

Moonlanding EDA and Feature Engineering

September 3, 2023

```
[1]: import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import warnings
warnings.filterwarnings('ignore')
%matplotlib inline
```

```
[2]: !pip install chardet
```

Requirement already satisfied: chardet in c:\anaconda\lib\site-packages (4.0.0)

```
[3]: import chardet
# Replace 'your_file.csv' with the actual file path
file_path = 'data\Moonlanding_raw_data.csv'

# Detect the encoding of the file
with open(file_path, 'rb') as f:
    result = chardet.detect(f.read())

detected_encoding = result['encoding']
confidence = result['confidence']

print(f"Detected Encoding: {detected_encoding} (Confidence: {confidence})")
result
```

Detected Encoding: Windows-1252 (Confidence: 0.73)

```
[3]: {'encoding': 'Windows-1252', 'confidence': 0.73, 'language': ''}
```

```
[4]: # To read the dataset from the database
df = pd.read_csv("data\Moonlanding_raw_data.csv", encoding= 'Windows-1252')
```

```
[5]: # To see the head of the dataset
df.head(5)
```

```
[5]:
```

	Mission	Spacecraft	Launch Date	Carrier Rocket	\
0	Pioneer 0 (Able I)	Pioneer 0	17-Aug-58	Thor DM-18	Able I
1	Luna E-1 No.1	Luna E-1 No.1	23-Sep-58		Luna

2	Pioneer 1 (Able II)	Pioneer 1	11-Oct-58	Thor DM-18 Able I
3	Luna E-1 No.2	Luna E-1 No.2	11-Oct-58	Luna
4	Pioneer 2 (Able III)	Pioneer 2	08-Nov-58	Thor DM-18 Able I

	Operator	Mission	Type	Outcome	\
0	United States	USAF	Orbiter	Launch failure	
1	Soviet Union	OKB-1	Impactor	Launch failure	
2	United States	NASA	Orbiter	Launch failure	
3	Soviet Union	OKB-1	Impactor	Launch failure	
4	United States	NASA	Orbiter	Launch failure	

Additional Information

0	First attempted launch beyond Earth orbit; fai...
1	Failed to orbit; rocket disintegrated due to e...
2	Failed to orbit; premature second-stage cutoff...
3	Failed to orbit; carrier rocket exploded due t...
4	Failed to orbit; premature second-stage cutoff...

```
[6]: #to see the last 5 data in the dataset
df.tail(5)
```

```
[6]:
```

	Mission	Spacecraft	Launch Date	\
153	Emirates Lunar Mission	Rashid	11-Dec-22	
154	Lunar Flashlight	Lunar Flashlight	11-Dec-22	
155	Jupiter Icy Moons Explorer	Jupiter Icy Moons Explorer	14-Apr-23	
156	Chandrayaan-3	Chandrayaan-3	14-Jul-23	
157	Luna 25	Luna 25	10-Aug-23	

	Carrier Rocket	Operator	Mission	Type	Outcome	\
153	Falcon 9 Block 5	UAE	UAESA/MBRSC	Rover	Spacecraft failure	
154	Falcon 9 Block 5	United States	NASA	Flyby	Spacecraft failure	
155	Ariane 5 ECA	European Union	ESA	Flyby	En route	
156	LVM3 M4	India	ISRO	Orbiter	Operational	
157	Soyuz-2.1b/Fregat	Russia	Roscosmos	Lander	Spacecraft failure	

Additional Information

153	Lunar rover demonstration launched with Hakuto...
154	Moved from Artemis 1 to Falcon 9. Thruster iss...
155	Will fly by the Moon in August 2024 en route t...
156	Lander and rover operational. Soft-landed near...
157	Launched, attempted orbital maneuver failed, c...

```
[7]: # To check random 5 samples in the dataset
df.sample(5)
```

```
[7]:
```

	Mission	Spacecraft	Launch Date	\
145	Near-Earth Asteroid Scout	Near-Earth Asteroid Scout	16-Nov-22	

137	Chang'e 5	Chang'e 5 Returner	23-Nov-20
32	Zond 3 (3MV-4 No.3)	Zond 3	18-Jul-65
4	Pioneer 2 (Able III)	Pioneer 2	08-Nov-58
146	EQUULEUS	EQUULEUS	16-Nov-22

	Carrier Rocket	Operator	Mission Type \
145	SLS Block 1	United States NASA	Flyby
137	Long March 5	China CNSA	Sample Return
32	Molniya	Soviet Union Lavochkin	Flyby
4	Thor DM-18 Able I	United States NASA	Orbiter
146	SLS Block 1	Japan JAXA	Flybys

	Outcome	Additional Information
145	Spacecraft failure	Solar sail for flyby of a near-Earth asteroid...
137	Successful	Returned lunar samples on 16 December 2020. Or...
32	Successful	Flew past the Moon on 20 July 1965 at a distan...
4	Launch failure	Failed to orbit; premature second-stage cutoff...
146	Operational	Intended to image Earth's plasmasphere, impact...

```
[8]: # To check the information in the dataset
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 158 entries, 0 to 157
Data columns (total 8 columns):
#   Column                Non-Null Count  Dtype
---  -
0   Mission                158 non-null   object
1   Spacecraft             158 non-null   object
2   Launch Date            158 non-null   object
3   Carrier Rocket         158 non-null   object
4   Operator               158 non-null   object
5   Mission Type           158 non-null   object
6   Outcome                158 non-null   object
7   Additional Information  157 non-null   object
dtypes: object(8)
memory usage: 10.0+ KB
```

Observation

1. There are total 8 features
2. Total rows/entries are 178.
3. Data types of all the features are Object
4. "Additional Information" has 1 null entry

```
[9]: #To check the null values
df.isna().sum()
```

```
[9]: Mission          0
      Spacecraft      0
      Launch Date     0
      Carrier Rocket   0
      Operator         0
      Mission Type     0
      Outcome          0
      Additional Information 1
      dtype: int64
```

```
[10]: df[df['Additional Information'].isna()]
```

```
[10]:      Mission Spacecraft Launch Date Carrier Rocket   Operator \
110  SELENE (Kaguya)      Okina   14-Sep-07   H-IIA 2022  Japan JAXA

      Mission Type      Outcome Additional Information
110      Orbiter  Successful                NaN
```

```
[11]: # Checking the Duplicate entries in the dataset
df.duplicated().sum()
```

```
[11]: 0
```

```
[12]: df.head(5)
```

```
[12]:      Mission      Spacecraft Launch Date      Carrier Rocket \
0  Pioneer 0 (Able I)    Pioneer 0   17-Aug-58  Thor DM-18 Able I
1      Luna E-1 No.1  Luna E-1 No.1   23-Sep-58            Luna
2  Pioneer 1 (Able II)    Pioneer 1   11-Oct-58  Thor DM-18 Able I
3      Luna E-1 No.2  Luna E-1 No.2   11-Oct-58            Luna
4  Pioneer 2 (Able III)    Pioneer 2   08-Nov-58  Thor DM-18 Able I

      Operator Mission Type      Outcome \
0  United States USAF      Orbiter  Launch failure
1  Soviet Union OKB-1      Impactor  Launch failure
2  United States NASA      Orbiter  Launch failure
3  Soviet Union OKB-1      Impactor  Launch failure
4  United States NASA      Orbiter  Launch failure

      Additional Information
0  First attempted launch beyond Earth orbit; fai...
1  Failed to orbit; rocket disintegrated due to e...
2  Failed to orbit; premature second-stage cutoff...
3  Failed to orbit; carrier rocket exploded due t...
4  Failed to orbit; premature second-stage cutoff...
```

```
[13]: df['Mission'].unique()
```

```
[13]: array(['Pioneer 0 (Able I)', 'Luna E-1 No.1', 'Pioneer 1 (Able II)',
'Luna E-1 No.2', 'Pioneer 2 (Able III)', 'Luna E-1 No.3',
'Pioneer 3', 'Luna 1 (E-1 No.4)', 'Pioneer 4', 'E-1A No.1',
'Luna 2 (E-1A No.2)', 'Luna 3 (E-2A No.1)',
'Pioneer P-3 (Able IVB)', 'Luna E-3 No.1', 'Luna E-3 No.2',
'Pioneer P-30 (Able VA)', 'Pioneer P-31 (Able VB)',
'Ranger 3 (P-34)', 'Ranger 4 (P-35)', 'Ranger 5 (P-36)',
'Luna E-6 No.2', 'Luna E-6 No.3', 'Luna 4 (E-6 No.4)',
'Luna E-6 No.6', 'Luna E-6 No.5', 'Ranger 7', 'Ranger 8',
'Kosmos 60 (E-6 No.9)', 'Ranger 9', 'Luna E-6 No.8',
'Luna 5 (E-6 No.10)', 'Luna 6 (E-6 No.7)', 'Zond 3 (3MV-4 No.3)',
'Luna 7 (E-6 No.11)', 'Luna 8 (E-6 No.12)', 'Luna 9 (E-6 No.13)',
'Kosmos 111 (E-6S No.204)', 'Luna 10 (E-6S No.206)', 'Surveyor 1',
'Explorer 33 (AIMP-D)', 'Lunar Orbiter 1',
'Luna 11 (E-6LF No.101)', 'Surveyor 2', 'Luna 12 (E-6LF No.102)',
'Lunar Orbiter 2', 'Luna 13 (E-6M No.205)', 'Lunar Orbiter 3',
'Surveyor 3', 'Lunar Orbiter 4', 'Surveyor 4',
'Explorer 35 (AIMP-E)', 'Lunar Orbiter 5', 'Surveyor 5',
'Soyuz 7K-L1 No.4L', 'Surveyor 6', 'Soyuz 7K-L1 No.5L',
'Surveyor 7', 'Luna E-6LS No.112', 'Luna 14 (E-6LS No.113)',
'Soyuz 7K-L1 No.7L', 'Zond 5 (7K-L1 No.9L)',
'Zond 6 (7K-L1 No.12L)', 'Apollo 8', 'Soyuz 7K-L1 No.13L',
'Luna E-8 No.201', 'Luna E-8-5 No.402', 'Luna 15', 'Apollo 11',
'Zond 7', 'Kosmos 300', 'Kosmos 305', 'Apollo 12',
'Luna E-8-5 No.405', 'Apollo 13', 'Luna 16', 'Zond 8', 'Luna 17',
'Apollo 14', 'Apollo 15', 'PFS-1', 'Luna 18', 'Luna 19', 'Luna 20',
'Apollo 16', 'PFS-2', 'Soyuz 7K-LOK No.1', 'Apollo 17', 'Luna 21',
'Explorer 49', 'Mariner 10', 'Luna 22', 'Luna 23',
'Luna E-8-5M No.412', 'Luna 24', 'ISEE-3', 'Hiten', 'Geotail',
'WIND', 'Clementine', 'HGS-1', 'Lunar Prospector', 'Nozomi',
'WMAP', 'SMART-1', 'STEREO A', 'STEREO B', 'ARTEMIS P1',
'ARTEMIS P2', 'SELENE (Kaguya)', "Chang'e 1", 'Chandrayaan-1',
'Lunar Reconnaissance Orbiter', 'LCROSS', "Chang'e 2", 'GRAIL',
'LADEE', "Chang'e 3", "Chang'e 5-T1",
'Manfred Memorial Moon Mission', 'TESS', 'Queqiao', 'Longjiang-1',
'Longjiang-2', "Chang'e 4", 'Beresheet', 'Chandrayaan-2',
'Chang'e 5', 'CAPSTONE', 'Danuri', 'Artemis 1', 'LunaH-Map',
'Lunar IceCube', 'ArgoMoon', 'LunIR', 'Near-Earth Asteroid Scout',
'EQUULEUS', 'OMOTENASHI', 'BioSentinel',
'CubeSat for Solar Particles', 'Team Miles', 'Hakuto-R Mission 1',
'SORA-Q', 'Emirates Lunar Mission', 'Lunar Flashlight',
'Jupiter Icy Moons Explorer', 'Chandrayaan-3', 'Luna 25'],
dtype=object)
```

```
[14]: df.Mission.value_counts()
```

```
[14]: Chang'e 5          4
      SELENE (Kaguya)    3
      Chang'e 5-T1      2
      Hiten              2
      Chang'e 4          2
      ..
      Surveyor 4         1
      Explorer 35 (AIMP-E) 1
      Lunar Orbiter 5    1
      Surveyor 5         1
      Luna 25            1
      Name: Mission, Length: 147, dtype: int64
```

Observation

1. There are 11 missions that were same or repeated.

```
[15]: df['Spacecraft'].unique()
```

```
[15]: array(['Pioneer 0', 'Luna E-1 No.1', 'Pioneer 1', 'Luna E-1 No.2',
        'Pioneer 2', 'Luna E-1 No.3', 'Pioneer 3', 'Luna 1', 'Pioneer 4',
        'E-1A No.1', 'Luna 2', 'Luna 3', 'Pioneer P-3', 'Luna E-3 No.1',
        'Luna E-3 No.2', 'Pioneer P-30', 'Pioneer P-31', 'Ranger 3',
        'Ranger 4', 'Ranger 5', 'Luna E-6 No.2', 'Luna E-6 No.3', 'Luna 4',
        'Luna E-6 No.6', 'Luna E-6 No.5', 'Ranger 7', 'Ranger 8',
        'Kosmos 60', 'Ranger 9', 'Luna E-6 No.8', 'Luna 5', 'Luna 6',
        'Zond 3', 'Luna 7', 'Luna 8', 'Luna 9', 'Kosmos 111', 'Luna 10',
        'Surveyor 1', 'Explorer 33', 'Lunar Orbiter 1', 'Luna 11',
        'Surveyor 2', 'Luna 12', 'Lunar Orbiter 2', 'Luna 13',
        'Lunar Orbiter 3', 'Surveyor 3', 'Lunar Orbiter 4', 'Surveyor 4',
        'Explorer 35', 'Lunar Orbiter 5', 'Surveyor 5',
        'Soyuz 7K-L1 No.4L', 'Surveyor 6', 'Soyuz 7K-L1 No.5L',
        'Surveyor 7', 'Luna E-6LS No.112', 'Luna 14', 'Soyuz 7K-L1 No.7L',
        'Zond 5', 'Zond 6', 'Apollo 8', 'Soyuz 7K-L1 No.13L',
        'Luna E-8 No.201', 'Luna E-8-5 No.402', 'Luna 15', 'Apollo 11',
        'Zond 7', 'Kosmos 300', 'Kosmos 305', 'Apollo 12',
        'Luna E-8-5 No.405', 'Apollo 13', 'Luna 16', 'Zond 8', 'Luna 17',
        'Apollo 14', 'Apollo 15', 'PFS-1', 'Luna 18', 'Luna 19', 'Luna 20',
        'Apollo 16', 'PFS-2', 'Soyuz 7K-LOK No.1', 'Apollo 17', 'Luna 21',
        'Explorer 49', 'Mariner 10', 'Luna 22', 'Luna 23',
        'Luna E-8-5M No.412', 'Luna 24', 'ISEE-3', 'Hiten', 'Hagoromo',
        'Geotail', 'WIND', 'Clementine', 'HGS-1', 'Lunar Prospector',
        'Nozomi', 'WMAP', 'SMART-1', 'STEREO A', 'STEREO B', 'ARTEMIS P1',
        'ARTEMIS P2', 'Kaguya', 'Okina', 'Ouna', 'Chang'e 1',
        'Chandrayaan-1', 'Moon Impact Probe',
        'Lunar Reconnaissance Orbiter', 'LCROSS', 'Chang'e 2', 'Ebb',
        'Flow', 'LADEE', 'Chang'e 3', 'Yutu', 'Chang'e 5-T1',
        'Return Capsule', 'Manfred Memorial Moon Mission', 'TESS',
```

```
'Queqiao relay satellite', 'Longjiang-1', 'Longjiang-2',
'Chang'e 4', 'Yutu-2', 'Beresheet', 'Chandrayaan-2 Orbiter',
'Chang'e 5 Orbiter', 'Chang'e 5 Lander', 'Chang'e 5 Ascender',
'Chang'e 5 Returner', 'CAPSTONE', 'Danuri',
'Artemis 1 Orion MPCV CM-002', 'LunaH-Map', 'Lunar IceCube',
'ArgoMoon', 'LunIR', 'Near-Earth Asteroid Scout', 'EQUULEUS',
'OMOTENASHI', 'BioSentinel', 'CubeSat for Solar Particles',
'Team Miles', 'Hakuto-R', 'SORA-Q', 'Rashid', 'Lunar Flashlight',
'Jupiter Icy Moons Explorer', 'Chandrayaan-3', 'Luna 25'],
dtype=object)
```

```
[16]: # To see the value counts of each entry.
df.Spacecraft.value_counts()
```

```
[16]: Pioneer 0          1
      ARTEMIS P2         1
      Lunar Prospector  1
      Nozomi             1
      WMAP               1
      ..
      Soyuz 7K-L1 No.4L  1
      Surveyor 6         1
      Soyuz 7K-L1 No.5L  1
      Surveyor 7         1
      Luna 25            1
      Name: Spacecraft, Length: 158, dtype: int64
```

Observations

1. None of the Spacecraft has been repeated.

```
[17]: df.head()
```

```
[17]:
```

	Mission	Spacecraft	Launch Date	Carrier Rocket	\
0	Pioneer 0 (Able I)	Pioneer 0	17-Aug-58	Thor DM-18 Able I	
1	Luna E-1 No.1	Luna E-1 No.1	23-Sep-58	Luna	
2	Pioneer 1 (Able II)	Pioneer 1	11-Oct-58	Thor DM-18 Able I	
3	Luna E-1 No.2	Luna E-1 No.2	11-Oct-58	Luna	
4	Pioneer 2 (Able III)	Pioneer 2	08-Nov-58	Thor DM-18 Able I	

	Operator	Mission Type	Outcome	\
0	United States USAF	Orbiter	Launch failure	
1	Soviet Union OKB-1	Impactor	Launch failure	
2	United States NASA	Orbiter	Launch failure	
3	Soviet Union OKB-1	Impactor	Launch failure	
4	United States NASA	Orbiter	Launch failure	

Additional Information

```

0 First attempted launch beyond Earth orbit; fai...
1 Failed to orbit; rocket disintegrated due to e...
2 Failed to orbit; premature second-stage cutoff...
3 Failed to orbit; carrier rocket exploded due t...
4 Failed to orbit; premature second-stage cutoff...

```

```
[18]: df['Mission Type'].unique()
```

```
[18]: array(['Orbiter', 'Impactor', 'Flyby', 'Lander', 'Crewed orbiter',
        'Orbiter,Lander,Rover', 'Lander,Sample Return', 'Rover',
        'Flyby / Impactor (post mission)', 'Relay Satellite',
        'Launch Vehicle', 'Sample Return', 'Flybys'], dtype=object)
```

```
[19]: # To see the value counts of each entry.
df['Mission Type'].value_counts()
```

```
[19]: Orbiter          59
      Lander          38
      Flyby          31
      Impactor        15
      Rover           4
      Orbiter,Lander,Rover  2
      Lander,Sample Return  2
      Flybys          2
      Crewed orbiter    1
      Flyby / Impactor (post mission)  1
      Relay Satellite    1
      Launch Vehicle    1
      Sample Return     1
      Name: Mission Type, dtype: int64
```

```
[20]: df[(df['Mission Type']== 'Flybys') | (df['Mission Type']== 'Flyby')]
```

```
[20]:
```

	Mission	Spacecraft	Launch Date \
6	Pioneer 3	Pioneer 3	06-Dec-58
8	Pioneer 4	Pioneer 4	03-Mar-59
11	Luna 3 (E-2A No.1)	Luna 3	04-Oct-59
13	Luna E-3 No.1	Luna E-3 No.1	15-Apr-60
14	Luna E-3 No.2	Luna E-3 No.2	16-Apr-60
32	Zond 3 (3MV-4 No.3)	Zond 3	18-Jul-65
53	Soyuz 7K-L1 No.4L	Soyuz 7K-L1 No.4L	27-Sep-67
55	Soyuz 7K-L1 No.5L	Soyuz 7K-L1 No.5L	22-Nov-67
59	Soyuz 7K-L1 No.7L	Soyuz 7K-L1 No.7L	22-Apr-68
60	Zond 5 (7K-L1 No.9L)	Zond 5	14-Sep-68
61	Zond 6 (7K-L1 No.12L)	Zond 6	10-Nov-68
63	Soyuz 7K-L1 No.13L	Soyuz 7K-L1 No.13L	20-Jan-69
68	Zond 7	Zond 7	07-Aug-69

75	Zond 8	Zond 8	20-Oct-70
89	Mariner 10	Mariner 10	03-Nov-73
94	ISEE-3	ISEE-3	12-Aug-78
97	Geotail	Geotail	24-Jul-92
98	WIND	WIND	01-Nov-94
100	HGS-1	HGS-1	24-Dec-97
102	Nozomi	Nozomi	03-Jul-98
103	WMAP	WMAP	30-Jun-01
105	STEREO A	STEREO A	25-Oct-06
106	STEREO B	STEREO B	25-Oct-06
126	TESS	TESS	18-Apr-18
143	ArgoMoon	ArgoMoon	16-Nov-22
144	LunIR	LunIR	16-Nov-22
145	Near-Earth Asteroid Scout	Near-Earth Asteroid Scout	16-Nov-22
146	EQUULEUS	EQUULEUS	16-Nov-22
148	BioSentinel	BioSentinel	16-Nov-22
149	CubeSat for Solar Particles	CubeSat for Solar Particles	16-Nov-22
150	Team Miles	Team Miles	16-Nov-22
154	Lunar Flashlight	Lunar Flashlight	11-Dec-22
155	Jupiter Icy Moons Explorer	Jupiter Icy Moons Explorer	14-Apr-23

	Carrier Rocket	Operator	Mission Type \
6	Juno II	United States NASA	Flyby
8	Juno II	United States NASA	Flyby
11	Luna	Soviet Union OKB-1	Flyby
13	Luna	Soviet Union OKB-1	Flyby
14	Luna	Soviet Union OKB-1	Flyby
32	Molniya	Soviet Union Lavochkin	Flyby
53	Proton-K/D	Soviet Union Lavochkin	Flyby
55	Proton-K/D	Soviet Union Lavochkin	Flyby
59	Proton-K/D	Soviet Union Lavochkin	Flyby
60	Proton-K/D	Soviet Union Lavochkin	Flyby
61	Proton-K/D	Soviet Union Lavochkin	Flyby
63	Proton-K/D	Soviet Union Lavochkin	Flyby
68	Proton-K/D	Soviet Union Lavochkin	Flyby
75	Proton-K/D	Soviet Union Lavochkin	Flyby
89	Atlas SLV-3D Centaur-D1A	United States NASA	Flyby
94	Delta 2914	United States NASA	Flyby
97	Delta II 6925	Japan United States ISAS/NASA	Flyby
98	Delta II 7925-10	United States NASA	Flyby
100	Proton-K/DM3	United States Hughes	Flyby
102	M-V	Japan ISAS	Flyby
103	Delta II 7425-10	United States NASA	Flyby
105	Delta II 7925-10L	United States NASA	Flyby
106	Delta II 7925-11L	United States NASA	Flyby
126	Falcon 9 Full Thrust	United States NASA	Flyby
143	SLS Block 1	Italy ASI	Flybys

144	SLS Block 1	United States Lockheed Martin	Flyby
145	SLS Block 1	United States NASA	Flyby
146	SLS Block 1	Japan JAXA	Flybys
148	SLS Block 1	United States NASA	Flyby
149	SLS Block 1	United States NASA	Flyby
150	SLS Block 1	United States Fluid & Reason	Flyby
154	Falcon 9 Block 5	United States NASA	Flyby
155	Ariane 5 ECA	European Union ESA	Flyby

	Outcome	Additional Information
6	Launch failure	Failed to orbit; premature first-stage cutoff...
8	Partial failure	Second-stage overperformance resulted in flyby...
11	Successful	Returned first images of the far side of the M...
13	Launch failure	Failed to orbit; premature third-stage cutoff...
14	Launch failure	Failed to orbit; rocket disintegrated ten seco...
32	Successful	Flew past the Moon on 20 July 1965 at a distan...
53	Spacecraft failure	Blocked propellant line caused first-stage eng...
55	Launch failure	Unable to achieve orbit after second-stage eng...
59	Launch failure	Second-stage engine incorrectly commanded to s...
60	Successful	Carried life forms, circled the Moon, and retu...
61	Spacecraft failure	Closest approach to Moon on 14 November. Reent...
63	Launch failure	Failed to orbit after second-stage engine shut...
68	Successful	Carried turtles in lunar flyby, closest approa...
75	Successful	Technology demonstration for planned crewed mi...
89	Successful	Interplanetary spacecraft, mapped lunar north ...
94	Successful	Flybys in 1982 and 1983 en route to comet 21P/...
97	Successful	Series of flybys to regulate high Earth orbit.
98	Successful	Made flybys to reach the Earth-Sun L1 Lagrangi...
100	Successful	Communications satellite, made flybys en route...
102	Successful	Made two flybys en route to Mars.
103	Successful	Flyby to reach the Earth-Sun L2 Lagrangian point.
105	Successful	One component of STEREO mission.
106	Successful	Second component of STEREO mission.
126	Successful	Flyby on 17 May 2018 to designated high Earth ...
143	Operational	Designed to image the Interim Cryogenic Propul...
144	Successful	Intended to flyby the Moon and collect surface...
145	Spacecraft failure	Solar sail for flyby of a near-Earth asteroid...
146	Operational	Intended to image Earth's plasmasphere, impact...
148	Successful	CubeSat on astrobiology mission to study impac...
149	Spacecraft failure	Intended to orbit the Sun to study particles a...
150	Successful	CubeSat to demonstrate navigation in deep spac...
154	Spacecraft failure	Moved from Artemis 1 to Falcon 9. Thruster iss...
155	En route	Will fly by the Moon in August 2024 en route t...

```
[21]: # Lets replace 'Flybys' to 'Flyby'
df['Mission Type'].replace('Flybys', 'Flyby', inplace= True)
```

```
[22]: df[df['Mission Type']=='Orbiter,Lander,Rover']
```

```
[22]:      Mission Spacecraft Launch Date Carrier Rocket      Operator \
83  Apollo 16  Apollo 16   16-Apr-72      Saturn V  United States NASA
86  Apollo 17  Apollo 17   07-Dec-72      Saturn V  United States NASA

      Mission Type      Outcome \
83  Orbiter,Lander,Rover  Successful
86  Orbiter,Lander,Rover  Successful

      Additional Information
83  Fifth crewed lunar landing. Lunar Module and R...
86  Sixth and last crewed lunar landing. Lunar Mod...
```

```
[23]: df[df['Mission Type']=='Lander,Sample Return']
```

```
[23]:      Mission      Spacecraft Launch Date Carrier Rocket \
92  Luna E-8-5M No.412  Luna E-8-5M No.412   16-Oct-75   Proton-K/D
93      Luna 24      Luna 24   09-Aug-76   Proton-K/D

      Operator      Mission Type      Outcome \
92  Soviet Union Lavochkin  Lander,Sample Return  Launch failure
93  Soviet Union Lavochkin  Lander,Sample Return    Successful

      Additional Information
92      Failed to orbit.
93  Landed in Mare Crisium, returned lunar samples...
```

