MODELING AND ANALYSIS OF RELIABILITY, AVAILABILITY AND MAINTAINABILITY OF REPAIRABLE SYSTEMS USING CERTAIN ARTIFICIAL INTELLIGENCE TECHNIQUES

by

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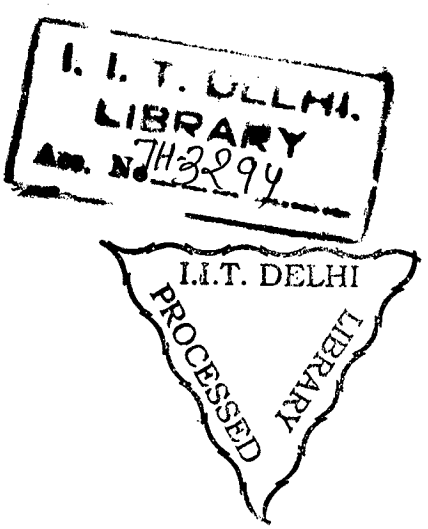
1. Repairable systems – Maintenance
2. Mechanical repair



INSIGHT

"Insight, is the intuitive light flashing forth and exposing the truth of *impermanency*, the *suffering* and the *impersonal* and *unsubstantial* nature of all corporeal and mental phenomena of existence. It is **Insight-wisdom** that is the decisive liberating factor in Buddhism, though it has to be developed along with the two other trainings in morality and concentration. The culmination of Insight practice leads directly to the stages of Holiness. Insight is not the result of a mere intellectual understanding, but is won through direct meditative observation of one's own bodily and mental processes."

- Ven. Nyanatiloka

"A large number of poems by the nuns emphasize the danger of *worldly desire*. The bhikkhuni named **Sumedha** shaved off her hair herself in order to force her parents to cancel her proposed marriage and permit her to enter the Sangha. But before she left home, **Sumedha** convinced her whole family and its retinue of the validity of the Buddha's message. To her fiance, King Anikaratta, she explained the futility of sense desires and the insatiability of the senses:

Even if the rain-god rained all seven kinds
Of gems, until earth and heaven were full,
Still senses would crave and men die unsatiated.

No matter how large a quantity of worldly goods we may have, if the mind has not gained insight, craving will recur. If ignorance has not been uprooted, *desire* will seek more and different objects, always hoping for lasting satisfaction. Durable happiness is impossible in this mundane sphere because all sense objects change and decay every moment, as does the mind itself. This perpetual state of underlying dissatisfaction — craving looking for gratification — is one of the many forms of present suffering. In addition, *desire* itself generates the kammic energy, which propels life towards rebirth in order for it to continue its efforts at finding fulfillment. If *desire* is present in the mind at the moment of death, rebirth has to ensue.

After speaking the above verse, **Sumedha** gave a lengthy discourse to the whole assembly in her palace on the great value of a human birth in the infinity of *samsara.* Life in this world is precious because it provides a very rare opportunity for learning the way to put an end to rebirth and suffering, for putting into practice the teachings of the Buddha. **Sumedha** also spoke on the danger inherent in sensual joy and *sense desire* and she uttered verses about the Noble Eightfold Path as well. She enthusiastically exhorted her audience:

When the undying (Nibbana) exists, what do you want with sensual pleasures which are burning fevers? For all delights in sensual pleasures are on fire, aglow, seething."

- Susan Elbaum Jootla

Dedicated to all the sentient beings working

incessently towards the path of liberation from this

world of mind and matter,

to my Parents,

and to my little grandson Pranit

CERTIFICATE

This to certify that the thesis entitled "*Modeling and Analysis of Reliability, Availability and Maintainability of Repairable Systems using Certain Artificial Intelligence Techniques*" being submitted by Mr. Paramjeet Singh Rajpal to the Indian Institute of Technology, Delhi for the award of the Degree of Doctor of Philosophy is a record of bonafide research work carried out by him. Mr. Paramjeet Singh Rajpal has worked under our supervision and guidance and has fulfilled the requirements for the submission of the thesis, which to our knowledge has reached the requisite standard for the Doctor of Philosophy degree.

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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ABSTRACT

The present thesis deals with modeling and analysis of reliability, availability and maintainability of repairable systems using certain artificial intelligence techniques. The first chapter of the thesis gives an introduction to the present investigation and an overview of the different chapters of the thesis. Literature on discrete-event simulation, genetic algorithms and artificial neural networks is reviewed in chapter II. The survey indicates the scarcity of published studies on the use of artificial intelligence for analysis of reliability, availability and maintainability (RAM) of complex repairable systems. A brief review of the theory underlying the proposed models is also included for ready reference in chapter III. Three different models based upon discrete-event simulation, artificial neural networks and multi-objective genetic algorithms have been proposed. These models are described at length in chapters IV to VI.

The proposed discrete-event simulation model applied to a complex repairable system, namely the transport helicopter, is based upon the use of the well-known Weibull distribution for modeling the failure behavior of different subsystems comprising a given repairable system. Another model based upon the concept of an artificial neural network (ANN) helps predict a composite measure of reliability, availability and maintainability (CMRAM) of the complex repairable system. Also a multi-objective genetic algorithm has been developed for reliability-based optimization of the complex repairable system. Cost and the above-mentioned CMRAM are used as the objective functions.

The proposed models are capable of using actual or field data on operation and maintenance of the given system. They can be used to study the effect of different parameters associated with system operation, system environment, availability of spare-

parts and consumables, severity of operations, system maintenance, operating and also maintenance personnel. The models may be used to predict RAM parameters of the given system, identify corrective actions and obtain guidance for system improvement.

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