WHOLE LIFE PERFORMANCE STRATEGY: BEYOND INCREMENTAL COST AND SERVICE LIFE
Whole Life Performance Strategy

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Abstract

The cost comparison of component and product options is an essential aspect of design, construction, operation and maintenance. But there is a case for looking beyond incremental costing to embrace socio-environmental and business impacts. Decision-making has included these wider impacts where a financial proxy has been developed or to satisfy legislative requirements or appease project opposition. There is, however, no clear and comprehensive contemporary strategy to integrate with a whole life appraisal those issues that do not easily align themselves with economic description. The basis of UK construction industry decision-making is reviewed to establish the range and influence of whole life performance issues. Shortcomings are identified in this process and it is argued that, in order to achieve improvement in whole life performance, there is a need to reform the scope of decision-making. A case is put forward to achieve this by explicitly considering performance from multiple perspectives. It is recommended that discounted cash flow analyses are supplemented by the development and application of a multi-perspective performance model. Current industry organisation plays a key role in failing to motivate broad whole life appraisal. Procurement arrangements typically lack incentives for construction industry participants to concern themselves with whole life issues. Where whole life issues are addressed, much emphasis is placed upon service life, deterioration, and repair and maintenance interventions. These are important and their prediction is still raising many challenges. But genuine functional value and issues associated with greater levels of uncertainty and risk such as technological innovation, obsolescence, sustainability and procurement efficiency should not be marginalised owing to difficult prediction. There is a need for professional project participants to think in terms of a softer interface between disciplines and to engage issues traditionally regarded as immovable or outside their remit.

Keywords: asset management, whole life performance, life cycle costing, service life, value management.
1 Introduction

Construction industry protagonists have a long history of artfully resolving the technical complexity of marrying natural and manufactured materials. Civil engineering in particular has been portrayed as an art because practitioners have been expected to operate within an environment made uncertain by dealing with nature and by making allowances for gaps in knowledge and information. Decision-making has therefore relied heavily on individual experience.

Whilst the ability to base decisions on partial information and from individual experience may have proved a strong and sufficient characteristic in the past, the emerging expectation of predictable, efficient and safe construction (DETR 1998a) demands an increasingly structured approach. Such expectations are concerned with the role that construction has to play in serving the immediate needs of asset creation and management. They are being addressed through a variety of initiatives including that of the Agile Construction Initiative (ACI) of which the research for this paper forms a part. But these immediate needs are supplemented by an increasing emphasis on infrastructure management driven by long term objectives of sustainability (DETR 1998b), service (DETR 1998a) and hence value. The developing importance of these objectives is affording a growing significance to the recognition of Whole Life Performance (WLP).

The issues, solutions and conclusions discussed within this paper are applicable to construction generally. Many authors, however, due to the wide and varied scope of life cycle issues, have written on WLP in connection with specific sectors and with respect to specific problems within sectors. In keeping with the initial application of the ACI to the roads sector, many of the arguments in the proceeding discussion are supported by references within that sector. Similarly, the proposed approach to WLP that leads beyond incremental cost and service life is illustrated within the context of trunk road management.

2 What is whole life performance?

The key principle distinguishing WLP from the majority of appraisal effort is the consideration of project impacts for more than just the imminent single project phase (such as initial construction or refurbishment). WLP is used, within the context of this paper, to represent the securing of efficient long-term value via the appraisal of impacts occurring throughout the project life cycle. WLP is discussed in the context of the widest possible scope of issues influencing the value obtained from asset management (an intentional strategy to avoid pre-determining important issues). WLP is considered a description for the holistic management of infrastructure. It is not prescriptive, but serves as a conceptual framework within which a system of conventional models can be applied.

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1 The Agile Construction Initiative was established at the University of Bath in 1996 to investigate and promote the application of lean manufacturing principles to construction.

