A Decision Support Model Proving 'Value for Money' Selection of Elements and Components on Hospital Refurbishments

Development of a Functioning Prototype

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Abstract

Capital investment in current economic circumstances is severely challenged. This is especially evident within the NHS built estate. Estate managers and Design Teams have the duty to achieve Value for Money on projects; yet, no measured and standardised system exists. A user friendly software model is described to achieve this aim.

Keywords

Decision-Making;NHS; MCDM; Prototype Development; Capital Investment

Introduction

The current economic situation across most of the western world is placing enourmous pressures on governments and institutions in respect of capital spending and investment. This is especially noticeable when considered against vital services and functions such as the maintenenace of the healthcare estate, and delivery of healthcare services.

In the United Kingdom, the dominant healthcare provider is the publicly funded National Health Service (NHS). The BBC News service reported on the UK Governments requirement for the NHS to achieve a 4% (year on year) reduction in costs, equal to circa 20 billion pounds (BBC News Online). This is a significant challenge for a service that is tasked with adapting to and treating, an ever increasing range of emergent diseases and phenomenon, such as obesity, and an ageing population, respectively (Mckee and Healy 2002)

Notwithstanding the clinical challenges touched on above; it is naturally critical that the healthcare facilities and the built estate, are maintained and developed to ensure that service delivery is minimally affected. Given the sheer scale and diversity (in regards to age and condition) of the NHS estate, this challenge is exacerbated, not least for the reason that the rapidity of clinical advances and the changes to the care models themselves often overtake the physical design and construction processes in terms of both new-build hospital facilities and refurbishment projects (Rechel et al 2009)

In terms of capital investment, and crucially, it is evident that Value for Money has been achieved as far as practicably possible for each specific project, secondary and primary research as part of an ongoing PhD research programme has identified that no standardised or formalised decision making process currently exists that integrates the healthcare management teams, with the design and construction teams to find and agree 'best fit' specification and design choices. Given that proving a Value for Money approach in capital investement terms is not an *aspiration*, but a *duty* (HM Treasury 2011) , which presents a clear gap in the current business case processes.

The development of a user friendly and integrated decision support model has therefore been identified as a key objective in allowing for the consideration of multiple and often conflicting, criteria and options choices, and applying a measured, weighted, and replicable approach to be undertaken at the optimum point in the wider business case process.

Context of the Existing Processes

Key to understanding the requirements for designing a prototype was an understanding of the current actors knowledge base and experience in regards to the main guidance and techniques associated with the current business case and decision making processes. It was decided in the early phases of the research to identify a case study of health facility (in this case, an acute hospital) within a consenting health board in the UK. This was agreed on a Scottish hospital facility, and as such, the documentation and guidance references are tailored to the NHS Scotland suite of guidance documents.

The Scottish Capital Investment Manual (SCIM)

Although closely aligned with general capital investment guidance, an identified sample frame was employed to participate in a data collection exercise to lay foundations for the prototype development. The participants were all identified as industry and discipline experts. As the SCIM is the key mandatory guidance document used by all parties, it was considered elementary to measure the sample frames knowledge base. In respect of this, Fig. 1 illustrates that the NHS management teams claim a greater level of understanding of the SCIM.

