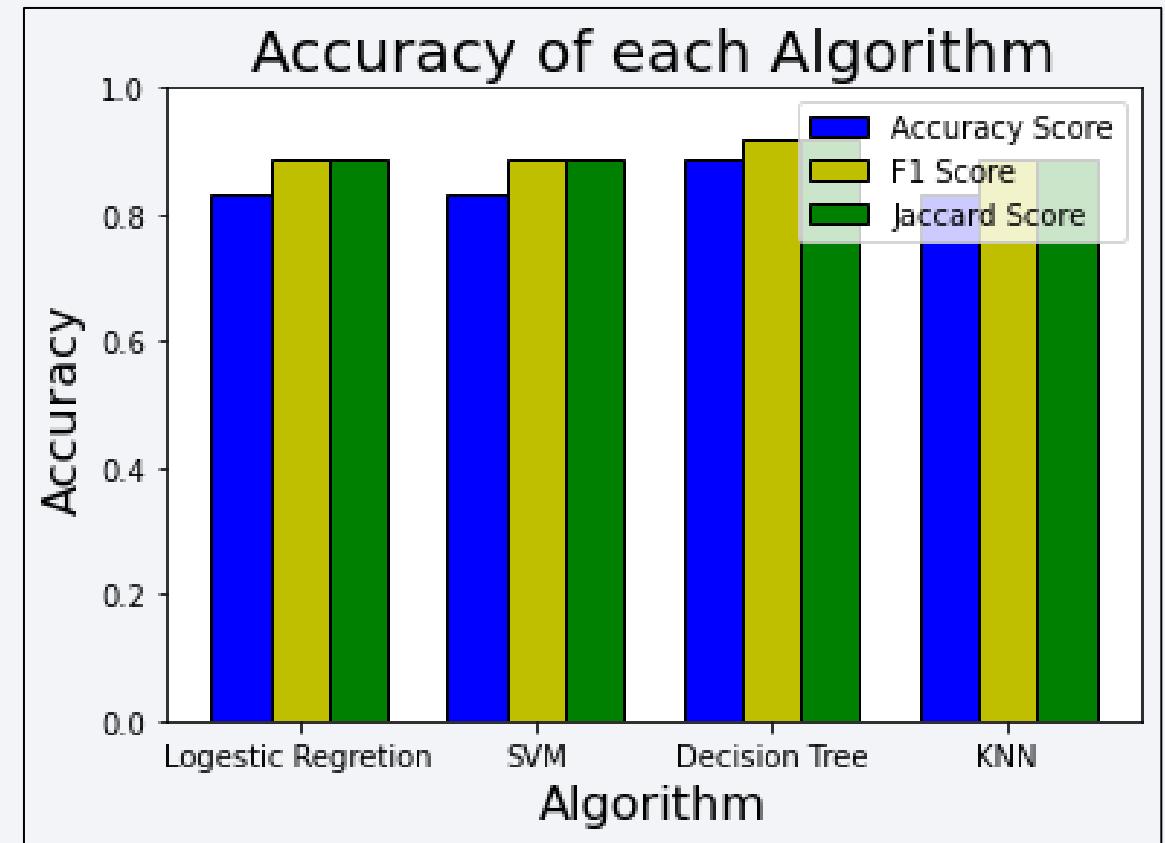
- Scatter plot of payload vs. Launch Outcome for all sites, with different range of payload.
- In payload range [2000, 4000], the greatest success rate occurred.
- Success rate of FT, B4, and B5 are greater than others.

Section 5

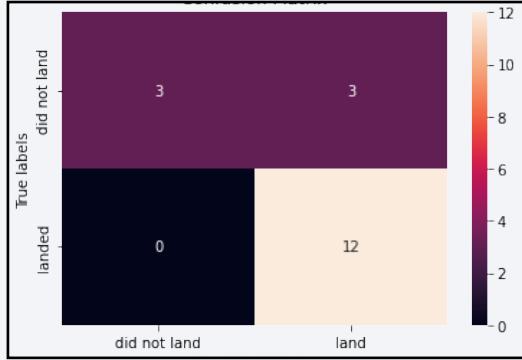
Predictive Analysis (Classification)

