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Mean time to system failure and availability analysis of yarn industry of Malwa region using RPGT technique

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Abstract

This paper discusses the use of RPGT for reliability analysis of three unit systems, a case study of the yarn industry. Because units A, B, and D all comprise equivalent subcomponents, the organization can exertion with less aptitude when individual additional unit fails. On the other hand, when two units are in a concentrated condition, the structure is not profitable to operate, so it is deemed to subsist in a unsuccessful state. The rates of failure and repair are different for all three units. One server is accessible around-the-clock to promptly restore the malfunctioning units. The constant disappointment/repair rates of units are used to model the issue. To examine the effects of dissatisfaction and overhaul rates on organizational standards, specific situations must be observed. After strained tables, there are talks and conclusions.

Keywords: RPGT, Failure Rate, Repair Rate, Reliability

1. Introduction

The Abohor and Fazilka Districts in Punjab, Malwa area, are globally renowned for their cotton production because of their fertile soil and water availability due to weather and geography. The majority of the high-quality cotton produced in the area is shipped to other regions of India and outside due to its abundance, but a significant amount is still left over and used sparingly as a raw material for the yarn industry. To extract cotton seeds from raw cotton, row cotton is processed in cotton mills. Bales of cotton are then shipped to different regions for marking. The Malwa region has a number of yarn industries because it is profitable for a small number of cotton farmers, self-employment, and job satisfaction for the local population. This is because transporting bales of cotton to other locations is more expensive, time-consuming, and involves labor costs. This paper discusses machine learning-based dependability analysis of three unit systems (a case study of the textile industry). Because units A, B, and D all include equivalent subcomponents, the organization can effort with less facility when lone additional unit fails. Finding elements C0 involves considering a number of assumptions, probabilities, and an aggregated transition representation of the system. System parameter expressions are derived. The bread plant and the edible petroleum treatment facility plant were the main subjects of Kumar *et al.* (2018) ^[5] investigation. The reliability, accessibility, and maintainability study, as mentioned by Komal (2009) ^[1], provides a specific plan to remove assembly change, if any is necessary to achieve superior of the complicated mechanical systems. Benefit scrutiny of agricultural reaper plants in a continuous state via RPGT be discuss by Kumari (2021) ^[7]. In order to address steadfast quality stochastic enhancement problems in series architecture with span bit, Bhunia (2010) ^[8] suggested GA. Stochastic steady quality reformation in beam of probability imperative in the succession scaffold was addressed in the review. The urea manure sector was analyzed by Kumar *et al.* (2017) ^[2] using system parameters, and the main objective of the article by Kumar (2019) ^[1] is to examine the washing aspect in paper businesses that spend RPG. T. The steam assembly of a coal-fired updraft influence climber is optimized via Malik (2022) ^[3]. Following the drawing of tables and graphs, conclusions are reached. Jieong (2009) ^[9] used a half-and-half approach identified as GA to address multi-objective reformation problems.

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Anchal (2021) [6] looked at SRGM classic using the variance condition that has been planned, which has two category of shortages: easy and difficult, depending on the time period in which they occur due to disengagement and dismissal after their thankfulness has been expressed. Tables and graph stay drawn which is follow by conclusions.

2. Assumptions and Notations

- Single repairman whose availability is 24x7 and another server is called on need basis.
- There are consistent and distinct distributions of let-down and repair times.
- The structure is as good as new after the repair, which is flawless.
- Switching is perfect.

λ_i ($1 \leq i \leq 6$): Failure Rates

w_i ($1 \leq i \leq 6$): Repair Rates

3. Transition Diagram Description

Considering the various possibilities and succeeding the assumptions and symbolizations the transition diagram of the structure is drawn as under in Figure 1.

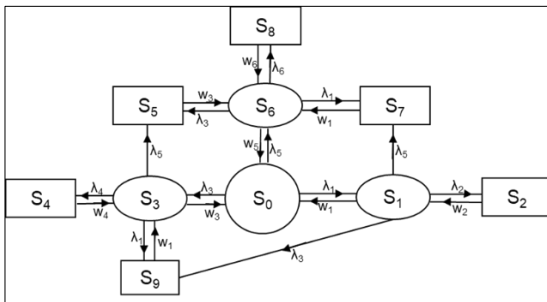


Fig 1: Transition Diagram

$S_0 = ABD$, $S_1 = \bar{A}BD$, $S_2 = aBD$, $S_3 = A\bar{B}D$, $S_4 = AbD$, $S_5 = A\bar{B}\bar{D}$, $S_6 = AB\bar{D}$, $S_7 = \bar{A}B\bar{D}$, $S_8 = ABd$, $S_9 = \bar{A}B\bar{D}$

