Benefit-Function of Two- Identical Cold Standby submarines System subject to failure due to accident or repair was deemed impossible and decommissioning too expensive

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Abstract- Eight nuclear submarines have sunk as a consequence of either accident or extensive damage: two from the United States Navy, four from the Soviet Navy, and two from the Russian Navy. Only three were lost with all hands: two from the United States Navy and one from the Russian Navy. All sank as a result of accident with the exception of K-27, which was scuttled in the Kara Sea when repair was deemed impossible and decommissioning too expensive. All of the Soviet/Russian submarines belonged to the Northern Fleet. Although the Soviet submarine K-129 (Golf II) carried nuclear ballistic missiles when it sank, it was a diesel-electric submarine and is not in the list below.

Of the 8 sinkings, 2 were due to fires, 2 were due to explosions of weapons systems, 1 was due to flooding, 1 was weather-related, and 1 was sunk intentionally due to a damaged nuclear reactor. In 1 case, the cause of sinking is unknown. All of the subs are in the Northern Hemisphere, and there are none in either the Indian or Pacific Oceans.

In this paper we have taken failure due to accident or repair was deemed impossible and decommissioning too expensive. When the main unit fails then cold standby system becomes operative. Failure due to repair was deemed impossible and decommissioning too expensive cannot occur simultaneously in both the units and after failure due to accident undergoes very costly repair facility immediately. Applying the regenerative point technique with renewal process theory the various reliability parameters MTSF, Availability, Busy period, Benefit-Function analysis have been evaluated.

Keywords: Cold Standby, failure due to accident or repair was deemed impossible and decommissioning too expensive, first come first serve, MTSF, Availability, Busy period, Benefit -Function.

INTRODUCTION

Soviet Union

K-27: The only Project 645 submarine, it was irreparably damaged by a reactor accident (control rod failure) on May 24, 1968. 9 were killed in the reactor accident. After shutting down the reactor and sealing the compartment, the Soviet Navy scuttled her in shallow water (108 ft (33 m)) in the Kara Sea on September 6, 1982, contrary to the recommendation of the International Atomic Energy Agency (IAEA).

K-8: A Project 627 November class submarine was lost April 11, 1970 while being towed in rough seas following a fire on board. The submarine was initially evacuated, but 52 reembarked for the towing operation. All hands on board were lost (52), while 73 crewmen survived on the rescue vessel. Location: Bay of Biscay, 490 kilometres (260 nmi) northwest of Spain in the North Atlantic Ocean.

K-219: A Project 667A Yankee I class sub was damaged by a missile explosion October 3, 1986, then sank suddenly while being towed after all surviving crewmen had transferred off. 6 crew members were killed. Location: 950 kilometres (510 nmi) east of Bermuda in the North Atlantic Ocean.

K-278 Komsomolets: The only Mike-class sub built sank due to a raging fire April 7, 1989. All but 5 crewmen evacuated prior to sinking. 42 perished, many from smoke inhalation and exposure to the cold waters of the Barents Sea. A total of 27 crew members survived.

Soviet submarine K-429 sank twice, but was raised after each incident.

Russia

K-141 Kursk: The Oscar II class sub sank in the Barents Sea on August 12, 2000 after an explosion in the torpedo compartment. See Kursk submarine disaster. All 118 men on board were lost. However, all except the extreme bow section was later salvaged.

K-159: The hulk of the decommissioned Soviet-era November class submarine sank in the Barents Sea on August 28, 2003, when a storm ripped away the pontoons necessary to keep it afloat under tow. 9 men perished in the accident

In this paper we have taken failure due to accident or repair was deemed impossible and decommissioning too expensive. When the main operative unit fails then cold standby system becomes operative. Failure due to repair

was deemed impossible and decommissioning too expensive cannot occur simultaneously in both the units and after failure the unit undergoes repair facility of very high cost in case of failure of failure due to accident immediately. The repair is done on the basis of first fail first repaired.