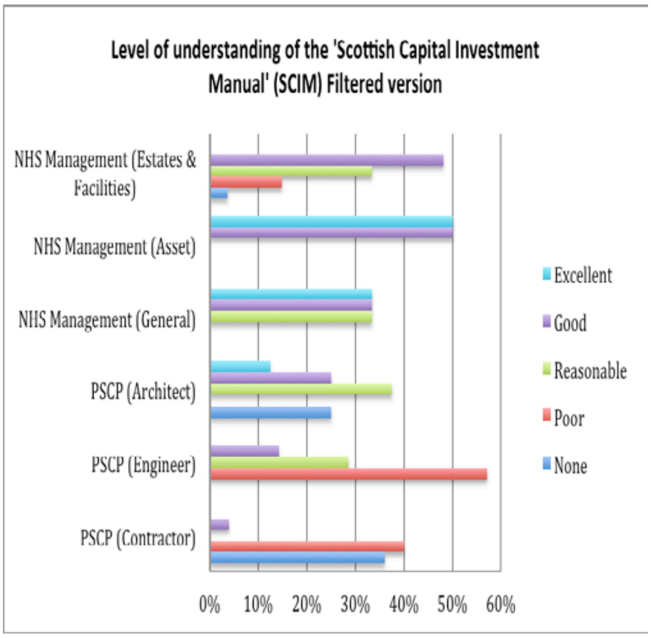

FIG. 1 UNDERSTANDING OF SCIM

This point needs reiteration, as it is a key finding that there appears to have a clear gap in the familiarity part, and therefore understanding of the main project guidance documents and process. Given that the SCIM itself highlights that one of the main overall aims of the business case process is to

"Identify the option which optimises value for money (VFM) and overall sustainability" (SCIM pp. 57)

It is self evident that a built asset as complex and potentially cost intensive as an acute hospital will face with a vast array of decision making requirements, each of which may be subjected to a correspondingly vast amount of complex and often competing criteria. Secondary data collection techniques by means of a detailed and extensive literature review identified the field of Multi-Criteria Decison Making (MCDM) as an obvious choice in application to the challenges described above. This directed the research to test the sample frames knowledge base and experience in use of these types of model.

Multi- Criteria Decision Making

Fig. 2 shows the sample frames response when questioned on their experience in the use of MCDM techniques.

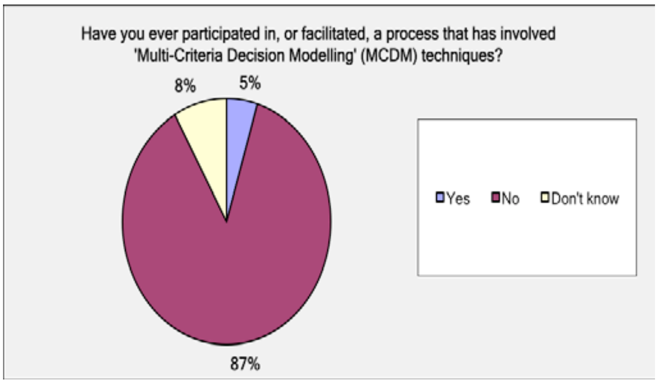

FIG. 2 EXPERIENCE OF USING MCDM

Reference is made again to the extract from the SCIM in the previous section, which categorically states that a process of options selection must be undertaken, which optimises VFM. Subsequent interviews with the sample frame professionals identified that decision making as an activity is an ongoing and integral part of any business case and options selection process, however; the current methodologies are driven largely by the heuristic and experiential capabilities of the NHS and design team/construction professionals.

This is by no means an inferior method of decision making, although given the wide differences in the actors professional disciplines, and there is no identifiable (or recordable) means in which to measure, validate, and test the system, elemental, or component choices specific to the facility in question. This supports the research objective of developing a functioning prototype.

The Conceptual Decision Making Model

In developing an MCDM approach (and thus 'functioning prototype'), it was necessary to build the model in phases. The first phase was the construction of the conceptual design. Loken (2005) presented a fundamental truth that the decision maker is primarily concerned with finding the 'optimal solution'. This, however, may only be possible if measured against a single criterion. In the case of capital investment and the healthcare estate, this is undeniably impractical from the outset. Triantaphllou (2000) expanded upon this, and identified MCDMs key advantage as being able to ascertain the best alternative (or option), when facing with multiple sets of competing criteria.

