A two-unit system with inspection before failure essay

A Two-unit System with review before failure

Abstraction

As the market becomes competitory and diversified, So Now a yearss, in an international market context, companies needs to better their productiveness. In this context, Inspection agenda and care schemes are included to better dependability of the merchandise. In this paper, an operative unit is inspected after a certain period of its operation and so it is distinct whether unit can run further or needs certain care. Besides it is assumed that operative unit is non inspected if another unit is failed and when a working unit is fails it goes under review of the maintenance man and he decides whether the unit is repairable or non. If a unit is non repairable it is replaced by a new one. In this paper system will be analyzed to find assorted dependability steps by utilizing mathematical tools MTSF/MTBF, Markov concatenation, Markov procedure, reclamation procedure etc.

KeywordsRegenerative Point, MTSF, Availability, Busy period, Cold standby, care, replacing policy.

Introduction

The growing of present twenty-four hours societies in transit, communicating and engineering, point towards the usage of larger and more complex systems. Today I? s concern faces these above jobs and seek to work out the organisational alterations really high degree of quality and dependability trial, the rapid promotion of design, development and fabrication complexnesss. Reliability is a new construct needed to work out these type job affecting due to the complexness, edification and mechanization developed in modern engineering. The construct of dependability has been interpreted in many different ways in legion plants. Dependability of the system is the chance that a system will run without failure for a given period of clip under given operating conditions. A system is considered to hold failed under three conditions: One is due to when it becomes wholly inoperable. Second is due to when it is still operable but is no longer able to execute its intended map satisfactorily and 3rd is due to when the serious impairment has made it undependable and insecure for continued usage, So this needs its immediate remotion for the system for fix or replacing. Numerous dependability theoretical accounts for standby with different fix mechanism have been proposed by the research worker including Mishra and Balagurusamy [1976] , Chiang and Niu [1981] , Gopalan and Naidu [1982] , Goel et. al [1985] , Tuteja and malik [1994] taking some certain premises. To increase the dependability and handiness of the system, we take a normal review of two indistinguishable unit before failure. In this paper, an operative unit is inspected after a certain period of its operation and so it is distinct whether unit can run further or needs certain care. Besides it is assumed that operative unit is non inspected if another unit is failed and when a working unit is fails it goes under review of the maintenance man and he decides whether the unit is repairable or non. If a unit is non repairable it is replaced by a new one. In this paper system will be analyzed to find assorted dependability steps by utilizing mathematical tools MTSF/MTBF, Markov concatenation, Markov procedure, reclamation procedure etc.

Description of system and Premise: –

In this paper, an operative unit is inspected after a certain period of its operation and it is distinct whether unit can run further or needs certain care.

- The system consists of two indistinguishable units – Initially one unit is operative and 2nd unit is kept as cold standby.
- System is considered in Up-state if one unit is working and in down province if no unit is working.
- Each unit of the system has two modes-normal operative or failed.
- Here a everyday review is conducted to analyze the operating unit after a certain fixed period.
- It is assumed that operative unit is non inspected if another unit is failed.
- Besides it is assumed that when a working unit is fails it goes under review of the maintenance man and he decides whether the unit is repairable or not. If a unit is non repairable, it is replaced by a new one.
- Inspection clip is excessively little to travel for care of 2nd unit.
- A unit under care would non neglect.
- A repaired and replaced unit is every bit good as new.
- All the random variable are independent.

Notations

Tocopherol: Set of regenerative provinces

A’ : Set of non-regenerative provinces

Nitrogen $_I$: Routine review

Nitrogen $_I$: Everyday review uninterrupted

Oxygen: Unit of measurement is in operative province

C $_{Second}$: Unit of measurement is in cold standby province

? : Changeless failure rate of a unit

g (T) , G (T) : pdf and cdf of fix clip of a failed unit

Nitrogen $_m$ Care of unit

F $_R$: Failed unit under fix

F $_I$: Failed unit under review

F $_{I:}$ Failed unit under review

F $_{Wisconsin}$ Failed unit waiting for review

M (T) Care rate

I (T) , I (T) pdf and cdf of review clip of normal unit

H (T) , H (T) pdf and cdf of fix clip of a failed unit before review

©Symbol for Laplace whirl

®symbol for Laplace Stieltjes Convolution

The system can be in any of the undermentioned provinces with regard of the above symbols:

Second $_0$ = (O, N $_s$) Second $_4$ = (N $_I$, F $_{\text{Badger state}}$)

Second $_1$ = (N $_{I,}$ O) S $_5$ = (N $_m$, F $_{\text{Wisconsin}}$)

Second $_2$ = (F $_I$, O) S $_6$ = (F $_{R,}$ O)

Second $_3$ = (N $_m$, O) S $_7$ = (F $_I$, F $_{\text{Badger state}}$)

Second $_8$ = (F $_R$, F $_{\text{Wisconsin}}$)

Passage Probabilities

The era of entry into provinces { S $_0$, S $_1$, S $_2$, S $_{3,}$ Second $_5$, S $_6$, S $_8$ } are regenerative provinces. The passage chances from the provinces S $_I$ to S $_J$ are given by Q $_{ij}$ and in the provinces provinces p $_{ij}$ denotes the passage chance from provinces S $_I$ to S $_J$ are given under

P $_{01}$ = ?/ (?+?) P $_{26}$ = qh * (?)

P $_{02}$ = ?/ (?+?) P $_{20}$ = pH * (?)

P $_{10}$ = a i* (?) P $_{27}$ = { 1- H * (?) }

P $_{13}$ = B i* (?) P $_{30}$ = m * (?)

P $_{14}$ = { 1- I * (?) } P $_{35}$ = { 1- m * (?) }

P $_{52}$ = 1 P $_{60}$ = g * (?)

$P_{82} = 1p_{68} = \{ 1- g^{*} (?) \}$

$P_{1}^{(4)}{}_{2} = a \{ 1- I^{*} (?) \}$ $P_{1}^{(4)}{}_{5} = b \{ 1- I^{*} (?) \}$

$P_{2}^{(7)}{}_{2} = p \{ 1- H^{*} (?) \}$ $P_{2}^{(7)}{}_{8} = q \{ 1- H^{*} (?) \}$

It can be easy verified that

$P_{01} + p_{02} = 1p_{52} = 1$

$P_{10} + p_{13} + p_{14} = 1p_{82} = 1$

$P_{20+} P_{26} + p_{27} = 1p_{1}^{(4)}{}_{2} + P_{1}^{(4)}{}_{5} = p_{14}$

$P_{30} + p_{35} = 1p_{60} + p_{68} = 1$

$P_{1}^{(4)}{}_{2} + P_{1}^{(4)}{}_{5} + p_{13} + p_{10} = 1p_{20+} P_{26} + P_{2}^{(7)}{}_{2} + P_{2}^{(7)}{}_{8} = 1$

$P_{2}^{(7)}{}_{2} + P_{2}^{(7)}{}_{8} = p_{27}$ $P_{35} = 1-p_{30}$

$P_{68} = 1-p_{60}$

Mean Sojourn Times

Mean Sojourn Times may be defined by

$\mu_{I} =$

So that in steady province we have following dealingss

$\mu_{0} = 1/ (?+?)$ $\mu_{1} = \{ 1- I^{*} (?) \} / ?$

$\mu_2 = [1- H^* (?)] /? \mu_3 = [1- m^* (?)] /?$

$\mu_6 = [1- g^* (?)] /?$

The unconditioned mean clip taken by the system to pass through from any provinces S_I to S_J is mathematically given by

$mij = tdQij (T) =-q_{ij}^* (s)' / _{at\ s= 0}$

So that

$m_{01} =?/ (?+?)^2 m_{20} =-ph^{*'} (?)$

$m_{02} = ?/ (?+?)^2 m_{26} =-qh^{*'} (?)$

$m_{10} = -ai^{*'} (?) m_{27} = [\{ 1- H^* (?) \} /?] +h^{*'} (?)$

$m_{13} = -bi^{*'} (?) m_{30} = -m^{*'} (?)$

$m_{14} = [\{ 1- I^* (?) \} /?] +i^{*'} (?) m_{35} = [\{ 1- m^* (?) \} /?] +m^{*'} (?)$