Assumptions

λ_1, λ_2 are constant failure rates for **failure due to accident or repair was deemed impossible and decommissioning too expensive** respectively. The CDF of repair time distribution of Type I and Type II are $G_1(t)$ and $G_2(t)$.

1. The failure due to repair was deemed impossible and decommissioning too expensive is non-instantaneous and it cannot come simultaneously in both the units.
2. The repair starts immediately after failure due to accident and works on the principle of first fail first repaired basis.
3. The repair facility does no damage to the units and after repair units are as good as new.
4. The switches are perfect and instantaneous.
5. All random variables are mutually independent.
6. When both the units fail, we give priority to operative unit for repair.
7. Repairs are perfect and failure of a unit is detected immediately and perfectly.
8. The system is down when both the units are non-operative.

Notations

λ_1 , λ_2 - failure due to accident or repair was deemed impossible and decommissioning too expensive respectively.

$G_1(t)$, $G_2(t)$ – repair time distribution Type –I or Type-II due to accident or repair was deemed impossible and decommissioning too expensive respectively.

p, q - probability of failure due to accident or repair was deemed impossible and decommissioning too expensive respectively such that p+ q=1

$M_i(t)$ System having started from state i is up at time t without visiting any other regenerative state

$A_i(t)$ state is up state at instant t

R_i (t) System having started from state i is busy for repair at time t without visiting any other regenerative state.

$B_i(t)$ the server is busy for repair at time t.

$H_i(t)$ Expected number of visits by the server for repairing given that the system initially starts from regenerative state i

Symbols for states of the System

Superscripts O, CS, SAF, RIDEF

Operative, Cold Standby, failure due to accident or repair was deemed impossible and decommissioning too expensive respectively

Subscripts nride, ride, saf, ur, wr, uR

No failure due to repair was deemed impossible and decommissioning too expensive, failure due to repair was deemed impossible and decommissioning too expensive, failure due to accident, under repair, waiting for repair, under repair continued from previous state respectively

Up states – 0, 1, 2, 7, 8 ;

Down states – 3, 4, 5, 6

regeneration point – 0,1,2, 7, 8

States of the System

0(O_{nride}, CS_{nride})

One unit is operative and the other unit is cold standby and there is no failure due to repair was deemed impossible and decommissioning too expensive in both the units.

1($SAF_{saf, ur}$, O_{nride})

The operating unit fails due to accident and is under repair immediately of very costly Type- I and standby unit starts operating with no failure due to repair was deemed impossible and decommissioning too expensive.

2($RIDEF_{ride, ur}$, O_{nride})

The operative unit fails due to failure due to repair was deemed impossible and decommissioning too expensive and undergoes repair of type II and the standby unit becomes operative with no failure due to repair was deemed impossible and decommissioning too expensive, failure due to repair was deemed impossible and decommissioning too expensive

3($SAF_{saf,uR}$, $RIDEF_{ride, wr}$)

The first unit fails due to accident and under Type-I repair is continued from state 1 and the other unit fails due to RIDEF resulting from failure due to repair was deemed impossible and decommissioning too expensive and is waiting for repair of very costly Type -II.

4($SAF_{saf,uR}$, $SAF_{saf,wr}$)

The repair of the unit is failed due to SAF resulting from failure due to accident is continued from state 1and the other unit failed due to SAF resulting from failure due to accident is waiting for repair of Type-I.

5($RIDEF_{ride, uR}$, $RIDEF_{ride, wr}$)

The operating unit fails due to repair was deemed impossible and decommissioning too expensive and under repair of Type – I continue from the state 2 and the other unit fails also due to failure due to repair was

deemed impossible and decommissioning too expensive is waiting for repair of Type- I.

