Space_Missions_Analysis_(start)

November 21, 2025

1 Introduction

This dataset was scraped from nextspaceflight.com and includes all the space missions since the beginning of Space Race between the USA and the Soviet Union in 1957!

1.0.1 Install Package with Country Codes

[2]:
```
# pip install iso3166
```

1.0.2 Upgrade Plotly

Run the cell below if you are working with Google Colab.

[3]:
```
# %pip install --upgrade plotly
```

1.0.3 Import Statements

[4]:
```
import numpy as np
import pandas as pd
import plotly.express as px
import matplotlib.pyplot as plt
import seaborn as sns

# These might be helpful:
from iso3166 import countries
from datetime import datetime, timedelta
```

1.0.4 Notebook Presentation

[5]:
```
pd.options.display.float_format = '{:,.2f}'.format
```

1.0.5 Load the Data

[7]:
```
df_data = pd.read_csv('mission_launches.csv')
```

2 Preliminary Data Exploration

- What is the shape of `df_data`?

- How many rows and columns does it have?
- What are the column names?
- Are there any NaN values or duplicates?

[8]:
```
df_data.shape
```

[8]:
```
(4324, 9)
```

There are 4324 rows and 9 columns

[9]:
```
print(f'The columns names are : {df_data.columns.values}')
```

```
The columns names are : ['Unnamed: 0.1' 'Unnamed: 0' 'Organisation' 'Location'
'Date' 'Detail'
 'Rocket_Status' 'Price' 'Mission_Status']
```

[10]:
```
print(f'There are NaN values : {df_data.isna().values.any()}')
```

```
There are NaN values : True
```

[11]:
```
df_data.isna().any()
```

[11]:
```
Unnamed: 0.1      False
Unnamed: 0        False
Organisation      False
Location          False
Date              False
Detail            False
Rocket_Status     False
Price              True
Mission_Status    False
dtype: bool
```

[12]:
```
print(f'There are duplicated values : {df_data.duplicated().values.any()}')
```

```
There are duplicated values : False
```

2.1 Data Cleaning - Check for Missing Values and Duplicates

Consider removing columns containing junk data.

[13]:
```
df_data.head()
```

[13]:

	Unnamed: 0.1	Unnamed: 0	Organisation
0	0	0	SpaceX
1	1	1	CASC
2	2	2	SpaceX
3	3	3	Roscosmos
4	4	4	ULA

```
                                          Location  \
0        LC-39A, Kennedy Space Center, Florida, USA
1  Site 9401 (SLS-2), Jiuquan Satellite Launch Ce…
2                     Pad A, Boca Chica, Texas, USA
3      Site 200/39, Baikonur Cosmodrome, Kazakhstan
4          SLC-41, Cape Canaveral AFS, Florida, USA

                         Date                                     Detail  \
0  Fri Aug 07, 2020 05:12 UTC  Falcon 9 Block 5 | Starlink V1 L9 & BlackSky
1  Thu Aug 06, 2020 04:01 UTC           Long March 2D | Gaofen-9 04 & Q-SAT
2  Tue Aug 04, 2020 23:57 UTC            Starship Prototype | 150 Meter Hop
3  Thu Jul 30, 2020 21:25 UTC  Proton-M/Briz-M | Ekspress-80 & Ekspress-103
4  Thu Jul 30, 2020 11:50 UTC                     Atlas V 541 | Perseverance

  Rocket_Status  Price Mission_Status
0  StatusActive   50.0        Success
1  StatusActive  29.75        Success
2  StatusActive    NaN        Success
3  StatusActive   65.0        Success
4  StatusActive  145.0        Success
```

[12]:
```
df_data.tail()
```

[12]:
```
      Unnamed: 0.1  Unnamed: 0 Organisation  \
4319          4319        4319      US Navy
4320          4320        4320         AMBA
4321          4321        4321      US Navy
4322          4322        4322    RVSN USSR
4323          4323        4323    RVSN USSR

                                      Location                         Date  \
4319   LC-18A, Cape Canaveral AFS, Florida, USA  Wed Feb 05, 1958 07:33 UTC
4320   LC-26A, Cape Canaveral AFS, Florida, USA  Sat Feb 01, 1958 03:48 UTC
4321   LC-18A, Cape Canaveral AFS, Florida, USA  Fri Dec 06, 1957 16:44 UTC
4322  Site 1/5, Baikonur Cosmodrome, Kazakhstan  Sun Nov 03, 1957 02:30 UTC
4323  Site 1/5, Baikonur Cosmodrome, Kazakhstan  Fri Oct 04, 1957 19:28 UTC

                          Detail  Rocket_Status Price Mission_Status
4319   Vanguard | Vanguard TV3BU  StatusRetired   NaN        Failure
4320         Juno I | Explorer 1  StatusRetired   NaN        Success
4321     Vanguard | Vanguard TV3  StatusRetired   NaN        Failure
4322  Sputnik 8K71PS | Sputnik-2  StatusRetired   NaN        Success
4323  Sputnik 8K71PS | Sputnik-1  StatusRetired   NaN        Success
```

[13]:
```
df_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4324 entries, 0 to 4323
```

```
Data columns (total 9 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
 0   Unnamed: 0.1    4324 non-null   int64
 1   Unnamed: 0      4324 non-null   int64
 2   Organisation    4324 non-null   object
 3   Location        4324 non-null   object
 4   Date            4324 non-null   object
 5   Detail          4324 non-null   object
 6   Rocket_Status   4324 non-null   object
 7   Price           964 non-null    object
 8   Mission_Status  4324 non-null   object
dtypes: int64(2), object(7)
memory usage: 304.2+ KB
```

[14]:
```
df_data.drop(['Unnamed: 0', 'Unnamed: 0.1'], inplace=True, axis = 1)
df_data.head()
```

[14]:

	Organisation	Location	Date	Detail	Rocket_Status	Price	Mission_Status
0	SpaceX	LC-39A, Kennedy Space Center, Florida, USA	Fri Aug 07, 2020 05:12 UTC	Falcon 9 Block 5 | Starlink V1 L9 & BlackSky	StatusActive	50.0	Success
1	CASC	Site 9401 (SLS-2), Jiuquan Satellite Launch Ce…	Thu Aug 06, 2020 04:01 UTC	Long March 2D | Gaofen-9 04 & Q-SAT	StatusActive	29.75	Success
2	SpaceX	Pad A, Boca Chica, Texas, USA	Tue Aug 04, 2020 23:57 UTC	Starship Prototype | 150 Meter Hop	StatusActive	NaN	Success
3	Roscosmos	Site 200/39, Baikonur Cosmodrome, Kazakhstan	Thu Jul 30, 2020 21:25 UTC	Proton-M/Briz-M | Ekspress-80 & Ekspress-103	StatusActive	65.0	Success
4	ULA	SLC-41, Cape Canaveral AFS, Florida, USA	Thu Jul 30, 2020 11:50 UTC	Atlas V 541 | Perseverance	StatusActive	145.0	Success

[15]:
```
df_data.Date = pd.to_datetime(df_data.Date, utc=True)
```

[16]:
```
df_data.Date
```

[16]:
```
0      2020-08-07 05:12:00+00:00
1      2020-08-06 04:01:00+00:00
2      2020-08-04 23:57:00+00:00
3      2020-07-30 21:25:00+00:00
4      2020-07-30 11:50:00+00:00
```

```
                  …
4319   1958-02-05 07:33:00+00:00
4320   1958-02-01 03:48:00+00:00
4321   1957-12-06 16:44:00+00:00
4322   1957-11-03 02:30:00+00:00
4323   1957-10-04 19:28:00+00:00
Name: Date, Length: 4324, dtype: datetime64[ns, UTC]
```

[17]:
```
df_data.Price = df_data.Price.apply(lambda x:str(x).replace(',','')).
↪astype('float64')
```

[18]:
```
df_data.Price
```

[18]:
```
0       50.00
1       29.75
2         NaN
3       65.00
4      145.00
        …
4319      NaN
4320      NaN
4321      NaN
4322      NaN
4323      NaN
Name: Price, Length: 4324, dtype: float64
```

[19]:
```
df_data.Price.isna().sum()
```

[19]:
```
3360
```

2.2 Descriptive Statistics

[20]:
```
df_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4324 entries, 0 to 4323
Data columns (total 7 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
 0   Organisation    4324 non-null   object
 1   Location        4324 non-null   object
 2   Date            4324 non-null   datetime64[ns, UTC]
 3   Detail          4324 non-null   object
 4   Rocket_Status   4324 non-null   object
 5   Price           964 non-null    float64
 6   Mission_Status  4324 non-null   object
dtypes: datetime64[ns, UTC](1), float64(1), object(5)
memory usage: 236.6+ KB
```

[21]:
```
df_data.describe()
```

[21]:
```
          Price
count   964.00
mean    153.79
std     288.45
min       5.30
25%      40.00
50%      62.00
75%     164.00
max   5,000.00
```

3 Number of Launches per Company

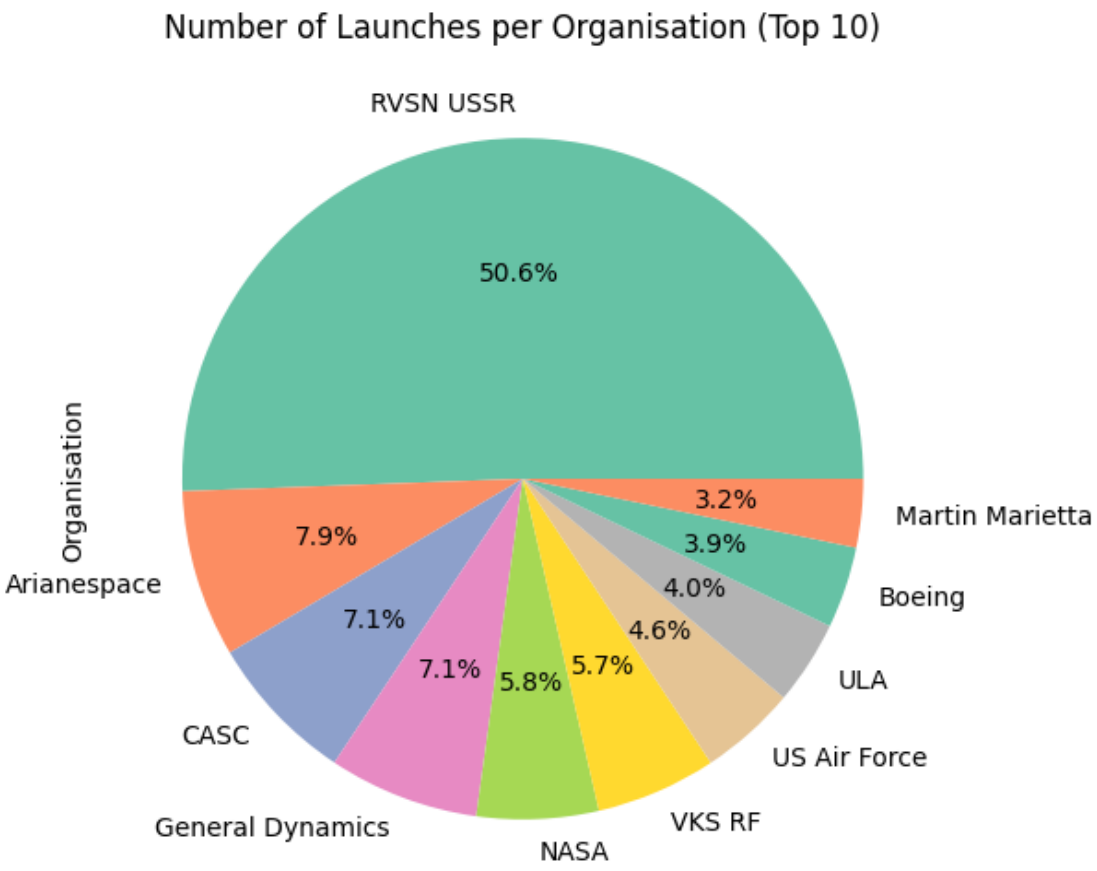
Create a chart that shows the number of space mission launches by organisation.