$m_{60} =-g^{*'} (?) m_{68} = [\{ 1- g^* (?) \} /?] +g^{*'} (?)$

It can be easy verified that

$m_{01} + m_{02} = \mu_0\ m_{10} + m_{13} +m_{14} = \mu_1$

$m_{20} + m_{26} + m_{27} = \mu_2\ m_{30} + m_{35} = \mu_3$

$m_{60} + m_{68} = \mu_6$

Average Time to System Failure

The average clip to system failure is given by the equations

$? _0 (T) = Q_{01} (T) ® ? _1 (T) + Q_{02} (T) ® ? _2 (T)$

$? _1 (T) = Q_{10} (T) ® ? _0 (T) + Q_{13} (T) ® ? _3 (T) + Q_{14}$

$? _2 (T) = Q_{20} (T) ® ? _0 (T) + Q_{26} (T) ® ? _6 (T) + Q_{27} (T)$

$? _3 (T) = Q_{30} (T) ® ? _0 (T) + Q_{35} (T)$

$? _6 (T) = Q_{60} (T) ® ? _0 (T) + Q_{68} (T)$

Solving above equation by taking Laplace Stieltjes transmutations and work outing for $? _0^{**} (s)$, we get

$? _0^{**} (s) =$

Where

$N (s) = – Q_{01} Q_{14} – Q_{01} Q_{13} Q_{35} – Q_{02} Q_{27} – Q_{02} Q_{26} Q_{68}$

$D (s) = -1+ Q_{01} Q_{10} + Q_{01} Q_{13} Q_{30} + Q_{02} Q_{20} + Q_{02} Q_{26} Q_{60}$

$MTSF = ? _0 =[\{ 1-? _0^{**} (s) \} /s] = \{ D^? (0) -N^? (0) \} /D (0)$

Where

Calciferol $^? (0) -N^? (0) = – [μ_0 + μ_1 P_{01} + μ_2 P_{02} + μ_3 P_{01} P_{13} + μ_6 P_{02} P_{26}]$

$D(0) = -[P_{01} P_{14} + p_{01} P_{13} P_{35} + p_{02} P_{27} + p_{02} P_{26} P_{68}]$

Handiness of the system

The point wise handiness a,? $_{I}$ (T) of the system is given by

a,? $_{0}$ (T) = I? $_{0}$ (T) + Q $_{01}$ (T) © a,? $_{1}$ (T) + Q $_{02}$ (T) © a,? $_{2}$ (T)

a,? $_{1}$ (T) = I? $_{1}$ (T) + Q $_{10}$ (T) © a,? $_{0}$ (T) + Q $_{1}{}^{(4)}{}_{2}$ (T) © a,? $_{2}$ (T) +q

$_{13}$ (T) © a,? $_{3}$ (T)

a,? $_{2}$ (T) = I? $_{2}$ (T) + Q $_{20}$ (T) © a,? $_{0}$ (T) + Q $_{26}$ (T) © a,? $_{6}$ (T) +q $_{2}{}^{(7)}$

$_{2}$ © a,? $_{2}$ (T) +q $_{2}{}^{(7)}{}_{8}$ © a,? $_{8}$ (T)

a,? $_{3}$ (T) = I? $_{3}$ (T) +q $_{30}$ (T) © a,? $_{0}$ (T) + Q $_{35}$ (T) © a,? $_{5}$ (T)

a,? $_{5}$ (T) = Q $_{52}$ (T) © a,? $_{2}$ (T)

a,? $_{6}$ (T) = I? $_{6}$ (T) +q $_{60}$ (T) © a,? $_{0}$ (T) + Q $_{68}$ (T) © a,? $_{8}$ (T)

a,? $_{8}$ (T) = Q $_{82}$ (T) © a,? $_{2}$ (T)

Now taking Laplace transform of these equations and work outing them for

a,? $_{0}{}^{*}$ (s) , we get

a,? $_{0}{}^{*}$ (T) =

The steady provinces handiness is given by

a,? $_{0}{}^{**}$ =

Where

Nitrogen $_{1}$ (0) = µ $_{1}$ P $_{01}$ [P $_{26}$ +1] + µ $_{3}$ P $_{01}$ P $_{13}$ [P $_{26}$ P $_{68}$ +p $_{2}$ $^{(7)}$ $_{8}$]

and

Calciferol $_{1}$ (0) = 0I? $_{0}$ (T) =? $_{0}$ (T) I? $_{1}$ (T) =? $_{1}$ (T) I? $_{2}$ (T) =? $_{2}$ (T) I? $_{3}$ (T) =? $_{3}$ (T) I? $_{6}$ (T) =? $_{6}$ (T)

Calciferol $_{1}$ ′ (0) = – { (m $_{2}$ $^{(7)}$ $_{2}$ +m $_{26}$ P $_{68}$ +m $_{68}$ P $_{26}$ + m $_{2}$ $^{(7)}$ $_{8}$) (1-p $_{01}$ P $_{10}$ -p $_{01}$ P $_{13}$ P $_{30}$)

+ (1-p $_{27}$ -p $_{26}$ P $_{68}$) (m $_{01}$ P $_{10}$ +m $_{10}$ P $_{01}$ +m $_{01}$ P $_{13}$ P $_{30}$ +m $_{13}$ P $_{01}$ P $_{30}$ +m $_{30}$ P $_{01}$ P $_{13}$)

+ (m $_{01}$ P $_{1}$ $^{(4)}$ $_{2}$ +m $_{1}$ $^{(4)}$ $_{2}$ P $_{01}$ +m $_{01}$ P $_{13}$ P $_{35}$ +m $_{13}$ P $_{01}$ P $_{35}$ +m $_{35}$ P $_{01}$ P $_{13}$ +m $_{02}$) (P $_{20}$ +p $_{26}$ P $_{60}$)

+ (m $_{20}$ +m $_{26}$ P $_{60}$ +m $_{60}$ P $_{26}$) (P $_{01}$ P $_{1}$ $^{(4)}$ $_{2}$ +p $_{01}$ P $_{13}$ P $_{35}$ +p $_{02}$) }

Inspection Time Before Failure-

Let I $_{I}$ is the review clip get downing from a regenerative provinces S $_{I}$ at t= 0 is given by

O? $_{0}$ (T) = Q $_{01}$ (T) © O? $_{1}$ (T) + Q $_{02}$ (T) © O? $_{2}$ (T)

O? $_{1}$ (T) = U $_{1}$ (T) + Q $_{10}$ (T) © O? $_{0}$ (T) + Q $_{1}$ $^{(4)}$ $_{2}$ (T) © O? $_{2}$ (T) +q $_{13}$ (T) © O? $_{3}$ (T)

O? $_2$ (T) = Q $_{20}$ (T) © O? $_0$ (T) + Q $_{26}$ (T) © O? $_6$ (T) +q $_2{}^{(7)}{}_2$ © O? $_2$ (T) +q $_2{}^{(7)}{}_8$ © O? $_8$ (T)

O? $_3$ (T) = Q $_{30}$ (T) © O? $_0$ (T) + Q $_{35}$ (T) © O? $_5$ (T)

O? $_5$ (T) = Q $_{52}$ (T) © O? $_2$ (T)

O? $_6$ (T) = Q $_{60}$ (T) © O? $_0$ (T) + Q $_{68}$ (T) © O? $_8$ (T)

O? $_8$ (T) = Q $_{82}$ (T) © O? $_2$ (T)

Where

Nitrogen $_2$ (0) = U $_1$ P $_{01}$ (-1+p $_{27}$ +p $_{26}$ P $_{68}$)

and

Uracil $_1$ =+ ?

The review clip is given by

O? $_0{}^*$ (T) =

O? $_0{}^{**}$ =

Calciferol $_1{}^?$ (0) is already defined

Inspection Time After Failure-

Let A¬ $_l$ is the review clip get downing from a regenerative provinces S $_l$ at t= 0 is given by

$A¬_0 (T) = Q_{01} (T) © A¬_1 (T) + Q_{02} (T) © A¬_2 (T)$

$A¬_1 (T) = Q_{10} (T) © A¬_0 (T) + Q_1{}^{(4)}{}_2 (T) © A¬_2 (T) +q_{13} (T) ©$

$A¬_3 (T)$

$A¬_2 (T) = V_2 + Q_{20} (T) © A¬_0 (T) + Q_{26} (T) © A¬_6 (T) +q_2{}^{(7)}{}_2 ©$

$A¬_2 (T) +q_2{}^{(7)}{}_8 © A¬_8 (T)$

$A¬_3 (T) = Q_{30} (T) © A¬_0 (T) + Q_{35} (T) © A¬_5 (T)$

$A¬_5 (T) = Q_{52} (T) © A¬_2 (T)$

$A¬_6 (T) = Q_{60} (T) © A¬_0 (T) + Q_{68} (T) © A¬_8 (T)$

$A¬_8 (T) = Q_{82} (T) © A¬_2 (T)$

Where

Nitrogen $_3 (0) = -V_2 (P_{01} P_1{}^{(4)}{}_2 +p_{01} P_{13} P_{35} +p_{02})$

and

The review clip is given by

$A¬_0{}^* (T) =$

$A¬_0{}^{**} =(sA¬_0{}^* (s)) =<$

Calciferol $_1{}^? (0)$ is already defined

Care Time

Let K_I is the Maintenance clip get downing from a regenerative provinces S_I at t= 0 is given by

$K_0 (T) = Q_{01} (T) © K_1 (T) + Q_{02} (T) © K_2 (T)$

$K_1 (T) = Q_{10} (T) © K_0 (T) + Q_1{}^{(4)}{}_2 (T) © K_2 (T) +q_{13} (T) © K_3 (T)$

$K_2 (T) = Q_{20} (T) © K_0 (T) + Q_{26} (T) © K_6 (T) +q_2{}^{(7)}{}_2 © K_2 (T) +q_2{}^{(7)}{}_8 © K_8 (T)$

$K_3 (T) = W_3 + Q_{30} (T) © K_0 (T) + Q_{35} (T) © K_5 (T)$

$K_5 (T) = W_5 +q_{52} (T) © K_2 (T)$

$K_6 (T) = Q_{60} (T) © K_0 (T) + Q_{68} (T) © K_8 (T)$

$K_8 (T) = Q_{82} (T) © K_2 (T)$

The Maintenance clip is given by

$K_0{}^* (T) =$

$K_0{}^{**} =(sK_0{}^* (s)) =$

Where

Nitrogen $_4 (0) = P_{01} P_{13} (W_3 +W_5 P_{35}) (P_{26} P_{68} +p_2{}^{(7)}{}_8)$

Where

Calciferol $_{1}^{?}$ (0) is already defined

Repair Time

Let R $_{I}$ is the Repair clip get downing from a regenerative provinces S $_{I}$ at t= 0 is given by

Roentgen $_{0}$ (T) = Q $_{01}$ (T) © R $_{1}$ (T) + Q $_{02}$ (T) © R $_{2}$ (T)

Roentgen $_{1}$ (T) = Q $_{10}$ (T) © R $_{0}$ (T) + Q $_{1}^{(4)}$ $_{2}$ (T) © R $_{2}$ (T) +q $_{13}$ (T) © R $_{3}$ (T)

Roentgen $_{2}$ (T) = Q $_{20}$ (T) © R $_{0}$ (T) + Q $_{26}$ (T) © R $_{6}$ (T) +q $_{2}^{(7)}$ $_{2}$ © Roentgen $_{2}$ (T) +q $_{2}^{(7)}$ $_{8}$ © Roentgen $_{8}$ (T)

Roentgen $_{3}$ (T) = Q $_{30}$ (T) © R $_{0}$ (T) + Q $_{35}$ (T) © R $_{5}$ (T)

Roentgen $_{5}$ (T) = Q $_{52}$ (T) © R $_{2}$ (T)

Roentgen $_{6}$ (T) = Ten $_{6}$ +q $_{60}$ (T) © R $_{0}$ (T) + Q $_{68}$ (T) © R $_{8}$ (T)

