The 15th International Scientific Conference
"DEFENSE RESOURCES MANAGEMENT IN THE 21st CENTURY"
Braşov, November 12th-13th 2020

LIFE CYCLE COST (LCC) FOR MILITARY SYSTEMS

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Abstract:
In an era of rapidly changing technology, every military establishment and culture faces major problem. That problem is not what new weapon system should be bought, but how best to reduce the Total Operating Cost (TOC) of existing weapon systems. The difficult question that keeps decision makers and Life Cycle Management (LCM) on edge is in how to manage and maintain that current system during its operation life until disposal or retirement in such a way as to reduce its cost, i.e. to save money and time. Each country is faced with rising costs in maintenance.

Key words: life cycle cost, military, decision making, management

1. Introduction

Costs have long since become a major issue in military systems analysis. Attention is not limited to the acquisition costs alone, but encompasses all costs involved in the use and disposal of systems.

Concepts such as Life Cycle Cost (LCC), Whole Life Cost (WLC), Cost of Ownership (COO) or Total Ownership Cost (TOC) are more and more frequent in dealing with system analysis. Early in the project life cycle, studies need to address the capability gap, the numbers of equipment or platforms required and the technologies that can help to fill the gap at lowest cost.

Once a project team has been formed and given a user requirement, the focus turns to the performance, cost and time envelope of various options that will meet the requirement.

Life-cycle cost is defined as the sum of four major cost categories: (1) research and development costs; (2) investment costs, consisting of procurement, military construction, and acquisition-related operations and maintenance (O&M) associated with the production and deployment activities; (3) O&S costs; and (4) disposal costs.

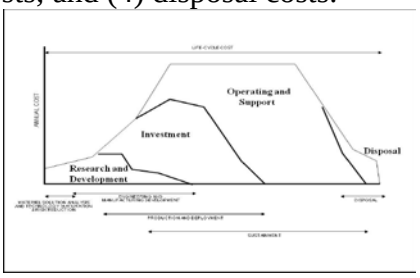

Fig.1 Life-cycle cost

2. Life Cycle Cost Analysis

Life cycle cost analysis (LCCA) is an approach used to assess the total cost of owning a facility or running a project. LCCA considers all the costs associated with obtaining, owning, and disposing of an investment.

Fig.2 Life Cycle Cost Analysis

Life Cycle Costing (LCC) has been used for many years to describe the process by which costs associated with each phase of an equipment's life, development, procurement, operation, support and disposal are brought together to address questions of 'best buy'.

Whole Life Costing (WLC) is a methodology for the systematic economic consideration of all whole life costs and benefits over a period of analysis, as defined in the agreed scope.

Cost of ownership (COO) is defined as the "total lifetime cost associated with acquisition, installation and operation of fabrication equipment".

The Total Ownership Cost (TOC) is the summation of the cost of acquiring and owning or converting an item of material, piece of equipment, or service and post-ownership cost, including the disposal of hazardous and other manufacturing waste. It also includes the cost of lost sales as a result of a reputation for poor product quality causes by defective materials or purchased services that are incorporated in the end product or service.

Life Cycle Costs have been considered key to procurement decisions for many years in a number of NATO countries. Whilst resources in terms of people and cash were considered, often only the marginal (difference) costs between options have been considered. Firstly, because of the practical need to set aside sufficient funds to pay industry for Tanks, Aircraft and Ships and the spares and maintenance required to support them. Secondly because Defense Ministries are large organizations it has been difficult to gather data on resource consumption or communicate costs effectively between budget holders.

Financial Appraisals however include all cash flows and transfer payments and hence assess affordability. In the UK, Cost of Ownership will provide this viewpoint. In financial appraisal, costs need to be split by budget holder, so they know their contribution, by phase to understand the significance over the life cycle and by major 'input' cost category (manpower, stocks purchased, in year expenses etc.).

Provided that in any assessment of options there is an affordable option (comparing COO for the new and existing capability will provide this check) then the IA should be able to identify any alternatives that offer better value for money. In the UK the primary means of distinguishing between options is cost effectiveness. The chart below shows four options with point estimates and ellipses that represent uncertainty in the costs and effectiveness forecasts.

3. Requirements for tools and project phases

The move to Cost of Ownership will help to provide data on existing platforms and hence inform modelling. To support the initiative new tools and approaches have or are being developed. They need to be directed and designed at the whole life cycle of equipment and capability.

Early in the project life cycle, studies need to address the capability gap, the numbers of equipment or platforms required and the technologies that can help to fill the gap to offer best value for money. This requires strategic cost models that can provide a capability to look at the 'big picture'.

Once a project team has been formed and given a user requirement, the focus turns to the performance, cost and time envelope of various options that will meet the requirement. Forecasts of costs for new equipment and platforms are needed. This requires models that have a holistic view and can provide a 'what if' capability.