3. Probability Density function ($q_{i,j}(t)$)

$$\begin{aligned}
 q_{0,1} &= \lambda_1 e^{-(\lambda_1 + \lambda_5 + \lambda_3)t} \\
 q_{0,3} &= \lambda_3 e^{-(\lambda_1 + \lambda_5 + \lambda_3)t} \\
 q_{0,6} &= \lambda_5 e^{-(\lambda_1 + \lambda_5 + \lambda_3)t} \\
 q_{1,0} &= w_1 e^{-(\lambda_5 + \lambda_2 + \lambda_3 + w_1)t} \\
 q_{1,2} &= \lambda_2 e^{-(\lambda_5 + \lambda_2 + \lambda_3 + w_1)t} \\
 q_{1,7} &= \lambda_5 e^{-(\lambda_5 + \lambda_2 + w_1 + \lambda_3)t} \\
 q_{1,9} &= \lambda_3 e^{-(\lambda_5 + \lambda_2 + \lambda_3 + w_1)t} \\
 q_{2,1} &= w_2 e^{-w_2 t} \\
 q_{3,0} &= w_3 e^{-(w_3 + \lambda_i)t} \\
 q_{3,4} &= \lambda_4 e^{-(w_3 + \lambda_i)t} \\
 q_{3,5} &= \lambda_5 e^{-(w_3 + \lambda_i)t} \\
 q_{3,9} &= \lambda_1 e^{-(w_3 + \lambda_i)t} \\
 i &= 1, 4, 5 \\
 q_{4,3} &= w_4 e^{-w_4 t} \\
 q_{5,6} &= w_5 e^{-w_5 t} \\
 q_{6,0} &= w_5 e^{-(\lambda_i + w_5)t} \\
 q_{6,5} &= \lambda_3 e^{-(\lambda_i + w_5)t} \\
 q_{6,7} &= \lambda_1 e^{-(\lambda_i + w_5)t} \\
 q_{6,8} &= \lambda_6 e^{-(\lambda_i + w_5)t} \\
 i &= 1, 3, 6 \\
 q_{7,6} &= w_1 e^{-w_1 t} \\
 q_{8,6} &= w_6 e^{-w_6 t}
 \end{aligned}$$

$$q_{9,3} = w_1 e^{-w_1 t}$$

Cumulative PDF within affecting commencing state 'i' to state 'j' in attractive LT of on top of function in favor of never-ending time interval is specified as in

$$\begin{aligned}
 p_{0,1} &= \lambda_1 / (\lambda_3 + \lambda_5 + \lambda_1) \\
 p_{0,3} &= \lambda_3 / (\lambda_1 + \lambda_5 + \lambda_3) \\
 p_{0,6} &= \lambda_5 / (\lambda_1 + \lambda_5 + \lambda_3) \\
 p_{1,0} &= w_1 / (\lambda_i + w_1) \\
 p_{1,2} &= \lambda_2 / (\lambda_i + w_1) \\
 p_{1,7} &= \lambda_5 / (\lambda_i + \lambda_3) \\
 p_{1,9} &= \lambda_3 / (\lambda_i + w_1) \\
 i &= 2, 3, 5 \\
 p_{2,1} &= 1 \\
 p_{3,0} &= w_3 / (w_3 + \lambda_i) \\
 p_{3,4} &= \lambda_4 / (w_3 + \lambda_i) \\
 p_{3,5} &= \lambda_5 / (w_3 + \lambda_i) \\
 p_{3,9} &= \lambda_1 / (w_3 + \lambda_i) \\
 i &= 1, 4, 5 \\
 p_{4,3} &= 1 \\
 p_{5,6} &= 1 \\
 p_{6,0} &= w_5 / (\lambda_i + w_5) \\
 p_{6,5} &= \lambda_3 / (\lambda_i + w_5) \\
 p_{6,7} &= \lambda_1 / (\lambda_i + w_5) \\
 p_{6,8} &= \lambda_6 / (\lambda_i + w_5) \\
 i &= 1, 3, 6 \\
 p_{7,6} &= 1 \\
 p_{8,6} &= 1 \\
 p_{9,3} &= 1
 \end{aligned}$$

5. Mean Sojourn Transition rate ($R_i(t)$)

$$\begin{aligned}
 R_0^{(t)} &= e^{-(\lambda_3 + \lambda_5 + \lambda_1)t} \\
 R_1^{(t)} &= e^{-(\lambda_3 + \lambda_2 + \lambda_5 + w_1)t} \\
 R_2^{(t)} &= e^{-w_2 t} \\
 R_3^{(t)} &= e^{-(w_3 + \lambda_4 + \lambda_1 + \lambda_4)t} \\
 R_4^{(t)} &= e^{-w_4 t} \\
 R_5^{(t)} &= e^{-w_3 t} \\
 R_6^{(t)} &= e^{-(\lambda_2 + \lambda_5 + \lambda_1 + w_5)t} \\
 R_7^{(t)} &= e^{-w_1 t} \\
 R_8^{(t)} &= e^{-w_6 t} \\
 R_9^{(t)} &= e^{-w_1 t}
 \end{aligned}$$

