AN INTEGRATED FRAMEWORK FOR THE OPTIMAL SELECTION OF HOSPITAL FINISHES – SYSTEM ALGORITHM AND METHODOLOGY

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ABSTRACT

This paper is the second in a series reporting on on-going research within an NHS-Estates funded project. This project aims to develop an integrated System for the Optimal Selection of Hospital Finishes. Motivated by the lack of effective tools that would facilitate the effective choice of hospital finishes; a methodological framework for the optimal selection of hospital finishes is proposed. The development of the framework involved three main steps. First, published methodologies are critically reviewed to identify their desirable features and limitations. Secondly, other crucial requirements for effective decision-making are identified. Thirdly, the framework logic is outlined and a practical implementation mechanism is proposed.

The proposed framework utilizes desirable features of a number of existing well-developed methods. Besides, it employs a phased approach in the identification of decision criteria and alternatives where each phase results in a more specific list of criteria and alternatives. The main idea is to identify all available alternatives with the smallest set of key criteria. Alternatives that do not meet the statutory requirements and the minimum specification and performance requirements are excluded early in the process. Finally, the ideal alternative is selected based on a rigorous value for money analysis. The paper concludes by introducing further research within the project to implement the proposed framework into a useful practical tool.

KEY WORDS

database systems, finishes, hospital design, MCDM, whole-life costing

INTRODUCTION

There has been little progress towards achieving an integrated approach that decomposes the process of selecting hospital finishes into a flexible and logical series of activities that can be easily followed. Ideally, this should be done within a whole life costing (WLC) context. In

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addition, the selection should take into account other requirements including planning, user, space, environmental and legal criteria (Laing et al., 2006).

Most of these factors, however, cannot be assessed in a strict WLC framework. This is mainly because either they are in conflict with the main WLC objective or because they are mostly 'non-financial'. Some of these factors are even intangible such as aesthetics. In many cases, these intangibles are also in conflict with results of WLC analyses (Wilkinson, 1996).

In this paper, an integrated approach for the selection of hospital finishes is proposed. First, the processes of identification of decision criteria, generation of alternatives, and the decision-making process are identified. Then, the approach is outlined using simple process flow diagrams. Finally, direction for further research are introduced.

DECSION CRITERIA

IDENTIFICATION OF DECISION CRITERIA

A well-defined, small set of criteria is crucial for an effective decision-making process. Criteria should be defined clearly in order to avoid confusion and double consideration. Braunschweig et al. (2001) proposed a three-phase framework for criteria identification. The main idea is to capture as many relevant facets of the decision problem with the smallest set of criteria and consequently each phase results in a more specific list of criteria. This idea can be employed as follows (figure 1)

