ROBUSTNESS IN VALUE ENGINEERING

Ahmad O. Alkizim[1] and Stuart Green

[1]*School of Construction Management and Engineering, University of Reading, PO Box 219, Reading, RG6 6AW, UK*

Current value engineering practice tends to emphasize value for money from a functional requirements point of view, seeking 'optimal' solutions to design problems that are assumed to be static and well-defined. Requirements however change with time. Supposedly optimal solutions are frequently outflanked by changing circumstances. Designs therefore ought to have an element of robustness, such that should circumstances change, they are versatile enough to adapt. This paper describes an ongoing PhD research which starts with the contention that a design with an element of 'robustness' enhances the value of a finished product. It is proposed that robustness analysis be incorporated into the value engineering methodology to facilitate/enhance robustness into a design so as to attempt to 'future-proof' it in the face of alternative future scenarios.

Keywords: robustness analysis, scenarios, value engineering.

INTRODUCTION

This paper describes an ongoing PhD research currently being undertaken, that challenges the notion that a building design should revolve around specific functions, as is encouraged by current value engineering discourse and practice. Functions change with time. Designs therefore ought to be robust, capable of adapting to the said changes. A new value methodology is therefore proposed, that incorporates robustness analysis, to assist enhance robustness in a design.

The first section of this paper, the research context, discusses the background within which the practice of designing tightly around specific functions is found to be contentious. This is followed by the problem statement, the research proposition, the aims and objectives of the research, and the research questions. The proposed research strategy is then illustrated. Before the conclusion is made, a brief discussion of what robustness analysis is, and how robustness scores are calculated, is presented.

RESEARCH CONTEXT

Value engineering is too often slavishly viewed as a methodology that brings out best value for money based on functional analysis. Current value engineering practice tends to emphasize value for money from a functional requirements point of view, seeking 'optimal' solutions to design problems that are assumed to be static and well-defined. As Woodhead and Downs (2001) put it, '…[it] analyzes the functions that need to be performed and seeks to produce a "best" way of performing those functions, after generating and evaluating creative options.' The required sets of functions are supposedly established beyond dispute and doubt, and good value is

[1] a.o.alkizim@reading.ac.uk

Alkizim, A O and Green, S (2005) Robustness in value engineering. *In:* Khosrowshahi, F (Ed.), *21st Annual ARCOM Conference*, 7-9 September 2005, SOAS, University of London. Association of Researchers in Construction Management, Vol. 2, 833-40.

attained when a design solution that accommodates the said functions is derived at the lowest possible cost.

This point of view, however, seems to ignore early concerns highlighted by Weeks (1973) who argued that the usual tendency to plan buildings tightly around functions was not a sound basis for design. This tendency, according to Weeks, assumed that there was no divergence between function systems, which may be expected to change continually, and the relative permanence of a building structure. He stressed that '[t]he real requirement,…,is to design a building that will inhibit change of function least, and not one which will fit specific functions best'. He even went further to suggest that '…buildings must be designed on the assumption that, in the long run, the brief is wrong'. This latter view is consistent with the concept of bounded rationality (Simon 1973), whose general theme is that humans are limited in terms of their ability to obtain complete knowledge and information. Even with this limited knowledge, they are incapable of identifying all the possible solutions to problems they face. Therefore Weeks's assertion that a designer should assume that a design brief that is perceived to be complete could prove to be inadequate in the long run, is plausible.

In a turbulent world subject to rapidly changing circumstances, designs should have a degree of 'robustness' to be able to adapt to different future scenarios. Robustness is '…a measure of the ability of a planning decision to survive through multiple future states' (Weeks 1973).This concept of robustness in a design is not a new phenomenon. The Northwick Park Hospital which was built in the 1970s was designed with a *loose fit* plan that was capable of accommodating future growth and change, based on a new kind of architecture of that time dubbed *'inderterminate architecture'*. Its architect, John Weeks, is credited to have pioneered this so called *new kind of architecture,* that was '…capable of responding to the complex and continually changing needs of large institutions such as hospitals, universities and research organizations (Weeks, 1973). It was designed with the following assumptions:

1. *Assumed that function is more ephemeral than structure, and that a building must not be integrated with a single set of functions*
2. *Accepted positively that pressures which will force change in work regimes may move from point to point in the system but that they will never disappear*
3. *Embodied in their designs a high index of robustness, that is, the ability to survive through multiple futures*

Notwithstanding this early acknowledgment of the need for robustness in a design, which was introduced via 'indeterminate architecture', there does not seem to have been any consistent progression and proliferation of this initiative. As Be/nCRISP (2005) wrote in their report, '[t]he recommendation that buildings are designed to be "long life, loose fit, low energy" was extolled more than thirty years ago, and it has reappeared periodically since then, most recently within the sustainability agenda', suggesting this apparent inconsistency. Apart from Weeks's own publications (Weeks 1964, 1973, 1987, 2000), Fisk (1996), and Blyth and Worthington (2001) mention, in passing, '*loose-fit*' as useful when faced with uncertainty.

