RESEARCHING WHOLE LIFE VALUE METHODOLOGIES FOR CONSTRUCTION

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Whole life value (WLV) can be seen to encompass economic, social and environmental aspects associated with the planning, design, construction, operation, decommissioning and where appropriate, the re-use of the asset or its constituent materials at the end of its useful life. WLV represents the optimum balance of stakeholders' aspirations, needs and requirements, and the costs over the life of an asset. Various methods, techniques and tools have been used for supporting whole-life value principles in construction. Among these methods, whole-life costing, life-cycle assessment, multi-criteria analysis, value and risk management are the most prominent. This paper reviews these key methods and techniques in an attempt to integrate the current thinking on whole life value. Building on these available methods and techniques, the paper then introduces a research-in-progress, which is reviewing whole-life thinking, concepts and methods outside construction in different industry contexts that can be applicable to the construction industry.

Keywords: whole life value, whole life costing, risk and value, asset management, innovation, technology transfer, cross-industry learning

INTRODUCTION

Construction investment and procurement decisions have been traditionally based on initial capital costs. In recent years however the consideration of whole life costs and to some extent a whole life value approach are becoming increasingly important in investment decisions in the public sector and in the private sector. Various drivers for this shift have come about as both public and private sector clients and their supply chains increasingly recognise the greater benefits that can be achieved by adopting a whole life and sustainable approach to construction. Indeed a recent National Audit Office report (2005) states that design, procurement and decision-making need to be based on whole life value. Whole life value represents more than just the costs associated with the acquisition and operation of an asset.

Whole life value (WLV) encompasses economic, social and environmental aspects associated with the design, construction, operation, decommissioning, and where appropriate, the re-use of the asset or its constituent materials at the end of its useful life. WLV takes account of the costs and benefits associated with the different stages of the whole life of the asset. The WLV of an asset therefore represents the optimum balance of stakeholders' aspirations, needs and requirements, and the costs over the life of the asset (Bourke et al. 2005). There will be trade-offs between the various

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short-term project constraints (such as time, costs and quality) and the conflicts in stakeholders' longer-term interests and objectives.

DRIVERS FOR WHOLE LIFE VALUE

Public sector procurement

In the public sector, a series of initiatives and policy reviews have progressively changed the approach of the public sector to procuring construction projects. These initiatives directly affect the private sector as partners and suppliers to the public sector. These include:

- Review of Civil Procurement in Central Government (Gershon 1999).
- Achieving Excellence in Construction (Office of Government Commerce 1999).
- Her Majesty's Treasury Guidance Note 7 on Whole Life Costs (HM Treasury 2000).
- Building a Better Quality of Life (Department of Environment, Transport & the Regions (DETR 2000) - promoting a sustainability agenda.
- The OGC Gateway™ Process (see www.ogc.gov.uk) and (OGC/NAO 2001).
- Best Value in Local Government (see www.bvpi.gov.uk)
- Modernising Construction (National Audit Office, 2001)
- Independent Review of Public Sector Efficiency (Gershon 2004) and
- The latest National Audit Office report: Improving public services through better construction (NAO 2005).

PPP/PFI sector

In PPP/PFI procurement, the number of projects has increased steadily since 1997 to over 600 projects (International Financial Services 2003) in different industry sectors. PPPs are theoretically expected to deliver greater value for money than traditional procurement methods, due to expected efficiency gains and reduction in costs resulting from the sharing of knowledge and skills in design, construction and operation. There is increased focus on service delivery over 25 to 30 years to a defined standard based on outputs specifications and not just delivery of the asset or project. Improvement in efficiency is expected by exploiting the private sector's managerial practices, ability to innovate and to take risks. Risk is transferred to the private sector according to the principle of risk to be transferred to the party best able to manage it. The private sector service provider is expected to provide innovative methods of delivering the service, thereby reducing whole life costs. A clear understanding of risk in conjunction with the enhancement of long term value in a PPP project is essential for achieving value for money.