Observation

1. Luna 24 Mission was launched by Russia and it was Successful mission where the astronauts returned successfully with sa Moon/Lunar samples.

```
[24]: df[df['Mission Type']=='Sample Return']
```

```
[24]:      Mission      Spacecraft Launch Date Carrier Rocket      Operator \
137  Chang'e 5  Chang'e 5 Returner   23-Nov-20   Long March 5  China CNSA

      Mission Type      Outcome \
137  Sample Return  Successful

      Additional Information
137  Returned lunar samples on 16 December 2020. Or...
```

Observation

1. Chang'e 5 Mission was launched by China and it was Successful mission where Chang'e 5 returned successfully with sa Moon/Lunar samples.

```
[25]: df[df['Mission Type'] == 'Launch Vehicle']
```

```
[25]:      Mission      Spacecraft Launch Date Carrier Rocket  Operator \
136  Chang'e 5  Chang'e 5 Ascender   23-Nov-20   Long March 5  China CNSA

      Mission Type      Outcome \
136  Launch Vehicle  Successful

      Additional Information
136  Returned lunar samples on 16 December 2020. Or...
```

We have to drop the above row as it is found duplicate with the row no. 137.

```
[26]: # Dropping the row no. 136
df.drop(136, axis=0, inplace= True)
```

```
[27]: df['Mission Type'].value_counts()
```

```
[27]: Orbiter          59
Lander              38
Flyby              33
Impactor           15
Rover              4
Orbiter,Lander,Rover    2
Lander,Sample Return    2
Crewed orbiter         1
Flyby / Impactor (post mission)  1
Relay Satellite        1
Sample Return          1
Name: Mission Type, dtype: int64
```

```
[28]: df[df['Mission Type'] == 'Flyby / Impactor (post mission)']
```

```
[28]:      Mission      Spacecraft Launch Date \
125  Manfred Memorial Moon Mission  Manfred Memorial Moon Mission   23-Oct-14

      Carrier Rocket      Operator      Mission Type \
125  Long March 3C  Luxembourg LuxSpace  Flyby / Impactor (post mission)

      Outcome      Additional Information
125  Successful  Attached to third stage of CZ-3C used to launc...
```

```
[29]: df[df['Mission Type'] == 'Crewed orbiter']
```

```
[29]:      Mission Spacecraft Launch Date Carrier Rocket      Operator \
62  Apollo 8   Apollo 8   21-Dec-68      Saturn V  United States NASA

      Mission Type      Outcome \
```

62 Crewed orbiter Successful

Additional Information

62 First crewed mission to the Moon. Entered orbi...

```
[30]: df[(df['Mission Type'] == 'Orbiter') & (df['Outcome'] != 'Successful')]
```

```
[30]:
```

	Mission	Spacecraft	Launch Date \
0	Pioneer 0 (Able I)	Pioneer 0	17-Aug-58
2	Pioneer 1 (Able II)	Pioneer 1	11-Oct-58
4	Pioneer 2 (Able III)	Pioneer 2	08-Nov-58
12	Pioneer P-3 (Able IVB)	Pioneer P-3	26-Nov-59
15	Pioneer P-30 (Able VA)	Pioneer P-30	25-Sep-60
16	Pioneer P-31 (Able VB)	Pioneer P-31	15-Dec-60
36	Kosmos 111 (E-6S No.204)	Kosmos 111	01-Mar-66
39	Explorer 33 (AIMP-D)	Explorer 33	01-Jul-66
40	Lunar Orbiter 1	Lunar Orbiter 1	10-Aug-66
41	Luna 11 (E-6LF No.101)	Luna 11	21-Aug-66
57	Luna E-6LS No.112	Luna E-6LS No.112	07-Feb-68
73	Apollo 13	Apollo 13	11-Apr-70
85	Soyuz 7K-LOK No.1	Soyuz 7K-LOK No.1	03-Jul-72
96	Hiten	Hagoromo	24-Jan-90
107	ARTEMIS P1	ARTEMIS P1	17-Feb-07
108	ARTEMIS P2	ARTEMIS P2	17-Feb-07
115	Lunar Reconnaissance Orbiter	Lunar Reconnaissance Orbiter	18-Jun-09
128	Longjiang-1	Longjiang-1	21-May-18
133	Chandrayaan-2	Chandrayaan-2 Orbiter	22-Jul-19
134	Chang'e 5	Chang'e 5 Orbiter	23-Nov-20
138	CAPSTONE	CAPSTONE	28-Jun-22
139	Danuri	Danuri	04-Aug-22
141	LunaH-Map	LunaH-Map	16-Nov-22
142	Lunar IceCube	Lunar IceCube	16-Nov-22
156	Chandrayaan-3	Chandrayaan-3	14-Jul-23

	Carrier Rocket	Operator	Mission Type \
0	Thor DM-18 Able I	United States USAF	Orbiter
2	Thor DM-18 Able I	United States NASA	Orbiter
4	Thor DM-18 Able I	United States NASA	Orbiter
12	Atlas-D Able	United States NASA	Orbiter
15	Atlas-D Able	United States NASA	Orbiter
16	Atlas-D Able	United States NASA	Orbiter
36	Molniya-M	Soviet Union Lavochkin	Orbiter
39	Delta E1	United States NASA	Orbiter
40	Atlas SLV-3 Agena-D	United States NASA	Orbiter
41	Molniya-M	Soviet Union Lavochkin	Orbiter
57	Molniya-M	Soviet Union Lavochkin	Orbiter
73	Saturn V	United States NASA	Orbiter

85	N1	Soviet Union OKB-1	Orbiter
96	Mu-4S-II	Japan ISAS	Orbiter
107	Delta II 7925	United States NASA	Orbiter
108	Delta II 7925	United States NASA	Orbiter
115	Atlas V 401	United States NASA	Orbiter
128	Long March 4C	China CNSA	Orbiter
133	LVM3 M1	India ISRO	Orbiter
134	Long March 5	China CNSA	Orbiter
138	Electron	United States NASA	Orbiter
139	Falcon 9	South Korea KARI	Orbiter
141	SLS Block 1	United States NASA	Orbiter
142	SLS Block 1	United States NASA	Orbiter
156	LVM3 M4	India ISRO	Orbiter

	Outcome	Additional Information
0	Launch failure	First attempted launch beyond Earth orbit; fai...
2	Launch failure	Failed to orbit; premature second-stage cutoff...
4	Launch failure	Failed to orbit; premature second-stage cutoff...
12	Launch failure	Failed to orbit; payload fairing disintegrated...
15	Launch failure	Failed to orbit; second-stage oxidizer system ...
16	Launch failure	Failed to orbit, exploded 68 seconds after lau...
36	Launch failure	Upper stage lost attitude control and failed t...
39	Launch failure	Rocket imparted greater velocity than planned,...
40	Partial failure	Orbital insertion at around 15:36 UTC on 14 Au...
41	Partial failure	Entered orbit on 28 August 1966. Failed to ret...
57	Launch failure	Failed to orbit after third stage ran out of f...
73	Spacecraft failure	Lunar landing aborted due to Service Module ex...
85	Launch failure	Failed to orbit; intended to orbit the Moon an...
96	Spacecraft failure	Carried by Hiten, intended for flyby, deorbite...
107	Operational	Two THEMIS spacecraft moved to selenocentric o...
108	Operational	Two THEMIS spacecraft moved to selenocentric o...
115	Operational	Entered orbit on June 23, 2009.
128	Spacecraft failure	Did not enter Moon orbit.
133	Operational	Orbiter operational, but Lander and Rover were...
134	Operational	Returned lunar samples on 16 December 2020. Or...
138	Operational	Lunar orbiting CubeSat to test orbital stabili...
139	Operational	Lunar Orbiter by South Korea's KARI. Will surv...
141	Partial failure	Intended to search for lunar water ice. Spacec...
142	Spacecraft failure	Intended to detect water and organic compounds...
156	Operational	Lander and rover operational. Soft-landed near...

```
[31]: df['Operator'].unique()
```

```
[31]: array(['United States USAF', 'Soviet Union OKB-1', 'United States NASA',
        'Soviet Union Lavochkin', 'Japan ISAS',
        'Japan United States ISAS/NASA', 'United States USAF/NASA',
        'United States Hughes', 'European Union ESA', 'Japan JAXA',
```

```
'China CNSA', 'India ISRO', 'Luxembourg LuxSpace',
'Israel SpaceIL', 'South Korea KARI', 'Italy ASI',
'United States Lockheed Martin', 'United States Fluid & Reason',
'Japan ispace', 'Japan Tomy/JAXA/Dodai', 'UAE UAESA/MBRSC',
'Russia Roscosmos'], dtype=object)
```

```
[32]: df['Country'] = df['Operator'].str.split().str[0]
```

```
[33]: df['Country'].unique()
```

```
[33]: array(['United', 'Soviet', 'Japan', 'European', 'China', 'India',
'Luxembourg', 'Israel', 'South', 'Italy', 'UAE', 'Russia'],
dtype=object)
```

```
[34]: # We are replacing the country with the corect abbr.
df['Country'].replace({'United': 'USA', 'Soviet': 'Russia', 'South': 'South_
↳Korea', 'Russia': 'Russia' }, inplace = True)
```

```
[35]: df['Country'].unique()
```

```
[35]: array(['USA', 'Russia', 'Japan', 'European', 'China', 'India',
'Luxembourg', 'Israel', 'South Korea', 'Italy', 'UAE'],
dtype=object)
```

```
[36]: df.drop('Operator', axis=1, inplace = True)
```

```
[37]: df['Carrier Rocket'].unique()
```

```
[37]: array(['Thor DM-18 Able I', 'Luna', 'Juno II', 'Atlas-D Able',
'Atlas LV-3 Agena-B', 'Molniya-L', 'Molniya-M', 'Molniya',
'Atlas LV-3C Centaur-D', 'Delta E1', 'Atlas SLV-3 Agena-D',
'Atlas SLV-3C Centaur-D', 'Proton-K/D', 'Saturn V', 'N1',
'Delta 1913', 'Atlas SLV-3D Centaur-D1A', 'Delta 2914', 'Mu-3S-II',
'Mu-4S-II', 'Delta II 6925', 'Delta II 7925-10',
'Titan II (23)G Star-37FM', 'Proton-K/DM3', 'Athena II', 'M-V',
'Delta II 7425-10', 'Ariane 5G', 'Delta II 7925-10L',
'Delta II 7925-11L', 'Delta II 7925', 'H-IIA 2022',
'Long March 3A', 'PSLV-XL C11', 'Atlas V 401', 'Long March 3C',
'Delta II 7920H', 'Delta II 7921H', 'Minotaur V', 'Long March 3B',
'Falcon 9 Full Thrust', 'Long March 4C', 'Falcon 9', 'LVM3 M1',
'Long March 5', 'Electron', 'SLS Block 1', 'Falcon 9 Block 5',
'Ariane 5 ECA', 'LVM3 M4', 'Soyuz-2.1b/Fregat'], dtype=object)
```

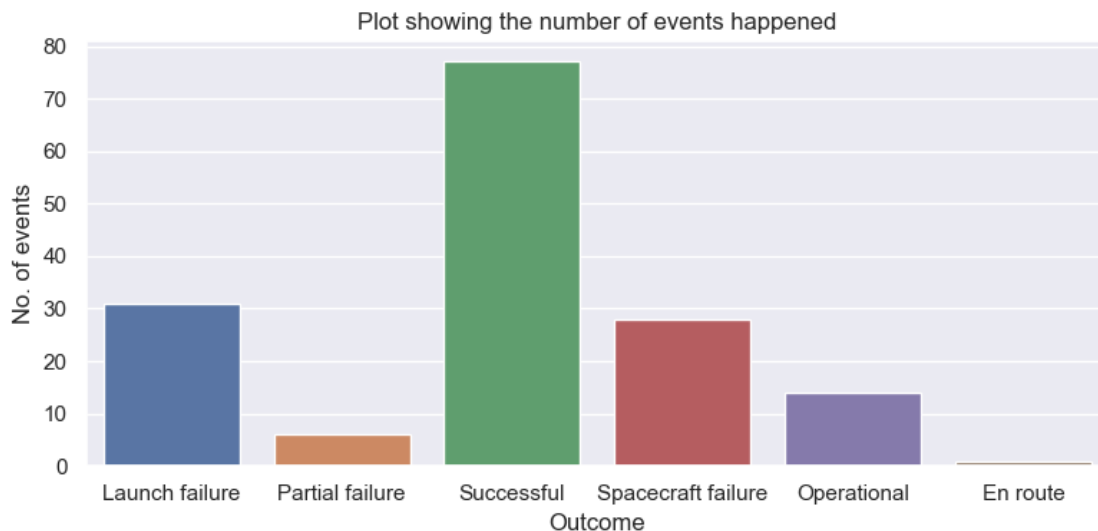
```
[38]: # Fetching the Launch Vehicle from the 'Carrier Rocket' column.
df['launch vehicle'] = df['Carrier Rocket'].str.split().str[0]
#df['launch vehicle'] = df['Carrier Rocket'].str.strip().str[:10]
```

```
[39]: df['launch vehicle'].unique()
```

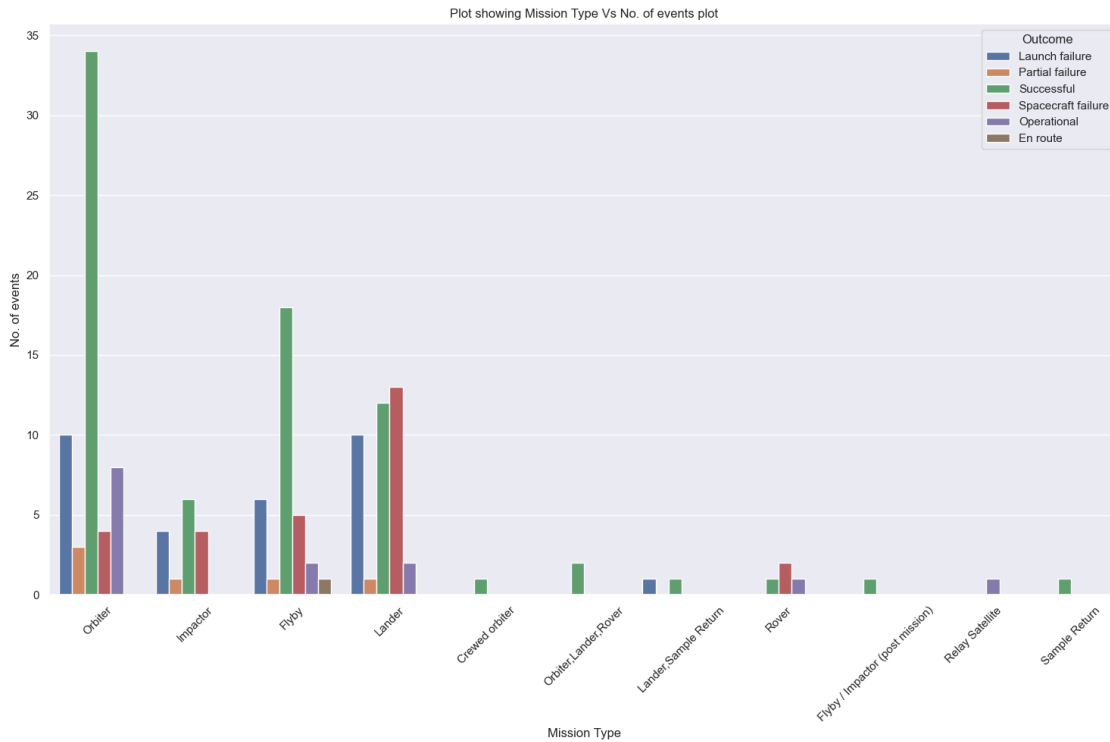
```
[39]: array(['Thor', 'Luna', 'Juno', 'Atlas-D', 'Atlas', 'Molniya-L',
        'Molniya-M', 'Molniya', 'Delta', 'Proton-K/D', 'Saturn', 'N1',
        'Mu-3S-II', 'Mu-4S-II', 'Titan', 'Proton-K/DM3', 'Athena', 'M-V',
        'Ariane', 'H-IIA', 'Long', 'PSLV-XL', 'Minotaur', 'Falcon', 'LVM3',
        'Electron', 'SLS', 'Soyuz-2.1b/Fregat'], dtype=object)
```

```
[40]: df['launch vehicle'].replace('Long', 'Long March', inplace= True)
```

```
[41]: sns.set(rc = {'figure.figsize':(8,4)})
sns.countplot(data=df, x= 'Outcome')
plt.title("Plot showing the number of events happened")
plt.xlabel("Outcome")
plt.ylabel("No. of events")
plt.tight_layout()
plt.show()
```

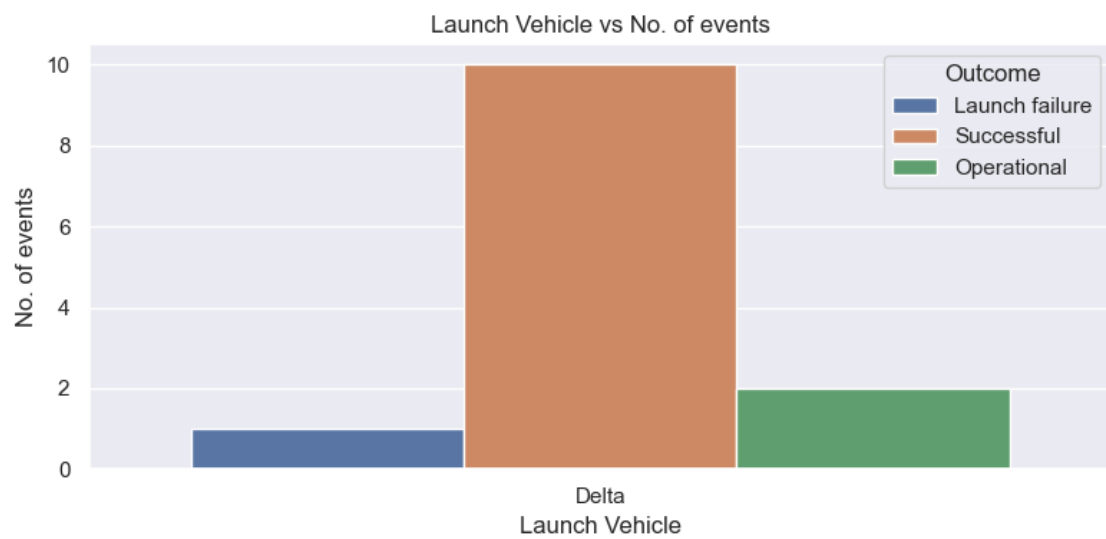
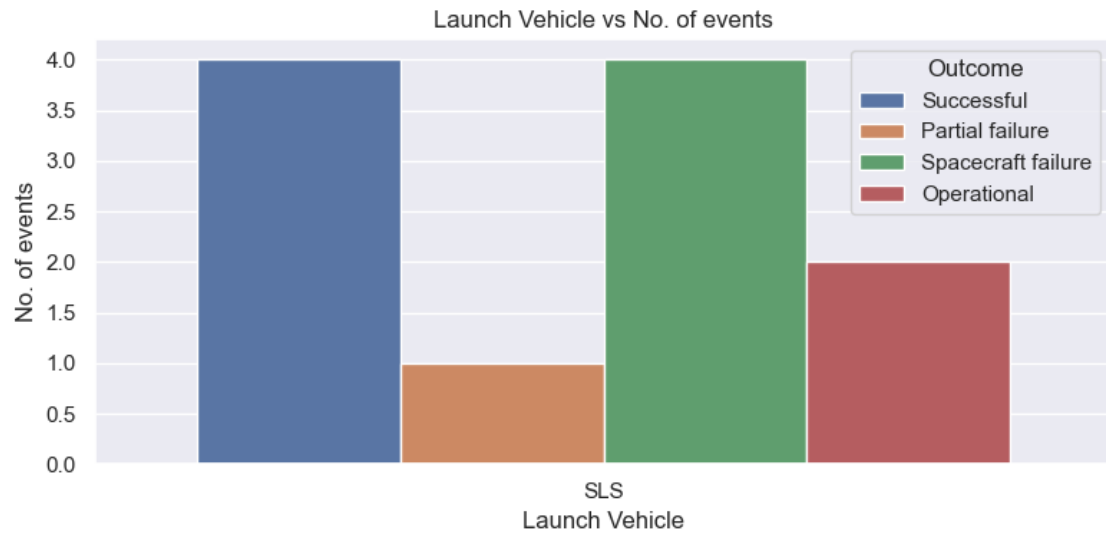


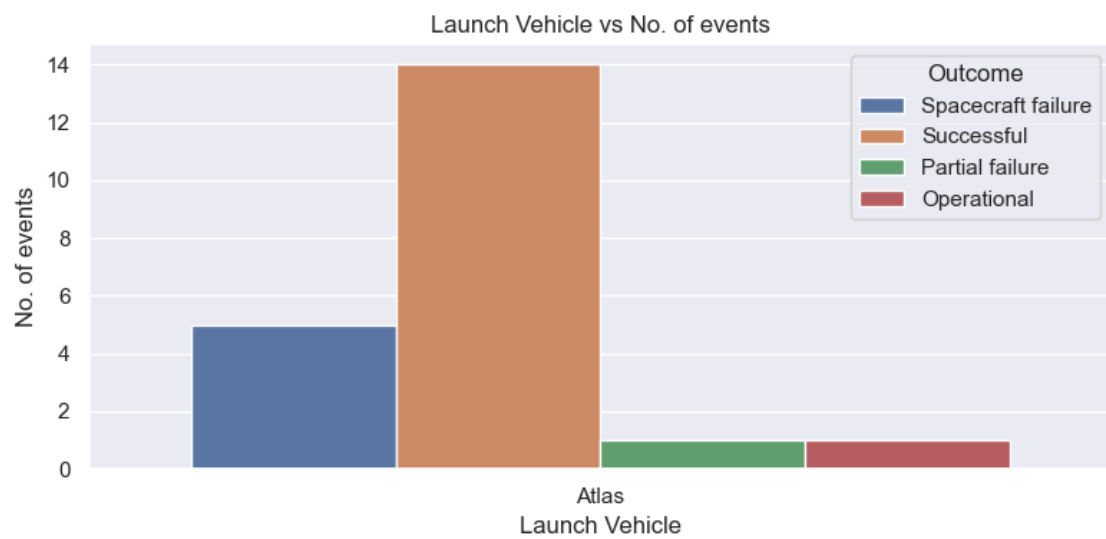
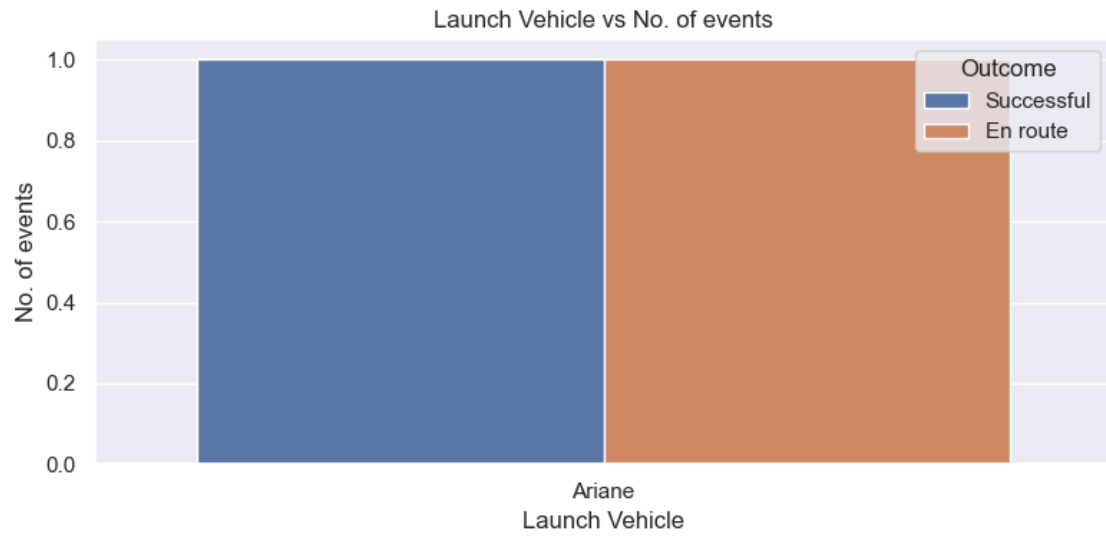
```
[42]: sns.set(rc = {'figure.figsize':(15,10)})
sns.countplot(data=df, x= 'Mission Type', hue= 'Outcome')
plt.xticks(rotation=45)
plt.title("Plot showing Mission Type Vs No. of events plot")
plt.xlabel("Mission Type")
plt.ylabel("No. of events")
plt.tight_layout()
plt.show()
```

