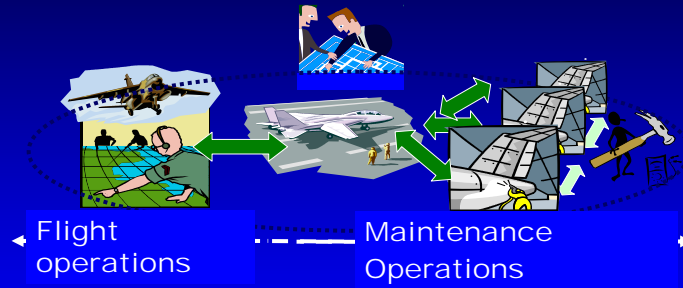




Optimization of Maintenance Intervals for Aircraft Systems and Components



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Outline

- **Introduction**
- **Modeling of component failures**
- **Collection of failure data**
- **Conclusions**



Aircraft operators maintenance program

An air carrier's maintenance program is a document which answers three questions:

- 1) **What** (Component , system, etc)
- 2) **When** (time limit)
- 3) **How** (tasks)



Importance of the time interval optimization

- The most important factor in the maintenance program is the time interval for replacements, inspections or overhauls.
- If the time intervals are not well determined, it may results in many **unscheduled maintenance** actions and create safety risks.
- Thus, it is necessary to optimize the maintenance time intervals to minimize the safety risks, to reduce unscheduled maintenance actions and operation costs.

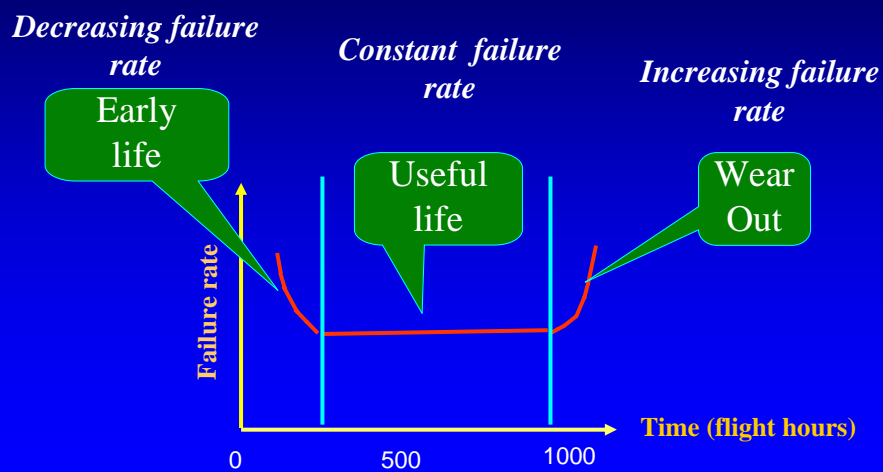


How maintenance time intervals are determined?

- Operators usually use manufacturers' recommended time intervals in developing their own maintenance programs at the beginning. In other words, maintenance and inspection policies are initially dictated by manufacturers.
- Environmental conditions and other local conditions have great effect on the failures of the aircraft system and/or components. Thus, it is quite likely that the maintenance intervals need to be tailored in accordance with the conditions peculiar to the airline.
- Adjusting maintenance/inspection/overhaul intervals is based on information about the component/system failure rate function.



Failure characteristics of aircraft components





Modeling of component failures

- There are two general approaches to model the failure data.
- **Parametric approach**
It is also known as theoretical distribution approach.
It includes comparison of failure data with predetermined theoretical distributions to estimate the failure rate function of the component.
- **Empirical (nonparametric) approach**
In this approach the failure rate function is obtained directly from the failure data.



Parametric approach for modeling failures

1. Exponential Model
2. Weibull Model
3. Normal Model
4. Log-Normal Model
5. Gamma Model



Weibull Model

- One of the most widely used failure distributions
 - Two-parameter Weibull Model
 - Three-Parameter Weibull Model
 - Mixture Model
 - Phased Bi-Weibull Model

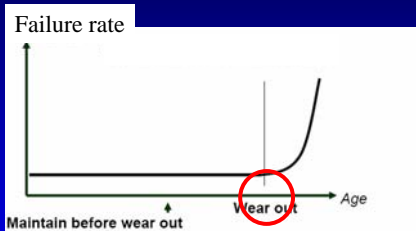
Two-parameter Weibull model



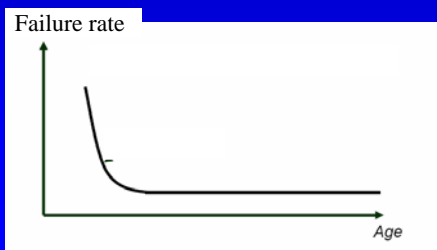
$$\lambda(\text{Failure rate}) = \frac{\beta}{\eta} \left(\frac{t}{\eta} \right)^{\beta-1}$$



What can we get by analyzing failure data ?