Private sector procurement

In the private sector, owners and clients have recognised the need to measure projects on value rather than cost alone. The Latham report (1994) recommended that clients should seek to evaluate all tenders on the basis of quality, likely cost-in-use, out-turn price and known past performance as well as price. Then came 'Rethinking Construction' (Egan 1998) which promoted the view that construction should be designed and costed as a total package, including costs in use and final decommissioning. The Construction Clients' Forum (2000) wanted whole life costs to be appraised and the supply chain to commit itself to build on time, to budget and quality, and provide genuine value for money throughout the life of the construction. Another initiative, 'Accelerating Change' (Strategic Forum 2002) stated that advice (to clients) should cover a range of procurement and management options, including environmental performance, operating and whole life costs.

However, despite the growing recognition by both public and private sectors to consider a whole life and sustainable approach to construction, some clients are still reluctant to go beyond the initial thinking.

KEY QUESTIONS FOR ACHIEVING WHOLE LIFE VALUE

WLV extends the scope of the appraisal process by focusing on more than just the economic aspects of the costs associated with commissioning and operation of an asset and helps the decision makers to consider all the competing factors that drive value, including the values held by the different stakeholders. Stakeholder values differ between different industry sectors and different stakeholders, and in practice it is rare for each of these values to be given the same level of importance. Some key questions need to be asked therefore when considering procurement by whole life value.

Table 1: Key questions for whole life value (adapted from Bourke et al 2005)

Stakeholders • Who are they? • What are their requirements and roles? • Their expected degree of influence and involvement?	**Environmental sustainability** • Impact of asset on environment • How can any adverse impacts be reduced/mitigated? • What is the cost and value of the impact?
Functionality • What is the business need? • What is the constructed asset for? • What are the outputs required? • What tasks does it need to facilitate?	**End of life issues** • What are the issues around decommissioning, potential re-use/recycling?
Performance and time • Asset behaviour in use? • How long does it need to last?	**Cost** • What is the cost to build? • What is the cost to operate and maintain? • What is the cost of renewal/disposal? • How reliable are the whole-life data used (e.g. assets’ service lives, maintenance and renewals regimes?)
Risk • What are the risks? • Who will manage the risks and costs? • How realistic are the assumptions?	**Inputs v/s outputs** • What are the inputs required? • What is the balance of inputs, outputs and outcomes? • Does this balance provide VFM in the long term?

These questions may look simple in their formulation but they are fundamental to achieving WLV at any stage in the creation, development, construction, operation and decommissioning of an asset. Depending on the stage in the life cycle of the asset, answers to these questions will vary in their depth and complexity, and multiple methods and techniques can be used to aim for and achieve WLV.

KEY METHODOLOGIES, PROCESSES AND TECHNIQUES

The key methodologies and techniques supporting WLV currently include whole life costing (WLC), life-cycle assessment (LCA), value management (VM), risk management (RM) and multi-criteria assessment (MCA). WLC deals primarily with financial costs, whereas LCA deals primarily with environmental impacts. Individually, WLC and LCA cannot comprehensively cover all financial, environmental, social costs and benefits associated with achieving the best WLV. MCA is used in conjunction with WLC, LCA and VM to evaluate alternative options based on criteria developed with stakeholders. VM and RM processes are used as group decision processes to engage stakeholder participation for achieving WLV.

Whole life costing and life cycle assessment methods

Whole life costing is the 'economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value. The projected costs are those needed to achieve defined levels of performance, including reliability, safety and availability' (ISO 2004). A WLC model looks at costs incurred from inception to disposal, that is the total costs associated with the procurement, use during service-life, and disposal at the end of life. Such a model invariably includes cost of finance, capital costs (design and construction costs), operational and maintenance costs, occupancy costs, costs of disposal or renewal of the assets. However one has to allow for risks in modelling assumptions made in the estimation of asset costs in the long term, discount rates used, missed components in the analysis, wrong service lives of components, wrong costs etc.

LCA is 'a systematic set of procedures for compiling and examining the inputs and outputs of materials and energy and the associated environmental impacts directly attributable to the functioning of a product or service system throughout its life cycle' (ISO 1998).

Risk management processes

Risk management is the systematic process of identifying and managing risks and opportunities for a project or business (Godfrey 1996, and many others). Many techniques are available for identifying, assessing and managing risks throughout a project's life.   Typically participants in a project or business would address the management of risk through successive stages. Participants first need to brainstorm risks and opportunities by a suitable creative technique, then assess their probabilities of occurrence and consequences through (i) a qualitative approach involving simple scales for prioritising risks, and/or (ii) a quantitative approach involving modelling and simulation, taking account of Optimism Bias (OB).

