System Engineering and Analysis (SEA): System/System Life Cycle (SLC) - IV

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

IYK 32 – FEB 26, 2013

In this IYK, we will continue our journey, through the phases of the Life-Cycle of the System. In the last IYK (31), we have discussed the Conceptual Design. Now, let's go to discuss the Development Phase itself, starting with the subphase named Preliminary Design.

The Configuration Management activity starts to get intense in this subphase. It is extremely important for designers and analysts to know the history of configuration changes and the reasons that led to them, either in the development phase, either in the operational phase.

The goal is to obtain the called System Allocated Configuration, one essential activity to define all the hardware (with its software) necessary to build a model or prototype system in the following subphase.

The Preliminary Design begins with the consolidation of the functional configuration of the system, followed by the allocation of requirements (standards and attributes) for each function. Then the process repeats for the subsystems and equipment or, components.

A function is an action. There are authors that use noun expressions to denote a function. Others, and we are with these, consider that actions are expressed by verbs (well according to the grammar). In order to avoid "personality", supporters of this concept use the verb in the infinitive (fly, act, divert, communicate, etc.).

Examples: "Present the information of aircraft's attitude , in roll and pitch"; "Establish voice communication in VHF ".

We repeat that a system has two major subsystems: Operational and Logistic. So when we talk about functional allocation, we are talking about the system functions, as a whole, ie about functions of these two subsystems.

Whatever the function, it must be considered from two points of view: Performance and Safety (Safety).

The term performance refers to the ability of the system to perform its function as it has to be performed.

Let us consider the second example (VHF communication). The requirements could be: communications two-way (transmit and receive), in the range between 118.00 and 136.95 MHz (AM). The MTBF shall be 2,000 hours. The maximum dimensions of the box must be: width = x cm; length = y cm; and height = z cm.

The subsystem must transmit and receive, within the range established for communication with the ground, on a minimum radius of yy Km, taking the aircraft as reference.

The equipment that will perform the main function of the communication subsystem must have a transmission power of 25 Watts and a reception sensitivity zz. Should operate with two antennas (ventral and dorsal) to facilitate communication air-to-ground and air-to-air, and so on.

Other performance requirements could be: speed, rate of climb, accuracy, takeoff and landing distance, etc.

Of course, there are others requirements to be considered (see References).

From the point of view of safety, we must consider a slightly different approach to requirements allocation. We suggest that the reader see the IYK 10, to get an idea of how we should deal with the allocation of safety requirements to functions of the system, subsystems and equipment.

The reference 6, which deals with safety assessment, is an excellent work on safety requirements allocation, and can even be used in certification, to demonstrate compliance with the specific requirements laid down in regulations (14 CFR) 23.1309 25.1309, 27.1309, and 29.1309.

To illustrate a little bit more, let's consider also a function of Logistic Subsystem: "Remove and install the generator of the aircraft". The performance requirement to be allocated to this function might be: "the generator must be removed or installed by means of a GSE - Ground Support Equipment - with features of a lift with vertical offset of uu meters per minute and should withstand a minimum weight of vv Kg".

The company cannot lose sight that all this requirements allocation must take into account the certification activity, carried out by the airworthiness authority of the respective country.

Thus, when making the allocation of requirements, it is necessary to be attentive to the certificability's characteristics of the system design as a whole. With respect to this issue, we suggest the reader consults the reference 7, which presents, in detail, this certification activity. But the fact is that, from this functional allocation and requirements allocation, engineers will identify the components or equipment necessary to construct the various subsystems

At the same time, it is defined the support necessary to the construction of models, prototypes for the tests and evaluations, e.g. tools, jigs, SLTE (Special Laboratory Test Equipment).

As part of this support we have the so called rigs, i.e. sets of equipment or components that will constitute some subsystems, such as avionics and electrical rigs, which can be used to test the concept of the project and make functional tests, but the big difference between these rigs and the actual subsystems is the physical layout. The rig, in General, does not represent the physical layout that will have the actual subsystem. This would be a reason why a rig may not be valid for electromagnetic compatibility checking.

Let us consider some other important requirements that are allocated to the functions:

Reliability - It is a requirement that we have treated in our IYK. It is expressed as a probability of success in mission execution of the system in a given interval of time and under certain conditions. But it can also be expressed in terms of reliability parameters, such as MTBF (Mean Time Between Failure).

Maintainability - A characteristic of design that will have a huge influence on logistical factors, in particular on the maintenance, in terms of execution time of each task of maintenance and ease of their implementation. It is characterized by several parameters, such as MTBM (Mean Time Between Maintenance) and Mct (Mean Corrective Maintenance Time).

Anyway, there are several other requirements that can be analyzed in the works of reference.

During the preliminary design phase, review meetings are held, comparing the ongoing design with the SPEC, and are developed the various others specifications for the subsystems (SPEC's SSi, with i = 1, 2, 3, ..., m, and m = number of subsystems) and equipment or components (SPEC's ESj, with j = 1, 2, 3, ..., n, where n = number of items of equipment), as the basis for the acquisition of items needed to compose the architecture of subsystems, including software.

Well, we stopped here.

See you.

References:

(1). Boulding, K. **General Systems Theory: The Skeleton of Science**. Management Science. USA. 1956.

(2). Hall, A. D. **Methodology for Systems Engineering**. D. Van Nostrand Co., Ltd. Princeton, NJ, USA. 1962.

(3). Forrester, J. W. **Principles of Systems**. MIT Press. Cambridge, MA., USA. 1968.

(4). DAU (Defense Acquisition University). **Systems Engineering Fundamentals**. Fort Belvoir, VA, USA. 2000.

(5). Blanchard, B. S.; Fabrick, W. J. **Systems Engineering and Analysis,** 5th. Ed. Prentice Hall. Upper Saddle River, NJ, USA. 2006.

(6). SAE: ARP 4761, **Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment**, SAE. USA, 1996.

(7). SAE: ARP 4754, **Guidelines for Development of Civil Aircraft and Systems,** SAE, USA, 2010.