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Reliability Analysis during the Design Phase of a Complex Asset

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INTRODUCTION

The reliability and availability of a system depends, first of all, on its design and its installation quality. Also, the reliability and availability conservation, as well as the warranty assistance to be applied, will depend on the maintenance to be performed. A good maintenance plan has to be able to analyse all possible failures, and has to be designed to avoid them. That means it is necessary to elaborate a detailed failure analysis of all those components that make up the system. Due to the complexity of such a task, it is important to take into account all those indications given by the own manufacturer for the main equipment, performing a reliability analysis for the rest of components.

In general terms, if maintenance would be only corrective (attending problems just when they arise) it could be a profitable short-term policy, but not longer. Achieving a good preventive maintenance however, the system life cycle can be increased and, consequently, its profitability in the middle and long term. It is also important to keep in mind that the application of preventive maintenance does not present an immediate consequence, but the effect of taken actions appears after a certain time. In addition to this, these plans should apply the principle of continuous improvement, being updated as a better and deeper knowledge of the system is available. In this article, a mathematical formulation to perform a reliability analysis is developed, and will be focused on customer service planning. That is, the intention here is to develop a methodology that would allow us to analyse "a priori" the behaviour of a future product.

This article presents a simplified formulation for RAMS variables (Reliability, Availability, Maintainability and Safety), particularly for two subsystems arranged in series or in parallel. This analysis offers an approximate assessment of the behaviour of equipment that operate under severe conditions, such as those elements with complex systems of the Aerospatiale sector, defence, self-propulsion, industry, etc. the terms of the acronym RAMS transmit the following concepts (ISO/DIS 14224) that are usually expressed in terms of probability:

- Reliability is the capacity of a system to carry out the functions that are expected from it, under established conditions and during a specified period of time.
- Availability is the degree to which a system can be used during a determined period of time. It is usually expressed as a time ratio.
- Maintainability is the characteristic of the design and the installation of an element in which it must be re-established or substituted after a determined period of time, it is the maintenance done according to the prescribed procedures.
- Safety is the condition of being protected against failures, errors, damage or any other incident that can be considered undesired.

For these cases, it will be deduced the following system features: "Ratio of system failure," "Mean Time Between Failure," "Availability and Unavailability of the system," and "Mean Down Time" (Høyland &

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Rausand, 1994). It should be noted also that sometimes conventional formulas are not used in cases of hybrid configurations, applying for these cases other methods such as a probabilistic formulation (Henley & Kumamoto, 1992).

BACKGROUND

As far as the new Information acquisition and management environment develops a full range of concepts, methods, trends etc. which serve to diverse research needs in numerous fields, this article is intended to show a simplified reliability analysis focused as a decision support tool for business analytics. In order to place this work in a proper context, it is important to underline that the novelty here in relation to reliability is the inclusion of a simplified method which is illustrated with its application to a solar energy system, which provides to academicians, technology developers and, of course, managers who take decisions in this field, a useful tool that help and improve their efforts in the organizational progress.

In order to provide enough theoretical and basic information to clearly illustrate the problem, but trying to avoid at the same time to deepen excessively in the technical content (which is not the purpose of the article), this section will briefly describe the current formulation in reliability for subsystems in series and in parallel connection. This clear manner of presenting a methodology will finally address to the issue about how to tailor a list of recommended spare parts and what lines in maintenance can be deduced from the performance of a simple reliability analysis.

Particularizing, a system conformed by two non-identical subsystems arranged in series is shown in Figure 1. Considering only one subsystem, the failure rate will be λ1, which is usually expressed in number of failures per hour (or per 106 hours). The probability of failure in a time differential dt is obviously λ1dt. When there are two subsystems in series, the probability of failure in dt is then (λ1dt + λ2dt). The system failure rate is therefore (λ1 + λ2) and the reliability function (assuming an exponential distribution) will be:

$$R(t)=exp[-(\lambda_1 + \lambda_2)t] \quad (1)$$

According to this configuration, at any moment, the system will be in one of the following four states:

- Both subsystems work properly.
- Subsystem #1 does not work, but #2 does.
- Subsystem #2 does not work, but # 1does.
- None of the two subsystems works.

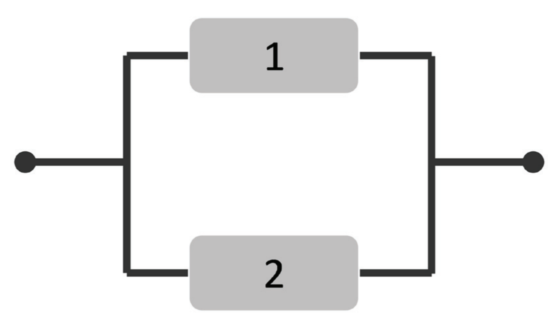
In series, the last three cases are responsible that the entire system would not be operable. A system of two non-identical subsystems arranged in parallel is shown in Figure 2.

If the system was only established by the subsystem #1, the ratio of complete system failure rate would be λ_1 and the probability of failure in dt would be $\lambda_1$dt. Adding the subsystem #2 in parallel, the likelihood of system failure in dt will be $\lambda_1$dt reduced by the probability that the subsystem #2 is in failure mode. In order to summarize the corresponding formulas for those RAMS variables related to the units and according to the configuration that make up the industrial assets in terms from the components themselves, it is provided Table 1. These formulas can be found in readily available literature like Crespo 2007 or Muller et al., 2008.

With this formulation, the next step is to provide a quantitative assessment of these parameters (González-Prida et al., 2009). From the quantitative assessment one can observe that subunit or component which can be critical in the functioning of the entire system (Crespo & Iung, 2007).The obtained results can be useful to establish a reliability ranking for the components, under certain assumptions and boundary conditions. It allows too the possibility of drawing up a preliminary list of recommended spares, useful for the warranty

Figure 1. Subsystems in series connection

Figure 2. Subsystems in parallel connection



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