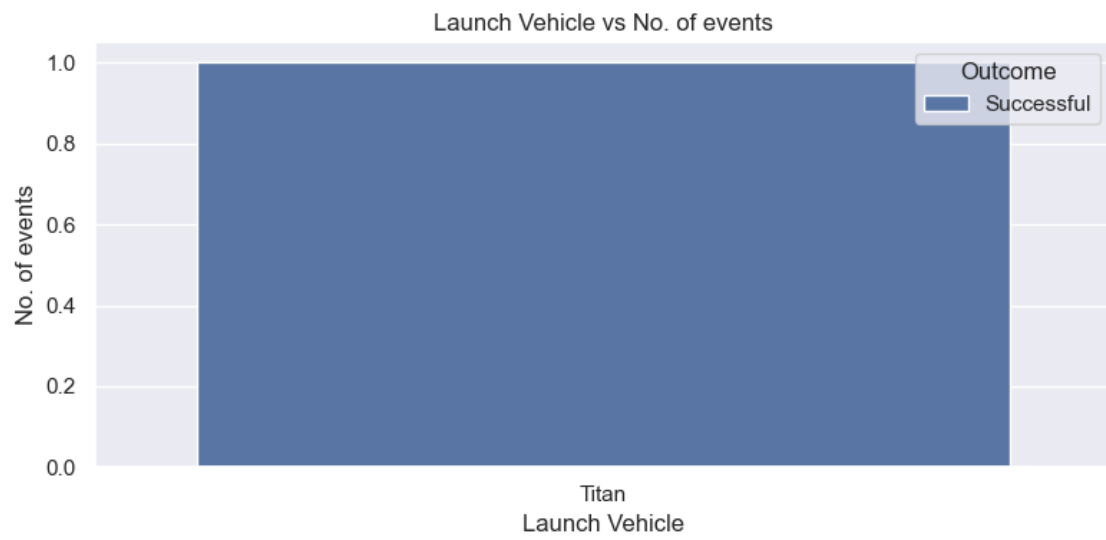
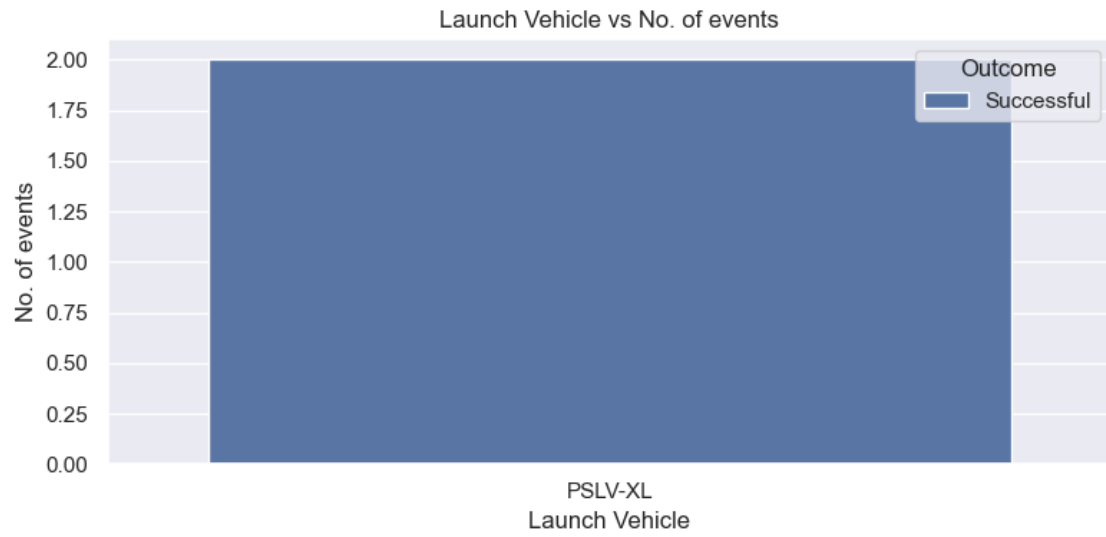



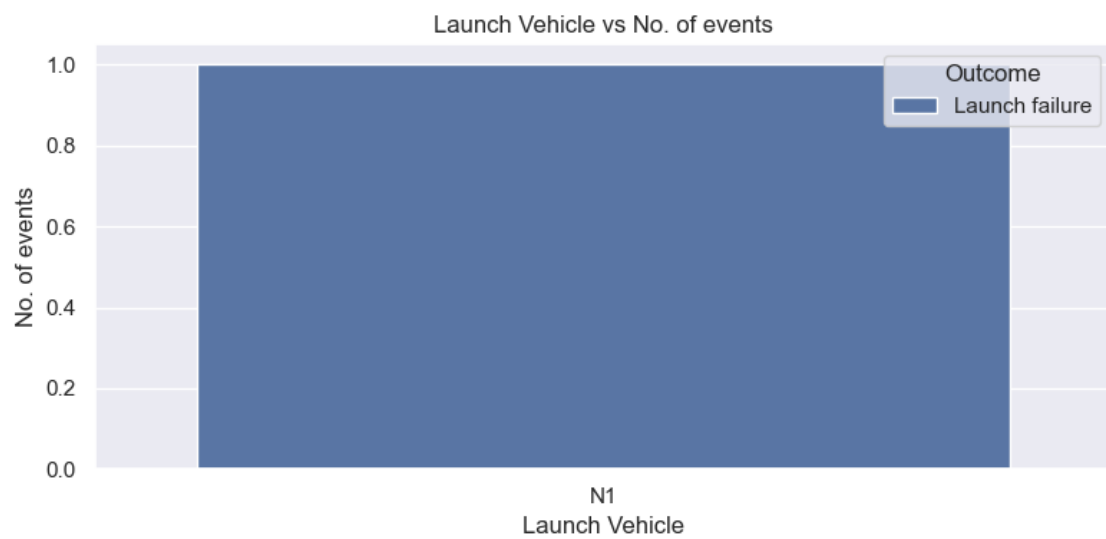
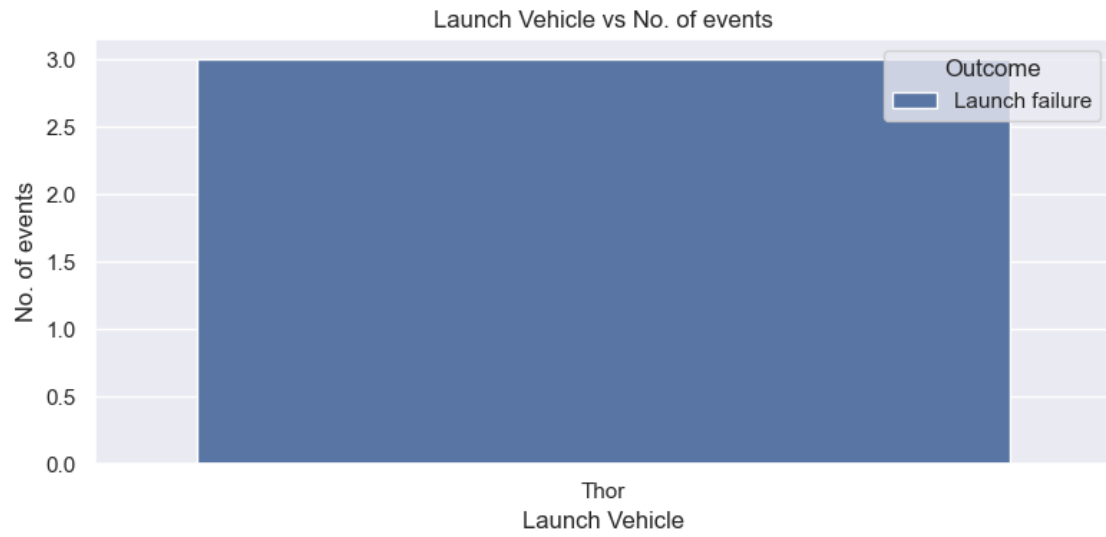
[]:

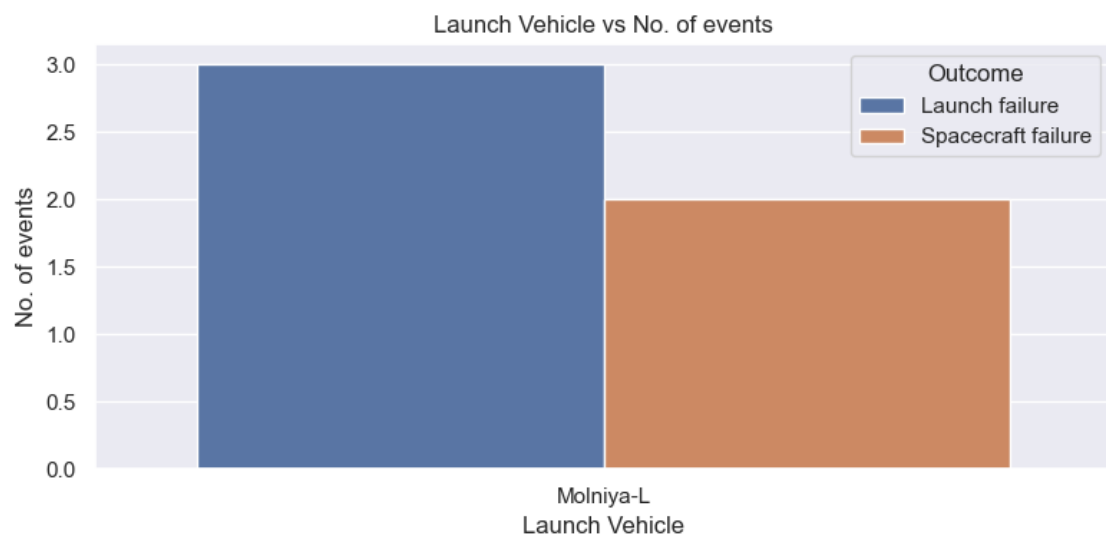
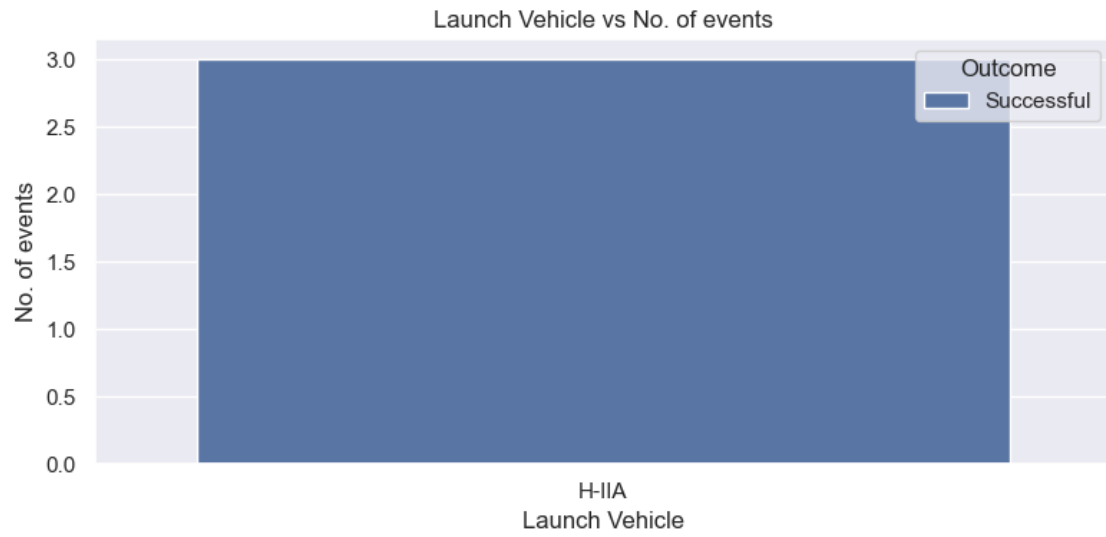
```
[43]: # "Launch Vehicle vs No. of events"
list1 = []
for i in df['launch vehicle']:
    list1.append(i)
l1= list(set(list1))
for j in l1:
    df1= df[df['launch vehicle'] == j]
    sns.set(rc = {'figure.figsize':(8,4)})
    sns.countplot(data=df1, x='launch vehicle', hue= 'Outcome')
    plt.title("Launch Vehicle vs No. of events")
    plt.xlabel("Launch Vehicle")
    plt.ylabel("No. of events")
    plt.tight_layout()
    plt.show()
```

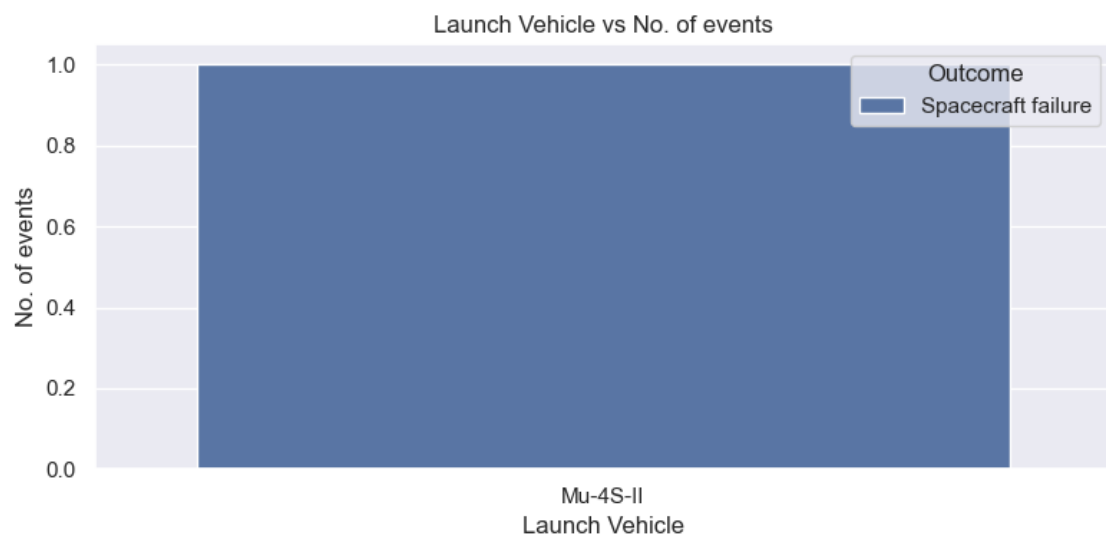
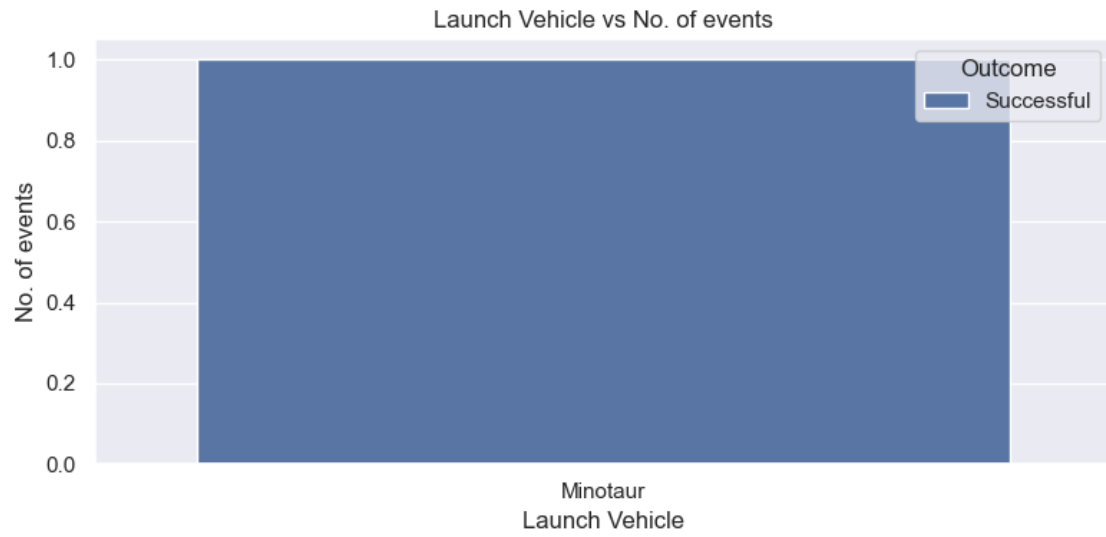


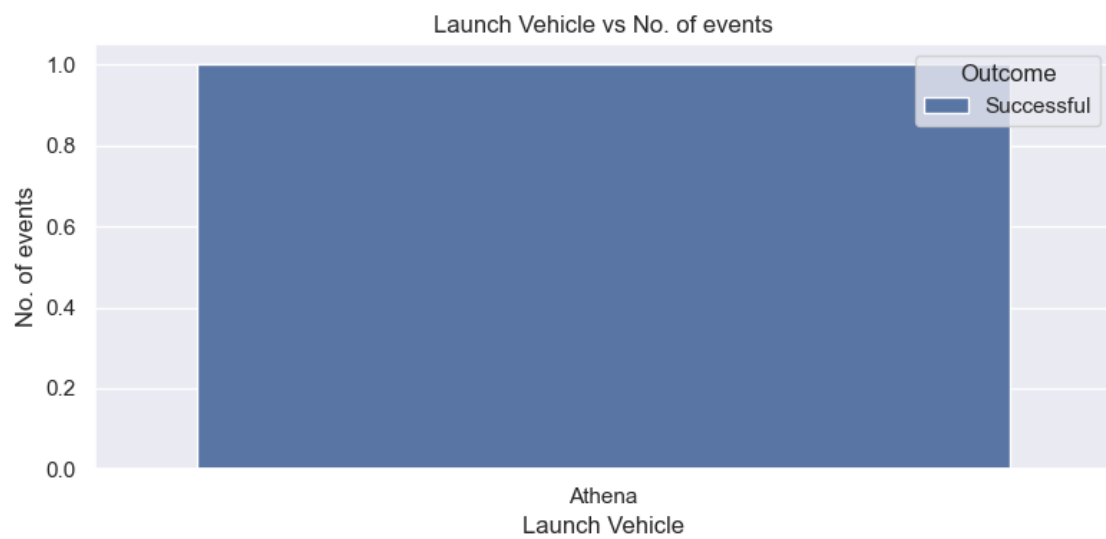
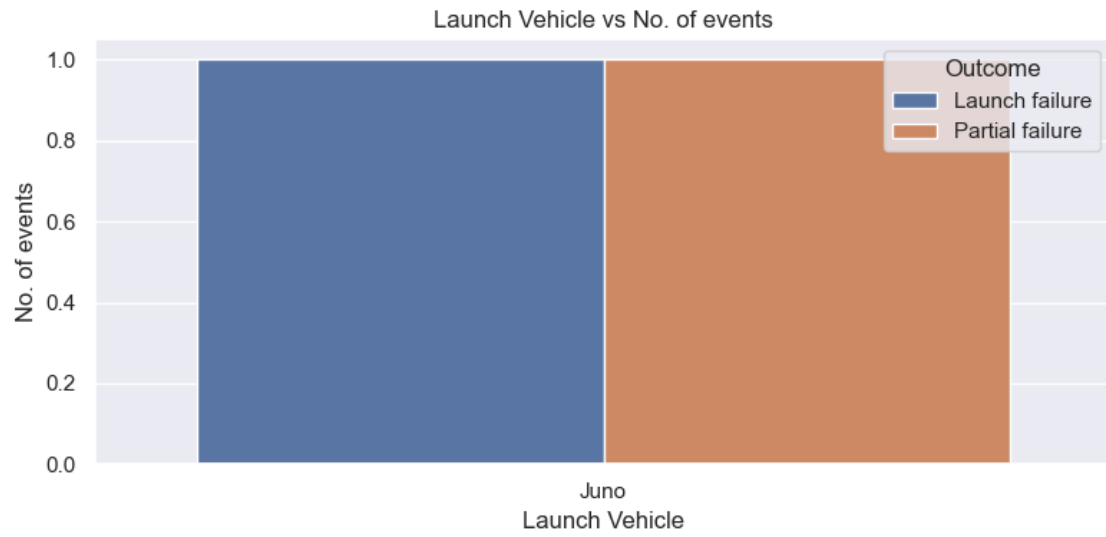


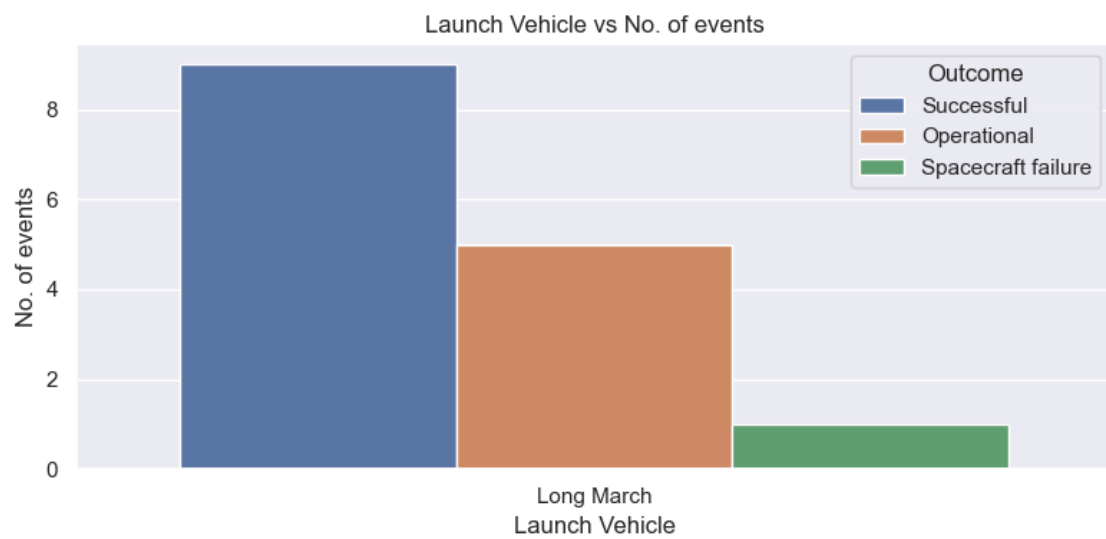
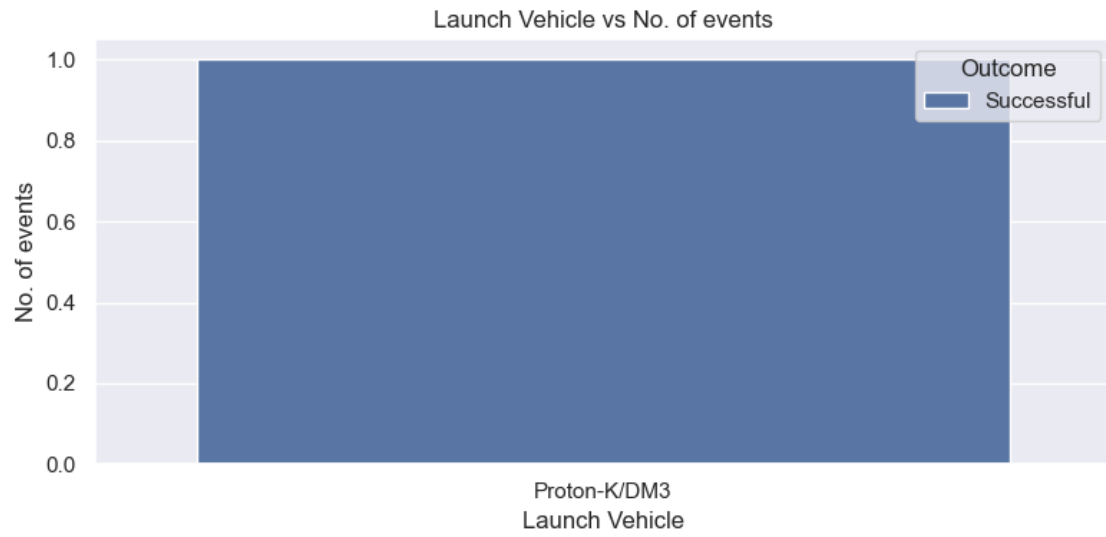


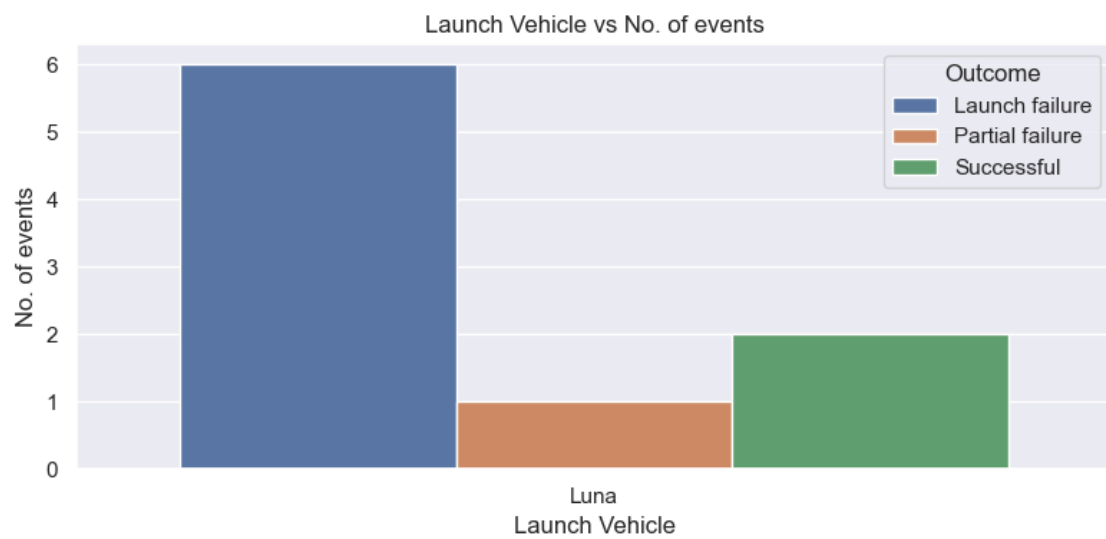
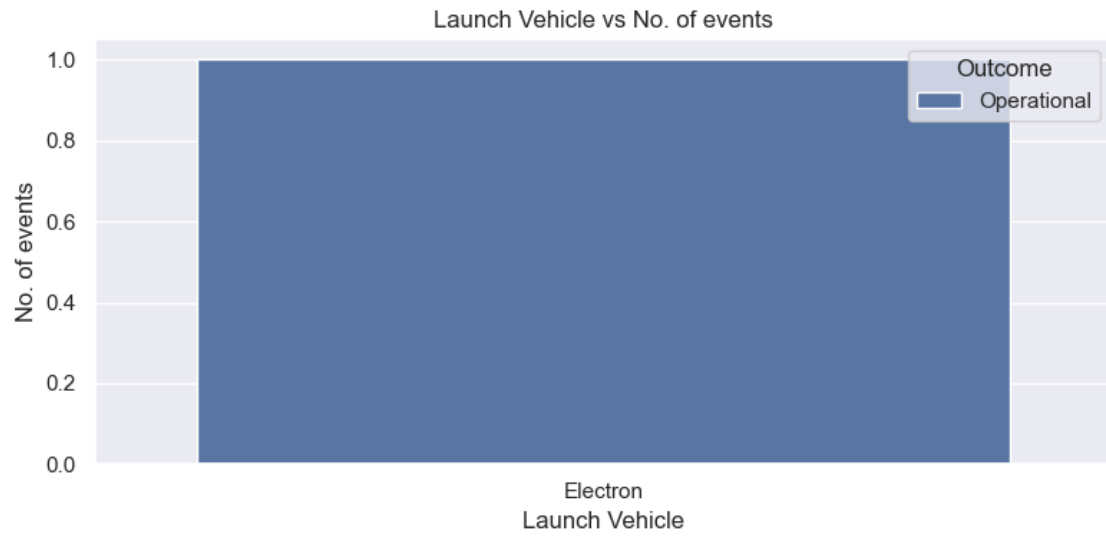


