Weapons' Life Cycle Cost: The Key of Success in Logistics

THEODOROS ZIKOS[1], NIKOLAOS V. KARADIMAS[2], ALEXANDROS TSIGKAS[3], KYRIAKI SIDIROPOULOU[4]

[1]Deputy Director of Ordnance Directorate of Hellenic Army General Staff, Hellas (GR)
[2]Ass. Professor, Div. of Mathematics and Engineering Science, Dept. of Military Science, Hellenic Army Academy, Hellas (GR)
[3]Ret. Professor, Alexandros Tsigkas, Div. of Production and Management Engineering, Democritus University of Thrace, Hellas (GR)
[4]Staff Officer of Logistics Support Directorate of Hellenic Army General Staff, Hellas (GR)

Abstract: - Optimal cost management in terms of logistics systems and the utilization of the science of "Logistics", as it has been shaped with modern technology, lead the exported cost elements to the most important factor in decision making. One of the tools that contribute to the decision-making process is the cost of life cycle of weapon systems. This tool can be extremely useful as it contains information, such as codified materials, and spare parts according to NATO Codification System, which assists and facilitates the work of the logisticians in supporting army's weapon systems. Furthermore, the degree of dependence of a material or a spare part (which make up a weapon system) by its OEM (Original Equipment Manufacturer) and the significant role of it, could consist of an extra key in changing all the life cycle support of the weapon system and the decisions related to it.

Key-Words: Life Cycle Costs, Decision Making, Weapon System.

Received: July 17, 2021. Revised: February 22, 2022. Accepted: March 27, 2022. Published: April 19, 2022.

1 Introduction

A huge development in software was observed during the previous decades (mainly after 1970) in the stages of production control and process management, as a consequence of the great development in the field of information technology. The fact that industries have been looking for additional or alternative ways in their effort to reduce lost sales and meet supply and demand with less inventory, led to the adoption of concepts, forecasting and cost. The goal was to achieve the concept of "optimal" by delivering the combination of maximum result and minimum cost.

It is thus concluded that the development and use of new cost tools, such as Life Cycle Cost (LCC), in decision-making regarding the evaluation of defense materials based on the specific standards of the army, is absolutely necessary. Decision-makers in companies and headquarters in the army, having this tool (LCC) in their quiver, will be now able to make more accurate and right decisions on options presented to them. These options can include evaluation of future expenditure, comparison among various solutions, management of existing budgets, guidance for system acquisition and cost reduction opportunities.

As it is common knowledge, that all decisions include the factor of risk, sometimes smaller and other times larger, this tool is coming to reduce it and alleviate their fear.

Especially, when the decision-makers know that what they decide is going to drive their chain of command, to change production lines to a desired more beneficial one, or for the army the timing to replace a weapon system with another one. One of the factors that affect their decision and is introduced here, is the degree of dependency of a weapon system by the manufacturers. So, it is interesting to understand how all these risks, LCC, and degree of dependency are incorporated in a way, in order to take the right decision.

2 Problem Formulation

The main aim of the current study is to present and propose a methodology for the evaluation of a weapon system - equipment. Its purpose is through the utilization of key process variables such as the degree of dependency of spare parts towards the manufacturers through the life cycle costs, to contribute to the most efficient benchmarking of defense weapons systems - units.

2.1 Definitions

At this point, it is advisable for some definitions of the defense materials used in the armed forces to be given, which will assist the reader to drive to a more complete understanding of the presentation but also to draw a conclusion as well [1].

2.1.1 Weapon System

It is called any complete combination of Main Materials (when it consists of more than one Main Materials), systems and subsystems of military specifications, whose main mission is a defense activity or to support this activity.

The weapon system can consist of more than one Main Materials, either as interdependent parts or as cooperating autonomous systems.

2.1.2 Main Material

It is called any combination of finished systems, components and other materials into a complete system, which is ready to carry out the mission for whom it was built.

2.1.3 Configuration

The set of functional and physical characteristics of a weapon system or main material is defined as it has been determined by the technical specification or its documentation and has been integrated into it [2].

2.1.4 Tree Configuration

Tree configuration is a way to represent graphically the hierarchy of a weapon system structure. It is defined as the physical representation of the weapon system in the form of a tree.

