Space Race Analysis and Visualization

The Space Race project studies more than 4300 space missions from 1957 to 2020. We look at who's involved, when missions happened, what they aimed to do, how successful they were, how much they cost, and if the rockets used are still in use. We want to see patterns in how many launches there are, how history like the Cold War affected space activities, and which countries and groups are most active in space exploration. Our goal is to understand how space exploration has changed over time and why.

Data Dictionary:

Variable	Description
Unnamed: 0.1	Junk column
Unnamed: 0	Junk column
Organisation	Organisation, that created and launched the rocket
Location	Location from where the rocket was launched
Date	Mission Date
Detail	Rocket Name
Rocket_Status	Represents if rocket is still active or retired
Price	Price of the whole mission (millions)
Mission_Status	Shows whether the mission was successful or not

In [7]:
```
df.head(20)
```

Out[7]:

	Unnamed: 0.1	Unnamed: 0	Organisation	Location	Date	Detail	Rocket_Status	Price	Mission_Status
0	0	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	1	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	2	2	SpaceX	Pad A, Boca Chica, Texas, USA	Tue Aug 04, 2020 23:57 UTC	Starship Prototype | 150 Meter Hop	StatusActive	NaN	Success
3	3	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	4	4	ULA	SLC-41, Cape Canaveral AFS, Florida, USA	Thu Jul 30, 2020 11:50 UTC	Atlas V 541 | Perseverance	StatusActive	145.0	Success
5	5	5	CASC	LC-9, Taiyuan Satellite Launch Center, China	Sat Jul 25, 2020 03:13 UTC	Long March 4B | Ziyuan-3 03, Apocalypse-10 & N...	StatusActive	64.68	Success

Data Preprocessing

In [8]:
```
df.shape
```

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

In [9]:
```
df.columns
```

Out[9]:
```
Index(['Unnamed: 0.1', 'Unnamed: 0', 'Organisation', 'Location', 'Date',
       'Detail', 'Rocket_Status', 'Price', 'Mission_Status'],
      dtype='object')
```

In [10]:
```
df['Price'] = pd.to_numeric(df['Price'], errors='coerce')
df['Date'] = pd.to_datetime(df['Date'], errors='coerce')
print(df.dtypes)
```

```
Unnamed: 0.1                    int64
Unnamed: 0                      int64
Organisation                   object
Location                       object
Date              datetime64[ns, UTC]
Detail                         object
Rocket_Status                  object
Price                         float64
Mission_Status                 object
dtype: object
```

In [11]:
```
df.isna().sum()
```

Out[11]:
```
Unnamed: 0.1         0
Unnamed: 0           0
Organisation         0
Location             0
Date               126
Detail               0
Rocket_Status        0
Price             3375
Mission_Status       0
dtype: int64
```

Data Cleaning

In [13]:

```
#df['Price'] = df['Price'].fillna(df['Price'].mean().round(2))
#df.dropna(subset=['Price'], inplace=True)
df['Price'].fillna(0, inplace = True)
df['Date'].fillna(method='ffill', inplace=True)
print(df.isna().sum())
```

```
Unnamed: 0.1      0
Unnamed: 0        0
Organisation      0
Location          0
Date              0
Detail            0
Rocket_Status     0
Price             0
Mission_Status    0
dtype: int64
```

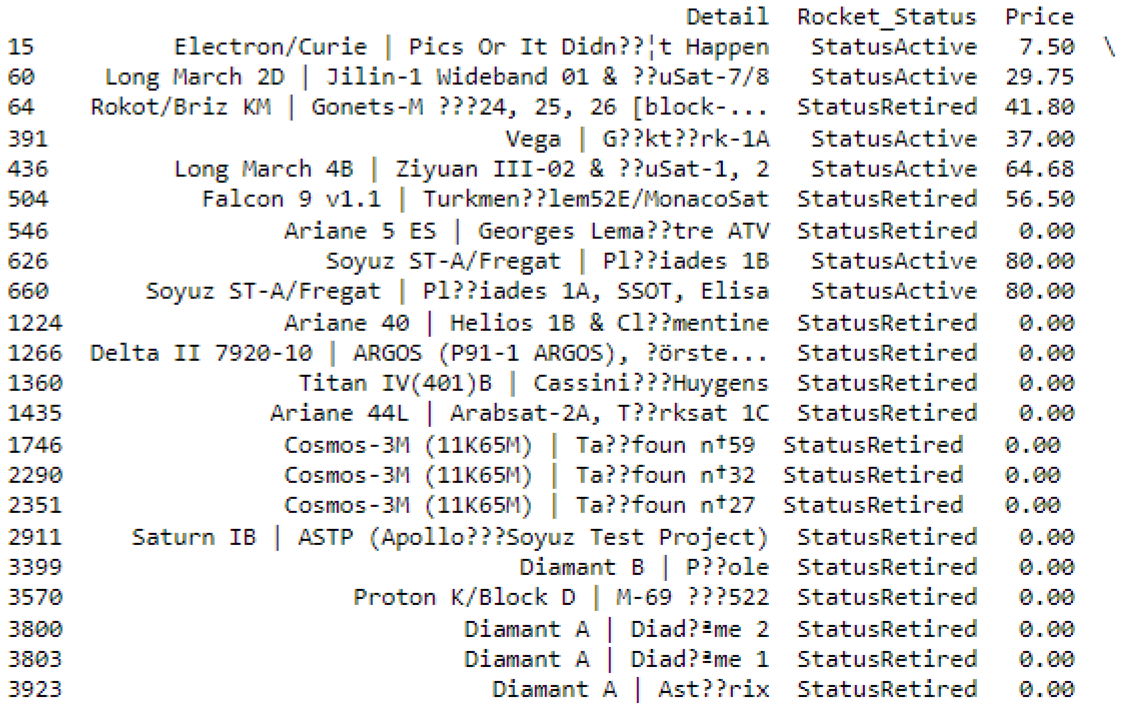
In [16]:

```
df = df.drop(["Unnamed: 0.1", "Unnamed: 0"], axis=1)
```