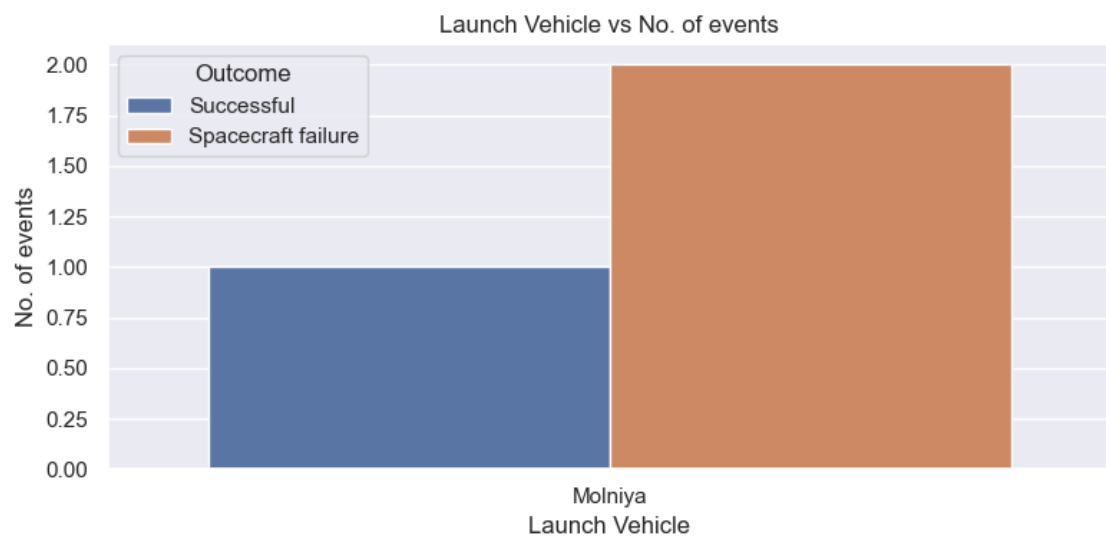
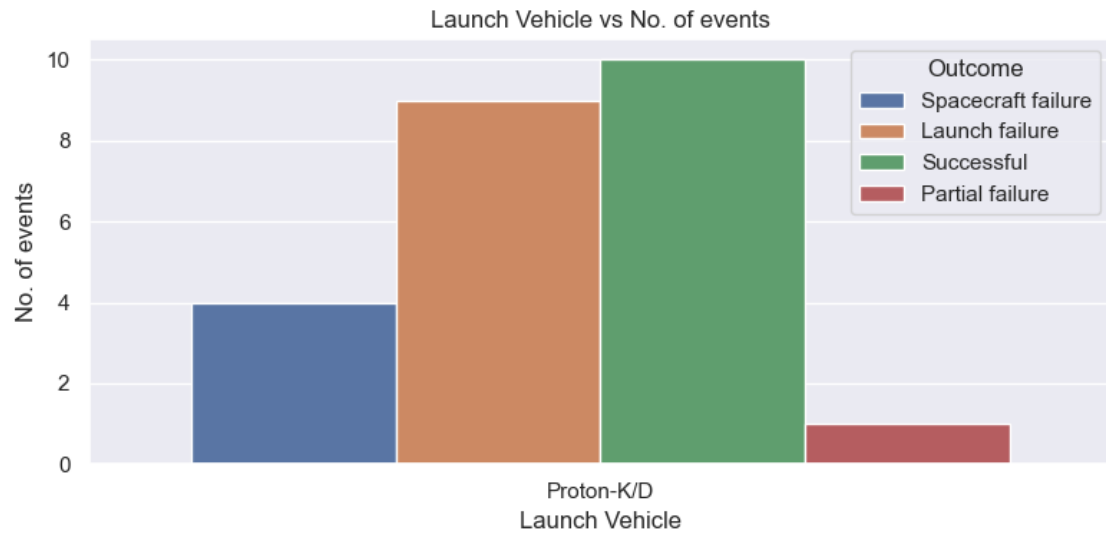


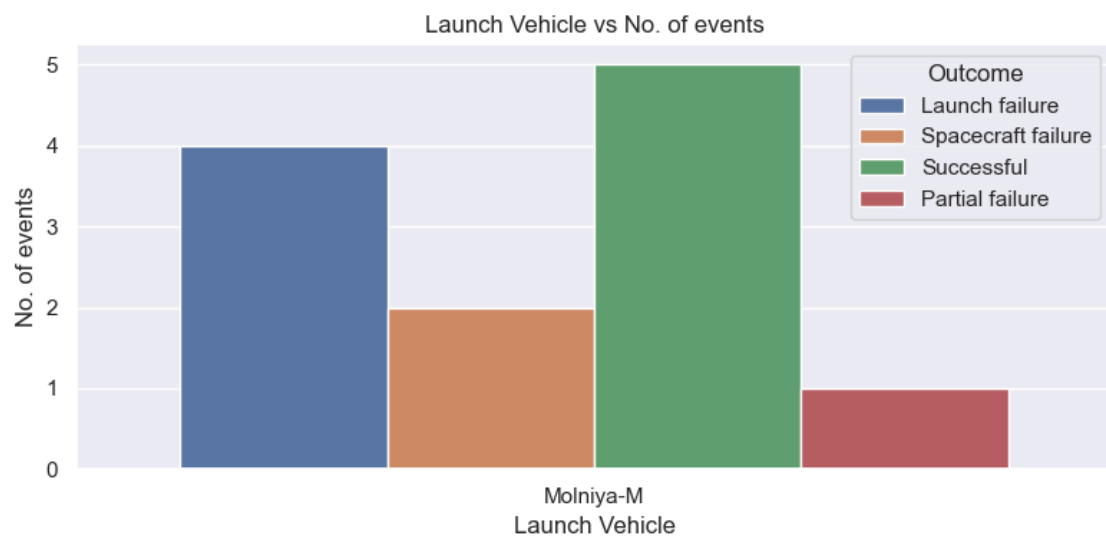
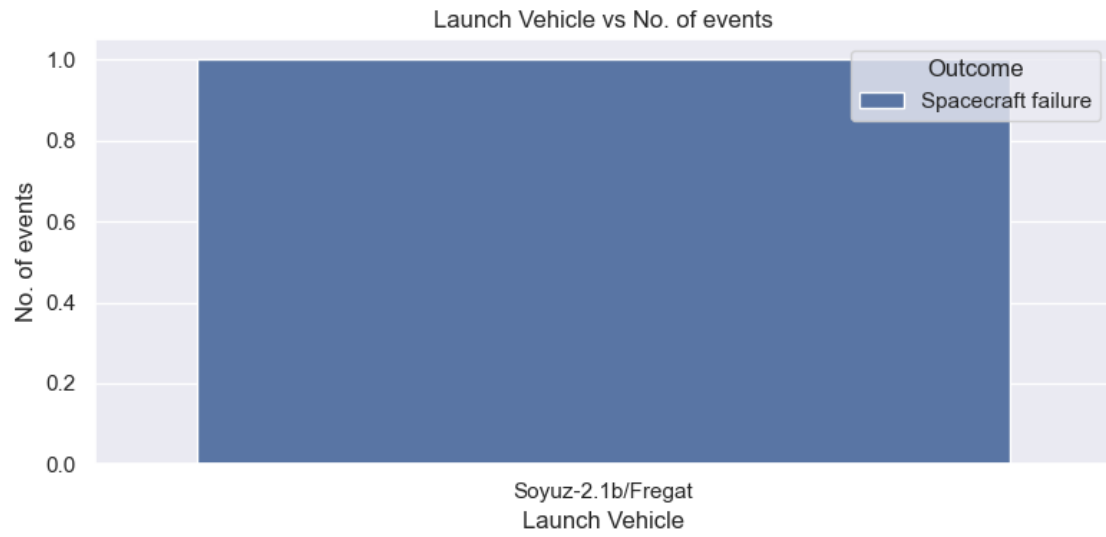


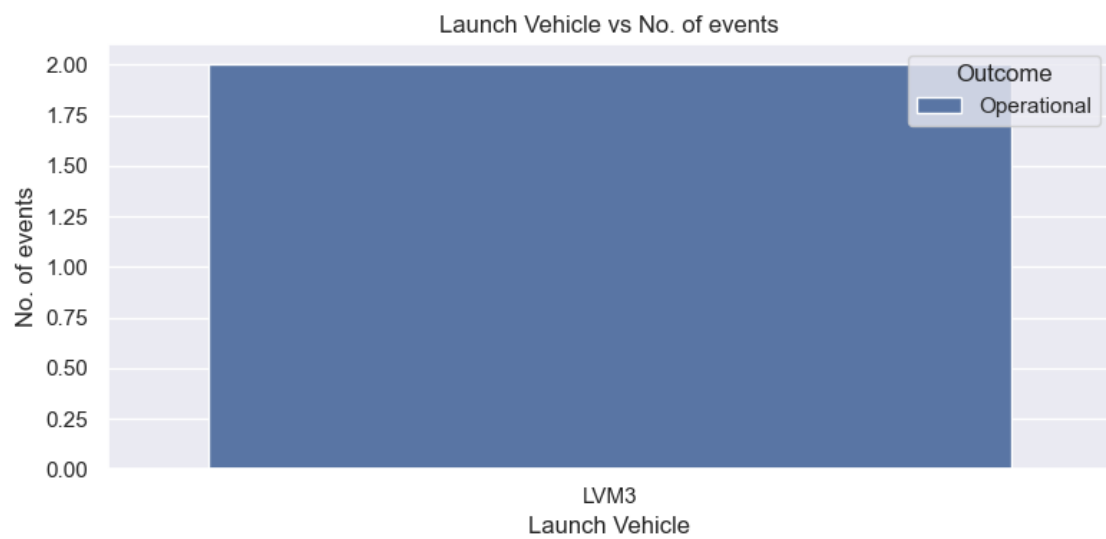
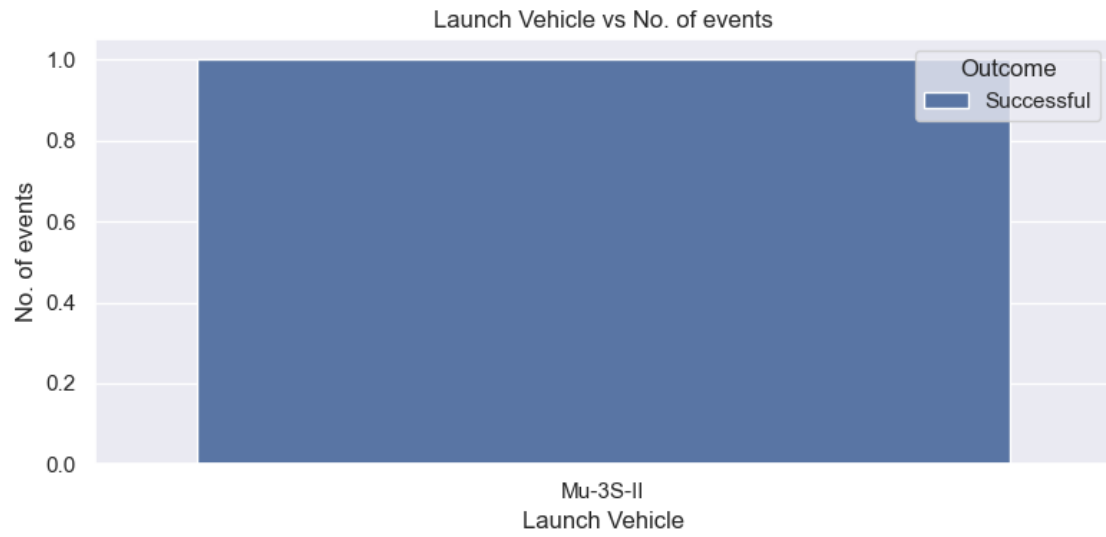


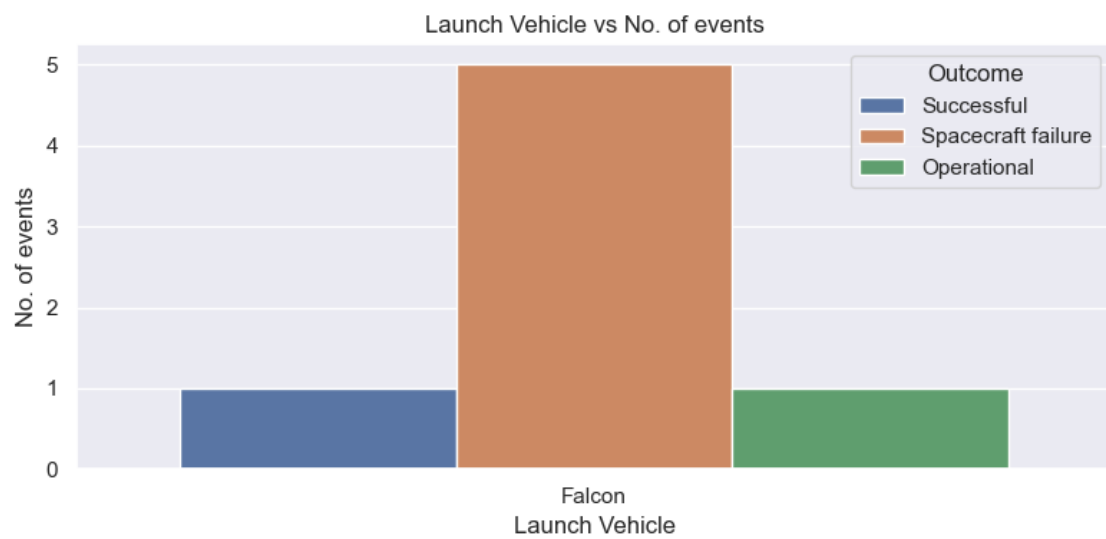
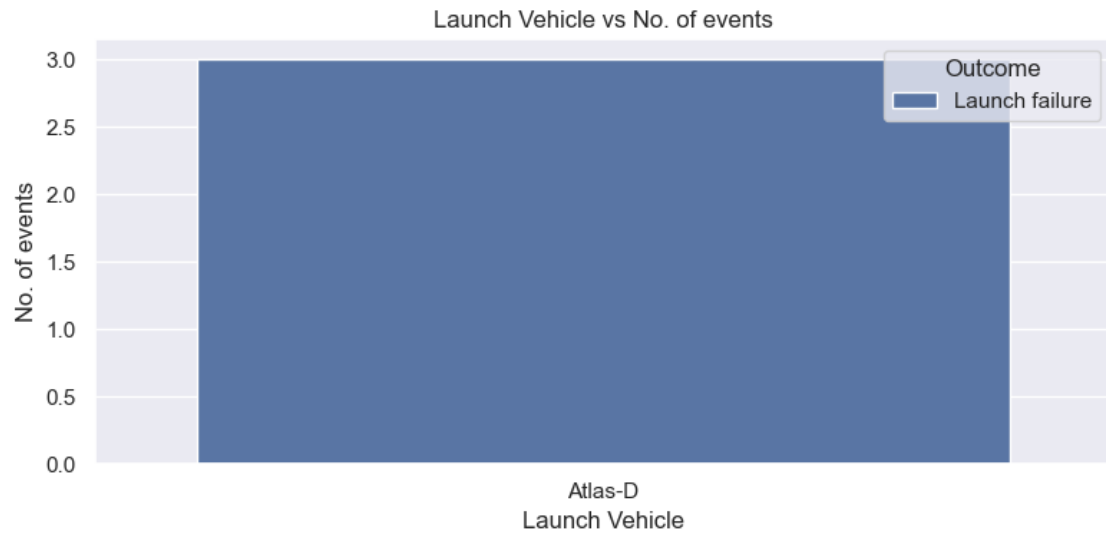


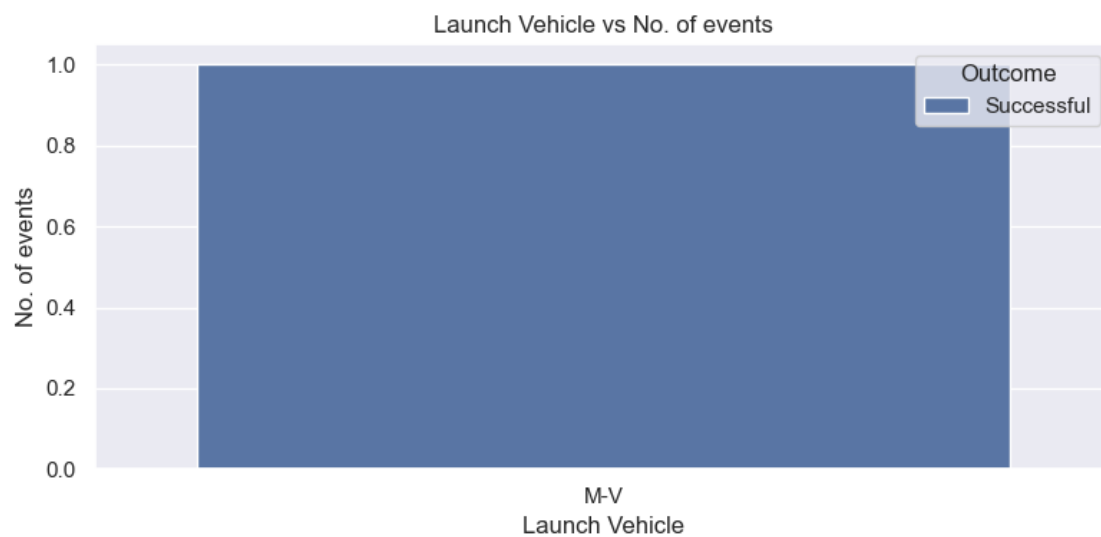
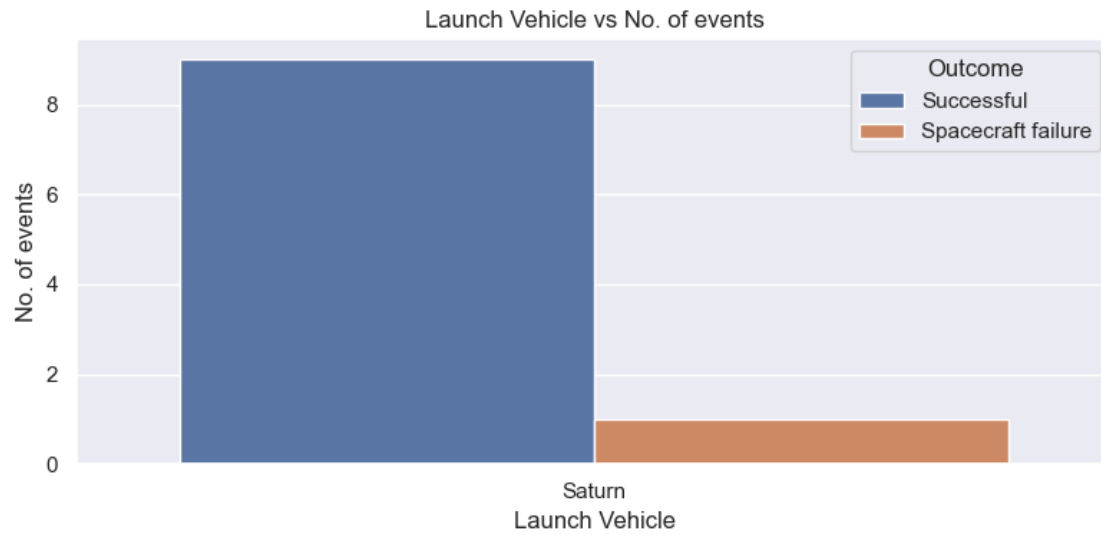












```
[ ]:
```

```
[ ]:
```

```
[ ]:
```

```
[44]: df['Mission Type'].unique()
```

```
[44]: array(['Orbiter', 'Impactor', 'Flyby', 'Lander', 'Crewed orbiter',
        'Orbiter,Lander,Rover', 'Lander,Sample Return', 'Rover',
```

```
'Flyby / Impactor (post mission)', 'Relay Satellite',
'Sample Return'], dtype=object)
```

```
[45]: df[df['Country'] == 'India']
```

```
[45]:
```

	Mission	Spacecraft	Launch Date	Carrier Rocket	\
113	Chandrayaan-1	Chandrayaan-1	22-Oct-08	PSLV-XL C11	
114	Chandrayaan-1	Moon Impact Probe	22-Oct-08	PSLV-XL C11	
133	Chandrayaan-2	Chandrayaan-2 Orbiter	22-Jul-19	LVM3 M1	
156	Chandrayaan-3	Chandrayaan-3	14-Jul-23	LVM3 M4	

	Mission Type	Outcome	\
113	Orbiter	Successful	
114	Impactor	Successful	
133	Orbiter	Operational	
156	Orbiter	Operational	

		Additional Information	Country	launch vehicle
113	Moon Impact Probe	deployed, discovered water i...	India	PSLV-XL
114	Moon Impact Probe	deployed, discovered water i...	India	PSLV-XL
133	Orbiter	operational, but Lander and Rover were...	India	LVM3
156	Lander and rover	operational. Soft-landed near...	India	LVM3

```
[46]: # Dropping the column 'Carrier Rocket' as we have transformed this feature to
↳ 'launch vehicle'
df.drop('Carrier Rocket', axis= 1, inplace = True)
```

```
[47]: # Identify how many mission are currently operational
df[df['Outcome'] == 'Operational']
```

```
[47]:
```

	Mission	Spacecraft	Launch Date	\
107	ARTEMIS P1	ARTEMIS P1	17-Feb-07	
108	ARTEMIS P2	ARTEMIS P2	17-Feb-07	
115	Lunar Reconnaissance Orbiter	Lunar Reconnaissance Orbiter	18-Jun-09	
121	Chang'e 3	Chang'e 3	01-Dec-13	
127	Queqiao	Queqiao relay satellite	21-May-18	
130	Chang'e 4	Chang'e 4	07-Dec-18	
131	Chang'e 4	Yutu-2	07-Dec-18	
133	Chandrayaan-2	Chandrayaan-2 Orbiter	22-Jul-19	
134	Chang'e 5	Chang'e 5 Orbiter	23-Nov-20	
138	CAPSTONE	CAPSTONE	28-Jun-22	
139	Danuri	Danuri	04-Aug-22	
143	ArgoMoon	ArgoMoon	16-Nov-22	
146	EQUULEUS	EQUULEUS	16-Nov-22	
156	Chandrayaan-3	Chandrayaan-3	14-Jul-23	

	Mission Type	Outcome	\
--	--------------	---------	---

107	Orbiter	Operational
108	Orbiter	Operational
115	Orbiter	Operational
121	Lander	Operational
127	Relay Satellite	Operational
130	Lander	Operational
131	Rover	Operational
133	Orbiter	Operational
134	Orbiter	Operational
138	Orbiter	Operational
139	Orbiter	Operational
143	Flyby	Operational
146	Flyby	Operational
156	Orbiter	Operational

	Additional Information	Country \
107	Two THEMIS spacecraft moved to selenocentric o...	USA
108	Two THEMIS spacecraft moved to selenocentric o...	USA
115	Entered orbit on June 23, 2009.	USA
121	Yutu rover was deployed from Chang'e 3.	China
127	Entered Earth-Moon L2 orbit to support Chang'e...	China
130	First soft landing on the far side of the Moon...	China
131	First soft landing on the far side of the Moon...	China
133	Orbiter operational, but Lander and Rover were...	India
134	Returned lunar samples on 16 December 2020. Or...	China
138	Lunar orbiting CubeSat to test orbital stabili...	USA
139	Lunar Orbiter by South Korea's KARI. Will surv...	South Korea
143	Designed to image the Interim Cryogenic Propul...	Italy
146	Intended to image Earth's plasmasphere, impact...	Japan
156	Lander and rover operational. Soft-landed near...	India

	launch vehicle
107	Delta
108	Delta
115	Atlas
121	Long March
127	Long March
130	Long March
131	Long March
133	LVM3
134	Long March
138	Electron
139	Falcon
143	SLS
146	SLS
156	LVM3

```
[48]: df[df['Outcome'] == 'Operational'].count()
```

```
[48]: Mission          14
      Spacecraft      14
      Launch Date     14
      Mission Type    14
      Outcome         14
      Additional Information 14
      Country         14
      launch vehicle   14
      dtype: int64
```

Observation Total 14 Operational missions are currently going on.

```
[49]: # Identify how many mission are currently Successful
      df[df['Outcome'] == 'Successful']
```

```
[49]:
```

	Mission	Spacecraft	Launch Date \
10	Luna 2 (E-1A No.2)	Luna 2	12-Sep-59
11	Luna 3 (E-2A No.1)	Luna 3	04-Oct-59
25	Ranger 7	Ranger 7	28-Jul-64
26	Ranger 8	Ranger 8	17-Feb-65
28	Ranger 9	Ranger 9	21-Mar-65
..
137	Chang'e 5	Chang'e 5 Returner	23-Nov-20
140	Artemis 1	Artemis 1 Orion MPCV CM-002	16-Nov-22
144	LunIR	LunIR	16-Nov-22
148	BioSentinel	BioSentinel	16-Nov-22
150	Team Miles	Team Miles	16-Nov-22

	Mission Type	Outcome \
10	Impactor	Successful
11	Flyby	Successful
25	Impactor	Successful
26	Impactor	Successful
28	Impactor	Successful
..
137	Sample Return	Successful
140	Orbiter	Successful
144	Flyby	Successful
148	Flyby	Successful
150	Flyby	Successful

	Additional Information	Country	launch vehicle
10	Successful impact at 21:02 on 14 September 195...	Russia	Luna
11	Returned first images of the far side of the M...	Russia	Luna
25	Impacted on 30 July 1964 at 13:25:48 UTC. ([27])	USA	Atlas

26	Impacted on 20 February 1965 at 09:57:37 UTC. ...	USA	Atlas
28	Impacted on 24 March 1965 at 14:08:20 UTC. ([2...	USA	Atlas
..
137	Returned lunar samples on 16 December 2020. Or...	China	Long March
140	Uncrewed test of Orion spacecraft in lunar fly...	USA	SLS
144	Intended to flyby the Moon and collect surface...	USA	SLS
148	CubeSat on astrobiology mission to study impac...	USA	SLS
150	CubeSat to demonstrate navigation in deep spac...	USA	SLS

[77 rows x 8 columns]

Observation

1. Total 77 successful missions happened.

[]:

```
[50]: df['Outcome'].unique()
```

```
[50]: array(['Launch failure', 'Partial failure', 'Successful',
        'Spacecraft failure', 'Operational', 'En route'], dtype=object)
```

```
[51]: # Identify how many mission are failure be it 'Partial failure', 'Launch
        ↳ failure' or 'Spacecraft failure'
df[(df['Outcome'] == 'Partial failure') | (df['Outcome'] == 'Launch failure') |
    ↳ (df['Outcome'] == 'Spacecraft failure')]
```

```
[51]:
```

	Mission	Spacecraft	Launch Date	Mission Type \
0	Pioneer 0 (Able I)	Pioneer 0	17-Aug-58	Orbiter
1	Luna E-1 No.1	Luna E-1 No.1	23-Sep-58	Impactor
2	Pioneer 1 (Able II)	Pioneer 1	11-Oct-58	Orbiter
3	Luna E-1 No.2	Luna E-1 No.2	11-Oct-58	Impactor
4	Pioneer 2 (Able III)	Pioneer 2	08-Nov-58	Orbiter
..
151	Hakuto-R Mission 1	Hakuto-R	11-Dec-22	Lander
152	SORA-Q	SORA-Q	11-Dec-22	Rover
153	Emirates Lunar Mission	Rashid	11-Dec-22	Rover
154	Lunar Flashlight	Lunar Flashlight	11-Dec-22	Flyby
157	Luna 25	Luna 25	10-Aug-23	Lander

	Outcome	Additional Information \
0	Launch failure	First attempted launch beyond Earth orbit; fai...
1	Launch failure	Failed to orbit; rocket disintegrated due to e...
2	Launch failure	Failed to orbit; premature second-stage cutoff...
3	Launch failure	Failed to orbit; carrier rocket exploded due t...
4	Launch failure	Failed to orbit; premature second-stage cutoff...
..
151	Spacecraft failure	Lunar lander technology demonstration. Contact...

```

152 Spacecraft failure Lunar lander technology demonstration. Lost co...
153 Spacecraft failure Lunar rover demonstration launched with Hakuto...
154 Spacecraft failure Moved from Artemis 1 to Falcon 9. Thruster iss...
157 Spacecraft failure Launched, attempted orbital maneuver failed, c...

