CEE 498REMM Project Presentation

Project I: Failure Data Analysis

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1. Background and Datasets

- The air conditioning unit in commercial jet planes is essential for passengers and crew. To ensure a comfortable and safe flight, a reliability engineer investigated 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.

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. 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.

2. Differences in repair patterns between individual airplanes

- We record the inter-failure times for each airplane's air conditioning unit via data visualizations.
- Most airplanes' inter-failure times gather around 0-100 days, except for Airplane 7911, 7915, 7916, and 7917.

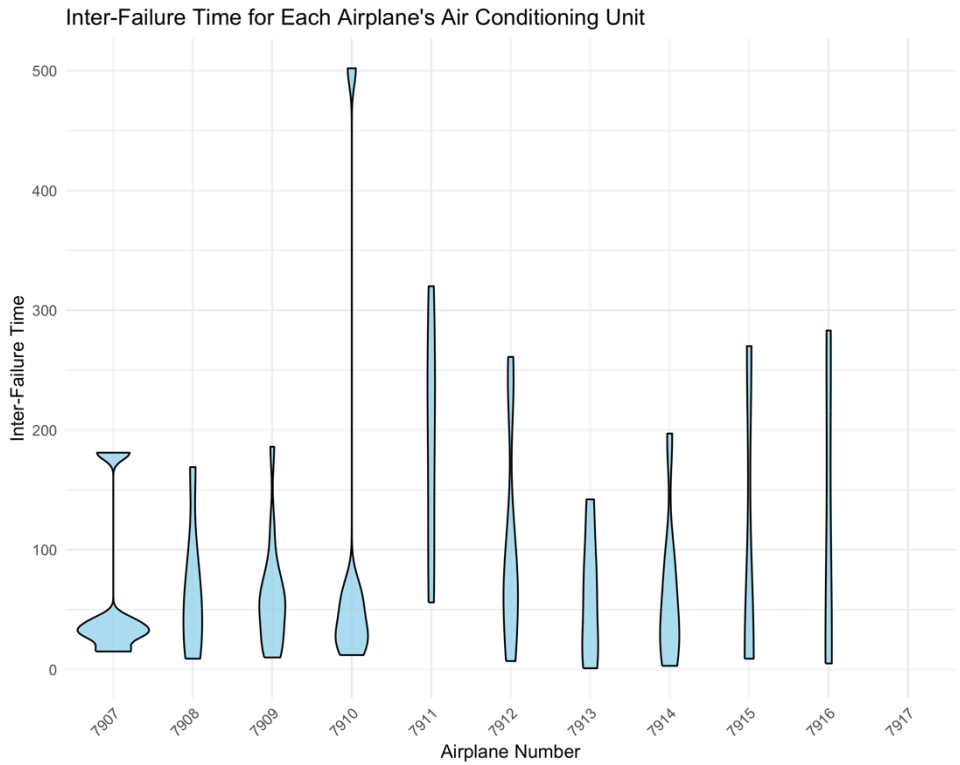


Figure 1: The violin plot of inter-failure times for each air conditioner on an airplane.