Theoretically, value for money is achieved by establishing specific functions which are required to be accommodated within a design. A solution that fits tightly around the identified functions is then provided at the lowest possible cost. Kelly et al (2004) define function as

> *'…a characteristic activity or action for which a thing is specifically fitted or used or for which something exists. Therefore something can be termed functional when it is designed primarily in accordance with the requirements of use…'*

It is this aspect of designs being directed towards filling a narrow range of identified functions exactly, as is emphasised within value engineering practice that is contentious. There is little acknowledgement, if any, that functions often change with time. This presents the research problem.

PROBLEM STATEMENT

The preceding discussion is the starting point of this research. As opposed to current emphasis within value engineering discourse and practice that functional analysis be undertaken to identify the exact functions that need to be provided for in a design, it is proposed that value engineering be used to assist a design to be robust, capable of providing a range of current, and future unforeseen functions based on alternative future scenarios. It is suggested that a design of this nature is of better value for money as it is relatively more 'future proof' than the supposedly optimal solutions with narrow sets of functions that are frequently outflanked by changing circumstances. It is apparent that a building that can conform to the continual re-adjustment of needs and survive a range of unforeseen future circumstances is more valuable to man.

Robustness therefore ought to be a fundamental component of any value engineering study. There is, however, no structured methodology within value engineering that conceptualizes robustness as a major component of value for money. In consequence, it is possible that a design that is good value for money from a functionality perspective in the short term, ill-serves the client organisation in the long term.

THE RESEARCH PROPOSITION

The PhD research being undertaken proposes to develop a new value methodology that can be used as criteria for robust design and planning decisions. This proposed new methodology, which would incorporate robustness analysis, would seek to encourage a design team to consider a design option that least hinders change of functions. The design or planning decision that would enhances redeployment of functions as and when necessary, that has the least cost implication, would be the more ideal one. This would represent a shift from value engineering being a tool to derive 'best' value for money based on functional analysis to it being a tool to derive good value for money based on robustness in the face of alternative future scenarios.

AIMS AND OBJECTIVES

The aim of the research is to develop a new value engineering methodology that incorporates robustness analysis that can be used as criteria for robust design and planning decision.

The specific objectives are:

1. To establish the most commonly used strategy (if at all) that current designers and value engineering practitioners use to deal with uncertainty of the future and adaptability to the same.

2. To trace and evaluate the development of indeterminate architecture, which conceptualises the concept of robustness in a design and investigate its use/disuse since its inception
3. To develop a new value engineering methodology which conceptualizes the concept of robustness and that can be used as criteria for robust design and planning decisions as a tool to enhance value

RESEARCH QUESTIONS

In order to address the aims and objectives of the research the following guiding questions were put forward:

1. How do current designers and value engineers deal with uncertainty of the future and how do they facilitate adaptability into their designs?
2. Why is indeterminate architecture not established and widespread?
3. How can robustness analysis be used to measure the robustness index of a design, in terms of the ability to survive through multiple futures? How can this then be incorporated into value engineering?

RESEARCH STRATEGY

A tripartite strategy is proposed, as illustrated below. It is envisaged that this approach would provide a firm basis in which to inform the development of the proposed new methodology.