```

```

      Country      launch vehicle
0         USA              Thor
1      Russia              Luna
2         USA              Thor
3      Russia              Luna
4         USA              Thor
..      ...
151    Japan              Falcon
152    Japan              Falcon
153     UAE              Falcon
154     USA              Falcon
157  Russia  Soyuz-2.1b/Fregat

```

[65 rows x 8 columns]

Observation There are total 65 mission failure that happened

```

[52]: # Lets replace 'Partial failure', 'Launch failure' and 'Spacecraft failure'
      ↪with 'Failure'
df['Outcome'].replace(['Partial failure', 'Launch failure', 'Spacecraft
      ↪failure'], 'Failure', inplace= True)

```

```

[53]: df

```

```

[53]:
      Mission      Spacecraft Launch Date \
0    Pioneer 0 (Able I)      Pioneer 0  17-Aug-58
1      Luna E-1 No.1    Luna E-1 No.1  23-Sep-58
2    Pioneer 1 (Able II)      Pioneer 1  11-Oct-58
3      Luna E-1 No.2    Luna E-1 No.2  11-Oct-58
4    Pioneer 2 (Able III)      Pioneer 2  08-Nov-58
..      ...
153  Emirates Lunar Mission      Rashid  11-Dec-22
154      Lunar Flashlight    Lunar Flashlight  11-Dec-22
155  Jupiter Icy Moons Explorer  Jupiter Icy Moons Explorer  14-Apr-23
156      Chandrayaan-3    Chandrayaan-3  14-Jul-23
157      Luna 25      Luna 25  10-Aug-23

```

```

      Mission Type      Outcome \
0      Orbiter      Failure
1    Impactor      Failure
2      Orbiter      Failure
3    Impactor      Failure

```

4	Orbiter	Failure
..
153	Rover	Failure
154	Flyby	Failure
155	Flyby	En route
156	Orbiter	Operational
157	Lander	Failure

	Additional Information	Country \
0	First attempted launch beyond Earth orbit; fai...	USA
1	Failed to orbit; rocket disintegrated due to e...	Russia
2	Failed to orbit; premature second-stage cutoff...	USA
3	Failed to orbit; carrier rocket exploded due t...	Russia
4	Failed to orbit; premature second-stage cutoff...	USA
..
153	Lunar rover demonstration launched with Hakuto...	UAE
154	Moved from Artemis 1 to Falcon 9. Thruster iss...	USA
155	Will fly by the Moon in August 2024 en route t...	European
156	Lander and rover operational. Soft-landed near...	India
157	Launched, attempted orbital maneuver failed, c...	Russia

	launch vehicle
0	Thor
1	Luna
2	Thor
3	Luna
4	Thor
..	...
153	Falcon
154	Falcon
155	Ariane
156	LVM3
157	Soyuz-2.1b/Fregat

[157 rows x 8 columns]

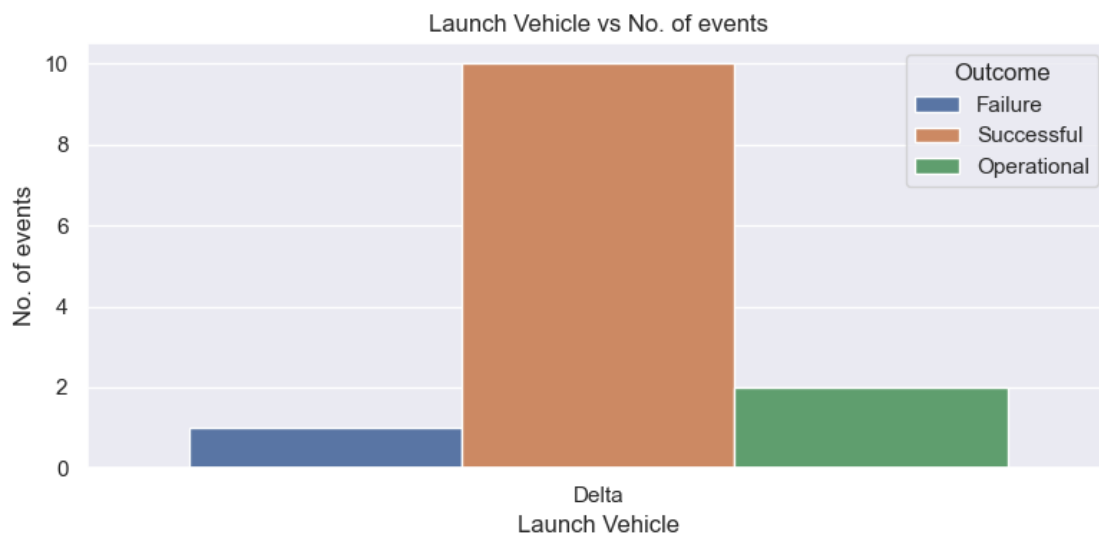
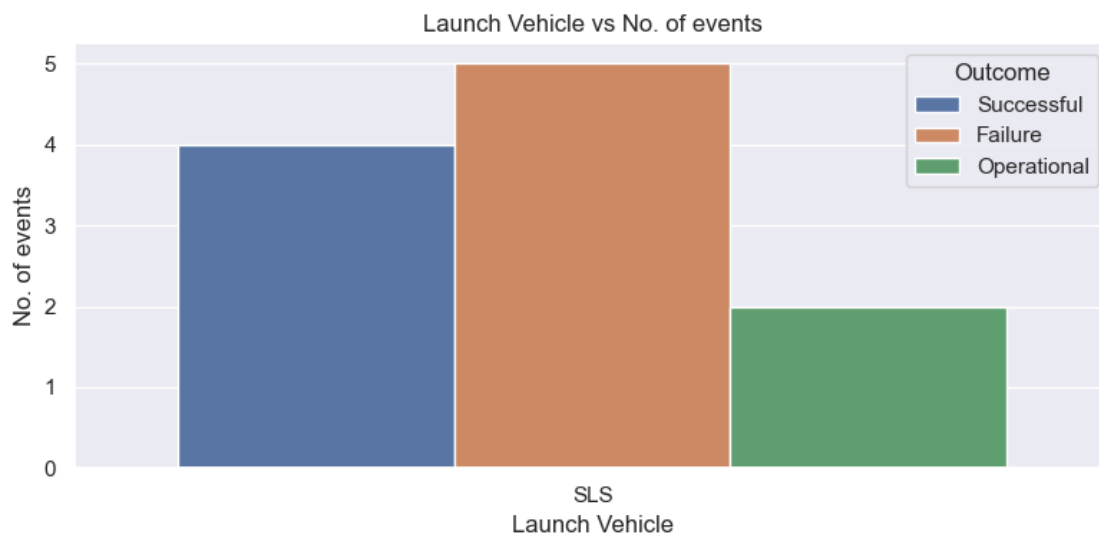
```
[54]: # Checking how many missions are currently in route to the targetted planet.
df[(df['Outcome'] == 'En route')]
```

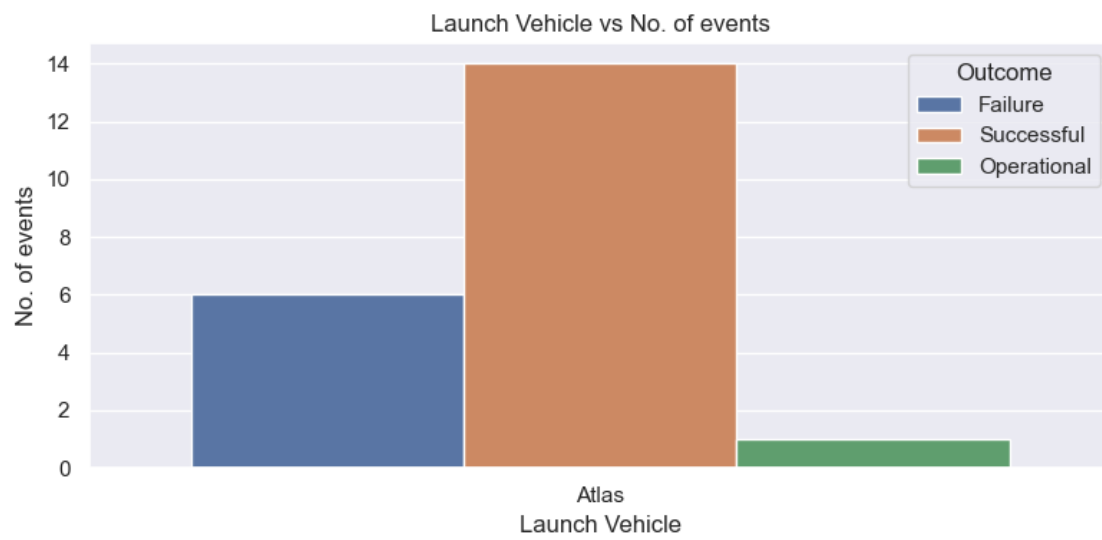
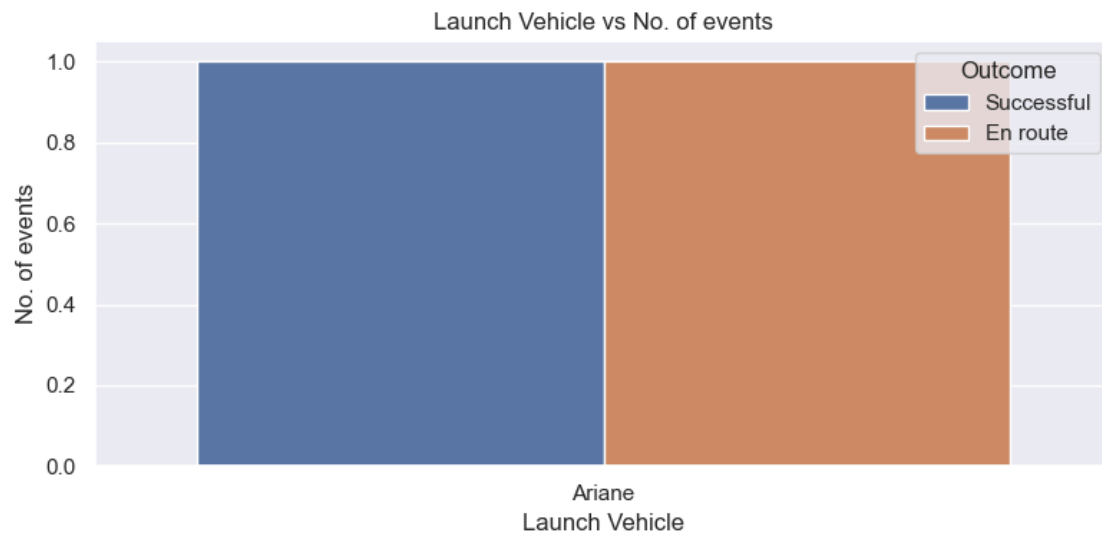
	Mission	Spacecraft	Launch Date \
155	Jupiter Icy Moons Explorer	Jupiter Icy Moons Explorer	14-Apr-23

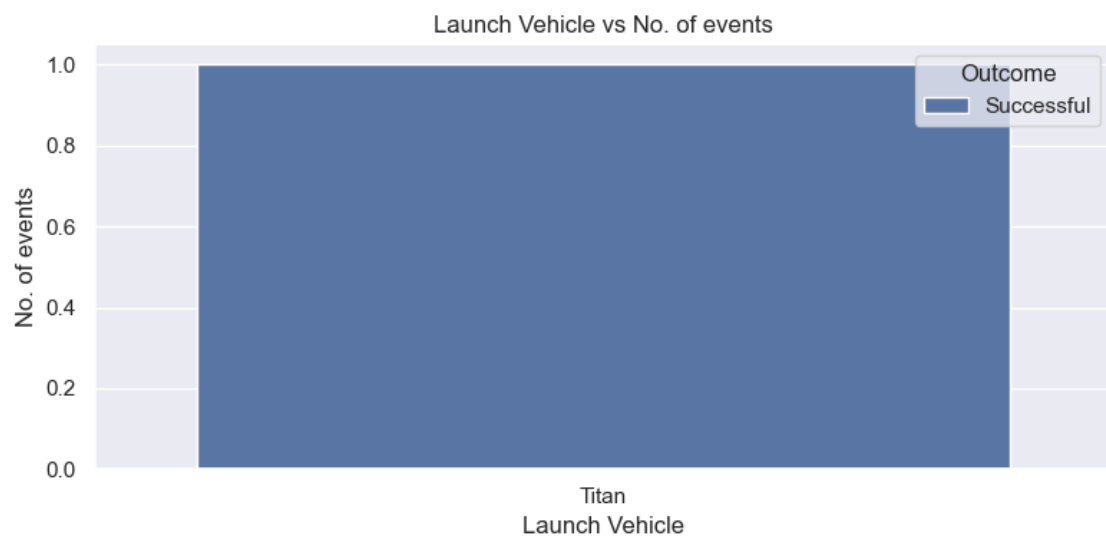
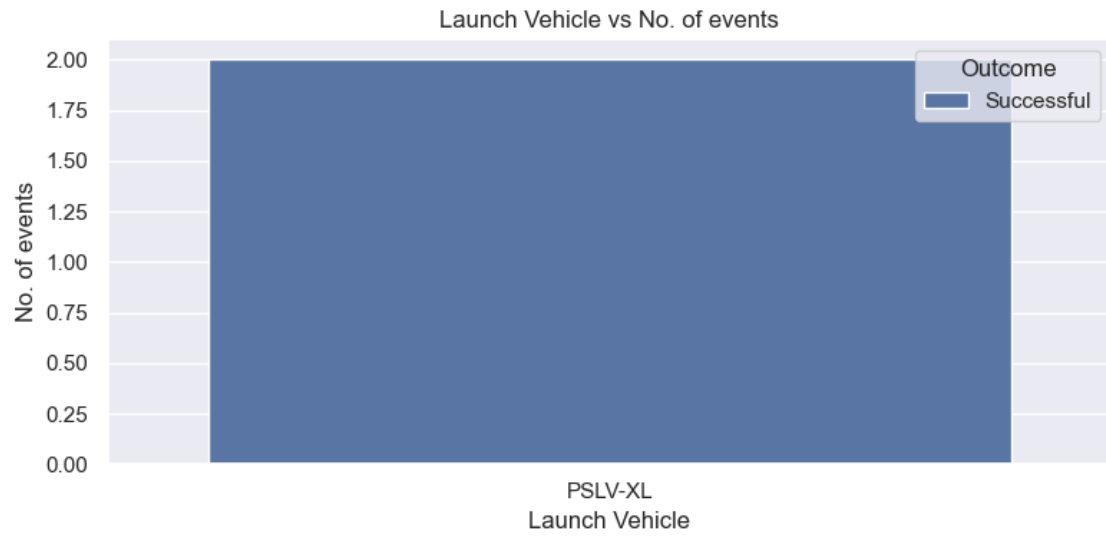
	Mission Type	Outcome	Additional Information \
155	Flyby	En route	Will fly by the Moon in August 2024 en route t...

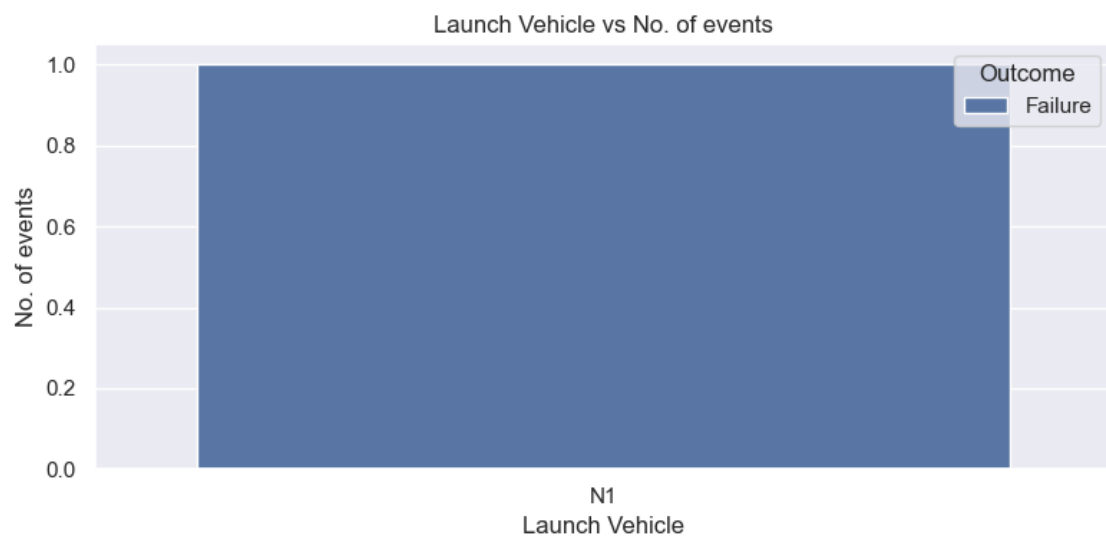
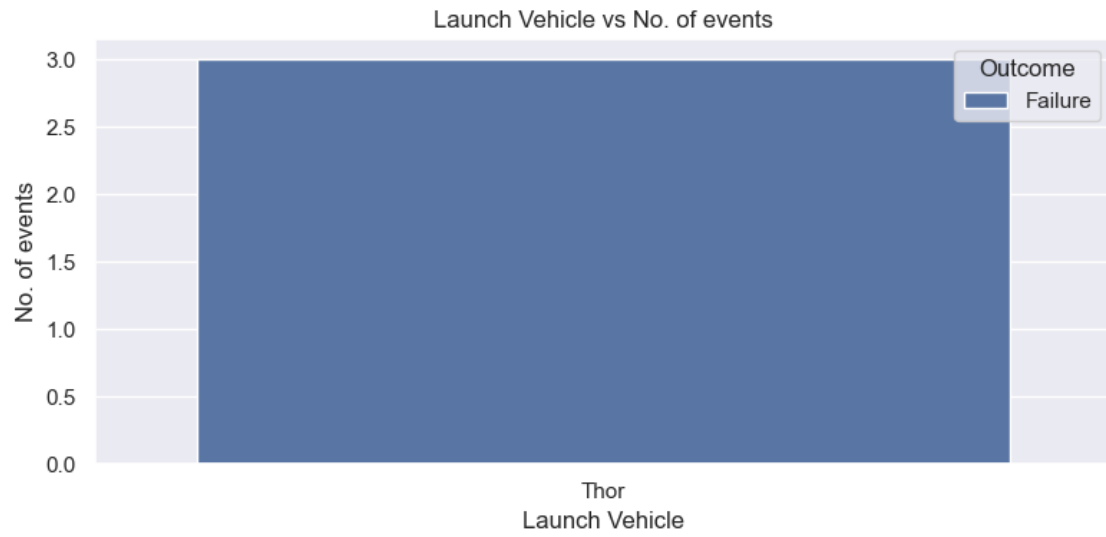
	Country	launch vehicle
155	European	Ariane

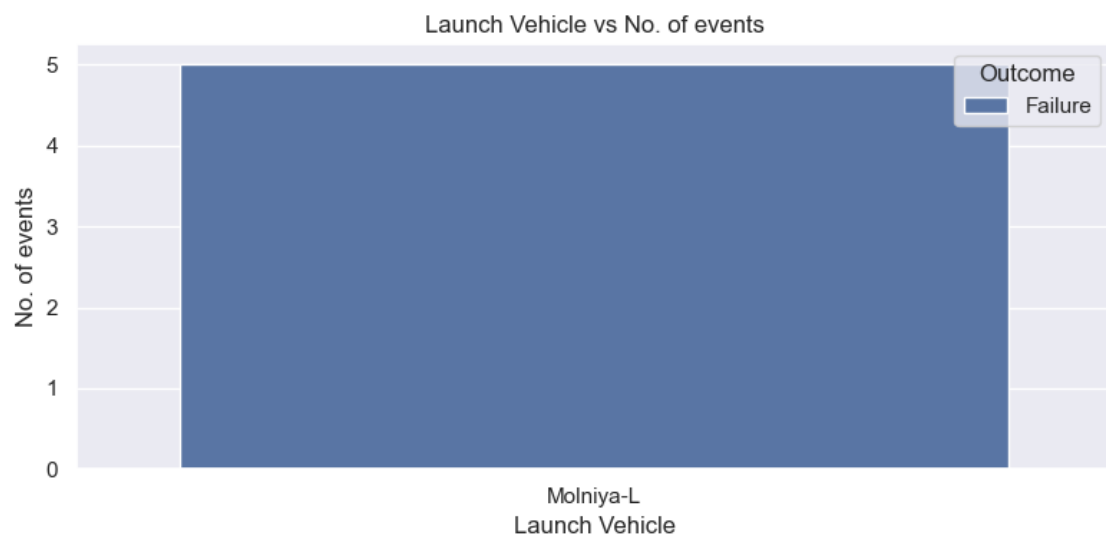
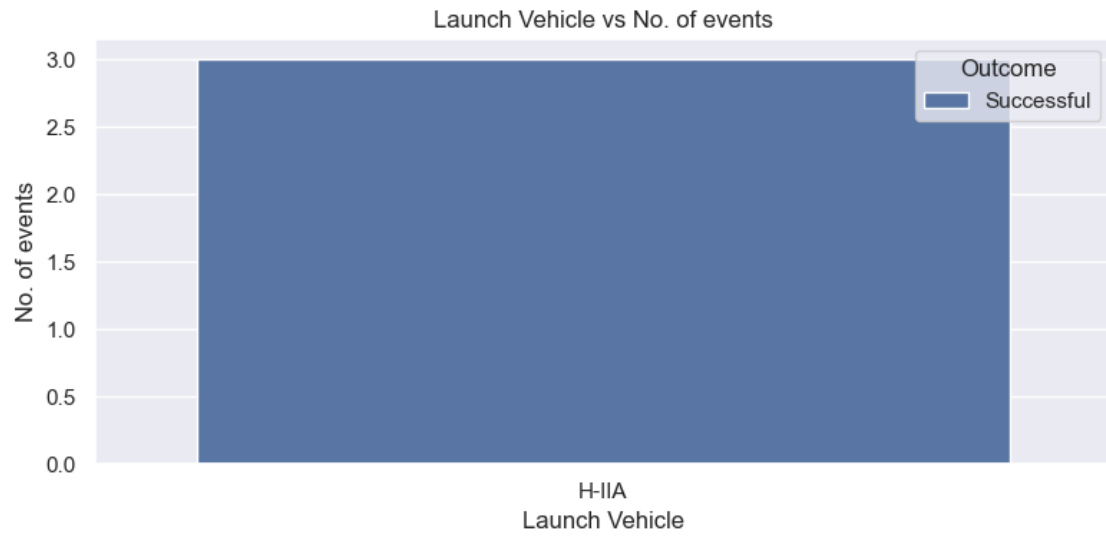
```
[55]: list1 = []
for i in df['launch vehicle']:
    list1.append(i)
l1= list(set(list1))
for j in l1:
    df1= df[df['launch vehicle'] == j]
    sns.set(rc = {'figure.figsize':(8,4)})
    sns.countplot(data=df1, x='launch vehicle', hue= 'Outcome')
    plt.title("Launch Vehicle vs No. of events")
    plt.xlabel("Launch Vehicle")
    plt.ylabel("No. of events")
    plt.tight_layout()
    plt.show()
```

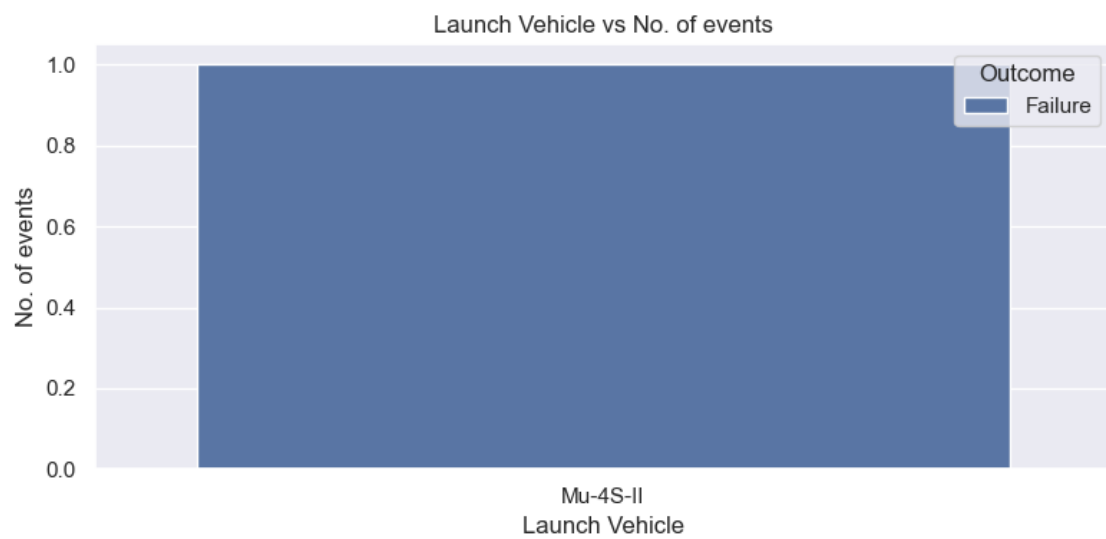
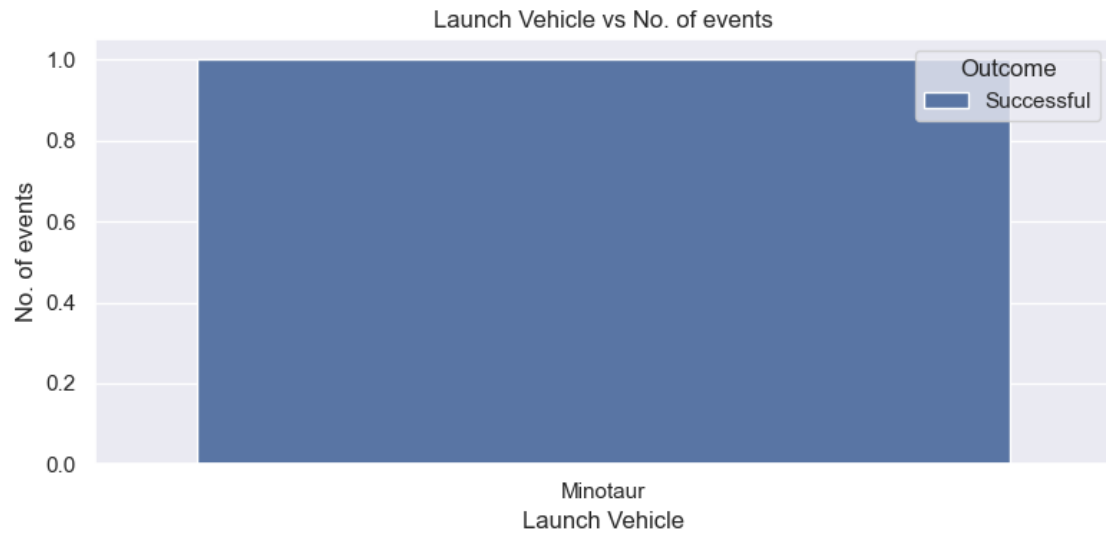