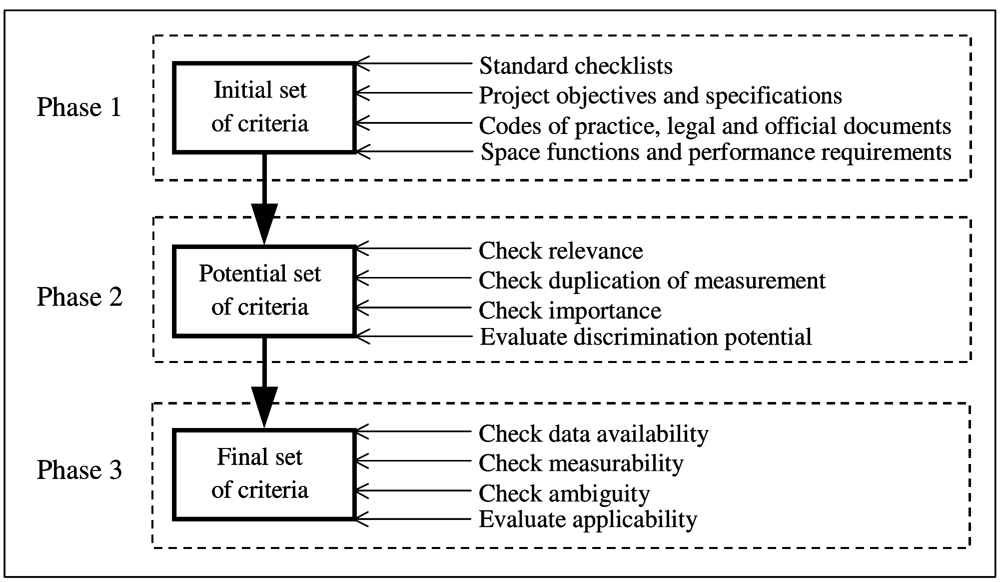

Figure 1: Schematic representation of the criteria identification process

- In the first phase, the initial set of criteria is generated. Although there is no universal set of criteria that is equally applicable in all cases, standard checklists of system attributes are useful in this initial phase. Codes of practice, project objectives and specifications, literature including legal and other official documents are crucial in identifying relevant criteria from checklists. In addition, an analysis of the space function and traffic requirements would help in compiling the initial criteria list. For example, abrasion resistance is relevant for areas with high traffic.

- In the second phase, criteria with no discrimination potential for the specific problem are excluded. These are usually criteria that are irrelevant, of negligible importance, or that measure the same dimension as other criteria.
- In the third phase, criteria applicability is evaluated in terms of data availability or ability to measure the criteria. The idea is to remove a criterion from the list rather than use poor or ambiguous indicators.

CRITERIA WEIGHTING

It is hypothesised that overall value can only be understood through a thorough examination of its constituent parts. Besides, it should reflect their relative weights of importance. In the elicitation of weights of importance, criteria are rated for each criterion from 'most' to 'least' important. A direct scoring approach or a pair-wise approach is utilised. In the first approach, weights are directly assigned to various criteria. In doing so, a normalised scale (sums up to unity) is used to model various linguistic assessments of importance given by the decision-maker. In the pair-wise approach, however, each attribute is compared individually against all other attributes. A comprehensive analysis by Triantaphyllou and Lin (1996) revealed that systematic approaches that employ pair-wise comparisons are more capable of capturing a human's appraisal of ambiguity when complex decision-making problems are considered. They attributed this to the flexibility and realism of pair-wise comparisons in accommodating real-life data.

Another crucial requirement is to use a normalised set of weights in calculating the total scores as recommended by Bass and Kwakernaak (1977). They employed the following normalised formula

$$S_i = \sum_{j=1}^{m} w_j s_{ij} \Big/ \sum_{j=1}^{m} w_j \qquad (1)$$

where S_i is the aggregated rating for alternative i; w_j is the relative weight of importance of aspect j; and s_{ij} is the rating for alternative i, reflecting the relative merit of aspect j. This formula has the desirable property that if all scores are equal, the final weighted score is independent of the weights and equals the common value of the score.

GENERATION OF ALTERNATIVES

Obviously, the generation of a number of competing alternatives is crucial for the selection process to be meaningful. Because the number of finishes' materials and products has been greatly increased in recent years, it is crucial to compile a balanced set of potential alternatives. This set should be neither too narrow to exclude potential ideal options nor too wide to increase the cost of data collection and analysis. To achieve that, a phased approach similar to that suggested for decision criteria can be employed such that each phase results in a more specific list of alternatives as follows (figure 2).