[22]:
```
launches_per_company = df_data.Organisation.value_counts()
launches_per_company
```

[22]:
```
RVSN USSR           1777
Arianespace          279
CASC                 251
General Dynamics     251
NASA                 203
VKS RF               201
US Air Force         161
ULA                  140
Boeing               136
Martin Marietta      114
SpaceX               100
MHI                   84
Northrop              83
Lockheed              79
ISRO                  76
Roscosmos             55
ILS                   46
Sea Launch            36
ISAS                  30
Kosmotras             22
US Navy               17
ISA                   13
Rocket Lab            13
Eurockot              13
ESA                   13
Blue Origin           12
IAI                   11
ExPace                10
```

```
ASI                     9
CNES                    8
AMBA                    8
MITT                    7
JAXA                    7
Land Launch             7
UT                      5
KCST                    5
CASIC                   5
Exos                    4
CECLES                  4
Arm??e de l'Air         4
KARI                    3
SRC                     3
AEB                     3
RAE                     2
OKB-586                 2
Yuzhmash                2
Landspace               1
Douglas                 1
EER                     1
Starsem                 1
Virgin Orbit            1
IRGC                    1
i-Space                 1
OneSpace                1
Sandia                  1
Khrunichev              1
Name: Organisation, dtype: int64
```

[23]:
```
color_palette = sns.color_palette("Set2")
launches_per_company[:10].plot(
    kind='pie',
    title='Number of Launches per Organisation (Top 10)',
    figsize=(6,6),
    autopct='%1.1f%%',
    colors=color_palette
)
plt.ylabel('Organisation')  # Set the y-axis label

plt.show()
```



4 Number of Active versus Retired Rockets

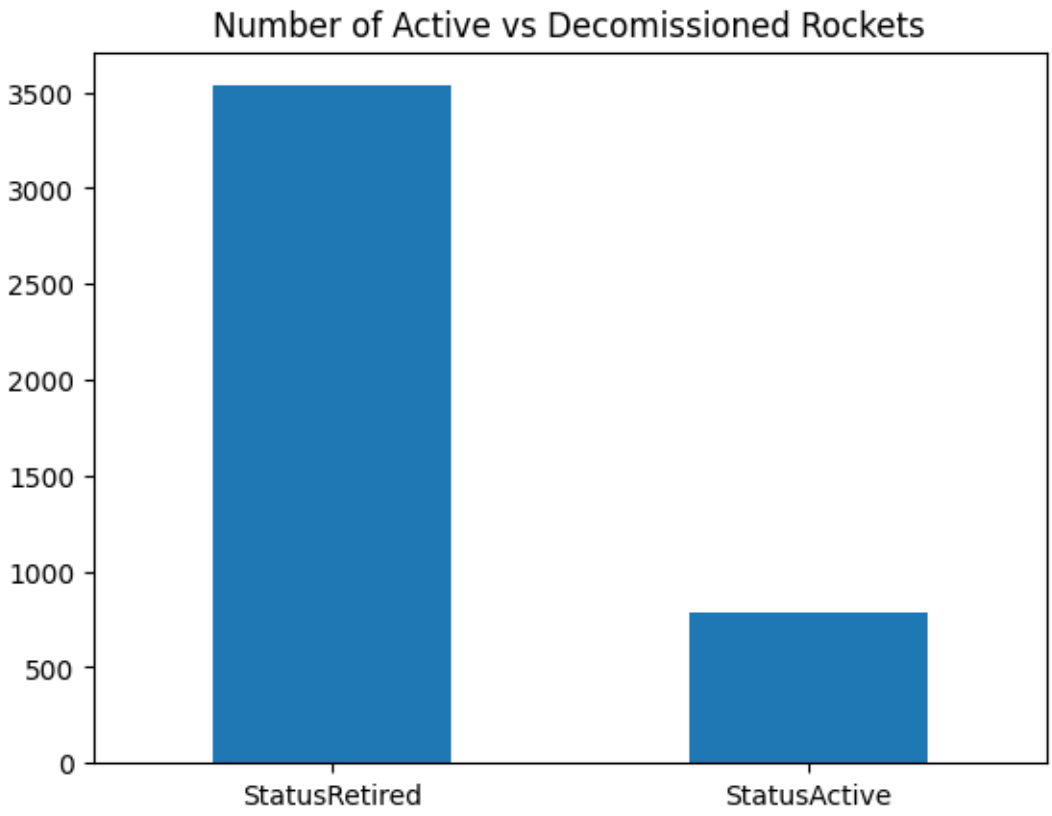
How many rockets are active compared to those that are decomissioned?

[24]:
```
df_data.Rocket_Status.value_counts()
```

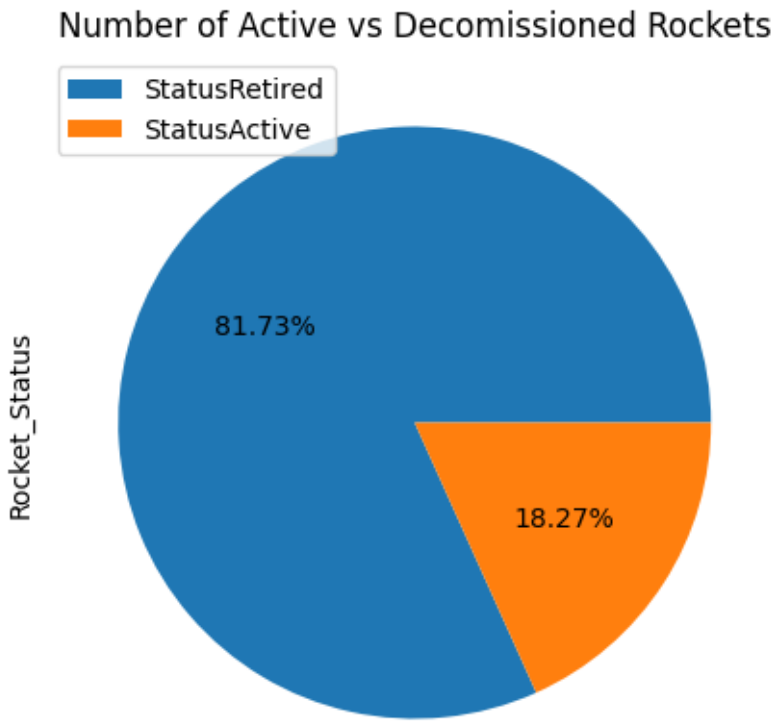
[24]:
```
StatusRetired    3534
StatusActive      790
Name: Rocket_Status, dtype: int64
```

[25]:
```
df_data.Rocket_Status.value_counts().plot(
    kind='bar',
    title='Number of Active vs Decomissioned Rockets',
    rot=0,
)
```

[25]:
```
<Axes: title={'center': 'Number of Active vs Decomissioned Rockets'}>
```



[26]:
```
df_data.Rocket_Status.value_counts().plot(
    kind='pie',
    title='Number of Active vs Decomissioned Rockets',
    figsize = (5,5),
    autopct = '%1.2f%%',
    labels = None
)

plt.legend(labels = df_data.Rocket_Status.value_counts().index)
plt.show()
```



18.27% of the rockets are still active.

5 Distribution of Mission Status

How many missions were successful? How many missions failed?

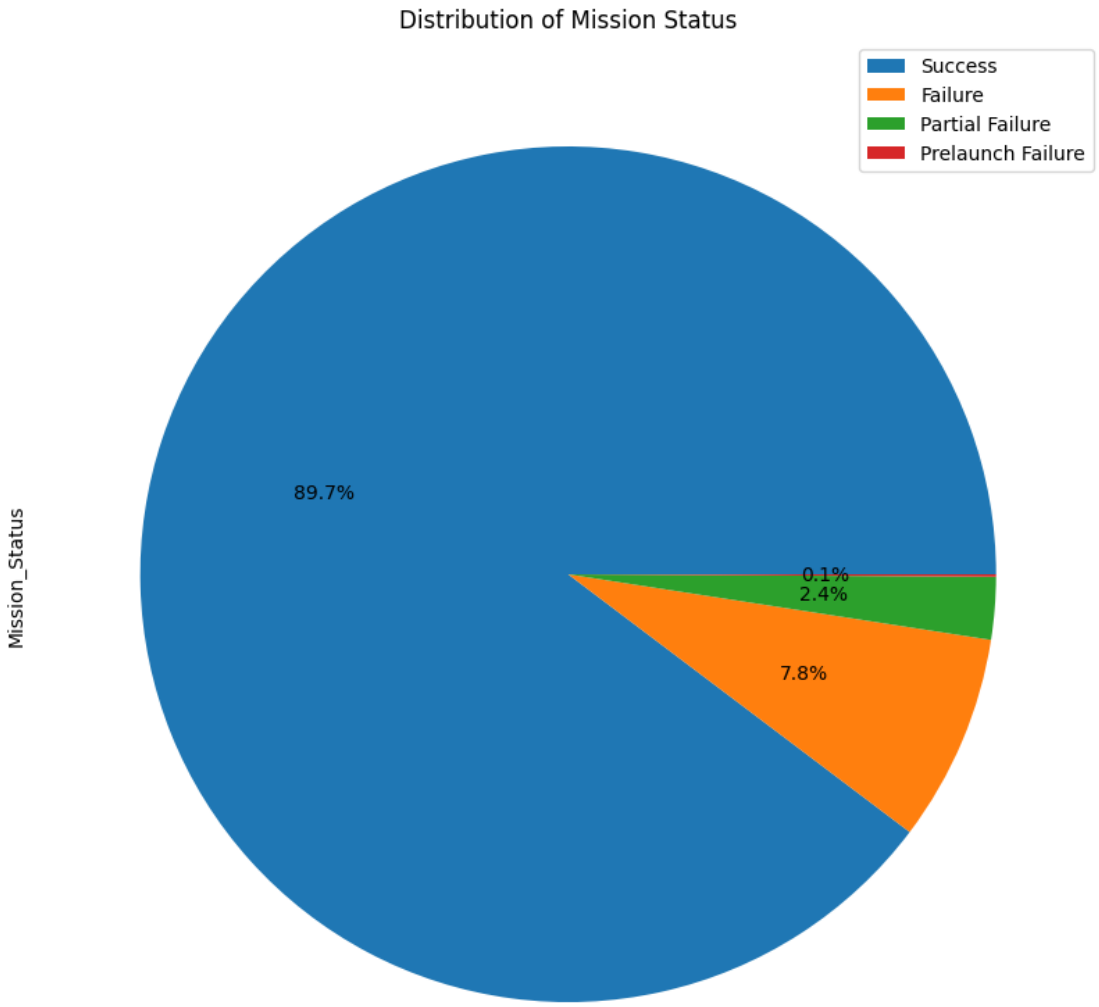
[27]:
```
mission_status_df = df_data.Mission_Status.value_counts()
```

[28]:
```
mission_status_df
```

[28]:
```
Success              3879
Failure               339
Partial Failure       102
Prelaunch Failure       4
Name: Mission_Status, dtype: int64
```

[29]:
```
mission_status_df.plot(
    kind='pie',
    figsize=(10,10),
    autopct='%1.1f%%',
    title = 'Distribution of Mission Status',
```

```
    labels=None
)

plt.legend(labels=mission_status_df.index)
plt.show()
```



89.7% of the missions were succesful while 7.8% failed to launch.