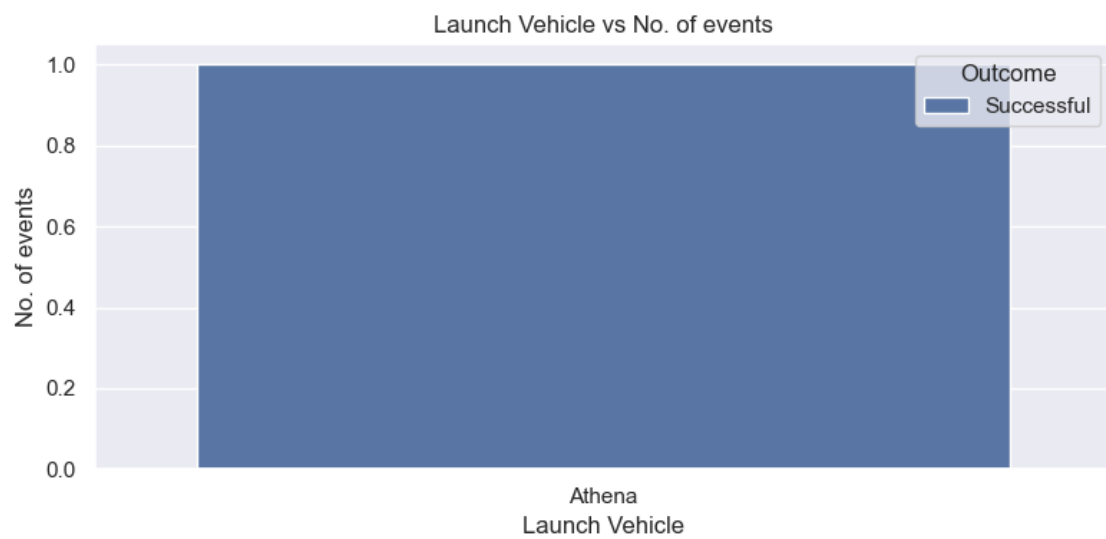
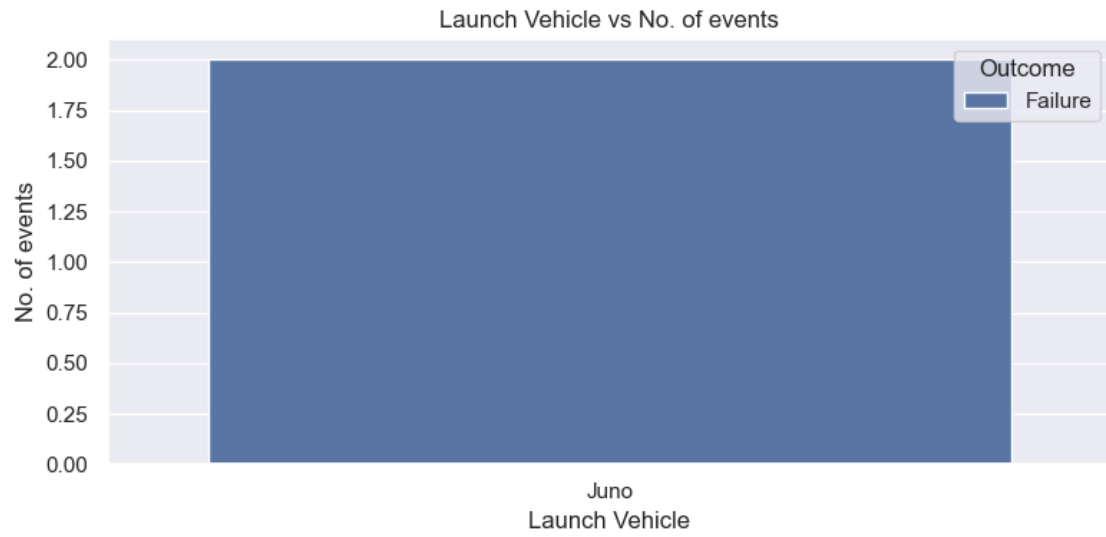


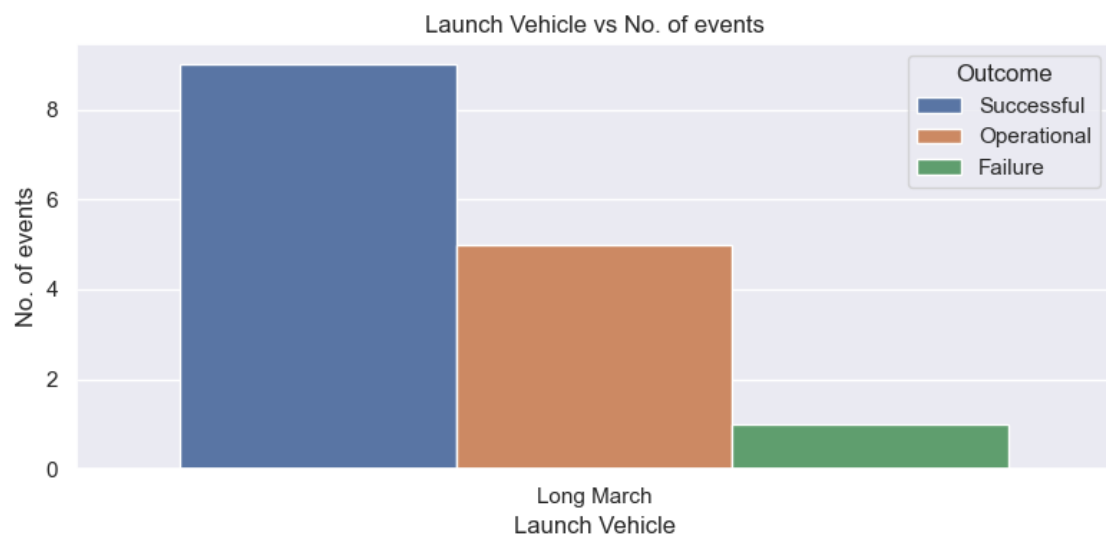
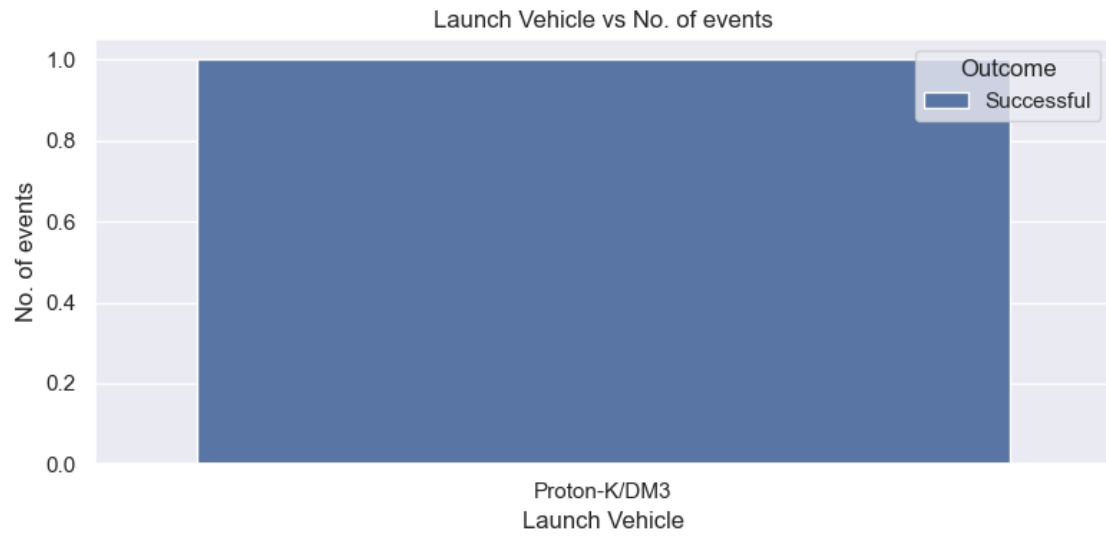


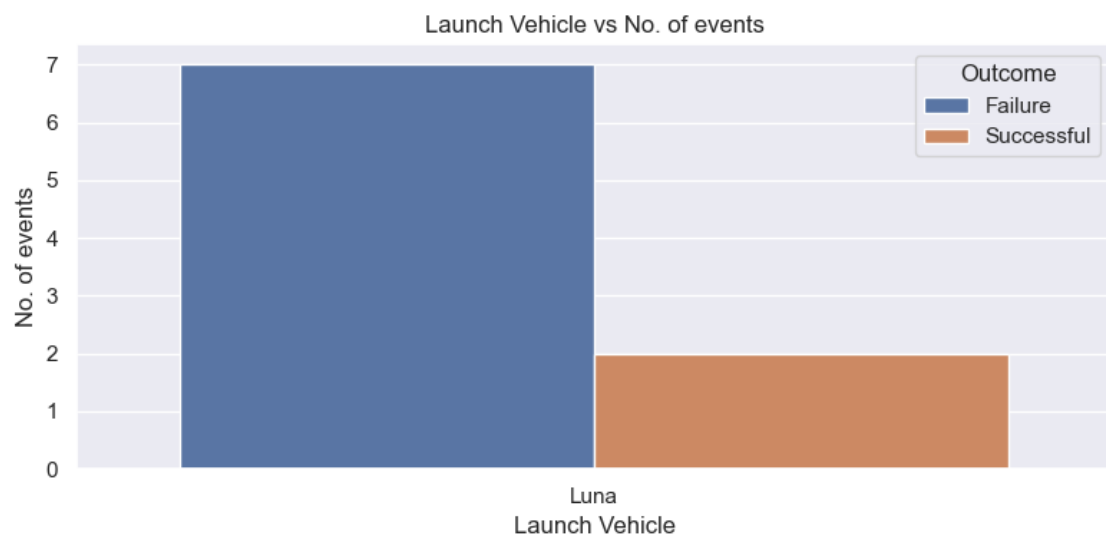
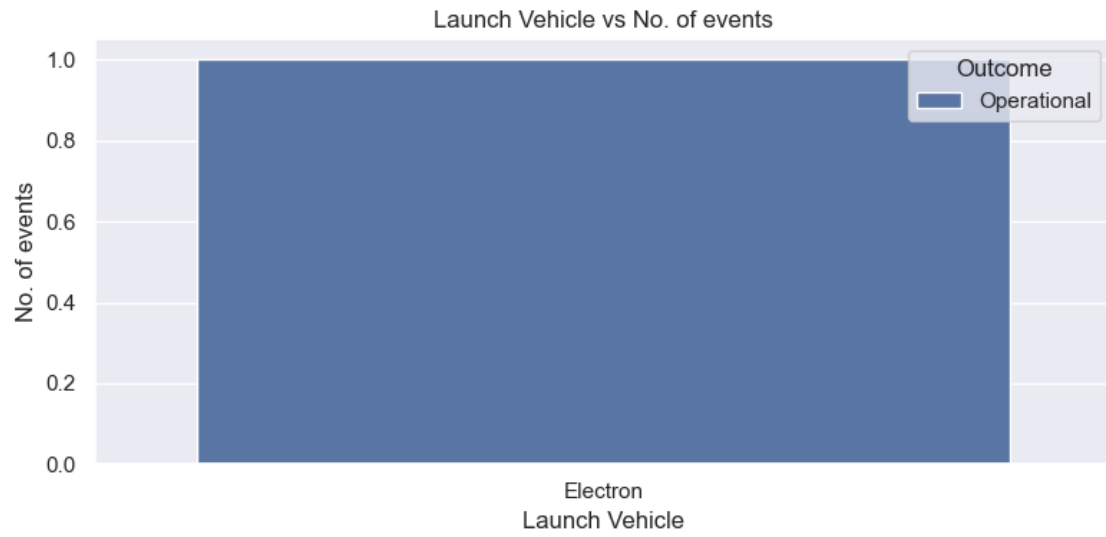


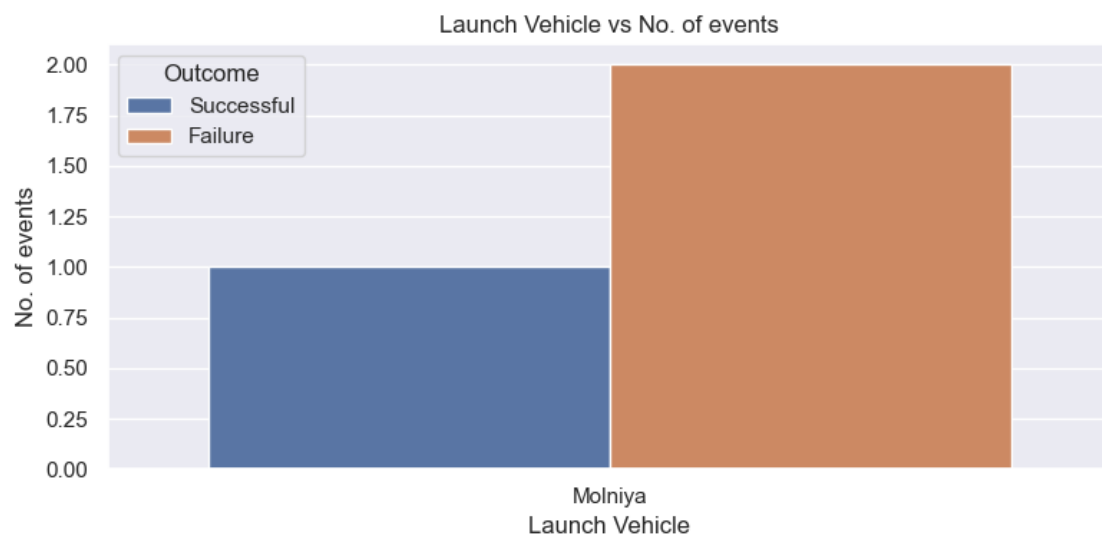
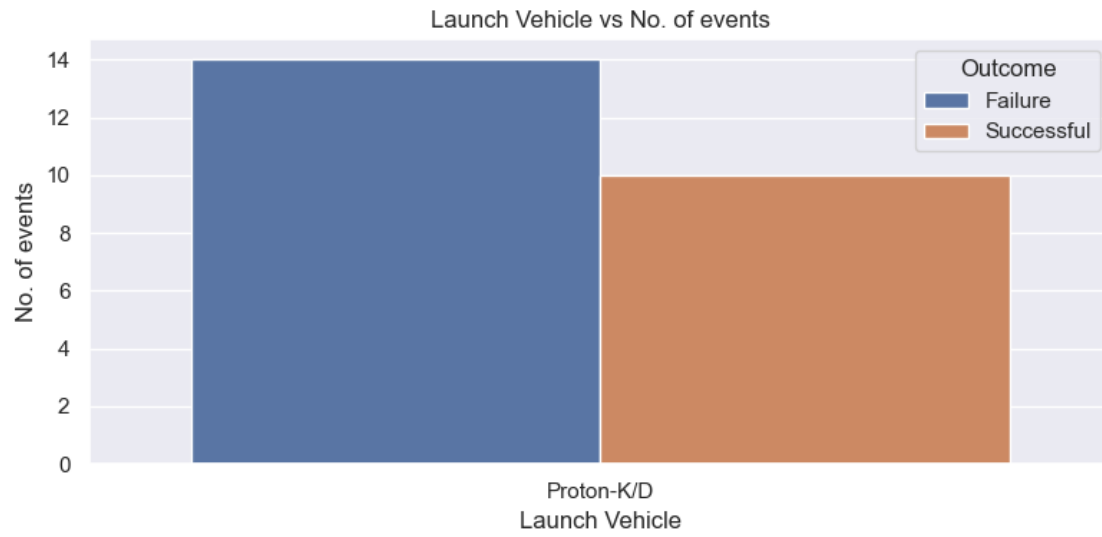


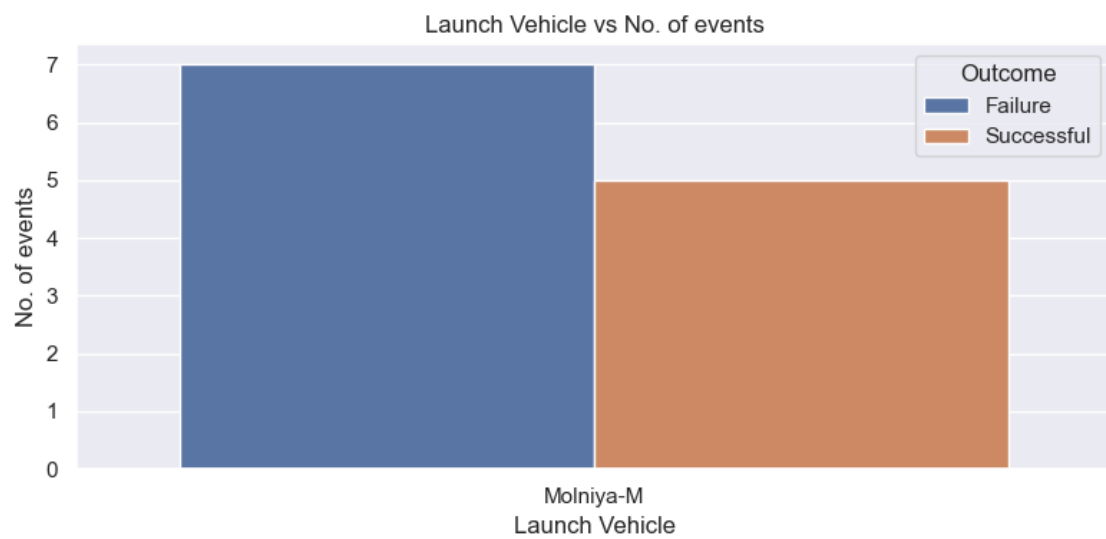
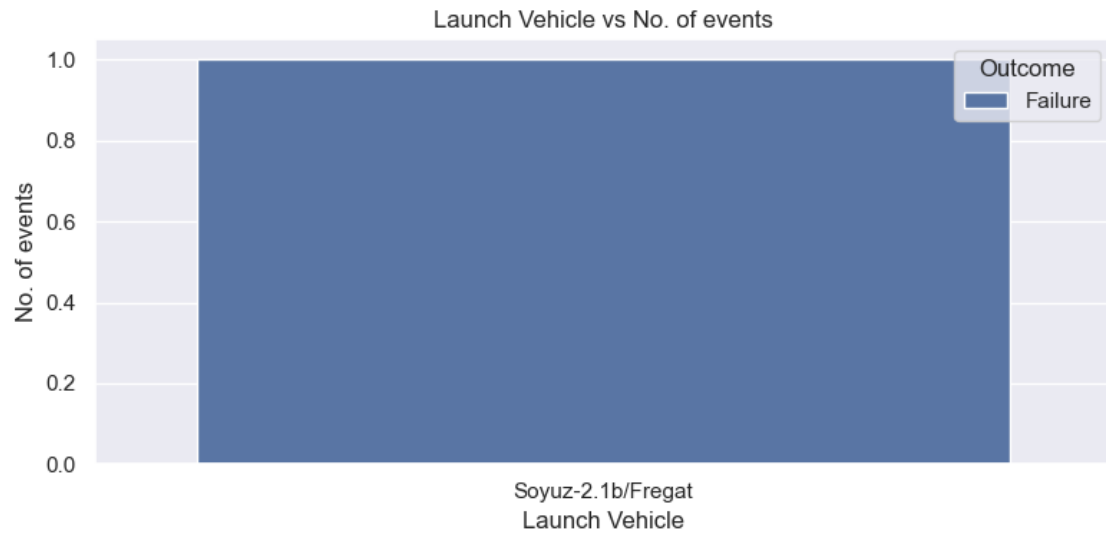


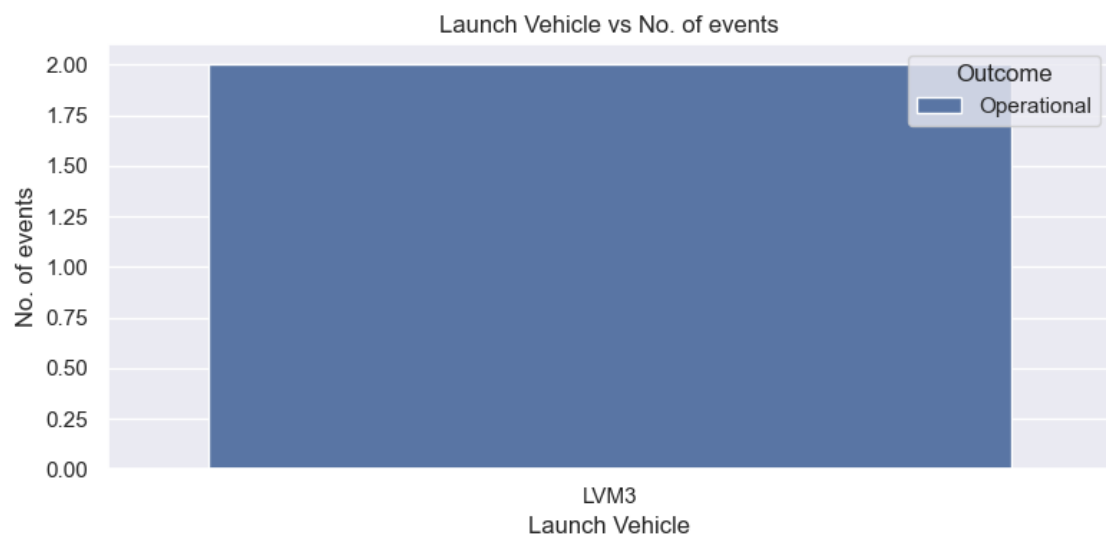
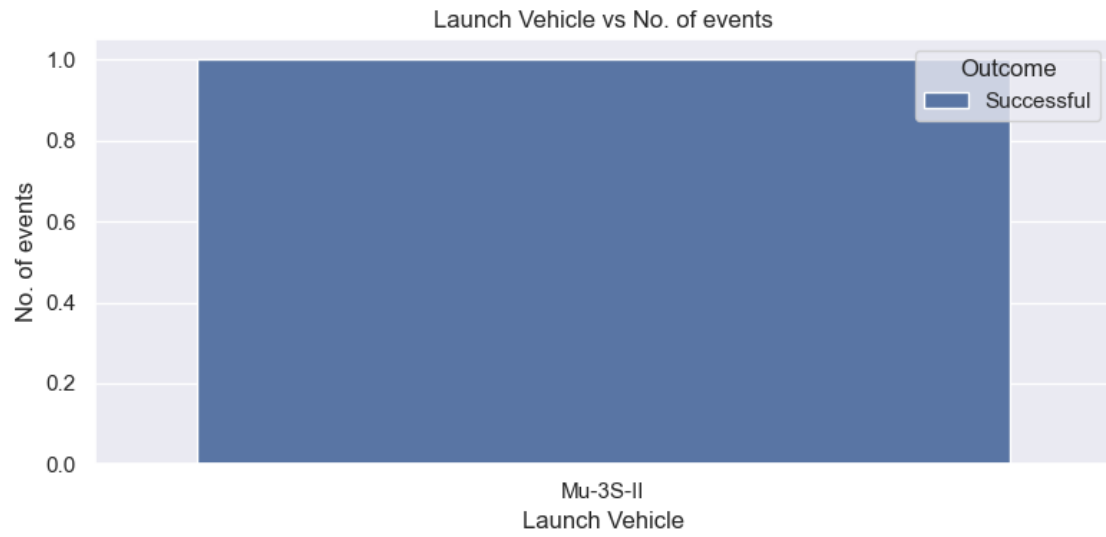


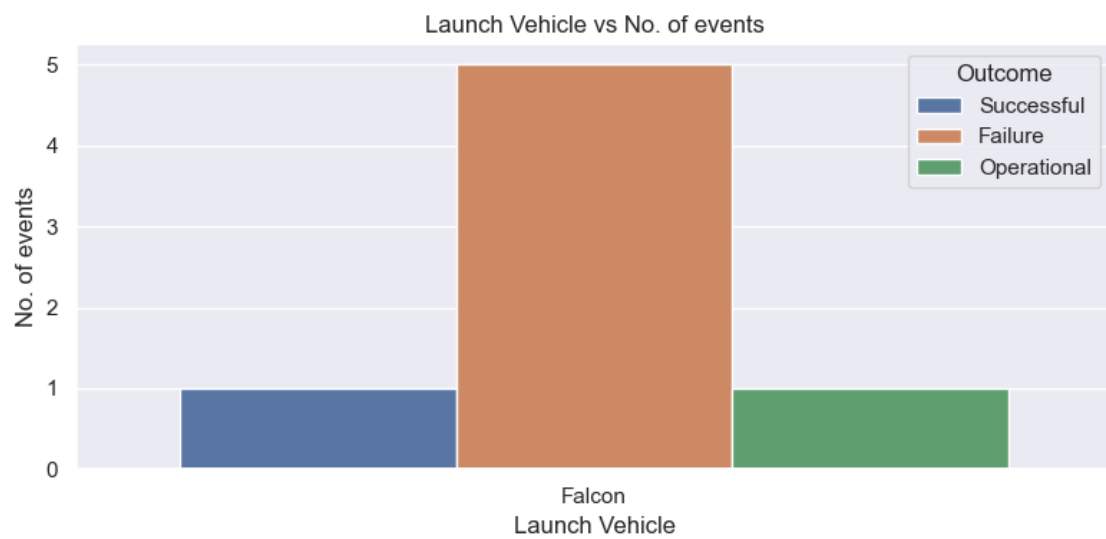
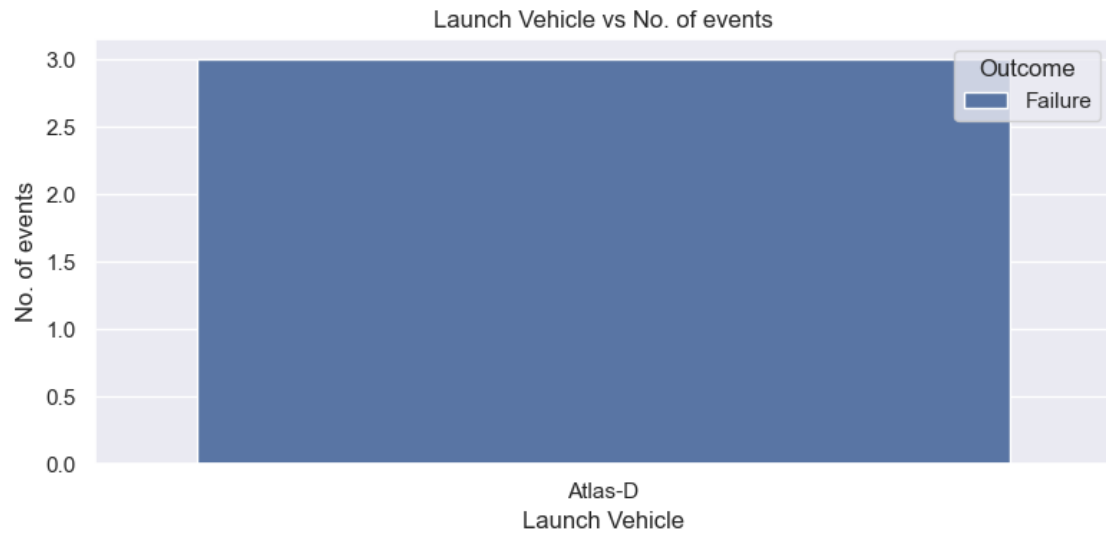


