Research Article

Profit-function of two - identical cold standby aircraft system subject to failure due to damaged by explosive device/weapons and failure due to extreme cold

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Abstract

Several aviation incidents and accidents have occurred in which the control surfaces of the aircraft became disabled, often due to failure of hydraulic systems or the flight control system. Other incidents have occurred where controls were not functioning correctly prior to take-off, either due to maintenance or pilot error, and controls can become inoperative from extreme weather conditions. Aircraft are not designed to be flown in such circumstances, however a small number of pilots have had some success in flying and landing aircraft with disabled controls. **Control techniques** A basic means of controlling an aircraft with disabled flight controls, discovered through crew experience, is by making use of the position of the engines. If the engines are mounted under the centre of gravity, as is the case in most passenger jets, then increasing the thrust will raise the nose, while decreasing the thrust will lower it. This control method may call for control inputs that go against the pilot's instinct: when the aircraft is in a dive, adding thrust will raise the nose and vice versa. Additionally, asymmetrical thrust has been used for directional control: if the left engine is idled and power is increased on the right side this will result in a yaw to the left, and vice versa. If throttle settings allow the throttles to be shifted without affecting the total amount of power, then yaw control can be combined with pitch control. If the aircraft is yawing, then the wing on the outside of this yaw movement will go faster than the inner wing. This creates higher lift on the faster wing, resulting in a rolling movement, which helps to make a turn. Controlling airspeed has been shown to be very difficult with engine control only, often resulting in a fast landing. A faster than normal landing also results when the flaps can not be extended due to loss of hydraulics. Another challenge for pilots who are forced to fly an aircraft without functioning control surfaces is to avoid the phugoid instability mode (a cycle in which the aircraft repeatedly climbs and then dives), which requires careful use of the throttle. Because this type of aircraft control is difficult for humans to achieve, researchers have attempted to integrate this control ability into the computers of fly-by-wire aircraft. Early attempts to add the ability to real aircraft were not very successful, the software having been based on experiments conducted in flight simulators where jet engines are usually modelled as "perfect" devices with exactly the same thrust on each engine, a linear relationship between throttle setting and thrust, and instantaneous response to input. More modern computer systems have been updated to account for these factors, and aircraft have been successfully flown with this software installed. However, it remains a rarity on commercial aircraft. In this paper we have taken **failure due to damaged by explosive device/weapons or failure due to Extreme cold.** When the main unit fails due to failure due to damaged by explosive device/weapons then cold standby system becomes operative. Failure due to damaged by explosive device/weapons cannot occur simultaneously in both the units and after failure the unit undergoes Type-I or Type-II or Type-III 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 damaged by explosive device/weapons or failure due to Failure in cooling loop A, first come first serve, MTSF, Availability, Busy period, Benefit -Function.

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INTRODUCTION

Controls damaged by explosive device/weapons

- Philippine Airlines Flight 434, a Boeing 747, on 11 December 1994. The hydraulics were damaged by a bomb in the passenger cabin.
- DHL shoot down incident in Baghdad on 22 November 2003. The Airbus A300 DHL aircraft, hit by a surface-to-air missile, was the first jet airliner to land safely without any hydraulics using only engine controls.

