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Procedure for Improving Quality Through Reliable Data

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Abstract

Truncation test is the ability to search small number of samples from the search limits. In the Longest test testing process, the software tested with an exponentially distributed error probabilities which leads to time consuming process. Average sample numbers for this test is relatively large and have a high resolving power. On testing the software, the failure which involves iterative approximations is considered. Though the test results in low resolving power, the reduced time requirement and the achieved closeness to the optimum which depends on successful choice of the initial approximation and its search boundaries (that yields highly efficacious tests). At the same time, reliability of the system that makes greater interest in deciding the low number of failures. This proposed system focus on improving test by using low average sample number in short term which is having the advantage of economy in time requirement and cost. It produces optimum truncated test called binomial Sequential Probability Ratio Test. Criteria are proposed for determining the characteristics of truncated test followed with the discretizing effect of truncation on error probabilities with a view to optimization of its parameters.

Index Terms— Reliability,Truncation test,long run test, short run,MTBF,MTTF

I. INTRODUCTION

Quality is the non-functional requirements that support the delivery of the functional requirements, such as robustness or maintainability, the degree to which the software was produced correctly. Reliability [2] is the indirect measure to improve the quality of the software. Testing is the process of running a system with the intention of finding errors. Testing enhances the integrity of a system by detecting deviations in design and errors in the system [1] Failure Data used for the testing should be reliable. This chapter proposes a procedure for analyzing reliable data[2].

II. FAILURE RATE

The failure rate of a system usually depends on time, with the rate varying over the life cycle of the system [4]. For example, an automobile's failure rate in its fifth year of service may be many times greater than its failure rate during its first year of service.

III. MEAN TIME BETWEEN FAILURES

Mean time between failures (MTBF) is the predicted elapsed time between inherent failures of a system during operation Trivedi (2002). MTBF can be calculated as the arithmetic mean (average) time between failures of a system [3]. The MTBF [4] is typically part of a model that assumes the failed system is immediately repaired (mean time to repair, or MTTR), as a part of a renewal process. This is in contrast to the mean time to failure (MTTF), which measures average time to failures with the modelling assumption that the failed system is not repaired (infinite repair rate).

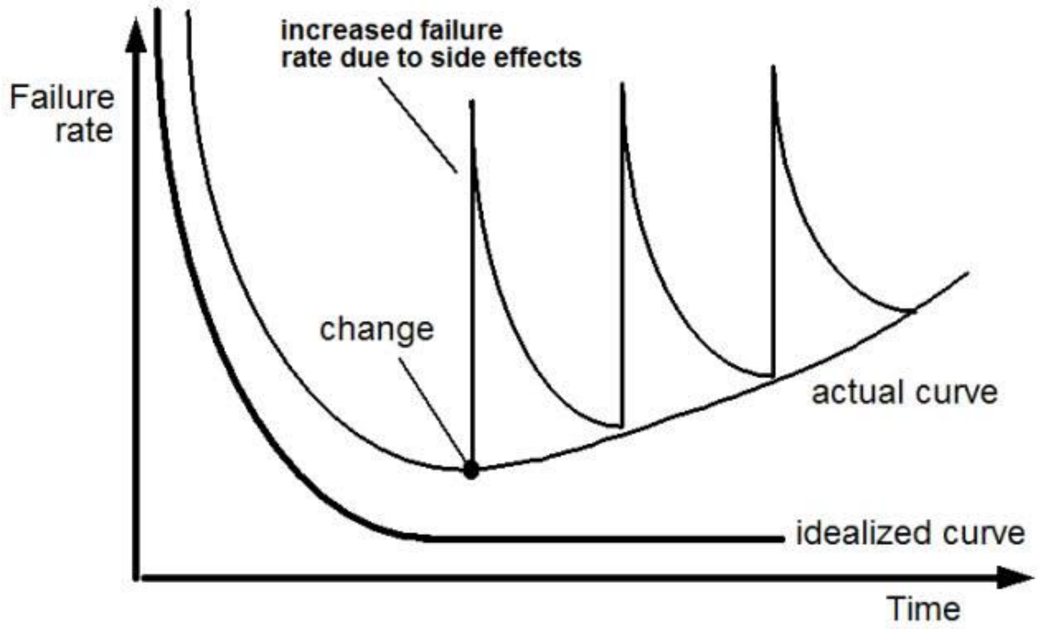
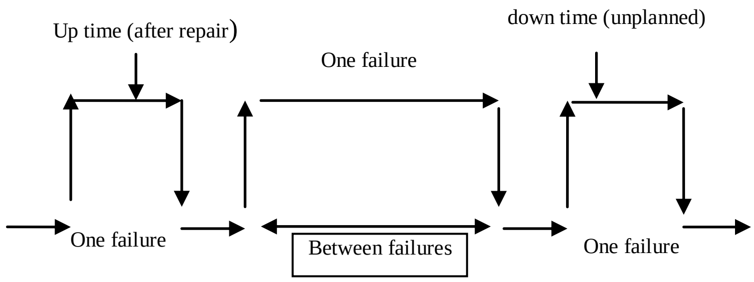


