BUILDING LIFE CYCLE COST

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Abstract - *LCC consists of all direct costs plus indirect-variable costs associated with the procurement and disposal of the system. Indirect costs may include linked costs such as additional common support equipment, additional administrative personnel and non-linked costs such as new recruiters to recruit additional personnel. All indirect costs related to activities or resources that are not affected by the introduction of the system are not part of LCC. LCC comprises the marginal costs (both direct and indirect) of introducing a new equipment or capability. There are many ways finding out the life cycle cost of structures. although LCC Provides budgeted owner cost and present decision-making scenario in final prospective to achieve the lowest long-term cost of ownership but does not include building life cycle cost. The Present Study consists of LCC Study done for three Residential buildings of Mumbai Location to evaluate economical year or demolition year of structures.*

***Key Words*: Whole Building Life cycle cost analysis.**

1. INTRODUCTION

LCC is used in different ways and the way analysts and decision makers use LCC has necessarily an impact on its definition. This aspect includes the classification of costs into several categories (direct, indirect, variable, etc.), the definition of LCC variants (LCC, TOC, WLC) and the use of each one.

The following definitions have been developed:

Linked costs: Costs that can be associated to the acquisition, operation, support and disposal of the system. Example: system specific training.

Non linked costs:, Costs that cannot be readily associated to the system. Examples: medical services, ceremonial units, basic general training (not related to a specific equipment), headquarters and staff, academies, recruiters, etc.

Direct costs: Costs referring to activities that can easily be allocated to a system or product. Example: Costs for a system specific tool.

Indirect costs: Costs referring to activities that can be associated to several systems and cannot easily be distributed between them. Example: Cost for a multi-functional tool.

Variable costs: These costs are affected by the existence of the system. They fluctuate with a characteristic of the system. Example: Costs for fuel.

Fixed costs: These costs do not vary because of the existence of the system. Example: Costs for infrastructure.

Life Cycle Cost (LCC) consists of all direct costs plus indirect-variable costs associated with the procurement and disposal of the system. Indirect costs may include linked costs s additional common support equipment, additional administrative personnel and non-linked costs such as new recruiters to recruit additional personnel. All indirect costs related to activities or resources that are not affected by the introduction of the system are not part of LCC. LCC comprises the marginal costs (both direct and indirect) of introducing a new equipment or capability. LCC is used as a minimum for the analysis of alternatives; it does not include notional allocation of costs, whereas TOC and WLC might do so. LCC is used to compare options of alternatives, and often for economic analyses.

LCC: Life Cycle Costs = direct costs + indirect, variable costs

Total Ownership Costs (TOC) consists of all elements that are part of LCC plus the indirect, fixed, linked costs. These latter may include items such as common support equipment, common facilities, personnel required for unit command, administration, supervision, operations planning and control, fuel and munitions handling. TOC represents all costs associated with the ownership of a system except non-linked fixed costs that are related to the running of the organisation. TOC is used for budgeting purposes, determining the use of services between systems, for optimisation purposes and for financial analysis.

TOC: Total Ownership Cost = LCC + linked, indirect, fixed costs

Whole Life Costing (WLC) consists of all elements that are part of TOC plus indirect, fixed, non-linked costs. These latter may include items such as family housing, medical services, ceremonial units, basic training, headquarters and staff, academies, recruiters. In WLC all costs or expenses made by the organisation are attributed to the systems or products they produce. As WLC represents the total budget provision including such element as headquarters costs, it allows the visibility of the complete allocation of funds. WLC is used for a strategic view and high level studies.

WLC: Whole Life Cost = TOC + non linked, indirect, fixed costs

1.1 LIFE CYCLE COST PROGRAMME

All multi-national programmes must implement a life cycle cost programme. A life cycle cost estimate, done properly, is the single best metric for measuring the value for money of defence resources. This metric, in turn, is useful in wide range of applications including:

- Evaluating alternative solutions and source selection
- Assessing the affordability of the programme
- Managing existing budgets
- Developing future expenditure profiles
- Evaluating cost reduction opportunities
- Evaluating areas of financial risk and uncertainty.
- Improving the business processes of the organisation.