6(RIDEF $_{ride,\ uR}$, SAF $_{saf,wr}$)

The operative unit fails due to failure due to repair was deemed impossible and decommissioning too expensive and under repair continues from state 2 of Type –II and the other unit is failed due to SAF resulting from failure due to accident and under very costly Type-I

7(O $_{nride}$, SAF $_{saf,ur}$)

The one unit is operative with no failure due to repair was deemed impossible and decommissioning too expensive and the other unit failed due to SAF resulting from failure due to accident is under repair of very costly Type-I

8(O $_{nride}$, RIDEF $_{ride,\ ur}$)

The one unit is operative with no failure due to repair was deemed impossible and decommissioning too expensive and the other unit is failed due to failure due to repair was deemed impossible and decommissioning too expensive is under repair of Type-II.

Transition Probabilities

Simple probabilistic considerations yield the following expressions:

$p_{01} = p,\quad p_{02} = q,$

$p_{10} = pG_1^*(\lambda_1)+q\,G_1^*(\lambda_2)= p_{70},$

$p_{20} = pG_2^*(\lambda_1)+q\,G_2^*(\lambda_2)= p_{80},$

$p_{11}^{(3)}= p(1- G_1^*(\lambda_1))= p_{14} = p_{71}^{(4)}, p_{28}^{(5)}= q(1- G_2^*(\lambda_2))= p_{25} = p_{82}^{(5)}$ (1)

We can easily verify that

$p_{01} + p_{02} = 1,$

$p_{10} + p_{17}^{(4)} (= p_{14}) + p_{18}^{(3)} (= p_{13}) = 1,$

$p_{80} + p_{82}^{(5)} + p_{87}^{(6)} = 1$ (2)

And mean sojourn time is

$\mu_0 = E(T) = \int_0^\infty P[T > t]dt$

Mean Time To System Failure

$\emptyset_0(t) = Q_{01}(t)[s]\,\emptyset_1(t) + Q_{02}(t)[s]\,\emptyset_2(t)$

$\emptyset_1(t) = Q_{10}(t)[s]\,\emptyset_0(t) + Q_{13}(t) + Q_{14}(t)$

$\emptyset_2(t) = Q_{20}(t)[s]\,\emptyset_0(t) + Q_{25}(t) + Q_{26}(t)$ (3-5)

We can regard the failed state as absorbing

Taking Laplace-Stiljes transform of eq. (3-5) and solving for

$\emptyset_0^*(s) = N_1(s) / D_1(s)$ (6)

where

$N_1(s) = Q_{01}^*[\,Q_{13}^*(s) + Q_{14}^*(s)\,] + Q_{02}^*[\,Q_{25}^*(s) + Q_{26}^*(s)\,]$

$D_1(s) = 1 - Q_{01}^*\,Q_{10}^* - Q_{02}^*\,Q_{20}^*$

Making use of relations (1) & (2) it can be shown that $\emptyset_0^*(0) = 1$, which implies that $\emptyset_0(t)$ is a proper distribution.

$$MTSF = E[T] = \frac{d}{ds}\,\emptyset_0^*(s)\Big|_{s=0}$$

$= (D_1'(0) - N_1'(0)) / D_1(0)$

$= (\mu_0 + p_{01}\,\mu_1 + p_{02}\,\mu_2) / (1 - p_{01}\,p_{10} - p_{02}\,p_{20})$

where

$\mu_0 = \mu_{01} + \mu_{02}$,

$\mu_1 = \mu_{01} + \mu_{17}^{(4)} + \mu_{18}^{(3)}$,

$\mu_2 = \mu_{02} + \mu_{27}^{(6)} + \mu_{28}^{(5)}$

Availability analysis

Let $M_i(t)$ be the probability of the system having started from state i is up at time t without making any other regenerative state. By probabilistic arguments, we have

$M_0(t) = e^{-\lambda_1 t}e^{-\lambda_2 t}$, $M_1(t) = p\,G_1(t)\;e^{-(\lambda_1+\lambda_2)} = M_7(t)$