2 The definition of value is case-specific, but is generically determined within lean manufacturing as that “which meets the customer’s needs at a specific price and a specific time.” (Womack J, Jones D, Lean Thinking, 1996)
Various terms have been applied to the assessment of the long-term consequences of asset management decisions. Terms do not appear, however, to correspond to a universally agreed scope, and many of the terms overlap in definition. Life Cycle Costing (LCC) has been quoted, for example, as “total cost of an item throughout its life, including the cost of planning, design, acquisition, operations, maintenance and disposal, less any residual value.” (BSI 1997). But many definitions of LCC have been proposed (Woodward 1997) and, because it is often used to represent Investment Appraisal, the scope of LCC often incorporates benefits as well as costs (Ferry and Flanagan 1991). What emerges, however, is a polarisation of analysis between financial modelling and socio-environmental statement. It is proposed that WLP is represented by models providing equal representation across the range of socio-environmental-economic issues.

3 Why is an understanding of whole life performance important?

The profile of WLP is rising in some non-UK construction sectors. The Victorian government in Australia has placed WLC for construction projects exceeding A$5m on the legislature (Graves et al. Unpublished). Legislation in the USA has taken this still further with mandatory LCC consideration for all federal transport infrastructure projects (Markow 1995; Bettigole 1995). The important potential strategic role of WLP has already been recognised to varying degrees in sectors outside construction including the oil, automotive and aerospace/defence.

UK Construction industry attitudes towards an increased consideration of whole life issues are changing. A strong awareness by client and supply sides of the importance of whole life issues has been confirmed by recent studies (Clift Forthcoming; Graves et al. 1998). WLP is important as it can drive value-added construction products and reduce construction defects (Rigden et al. 1995), drive value-added construction design (Leeming 1993; Markow 1995; Wallbank and Lickiss 1990) and, as suggested from experience in the oil industry, facilitate ideas and reduce reliance on conventional wisdom (Harding 1996). The need to investigate the long-term implications of decision-making has been reinforced by many factors exemplified in the UK public sector by year on year reductions in funding availability (Leadbetter 1996).

Contractors and suppliers have traditionally retained a phase by phase involvement with construction projects. But the last five years has seen the client-driven Private Finance Initiative (PFI) introduced to re-distribute many of the root causes of poor project value, including short-term responsibility. Two of the intended benefits arising from PFI schemes are minimised lifetime costs and “Whole Asset Life” benefits (Treasury Taskforce 1997).

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iv The Intermodal Surface Transportation Efficiency Act (ISTEA) was introduced in 1991 to mandate “the use of life-cycle costs in the design and engineering of bridges, tunnels, or pavement.” This was supplemented in 1994 by an Executive order that requires “a systematic analysis”, considering “design standards that incorporate new technologies and construction techniques.”

v The UK PFI represents a culture change in public sector procurement where the public sector role of asset owner and direct service provider is transferred to being a purchaser of those services from the private sector.
A commitment to appraise WLC by representatives from both client sectors has been made by the Construction Clients’ Forum (CCF 1998). This acknowledges the client’s role in developing long-term cost-effective construction.

4 Shortcomings of whole life performance in contemporary application

4.1 A commitment to financial modelling

Whole Life Costing (WLC) is commonly used to describe financial modelling for WLP. The definition for WLC proposed by the Construction Research and Innovation Strategy Panel (CRISP) is “the systematic consideration of all relevant costs and revenues associated with the acquisition and ownership of an asset”. (DETR 1998c). Discounted Cash Flow analysis (DCF) is the technique used to model the temporal distribution of costs and revenues for WLC. DCF provides an investment appraisal technique to undertake budgetary planning. It utilises a cost of capital to provide a discount rate, allowing future cash liabilities to be expressed in terms of present values and therefore allowing comparison of investment options in terms of a single present value. Hence economic appraisal provides an objective ranking method for decision-makers. It is, however, limited by the adequacy of financial model, and it poorly communicates the socio-environmental consequences of proposals.

