Reliability Engineering and Maintenance Management

Project I: Failure Data Analysis

Background and datasets:

The air conditioning unit in commercial jet planes is a critical component that ensures passenger comfort and flight safety. Its reliability is directly linked to the aircraft's normal operation and maintenance costs. To evaluate the failure patterns of a specific model of air conditioning unit, a reliability engineer collected and analyzed failure data from the air conditioning units of 11 airplanes of the same model. Each time a unit failed, the engineer recorded the failure time and returned it to service after repair.

The collected data is shown in the table 1. The first column of the table represents the airplane ID, and each row records the maintenance times for air conditioning system failures on the respective airplane. For instance, data on airplane 7907 is contained in the first row. The first repair occurred on day 194, the second repair occurred on day 209, and the final air conditioner failure occurred on day 493.

Number	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16
7907	194	209	250	279	312	493										
7908	413	427	485	522	622	687	696	865								
7909	90	100	160	346	407	456	470	494	550	570	649	733	777	836	865	983
7910	74	131	179	208	710	722	792	813	842							
7911	55	375	431	535	755	994										
7912	23	284	371	378	498	512	574	621	846	917						
7913	97	148	159	163	304	322	464	532	609	689	690	706	812			
7914	50	94	196	268	290	329	332	347	544	732	811	899	945	950	955	991
7915	359	368	380	650												
7916	50	304	309	592	627	639										
7917	130	623														

Table 1: Failures times for Air conditioners in 11 Airplanes

Using the provided data, complete the following tasks and submit a comprehensive analysis report (including background, methods, computation steps, results discussion, and code implementation).

Tasks:

(1) Calculate the inter-failure times for each airplane's air conditioning unit and conduct corresponding descriptive statistical analysis. Can differences in repair patterns between individuals be observed from the visualization results?

(2) Order the unique failure times for all air conditioners and compute the mean cumulative repair function (MCRF). Plot the cumulative plot of MCRF. Are the systems experiencing more failures as time goes by?

(3) Disregarding the heterogeneity between units, calculate the number of failures occurring within each time interval. Choose either a homogeneous or non-homogeneous Poisson Process to model the failure count data, and provide a reasonable explanation.

(4) Estimate the parameters of your model and apply the fitted model to the data. Evaluate whether the model provides a good fit. How can you assess the goodness-of-fit for your model?

Extensions:

What impact could heterogeneity among units have on the results? Which models would be appropriate for fitting such data? You may review relevant literature and consider methods such as random effect models or hierarchical Bayesian approaches to enhance your original model.

Software:
You can choose whichever software you want to use: R, Matlab, Python.

Minimum requirements to pass the course
In order to pass the course, you need to satisfactorily cover tasks (1)-(4). Bare in mind that providing the minimum solution for this problem will give you a minimum passing grade for this course.

Outcomes and examination
The outcomes of your group's work are a report and a video. The final report **should not exceed 25 pages** (excluding appendices). It should be clearly written (in English) and should contain sufficient background information of the concepts and methods you are using. The appendix should include the code used for your analysis, pictures or tables that you want to report but do not fit in the report, other background information, etc. The report will be evaluated based on: a) theoretical knowledge application: 25%, b) accuracy of data analysis: 25%, c) clarity of report: 20%, d) logical flow of report: 20% and e) creativity in analysis: 10%.

The video (**max 8 minutes**) should summarize your findings. The basic requirement is to simply record your presentation (i.e., make slides, predent and record), but you are encouraged to be creative. The videos will be evaluated based on: a) content: 40%, b) clarity: 40% and c) entertainment and creativity: 20%.

Finally, your final grade of the project will be computed based on these factors and weights

- 80% of your final report
- 20% of your video