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 databse
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]:
```
# Droping 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]:
```python
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 abbvr.
      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)
```

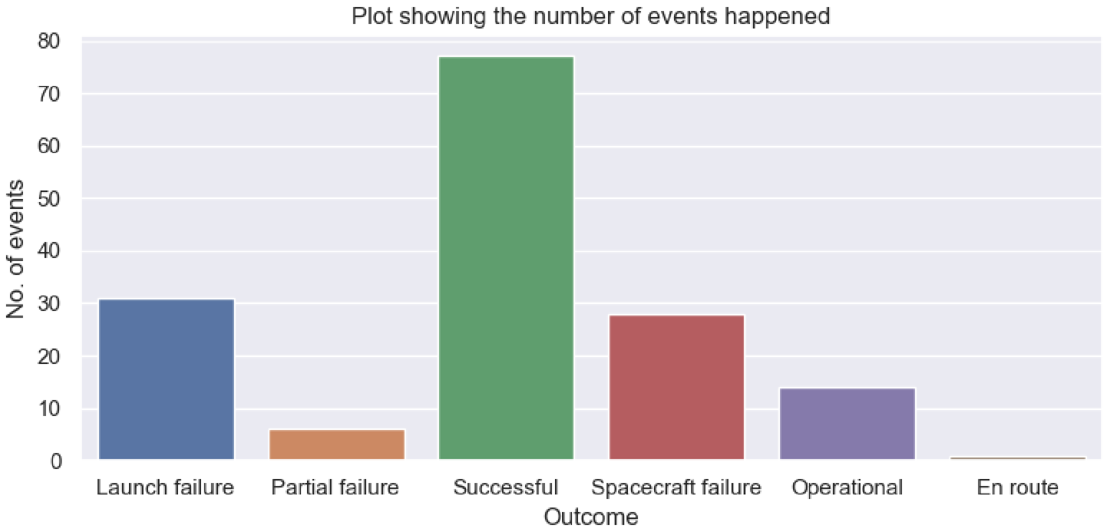
```
[38]: # Fetching the Launch Vehicle from the 'Carrier Rocket' column.
      df['launch vehicle']= df['Carrier Rocket'].str.split().str[0]
      #df['launch vehicle']= df['Carrier Rocket'].str.strip().str[:10]
```

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

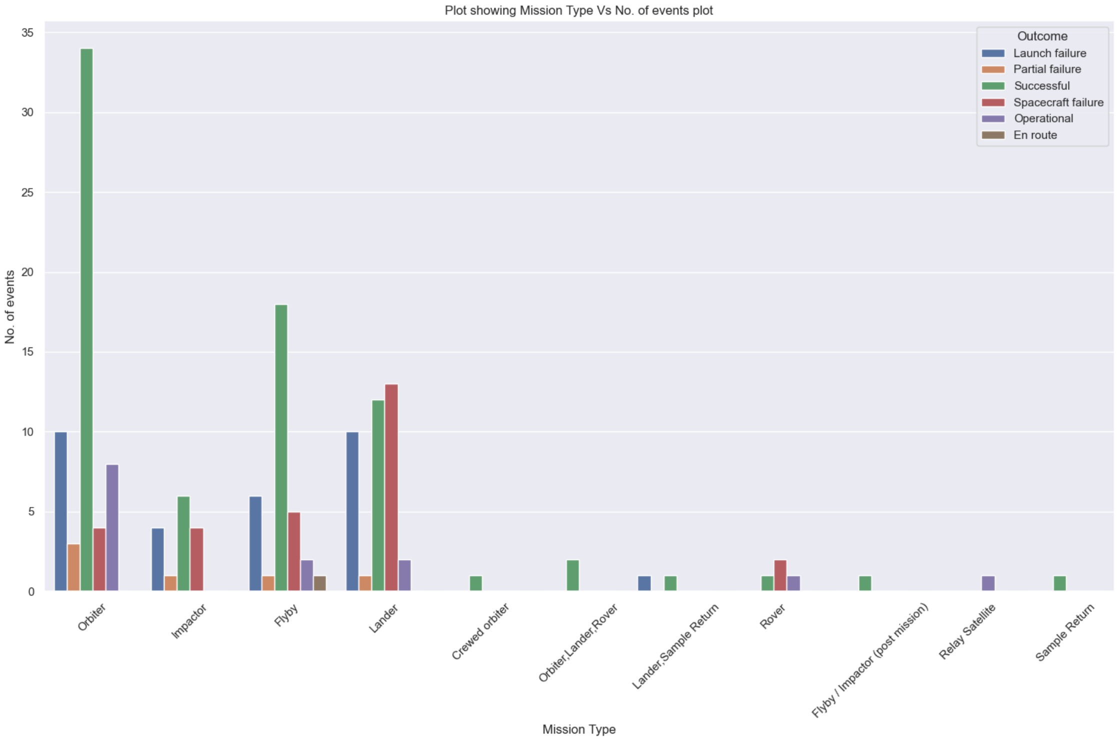
```
[39]: array(['Thor', 'Luna', 'Juno', 'Atlas-D', 'Atlas', 'Molniya-L',
             'Molniya-M', 'Molniya', 'Delta', 'Proton-K/D', 'Saturn', 'N1',
             'Mu-3S-II', 'Mu-4S-II', 'Titan', 'Proton-K/DM3', 'Athena', 'M-V',
             'Ariane', 'H-IIA', 'Long', 'PSLV-XL', 'Minotaur', 'Falcon',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



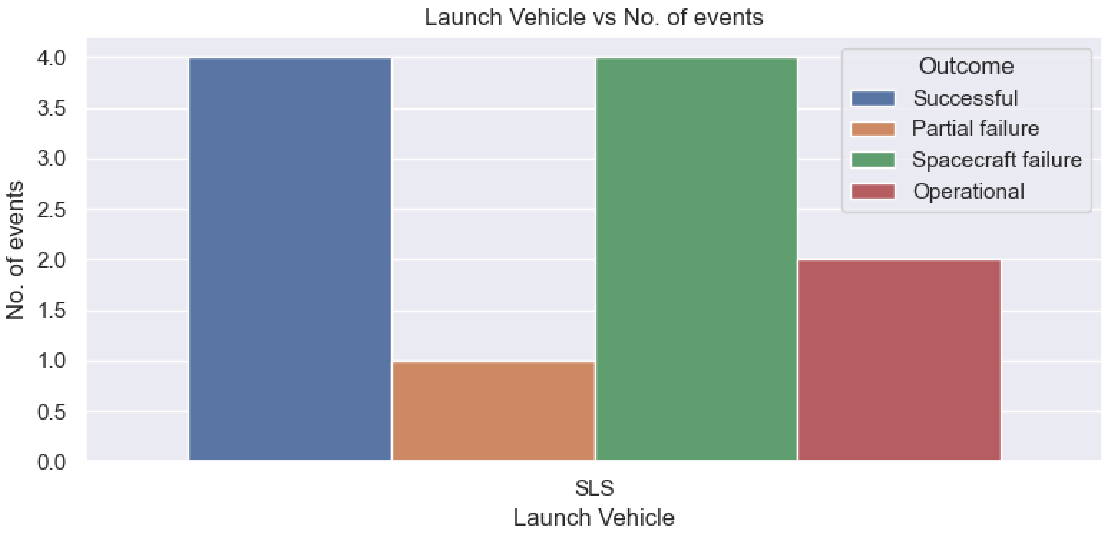
```
[42]: sns.set(rc = {'figure.figsize':(15,10)})
      sns.countplot(data=df, x= 'Mission Type', hue= 'Outcome')
      plt.xticks(rotation=45)
      plt.title("Plot showing Mission Type Vs No. of events plot")
      plt.xlabel("Mission Type")
      plt.ylabel("No. of events")
      plt.tight_layout()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

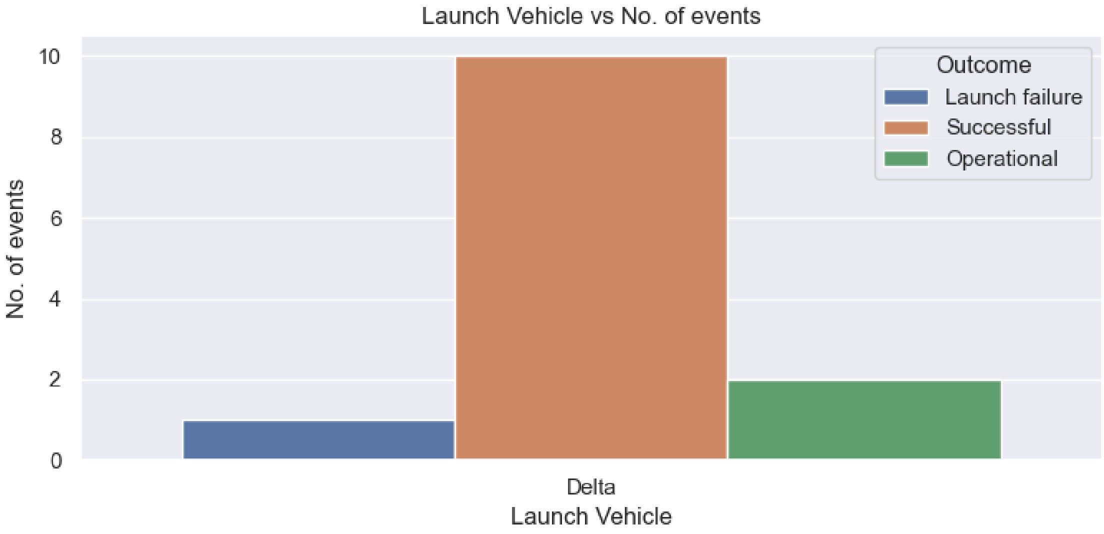


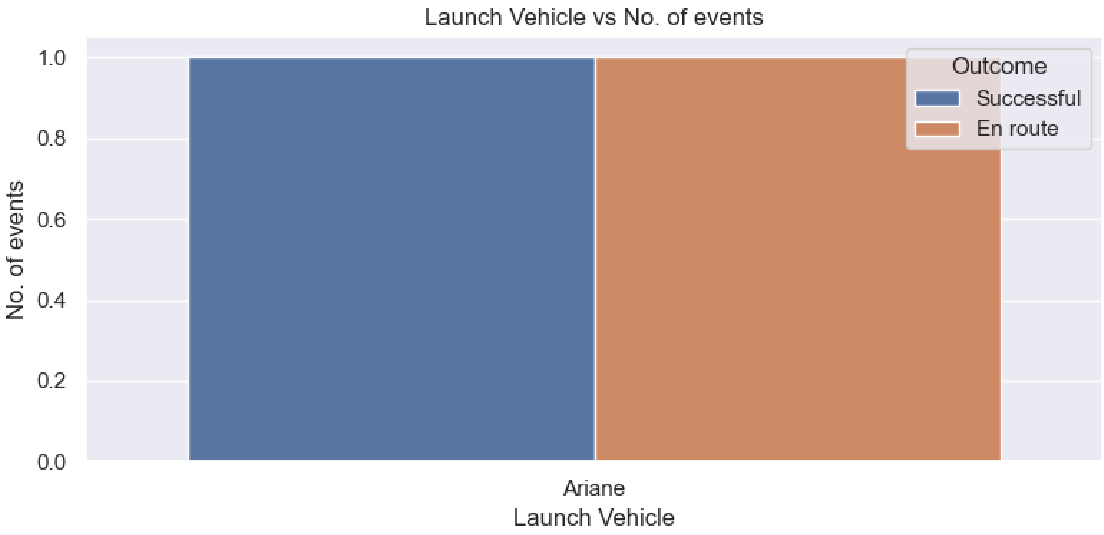
[ ]:

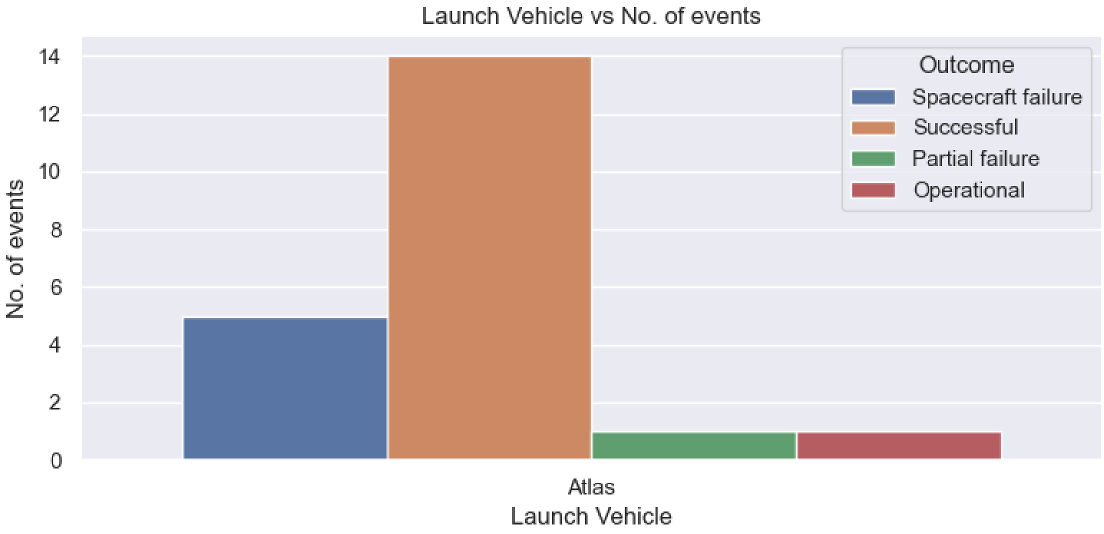
[43]:

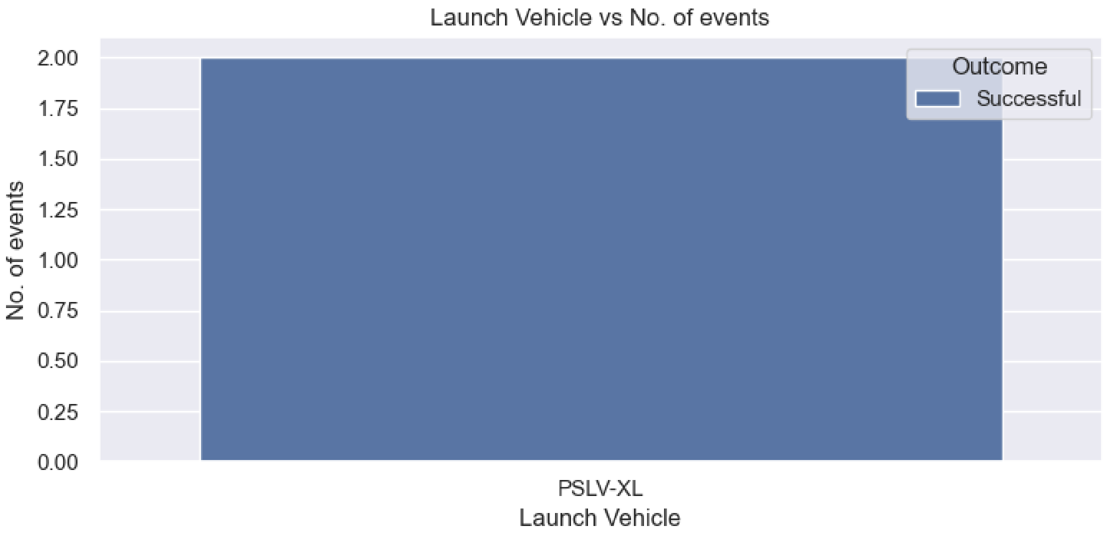
```
# "Launch Vehicle vs No. of events"
list1 = []
for i in df['launch vehicle']:
    list1.append(i)
l1= list(set(list1))
for j in l1:
    df1= df[df['launch vehicle'] == j]
    sns.set(rc = {'figure.figsize':(8,4)})
    sns.countplot(data=df1, x='launch vehicle', hue= 'Outcome')
    plt.title("Launch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

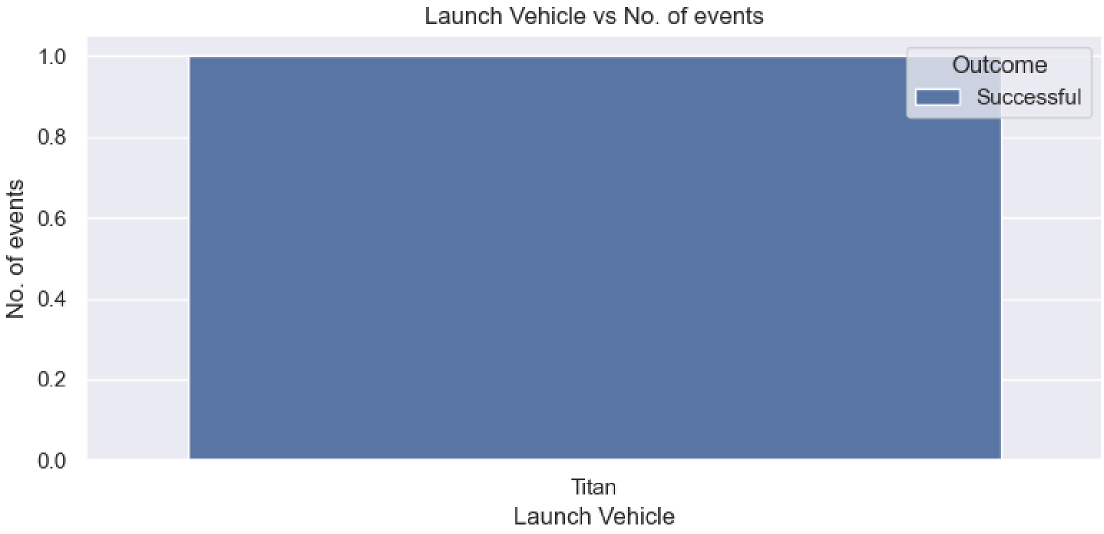

Launch Vehicle vs No. of events
No. of events
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Outcome
Successful
Partial failure
Spacecraft failure
Operational
SLS
Launch Vehicle

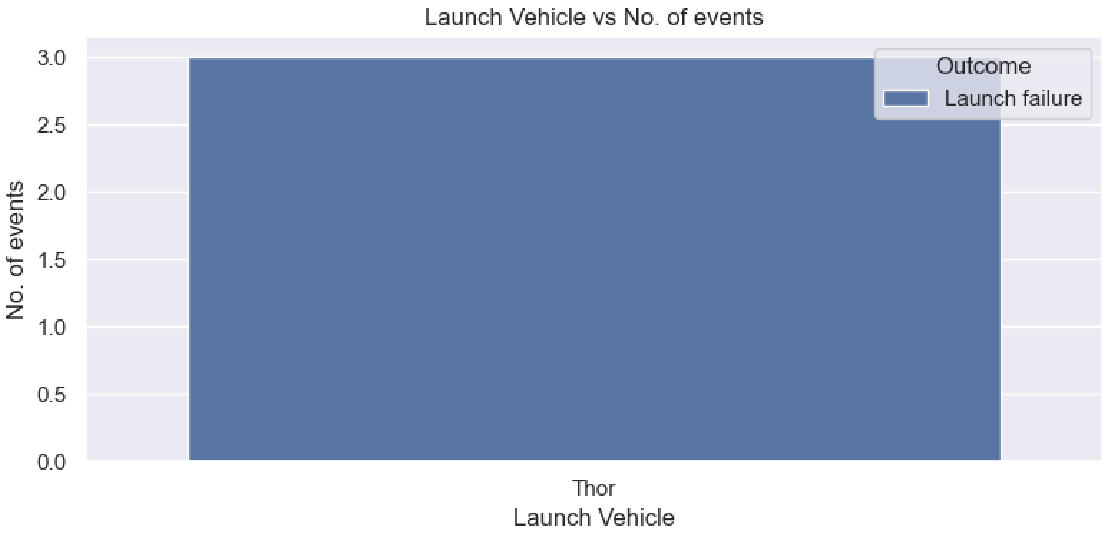

Launch Vehicle vs No. of events
No. of events
10
8
6
4
2
0
Outcome
Launch failure
Successful
Operational
Delta
Launch Vehicle

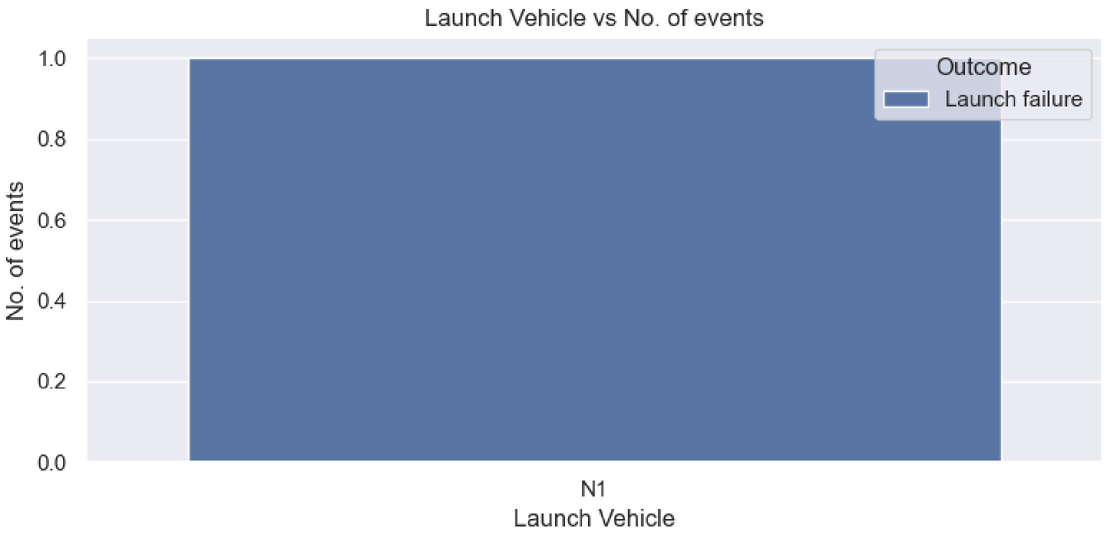

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Ariane
Launch Vehicle
Outcome
Successful
En route