When the preferred option is identified, industry is generally asked to compete for its supply. Assessments of these bids are based on life cycle cost analysis and need to address economic and financial treatments.

Cost figures need to compliant with rules on Investment Appraisal set out by the Treasury and at the same time provide the data by which budgets can be agreed for the long term operation and support of the assets.

The following are necessary considerations to establish the nature of each cost element when making the forecast:

• Substantially constant regardless of operation and support volumetric changes
• Simply related to operation and support volumetric changes (may use scaling factors)
• Complex relationship due to changing patterns and cost drivers over time (e.g. maintenance concept changes, ageing effects, etc.)
• Periodic, event driven, recurring or non-recurring (e.g. mid-life updates, refits, deployment changes, peace keeping etc.)
• Changing over time (e.g. ageing)
• Step changes (macro-economic impacts)

4. Output (activity) costing and input cost categories

The number of potential activities performed in development, production, operation and support etc. may be considered almost infinite e.g. Prototype manufacture, Maintenance at 1st line, Basic Training, Post Design Support, Storage, Recruitment etc. In the UK a generic Cost and Resource Breakdown Structure (CRBS) has been promulgated to provide a consistent set of activities for equipment cost forecasts.

In support based organizations, overheads are often a major part of the total cost (as they now are in a manufacturing). Any traditional costing system which recovers overheads only in proportion to direct labor costs or time may be of limited use as a management tool because activities other than direct labor may be more closely linked to the generation of costs. In Activity Based Costing (ABC) costs are linked to products via the most appropriate 'cost drivers' not solely by direct labor. Once Activity Based Costing is fully operational it may prove possible to generate cost drivers from this data.

Contributing elements of input cost (i.e. resources consumed in producing the activities) can be reduced to just 9 categories.

• Manpower expenditure (internal staff)
• Payments on contract
• Development expenditure and intangible assets
• Assets in the Course Of Construction (ACOC)
• Other fixed assets
• Capital spares purchase (e.g. spare aero plane engines)

• RMC (Raw Materials and Consumables) GWMB (Guided Weapons, Missiles and Bombs) purchase

• Stock and RMC purchase

• Other expenditure

Regarding force and armament planning the relatively long life cycle of military systems has to be considered and a total life cycle cost (LCC) in the evaluation of optimal decision reflected. When analyzing LCC a cost breakdown structure (CBS) has to be determined as the first step and a cost estimating follows. A variety of methods are available to develop a cost estimate (e.g. parametric, analogous, accounting method, expert opinion) and the methodology chosen depends on the level of detail required, the availability of data, and time constraints. An example of simplified preliminary cost estimate from the Czech Armed Forces is based on the relationship of LCC elements to the cost of acquisition alone. As a decision support tool for defense planning a simulation model ForceSim has been developed. This model is based on the optional scenario portfolio of security risks. Each scenario requires the corresponding kind and number of military systems and when we sum up the demands of all risks regarding possible concurrency and substitution, the outcome is the required structure of defense force pool. But each system represents a corresponding cost demand in the case of activation (initial cost), cost for the operation and support of deployed system, as well cost for the deactivation of
a superfluous system (disposal cost).

DOD-USA: operating and support cost-estimating guide office of the secretary of defense cost assessment and program evaluation march 2014.

For many programs, the system O&S costs will be the largest of the four cost categories, which is why there is renewed emphasis on O&S affordability and cost management. Based on cost estimates from recent Selected Acquisition Reports (SARs), the percentage of program life-cycle cost associated with O&S costs (for seven system types) calculated in constant base-year dollars is presented in the next two Figures: O&S Costs as Percentage of Total Life-Cycle Cost for Selected System Types.

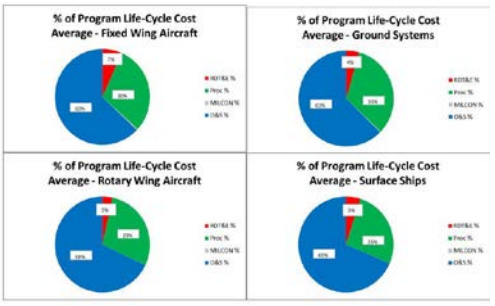

Fig.3.1 the percentage of program life-cycle cost associated with O&S costs (for seven system types) calculated in constant base-year dollars.

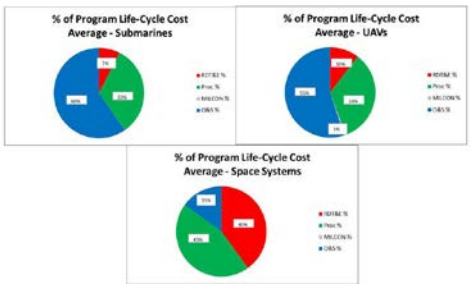

Fig.3.2 the percentage of program life-cycle cost associated with O&S costs (for seven system types) calculated in constant base-year dollars.

