System Engineering and Analysis (SEA): What Is a System?

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

IYK 29 – JAN 14, 2013

When we treat of Systems Engineering and Analysis (SEA), the first thing we must do is to make clear the concept of system. It is a concept that sometimes is not clear even to the area of systems engineers. In this MSC, we'll start a series of articles focused on the subject SEA, beginning, as we said, with the concept of system.

All we have talked in MSC presented so far is part of the SEA. It is therefore important to explore a little on this subject.

SEA is a widespread discipline in the United States and in several European countries. But here in Brazil it is still in its infancy.

We will present, then, a possible concept for EAS. In a next IYK, we will treat with more details of this concept.

"Set of all engineering activities that occur throughout the life cycle of a System"

Therefore, the central object of the SEA is the System.

It worries about the System from its conception to its disposal or alienation.

So the first thing to do is to answer the question: "What is a System?"

There are natural systems and systems developed by human being. Among the natural systems we can cite a hydrographical basin. Our concern, however, is in the systems developed by human being.

A System developed by the human being can be conceptual or physical.

A System is said conceptual when it is structured only in a set of ideas, plans, specifications, etc., which, for example, precedes and extends during the development of the physical system.

On the other hand, the System classified as physical is one that is structured with physical components (hardware and its software). It occupies physical space. Ex: an engine of a car.

In this work, we are interested in physical systems with their corresponding conceptual systems.

But let us go to present the System concept.

"Set of pieces (people, procedures, materials, tools, equipment, facilities and software), working together to achieve one or more goals."

The "parts" are also called "System Components", or just "Components".

A system has inputs and outputs and one or more forms of energy to power the components in their work. Figure 1 gives an idea of what we are talking about.

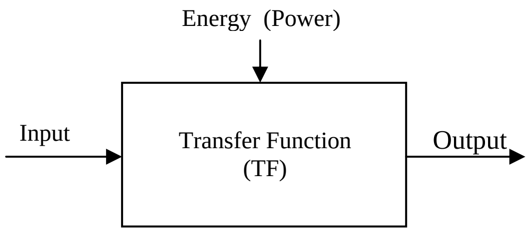

Fig. 1 - System

Each component has its attributes or characteristics, allowing the systems engineer to establish relationships between them, so as to produce together the desired output. These relationships, as a whole, constitute the so-called transfer function.

Theoretically, the FT, as any function, applies to the input to produce the output.

Practically, almost everything we know can be considered a System. A simple procedure and the person who uses it, with or without material resources, constitute a System. Marriage is a System, as we know, too complex.

A country is a System. A ministry of a government is a System. Unfortunately, almost always the ministers have no notion of it.

Other examples: Spatial System, Weapons System, Transport System, Communications System, Services, Manufacturing or Assembly Processes, etc.

The Spatial System of Satellite Launch, for example, includes the launch vehicle and everything that somehow interacts with it, during its assembly and preparation for launch, in the Launch Center.

It is customary to denominate System Main Component or System Main Equipment that part which performs the main task of the System. In this way, to know which the Main Component is, we must ask the following: "which is the part of the System that performs the main task"? For example: Spatial System of Satellite Launch. If we asked that question, the answer would be: "launch vehicle". In the case of the military weapon system, would be the aircraft, tank, ship, etc.

All parts of a System have their function. There is talk of function of the System, Subsystem, equipment, modules and components. To get to the final architecture specification of a System, it is necessary to know all these functions. Once identified, you can then verify who or what can perform them (hardware, software, human being, or a combination of these factors), respecting the restrictions of safety requirements, cost and operational effectiveness.

Also important is the concept of the Subsystem. It can be thus stated:

"Set of components (people, procedures, materials, tools, equipment, facilities and software), working together, so predetermined, in order to achieve one or more objectives for the achievement of the objectives of the System".

Note that this concept tells us clearly that the Subsystem is part of the System.

An important aspect to be considered is the System hierarchy.

In general, there is the following hierarchy in the systems:

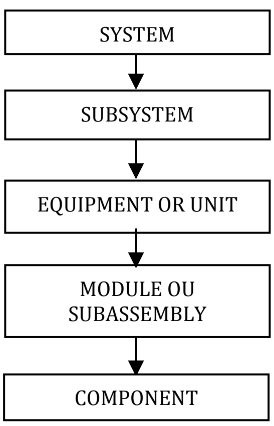

Fig. 2 – Hierarchy of systems

Table 1 gives an example of hierarchy in systems, whereas the product and related services.

Table 1 – Example of hierarchy in systems

HIERARCHY	PRODUCT	SERVICE
System	Spatial System of Satellite Launch	Vehicles Maintenance
Subsystem	Shooting subsystem for the first stage Enginees	Mechanical/Electrical Sector
Equipment or Unit	Shooting command and control panel	Facilities (workshop, electricity, computers, parts warehouse, communication)
Module or Subassemblies	Shooting Command Panel	Maintenance resources (personnel, test benches, procedures, tools)
Component	Shooting Command Panel Devices	Spare Parts

Not always the System in question has all the levels presented in Figure 2. Consider, for example, a truck from a shipping company. The global System is the entire company. One of its subsystems would be the Operational Subsystem, where are the trucks and drivers, which are the units or equipment. But if our interest in the analysis is only that level of Subsystem, the truck and the truck driver would be components (last level of the hierarchy), and we would not have the levels of units or equipment, modules or subassemblies.

On the other hand, if in our analysis we are performing a study focused on the truck, then our system under study is the truck, and everything that is around the same will be its environment. Thus, in such a context, the truck is no longer an equipment or unit, but a System.

In short, the hierarchy presented is relative, i.e., depends on our interest in the analysis. The System, in a particular context, can be Subsystem or equipment; in another, can be component, and so on.

The important matter is to identify, in our analysis, the System of our interest, and everything that is outside its borders, interacting in any way with it, i.e. its environment.

As we have seen, all energy (signal), material or information that passes from the environment to the System is commonly referred to as input, and all energy (signal), material or information, which passes from the System to your environment is called output .

When we perform an analysis, we consider the System of our interest as a black box (term used to mean that, in principle, we do not know what is inside), with inputs and outputs.

After that, we go to the next lower level, that is, we look at the smaller black boxes that make up the system. They are the subsystems. But, when we focus on those "boxes-subsystems", we should consider them, for purposes of analysis, as systems, looking for their inputs and outputs, and come down to smaller levels, to achieve the level of visible indivisibility, coming so to components.

The components themselves can be considered systems, when our analysis to focus on them, and then we can arrive to microscopic systems. Everything, we repeat, depends on the analyst's interest

We stopped by here. Forgive us for this slightly elongated IYK, fleeing the abbreviated spirit of the "Flashes".

See You.

References:

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

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

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

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

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