Figure 1: Failure due to Extreme cold

The XCO-5, an experimental observation biplane flown in altitude tests. On October 10, 1928, U.S. Army photographer Albert William Stevens and Captain St. Clair Streett, the chief of the U.S. Army Air Corps Materiel Division's Flying Branch, flew the XCO-5 experimental biplane to achieve an unofficial altitude record for aircraft carrying more than one person: 37,854 feet (11,538 m); less than 1,000 feet (300 m) short of the official single-person altitude record. Stevens snapped photographs of the ground below, warmed by electrically heated mittens and many layers of clothing. At that height the men measured a temperature of −78 °F (−61 °C), cold enough to freeze the aircraft controls. When Stevens was finished with his camera, Streett found that the aircraft's controls were rendered immobile in the cold, with Streett unable to reduce throttle for descent. The aircraft's engine continued to run at the high power level necessary for maintaining high altitude. Streett contemplated diving at full power, but the XCO-5 was not built for such strong maneuvers—its wings could have sheared off. Instead, Streett waited until fuel was exhausted and the engine sputtered to a stop, after which he piloted the fragile aircraft down in a gentle glide and made a deadstick landing. An article about the feat appeared in *Popular Science* in May 1929, entitled "Stranded—Seven Miles Up!" Stochastic behavior of systems operating under changing environments has widely been studied. Dhillon, B.S. and Natesan, J. (1983) studied an outdoor power systems in fluctuating environment. Kan Cheng (1985) has studied reliability analysis of a system in a randomly changing environment. Jinhua Cao (1989) has studied a man machine system operating under changing environment subject to a Markov process with two states. The change in operating conditions viz. fluctuations of voltage, corrosive atmosphere, very low gravity etc. may make a system completely inoperative. Severe environmental conditions can make the actual mission duration longer than the ideal mission duration. In this paper we have taken **failure due to damaged by explosive device/weapons and failure due to Extreme cold.** When the main operative unit fails then cold standby system becomes operative. Failure due to Extreme cold cannot occur simultaneously in both the units and after failure the unit undergoes repair facility of Type- II by ordinary repairman or Type III by multispecialty repairman in case of failure due to damaged by explosive device/weapons immediately. The repair is done on the basis of first fail first repaired.

Assumptions

1. λ_1, λ_2 are constant failure rates for failure due to damage by explosive device/weapons or failure due to Extreme cold respectively. The CDF of repair time distribution of Type I, Type II and multispecialty repairmen Type-III are $G_1(t)$, $G_2(t)$ and $G_3(t)$.
2. The failure due to Extreme cold is non-instantaneous and it cannot come simultaneously in both the units.
3. The repair starts immediately after failure due to damaged by explosive device/weapons or failure due to Extreme cold and works on the principle of first fail first repaired basis.
4. The repair facility does no damage to the units and after repair units are as good as new.
5. The switches are perfect and instantaneous.
6. All random variables are mutually independent.
7. When both the units fail, we give priority to operative unit for repair.
8. Repairs are perfect and failure of a unit is detected immediately and perfectly.
9. The system is down when both the units are non-operative.

Notations

λ_1, λ_2 - failure rates for failure due to damaged by explosive device/weapons, failure due to Extreme cold respectively. $G_1(t)$, $G_2(t)$, $G_3(t)$ – repair time distribution Type –I, Type-II, Type III due to damaged by explosive device/weapons, due to Extreme cold, repair by the multispecialty repairman respectively. p, q - probability of failure due to damaged by explosive device/weapons and failure due to Extreme cold 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, DEDF, ECF,

Operative, Cold Standby, failure due to damaged by explosive device/weapons, failure due to Extreme cold respectively

Subscripts: ndedf, dedf, ecf, ur, wr, uR

No failure due to damaged by explosive device/weapons, failure due to damaged by explosive device/weapons, failure due to Extreme cold**,** under repair, waiting for repair, under repair continued from previous state respectively

Up states: 0, 1, 2, 3, 8, 9;

Down states: 4, 5, 6, 7

Regeneration point: 0, 1, 2, 3, 8, 9

States of the System

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

One unit is operative and the other unit is cold standby and there is no failure due to damaged by explosive device/weapons in both the units.

1($DEDF_{dedf, urI}$, O_{ndedf})

The operating unit fails due to failure due to damaged by explosive device/weapons and is under repair immediately of Type- I and standby unit starts operating with no failure due to damaged by explosive device/weapons.

2($ECF_{ecf, urII}$, O_{ndedf})

The operative unit fails due to Extreme cold and undergoes repair of type II and the standby unit becomes operative with no failure due to damaged by explosive device/weapons.

3($ECF_{ecf, urIII}$, O_{ndedf})

The first unit fails due to Extreme cold and under Type-III multispecialty repairman and the other unit is operative with no failure due to damaged by explosive device/weapons.

4($DEDF_{dedf,uR1}$, $DEDF_{dedf,wrI}$)

The unit failed due to DEDF resulting from Failure due to damaged by explosive device/weapons is under repair of Type- I continued from state 1and the other unit failed due to DEDF resulting from Failure due to damaged by explosive device/weapons is waiting for repair of Type-I.