The Green Book (HM Treasury 2003) requires that OB be taken into account when assessing the costs of risks at the early stages of project development. OB takes account of a systematic tendency by project appraisers to be over optimistic when estimating benefits and tend to understate timings and costs, both capital and operational. To redress this tendency, appraisers should make adjustments by increasing the cost estimates and decreasing, and delaying the receipt of, estimated benefits. The Green Book also recommends that sensitivity analysis be used to test assumptions about operating costs and expected benefits.

After the assessment, a risk mitigation and contingency plan will normally be developed and risk ownership will be determined according to the capability of the risk owner(s) to bear specific risks and costs involved. The likely deliverables of such a risk management process include, depending on the depth of the RM study and techniques used a detailed risk register, including all risks identified, probabilities, consequences, cost impacts/allocations, mitigation actions to be monitored periodically.

Value methodologies

Value Management (VM) is a structured, systematic and participatory decision-making process to develop best-value optimum solutions, to ensure client's objectives are achieved with stakeholders' buy-in. VM evolved from Value Engineering (VE) which originated during the Second World War at General Electric and is nowadays a proven management process used internationally in many industries such as construction, services, government, and manufacturing.

BS EN 12973 (2000) defines VM as a style of management, particularly dedicated to motivating people, developing skills and promoting synergies and innovation, with the aim of maximising the overall performance of an organisation. Applied at the corporate level, value management relies on a value-based organisational culture taking into account value for both stakeholders and customers. At the operational level (project oriented activities) it implies, in addition, the use of appropriate methods and tools.

In the construction industry context, VM can be defined as a structured approach to defining what value means to a client in meeting a perceived need by establishing a clear consensus about the project objectives and how they can be achieved (Connaughton and Green 1996). Value Engineering is incorporated into Value Management as a systematic approach to delivering the required functions at lowest cost without detriment to quality, performance and reliability. Function Analysis is one of the fundamental techniques involved in a VE study. Its purpose is to develop a systematic breakdown of functional requirements, concentrating on the actual needs, aspirations and wants of the client and project stakeholders. A VM study can be applied at varying stages of a project but for best results, a study should be done early in the planning/concept stage to ensure that the best project strategy is adopted, to reduce uncertainty and identify future opportunities. VM involves all relevant stakeholders sitting in the same room and making informed decisions in a rational way and achieve consensus under the guidance of an expert facilitator through successive collaborative workshops.

A recent research (Thomson et al 2003), the VALiD Framework (www.valueindesign.com) helps project stakeholders discuss value by helping them understand the influence of their values over their judgements of WLV. In this framework, value is represented by the stakeholders' collective judgements of the extent to which the entire project's benefits and sacrifices are represented, compared with the targets set. Approaches to delivering WLV need to help each stakeholder make structured assessments of the value (to them) of the built product and the services it supports. These assessments can be shared by the project team during design and construction to help guide their decision-making process.

Integration of methodologies

In recent years, methodologies for the integration of value and risk management have been developed for understanding, optimising, communicating and tracking the different perspectives of value and risk throughout all project development phases. (Mootanah, 1998, 1999, 2004; Green 2001; Cruickshank 2003; Weatherhead et al.

2005). Indeed risks can be assessed, modelled, costed, shared, transferred and managed out, but they cannot be considered in isolation from the other factors that contribute to achieving whole life value.

Similarly, the integration of whole life costing and life cycle assessment presents a powerful route to obtain best value solutions in both financial and environmental terms, to contribute to achieving sustainable development. There is commonality in some of the issues considered in both techniques, leading to synergies in the analysis, but also potentially to conflicts between the conclusions resulting from use of each technique. Generally these are minimised when the techniques are used jointly from the outset on a project (Bourke et al. 2005).

As argued above, the relevant questions and attributes for whole life value involve invariably: people/stakeholders and theirs needs, wants and aspirations; functionality and business needs; whole life costs, performance and reliability; risk and value issues; environmental sustainability; the 'optimal' balance of inputs, outputs and outcomes. It is useful therefore to integrate the current thinking on whole life value concepts and methods in construction with other industries' practices that could be applicable or transferable to the construction industry context.