6. Mean Sojourn Time ($\mu_i = R_i^*(0)$)

$$\begin{aligned}
 \mu_0 &= 1 / (\lambda_3 + \lambda_5 + \lambda_1) \\
 \mu_1 &= 1 / (\lambda_2 + \lambda_5 + \lambda_3 + w_1) \\
 \mu_2 &= 1 / w_2 \\
 \mu_3 &= 1 / (w_3 + \lambda_4 + \lambda_5 + \lambda_2) \\
 \mu_4 &= 1 / w_4 \\
 \mu_5 &= 1 / w_3 \\
 \mu_6 &= 1 / (\lambda_6 + \lambda_3 + \lambda_1 + w_5) \\
 \mu_7 &= 1 / w_1 \\
 \mu_8 &= 1 / w_6 \\
 \mu_9 &= 1 / w_1
 \end{aligned}$$

7. Transition Probability

Now path probability of the system from the base position of system are given as

$$\begin{aligned}
 V_{0,0} &= 1 \text{ (Verified)} \\
 V_{0,1} &= (\lambda_1 / \lambda_5 + \lambda_2 + \lambda_3 + w_1) / (\lambda_1 + \lambda_5 + \lambda_3)(\lambda_5 + \lambda_3 + w_1) \\
 V_{0,2} &= \lambda_1 \lambda_2 / (\lambda_1 + \lambda_5 + \lambda_3)(\lambda_5 + \lambda_3 + w_1) \\
 V_{0,3} &= \dots \dots \dots \text{Continuous}
 \end{aligned}$$

8. Methodology and Discussions

MTSF (T₀): The states to which the structure can transportation from preliminary state '0', previously joining losing state stand: 'i' = 0,1,3,6 attractive early state 'ξ' = '0'.

$$MTSF (T_0) = \left[\sum_{i, sr} \left\{ \frac{\left\{ \text{pr} \left(\xi \xrightarrow{sr(sff)} i \right) \right\} \mu_i}{\Pi_{m_1 \neq \xi} \{1 - V_{m_1 m_1}\}} \right\} \right] \div \left[1 - \sum_{sr} \left\{ \frac{\left\{ \text{pr} \left(\xi \xrightarrow{sr(sff)} \xi \right) \right\}}{\Pi_{m_2 \neq \xi} \{1 - V_{m_2 m_2}\}} \right\} \right] \quad (1)$$

$$\begin{aligned} T_0 = & (V_{0,0} \mu_0 + \{ (\lambda_1 / \lambda_5 + \lambda_2 + \lambda_3 + w_1) / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + w_1) \mu_1 \} + \{ \lambda_3 (\lambda_1 + \lambda_4 + \lambda_5 + w_3)^2 \\ & / (\lambda_1 + \lambda_5 + w_3) (\lambda_1 + \lambda_3 + \lambda_5) \{ (\lambda_3 \lambda_5 + w_3 + \lambda_5^2 + \lambda_5 w_3 + w_1 w_3 + \lambda_1 + \lambda_1 \lambda_4 + \lambda_1 \lambda_5) \\ & / (w_3 + \lambda_4 + \lambda_5) (\lambda_3 + \lambda_5 + w_7) (\lambda_5 + w_3) \} \mu_3 \} + \{ \lambda_5 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) \\ & (\lambda_6 + \lambda_3 + w_5) + \lambda_3 \lambda_5 \} (\lambda_3 + \lambda_6 + \lambda_1 + w_5) / (\lambda_5 + \lambda_3 + w_1) (\lambda_1 + \lambda_5 + \lambda_3) \\ & (w_3 + \lambda_5 + \lambda_4) (\lambda_6 \lambda_1 + \lambda_6 w_5 + w_3 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1 \lambda_5 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) \\ & (\lambda_6 \lambda_3 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1 \lambda_3 \lambda_5 (w_3 + \lambda_1 + \lambda_5 + \lambda_4) (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) \\ & (w_3 + \lambda_5 + \lambda_4) (w_3 + \lambda_1 + \lambda_5) (\lambda_3 w_5 + \lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2 + w_3 \lambda_3) \mu_6 \} \\ & / (1 - p_{0,1} p_{1,0} - p_{0,6} p_{0,6} - p_{0,3} p_{3,0}) \end{aligned}$$