The conceptual modelling phase is important in presenting the methodology and format of the modelling process, and identifying the model type. In this instance, a discrete (or finite) approach is undertaken, and validated by the exisiting processes and short listing approaches currently undertaken within the standard business case process. Fig. 3 shows the conceptual model (adapted from Zarghami & Szidarovzsky 2011)

Step	Activity
1	Identify Goal (and Objectives)
2	Identify Criteria
3	Identify Alternatives
4	Alternatives/Criteria Evaluation
5	Make Decision

FIG. 3 MCDM CONCEPTUAL PROCESS

Selection of the Criteria

The 'criteria' in the context of the MCDM process may be referred to as the issues or aspects of the project, and project requirements which are deemed important to the decision maker. Reiterating the complexity of the exemplar acute hospital, however, understanding and isolating the criteria demands a measured and reasoned approach itself. This is strongly supported by Braunschweig et al (2001) who observed that decision makers

"…have to know the critical issues involved and these are usually veiled at first"

TABLE 1 CRITERIA SELECTION PROCESS

Generation: Initial set of Criteria	Relevance: Potential set of Criteria	Applicability: Final set of Criteria
Legislation Codes of Practice Health Technical Memorandum Health Building Notes Clinical Output Specification BREEAM/AEDET Standard Checklists	Relevance to Project Measurement Duplication Goal Conflicts Importance to Project	Availability of Data Measurability of Data Ambiguities Evaluate Applicability

This directs the decision maker to develop a framework for the identification of 'key' and 'relevant' criteria. Braunschweig at al (2001) suggested a filtering and reductionist process which narrows from the high level and mandatory down to the detailed level. Table 1 illustrates this in the context of the hospital.

Selection of the Options

In selecting the potential options, exactly the same process of reductionism and filtering is undertaken, as described by Kishk et al (2008). Table 2 demonstrates this process.

TABLE 2 CRITERIA SELECTION PROCESS

Initial set of Options	Potential set of Options	Final set of Options
Case Studies/similar projects Supply Chain Confidence Clinical Output Specs Project refurbishment Specs	Integration Challenges Maintenance Issues Evaluate Suitability Evaluate functionality	Meet Minimum Performance Meet Legal Requirements Within Funding Parameters Availability of Systems/Data

The Decision Making Framework

The interim step in development of the prototype was the development of the mechanical framework. This allowed the conceptual design to be mathematically modelled, and pursued another key identified objective of the research, which was to capture the subjective and the heuristic, and to transpose this into measurable and objective terms that could be weighted, ranked, and ultimately, sensitivity tested for validity.

The Weighted Evaluation Framework

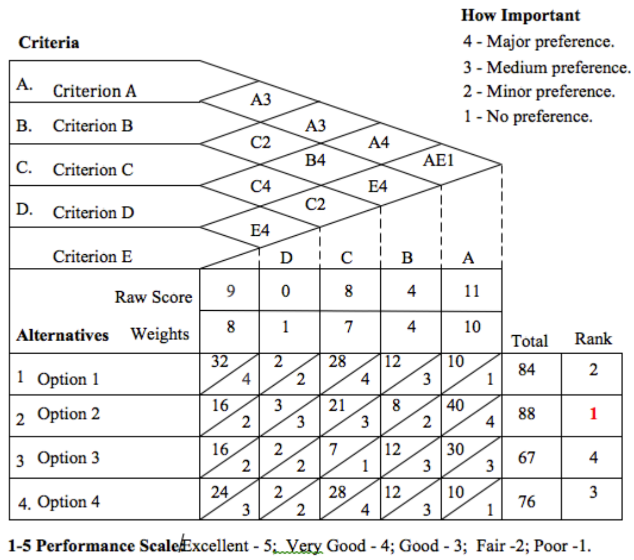

FIG. 4 THE WE DECISION MAKING FRAMEWORK

The weighted evaluation (WE) technique has been demonstrated by Kirk and Dell'Isolla (1995) and Kishk et al (2008) in terms of whole life costing (WLC) techniques. This, however, presents no limitation to the use of WE for the objectives of the research aims and the prototypes function. Fig 4. demonstrates the WE decision making framework in action.

Framework Mechanics

The relative importance of Criteria A through E is established in respect to the 'importance' ratings on a scale of 1 to 4, from 'No Preference' to 'Major Preference' respectively. This process is clearly a process of consensus and value judgments from the decision makers are critical. It is noted, however, that these value judgments may be supported (or driven) by the criteria selection process in regards to legislative, regulatory, or institutional requirements. Each criterion comparison space is then summed to attain a 'raw score' for each criterion.