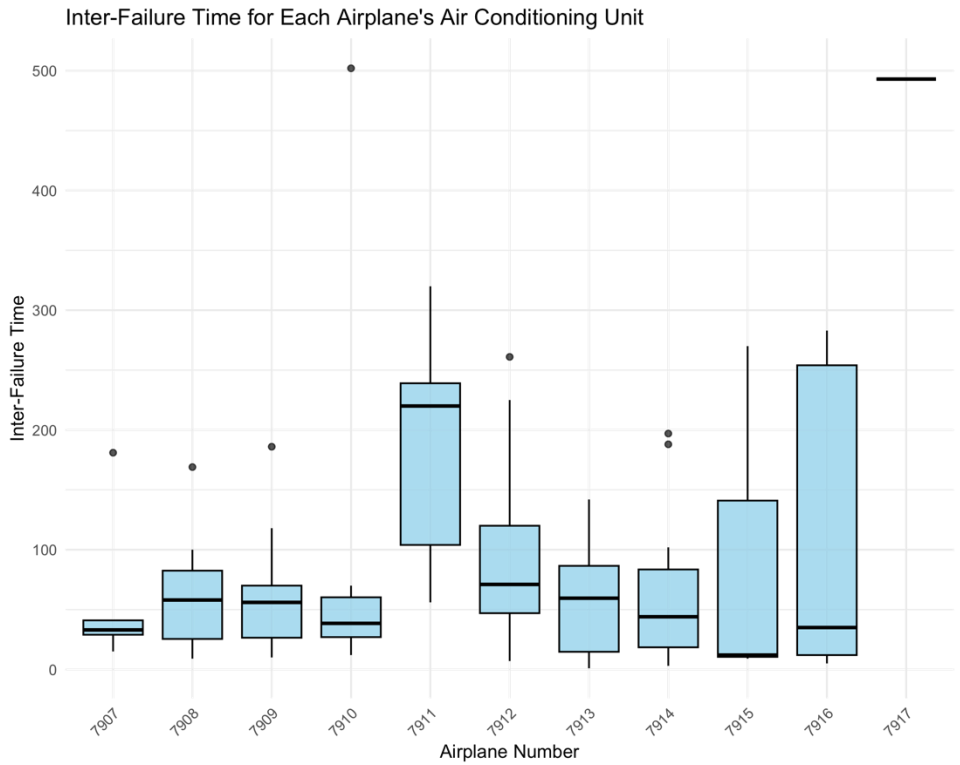


Figure 2: The box plot of inter-failure times for each air conditioner on an airplane.

3. Unique failure times and MCRF

- The systems are experiencing more failures as time goes by.

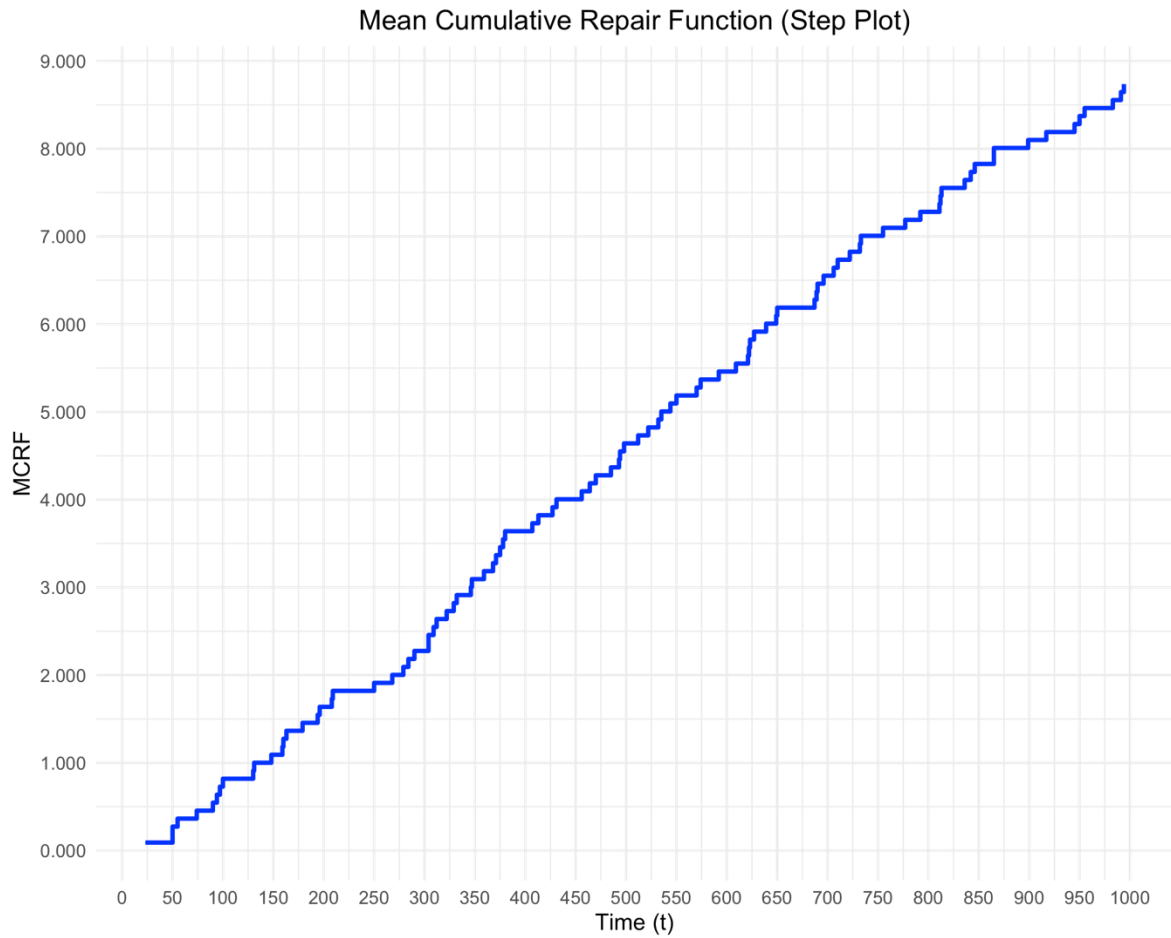


Figure 3: MCRF step plot of unique failure times for all air conditioners.