In [17]:

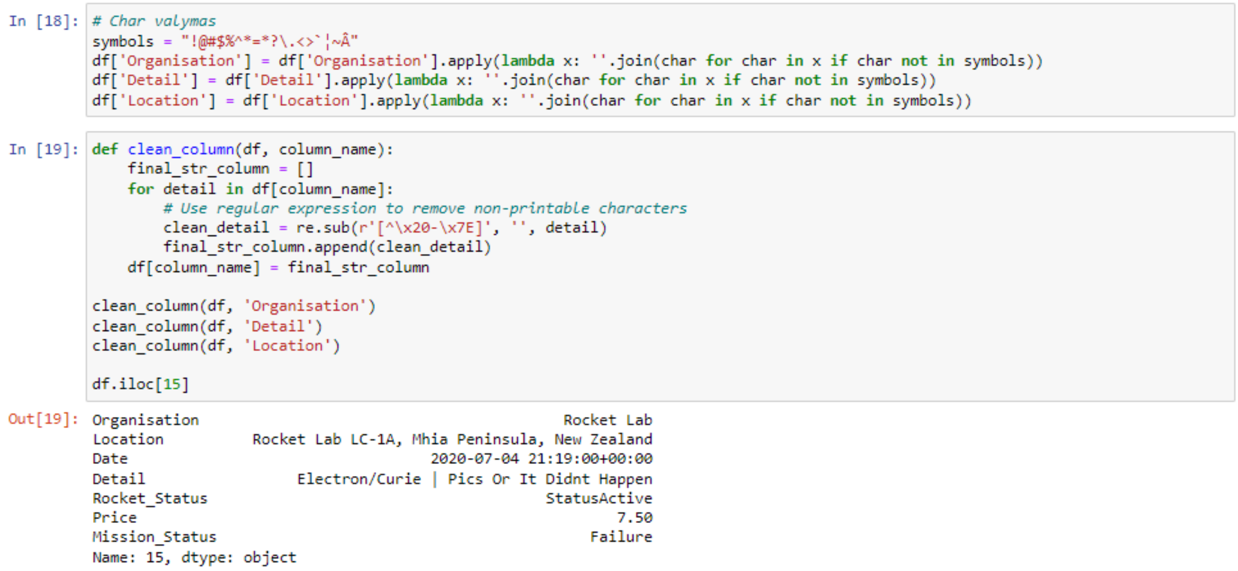
```
symbols = "@$%^*=*?\<>`~Â"

for column in df.columns:
    if df[column].dtype != 'object':
        continue
    symbols_found = df[column].apply(lambda x: any(char in symbols for char in x))
    rows_with_symbols = df[symbols_found]
    if not rows_with_symbols.empty:
        print(f"Symbols found in '{column}' column:")
        print(rows_with_symbols)
```

```
Symbols found in 'Organisation' column:
        Organisation                                 Location  \
3800  Arm??e de l'Air  Brigitte, Hammaguir, Algeria, France
3803  Arm??e de l'Air  Brigitte, Hammaguir, Algeria, France
3903  Arm??e de l'Air  Brigitte, Hammaguir, Algeria, France
3923  Arm??e de l'Air  Brigitte, Hammaguir, Algeria, France

                          Date                  Detail  Rocket_Status  Price  \
3800 1967-02-15 10:06:00+00:00  Diamant A | Diad?ªme 2  StatusRetired   0.00
3803 1967-02-08 08:39:00+00:00  Diamant A | Diad?ªme 1  StatusRetired   0.00
3903 1966-02-17 07:33:00+00:00    Diamant A | Diapason  StatusRetired   0.00
3923 1965-11-26 14:47:00+00:00    Diamant A | Ast??rix  StatusRetired   0.00

      Mission_Status
3800         Success
3803  Partial Failure
3903         Success
3923         Success
Symbols found in 'Location' column:
     Organisation                                    Location  \
15     Rocket Lab    Rocket Lab LC-1A, M?⍰hia Peninsula, New Zealand
21     Rocket Lab    Rocket Lab LC-1A, M?⍰hia Peninsula, New Zealand
55     Rocket Lab    Rocket Lab LC-1A, M?⍰hia Peninsula, New Zealand
77     Rocket Lab    Rocket Lab LC-1A, M?⍰hia Peninsula, New Zealand
93     Rocket Lab    Rocket Lab LC-1A, M?⍰hia Peninsula, New Zealand
```



```
                                                 Detail  Rocket_Status  Price
15          Electron/Curie | Pics Or It Didn??¦t Happen   StatusActive   7.50  \
60     Long March 2D | Jilin-1 Wideband 01 & ??uSat-7/8   StatusActive  29.75
64    Rokot/Briz KM | Gonets-M ???24, 25, 26 [block-...  StatusRetired  41.80
391                                 Vega | G??kt??rk-1A   StatusActive  37.00
436         Long March 4B | Ziyuan III-02 & ??uSat-1, 2   StatusActive  64.68
504           Falcon 9 v1.1 | Turkmen??lem52E/MonacoSat  StatusRetired  56.50
546                 Ariane 5 ES | Georges Lema??tre ATV  StatusRetired   0.00
626                    Soyuz ST-A/Fregat | Pl??iades 1B   StatusActive  80.00
660       Soyuz ST-A/Fregat | Pl??iades 1A, SSOT, Elisa   StatusActive  80.00
1224                Ariane 40 | Helios 1B & Cl??mentine  StatusRetired   0.00
1266  Delta II 7920-10 | ARGOS (P91-1 ARGOS), ?örste...  StatusRetired   0.00
1360                 Titan IV(401)B | Cassini???Huygens  StatusRetired   0.00
1435               Ariane 44L | Arabsat-2A, T??rksat 1C  StatusRetired   0.00
1746                Cosmos-3M (11K65M) | Ta??foun n†59  StatusRetired   0.00
2290                Cosmos-3M (11K65M) | Ta??foun n†32  StatusRetired   0.00
2351                Cosmos-3M (11K65M) | Ta??foun n†27  StatusRetired   0.00
2911     Saturn IB | ASTP (Apollo???Soyuz Test Project)  StatusRetired   0.00
3399                                 Diamant B | P??ole  StatusRetired   0.00
3570                     Proton K/Block D | M-69 ???522  StatusRetired   0.00
3800                             Diamant A | Diad?ªme 2  StatusRetired   0.00
3803                             Diamant A | Diad?ªme 1  StatusRetired   0.00
3923                               Diamant A | Ast??rix  StatusRetired   0.00
```