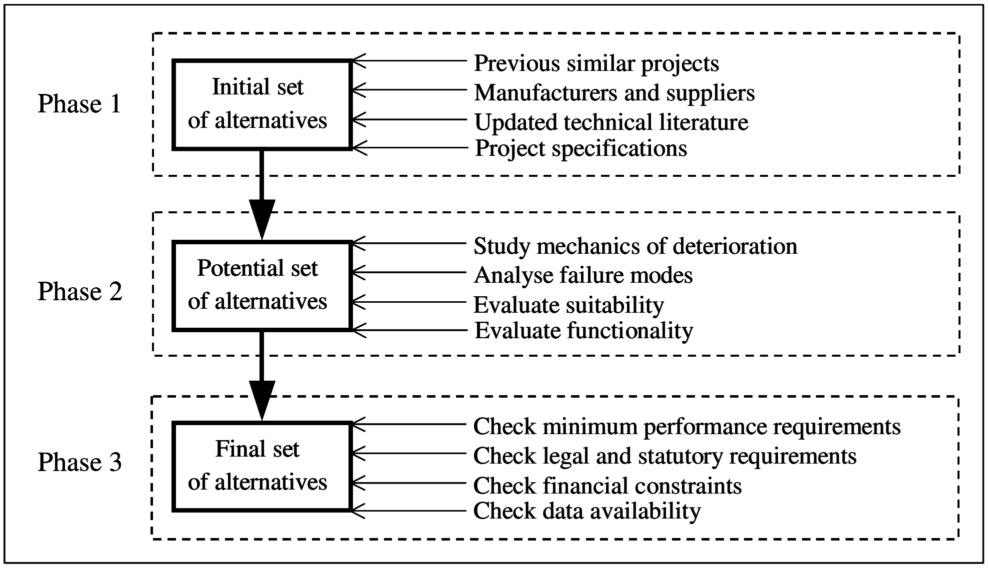

Figure 2: Schematic representation of the process of generation of alternatives.

- An initial alternative set is created from various sources including previous similar projects, various British standards, NHS guide notes (e.g. NHS, 1995, 2000a, 2000b), manufacturers and suppliers literature, and other publications.
- In the second phase, alternatives are screened based on functionality and suitability criteria. This can be facilitated by the understanding of mechanics of deterioration and failure modes of finishes and linking the space function and performance requirements.
- In the third phase, alternatives that don't satisfy the financial constraints and/or the minimum specifications, performance or statutory requirements are excluded. This can be done by indicating critical performance requirements for finishes in different environments. These thresholds are then used to screen early unsuitable alternatives. This will help in minimizing the time and cost of the detailed selection exercise.

ANALYSIS AND DECISION MAKING

TECHNIQUES

Classical MCDM methods require the determination of alternative ratings and criteria weights. The simplest and most employed function is the weighted average formula (equation 1). However, a means of assessing the overall value is necessary for an objective and defendable decision. In this sense, the traditional weighted average formula is not enough. Kirk and Dell'Isola (1995) recommend ranking alternatives according to their benefit to cost (BTC) ratios. A BTC ratio is calculated as

$$BTC_i = \frac{S_i}{WLC_i} \tag{2}$$

where WLC_i is the WLC measure of alternative i (NPV or EAC as appropriate).

Kishk (2001) has shown that the use of BTC ratio is recommended only in the case of uncertainty-tied alternatives. However, the use of the total combined score is crucial when no detailed cost results are available or when the relative importance of cost and non-financial criteria should be considered.

It should be noted, however, that although a value-for-money metric is used to make the final decision, other measures may be required in earlier stages of the decision-making process as discussed earlier, e.g. alternatives that do not satisfy the minimum technical and performance requirements are excluded regardless of their value-for-money metrics.

HANDLING UNCERTAINTY

The uncertainty of various input parameters may produce a considerable decision uncertainty region. In such cases, competing alternatives are assumed to be tied, and some means of breaking the tie is needed (Kishk, 2001). In these cases, it is crucial to systematically analyse uncertain input data and provides the decision-maker with a better impression of their validity and usability by the employment of two sets of measures. The first set should include a ranking measure and a confidence measure to rank various competing alternatives and to evaluate the resulting rank order, respectively.

The second set of measures should include appropriate uncertainty measures to assess the contribution of various parameters regarding the ambiguity of the decision. Then, the quality of the decision may be improved by seeking more 'precise and specific' information regarding these items only. By focusing on a smaller data set, the cost of undertaking the analysis can be greatly reduced. Figure 3 shows schematically how various decision metrics/techniques can be effectively used in various stages of the decision making process.