Availability of System: The re-forming states at which structure is presented be 'j' = 0,1,3,6 and re-forming states be situated 'i' = 0 to 9 attractive 'ξ' = '0' the accessibility in favor of which structure is obtainable is specified by

$$A_0 = \left[\sum_{j, sr} \left\{ \frac{\left\{ \text{pr}(\xi \xrightarrow{sr} j) \right\} f_j \mu_j}{\Pi_{m_1 \neq \xi} \{1 - V_{m_1 m_1}\}} \right\} \right] \div \left[\sum_{i, sr} \left\{ \frac{\left\{ \text{pr}(\xi \xrightarrow{sr} i) \right\} \mu_i^1}{\Pi_{m_2 \neq \xi} \{1 - V_{m_2 m_2}\}} \right\} \right] \quad (2)$$

$$A_0 = \left[\sum_j V_{\xi, j}, f_j, \mu_j \right] \div \left[\sum_i V_{\xi, i}, f_j, \mu_i^1 \right]$$

$$\begin{aligned} A_0 = & V_{0,0} \mu_0 + \{ (\lambda_1 / \lambda_5 + \lambda_2 + \lambda_3 + w_1) / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) \mu_1 \} + \{ \lambda_3 (\lambda_1 + \lambda_5 + w_3)^2 \\ & (w_3 \lambda_4 + \lambda_5) (\lambda_3 + \lambda_5 + w_7) (\lambda_5 + w_3) \} \mu_3 \} + V_{0,5} \mu_5 + \{ \lambda_5 (\lambda_1 + \lambda_5 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_1 + w_5) \\ & (\lambda_6 + \lambda_3 + w_5) + \lambda_3 \lambda_5 (\lambda_5 + \lambda_2 + \lambda_3 + w_1) (\lambda_3 + \lambda_6 + \lambda_1 + w_5) / (\lambda_5 + \lambda_3 + w_1) (\lambda_1 + \lambda_5 + \lambda_3) \\ & (w_3 + \lambda_5 + \lambda_4) (\lambda_6 \lambda_1 + \lambda_6 w_5 + w_3 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1 \lambda_5 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) \\ & (\lambda_6 \lambda_3 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1 \lambda_3 \lambda_5 (w_3 + \lambda_1 + \lambda_5 + \lambda_4) (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) \\ & (w_3 + \lambda_1 + \lambda_5) (\lambda_3 w_5 + \lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2 + w_3 \lambda_3) \mu_6 \} / k \end{aligned}$$

Where,

$$\begin{aligned} k = & (V_{0,0} \mu_0 + \{ (\lambda_1 / \lambda_5 + \lambda_2 + \lambda_3 + w_1) / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) \mu_1 \} \\ & + \{ \lambda_1 \lambda_2 / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) \mu_2 + V_{0,5} \mu_5 + \{ \lambda_5 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 \\ & / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_6 + \lambda_1 + w_5) (\lambda_6 + \lambda_3 + w_5) (\lambda_3 + \lambda_1 + w_5) + \lambda_3 \lambda_5 (\lambda_5 + w_1) (\lambda_3 + \lambda_6 + \lambda_1 + w_5) \\ & / (\lambda_5 + \lambda_3 + w_1) (\lambda_1 + \lambda_5 + \lambda_3) (w_3 + \lambda_5 + \lambda_4) (\lambda_6 \lambda_1 + \lambda_6 w_5 + w_3 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1 \lambda_5 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 \\ & / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) (\lambda_6 \lambda_3 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1 \lambda_3 \lambda_5 (w_3 + \lambda_1 + \lambda_5 + \lambda_4) \\ & (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) (w_3 + \lambda_5 + \lambda_4) (w_3 + \lambda_1 + \lambda_5) \\ & (\lambda_3 w_5 + \lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2 + w_3 \lambda_3) \mu_6 \} + \{ \lambda_5 \lambda_1 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) \\ & \Lambda_3 + \lambda_6 + w_5 \} (\lambda_3 + \lambda_1 + w_5) + \lambda_1 \lambda_5 (\lambda_6 + \lambda_1 + w_3) (\lambda_3 + \lambda_1 + w_5) / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) \\ & (\lambda_6 \lambda_3 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_3 \lambda_5 \lambda_1 (w_3 + \lambda_1 + \lambda_5 + \lambda_4) / (w_3 + \lambda_6 + \lambda_1 + \lambda_5) / (\lambda_1 + \lambda_5 + \lambda_3) \\ & (w_3 + \lambda_1 + \lambda_5) (w_3 + \lambda_5 + \lambda_4) (\lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1^2 \lambda_3 \lambda_5 (w_3 + \lambda_6 + \lambda_1 + \lambda_5) / (\lambda_1 + \lambda_5 + \lambda_3) \\ & (\lambda_5 + \lambda_2 + \lambda_3 + w_1) (\lambda_5 + \lambda_3 + w_1) (w_3 + \lambda_5) (\lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) \mu_7 \} \\ & + \{ \lambda_5 \lambda_6 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_6 + \lambda_1 + w_5) (\lambda_3 + \lambda_6 + w_5) (\lambda_3 + \lambda_1 + w_5) \\ & (\lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_1 + \lambda_3 w_5 + w_5^2) + \lambda_1 \lambda_5 \lambda_6 (\lambda_3 + \lambda_6 + \lambda_1 + w_5) / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) \\ & (\lambda_6 \lambda_3 + w_5 \lambda_3 + w_5 \lambda_1 + \lambda_6 w_5 + w_5^2) + \lambda_1 \lambda_3 \lambda_5 \lambda_6 (w_3 + \lambda_6 + \lambda_1 + \lambda_5) / (\lambda_5 + \lambda_3 + w_1) (w_3 + \lambda_5) \\ & (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_3 w_5 + \lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) \mu_8 \} + \{ \lambda_3 \lambda_1 (w_3 + \lambda_1 + \lambda_5 + \lambda_4) / (\lambda_1 + \lambda_5 + w_3) \mu_9 \} \end{aligned}$$