The weighting process is now applied in the form of 'normalising' the raw scores. Normalisation for the purposes of the framework is given the parameter values of 1 (being the lowest weight value) to 10 (being the highest weight value). Selecting the normalisation method was considered in terms of the associated data requirements of the framework, and the objective of retaining simplification as far as possible. It is common practice for decision makers to frame the normalised scales from 1 to 100, or by adopting a process of 'adding to unity' of 1, with fractions of less than 1 where relevant (Selih, 2008. Zavrl et al, 2009. Zavadskas et al, 2008) However; given the nature of the values added and derived from the matrix shown in Figure 4, it has been deemed appropriate to use whole integers only with the maximum and minimum parameters stated above.

It should be noted that the weighting process will deliberately prohibit a 'zero' value derived from the weighted values. This recognises that the criterions are all selected by their nature, of a certain level of importance or value to the decision maker. The process of deriving weights is a simple calculation.

This can be described by example, considering Criterion C (raw score of 8). The maximum raw score (criterion A) is 11, following the normalisation rule, converts to the maximum allowable of 10. To derive the weighting of Criterion C, therefore, the maximum weight is divided by the maximum raw score, and the resulting figure is multiplied by the raw score being considered (in this instance, Criterion C). It is likely that the result will not in fact be a whole integer, so a simple rounding process is undertaken which uses the rule that any value < x .5 is rounded down, and anything from x .51 onwards is rounded up.

Addressing the Options

Evaluating the options is the preceding step to assign a ranking of preference for the 'preferred option'. The process (excluding the final ranking) consists of three actions. Action 1 is the assignation of a value in respect of the 'Performance Scale' which runs from 1 (poor) through to 5 (Excellent). As the scales title implies that the decision makers consider each option against each criterion, and assess a value of performance (or perceived performance) for each. This follows the pairwise comparison technique, which is the heart of the frameworks process. Action 2 sees that simple multiplication is carried out of the (now whole) integers of each weights performance score, against the derived weighting for each criterion. This derived value can be seen in Fig. 4 as the higher value sharing the split options cells. This action is also the beginning of the transition phase of the qualitative to the quantitative, or the objective to the subjective. Action 3 shows that the completed scores are then summed to a raw total, and by merit of the highest value total being the most preferred are ranked from 1 through to x (dependent upon the number of options being considered)

Developing the Functioning Prototype

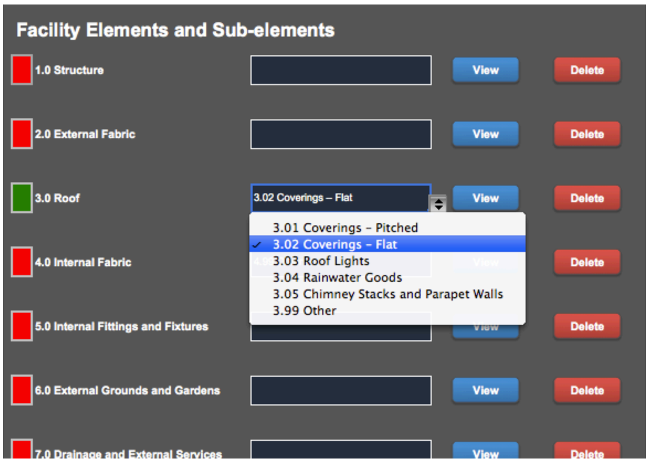

FIG. 6 ELEMENT & SUB-ELEMENT SELECTION

The third and final phase of the decision supporting models development was the design and construction of the functioning software based prototype. The secondary and primary data collection excercises identified the MS Excel® platform as the most familiar to the potential user. An added benefit was that Excel is also compatable with the existing Estate Management Systems currently used by the NHS. This allowed for the coding numbers and reference structures to be replicated within the Graphical User Interface (GUI). A 'home page' provides project information in regards to facility type, location, size, age etc; although the key user interface at this stage is the selection of the element or sub-element which is the focus of the decision making process (as outlined in the conceptual phase discussed earlier). Fig. 6 shows a screen capture of the GUI.