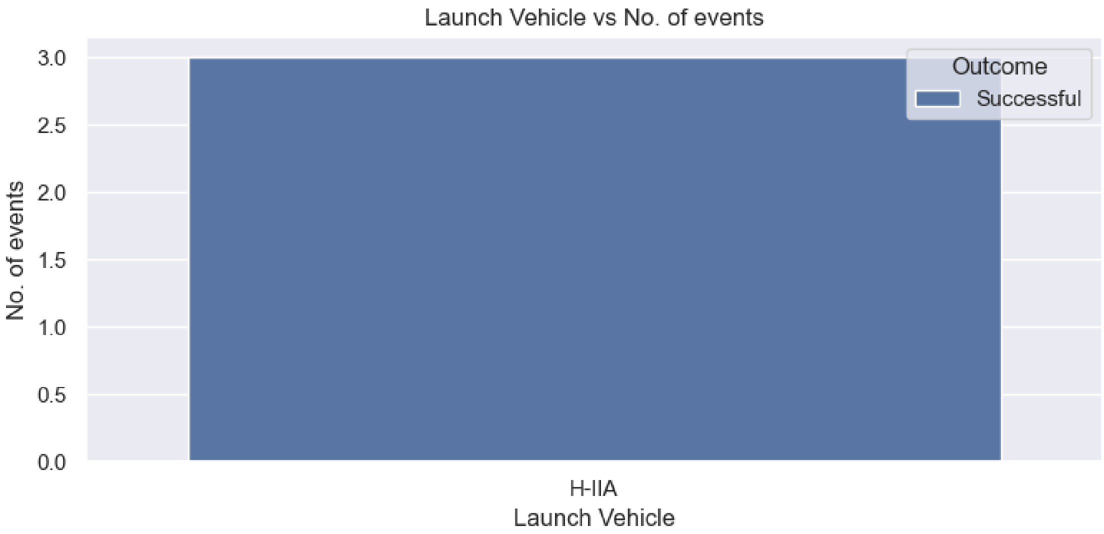

Launch Vehicle vs No. of events
No. of events
14
12
10
8
6
4
2
0
Atlas
Launch Vehicle
Outcome
Spacecraft failure
Successful
Partial failure
Operational

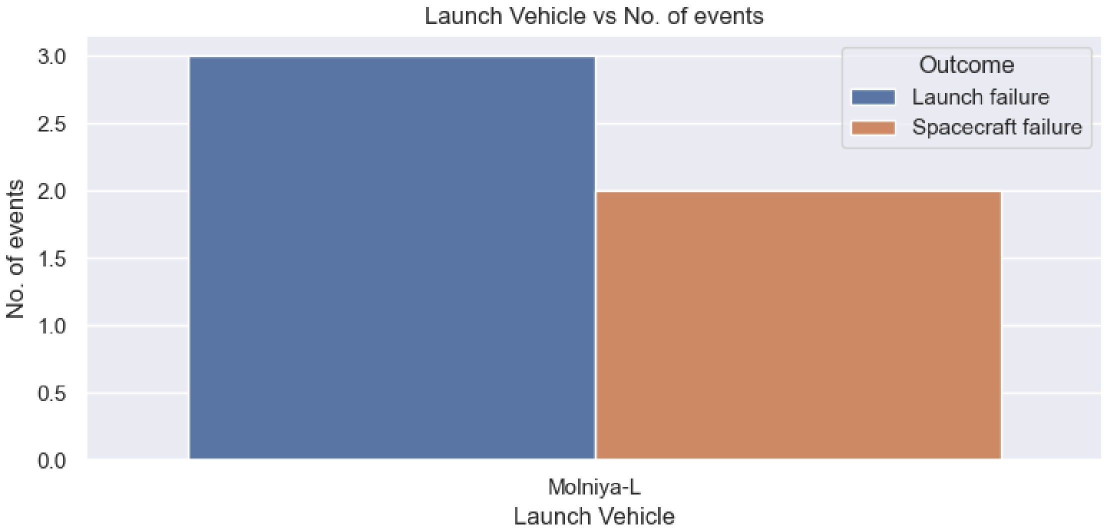

Launch Vehicle vs No. of events
No. of events
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
PSLV-XL
Launch Vehicle
Outcome
Successful

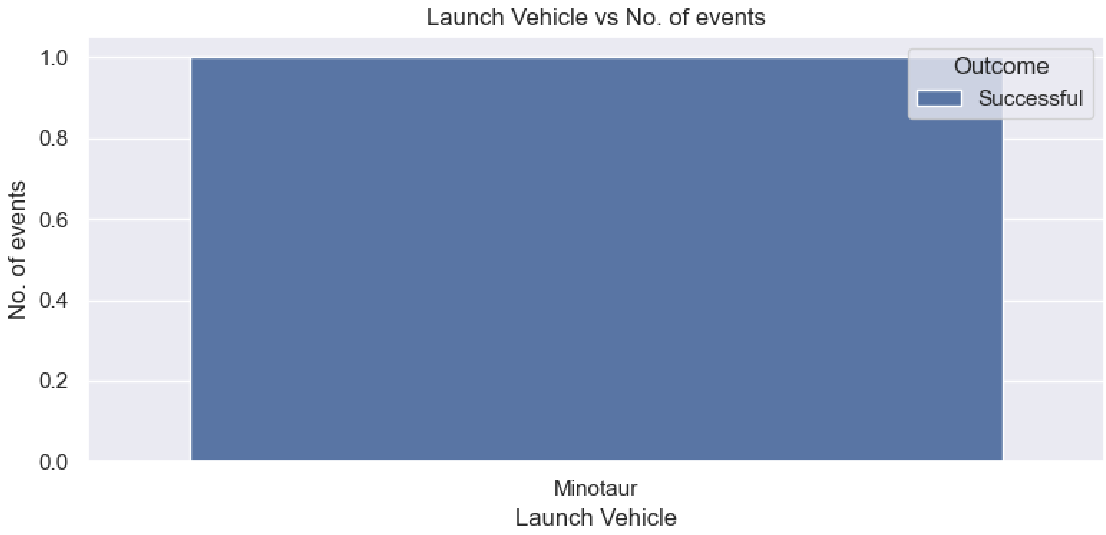

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Titan
Launch Vehicle
Outcome
Successful

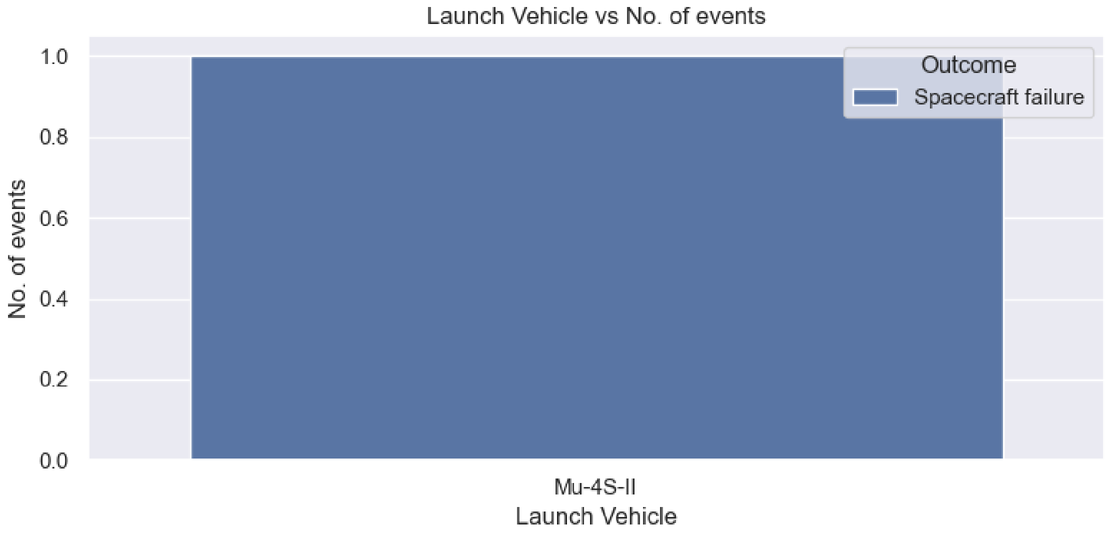

Launch Vehicle vs No. of events
No. of events
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Outcome
Launch failure
Thor
Launch Vehicle

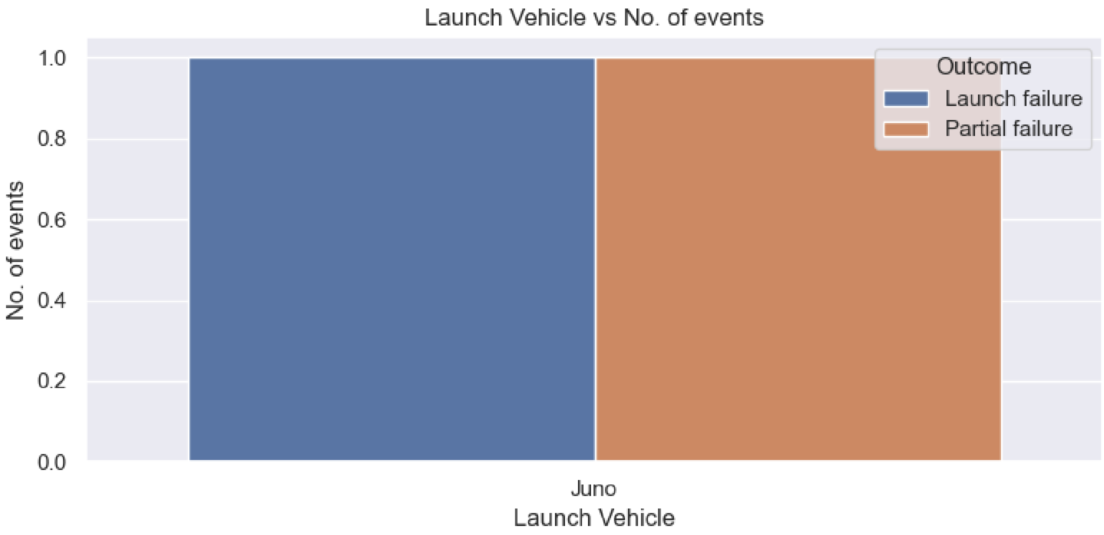

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Outcome
Launch failure
N1
Launch Vehicle

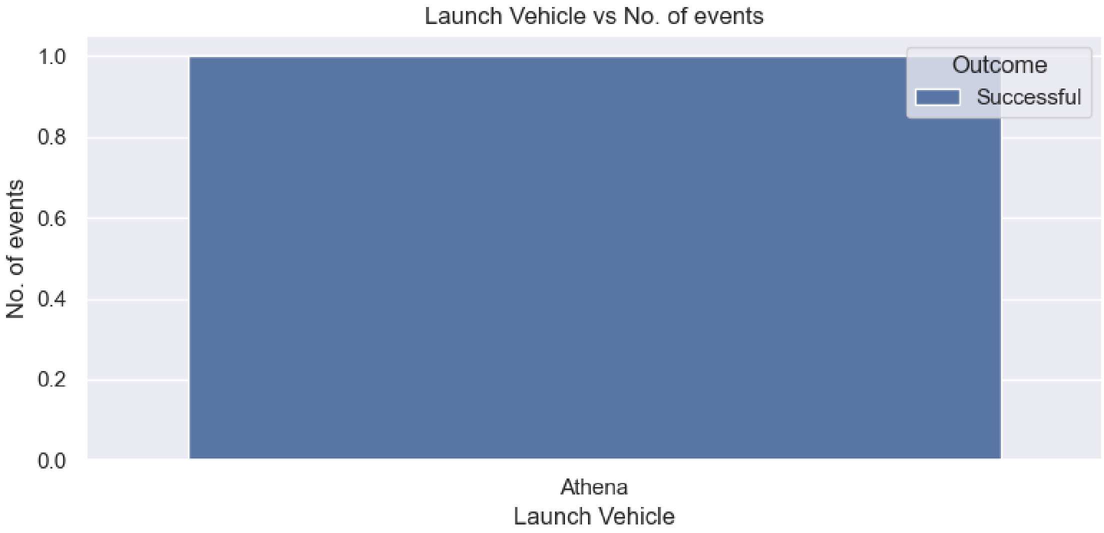

Launch Vehicle vs No. of events
No. of events
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Outcome
Successful
H-IIA
Launch Vehicle

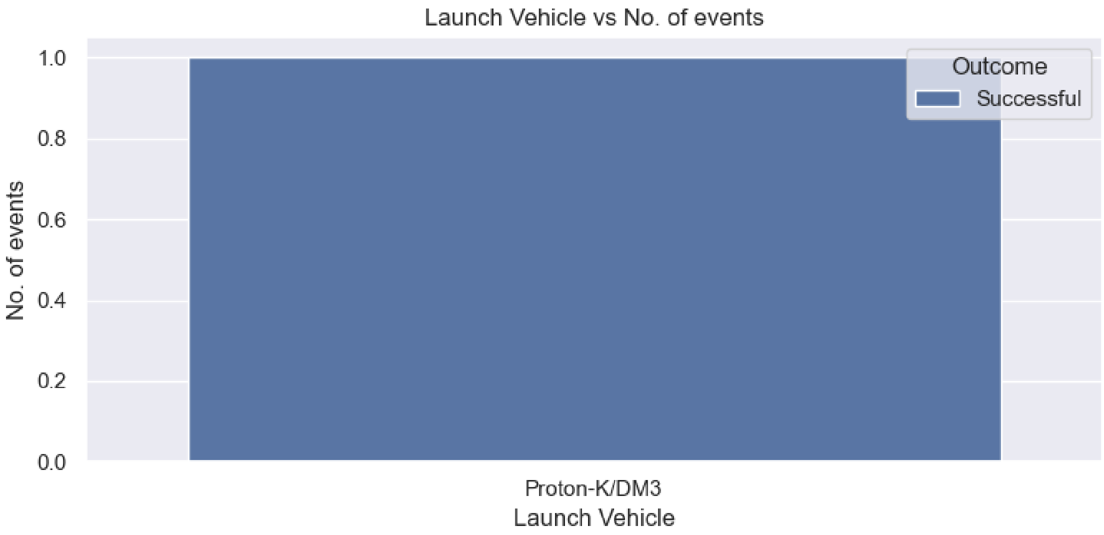

Launch Vehicle vs No. of events
No. of events
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Outcome
Launch failure
Spacecraft failure
Molniya-L
Launch Vehicle

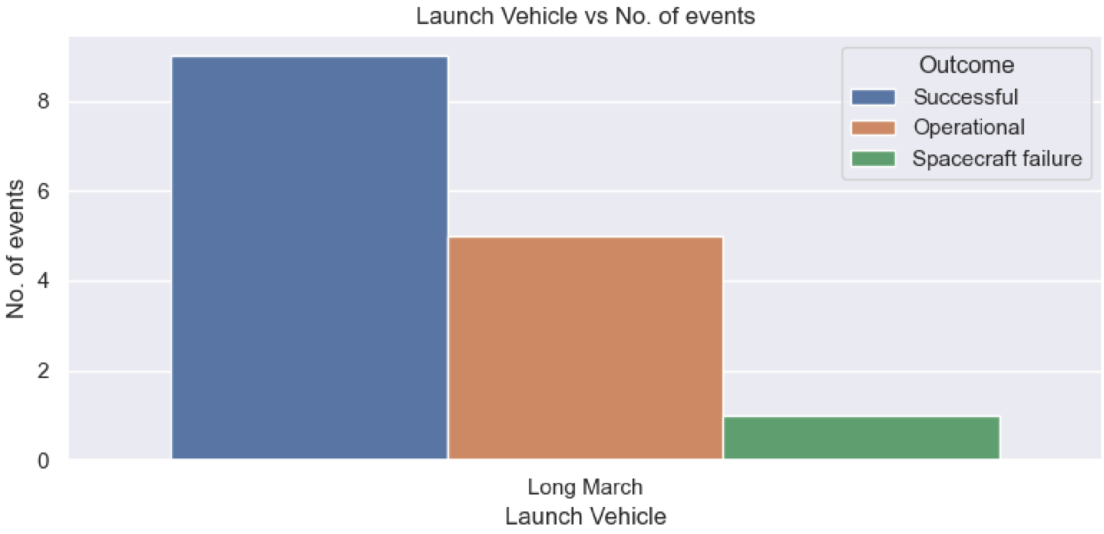

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Outcome
Successful
Minotaur
Launch Vehicle

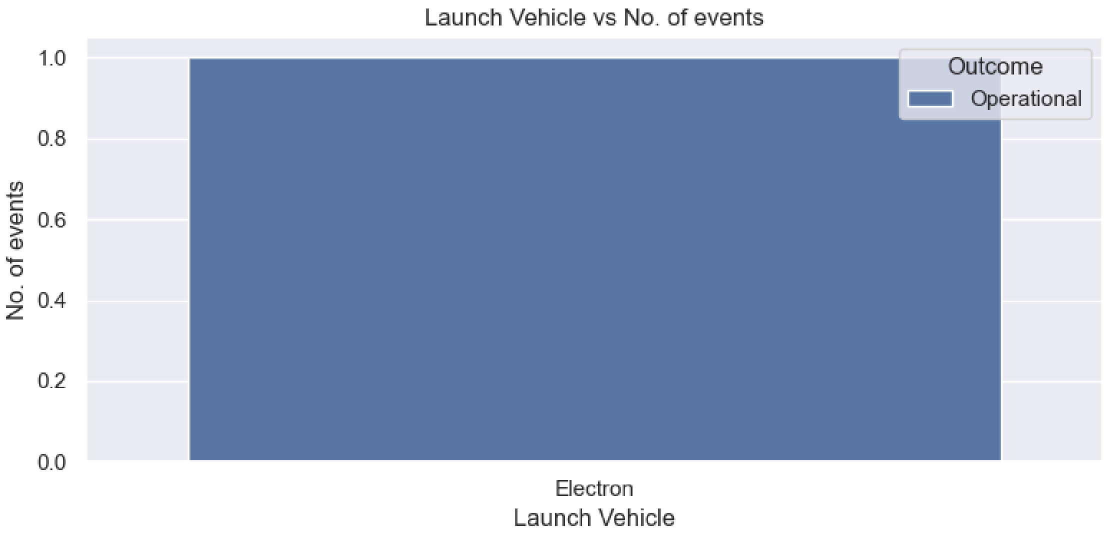

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Outcome
Spacecraft failure
Mu-4S-II
Launch Vehicle

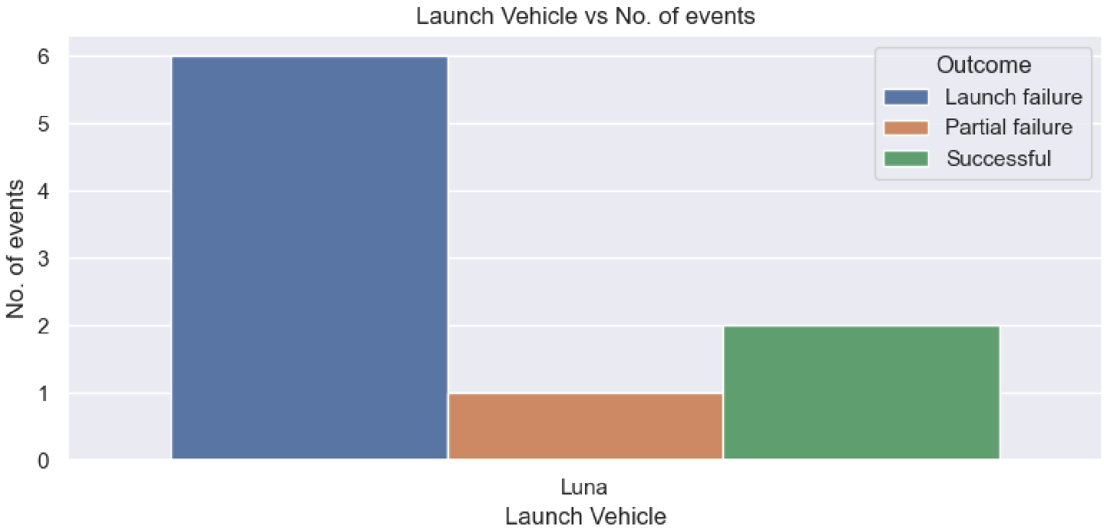

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Juno
Launch Vehicle
Outcome
Launch failure
Partial failure

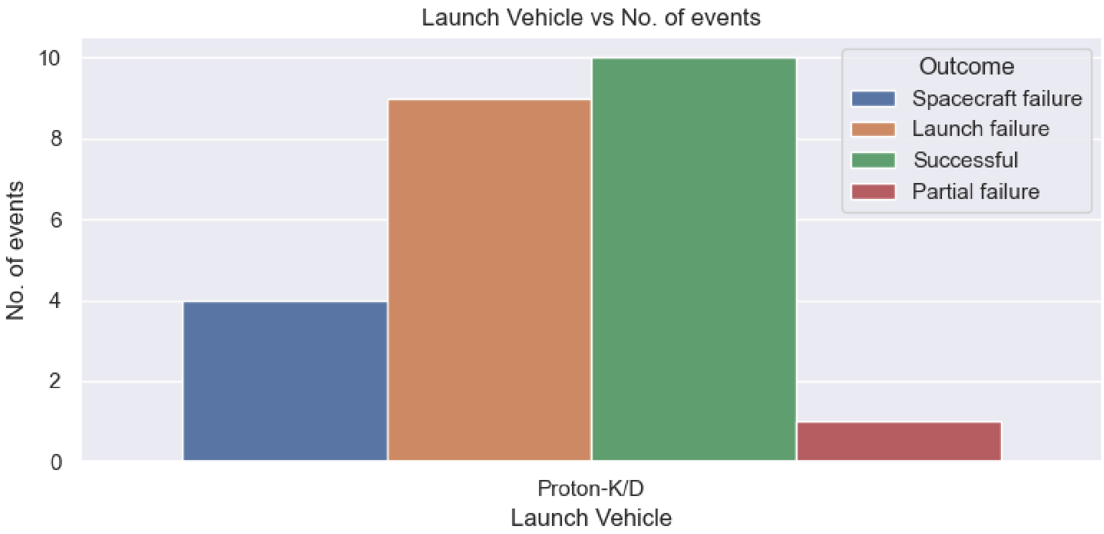

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Athena
Launch Vehicle
Outcome
Successful

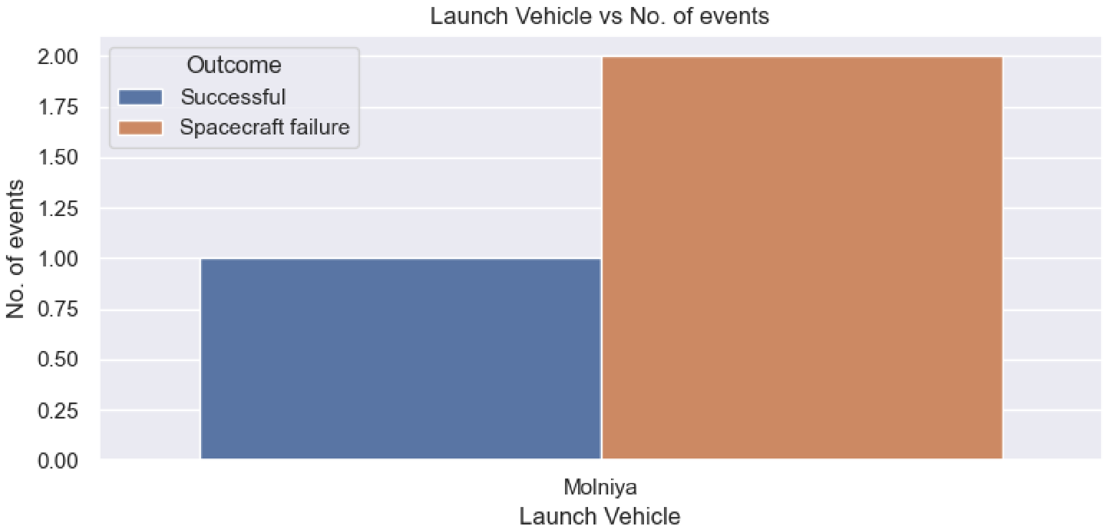

Launch Vehicle vs No. of events
1.0
0.8
0.6
0.4
0.2
0.0
No. of events
Outcome
Successful
Proton-K/DM3
Launch Vehicle