6 How Expensive are the Launches?

Create a histogram and visualise the distribution. The price column is given in USD millions (careful of missing values).

[30]:
```
cost_distribution = df_data.Price.value_counts()
```

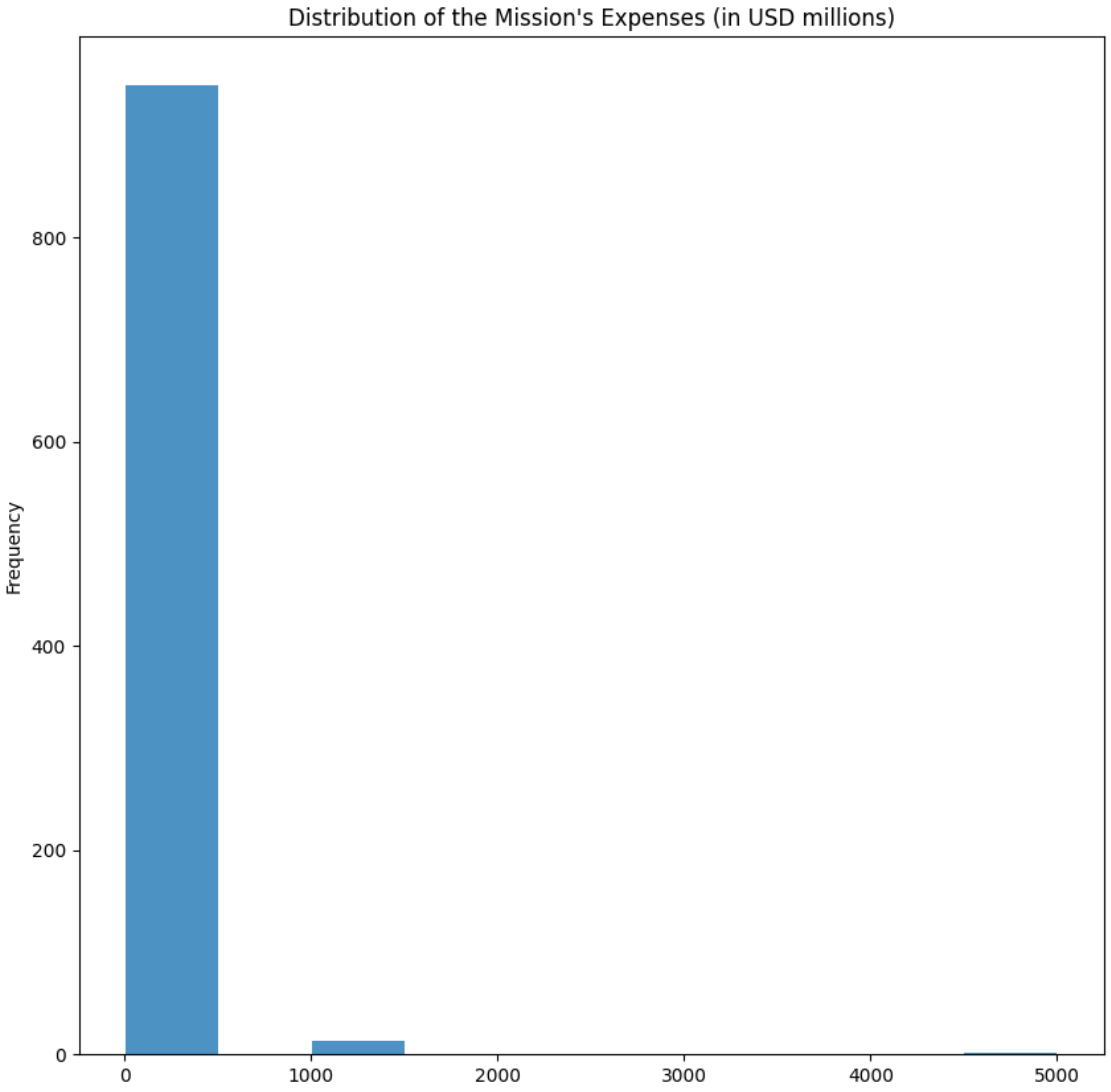
[31]:
```
cost_distribution
```

[31]:
```
450.00      136
200.00       75
40.00        55
62.00        41
30.80        38
109.00       37
50.00        34
64.68        34
29.75        33
90.00        32
41.80        31
48.50        26
29.15        25
31.00        22
29.00        22
59.00        22
69.70        17
21.00        16
65.00        16
35.00        16
56.50        15
37.00        15
164.00       15
7.50         14
1,160.00     13
47.00        13
25.00        12
350.00       11
153.00       11
45.00        10
112.50        9
5.30          9
123.00        8
145.00        7
85.00         7
120.00        7
80.00         7
115.00        6
59.50         5
7.00          5
46.00         5
136.60        4
63.23         4
```

```
140.00        3
133.00        3
190.00        3
130.00        3
135.00        2
5,000.00      2
39.00         2
55.00         1
15.00         1
20.14         1
20.00         1
12.00         1
28.30         1
Name: Price, dtype: int64
```

[32]:
```
df_data.Price.plot(
    kind='hist',
    title = "Distribution of the Mission's Expenses (in USD millions)",
    figsize = (10,10),
    alpha=0.8
)
```

[32]:
```
<Axes: title={'center': "Distribution of the Mission's Expenses (in USD
millions)"}, ylabel='Frequency'>
```



[ ]:

7 Use a Choropleth Map to Show the Number of Launches by Country

- Create a choropleth map using the plotly documentation
- Experiment with plotly's available colours. I quite like the sequential colour `matter` on this map.
- You'll need to extract a `country` feature as well as change the country names that no longer exist.

Wrangle the Country Names

You'll need to use a 3 letter country code for each country. You might have to change some country

names.

- Russia is the Russian Federation
- New Mexico should be USA
- Yellow Sea refers to China
- Shahrud Missile Test Site should be Iran
- Pacific Missile Range Facility should be USA
- Barents Sea should be Russian Federation
- Gran Canaria should be USA

You can use the iso3166 package to convert the country names to Alpha3 format.

[33]:
```
df_data['Country'] = df_data['Location'].apply(lambda x: x.split(',')[-1].
 ↪strip())
df_data['Country'].value_counts()
```

[33]:
```
Russia                           1395
USA                              1344
Kazakhstan                        701
France                            303
China                             268
Japan                             126
India                              76
Pacific Ocean                      36
New Zealand                        13
Iran                               13
Israel                             11
Kenya                               9
Australia                           6
North Korea                         5
New Mexico                          4
South Korea                         3
Barents Sea                         3
Brazil                              3
Gran Canaria                        2
Pacific Missile Range Facility      1
Yellow Sea                          1
Shahrud Missile Test Site           1
Name: Country, dtype: int64
```

[34]:
```
df_data['Country'].replace(
    {
        'Russia':'Russian Federation',
        'Iran':'Iran, Islamic Republic of',
        'New Mexico':'USA',
        'Barents Sea':'Russian Federation',
        'Gran Canaria':'USA',
        'Yellow Sea':'China',
```

```
        'Shahrud Missile Test Site':'Iran, Islamic Republic of',
        'Pacific Missile Range Facility':'USA',
        'North Korea':"Korea, Democratic People's Republic of",
        'Pacific Ocean':'Kiribati',
        'South Korea':'Korea, Republic of'
    },
    inplace=True
)
df_data['Country'] = df_data['Country'].apply(lambda x: countries.get(x).alpha3)
df_data['Country'].value_counts()
```

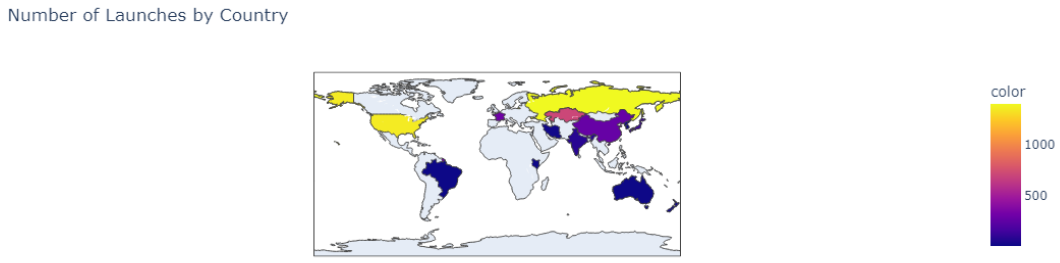
[34]:
```
RUS    1398
USA    1351
KAZ     701
FRA     303
CHN     269
JPN     126
IND      76
KIR      36
IRN      14
NZL      13
ISR      11
KEN       9
AUS       6
PRK       5
KOR       3
BRA       3
Name: Country, dtype: int64
```

[35]:
```
launches_per_country = df_data['Country'].value_counts()
launches_per_country
```

[35]:
```
RUS    1398
USA    1351
KAZ     701
FRA     303
CHN     269
JPN     126
IND      76
KIR      36
IRN      14
NZL      13
ISR      11
KEN       9
AUS       6
PRK       5
KOR       3
```

```
BRA       3
Name: Country, dtype: int64
```

[36]:
```
px.choropleth(
    launches_per_country,
    locations=launches_per_country.index,
    color=launches_per_country,
    title = 'Number of Launches by Country'
)
```



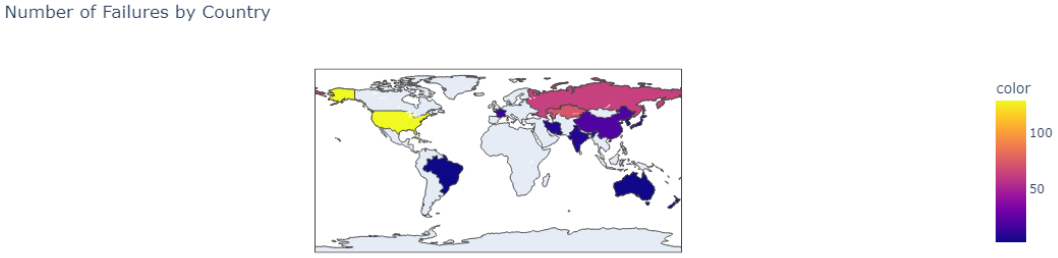
8 Use a Choropleth Map to Show the Number of Failures by Country