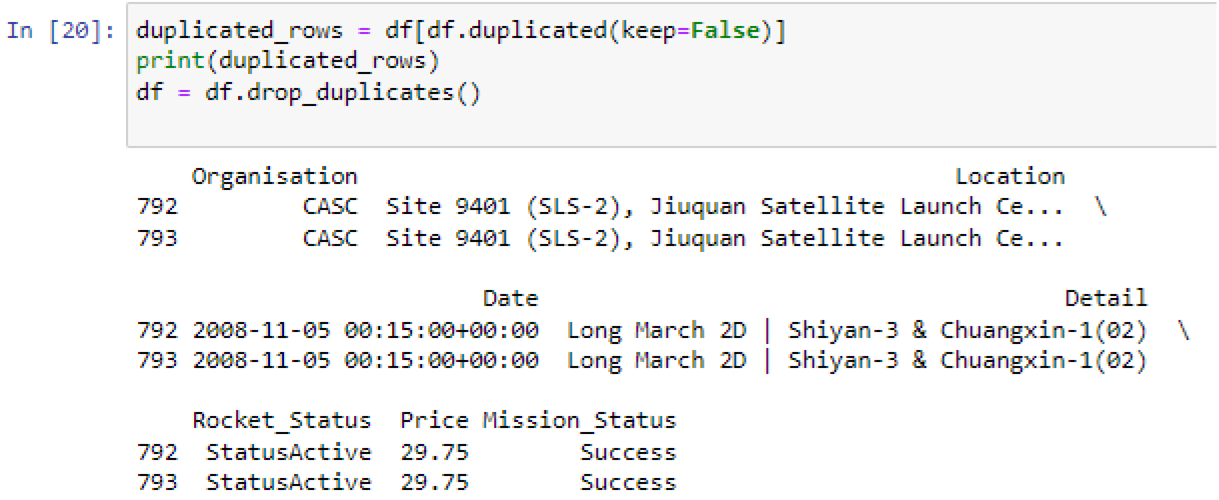
Noticing that there are many values that have char and other symbols in the middle of word letters, I am trying to find all the lines where any column has unclear or mismatched symbols.



```
In [18]: # Char valymas
         symbols = "!@#$%^*=*?\.<>`¦~Â"
         df['Organisation'] = df['Organisation'].apply(lambda x: ''.join(char for char in x if char not in symbols))
         df['Detail'] = df['Detail'].apply(lambda x: ''.join(char for char in x if char not in symbols))
         df['Location'] = df['Location'].apply(lambda x: ''.join(char for char in x if char not in symbols))
```

```
In [19]: def clean_column(df, column_name):
             final_str_column = []
             for detail in df[column_name]:
                 # Use regular expression to remove non-printable characters
                 clean_detail = re.sub(r'[^\x20-\x7E]', '', detail)
                 final_str_column.append(clean_detail)
             df[column_name] = final_str_column

         clean_column(df, 'Organisation')
         clean_column(df, 'Detail')
         clean_column(df, 'Location')

         df.iloc[15]

Out[19]: Organisation                                         Rocket Lab
         Location          Rocket Lab LC-1A, Mhia Peninsula, New Zealand
         Date                                  2020-07-04 21:19:00+00:00
         Detail                     Electron/Curie | Pics Or It Didnt Happen
         Rocket_Status                                      StatusActive
         Price                                                      7.50
         Mission_Status                                          Failure
         Name: 15, dtype: object
```

Then I create an algorithm that cleans any char or other non-printable characters in the middle of word letters. Also I use regular expression to correct this problem.