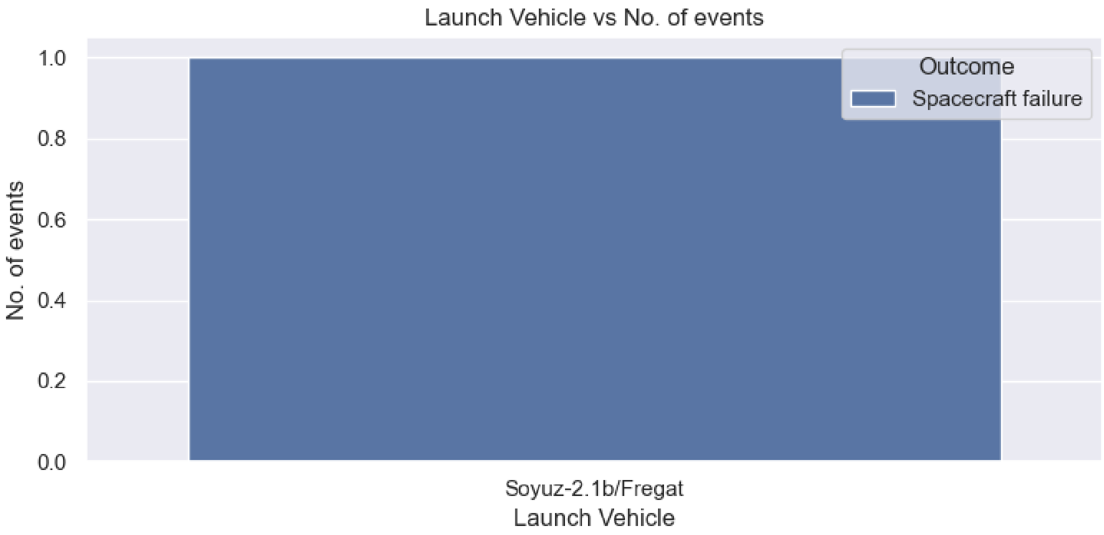

Launch Vehicle vs No. of events
8
6
4
2
0
No. of events
Outcome
Successful
Operational
Spacecraft failure
Long March
Launch Vehicle

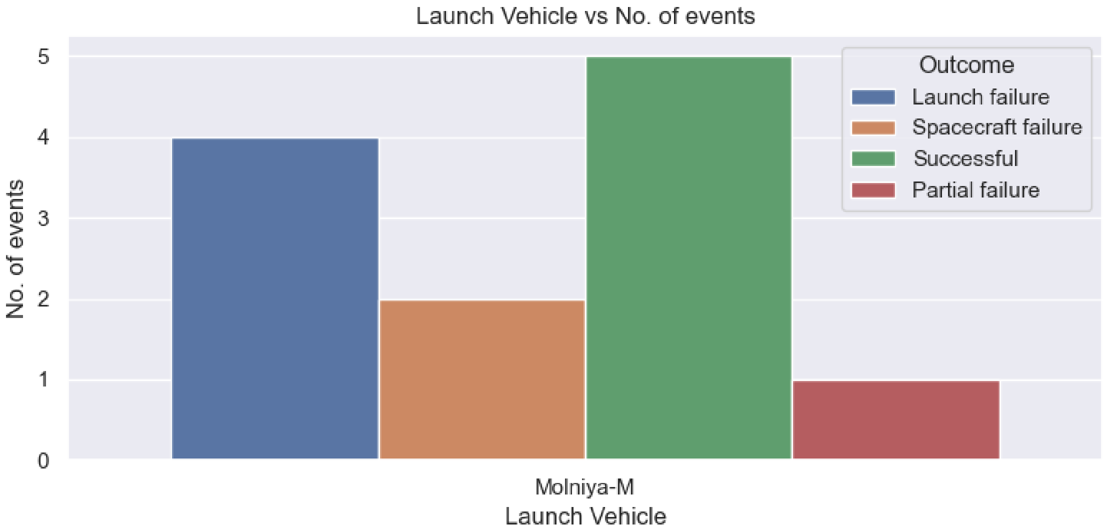

Launch Vehicle vs No. of events
Outcome
Operational
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Electron
Launch Vehicle

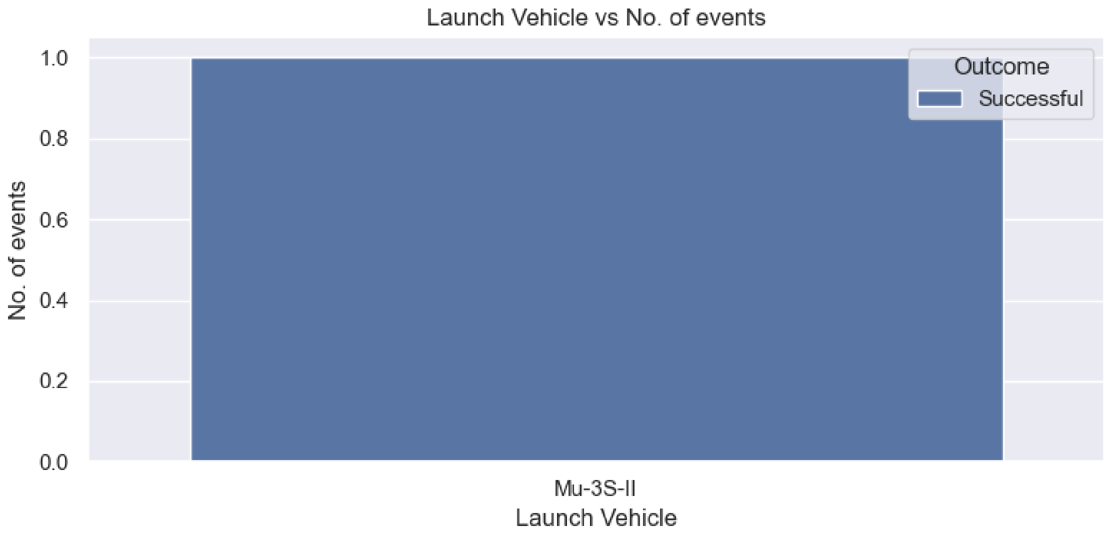

Launch Vehicle vs No. of events
Outcome
Launch failure
Partial failure
Successful
No. of events
6
5
4
3
2
1
0
Luna
Launch Vehicle

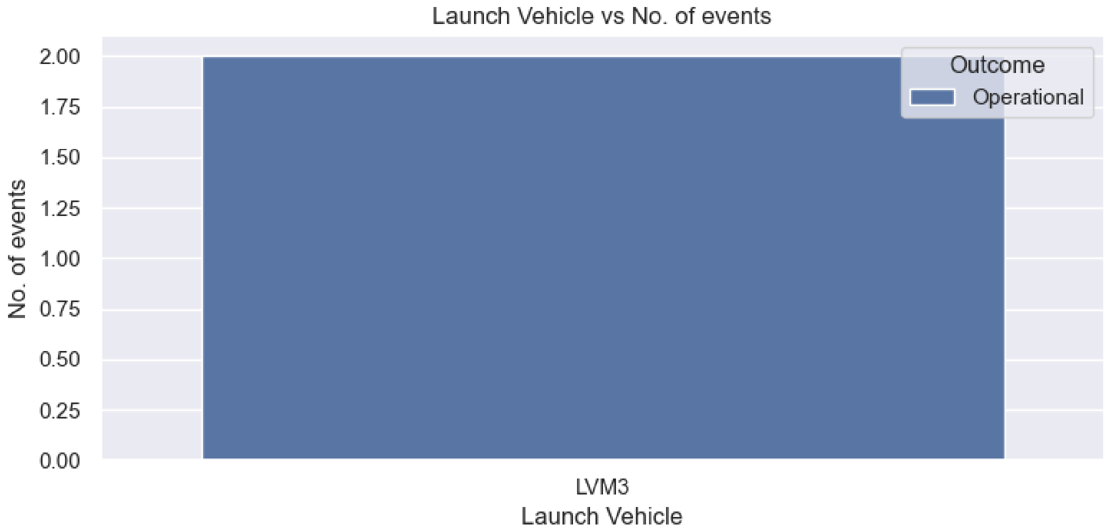

Launch Vehicle vs No. of events
No. of events
0
2
4
6
8
10
Outcome
Spacecraft failure
Launch failure
Successful
Partial failure
Proton-K/D
Launch Vehicle

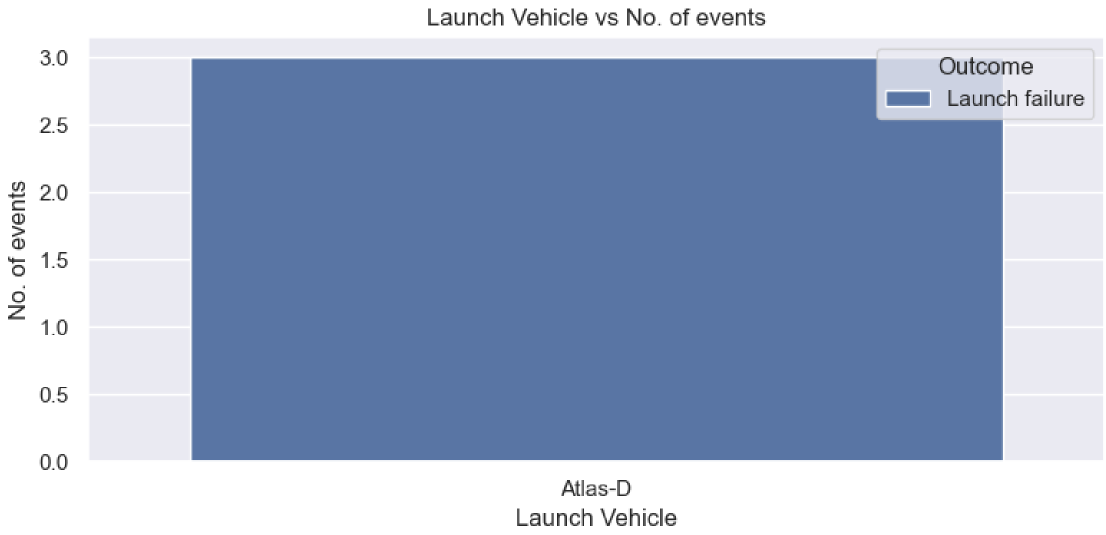

Launch Vehicle vs No. of events
No. of events
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Outcome
Successful
Spacecraft failure
Molniya
Launch Vehicle

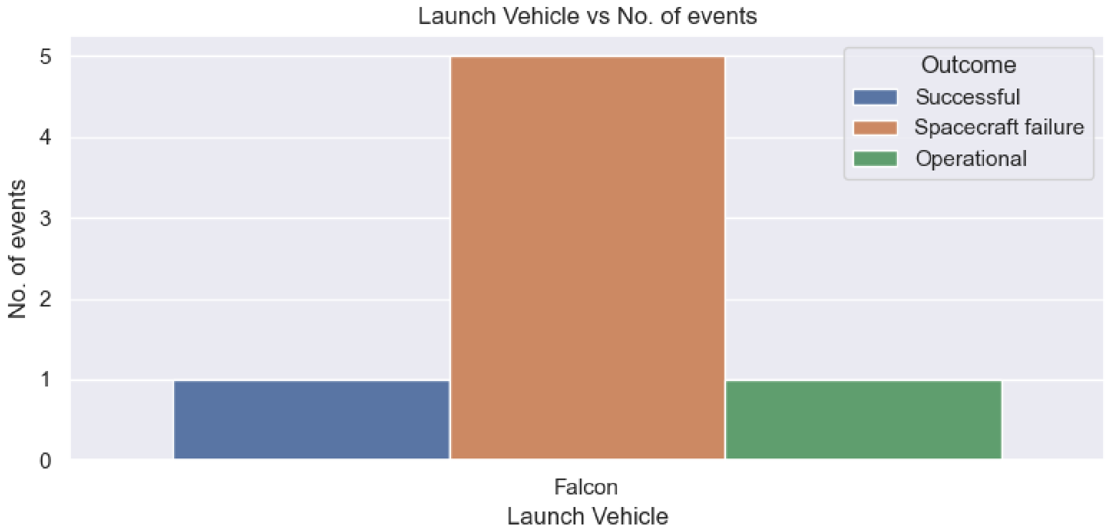

Launch Vehicle vs No. of events
1.0
0.8
0.6
0.4
0.2
0.0
No. of events
Outcome
Spacecraft failure
Soyuz-2.1b/Fregat
Launch Vehicle

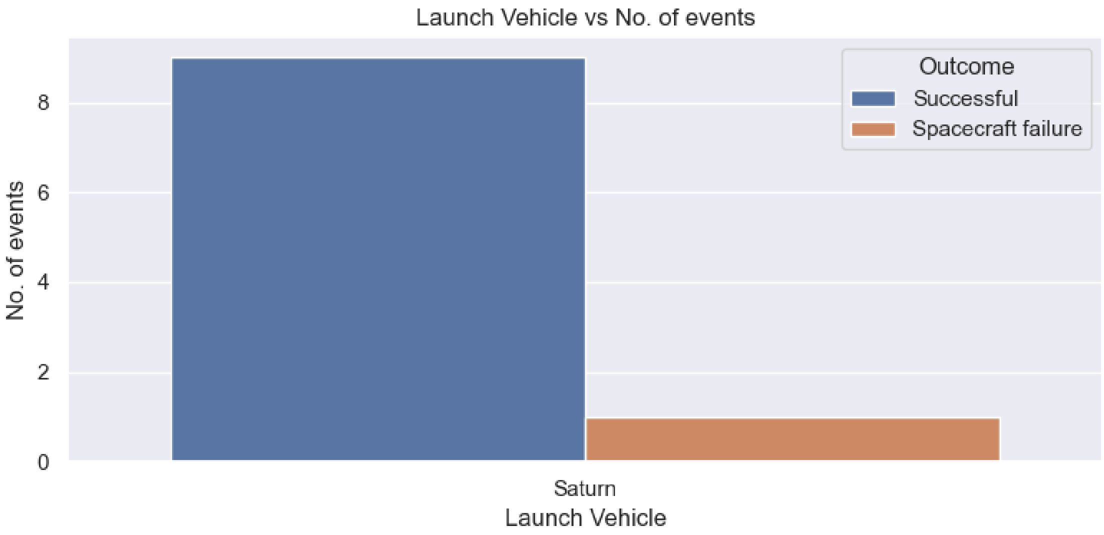

Launch Vehicle vs No. of events
5
4
3
2
1
0
No. of events
Outcome
Launch failure
Spacecraft failure
Successful
Partial failure
Molniya-M
Launch Vehicle

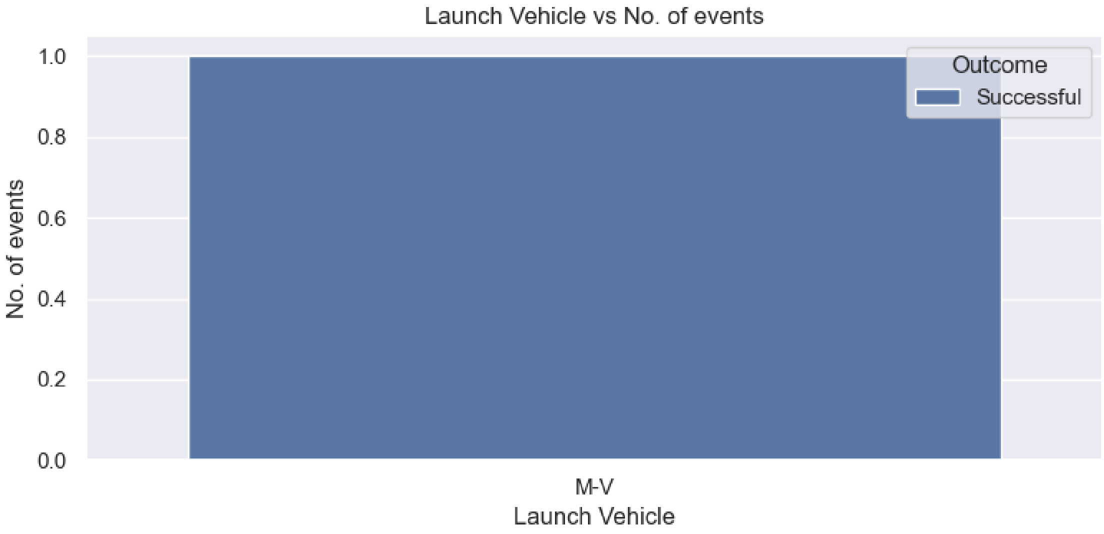

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Outcome
Successful
Mu-3S-II
Launch Vehicle


Launch Vehicle vs No. of events
No. of events
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Outcome
Operational
LVM3
Launch Vehicle


Launch Vehicle vs No. of events
Outcome
Launch failure
3.0
2.5
2.0
1.5
1.0
0.5
0.0
No. of events
Atlas-D
Launch Vehicle


Launch Vehicle vs No. of events
Outcome
Successful
Spacecraft failure
Operational
5
4
3
2
1
0
No. of events
Falcon
Launch Vehicle





```
[ ]:
```

```
[ ]:
```

```
[ ]:
```

```
[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]:

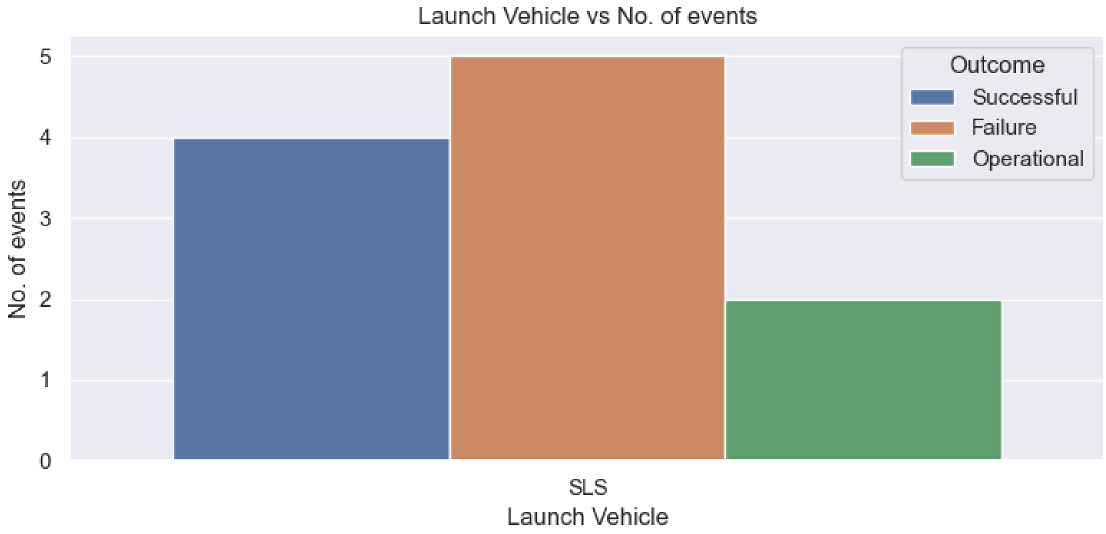
```
# Checking how many missions are currently in route to the targetted planet.
df[(df['Outcome'] == 'En route')]
```

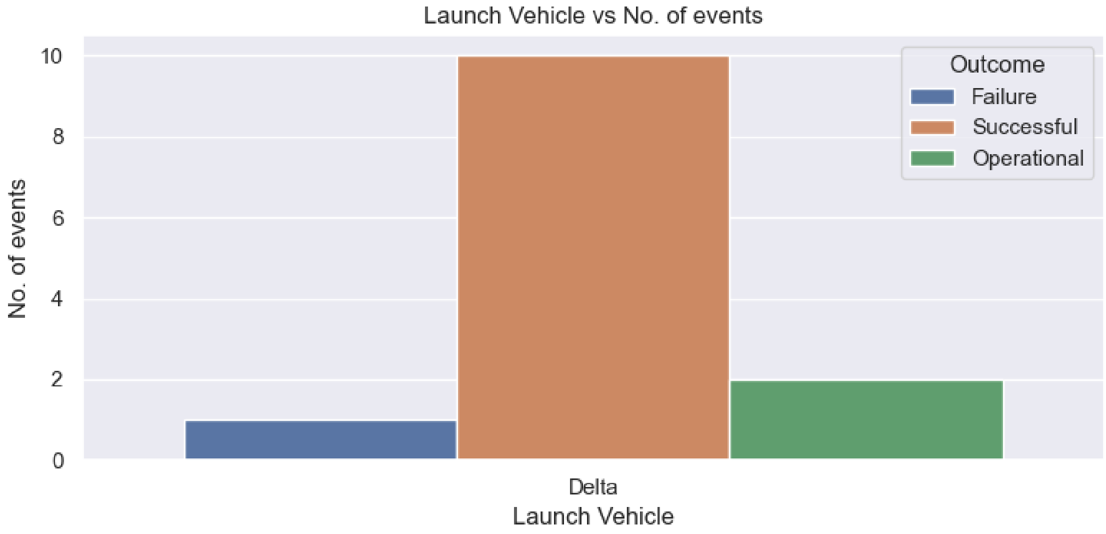
[54]:

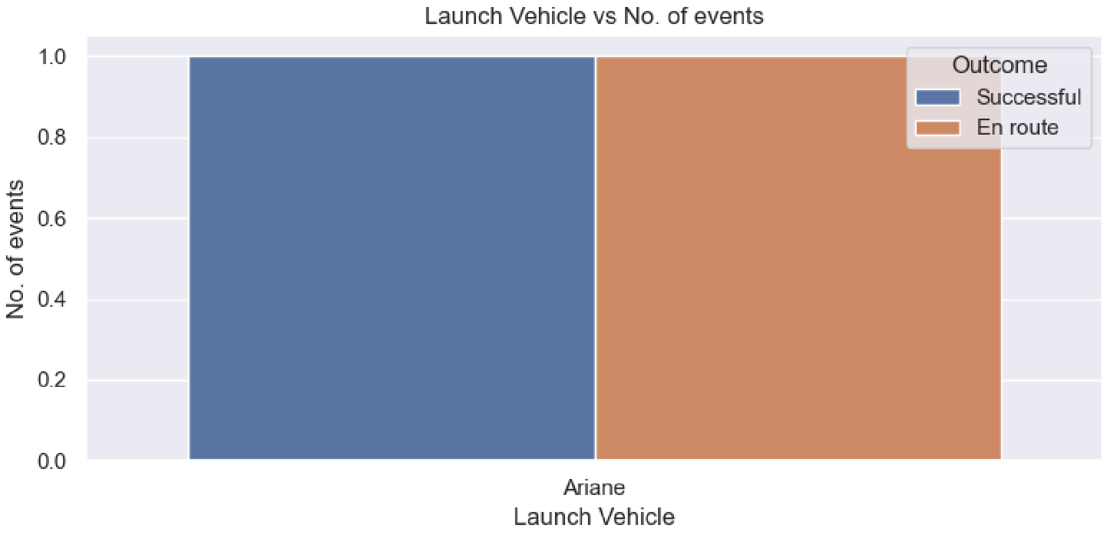
```
                         Mission                  Spacecraft Launch Date  \
155  Jupiter Icy Moons Explorer  Jupiter Icy Moons Explorer   14-Apr-23