[37]:
```
failures_per_country = df_data[df_data['Mission_Status'] ==␣
↪'Failure']['Country'].value_counts()
failures_per_country
```

[37]:
```
USA    129
KAZ     72
RUS     63
CHN     19
FRA     13
JPN     10
IRN      8
IND      8
KIR      3
PRK      3
AUS      3
NZL      2
KOR      2
ISR      2
BRA      2
```

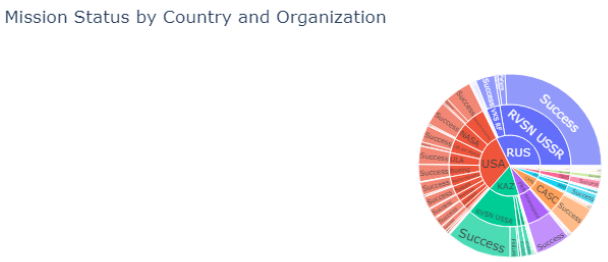
```
Name: Country, dtype: int64
```

[38]:
```
px.choropleth(
    failures_per_country,
    locations=failures_per_country.index,
    color=failures_per_country,
    title = 'Number of Failures by Country'
)
```



9 Create a Plotly Sunburst Chart of the countries, organisations, and mission status.

[39]:
```
px.sunburst(df_data, path=['Country', 'Organisation', 'Mission_Status'],␣
↪title='Mission Status by Country and Organization')
```

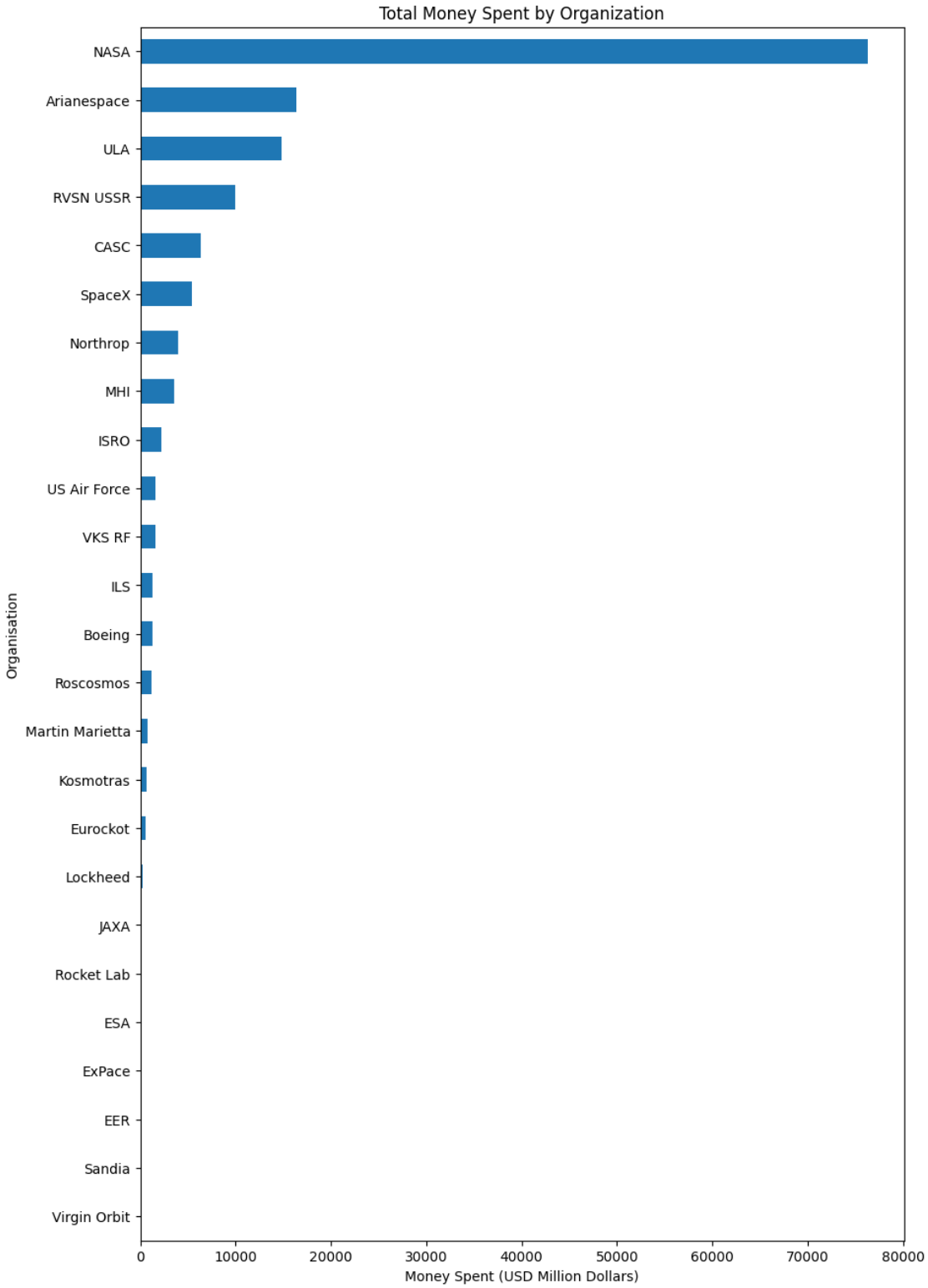


10 Analyse the Total Amount of Money Spent by Organisation on Space Missions

[40]:
```
money_spent_by_organization = df_data.groupby('Organisation')['Price'].sum()
money_spent_by_organization[money_spent_by_organization!=0]
```

[40]:
```
Organisation
Arianespace        16,345.00
Boeing              1,241.00
CASC                6,340.26
EER                    20.00
ESA                    37.00
Eurockot              543.40
ExPace                 28.30
ILS                 1,320.00
ISRO                2,177.00
JAXA                  168.00
Kosmotras             638.00
Lockheed              280.00
MHI                 3,532.50
Martin Marietta       721.40
NASA               76,280.00
Northrop            3,930.00
RVSN USSR          10,000.00
Rocket Lab             97.50
Roscosmos           1,187.50
Sandia                 15.00
SpaceX              5,444.00
ULA                14,798.00
US Air Force        1,550.92
VKS RF              1,548.90
Virgin Orbit           12.00
Name: Price, dtype: float64
```

[41]:
```
money_spent_by_organization[money_spent_by_organization!=0].sort_values().plot(
    kind='barh',
    title = 'Total Money Spent by Organization',
    figsize=(10,16)
)

plt.xlabel('Money Spent (USD Million Dollars)')
plt.show()
```


Total Money Spent by Organization
NASA
Arianespace
ULA
RVSN USSR
CASC
SpaceX
Northrop
MHI
ISRO
US Air Force
VKS RF
ILS
Boeing
Roscosmos
Martin Marietta
Kosmotras
Eurockot
Lockheed
JAXA
Rocket Lab
ESA
ExPace
EER
Sandia
Virgin Orbit
Organisation
0
10000
20000
30000
40000
50000
60000
70000
80000
Money Spent (USD Million Dollars)

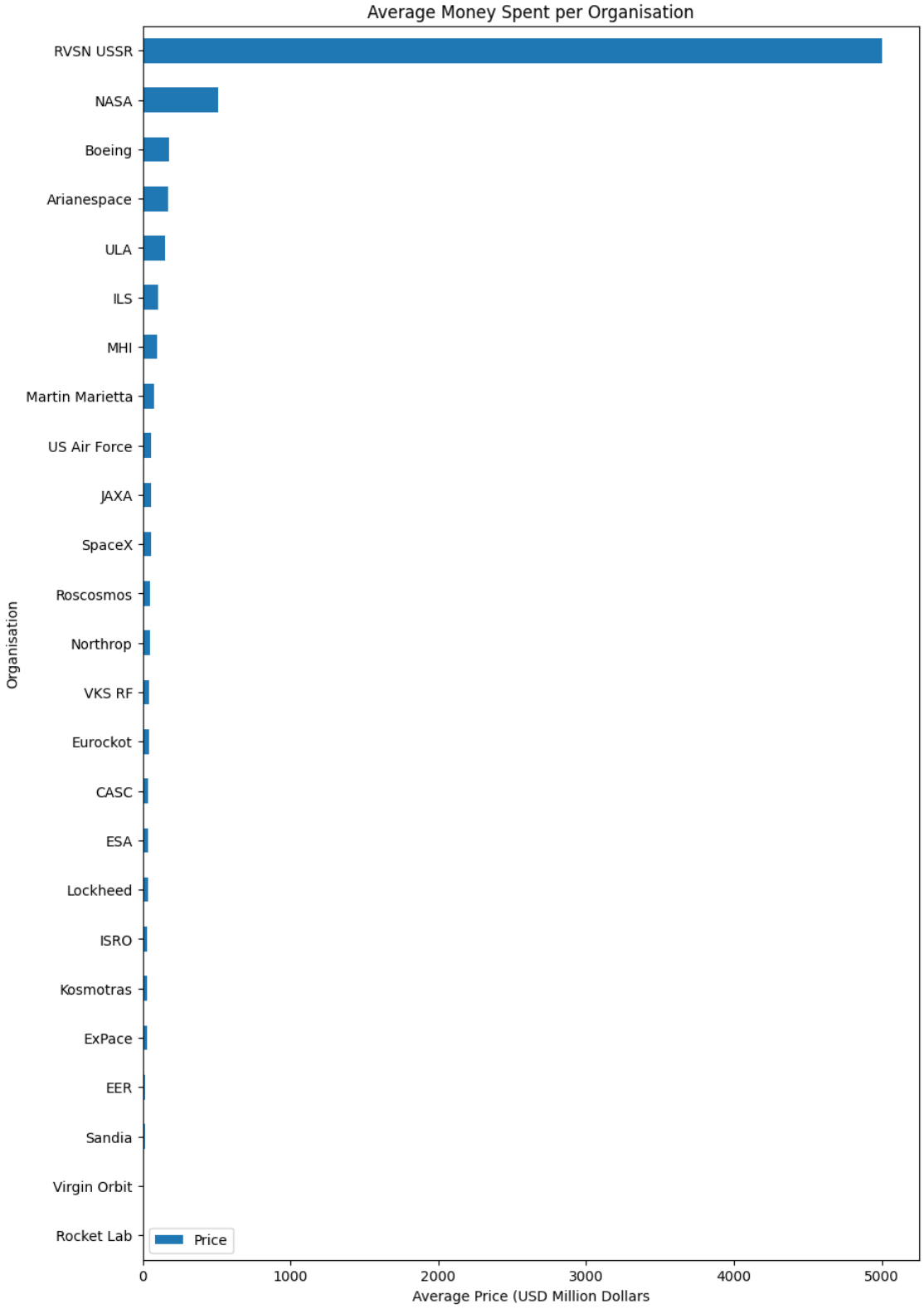
11 Analyse the Amount of Money Spent by Organisation per Launch

