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EDITORIAL

First of all, I would like to thank Dr. Roy Woodhead, the Immediate Past Vice President (Education) of SAVE International, for giving me the opportunity to manage the Value World, the journal of the SAVE International. I would also like to express my sincere congratulations to our new Vice President (Education) of SAVE International, Professor Dr. Steven Male of Leeds University.

During this task, I expect to combine the theoretical and practical knowledge on value engineering/value management methods. Any paper that lies on these mainstreams will be considered for publication, as long as the Editorial Board considers it to sufficiently advance the communities interest and understanding. I would like to solicit your valuable contribution to continually promote our journal as a key journal for the development and discussion on both in academic and practical knowledge relating to “Value”.

Value in Practices

This issue of Value World presents an exposition of the state-of-the-art from the SAVE International 2007 Annual Conference in Houston, Texas and the ongoing debate on definition and application of value concept. The previous summer edition of Value World discussed on the philosophical and definition of value; whether there is a discrete number of variables for judging “value” concepts. This current edition will bring forward the enquiry on how the concept of “value” is implemented in construction and manufacturing industries.

There are four papers selected to stimulate a debate and to explore the systemic relationship between value, systems, functions, and other attributes necessary to aid the creation, delivery of products and services performance in terms of industrial application. Again it shows that, “value” exists in a complex mechanism and relationship between attributes within a dynamic system.

In the first paper presented in this edition, Dr. Berawi and Dr. Woodhead examine how the “value of a thing” can be measured from how well a “thing” performs its designated functions and achieves its purpose. In particular, this is achieved by distinguishing “purposes”, “outcomes”, “processes” and “functions” and the need to make explicit external mechanisms such as “context and perspectives” so as to build more consistent understanding of the relationships between our thoughts and how things actually work. As identifying functions enables us to propose alternative ways to perform those functions in the act of idea generation, an “extended function” and the ability to consider alternative ways or processes with added benefit will set a new context (purpose and goal) of a system. Thus it will leads to an improvement of “products value”.

In the second paper, Professor Dr. John Kelly and Professor Dr. Steven Male determine the way how the best value can be delivered in the initial construction project stage particularly in tender and procurement. They argue that there are four factors which may be used in the judgment of “value for money” tenders for design build namely, basic factors, measurable performance factors, non-measurable performance factors and risks. The basic factors are those which can be determined through the pre-qualification questionnaire, the measurable and non-measurable performance factors are highly correlated with capital cost, operations cost, time, community, environmental impact, exchange (earning potential) flexibility, esteem, and comfort and the risks involved with the technical solution offered are taken into account in the weighting and scoring matrix exercise.

In the third paper, Professor Dr. Ed McMahon illustrates why a valuable product and process development in manufacturing industry requires an understanding of the business environment and key customer objectives early in the product or process development. He proposes a value framework that includes customer value chain analysis, functional analysis, high level concept generation, and organizing the information into a house-of-quality. By understanding the stakeholders and their respective relationships, the value propositions between the stakeholders can be clarified and expressed as functional relations. The ‘value propositions’ change as the business model changes as a result of changing the roles of the stakeholders.

The fourth paper, written by Dr. Stephen Kirk and Stephen Garrett, presents a number of international construction projects as case studies to illustrate how value based design decision-making methods were used to maximize value. Managing value in construction is about managing
various indicators in projects such as operational effectiveness, flexibility, comfort, site and architectural image, cultural values, engineering performance, safety and security, environmental sustainability, construction schedule and initial and long term cost effectiveness. Thus by applying the techniques of function analysis, quality modeling, risk modeling, creativity, Choosing by Advantages® (CBA) and life cycle costing (LCC) can be used to improve the “value of large, complex international projects”.

I hope this edition of Value World brings new insights in the way we view the relationship between our thinking, models and practice in order to strengthen the meaning of Value. I can be contacted at maberawi@um.edu.my and I will gladly accept and respond to any comment and enquiry you may have on the direction and content of Value World. Your feedback is important to the success of our journal as it will guide its future development.

With warmest regards from editorial desk,

Dr. M.A. Berawi
Editor in Chief

Introducing the New VP-Education: Dr. Steven Male

Steven Male BSc., MSc., Ph.D. is currently Professor of Construction Management, School of Civil Engineering, University of Leeds, having held the Balfour Beatty Chair in building engineering and construction management between September, 1993, and September, 2004, at the University. Male has regularly presented at SAVE conferences on his research.

Male has undertaken extensive industrial research and consultancy in value management and value engineering. Major themes in industrial contracts have involved knowledge and technology transfer, including value-for-money studies with a range of blue chip and government clients on major projects or with significant refurbishment programmes; studies for clients or consortia wishing to develop long term partnering and supply chain arrangements, organisational change and restructuring, implementing information technology systems or business process re-engineering of projects and teams. High profile industrial and public sector projects have ranged in size from £1 million to £1 billion. Male is currently working with the Office of Government Commerce (OGC), part of Her Majesty’s Treasury, to investigate government capabilities in the management of major construction programmes and projects. This is linked to previous work with OGC on enhancing the Property Asset Management of the £220 billion civil government estate.

Male is currently an executive member of the United Kingdom’s Institute for Value Management and serves as Chair of the IVM’s Certification Board and Secretary-General of the European Governing Body (EGB) for value management.

I would like to thank the SAVE International board of directors for their confidence in asking me to be VP (Education) and I look forward to working with them over the coming term of my office.
Stimulating Innovation Using Function Models: Adding Product Value

Mohammed A Berawi, Ph.D. & Roy. M. Woodhead, Ph.D., CVS, PVM, TVM

Abstract

The paper outlines the articulation of a theory of idea generation based around the act of building falsifiable models of reality (i.e., making complex mechanisms explicit). It positions the source of ideas not “singularly” within the human mind but within the relationship between mind and world. In the context of innovation, a function is that which needs to be done in order to achieve a purpose of a system that has been designed. Identifying functions enables us to propose alternative ways to perform those functions in the act of creation and innovation such that the purpose of modelling functions is to yield improvement. The paper concludes by differentiating between “ideas as purposes”, “ideas as outcomes”, “ideas as processes” and “ideas as functions” and the need to model complex mechanisms stimulating a better understanding of the relationship between our thoughts and how things work in the concrete world. This paper shares insights and offers a theory of ideas that opens the way for researchers and practitioners to explore the ability to manage invention as a capability.

Introduction

The main reason why companies need to innovate is to survive and stay competitive in the competition (Twiss, 1992; Tidd, et. al, 2001; Trott, 2002; Howells, 2005; Muller, et. al., 2005). The companies must exploit their innovative capabilities through the development and use of innovation programme and technique (Crawford and Di Benedetto, 2006). The innovation has been seen as the idea generation in the creativity stage (Oetinger, 2004; Birdi; 2005), formalisation processes (Bodewes, 2002) and the successful application of the concept in terms of output or product (Cumming, 1998). The need for innovator to distinguish and categories the idea(s) generation in terms of their meaning and usage would enrich meaning as well as opening the opportunity to seek where the innovation can be stipulated.

There are various modes of understanding the “how” and “why” a function belongs to an object such as a high-rise building or to an artificial heart in human body (Berawi & Woodhead, 2004; Woodhead & Berawi, 2004). In biology and science, the functional concept plays an important role in determining the core process of biological evolution and adaptation (Wright, 1973; Cummins, 1975; Millikan, 1989; Preston, 1998). It determines why the traits of an organism can adapt and survive in nature. Meanwhile an understanding of functional concepts in technological artefacts is an important step towards product creation and innovation (Kroes, 1998; Vermaas & Houkes, 2003). It argues that the first step in product engineering is to identify the functions at play (Miles, 1961; Bytheway, 1965; Neyer, 1967; Woodhead & McCuish, 2002; Kaufman & Woodhead, 2006).