There are clear and unequivocal benefits to be gained by all the stakeholders through undertaking a life cycle cost analysis on the system of interest. These include:

- Providing a better insight of all the costs in the programme and identifying the key cost drivers for potential cost savings.
- Providing a realistic planning programme and budgeting through a methodical and consistent estimating approach.
- Providing the basis for measurement of effective organisational and logistic scenarios and provisions.
- Providing a measure to evaluate two or more technically different solutions to assist the decision-making process.

1.2 BENEFITS OF LIFE CYCLE COSTING

Life cycle costing is a very useful process to support the control and management of all the mandatory and stakeholders' multi-criteria requirements in the most effective and economical way.

The stakeholders in the life cycle are those who have a justifiable claim to be allowed to influence requirements which defines the system of interest. These include, but are not limited to:

- Those affected by the system of interest, such as clients and suppliers;
- Project and programme managers who are concerned for the system of interest to succeed;
- Regulators such as defence decision makers, local and state governments and standardisation bodies;

Those involved in the development, acquisition and support organisation such as engineers, architects, planners and financial personnel.

1.3 LIFE CYCLE COSTING APPROACH

The approach taken to conduct life cycle costing is highly dependent on the life cycle stage of the system of interest as this determines the availability of data and the technical maturity of the system.

Concept Stage 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.

Development Stage The development stage is executed to develop a system of interest that meets the user requirements and can be produced, tested, evaluated, operated, supported and retired.

Production Stage The production stage is executed to produce or manufacture the product, to test the product and to produce related supporting and enabling systems as needed.

Utilisation Stage The utilisation stage is executed to operate the product at the intended operational sites, to deliver the required services with continued operational and cost effectiveness.

Support Stage The support stage is executed to provide logistics, maintenance, and support services that enable the continued system of interest in operational and sustainable service. The support stage is completed with the retirement of the system of interest and termination of support services.

Retirement Stage The retirement stage provides for the removal of a system of interest and related operational and support services and to operate and support the retirement system itself. This stage begins when a system of interest is taken out of service.

Life Cycle Cost analysis should be applied as early as possible in the life cycle of the system of interest, as the greatest opportunities to reduce life cycle costs usually occur during the early phases of the programme.

1.4 FACTORS INFLUENCING LIFE CYCLE COSTING

Before a life cycle cost can start many factors have to be determined as they have influence on the way a Life Cycle Cost analysis can be conducted. These factors include: the objective, requirements, constraints and the assumptions are discussed below.

Furthermore, various methods and models to estimate costs were reviewed and issues related to data collection, uncertainty and risk, reporting and presentation and multi national aspects were discussed. Furthermore for all these topics recommendations were provided.

2. LITERATURE SURVEY

Isabel Pedro, Jose Antonio Filipe, Bruno Rodriguez studied model that allows the manager to have tools that will help him to calculate and justify his decisions, and it is desirable that he can have, over the lifetime of the equipment, the full perception of the expenses and income.

This model was therefore developed with the aim of functioning as a decision support tool in the company. In this sense, and into the future, the company should develop a more sophisticated equipment expenses study of its equipments since there are expenses that are not being addressed.

Given the simplicity of this model it can be implemented with the systems already used in the company, which in this particular case is SAP, so, every year, automatically, costs and revenues are updated and allow projections of future costs based on past data, credible and real.

Vidya Patil investigates that financial decisions can be based on life cycle cost. Life Cycle Cost analysis is to arrive at such an economic equitable assessment of competing design alternatives and it further useful for budget planning. Life cycle cost analysis of the assets of road pavement by using present worth method. The information regarding the user cost and vehicle operating cost as per IRC recommendation is also discussed in detail.

Palle Thoft-Christensen discussed design and maintenance of infrastructures using Life-Cycle Cost-Benefit analysis with special emphasis on users' costs. This is for several infrastructures such as bridges,highways etc. of great importance.

Francesco Testa, Fabio Iraldo, Marco Frey, Ryan O'connor has shown how life cycle costing is a very flexible tool that supports the various actors in the economic arena in the new challenge of sustainability. The capacity of life cycle costing to estimate environmental burdens in financial values, by integrating economic and environmental information of physical evidence, has been largely demonstrated, however, some doubts and uncertainties remain concerning the approach to be used.