[42]:
```
avg_money_spent = df_data.groupby('Organisation').agg({'Price':np.mean})
avg_money_spent.dropna()
```

[42]:

Organisation	Price
Arianespace	170.26
Boeing	177.29
CASC	40.13
EER	20.00
ESA	37.00
Eurockot	41.80
ExPace	28.30
ILS	101.54
ISRO	32.49
JAXA	56.00
Kosmotras	29.00
Lockheed	35.00
MHI	95.47
Martin Marietta	80.16
NASA	511.95
Northrop	47.35
RVSN USSR	5,000.00
Rocket Lab	7.50
Roscosmos	51.63
Sandia	15.00
SpaceX	54.99
ULA	151.00
US Air Force	59.65
VKS RF	46.94
Virgin Orbit	12.00

[43]:
```
avg_money_spent.dropna().sort_values('Price').plot(
    kind='barh',
    figsize=(10,16),
    title='Average Money Spent per Organisation',
)

plt.xlabel('Average Price (USD Million Dollars')
plt.show()
```

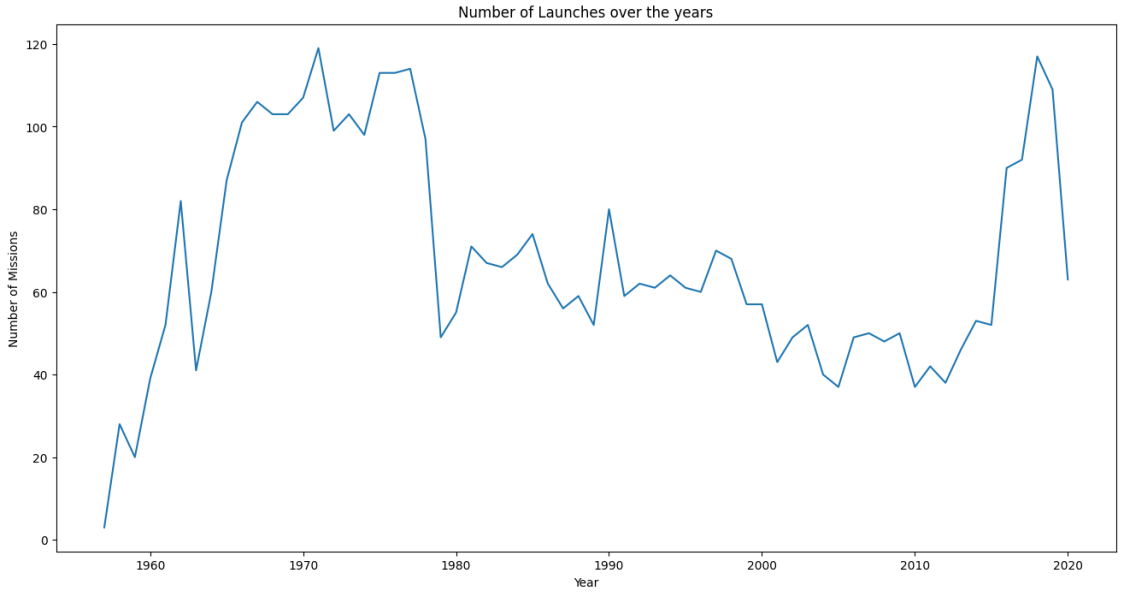

Average Money Spent per Organisation
RVSN USSR
NASA
Boeing
Arianespace
ULA
ILS
MHI
Martin Marietta
US Air Force
JAXA
SpaceX
Roscosmos
Northrop
VKS RF
Eurockot
CASC
ESA
Lockheed
ISRO
Kosmotras
ExPace
EER
Sandia
Virgin Orbit
Rocket Lab
Organisation
Price
0
1000
2000
3000
4000
5000
Average Price (USD Million Dollars

12 Chart the Number of Launches per Year

[44]:
```
df_data['Year'] = df_data['Date'].dt.year
launches_per_year = df_data.groupby('Year')['Detail'].count()
launches_per_year
```

[44]:
```
Year
1957      3
1958     28
1959     20
1960     39
1961     52
        ...
2016     90
2017     92
2018    117
2019    109
2020     63
Name: Detail, Length: 64, dtype: int64
```

[45]:
```
launches_per_year.plot(
    title='Number of Launches over the years',
    figsize = (16,8)
)

plt.ylabel('Number of Missions')
plt.show()
```



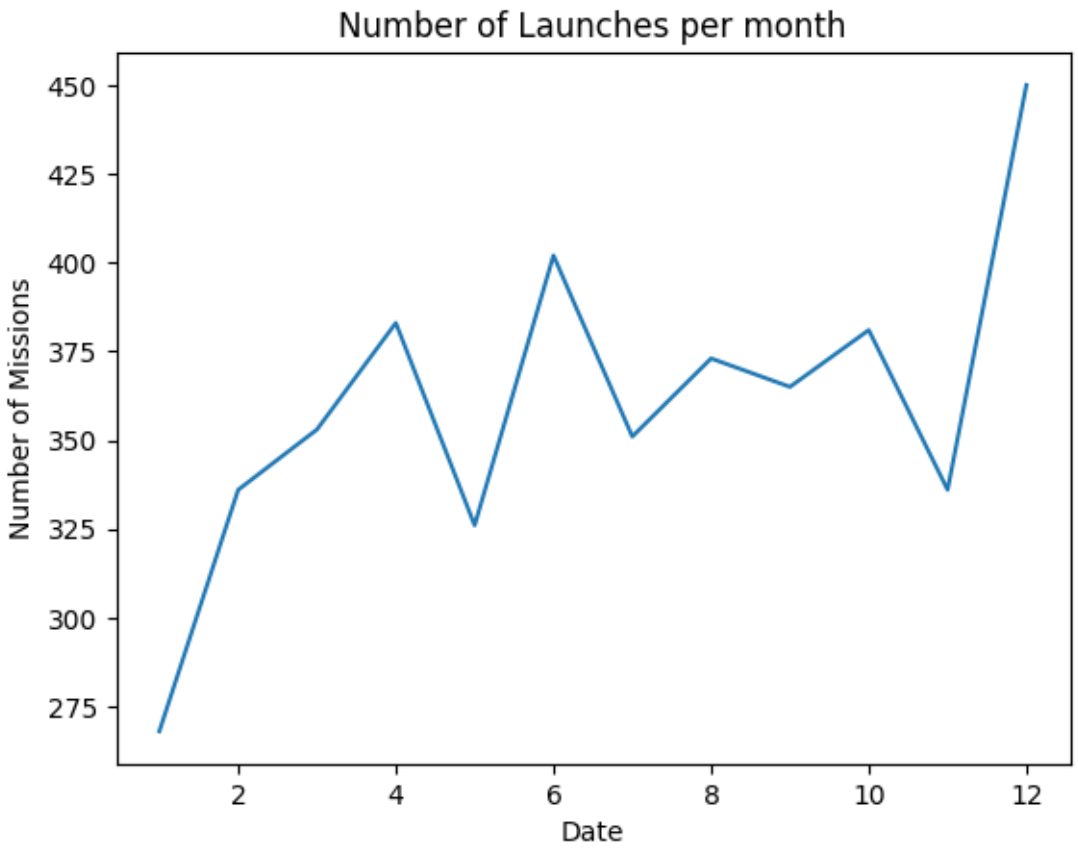
13 Chart the Number of Launches Month-on-Month until the Present

Which month has seen the highest number of launches in all time? Superimpose a rolling average on the month on month time series chart.

[46]:
```
launches_per_month = df_data.groupby(df_data['Date'].dt.month)['Detail'].count()
launches_per_month
```

[46]:
```
Date
1     268
2     336
3     353
4     383
5     326
6     402
7     351
8     373
9     365
10    381
11    336
12    450
Name: Detail, dtype: int64
```

[47]:
```
plt.figsize = (16,8)
launches_per_month.plot(title = 'Number of Launches per month')

plt.ylabel('Number of Missions')
plt.show()
```



14 Launches per Month: Which months are most popular and least popular for launches?

Some months have better weather than others. Which time of year seems to be best for space missions?

[48]:
```
launches_per_month[launches_per_month == launches_per_month.max()]
```

[48]:
```
Date
12    450
Name: Detail, dtype: int64
```

[49]:
```
launches_per_month[launches_per_month == launches_per_month.min()]
```

[49]:
```
Date
1    268
Name: Detail, dtype: int64
```

It appears that most launches take place in December

15 How has the Launch Price varied Over Time?

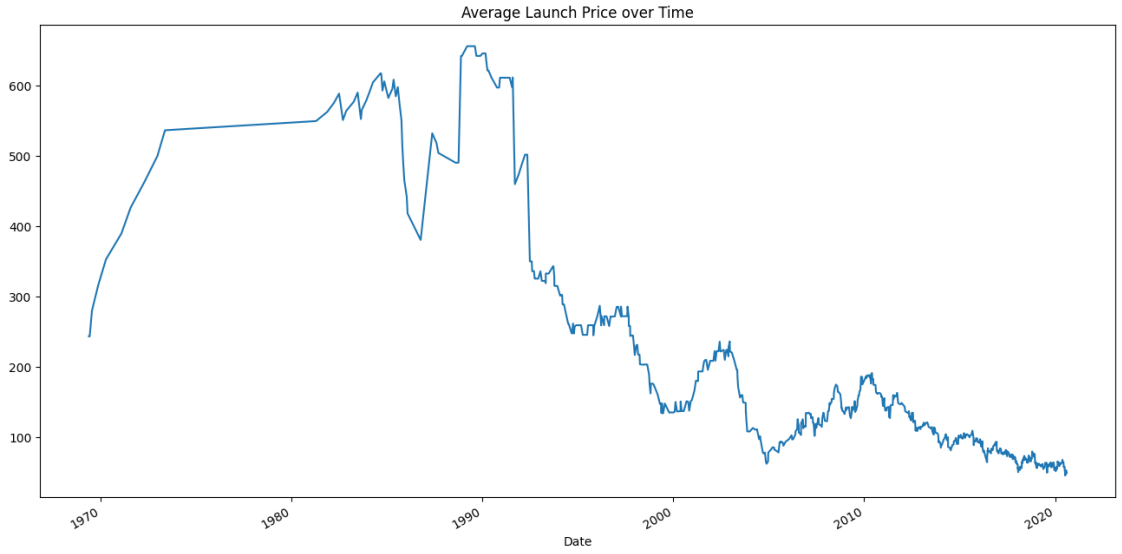
Create a line chart that shows the average price of rocket launches over time.