The transformation of function-directed causal relations into manufacturing makes it possible to bridge the gap between physical structure and intentional function in a technological design (Berawi & Woodhead, 2004; Woodhead & Berawi, 2004). However, this process is often left implicit within the minds of the designers and engineers and is why an advantage is afforded to those that make it explicit (Woodhead & Downs, 2001; Berawi, 2004; Berawi & Woodhead, 2005a). On other words, an agent’s or designer’s intention to use a particular word (e.g., function) in different ways and with different meanings was seen as potentially reducing an ability to generate key insights consistently (Woodhead, Kaufman & Berawi, 2004).

The Abstract and Real World Concepts

There is a need for innovators to distinguish types of concepts in terms of meaning and usage. In particular, this is achieved by distinguishing “purposes”, “outcomes”, “processes” and “functions” and the need to make explicit external mechanisms such as context and perspectives so as to build more consistent understanding of the relationships between our thoughts and how things actually work.

During idea generation stages, by distinguishing types of concept, designers/manufacturers can better direct investigation and innovation that will lead to improved results. A particular concept type will fall into one of four mutually exclusive categories within a particular context (Berawi, 2006), as follows:

Context: Environment in which a system exists. A system is a dynamic entity. The context
becomes a transcending framework that
directs attention to the way in which we
view a system. A single phenomenon can
therefore be viewed from different contexts
and have different imperatives applied.

Purpose: The principal reason a project, product, or
service is needed. A purpose is a final result
delivered by a system and is what we want
to achieve (overall goal-directedness). Pur-
pose is achieved by the outcomes delivered
by processes.

Outcome: A description of the result, effect, or con-
sequence that will occur after carrying out
a program or activity. An outcome resides
between process and purpose. An outcome
is a result of a process. Some outcomes will
directly enable a purpose to be achieved.
Others may not.

Function: The essential work or essential contribu-
tion a designer of a system needs to achieve.
In other words, a function is a reason why
a “thing” exists in a system. Functions ex-
ist in a conceptual sense and require pro-
cesses to be conducted in order to achieve
them. Functions are conceptual and so
cannot be measured. It is the process ap-
plied to the function that is measured as
that is ‘real’ not conceptual. We can select
different processes to perform the same
function and this is why they are useful to
innovation.

Process: A set of activities that can be recognised
and measured. A process leads to an out-
come. A process is a concrete action in the
real world that has been selected to perform
either a particular function or many func-
tions. That is, all processes should have at
least one function that justifies their use.

As we distinguish idea types we realise that the implied
functional and process theories in product development
are often purposive and as such teleological and intentional
(Berawi & Woodhead, 2005b). However, other functional
and process theories are also found in the context of causal
relationships and so represent alternative methods to sup-
port intentionality (Searle, 1995; Preston, 1998). There is a
need to determine an artefact’s function in terms of inten-
tionality and how it can be produced through its etiological
form (Woodhead & Berawi, 2005).

Central to this is a clear understanding of essential
functions that need to be performed by processes in or-
der to achieve selected outcomes and purpose (Figure 2).
Functions exist in a conceptual sense whereas processes
are recognisable phenomena in the real-world. A process is
a concrete action, in the real world, and has been selected
to perform a particular function. An outcome is a result of
concrete action (i.e. process leads to outcome). Removing
unnecessary processes with no essential contribution (i.e.
outcomes that have no value) will result in greater efficien-
cy and effectiveness in a system (Berawi, 2006; Woodhead
& Berawi, 2008). In the act of innovation these relations
between “Function”, “Process” and “Outcome” are designed
to achieve intended “Purpose” (figure 1).

The value of a “thing” can be measured from how well
a “thing” performs its designated functions and achieves
its purpose. As identifying functions enables us to propose
alternative ways to perform those functions in the act of

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Figure 1. The relationship between Functions, Outcomes, and Purpose (Woodhead &
Berawi, 2008)
idea generation, an “extended function” will set a new context (purpose and goal) of a system. It also leads to an improvement of products. The ability to consider alternative ways or processes that could perform the same work with added benefit stimulates enquiry and further exploration of the origin of ideas (Berawi, 2006; Woodhead & Berawi, 2008) as shown in figure 2. For example, we can achieve a fairly consistent view when we characterise the function of an object (e.g., a chair) and establish the context in which the object is in a system (e.g., chair and person sitting on it; chair and used to prop open a door). Therefore, there is a need to make the interconnectedness of functioning objects explicit.

Conclusion

Functions can be modelled as intentions and as “unthinking” cause-effect relationships in an explanatory model of how a system works. The implied functional and process theories in product development are often purposive and as such teleological and intentional. However, other functional and process theories are also found in the context of causal relationships and so represent alternative methods to support intentionality. There is a benefit found by distinguishing an artefact’s function in terms of either intentionality or its etiological form (i.e., causal mechanism) as clearer understanding leads to better ideas and innovation.

A particular concept type will fall into one of four mutually exclusive categories, within a particular context, an environment in which a system exists. A system is a dynamic entity. The context, the perspective we adopt to view a system, becomes a transcending framework that directs attention to the way in which humans attach meaning and significance to certain data and not to other data. A single phenomenon (e.g., global warming) can therefore be viewed from different contexts and have different imperatives applied. By classifying concepts into what outcome and purpose we want to achieve, how the sequence of processes can be executed, and why we need to perform a function, we are led to a shared understanding and better ability to produce new ideas to stimulate innovation and adding product value.

References


A Procedure for Best Value Tendering

John Kelly, Ph.D. & Steven Male, Ph.D.

This paper was presented at the SAVE International 2007 Annual conference.

ABSTRACT

The United States Federal Acquisition Regulations in common with other public sector organisations internationally, permit the appointment of construction consultants and contractors on a value for money or best value basis. However, there is often a concern on the part of the public sector purchasing officer that the best value criteria for the selection of consultants and contractors are vague and that a subsequent audit will fail to confirm that value for money was achieved. The lowest bid therefore remains the most attractive procurement option even in situations such as design build where it is clearly inappropriate.

This paper reports on research and proposes a value management based method for the discovery of the project value criteria which become the measurement principles against which a consultant or contractor may be chosen. The paper describes the application of notional discounting of the bid price to determine the best value for money bid. The methodology for discovery of value for money criteria and its application in competitive bidding is clear and conducive to successful audit.

Keywords

Best value, value for money, procurement, value management

Introduction

The United States Federal Acquisition Regulations (FAR 2005) aims to set out a method by which best value products or services may be delivered to the customer in a manner which maintains the public's trust. In this context best value is defined as “the expected outcome of an acquisition that in the Government’s estimation provides the greatest overall benefit in response to the requirement”.

Within the past decade there has been a move by public sector organisations internationally towards the procurement of public works on a design build basis. The design build is either procured as a capital purchase or, as a public-private partnership. In the latter the private sector partner tenders a unitary charge and remains responsible for the overhaul and maintenance of the capital product for a number of years. Additionally, public sector organisations have, concurrently, increasingly moved towards best value procurement in which the successful tender is judged on a number of factors in addition to price.

These changes bring new and unique challenges to the probity of public sector procurement. The first challenge is to define the design build procurement process so that judgment can be made on factors other than price. The second challenge is to define the design build procurement process such that the methodology employed in the selection of the contractor and consultants is transparent and capable of audit. This paper introduces such a methodology based upon a value management approach.

Best Value, FAR 2005

A number of international public sector organisations have produced regulations for the purchase of products and services on a value for money basis and use a similar definition of “best value” (Kelly and Hunter, 2006 and Chung et al, 2006). FAR 2005 (8.405-1) gives indicative factors which should be considered in determining a “best value” offer. These factors include:

- Past performance/performance history of the supplier
- Special features of the supplier or service required for effective programme performance
- Trade-in considerations
- Probable life of the items selected as compared to that of a comparable item
- Warranty considerations
- Maintenance availability
- Environmental and energy efficiency considerations
- Delivery terms.