4. Heterogeneity among the number of failures occurring within each time interval

- Using a non-homogeneous Poisson Process to model the failure count data is more appropriate than a homogeneous one.
- **Reasons:** The failure number within each time interval varies interval by interval, indicating that the rate of failures is not constant over time but changes dynamically, which aligns with the assumptions of a non-homogeneous Poisson Process.

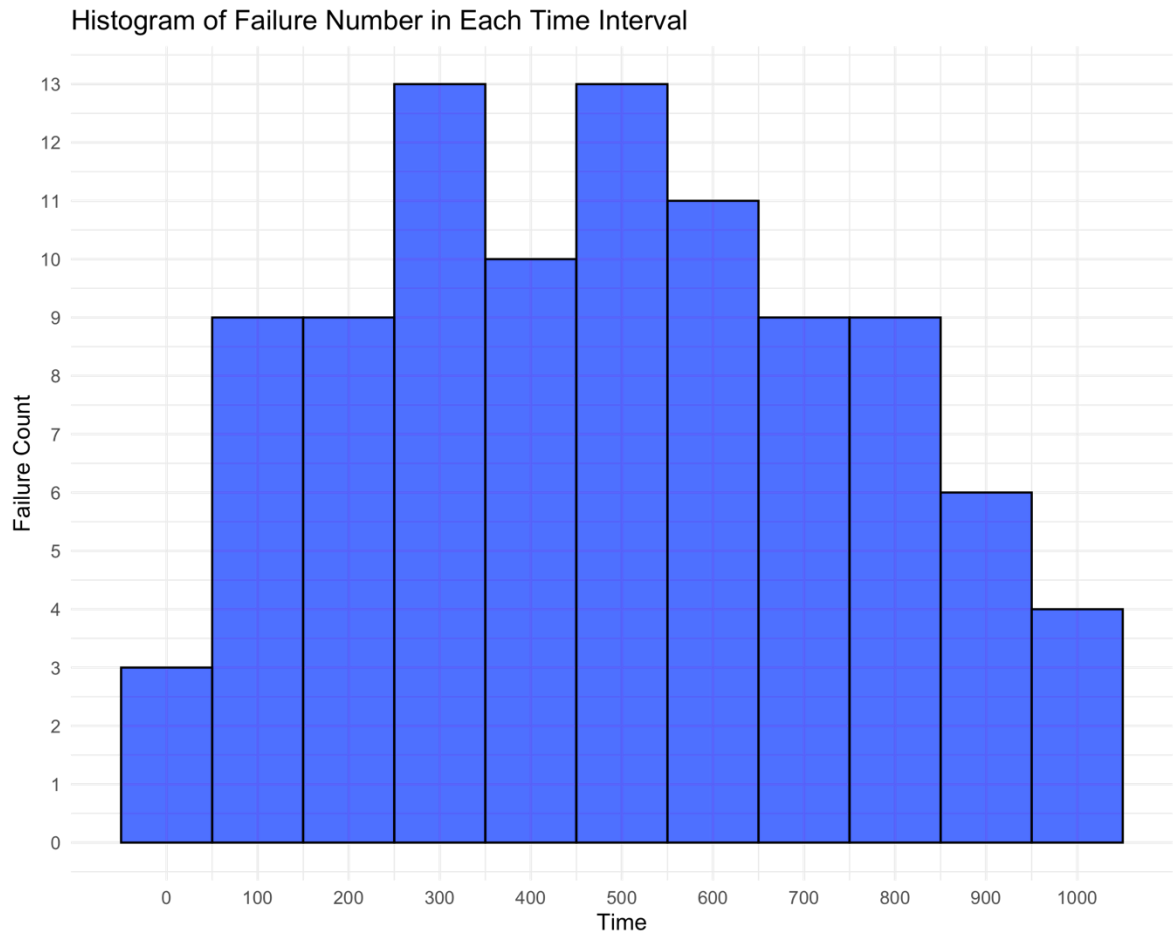
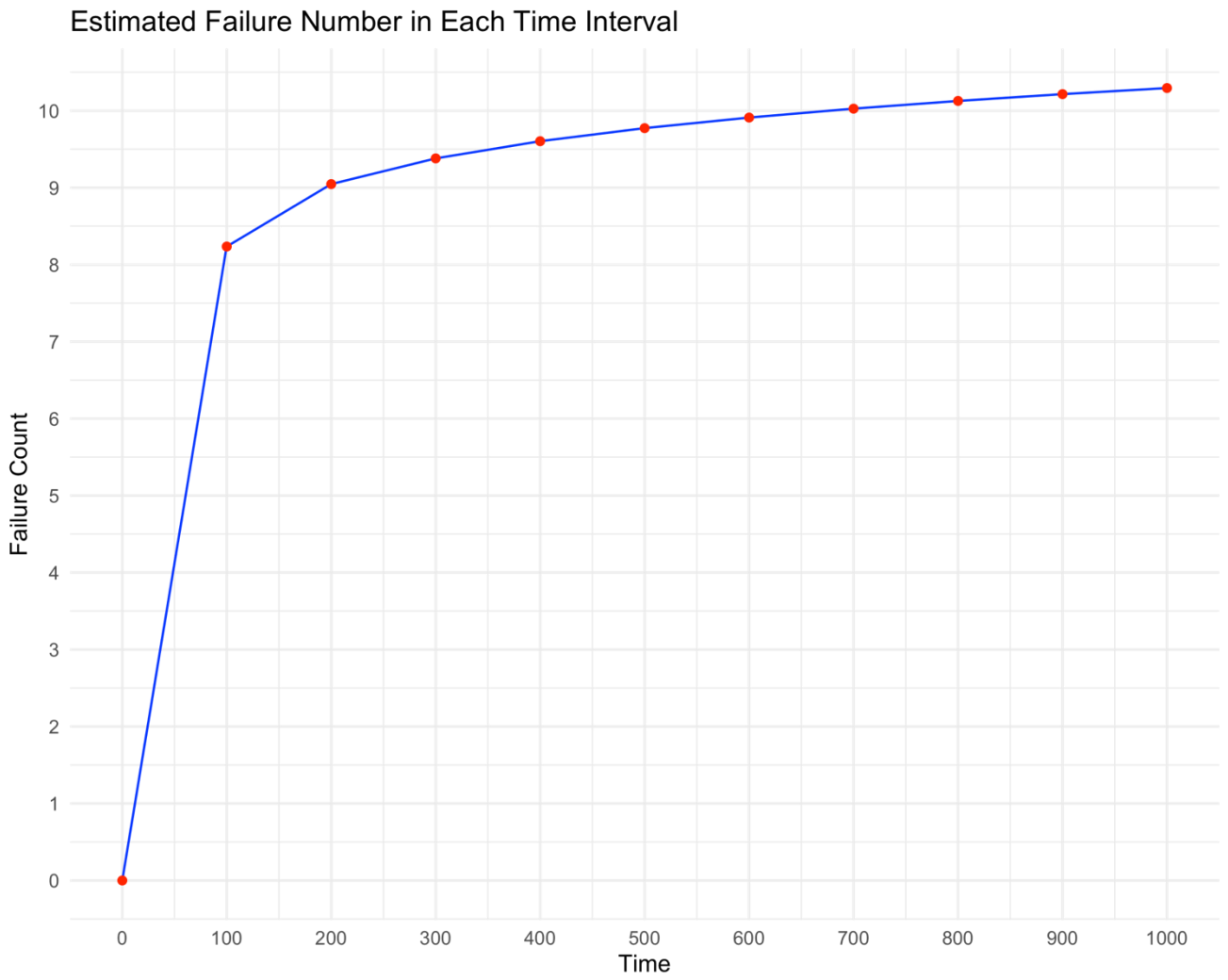