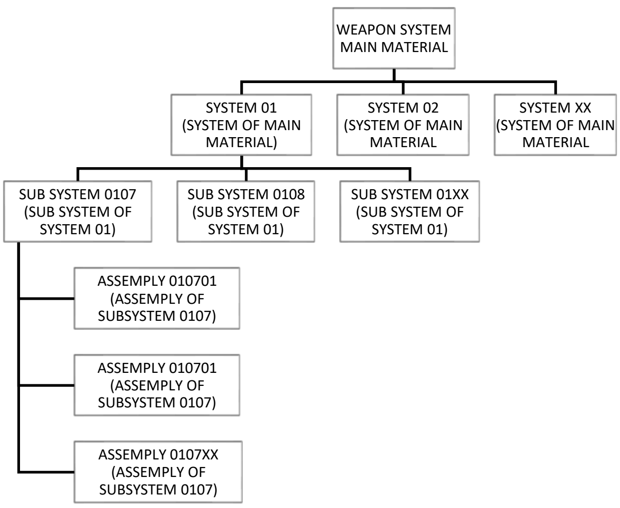

Fig. 1 Tree Structure

Initially, the levels at which the basic materials compose and fully describe the weapon system (assemblies - subassemblies) in tree form are determined. Synonymous terms in the literature are the following: modular design, structural decomposition, and tree representation [3].

So, in Fig. 1 if the weapon system is a tank, then as system 01 is considered the tank itself. The main materials are the cannon 02 and the radio transmitter 03. The subsystems are the vessel 0107 and the turret 0108 of the tank. Respectively the other parts until the smallest piece namely a spare part, show of what it is composed.

Basic coded structure and structure of a tree system of Main System or Main Material							
	TREE LEVEL						
	A'	B΄	C΄	D΄	E΄	F΄	
Code	System	Sub System	Assembly	Sub Assembly	Component	Spare	
	XX	00	00	00	00	000	A΄ Level
	XX	XX	00	00	00	000	B΄ Level
	XX	XX	XX	00	00	000	C΄ Level
	XX	XX	XX	XX	00	000	D΄ Level
	XX	XX	XX	XX	XX	000	E΄ Level
	XX	XX	XX	XX	XX	XXX	F΄ Level

Fig. 2 Tree Levels Analysis

The countries' armed forces usually have six levels in their tree configuration form and are structured as seen in Fig. 2. The lowest level is the "F», and the other levels are shaped, having based on it. It is important to be mentioned that there is no obligation for all the weapon systems to have six levels in their tree configuration. For example, the gun G3A3 has only two levels: Level A which is consisted of barrel-slide-stock-magazine and Level B with the spares of them.

2.2 Decisions-Taking

The concept of the decision is timeless and has been interpreted from time to time in various ways. Since ancient times it was well known already in the words of Solon «Νουν ηγεμόνα ποιου» (let your mind reign in your decisions), while today it can be found in every business activity, where actually the element of prudence required to characterize the decision. According to Emory and Niland, the decision-making process is a necessary step in choosing a solution among alternatives [4].

The same conclusion is reached by Eilon who was studying the definitions that have been given from time to time in the term "decision" and found out that the decision-maker must have many solutions in order to be able to compare them and choose-have namely more options after evaluating the impact of their alternatives [5].

According to Roy and Bouyssou, the "impact of alternatives" could be defined as any possible outcome, that may be linked to the objectives of the decision or the value system of one involved in the decision process [6]. The latter has the ability to process, support or differentiate his choices. So, each of his choices influences his decision and the impact of this choice can be a key point in making the next decision.

Thus, in the case of multi-complex decisions, such as the choice of a weapon system, which by the nature of their object are complex, require according to Simon, the decision-maker or the executive manager to act within the limits of bounded rationality [7]. According to his theory, the ability of the human brain to create and solve complex problems is small, compared to the number of problems that need to be solved, in order to achieve - or at least to approach to achieve - the objective rationality in the empirical world [8]. So, complex decisions which require in-depth analysis and mental processing, oblige the executive managers to gather information to achieve the optimal solution.

The basic methodology for decision support is the Analytical Hierarchy Process (AHP). Its widespread use in the decision-making process for the procurement of defense systems is highlighted by a relevant study [9]. Moreover, in our days is more imperative than ever, due to events that take place such as the reduction of defense spending, the need for optimal distribution of invested funds, the need for enhanced transparency and efficiency and a complex legislative framework.

Decisions involve logically a risk, which must be managed to minimize as much as possible the probability of failure. At this point, information systems provide great assistance in achieving the goal since they reduce the risk in decision making with their accuracy and immediate use.