[50]:
```
price_over_time = df_data.dropna().groupby('Date')['Price'].mean()
price_over_time
```

[50]:
```
Date
1964-09-01 15:00:00+00:00    63.23
1964-12-10 16:52:00+00:00    63.23
1965-02-11 15:19:00+00:00    63.23
1965-05-06 15:00:00+00:00    63.23
1966-07-29 18:43:00+00:00    59.00
                             ...
2020-07-25 03:13:00+00:00    64.68
2020-07-30 11:50:00+00:00   145.00
2020-07-30 21:25:00+00:00    65.00
2020-08-06 04:01:00+00:00    29.75
2020-08-07 05:12:00+00:00    50.00
Name: Price, Length: 963, dtype: float64
```

[51]:
```
price_over_time.rolling(30).mean().plot(
    figsize = (16,8),
    title = 'Average Launch Price over Time'
)
```

[51]:
```
<Axes: title={'center': 'Average Launch Price over Time'}, xlabel='Date'>
```



16 Chart the Number of Launches over Time by the Top 10 Organisations.

How has the dominance of launches changed over time between the different players?

[52]:
```
top_10_organisations = df_data['Organisation'].value_counts().
↪sort_values(ascending=False)[:10].index.tolist()
top_10_organisations
```

[52]:
```
['RVSN USSR',
 'Arianespace',
 'CASC',
 'General Dynamics',
 'NASA',
 'VKS RF',
 'US Air Force',
 'ULA',
 'Boeing',
 'Martin Marietta']
```

[53]:
```
launches_by_top_10 = df_data[df_data['Organisation'].
↪isin(top_10_organisations)].groupby(['Year','Organisation'])['Detail'].
↪count().unstack(level=1)
launches_by_top_10.fillna(0, inplace=True)
launches_by_top_10
```

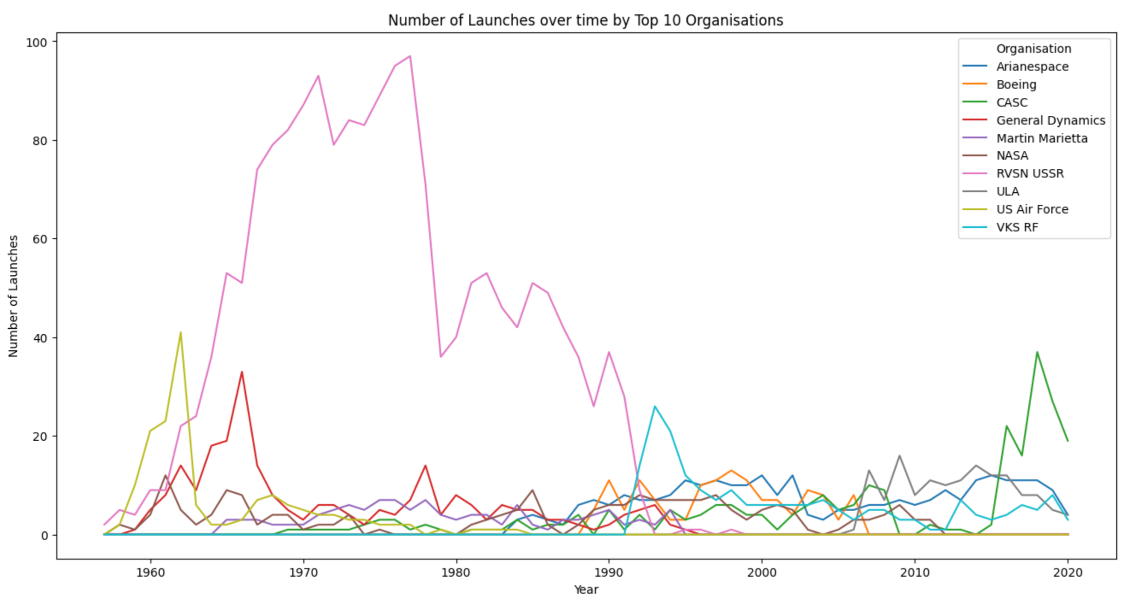
[53]:

Organisation	Arianespace	Boeing	CASC	General Dynamics	Martin Marietta
Year					
1957	0.00	0.00	0.00	0.00	0.00
1958	0.00	0.00	0.00	0.00	0.00
1959	0.00	0.00	0.00	1.00	0.00
1960	0.00	0.00	0.00	5.00	0.00
1961	0.00	0.00	0.00	8.00	0.00
…	…	…	…	…	…
2016	11.00	0.00	22.00	0.00	0.00
2017	11.00	0.00	16.00	0.00	0.00
2018	11.00	0.00	37.00	0.00	0.00
2019	9.00	0.00	27.00	0.00	0.00
2020	4.00	0.00	19.00	0.00	0.00

Organisation	NASA	RVSN USSR	ULA	US Air Force	VKS RF
Year					
1957	0.00	2.00	0.00	0.00	0.00
1958	2.00	5.00	0.00	2.00	0.00
1959	1.00	4.00	0.00	10.00	0.00
1960	4.00	9.00	0.00	21.00	0.00
1961	12.00	9.00	0.00	23.00	0.00

```
…            …      …    …          …       …
2016         0.00      0.00  12.00       0.00     4.00
2017         0.00      0.00   8.00       0.00     6.00
2018         0.00      0.00   8.00       0.00     5.00
2019         0.00      0.00   5.00       0.00     8.00
2020         0.00      0.00   4.00       0.00     3.00

[64 rows x 10 columns]
```

[54]:
```python
launches_by_top_10.plot(
    figsize=(16,8),
    title = 'Number of Launches over time by Top 10 Organisations',
)

plt.ylabel('Number of Launches')
plt.show()
```



USAF was realising the most launches up until the beginning of the 60s when RVSN USSR took helm on the race until the beginning of the 90s. That's when the RVSN rapidly lost ground up until they completely stoped launching. After that Arianespace, Boeing and VKS RF seemed to lead the race, up until mid 2010s when CASC surpassed them and has been leading since.

17 Cold War Space Race: USA vs USSR

The cold war lasted from the start of the dataset up until 1991.

[55]:
```
cold_war_df = df_data[df_data['Year']<=1991].sort_values('Year').
↪reset_index(drop=True)
```

[56]:
```
cold_war_df.head()
```

[56]:

	Organisation	Location	Date	Detail	Rocket_Status	Price	Mission_Status	Country	Year
0	RVSN USSR	Site 1/5, Baikonur Cosmodrome, Kazakhstan	1957-10-04 19:28:00+00:00	Sputnik 8K71PS | Sputnik-1	StatusRetired	NaN	Success	KAZ	1957
1	RVSN USSR	Site 1/5, Baikonur Cosmodrome, Kazakhstan	1957-11-03 02:30:00+00:00	Sputnik 8K71PS | Sputnik-2	StatusRetired	NaN	Success	KAZ	1957
2	US Navy	LC-18A, Cape Canaveral AFS, Florida, USA	1957-12-06 16:44:00+00:00	Vanguard | Vanguard TV3	StatusRetired	NaN	Failure	USA	1957
3	AMBA	LC-26A, Cape Canaveral AFS, Florida, USA	1958-02-01 03:48:00+00:00	Juno I | Explorer 1	StatusRetired	NaN	Success	USA	1958
4	US Air Force	LC-11, Cape Canaveral AFS, Florida, USA	1958-12-18 23:02:00+00:00	SM-65B Atlas | SCORE	StatusRetired	NaN	Success	USA	1958

[57]:
```
cold_war_df.shape
```

[57]:
```
(2607, 9)
```

[58]:
```
cold_war_df['Country'].duplicated().any()
```

[58]:
```
True
```

[59]:
```
for country in cold_war_df['Country'].drop_duplicates():
  print(countries.get(country))
```

```
Country(name='Kazakhstan', alpha2='KZ', alpha3='KAZ', numeric='398',
apolitical_name='Kazakhstan')
Country(name='United States of America', alpha2='US', alpha3='USA',
numeric='840', apolitical_name='United States of America')
Country(name='Russian Federation', alpha2='RU', alpha3='RUS', numeric='643',
apolitical_name='Russian Federation')
Country(name='France', alpha2='FR', alpha3='FRA', numeric='250',
apolitical_name='France')
Country(name='Japan', alpha2='JP', alpha3='JPN', numeric='392',
apolitical_name='Japan')
Country(name='Australia', alpha2='AU', alpha3='AUS', numeric='036',
```

```
apolitical_name='Australia')
Country(name='Kenya', alpha2='KE', alpha3='KEN', numeric='404',
apolitical_name='Kenya')
Country(name='China', alpha2='CN', alpha3='CHN', numeric='156',
apolitical_name='China')
Country(name='India', alpha2='IN', alpha3='IND', numeric='356',
apolitical_name='India')
Country(name='Israel', alpha2='IL', alpha3='ISR', numeric='376',
apolitical_name='Israel')
```

17.1 Create a Plotly Pie Chart comparing the total number of launches of the USSR and the USA

Hint: Remember to include former Soviet Republics like Kazakhstan when analysing the total number of launches.

[60]:
```
cold_war_df['Country'].replace(
    {'KAZ':'RUS'},
    inplace=True
)
cold_war_df['Country'].value_counts()
```

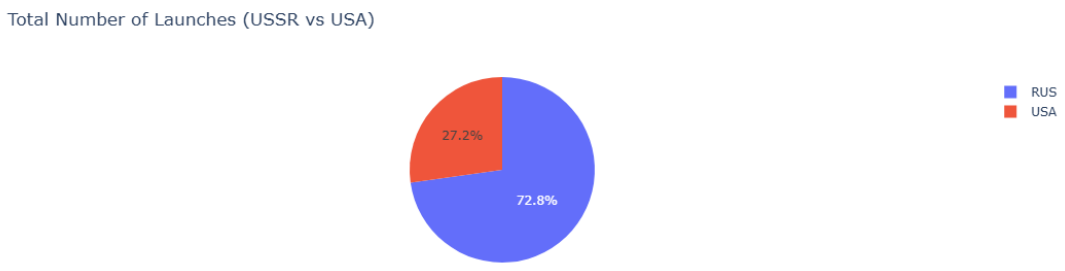
[60]:
```
RUS    1770
USA     662
FRA      61
JPN      52
CHN      38
KEN       9
IND       7
AUS       6
ISR       2
Name: Country, dtype: int64
```

[61]:
```
ussr_vs_usa = cold_war_df[cold_war_df['Country'].isin(['RUS','USA'])]
ussr_vs_usa
```