Figure 3: The histogram of failure numbers occurring within each time interval. The range of each time interval is set to 100 since the mean value of inter-failure times is about 85.

5. Parameter Estimation and Evaluation (1)

- We use $\lambda(t) = abt^{b-1}$ as the parameter of the non-homogeneous Poisson Process.
- The estimated $\lambda(t) = 0.0639t^{0.0694}$.



5. Parameter Estimation and Evaluation (2)

- As an evaluation, we compare our NHPP model with a homogenous one. We record the probability of on the real failure number within each time interval using both models. We aim for a higher probability as possible via our NHPP model.
- If our model is a good model to estimate failure times within each time interval, it should outperform than the homogenous one with respect to the above probability.
- However, we observe a similar probability distribution between our NHPP model and the homogenous one.

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[1] "Probability from our NHPP model: "
 [1] 0.00000000 0.12728831 0.13174022 0.05896931 0.12410252 0.06787580 0.11267126
 [8] 0.12478007 0.12345236 0.05778827 0.01583213
[1] "Probability from the homogenous Poisson Process model: "
 [1] 0.01795883 0.13120111 0.13120111 0.04435417 0.11450279 0.04435417 0.09084519
 [8] 0.13120111 0.13120111 0.09947923 0.03918290
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Table 2: Probability distributions from both models (our NHPP model and the homogenous Poisson Process model with $\lambda = 8.727273$, the mean value of failure number within each time interval). Means and standard deviations for two models: [Our NHPP Model] - $0.08586366 \pm 0.04800104$, [The Homogenous Poisson Process Model] - $0.08868015 \pm 0.04404692$.

Thank you!