    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
```

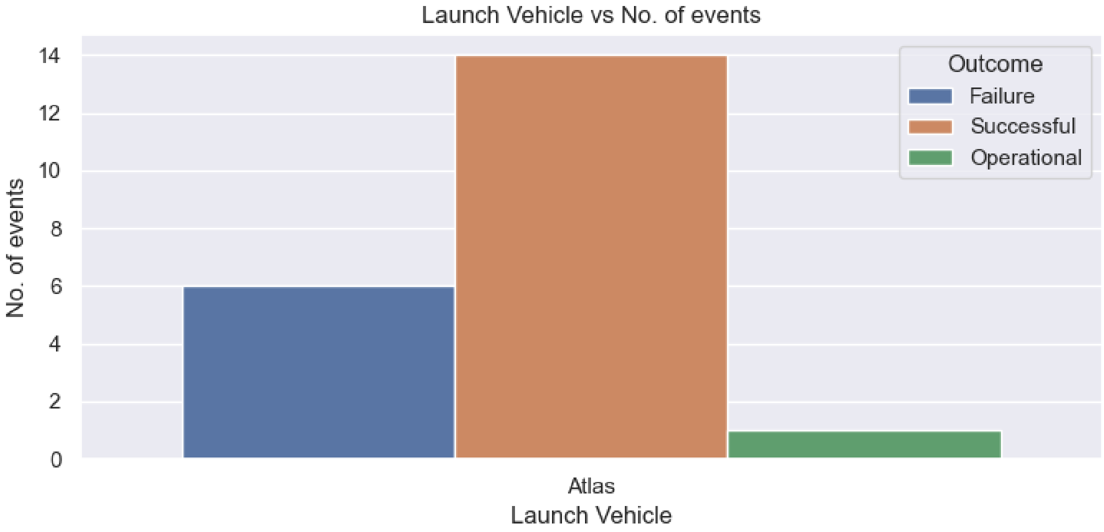
[55]:

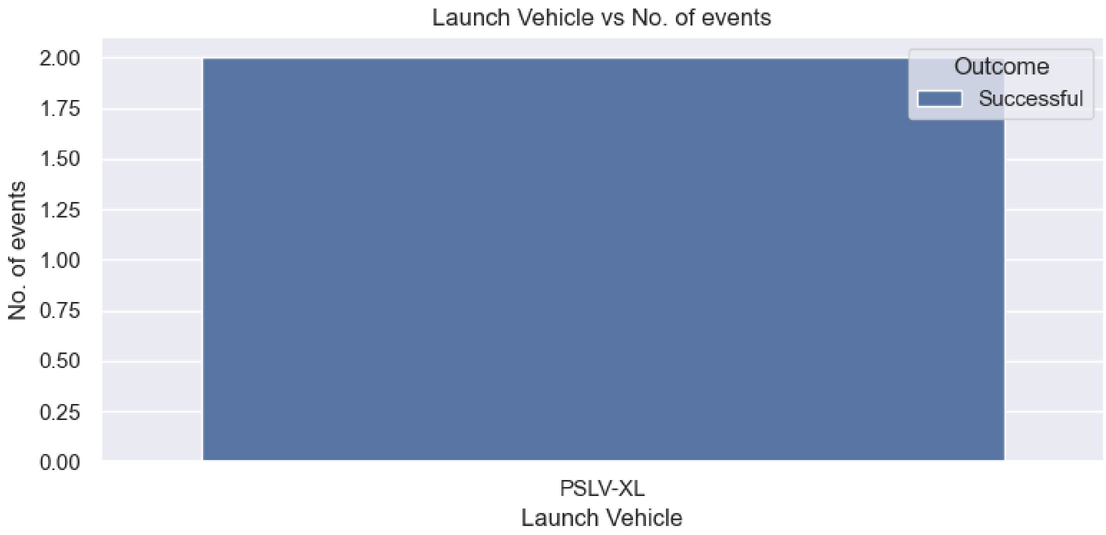
```
list1 = []
for i in df['launch vehicle']:
    list1.append(i)
l1= list(set(list1))
for j in l1:
    df1= df[df['launch vehicle'] == j]
    sns.set(rc = {'figure.figsize':(8,4)})
    sns.countplot(data=df1, x='launch vehicle', hue= 'Outcome')
    plt.title("Launch Vehicle vs No. of events")
    plt.xlabel("Launch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

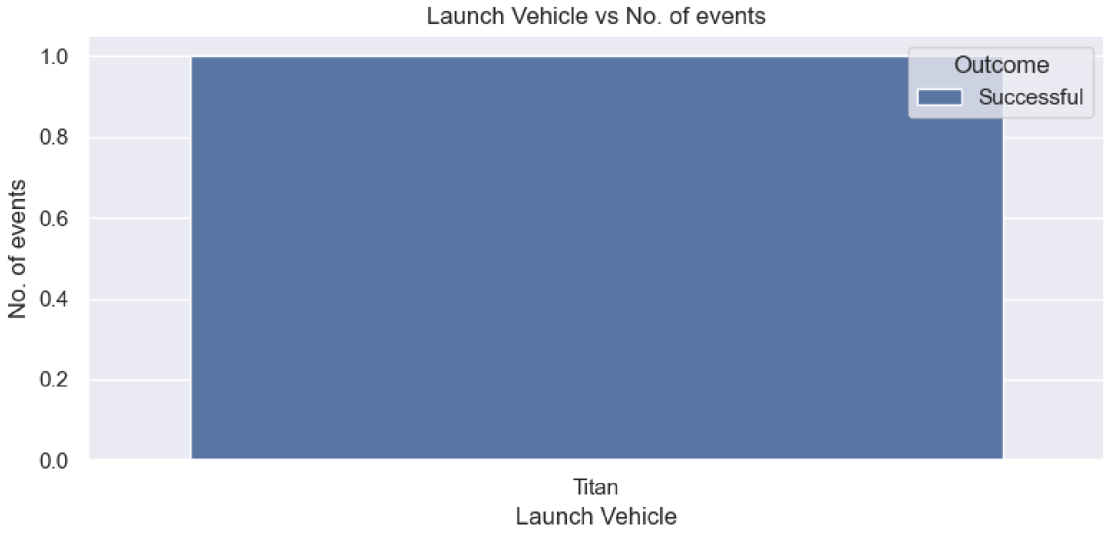


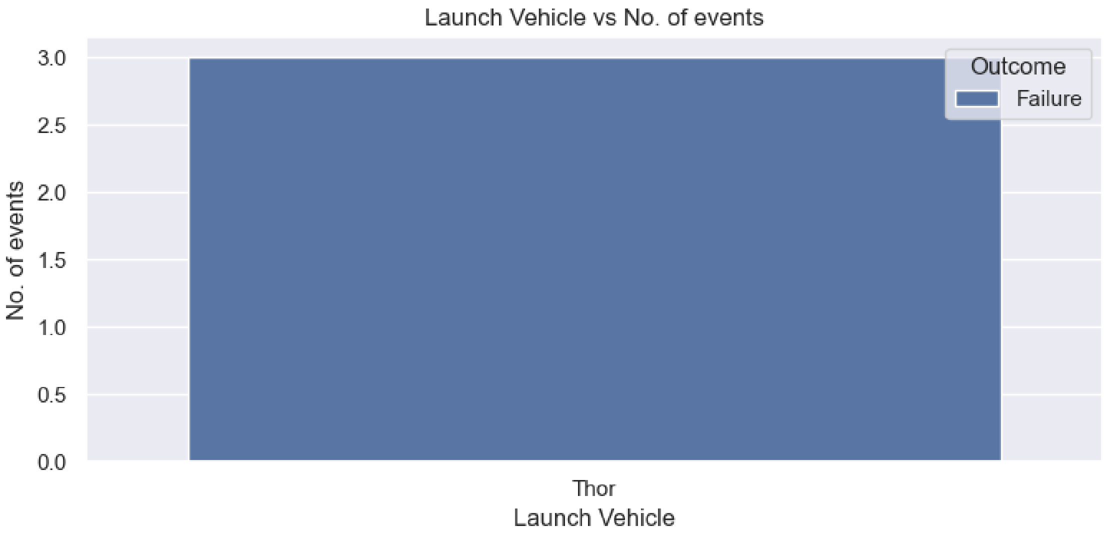


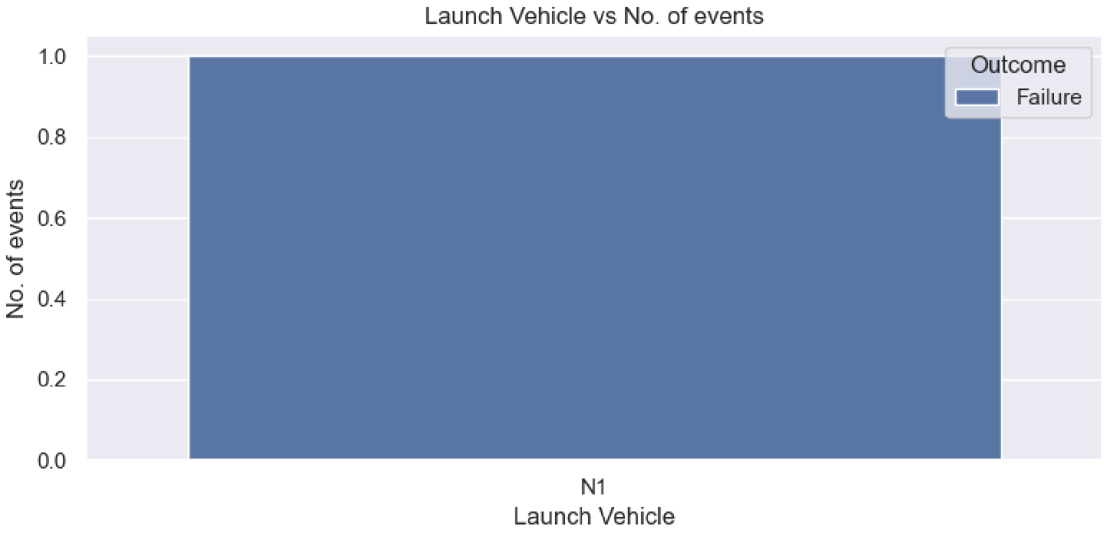

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Ariane
Launch Vehicle
Outcome
Successful
En route

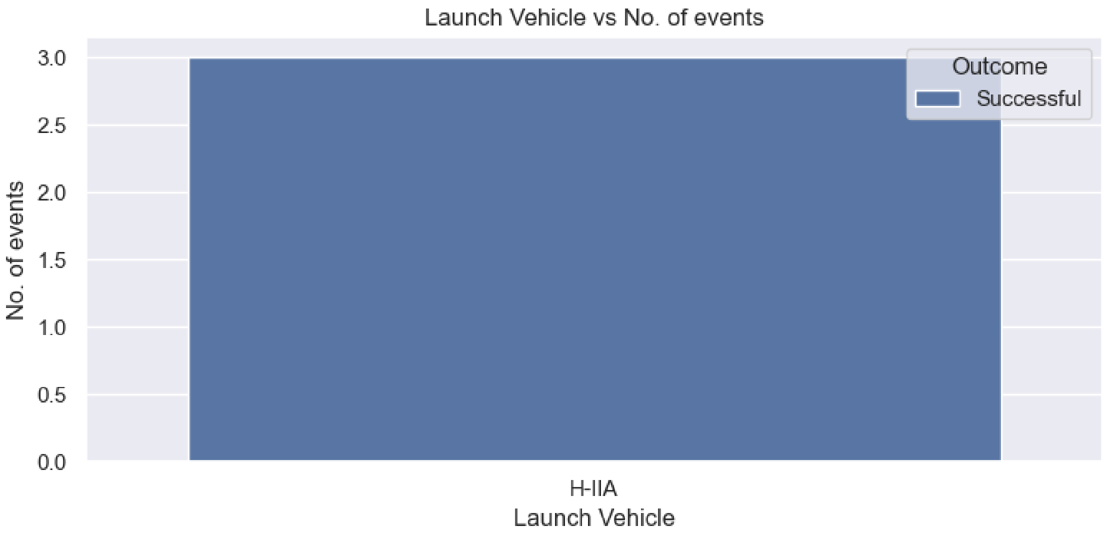

Launch Vehicle vs No. of events
No. of events
14
12
10
8
6
4
2
0
Atlas
Launch Vehicle
Outcome
Failure
Successful
Operational

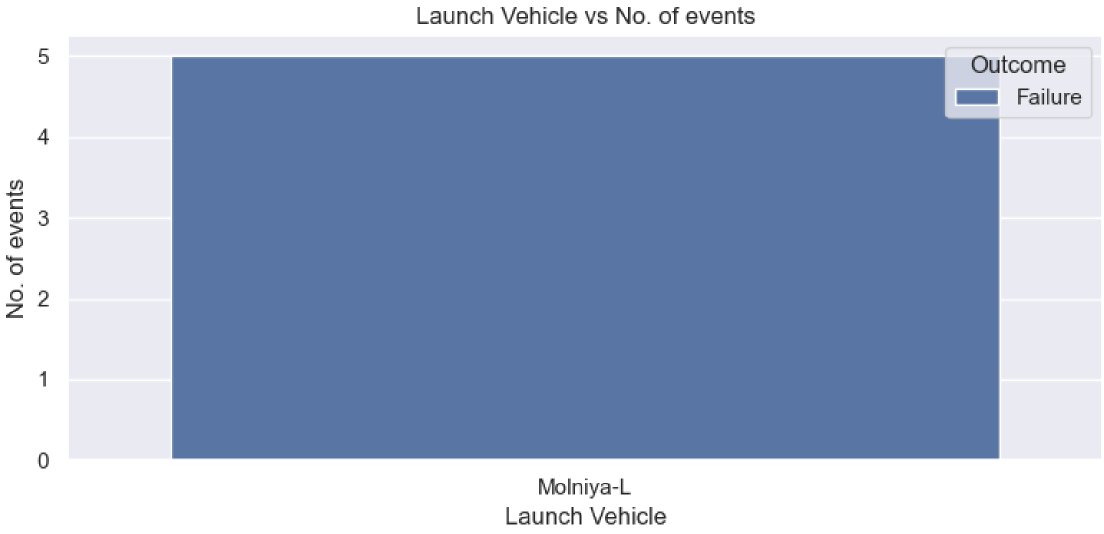

Launch Vehicle vs No. of events
No. of events
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Outcome
Successful
PSLV-XL
Launch Vehicle

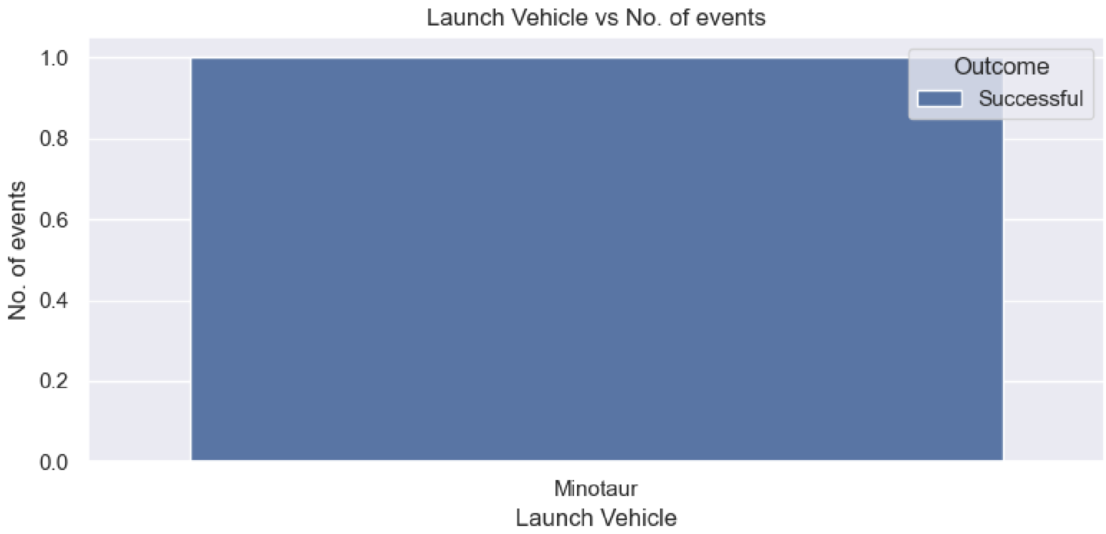

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Outcome
Successful
Titan
Launch Vehicle

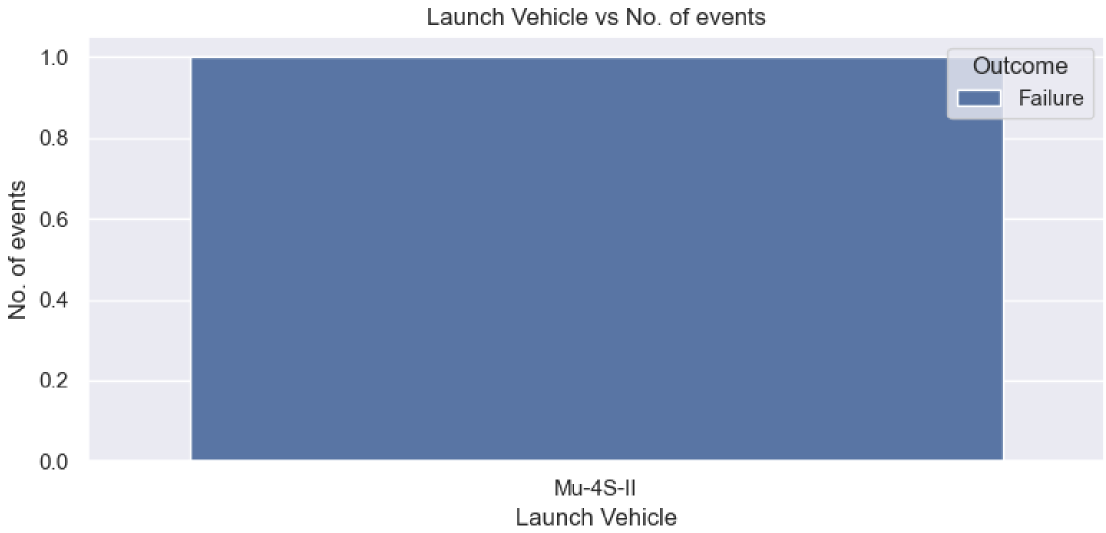

Launch Vehicle vs No. of events
No. of events
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Thor
Launch Vehicle
Outcome
Failure

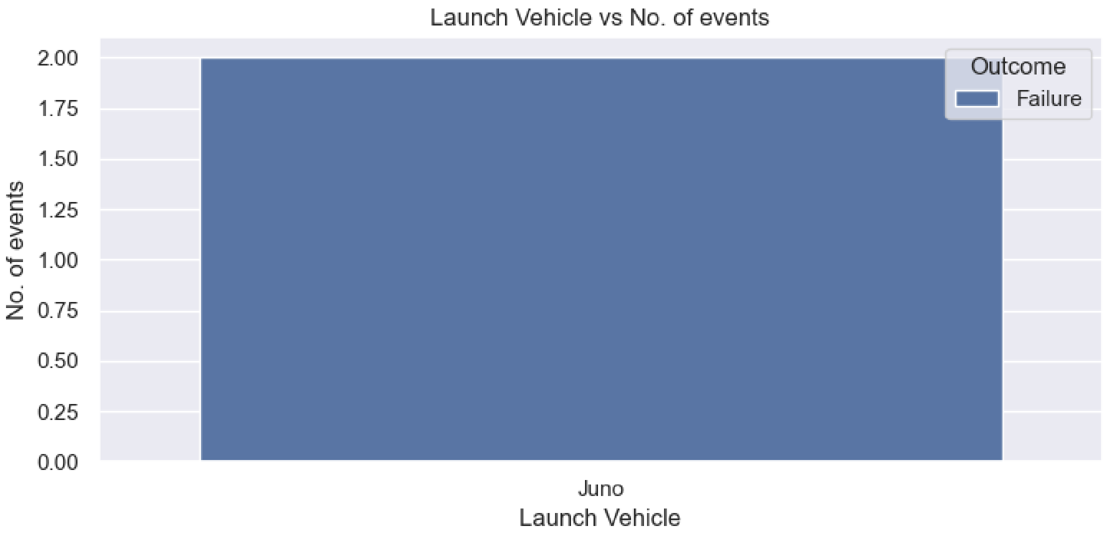

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
N1
Launch Vehicle
Outcome
Failure

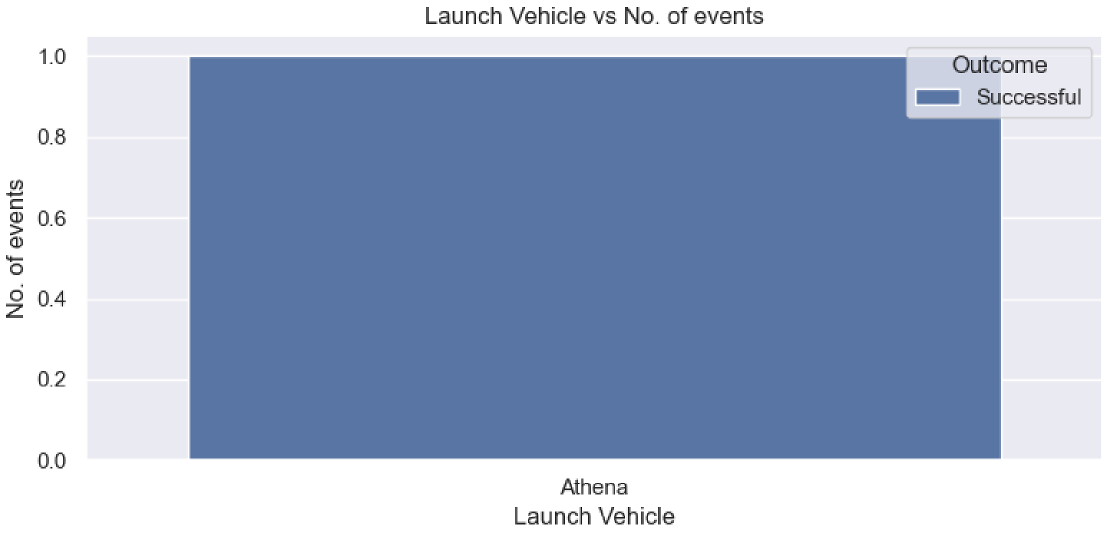

Launch Vehicle vs No. of events
3.0
2.5
2.0
1.5
1.0
0.5
0.0
No. of events
Outcome
Successful
H-IIA
Launch Vehicle