Identification and Selection of the Criteria

Again, this process mirrors the conceptual model design discussed previously. The prototype is constructed so that there are automatic functions which take place as the modelling process progresses. For example, once the Sub-element has been selected (in the case of Fig. 6, this is '3.02 Coverings-Flat'), the 'View' button will automatically take the model user to the options selection page (or worksheet)

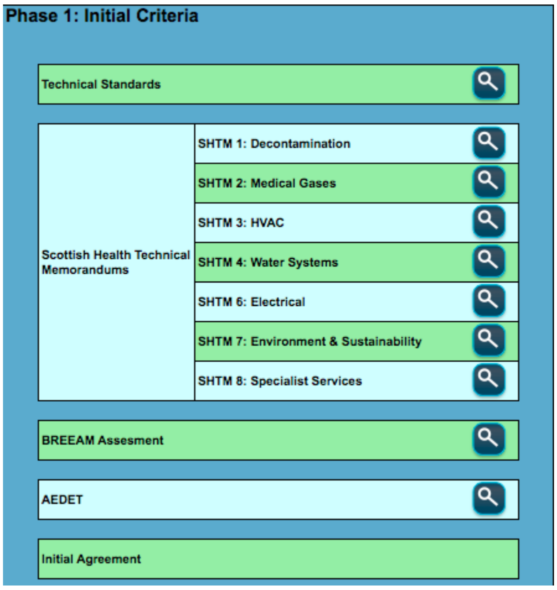

FIG. 7 INTIAL CRITERIA SELECTION

The 3 phases of criteria selection are demonstrated in the screenshot captures shown in Figures 7, 8, and 9 respectively. The looking glass buttons connect the model user directly to the relevant legislation, guidance, or documentation. It is reiterated that the case study shown is in respect of an acute hospital. Where relevant, the links are hyperlinked to the relevant website (assuming the model user is web connected)

Once final options have been identified and confirmed, the user is taken automatically to 'Options Selection' page.

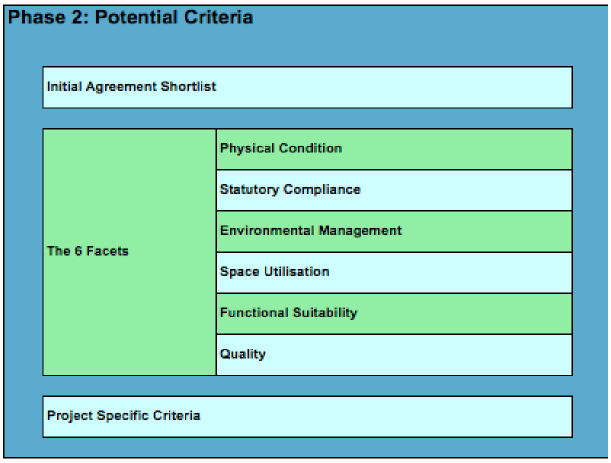

FIG. 8 POTENTIAL CRITERIA SELECTION

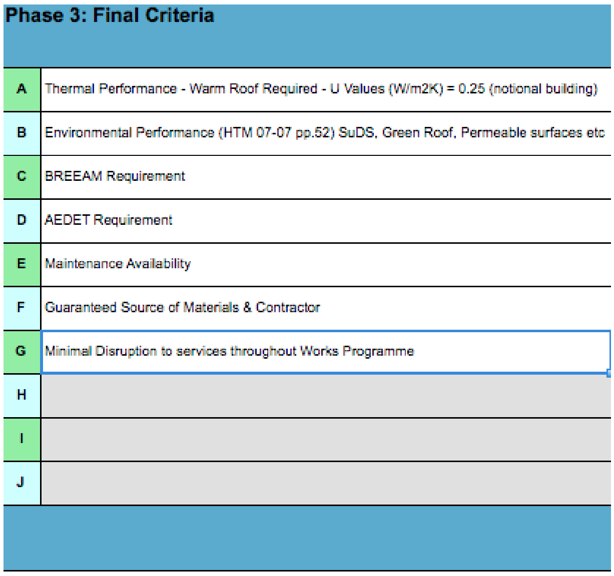

FIG. 9 FINAL CRITERIA SELECTION

Identification and Selection of the Options

The same process is undertaken within the prototype, as that discussed in the conceptual design. Again, this mirrors the same technique used for criteria selection. Figures 10, 11, and 12 illustrate this with screenshot captures from the GUI.