FAR 2005 under the heading of “best value continuum” (15.101) also lays out the rules under which an agency can “obtain best value in negotiated acquisitions by using any one of a combination of source selection approaches. In different types of acquisitions, the relative importance of cost or price may vary. For example, in acquisitions where the requirement is clearly definable and the risk of unsuccessful contract performance is minimal, cost or price may play a dominant role in source selection. The less definitive the requirement, the more development work required, or the
greater the performance risk” then other factors such as those listed above may become increasingly important in the selection process. However, the factors which are to be taken into consideration and the method by which the proposals are to be evaluated, including details of multiple step processes, must be fully described in the solicitation documents. “Evaluations may be conducted using any rating method or combination of methods, including color or adjectival ratings, numerical weights, and ordinal rankings”.

The conclusion to this brief review of best value bidding in FAR 2005 is that there is wide scope for evaluating bids on factors other than lowest price however, the methodology for so doing has to be clear and made explicit in the bid documents.

**A Method for Classifying Selection Criteria**

A logical approach to managing best value and value for money is Value Management (VM). Clearly the procurement method is a valid topic for discussion at a project programming value management study and the criteria for judging a value for money tender could be determined at that time. The question of whether there are a discrete number of factors for judging value for money tenders can be answered by considering value itself.

Value is commonly cited as being a relationship between cost and function (O’Brien:1976 p16, Crum: 1971 p14, EUR 14394:1993, ICE: 1996 p3, Hayden and Parsloe: 1996 p5, RJ Park: 1999 p96). Adam (1993 p176) defines value as the lowest cost to reliably perform a function where the definition of function is that which the product process or system delivers to make it work and sell, the definition of basic function is the specific reason why the device was designed and made. Norton and Mcelligott (1995 p13) define value as a relationship between cost, time and function. They state that in a value management study the objective is to improve value through the balancing of cost, time and function which can be achieved in three ways:

- to provide for all the required project functions but at a reduced cost
- to provide additional desirable project functions without adding to the cost
- to provide additional desirable project functions while at same time reducing costs.

Other authors introduce the relationship between value, quality and cost for example, Burt (1975) states that maximum value is obtained from a required level of quality at least cost, the highest level of quality for a given cost or from an optimum compromise between the two. Best & De Valence (1999 p14) state that value is a relationship between time, cost and quality, and illustrate the time, cost, quality triangle, a technique commonly used in project management and illustrated on numerous commercial websites. Although accredited to Dr Martin Barnes academic debate is thin and citations are dominated by Atkinson (1999).

The relationship between quality and function is best illustrated by reference to Juran and Gryna (1988) who defined quality as the totality of features and characteristics (functions) of a product or service that bear on its ability to satisfy stated needs or implied needs. The definition of value as being a relationship between time, cost and quality is helpful in the search for characteristic factors of value for money.

Bicheno (2000: p170) describes the Kano model developed by the Japanese quality guru Dr Noriaki Kano who states that maximum quality is attained when targeted characteristics are achieved and the customer is delighted. There are three variables within the model. These are ‘basic

![Figure 1. The Kano model (adapted from Bicheno: 2000)](image_url)
factors’, ‘performance factors’ and ‘delighters’, which have a relationship to the presence of quality characteristics and customer satisfaction. These variables are included in the Kano model, illustrated in figure 1.

In the Kano model a basic characteristic is expected to be present. The customer will be dissatisfied if it is absent and only neutral if the characteristic is completely fulfilled. The performance characteristic relates to the essential function. The customer will be more satisfied if higher levels of performance are achieved. The delimiter is a performance characteristic, not specified by the customer but desired by the customer once its benefits have been revealed. There is however a time dimension to the model such that the three variables will tend to sink over time, i.e. what once delighted is now expected and higher levels of performance are always sought. For example, power expected as a basic characteristic and its absence would lead to dissatisfaction. The relationship between time, cost and quality and definition of quality in terms of basic and performance criteria is useful in the analysis of factors to be considered in the judgement of value for money tenders.

An analysis of the factors listed above based upon Kano results in their classification into 4 types:

- Basic characteristics. Either the tenderer meets the required level of performance or not. This applies to such factors as health and safety and fraud prevention. Basic factors, which relate to the company as opposed to the proposed design, should be determined through the pre-qualification questionnaire such that those tendering will all meet the requirements. Alternatively, an acceptable level should be specified such that a tenderer with an unacceptable performance will not be considered. For example, any company having a company director with a fraud conviction should not apply.

- Measurable performance characteristics. These characteristics are those such as energy consumption, hard facilities management costs, soft facilities management costs, capital cost and time. These are valid characteristics of a tender appraisal process. In a design build lump sum tender the tenderer should be required to submit an estimate of all these costs to be used in judging the tender whether or not there is a contractual compliance requirement i.e. a proving of energy and FM costs over say the first five years of operation.

- Non-measurable performance characteristics. These characteristics are those such as aesthetics, contribution to community, popularity with stakeholders, etc. These are valid characteristics of a tender appraisal process.

- Risk. Risk is commonly defined as being a hazard, the chance of a bad consequence or loss, or the exposure to miss chance. Risk management maximises the certainty of the functional value of a project. Risk is a solution focused factor of value and is a valid criterion when viewed from the perspective of the client. However, although it could be a discrete discretionary factor in the choice of a design it is better incorporated into the scoring system as risk is an overlay on basic and performance characteristics. The client should only consider those risks incorporated into the design which affect operability; construction risks will be incorporated into the tender by the tenderer.

The 4 types give a useful classification system when determining those factors for judging value for money tenders.

A Method for Identifying Selection Criteria

During a value management workshop at the project programming stage, at which all client stakeholders are present, the subject of procurement should be discussed and a method of procurement selected. The criteria for judging best value/value for money tenders will depend on whether the tender is to be based upon a full design by the client (or client’s consultants) or whether the tender will contain elements of design by the tenderer. The primary difference in the criteria will be the relevant performance characteristics and risk. In the situation where a tender is submitted based upon the client’s design the only performance characteristics relevant are capital cost and time. The risk to the client should be the same for each tenderer. The basic characteristics of a design-bid-build project should be defined as a prescribed requirement and the information on this gleaned through a pre-qualification questionnaire. Those that do not meet the basic criteria will not be invited to move to the next stage. In this way all qualified tenderers will meet the basic criteria.

For those tenders which contain elements of design by the tenderer a new technique is required to elicit the measurable and non-measurable performance variables. The following technique has been evolved and tested within two training workshops. It is considered that the technique is ready to go live. The stages of the new technique are described with reference to a design build project for a new primary school. The method assumes that that Value Management programming workshop is held with the head and deputy head designate for the new school together with the local councillor and representatives from; the local authority education department, the local authority facilities management department and the local community council.
Stage 1 – Brainstorming and classifying relevant criteria

As a part of the workshop the team should brainstorm those factors considered relevant in judging tenders. The factors should then be categorised the four sub-headings described above. An example of the brainstorming and categorisation exercise is given in figure 2.

In Figure 2 the basic criteria relates more to the company and not to the designed solution. These issues should be discovered as a part of the pre-qualification questionnaire and the companies selected to tender for the project will therefore be acceptable on these counts. The measurable and non-measurable performance criteria relate to the building and should be judged on a weighted scale. The risks associated with the company should be dealt with through the basic criteria. Risks associated with the design should be assessed as a part of the evaluation.

Kelly et al (2004: p212) describe the generic criteria for a value system as capital cost, operations cost, time, community, environmental impact, exchange (earning potential) flexibility, esteem, and comfort. From the above brainstorming session it can be seen that all of the measurable and non-measurable performance criteria fit within the generic criteria, for example soft and hard FM costs are operational costs and aesthetics and culture could be considered parts of esteem. The generic criteria therefore are a useful checklist.

Stage 2 – Determining the weights to factors

To determine the weights given to the various factors a paired comparison matrix exercise is undertaken. An example for the primary school is given in figure 3.