5. Life-cycle cost categories

The life-cycle cost categories correspond not only to phases of the acquisition process, but also to budget appropriation categories. Research and development costs are funded from Research, Development, Test and Evaluation (RDT&E) appropriations; and investment costs are funded from Procurement, Military Construction (MILCON), and, occasionally, acquisition-related O&M appropriations. O&S costs are primarily funded from Military Personnel (MILPERS) and O&M appropriations.

Note that for both MILPERS and O&M, there are distinct appropriations for the Active, Reserve, and Guard Components. In addition, the O&S cost elements for continuing system improvements (system hardware modifications and software maintenance) may be funded by RDT&E and/or Procurement appropriations.

A cost benefit analysis is an exercise in which all of the costs and benefits of an activity are quantified and valued in monetary terms. It is therefore possible to evaluate and compare options and see if the benefits exceed the costs i.e. 'send to save'.

Life Cycle Costing is the method used to quantify the relative costs to acquire and operate each option. This analysis will develop the costs for each option. This could be the first estimate of Life Cycle Cost (LCC). The first estimate of LCC is based upon a comprehensive statement of requirement in mission terms and an outline of a solution.

Such an estimate is strictly an indication of the total project cost and completion date.

After this preliminary evaluation, a Program Planning Proposal (PPP) is prepared.

The PPP identifies resources required in broad terms and is equivalent to a defeasibility study. Following approval of PPP, a Project Development Study is performed.

The Visibility and Management of Operating and Support Costs (VAMOSC) program is the most complete source of operating and support (O&S) cost data available to the three U.S. Military Services (Army, Navy and Air Force). Under the general VAMOSC umbrella, each of the services has developed its own system based on the OSD Cost Analysis Improvement Group (CAIG) cost element structure documented in DOD 5000.4M, entitled "DoD Cost Analysis Guidance and Procedures". The program includes the Navy's VAMOSC system, managed by the Naval Center for Cost Analysis (NCCA), the Air Force's system, known as Air Force Total Ownership Cost (AFTOC) and managed by the Air Force Cost Analysis Agency (AFCAA), and the Army's Operating and Support management Information System (OSMIS), and managed by the Cost and Economic Analysis Center (CEAC). These Service programs track the O&S costs for major weapon systems and some sub-systems using data drawn from their respective reporting organizations. Typical users of VAMOSC include estimators, financial programmers and logisticians.

All three Service systems face challenges to standardize cost elements and be able to validate these costs against financial data by appropriation. Each of the Service VAMOSC systems currently reports O&S costs in a format somewhat different from the CAIG O&S cost element structure. There is a continuing need to improve data sources to ensure that weapon system life cycle costs (LCC) are fully reported in a more timely fashion. Ideally, "real time" reporting of data is desired, but that is a very difficult goal to achieve. At present, Navy VAMOSC data is reported once a year. As enhancements and improvements are made, cost comparisons across Services will be easier as the systems, sources and coverage of the CAIG cost element structure are made more uniform.

6. LCC in Defence planning

Within the last few years, the needs of defense planners have changed radically, with the collapse of the Warsaw Pact, reductions in defense expenditures in most countries, and growing instability in some parts of the world. There is much uncertainty as to what type of force may be appropriate, what equipment is needed, and what concept of operations might be required in scenarios, which are still unfolding. The time horizon of defense planning must be commensurable with the average life of force structures, and it appears that force structure life time's become ever longer. For instance, combat aircraft that used to live for 10 to 20 years in peacetime, now live for 20 or 30 years (or more, e.g. the case of bomber B-52) with capability enhancing mid-life upgrades. There is other related factor that demands a rather long time horizon. The time constants required to change organization, operational procedures, training and doctrines are significant too. But a defense budget is a key factor that drives the size of defense force, the level of technology implemented, the level of readiness that can be maintained and the amount of research that can be supported to develop new technology. The
Constraints of the defense budget produce competing demands among various elements of defense force. As requirements almost exceed resources, defense planners must balance these competing demands to achieve effectiveness and affordability.

The next Annex is from "Development of cost breakdown structure for defence acquisition projects"- details at References, and is presenting a generic CBS (Cost Breakdown Structure) for military equipment in a typical Canadian context

Life cycle costing is a complex process that involves estimating the overall costs of an item over its entire life. A CBS is a hierarchical structure whereby the project cost elements are organized to avoid missing or double counting errors.