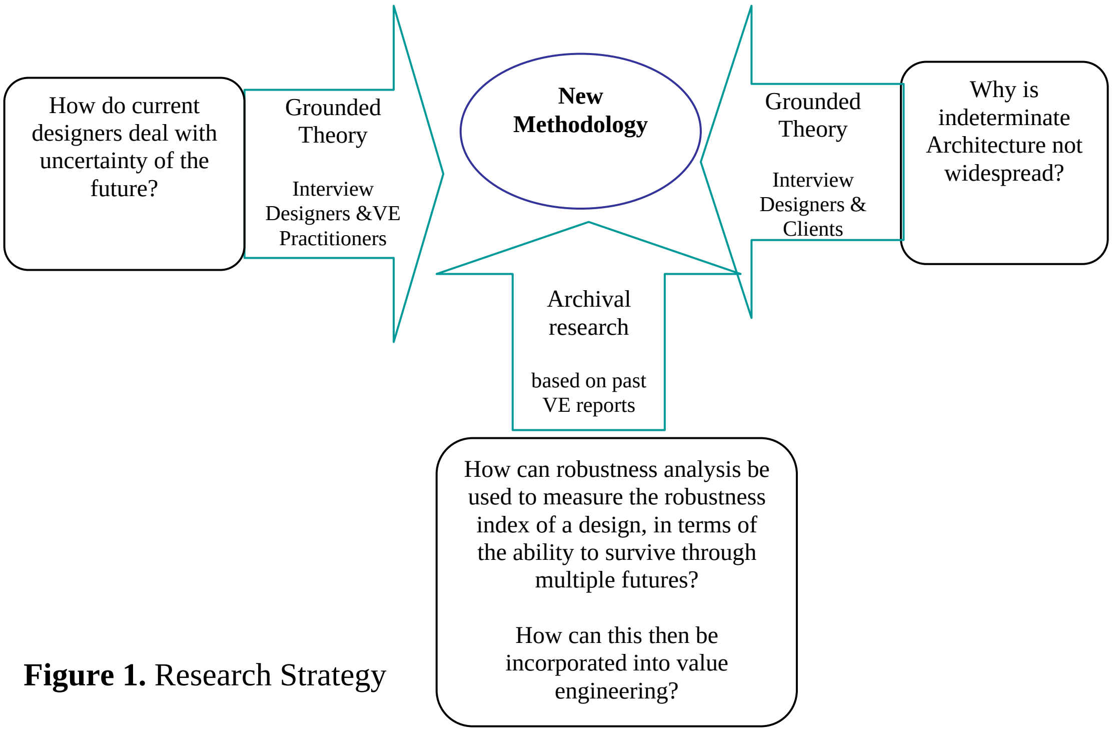

Figure 1. Research Strategy

It is expected that the first question, *how do current designers deal with uncertainty,* will establish if there is an alternative methodology, other than indeterminate architecture, that is used to deal with uncertainty and therefore, by default, enhancing robustness into a design. It is possible that they have an alternative and more effective means to facilitating adaptability. Any useful aspects of the alternative strategy to dealing with uncertainty, if any, may possibly be incorporated into the proposed new methodology.

To answer the second research question, *why is indeterminate architecture not widespread*, interviews with various designers and construction clients will be conducted. It is envisaged that this will establish the general attitude towards the concept of robustness within a design and detect any reluctance there may be and the reasons for this reluctance, if at all.

The third and fourth questions*, how can robustness analysis be used to measure the robustness index of a design, in terms of the ability to survive through multiple futures,* and *How can this then be incorporated into value engineering*, respectively, can be answered through archival research. This would be based on past value engineering reports and assessing the possibility of using robustness analysis to select a ‘robust’ option among those that were generated in the particular study. This approach will give the research a realistic and practical background rather than trying to implement robustness analysis based on superficial projects. In addition, it would provide an interesting view of the instances when another option, other than the one that was actually selected, proves to be more robust.

ROBUSTNESS ANALYSIS

The preceding sections argued a case for the importance of robustness in a design. The implementation of robustness in the Northwick Park hospital was based on a concept of robustness, in terms of the design being capable of surviving alternative future scenarios. Robustness analysis, however, is a tool used to measure the relative robustness of a decision option, among a number of alternative options. The research therefore is looking into ways of utilising this technique or tool to enhance robustness in a design by aiding a design team to select an option that would be more robust among various other design options that my have been considered. The next section describes robustness analysis and how a robustness measure/index can be worked out.

Robustness analysis methodology

Rosenhead developed robustness analysis as a method that embraces the reality that decisions made today may not be astute ones if they do not allow for unanticipated options. He champions it as a method that ‘…addresses the seeming paradox: how can we be rational in taking decisions today if the most important fact that we know about the future conditions is that they are unknown?’ (Rosenhead 2001a). This method therefore encourages the consideration of desired end results such that they are built into the initial commitments made, notwithstanding the current position that may not otherwise allow such desirables.

In situations where an end result is desired, and this is achievable by a series of commitments along the way, robustness analysis creates a framework that has in-built flexibility. Initial decisions are made and commitments entered into that would leave a number of other desired end results open, should circumstances change. The decision makers therefore strive to select the initial or early decision that does not constrain any subsequent decisions to foreclose the possibility of settling for an alternative desired option. This clearly enhances the level of flexibility given the un-predictable future conditions.