Busy Period of the Server: States where attendant is busy used for exploit a number of job are 'i' = 1 to 9, attractive 'ξ' = '0',

$$B_0 = \left[\sum_{j, sr} \left\{ \frac{\left\{ \text{pr}(\xi \xrightarrow{sr} j) \right\} n_j}{\Pi_{m_1 \neq \xi} \{1 - V_{m_1 m_1}\}} \right\} \right] \div \left[\sum_{i, sr} \left\{ \frac{\left\{ \text{pr}(\xi \xrightarrow{sr} i) \right\} \mu_i^1}{\Pi_{m_2 \neq \xi} \{1 - V_{m_2 m_2}\}} \right\} \right] \quad (3)$$

$$B_0 = \left[\sum_j V_{\xi, j}, n_j \right] \div \left[\sum_i V_{\xi, i}, \mu_i^1 \right]$$

$$B_0 = \left[\{ (\lambda_1 / \lambda_5 + \lambda_2 + \lambda_3 + w_1) / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) \mu_1 \} \right]$$

$$\begin{aligned} & + V_{0,5} \mu_5 + \{ \lambda_5 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_6 + \lambda_1 + w_5) (\lambda_6 + \lambda_3 + w_5) \\ & (\lambda_3 + \lambda_1 + w_5) + \lambda_3 \lambda_5 (\lambda_3 + \lambda_6 + \lambda_1 + w_5) / (\lambda_5 + \lambda_3 + w_1) (\lambda_1 + \lambda_5 + \lambda_3) (w_3 + \lambda_5 + \lambda_4) \\ & (\lambda_6 \lambda_1 + \lambda_6 w_5 + w_3 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1 \lambda_5 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) \\ & (\lambda_6 \lambda_3 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1 \lambda_3 \lambda_5 (w_3 + \lambda_1 + \lambda_5 + \lambda_4) (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) \\ & (\lambda_5 + \lambda_3 + w_1) (w_3 + \lambda_5 + \lambda_4) (w_3 + \lambda_1 + \lambda_5) (\lambda_3 w_5 + \lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2 + w_3 \lambda_3) \mu_6 \} \end{aligned}$$

$$\begin{aligned}
& + \{ \lambda_5 \lambda_1 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_6 + \lambda_1 + w_5) (\lambda_3 + \lambda_6 + w_5) \\
& + \lambda_1 \lambda_5 (\lambda_6 + \lambda_1 + w_3) (\lambda_3 + \lambda_1 + w_5) / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) (\lambda_6 \lambda_3 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) \\
& + \lambda_3 \lambda_5 \lambda_1 (w_3 + \lambda_1 + \lambda_5 + \lambda_4) / (w_3 + \lambda_6 + \lambda_1 + \lambda_5) / (\lambda_1 + \lambda_5 + \lambda_3) (w_3 + \lambda_1 + \lambda_5) (w_3 + \lambda_5 + \lambda_4) \\
& (\lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1^2 \lambda_3 \lambda_5 (w_3 + \lambda_6 + \lambda_1 + \lambda_5) / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_2 + \lambda_3 + w_1) \\
& (\lambda_5 + \lambda_3 + w_1) (w_3 + \lambda_5) (\lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5 \lambda_1 + w_5^2) \mu_7 \} + \{ \lambda_5 \lambda_6 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 \\
& / (\lambda_1 + \lambda_5 + \lambda_3) (w_3 + \lambda_5 + \lambda_4) (\lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_1 + \lambda_3 w_5 + w_5^2) + \lambda_1 \lambda_5 \lambda_6 (\lambda_3 + \lambda_6 + \lambda_1 + w_5) / \\
& (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) (\lambda_6 \lambda_3 + w_5 \lambda_3 + w_5 \lambda_1 + \lambda_6 w_5 + w_5^2) + \lambda_1 \lambda_3 \lambda_5 \lambda_6 (w_3 + \lambda_6 + \lambda_1 + \lambda_5) \\
& / (\lambda_5 + \lambda_3 + w_1) (\lambda_3 w_5 + \lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_1 + w_5 \lambda_1 + w_5^2) \mu_8 \} \mu_9 \} / k = (1 - \mu_0 / k)
\end{aligned}$$