Fig 1 Software Failure Rate



Time Between Failures={down time-uptime}

Fig 2 Mean Time Between Failures

III. TRUNCATION TEST AND ISSUES IN LONGEST TEST

Truncation test is the ability to search small number of samples from the search limits. In the Longest test testing process, the software tested with an exponentially distributed error probabilities [5] which leads to time consuming process (long term).

Average sample numbers for this test is relatively large and have a high resolving power. On testing the software, the failure which involves iterative approximations is considered. Though the test results in low resolving power, the reduced time requirement and the achieved closeness to the optimum which depends on successful choice of the initial approximation [7] and its search boundaries (that yields highly efficacious tests). At the same time, reliability of the system that makes greater interest in deciding the low number of failures.

IV. PROPOSED SYSTEM

This proposed system focus on improving test by using low average sample number in short term which is having the advantage of economy in time requirement and cost. It produces optimum truncated test called binomial Sequential Probability Ratio Test [7]). Criteria are proposed for determining the characteristics of truncated test followed with the discretizing effect of truncation on error probabilities [8] with a view to optimization of its parameters. The search algorithm for truncation apex used in this system achieves closeness to the optimum which depends on successful choice of the initial approximation, search boundaries and on the search step. The enhanced reliability of modern technological systems, combined with the reduced time quotas allotted for creating new system is capable of yielding a highly efficacious test which increases reliability and feasibility of decisions.

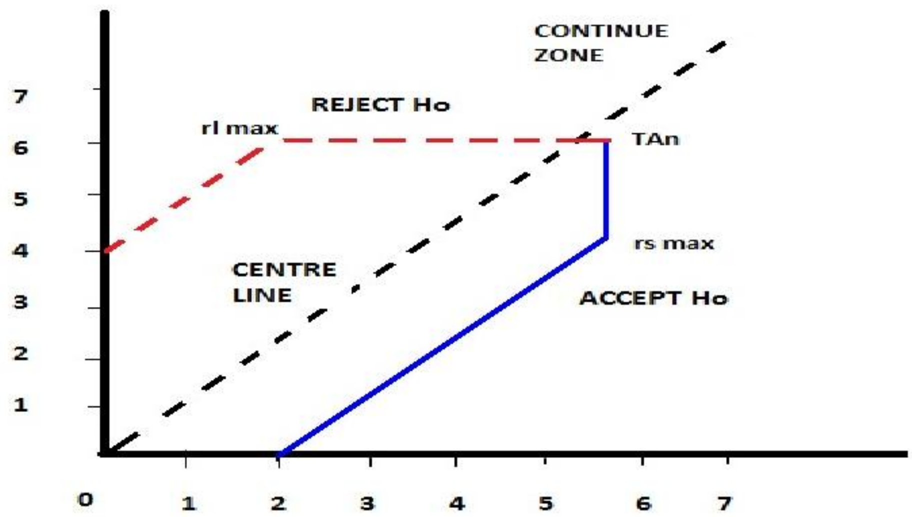


Fig 3 Solution Plane

*A. **Test Method***

Figure 3. shows the test procedure for the proposed system follows that when the software under process fails, it is immediately replaced/restored on considering the MTBF, and on the acceptance and rejection of the null hypothesis H_0 based on the ratio of MTBF of short term test to the MTBF of long term test i.e**.** θ_s / θ_t.