2.3 Risk management

Risk management is an important process for any business, which helps to increase the chances of success of its plans. This is achieved by protecting the decision makers against wrong investment decisions, by avoiding predictable risks, and by minimizing losses from unpredictable events or conditions.

The operation of a decision support system (like any system) is based on its input. This information in turn should be reliable and cover the full range of information required. Therefore, reliability and range are key features of such a system.

As far as the army is concerned it is the key factor when HAGS (Hellenic Army General Staff) is going to choose a weapon system to be supplied, its maintenance time and finally concludes in choosing its replacement time when it comes. A key tool in making this decision is the cost throughout the life cycle of the weapon system.

2.4 Weapon System Life Cycle Cost

Weapon Life Cycle is defined as the evolution of the weapon system over time from the decision on the necessity of its existence, until its withdrawal [10].

The idea of managing and costing the life cycle of a weapon system dates back to 1939 when the United States issued the first government directive on armaments life cycle costing.

From that time until today, the life cycle cost of a weapons system is a key parameter that must be taken into account and approached through a detailed study in order to implement a defense procurement program.

The decision-makers of the countries have realized the importance of the process of evaluating the LCC of the systems to be procured. Indicatively, in France, the General Directorate of Armaments (GDA) is responsible for this process, which applies the "integrated" concerning the older "serial" model in order to achieve optimal results. In Germany, the relevant body is the Military Technology and Procurement Agency (BWB), which is responsible for the definition, design, development, testing and testing, production and supply of defense systems [11].

In the case of the United Kingdom, the "Downey Cycle" system was originally implemented by the Ministry of Defense, because it did not work in terms of time. It was replaced in 1998 and the principle of smart procurement was introduced, with particular emphasis on risk assessment in the various stages of implementation of the process [12].

The survey found that countries have different models for calculating life cycle costs. A calculation model includes by definition mathematical equations (which in turn include relations, constants and variables) with a specific structure that must be followed to solve the problem.

In the case of LCC evaluation standards, two main categories of models can be distinguished:

- Prefabricated standards ("ready-made" commercial applications used directly to model a problem such as PRICE, CATLOC, ACES, CRYSTAL BALL, etc.).

- Those standards that are made-up by LCC analysts (custom made - in house).

All models follow the basic stages of the LCC which are the following, in terms of their succession in time: Conception as an idea, development, production, operation - utilization, support (support) and retirement while the direct total life cycle cost of the weapon system is given by equation (1).

$$TOC = C1 + C2 + C3 + C4 + C5 + C6 \quad (1)$$

Where TOC and C_1 through C_6 are respectively:
Total Cost = Concept + Development + Production + (Operation - Utilization) + Support + Retirement

As shown in Fig. 3, the use and support follow a parallel path and extend until the withdrawal of the weapon system. The other stages are not or partially overlapped giving more time in decision making process.

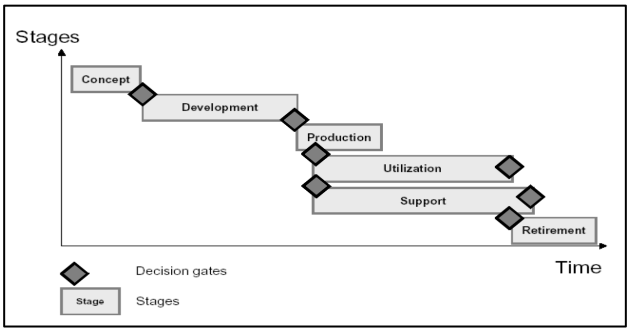

Fig. 3. LCC Stages

LCC is the sum of the direct and indirect variable costs as referred to the relation (2) below.

$$\text{Life Cycle Cost} = \text{Direct Cost} + \text{Indirect Variable Cost} \quad (2)$$

The term «direct» refers to the fact that it is directly related to the existence and operational function of the system (as well as the functions and equipment that support it, e.g., spare parts and maintenance work). The term «indirect» refers to those costs which are not exclusively related to the particular system, but to other similar ones as well (e.g., a tank simulator involving a series of tanks models and not the particular one which is going to be procured or retire of the army).

The approach that says: “I buy a weapon system based on the cost of acquisition”, can "lead" the decision in a totally irrational direction. Thus, a weapon system for instance, which has been chosen by the army among others because of its low purchase cost, may will turn to be very costly based on its life cycle cost in comparison to others weapon systems. This would consist of a very wrong choice and the financial department of the army may will be not able to support it in the future. The abovementioned approach approves that the hidden costs which accompany a weapon system throughout its life cycle must be taken into account. In any case, the fact that the purchase cost is only the "tip of the iceberg" should, not be overlooked as shown in Fig.4 (as seen hereunder).