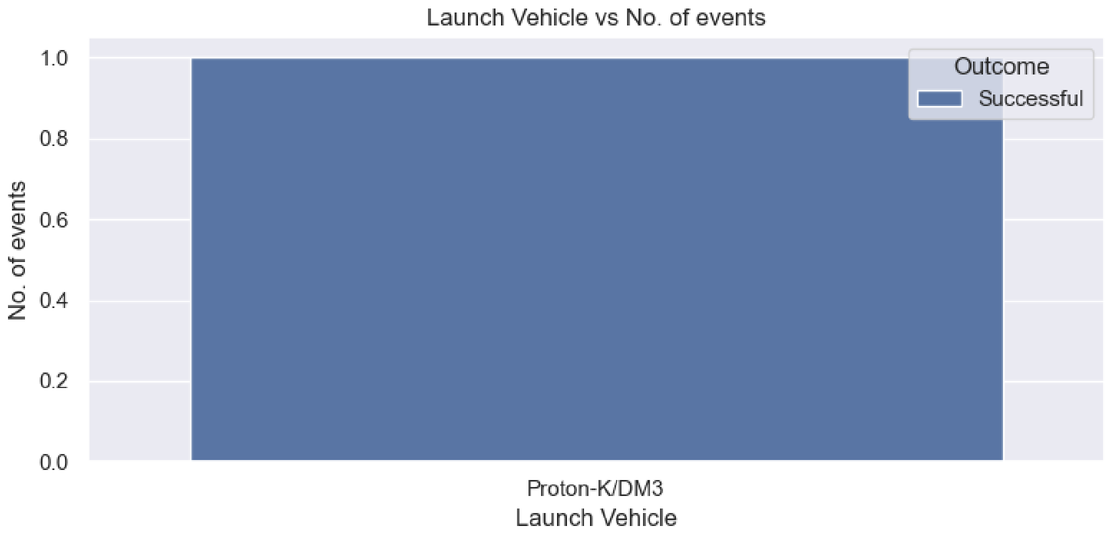

Launch Vehicle vs No. of events
5
4
3
2
1
0
No. of events
Outcome
Failure
Molniya-L
Launch Vehicle

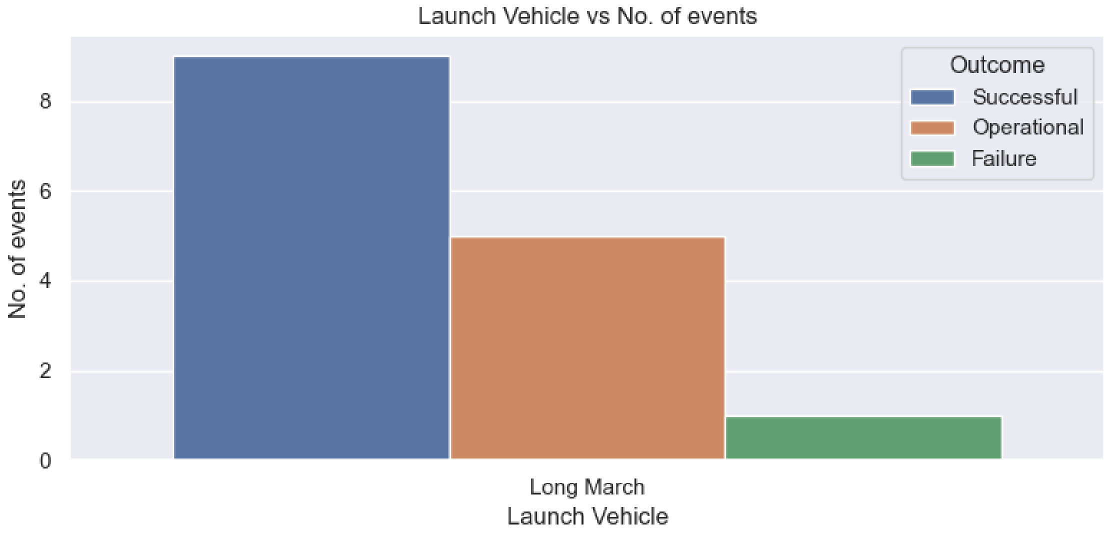

Launch Vehicle vs No. of events
1.0
0.8
0.6
0.4
0.2
0.0
No. of events
Outcome
Successful
Minotaur
Launch Vehicle

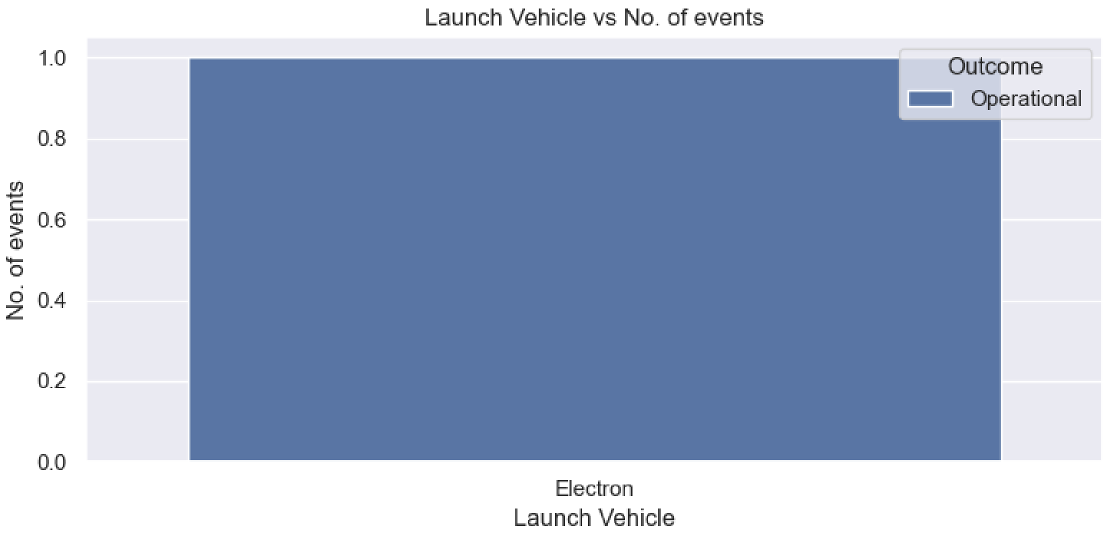

Launch Vehicle vs No. of events
1.0
0.8
0.6
0.4
0.2
0.0
No. of events
Outcome
Failure
Mu-4S-II
Launch Vehicle

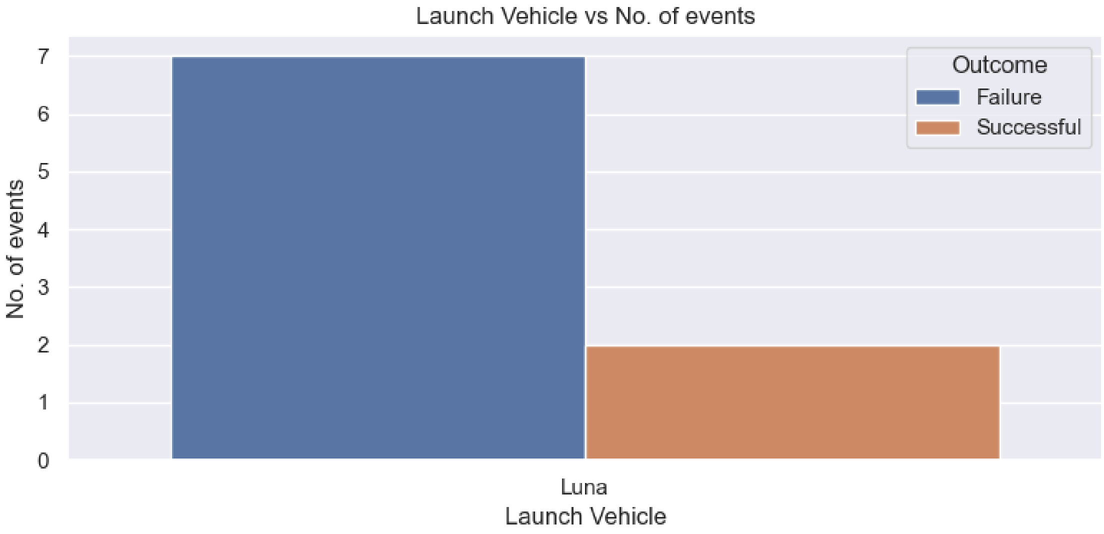

Launch Vehicle vs No. of events
No. of events
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Outcome
Failure
Juno
Launch Vehicle

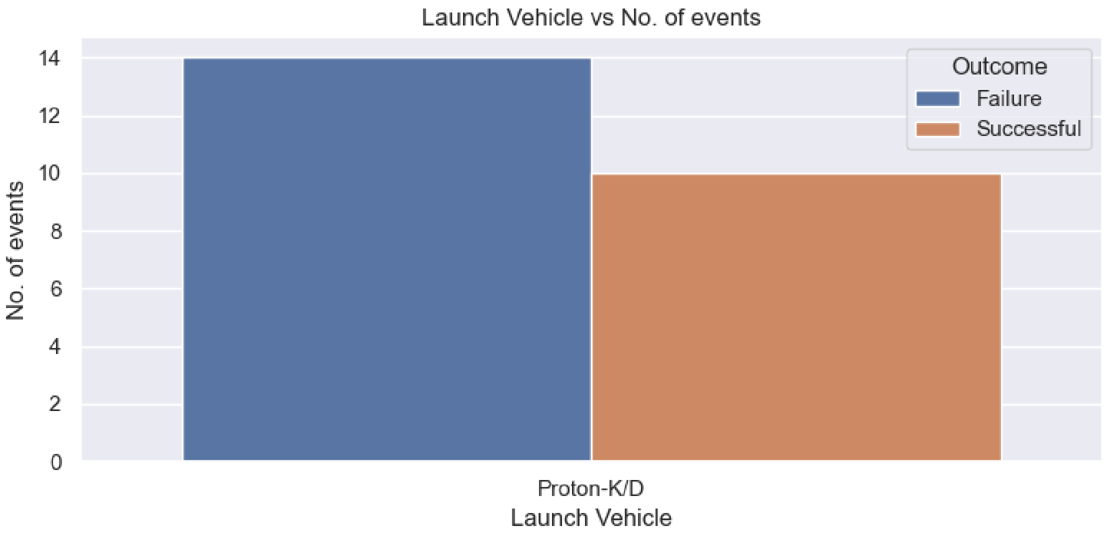

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Outcome
Successful
Athena
Launch Vehicle

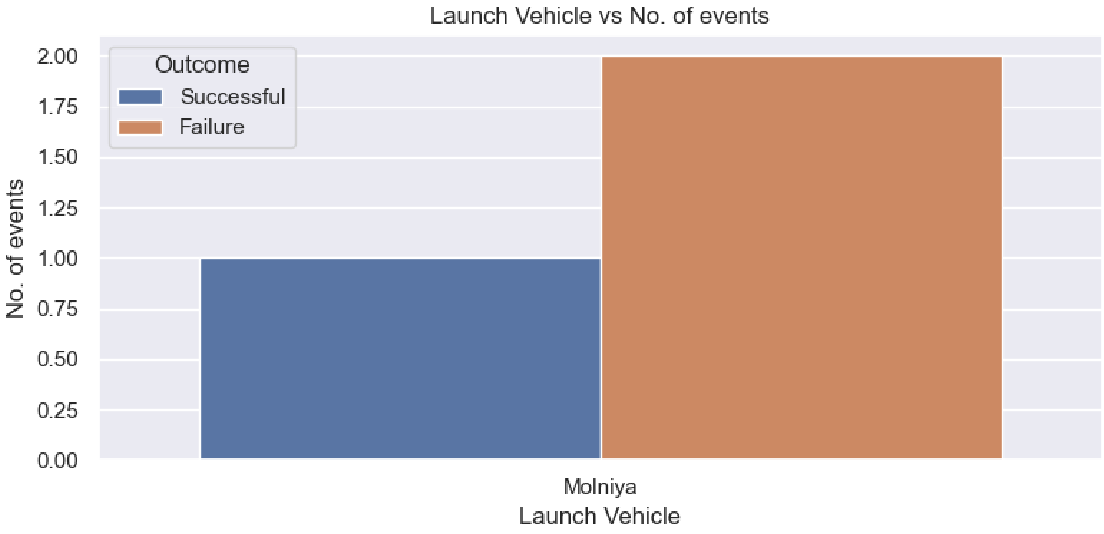

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Outcome
Successful
Proton-K/DM3
Launch Vehicle

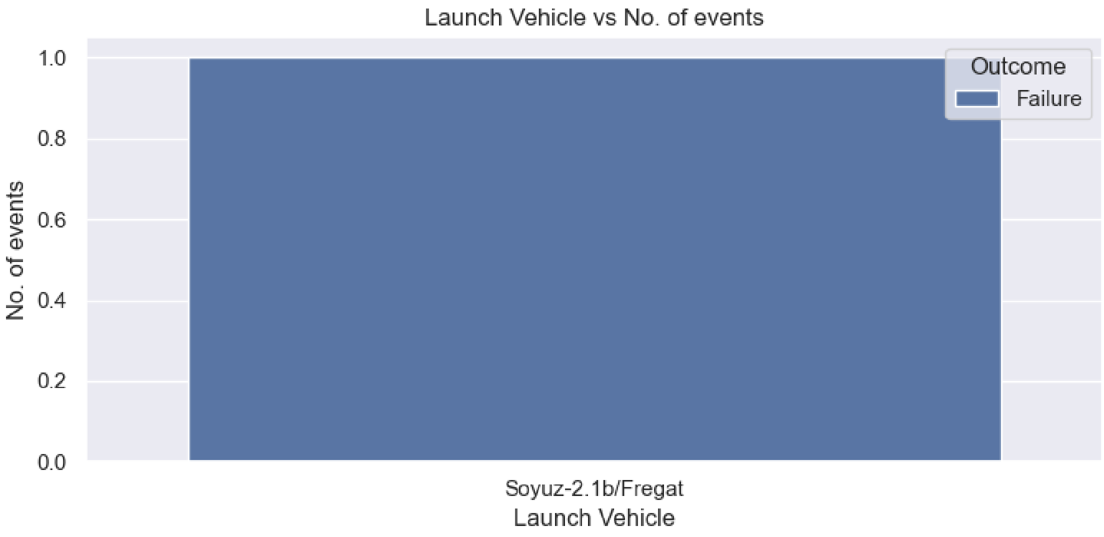

Launch Vehicle vs No. of events
No. of events
8
6
4
2
0
Outcome
Successful
Operational
Failure
Long March
Launch Vehicle

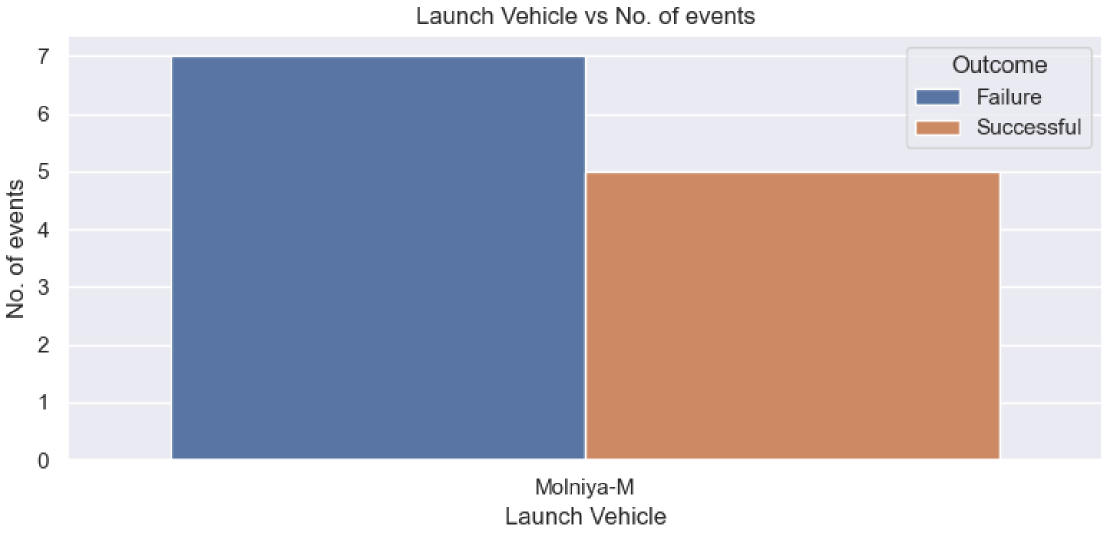

Launch Vehicle vs No. of events
1.0
0.8
0.6
0.4
0.2
0.0
No. of events
Outcome
Operational
Electron
Launch Vehicle

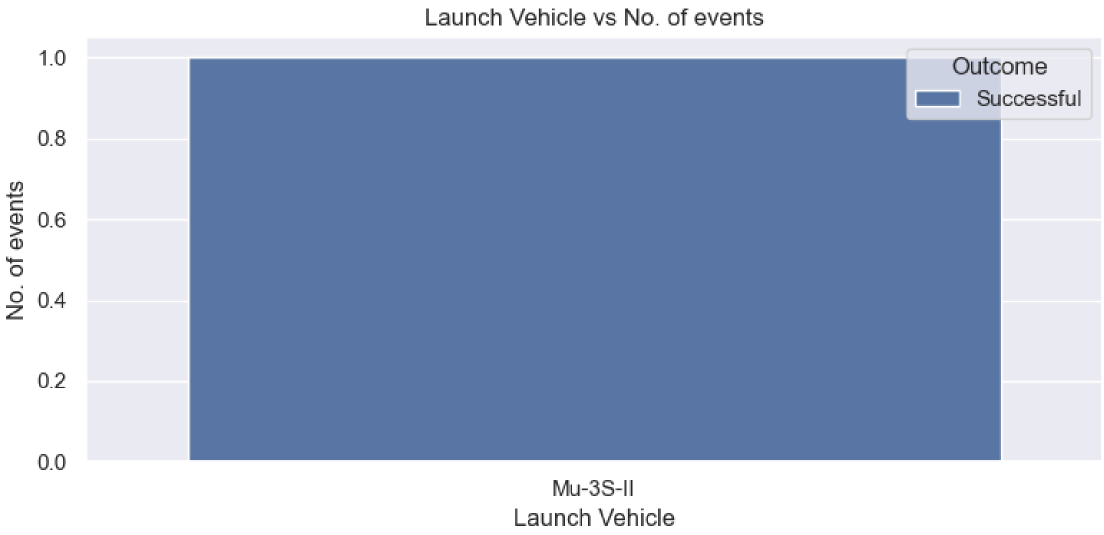

Launch Vehicle vs No. of events
7
6
5
4
3
2
1
0
No. of events
Outcome
Failure
Successful
Luna
Launch Vehicle

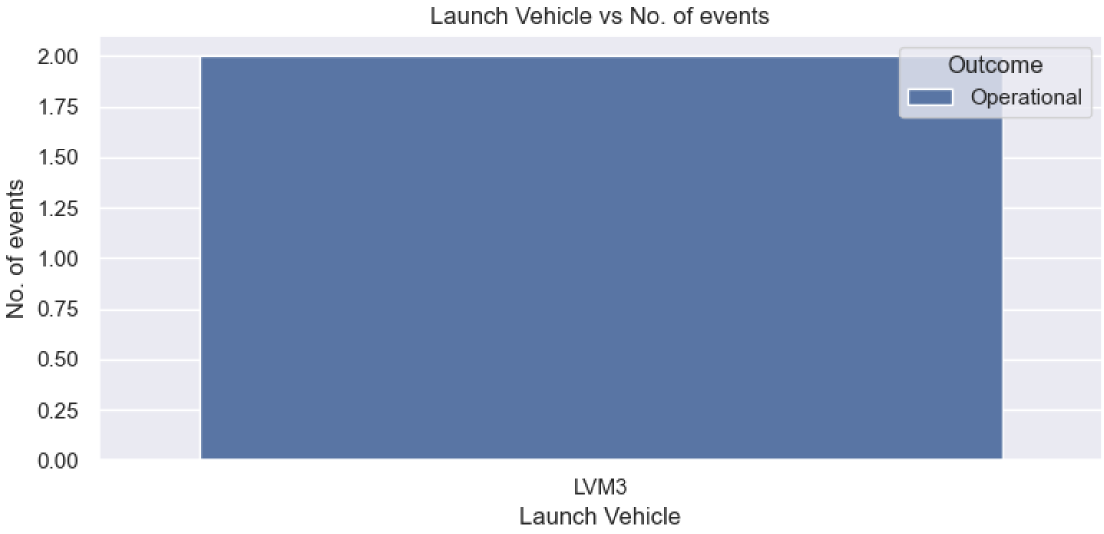

Launch Vehicle vs No. of events
Outcome
Failure
Successful
No. of events
0
2
4
6
8
10
12
14
Proton-K/D
Launch Vehicle

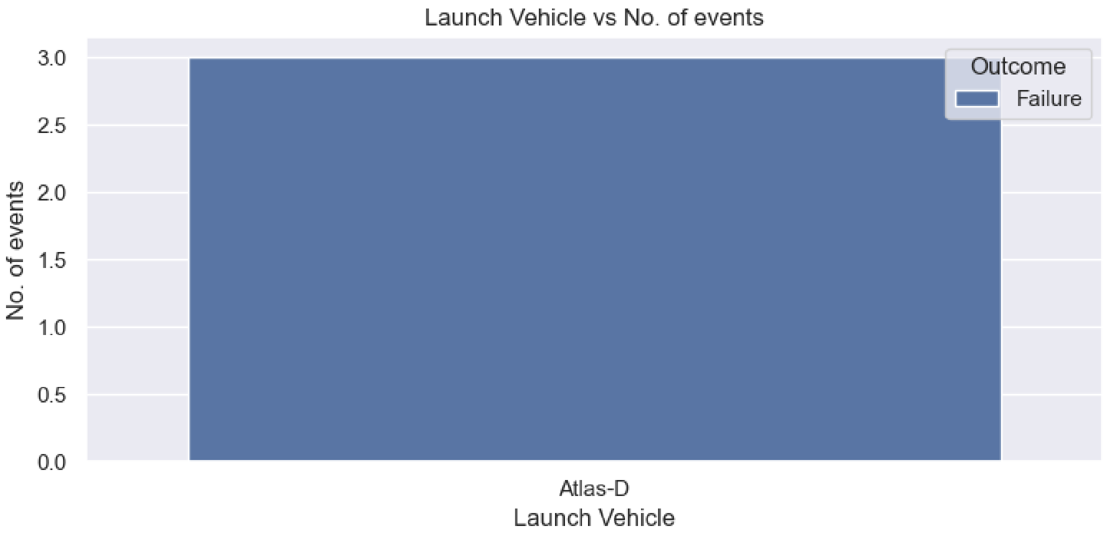

Launch Vehicle vs No. of events
Outcome
Successful
Failure
No. of events
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
Molniya
Launch Vehicle

