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Reliability Analysis of Warranty Period and Insurance Policies of a Product

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Abstract
Reliability analysis of a product is an essential tool in determining its expected lifetime and probability of its failure under given condition of operation. Warranty period is an important factor to ensure the reliability of a product and is a key factor in increasing the sales. Analyzing the statistics of failure behavior of product is the adopted method to determine the life expectancy of a product which follows various reliability distributions patterns. I insist to derive suitable conditions for determining the correlation between the reliability of a product to set the warranty period and the insurance policies to be provided. These algorithms hold the foundation for sales of firms who provide these reliability solutions. Slight deviation from expected values of life expectancy of product may results in loss or gain of a considerable amount of sales of these firms. This paper will shed light on algorithms and critical conditions for accurately limiting the warranty period and insurance policies under safe & profitable sales.

Keywords: Reliability Analysis, Warranty Period, Life Expectancy, Failure Probability, Hazard Factors, Product Failure.

1. Introduction
Methods to find correlation between the product failure behavior and its reliability over time includes statistic distributions of probability and various functions holding accuracy depending upon the failure behaviors of the product. In general the reliability at particular time is represented by the probability of the product not failing at that particular time. The variation of probability with time follows a continuous distribution curve or function with specific value depending upon the failure pattern of the product. Assuming the reliability of the product to be equal to 1 the beginning of its life and equal to zero at infinitely large time in the future. The probability distribution curve follows a continuous exponential curve with decreasing reliability with time. The other assumption is that the rate of failure decreases as time passes by and is maximum at the beginning of the life cycle of the product. This assumption is made on the basis of the fact that a set of product contains highly reliable and low reliable products. As every product is designed for a high reliability but due to a combination of reliability of individual components a number of product fails by chance while some products with high reliability do not fails by chance so the rate of failure of Hazard factor decreased with time. As time passes by the low reliability products are eliminated as they fails and the remaining products only contains high concentration of high reliable products, this leads to the reduction of rate of failure of the failure.

$$R(t) = e^{(-t/MTTF)}$$

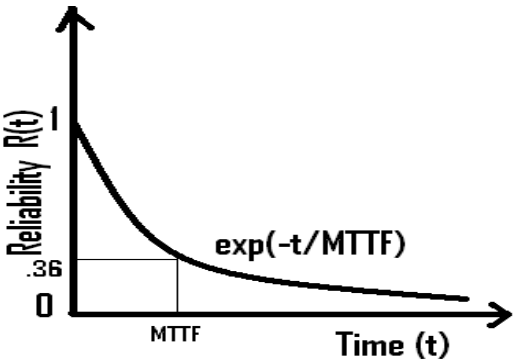
R(t)- Reliability Probaility at a given time t;
MTTF- Mean time to failure for a product;

2 Reliability Function R(t)
The function for a product is defined as the probability of expected working or lifetime of the product at a certain value of time "t". Mathematically it is the exponential of the value "negative of the ratio of the time "t" to the Mean time to failure of the product". A time t=0 the value of reliability or probability of successful working of the product is unity. At the initial time of start the product is said to be 100% reliable. At infinitely large time t= infinity the reliability function reduces to zero. Means at t= infinity the product will fail for sue with 0% reliability. The rate of failure is exponentially decreasing with time as the remaining product left will be high reliability products only. Reliability distribution will be a smooth continuous curve expressed by the exponential function R(t).

At t = 0;
R(t) = 1 (100% reliability)
At t = infinity;
R(t) = 0 (0% reliability)

3 Mean Time to Failure (MTTF)

Mean time to failure for a product is defined the mean average time period after which the product will fail. It is a constant for a product or else it is an independent constant for a product tested under highly practical environmental conditions. It is measured by testing a set of product under a given condition and determining mean failure time with standard deviation from the given value.



Variation of R(t) with Time (t)

Analyzing the value of reliability at the time MTTP we find out that the product is 36.8% reliable. So, probability of its failure is given by "1-R(t)"; which at mean time to failure comes out to be 63.2%. Above analysis provides us important statistics on product condition regardless of the nature of the failure. These factors can help in approximately calculating the time period of warranty need to be provided so that company producing the product don't lose sales or go into loss by these failures of product.

R(t) = exp(-t/MTTF)
At t = MTTF
R(t)= exp(-MTTF/MTTF)
R(t)= exp(-1)
R(t)= $^1/_e$
=0.367

4 Determining Optimum Warranty Period

Providing a warranty period on a product is an essential marketing strategy. It can be a deciding factor in the success of the product while other companies providing same product with high warranty, high warranty represents the high reliability and high level confidence level of the company in that product. Product with high warranty is always desirable as it seems more reliable to consumers. But in the race of marketing a company cannot simply go for a "life time warranty". Some criterion has to be there to determine the optimum time period of warranty. Let the company wants to give warranty till the point when the product is 50% reliable. This risk factor is up to the company which depends on their sales and demand in the market of the product. This limit till the company wants to provide the warranty is also dependent on the cost of repair or placement of the product. Let us consider the product to be a Smart Phone and company wants to take risk till the product is 50% reliable.

Analyzing and calculating the most optimum time period of the warranty period of a Smart Phone.

Assumptions: Smart Phone follows the reliability distribution of an exponential probability distribution. Mean time to failure is assumed to be "T".

Product: Smart Phone
MTTF="T"years
Reliabilty at warranty
period= 50%
R(t) = exp(-t/MTTF)
R(t)=50%
.50= exp(-t/T)
log(.50)=-t/T
t= -T(log.50)
t= .301 × T
T= 60000 hours for a iphone
= 6.8 years
t= 6.8×.301
t= 2.04 years

The time period of the warranty that should be provided by apple.inc an iPhone is about 2 years at a confidence level of 50%, or the reliability assumed at the time of end of warranty is exactly 50%. At the time of warranty the product is 50% reliable for working in good condition.

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5 Insurance Policies on an Individual Product

Taking the insurance companies into account, the factors affecting their profits are totally statistically dependent. A slight fluctuation in these condition or probability can leads to bankrupt situation of these companies. Below analysis shows the reliability of a human being as a product to be reliable to provide insurance by an insurance company. Considering the condition of India as a test situation. The average life expectancy in India is about 65 years. But there is slight but major difference in the liability or probability of healthy being of human. The reliability distribution of a human being follows a inverse relation regarding the rate of failure of health with time. The rate of failure of human health increases exponentially with time. But approximating these slight fluctuation of human health behavior and assuming the domain of age in human health to be from 0 year to 100 years.

Statically important data for designing the insurance policies for human being

At t = 0 years
R(t)= 100 %
At t = 65 years
R(t)= 36.8%
So at the age of 65
a human in India is
Expected to die at a
probability of about 63.2%

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