The concept behind robustness analysis is the creation of a framework with the ability to control the variables such that the possible outcomes of the future are not entirely unexpected. Courses of action following any turn of events are at hand such that a prescribed solution is immediately available should the future events happen in an unanticipated fashion. The crux of robustness analysis is '…focusing on the immediate decisions and delaying less pressing ones…' (Wong 1998). By doing so, time is 'bought', and more informed subsequent decisions can be made according to up-to-date information and trends.

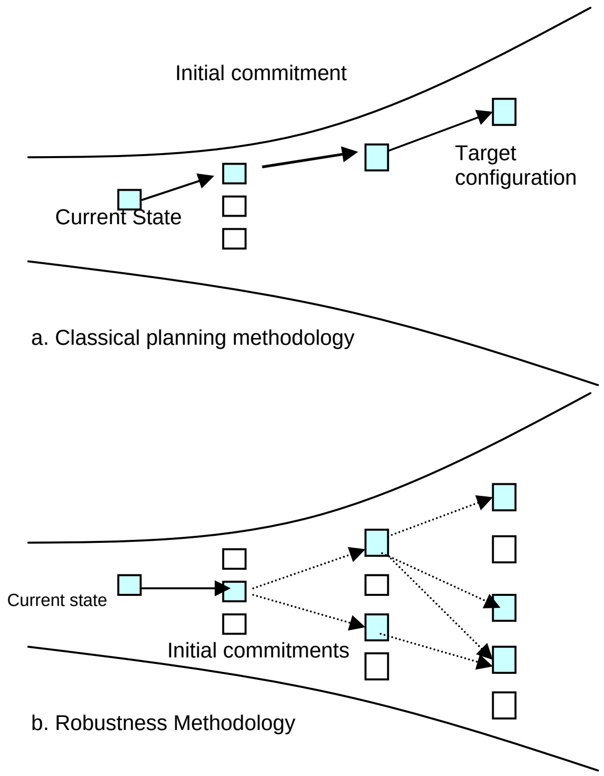

Figure 2. Planning and the trumpet of uncertainty (source Rosenhead, 2001a)

The process of robustness analysis

Consider a number of initial commitments that can lead to the realisation of a number of compatible future configurations. Robustness is a measure of relative flexibility, among these initial commitments (Wong 1998). Rosenhead (2001a) summarizes robustness as follows:

> *The robustness of any of the candidate initial commitments under consideration can then be defined as the ratio of the number of acceptable configurations which have been identified as having acceptable expected performance at the planning horizon*

These ratios or 'robustness scores' facilitate ranking and the initial commitment with the highest score, relative to the rest, is the most 'robust' commitment. In effect, '[t]he higher the robustness, the less the initial decision reduces the effective freedom to reconfigure the system in the future'(Rosenhead 2001a)

Considering the 4-stage decision tree illustrated in figure 3, nodes 2-4 represent initial decision options available and fall under stage 2 of the planning horizon. Nodes 5-11 are intermediate decision stages (stage 3) and nodes 12-21 are the possible end-states. The end-states are considered under 2 different future scenarios, Future F1 and Future F2. Under each future, the end-states are evaluated based on a grading system as follows: Desirable, Acceptable, Undesirable, Catastrophic and Questionable. The symbols representing these grades/categories are as indicated in the figure 3 above. After considering the different end-states and allocating the relevant categorising symbol to each, the robustness score is calculated.