Erika Levander, Jutta Schade, Lars Stehn discussed advantages and disadvantages of various economic evaluation methods for LCC because data collection causes difficulties. Data need to be predictable if the LCC analysis is to be reliable. Regional databases are seldom available or usable. Collecting data by hand, takes much time and money. This is worthwhile if the project is big enough. When historical data are collected and updated over time, their use can become more reliable and the LCC analysis more trustworthy

Gary Hicks, Jon A. Epps evaluated the life cycle costs (LCC) of paving materials containing asphalt rubber binders as well as alternate treatments. They have shown comparative results to evaluate the LCC for hot-mix structural overlays, nonstructural surface courses, and chip seals containing conventional (or polymer modified) binders with similar applications containing asphalt rubber binders. The findings indicate asphalt rubber is cost effective in many of the applications used by local agencies.

C. Vipulanandan, G. Pasari focused on developing a model to estimate the Life Cycle Cost (LCC) for operating a wastewater sewer system. A spreadsheet model has been developed, which is based on population and average household occupancy. Essential components of a wastewater system have been identified and divided into sectors with housing, commercial, educational and recreational facilities.

Kaan Ozbay, Dima Jawad, Neville A. Parker, Sajjad Hussain observed gap between the state-of-the-practice and state-of-the-art of the LCCA. After all,this gap set up grounds for the noted mistrust in the credibility of LCCA. In addition to presenting the study results, their paper presents an analysis of the observed gap and its cause and concludes with recommendations on what can be done to bridge this gap

Pernilla Gluch, Henrikke Baumann discussed theoretical assumptions and the practical usefulness of the LCC approach in making environmentally responsible investment decisions. LCC's monetary unit and extended scope may speak in favour of using LCC but LCC fails to handle irreversible decisions, neglects items that have no owner and does not consider costs to future generations.

Moreover, LCC does not take into account the decision makers' limited ability to make rational decisions under uncertainty. LCC's practical usefulness is constrained by its oversimpli5cation to a monetary unit, the lack of reliable data, complexity of the building process and conceptual confusions. To handle these inconsistencies in future development of environmental decision support tools three research solutions are proposed.

Y. Asiedu attempted to improve the design of products and reduce design changes, cost, and time to market, concurrent engineering or life cycle engineering has emerged as an effective approach to addressing these issues in today's competitive global market.

3. METHODS USED TO PREDICT LCC

3.1 ANALOGY COST ESTIMATING

This cost estimating method is accomplished by forecasting the cost of the future based on the historical cost of a similar or analogous item. The costs of the historical item must first be normalized for both content and historical price differences. Normalizing for content entails deducting the cost of components that are not comparable to the new design and adding estimated costs of the new components.

Normalizing for inflation entails converting historical cost to an appropriate base year value and applying the proper escalation indices to achieve then-year costs. Estimating by analogy involves comparing your system and/or cost breakdown structure elements to comparable current and or historical systems or cost breakdown elements.

This involves understanding the programme and how it derives its history, for example, what programme it is based upon. It is important to interact with programme engineers to ensure the validity and credibility of candidate analogous programme to the future system; once comparable programmes are considered, it is necessary to seek out those specific systems if possible, to obtain necessary data and cost information.

The estimator will also need to talk to the programme engineers to understand differences between the future system and the comparable analogous system.

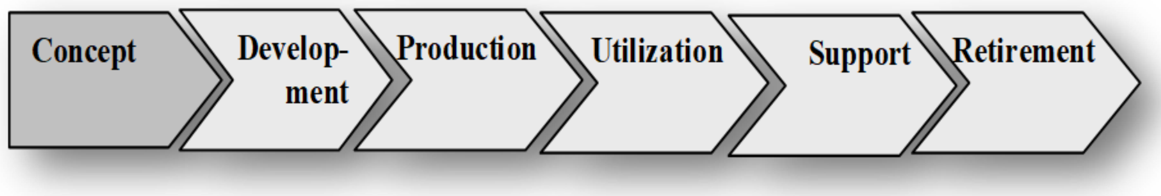

Figure 3.1: Life Cycle Stages

3.2 PARAMETRIC COST ESTIMATING

Parametric estimating requires that a statistically valid relationship be established among the dependent variable, such as cost, and independent variables, such as costs of other elements, and or various physical and performance characteristics of that system. This parametric CER (cost estimating relationship) is then used to estimate the cost of a new system with different values for the same physical and performance characteristics.