As one observes in the iceberg, the purchase cost of the weapons system is visible on the side that is visible by once, while many other costs that are the majority, accompany it and are not clearly visible. These one in most cases are not taken into account in the initial stage of purchase, resulting in wrong decisions.

Fig. 4 Tip of the Iceberg

In this case, the point is that the total cost must be taken into account, as this will not only have a consequence on the specific financial burden, but also the "mistake" will be passed on to other areas, minimizing or depriving simultaneously the possibility the committed funds or resources to be used in different ways. The following Fig. 5 shows an indicative breakdown of the cost of each stage in relation to the total [13].

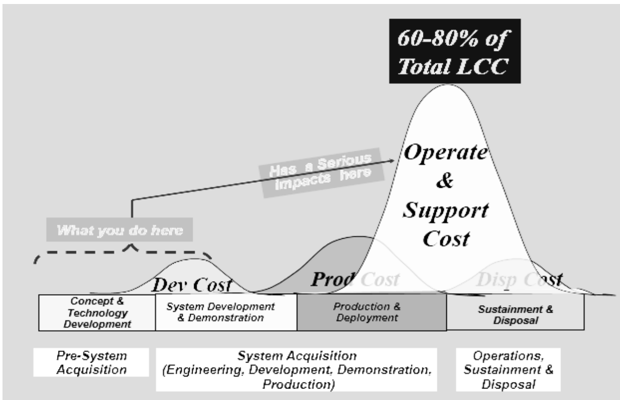

Fig. 5 Breakdown Cost

As it seems in the Fig. 5, the largest share in the life cycle cost of a weapon system has the stage of operation and support at a rate of 60-80%.

The weapon system is now in operation, with the aim of this operation to be efficient under every necessary conditions. This stage lasts until the operation of the weapon system is completely stopped. That means that this stage is of highest significance for a decision to be taken. Namely the weapon system is going to continue its maintenance and remain to the army or to be replaced with another. It becomes even more important when a country such as Northern Macedonia does not develop a new system due to weakness and lack of know-how but acquires it in a condition "ready for use" (so there are no stages of research, development and production).

In addition, such a process can also prevent cases of corruption and embezzlement of national resources and effectively help to respond to the conditions of an unstable geopolitical environment [14].

2.5 Degree of Dependency

The degree of dependency defines the degree to which a system depends on its availability from external factors. Exogenous factors can be considered the supply of spare parts to support the weapon system, its maintenance requirements, special operating conditions and support, etc. The degree of dependence (BE) is determined by the relation (3):

$$BE = 100 * (1 / K) \quad (3)$$

where K is the number of manufacturers producing the spare part.

For example, if there are 15 manufacturers for the spare part then the degree of dependence of the weapon system on this spare part is:

$$BE = (1:15)*100 = 6{,}6\%. \quad (4)$$

Conversely, if there is only one supplier then the degree of dependence on this material is:

$$BE = (1:1)*100 = 100\% \quad (5)$$

Using the degree of dependence for the entire weapon system one can define different levels for it, depending on the degree of maintenance of the weapon system. Maintenance is the function of sustaining materiel in an operational status, restoring it to a serviceable condition, or updating and upgrading its functional utility through modification. Modern, mechanized warfare demands an effective maintenance system [15]. The correlation of the degree of dependence and maintenance is as follows:

- Degree of dependence Level 1 for the 1st - 2nd Maintenance Level which includes work performed by the specially trained technicians of the Unit and includes limited repairs, adjustments, replacement of quorums and small units, inspections, tests and inspections.
- Degree of dependence of Level 2 for the 3rd - 4th Maintenance Level which includes works that require special technological equipment, permanent installations, tools and means, as well as specialized personnel for the repair of large complexes.
- Degree of dependence of the Level 3 for the 5th Maintenance Level which includes works that are precise and are performed in permanent facilities of the army factories and repair facilities in country and abroad as well (for weapons systems where the army has no know-how).

At this point, it is important to be understood how the spares for each level of maintenance can be located. Having in mind the tree structure we discussed in previous paragraphs, each spare which belongs to this structure is accompanied by maintenance identification codes, named SM&Rcodes.