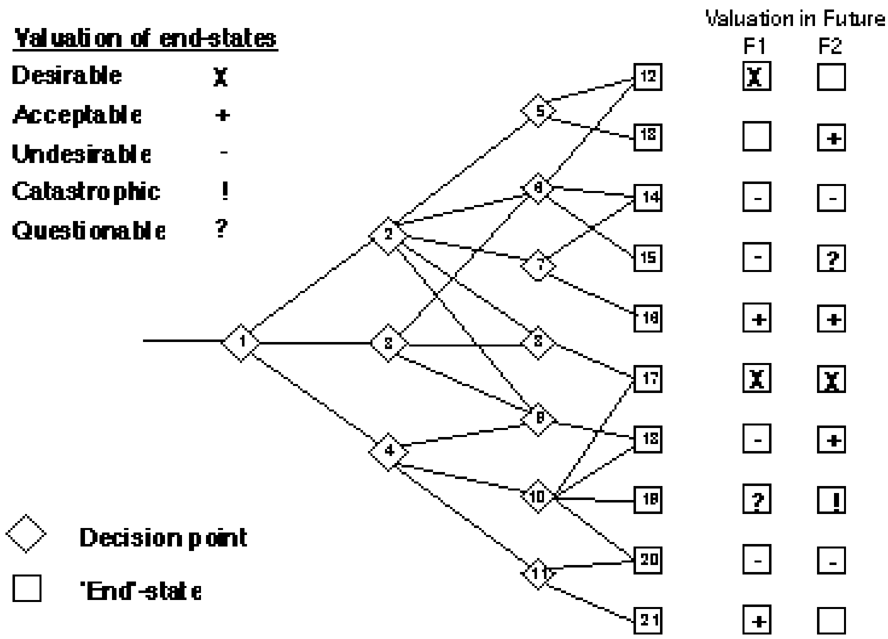

Figure 3 (Source Rosenhead (2001a) (modified)

Commitment 2 can lead to 7 different end-results via 9 different configurations. Based on Future F1, commitment 2 can lead to 2no desirable end-state and 1no acceptable end-state. Desirable and Acceptable end-states are lumped together, making a robustness score of 3 out of a possible total of 4no desirable or acceptable end-state. The score would therefore read ¾. In the same way, the score for commitment no 3 is 2/4 and for commitment no 4, ¼.

The end-states can also be assessed and graded from an undesirable and catastrophic point of view. This can assist in decision making by discouraging a commitment that has a high ‘debility’ score, meaning that commitment that has a high chance of leading to catastrophic end-state/s.

The robustness and debility scores can be arranged into matrices and these can be used to aid in decision making. The matrices for the above decision tree are tabulated below:

Initial Commitment	Robustness		Debility	
	F1	F2	F1	F2
2	¾	4/4	¾	1/3
3	2/4	2/4	¾	1/3
4	¼	¼	2/4	2/3

Table 1 Robustness and debility scores

It is evident that commitment no 2 is the most robust under either future scenario. It at the same time does not have the highest debility score.

CONCLUSIONS

The justification for pursuing this study is based on the contention that robustness of a design enhances the value of the finished product by 'future-proofing' it against changing needs. Consequently, it can be argued that the process of imparting and enhancing robustness into a design is, by default, a value engineering exercise.

As has been discussed in the previous section, robustness analysis was developed to aid decision making that is confronted with uncertainty of the future. It encourages the selecting of decisions that leave as many desirable options open, as opposed to making a commitment that would foreclose other acceptable possibilities. This management tool is undoubtedly useful in a construction design and planning context. Its incorporation into value engineering can prove valuable in attempting to future-proof construction projects. The advancement of flexibility can assist in addressing concerns brought about by change in requirements due to dynamic human needs and user's future requirements and the effects of technological advancement that may render a building prematurely obsolescent. It is thus proposed that, in this turbulent world, designs ought to be robust enough to adapt and withstand the challenges of the future.

REFERENCES

Blyth, A and Worthington, J (2001) Managing the Brief for Better Design. London: Spon.

Fisk, D (1996) Sustainable Development and Building Design. In: Leaman, A (Ed.), Buildings in the Age of Paradox, The University of York. Institute of Advanced Architectural Studies, 15-9.

Group, n V T (2005) Report of the Be/nCRISP Value Task Group,

Kelly, J, Male, S and Graham, D (2004) Value management of construction projects. Oxford: Blackwell Science.

Rosenhead, J (2001a) Robustness analysis: keeping your options open. In: Rosenhead, J and Mingers, J (Eds.), Rational analysis for a problematic world revisited, 2nd edn., pp. 180-207: John Wiley & Sons Ltd.

Simon, H (1973) The Structure of Ill-structured Problems. In: Cross, N (Ed.), Developments in Design Methodology, pp. 145-66: John Wiley & Sons.

Weeks, J (1964) Indeterminate Architecture. Transactions of the Bartlett Society, 2.

Weeks, J (1973) Hospitals. Architectural Design, 43, 436-63.

Weeks, J (1987) Geography of hospitals. Hospitals, 46(11), 961-6,76.

Weeks, J (2000) Can hospitals cope with growth and change: Case study at Northwick Park Hospital. Hospitals, 59(9), 70-4,88.

Wong, H-Y (1998) Making Flexible Planning Decisions: Clarification and Elaboration of the Theory and Methodology of Robustness Analysis, University of London.

Woodhead, R and Downs, C (2001) Value Management Improving Capabilities. London: Thomas Telford Publishing.