Assignment 3 – Maintenance Optimisation

1. Problem Description
   This project aims to improve maintenance planning for 12 railway vehicles. The goal is to study failure and repair data to find:
   - MTTF (Mean Time to Failure): Average time between failures.
   - MTTR (Mean Time to Repair): Average time to fix a failure.
     These metrics help understand how often vehicles break down and how quickly they are repaired.
2. Solution Steps
   - Read Data
     The CSV file containing failure data was read into a Pandas DataFrame using:

```
import pandas as pd
import matplotlib.pyplot as plt

# Steg 1: Läs in data från CSV-filen
file_path = "openDamagesinTrains.csv"
df = pd.read_csv(file_path)
```

   - Convert date columns

The 'damage reporting date' and 'damage closing date' columns were converted into a standard datetime format using:

```
# Steg 2: Konvertera datumkolumner till datetime-format
df['Damage reporting date'] = pd.to_datetime(df['Damage reporting date'], errors='coerce', dayfirst=False)
df['Damage closing date'] = pd.to_datetime(df['Damage closing date'], errors='coerce', dayfirst=False)
```

   - Calculate MTTF (Mean Time to Failure)

The dataset was sorted by Vehicle and Damage Reporting Date:

```
# Steg 3: Beräkna MTTF (Mean Time to Failure)
df = df.sort_values(by=['Vehicle', 'Damage reporting date'])  # Sortera per fordon och datum
```

The time between each failure for the same vehicle was calculated using:

```
df['TTF'] = df.groupby('Vehicle')['Damage reporting date'].diff().dt.days  # Beräkna skillnad i dagar
```

   - Calculate MTTR (Mean Time to Repair)

The difference between Damage Closing Date and Damage Reporting Date was computed:

```
# Steg 4: Beräkna MTTR (Mean Time to Repair)
df['TTR'] = (df['Damage closing date'] - df['Damage reporting date']).dt.days
```

   - Statistical Analysis and Visualization

Histograms for both MTTF and MTTR were generated using `matplotlib`:

```
# Steg 5: Rita histogram för MTTF
plt.figure(figsize=(10, 5))
plt.hist(df['TTF'].dropna(), bins=20, edgecolor='black', alpha=0.7)
plt.xlabel('Time to Failure (Days)')
plt.ylabel('Frequency')
plt.title('Histogram över MTTF')
plt.grid(axis='y', alpha=0.75)
plt.show()
```