Source Maintenance and Recoverability (SM&R) Codes identify the source of spares and the levels of maintenance authorized to maintain, repair, overhaul, or dispose of all equipment. These codes are assigned to each support item based on the logistic support planned for the weapon system (end item) and its components. Thus, the establishment of uniform SMR codes is an essential step toward improving overall capabilities for more effective interservice and integrated support [16].

The uniform SMR codes format is composed of four parts consisting of a two-position source code, a two-position maintenance code, a one position recoverability code, and a one position Service option code, as seen in figure 6:

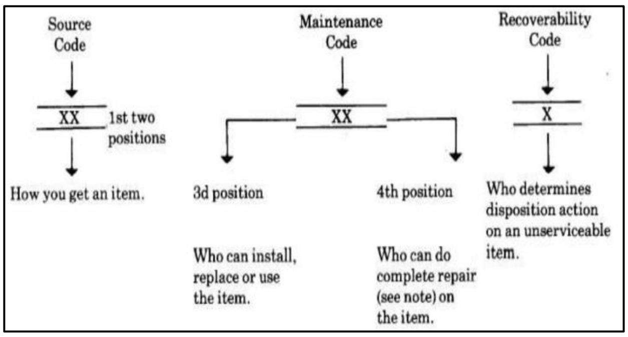

Fig. 6 SM&R Codes Analysis

The Source codes (two positions) indicate the source for acquiring the item for replacement purposes (for instance, procured and stocked, manufactured or assembled).

The Maintenance codes (two positions), for which this study is interested in, entered in the third and fourth positions of the uniform code format are as seen below:

- Third position. The maintenance code entered in the third position, will indicate the level of maintenance and/or maintenance activity authorized to remove or replace and use the item. The decision to code the item for removal and replacement will require that all the resources necessary to install and assure proper operation after installation of a replacement item (for example, pre-installation inspection, testing, and post-installation checkout) are provided.
- Fourth position. The maintenance code entered in the fourth position, indicates whether the item is to be repaired and identifies the LOM and/or maintenance activity with the authority/capability to perform a complete repair action.
- Recoverability code (one position). Code entered in the fifth position of the uniform format, indicates the desired disposition of the support item.
- Reserved for Service option code (one position). Code entered in the sixth position of the uniform format, is used to convey specific information to the logistic community and to the operating forces.

So, the CODE PAGGD6 in Fig x means that the spare is a procured and stocked item for anticipated or known usage. This item is normally considered for replenishment. In addition, it is removed, replaced, or used at both afloat and ashore intermediate activities and complete repair of support item. In this way, the item belongs to the second level degree of dependency.

Going back to the correlation between level of dependency and level of maintenance, we can easily note that for each level of degree of dependency it is possible to proceed with material criticality studies in order to draw conclusions and make decisions about the degree of dependence of a weapon system in relation to its manufacturers.

Also, a significant "gap" is presented by the process of support and the use of the required materials and manpower support of a system, with the impossibility of timely and valid information of the relevant stocks and the respective cost center.

The significant role of this "gap" is even greater if one takes into consideration that the support process applies almost the entire life cycle of the respective CS. This "gap" is not the object of the present.

2.6 Codification

It is possible that the degree of dependence on the spare parts which make it up and described above, can be greatly reduced by using the NATO material codification system.

The NCS has been the appropriate/most suitable method for the identification of all managed stock items since its first development soon after WWII. By creating an effective relationship between the military and its suppliers, and ensuring proper codification, the NCS has become a critical enabler for international and multinational military organisations to manage stock effectively and maintain the armed force at a high level [17].

The NATO Codification System is the official programme under which the equipment components and parts of the military supply systems, are uniformly named, described, classified, and assigned a NATO Stock Number.

Codification is the procedure that examines one item while it compares it with other similar items and gives one and unique number, named NATO stock number, to the items which they have exactly the same characteristics. So, the basic principle for NATO codification system is one stock number for one item.

Fig.7 NATO Codification System Principle

The NATO stock number is a thirteen number which is divided in three parts. The first one is the classification of the item. The classification of materials is done by dividing them into basic categories called groups and identified by a two-digit number. The structure of the system allows the use of 99 groups of which currently about 78 are in use.

Then within each Group, the materials are divided into Classes. These are distinguished by two more digits which together with the two-digit Group Code, form the four-digit NATO Classification Code (NSC). Then there are two numbers that indicate the country that encodes the material for the first time as for example the 12 is for France, the 01 corresponds to USA, the 14 to Germany etc. Finally, there is a seven-digit number which indicates the serial number of the material that the country has coded to date. All the above are summarized in Fig.8 [18].

