-Testing and Evaluation of Systems Reliability (I/II)-

Berquó, Jolan Eduardo – Electronic Eng. (ITA)
Aerospace Product Certifier (DCTA/IFI)
Government Representative for Quality Assurance – RGQ (DCTA/IFI)
jberquo@dcabr.org.br

IYK 27 – JAN 03, 2013

Normally, there is, throughout the life cycle of a system, the continued evaluation of the system. This evaluation starts at the conceptual stage and will only finish in the penultimate stage of the life cycle of the system (operational phase). We remember that the last phase is the Disposal or Alienation phase of the system, that is, the "death" of the system.

But let us consider here the assessments that occur in the detailed development phase and, soon after, in the production of the first series systems, the so called pre-series. But we only consider here the tests and assessment of Reliability.

Before the series production, the productor assembles some pre-series aircraft to be submitted to tests in an intensive testing program. The aircraft are placed to operate, in the mission configuration and in the same environment of the operational phase.

The process culminates in a detailed report on its behavior during the tests, its maintainability features, compatibility of ground support equipment with the aircraft, electromagnetic compatibility between subsystems, besides other features. All this is compared with the requirements for the system related to these features.

This whole process is valid for any system, but here we refer specifically to aircraft and to the testing and evaluation of Reliability.

Of course, when we perform these tests to an aircraft, we are also performing tests with their subsystems and their equipment. So, these tests can also reveal the behavior of all the equipment installed in the aircraft. In consequence, may arise (usually arises) design changes.

The discussion contained herein is based on the standard MIL-STD-781C (REF. 1), assisted by the book System Engineering and Analysis (Ref. 2) and the experience lived by the author, at the Program AM-X (Brazil-Italy).

As any organized activity, first it is necessary to prepare a plan, including the tasks which will be performed during the tests and the methodology of the data collection.

The goal of the tests is to evaluate the reliability parameter MTBF (mean time between failures), to verify that the behavior of the aircraft complies with the requirements established for this parameter.

However, this "... complies with the requirements the requirements established for this parameter" cannot be considered of absolute mode. We must bear in mind that this is a statistical process that depends on the sample size (number of hours flown). As we cannot fly thousands of hours, for economic and operational reasons, we must settle ourselves for a small sample, make the relevant statistical inferences (including those mentioned in IYK 23) and, later, in fact, if applicable, go improving the reliability features, based on field data collection.

But here we have another important observation: the collected data can be completely useless if their collection activity is not made by people imbued with the importance of a collection made with strict criteria.

Well, but back to our universe, the process configuration is simple (but only the configuration). The aircraft have to operate for a pre determined time (multiple of the estimated MTBF) and the failures and their moments of occurrence are recorded.

Here arises another question: how many multiples of the supposed MTBF shall be established for this evaluation? In fact, there is not a fixed rule. It is a decision of the management of the program. But the longer this period, the better will be the inference.

However, it is considered reasonable to at least a period equivalent to ten (10) times the predicted MTBF. This was the period considered in our experience.

Well, in the evaluation of these tests, we can take one of three decisions:

1. accept the result;
2. reject the result; and
3. continue with the tests.

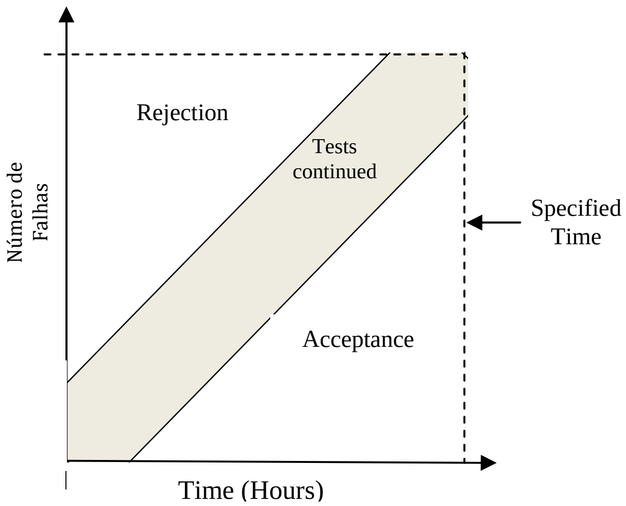

Fig. 1 – Testing Plan

We can observe that there are three areas: Rejection, acceptance and Doubt (continuity of the tests).

Clearly, the first problem is how the lines of rejection and acceptance are drawn, in order to delimit the regions of rejection, acceptance and the tests continuity

To do this, first we need to know two things:

Producer's risk (α)- likely to reject the system, when the observed MTBF is equal to or better than the specified MTBF (called type I error); and

Customer's risk (β) – probability of accepting a system, when the observed MTBF is less than the specified MTBF (called type II error).

Now, we are faced with the most difficult part of interpretation. But let us first trace the lines of acceptance and rejection.

First, we need two values of MTBF:

1. specified MTBF (let's call it θ_0); and
2. minimum acceptable MTBF (let's call it θ_1).

The slope of the line of acceptance is given by the expression:

$$t_1 = \left(\frac{\ln(\theta_0/\theta_1)}{\frac{1}{\theta_1}-\frac{1}{\theta_0}}\right).(r)-\frac{\ln[(\beta/(1-\alpha)]}{\frac{1}{\theta_1}-\frac{1}{\theta_0}} \quad (1)$$

Where r is the number of failures (the acceptance line is drawn for values of supposed values of r). The reason θ_0 / θ_1 is called "Discrimination Ratio".

The slope of the line of rejection is given by equation (2):

$$t_2 = \left(\frac{\ln(\theta_0/\theta_1)}{\frac{1}{\theta_1}-\frac{1}{\theta_0}}\right).(r)-\frac{\ln[(1-\beta)/\alpha]}{\frac{1}{\theta_1}-\frac{1}{\theta_0}} \quad (2)$$

We will continue in the next MSC with an example taken from REF. 1.

See you

References:

(1) MIL-STD-781C - **Reliability Design Qualification and Production Acceptance Tests: Exponential Distribution**. EUA:DoD.1977.

(2) Blanchard, B. S.; W. J. Fabrick**. Systems Engineering and Analysis,** 4th. Ed. Prentice Hall. UpperSaddle River, NJ, USA. 2006.