In order to better facilitate life cycle costing, each project is divided into four main phases: development, acquisition, in-service, and disposal phases. Each phase is also divided into smaller and manageable activities. The suggested approach is rationally guided by the principle of three constituents (activity, product and resource). This principle states that a cost appears when a resource is used by an activity applied to develop, produce, operate, sustain, or dispose a specific product. The first step in this approach is to identify the activities to be performed and their respective resources. The second is to assign resource costs to each activity. The third is to assign activity costs to cost objects.

We will focus on the first step.

Canadian generic CBS (Cost Breakdown Structure) for defense acquisition projects

1.0 Development
1.1 Project management
- Salaries (Civilian and military)
- Contracted Support
- Operating Expenses (Travel, Office Space/Supplies, Training, Legal, Security etc.)
- Professional Service
- PWGSC Revenue Dependency

1.2 Studies and analyses
1.3 Solicitation and Contracts
1.4 Research and Design (Optional)
- Design & Development
- System Engineering/Program Management
- Engineering Development Model

- Operational Test and Evaluations
- Other Studies
1.5 Other
2.0 Acquisition
2.1 Management
- Salaries
- Contracted Support
- Operating Expenses
- Professional Service
2.2 Studies, Analysis and Simulation
2.3 Engineering
- System Engineering
- Design and Development Engineering
- Design and Engineering Changes
2.4 Purchase
- Main Mission System
- Major Sub-systems
- Support System:
Peculiar Equipment
Common Equipment
- Initial Spares and Repair Parts
2.5 System Integration
2.6 System Test, Trials and Evaluation
- Developmental Test and Evaluation
- Operational Test and Evaluation
- Mock-ups/System Integration Labs
- Test and Evaluation Support
- Test Facilities
2.7 Deployment
- Delivery (PHST – Packaging, Handling, Storage and Transportation)
- Initial Training
- Installations and Set-To-Work
- Final Acceptance Test
2.8 Infrastructure, Facilities and Investment on Specific Means
- Industrial Investment
- Government Investment
2.9 Other
3.0 Operations & Sustainment
3.1 Operations
- System Manpower
- Energy (Fuel, Petroleum, Oil and Lubricates, Electricity, etc.)
- Training Munitions and Expendable Stores
- Other Operating Materials
- Operation Support and Services
3.2 Maintenance
- Level 1 Maintenance
- Level 2 Maintenance

- Level 3 Maintenance
- Level 4 Maintenance

3.3 Sustaining Support
- System Specific Training
- Support Equipment Maintenance and Repair
- Sustaining/System Engineering
- Program Management
- Software Maintenance Support
- Maintaining and Updating of Data and Technical Publications
- Replenishment and PHST

3.4 Continuing System Improvements
- Software Upgrade
- Modification and Engineering Change
- Major System/Capability Upgrade

3.5 Indirect Support
- Installation/Operation Support
- Personnel Support
- General Training and Education
- Other Indirect Support (Legal, Security, Housing, etc.)

4.0 Disposal
4.1 Disposal Planning
- Disposal Project Management plan
- Disposal Environmental Management Plan
- Tenders and Tender evaluation

4.2 Demilitarization
4.3 Disposal of hazardous materials
4.4 Dismantle or Destruction of System
4.5 Storage
4.6 Transportation
4.7 Resale of Demilitarized System (revenue)

The suggested hierarchical structure is comprehensive ensuring all activities are well-defined. It is also flexible and easy to use and to update as the project evolves. The suggested CBS is establishing a common ground for preparing and presenting a cost structure for national defense acquisition projects. They can also provide guidance to LCC studies in multinational projects involving allied members.

As far as I personally know, Romania military doesn't have anything like this. It can use this because of all the arguments mentioned above.

7. Conclusions

In an era of rapidly changing technology, every military establishment and culture faces major problem. That problem is not what new weapon system should be bought, but how best to reduce the Total Operating Cost (TOC) of existing weapon systems. The difficult question that keeps decision makers and Life Cycle Management (LCM) on edge is in how to manage and maintain that current system during its operation life until disposal or retirement in such a way as to reduce its cost, i.e. to save money and time. Each country is faced with rising costs in maintenance.

The decision to field a new system requires a commitment to support that system throughout its life cycle.

Decisions to develop, procure, and support new systems are based on many factors, one of which is the projected cost of the systems over their operational lifetime.

Aircraft operating costs are expected to decline initially, plateau, and then increase during a final phase of their life cycle.

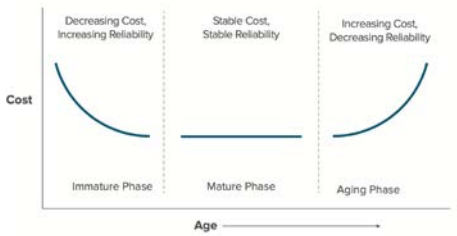

Fig.4 Aircraft operating costs are expected to decline initially, plateau, and then increase during a final phase of their life cycle.

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