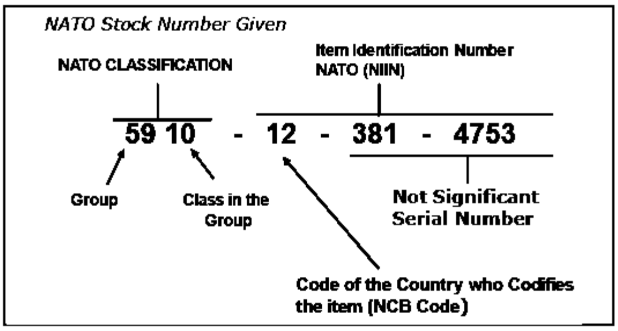

Fig. 8 NATO Stock Number Analysis

These stock numbers and item descriptions are published in supply catalogues and repair parts lists and are used as the key identifiers within logistic information systems. The NCS is a common supply language which operates effectively in a multilingual environment. It facilitates interoperability, curbs duplication (both within nations and between nations), permits interchange ability, and maximises logistics support in the most economical manner possible [19]. However, the primary goal of the NATO Codification System is to ensure that military personnel deployed in an operational scenario, can be assured of getting the right items to accomplish their mission as successfully described below in Fig.9.

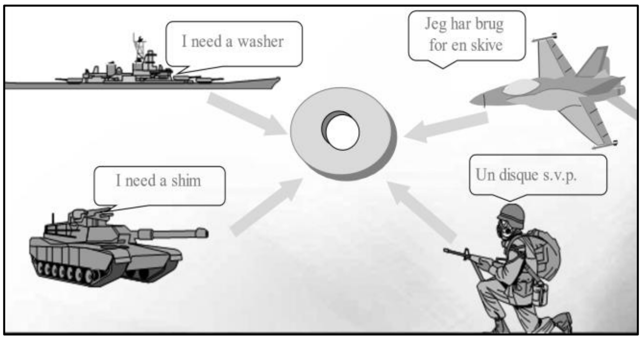

Fig. 9 Need for a Common Language.

It is important to be mentioned that the NCS is so useful and widespread that is followed by other non-NATO nations. In these nations are included non-NATO friendly countries as traditionally is Russia. Moreover, the NCS is open to all manufacturers who want to do business with NATO, offering them unique opportunity to codify their products and be available to all countries who have access to the system belonging or not, to NATO /even if they are a NATO member or not.

3 Problem Solution

At this point an approach on how all of the above are linked to making a decision, is described.

As it was highlighted before, the decision whether a weapon system can be replaced by another one or to be kept in the country's army fleet, this carries great risk, as the cost to be borne by the country, is high. Therefore, the decision should have as little risk as possible.

Knowledge plays an important role in decision making and the more information are collected and processed, then the better decisions one can make. At this point, the information systems offer a great assistance in receiving, classifying and organizing the data in order to provide the maximum result in the field of their utilization. An important aid in this direction is the information extracted from the "tool" that supplies information and is called life cycle cost.

This tool collects and provides information on all stages of a weapon system. What is the most important in the life cycle of the weapon system as mentioned above, is the stage of use and support since it determines its future (maintenance in the weapon systems of the army or its replacement).

Speaking of support now, the most important part concerns the spare part that the system supports. Any information on this is valuable such as its cost, lifetime, level of maintenance, etc.

The specific information as well as many others is provided by the NATO codification system of spare parts. Codification touches virtually every area of the supply chain: in practice it addresses the challenge to correctly identify material and exchange complex technical data regardless of language barriers. The technological support is a key enabler to Codification success [20]. Manufacturers of defense equipment seek to become subscribers of the NATO codification system as they increase the chances of expanding their business activities with the ultimate goal of profiting their business. On the other hand, member and connected to NATO no members countries, require arms manufacturers to have NATO-coded materials when signing defense procurement contracts.

All materials - spare parts of a weapon system are coded according to NATO, so the information provided is exploitable if it is extracted from the appropriate sources and channeled to the "tool" of the life cycle cost. To date, it has been established that all the information provided, focuses on the spare material itself and is neglected by the manufacturer.

In the present study, the manufacturer is called upon to play a key role in decision making. As mentioned above, the NATO stock number is a unique number for each material - spare part. This means that if more than one manufacturer makes the same spare material then they use the same stock number. Then it is very easy to derive the degree of dependency of each spare part on its manufacturers, as presented in a previous section.

