RELIABILITY CONCEPT AND OVERVIEW

Arrelic Insights

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Overview

In recent years, manufacturing companies, government agencies, and civilian populations have placed a greater emphasis on reliability. With recent concerns about government spending, departments are attempting to buy systems that are more dependable and need less maintenance. We, as customers, are primarily interested in purchasing goods that last longer and are less expensive to maintain, , i.e., have a higher reliability. The benefits of high product, variable, or device reliability are self-evident:

- Improved customer loyalty
- Increased revenue
- Increased protection
- Lower warranty costs
- Lower maintenance costs, etc.

Introduction

The likelihood that a product, device, or service will perform its intended function adequately for a specified period of time or in a given environment without failure is defined as reliability.

To fully understand how reliability in a product or service is defined, the following are the most important components of this definition:

- Probability: the likelihood of mission success
- Intended function: for example, to light, cut, rotate, or heat
- Satisfactory: perform according to a specification, with an acceptable degree of compliance

- Specific period of time: minutes, days, months, or number of cycles
- Specified conditions: for example, temperature, speed, or pressure

Stated another way, reliability can be seen as:

- Probability of success
- Durability
- Dependability
- Quality over time
- Availability to perform a function

In a strict sense, reliability refers to the likelihood that a system will perform its intended operation over a specified time span under specified conditions. It is difficult to estimate the failure probability for unlimited conditions, so the restriction of "stated conditions" is critical. R stands for reliability, which is measured as a function of time (t).

For example:

- The warranty's basic coverage lasts 36 months or 36,000 miles.
- We guarantee that the bulb will be free of defects and will last for three years when used for three hours a day.

  The formula for calculating reliability is:

$$R(t) = \frac{n_{operational}(t)}{n_{total}(0)}$$

Failure Probability

The failure rate, F(t), is the chance that something will go wrong. Since reliability is one minus failure probability, the two definitions are inextricably linked. Assume we've purchased a total of 100 products. When you buy a product at time t=0, it's assumed that it's working and that R(0) = 1 and F(0) = 0. With the passage of time, the goods will begin to fail. Owing to inherent variations in the products, materials used, and the operation of the products in the real world, different products will fail at different times. As a result, reliability and failure probability are expressed as the likelihood of success or failure. The formula for estimating the likelihood of failure is as follows:

$$F(t) = \frac{n_{non-operational}(t)}{n_{total}(0)} = 1 - R(t)$$

Failure Rate

The failure rate, typically denoted by lambda, is a related term that is usually useful to define (t). The failure rate is a number that quantifies the rate of product failure in comparison to existing products. We must determine whether faulty goods can be restored and reinstalled, or whether they cannot be repaired after failure. For repairable systems, the number of operational systems at the beginning of each time cycle would be the same. When non-repairable systems malfunction, the number of functioning systems decreases.

The formula for estimating the likelihood of failure is as follows:

$$\lambda(t) = \frac{n_{operational}(t) - n_{operational}(t + \Delta t)}{\Delta t * n_{operational}(t)}$$

Reliability in the Real World

When we try to describe reliability in the real world, there are some complicating factors. Not all of the items are available for purchase and installation at the same time. Since different products are built at various times, estimating reliability in the real world is more difficult. Second, due to repairs, improvements, and changes, the status of the product is constantly changing, making it difficult to compare data across products. Finally, not all goods are always operational. For example, one person can watch TV for one hour per day while another watches it for four hours. As a result, using calendar time to measure reliability is difficult because calendar time is often not the operating time.

In the real world, parameter estimation is also difficult and does not involve a simple regression fit of the results. Any analysis we conduct to predict failure data will result in some units failing before the end of the test period (also called censored data). If we start testing with ten items, the first one will fail after 110 hours, the second after 124 hours, and the third after 200 hours. We had to stop the study due to time and/or cost constraints, but the remaining items are still running at 500 hours. When estimating the Weibull parameters, we must account for these seven non-failed products. In a later post, we'll look at estimating Weibull parameters in the presence of censored results.

Quality Vs. Reliability

"How consistency varies over time" is one way to classify reliability. The distinction between quality and reliability is that quality refers to how well an object performs its intended purpose, while reliability refers to how well the object retains its original quality over time and under different conditions.

A high-quality car, for example, is one that is clean, fuel-efficient, and simple to run. This car can be considered dependable if it meets this requirement for many years, performs well, and stays healthy even when driven in inclement weather.

A few main questions will aid in determining the distinction between consistency and dependability:

• Quality = Is the item of sufficient quality to perform its intended function? If that's the case, how well does it fulfil its purpose?

• Reliability = To what extent has the object's consistency been preserved over time?

Understanding User Requirements and Constraints

Eliciting knowledge about functional requirements, constraints (e.g., mass, power consumption, spatial footprint, life cycle cost), and needs that correlate to RAM requirements is part of understanding user requirements. System requirements should arise from these, and should include criteria for reliability, maintainability, and availability, all of which should be conditioned on the expected operating environments. The concept of RAM requirements is just as difficult as defining general functional requirements, but it's just as essential for development success.

Summary

The concepts of reliability, failure likelihood, and failure rate were discussed. We also distinguished between consistency and dependability. Finally, we looked at how to use the Weibull distribution to model reliability. We'll talk about how to approximate the Weibull model parameters from real-world failure data in the next article in this series.