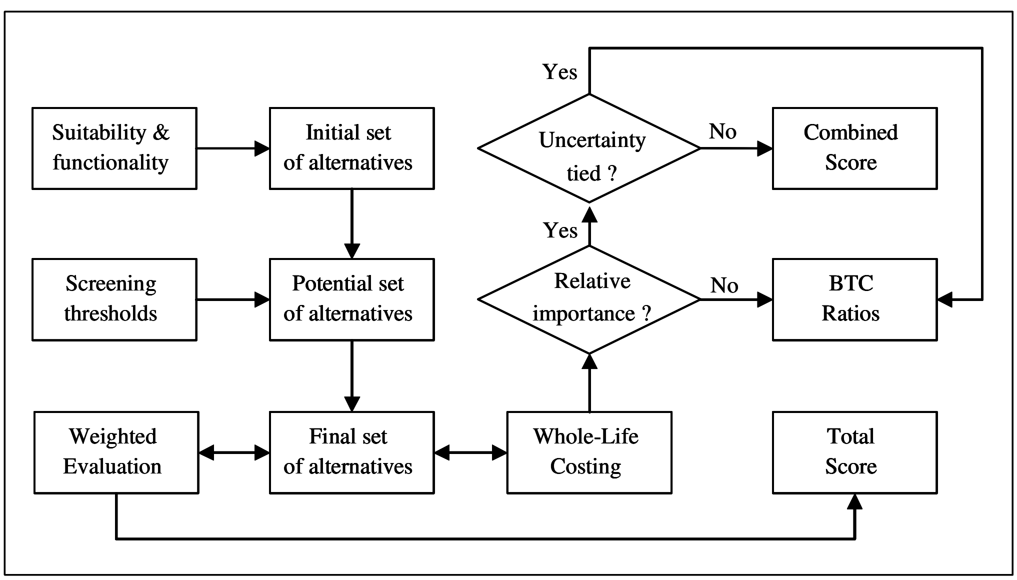

Figure 3: Schematic representation of the use of decision metrics and techniques.

A SELECTION ALGORITHM AND METHODOLOGY

Based on the above arguments, a methodological framework may be proposed. Figure 4 shows a diagrammatic representation of the algorithm.