$$H_o: \omega \geq \omega_o,\ P_a(\omega_o) = 1 - e_1 \quad (1)$$

$$H_1: \omega < \omega_o,\ P_a(\omega_1) = e_2 \quad (2)$$

where $\omega_1 = \omega_o / d$, $d > 1$ $P_a(\omega)$, the probability of H_0 at a given ω represents the OC curve ($\equiv P_a(\omega)$) which is replaced with the parameters e_1, e_2, ω_o, and d which determines the coordinates of (ω_o (1- e_1) and (ω_1, e_2). From the Figure 3. slope S is determined between the two oblique boundary lines, which is given by

$$S = \frac{\ln((1+\omega_o)/(d+\omega_o))}{\ln(d(1+\omega_o)/(d+\omega_o)} \quad (3)$$

The absolute terms for the reject and the accept line is determined by long term test.

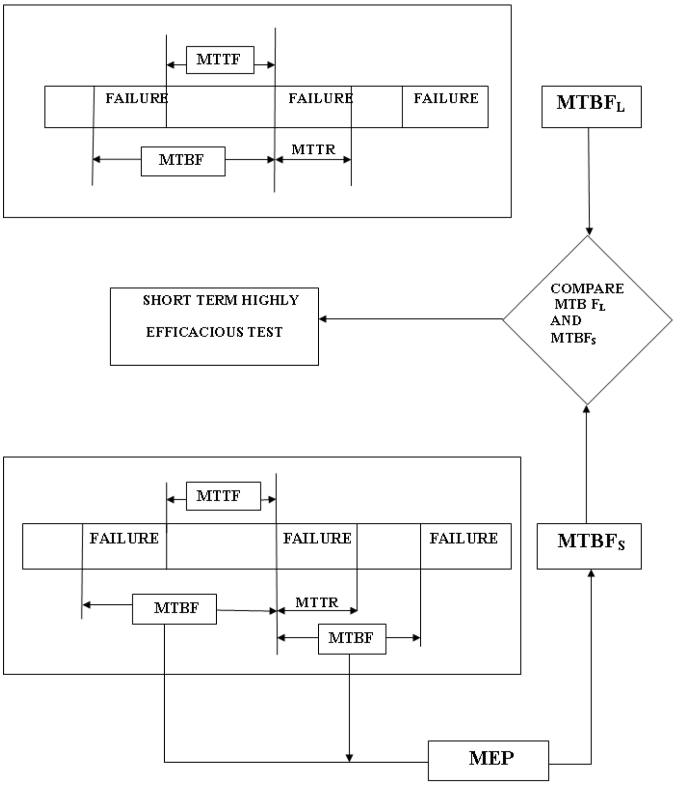


Fig 4 Architecture for Short Term Test

$$A = \frac{\ln(e_2^* / (1 - e_1^*))}{\ln(d(1 + \omega_o)/(d + \omega_o))} \quad (4)$$

$$R = \frac{\ln((1 - e_2^*)/(e_1^*))}{\ln(d(1 + \omega_o)/(d + \omega_o))} \quad (5)$$

Truncation boundaries are determined for the short and long term test by taking the maximum of the failures occurred.

$$B_\iota = (T_\iota \max) \quad (6)$$

$$B_s = (T_s \max) \quad (7)$$

where T_s = truncation value of RDP (T_ι) The boundary points for the test is determined by using the parameters S, e_1*, e_2*, B_t, B_s, which are chosen to ensure the specific test characteristics e_1, e_2, ω_o, d, EASN. Having the probability 1, the plan point (T_ι, T_s) is given by

$$P(T_\iota, T_s)(\omega) = P(T_\iota, T_{s-1})(\omega).P_s(\omega) + P(T_{\iota-1}, T_s)(\omega).(1 - P_s(\omega)) \quad (8)$$

where P_s is the probability of failing next during short term test,

$$P_s=1/(1+\omega) \quad (9)$$

For all the values of ω, starting from (0, 0), it is possible to calculate the probability of all the test points including ADP and RDP. Thus the acceptance probability $P_a(\omega)$ is obtained by summing of all ADP.