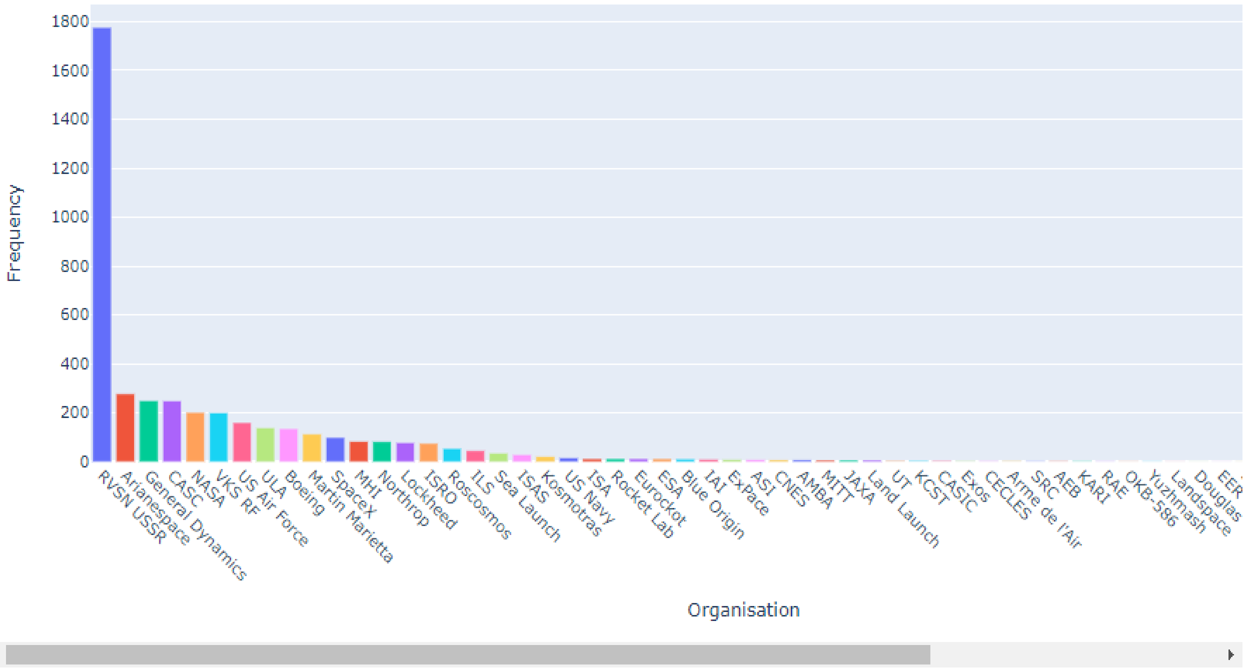
```
In [20]: duplicated_rows = df[df.duplicated(keep=False)]
         print(duplicated_rows)
         df = df.drop_duplicates()
```

```
    Organisation                                           Location
792         CASC  Site 9401 (SLS-2), Jiuquan Satellite Launch Ce...  \
793         CASC  Site 9401 (SLS-2), Jiuquan Satellite Launch Ce...

                         Date                                      Detail
792 2008-11-05 00:15:00+00:00  Long March 2D | Shiyan-3 & Chuangxin-1(02)  \
793 2008-11-05 00:15:00+00:00  Long March 2D | Shiyan-3 & Chuangxin-1(02)

    Rocket_Status  Price Mission_Status
792  StatusActive  29.75        Success
793  StatusActive  29.75        Success
```

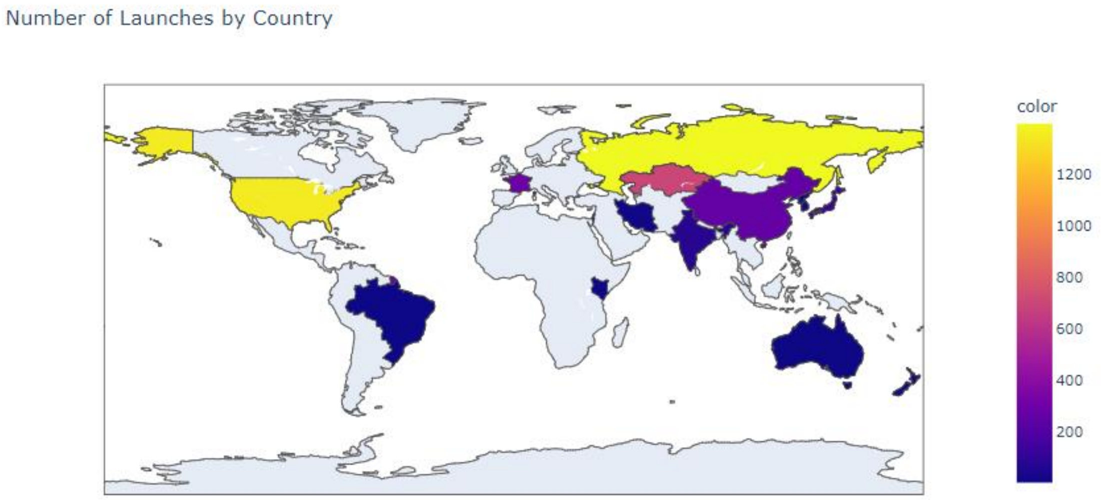
The dataset is now clean. We dealt with the missing values in the Price column in three ways: 1. Filling them with the average price 2. Removing rows with missing prices 3. Setting missing prices to 0. However, since about 78% of the prices were missing (3375 out of 4323), using the average or 0 wouldn't provide meaningful insights. Removing rows would lose a lot of data, so we only did it for certain categorical variables when calculating statistics. We also removed any duplicate entries from the dataset to improve its quality.