- ✓ Cause of failure
- ✓ Time for replacement

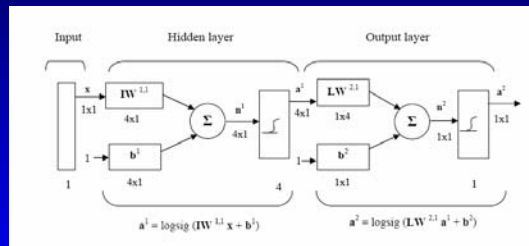


- ✓ Cause of failure
- ✓ MTBF for scheduling inspection times



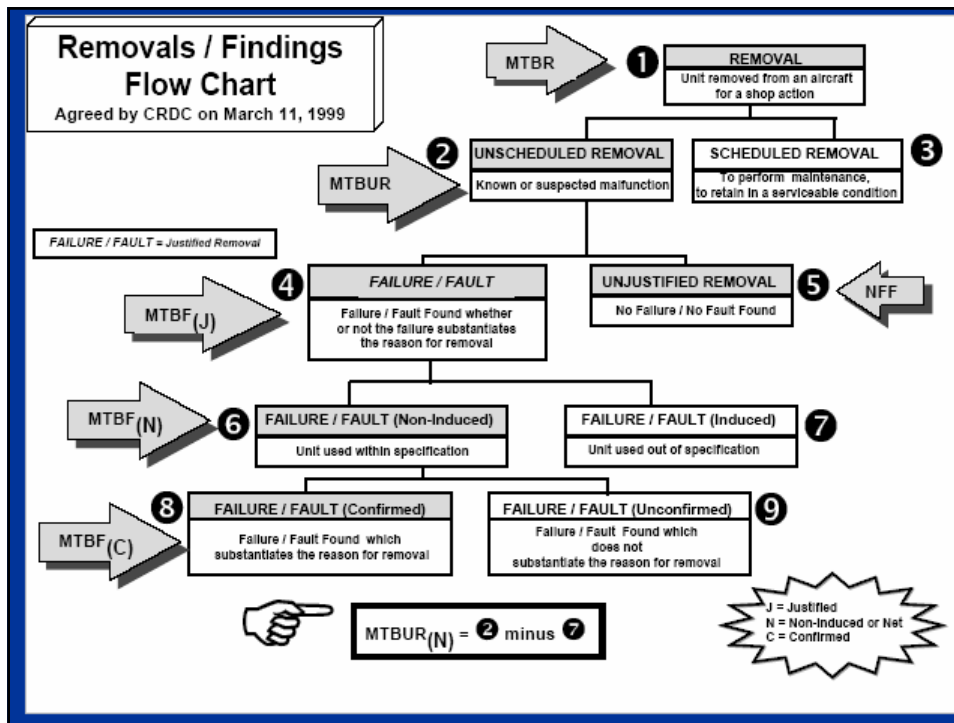
Non-parametric approach for modeling failures


- This approach derives an empirical failure distribution directly from the data.
- Artificial neural network (ANN) method is a very good representative of data-based empirical models
- Basically ANNs consist of interconnected layers of processing units, called neurons or nodes.
- It resembles the brain in the way in which knowledge is acquired from its environment through a learning process.



Collection and Arrangement of Failure Data

Failure No	Time to failure (aircraft flight hour, t)
1	10
2	15
3	25
4	38
5	53
6	65
7	75
8	88





Conclusions

- Optimizing the maintenance time intervals in accordance with local environmental and operational conditions is necessary to minimize the safety risks, reduce unscheduled maintenance actions and reduce operation costs
- There are methods for optimizing maintenance intervals. However, a well organized failure data collection system is important.
- Sharing the failure (reliability) data among the operators in the region will improve the maintenance efficiency.



Conclusions

- **Followings are some potential advantages of Sharing Reliability in the region to the operators are**
 - Determining if specific problems are unique
 - Assessing if an MTBUR or MTBF is normal
 - Comparing no fault found (NFF) rate among other operators
 - Be ready for failures that might occur in the future
 - Comparing the maintenance performance



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Questions

