THE DEVELOPMENT OF AN INTEGRATED LIFE CYCLE COSTING MODEL USING OBJECT ORIENTED AND VR TECHNOLOGIES

An integrated life cycle costing model

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Abstract

There is an increasing realisation of the importance of operation and maintenance as opposed to capital costs throughout the life of an asset. In addition, new styles of contracts such as PFI (Private Finance Initiative) are becoming more popular. This will require that the building product is addressed within its holistic picture including the design, construction and maintenance. It is therefore vital to embed the life cycle costing element of a facility within its design and construction. Whole Life Costing is a technique used to facilitate effective choice between alternatives in the search of economic solutions. Information technology, particularly integrated databases and VR (Virtual Reality), can provide the mechanism to facilitate the integration of the whole life cost information.
The research project described in this paper aims to add a life cycle costing element to the design phase of the OSCON integrated database developed at Salford University in the UK. The current integrated database within OSCON supports the functions of design, estimating and planning. The proposed system will allow the user within a VR environment to navigate inside the building retrieving information about building components that need replacement or repair. A colouring mechanism will be developed to show various elements in different colours according to cost criteria. This would allow the user to easily inspect the building and get rough ideas of repair and maintenance programmes, running costs and cash flows. The system will allow data to be updated continuously so that it will enable the comparison with initial plans and estimates and provides a fresh view of future action and feedback.

Keywords: life cycle costing, information technology, virtual reality, construction projects.

1 Introduction

Design for whole life cost is becoming a major issue in the construction industry. The days where the asset was separated from its use are over. Whole Life Costing provides an opportunity to integrate design, operation and maintenance information. Whole Life Costing is an evaluation tool for choosing among alternative options taking into consideration all costs that emerge throughout the life of an asset, from initial investment costs to subsequent maintenance and operating costs through to salvage and resale value. The DETR (Department of Environment, Transport and the Regions) Constructing Quality reports identifies whole life costing as an area of major concern (Department of the Environment 1995). It is clearly stated in the report that cheap initial costing is rarely the same as best value for money. It is the holistic picture that needs to be taken into account including life cycle costing.

This paper describes a research project which aims to add a life cycle costing element to the design phase which will allow the user within a VR environment to navigate inside the building retrieving information about building components which need replacement or repair. A colouring mechanism will be developed to show various elements in different colours according to a cost criterion. This would allow the user to easily inspect the building and retrieve information about repair and maintenance programmes, running costs and cash flows. The system will allow data to be updated continuously so that it will enable the comparison with initial plans and estimates and provides a fresh view of future action and feedback. The life cycle costing data will be incorporated into the OSCON (Open Systems for Construction) database developed at Salford to facilitate the integration of design, planning and estimating information. Like OSCON, the interface will be built around the VRML (Virtual Reality Modelling Language) standard. As VRML is a web based application, this environment will allow users based in various geographical locations to interact with the same model and retrieve relevant information (Aouad et al 1997a, 1997b, 1997c, 1997d). The user can fly through the proposed model retrieving information about maintenance and operation costs at specific points in time.

2 Life cycle costing

2.1 The concept

The *British Standard Glossary of Maintenance Management Terms in Terotechnology* defines Life Cycle Costing as:

" The technique of considering the total cost of ownership of an item of material, taking into account all the costs of acquisition, personnel training, modification and disposal, for the purpose of making decisions on new or changed requirements and as a control mechanism in service, for existing and future items"

The primary objective of LCC is to evaluate and optimise a building's life cycle costs and provide a means to aid the decision making process in all phases

of the building's life. Some examples are shown below (BS5760, Flanagan & Norman 1983, 1987):

- Evaluation and comparison of alternative design approaches
- Assessment of economic viability of projects/products;
- Identification of cost drivers and cost effective improvements;
- Evaluation and comparison of alternative strategies for product use, operation, test, inspection, maintenance, etc.;
- Evaluation and comparison of different approaches for replacement, rehabilitation/life extension or retirement of ageing facilities;

In short, life cycle costing is the technique of considering the initial and subsequent running costs of an asset over its planned life. The concept is not new, yet under used in the construction industry (Bull 1993). Nevertheless, the need and desire to implement life cycle costing was much talked about but little practised. This can be attributed to a number of major obstacles which can be classified under the following two categories:

1. Managerial:
   - Failure of designers to be able to visualise and include life cycle cost goals in their design criteria,
   - Failure of owners or managers with short-term responsibility for an asset to consider effectively the longer-term impact of their decisions on the asset's operations and maintenance requirements, and
   - General desires to minimise the initial expenditures in order to increase return on investment, meet budgetary restrictions, or both'.