In the UK, and many other countries, a single public sector discount rate is universally applied (Rigden et al. 1995). A high public sector discount rate has been cited as a barrier to the construction of long life, low maintenance infrastructure (Leeming 1993), the converse applying with a low discount rate (Tilly 1997). Discount rates are seen to be highly influential to maintenance policy (Vassie 1998; Singh 1996). The effect of typical discount rates feature prominently in the assertion that DCF is relevant mainly to assets requiring frequent maintenance and with relatively large operating costs (Ferry and Flanagan 1991). This position has been directly opposed by examples of civil infrastructure (Leeming 1993), and further evidence is available from both the public (Treasury 1992) and private (Owen 1995) sectors that supports DCF evaluation over a 25 year period.

It is inevitable that discounting will reduce the benefits accruing from options requiring low future expenditure levels. A widely expressed opinion is that, whilst WLP is considered very important, the solutions supported by DCF-led WLC often do not coincide with the solutions intuitively considered best by those involved in their development. This is exemplified in bridge management where it has been shown that considerably different strategies typically show only a small difference in present values (de Brito and Franco 1994).

Whilst a case could be argued for the development of project-specific discount rates, this fails to address the issue that financial models are generally inadequate for comprehensive project or strategy appraisal. Difficulties with economic evaluation of socio-environmental effects are well recognised (Mishan 1988a). And it has been argued that a traditional insistence on economic argument is probably less effective than argument based on quality of life issues (based on current financial models) to support transport infrastructure investment (Simon 1996). Indeed, in global terms, there is growing recognition of the limitations of GDP as the primary indicator of social and economic welfare (The Labour Party). Yet there is a continued emphasis on developing monetary equivalents to socio-environmental effects, where no market mechanism exists, in
order to simplify and make more direct the objective comparison of project options (Glendinning 1997; Willis et al. 1998).

Recent studies of both client and supply side representatives found that WLC is not carried out on many projects (Clift Forthcoming; Graves et al. 1998). Respondents confirmed the lack of WLC to result from a number of sources, the most notable of which were: an absence of requirement for WLC; no long-term interest in ownership; insufficient data on WLC; rare monitoring of WLC targets; and lack of a standard approach or methodology for WLC (Clift Forthcoming).

The short-term objectives of minimising capital cost and time were quoted as the main decision-making drivers in project procurement. Budgeting arrangements were also found to obstruct developing an interest in long-term performance, more particularly in the public sector but also in the private sector (Graves et al. 1998). This finding supports previous assertions over the lack of a stakeholder link to budget allocation and to project phases as a root cause of apparent client disaffection with WLC (Ferry and Flanagan 1991).

The finding that insufficient data was available on WLC receives mixed support. Sources have cited a lack of maintenance cost (Leeming 1993) and service life (Loudon 1998) data as being a barrier to WLC. Other sources, however, suggest that this may not be the case. Indeed, large information databases have been cited as unnecessary and potentially misleading due to their retrospective viewpoint and tacit implication of the ability to make absolute predictions (Ferry and Flanagan 1991; Markow 1995; Bettigole 1995). It is, however, widely agreed that data does need to be managed through the project phases, providing feedback to close the knowledge loop (Owen 1995).

A picture is thus emerging of widespread problems and disaffection with the financial modelling of WLP (fig.1) as currently practised. Whilst financial modelling plays an important role in determining likely cash flows and estimating returns to shareholders or taxpayers, it does not currently provide a balanced and comprehensive holistic appraisal technique.

4.2 Beyond financial modelling

Conventional financial modelling under-represents issues such as inter-disciplinarity, socio-environmental consequences, obsolescence, long term market productivity, incentivisation, innovation, risk and uncertainty (Markow 1995). New themes including sustainability (DETR 1998b) and quality of service provision are becoming increasingly important, and shareholders and taxpayers are becoming increasingly aware of ethical issues. This wide range of emerging issues, which currently receive highly variable consideration, is driving the need for an holistic decision-making process equipped to take equitable account of issues beyond those currently included in financial models.

