Research Article

Profit-function of two- identical cold standby satellite system subject to failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to developmental flight, payload placed into lower than planned orbit

Ashok Kumar Saini

Associate Professor, (Maths), Bljs College, Tosham (Bhiwani) Haryana, INDIA.
Email: drashokksaini2009@gmail.com

Abstract

Background: In this paper we have taken failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit. When the main unit fails then cold standby system becomes operative. Failure payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit 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, sub-orbital flight of the vehicle, failure due to Developmental Flight, payload placed into lower than planned orbit, first come first serve, MTSF, Availability, Busy period, Benefit -Function.

***Address for Correspondence:**
Dr Ashok Kumar Saini, Associate Professor, (Maths), Bljs College, Tosham (Bhiwani) Haryana, INDIA.
Email: drashokksaini2009@gmail.com
Received Date: 20/10/2021 Revised Date: 19/11/2021 Accepted Date: 11/12/2021
DOI:

Access this article online	
Quick Response Code:	Website: www.statperson.com
	Volume 12 Issue 1

INTRODUCTION

The following list gives a detailed record of the launches taken place in **Satish Dhawan Space Centre**. It is the main satellite launch centre for the Indian Space Research Organisation (ISRO). It is located in Sriharikota, Andhra Pradesh, 80 km (50 mi) north of Chennai. Originally called **Sriharikota High Altitude Range** (**SHAR**), an acronym ISRO have retained to the present day) and then **Sriharikota Launching Range**, the centre was renamed in 2002 after the death of ISRO's former chairman Satish Dhawan.

No. of launches
As of 18 December 2014,
Total no. of launches = **45**
Mission status wise
Successful launches = **33,**
Launches which left payloads usable = **37,**
Failed launches = **8**

How to cite this article: Manaswini Khuntia, Ritanjali Behera. Etiology and management of pubertymenorrhagia in adolescent girls. *International Journal of Recent Trends in Science and Technology* January to March 2022; 12(1): 36-42 http://www.statperson.com

Rocket used wise
SLV = **4** (1 failure, 1 partial failure and 2 successful),
ASLV = **4** (2 failures, 1 partial failure and 1 successful)
PSLV = **28** (1 failure, 1 partial failure and 26 successful),
GSLV = **9** (4 Failures, 1 partial failure and 4 successful)
Launch Pad used wise
SLV Launch Pad = **8** (3 Failures, 2 partial failure and 3 successful)
First Launch Pad = **25** (2 Failures, 1 partial failure and 22 successful)
Second Launch Pad = **12** (3 Failures, 1 partial failure and 8 successful)

20 September 1993	First	PSLV	D1	Failure	Unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle. One of the retro rockets designed to pull the burnt second stage away from the third stage failed.
18 April 2001	First	GSLV Mk I(a)	D1	Failure	Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit.

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 unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit. When the main operative unit fails then cold standby system becomes operative. Failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit 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 Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit immediately. The repair is done on the basis of first fail first repaired.

Assumptions

1. λ_1, λ_2 are constant failure rates due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit 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 Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit is non-instantaneous and it cannot come simultaneously in both the units.
3. The repair starts immediately after critical failure of ISS without astronauts 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 unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit respectively.

$G_1(t)$, $G_2(t)$, $G_3(t)$ – repair time distribution Type –I, Type-II, Type III due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbite to, repair by the multispecialty repairman respectively.

p, q - probability of failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit 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, SOFF, LPOF,

Operative, Cold Standby, failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit respectively

Subscripts nsoff, soff, lpof, ur, wr, uR

No failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle, failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle, failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit, 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_{nsoff}, CS_{nsoff})

One unit is operative and the other unit is cold standby and there is no failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle in both the units.

1($SOFF_{soff, urI}$, O_{nsoff}): The operating unit fails due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and is under repair immediately of Type- I and standby unit starts operating with no failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle.