WHOLE LIFE VALUE MANAGEMENT ACROSS INDUSTRIES

Past examples of management methodologies, techniques and practices transferred between industries are wide-ranging. For example, the Critical Path Method (CPM) developed in the late 1950s by DuPont and Remington Rand Univac to co-ordinate complex plant maintenance projects. The Program Evaluation and Review Technique (PERT) was developed as a project planning tool as part of the Polaris submarine program. Adaptations of these tools have been in use in different industries such as construction, transport etc for a number of years. Value engineering originated during the Second World War at General Electric and has evolved into different applications in industries such as transport, construction, and manufacturing. Risk analysis principles from Oil & Gas ventures have been adapted to other industry contexts such as construction and railways.

Different industries such as railways, building & construction, highways, water, aerospace, manufacturing, oil & gas have been applying varying infrastructure asset management principles to their operations for years to increase profitability, better manage activities, achieve efficiency gains and plan for long-term growth. A recent comparison between the aerospace and construction industries exemplified the opportunities for learning across industries while recognising the contextual nature of management knowledge and experiences (Green et al 2004). Many industries commissioning, owning and managing infrastructure assets face issues that are often similar to one another, although in different contexts. The constant drive for efficiency savings and safety performance targets in the rail industry calls for improvements in not only project procurement but also more importantly in whole life asset performance. Improvement in asset performance has to contribute not only to strategic objectives of regulators and infrastructure owners, but should demonstrate positive impact on user's experience of the network. In the Local Government arena, the need to demonstrate value for money and best value in procurement of services is a major driver to have asset management plans in place.

On the other hand, infrastructure owners are struggling with challenges such as escalating maintenance costs, lack of reliable knowledge of asset condition and performance at a given time, and varying infrastructure management processes for their different contexts. Asset owners are therefore recognising the benefits of managing assets along whole-life principles: effective and efficient infrastructure asset management and whole-life costing are becoming increasingly important in any owner's investment decisions.

There is a need for a holistic approach that can bring significant whole life value, and more effective infrastructure asset management in the long term.

A CIRIA research project (2005) is looking at whole-life infrastructure management strategies, processes, plans, methods and techniques that are used in the different industries. The focus is on whole life approaches to infrastructure asset management through the life of an asset from creation to end-of life/disposal, including asset acquisition, maintenance, operation, upgrading, disposal and renewal. Current industry practices will be benchmarked and case-studies of lessons learnt will be documented for different industries. The industries covered include building & construction, railways, highways, water and potentially aerospace, oil & gas and defence. The areas of research cover: asset management strategy and planning, whole life value methodologies, investment optimisation, life-cycle data requirements, performance, risk, reliability, availability, maintenance management methods, service life predictions, security and business continuity processes, and barriers and enablers to more efficient and effective asset management.

The project is reviewing and building on previous relevant research and standards. The research methodology is based on a mixed methodological approach (drawn from methodological pluralism) including: a broad literature review, semi-structured interviews with practitioners in different industries, benchmarking current practices and processes, and elaborating case-studies in different contexts to build understanding and learning between the different industries.

The literature review in progress and current discussions with practitioners are looking at issues such as:

- the different definitions used in different industries
- business-related issues (reconciliation/trade-off of short-term business aims with whole life thinking)
- views of asset management (whole-view, systems approach, wider aspects)
- monitoring predictability, performance and reliability (asset lives, obsolescence, inputs v/s outputs and outcomes)
- levels of asset management (strategic and tactical levels, transferability of practices between industries without losing context)
- the determination of best practice (benchmarking or other methods and the inherent limits), amongst other issues and research questions to be identified.

CONCLUSIONS

In response to many drivers through the recent years, different processes, methods, tools and techniques have been developed to enhance the understanding of whole life value thinking in both the public and private sectors. However their applications depend on the circumstances of projects and requirements of the authorities or clients involved. This paper covers very briefly the existing key methodologies, processes and techniques that can support whole life value thinking in construction and looks at integrating the thinking further with relevant knowledge and practice from other industries. The aims, scope and methodology of inquiry of a current research by CIRIA are explained. The research will identify opportunities for the transfer of technology and innovations in whole life value thinking across industries without losing contextual industry knowledge.

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