Expected fraction Number of Inspections by the repair man: The re-forming states where the restoration man visit afresh are states 1, 3 and 6 to do this job the digit of visit thru the repair man stands known by

$$V_0 = \left[\sum_{j, sr} \left\{ \frac{\{pr(\xi^{sr \rightarrow j})\}}{\prod_{k_1 \neq \xi} \{1 - V_{k_1 k_1}\}} \right\} \right] \div \left[\sum_{i, sr} \left\{ \frac{\{pr(\xi^{sr \rightarrow i})\} \mu_i^1}{\prod_{k_2 \neq \xi} \{1 - V_{k_2 k_2}\}} \right\} \right] = [\sum_j V_{\xi, j}] \div [\sum_i V_{\xi, i}, \mu_i^1] \quad (4)$$

$$\begin{aligned}
V_0 = & \{ (\lambda_1 / \lambda_5 + \lambda_2 + \lambda_3 + w_1) / (\lambda_5 + w_3) \} + \{ \lambda_5 (\lambda_6 + w_5)^2 / (\lambda_6 + \lambda_1 + w_5) (\lambda_6 + \lambda_3 + w_5) (\lambda_3 + \lambda_1 + w_5) \\
& + \lambda_3 \lambda_5 (\lambda_5 + \lambda_2 + \lambda_3 + w_1) (\lambda_3 + \lambda_6 + \lambda_1 + w_5) / (\lambda_5 + \lambda_3 + w_1) (\lambda_1 + \lambda_5 + \lambda_3) (w_3 + \lambda_5 + \lambda_4) \\
& (\lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1 \lambda_5 (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) (\lambda_5 + \lambda_3 + w_1) \\
& (\lambda_6 \lambda_3 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2) + \lambda_1 \lambda_3 \lambda_5 (w_3 + \lambda_1 + \lambda_5 + \lambda_4) (\lambda_3 + \lambda_6 + \lambda_1 + w_5)^2 / (\lambda_1 + \lambda_5 + \lambda_3) \\
& (\lambda_5 + \lambda_3 + w_1) (w_3 + \lambda_5 + \lambda_4) (w_3 + \lambda_1 + \lambda_5) (\lambda_3 w_5 + \lambda_6 \lambda_1 + \lambda_6 w_5 + w_5 \lambda_3 + w_5 \lambda_1 + w_5^2 + w_3 \lambda_3) \} / k
\end{aligned}$$

8.1 Particular Cases

Specific Cases: $w_i (1 \leq i \leq 6) = w$; $\lambda_i (1 \leq i \leq 6) = \lambda$

Mean Time to System Failure (MTSF) (T_0)

Table 1: MTSF

T_0	$w = 0.50$	$w = 0.60$	$w = 0.70$
$\lambda = 0.10$	14.42	14.23	14.04
$\lambda = 0.20$	11.23	11.09	10.98
$\lambda = 0.30$	9.85	9.72	9.59

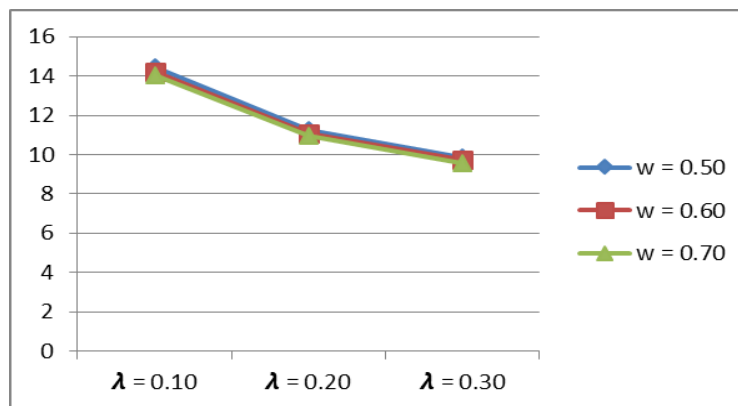


Fig 2: MTSF

Availability of the System (AOS) (A_0)

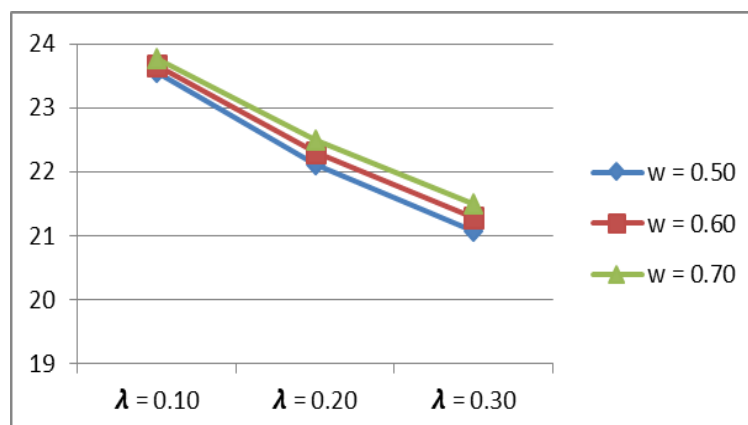


Fig 3: AOS

Table 2: AOS

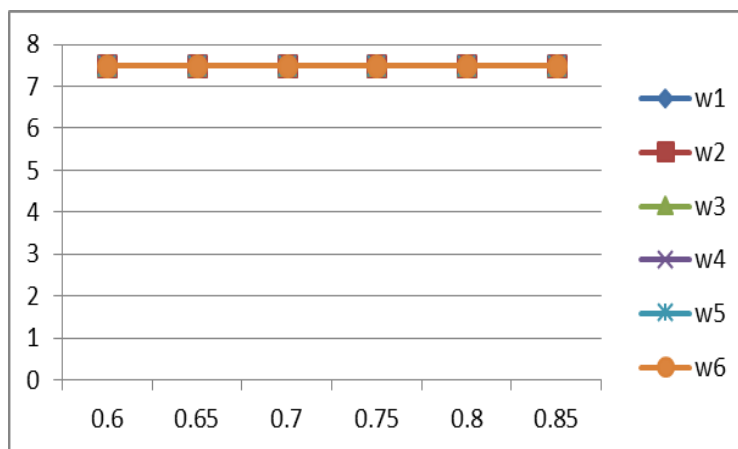
A_0	$w = 0.50$	$w = 0.60$	$w = 0.70$
$\lambda = 0.10$	23.56	23.66	23.76
$\lambda = 0.20$	22.12	22.31	22.50
$\lambda = 0.30$	21.08	21.28	21.49

Sensitivity Analysis: Also, the upstairs subsequent paragraphs depict dual sensitivity analysis set-ups and consistent consequences in tabular and graphical procedures examined.

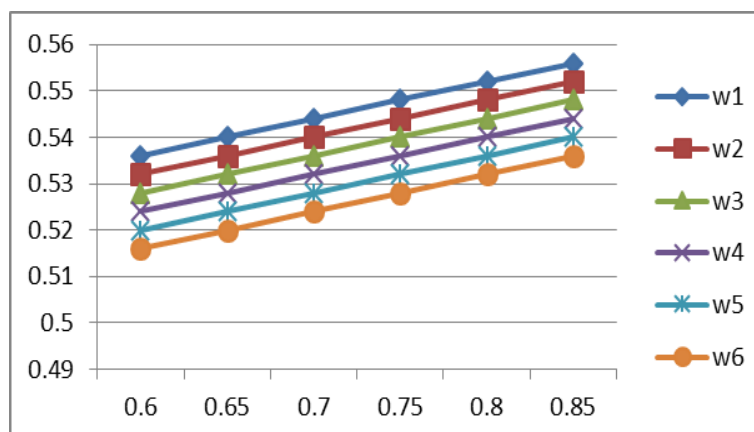
Scenario1: Sensitivity analysis w. r. t. variation in repair rates. Attractive $\lambda_i = 0.15$ ($1 \leq i \leq 6$) and unpredictable w_i ($1 \leq i \leq 6$) one-to-one at 0.60, 0.65, 0.70, 0.75, 0.80, 0.85

Table 3: MTSF

w_i	w_1	w_2	w_3	w_4	w_5	w_6
0.60	7.49	7.49	7.49	7.49	7.49	7.49
0.65	7.49	7.49	7.49	7.49	7.49	7.49
0.70	7.49	7.49	7.49	7.49	7.49	7.49
0.75	7.49	7.49	7.49	7.49	7.49	7.49
0.80	7.49	7.49	7.49	7.49	7.49	7.49
0.85	7.49	7.49	7.49	7.49	7.49	7.49

**Fig 4: Mean Time to System Failure****Table 4: AOS**

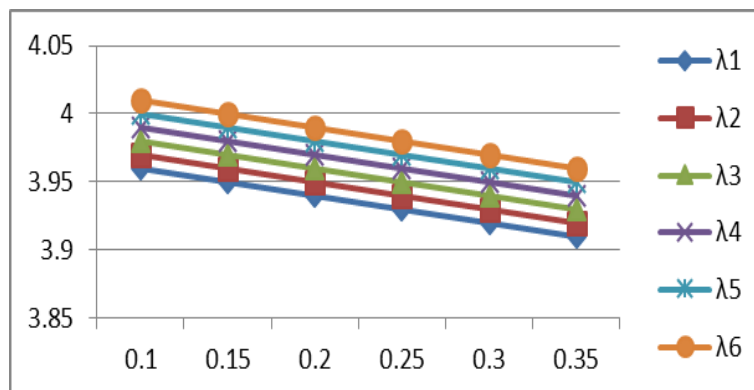
w_i	w_1	w_2	w_3	w_4	w_5	w_6
0.60	0.536	0.532	0.528	0.524	0.520	0.516
0.65	0.540	0.536	0.532	0.528	0.524	0.520
0.70	0.544	0.540	0.536	0.532	0.528	0.524
0.75	0.548	0.544	0.540	0.536	0.532	0.528
0.80	0.552	0.548	0.544	0.540	0.536	0.532
0.85	0.556	0.552	0.548	0.544	0.540	0.536

**Fig 5: AOS**

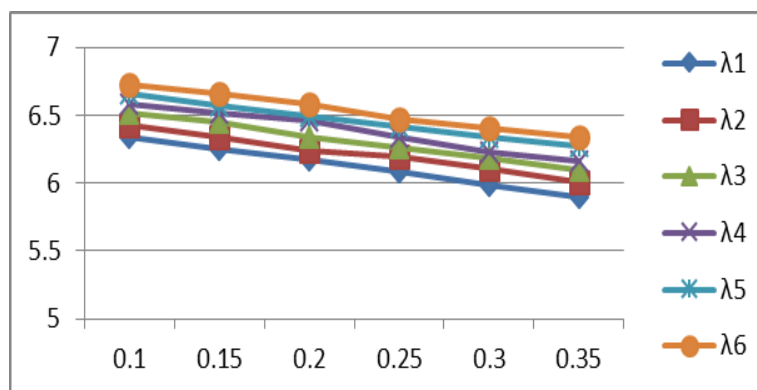
Scenario 2: Currently one reflects sensitivity analysis scenario 2 for vagaries in disappointment rates: enchanting repair rates $w_i = 0.85$ ($1 \leq i \leq 6$) and erratic λ_i ($1 \leq i \leq 6$) one by one respectively at 0.10, 0.15, 0.20, 0.25, 0.30, 0.35.

Table 5: MTSF

λ_i	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6
0.10	3.96	3.97	3.98	3.99	4.00	4.01
0.15	3.95	3.96	3.97	3.98	3.99	4.00
0.20	3.94	3.95	3.96	3.97	3.98	3.99
0.25	3.93	3.94	3.95	3.96	3.97	3.98
0.30	3.92	3.93	3.94	3.95	3.96	3.97
0.35	3.91	3.92	3.93	3.94	3.95	3.96

**Fig 6: MTSF****Table 6: AOS**

λ_i	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6
0.10	6.34	6.43	6.51	6.58	6.66	6.73
0.15	6.25	6.34	6.45	6.52	6.57	6.66
0.20	6.17	6.24	6.34	6.46	6.49	6.58
0.25	6.08	6.20	6.26	6.34	6.42	6.47
0.30	5.98	6.11	6.18	6.23	6.34	6.41
0.35	5.90	6.01	6.10	6.16	6.27	6.34

**Fig 7: AOS**

9. Conclusions

Table 1 and Figure 2 illustrate the relationship between MTSF and the unit's repair rate for various failure rates. It is possible to deduce from the preceding table that MTSF increases with overhaul rates but decreases with letdown rates. As expected, Table 2 shows that convenience rises with increasing overhaul rates and decreases with increasing disappointment rates. Additionally, Figure 3 suggests that availability values provide an approximated trend that aims to address different failure rate principles by showing an increase in availability in tandem with a rise in the value of the repair rate. Table 3 and Figure 4 demonstrate that the MTSF does not change by changes in the repair rates for various units. Table 4 and Figure 5 conclude that the value of system availability is not greatly increased by higher repair rates. Table 5 and Fig. 6 demonstrate that the MTSF does not change by changes in the repair rates for various units. Table 6 and Fig. 7 conclude that

the value of system availability is not greatly increased by higher repair rates. We arrive at a conclusion that Preventive Maintenance plays a vital role in optimization of performance of system.

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