5($DEDF_{dedf,uR1}$, $ECF_{ecf, wrII}$)

The unit failed due to DEDF resulting from Failure due to damaged by explosive device/weapons is under repair of Type- I continued from state 1and the other unit fails also due to Failure due to Extreme cold is waiting for repair of Type- II.

6($ECF_{ecf,\ uRII}$, $DEDF_{dedf,\ wrI}$)
The operative unit fails due to Failure due to Extreme cold and under repair continues from state 2 of Type –II and the other unit is failed due to DEDF resulting from Failure due to damaged by explosive device/weapons and under Type-I

7($ECF_{ecf,\ uRII,}$ $DEDF_{dedf,wrII}$)
The one unit fails due to Failure due to Extreme cold is continued to be under repair of Type II and the other unit failed due to DEDF resulting from Failure due to damaged by explosive device/weapons is waiting for repair of Type-II

8($DEDF_{dedf,urIII,}$ $ECF_{ecf,\ wrII}$)
The one unit fails due to damaged by explosive device/weapons is under multispecialty repair of Type-III and the other unit is failed due to Extreme cold is waiting for repair of Type-II.

9($DEDF_{dedf,urIII}$, $ECF_{ecf,\ wrI}$)
The one unit fails due to damaged by explosive device/weapons is under multispecialty repair of Type-III and the other unit is failed due to Extreme cold is waiting for repair of Type-I

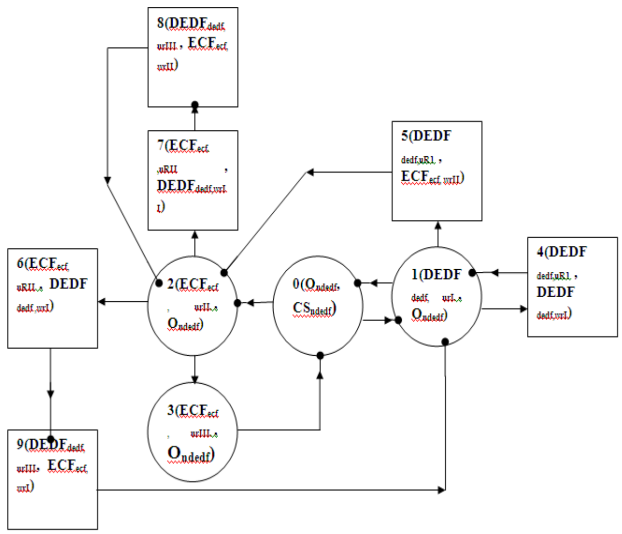

Figure 1: The State Transition Diagram

Up-State Down-State Regeneration point

TRANSITION PROBABILITIES

Simple probabilistic considerations yield the following expressions:

$p_{01} = \lambda_1 / \lambda_1 + \lambda_2$, $p_{02} = \lambda_2 / \lambda_1 + \lambda_2$, $p_{10} = pG_1^*(\lambda_1) + q\, G_2^*(\lambda_2)$,
$p_{14} = p - pG_1^*(\lambda_1) = p_{11}^{(4)}$, $p_{15} = q - q\, G_1^*(\lambda_2) = p_{12}^{(5)}$,
$p_{23} = pG_2^*(\lambda_1) + q\, G_2^*(\lambda_2)$, $p_{26} = p - pG_2^*(\lambda_1) = p_{29}^{(6)}$,
$p_{27} = q - qG_2^*(\lambda_2) = p_{28}^{(7)}$, $p_{30} = p_{82} = p_{91} = 1$ (1)

We can easily verify that

$p_{01} + p_{02} = 1$, $p_{10} + p_{14}\ (=p_{11}^{(4)}) + p_{15}\ (=p_{12}^{(5)}) = 1$,
$p_{23} + p_{26}\ (=p_{29}^{(6)}) + p_{27}\ (=p_{28}^{(7)}) = 1$ (2)