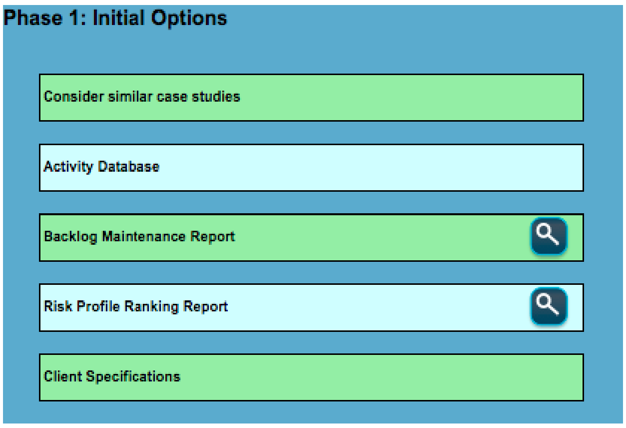

FIG. 10 INTIAL OPTIONS

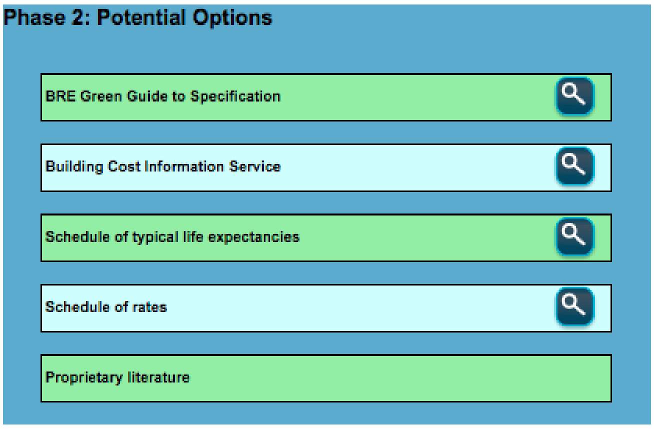

FIG. 11 POTENTIAL OPTIONS

Final Options

1	Knauf. Perimeter Plus Cellulose Blown System (Green Guide Rating)
2	IKO Mach One - Bituminous Single Layer Membrane (Green Guide Rating)
3	IKO Permatech - Ecowrap (Hot melt waterproofing system) (Green Guide Rating)
4	Kingspan Thermataper (All in one insulation & drainage system) (Green Guide Rating)
5	Icopal. Noxite Membrane (Over metal decking + vapour control system) (Green Guide Rating)

FIG. 12 FINAL OPTIONS

As with the previous functions, once the final set of options to be considered has been identified and confirmed, the user automatically takes the Decision Support Model (DSM) page, where the goals, criteria and options are automatically input and awaiting the next phase of the user input. The next phases should be observed as steps 4 and 5 of the conceptual decision making process shown earlier in Figure 3, which are the alternatives/criteria evaluation step and the decision making step, respectively.

The Decison Making Function

The Decision Support Model (DSM) stage of the prototype is multi-faceted. The calculations described earlier within the interim (or framework) stage of the models design have been coded into the GUI by means of Excel formulae functions and Macros protection. The scales and ranking protocols described in regards to the criterion comparison and the performance of options have definitive parameters to the possibilities of user selection (i.e. 1 to 4 for Criterion, and 1 to 5 for Options), and thereforedeally suited to pre-programmed drop-down menu selection.

Similarly, the derivation of criterion weightings as illustrated in Fig. 5 are automatically calculated, rounded, and ranked with background formula coding.

The criterion ranking and weighting aspects of the GUI DSM are shown in the screen capture extract in Fig. 13.