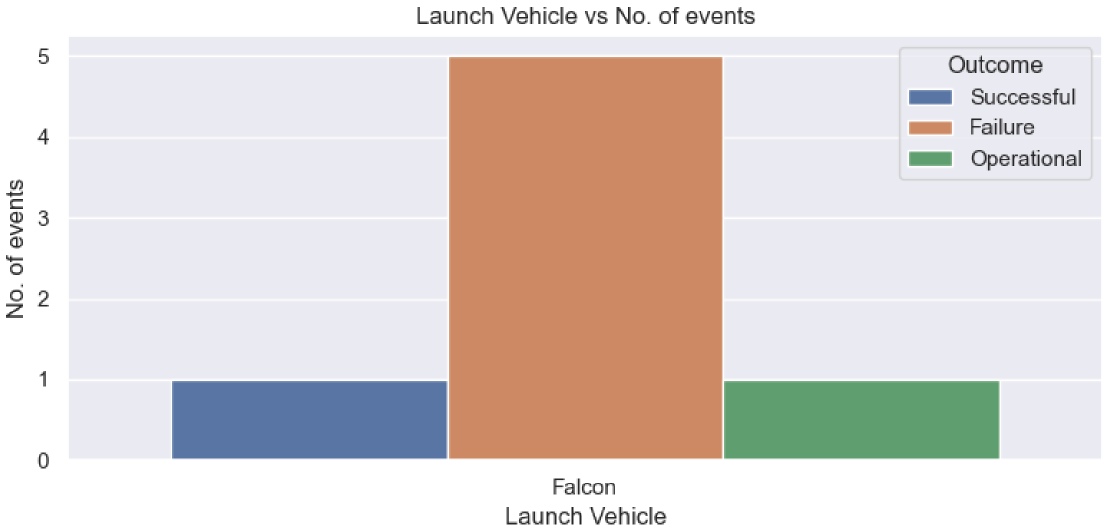

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Outcome
Failure
Soyuz-2.1b/Fregat
Launch Vehicle

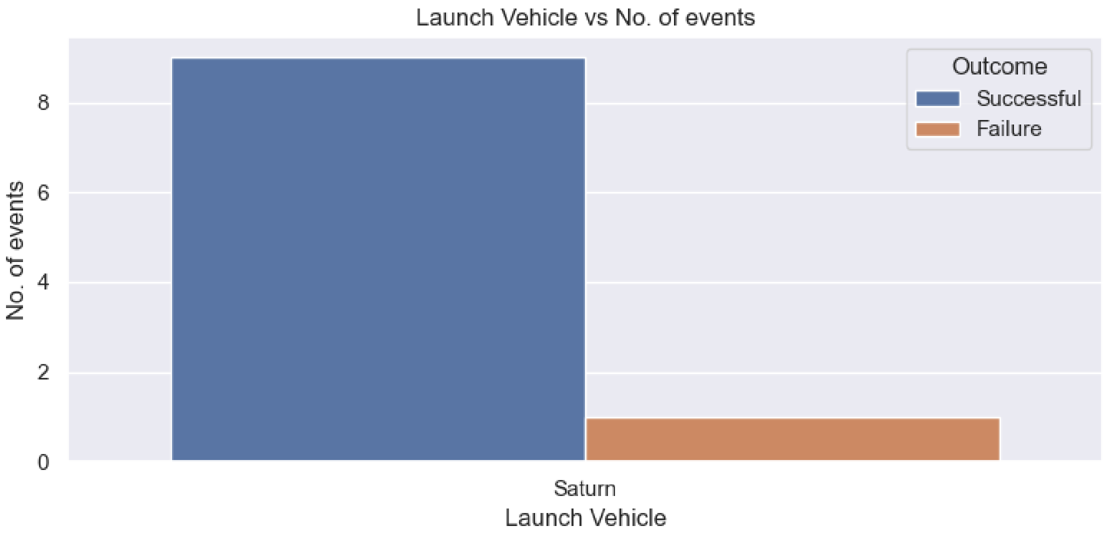

Launch Vehicle vs No. of events
No. of events
7
6
5
4
3
2
1
0
Outcome
Failure
Successful
Molniya-M
Launch Vehicle

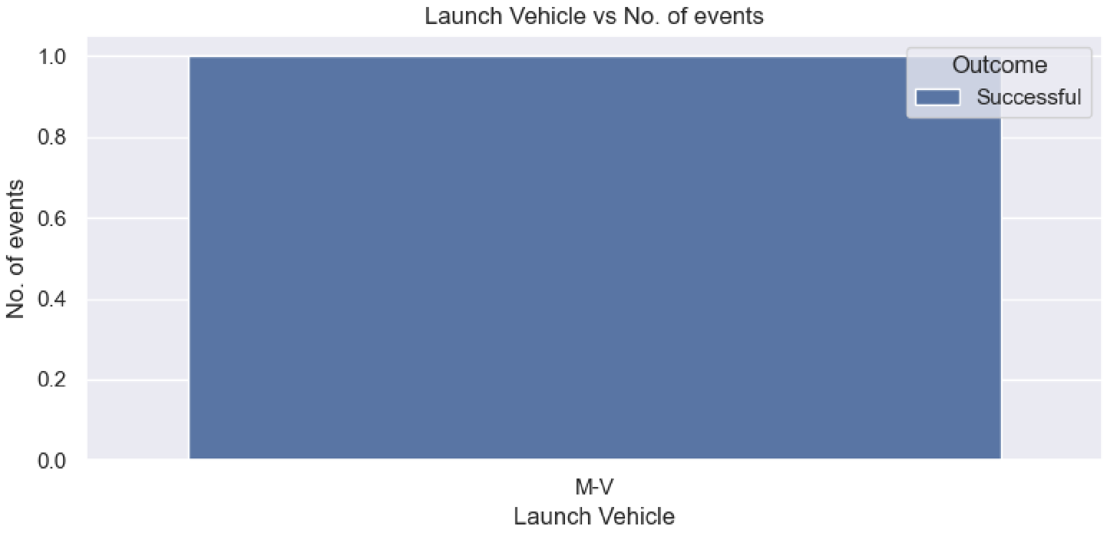

Launch Vehicle vs No. of events
No. of events
1.0
0.8
0.6
0.4
0.2
0.0
Outcome
Successful
Mu-3S-II
Launch Vehicle


Launch Vehicle vs No. of events
No. of events
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Outcome
Operational
LVM3
Launch Vehicle


Launch Vehicle vs No. of events
No. of events
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Outcome
Failure
Atlas-D
Launch Vehicle


Launch Vehicle vs No. of events
No. of events
5
4
3
2
1
0
Outcome
Successful
Failure
Operational
Falcon
Launch Vehicle





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
```

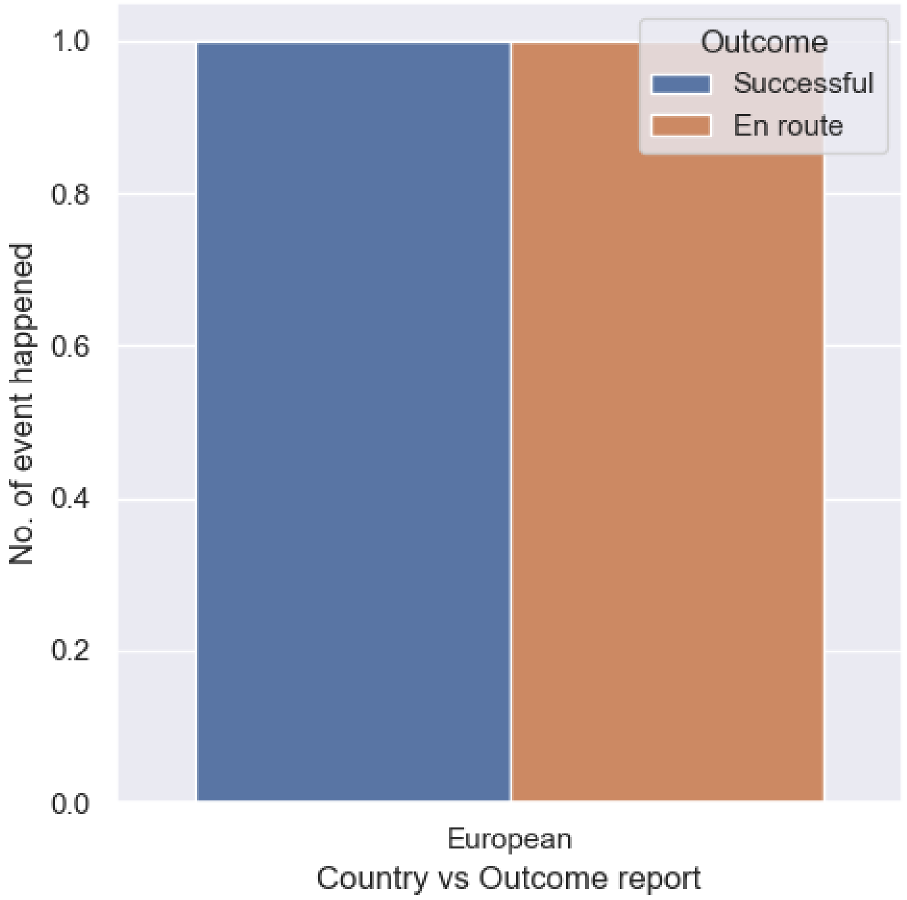
[65]:
```
# Space mission happened in india
space_mission[space_mission['Country'] == 'India']
```

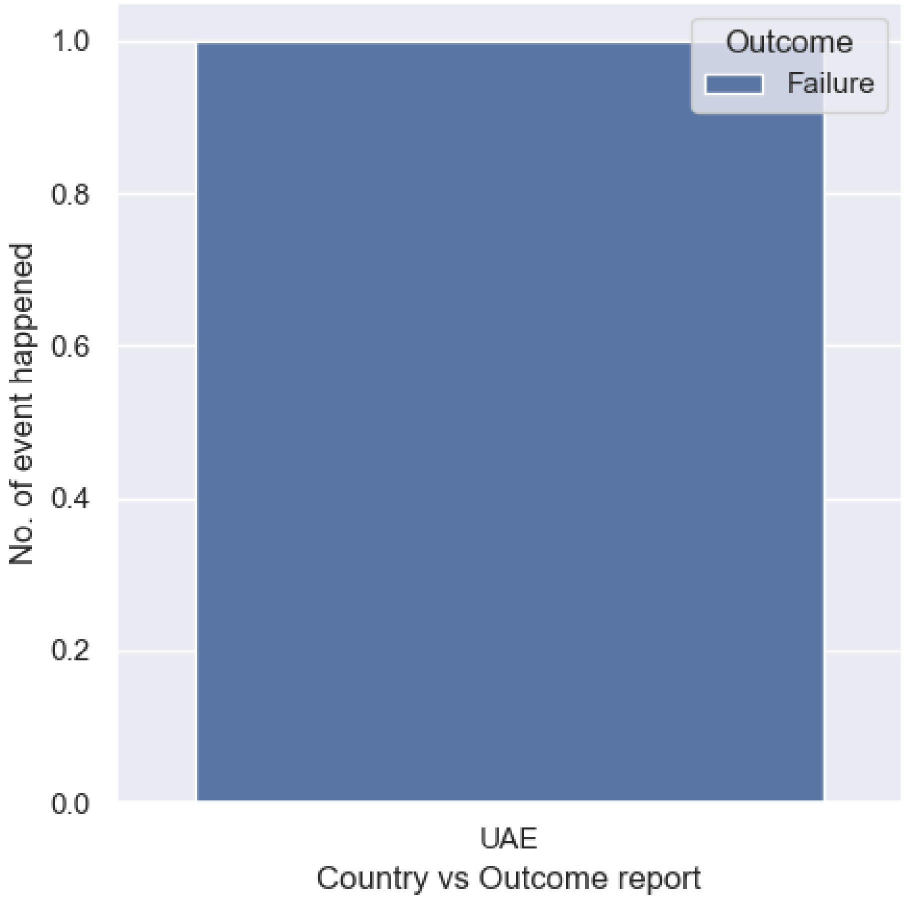
[65]:
```
           Mission     Spacecraft Launch Date Mission Type      Outcome  \
113  Chandrayaan-1  Chandrayaan-1  2008-10-22      Orbiter   Successful
114  Chandrayaan-1           Moon  2008-10-22     Impactor   Successful
133  Chandrayaan-2  Chandrayaan-2  2019-07-22      Orbiter  Operational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

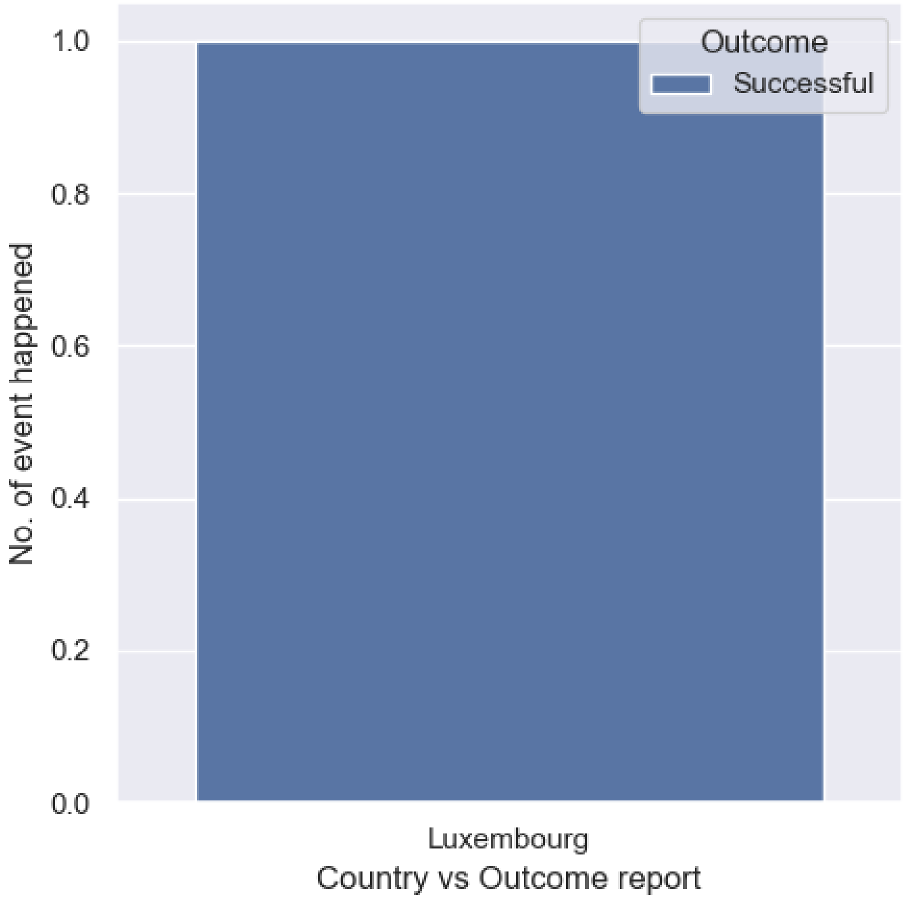
```
    Launch year
113        2008
114        2008
133        2019
156        2023
```

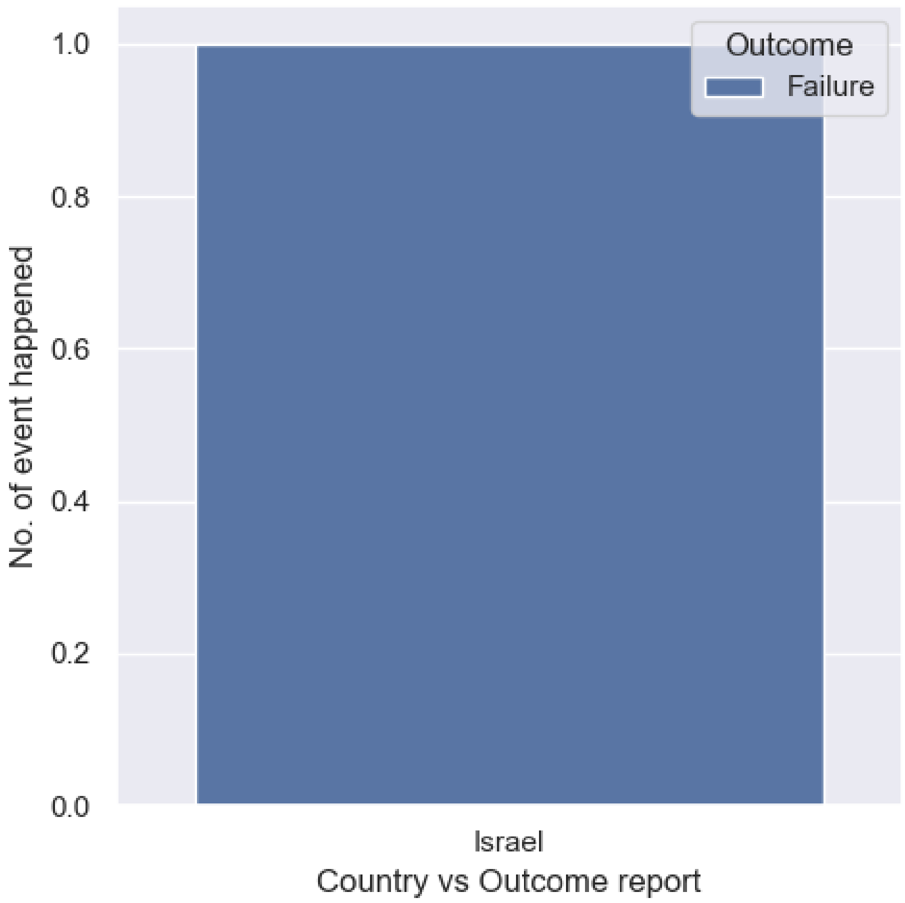
[66]:

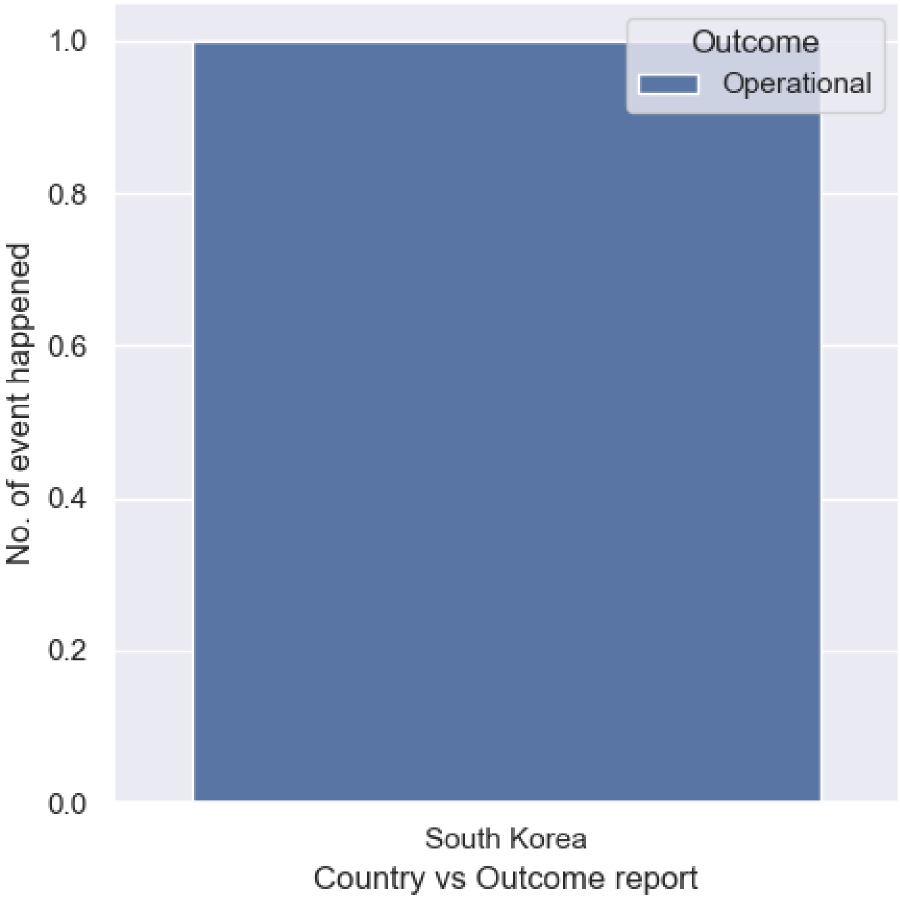
```python
# Plot to show the space mission by each country with respect to the outcome happened.
list1= []
for i in space_mission['Country']:
    list1.append(i)
Country_Name=list(set(list1))
for i in Country_Name:
    df1 = space_mission[space_mission['Country'] == i]
    sns.set(rc = {'figure.figsize':(5,5)})
    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()
```

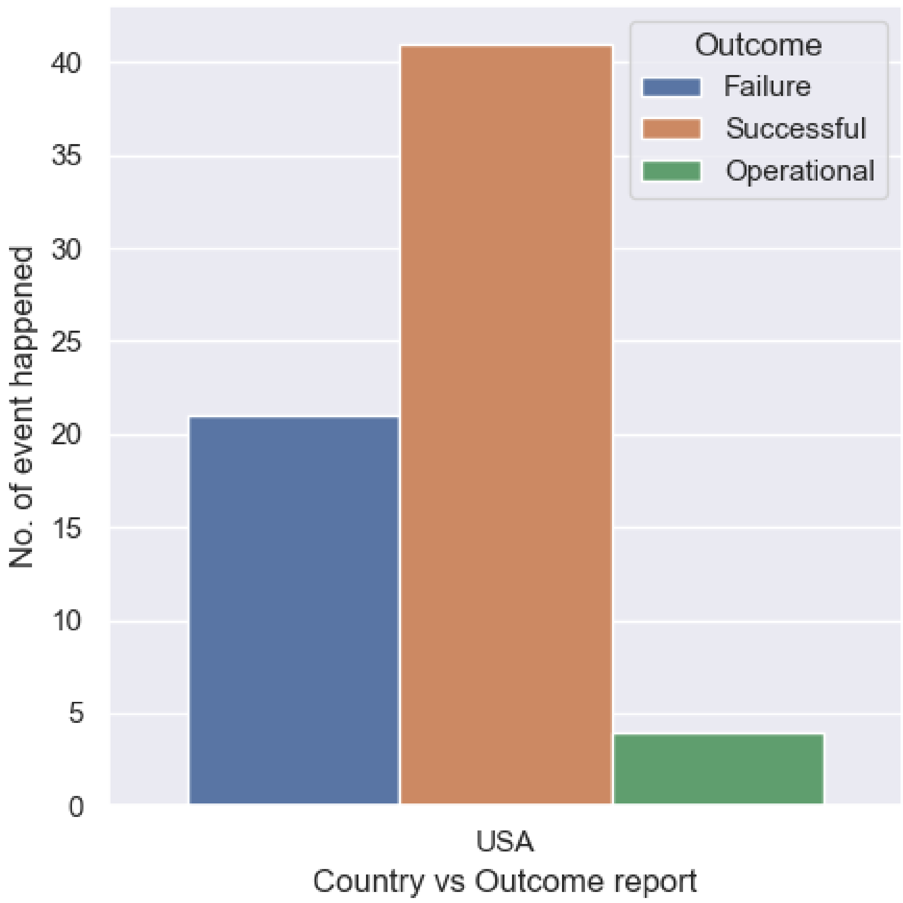

Outcome
Successful
En route
1.0
0.8
0.6
0.4
0.2
0.0
No. of event happened
European
Country vs Outcome report