Provided below is an example, based on a dozen historical observations on number of man-months required for lead ship construction and the displacement tonnage of that ship. Note, that construction for the first ship in a class is typically a development contract, and includes non-recurring design effort.

First, a CER is estimated using least-squares regression analysis.
Yi = 10.3 + 100.7Xi + ei (4.3) (3.2)
n = 12
R^2 = 0.87
F = 17.1,
Where
n = the number of historical observations used to estimate the equation.
Yi = number of man-months required to construct the ith ship (in millions).
Xi = displacement tonnage of the ith ship (in thousands).
ei = the i^{th} regression residual.

R^2 = The coefficient of determination, or the proportion of variation of Y (dependent variable) that can be attributed to the variation of the explanatory or independent variables

(X's). It is a measure commonly used to describe how well the sample regression line fits the observed data. Note that 0 <= R^2 <= 1.
F = measures the overall power of the regression equation in explaining changes in the dependent variable.

More specifically, it is used in testing the null hypothesis of no relationship between the set of X's (explanatory variables) and Y (the dependent variable).
and where t-statistics are shown in parentheses.

Then, a value for displacement tonnage for the new system is input into the estimated regression equation to give an estimate of man-months of effort required to design and construct the new ship.

3.3 HISTORICAL TREND ANALYSIS

In addition to the estimating techniques discussed above conducting a historical trend analysis provides the estimator with the ability to set estimated costs and time schedules either separately or together in the context of historical costs for similar or related programmers. This is distinct from any cost estimating models themselves. Its uses are:

- To provide supplementary background information of a kind that can assist an estimator by giving a wider context to their work upon an individual program.

- Similarly, by providing context and background to a study, it facilitates the work of those responsible for the scrutiny of estimates prepared by others e.g. as in auditing and due diligence work.

Line chart of historical trends illustrates the estimated cost of a new program in the context of historical trends as amplified by the actual outturn costs of a substantial number of similar programmers completed in the past. All the costs having been normalized to common economic conditions and due allowance made for differences in scale. How well the estimated costs of the new program fit into this context is both seen by the user in readily-understood graphical form and can also analyzed statistically.

3.4 ESTIMATION BY PROBABILITY DISTRIBUTION

In probability and statistics, density estimation is the construction of an estimate, based on observed data, of an unobservable underlying probability density function. The unobservable density function is thought of as the density according to which a large population is distributed; the data are usually thought of as a random sample from that population.

3.5 SCHEDULE OF RATES

The Schedule of Rates is the best-known rate guide in the construction industry and is the standard document used in construction work. It generally contains over 10,000 rates spanning the whole range of building works and materials. Schedule of rates are generally used to determine initial construction cost, demolition and dismantling cost.

Unified Schedule of Rates (USR) is prepared by Bombay Municipal Corporation (now Municipal Corporation of Greater Mumbai) which one of the largest local self-government in the Asian Continent. M/s.Tata Consulting Engineers Ltd were directed by MCGM to conduct an integrated factual market research for major materials from stockists /manufacturers /dealers and to study schedules of rates of Govt. bodies like C.P.W.D., P.W.D. etc Unified Schedule of Rates (USR) are operative from 16-09-2013

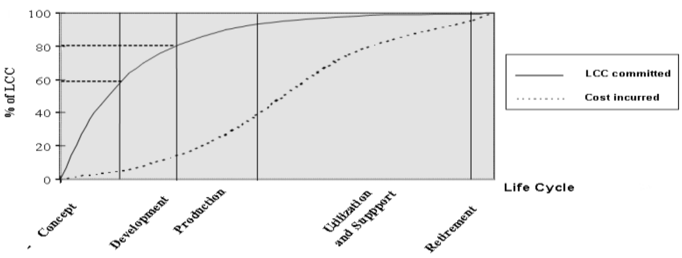

Figure 1.5: Traditional LCC committed versus incurred cost curve

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