The range of shortcomings identified by studies of WLP appraisal implementation (Clift Forthcoming; Graves et al. 1998) provide many of the demotivating characteristics associated with weak project implementation from a people management perspective. These include: a lack of top-down commitment; ill-defined objectives; constraints on workability; a lack of procedures; and a lack of incentives (Kliem and Ludin 1994). It is, perhaps, not surprising therefore that whole life issues have not been widely implemented in WLP appraisal. It has been noted in the oil industry that, in order for WLP to work, it needs to be championed (Harding 1996). Top-level commitment is required to integrate WLP facilitating processes and techniques into decision-making.
Fig. 1: Perpetuating disaffection with whole life performance

A systematic adoption of WLP is lacking in construction design according to a cross-industry comparison of WLC (Garnett and Owen 1995). This supports the assertion that WLC (constrained by its image as financial ‘rubber-stamping’) is a marginal activity. Financial modelling can clearly inform the design process, but, to realise the potential of WLP, it needs to be central to the design process. It should form the starting point for the generation of new ideas (Rigden et al. 1995) and a technique to challenge conventional wisdom (Harding 1996).

Experience from industries outside mainstream construction suggests that it is not possible to establish universally applicable models to measure WLP. Risk and uncertainty, central to an examination of WLP, cannot generally be determined by mechanistic forecasting (Proffitt 1994). But there is support for the notion that much can be gained from simple analyses of the problems and by actively developing potential solutions at an early stage across disciplines and through the project hierarchy (Harding 1996). Hence the development of WLP requires the selection of appropriate detailed evaluation models within a universal framework. Much effort has and continues to be devoted to the development of detailed models. The pressing need is to develop and promote a universal framework.

It is proposed that the key requirement to facilitate successful WLP is an appraisal framework that transcends strategic and project levels of decision-making. The framework should facilitate decision-making in the context of the
lifetime strategic or project interface with social, environmental and economic well-being. Such a methodology should be amenable to a championed approach.

5 What can balanced scorecards offer to whole life performance?

The Balanced Scorecard (BSC) was introduced by Kaplan and Norton (Kaplan and Norton 1992, 1996) for the monitoring and, later, implementation of organisational strategy (fig 2). It is proposed as a framework for an approach that is both strategic and facilitates devolution to project level, and that achieves both objectivity and balance. It does this through two key features:

- It proposes explicit appraisal from a range of perspectives. This overtly avoids undue focus on any one aspect and avoids the loss of clarity associated with the single step presentation of a balanced judgement. Appraisal based on multiple perspectives offers the potential for objectives to be transferred from strategy to project levels and from client to other supply chain participants.
- It offers the potential to make considerable improvement over traditional appraisals that marginalise aspects failing to be defined adequately in terms of an economic proxy. Environmental and quality of life issues fall into this category, as well as behavioural influences on organisations.

The BSC achieves a whole life perspective by taking a balanced measurement of what has happened and what is expected to happen. It is essential that a discriminating selection of performance indicators is carried out to provide a mix of outcome measurement and performance drivers (so-called lag and lead indicators) (Tsang 1998). A very important message from experience with WLP is that a considerable improvement in WLP is likely to be brought about through the improved management of existing knowledge rather than the development of new knowledge.

Application of the BSC requires the identification of key perspectives from which to view the organisation under scrutiny, together with statements of strategic goals and measures by which such goals may be achieved. Construction is concerned with the development of infrastructure to facilitate social development. The ultimate motivation behind construction is therefore governed by function, and it follows that the ultimate value rests with functionality and not with the products that provide that functionality. Currently in construction there is often an implied link between a specified product and the expectation of functional performance that that product will provide. But, as evidenced by the introduction of PFI, things are changing. Construction client organisations are progressively adopting a shift in emphasis from delivery of products to delivery of services. Evidence that the industry is ready to adopt service performance measures to support strategic goals provides the required opportunity for the application of a BSC approach.