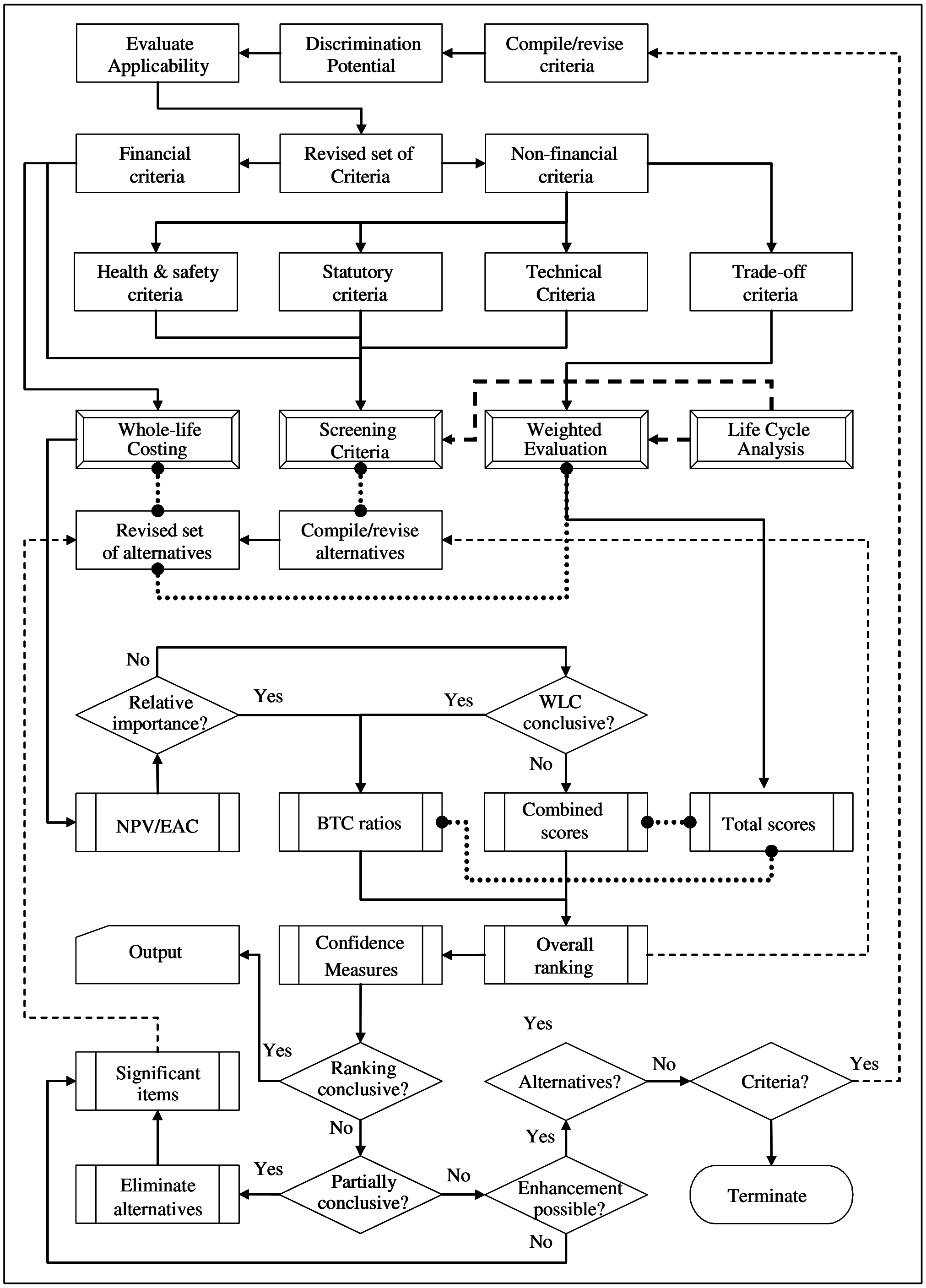

Figure 4: Schematic representation of the proposed framework.

As shown, five main phases can be identified: identification of criteria, generation of alternatives, analysis, ranking, and recycle phases.

- In the first phase, decision criteria are identified and grouped into two categories: screening and trade-off criteria. Screening criteria are those attributes that cannot be compromised because of limited resources, legal or minimum performance requirements. They are mainly quantitative criteria that might include financial, health and safety, statutory and technical criteria.
- In the second phase, all potential alternatives for the space/element under consideration are generated in three steps as discussed earlier. In the last step, the screening criteria identified in the first phase are used to decide upon the final set.
- In the third phase, WLC analysis and weighted evaluation are carried out to calculate WLC measures and total scores for various competing alternatives.
- In the fourth phase, alternatives are ranked according to their BTC ratios or combined scores, as appropriate, and confidence measures in ranking are calculated.
- The last phase is a recycle phase. If the ideal alternative is not clear as reflected by confidence measures in the ranking, uncertainty measures of various variables are calculated to identify those items that contribute significantly to the uncertainty of the decision. Then, the optimum improvement recycle loop(s) can be identified.

CONCLUSIONS AND THE WAY FORWARD

Crucial requirements for effective identification of decision criteria, generation of alternatives, and the decision-making process have been identified. Then, an integrated approach for the selection of hospital finishes is outlined using simple process flow diagrams.

Future work includes implementing and testing the suggested framework as an integrated decision support system in the following steps.

- Finishes being used in for a variety of purposes in a variety of healthcare environments will be identified. The project will, by agreement with the Steering Group, limit consideration to a subset of finishes and environments. It is envisaged that this might include internal floor, wall and ceiling finishes in relatively common, large volume areas such as wards, circulation/corridors and food preparation and dining areas.
- Relevant selection criteria for these finishes will be identified. Questionnaires are administered to relevant managers in hospitals and suppliers and an extensive review of the literature, specifications and other official documents is conducted.
- A finishes resource database to house the above information. A recently developed WLC resource database (Kishk et al., 2003) will be tailored for hospital finishes and extended to house minimum performance thresholds and other trade-off criteria particular to specialist healthcare environments. A compatible facility-specific database is developed to manage actual performance and cost data of finishes in occupied hospital buildings.

- A extended WLC application based on the theory presented in Kishk et al. (2002) is developed.
- The system is developed by integrating the decision-making application and the two databases through an interactive interface.
- Test and validate the system. This will be done in four phases. First, the usability of the system's interface will be tested in a laboratory environment. A second phase will be to demonstrate the system both to users and a panel of experts to get feedback on further refinements to the system's capabilities. The third phase will be to use case study healthcare organizations from the Steering Group to demonstrate the validity of the model. The wider market for the system will be tested in a launch event aimed at all major UK healthcare organizations, which will be followed up by training and feedback events by agreement with the Client.

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