And mean sojourn time is

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

Mean Time To System Failure

$Ø_0(t) = Q_{01}(t)[s]\, Ø_1(t) + Q_{02}(t)[s]\, Ø_2(t)$
$Ø_1(t) = Q_{10}(t)[s]\, Ø_0(t) + Q_{14}(t) + Q_{15}(t)$
$Ø_2(t) = Q_{23}(t)[s]\, Ø_3(t) + Q_{26}(t) + Q_{27}(t)$
$Ø_3(t) = Q_{30}(t)[s]\, Ø_0(t)$ (3-6)

We can regard the failed state as absorbing

Taking Laplace-Stiljes transform of eq. (3-6) and solving for

$ø_0^*(s) = N_1(s) / D_1(s)$ (6)

where

$N_1(s) = Q_{01}^*[\,Q_{14}^*(s) + Q_{15}^*(s)\,] + Q_{02}^*[\,Q_{26}^*(s) + Q_{27}^*(s)\,]$
$D_1(s) = 1 - Q_{01}^* Q_{10}^* - Q_{02}^* Q_{23}^* Q_{30}^*$
Making use of relations (1) and (2) it can be shown that $ø_0^*(0) = 1$, which implies that $ø_0(t)$ is a proper distribution.

$$MTSF = E[T] = \frac{d}{ds} ø_0^*(s) \Big|_{s=0} = (D_1'(0) - N_1'(0)) / D_1(0)$$

$= (\mu_0 + p_{01}\mu_1 + p_{02}\mu_2) / (1 - p_{01}p_{10} - p_{02}p_{23})$
where
$\mu_0 = \mu_{01} + \mu_{02}$,
$\mu_1 = \mu_{10} + \mu_{11}^{(4)} + \mu_{12}^{(5)}$,
$\mu_2 = \mu_{23} + \mu_{28}^{(7)} + \mu_{29}^{(6)}$

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
$M_0(t) = e^{-\lambda_1 t} e^{-\lambda_2 t}$, $M_1(t) = p\, G_1(t)\, e^{-\lambda_1 t}$ $\overline{\ }$
$M_2(t) = q\, \overline{G_2(t)}$, $M_3(t) = \overline{G_3(t)}$
The point wise availability $A_i(t)$ have the following recursive relations
$A_0(t) = M_0(t) + q_{01}(t)[c]A_1(t) + q_{02}(t)[c]A_2(t)$
$A_1(t) = M_1(t) + q_{10}(t)[c]A_0(t) + q_{12}^{(5)}(t)[c]A_2(t) + q_{11}^{(4)}(t)[c]A_1(t)$,
$A_2(t) = M_2(t) + q_{23}(t)[c]A_3(t) + q_{28}^{(7)}(t)[c]\, A_8(t) + q_{29}^{(6)}(t)]\, [c]A_9(t)$
$A_3(t) = M_3(t) + q_{30}(t)[c]A_0(t)$
$A_8(t) = q_{82}(t)[c]A_2(t)$
$A_9(t) = q_{91}(t)[c]A_1(t)$ (7-11)

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

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

where
$N_2(s) = \hat{M}_0[\{1 - \hat{q}_{11}^{(4)}\}\{1 - \hat{q}_{28}^{(7)}\hat{q}_{82}\} - \hat{q}_{12}^{(5)}\hat{q}_{29}^{(6)}\hat{q}_{91}] + \hat{q}_{01}[\hat{M}_1\{1 - \hat{q}_{28}^{(7)}\hat{q}_{82}\} + \hat{q}_{12}^{(5)}\hat{q}_{23}\hat{M}_3] + \hat{q}_{02}[\{\hat{q}_{23}\hat{M}_3 + \hat{M}_2\}\{1 - \hat{q}_{11}^{(4)}\} + \hat{q}_{29}^{(6)})\hat{q}_{91}\hat{M}_1]$
$D_2(s) = \{1 - \hat{q}_{11}^{(4)}\}\{1 - \hat{q}_{28}^{(7}\hat{q}_{82}\} - \hat{q}_{12}^{(5)}\hat{q}_{29}^{(6)}\hat{q}_{91} - \hat{q}_{01}[\hat{q}_{10}\{1 - \hat{q}_{28}^{(7)}\hat{q}_{82}\} + \hat{q}_{12}^{(5)}\hat{q}_{23}] - \hat{q}_{02}[\{\hat{q}_{23}\hat{q}_{30}\{1 - \hat{q}_{11}^{(4)}\} + \hat{q}_{29}^{(6)}\hat{q}_{91}\hat{q}_{10}]$
(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