From the matrix it should be noted that capital cost is excluded since all other factors will be judged in the context of capital cost. The matrix is designed to be included with descriptive text in the tender documents together with a statement of the proportions used for capital cost and other factors. In this example the judgement is made on the basis of 70% capital cost and 30% other factors.

Stage 3 – Judging the tenders

Once the tenders are received a panel, ideally including representatives from the value management workshop...
The tenders received are adjusted to take account of the notional discount to give their relative position in value for money terms:

Tenderer A
£2,130,000 less 15.86% notional discount = £1,792,182

Tenderer B
£2,365,000 less 28.71% notional discount = £1,686,009

Tenderer C
£1,950,000 less 11.14% notional discount = £1,732,770

Tenderer D
£2,225,000 less 21.64% notional discount = £1,743,510

Therefore, based upon the notional tenders, Tenderer B, the highest tenderer should be awarded the contract as the full solution offered gives the best value for money as proved through the value for money process.

Conclusion

The research undertaken has proved that there are four factors which may be used in the judgement of value for money tenders for design build namely, basic factors, measurable performance factors, non-measurable performance factors and risks. The basic factors are those which relate primarily to the company as opposed to the proposed design and should be determined through the pre-qualification questionnaire such that those tendering will all meet the requirements. The measurable and non-measurable performance factors will need to be determined for each tender but are likely to be highly correlated with capital cost, operations cost, time, community, environmental impact, exchange (earning potential) flexibility, esteem, and comfort. The risks involved with the technical solution offered by the tenderers are taken into account in the weighting and scoring matrix exercise as shown in figure 4. Whether risk analysis should be a separate exercise is an interesting but detached debate.

The criticism of the method is that the weights and
scores are subjective and can be sensitive to change. In the example illustrated in figure 4, altering the weighting under the headings by one in turn had no impact on the position of the tenderers after the notional discount was taken into account. However, if tenderer B scored 4 instead of 5 in two situations then this tenderer would no longer be the lowest. Sensitivity checking is therefore of prime importance and should be undertaken with the whole panel present.

The research demonstrates a value based method capable of description within the tender documents which meets all the requirements of probity. A panel of stakeholders will construct the paired comparison and blank scoring matrix at the time of preparing the brief. A value management workshop is not fundamental to the method but preparing the necessary pre-tender documents through a value management workshop and using a panel of members from the workshop to judge tenders reinforces the probity and increases the certainty that judgements are fair. In application it appears to comply with FAR 2005.

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Author Information

John Kelly, Professor of Construction Innovation, Glasgow Caledonian University and Steven Male, Professor of Building Engineering and Construction Management, University of Leeds, have worked extensively with client and construction industry supply chain members. They have jointly researched, developed, benchmarked and implemented a value management methodology for the UK construction industry described in “The Value Management Benchmark” published by Thomas Telford. John and Steven follow their first UK book on value management, published in 1993 with a new book, “Value Management of Construction Projects” published by Blackwell in February 2004. This book, written in conjunction with a practitioner Drummond Graham, consolidates 10 years of research and consultancy into a practical text.

Steven and John have facilitated a number of value-for-money studies for a variety of construction clients and contracting organisations. Themes within these action research consultancy studies have included: value management and value engineering studies with a range of Blue Chip and Government clients, studies for clients with major refurbishment programmes, studies for clients wishing to develop long term partnering and supply chain arrangements, studies for construction industry consortia or clients involved in Private Finance Initiative and Prime Contracting projects.
This paper was presented at the SAVE International 2007 Annual conference.

Abstract

Successful product and process development requires an understanding of the business environment and key customer objectives early in the product or process development. It is equally important to develop an understanding the business requirements, develop concepts, and screen concepts to meet the key customer objectives. A framework is presented in this paper that results in a function-based concept that meets the key customer objectives.

The framework includes customer value chain analysis, functional analysis, high level concept generation, and organizing the information into a house-of-quality. The “Zero look” house-of-quality defines a function-based concept, key customer functions/objectives, and key business functions/requirements. The function-based concept generated in the “Zero look” house-of-quality does not consider the means for achieving the functions; thus a “Zero look”. A step-by-step guide to the “Zero look” framework, with an example, is included in the paper.

The result of applying the framework is a function-based concept, key customer functions/objectives, key business functions/requirements that are the foundation of product or process development.

Background

The paper develops a framework for identifying an initial design concepts based on an application of functional analysis, customer value chain analysis, and the QFD house-of-quality. A brief introduction to these tools is presented here followed by a description of the framework and an example.

Customer Value Chain Analysis

Customer Value Chain Analysis (CVCA) [2] is a tool that enables design teams in the product definition phase to look at the proposed business model and identify pertinent stakeholders, their relationships with each other, and their role in the product’s life cycle. By understanding the stakeholders and their relationship with each other the value propositions between the stakeholders can be clarified and expressed as functional relations. The value propositions change as the business model changes as a result of changing the roles of the stakeholders.

Functional Analysis

Value Analysis can be defined as, “An organized effort directed at analyzing the functions of goods and services to achieve those necessary functions and essential characteristics in the profitable manner.” [6], or as T.C. Fowler [3] simply states, “The single object of modern value analysis is to deliver to the user/customer the required functions at minimum cost.”

The primary tool in Value Analysis is the Functional Analysis and Systems Technique (FAST). The customer-based FAST diagram [3] is used with some modification. The diagram used in this paper is a modified customer-based FAST diagram that is based on the process not the device. For example, the function of a hair dryer is to dry hair. The FAST diagram for the task function, Dry Hair, looks at the process for drying hair not just what the product, a hair dryer, does. [4]

House-of-Quality

The house-of-quality is a tool of Quality Function Deployment that identifies the relationship between the customer requirements (CR) and the engineering or technical characteristics (EC). The two are related by a correlation matrix. [1] Other components of the house-of-quality are the roof, which relates the EC’s to each other, the relative performance on of the CR’s and the performance level of the EC’s. The roof is not included in this study.

Framework

The framework presented in this paper is an innovative approach for the early stages of the product development process that considers functional analysis, business models, customer value chain analysis and the house-of-quality.

Steps:

1) Develop a business model and perform a customer val-
ue chain analysis.

2) Define the critical customers and the value propositions.

3) Develop a process based FAST diagram from the business perspective.

4) Examine the business FAST to identify the “actors” for the various functions, vary the actors, and develop revised business models.

5) Develop a process based FAST diagram from the various customer perspectives.

6) Identify the customer objectives and the business requirements based on the customer functions and business functions.

7) Develop a “Zero-look” house-of-quality based on the customer function/objectives and the business function/requirements.

8) Use the “Zero-look” house-of-quality to evaluate design concepts and identify the best design concept.

9) Identify the key customer function/objectives and key business function/requirements.

The result of this framework is a design concept that meets the customer objectives and adheres to the desired business model.

**An Example**

The framework can best be described illustrated by an example. The example selected for this paper is a propane tank distribution center like those commonly located at gas stations and convenience stores.

1. **Develop a business model and perform a customer value chain analysis (CVCA).** The current design of propane tank distribution, commonly located at gas stations and convenience stores, was used to perform customer value chain analysis. The stakeholders impacted by the Propane Container in the value chain analysis are the Convenience Store, the Propane Customer, and the Propane Supplier. The value chain analysis for Model A is shown in Figure 1.

2. **Define the critical customers, the value propositions.** The critical customers are the convenience store and the propane customer. The propane supplier is a customer.

The value propositions for business model A include:

1. The dispenser manufacturer sells the propane container to the propane distributor for a fee.

2. The propane distributor pays the convenience store to rent space to place the propane dispenser on the site.

3. The propane customer pays a fee to the convenience store.

4. The convenience store operator accesses the propane container, returns an empty tank, and accesses a full tank from the propane container. (The propane customer may purchase a full tank at a higher fee without returning an empty tank)

5. The propane supplier delivers full tanks and takes the empty tanks and the money for the sale of the propane.
3. Functional analysis from the business point-of-view. The task function from the business point-of-view is Sell Propane. The business will need to supply propane, receive empty tanks, receive payments, and restock tanks. Other functions include controlling access, securing space and containing the tanks. These functions are shown in the business FAST diagram in Figure 1.