[61]:
```
      Organisation                                    Location  \
0        RVSN USSR   Site 1/5, Baikonur Cosmodrome, Kazakhstan
1        RVSN USSR   Site 1/5, Baikonur Cosmodrome, Kazakhstan
2          US Navy    LC-18A, Cape Canaveral AFS, Florida, USA
3             AMBA    LC-26A, Cape Canaveral AFS, Florida, USA
4     US Air Force     LC-11, Cape Canaveral AFS, Florida, USA
…              …                                           …
2601     RVSN USSR      Site 32/2, Plesetsk Cosmodrome, Russia
2602          NASA  LC-39B, Kennedy Space Center, Florida, USA
2603     RVSN USSR     Site 133/3, Plesetsk Cosmodrome, Russia
2604     RVSN USSR      Site 32/2, Plesetsk Cosmodrome, Russia
2605     RVSN USSR     Site 132/1, Plesetsk Cosmodrome, Russia
```

```
                          Date                                Detail  \
0    1957-10-04 19:28:00+00:00          Sputnik 8K71PS | Sputnik-1
1    1957-11-03 02:30:00+00:00          Sputnik 8K71PS | Sputnik-2
2    1957-12-06 16:44:00+00:00             Vanguard | Vanguard TV3
3    1958-02-01 03:48:00+00:00                 Juno I | Explorer 1
4    1958-12-18 23:02:00+00:00               SM-65B Atlas | SCORE
…                          …                                   …
2601 1991-06-04 09:00:00+00:00                Tsyklon-3 | Okean 3
2602 1991-06-05 13:24:00+00:00     Space Shuttle Columbia | STS-40
2603 1991-06-11 05:42:00+00:00    Cosmos-3M (11K65M) | Cosmos 2150
2604 1991-06-13 15:41:00+00:00             Tsyklon-3 | Cosmos 2151
2605 1991-06-25 13:20:00+00:00  Cosmos-3M (11K65M) | Ta??foun n†59

      Rocket_Status  Price Mission_Status Country  Year
0     StatusRetired    NaN        Success     RUS  1957
1     StatusRetired    NaN        Success     RUS  1957
2     StatusRetired    NaN        Failure     USA  1957
3     StatusRetired    NaN        Success     USA  1958
4     StatusRetired    NaN        Success     USA  1958
…               …    …              …      …    …
2601  StatusRetired    NaN        Success     RUS  1991
2602  StatusRetired 450.00        Success     USA  1991
2603  StatusRetired    NaN        Success     RUS  1991
2604  StatusRetired    NaN        Success     RUS  1991
2605  StatusRetired    NaN        Failure     RUS  1991

[2432 rows x 9 columns]
```

[62]:
```
px.pie(
    title = 'Total Number of Launches (USSR vs USA)',
    values = ussr_vs_usa['Country'].value_counts(),
    names = ussr_vs_usa['Country'].value_counts().index,
)
```



17.2 Create a Chart that Shows the Total Number of Launches Year-On-Year by the Two Superpowers

[63]:
```
cold_war_launch_by_year = ussr_vs_usa.
↪groupby(['Year','Country'])['Mission_Status'].count().unstack(level=1)
cold_war_launch_by_year
```

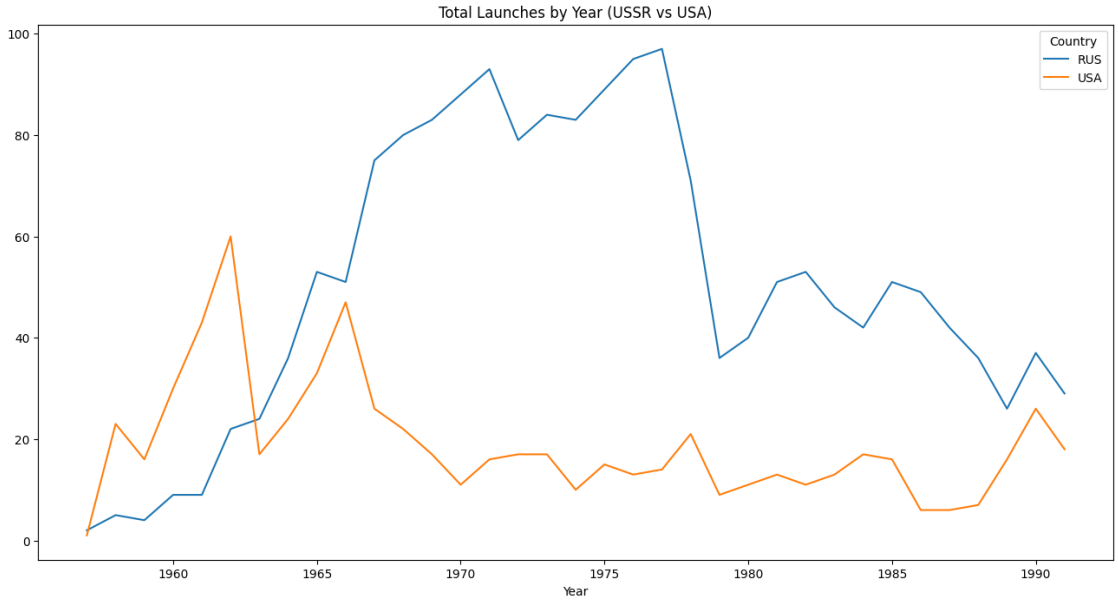
[63]:

Country	RUS	USA
Year		
1957	2	1
1958	5	23
1959	4	16
1960	9	30
1961	9	43
1962	22	60
1963	24	17
1964	36	24
1965	53	33
1966	51	47
1967	75	26
1968	80	22
1969	83	17
1970	88	11
1971	93	16
1972	79	17
1973	84	17
1974	83	10
1975	89	15
1976	95	13
1977	97	14
1978	71	21
1979	36	9
1980	40	11
1981	51	13
1982	53	11
1983	46	13
1984	42	17
1985	51	16
1986	49	6
1987	42	6
1988	36	7
1989	26	16
1990	37	26
1991	29	18

[64]:
```
cold_war_launch_by_year.plot(
    figsize = (16,8),
```

```
    title = 'Total Launches by Year (USSR vs USA)'
)
```

[64]:
```
<Axes: title={'center': 'Total Launches by Year (USSR vs USA)'}, xlabel='Year'>
```



17.3 Chart the Total Number of Mission Failures Year on Year.

[65]:
```
cold_war_mission_failures_by_year = ussr_vs_usa[ussr_vs_usa['Mission_Status']!
 ↪='Success'].groupby(['Year', 'Country'])['Mission_Status'].count().
 ↪unstack(level=1)
cold_war_mission_failures_by_year.fillna(0, inplace=True)
cold_war_mission_failures_by_year
```

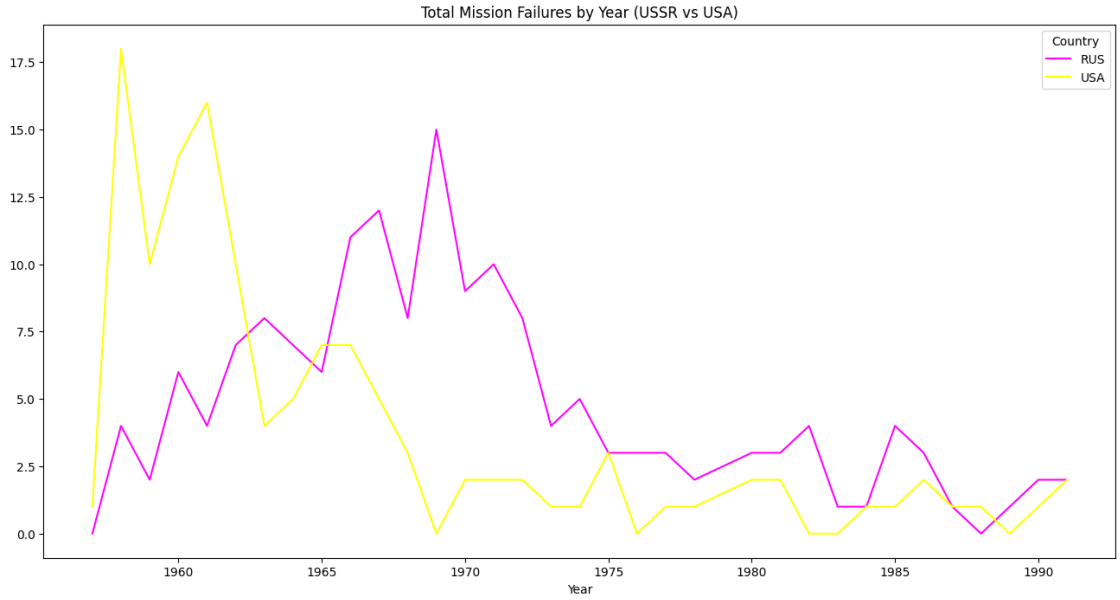
[65]:

Country	RUS	USA
Year		
1957	0.00	1.00
1958	4.00	18.00
1959	2.00	10.00
1960	6.00	14.00
1961	4.00	16.00
1962	7.00	10.00
1963	8.00	4.00
1964	7.00	5.00
1965	6.00	7.00
1966	11.00	7.00
1967	12.00	5.00
1968	8.00	3.00

```
1969    15.00  0.00
1970     9.00  2.00
1971    10.00  2.00
1972     8.00  2.00
1973     4.00  1.00
1974     5.00  1.00
1975     3.00  3.00
1976     3.00  0.00
1977     3.00  1.00
1978     2.00  1.00
1980     3.00  2.00
1981     3.00  2.00
1982     4.00  0.00
1983     1.00  0.00
1984     1.00  1.00
1985     4.00  1.00
1986     3.00  2.00
1987     1.00  1.00
1988     0.00  1.00
1989     1.00  0.00
1990     2.00  1.00
1991     2.00  2.00
```

[66]:
```
cold_war_mission_failures_by_year.plot(
    figsize = (16,8),
    title = 'Total Mission Failures by Year (USSR vs USA)',
    colormap='spring'
)
```

[66]:
```
<Axes: title={'center': 'Total Mission Failures by Year (USSR vs USA)'},
xlabel='Year'>
```



17.4 Chart the Percentage of Failures over Time

Did failures go up or down over time? Did the countries get better at minimising risk and improving their chances of success over time?

[67]:
```
cold_war_failpct_by_year = cold_war_mission_failures_by_year/
 ↪cold_war_launch_by_year * 100
cold_war_failpct_by_year.fillna(0, inplace=True)
cold_war_failpct_by_year
```

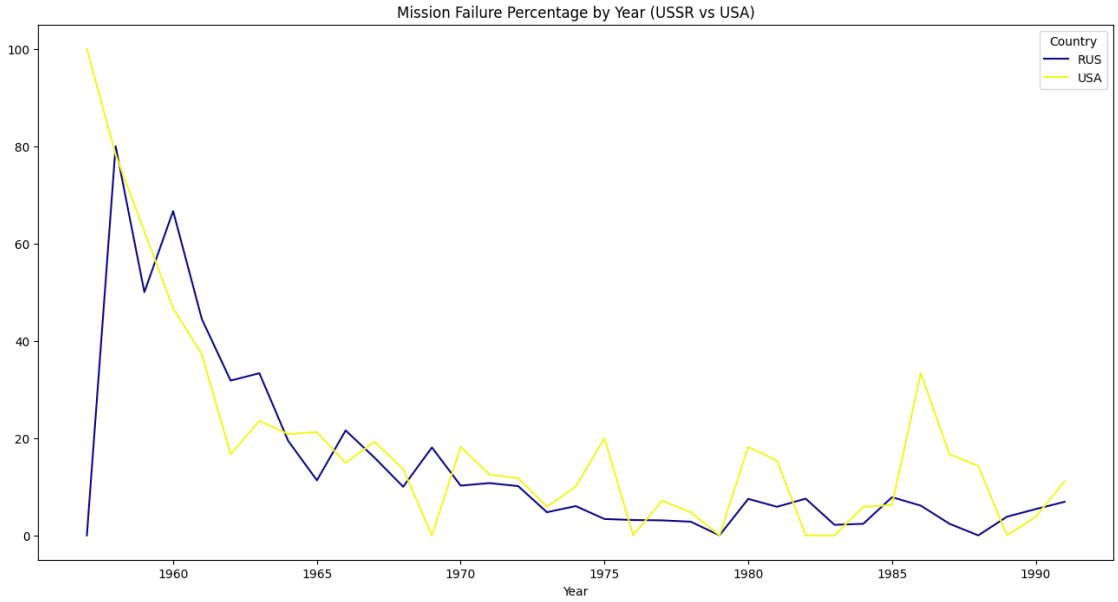
[67]:

Country	RUS	USA
Year		
1957	0.00	100.00
1958	80.00	78.26
1959	50.00	62.50
1960	66.67	46.67
1961	44.44	37.21
1962	31.82	16.67
1963	33.33	23.53
1964	19.44	20.83
1965	11.32	21.21
1966	21.57	14.89
1967	16.00	19.23
1968	10.00	13.64
1969	18.07	0.00
1970	10.23	18.18
1971	10.75	12.50

```
1972    10.13  11.76
1973     4.76   5.88
1974     6.02  10.00
1975     3.37  20.00
1976     3.16   0.00
1977     3.09   7.14
1978     2.82   4.76
1979     0.00   0.00
1980     7.50  18.18
1981     5.88  15.38
1982     7.55   0.00
1983     2.17   0.00
1984     2.38   5.88
1985     7.84   6.25
1986     6.12  33.33
1987     2.38  16.67
1988     0.00  14.29
1989     3.85   0.00
1990     5.41   3.85
1991     6.90  11.11
```

[68]:
```
cold_war_failpct_by_year.plot(
    figsize = (16,8),
    title = 'Mission Failure Percentage by Year (USSR vs USA)',
    colormap='plasma'
)
```

[68]:
```
<Axes: title={'center': 'Mission Failure Percentage by Year (USSR vs USA)'},
xlabel='Year'>
```



18 For Every Year Show which Country was in the Lead in terms of Total Number of Launches up to and including including 2020)

Do the results change if we only look at the number of successful launches?

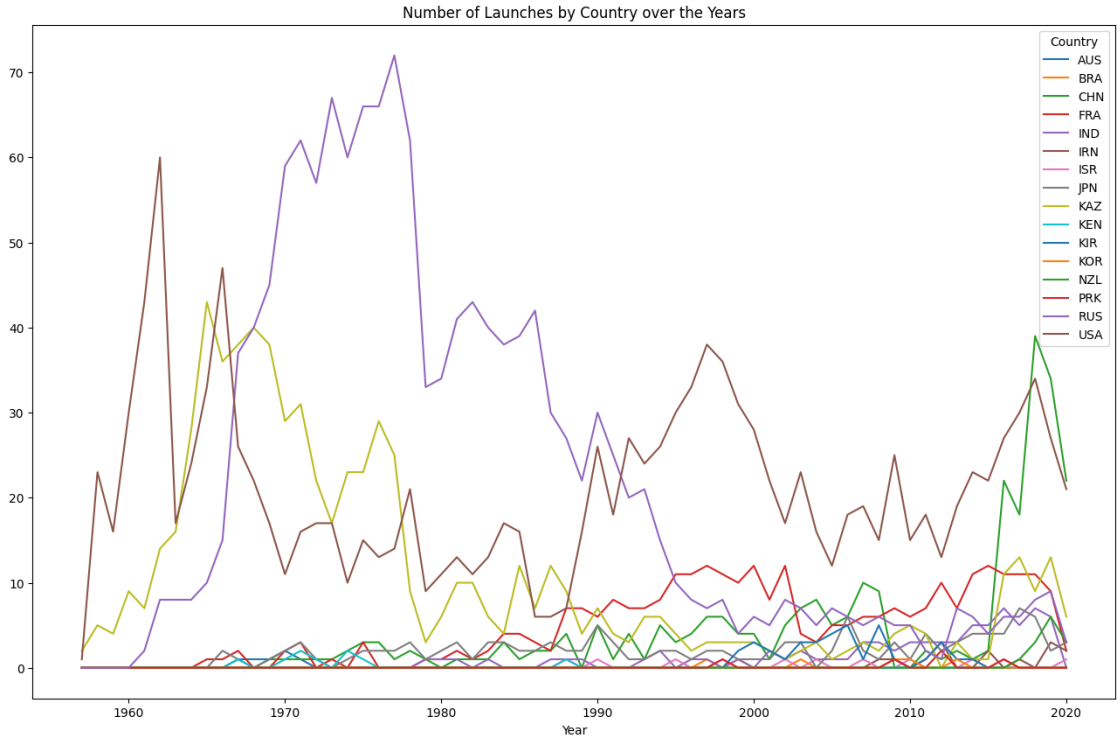
[69]:
```
launches_by_country_per_year = df_data.groupby(['Year',␣
 ↪'Country'])['Mission_Status'].count().unstack(level=1)
launches_by_country_per_year.fillna(0, inplace=True)
launches_by_country_per_year
```

[69]:
```
Country  AUS  BRA   CHN   FRA  IND  IRN  ISR  JPN   KAZ  KEN  KIR  KOR  NZL  \
Year
1957    0.00 0.00  0.00  0.00 0.00 0.00 0.00 0.00  2.00 0.00 0.00 0.00 0.00
1958    0.00 0.00  0.00  0.00 0.00 0.00 0.00 0.00  5.00 0.00 0.00 0.00 0.00
1959    0.00 0.00  0.00  0.00 0.00 0.00 0.00 0.00  4.00 0.00 0.00 0.00 0.00
1960    0.00 0.00  0.00  0.00 0.00 0.00 0.00 0.00  9.00 0.00 0.00 0.00 0.00
1961    0.00 0.00  0.00  0.00 0.00 0.00 0.00 0.00  7.00 0.00 0.00 0.00 0.00
…       …  …    …    …  …  …  …  …   …   …  …  …  …  …
2016    0.00 0.00 22.00 11.00 7.00 0.00 1.00 4.00 11.00 0.00 0.00 0.00 0.00
2017    0.00 0.00 18.00 11.00 5.00 1.00 0.00 7.00 13.00 0.00 0.00 0.00 1.00
2018    0.00 0.00 39.00 11.00 7.00 0.00 0.00 6.00  9.00 0.00 0.00 0.00 3.00
2019    0.00 0.00 34.00  9.00 6.00 3.00 0.00 2.00 13.00 0.00 0.00 0.00 6.00
2020    0.00 0.00 22.00  2.00 0.00 2.00 1.00 3.00  6.00 0.00 0.00 0.00 3.00

Country  PRK  RUS   USA
Year
1957    0.00 0.00  1.00
1958    0.00 0.00 23.00
1959    0.00 0.00 16.00
1960    0.00 0.00 30.00
1961    0.00 2.00 43.00
…       …  …    …
2016    1.00 6.00 27.00
2017    0.00 6.00 30.00
2018    0.00 8.00 34.00
2019    0.00 9.00 27.00
2020    0.00 3.00 21.00

[64 rows x 16 columns]
```

[70]:
```
launches_by_country_per_year.plot(
    title = 'Number of Launches by Country over the Years',
    figsize = (16,10),
```

```
)
```

[70]:
```
<Axes: title={'center': 'Number of Launches by Country over the Years'},
xlabel='Year'>
```



19 Create a Year-on-Year Chart Showing the Organisation Doing the Most Number of Launches

Which organisation was dominant in the 1970s and 1980s? Which organisation was dominant in 2018, 2019 and 2020?

[71]:
```
launches_by_organisation_per_year = df_data.groupby(['Year',␣
↪'Organisation'])['Mission_Status'].count().unstack(level=1)
launches_by_organisation_per_year.fillna(0, inplace=True)
launches_by_organisation_per_year
```

[71]:

Organisation	AEB	AMBA	ASI	Arianespace	Arm??e de l'Air	Blue Origin	\
Year							
1957	0.00	0.00	0.00	0.00	0.00	0.00	
1958	0.00	7.00	0.00	0.00	0.00	0.00	
1959	0.00	0.00	0.00	0.00	0.00	0.00	
1960	0.00	0.00	0.00	0.00	0.00	0.00	

```
1961         0.00  0.00 0.00         0.00             0.00         0.00
…             …   …  …           …               …          …
2016         0.00  0.00 0.00        11.00             0.00         4.00
2017         0.00  0.00 0.00        11.00             0.00         1.00
2018         0.00  0.00 0.00        11.00             0.00         2.00
2019         0.00  0.00 0.00         9.00             0.00         3.00
2020         0.00  0.00 0.00         4.00             0.00         0.00

Organisation  Boeing  CASC  CASIC  CECLES  …  SpaceX  Starsem   ULA  \
Year                                       …
1957            0.00  0.00   0.00    0.00  …    0.00     0.00  0.00
1958            0.00  0.00   0.00    0.00  …    0.00     0.00  0.00
1959            0.00  0.00   0.00    0.00  …    0.00     0.00  0.00
1960            0.00  0.00   0.00    0.00  …    0.00     0.00  0.00
1961            0.00  0.00   0.00    0.00  …    0.00     0.00  0.00
…               …   …    …     …  …     …       …   …
2016            0.00 22.00   0.00    0.00  …    9.00     0.00 12.00
2017            0.00 16.00   1.00    0.00  …   18.00     0.00  8.00
2018            0.00 37.00   0.00    0.00  …   21.00     0.00  8.00
2019            0.00 27.00   0.00    0.00  …   13.00     0.00  5.00
2020            0.00 19.00   0.00    0.00  …   14.00     0.00  4.00

Organisation  US Air Force  US Navy   UT  VKS RF  Virgin Orbit  Yuzhmash  \
Year
1957                 0.00     1.00 0.00    0.00          0.00      0.00
1958                 2.00    12.00 0.00    0.00          0.00      0.00
1959                10.00     4.00 0.00    0.00          0.00      0.00
1960                21.00     0.00 0.00    0.00          0.00      0.00
1961                23.00     0.00 0.00    0.00          0.00      0.00
…                   …       …  …     …           …       …
2016                 0.00     0.00 0.00    4.00          0.00      0.00
2017                 0.00     0.00 0.00    6.00          0.00      0.00
2018                 0.00     0.00 0.00    5.00          0.00      0.00
2019                 0.00     0.00 0.00    8.00          0.00      0.00
2020                 0.00     0.00 0.00    3.00          1.00      0.00

Organisation  i-Space
Year
1957             0.00
1958             0.00
1959             0.00
1960             0.00
1961             0.00
…                …
2016             0.00
2017             0.00
2018             0.00
```

```
2019              1.00
2020              0.00

[64 rows x 56 columns]
```

[72]:
```
launches_by_organisation_per_year.plot(
    title = 'Number of Launches by Organisation over the Years',
    figsize = (16,10),
)

plt.ylabel('Number of Missions')
plt.xlim(1957, 2020)
plt.legend(loc="upper right", ncol=4)
plt.show()
```