Available at
www.ElsevierMathematics.com
POWERED BY SCIENCE @ DIRECT®

Journal of Statistical Planning and Inference 131 (2005) 89–100

journal of statistical planning and inference

www.elsevier.com/locate/jspi

Availability of a periodically inspected system with random repair or replacement times

Lirong Cui[a], M. Xie[b,*]

[a]School of Management and Economics Beijing Institute of Technology, Beijing, China
[b]Department of Industrial and Systems Engineering, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260, Singapore

Received 14 February 2001; accepted 19 December 2003

Abstract

The availability of systems undergoing periodic inspections is studied in this paper. A perfect repair or replacement of a failed system is carried out requiring either a constant or a random length of time. In Model A, the system is assumed to be as good as new on completion of inspection or repair. For Model B, no maintenance or corrective actions are taken at the time of inspection if the system is still working, and the condition of the system is assumed to be the same as that before the inspection. Unlike that studied in a related paper by Sarkar and Sarkar (J. Statist. Plann. Inference 91 (2000) 77.), our model assumes that the periodic inspections take place at fixed time points after repair or replacement in case of failure. Some general results on the instantaneous availability and the steady-state availability for the two models are presented under the assumption of random repair or replacement time.

MSC: primary 90B25; secondary 60K10

Keywords: Instantaneous availability; Steady-state availability; Maintained system; Periodic inspection

1. Introduction

Recently, Sarkar and Sarkar (2000) studied the problem of determining the availability of systems which are maintained through periodic inspections and a perfect repair

* Corresponding author. Tel.: +65-6874-2203; fax: +65-6777-1434.
E-mail addresses: lirongcui@bit.edu.cn (L. Cui), mxie@nus.edu.sg (M. Xie).

0378-3758/$ - see front matter © 2004 Published by Elsevier B.V.
doi:10.1016/j.jspi.2003.12.008

or replacement policy. There has been a lot of research on the availability of maintained systems that are continuously monitored, e.g., Barlow and Proschan (1981) and Høyland and Rausand (1994), but little is known about the exact system availability, $A(t)$, when the inspections take place periodically.

Wortman et al. (1994) studied a maintenance strategy for systems subject to deterioration governed by random shocks. Similar studies, involving steady-state availability, limiting average availability or cost function, have been reported in Wortman and Klutke (1994), Yeh (1995), Klutke et al. (1996), Dieulle (1999), Vaurio (1999), Ito and Nakagawa (2000), Chelbi and Ait-Kadi (2000), Yang and Klutke (2000, 2001) and Yadavalli et al. (2002), among others. In all these papers, the steady-state availability (limiting availability) or the limiting average availability has been studied. However, the instantaneous availability is as important, if not more, from a practical point of view.

In general, continuous monitoring is more expensive than periodic inspection. Also, if an inspection leads to the stoppage of the system, continuous monitoring cannot be performed, and periodical inspections have to be employed. Examples for periodical inspections are fire detector systems, safety valves, among others, such as those mentioned in Høyland and Rausand (1994, p. 171) and Sarkar and Sarkar (2000). Hence it is important to consider models for periodic-inspected systems.

A system is either in the up-state or in the down-state at any time t, denoted by $X(t)=1$ and 0, respectively. At time $t=0$, the system is assumed to be up and it is tested or inspected at time τ. If the system is working at time τ, the next inspection is at time 2τ. Otherwise, the system is repaired or replaced requiring a random time w and the repaired or replaced system is put into operation immediately. The next inspection occurs at time $2\tau + w$, and so forth. Thus the system fails between two inspections, the system failure remains undetected until the next inspection, and then a perfect repair or replacement is carried out.

In this paper, two models which are common in practice are discussed. For Model A, the assumptions are as follows:

(1) The inspection interval length is τ, and after the inspection, necessary actions are taken to restore the system so that it is as good as a new system.
(2) The failure of the system can be detected at the time of inspection.
(3) After the detection of a failure, a perfect repair or replacement is carried out and it takes a random time of length Y (which is non-negative) with distribution function $G(y)$ (and pdf $g(y)$); As a special case, if the perfect repair or replacement time is a constant, then it is denoted by v.
(4) The system lifetime distribution is assumed to be $F(x)$ (with pdf $f(x)$, and $F(x)=0$ if $x<0$).

For Model B, Assumptions (2)–(4) are the same while the first one is modified as in the following:

(1*) Periodic inspections at intervals of length τ are carried out, and if the system is still working, nothing is done and the condition of the system is as before the inspection.