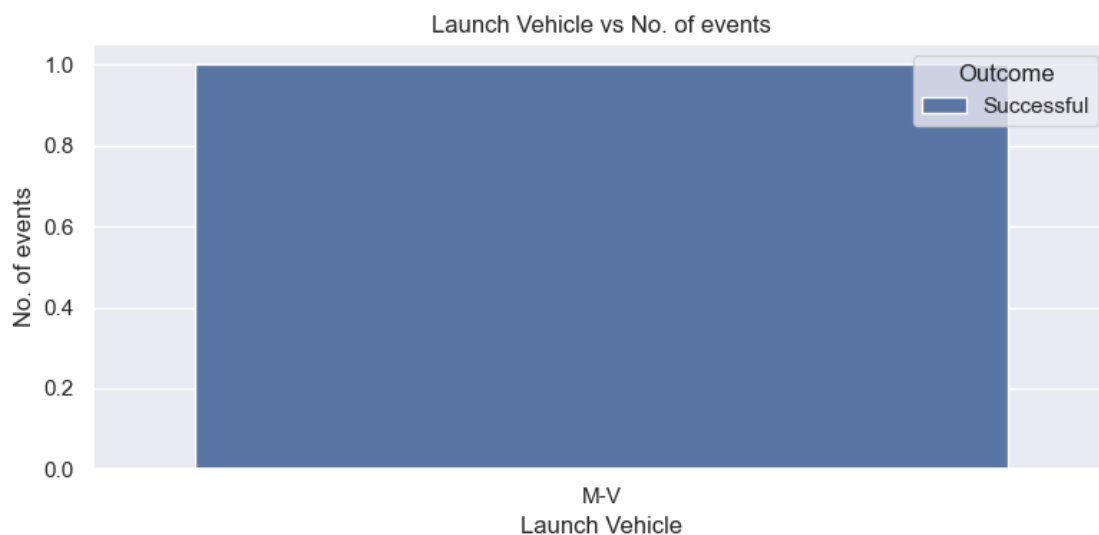
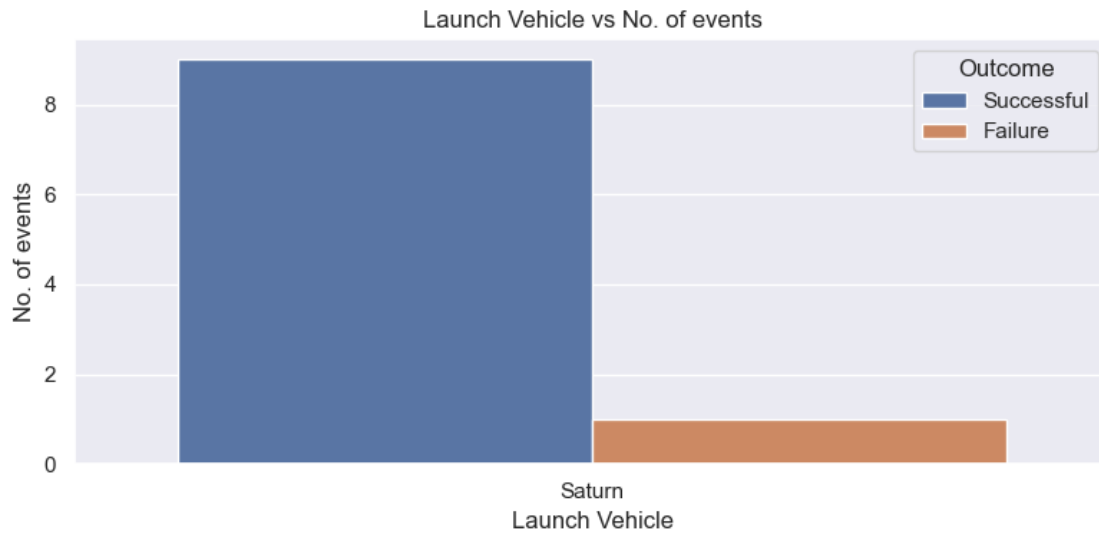












Observation:

1. Ariane is the Launch Vehicle which has 1 successful mission and 1 enroute mission
2. Falcon has 5, SLS has 5, Molniya-M has 7 and Proton-K/D has around 14 failure mission which is the highest.
3. Long march has around 9, Saturn has around 9, Delta has 10, Proton-K/D has 10, Atlas has 14 Successful missions which is the highest.

```
[56]: df['Spacecraft'] = df['Spacecraft'].str.split().str[0]
```

```
[57]: df['Spacecraft'].unique()
```

```
[57]: array(['Pioneer', 'Luna', 'E-1A', 'Ranger', 'Kosmos', 'Zond', 'Surveyor',
        'Explorer', 'Lunar', 'Soyuz', 'Apollo', 'PFS-1', 'PFS-2',
        'Mariner', 'ISEE-3', 'Hiten', 'Hagoromo', 'Geotail', 'WIND',
        'Clementine', 'HGS-1', 'Nozomi', 'WMAP', 'SMART-1', 'STEREO',
        'ARTEMIS', 'Kaguya', 'Okina', 'Ouna', "Chang'e", 'Chandrayaan-1',
        'Moon', 'LCROSS', 'Ebb', 'Flow', 'LADEE', 'Yutu', 'Return',
        'Manfred', 'TESS', 'Queqiao', 'Longjiang-1', 'Longjiang-2',
        'Yutu-2', 'Beresheet', 'Chandrayaan-2', 'CAPSTONE', 'Danuri',
        'Artemis', 'LunaH-Map', 'ArgoMoon', 'LunIR', 'Near-Earth',
        'EQUULEUS', 'OMOTENASHI', 'BioSentinel', 'CubeSat', 'Team',
        'Hakuto-R', 'SORA-Q', 'Rashid', 'Jupiter', 'Chandrayaan-3'],
        dtype=object)
```

```
[58]: # Rashid is the spacecraft used by UAE
df[df['Spacecraft'] == 'Rashid']
```

```
[58]:
```

	Mission	Spacecraft	Launch Date	Mission Type	Outcome	\
153	Emirates Lunar Mission	Rashid	11-Dec-22	Rover	Failure	

	Additional Information	Country	launch vehicle
153	Lunar rover demonstration launched with Hakuto...	UAE	Falcon

```
[59]: df['Launch Date'] = pd.to_datetime(df['Launch Date'])
```

We can see this conversion has converted the year 1958 as 2058 and so on..

```
[60]: Year_valid = range(1950, 2025)
df['Launch year'] = df['Launch Date'].dt.year
```

```
[61]: year_list = []
for year in df['Launch year']:
    last_two_digits = int(str(year)[-2:])
    if last_two_digits > 50:
        modified_year = '19' + str(year)[2:]
        year_list.append(modified_year)
    else:
        year_list.append(year)
df['Launch year'] = year_list
```

```
[62]: df['Launch year']
```

```
[62]: 0      1958
      1      1958
      2      1958
      3      1958
      4      1958
      ...
     153     2022
```

```

154    2022
155    2023
156    2023
157    2023
Name: Launch year, Length: 157, dtype: object

```

```
[63]: df.head()
```

```

[63]:
      Mission Spacecraft Launch Date Mission Type Outcome \
0  Pioneer 0 (Able I)   Pioneer  2058-08-17    Orbiter  Failure
1      Luna E-1 No.1      Luna  2058-09-23    Impactor  Failure
2  Pioneer 1 (Able II)   Pioneer  2058-10-11    Orbiter  Failure
3      Luna E-1 No.2      Luna  2058-10-11    Impactor  Failure
4  Pioneer 2 (Able III)   Pioneer  2058-11-08    Orbiter  Failure

      Additional Information Country launch vehicle \
0  First attempted launch beyond Earth orbit; fai...   USA      Thor
1  Failed to orbit; rocket disintegrated due to e... Russia      Luna
2  Failed to orbit; premature second-stage cutoff...   USA      Thor
3  Failed to orbit; carrier rocket exploded due t... Russia      Luna
4  Failed to orbit; premature second-stage cutoff...   USA      Thor

      Launch year
0          1958
1          1958
2          1958
3          1958
4          1958

```

```
[ ]:
```

```
[64]: space_mission = df
```

```

[65]: # Space mission happened in india
space_mission[space_mission['Country'] == 'India']

```

```

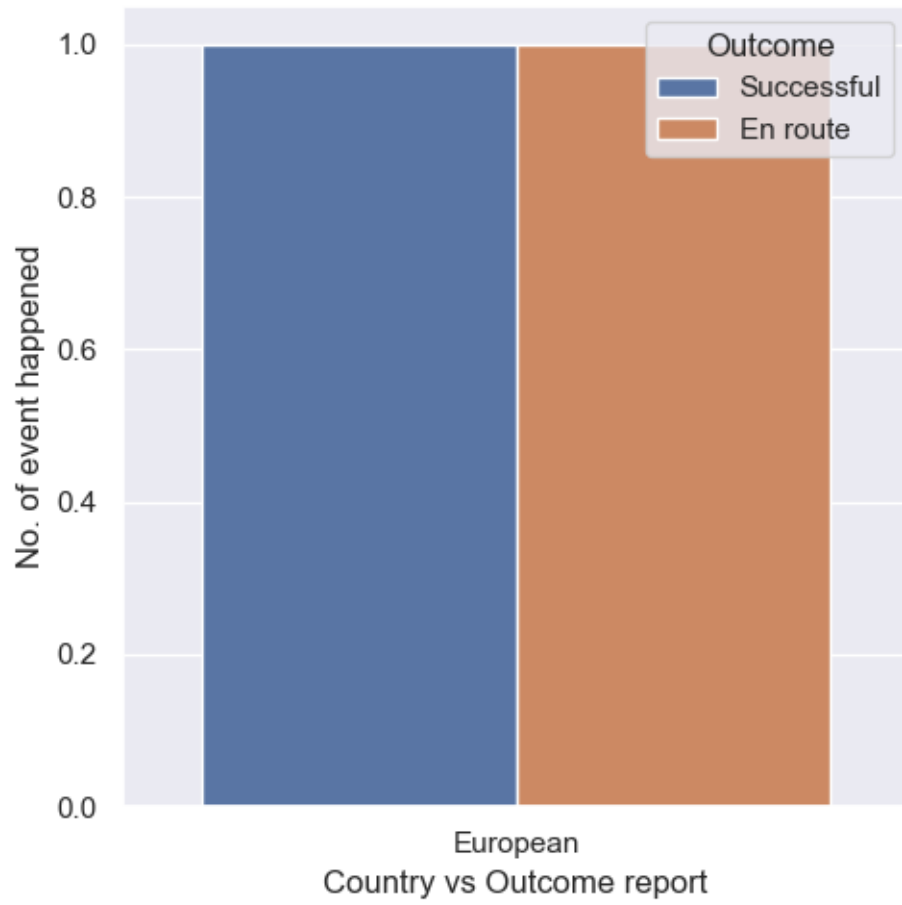
[65]:
      Mission Spacecraft Launch Date Mission Type Outcome \
113 Chandrayaan-1 Chandrayaan-1  2008-10-22    Orbiter  Successful
114 Chandrayaan-1      Moon  2008-10-22    Impactor  Successful
133 Chandrayaan-2 Chandrayaan-2  2019-07-22    Orbiter  Operational
156 Chandrayaan-3 Chandrayaan-3  2023-07-14    Orbiter  Operational

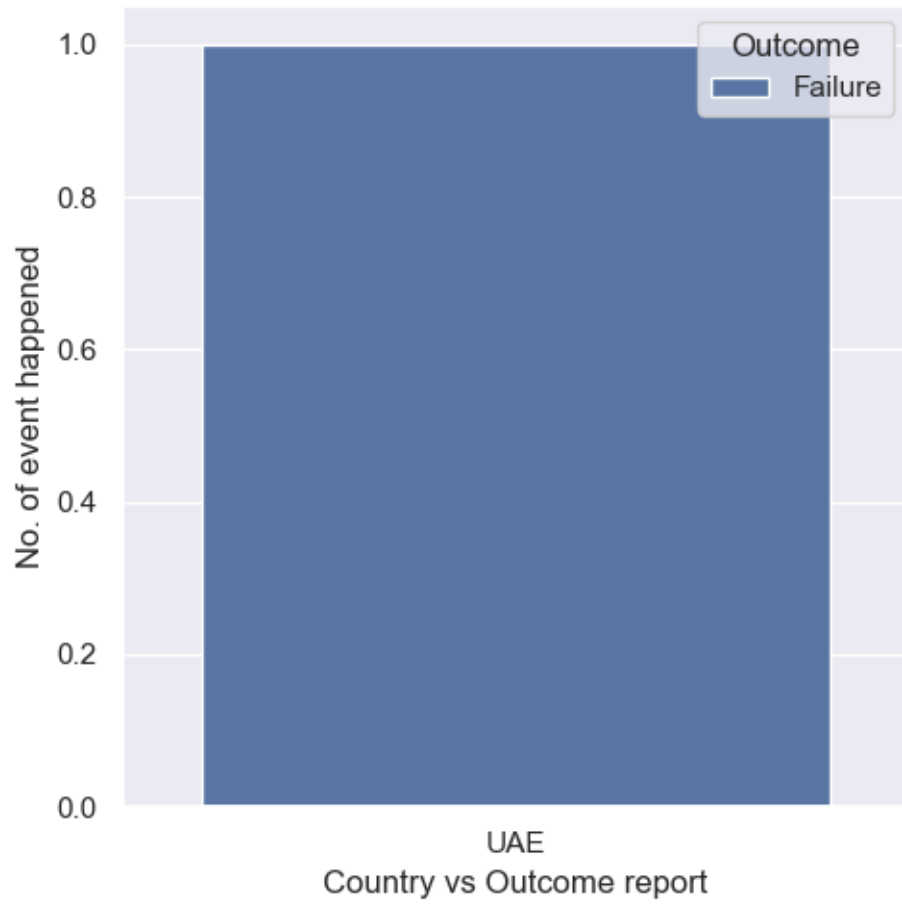
      Additional Information Country launch vehicle \
113 Moon Impact Probe deployed, discovered water i... India      PSLV-XL
114 Moon Impact Probe deployed, discovered water i... India      PSLV-XL
133 Orbiter operational, but Lander and Rover were... India      LVM3
156 Lander and rover operational. Soft-landed near... India      LVM3

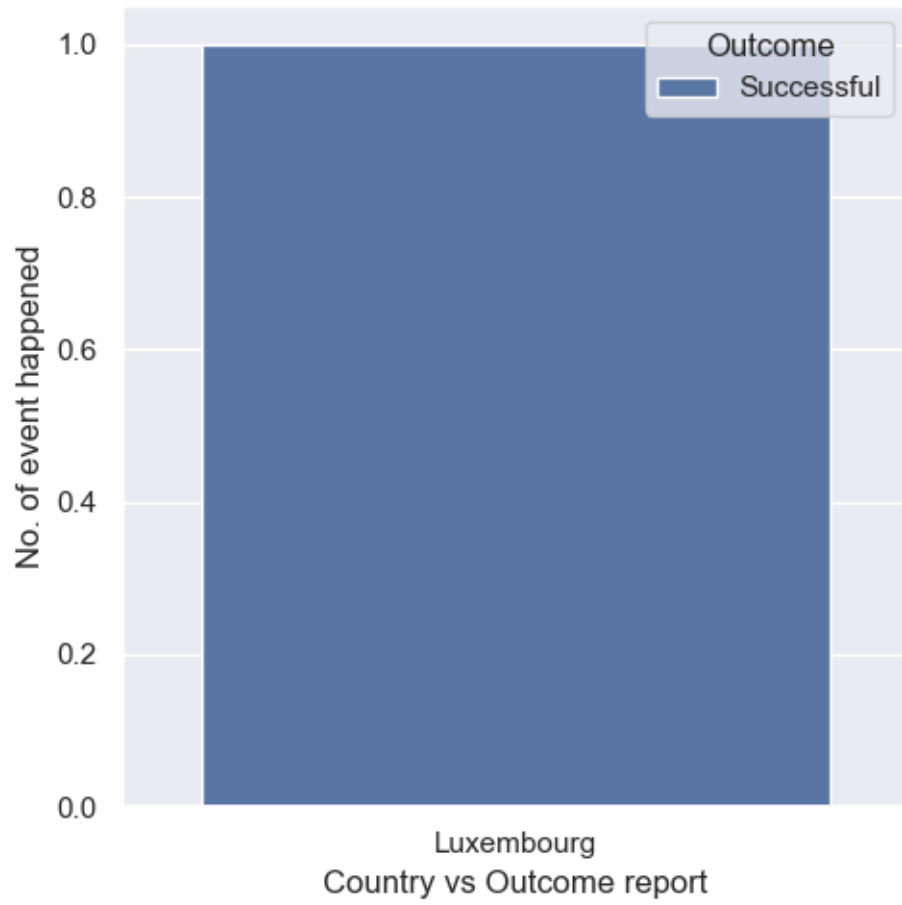
```

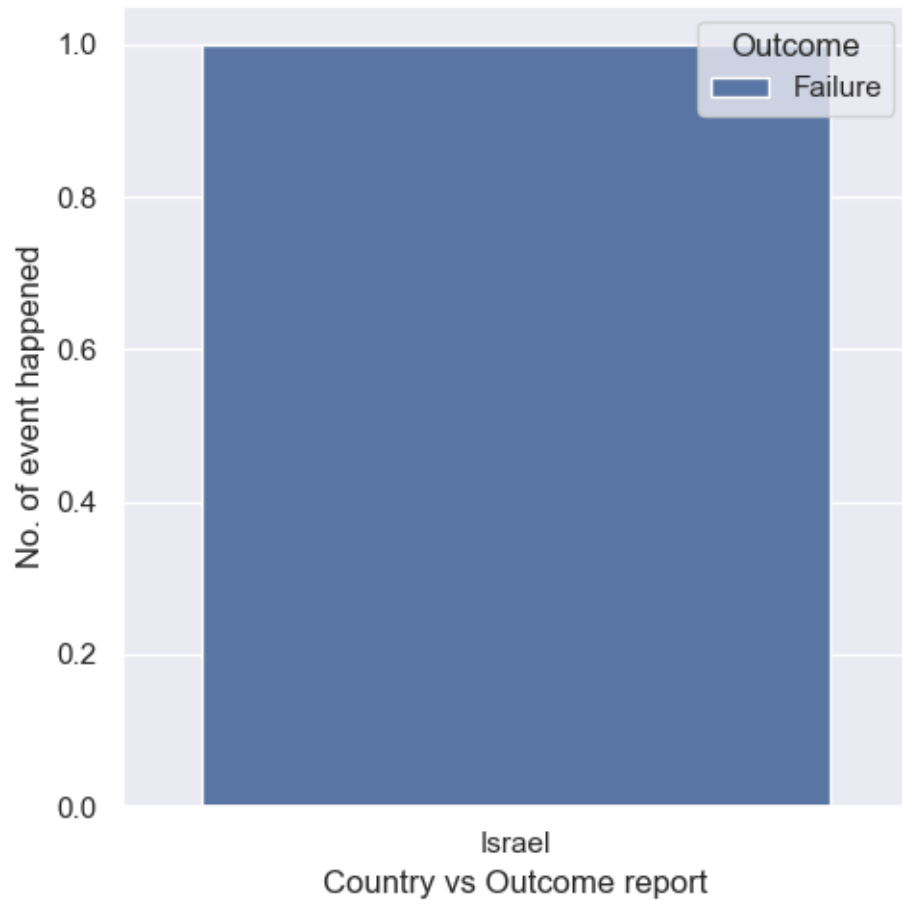
	Launch year
113	2008
114	2008
133	2019
156	2023

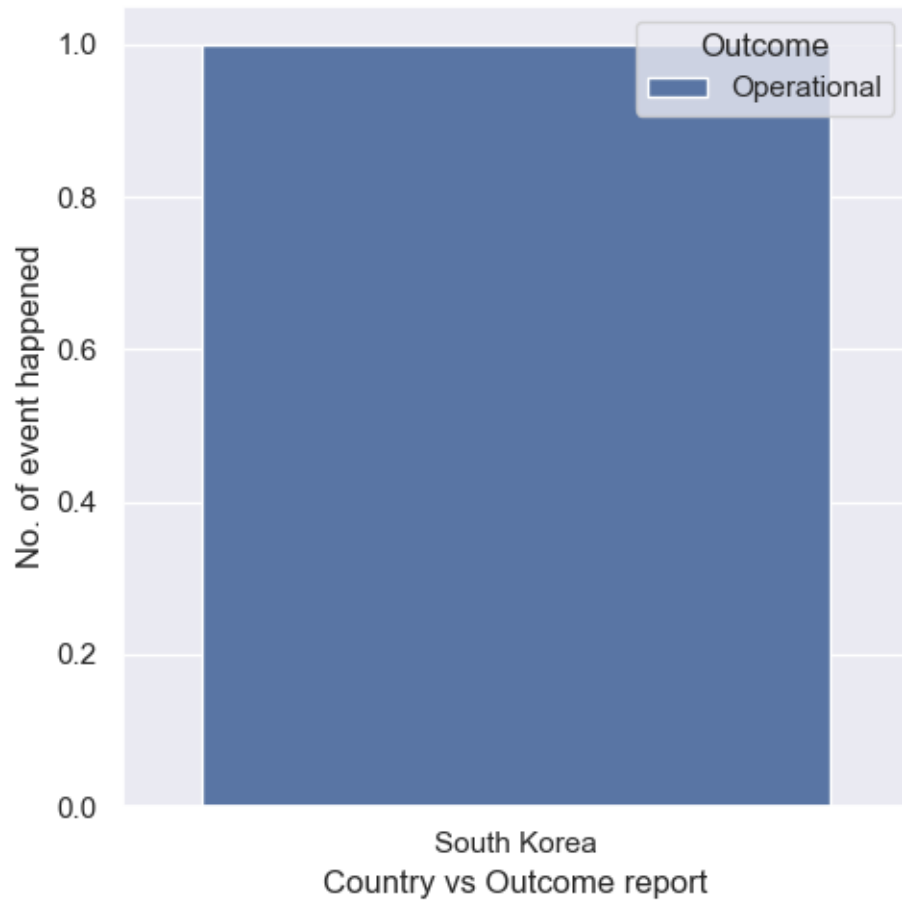
```
[66]: # Plot to show the space mission by each country with respect to the outcome
      ↪happened.
list1= []
for i in space_mission['Country']:
    list1.append(i)
Country_Name=list(set(list1))
for i in Country_Name:
    df1 = space_mission[space_mission['Country'] == i]
    sns.set(rc = {'figure.figsize':(5,5)})
    sns.countplot(data= df1, x= 'Country', hue= 'Outcome')
    plt.xlabel("Country vs Outcome report")
    plt.ylabel("No. of event happened")
    plt.tight_layout()
    plt.show()
```