$M_2(t) = q\,G_2(t)\,e^{-(\lambda_1+\lambda_2)} = M_8(t)$

The point wise availability $A_i(t)$ have the following recursive relations

$A_0(t) = M_0(t) + q_{01}(t)[c]A_1(t) + q_{02}(t)[c]A_2(t)$

$A_1(t) = M_1(t) + q_{10}(t)[c]A_0(t) + q_{18}^{(3)}(t)[c]A_8(t) + q_{17}^{(4)}(t)[c]A_7(t)$,

$A_2(t) = M_2(t) + q_{20}(t)[c]A_0(t) + [q_{28}^{(5)}(t)[c]\,A_8(t) + q_{27}^{(6)}(t)]\,[c]A_7(t)$

$A_7(t) = M_7(t) + q_{70}(t)[c]A_0(t) + [q_{71}^{(4)}(t)[c]\,A_1(t) + q_{78}^{(3)}(t)]\,[c]A_8(t)$

$A_8(t) = M_8(t) + q_{80}(t)[c]A_0(t) + [q_{82}^{(5)}(t)[c]\,A_2(t) + q_{87}^{(6)}(t)]\,[c]A_7(t)$ (7-11)

Taking Laplace Transform of eq. (7-11) and solving for $\hat{A}_0(s)$

$\hat{A}_0(s) = N_2(s) / D_2(s)$ (12)

where

$N_2(s) = \hat{M}_0(1 - \hat{q}_{78}^{(3)} - \hat{q}_{87}^{(6)}) - \hat{q}_{82}^{(5)}(\hat{q}_{27}^{(6)}\,\hat{q}_{78}^{(3)} + \hat{q}_{28}^{(5)} - \hat{q}_{71}^{(4)}(\hat{q}_{17}^{(4)} + \hat{q}_{87}^{(6)}\,\hat{q}_{18}^{(3)}) + \hat{q}_{71}^{(4)}\,\hat{q}_{82}^{(5)}(\hat{q}_{17}^{(4)} - \hat{q}_{27}^{(6)}\,\hat{q}_{18}^{(3)})] + \hat{q}_{01}[\hat{M}_1(1 -$

$\hat{q}_{78}^{(3)}\ \hat{q}_{87}^{(6)}) + \hat{q}_{71}^{(4)}(\ \hat{M}_7 + \hat{q}_{78}^{(3)}$

$\hat{M}_8) + \hat{q}_{18}^{(3)}(\ \hat{M}_7\ \hat{q}_{87}^{(6)} - \hat{M}_8) -$

$\hat{q}_{82}^{(5)}(\ \hat{M}_1(\ \hat{q}_{27}^{(6)}\ \hat{q}_{78}^{(3)} + \hat{q}_{28}^{(5)}) +$

$\hat{q}_{17}^{(4)}(-\hat{M}_2(\ \hat{q}_{78}^{(3)} + \hat{M}_7 \hat{q}_{28}^{(5)}) -$

$\hat{q}_{18}^{(3)}(\ \hat{M}_2 + \hat{M}_7 \hat{q}_{27}^{(6)})\}]\ \hat{q}_{02}[\ \hat{M}_2(1 - \hat{q}_{78}^{(3)}\ \hat{q}_{87}^{(6)}) + \hat{q}_{27}^{(6)}($

$\hat{M}_7 + \hat{q}_{78}^{(3)}\ \hat{M}_8) + \hat{q}_{28}^{(5)}(\ \hat{M}_7$

$\hat{q}_{87}^{(6)} + \hat{M}_8) - \hat{q}_{71}^{(4)}(\ \hat{M}_1(-\ \hat{q}_{27}^{(6)} -$

$\hat{q}_{28}^{(5)} + \hat{q}_{87}^{(6)}) + \hat{q}_{17}^{(4)}(\ \hat{M}_2 + \hat{q}_{28}^{(5)}$