4. Examine the business FAST to identify the “actors” for the various functions, vary the actors, and develop revised business models. Three models were created by changing the actors for the business functions.

- **Model A** – Model A is the model currently found at most locations. The customer goes in the store, pays the clerk, the clerk has to go outside and unlock the propane container, finds a full tank, and puts the empty tank in the container.

- **Model B** – This model is aimed at reducing the effort of the convenience store clerk. The clerk grants access to the customer from inside the store. The customer pays for the transaction in the store and then goes to the tank container and uses the code to open the container. The customer deposits the empty tank and finds a full tank. The clerk monitors the customer from inside the store.

- **Model C** – This model is similar to a normal vending machine. The customer deposits the empty in a specific place in the propane container. The customer pays by swiping a credit card or depositing cash based on the amount to be paid which is more if an empty is not returned. The customer is restricted to removing only one full tank. The propane container keeps track of the inventory.

5. Identify the process FAST diagram from the various customers’ perspective. The task function from the propane customer’s point-of-view is Buy Propane. The customer will need to receive the full tank, leave the empty tank (or pay a higher fee). The value propositions for business model C include.

<table>
<thead>
<tr>
<th>Function</th>
<th>Model A</th>
<th>Model B</th>
<th>Model C</th>
</tr>
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<tbody>
<tr>
<td>Receive Payment</td>
<td>Convenience Store</td>
<td>Convenience Store</td>
<td>Propane Supplier</td>
</tr>
<tr>
<td>Permit Access</td>
<td>Convenience Store</td>
<td>Propane Container</td>
<td>Propane Container</td>
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<tr>
<td>Schedule Restock</td>
<td>Propane Supplier</td>
<td>Propane Container</td>
<td>Propane Container</td>
</tr>
<tr>
<td>Identify Empties</td>
<td>Convenience Store</td>
<td>Propane Customer</td>
<td>Propane Container</td>
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</table>

For this paper only two business models are included. The two models selected are the extremes from the current model, shown in Figure 1, and a fully automated model, Model C, shown in Figure 3:

1. The dispenser manufacturer sells the propane container to the propane distributor for a fee.
2. The propane pays the convenience store to rent space to place the propane container on the site.
3. The propane customer deposits a fee of the propane container and delivers an empty tank and is granted access to a full tank. (The propane customer may purchase a full tank at a higher fee without returning an empty tank)
4. The propane supplier delivers full tanks and takes the empty tanks and the money for the sale of the propane.
fee), and pay for the propane. These functions are shown in the FAST diagram in Figure 4:

FAST diagrams are also developed for the convenience store, the regulator, and the propane supplier. The convenience store provides space and services the sale. The propane supplier identifies the empties, removes the empties, supplies the full tanks, and receives payment for the propane.

6. Identify the customer objectives and the business requirements.

The customer objectives are derived from the customer functions and the business requirements are derived from the business functions. For example, the objectives for the customer function, receive tank, are the availability of full tanks, the ease of identifying empty tanks, and the cost of the tank of propane. For the business function supply tanks, the business requirements are the number of full tanks available, ease of identifying full tanks, and ease of access of the tanks. All of the customer objectives and business requirements are seen in the house-of-quality.


The “Zero look” house-of-quality is developed with the customer functions/objectives on the left hand side, the business functions/requirements across the top. A simplified version of the “Zerolook” house-of-quality is shown in Figure 5. The two customers included are the propane customer and the convenience store. The propane supplier is also a customer of the propane container but is not included to simplify the analysis. The customer function/objectives and the business functions/requirements are connected by the relationship matrix. The relations are shown with a 9 for a strong relation, a 3 for a moderate relationship, and a 1 for a weak relationship. On the right hand side of the house-of-quality the performance rating for Model A, Model B and Model C are included. The weighted rating is shown as the sum of the importance of the customer objectives times the rating. The improvement of Model B vs. Model A and Model C vs. Model A are also shown. The impact on the marketing is estimated for Model B, Sales Point B, and Model C, Sales Point C. The score for B and C are calculated by multiplying the importance times the improvement times the sales point and normalizing. At the bottom of the correlation matrix the score for each of the business objectives is calculated by summing the customer objective score times the score for each business objective in the correlation matrix. These score are normalized to obtain the Percentage Score.

Discussion

While for simplicity the model does not include all of the elements including all of the customer functions/objec-

tives, the worth of the customer functions and the cost of the business functions, important information that can be gathered from this example.

Rating of Alternative Solutions — The evaluation includes a preliminary rating of the alternatives considered. In the example the overall weighted rating for Model A (the current model) is 81, for Model B it is 113 and for Model C it is 155. Clearly, Model B and C have improved performance over Model A and Model C is a considerable improvement over Model B. At this point the functional worth of the customer functions and the target cost for the business functions can be estimated. [5] The means of accomplishing the business functions and the actual costs have not been determined.

Identification of Key Functions/Customer Objectives — Considering the Normalized Scores for the customer objectives guides the designer towards improving the key customer objectives. These key customer objectives are identified by the highest normalized scores. In the example above, these are the propane purchaser’s weight time and ease of identifying a full tank, and the time spent and the convenience of the transaction for the store clerk. These are the function the designer should focus on.

Identification of Key Business Functions/Objectives — Considering the Normalized Scores for the business objectives guides the designer towards the business objectives and functions that will have the greatest impact on performance improvement. In the example above, these are the identification of the full and empty tanks, and controlling the access to the tanks. These are functions the designer should focus on improving.

The above discussion suggests a fourth alternative. An combination of B and C where the propane customer pays the store clerk and receives a code, the customer is presented an open space to deposit the empty and once the empty is in place and the code is entered a single full tank is presented for the propane customer. Once removed this space becomes the empty space for the next customer.

Conclusion and Recommendations

The framework presented in this paper produces a “Zero look” house-of-quality that enables the designer to identify a suitable business model and product or process concept in the very early stages of development without considering the means. The “Zero look” house-of-quality also identifies the key customer functions/objectives and the key business functions/requirements that guide the design focus.

Future work will integrate the customer worth with the customer objectives and the target cost with the business requirements. [5] The future work will also extend the
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Score B | 1659 | 173 | 132 | 114 | 68.6 | 126 | 68.1 | 70.7 | 82.5 | 37.3 | 23.1 | 148 | 241 | 278 | 204 | 34.7 | 77.1 | 81 | 113 | 155 |

Score C | 1665 | 136 | 100 | 193 | 55.5 | 207 | 63.1 | 65.2 | 77.8 | 36.5 | 8.81 | 132 | 215 | 287 | 198 | 19.8 | 2.94 |

Percent Score B | 10.4 | 7.9 | 6.8 | 4.1 | 7.6 | 4.1 | 4.3 | 5.0 | 2.2 | 1.6 | 8.9 | 14.5 | 16.8 | 12.3 | 2.1 | 0.5 |

Percent Score C | 8.1 | 6.0 | 11.6 | 3.3 | 12.4 | 3.8 | 3.9 | 4.7 | 2.2 | 0.5 | 7.9 | 12.9 | 17.2 | 11.9 | 1.2 | 0.2 |

Figure 5. Simplified “Zero Look” House-of-quality
house-of-quality to additional matrices that translates the business requirements into product or part characteristics and the product or part characteristics to manufacturing operations. [7]

Bibliography


Author Information

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He has 19 years of industrial experience in industrial process and product development in the detergent, paper, and packaging industries. He currently teaches design methodology at the undergraduate level and product development and value management in the graduate Engineering Management program.
Innovative Application of the Value Methodology (VM) for Large, Complex Facilities

Stephen J. Kirk, Ph.D., FAIA, FSAVE, CVS, LEEDTMAP & Stephen E. Garrett, AVS

Abstract

Value based methods are ideal for managing large, complex projects throughout the world. This presentation will utilize a number of international projects as case studies to illustrate how value based design decision-making methods were used to maximize value. Key VM principles often forgotten in large, complex projects will be discussed. In addition, large projects offer VM strategies that are not possible with small projects. Likewise complex projects require strategies that are somewhat different than simple projects. The presenters have years of first hand experience in applying the techniques of FAST, quality modeling, risk modeling, creativity, choosing by advantages (CBA) and life cycle costing (LCC) to improve on some very prestigious large, complex international projects. The audience will become familiar with issues particular to each case study, such as security, maintainability, quality, sustainability, schedule, constructability, operational effectiveness, as well as the life cycle cost implications. Ten case studies will help illustrate key points. Texas is an ideal setting to discuss VM applied to large, complex projects.