If the degree of dependency is being included in the life cycle of a weapon system in its usage - maintenance, then important information can be collected about its future. A typical example is the one where a weapon system is in use for over of 40 years in an army and the manufacturers have stopped to support it. The reason is that the production lines for obsolete spare parts used by probably one user turn to be unprofitable for the operation of their businesses. In this way, it is easily understood that if the manufacturer of a specific spare part is the only one, then the weapon system leads to devaluation. In addition, the cost of this spare part varies, depending on the time the weapon system was manufactured and always is increasing and often in an exponential form.

In addition, the decision-makers are able by using this information to locate any substitutes or interchangeable spare parts for different materials. A substitute of a material or a spare part is defined as the one which can be replaced by another one for a specific function under user's responsibility and without the approval of the manufacturer. An interchangeable spare part is defined as the situation where two or more materials can physically and functionally replace each other in all possible applications and have the approval of the manufacturer [21]. In this way, the decision maker has the opportunity to use each time alternatives, thereby reducing the degree of dependence.

The same thing is happening when a weapon system needs to be procured and the choice must be made, among other weapons. Again, using the cost of its life cycle, the degree of dependence of the spare parts in relation to their manufacturers is chosen and the decision of choice is among equivalent options, which they are based on the offers with the lowest possible degree of dependence.

Approaching a weapon system through its life cycle cost, this serves specific needs, such as:

- The perception of the "big picture", namely, to be perceived each time in terms of total cost of a weapon system.
- The forecasting and timely commitment of the required credits each time.
- Ensuring the business continuity and service of strategic planning.
- The ability to control in terms of exploring the cost-benefit ratio each time as well as in terms of considering the existing policy in order to support decisions to reduce or enhance corresponding costs. A key advantage of the degree of dependency through the life cycle cost approach is that it can be applied to all weapon systems, regardless of the level of complexity and type of use - application.

Fig. 10 Vehicle MS 240GD

This analysis presupposes the full utilization of the already existing information related to the materials - spare parts - assemblies - subassemblies of a weapon system. So, for our study the vehicle MS240 will be used as an example. This vehicle as it is shown in Fig. 10, is consisted by 4.297 spare parts- major items and the army depot has repair capabilities up to 5th Level of maintenance.

According to the manufacturer the life cycle of this vehicle is 30 years, and he decided the 2010 to stop the production of this model and by 2020 to support it. Currently there are few countries they have MS290 to their fleet more than 40 years, so the lifetime of this vehicle is over. So, the logisticians confront the question about the future of their national army vehicle. According to LCC they must propose to their hierarchy to directly replace it. The replacement of the national army vehicle is also a political decision which in time of recession, that's difficult to be accepted by any government because of the high cost. Having incorporated the degree of dependency to LCC they can see:

- The 3rd Level of dependency is for all the 485spares– major items which according to SMR codes belong to this level. Using the BE, the logisticians realized that only 9 of them after 2020 will be not supported anymore by any supplier.
- The 2nd Level of dependency is for 1217 spares – major items and using the BE only 27without support.

- The rest 2.595 spares belong to all levels and are common spares. Using the BE there is no problem in their support as there are not only a lot of manufacturers but many substitutes and interchangeable spares as well (average BE 20%).

Now the logisticians can come with a proposal to hierarchy as to maintain the national vehicle to the fleet instead to replace it, under the condition that a production line has to be established for the 36 spares (9 from the 3rd Level plus 27 from the 2nd Level) in country.

This is an easy example because of the number of spares, the repair capabilities (full repair capability by the army) and the nature-mission of the vehicle (without guns, canons, ammunitions etc.) and the commonality as a vehicle to a civilian edition of it. It was chosen only to indicate the necessity of the degree of dependency through LCC. Going to more complicated weapon systems, the BE is becoming a key factor in decisions making. At this point, it is essential to be highlighted that there are no possible limitations in order to use the abovementioned methodology and way of thinking. The key to success is to have the necessary know-how.

4 Conclusion

The research questions of this study concerned the elements of the life cycle cost analysis that should be taken into account in the case of weapons systems and what are the primary variables for shaping these costs. It was also investigated whether these variables as the degree of dependency are controllable and if so, what are the factors that influence their change by determining the decision that can be taken in order the reliability, support and maintenance of a weapon system to be achieved in the best way.