2($LPOF_{lpof, urII}$, O_{nsoff}): The operative unit fails due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit and undergoes repair of type II and the standby unit becomes operative with no failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle.

3($LPOF_{lpof, urIII}$, O_{nsoff}): The first unit fails due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit and under Type-III multispecialty repairman and the other unit is operative with no failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle.

4($SOFF_{soff,uR1}$, $SOFF_{soff,wrI}$): The unit failed due to SOFF resulting from unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and is under repair immediately of Type- I is under repair of Type- I continued from state 1and the other unit failed due to SOFF resulting from fails due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and is waiting for repair of Type-I.

5($SOFF_{soff,uR1}$, $LPOF_{lpof, wrII}$): The unit failed due to SOFF resulting from unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and is under repair of Type- I continued from state 1and the other unit fails due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit is waiting for repair of Type- II.

6($LPOF_{lpof, uRII}$, $SOFF_{soff ,wrI}$): The operative unit fails due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit and under repair continues from state 2 of Type –II and the other unit is failed due to SOFF resulting from unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and waiting for repair of Type-I

7($LPOF_{lpof ,uRII}$, $SOFF_{soff,wrII}$): The one unit fails due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit continued to be under repair of Type II and the other unit failed due to SOFF resulting from unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle is waiting for repair of Type-II

8($SOFF_{soff,urIII}$, $LPOF_{lpof, wrII}$): The one unit failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle is under multispecialty repair of Type-III and the other unit is failed due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit is waiting for repair of Type-II.

9($SOFF_{soff,urIII}$, $LPOF_{lpof, wrI}$): The one unit failure due to unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle is under multispecialty repair of Type-III and the other unit is failed due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit is waiting for repair of Type-I

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)