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

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

$$\lambda_u(t) = \int_0^{\infty} A_0(z)\,dz \text{ So that } \widetilde{\lambda_u}(s) = \frac{\hat{A}_0(s)}{s} = \frac{N_2(S)}{SD_2(S)} \qquad (14)$$

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

$$\lambda_d(t) = t - \lambda_u(t) \text{ So that } \widetilde{\lambda_d}(s) = \frac{1}{s^2} - \widetilde{\lambda_u}(s) \qquad (15)$$

The expected busy period of the server when there is failure due to Extreme cold and failure due to damaged by explosive device/weapons in (0,t]

$R_0(t) = q_{01}(t)[c]R_1(t) + q_{02}(t)[c]R_2(t)$
$R_1(t) = S_1(t) + q_{10}(t)[c]R_0(t) + q_{12}^{(5)}(t)[c]\, R_2(t) + q_{11}^{(4)}(t)[c]R_1(t)$
$R_2(t) = S_2(t) + q_{23}(t)[c]R_3(t) + q_{28}^{(7)}(t)\, R_8(t) + q_{29}^{(6)}(t)][c]R_9(t)$

$R_3(t) = S_3(t) + q_{30}(t)[c]R_0(t)$
$R_8(t) = S_8(t) + q_{82}(t)[c]R_2(t)$
$R_9(t) = S_9(t) + q_{91}(t)[c]R_1(t)$ (16-21)
where
$S_1(t) = p\, G_1\overline{(t)}\, e^{-\lambda_1 t}, S_1(t) = q\, G_2(t)\, e^{-\lambda_2 t}\, \overline{S_3(t)} = S_8(t) = S_9(t) = G_3(t)$ (22)
Taking Laplace Transform of eq. (16-21) and solving for $\overline{R_0}(s)$
$\overline{R_0}(s) = N_3(s) / D_2(s)$ (23)
where
$N_3(s) = \hat{q}_{01}[\hat{S}_1(1 - \hat{q}_{28}^{(7)}\hat{q}_{82}) + \hat{q}_{12}^{(5)}[\hat{S}_2 + \hat{q}_{23}\hat{S}3 + \hat{q}_{28}^{(7)}(\hat{S}8 + \hat{q}_{29}^{(6)}\hat{S}9)] + \hat{q}_{02}[(\hat{S}_2 + \hat{q}_{23}\hat{S}_3 + \hat{q}_{28}^{(7)}\hat{S}_8 + \hat{S}_9\hat{q}_{29}^{(6)})(1 - \hat{q}_{11}^{(4)}) + \hat{S}_1\hat{q}_{29}^{(6)}\hat{q}_{91}]$
and $D_2(s)$ is already defined. (Omitting the arguments s for brevity)
In the long run, $R_0 = \dfrac{N_3(0)}{D_2'(0)}$ (24)
The expected period of the system under failure due to Failure due to Extreme cold and failure due to damaged by explosive device/weapons is
$\lambda_{rv}(t) = \int_0^\infty R_0(z)dz$ So that $\overline{\lambda_{rv}}(s) = \dfrac{\hat{R}_0(s)}{s}$

The expected number of visits by the repairman Type-I or Type-II for repairing the identical units in (0, t]