The major concern today for both, manufacturers and army side, is to be organized in a manner which make them able to deliver not only quantitative and of high-quality services but cost effective as well. This means, from a technical point of view, the improvement of the network that decisions are taken in the chain of command, both internally in the companies or bases and externally between units and their higher headquarters.

In the light of the above, it becomes clear that the modern executive officer of a country's armed forces is called upon to carry out the desired result in decision-making. He must understand that he has finite possibilities to act effectively; he must realize the finite, depending on the ability to analyze the complex experiential reality, his mental abilities. The search for alternatives that will lead to a decision must be taken into consideration as the help of technologies which offer information processed like LCC does.

The usefulness of this process stems first from the need to streamline defense spending, let alone in a period of economic downturn or geopolitical change such as the current one. The basic advantage of this approach is that can be applied to all weapon systems, irrelevant to complexity level of them and the way they are used in the field. This happens because every weapon system has its own life cycle and every life cycle encompasses specific stages (concept -development –production-operation/utilization, support, retirement stage) associated with a cost. Thus, if we follow thoroughly the standard procedure in calculating the LCC of a weapon system, by adding all the costs generated by each stage and analyzing previously some basic parameters like risk, unpredictable conditions, BE, etc.), then we realize easily that this approach can be applied to all weapon systems.

So, this is of great assistance and beneficial to decisions makers giving them the possibility to follow the right path which is driving to the problems solution that every time appeared.

Finally, the BE through LCC could be used by the decision makers as a driving factor to the development of a country's economy. The establishment of new production lines for spare parts or subsystems, which cannot be supported by the weapon systems manufacturers, can bring added value in country (jobs creation, innovation etc.).

References:

[1] Army Regulation 230-3, Instructions for Organization and Operation of Group - Subdivision - Maintenance Unit and Independent Subunits, *Hellenic Army General Staff*, 1975.

[2] US Army/Military HDBK-61A, Configuration Management, 2001.

[3] US Army/DoD, Systems Engineering Fundamentals, *Defense Acquisition University* 2001.

[4] Emory W and Niland P, Making Management Decisions. *Boston: Houghton Mifflin*, 1968.

[5] Eilon S., «What is a Decision? », *Management Science*, 1969.

[6] Roy B and Bouyssou D, Multicriteria decision support: Methods and case "Aide multicritère à la decision: Méthodes et cas", *Economica, Collection Gestion; Paris*, 1993.

[7] Simon H, Economics and Psychology, Models of Bounded Rationality; Behavioral Economics

and Business Organizations, *Cambridge, Mass.: The MIT Press*, Vol.2, 1982.
[8] Simon H, Administrative Behavior, Vol.4.1997.
[9] Tsagdis A, The Use of the Analytical Hierarchy Process as a Source Selection Methodology and Its Potential Application within the Hellenic Air Force, 2008.
[10] NATO RTO-SAS-058, Cost Structure and Life Cycle Costs for Military Systems, 2003.
[11] StromatiasD,Procedures for acquisition-certification & evaluation of defense systems with criteria that cover the time, technical, operational and quality of the user with the minimum cost,2017.
[12] Kirkpatrick D, UK Perspective on Defence Equipment Acquisition, *Institute of Defence and Strategic Studies Singapore*, 2003.
[13] NATO, The CNAD Life Cycle Management Group AC/327.2008.
[14] http://www.point4023.gr/eksorthologismos-ton-amyntikon-dapanon-kai-elliniki-amyntiki-viomixania-i-dipli-proklisi-ton-kairon-mas.
[15] FM 63-4, Combat Service Support – Theater Army Area Command. *USA/DoD*, 1984.
[16] AR700–82/SECNAVINST 4410.23A/AFMAN 21–106, Joint Regulation Governing the Use and Application of Uniform Source, Maintenance, and Recoverability Codes. *USA/Headquarters Army-Navy-Air Forces*, 2020.
[17] NATO, The NATO Codification System, connecting global logistics through technology, 2017.
[18] NATO/NAMSA, NATO manual on codification ACodP-1, 2005.
[19] https://www.nato.int/structur/ac/135/main/pdf/ncs_brochure2005_e.pdf
[20] NATO ALCCP-1, Guidance on LCC, 2007.
[21] http://www.mabxience.com/blogs/differences-between-substitution-and-interchangeability

Creative Commons Attribution License 4.0 (Attribution 4.0 International, CC BY 4.0)

This article is published under the terms of the Creative Commons Attribution License 4.0
https://creativecommons.org/licenses/by/4.0/deed.en_US