$$P_a(\omega) = ADP(T_s, \omega) \quad (10)$$

The real values of the error probabilities e1 and e2 of the truncated test is determined by

$$e_1 \text{ (real)} = 1- P_a(\omega_o) \quad (11)$$

$$e_2 \text{ (real)} = P_a(\omega_1) \quad (12)$$

The expected number of failures from the two tests is determined by

$$ASN(\omega) = PRDP(T_\iota).\ PRDP(T_\iota, \omega) + PADP(T_s).\ PADP(T_\iota, \omega) \quad (13)$$

TPRDP, TPADP are the sum of failures in two tests on reaching RPD and ADP respectively: TPRDP

$$(T_\iota)= T_\iota + R(T_\iota) \quad \text{and} \quad (14)$$

$$TPADP(T_s) = T_s+A(T_s) \quad (15)$$

Average test duration is determined by,

$$ATD(\omega) = 2\,\theta_\iota.ASN(\omega) / (1+1/\omega) \quad (16)$$

B. ***Discreteness effect of solution***

From the Equation (5), for the short term and long term test, the points with coordinates e_1, e_2 does not form a continuous plane which leads to the main problem in short tests Mace (1974). Figure 3 shows that the solution planes for d=3.828, d=6.657 respectively without the truncation. For the construction of these planes e_1 (real), e_2 (real) were determined by using the geometric progression of the pair e_1^*/e_2^* with 120 terms between the interval [0.02……….0.30], these steps were performed as trial calculation on considering all the points between the above interval. The co-ordinate TAN was taken for each pair depending on the values of ASN (ω_0) obtained for adjoining values of e_1^*/e_2^*.

$$TA_s=C.\ ASN(\omega_0) \quad (17)$$

From the above experiment, it is found that at C=12, the test is being stopped. On reaching the truncation lines, similarly the corresponding error of e_1 (real) and e_2 (real) is less than 0.01% of the actual value. In the case of truncated test, value of C is low accordingly TA was close to the origin and probability of truncation lines being reached is high, and effect of truncation on the test characteristics is strong. The co-ordinate TA_ι was adjusted to TA_s with accuracy to nearest integer, so that truncation apex would fall on the centre line. From the solution planes, it is found that,

For the short tests in question, the planes of possible pairs are characterized by extreme sparseness, which increases with decreasing ASN (i.e. increasing) and decreasing, and poses a substantial problem in planning such tests.

Truncation affects the disposition of the points in the solution plane, especially in the drastic case; this provides extra possibilities in the search for a solution close to the given

In Figure 3, the zone of is demarcated by dashed lines. This extension of the exact relationship is dictated by the discreteness of the possible solutions, and by the fact that the narrower such a zone, the lower the number of possible solutions (points lying between the dashed lines). A consideration in choosing the zone width follows.

C. ***Evaluation of test quality***

The test quality is evaluated by the following characteristics due to the reasons such as *The test characteristics like OC, ASN and pmf is itself a function of multiple parameters and variables. *The characteristics en bloc, in discrete fashion are affected by shifting of test boundaries and a rule that cannot be framed to construct two tests with different boundaries and the same operating characteristics or even with the same e_1/e_2 pair. The criteria considered to fix the test quality are

- Closeness of the real OC.
- The degree of optimality of the test.

I Closeness of OC

The relative deviation R_d of $e_1$real and $e_2$real from the desired e_1=e_2 is given by

$$R_d = \sqrt{}\left(\left(e_{1real}-e_1\right)/e_1\right)^2 + \left(\left(e_{2real}-e_2\right)/e_2\right)^2 \quad (18)$$

The resultant is sought among the tests with $e_1$real, $e_2$real lying in solution plane within a circle with centre e_1=e_2 and radius $R_d.e_1$. The solution for long tests can always be found within such a circle even at small R_d. But for short tests, the points are sparsely distributed in solution and R_d has to be increased, R_d beyond 0.1 will cause difficulties in finding optimal solution and second criterion to be applied. Thus for tests with d>3, R_d should be 0.1