Large, Complex Projects

Large facility construction projects may not be complex. These include warehouses, big box retail stores, parking decks, etc. The reverse is also true; complex projects may small. Examples include restaurants, clinics, banks, single family houses, etc. Kirk Associates has had an opportunity to work on a great variety of projects over the past 25 years. We have selected some representative samples of what we consider to be large, complex projects. These include multi-family housing, hospitals, airports, court houses, office towers, K-12 Education, R&D laboratories, manufacturing, university campuses, and city planning.

10 Case Study Examples:

- Residential Tower and Townhouses (land reclamation; repetitive project items, material shortages, high inflation risk) (See below.)
- Medical Center: New Veterans Administration Hospital (patient needs, metrics, schedule, component construction) (See below.)
- Airport: New North Terminal Replacement, Detroit, Michigan (space planning efficiency, maintainability, material flow in restricted site) (See next page, top left.)
Value management is not simply about money, it is, as the name suggests, about value, which includes important issues such as operational effectiveness, flexibility, comfort, site & architectural image, cultural values, engineering performance, safety & security, environmental sustainability, construction schedule and initial and long term cost effectiveness.

Some claim VM is only for projects over budget. The experienced have found that VM should always be applied whether the project is within budget or not. For example, when a project is within budget the VM team focuses on adding even greater performance while finding cost savings to pay for the added features to stay within the budget. If over budget, the VM team first focuses on meeting the budget then looks for opportunities to add performance.

Value Based Design Decision-Making

Done correctly, value based design decision-making is about value over the lifetime of the facility being analyzed.
the methodology. The six step problem-solving process focuses on increasing value by improving performance (quality) and lowering cost (life cycle cost). The steps of decision-making are:

- Information gathering and benchmarking, for example creating cost and quality models
- Function analysis, which is the exercise of stating the project purpose in a verb/noun form
- Creativity phase, which does not stop with the first workable idea
- Evaluation of ideas generated using life cycle cost analysis and using benefit cost comparisons
- Development of those ideas into a workable preferred alternative using “choosing by advantages”
- Recommendations to the decision-makers balancing benefits and costs

While this methodology has been used frequently in small, simple projects, it is particularly important for large, complex facilities. It fosters the consideration of true alternatives when making decisions about whether to retain, consolidate, build new assets and it will benefit any field of consultation, including architects, every kind of engineer, and business managers. Moreover, it is a service that can be provided even when another architect is doing the design and documentation phases. The value specialist works closely with the client and architect to develop a variety of options from which to choose. This role works best with repeat clients, where the trust and rapport are already established. An option for providing these services to a first-time client is to come into a project as part of the design or construction management team.

**Strategy 1: Follow the Methodology**

Application of the value methodology as an “entire decision-making system” is critical for success. Don’t try to shortcut the methodology.

**Holistic Design Team Involvement**

Part of the strength of value-based decision-making is the holistic approach to design that is achieved by involving all the stakeholders. Traditional multi-disciplined team includes participants from:

- Owner
- User,
- Facility Manager,
- Constructor, and
- Design team (architect and engineers).

The owner, ultimately the decision-maker, must be involved from the beginning to assist in defining their value expectations for the project and in setting priorities. A value specialist is not a decision-maker; they can only facilitate sound decision-making.

In addition, the value team includes subject matter experts (SME’s) that include the traditional disciplines of:

- Architect,
- Structural Engineer,
- Mechanical Engineer, and
- Electrical Engineer
- A slightly more expanded team might include:
  - Civil Engineer,
  - Landscape Architect,
  - Interior Designer, and
  - Sustainability Specialist

Large, complex projects offer the opportunity to include “special” team members that financially would not be feasible in smaller projects. For example:

- Hospitals Nurses, Physicians,
- Airports Maintenance Specialists,
- Museum Lighting Designers
- Performing Arts Acousticians
- Historic Structures Historic Architects, State Historic Preservation Officer
- Courthouses Court Planners, Operations Specialists, Attorneys, Judges
- Housing Housing Managers, Interior Designers, Sales
- R & D Lab Planners,
- Schools Teachers, School Board Members
- Retail Traffic flow, branding, theming, Appeal
- Manufacturing Materials Handling, Lean Manufacturing Specialists
- All Technical consultants (curtainwall, vertical transportation, etc.)

**Workshop Setting for Real Time Decision-Making**

Real time decisions are reached using value based methods in a team “value enhancement workshop” setting. Many of these workshops have now evolved into a “value based design Charrette” to more fully explore a variety of ideas. Holding the workshops in a neutral location so all stakeholders feel comfortable is important. Paramount to the success is the skills of the value specialist to facilitate decision-making in these team-oriented sessions. Value methods used by the facilitator to help communicate to the...
team include: function analysis, quality modeling, LEED sustainability, group creativity/innovation techniques, life cycle costing, design/cost simulation modeling, and Choosing by Advantages (CBA).

Time
Small, simple projects can usually be studied in workshops of 2 to 3 days in duration. For large, complex facilities more time is required. How much time? This is a function of the number of VM objectives to be achieved (cost, quality, schedule, etc.) since more time is required to model and generate ideas for each objective. Additional time is also required to develop the ideas into proposals. A 5-day workshop is the norm for large, complex projects. Hospitals for example take time just to understand the complexity of layout, adjacencies, and flows of patients, staff, visitors, material handling, waste removal, etc. Identifying and analyzing alternative solutions is very time consuming and requires adequate time in the workshop to fully develop feasible alternatives for decision-maker consideration. This also allows for sub-team breakouts. For example exterior wall, maintainability, operations, constructability, etc.

Apply VM Early in the Design Process
In its history, value analysis was once applied late in the design process, when all the construction documents were finished. More information was known, however it was too late to make design changes if new ideas were identified which would improve project performance or lower life cycle costs. VM has moved closer to the crucial formative stage of decisions, the point where design decisions are made for the facility layout, massing, circulation, project sitting, and major building systems. At its best, value analysis is a process of coordinating and integrating interdisciplinary preservation teams.

In the process of recommending ideas, the importance of starting early is a matter of how changes become more expensive as project development progresses. A great idea for adding value to a project is not so great when it requires the whole team to back up and start over again on some of the basic assumptions. So some great ideas never get used. The over-arching mindset of the value analysis process is the integration of the whole for the benefit of the project life cycle, regardless of where the value management team came into the project. Naturally, a large part of the value specialist’s skill set is team building acumen and understanding of group dynamics in the facilitation of the team.

Large, complex projects offer the opportunity and the need to study the project multiple times during the design process. A simple project is usually only studied once, preferably at the conceptual stage.