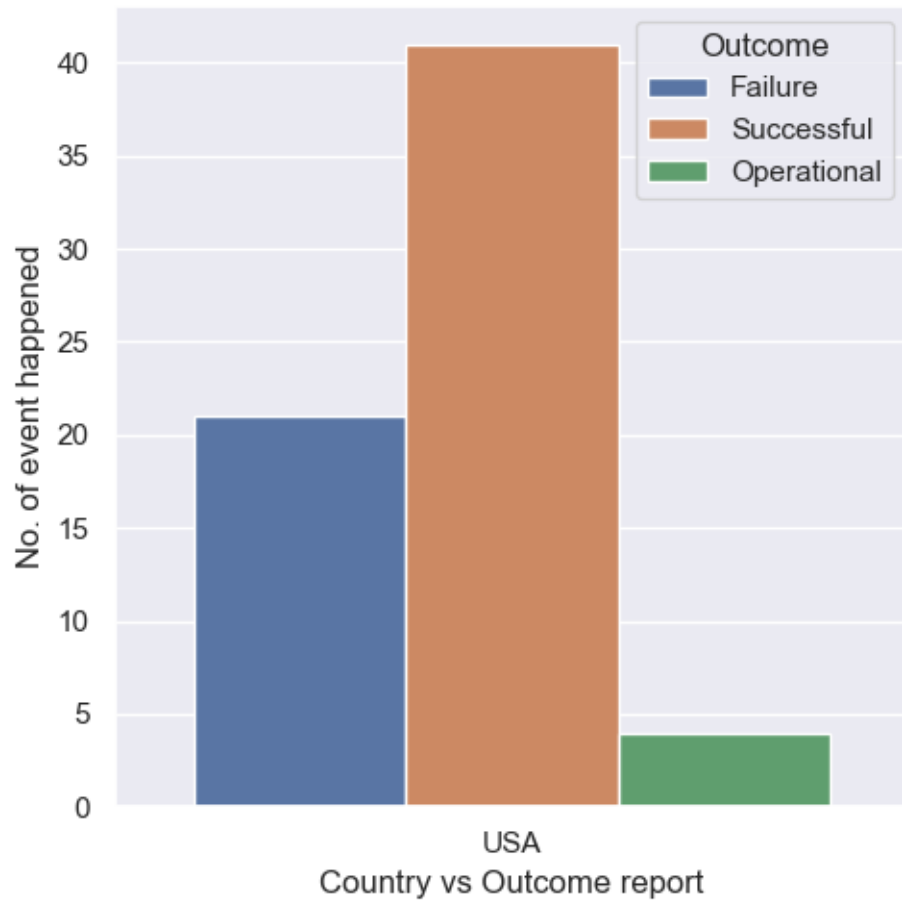


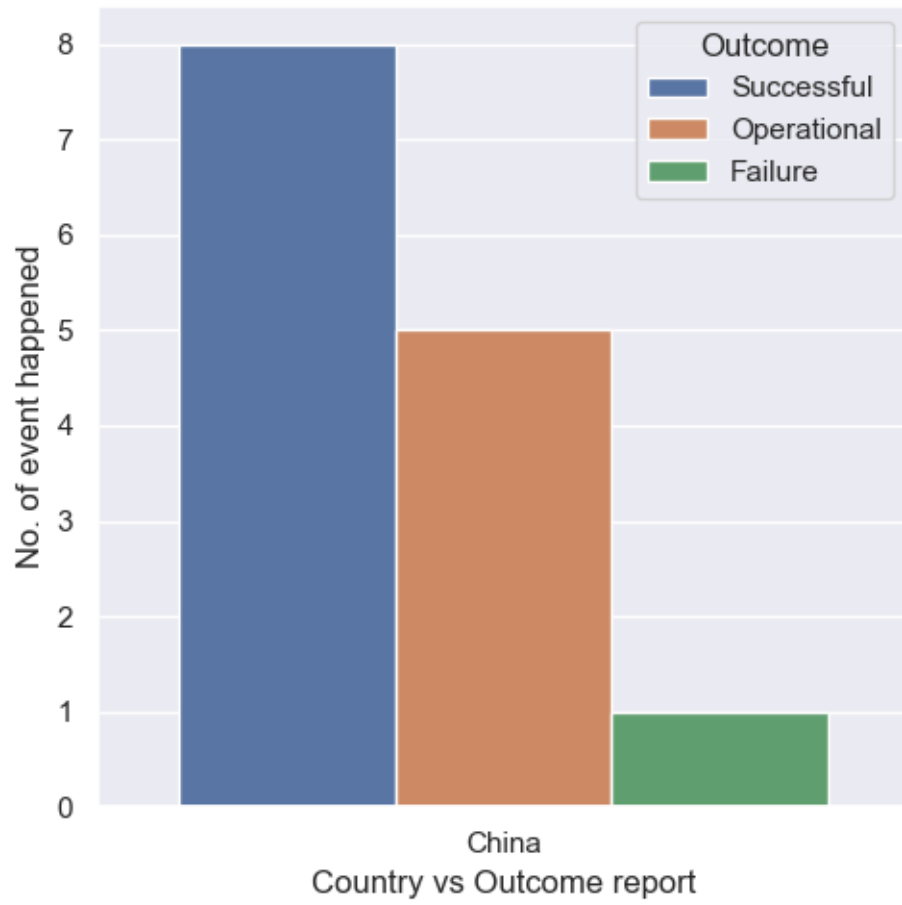


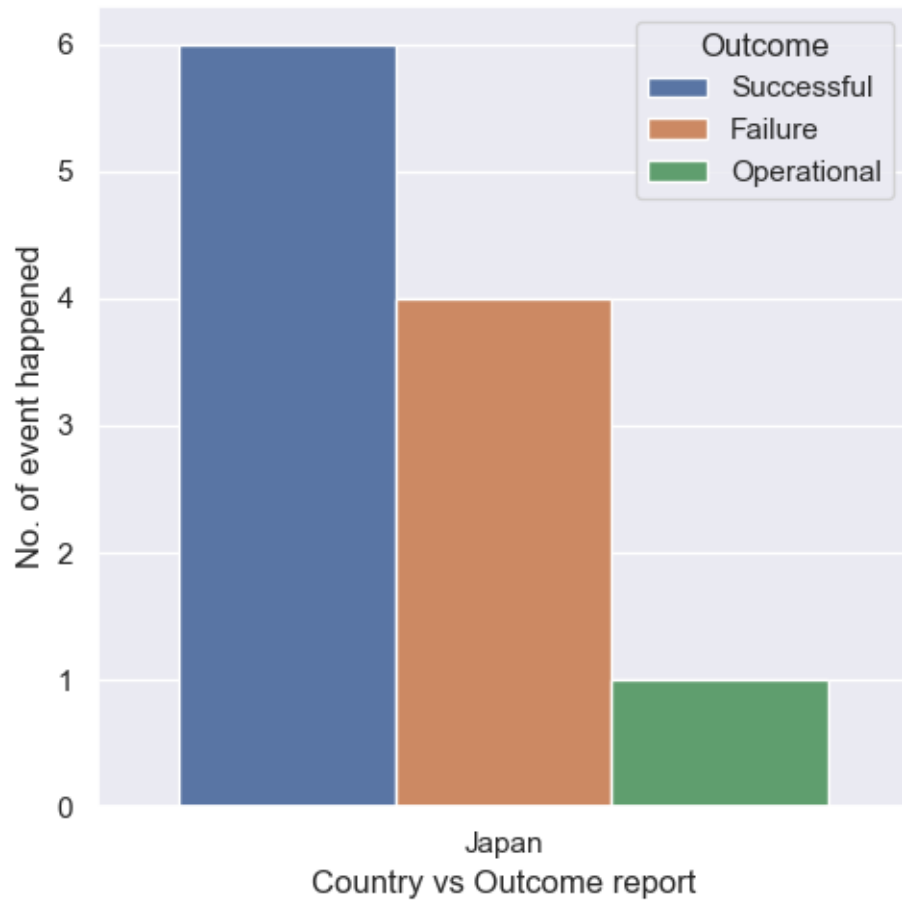


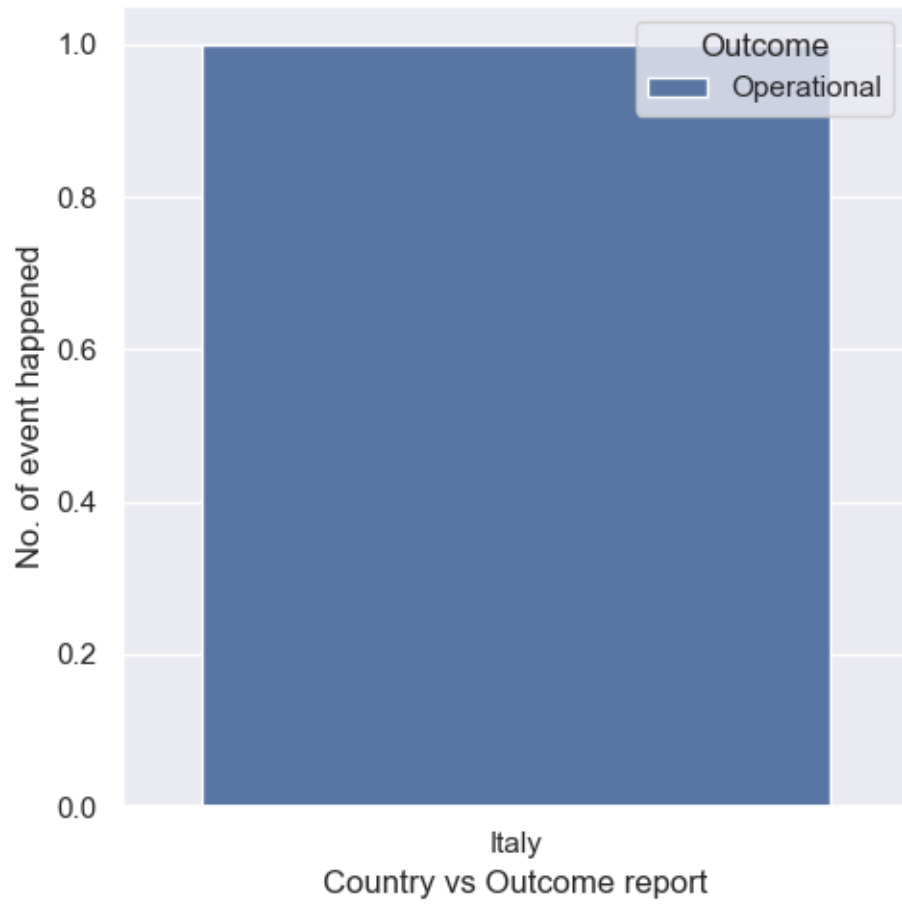


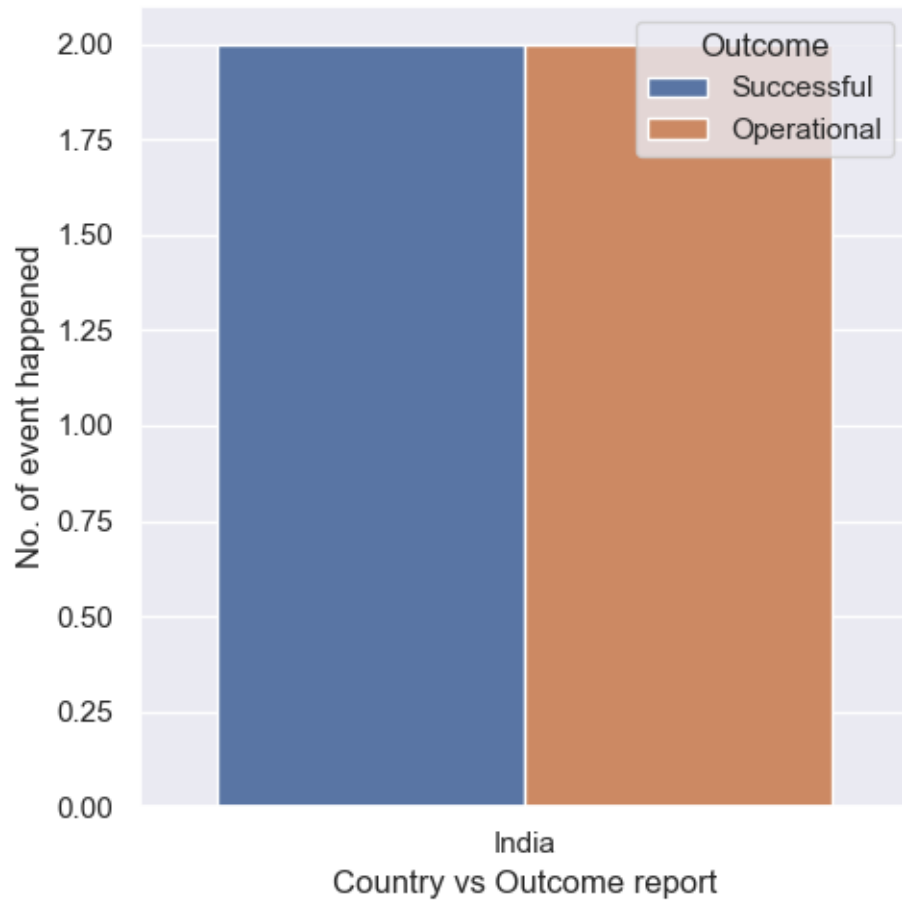


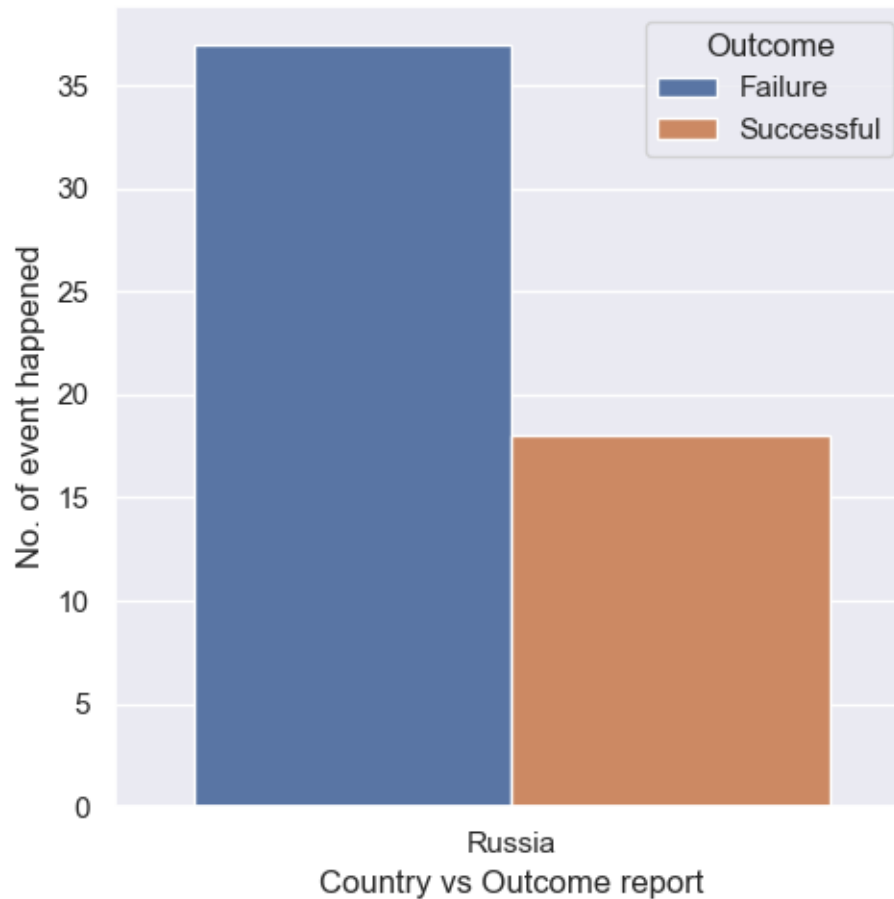










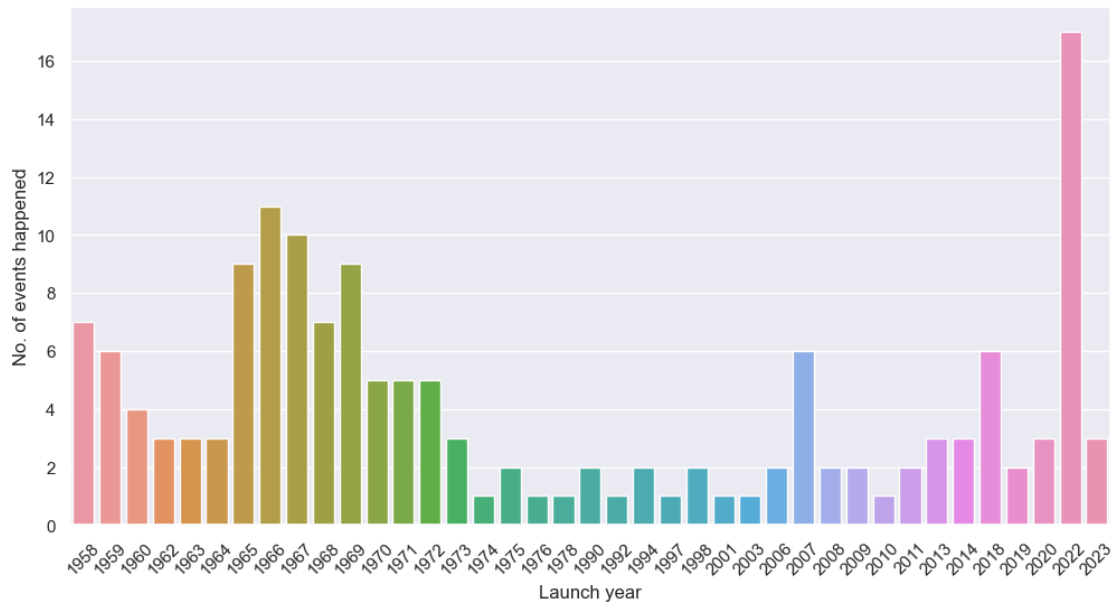


Observations

1. USA has very high number of missions where 40 missions are successful and 20+ mission failure.
2. China has 8 Successfull missions, where only 1 mission failed.
3. Russia has 35+ successful missions and 15+ failed missions
4. India has 2 successful missions and 2 operational missions.

```
[67]: # Lets plot the no. of missions launched per year.
sns.set(rc= {'figure.figsize':(12,6)})
sns.countplot(data=space_mission, x='Launch year' )
plt.xticks(rotation= 45)
plt.xlabel("Launch year")
plt.ylabel("No. of events happened")
```

```
[67]: Text(0, 0.5, 'No. of events happened')
```



Observations

1. Highest no. of space missions happened in the year 2022, around 16+
2. Between year 1965 to 1972, there were many mission which took place.
3. There were 6 missions happened in the year 2007 and 2018.

0.0.1 If the outcome is operational then we could consider that mission to be successful as it was not a failure at the time of launch. Also We can now divide outcome into successful and failure. Operational → Successful. Also we have to drop en-route outcome for now

```
[68]: space_mission[space_mission['Outcome'] == 'En route']
```

```
[68]:
```

	Mission	Spacecraft	Launch Date	Mission Type	Outcome	\
155	Jupiter Icy Moons Explorer	Jupiter	2023-04-14	Flyby	En route	

	Additional Information	Country	\
155	Will fly by the Moon in August 2024 en route t...	European	

	launch vehicle	Launch year
155	Ariane	2023

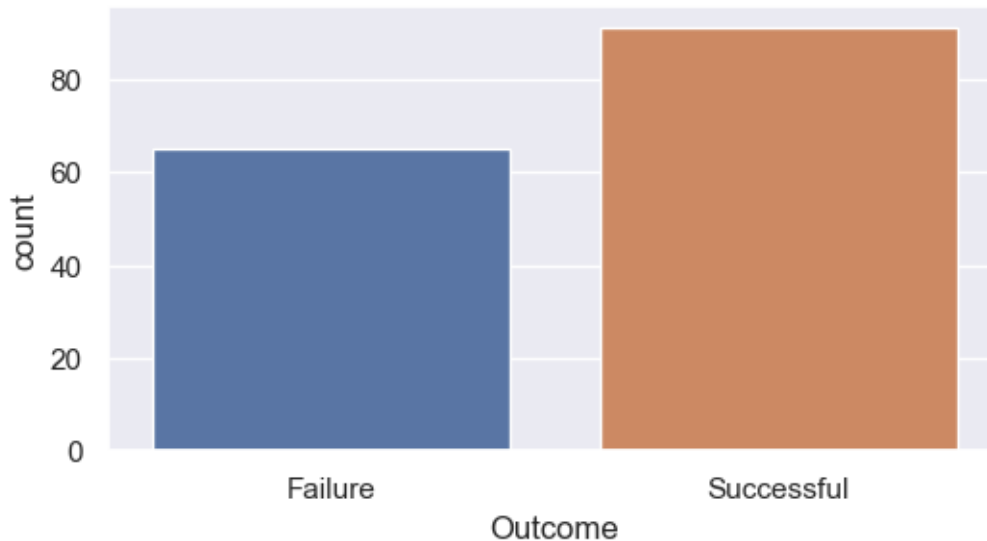
```
[69]: space_mission.drop(155, axis=0, inplace= True)
space_mission['Outcome'].replace('Operational','Successful', inplace= True)
```

```
[70]: space_mission['Outcome'].unique()
```

```
[70]: array(['Failure', 'Successful'], dtype=object)
```

```
[71]: sns.set(rc= {'figure.figsize':(6,3)})
sns.countplot(data= space_mission, x= 'Outcome')
```

```
[71]: <Axes: xlabel='Outcome', ylabel='count'>
```



Observation:

1. After conversion we have 80+ successful missions so far.
2. failure missions are in between 60 to 70 in counts.

```
[72]: space_mission.head(5)
```

```
[72]:
```

	Mission	Spacecraft	Launch Date	Mission Type	Outcome	\
0	Pioneer 0 (Able I)	Pioneer	2058-08-17	Orbiter	Failure	
1	Luna E-1 No.1	Luna	2058-09-23	Impactor	Failure	
2	Pioneer 1 (Able II)	Pioneer	2058-10-11	Orbiter	Failure	
3	Luna E-1 No.2	Luna	2058-10-11	Impactor	Failure	
4	Pioneer 2 (Able III)	Pioneer	2058-11-08	Orbiter	Failure	

	Additional Information	Country	launch vehicle	\
0	First attempted launch beyond Earth orbit; fai...	USA	Thor	
1	Failed to orbit; rocket disintegrated due to e...	Russia	Luna	
2	Failed to orbit; premature second-stage cutoff...	USA	Thor	
3	Failed to orbit; carrier rocket exploded due t...	Russia	Luna	
4	Failed to orbit; premature second-stage cutoff...	USA	Thor	

Launch year

```

0      1958
1      1958
2      1958
3      1958
4      1958

```

```
[73]: # Dropping columns like - Launch Date, Additional Information
space_mission.drop(['Launch Date', 'Additional Information'], axis = 1, inplace_
↳= True)
```

```
[74]: space_mission.head(5)
```

```
[74]:
```

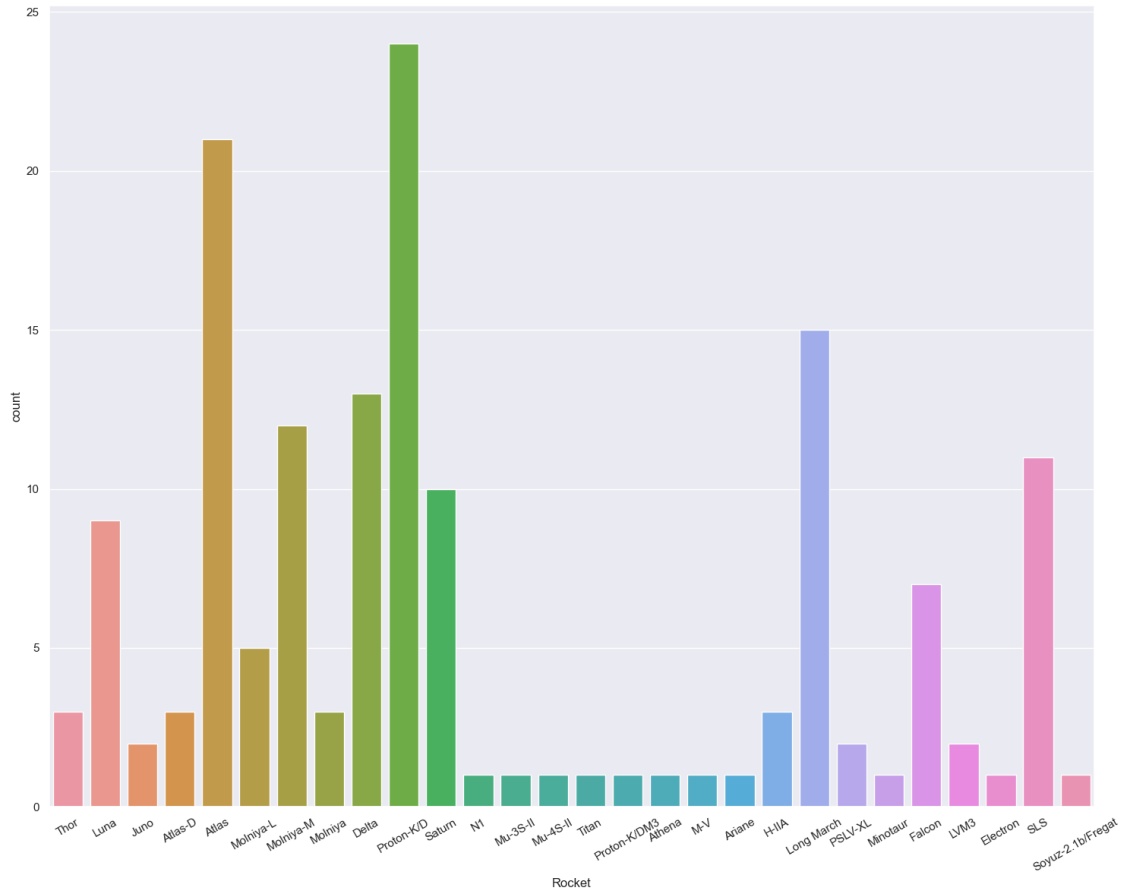
	Mission	Spacecraft	Mission Type	Outcome	Country	\
0	Pioneer 0 (Able I)	Pioneer	Orbiter	Failure	USA	
1	Luna E-1 No.1	Luna	Impactor	Failure	Russia	
2	Pioneer 1 (Able II)	Pioneer	Orbiter	Failure	USA	
3	Luna E-1 No.2	Luna	Impactor	Failure	Russia	
4	Pioneer 2 (Able III)	Pioneer	Orbiter	Failure	USA	

	launch vehicle	Launch year
0	Thor	1958
1	Luna	1958
2	Thor	1958
3	Luna	1958
4	Thor	1958

```
[75]: space_mission['Mission Type'].unique()
```

```
[75]: array(['Orbiter', 'Impactor', 'Flyby', 'Lander', 'Crewed orbiter',
        'Orbiter,Lander,Rover', 'Lander,Sample Return', 'Rover',
        'Flyby / Impactor (post mission)', 'Relay Satellite',
        'Sample Return'], dtype=object)
```

```
[76]: # check which rocket has been used and how many times.
sns.set(rc= {'figure.figsize':(15,12)})
sns.countplot(data=space_mission, x= 'launch vehicle')
plt.xticks(rotation=30)
plt.xlabel("Rocket")
plt.tight_layout()
```



Observation:

1. Rocket 'Proton-K/D' is used most of the time, aprox 22+ times
2. Atlas rockets have been used more than 20 times.
3. At the third place, Long March rocket was used, that is more than 15 times.

```
[77]: # lets save the modified CSV for future use
df.to_csv('data/data_cleaned_before_SM', index= False)
```

```
[78]: space_mission.to_csv('data/space_mission', index= False)
```

```
[79]: df
```

	Mission	Spacecraft	Mission Type	Outcome	Country \
0	Pioneer 0 (Able I)	Pioneer	Orbiter	Failure	USA
1	Luna E-1 No.1	Luna	Impactor	Failure	Russia
2	Pioneer 1 (Able II)	Pioneer	Orbiter	Failure	USA
3	Luna E-1 No.2	Luna	Impactor	Failure	Russia
4	Pioneer 2 (Able III)	Pioneer	Orbiter	Failure	USA

```

..
152          SORA-Q          SORA-Q          Rover          Failure          Japan
153 Emirates Lunar Mission          Rashid          Rover          Failure          UAE
154          Lunar Flashlight          Lunar          Flyby          Failure          USA
156          Chandrayaan-3 Chandrayaan-3 Orbiter Successful          India
157          Luna 25          Luna          Lander          Failure          Russia

```

```

          launch vehicle Launch year
0          Thor          1958
1          Luna          1958
2          Thor          1958
3          Luna          1958
4          Thor          1958
..
152          Falcon          2022
153          Falcon          2022
154          Falcon          2022
156          LVM3          2023
157 Soyuz-2.1b/Fregat          2023

```

[156 rows x 7 columns]

[]:

[]:

[]:

[]: