

Beyond value engineering: SMART value management for building projects

Stuart D Green

Department of Construction Management & Engineering, University of Reading, Whiteknights, PO Box 219, Reading RG6 2BU, UK

The paper distinguishes between value management and value engineering on the basis of their underlying assumptions. The traditional approach to value engineering is analysed, and is found to reflect the optimizing paradigm of hard systems thinking. In contrast, the alternative approach offered by value management is based on the learning paradigm of soft systems thinking. While the objectives of value engineering are dominated by cost reduction, the purpose of value management is to develop a common understanding of the design problem and to identify explicitly an agreed statement of design objectives by the project stakeholders. SMART value management is introduced as the means by which these ends can be achieved. It is further suggested that this approach enables project managers to exert an increased level of control over the early stages of building design. It also ensures that different interest groups within the client organization are actively involved in the design process, and that they thus 'buy in' to the decisions which are made.

Keywords: value engineering, value management, building design, systems engineering, soft systems thinking, problem structuring

The discipline of value management is receiving an increasing amount of attention within the international project-management community. This is particularly true for the building-construction industry, in which many clients are insisting on the application of value management to ensure value for money. However, while an increasing number of consultants are offering value management as a specific service, there are doubts about the extent to which the services offered differ from the established design and cost-management practices.

The main purpose of this paper is to develop a valid theoretical framework for the future development of value management. While it is primarily aimed at the building-construction industry, the paper is generally applicable to any projects which are distinguished by unclear and conflicting objectives. Initially, the term 'value engineering' is used to describe the traditional approach which was developed in the 1940s. The essential characteristics of value engineering are described, and the underlying assumptions are identified. On the basis of these assumptions, it becomes possible to suggest precise definitions for 'value management', and 'value engineering'. While it is recognized that the terms 'value management' and 'value

engineering' are often used interchangeably in practice, it is contended that the existence of two alternative paradigms justifies the development of distinctive definitions. It is further argued that value engineering is based on the optimizing paradigm of systems engineering. Value management differs in that it is based on the learning paradigm of soft systems thinking. SMART value management is then introduced as an approach which is consistent with the alternative *learning* paradigm. The underlying rationale is described, and an overview of the methodology of SMART value management is presented. Finally, the implications for construction project managers are discussed.

CHARACTERISTICS OF VALUE ENGINEERING

This section summarizes the basic characteristics of value engineering as they are described in the existing literature^{1–6}. The essential philosophy of value engineering is well illustrated by the following definition.

Definition: 'A disciplined procedure directed towards the achievement of necessary function for minimum cost without

detriment to quality, reliability, performance or delivery'.⁷ The disciplined procedure of value engineering is invariably structured around the stages of the 'job plan', which is usually described in terms of the following five key stages:

- information;
- speculation;
- evaluation;
- development;
- recommendation.

While value-engineering practitioners tend to attach considerable importance to the job plan, it is important to recognize that it is by no means unique. Indeed, Green⁸ has argued that the staged methodology of value engineering is directly analogous to the established stages of creative problem solving:

- Define and understand the nature of the problem.
- Generate alternative ideas about how the problem can be solved.
- Evaluate the feasibilities of the ideas generated.
- Fully develop and test the ideas that are judged to be the most suitable.
- Decide on the best solution.

The above sequence is common to several structured problem-solving techniques, including the well known Kepner-Tregoe⁹ approach. The same sequential methodology is also central to the systematic design method which was so popular during the 1960s¹⁰. There is therefore nothing unusual about the staged methodology of the value-engineering job plan. In the final analysis, perhaps value engineering is no more than the formal application of standard problem solving to building design. However, there is evidence that such an approach can indeed produce better solutions; it forces designers to take a step back and analyse the problem before jumping to conclusions. While many designers would claim that this problem-solving procedure was intrinsic to the nature of design itself, value engineering differs, in that the process is formalized, and therefore made explicit. Further, value-engineering studies tend to be retrospective, and they are usually commissioned in response to a projected cost overspend. They therefore tend to be initiated with the specific objective of reducing cost.

A further distinguishing characteristic of value engineering is the emphasis given to functional analysis. Indeed, the published definitions of value engineering are invariably built around the word 'function'. While the initial concept of functional analysis, as advocated by Miles⁴, was limited to the use of prompt questions such as 'what does it do?', practitioners have since developed the use of function diagrams to clarify client requirements. A typical function diagram is shown in *Figure 1*. The logic of the diagram is based on the initial identification of the building's basic function, which is placed on the left-hand side of the diagram. This is then progressively broken down into subfunctions by the asking of a series of 'how?' questions. The accepted format dictates that each function (or subfunction) is defined by two words: a verb and a noun. The structure of the diagram is verified by it being ensured that moving from right to left provides the answer to 'why?'. It is interesting to note that function diagrams of this type are directly analogous to the value trees which have been developed by decision analysts for the purposes

of problem structuring (see, for example, Reference 11). Nevertheless, the use of function diagrams in value engineering seems to have developed largely in isolation from the more theoretically rigorous field of decision analysis. Value engineering, as traditionally understood, is essentially a pragmatic discipline which is championed by its practitioners. Of central importance is the notion that value can be improved by maintaining function while reducing cost.

UNDERLYING ASSUMPTIONS OF TRADITIONAL VALUE ENGINEERING

While the traditional precepts of value engineering are superficially appealing, the underlying assumptions are rarely made explicit. First, it is taken for granted that the function of the component being studied is an objective characteristic which remains constant over time. Second, it is assumed that each alternative design solution provides an equivalent level of performance¹². This thereby enables their comparative merits to be assessed on the basis of cost alone. While these assumptions may well be justified if value engineering is being applied to individual building components during detailed design, this is rarely the case for the problems which occur during the earlier stages of building design.

Value engineering is perhaps the epitome of what has become known as 'hard systems thinking'. Many of the underlying assumptions are shared with the wider spectrum of systems-engineering approaches which came to prominence during the 1960s. Checkland^{13,14} describes how hard systems thinking is essentially concerned with searching for efficient ways of achieving an objective which is initially defined and remains constant over time. There is an implicit assumption that the problem can be identified and is well structured. Checkland goes on to argue convincingly that, while hard systems thinking is an entirely legitimate approach for static problems which are well defined, it has consistently failed when applied to real-world problems which are messy, dynamic and ill defined. Unfortunately, it is problems of this nature which invariably distinguish the early stages of building design¹⁵⁻¹⁷. Building projects are often commissioned by client organizations that comprise several interest groups, each of which possesses a different perception of what the 'problem' actually is. In these circumstances, it is meaningless to talk of 'analysing the building's function' without initially establishing a consensus about the objectives.

The continued failure of hard systems thinking as applied to social problems has led to the evolution of an alternative paradigm, which Checkland¹³ describes as 'soft systems thinking'. This is different in that there is no pretence at representing any sort of universal reality; the concern is with modelling the *perceptions* of the problem stakeholders. Of central importance are the soft issues of conflicting objectives, internal politics and contrasting value judgements, i.e. the issues which are invariably ignored by the techniques of systems engineering. Whereas hard systems thinking is predominantly concerned with the identification of optimum solutions to known technical problems, soft systems thinking is concerned with *learning* about multi-perspective human problem situations. In these situations, if project teams are to work effectively towards common objectives, it is initially necessary to establish a *shared social reality*¹⁸.

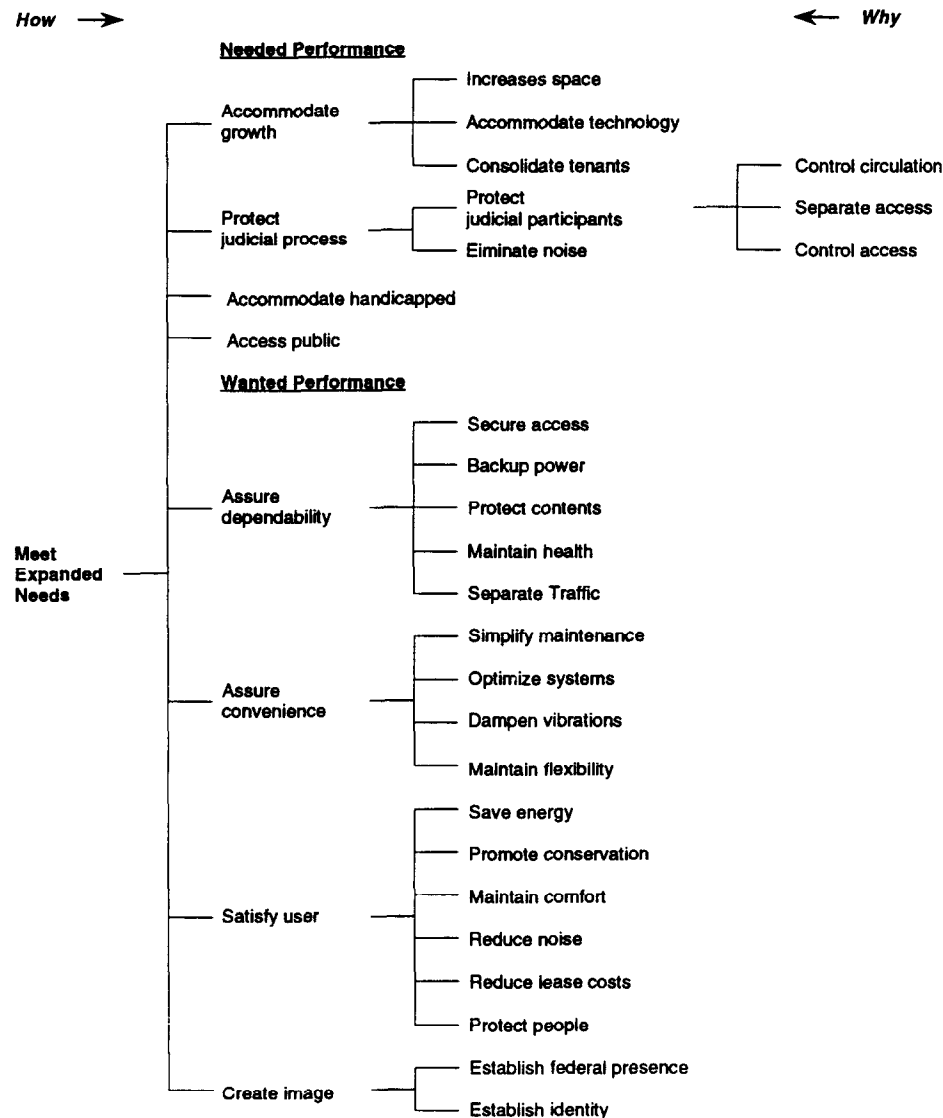


Figure 1 Function diagram for new federal courthouse and offices
[Source: Reference 20.]

VALUE MANAGEMENT VERSUS VALUE ENGINEERING: DISTINCTION DEFINED

As a result of the above discussion, it becomes possible to identify two distinctly different forms of value engineering. For the purposes of this paper, it is convenient to refer to the hard systems approach as 'value engineering', and the soft systems approach as 'value management'. While this distinction in terminology is by no means universally adopted, it is consistent with the current usage by several leading UK clients and project-management consultants. The following definition of value engineering broadly reflects that previously quoted, but the underlying assumptions of hard systems thinking are made explicit.

Definition of value engineering: A systematic procedure directed towards the achievement of the required functions at least cost. Value engineering is based on the assumption that all the parties share the understanding of the functions being provided. Further, it is assumed that all feasible design alternatives provide the same level of functional performance, and can therefore be assessed on the basis of

cost alone. Within this frame of reference, an increase in value can be directly related to a reduction in cost.

In the light of this extended definition of value engineering, it is now possible to offer a comparable definition for value management which reflects soft systems thinking:

Definition of value management: A structured process of dialogue and debate among a team of designers and decision makers during an intense short-term conference. The primary objective of value management is to develop a common understanding of the design problem, identify explicitly the design objectives, and synthesize a group consensus about the comparative merits of alternative courses of action. Value management makes no pretence about finding optimal answers; it is solely concerned with establishing a common decision framework around which participants can think and communicate*.

*This definition is based on the description of a decision conference provided by Watson and Buede¹⁹.

It is apparent that the more enlightened practitioners have intuitively recognized the existence of the two alternative paradigms. For example, Ellegant²⁰ has drawn an interesting distinction between what he describes as 'old value engineering' and 'modern value engineering'. The former is seen to be primarily concerned with reducing cost as 'a tool of last resort'. In contrast, the latter is seen to be primarily concerned with improving communication, and the role of the value-engineering consultant is equated to that of a therapist. The role of such a therapist is to work with clients, designers and users to help them to articulate their requirements. Ellegant's concept of 'modern value engineering' is directly comparable with the soft-systems paradigm of value management.

While the distinction between value engineering and value management is best understood in terms of their respective underlying paradigms, the difference is also apparent in the way in which they are implemented in practice. Value engineering is essentially retrospective, and it tends to take place during the later stages of design in response to a projected cost overspend*. In consequence, the problems which are addressed tend to be both well defined and technical. In these circumstances, the purpose of the exercise is to generate alternative design solutions and select the most cost-effective. Given the technical focus of such studies, it would be perfectly feasible for the value-engineering study to be conducted by a second design team who had not been involved previously. Choosing between competing design options may well be aided by the use of lifecycle cost models; these may also occasionally include an explicit consideration of risk.

The implementation of value management differs from that of value engineering in a number of important ways. First, it invariably takes place during the early stages of design, and it involves all the key project stakeholders. Second, the problems addressed tend to be dynamic and highly unstructured. Indeed, different parties often possess very different perceptions of what the problem actually is. These differences in perception constitute part of the problem. While single-criterion cost models may well be adequate for the purposes of value engineering, they are far too simplistic for value management. Given that value management is concerned with constructing a shared *perceived* reality, the use of the terminology relating to 'function' is often misleading, in that it implies a false degree of objectivity. This view is obviously unpopular with the more traditional value-engineering practitioners, who attach an almost mystical importance to the analysis of 'function'. However, it must also be stated that, in the final analysis, the choice of terminology is unimportant; there is no 'right' or 'wrong' way to frame a decision problem. The only issue of importance is that of whether or not the chosen frame makes sense to the participants.

A new approach to value management has recently been advocated by Green²¹. It is based on a simplified version of multiattribute utility theory known as the 'simple

multiattribute rating technique' (SMART). While SMART was initially devised by Edwards²² as a method of choosing between competing options, more recent publications have given an increased emphasis to the use of SMART for problem structuring^{23,24}. It is this revised emphasis which makes SMART particularly appropriate for value management.

SMART VALUE MANAGEMENT: UNDERLYING RATIONALE

It is important to appreciate that the SMART approach to value management lies firmly within the soft-systems paradigm. There is no pretence that any decision model can ever represent any sort of absolute truth. Of central importance is Phillips's¹⁸ concept of a *requisite* decision model. By definition, requisite models are produced by a process of group consensus to establish a common understanding of the decision objectives and to identify possible solutions. The group is guided in its deliberations by a facilitator skilled in the techniques of decision modelling. SMART provides the basic framework for the decision model, which is progressively revised in the light of discussion and debate. Indeed, the model continues to be revised up until the point when it is considered to be representative of the 'shared social reality'. The model is then taken to be requisite, and it forms the basis on which the decision can be made.

The SMART approach to value management is entirely consistent with the design workshops advocated by Kernohan *et al.*²⁵ to ensure user participation in the design of buildings. SMART value management only differs in the emphasis given to the development of a formal decision model. Nevertheless, the accent still lies very much on the social aspects of the decision-making process. In essence, the unique contribution of SMART value management is the way in which it provides a framework for facilitating *thought* and *communication*. While the hard systems concepts of 'value maximization' and 'design optimization' may well be superficially appealing, within the soft-systems paradigm they are meaningless.

In passing, it is perhaps worth noting that the single-criterion cost models commonly used in value engineering also only make sense in the requisite sense. Given the assumptions of value engineering about the equivalent performance of alternative design solutions, it is clearly reasonable to model selection decisions on the basis of cost alone. However, lifecycle cost models cannot be taken to represent any sort of universal reality, but only a perception of reality. This is particularly true when the responsibility is shared within a group. It is likely that any such model will also be progressively revised until it represents a 'shared social reality'. At this point, it will then be considered requisite for the purposes of making the decision. Ultimately, all discounted-cashflow models (and investment appraisals) are based on subjective beliefs about future outcomes. Further, it is only the well structured nature of the problems being addressed which makes the luxury of probabilistic risk assessment possible. The 'wicked' problems of value management cannot be tamed by the allocation of simplistic probability profiles. The inherent uncertainty of value management relates not just to outcomes, but also to the very nature of the problem itself. SMART value management is therefore based on the contention

*There are exceptions to this general rule. Consider, for example, the design and construction of a petrochemical process plant, in which the stated objective is to achieve a given output within the specified constraints of cost and safety. In this case, the problem is essentially technical; the use of the hard-systems paradigm is therefore appropriate from the very early stages.

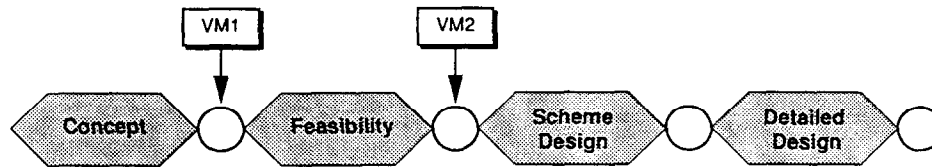


Figure 2 Timing of value-management workshops

that there is little point in modelling risk until there is a common perception of what the problem actually is. Nevertheless, the approach is flexible enough for risk preferences to be included in the decision model should this be considered necessary.

OUTLINE METHODOLOGY FOR SMART VALUE MANAGEMENT

Within the constraints of this paper, it is only possible to give an outline description of the methodology of SMART value management and how it works in practice. More detailed descriptions, together with comprehensive case studies, are available elsewhere^{21,26}.

The implementation of SMART value management consists of two one-day workshops, the timings of which are dictated by the existence of two identifiable pinch points in the building-design process at which important client decisions must be made (see Figure 2). The first workshop, known as VM1, is held at the end of the concept stage when the building of a new facility is first suggested as a possible solution to a perceived problem (RIBA (Royal Institute of British Architects) Stage A). VM1 is therefore closely linked to the decision as to whether the project should proceed. The primary objective is to verify the need to build before the client becomes committed to financial expenditure. The secondary objective is to ensure that there are clear project objectives which are understood by all the parties.

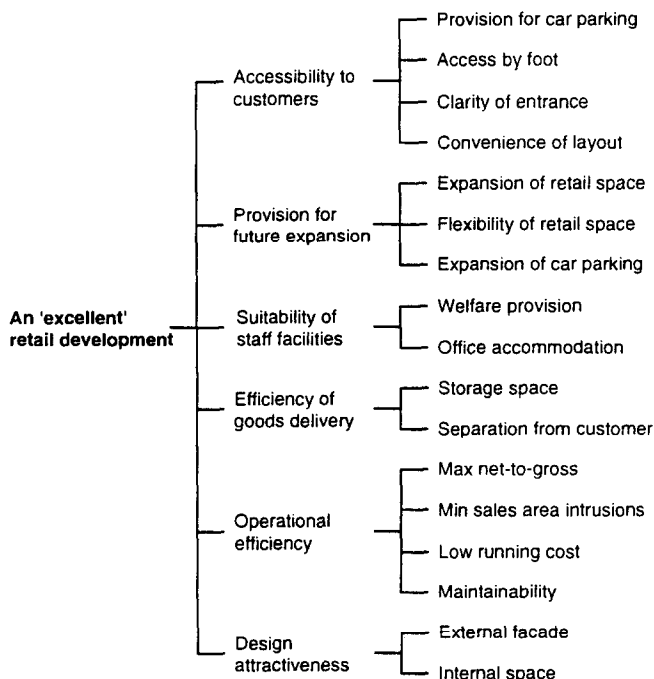


Figure 3 Value tree at VM1 for new retail development

The main stages of VM1 can be summarized as follows:

- **Stage 1: Identify the stakeholders:** It is vital that all the interest groups are represented at a senior level. Without this involvement, the exercise is pointless.
- **Stage 2: Identify the design objectives:** Each participant is invited to discuss his/her initial understanding of the problem and the associated design objectives. Differences are discussed until an agreed list of key objectives can be produced.
- **Stage 3: Construct the value tree:** The objectives listed in the previous stage are structured into a value tree, as shown in Figure 3. The top of the tree is characterized by the overriding *raison d'être* of the entire project. This is then progressively broken down into subobjectives. The development of the value tree is led by the facilitator, and it is an iterative process based on discussion and negotiation. Eventually, a shared understanding is reached in which all the parties accept the value tree as a fair representation of the design objectives. It is the lower-level attributes of the value tree which define the performance criteria for the evolving design.
- **Stage 4: Creativity:** The objectives generated are then used as the stimuli for a brainstorming session: in what other ways could these objectives be achieved? The success of this stage depends on creative thinking. It is therefore important that ideas are not yet criticized or evaluated.
- **Stage 5: Evaluation:** The ideas produced in the previous stage are now evaluated in terms of cost and feasibility. Any considered to possess merit are earmarked for development.
- **Stage 6: Development:** It is likely that each of the alternative schemes developed in the previous stage will need further development before their true merit can be assessed. While this detailed work is usually performed outside the formal workshop, it is important that the extent of the necessary follow-up work is agreed before the value-management team disperses.

The titles of the above stages have been deliberately chosen to shadow those of the traditional value-engineering job plan. However, in the case of SMART value management, the stages rarely unfold in a simple linear fashion; in many cases, it may well be felt to be necessary to iterate between stages several times. It is also clear that the value-management study will not provide 'optimal' solutions; an enhancement of the participants' understanding of the problem should be seen to be of sufficient benefit in itself.

The second stage of SMART value management is a further workshop (VM2) which takes place at the end of the feasibility stage (RIBA Stage C). It is at this stage that the outline brief will have been completed, and the design team will have produced a number of costed outline proposals.

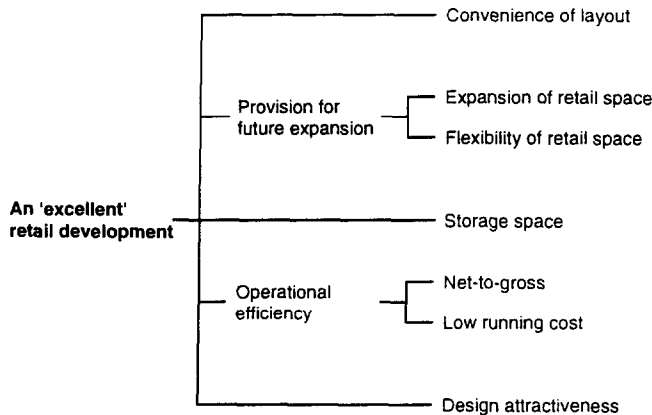


Figure 4 Value tree for new retail development: simplified version at VM2

The objectives of VM2 are as follows:

- to verify that the previously established design objectives are still valid;
- to ensure that the choice of outline design proposal is made in accordance with the appropriate performance criteria;
- to secure marginal value improvements in the chosen design option.

VM2 is therefore significantly different from VM1. There are seven key stages to VM2:

- *Stage 1: Redefine the design objectives:* The project is introduced by the project sponsor, and discussion is directed towards the extent to which the value hierarchy established during VM1 is still valid. The alternative design proposals are also introduced by the design team leader.
- *Stage 2: Reconstruct the value tree:* The design objectives identified in the previous stage are once again structured into a value tree. It is likely that this will be slightly different from that which was developed during VM1. It is also now necessary to simplify the hierarchy so that the lower-order attributes can be used to evaluate the alternative design proposals. The number of attributes can usually be reduced by eliminating those which do not directly influence the choice of outline design. It is usually preferable to omit capital cost until the end of the analysis. *Figure 4* shows the previous value tree after simplification.
- *Stage 3: Assignment of importance weights:* Importance weights are assessed for each branch of the value tree, and the final weights are calculated by 'multiplying through the tree'. *Figure 5* shows the example value tree with the importance weights for each attribute. The weights should be assigned on the basis of discussion and negotiation. Any temptation to implement a voting procedure should be rigorously avoided.
- *Stage 4: Evaluation:* Each outline design option is assessed on a scale of 0–100. A decision matrix is then used to obtain an aggregated utility rating for each design option, as shown in *Figure 6*.
- *Stage 5: Sensitivity analysis:* The sensitivities of the evaluation to changes in the chosen importance weights and utility scores are tested using sensitivity analysis.

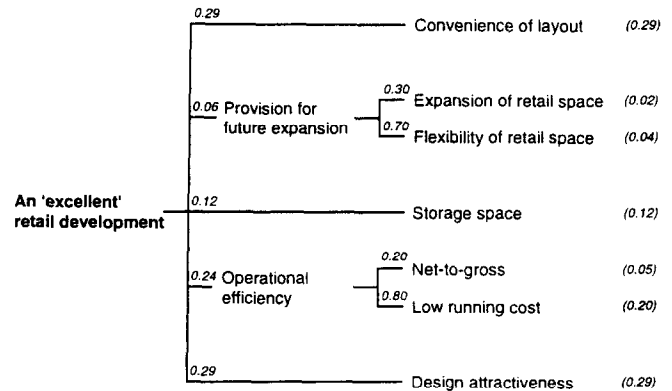


Figure 5 Value tree for new retail development: simplified version at VM2 with importance weights

This entails a series of adjustments to the decision model which only cease when it is considered to be requisite for the purposes of making the decision.

- *Stage 6: Cost/value reconciliation:* The estimated capital cost of each proposal is compared with the aggregated utility ratings, and the decision is made as to which design option represents the greatest value for money.
- *Stage 7: Marginal value improvement:* The team focuses attention onto the chosen option, and identifies areas of concern. A brainstorming session is used to generate ideas about how these concerns can be overcome. The VM2 workshop is then concluded by a summary of what has been agreed, and the identification of any follow-up work.

In essence, SMART value management is a means of group decision support that is based on the techniques of decision analysis. These techniques provide a *common language for understanding*, and a *grammar for manipulating meaning* in ways which are not easy with words alone²⁷. The structure

Project RETAIL DEVELOPMENT									
Date									
	Assessment Attributes							Total	
	Convenience of layout	Expansion of retail space	Flexibility of retail space	Storage space	Net-to-gross	Low running cost	Design attractiveness		
Weight of importance (0-1)	a	b	c	d	e	f	g		
	0.29	0.02	0.04	0.12	0.05	0.20	0.29		
1. Design Option A	70	30	60	40	20	10	20	36.9	
2. Design Option B	20.3	0.6	2.4	4.8	1.0	2.0	5.8	68.7 *	
3. Design Option C	90	80	60	70	60	20	80	23.2	
	26.1	1.6	2.4	8.4	3.0	4.0	14.5	50.6	
4.	50	40	40	10	40	80	50		
5.	14.5	0.8	1.6	1.2	2.0	16.0	14.5		
6.									
7.									
8.									
9.									
10.									

Score each design option against each attribute on a scale of 1 - 100

Figure 6 Decision matrix for new retail development

of value management also provides for a much more stimulating interchange than the staid agendas of traditional project-team meetings. At VM2, the problem of choosing between the alternative design options is modelled by the use of the decision matrix. There is, of course, a very subtle interaction between the 'gut feel' of the participants and both the structure of the value tree and the content of the decision matrix. The participants' preconceptions inevitably influence the importance weights and the utility ratings. However, at the same time, their perceptions change as a direct result of their participation in the decision-modelling process, and they thereby achieve a richer understanding of the problem situation. It is important to recognize that, within the soft-systems paradigm, there is no such thing as a 'right' answer; the value trees and decision matrices can only be assessed in terms of how useful they are to the participants. The objective of the exercise is to develop a common understanding, and to ensure the commitment of the stakeholders to the decision outcome. The decision model only becomes requisite when the understanding of the participants has converged with the content of the decision model.

It is particularly important that the numbers used in the decision matrix are not regarded as an end in themselves. While it is possible to use computer software for the arithmetic, there is a danger that this may divert attention away from the social aspects of the decision-making process. The real benefit of using such matrices is that they provide a structure for discussion and focus attention on to the critical issues. Decision models of this nature cannot be used in any normative sense; they can only be used as a guide to action.