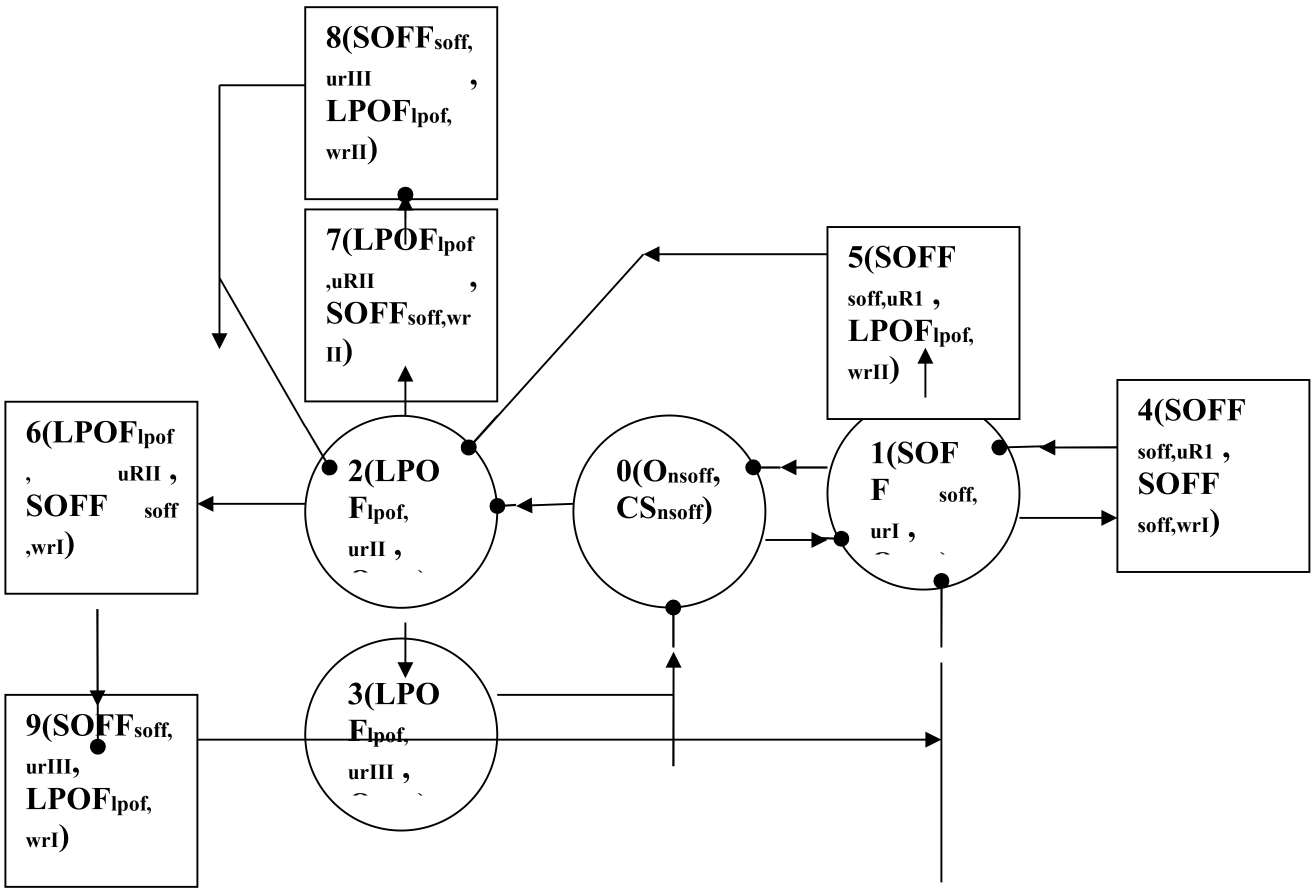

Fig. The State Transition Diagram

Up-State Down-State
regeneration point

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] = $\frac{d}{ds}\phi_0^{*}(s)$
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

$M_0(t) = e^{-\lambda_1 t} e^{-\lambda_2 t}$, $M_1(t) = p\, G_1(t)\, e^{-\lambda_1 t}$
$M_2(t) = q\, \overline{G_2(t)}$, $M_3(t) = \overline{G_3(t)}$

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 $\hat{A}_0(s)$

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

(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

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

(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 unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit respectively 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
$S_1(t) = p\,\overline{G_1(t)}\, e^{-\lambda_1 t}$, $S_1(t) = q\, G_2(t)\, e^{-\lambda_2 t}$ $\overline{S_3(t)} = S_8(t) = S_9(t) = G_3(t)$
(22)
Taking Laplace Transform of eq. (16-21) and solving for $\bar{R}_0(s)$

$$\bar{R}_0(s) = N_3(s) / D_2(s)$$

(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 unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit is
$\lambda_{rv}(t) = \int_0^\infty R_0(z)dz$ So that $\bar{\lambda}_{rv}(s) = \dfrac{\hat{R}_0(s)}{s}$

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 unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit, 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 unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit 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 unexpected large disturbance at the second stage separation resulting in a sub-orbital flight of the vehicle and failure due to Developmental Flight, payload placed into lower than planned orbit, and did not have sufficient fuel to reach a usable orbit increases, the MTSF, steady state availability decreases and the Profit-function decreased as the failure increases.

REFERENCES

1. Dhillon, B.S. and Natesen, J, Stochastic Anaysis of outdoor Power Systems in fluctuating environment, Microelectron. Reliab. ,1983; 23, 867-881.
2. Kan, Cheng, Reliability analysis of a system in a randomly changing environment, Acta Math. Appl. Sin. 1985, 2, pp.219-228.
3. Cao, Jinhua, Stochatic Behaviour of a Man Machine System operating under changing environment subject to a Markov Process with two states, Microelectron. Reliab. ,1989; 28, pp. 373-378.
4. Barlow, R.E. and Proschan, F., Mathematical theory of Reliability, 1965; John Wiley, New York.
5. Gnedanke, B.V., Belyayar, Yu.K. and Soloyer , A.D. , Mathematical Methods of Relability Theory, 1969 ; Academic Press, New York.

Source of Support: None Declared
Conflict of Interest: None Declared