A wide range of procurement types is being used across the industry and within organisations. The absence of clear evidence to promote one system over another (Sheath et al. Forthcoming) means that flexibility in procurement routes is expected to remain for the foreseeable future. Implementation of a BSC approach is valid regardless of procurement system. Indeed, the additional control promoted by a BSC approach may change the balance of argument and lead to an
improvement in WLP without the perceived need to transfer long-term responsibility as now with PFI.

The BSC cannot, of course, provide the final answers – the complexity of issues makes this the unavoidable role of decision-makers and follows the assertion that WLP should assist rather than replace rational thought processes (Bettigole 1995). But it does offer a rational and objective framework within which to make those decisions.

6 Application for the highways agency

ACI has established that the treatment of whole life issues for the management of trunk roads has developed and continues to develop via detailed models, but without an effectively communicated underlying strategy. Tools and techniques have developed in response to need. The historically disaggregated organisational structure of highway management has promoted considerable technical development within discipline areas. For example, advanced prediction techniques are available for pavement life and are rapidly developing for bridge structures. But there are many problems that obstruct WLP from realising its full potential.

The principal impacts to have been considered to date tend to be examined through a hybrid Environmental Assessment (EA) and DCF analysis (Willis et al. 1998). This separation acknowledges the difficulty of expressing environmental issues in terms of financial proxies, considerable shortcomings having been identified with this type of appraisal (Parrott and Moyes 1997). The outcome is that the DCF incorporates capital works costs with a limited consideration of operating and maintenance works costs. Certain social costs and benefits are also included. Many social and environmental impacts are included via the EA, although this is of limited scope. The impacts identified by the EA tend to be treated as either acceptable or not acceptable rather than with the incremental consideration given to DCF. Some effects are overlooked entirely. Hence the approach has favoured decision-making based on economic optimisation. The DETR has recently developed a new appraisal method for roads to reduce the prominence previously given to monetarised effects (DETR 1998d). But there is ready acceptance that the new approach can probably be refined further and be made more objective, including the introduction of multi-modal comparison (DETR 1998e).

The Highways Agency (HA) manages, maintains and improves the English trunk road network. The HA’s business plan (Highways Agency 1998) has been considered in terms of a BSC. It is acknowledged by Kaplan that the four perspectives originally espoused require review to reflect circumstances (Kaplan and Atkinson 1998). Of the four original perspectives, the customer perspective has been split into three to highlight the different requirements of road user, environment and the public. The taxpayer is considered synonymous to the shareholder in the originally proposed BSC. The six-perspective model is shown in fig. 2.
Fig. 2: The balanced scorecard adapted to meet the highways agency’s needs

The multi-perspective model offers several potential developments for the HA:

- the demand-led policies followed prior to the creation of the HA\textsuperscript{vi} (Halden 1996) provided an emphasis on the road user. The detailed model can provide a visual audit of balance with respect to strategic goals. These can be re-balanced if necessary.
- The strategic goals can be transferred through to project level via the performance measures and targets.
- The project goals with respect to the customer perspectives and, to some extent with the innovation and learning and internal business perspectives, can be transferred from the client to the supply sides via the performance measures and targets. This should promote the demonstration of genuine value (perhaps

\textsuperscript{vi} The Highways Agency was established in 1994 as an executive agency of the Department of Transport (now Department of the Environment, Transport and the Regions).
providing an objective means of moving towards best value contractor and supplier selection) and create a direct and measurable link between strategic and project level objectives.

7 Conclusions

Considerable effort with developing financial models has failed to provide a satisfactory universal appraisal technique. But the development of WLP appraisal is not simply about being able to forecast with increasing precision the future service life and incremental cost of products. WLP should be a pro-active process of improving value. The BSC approach offers the opportunity to implement WLP.

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9 References


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