IMPLICATIONS FOR PROJECT MANAGERS

Yeo²⁸ has recently argued that successful project management depends on the use of both hard systems thinking and soft systems thinking. The adoption of SMART value management, as applied within the learning paradigm, will go some way towards redressing the current bias towards techniques which are rooted in systems engineering. It has long been recognized that projects which have unclear and ill formulated objectives are less likely to be successful²⁹. SMART value management provides project managers with a method, and a set of techniques for ensuring that sufficient initial attention is given to 'exploring the problem'. Project managers are often impatient to start building; indeed, this *bias for action* is often an essential characteristic for a successful project manager. However, the desire to achieve early recognizable progress often acts to the detriment of the end product. There is surely little point in managing a project within time and cost if the various stakeholders have not agreed the performance objectives; this inevitably results in a dissatisfied client. The SMART approach can therefore play an important role in resolving conflict within the client organization relating to objectives. Even if a consensus cannot be achieved, there is benefit in simply making conflict explicit at an early stage.

SMART value management also provides project managers with a discipline and set of techniques which enable them to exert a greater degree of control over the early stages of the design process. Further, the important secondary benefits

of team building should not be underestimated; a successful value-management study can often create a climate for cooperation which will prevail throughout the project.

While this paper has tended to concentrate on the underlying theory of SMART value management, the approach described has already proved itself to be eminently practical. To date, the SMART approach to value management has been used on more than 100 construction projects in the UK. At least one major client has adopted SMART value management as mandatory for all projects with a value in excess of £1M. The approach has consistently been found to be of real benefit in providing clients with confidence that their money is being spent in a rational way. Further, SMART value management enables the stakeholders to 'buy in' to the early decisions. For far too long, project managers and clients' representatives have been excluded from the early stages of design by the 'black-box' nature of the process. SMART value management provides a way in which project stakeholders can participate in key design decisions, thereby maintaining some degree of control over the designers.

While some commentators have criticized the feasibility of securing the necessary time involvement, it should be stressed that the project stakeholders would have to be consulted in any case. The advantage of value management is that it saves time by providing a structured framework for discussion and negotiation.

CONCLUSIONS

It has been argued that traditional value engineering is only applicable to design problems which are well structured and easily defined. Value engineering reflects the optimizing paradigm of hard systems thinking in that it is primarily concerned with the identification of alternative solutions to well structured problems. The approach is distinguished by the assumption that 'function' is an objective characteristic which remains constant over time. It is further assumed that all solutions offer the same level of performance, and that 'good value' is achieved by selecting the solution with the lowest lifecycle cost.

While the systematic application of value engineering can often achieve real benefits when it is used with well structured technical problems, it should be recognized that the hard-systems approach has serious limitations when it is used with soft problems which are dominated by conflicting objectives and value judgments. Unfortunately, it is soft problems of this nature which invariably dominate during the early stages of building design. This is especially true for projects which are commissioned by multifaceted clients, where the requirements of several diverse interest groups need to be satisfied. In these circumstances, it becomes necessary to adopt a flexible version of value engineering which reflects the *learning* paradigm of soft systems thinking; such an approach has been defined as value management.

Value management is based on a way of thinking which is fundamentally different from that for value engineering. Of primary concern is the need to improve communication and establish a common perception of what is required. SMART value management has been suggested as one particular approach through which these ends can be achieved. The techniques of SMART value management provide project managers with the means through which they can exercise

control over the early stages of the design process. It is likely that the use of problem-structuring techniques of this type will become central to the discipline of project management. In the long term, the use of SMART value management will ensure that practitioners reflect on their decisions, and thereby learn from their experience.

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Stuart Green graduated from the University of Birmingham, UK, with a BSc in civil engineering, and later completed an MSc in construction management at Heriot-Watt University, UK. Having spent several years working on the design and construction of major projects, he now lectures on project management. His current research interests include value management and decision modelling in building design. He regularly acts as a consultant to major clients, and he is also the course director of the University of Reading, UK, part-time MSc course in project management.