$\hat{M}_8) - \hat{q}_{18}^{(3)}(-\hat{M}_2\ \hat{q}_{87}^{(6)} + \hat{M}_8$

$\hat{q}_{27}^{(6)})\}]\ \hat{q}_{18}^{(3)}(\ \hat{M}_2 + \hat{M}_7 \hat{q}_{27}^{(6)})\}]$

$D_2(s) = (1 - \hat{q}_{78}^{(3)} - \hat{q}_{87}^{(6)}) - \hat{q}_{82}^{(5)}($

$\hat{q}_{27}^{(6)}\ \hat{q}_{78}^{(3)} + \hat{q}_{28}^{(5)}) - \hat{q}_{71}^{(4)}$

$(\ \hat{q}_{17}^{(4)} + \hat{q}_{87}^{(6)}\ \hat{q}_{18}^{(3)}) + \hat{q}_{71}^{(4)}\ \hat{q}_{82}^{(5)}(\ \hat{q}_{17}^{(4)}\ \hat{q}_{28}^{(5)} - \hat{q}$

$_{18}^{(3)})] + \hat{q}_{01}[-\hat{q}_{10}(1 -$

$\hat{q}_{78}^{(3)}\ \hat{q}_{87}^{(6)}) - \hat{q}_{71}^{(4)}(\ \hat{q}_{70} + \hat{q}_{78}^{(3)}$

$\hat{q}_{80}) - \hat{q}_{18}^{(3)}(\ \hat{q}_{70}\ \hat{q}_{87}^{(6)} - \hat{q}_{80}) -$

$\hat{q}_{82}^{(5)}(-\hat{q}_{10}(\ \hat{q}_{27}^{(6)}\ \hat{q}_{78}^{(3)} + \hat{q}_{28}^{(5)}) +$

$\hat{q}_{17}^{(4)}(\hat{q}_{20}(\ \hat{q}_{78}^{(3)} - \hat{q}_{70}\hat{q}_{28}^{(5)}) +$

$\hat{q}_{18}^{(3)}(\ \hat{q}_{20} + \hat{q}_{70}\hat{q}_{27}^{(6)})\}]\ \hat{q}_{02}[-\hat{q}_{20}(1 - \hat{q}_{78}^{(3)}\ \hat{q}_{87}^{(6)})$

$-\hat{q}_{27}^{(6)}(\ \hat{q}_{70} + \hat{q}_{78}^{(3)}$

$\hat{q}_{80}) - \hat{q}_{28}^{(5)}(\ \hat{q}_{70}\hat{q}_{87}^{(6)} + \hat{q}_{80}) - \hat{q}_{71}^{(4)}(\ \hat{q}_{10}(\ \hat{q}_{27}^{(6)} +$

$\hat{q}_{28}^{(5)}\ \hat{q}_{87}^{(6)}) - \hat{q}_{17}^{(4)}(\hat{q}_{20} - \hat{q}_{28}^{(5)}\ \hat{q}_{80}) - \hat{q}_{18}^{(3)}(\ \hat{q}_{20}\ \hat{q}$

$_{87}^{(6)} +$

$\hat{q}_{80}\ \hat{q}_{27}^{(6)})\}]$

(Omitting the arguments s for brevity)

The steady state availability

$A_0 = \lim_{t\to\infty}[A_0(t)]$

$= \lim_{s\to 0}[s\,\hat{A}_0(s)] = \lim_{s\to 0}\frac{s\,N_2(s)}{D_2(s)}$

Using L' Hospitals rule, we get

$A_0 = \lim_{s\to 0}\frac{N_2(s)+s\ N_2'(s)}{D_2'(s)} = \frac{N_2(0)}{D_2'(0)}$ (13)

The expected up time of the system in (0,t] is

$\lambda_u(t) = \int_0^\infty A_0(z)dz$

So that $\overline{\lambda_u}(s) = \frac{\hat{A}_0(s)}{s} = \frac{N_2(S)}{SD_2(S)}$ (14)