2. Technical:
   - Lack of data, application, evaluation and feedback.
   - Absence of a database and systematic approach to collect and analyse the significant amount of information and knowledge generated over the life span of projects.
   - Assumptions, which have to be made, for future expectations, cost estimates and predictions.

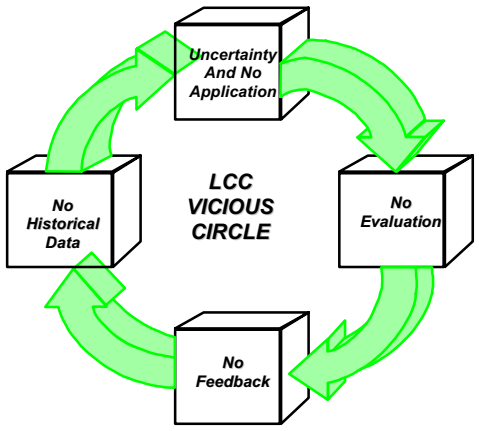

Fig. 1: Life cycle costing application vicious circle

Figure 1 shows the vicious circle in which LCC analysis is still entrapped. Any attempt to achieve meaningful analysis in LCC must provide a complete picture of a project from the initial conceptual stage until abandonment. This research project aims to provide the means to break into this vicious circle and start life into the improvement loop.

2.2 LCC and the building life cycle phases

Figure 2 shows the main phases of a complete building life cycle. It clearly indicates the potential benefits of applying LCC at the very early phases of the building's life. It is fundamental, therefore, to have a basic understanding of the activities that take place during the early phases of the project and the factors that determine their relationship to the building's performance, safety, operability, maintainability and other characteristics influencing the overall life cycle costs. Figure 2 also shows the extent that OSCON currently covers of the building life cycle and the proposed approach involving life cycle costing.

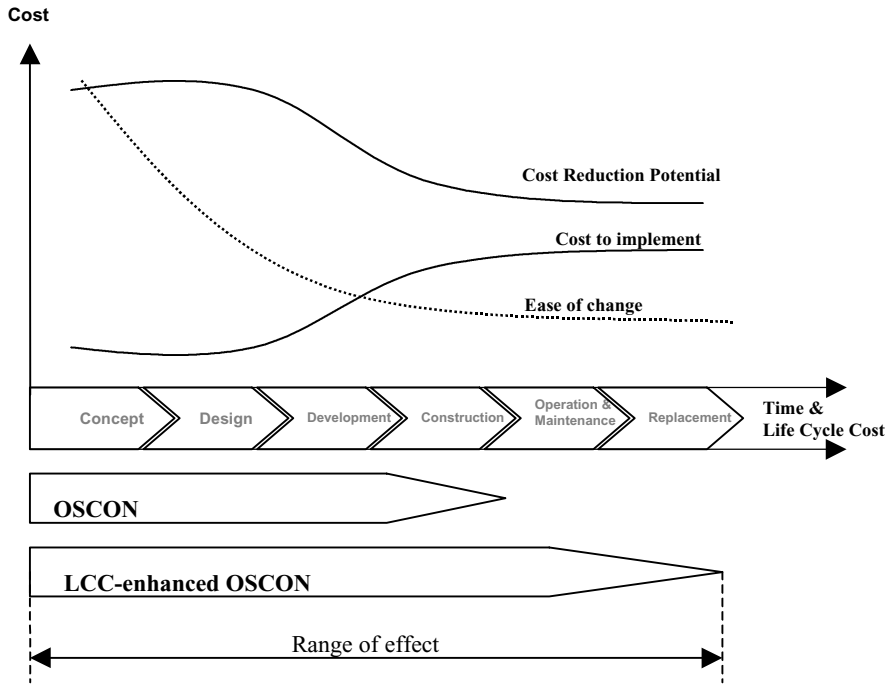

Fig. 2: Project life cycle phases and OSCON application

In order to be able to influence the uncertain relationships between present and future costs there is an urgent need to designate a clear and simple way for LCC analysis. It is also recognised that this concept will lead to major cultural changes in the approach to project investment decision making in the industry.