Number of Launches per Company

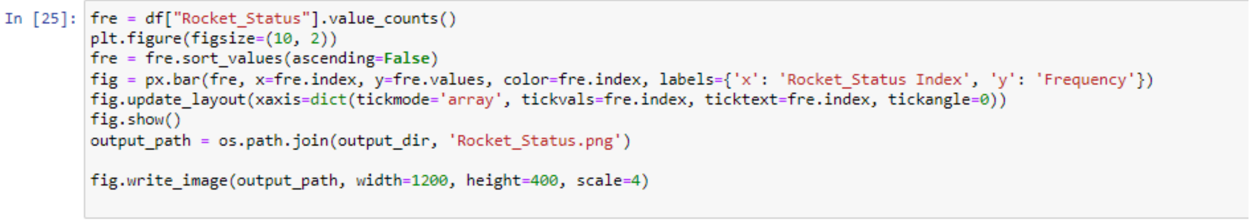
```
In [59]: fre = df["Organisation"].value_counts()
         fre = fre.sort_values(ascending=False)
         fig = px.bar(fre, x=fre.index, y=fre.values, color=fre.index, labels={'x': 'Organisation Index', 'y': 'Frequency'})

         fig.update_layout(xaxis=dict(tickmode='array', tickvals=fre.index, ticktext=fre.index, tickangle=45))

         fig.update_layout(width=1300)
```



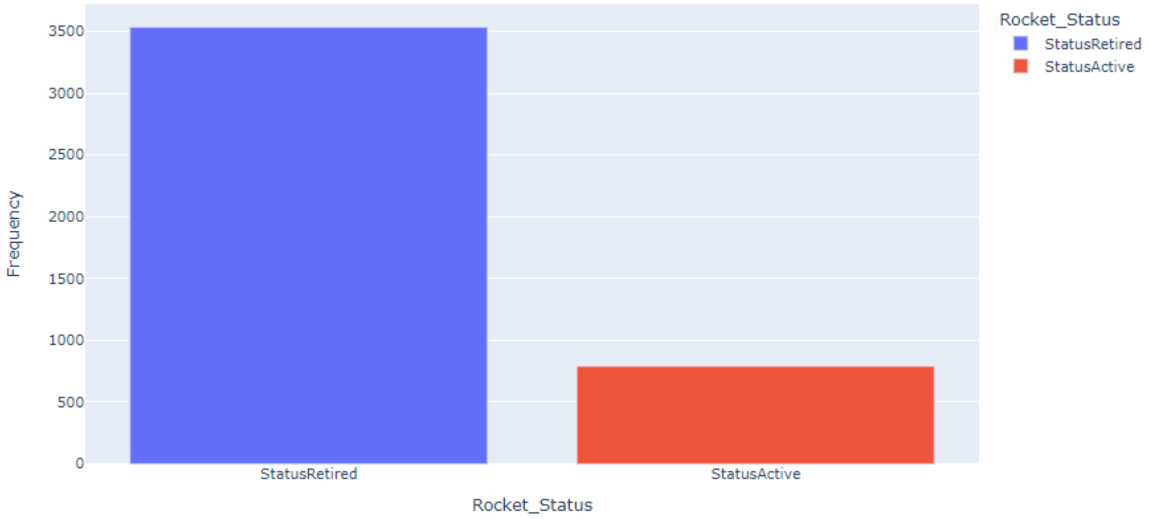
The graph shows number of launches per company. We see that RVSN USSR is highly dominating with nearly 1800 values. This is of course because RVSN USSR was the main force of these kind of operations.



Number of Active versus Retired Rockets

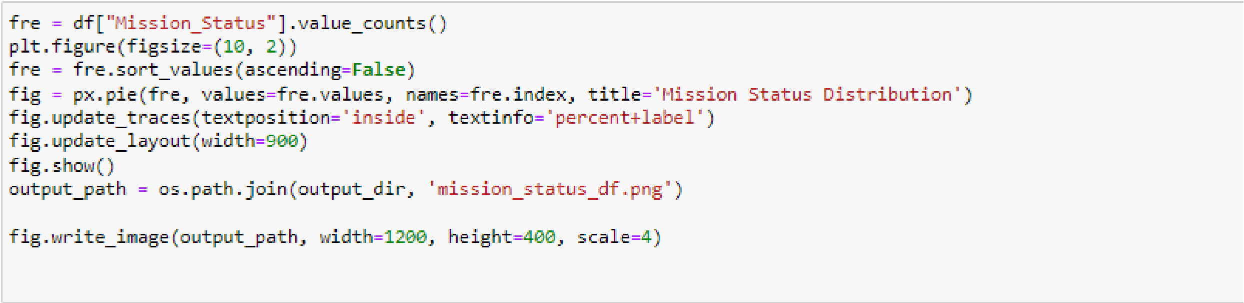


```
In [25]: fre = df["Rocket_Status"].value_counts()
         plt.figure(figsize=(10, 2))
         fre = fre.sort_values(ascending=False)
         fig = px.bar(fre, x=fre.index, y=fre.values, color=fre.index, labels={'x': 'Rocket_Status Index', 'y': 'Frequency'})
         fig.update_layout(xaxis=dict(tickmode='array', tickvals=fre.index, ticktext=fre.index, tickangle=0))
         fig.show()
         output_path = os.path.join(output_dir, 'Rocket_Status.png')

         fig.write_image(output_path, width=1200, height=400, scale=4)
```