Roentgen $_{8}$ (T) = Ten $_{8}$ +q $_{82}$ (T) © R $_{2}$ (T)

The Repair clip is given by

Roentgen $_{0}^{*}$ (T) =

Roentgen $_{0}^{**}$ =

Where

Nitrogen $_5$ (0) = – [{ (X $_6$ +X $_8$ P $_{68}$) P $_{26}$ +X $_8$ P $_2$ $^{(7)}$ $_8$ } { P $_{01}$ P $_1$ $^{(4)}$ $_2$ +p $_{01}$ P $_{13}$ P $_{35}$ +p $_{02}$ }]

Where

Ten $_6$ =

Particular instances:

If we take repair rate and review clip as negative binomial distributions as

I (T) = H (T) = ?

Then we get,

P $_{01}$ =?/ ?+? µ $_0$ = 1/?+?

P $_{02}$ =?/?+? µ $_1$ = 1/?+?

P $_{10}$ = a?/?+? µ $_2$ = 1/?+?

P $_{13}$ = b?/?+? µ $_3$ = 1/?+?

P $_{14}$ = ?/?+? µ $_6$ = 1/?+?

P $_{20}$ = p?/?+? m $_{01}$ =?/ (?+?) ^{2}

P $_{26}$ = q?/?+? m $_{02}$ =?/ (?+?) ^{2}

P $_{27}$ = ?/?+? m $_{10}$ = a?/ (?+?) ^{2}

P $_{30}$ = ?/?+? m $_{13}$ = b?/ (?+?) ^{2}

P_{35} = ?/?+? m_{14} =?/ (?+?) ^{2}

P_{52} = 1m $_{20}$ = p?/ (?+?) ^{2}

P_{82} = 1m $_{26}$ = q?/ (?+?) ^{2}

P_{60} = ?/?+? m_{27} =?/ (?+?) ^{2}

P_{68} = ?/?+? m_{30} =?/ (?+?) ^{2}

$P_1^{(4)}{}_2$ = a?/?+? m_{35} =?/ (?+?) ^{2}

$P_1^{(4)}{}_5$ = b?/?+? m_{60} =?/ (?+?) ^{2}

$P_2^{(7)}{}_2$ = p?/?+? m_{68} =?/ (?+?) ^{2}

$P_2^{(7)}{}_8$ = q?/?+? $m_1^{(4)}{}_2$ = a [(1/? ^{2}) – (1/ (?+?) ^{2})]

$m_1^{(4)}{}_5$ = b [(1/? ^{2}) – (1/ (?+?) ^{2})]

$m_2^{(7)}{}_2$ = p [(1/? ^{2}) – (1/ (?+?) ^{2})]

$m_2^{(7)}{}_8$ = q [(1/? ^{2}) – (1/ (?+?) ^{2})]

Mentions: –

1. Nakagawa, T. and Osaki, S. (1975) . Stochastic behavior of two unit analogues

redundant system with preventative care, Microlectron Reliab. 14, p. 457-461.

2. Jui-Hsiang Chian and John Yuan, (2001) , optimum care policy for a deteriorating production system under review, ,
3. Tuteja, R. K. , and Gulshan, T. " cost – benefit analysis of a two- server-two unit warm standby system with different type of failure " , Microelectron. Reliab. , 1992, VOL. 32, p1353-1359.
4. Brown, M. , Proschan, F. (1983) " Imperfect repair" , Journal of Applied Probability, 20: 851–859.
5. Jiang, R. and Jardine, A. K. S. (2005) " Two Optimization Models of the Optimum Inspection Problem" , Journal of the Operational Research Society, 56: 1176–1183.
6. LEWIS E. E. Introduction to Reliability Engineering. John Wiley and Sons. Co. 1987.
7. H. Wang. A study of care policies of deteriorating systems. European Journal of Operational Research, 139 (3) : 469–489, 2002
8. Barlow R. E. , Proschan F. Mathematical Theory of Reliability. SIAM, 1996.

State Transition Diagrams

Regenerative State: -S_0 , S_1 , S_2 , S_3 , S_5 , S_6 , S_8 Non-regenerative State: -S_4 , S_7