The expected down time of the system in (0,t] is

$\lambda_d(t) = t - \lambda_u(t)$

So that $\overline{\lambda_d}(s) = \frac{1}{s^2} - \overline{\lambda_u}(s)$ (15)

The expected busy period of the server when there is failure due to repair was deemed impossible and decommissioning too expensive or failure due to accident in (0,t]

$R_0(t) = q_{01}(t)[c]R_1(t) + q_{02}(t)[c]R_2(t)$

$R_1(t) = S_1(t) + q_{10}(t)[c]R_0(t) +$

$q_{18}^{(3)}(t)[c]\,R_8(t) + q_{17}^{(4)}(t)[c]R_7(t)$

$R_2(t) = S_2(t) + q_{20}(t)[c]R_0(t) +$

$q_{28}^{(5)}(t)\,R_8(t) + q_{27}^{(6)}(t)][c]R_7(t)$

$R_7(t) = S_7(t) + q_{70}(t)[c]R_0(t) +$

$Q_{71}^{(4)}(t)\,R_1(t) + q_{78}^{(3)}(t)][c]R_8(t)$

$R_8(t) = S_8(t) + q_{80}(t)[c]R_0(t) +$

$Q_{82}^{(5)}(t)\,R_2(t) + q_{87}^{(6)}(t)][c]R_7(t)$ (16-20)

Taking Laplace Transform of eq. (16-20) and solving for $\overline{R_0}(s)$

$\overline{R_0}(s) = N_3(s)\ /\ D_2(s)$ (21)

where

$N_3(s) = \hat{q}_{01}[\,\hat{S}_1(1 - \hat{q}_{78}^{(3)}\ \hat{q}_{87}^{(6)}) + \hat{q}_{71}^{(4)}(\,\hat{S}_7 + \hat{q}_{78}^{(3)}$

$\hat{S}_8) + \hat{q}_{18}^{(3)}(\,\hat{S}_7$

$\hat{q}_{87}^{(6)} - \hat{S}_8)] - \hat{q}_{01}\hat{q}_{82}^{(5)}(\,\hat{S}_1\ \hat{q}_{27}^{(6)}\ \hat{q}_{78}^{(3)} + \hat{q}_{28}^{(5)}) + \hat{q}_{17}^{(4)}$

$(\hat{S}_2\ \hat{q}_{78}^{(3)} + \hat{S}_7\hat{q}_{28}^{(5)}) -$

$\hat{q}_{18}^{(3)}(\,\hat{S}_2 + \hat{S}_7\hat{q}_{27}^{(6)})] + \hat{q}_{02}[\hat{S}_2(1 - \hat{q}_{78}^{(3)}\ \hat{q}_{87}^{(6)}) + \hat{q}$

$_{27}^{(6)}(\,\hat{S}_7 + \hat{q}_{78}^{(3)}\,\hat{S}_8) + \hat{q}_{28}^{(5)}(\,\hat{S}_7\ \hat{q}_{87}^{(6)} + \hat{S}_8) - \hat{q}_{02}\hat{q}_{71}^{(4)}($

$\hat{S}_1(-\ \hat{q}_{27}^{(6)} - \hat{q}_{28}^{(5)}\ \hat{q}_{87}^{(6)}\ \hat{q}_{17}^{(4)}(\hat{S}_2 + \hat{q}_{28}^{(5)}\,\hat{S}_8) - \hat{q}_{18}^{(3)}(-$

$\hat{S}_2\ \hat{q}_{87}^{(6)} + \hat{S}_8\ \hat{q}_{27}^{(6)})]$

and

$D_2(s)$ is already defined.

