

# **RELIABILITY AND AVAILABILITY ANALYSIS OF REPAIRABLE SYSTEMS USING DISCRETE EVENT SIMULATION**

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By  
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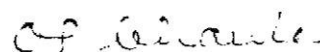
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## CERTIFICATE

This is to certify that the thesis entitled "RELIABILITY AND AVAILABILITY ANALYSIS OF REPAIRABLE SYSTEMS USING DISCRETE EVENT SIMULATION" has been prepared under our supervision in conformity with the rules and regulations of the Indian Institute of Technology Delhi. We further certify that the thesis has attained a standard required for a Ph.D. degree of the Institute. The results contained in this thesis have not been submitted in part or full to any other University or Institute for the award of any degree or diploma.



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DECLARATION

I hereby declare that the entire work embodied in this thesis has been carried out by me and no part of it has been submitted for any degree or diploma of any institution previously.

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## ABSTRACT

Occurrence of failures in repairable system may be represented as a stochastic point process. The pattern of failures necessarily develop in a specific sequence in calendar time. This marks a major difference between the failure patterns of a large number of synchronous samples and of a single system failing a large number of times in sequence. Reliability analysis of a repairable system therefore calls for an analytical approach quite different from that in the case of non-repairable parts. The rate of occurrence of failures considered over a relatively restricted time interval has been used in the past for such analysis. It has been shown that this may not give very realistic results. A technique based upon time between successive failures has been suggested.

Another factor that deserves attention is that most repairable systems have a number of constituent subsystems belonging to different functional categories, and possessing different patterns of failure. Analysis of a repairable system should therefore include consideration of the failure patterns of a number of separate entities arranged in a certain

configuration and forming a working whole. This requirement makes the reliability and availability analysis of repairable system mostly beyond the scope of the conventional analytical techniques that yield closed form solutions.

A discrete event simulation model has been proposed in this thesis for analysing reliability of a repairable system. It used time between successive failures as input data. The model was employed to compute aircraft reliability on the basis of hard data collected from the operational records of a fleet of trainer aircraft. The computed value of aircraft reliability appears very realistic.

The proposed simulation model may also be used to evaluate the effect of ageing of a repairable system over its temporal life. For instance, applying the model to the example of aircraft referred to above, reliability was found to improve during the initial 300 hours of operation, after which a gradual deterioration took place. This result is very close to actual experience with aircraft system.

The thesis describes another simulation model. It is concerned with analysis of availability of a service facility equipped with a number of copies of a repairable system. The model has been applied to an aircraft training facility. Data on probability distributions of time to failure, time to repair, down time due to non availability of spares and also the probability of a failed system being sidelined due to non availability of spares were used as input. In the proposed

model, a calendar time schedule was incorporated against which the down times were measured. A number of output parameters were computed for evaluation of equipment availability, mission availability, down time per sortie, total maintenance and repair times, average repair time, average waiting time for spares etc. Availabilities, repair rates, down time due to repairs and due to non availability of spares corresponding to individual subsystems were also computed.

The proposed reliability and availability models were used to study the system behaviour due to changes at subsystem or component level as a result of design modifications or changes in maintenance or operating procedures. The models were found to be versatile in carrying out a wide range of computer experiments. They also make it possible for the users to verify whether the reliability and availability predicted by the supplier is actually achieved or not. If not, the information as to which subsystem or component is causing the problem and which of the proposed modifications is likely to be most effective for achieving the desired results can also be obtained. The factual information available from the model output on the deterioration of the system reliability with increasing age could be an important input for deciding the overall life or the requirement of replacing the physical assets.

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