Assets, in general, have significant costs associated with their operation or use. These costs can add up to a large part of running expenses. A decision based on capital costs only often turns out to be more costly when the full life-cycle costs are considered. A study undertaken on three types of buildings demonstrated that a small number of cost elements consistently represent a high proportion of the total operating and maintenance costs (Al-Hajj, 1991). A further study conducted on schools in the Grampian Region has shown similar results. (Al-Hajj, 1996)

Figure 3 shows the framework of the LCC model that will be developed for integration into the OSCON system. In this model, LCC is calculated at two different levels. The first level focuses at individual elements in the building since each element is expected to have a full life cycle of its own. Thus, the model will include all costs incurring over the planned life including initial capital cost and subsequent maintenance and operation costs. The second level is at the building or asset level involving the analysis of the overall performance of the building. This includes items such energy consumption, management, cleaning, rates and insurance. At this stage the project is formatting the LCC model for the first stage.

The resulting system will obviously be, as good as the original data allows. Effective decision-making based on life cycle costing is possible only if the data input to the analytical process is sufficiently reliable. Figure 3 also shows the type of information to be collected and gives the indication that data will be gathered from a variety of sources. The system will involve gathering information on running costs and performance of occupied buildings, the identification of actual costs incurred in operating buildings and feedback to design team. The LCC model through its management system intends to monitor the performance of an asset and provide feedback. It further provides information on asset lives, reliability factors and establishes maintenance policy.