(Omitting the arguments s for brevity)

In the long run, $R_0 = \frac{N_3(0)}{D_2'(0)}$ (22)

The expected period of the system under failure due to repair was deemed impossible and decommissioning too expensive failure or failure of fuel cell operation due to accident is

$\lambda_{rv}(t) = \int_0^\infty R_0(z)dz$ So that $\overline{\lambda_{rv}}(s) = \frac{\hat{R}_0(s)}{s}$

The expected number of visits by the repairman for repairing the identical units in (0,t]

$H_0(t) = Q_{01}(t)[s][1 + H_1(t)] +$

$Q_{02}(t)[s][1+ H_2(t)]$

$H_1(t) = Q_{10}(t)[s]H_0(t)] + Q_{18}^{(3)}(t)[s]$

$H_8(t) + Q_{17}^{(4)}(t)] [s]H_7(t)$,

$H_2(t) = Q_{20}(t)[s]H_0(t) + Q_{28}^{(5)}(t) [s]$

$H_8(t) +Q_{27}^{(6)}(t)] [c]H_7(t)$

$H_7(t) = Q_{70}(t)[s]H_0(t) + Q_{71}^{(4)}(t) [s]$

$H_1(t) +Q_{78}^{(3)}(t)] [c]H_8(t)$

$H_8(t) = Q_{80}(t)[s]H_0(t) + Q_{82}^{(5)}(t) [s]$

$H_2(t) +Q_{87}^{(6)}(t)] [c]H_7(t)$ (23-27)

Taking Laplace Transform of eq. (23-27) and solving for $H_0^*(s)$

$H_0^*(s) = N_4(s) / D_3(s)$ (28)

In the long run ,

$H_0 = N_4(0) / D_3'(0)$ (29)

Benefit- Function Analysis

The Benefit-Function analysis of the system considering mean up-time, expected busy period of the system under failure due to repair was deemed impossible and decommissioning too expensive failure or failure due to accident, expected number of visits by the repairman for unit failure.

The expected total Benefit-Function incurred in (0,t] is

C(t) = Expected total revenue in (0,t]

- expected busy period of the system under failure due to repair was deemed impossible and decommissioning too expensive failure or failure due to accident for repairing the units in (0,t]

- expected number of visits by the repairman for repairing of identical the units in (0,t]

The expected total cost per unit time in steady state is

$$C = \lim_{t\to\infty}(C(t)/t)$$

$$= \lim_{s\to 0}(s^2 C(s))$$

$= K_1A_0 - K_2R_0 - K_3H_0$

where

K_1 - revenue per unit up-time,

K_2 - cost per unit time for which the system is under repair of type- I or type- II

K_3 - cost per visit by the repairman for units repair.

CONCLUSION

After studying the system , we have analyzed graphically that when the failure rate due to failure due to repair was deemed impossible and decommissioning too expensive or failure due to accident increases, the MTSF and steady state availability decreases and the Benefit-function decreased as the failure increases.

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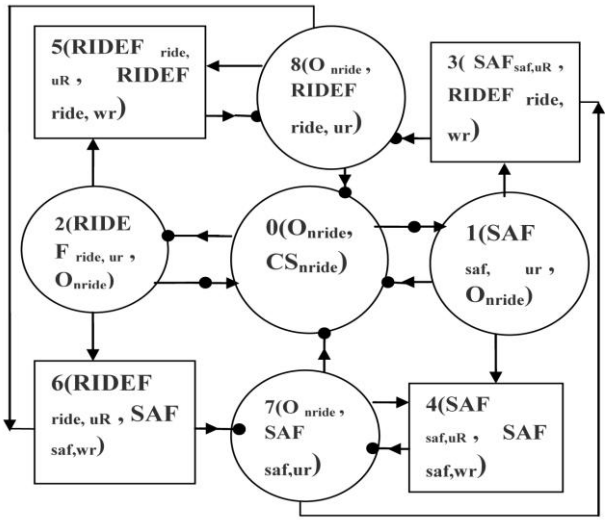

Fig. The State Space Diagram

◯ up state ▭ down state

• Regeration point