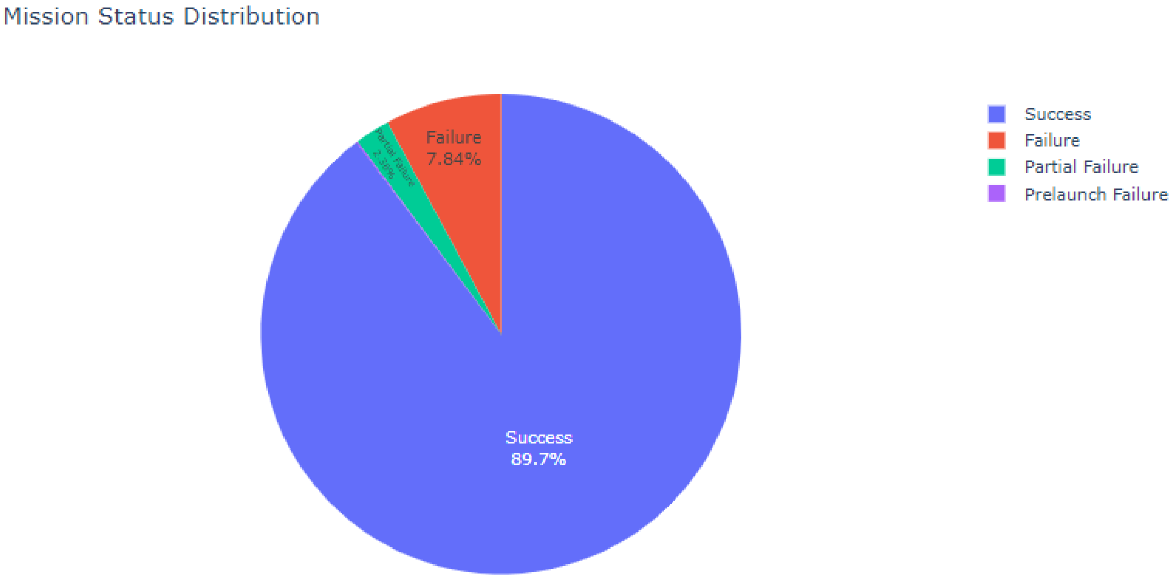


More than 3500 rockets are retired. Developing rockets capable of sustained long-term operation in space requires significant investment in research, engineering, and maintenance to ensure reliability and efficiency, leading to retirement decisions influenced by both technical feasibility and economic considerations.

Distribution of Mission Status

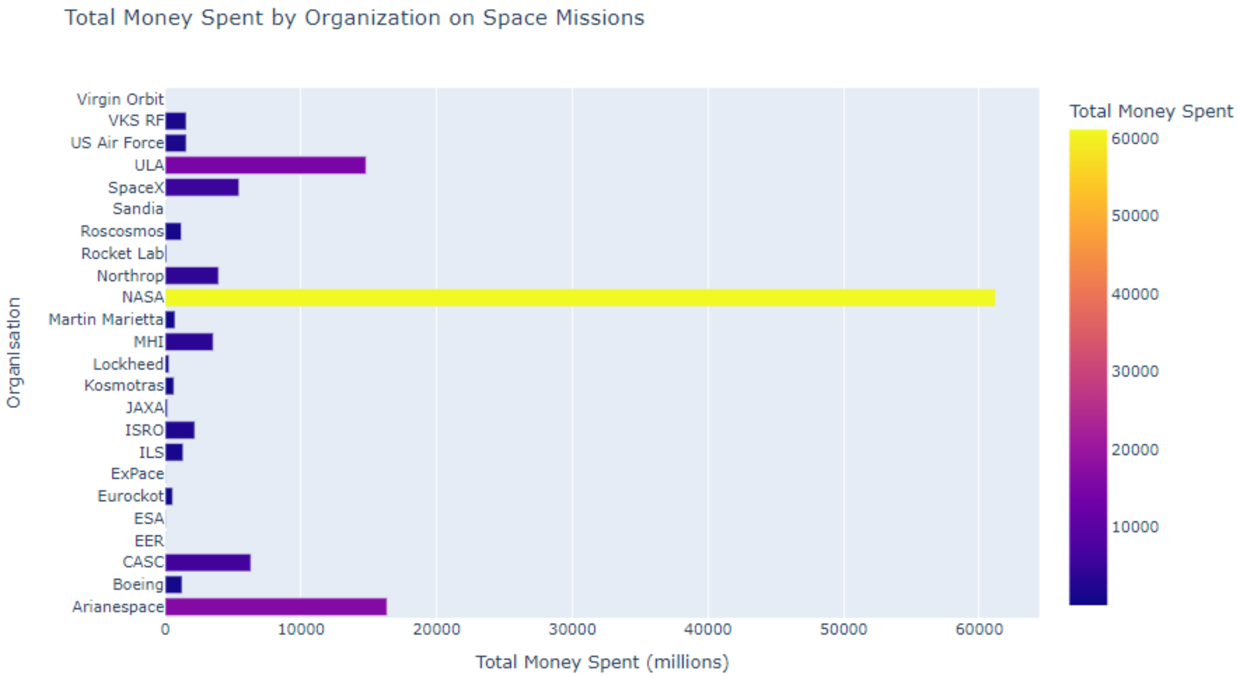


```
fre = df["Mission_Status"].value_counts()
plt.figure(figsize=(10, 2))
fre = fre.sort_values(ascending=False)
fig = px.pie(fre, values=fre.values, names=fre.index, title='Mission Status Distribution')
fig.update_traces(textposition='inside', textinfo='percent+label')
fig.update_layout(width=900)
fig.show()
output_path = os.path.join(output_dir, 'mission_status_df.png')

fig.write_image(output_path, width=1200, height=400, scale=4)
```