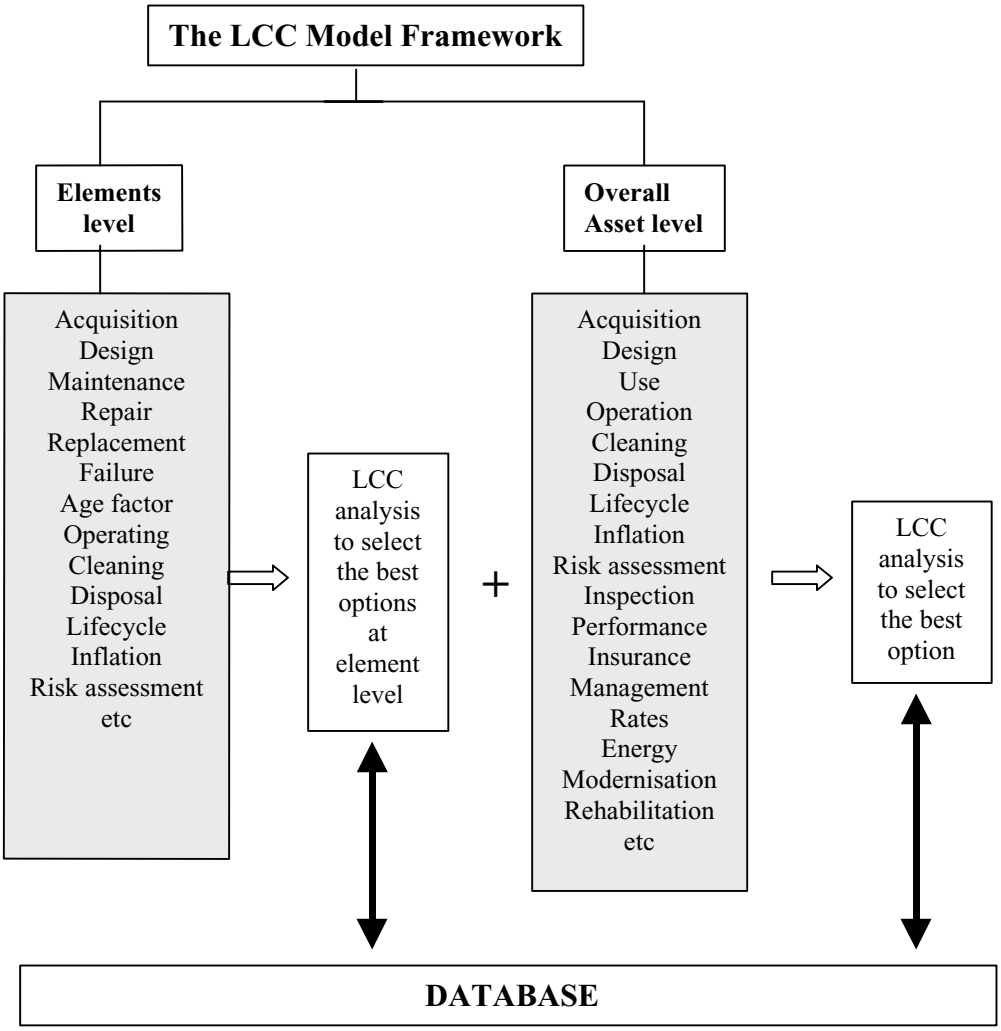

Fig. 3: The LCC framework

3 The proposed system

Studies on LCC will involve an extensive data gathering exercise even if performed for specific purposes. Computer aided systems will play a substantial role towards the efficient application of the technique considering the amount of information that needs to be taken into consideration when conducting LCC analysis. The role of information technology is becoming increasingly recognised for LCC as access to information is becoming universally viable through the internet.

Technology, particularly integrated databases and VR (Virtual Reality), can provide the mechanism to facilitate the integration of the whole life cost information. This can be achieved using the OSCON integrated database. OSCON, the Open Systems for Construction project, is a suite of integrated software that includes CAD application, cost estimating and planning, wrapper software for CA-Superproject, and a VRML interface applications (Aouad et al 1997). The system is developed at Salford University with the aim to ease and actively share construction information via a central object orientated project database. The integrated database within OSCON supports the functions of design, estimating and planning by allowing these phases to effectively share information dynamically and intelligently. The system revolves around a central object-oriented information model which consists of domain models which support integration of information within a specific domain, e.g. estimating. All the models in the system are fully independent of specific applications, and each domain model provides support for general classes of a given application. The CAD application allows a user to create and manipulate architectural components of a building. The components are stored as instances of classes in the object oriented database. These instances are read by the VRML interface in order to create a 3D view of the building which gives the user a better environment for navigation and walkthrough. Time and cost estimates are also generated automatically based on the design information stored in the database. The proposed approach is shown in Figure 4 below.

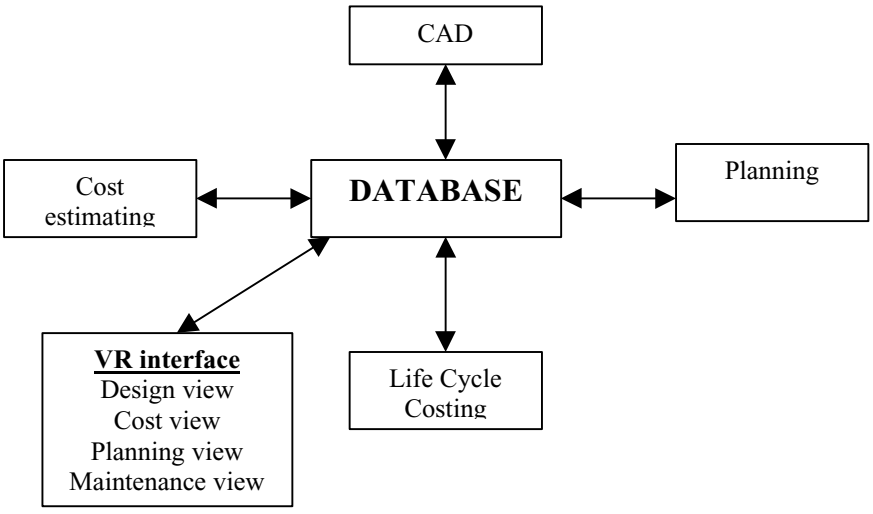

Fig. 4: Architecture of the integrated system

The proposed model will ensure that a holistic picture of the integrated project model is achieved through the support of design, planning, estimating and maintenance. The user will be able to interact with the model in real time using VR capabilities. A visual representation of the model is particularly useful for retrieving information about the maintenance phase.

As instances of design components are stored in the object oriented database, attributes related to life cycle costing will be populated. The information can then be displayed in the virtual reality environment using VRML capabilities. A maintenance view will be added to help the end user visits the model in time retrieving design and maintenance data as well as cost estimating and planning information.

4 Conclusions

This paper presented an approach to the integration of design, construction and maintenance data. The proposed model uses the state of art technologies, namely Virtual Reality (VR) and object orientation. The life cycle costing model will ensure that design is given a holistic picture that will result in better management of facilities. Life cycle costing information once inserted into the design model will allow a clearer picture of the maintenance data to be displayed in a VR environment. The system is still under development. However, once it is fully developed it will offer many opportunities for maintenance and cost engineers.

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