II ***Estimation of degree of optimality***

The ASN will not be helpful to find the degree of optimality when two tests with different boundaries and same $e_1$real/$e_2$real pair are used. So the degree of optimality is measured using RASN, the relative excess of the truncated tests over its non-truncated counterpart.

$$RASN = [\ \sum^{5}_{i=1} ASN(\omega_i) - \sum^{5}_{i=1} ASN_{nTr}(\omega_i)\ ] / \sum^{5}_{i=1} ASN_{nTr}(\omega_i) \qquad (19)$$

where ω_i is values of ω forming the geometric progression.

$$\omega_o /(\sqrt{d})^3 ,\ \omega_o /(\sqrt{d})^2 = \omega_1 ,\ \omega_o /\sqrt{d} ,\ \omega_o ,\ \omega_o\sqrt{d} \qquad (20)$$

Malaiya, Y. K., Li, M. N., Bieman, J. M. and Karcich, R.(2002) ,ASN is calculated both recursive method and non-truncated binomial SPRT for same e_{1real}/e_{2real} pair and represented as ASN () and ASN() respectively.

$$ASN(h) = \frac{(1+\omega(h)).P_a(h).InB + (1-P_a(h)).InA}{(1+w(h)).Inq + Ind} \qquad (21)$$

where

$\omega(h)=((d.q)^h-1)/(1-q^h)$
$P_a(h)=(A^h-1)/(A^h-B^h)$
$q= (1+ \omega_o)/ (d+ \omega_o)$
$A= (1-e_{2real})/e_{1real}$
$B=e_{2real}(1-e_{1real})$
R_{ASN} is selected under several conditions.

(i) For, the non-truncated SPRT is known to be optimal. It is expressed in another way as among all possible test with the given e_1/e_2 pair. The test results with smallest ASN() and ASN ()
(ii) The ASN is determined by an analytical formula (16) which overcomes the difficulty due to the discreteness of the possible pairs. It is eminently suitable for purposes of comparison of the latter with the ideal one.
(iii) ASN () increases when a shift of the TA to the left of the centreline at $e_1 \approx e_2$. When > ω_1 , the increase is larger .

This increases negligibility. In spite of being shifted to the right of the centreline increases the suitable values of R_{ASN} are Reliability Data Analysis Procedures for Comparing Failure Rates of the System Using Optimal Truncation of Short Tests 114 5% and 10%.When R_{ASN} <5%the truncation boundaries lie too far from the origin so that the truncation benefits are lost. And when R_{ASN}>10%, the benefits are lost because of the steep increase of the ASN.

*D. **Search limits for e_1*and e_2****

With the help of initial boundary lines (e_1*, e_2*) and (TA_l,TA_s), the test boundaries are defined. Narrow limits are always preferred since searching those limits with the help of a test is time consuming. This section determines the search limits for e_1* and e_2*.

$$d=1+ (\sqrt{2})^I \qquad (22)$$

d should be always chosen as greater than 3 for short term tests. e_1*/ e_2* values are compiled for e_{1real} and e_{2real}. The parameters d and R_{ASN} are found to have a narrow domain which in turn reduces the volume of analyzed variants. When the initial boundary lines (e_1 and e_2) value decreases, the e_1*/ e_2* value comes close to the bisector. When α/ β value is very low, the e_1*/ e_2* value crosses the bisector. The next figure is drawn by taking d=5, which are narrower than the above.

$$e_1*_U = [1-R_{ASN}-0.15.\ln (2. (d-1))].s.x, \quad (23)$$

$$e_1*_L=x-0.3.R_{ASN}, \quad (24)$$

$$e_2*_U=\min \{[1- R_{ASN} -0.05.\ln (2. (d-1))].s.x, \text{ and } x+0.1 \quad (25)$$

$$e_2*_L=x-0.2. R_{ASN} \quad (26)$$

where s is the slope and $x=e_1=e_2$.The above equations represent the upper and lower search limits which is close to the bisector when d decreases and RASN increases. These formulas refer to d=1.5...9 and R_{ASN} = 5=10% .The search steps for d=3 …9 is given by,

$$\Delta e_1 *= [e_1*_U-e_1*_L]/20 \quad (27)$$

$$\Delta e_2*= [e_2*_U- e_2*_L]/20 \quad (28)$$

*E. **Search limits for truncation apex coordinates***

The requirements for the TA location are as follows,

- e_1/e_2 pair must not have a deviation exceeding R_d.
- The ASN must not exceed given R_{ASN} because of the truncation.