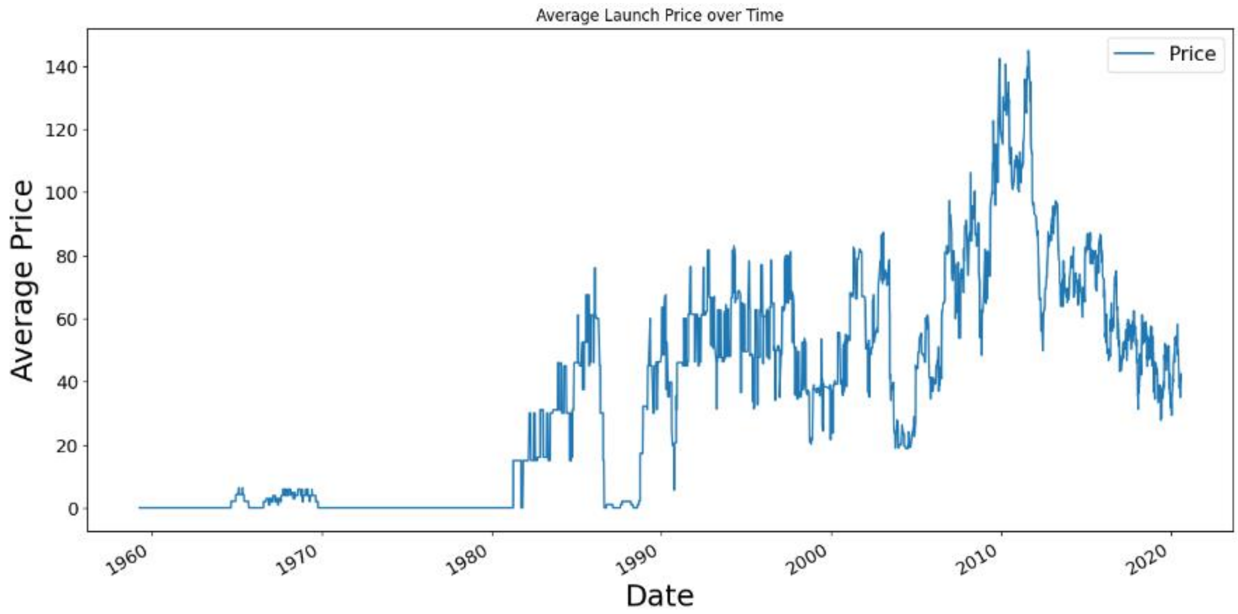


As we can see, 90% of the missions were successful. These figures are impressive and mean that every mission is taken very seriously.

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

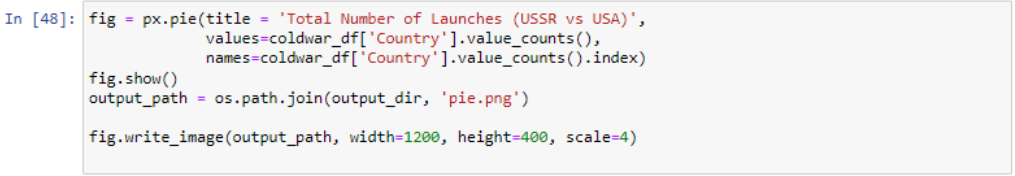


NASA is at the forefront in terms of the amount of money spent on space missions. NASA spends the most money on space missions because it carries out a wide range of ambitious projects, from exploring other planets to sending astronauts into space.

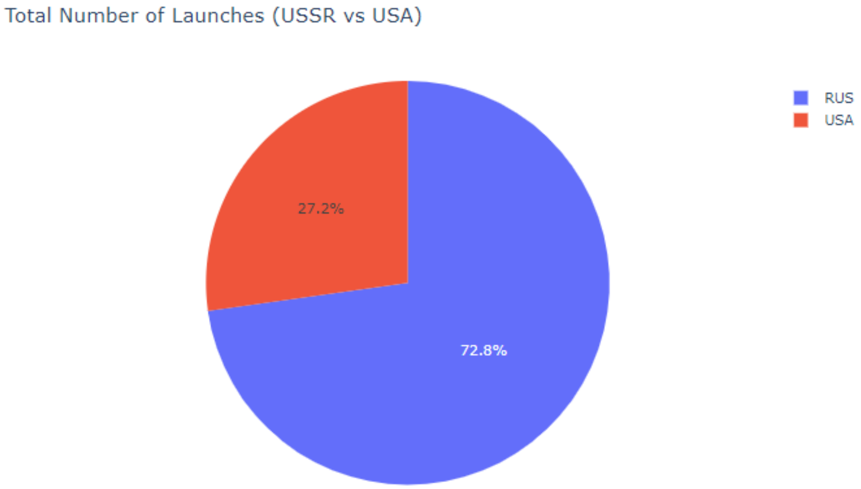


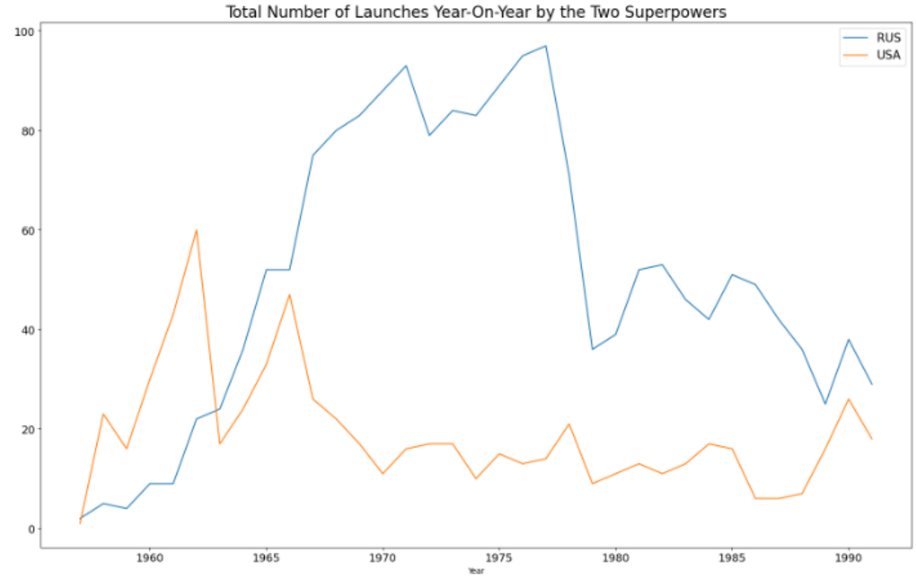
This graph shows how the average prices vary from 1957 to 2020. The beginning of the graph shows exactly 0 because in those years most of the mission's capital was classified, so we replaced those values with 0. The largest peak was during the period of 2010-2014. We also see a huge dip at the end of 1980 and a significant increase at the beginning of 1990.

