Cost Effectiveness Criteria for Defence Systems -

A Detailed Analysis from the User's Perspective

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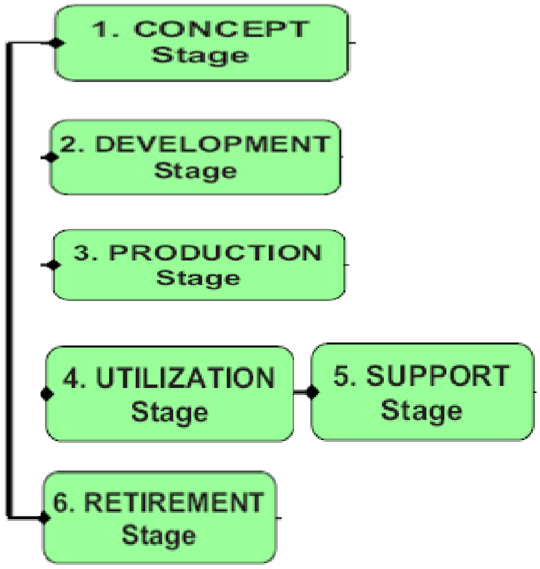
The devil is in the cost details. At least, this is the case for defence administrations and ministries around the world who face the herculean task of maintaining operational militaries whilst simultaneously struggling to procure and deploy reliable systems, equipment and materiel. If, generically speaking, we refer to a "system" as every type – however complex – of military asset, system procurement processes are influenced not only by the initial purchasing cost of a system, but particularly by all costs arising before, during and after the system is delivered for operational use. This would also include its respective *retirement stage* at the end of the system life cycle. The total amount of these costs, for a single system, is commonly defined as **"Life Cycle Cost"** (LCC).

In order to adequately evaluate the Life Cycle Cost of a given system, we require a basic understanding of the schedule evolution of the life cycle and of the procedures involved in its management. For that we can turn to NATO Publication AAP-48 *"Life Cycle Stages and Processes"*, complying with ISO/IEC 15288, *"Systems and software engineering – System life cycle processes"*, which describes stages and processes occurring during the life cycle of defence systems. One basic decision to be made is to choose between the design of a new system (i.e., the *make* option) and the purchase of a system already deployed and available on the market (i.e., the *buy* option). In the first of the two instances, Life Cycle Cost studies are required, so that the LCC can be quantitatively determined, e.g. for the purpose of supporting tender selection or comparing alternative solutions or different economic options.

In many cases, LCC studies have to be reiterated during the entire course of the life cycle in order to support modifications of user requirements or configuration change proposals.

According to NATO AAP-48 mentioned above, the life cycle of a generic system is built on the following *stages*:



"*The Concept Stage starts after the decision to fill a capability gap with a materiel solution and ends with the requirements specification for this materiel solution. The purpose is to evaluate the needs, potential risks, and cost benefit of a proposed system, or a major upgrade of an existing system prior to any commitment of resources. One or more alternative solutions to meet the identified need or concept are developed through analysis, feasibility evaluations, estimations (such as cost, schedule, market intelligence and logistics), trade-off studies, and experimental or prototype development and demonstration.*"

The system LCC estimation serves to ensure that all costs to be incurred (typically arranged in a CBS – *Cost Breakdown Structure* and explained in the CBS dictionary) are correctly accounted for and obtaining the system LCC can be achieved at the lowest possible cost. The LCC estimate must completely include all cost elements, along with their estimated costs, which are derived from a technical assessment of the system, as well as from schedule elements of interest. These are then translated into economic values, using appropriate cost analysis techniques. Technical issues must be iteratively re-examined in specific design reviews so as to ensure compliance of basic design requirements, capability requirements and 'fitness to operational' scenarios. This is the stage at which planners may determine spending limits for the system acquisition programme.

In the past, a great deal of attention has been given to the optimisation of system acquisition costs. In contrast, operating costs (occurring in the *Utilisation Stage*) and maintenance costs (incurred in

Support Stage) are not given the same consideration. In point of fact, technological innovations characterising more modern defence systems require a careful balance of the whole acquisition, ownership *and retirement* costs that compose the Life Cycle Cost, in order to avoid unjustified trends in cost growth.

The LCC estimation process offers several basic elements to support decisions, not only during the early life cycle stages, but in all subsequent periods. Specific decisions are required to manage maintenance policies and to calculate potential *trade-offs* between different possible alternatives, until the system life comes to its projected (and maybe, to some extent, unpredicted) end.

The following relationship:

$$\text{FOM} = \frac{SE}{LCC}$$

introduces a helpful quantitative tool called 'Figures of Merit' (FOM), by which any system to be procured can be characterised on the basis of calculated values of *System Effectiveness* and *Life Cycle Cost*.