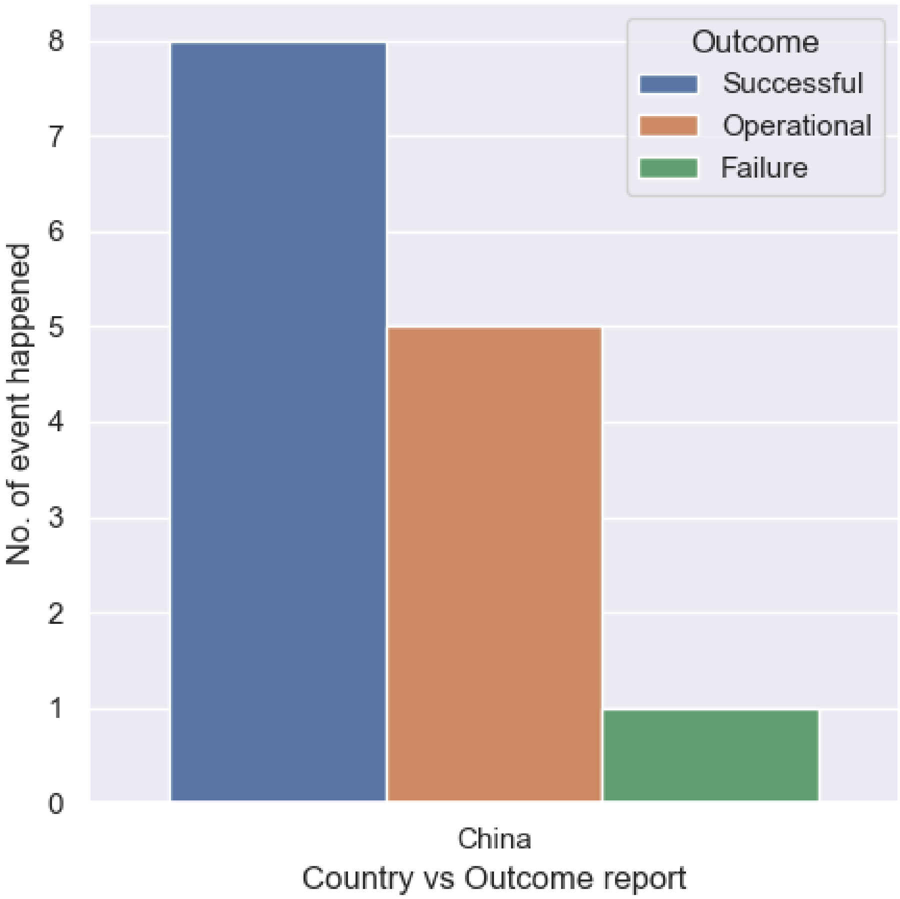

Outcome
Failure
1.0
0.8
0.6
0.4
0.2
0.0
No. of event happened
UAE
Country vs Outcome report

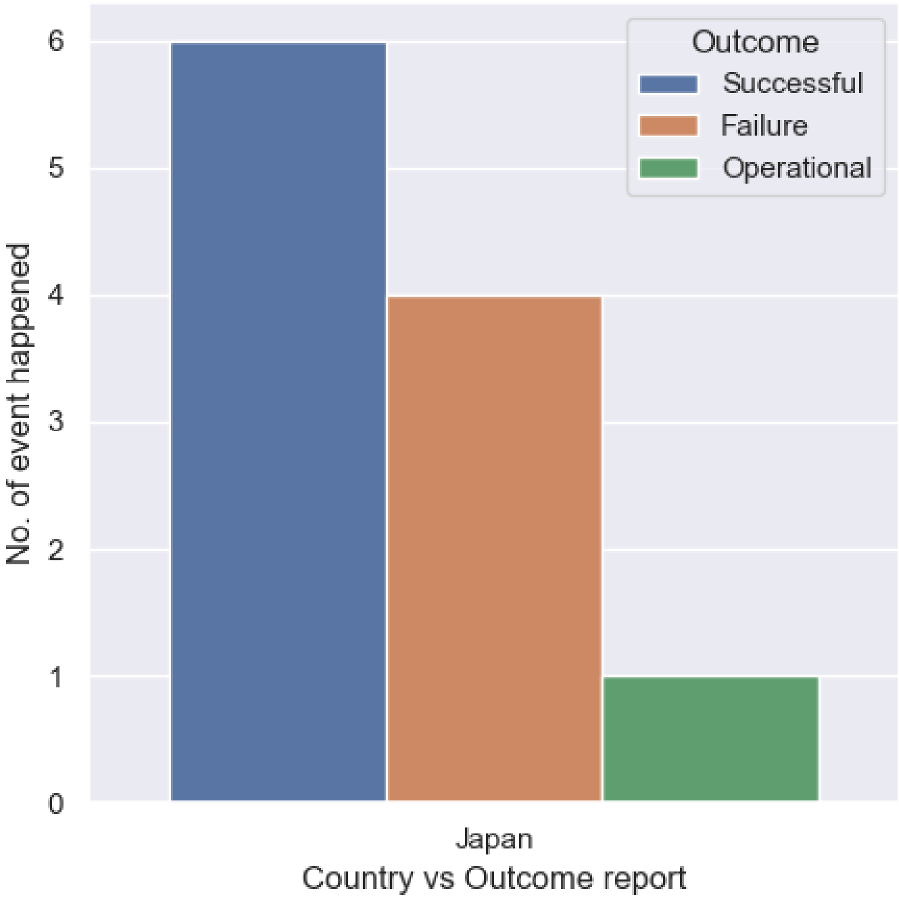

Outcome
Successful
No. of event happened
1.0
0.8
0.6
0.4
0.2
0.0
Luxembourg
Country vs Outcome report

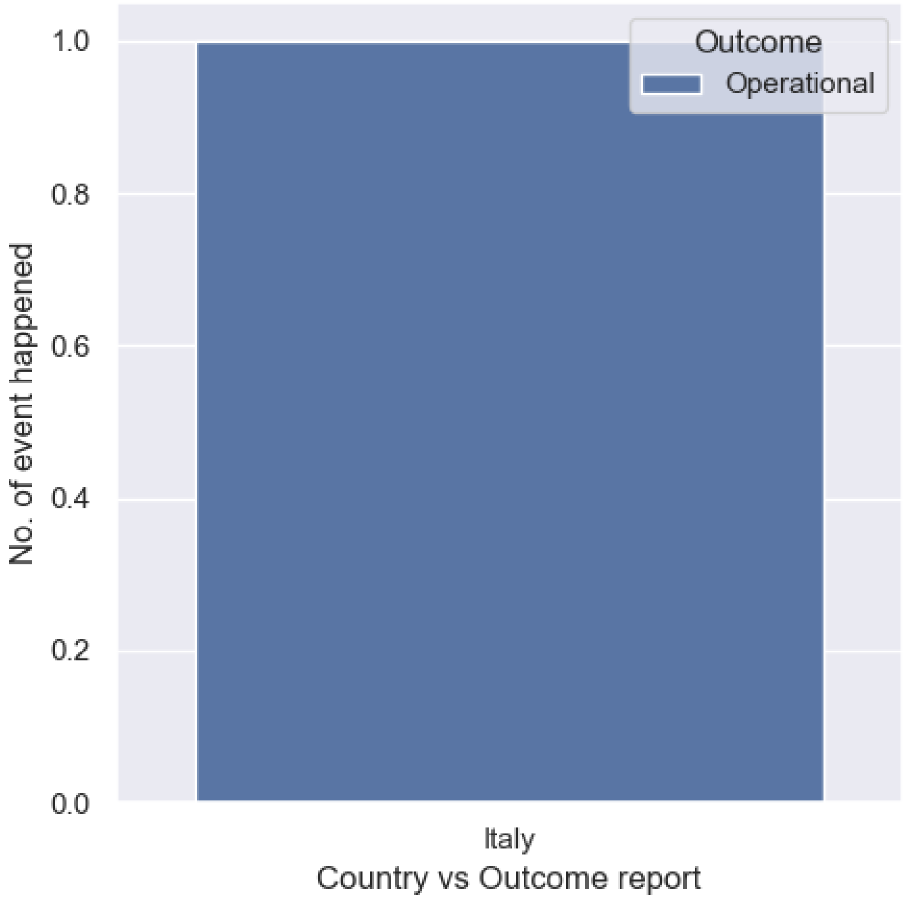

Outcome
Failure
1.0
0.8
0.6
0.4
0.2
0.0
No. of event happened
Israel
Country vs Outcome report

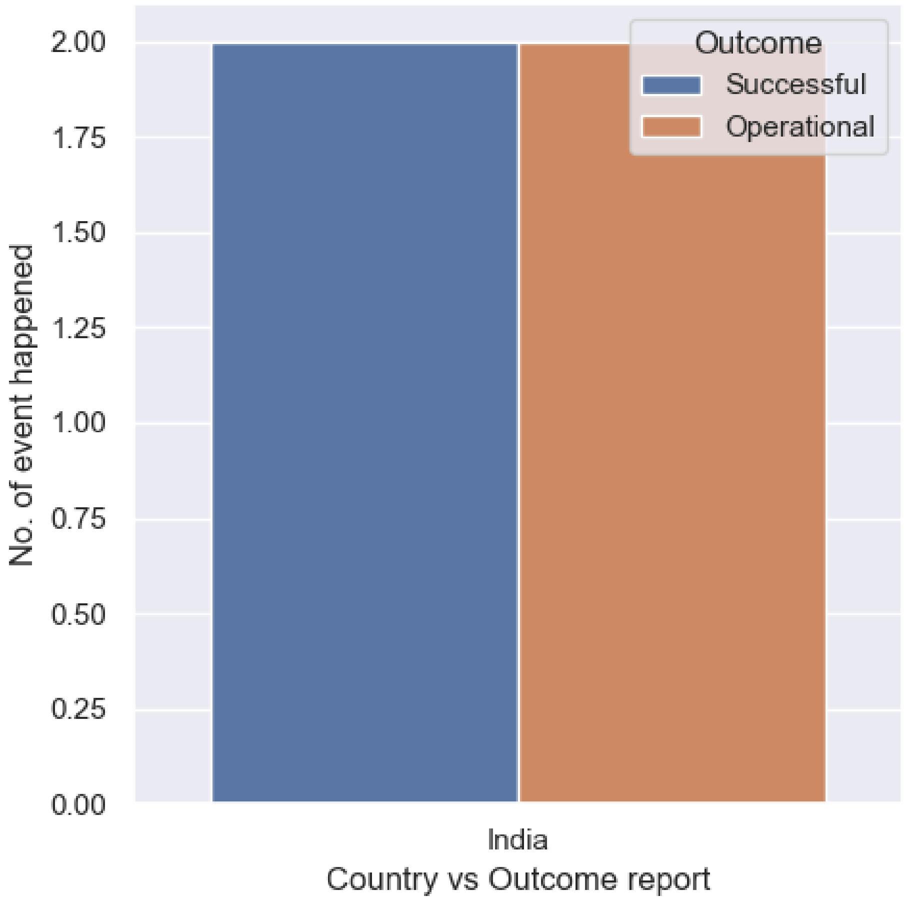

Outcome
Operational
1.0
0.8
0.6
0.4
0.2
0.0
No. of event happened
South Korea
Country vs Outcome report

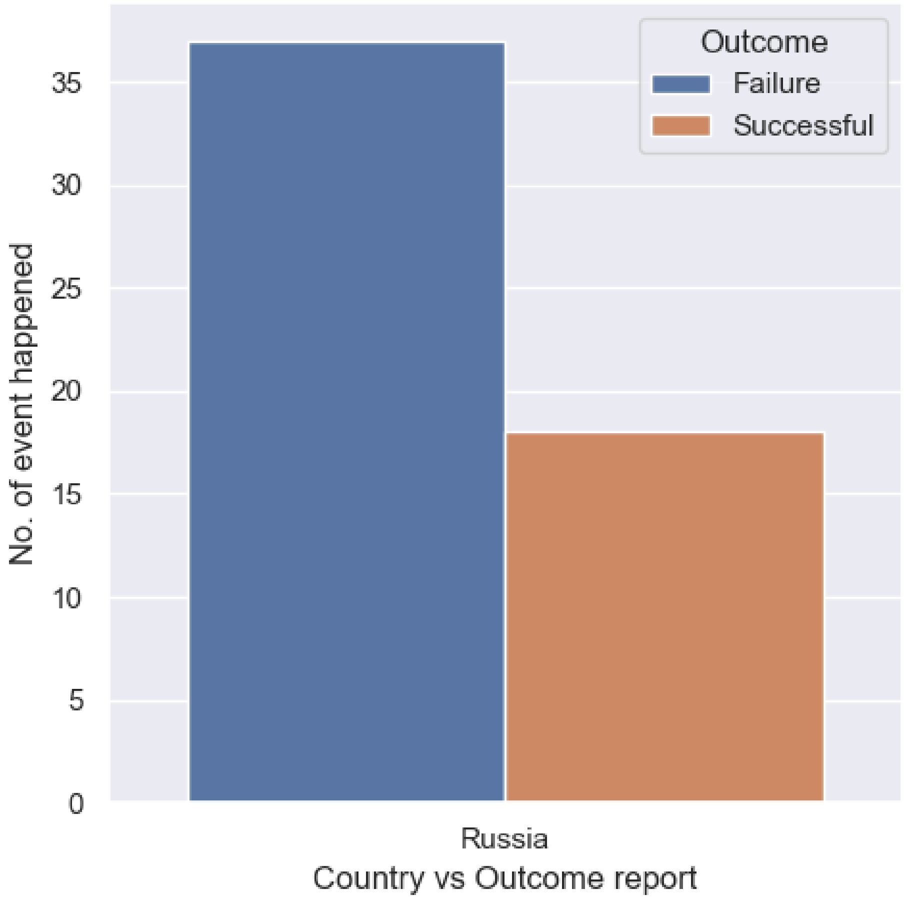

Outcome
Failure
Successful
Operational
No. of event happened
0
5
10
15
20
25
30
35
40
USA
Country vs Outcome report


Outcome
Successful
Operational
Failure
No. of event happened
0
1
2
3
4
5
6
7
8
China
Country vs Outcome report


Outcome
Successful
Failure
Operational
No. of event happened
0
1
2
3
4
5
6
Japan
Country vs Outcome report


Outcome
Operational
1.0
0.8
0.6
0.4
0.2
0.0
No. of event happened
Italy
Country vs Outcome report


Outcome
Successful
Operational
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
No. of event happened
India
Country vs Outcome report

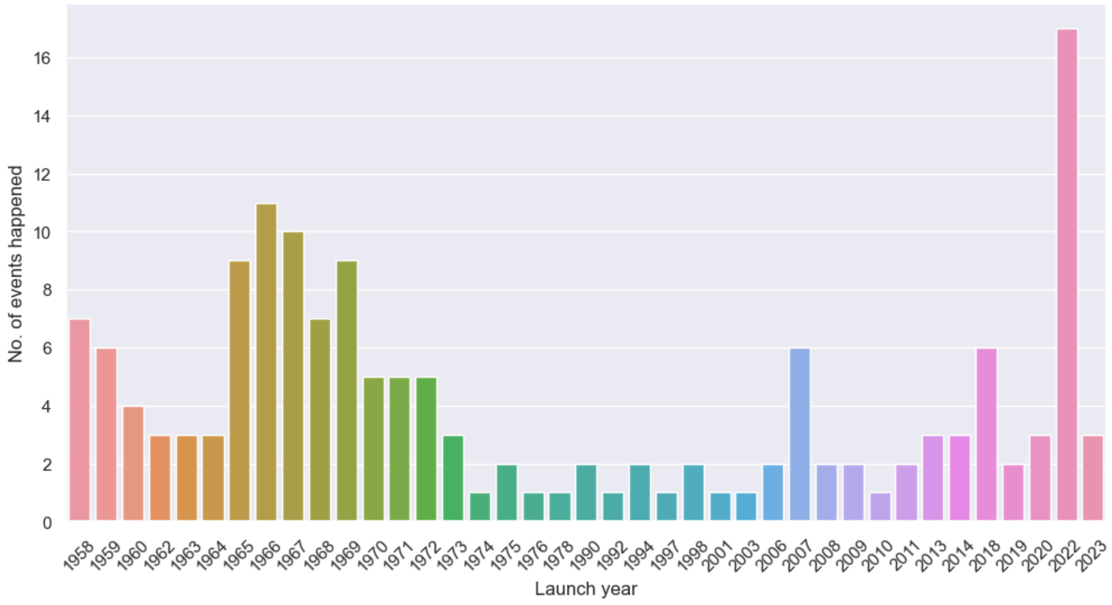


Observations

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 happedned 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 devide outcome into successfull and failure. Operational –> Successfull. 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
```

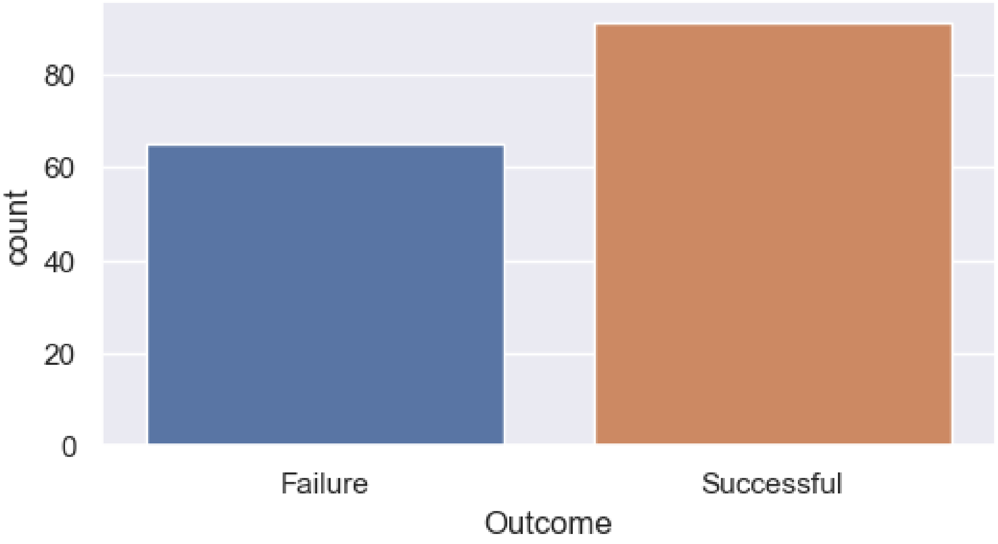
```
[69]: space_mission.drop(155, axis=0, inplace= True)
      space_mission['Outcome'].replace('Operational','Successful', inplace= True)
```

```
[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)
```

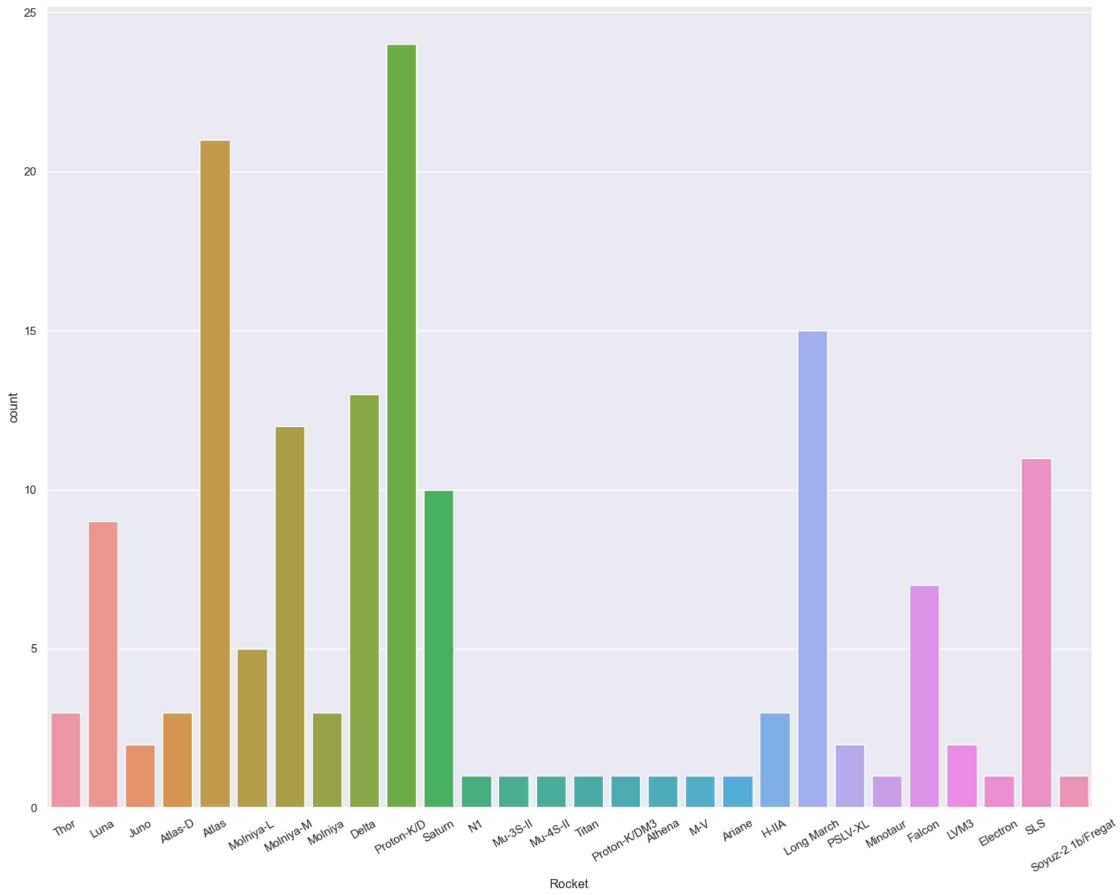
```
[74]: space_mission.head(5)
```