Examples of multiple applications

Courthouse  Planning developing design standards for all courthouses
Programming space needs

Concept Design concept selection (CBA), circulation, layout, adjacencies

Airport  Schematic design layout & engineering systems
Design Development maintainability & sustainability

Hospital  Infrastructure, energy plant, utilities, roads
Main Hospital, clinics, admin., surgery, emergency, long term care

Strategy 2: Use the Methodology

The techniques of VM have continued to evolve over the past 50 years. A single case study of an Research & Development (R&D) facility is used to offer examples of the methodology tools:
Function Logic Diagram

Function analysis is core to any value study. For a R&D facility, the VM team prepared a function logic/FAST diagram (Figure 1) to help understand the overall purposes of the new National Plant & Genetics Security Center (NPGSC). This diagram describes the essential functions of the project that will assist in discovering new knowledge by allowing scientists to “perform research” for the USDA. (See Figure 1, below right.)

Function Pareto Cost Model

The VM team prepared a “Function Pareto Cost Model” to help understand the overall building systems and associated functions of the NPGSC. The chart describes the item, its function (in parenthesis), its associated cost (from the A/E submitted estimate), and VA target worth based on team discussions (Figure 2). This information is shown in a “Pareto” bar chart (high cost to low cost) to help the team focus on the most expensive functions and to target areas of potential savings. (See Figure 2, next page, top right.)

Life Cycle Cost Model

At times the overall project life cycle costs are not available for the project under study. For the NPGSC, the VM team relied on historical costs of similar laboratory projects and from Whitestone Building Maintenance and Repair Data 2005-06.

The following life cycle cost model (Figure 3) is based on this information but adjusted for the NPGSC project. This graphical “pie” diagram helped the team focus on high energy, preventative maintenance & minor repair, and renewal & replacement cost items to identify areas of savings. Largest costs include energy, renewal, and replacement costs. This analysis was based on a 25 year life cycle and a 3% discount rate. The costs are shown in present worth.

Risk Model

The risk model (Figure 4) helped the VM team identify high project risks. The model was prepared during the value analysis workshop by the client and A/E team. It was used by the team to help identify ways to mitigate the risks identified earlier. Most significant risks to this project included: project schedule, changing government regulations, budget

---

**Figure 1. Function Logic Diagram**
limitations, inadequate subgrade testing, security concerning visual surveillance of site and building, architectural integration with the existing building, limited site laydown areas, traffic congestion on site, interference with other work on site, and utility relocations. (See Figure 3, next page.)

**Quality Model**

The quality model (Figure 5) helped the VM team identify the elements of quality most important to the success to the project. The model also indicates the client’s evaluation of how successfully the quality model elements were satisfied. The differences between the ideal and the current design were identified as “gaps” for later value improvement. The most significant gaps include: flexibility/expandability, site planning/image, community values (cultural response), engineering performance, security/safety, operation & maintenance, schedule, and capital cost. (See Figure 4, next page.)

Following is a description of the quality model elements:

**Operations**

- **Operational Effectiveness**: The degree to which the building is able to respond to the work process and flow of people, equipment, and materials.
- **Flexibility/Expandability**: The degree to which the building plan can be rearranged to conform to revised work processes and personnel changes. The ability of the building to grow to meet projected changes in the work process without disturbing existing building functions.

**Resources**

- **Capital Cost Effectiveness**: The economic consequences of the building in terms of initial capital investment including construction cost, design fees, land costs, etc.
At times the overall project life cycle costs are not available for the project under study. For the NPGSC, the VM team relied on historical costs of similar laboratory projects and from Whitestone Building Maintenance and Repair Data 2005-06. The following life cycle cost model (Figure 3) is based on this information but adjusted for the NPGSC project. This graphical “pie” diagram helped the team focus on high energy, preventative maintenance & minor repair, and renewal & replacement cost items to identify areas of savings. Largest costs include energy, renewal, and replacement costs. This analysis was based on a 25 year life cycle and a 3% discount rate. The costs are shown in present worth.

Figure 3. Life Cycle Cost Model

<table>
<thead>
<tr>
<th>ELEMENTS</th>
<th>RISK AREAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. MANAGEMENT, FINANCIAL &amp; ADMINISTRATIVE RISKS</td>
<td>Schedule (Design, Bidding, Construction, Startup)</td>
</tr>
<tr>
<td></td>
<td>Changing government regulations</td>
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<tr>
<td></td>
<td>Public and political perspectives</td>
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<tr>
<td></td>
<td>Budget limitations, approvals process, &amp; other constraints</td>
</tr>
<tr>
<td></td>
<td>Site acquisition - Adjacent site elements</td>
</tr>
<tr>
<td></td>
<td>Permitting delays</td>
</tr>
<tr>
<td></td>
<td>Agency jurisdictions and conflicts</td>
</tr>
<tr>
<td></td>
<td>Project mgt., organ., decision-making processes, info. flow</td>
</tr>
<tr>
<td></td>
<td>Labor issues</td>
</tr>
<tr>
<td></td>
<td>Other:</td>
</tr>
<tr>
<td>B. ENVIRONMENTAL, GEOTECHNICAL RISKS</td>
<td>Incllement weather, storms, floods</td>
</tr>
<tr>
<td></td>
<td>Hazardous waste disposals, site remediation</td>
</tr>
<tr>
<td></td>
<td>Environ. restrictions (air quality, noise, toxic mat., etc.)</td>
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<tr>
<td></td>
<td>Contaminated soils remediation</td>
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<tr>
<td></td>
<td>Groundwater remediation</td>
</tr>
<tr>
<td></td>
<td>Unchartered underground testing</td>
</tr>
<tr>
<td></td>
<td>Inadequate subgrade testing</td>
</tr>
<tr>
<td></td>
<td>Unanticipated archaeological or historical findings</td>
</tr>
<tr>
<td></td>
<td>Other:</td>
</tr>
<tr>
<td>C. TECHNICAL RISKS</td>
<td>Systems, processes, and material</td>
</tr>
<tr>
<td></td>
<td>New, unproven systems, processes and materials</td>
</tr>
<tr>
<td></td>
<td>Other: Dependence on university utilities</td>
</tr>
</tbody>
</table>

Figure 4. Risk Model (selected portion only)
- **Operations & Maintenance**: The degree to which the building is able to conserve energy resources through construction, site orientation, and solar design. Other considerations include maintenance, operations, and replacement costs.

- **Schedule**: The amount of time required to complete the various tasks including programming, design, construction and start-up/move-in.

**Technology**

- **Environmental**: The degree to which the facility is sensitive to environmental concerns such as hazardous waste, air & water pollution, use of sustainable materials, recycling, etc.

- **Security/Safety**: The degree to which the building can segregate sensitive functions from one another and prevent the entry of people to restricted areas.

- **Engineering Performance**: How the building operates in terms of mechanical systems, electrical systems, and laboratories.

**Image**

- **Site Planning/Image**: The degree to which the site responds to the needs of the project in terms of parking, vehicular & pedestrian traffic, outdoor amenities, and the visual impact to employees and visitors.

- **Architectural Image**: The visual concept of the building and the way in which the building attracts attention to itself. The form of the building and the degree to which it acts as a symbol for the government & partnerships.

- **Community**: Values How the building and its site project a “good neighbor” identity in terms of safety, security, and privacy. How the building responds to the culture of the community.

**LEED Sustainability Checklist Model**

The LEED (Leadership in Energy and Environmental Design) sustainability model (Figure 6) was prepared by the design team prior to the workshop. It helped the VM team identify opportunities to make the project more sustainable. Enough points were identified to achieve “silver” certification.
**Force Field Analysis**

This technique is used to identify both positive aspects of the project and areas to be improved if possible. A list was prepared of the best and weakest features as identified by the workshop attendees. The VM team then listed 111 creative ideas during the “brainstorming” portion of the workshop. Ideas were listed to improve on weak features, reduce risk, improve quality, lower initial and life cycle cost. All ideas were to achieve the functions of the project. As many ideas as possible were listed without judging them.