The highest Truncation level must be in terms of the sample number and TA must be as close as possible to the origin. From Equations (27) and (28) at $e_1=e_2$, the truncation apex falls on the centreline and TAN coordinate with high accuracy determined for d. In the present paper, dependences were found for short tests by means of test searching in the intervals d=3.8,……9, and $e_1=e_2$=0.05,….0.25 with step 0.05.The search zones by $e_1=e_2$ should slightly overlap, so that the possibility of an ―empty zone is avoided by setting RD value as 0.1.The test with smallest r_n max was chosen in empty zone .In terms of R_{ASN} three group of tests were established and the requirements were

R_{ASN} <=5%,
R_{ASN} >=10%,
R_{ASN} >10%

TA_n values are plotted in Figure 3. The dependences are considerably less smooth than those for d<=3. It contributes to the distribution of the operative points which are highlighted as d increases. At the same time, curves for respective R_{ASN} at same d moves close together and differences not exceed 3 to 4 failures. Hence for any RASN, the lower search limit can be set at min TA_N curves and upper search limit for R_{ASN} can be set at the curve lying four failures higher.

$$LTA_N=\min TA_N \quad (29)$$

$$UTA_N=LTA_n+4 \quad (30)$$

$$\text{Min } TA_N = g(d).f(x) \quad (31)$$

where

$$g(d)=\exp[0.5+0.06.(d-3)/d-1]-1 \quad (32)$$

$$f(x) =16.(\ln 1-x/x)^{1.6}-3.4 \quad (33)$$

Equation (31) is the product of two mutually s-in-dependent functions, one solely of d and the other solely of $e_1=e_2$, identical for all d in the examined interval d=1.5…9 i.e.) for short and long tests, g(x) differs only slightly in counterpart for d Optimal TA lies on the centreline, and so the upper and lower limits of TA_l . (UTA_l and LTA_l respectively) are determined for each TA_s as follows.

$$LTA= \text{floor}(TA_s/S) \quad (34)$$

$$UTA=\text{ceil}(TA_s/s) \quad (35)$$

S indicates the test slope and floor and ceil indicates the rounding off functions to closest integer below and above respectively. The dissimilarities prevailing in finding TA_s between the cases d>3 and d<=3 paves the way for the classification of tests into two groups as “short” and “long”.

F. Analysis of the relative efficacy of the test

In case of parameters ω_0 and ω_1, the non- truncated SPRT is optimal as the Truncation test sets a limit on its maximal sample number. But this development is offset by the detrimental effect on the corresponding average sample number over ω. This can be defined by the index of R_{ASN}.

In this module, it discuss about the efficiency of a truncated test between the average sample number line and a Fixed Sample Size Test (FSST). For example the test includes the parameter like ω_0=1, d=5, e_{1real}=0.101, e_{2real}=0.099, T_{ab}=5, T_{an}=10 and R_{ASN}=7.8% are the limits and Average Sample Number (ASN). Comparison for a non-truncated test with the same parameters like ω_0, d, e_{1real}, e_{2real} as per in the example. This ASN are the average cumulative number of failures of short and long term systems. A. Characteristics of FSST:

- Fixed number of failures should satisfy the relationship. That is,

$$F_{\alpha,2rn,\ 2rb}=1/dF_{1-\beta,\ 2rn,\ 2rb} \tag{36}$$

where, Fα, 2rn, 2rb are Inverse cumulative F-distribution function. 2rn is degrees of freedom in the numerator. 2rb is degrees of freedom in the denominator.

- The minimal cumulative of SN_{FSST} is obtained when the $r_s = r_l$

SN_{FSST} value is calculated. SN_{FSST}=10.92 for achieving the given e_{1real}, e_{2real} under the condition,

The cumulative test duration for the two systems will be,

$$TD_{FSST}\ (\omega) =\theta.\ (1+ \omega).SN_{FSST}/2 \tag{37}$$

The SN of a real FSST should be an integer. But TD_{FSST} as to permit evaluation of relative efficiency of the test.