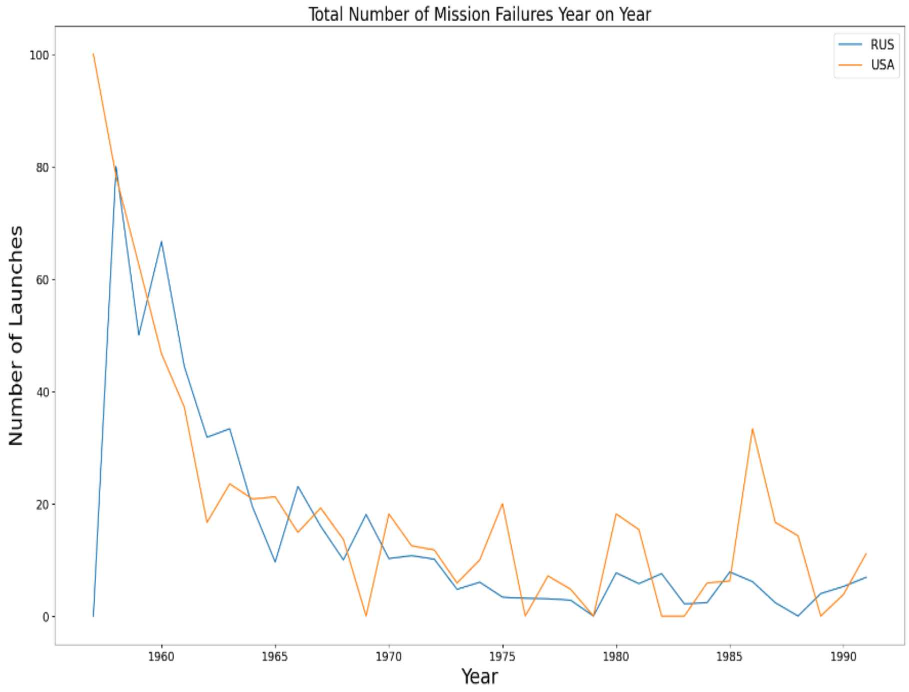
Cold War Space Race: USA vs USSR

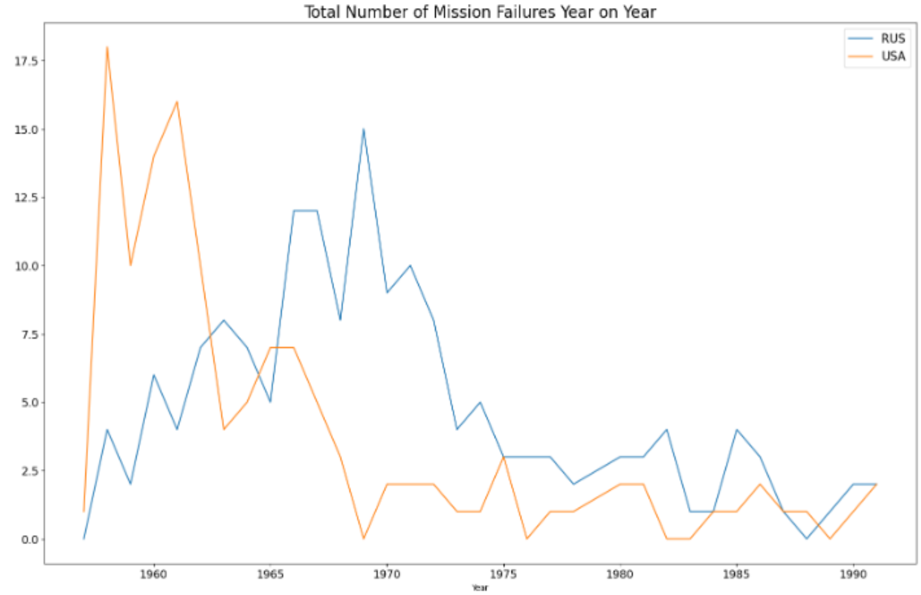


```
In [48]: fig = px.pie(title = 'Total Number of Launches (USSR vs USA)',
                      values=coldwar_df['Country'].value_counts(),
                      names=coldwar_df['Country'].value_counts().index)
         fig.show()
         output_path = os.path.join(output_dir, 'pie.png')

         fig.write_image(output_path, width=1200, height=400, scale=4)
```




Total Number of Launches Year-On-Year by the Two Superpowers
RUS
USA
100
80
60
40
20
0
1960
1965
1970
1975
1980
1985
1990
Year


Total Number of Mission Failures Year on Year
RUS
USA
Number of Launches
100
80
60
40
20
0
1960
1965
1970
1975
1980
1985
1990
Year


Total Number of Mission Failures Year on Year
RUS
USA
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
1960
1965
1970
1975
1980
1985
1990
Year