**Evaluation of Ideas**

Once ideas are listed, the VM team evaluated them to select the most promising for development. This task included having the team develop criteria which would be used to evaluate each idea. The following is the criteria or factors used to evaluate the list of ideas:

- Performance Improvements
  - Flexibility
  - Space Efficiency
  - Dependability
  - Redundancy
  - Durability
  - Sustainability
  - Quality

- Cost Savings (all part of Life Cycle Costing)
  - Capital cost
  - Energy
  - Maintenance
  - Major Replacements

- Ease of Implementation
  - Time to modify
  - Cost to change

**Development & Recommendation**

The VM team then developed the most promising ideas by preparing sketches, performing engineering calculations, estimating the initial and life cycle costs, and listing the non-monetary advantages and disadvantages. Each value analysis proposal is documented for the report including a one page summary followed by a complete description of each proposal, sketches where necessary and cost estimates used as a basis for initial and life cycle costs. Some recommendations will generate significant savings for the project. Other ideas may add costs but would improve performance or generate life cycle cost savings. Due to time constraints, some ideas were not developed into proposals, but may still warrant additional consideration by the client.

**Strategy 3: Don’t Be Afraid of the Big Ideas**

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Idea: Break up into components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefits:</td>
<td>schedule, constructability,</td>
</tr>
<tr>
<td></td>
<td>cost, labor</td>
</tr>
<tr>
<td>Airport</td>
<td>Idea: Use double loaded terminal layout</td>
</tr>
<tr>
<td>Benefits:</td>
<td>Reduced walking distance,</td>
</tr>
<tr>
<td></td>
<td>operational efficiency</td>
</tr>
<tr>
<td></td>
<td>Idea: 100 ideas to reduce</td>
</tr>
<tr>
<td></td>
<td>maintenance &amp; improve durability</td>
</tr>
<tr>
<td></td>
<td>Benefits: Didn’t add first cost</td>
</tr>
<tr>
<td>Housing</td>
<td>Idea: Small changes make a big difference</td>
</tr>
<tr>
<td>Benefits:</td>
<td>Improved housing quality,</td>
</tr>
<tr>
<td></td>
<td>improved constructability</td>
</tr>
<tr>
<td>Courthouse</td>
<td>Idea: Increase size of</td>
</tr>
<tr>
<td></td>
<td>corridors and reduce size of</td>
</tr>
<tr>
<td></td>
<td>courtroom since 95% of all cases</td>
</tr>
<tr>
<td></td>
<td>settled in corridors</td>
</tr>
<tr>
<td></td>
<td>Benefits: Improved basic function of settling cases</td>
</tr>
<tr>
<td>Office Tower</td>
<td>Idea: Single component into</td>
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<td></td>
<td>multiple components for 3-D</td>
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<tr>
<td></td>
<td>exterior skin</td>
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<tr>
<td></td>
<td>Benefits: Improved constructability, supported signature design</td>
</tr>
<tr>
<td>Schools K-12</td>
<td>Idea: Use of Cherokee images</td>
</tr>
<tr>
<td></td>
<td>and symbols, integrate LEED &amp;</td>
</tr>
<tr>
<td></td>
<td>Indian culture</td>
</tr>
<tr>
<td></td>
<td>Benefit: Improved cultural</td>
</tr>
<tr>
<td></td>
<td>expression and aesthetics</td>
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<tr>
<td>R &amp; D</td>
<td>Idea: Create “unique” work</td>
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<td></td>
<td>environment</td>
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<td></td>
<td>Benefits: Improved research</td>
</tr>
<tr>
<td></td>
<td>interaction</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Idea: Use “lean” principles to</td>
</tr>
<tr>
<td></td>
<td>simplify flows, just in time</td>
</tr>
<tr>
<td></td>
<td>delivery</td>
</tr>
<tr>
<td></td>
<td>Benefits: Eliminate waste (time,</td>
</tr>
<tr>
<td></td>
<td>materials, etc.)</td>
</tr>
<tr>
<td>University</td>
<td>Idea: Improve space use</td>
</tr>
<tr>
<td></td>
<td>efficiency</td>
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<tr>
<td></td>
<td>Benefits: Create more usable</td>
</tr>
<tr>
<td></td>
<td>space for teaching</td>
</tr>
<tr>
<td>City Planning</td>
<td>Idea: Explore options for</td>
</tr>
<tr>
<td></td>
<td>distribution of services</td>
</tr>
<tr>
<td></td>
<td>Benefits: Improve public services and reduced city taxes</td>
</tr>
</tbody>
</table>
VM Principles Often Forgotten in Large, Complex Projects

Following is a summary listing of the observations identified by this research on large, complex projects:

- Missed “basic function” of project (project goals & objectives)
- Project so large & complex skip function analysis to start brainstorming
- Forgot about “time” (project delivery schedule)
- No focus on scarcity of resources – materials & skilled labor
- Too much focus on LEED sustainability ilo “economic sustainability”
- Lost opportunity to build on VM “Big Idea”
- Lack of use of multi-disciplined VM team extended to unique specialists
- Too little development of proposals due to too many proposals (quantity vs. quality)
- 24/7 projects lack of focus on maintainability
- No discussion on cost / life cycle considerations because don’t have estimate
- Following is a summary of the key strategies to address those observations for large, complex projects:
  - Select VM team to include “specialists” for complex project issues (critical need to select experienced, knowledgeable team)
  - Follow VM methodology and conduct workshop in a neutral site to limit distractions
  - Use Function Logic Diagrams to identify Basic Functions (validation of goals & objectives of project)
  - Give you and your team enough time to cover key issues (use time wisely)
  - Brainstorm ideas on schedule, scarcity of resources, economic sustainability, and maintainability in addition to those based on function
  - Lean on the appropriate tools (discovered in pre-workshop or workshop)
  - Select ideas for development that reinforce VM team
    “Big Idea” discovery
  - Develop VM ideas into thorough, well thought out proposals
  - Follow through to discover those ideas implemented

Summary

Value based methods are ideal for managing large, complex projects throughout the world. A number of international projects were used as case studies to illustrate how value based design decision-making methods can maximize value. Key VM principles often forgotten in large, complex projects can make a big difference in the success of the study. In addition, large projects offer VM strategies that are not possible with small projects. Likewise complex projects require strategies that are somewhat different than simple projects. Applying the techniques of function analysis, quality modeling, risk modeling, creativity, choosing by advantages (CBA) and life cycle costing (LCC) are important to improve the value of large, complex international projects.

References


Whitestone Building Maintenance and Repair Data, published annually.

Author Information

Stephen J. Kirk is President of Kirk Associates, which specializes in value analysis, choosing by advantages, life cycle costing, sustainability, facility economics, and strategic value planning services. He has over 25 years experience in applying value based design decision-making techniques to large, complex facilities such as airports, offices, housing, courthouses, research facilities, and hospitals. He is an instructor at the Harvard Graduate School of Design. Dr. Kirk is a registered architect, a Fellow of the AIA, a CVS-Life, and is a “LEED Accredited Professional.” Steve is a Senior Fulbright Scholar in architecture and received his doctorate degree at the University of Michigan. He served as president of SAVE International in 1998-99, is Director and Vice President of Education for the Miles Value Foundation, and is a Fellow of SAVE. Currently Dr. Kirk serves on the Industry Advisory Panel of the US State Dept. Overseas Building Office. He is the author/co-author of eight books related to value analysis.

Stephen E. Garrett is a Principal of Kirk Associates, which specializes in value analysis services. Steve has over 22 years of professional experience including extensive skills in value engineering, cost estimating, scheduling, quality assurance/quality control (QA/QC), strategic planning, project criteria development, and program management for large, complex projects for national and international clients. As principal, he typically leads highly skilled, multi-discipline teams in generating strategies, developing project criteria, increasing value, directing planning efforts, and managing project completion efforts. He is also skilled in life cycle costing and frequently participates or runs workshops. His experience includes office, government, manufacturing, institutional, health care, education, and laboratory facilities. Steve received his Bachelor of Architecture degree from Lawrence Technological University. He is an Associate Value Specialist (AVS) and has been a member of SAVE for 10 years.

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