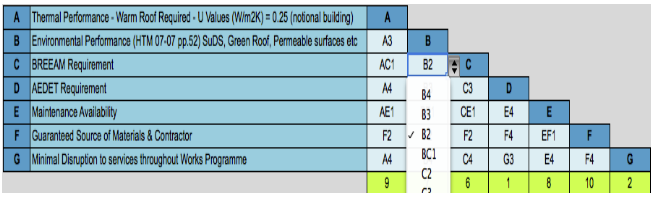

FIG. 13 GUI CRITERION & WEIGHTING MATRIX

The options matrix is shown in Fig. 14. It is noted that the weights in Figs 13 and 14 are the same, signifying the connection point.

		9	7	6	1	8	10	2	Total Score
1	Option A	4	4	3	2	1	2	5	122
2	Option B	5	3	2	2	4	2	5	142
3	Option C	4	3	2	2	3	3	5	135
4	Option D	5	4	3	2	4	4	5	175
5	Option E	4	4	3	2	2	3	5	140

FIG. 14 GUI OPTIONS MATRIX

The options values shown in Fig. 14 have also been automatically derived by means of excel formula coding, and the total scores automatically and dynamically updated to reflect the value judgements made throughout the criterion and options evaluation processes.

Application of Financial Ranking Considerations

The 'Total Score' value shown in Fig. 14 provides the decision maker/model user with a non-sensitivity tested and non-financial preference. This restricts the models results to a very basic form of option preference and selection. Use of Benefit to Cost ratio calculations, therefore, introduces a financial element into the prototypes function. This is illustrated in the screen capture extract shown in Fig.15.

Total Score	Cost	BTC Ratio
122	£140,000	0.87
142	£154,000	0.92
135	£146,000	0.92
175	£175,000	1
140	£151,000	0.93

FIG. 15 INTRODUCTION OF FINANCIAL PREFERENCE

What Fig. 15 shows is the use of Benefit to Cost (BTC) Ratio calculations to provide a financial preference ranking to the non-financial results derived previously. A simple calculation is undertaken which divides the total non-financial score by the cost (or projected cost) of the element or works from which each identified final option comprises. So for example, the case study demonstrates in Fig. 15 that 175 is the highest value (ranking) total non-financial score. The costs of this option are calculated as £175,000. This figure may be inserted to the model as element and components 'only', or as inclusive of all contractors fees etc. The only rule is that the same convention is undertaken for all identified options costs. The calculation is therefore:

$$175/175000 = 0.001$$

The prototype cells have been pre-set to multiply each BTC value by '1000' to negate the occurrence of extended decimal places. Therefore, the completed calculation for the BTC value is:

$$175/175000 = 0.001(x\ 1000) = 1$$

This calculation is carried out for each total non-financial ranking score against each option cost value. The option with the highest BTC value is identified as the highest ranked option in financial preference terms

Sensitivity Analysis Testing

Fig. 15 shows the results obtained from undertaking a single decision making process. It shows that the 4th listed option is the most preferential option in non-financial terms, and also by use of the BTC ratio calculation, it is the most preferential option in financial terms. Despite the fact that the modeled results shown in Fig. 15 have been derived from a process of both subjective and objective input, the decision maker must seek to reinforce confidence that the variables included within the process could not produce a more informed, functional, or value for money oriented approach, if the model was re-run with changes to the variables and/or scenario. This 'checking' process is defined as undertaking a process of sensitivity analysis (or testing). Ellingham and Fawcett (2006 pp.162) identified this as a full rounding process in evaluating a preferred option. They highlighted the point that relatively small changes in the earlier assumptions of the options appraisal process have the capacity to cause significant changes to the final result by means of exponential change and re-routing of connectivity's between variables. This is accepted within the model, and a process of sensitivity analysis has been designed into the GUI. Each Decision Support Model (DSM) or matrix is replicable within the decision-making section of the GUI. Although theoretically, there is no limit to the number of DSMs which can be replicated, it is unlikely that this will be carried out more than three or four times (given the restricted number of Criterion). It should be noted that it is only the criteria which may be changed within the sensitivity analysis in context of assigning precedence to any individually selected criterion, and that the sensitivity analysis changes are only applicable to the ranking results of the criteria importance scale (1 to 4). Any changes in the actual criteria or the options selected will necessitate the construction of a fresh matrix and DSM page by means of the criteria/options final selections discussed previously. The completed DSM page will, therefore, show a series of connected matrices, with different values which will allow for comparison. The prototype has 2 separate visualisation and comparison charts designed into the final DSM page specifically for this purpose. As with many other functions of the calculations, these graphs are dynamic, and will update automatically as changes are made or sensitivity analysis issues are tested.

Presenting the Preferred Options

As discussed previously, the prototype is designed to measure and sensitivity test preferred options in both non-financial, and financial terms. A key driver of the overall research is that the decision makers within the standard business case process can demonstrate that a measured and demonstrable process has been undertaken to evidence that a Valuee for Money approach has been considered. The presentation graphs shown in Figures 16 and 17. respectively, are in this context designed to allow for attachement or insertion in report format, within the relevant part of the business case documentation, and to be available where necessary for 3rd party audit of the Value for Money approach taken.

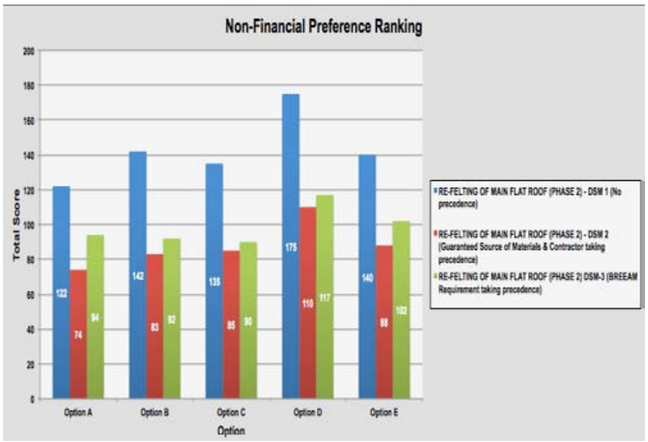

FIG. 16 NON-FINANCIAL RANKING COMPARISON GRAPH

Fig. 16 is presented and compared alongside the results shown in Fig. 17

A point to consider in regards to the BTC Financial rankings shown in Fig. 17 is that these are also a basic form of financial analysis. In reference to the 'Costs' column shown in Fig. 15; it is identified that these would be more accurate and commercially useful, if these figures were the results of a Life-Cycle Costing excercise.

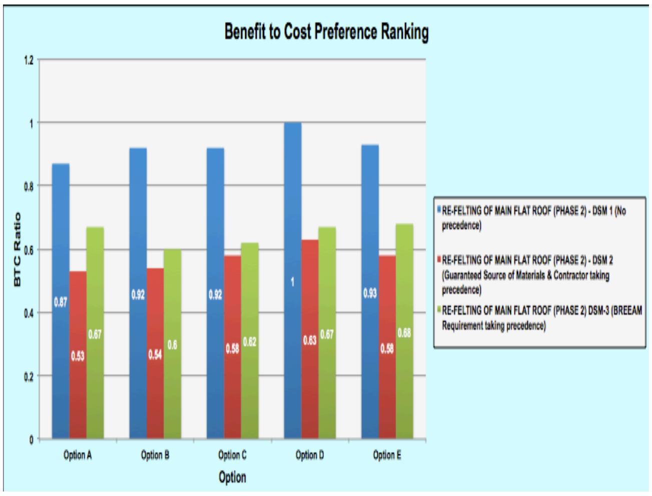

FIG. 17 FINANCIAL RANKING COMPARISON GRAPH

Conclusions

It has been discussed that the capital investment process, in regards to proving that the taxpayer is getting Value for Money, has become increasingly more challenging as a result of the current economic downturn. This is especially noticeable within the NHS which has a requirement to provide 'fit for purpose' clinical services, and also to maintain a vast and varied built estate. It has been shown that a simplified system of Multi-Criteria Decision Modelling may be used as the platform for which to facilitate, measure, and record this. In addition to facilitating the process itself, such a model will also provide a framework and common focus for professionals from completely different backgrounds and knowledge bases to approach decision making by means of measured consensus. However, further development of the prototype is identified, especially in terms of incorporating a Life-Cycle Costing function to inform the final decision making phase.

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