From a quantitative point of view, the effectiveness of a generic system is defined as a function of system performance and mission profile. Effectiveness must stand as a primary goal to be taken into account, even from the very early stages of the life cycle in which a larger degree of freedom is allowed in the implementation of system requirements:

$$\text{SE} = \text{A}_0 * \text{D}_0 * \text{C}$$

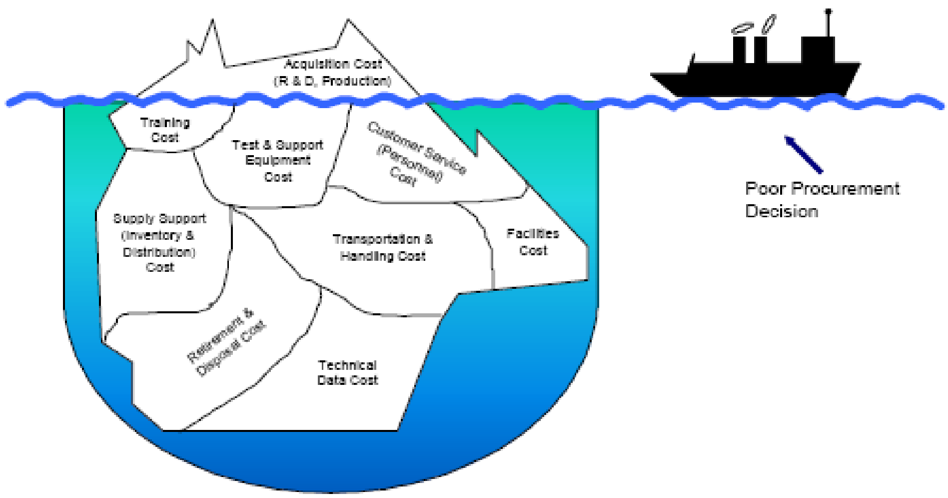
where:

SE (*System Effectiveness*) is a measure of the ability of a system to achieve a set of specific mission requirements.
A_0 (*Operational Availability*) is a measure of the degree to which a system is in the operable and committable state at the start of the mission, when the mission is called for at an unknown (random) time.
D_0 *(Operational Dependability)* is a measure of the degree to which an item is operable and capable of performing its required function at any (random) time during a specified mission profile, given system availability at the start of the mission.

C *(Capability)* is a measure of the ability of an item to achieve mission objectives, given the on-going conditions present during the mission.

The three components of System Effectiveness - *Availability*, *Dependability* and *Capability* - are therefore measures of a system's ability to operate (in terms of duration, repetition and efficacy) during a specified operational mission.

FOM is a Cost-Effectiveness parameter synthesising the overall life-long system performance and its corresponding cost. System Effectiveness may be regarded as a collective term used to describe the system availability performance and its design factors, e.g. reliability, maintainability and logistics support. Acquisition, operation and retirement costs should be estimated as soon as possible, so that responsible authorities can find an optimum balance between System Effectiveness factors and Life Cycle Cost.



B.S. Blanchard, Professor Emeritus at Virginia Tech, effectively metaphorised (in his work *"Design and Manage to Life Cycle Cost"*), the potentially stark contrast between acquisition costs (relatively well known, hence placed above the water line) and the ownership and retirement costs (largely unknown, therefore represented below the water level). Two main aspects that prove conceptually significant for the life cycle of any (defence) system are emphasised by Prof. Blanchard:

- different "visible" aspects of Life Cycle Cost components (in accordance with the iceberg metaphor);
- the fact that it is at the early stages in an acquisition programme that the greatest gains can be realised in terms of the system Life Cycle Cost (which should take into account some downstream events that can occur during the life of the system that might, in turn, influence the

Life Cycle Cost itself: life cycle schedule slips, changes in quantity of systems to be deployed and respective operational conditions; significant improvement programmes).

So how relevant is LCC decision making processes to acquisition programmes? Let’s turn to one prime example: the Pentagon's plan to terminate the US Marine Corps’ Expeditionary Fighting Vehicle (EFV) programme. The mainstream press was quick to share the verdict of US Secretary of Defense Robert Gates, who aptly pointed out that fully executing the programme, "which costs **far more to operate and maintain** than its predecessor, would essentially swallow the entire Marine vehicle budget and most of its total procurement budget for the foreseeable future."

Massimo Pica is a registered professional engineer and a certified cost analyst for advanced defence systems. He has co-authored several NATO publications and is completing a book on the theory and practice of Life Cycle Costing in Systems Engineering.