(module) plt

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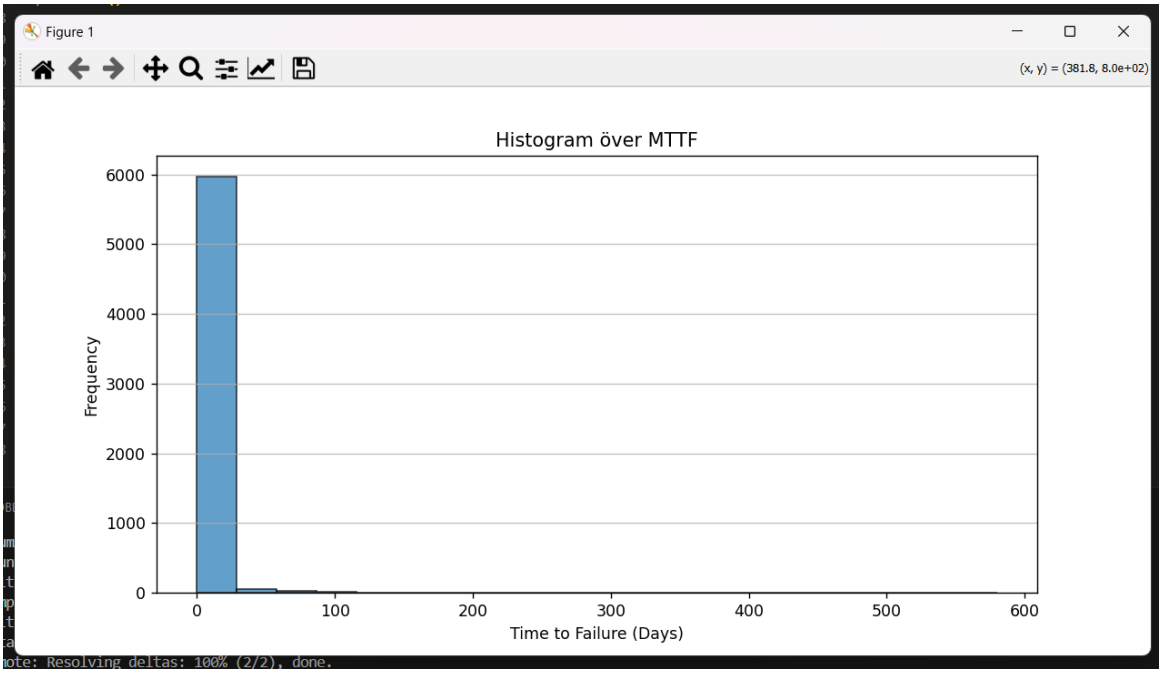
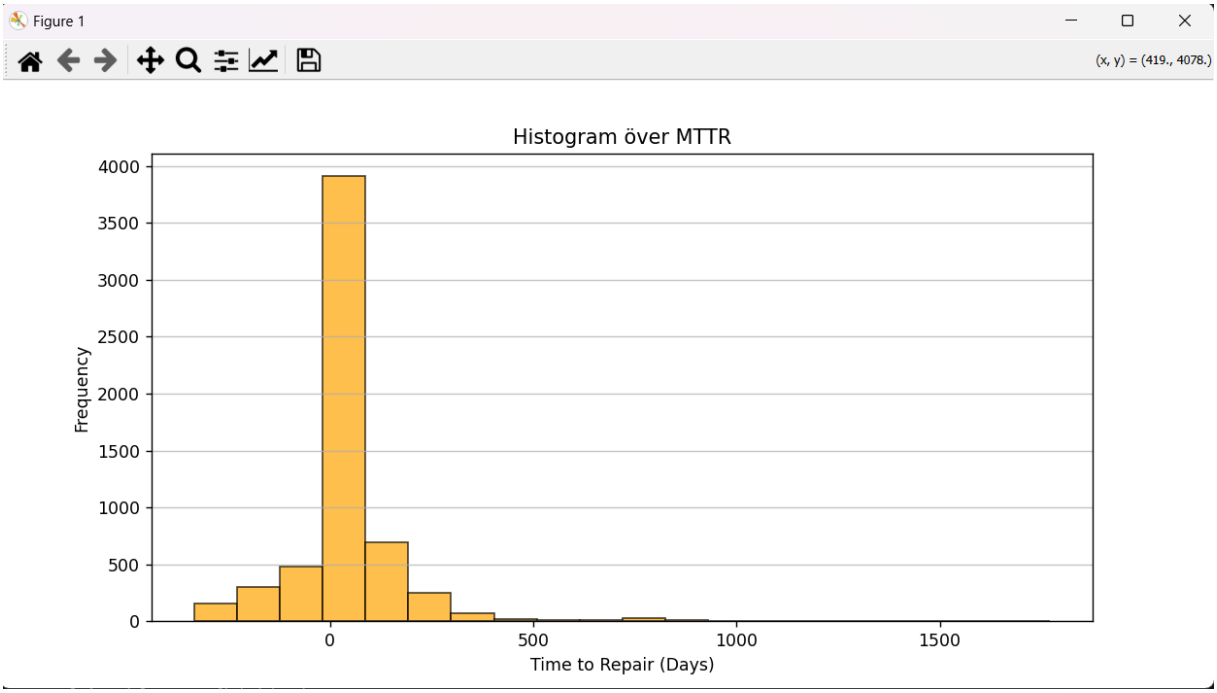
The mean and variance for both metrics were calculated using:

```
# Steg 6: Rita histogram för MTTR
plt.figure(figsize=(10, 5))
plt.hist(df['TTR'].dropna(), bins=20, edgecolor='black', alpha=0.7, color='orange')
plt.xlabel('Time to Repair (Days)')
plt.ylabel('Frequency')
plt.title('Histogram över MTTR')
plt.grid(axis='y', alpha=0.75)
plt.show()
```

Result Figure

Below is a histogram representing the distribution of Mean Time to Failure (MTTF) and Mean Time to Repair (MTTR).





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3. Observations and Reflections

Results Summary
Mean MTTF: 3.37 days
Variance MTTF: 354.55
Mean MTTR: 28.75 days
Variance MTTR: 19,236.79

- The results indicate that failures occur relatively frequently, with an average time between failures of **3.37 days**.
- Repair times show a much larger variance, suggesting that some repairs take significantly longer than others.
- A possible improvement could involve predictive maintenance strategies using machine learning to anticipate failures and reduce MTTR.

Github link – public github : https://github.com/AryaEisa/Assignment3.git