$H_0(t) = Q_{01}(t)[s][1 + H_1(t)] + Q_{02}(t)[s][1 + H_2(t)]$
$H_1(t) = Q_{10}(t)[s]H_0(t)] + Q_{12}^{(5)}(t)[s]\, H_8(t) + Q_{11}^{(4)}(t)]\,[s]H_1(t),$
$H_2(t) = Q_{23}(t)[s]H_3(t) + Q_{28}^{(7)}(t)\,[s]\, H_8(t) + Q_{29}^{(6)}(t)]\,[c]H_9(t)$
$H_3(t) = Q_{30}(t)[s]H_0(t)$
$H_8(t) = Q_{82}(t)[s]H_2(t)$
$H_9(t) = Q_{91}(t)[s]H_1(t)$ (25-30)
Taking Laplace Transform of eq. (25-30) and solving for $H_0^*(s)$
$H_0^*(s) = N_4(s) / D_3(s)$ (31)
$N_4(s) = \{Q_{01}^* + Q_{02}^*\}[\{1 - Q_{28}^{(7)*}Q_{82}^*\} - Q_{12}^{(5)*}Q_{29}^{(6)*}Q_{91}^*]$
And
$D_3(s) = \{1 - Q_{11}^{(4)*}\}\{1 - Q_{28}^{(7)*}Q_{82}^*\} - Q_{12}^{(5)*}Q_{29}^{(6)*}Q_{91}^* - Q_{01}^*[Q_{10}^*\{1 - Q_{28}^{(7)*}Q_{82}^*\} + Q_{12}^{(5)*}Q_{23}^*Q_{30}^*] - Q_{02}^*Q_{30}^*\{1 - Q_{11}^{(4)*}\} + Q_{29}^{(6)*}Q_{91}^*Q_{10}^*]$
(Omitting the arguments s for brevity)
In the long run,
$H_0 = N_4(0) / D_3'(0)$ (32)
where
$N_4(0) = \{1 - p_{11}^{(4)}\}\{1 - p_{28}^{(7)}\} - p_{12}^{(5)}p_{29}^{(6)}$

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

$W_0(t) = Q_{01}(t)[s][1 + W_1(t)] + Q_{02}(t)[s][1 + W_2(t)]$
$W_1(t) = Q_{10}(t)[s]W_0(t)] + Q_{12}^{(5)}(t)[s]\, W_8(t) + Q_{11}^{(4)}(t)]\,[s]W_1(t),$
$W_2(t) = Q_{23}(t)[s]W_3(t) + Q_{28}^{(7)}(t)\,[s]\, W_8(t) + Q_{29}^{(6)}(t)]\,[c]W_9(t)$
$W_3(t) = Q_{30}(t)[s]W_0(t)$
$W_8(t) = Q_{82}(t)[s]W_2(t)$
$W_9(t) = Q_{91}(t)[s]W_1(t)$ (33-38)
Taking Laplace Transform of eq. (33-38) and solving for $H_0^*(s)$
$H_0^*(s) = N_5(s) / D_3(s)$ (39)
$N_5(s) = Q_{01}^*Q_{12}^{(5)*}[Q_{23}^*Q_{30}^* + Q_{28}^{(5)*}Q_{82}^* + Q_{29}^{(6)*}Q_{91}^*] + Q_{02}^*[Q_{23}^*Q_{30}^* + Q_{28}^{(5)*}Q_{82}^* + Q_{29}^{(6)*}Q_{91}^*]\{1 - Q_{11}^{(4)*}\}]$
(Omitting the arguments s for brevity) In the long run,
$W_0 = N_5(0) / D_3'(0)$ (40)
Where
$N_5(0) = p_{01}p_{12}^{(5)} + p_{02}\{1 - p_{11}^{(4)}\}$

Benefit- Function Analysis

The Benefit-Function analysis of the system considering mean up-time, expected busy period of the system under failure due to Failure due to Extreme cold and failure due to damaged by explosive device/weapons, 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 Failure due to Extreme cold and failure due to damaged by explosive device/weapons for repairing the units in (0,t]
- expected number of visits by the repairman Type- I or Type- II for repairing of identical the units in (0,t]
- expected number of visits by the multispecialty repairman Type- III for repairing of identical the units in (0,t]

The expected total cost per unit time in steady state is

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

$= K_1A_0 - K_2R_0 - K_3H_0 - K_4W_0$

where

K_1: Revenue per unit up-time,

K_2: Cost per unit time for which the system is busy under repairing,

K_3: Cost per visit by the repairman type- I or type- II for units repair,

K_4: Cost per visit by the multispecialty repairman Type- III for units repair

CONCLUSION

After studying the system, we have analyzed graphically that when the failure rate failure due to Extreme cold and failure due to damaged by explosive device/weapons increases, the MTSF, steady state availability decreases and the Profit-function decreased as the failure increases.

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