Classification Accuracy

- Using 3 method to obtain accuracy
- With any accuracy test, decision tree has the greatest classification accuracy:
 1. Accuracy Score: 88.9%
 2. F1 Score: 91.7%
 3. Jaccard Score: 84.6%



Confusion Matrix



Logistic Regression



SVM



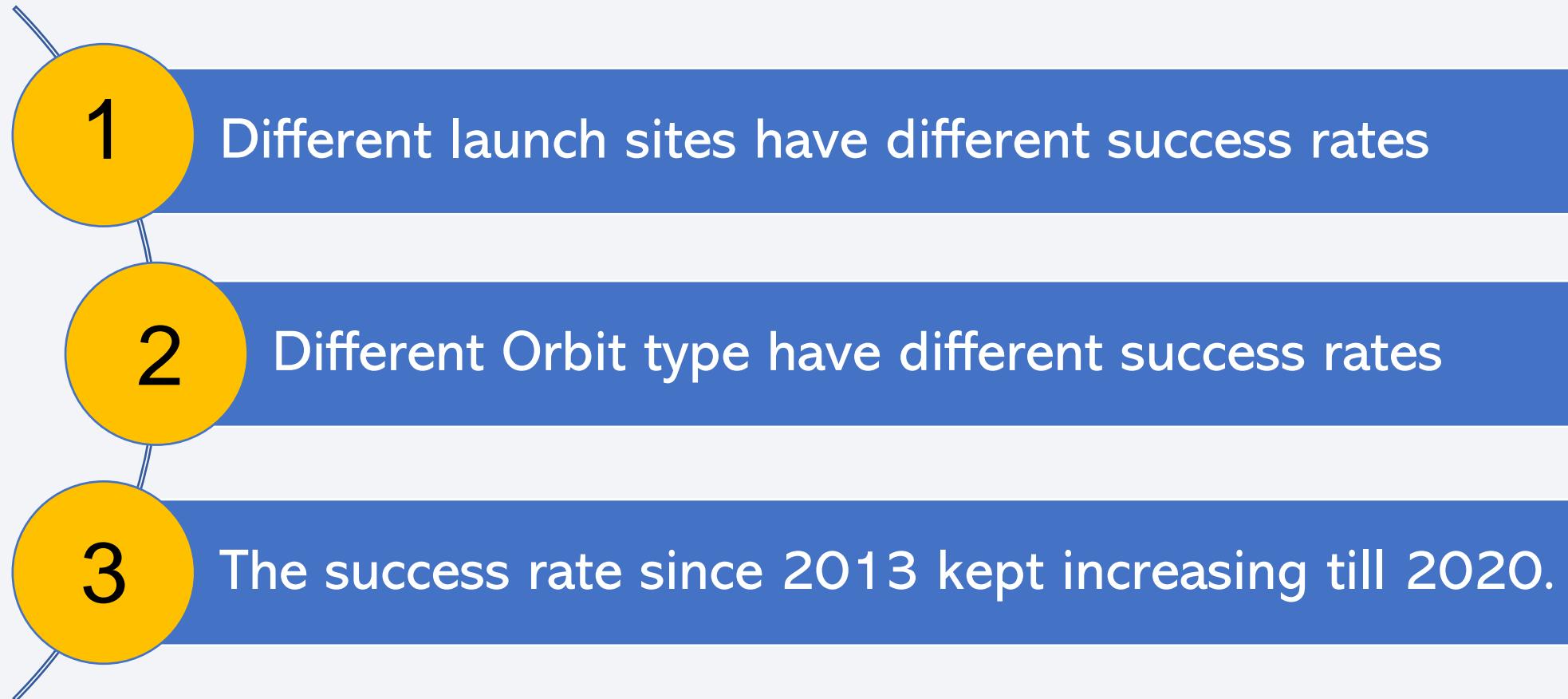
Decision Tree



KNN

- Confusion matrix parameters:
- True Positive
- False Positive
- True Negative
- False Negative

Conclusions

- 
- 1 Different launch sites have different success rates
 - 2 Different Orbit type have different success rates
 - 3 The success rate since 2013 kept increasing till 2020.

Thank you!