```
[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
```

[79]:
```
                   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]
```

[ ]:

[ ]:

[ ]:

[ ]:

Model Building for Space Missions

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]:
```
import chardet
with open('data\space_mission', 'rb') as f:
    result = chardet.detect(f.read())
result
```

[2]:
```
{'encoding': 'ascii', 'confidence': 1.0, 'language': ''}
```

[3]:
```
space_mission = pd.read_csv('data\space_mission', encoding= 'ascii')
space_mission
```

[3]:
```
                    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
..                      …            …          …         …     …
151                  SORA-Q         SORA-Q        Rover     Failure   Japan
152  Emirates Lunar Mission         Rashid        Rover     Failure     UAE
153        Lunar Flashlight          Lunar        Flyby     Failure     USA
154           Chandrayaan-3  Chandrayaan-3      Orbiter  Successful   India
155                 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
..                 …          …
```

```
151             Falcon         2022
152             Falcon         2022
153             Falcon         2022
154               LVM3         2023
155  Soyuz-2.1b/Fregat         2023

[156 rows x 7 columns]
```

```
[4]: space_mission.isna().sum()
```

```
[4]: Mission           0
     Spacecraft        0
     Mission Type      0
     Outcome           0
     Country           0
     launch vehicle    0
     Launch year       0
     dtype: int64
```

```
[ ]:
```

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

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

```
[6]: # Label Encoding by using map function
     space_mission['Outcome'] = space_mission['Outcome'].map({'Failure': 0,␣
      ↪'Successful': 1})
```

```
[7]: # One hot encoding for Country
     df1= pd.get_dummies(space_mission['Country'],dummy_na= False )
     space_mission = pd.concat([space_mission, df1], axis=1)
     space_mission.drop('Country', axis=1, inplace = True)
```

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

```
[8]:                 Mission Spacecraft Mission Type  Outcome launch vehicle  \
     0    Pioneer 0 (Able I)    Pioneer      Orbiter        0           Thor
     1         Luna E-1 No.1       Luna     Impactor        0           Luna
     2   Pioneer 1 (Able II)    Pioneer      Orbiter        0           Thor
     3         Luna E-1 No.2       Luna     Impactor        0           Luna
     4  Pioneer 2 (Able III)    Pioneer      Orbiter        0           Thor

        Launch year  China  European  India  Israel  Italy  Japan  Luxembourg  \
     0         1958      0         0      0       0      0      0           0
     1         1958      0         0      0       0      0      0           0
     2         1958      0         0      0       0      0      0           0
     3         1958      0         0      0       0      0      0           0
```

```
4         1958      0         0      0       0      0      0           0

   Russia  South Korea  UAE  USA
0       0            0    0    1
1       1            0    0    0
2       0            0    0    1
3       1            0    0    0
4       0            0    0    1
```

```
[9]: space_mission['launch vehicle'].unique()
```

```
[9]: 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 March', 'PSLV-XL', 'Minotaur', 'Falcon',
            'LVM3', 'Electron', 'SLS', 'Soyuz-2.1b/Fregat'], dtype=object)
```

```
[10]: space_mission['Spacecraft'].unique()
```

```
[10]: 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', 'Chandrayaan-3'], dtype=object)
```

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

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

```
[12]: space_mission[space_mission['Mission Type'] == 'Crewed orbiter']
```

```
[12]:      Mission Spacecraft    Mission Type  Outcome launch vehicle  Launch year  \
      62  Apollo 8     Apollo  Crewed orbiter        1         Saturn         1968

          China  European  India  Israel  Italy  Japan  Luxembourg  Russia  \
      62      0         0      0       0      0      0           0       0

          South Korea  UAE  USA
      62            0    0    1
```

[13]:
```
space_mission[space_mission['Mission Type'] == 'Sample Return']
```

[13]:
```
       Mission Spacecraft   Mission Type  Outcome launch vehicle  Launch year  \
136  Chang'e 5    Chang'e  Sample Return        1      Long March         2020

     China  European  India  Israel  Italy  Japan  Luxembourg  Russia  \
136      1         0      0       0      0      0           0       0

     South Korea  UAE  USA
136            0    0    0
```

[14]:
```
# Lets convert 'Crewed orbiter' --> 'Orbiter' and 'Lander,Sample Return' -- >␣
 ↪'Sample Return'
```

[15]:
```
space_mission['Mission Type'].replace({'Crewed orbiter':'Orbiter',␣
 ↪'Lander,Sample Return':'Sample Return'}, inplace = True )
```

[16]:
```
space_mission['Mission Type'].unique()
```

[16]:
```
array(['Orbiter', 'Impactor', 'Flyby', 'Lander', 'Orbiter,Lander,Rover',
       'Sample Return', 'Rover', 'Flyby / Impactor (post mission)',
       'Relay Satellite'], dtype=object)
```

[17]:
```
space_mission[space_mission['Mission Type'] == 'Sample Return']
```

[17]:
```
                Mission Spacecraft   Mission Type  Outcome launch vehicle  \
92   Luna E-8-5M No.412       Luna  Sample Return        0      Proton-K/D
93              Luna 24       Luna  Sample Return        1      Proton-K/D
136           Chang'e 5    Chang'e  Sample Return        1      Long March

     Launch year  China  European  India  Israel  Italy  Japan  Luxembourg  \
92          1975      0         0      0       0      0      0           0
93          1976      0         0      0       0      0      0           0
136         2020      1         0      0       0      0      0           0

     Russia  South Korea  UAE  USA
92        1            0    0    0
93        1            0    0    0
136       0            0    0    0
```

Lets replace Mission Type ‘Orbiter,Lander,Rover’ –> ‘Lander’ || ‘Rover’ –> ‘Lander’ || ‘Flyby / Impactor (post mission)’ –>‘Flyby’ || ‘Sample Return’ –> ‘Lander’ || ‘Relay Satellite’ –> ‘Orbiter’ || ‘Impactor’ –> ‘Flyby’

[18]:
```
space_mission['Mission Type'].replace({'Orbiter,Lander,Rover':'Lander', 'Rover':
 ↪ 'Lander','Flyby / Impactor (post mission)':'Flyby',
                                       'Sample Return': 'Lander','Relay␣
 ↪Satellite' : 'Orbiter', 'Impactor' : 'Flyby' }, inplace = True)
```

[19]:
```
space_mission['Mission Type'].unique()
```

[19]:
```
array(['Orbiter', 'Flyby', 'Lander'], dtype=object)
```

[20]:
```
df1 = pd.get_dummies(space_mission['Mission Type'])
space_mission = pd.concat([space_mission, df1], axis = 1)
space_mission.drop('Mission Type', axis=1, inplace = True)
space_mission.head()
```

[20]:
```
                 Mission Spacecraft  Outcome launch vehicle  Launch year  \
0    Pioneer 0 (Able I)    Pioneer        0            Thor         1958
1         Luna E-1 No.1       Luna        0            Luna         1958
2   Pioneer 1 (Able II)    Pioneer        0            Thor         1958
3         Luna E-1 No.2       Luna        0            Luna         1958
4  Pioneer 2 (Able III)    Pioneer        0            Thor         1958

   China  European  India  Israel  Italy  Japan  Luxembourg  Russia  \
0      0         0      0       0      0      0           0       0
1      0         0      0       0      0      0           0       1
2      0         0      0       0      0      0           0       0
3      0         0      0       0      0      0           0       1
4      0         0      0       0      0      0           0       0

   South Korea  UAE  USA  Flyby  Lander  Orbiter
0            0    0    1      0       0        1
1            0    0    0      1       0        0
2            0    0    1      0       0        1
3            0    0    0      1       0        0
4            0    0    1      0       0        1
```

1 Logistics Regression ML Model

[21]:
```
X= space_mission.drop(['Mission', 'Spacecraft', 'launch vehicle','Outcome' ],␣
 ↪axis = 1)
y= space_mission['Outcome']
```

[22]:
```
#make train test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=42,␣
 ↪test_size=0.33)
```

[23]:
```
# Standardise the data
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_train= scaler.fit_transform(X_train)
X_test=scaler.transform(X_test)
```

[ ]:

```
```

[24]:

```
# Logistics model
from sklearn.linear_model import LogisticRegression
LR = LogisticRegression()
LR.fit(X_train, y_train)
pred_data = LR.predict(X_test)
```

[25]:

```
# Calculating the Precision, Recall, Accuracy score
from sklearn.metrics import accuracy_score, recall_score, precision_score,␣
 ↪confusion_matrix, roc_auc_score, roc_curve
accuracy = accuracy_score(y_test, pred_data)
recall = recall_score(y_test, pred_data)
precision = precision_score(y_test, pred_data)
print('Accuracy score is: ',accuracy_score(y_test, pred_data))
print('Recall Score is : ',recall_score(y_test, pred_data))
print('Precision score is : ',precision_score(y_test, pred_data))
```

```
Accuracy score is:  0.6538461538461539
Recall Score is :  0.7272727272727273
Precision score is :  0.7272727272727273
```

[26]:

```
CM= confusion_matrix(y_test, pred_data)
CM
```

[26]:

```
array([[10,  9],
       [ 9, 24]], dtype=int64)
```

[27]:

```
TP= CM[0][0]
FP = CM[0][1]
FN= CM[1][0]
TN=CM[1][1]
Accuracy = (TP + TN)/(TP + TN+ FN+ FP)
Accuracy
```

[27]:

```
0.6538461538461539
```

[28]:

```
F1_score = 2 * (recall * precision)/(recall + precision)
F1_score
```

[28]:

```
0.7272727272727273
```

[29]:

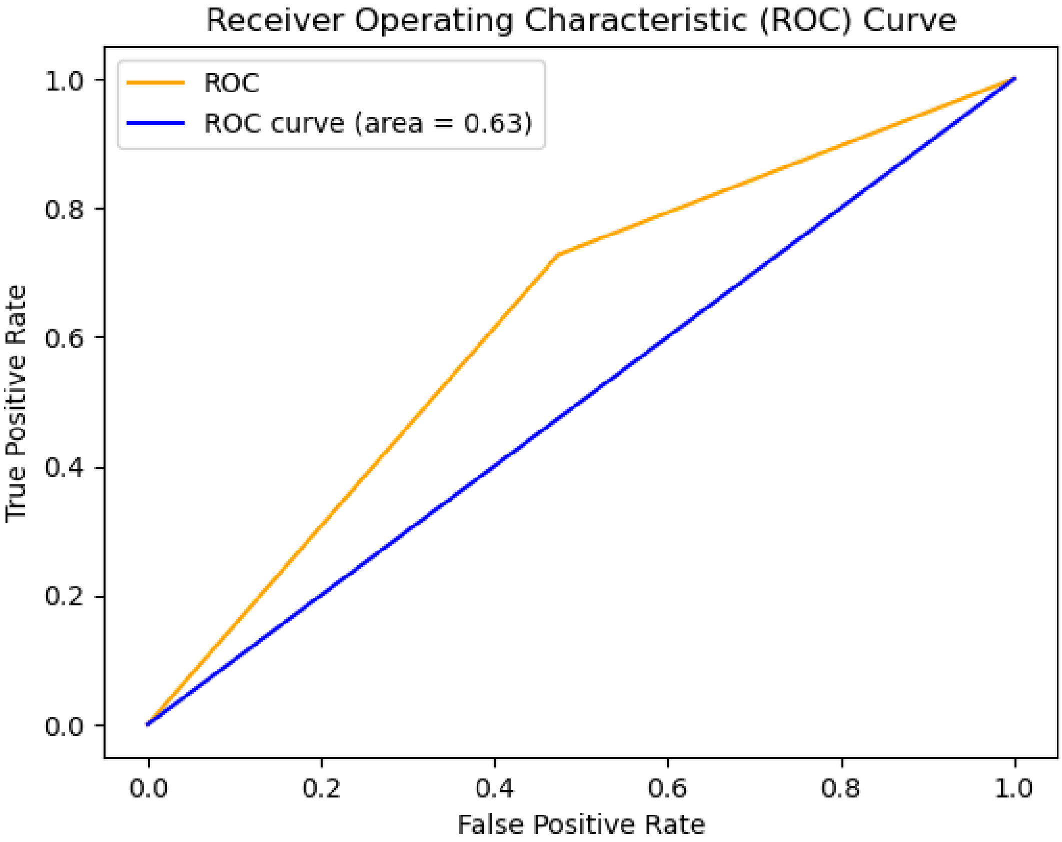
```
auc= roc_auc_score(y_test, pred_data)
auc
```

[29]:

```
0.6267942583732058
```

[30]:

```
# ROC
TPR, FPR, Treshold = roc_curve(y_test, pred_data)
plt.plot(TPR, FPR, label= "ROC", color= 'orange')
plt.plot([0,1], [0,1], color= 'blue', label= 'ROC curve (area = %0.2f)' % auc)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend()
plt.show()
```



2 SVM–> SVC ML Model

[31]:

```
X= space_mission.drop(['Mission', 'Spacecraft', 'launch vehicle','Outcome' ],␣
 ↪axis = 1)
y= space_mission['Outcome']
#make train test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=42,␣
 ↪test_size=0.33)
```

```
# Standardise the data
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_train= scaler.fit_transform(X_train)
X_test=scaler.transform(X_test)

from sklearn.svm import SVC
svc = SVC()
svc.fit(X_train, y_train)
pred_data= svc.predict(X_test)
```

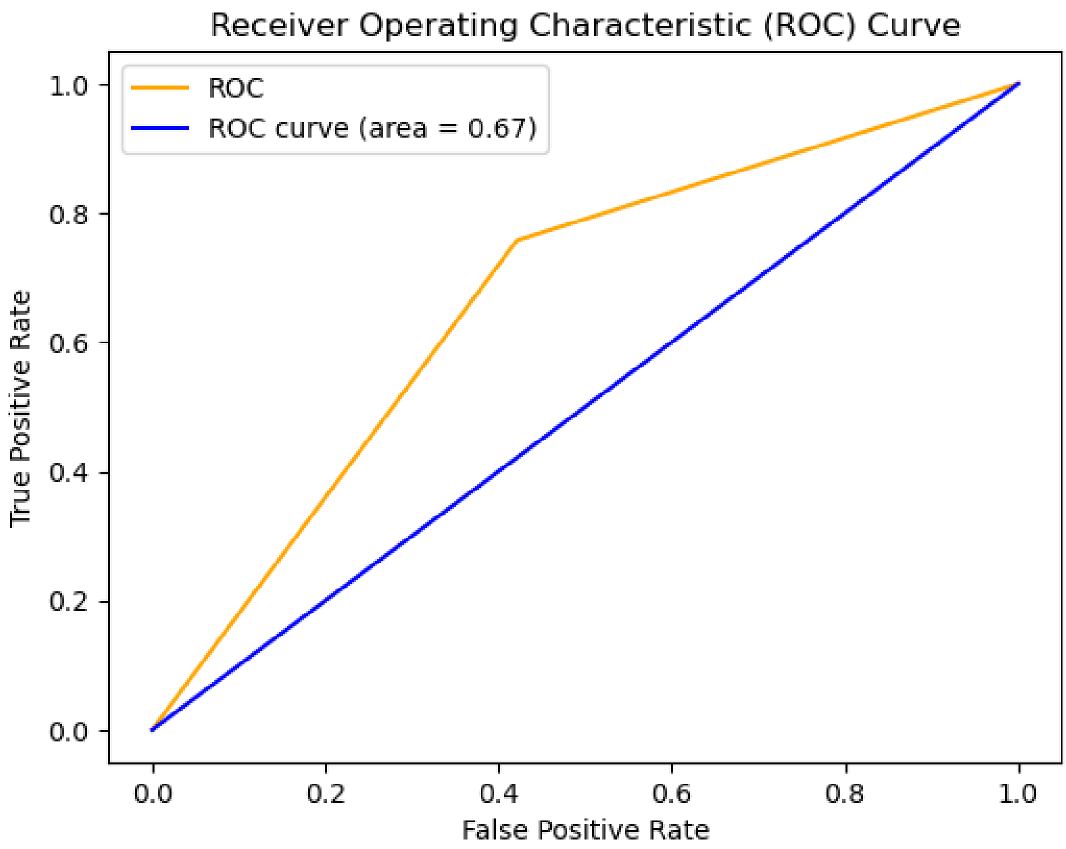
[32]:

```
# Calculating the Precision, Recall, Accuracy score
from sklearn.metrics import accuracy_score, recall_score, precision_score,␣
 ↪confusion_matrix, roc_auc_score, roc_curve
accuracy = accuracy_score(y_test, pred_data)
recall = recall_score(y_test, pred_data)
precision = precision_score(y_test, pred_data)
print('Accuracy score is: ',accuracy_score(y_test, pred_data))
print('Recall Score is : ',recall_score(y_test, pred_data))
print('Precision score is : ',precision_score(y_test, pred_data))
CM= confusion_matrix(y_test, pred_data)
print("Confusion Matrix is : ", CM)
F1_score = 2 * (recall * precision)/(recall + precision)
print("F1_score is : ", F1_score)
auc= roc_auc_score(y_test, pred_data)
print("auc is : ", auc)
```

```
Accuracy score is:  0.6923076923076923
Recall Score is :  0.7575757575757576
Precision score is :  0.7575757575757576
Confusion Matrix is :  [[11  8]
 [ 8 25]]
F1_score is :  0.7575757575757576
auc is :  0.6682615629984051
```

[33]:

```
# ROC
TPR, FPR, Treshold = roc_curve(y_test, pred_data)
plt.plot(TPR, FPR, label= "ROC", color= 'orange')
plt.plot([0,1], [0,1], color= 'blue', label= 'ROC curve (area = %0.2f)' % auc)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend()
plt.show()
```



3 Decision Tree

[34]:

```
#Importing and fiting the data in Decision Tree Classifier
from sklearn.tree  import DecisionTreeClassifier
regressor = DecisionTreeClassifier()
regressor.fit(X_train, y_train)
# Predicting the test data
pred_data = regressor.predict(X_test)
```

[35]:

```
# Predicting the training data
Training_data_Prediction= regressor.predict(X_train)
```

[36]:

```
# Calculating the Test data accuracy
Accuracy_test_data = accuracy_score(y_test, pred_data)
Accuracy_test_data
```

[36]:

```
0.7115384615384616
```

[37]:
```
# Calculating the Train data accuracy
Accuracy_training_data = accuracy_score(y_train, Training_data_Prediction)
Accuracy_training_data
```

[37]:
```
0.9038461538461539
```

We can clearly see that there is huge difference between train data accuracy score and test data accuracy score, this is a clear sign of overfitting data.

3.1 GridSearchCV

[38]:
```
## Hyperparameter tuning

hyperparameter = {
    'criterion' : ["gini", "entropy", "log_loss"],
    'splitter' : ["best", "random"],
    'max_depth' : [1,2,3,4,5,6,7,8,9,10,11,12],
    'max_features' : ["auto", "sqrt", "log2"]
}
regressor = DecisionTreeClassifier()
```

[39]:
```
# Using GridSearchCV
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import accuracy_score, make_scorer
scoring = {"AUC": "roc_auc", "Accuracy": make_scorer(accuracy_score)}
regressorCV = GridSearchCV(regressor, param_grid=hyperparameter,␣
 ↪cv=5,scoring=scoring, refit="AUC", n_jobs=2,
                           return_train_score=True)
```

[40]:
```
regressorCV.fit(X_train, y_train)
```

[40]:
```
GridSearchCV(cv=5, estimator=DecisionTreeClassifier(), n_jobs=2,
             param_grid={'criterion': ['gini', 'entropy', 'log_loss'],
                         'max_depth': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12],
                         'max_features': ['auto', 'sqrt', 'log2'],
                         'splitter': ['best', 'random']},
             refit='AUC', return_train_score=True,
             scoring={'AUC': 'roc_auc',
                      'Accuracy': make_scorer(accuracy_score)})
```

[41]:
```
# Getting the best parameters from GridSearchCV
regressorCV.best_params_
```

[41]:
```
{'criterion': 'log_loss',
 'max_depth': 5,
 'max_features': 'sqrt',
 'splitter': 'best'}
```

```
[42]: # Applying the best parameters inside the Decision Tree Classifier model.
      from sklearn.tree  import DecisionTreeClassifier
      regressor = DecisionTreeClassifier(criterion = 'log_loss',
                                         max_depth = 4, max_features = 'log2',␣
        ↪splitter = 'best')
      regressor.fit(X_train, y_train)
      pred_data = regressor.predict(X_test)
```

```
[43]: # Predicting the training data
      Training_data_Prediction= regressor.predict(X_train)
```

```
[44]: # Calculating the Test data accuracy
      Accuracy_test_data = accuracy_score(y_test, pred_data)
      Accuracy_test_data
```

```
[44]: 0.7115384615384616
```

```
[45]: # Calculating the Train data accuracy
      Accuracy_training_data = accuracy_score(y_train, Training_data_Prediction)
      Accuracy_training_data
```

```
[45]: 0.8076923076923077
```

This model has imploved a lot, compared to the previous one. we can clearly see there is low bias and low variance. Hence we can consider these parameters of GridSearchCV

3.2 RandomSearchCV

```
[46]: from sklearn.model_selection import RandomizedSearchCV
      regressor = DecisionTreeClassifier()
      hyperparameter = {
          'criterion' : ["gini", "entropy", "log_loss"],
          'splitter' : ["best", "random"],
          'max_depth' : [1,2,3,4,5,6,7,8,9,10,11,12],
          'max_features' : ["auto", "sqrt", "log2"]
      }
```

```
[47]: regressorCV = RandomizedSearchCV(regressor,hyperparameter, cv = 5)
```

```
[48]: regressorCV.fit(X_train, y_train)
```

```
[48]: RandomizedSearchCV(cv=5, estimator=DecisionTreeClassifier(),
                         param_distributions={'criterion': ['gini', 'entropy',
                                                            'log_loss'],
                                              'max_depth': [1, 2, 3, 4, 5, 6, 7, 8, 9,
                                                            10, 11, 12],
                                              'max_features': ['auto', 'sqrt',
                                                               'log2'],
                                         'splitter': ['best', 'random']})
```

```
[49]: regressorCV.best_params_
```

```
[49]: {'splitter': 'random',
       'max_features': 'sqrt',
       'max_depth': 6,
       'criterion': 'log_loss'}
```

```
[50]: from sklearn.tree  import DecisionTreeClassifier
      regressor = DecisionTreeClassifier(splitter = 'random', max_features = 'sqrt',␣
        ↪max_depth = 8, criterion = 'gini')
      regressor.fit(X_train, y_train)
      # Predicting the test data
      pred_data = regressor.predict(X_test)
```

```
[51]: # Predicting the training data
      Training_data_Prediction= regressor.predict(X_train)
```

```
[52]: # Calculating the Test data accuracy
      Accuracy_test_data = accuracy_score(y_test, pred_data)
      Accuracy_test_data
```

```
[52]: 0.6923076923076923
```

```
[53]: # Calculating the Training data accuracy
      Accuracy_training_data = accuracy_score(y_train, Training_data_Prediction)
      Accuracy_training_data
```

```
[53]: 0.8461538461538461
```

In RandomSearchCV we can clearly see there is low bias and high variance. He we cannot consider these parameters of RandomSearchCV

4

```
[ ]:
```

```
[ ]:
```

```
[ ]:
```