In Figure 3, the OC curve are practically coincident and the ω_0 and ω_1 are identical. The ASN of truncated test exceeds only its non-truncated counterpart at $\omega\approx\sqrt{\omega_0\omega_1}$ (values are almost equal). Both of them are substantially lower than SN_{FSST}. The superiority of SPRT is more obvious in term of ATD (Average Test Duration). The TD_{FSST} is much longer than those of the two SPRT. Regarding the relative quality of the latter and their ATD are practically coincident at $\omega<0.7$, and close at $\omega>0.7$.

Besides the ASN, of interest to a prospective performer of the SPRT is the Probability Mass Function (pmf), the respective probabilities PADP (r_s, ω), and PRDP (r_l, ω) of the test terminating at the given ADP/RDP. The pmf for a test with boundaries as per figure 3. And the relevant characteristics. Corresponding to five ω–values arranged in a descending progression as per (15). The lower part of Figure 3 shows the coordinates r_l of ADP versus r_s (curve 4), and r_s of RDP versus r_l (curve 3). These points demarcate the test boundaries, with the horizontal segments representing their truncated parts. The figure 3 shows that in practice the truncated part can be reached only at $\omega_1 \leq \omega \leq \omega_0$, beyond which limits this probability is insignificant. The maximum SN in this case is 14(as seen in figure 3), a number achievable with low probability only within the above limits.

Thus, the document demonstrates that the proposed planning methodology for truncated SPRT is capable of yielding highly efficacious tests, not inferior in practice to their non-truncated counterparts. The figure 5 shows the truncated part of the base system failures and new system failures can be reached only at $\omega_1 \leq \omega \leq \omega_0$, beyond which limits this probability is insignificant.

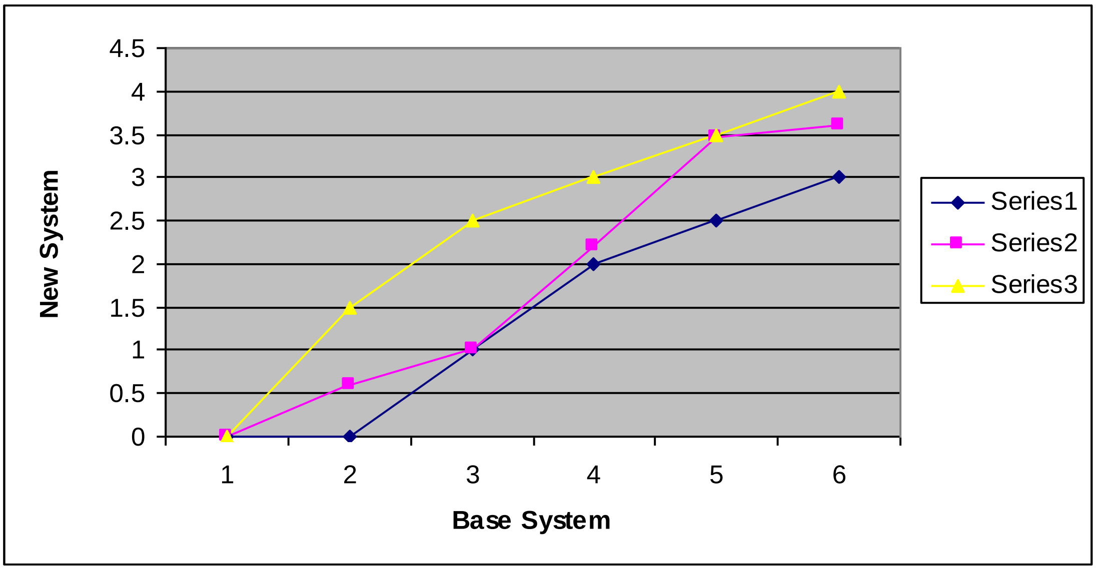


Fig 5 Search Limits for New System and Basic System

V. CONCLUSION

The previous system had the disadvantage of having test with high average sample number which required high resolving power. This is overcome by the proposed system which has the advantage of economy in time requirement and cost .The proposed planning methodology is capable of yielding a highly efficacious test which increases reliability and feasibility of decisions.

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