DEVELOPMENT OF QFD TO SUPPORT DECISION MAKING DURING THE BRIEFING PROCESS

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ABSTRACT

Briefing is seen by many as the key to successful construction particularly if a comprehensive brief can be obtained in the initial stages of the project. The problem in obtaining a brief is the very large number of issues that have to be considered and the difficulty of specifying a performance level as many of the values are subjective. Quality Function Deployment (QFD), a technique used in product design, enables the prioritisation of objectives, an understanding of the links between choices and the potential conflicts between them. It is also a cumbersome technique where there are a large number of variables. Previous applications to construction have not considered the special needs of the construction briefing process. An approach has been developed exploiting the features of QFD, but tailored to the needs of the construction briefing process. By using pre-selected data bases of issues and technologies that can be used to provide solutions the user is not faced with an impossible choice but a manageable choice. Where the user is faced with making choices the system has been developed to enable the user to access, at any point in the process, additional information from linked knowledge sources and the WWW so enabling them to be informed of the issues. The result is that the user can explore each area in depth. When a decision has been made the user can record the details which are captured in a data base that is then used to enhance the final report and so produce a full performance specification of the user's requirements.

The advantages of this approach is that there is a common decision framework for all stages of the briefing process. Each decision is an informed decision. A full record of the decision process is held for subsequent review. Not all requirements have the same priority and this approach requires a statement of the importance of each issue. The briefing can be conducted at a number of levels, each of which maintains continuity from the preceding stage. An application will be described for specifying Indoor Environments.

KEY WORDS

briefing, construction, QFD, management, performance, indoor environment

INTRODUCTION

Clear and early briefing is seen as the key to success in a construction project as the brief sets out the criteria for the completed work, the use of space, quality standards and establishes the basic policy for the job. Good briefing implementation is one key to providing a systematic and controlled process, which avoids expensive mistakes or inferior products (Blyth and Worthington, 2001). However, the briefing process is

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continuous throughout the construction project as it is so difficult to be sufficiently precise in the very early stages of the project. But the need is to maintain the consistency of the early decisions so that client's requirements are progressively captured and translated into effect (Barrett and Stanley, 2000). Often organisations find that their building does not meet their needs. The problem is the very large number of issues that have to be considered and the difficulty of specifying performance requirements of the final product, as these requirements are subjective (Cornick and Mather, 1999). On the other hand the end product is the result of interpretation by the designers, therefore the management efforts should focus on process rather than content (Van Loon, 2000 and Tunstall, 2000).

Designers, who have the responsibility of delivering a client's brief into a design product, deal with the issues of the integration of a wide range of subjects and topics. Mechanisms for decision-making must allow the consideration of a wide range of variables (Coles and Barritte, 2000). The key to success in complex, technologically driven, environments is to bring together all contributors in the development of the problem specification. The performance criteria need to be established and then the solution, at whatever stage and level of detail always be able to refer back to the original specification, to ensure it meets the requirements. This requires that the decision support system is able to be resident in all decision points so ensuring that the value chain remains unbroken from start to finish. To preserve the value chain this whole complex group of contributors must be operating within a focused vertically integrated management framework, which is supporting the development of the technology. Performance objectives and priorities should be brought explicitly into the value chain and maintained throughout the process from initiation to completion. Strategies should be implemented to ensure that all stakeholders understand the process and actively contribute to it (Egan, 1998).

What is needed is a management philosophy and tool that fully integrates the transformation of requirements into design, and where value is created through fulfilment of requirements (Huovila and Koskela, 1998).

THE BRIEFING PROCESS AND QFD

QFD is an engineering method for converting requirements into quality characteristics and for developing product design by systematically deploying the relationships of requirements and product characteristics (Lee and Sai On Ko, 2000). QFD employs mathematical techniques using a series of matrices, which depend on functional relationships, to arrive at the mechanisms and technologies capable of delivering the required level of quality in a product (Maharon, 1999). QFD can help in construction to help a client to define their needs and to create a performance brief based on those needs. The needs can include: designing the building, constructing, maintaining and operating it and finally, demolishing it (Leinonen and Huovila, 2000). The QFD method ensures that the client's expectations are met in a realistic way. The technique, due to its multi-level operation is ideally suited for the evolutionary development of the client requirements (Huovila, et al., 1997 and Kamara, et al., 1999, Leinonen and Huovila, 2000, Nieminen, et al., 2000 and Rawabdeh, et al., 2001).

RECENT DEVELOPMENTS IN THE USE OF QFD FOR CONSTRUCTION

QFD is one of the most promising tools that enable the rigorous requirement analysis, systematic management of requirements during engineering and collaborative iterations for improvement therefore reducing the value loss from the point view of the customer (Koskela and Huovila, 1999 and Kamara, et al, 1999). Recent QFD experimentation (Huovila, 1999 and Sarja, 2000) showed that using QFD helped set life cycle considerations early in the process by documenting the performance objectives and making transparent the decisions to the design team. In a recent review QFD was seen as a potentially valuable tool in setting performance specifications for construction projects. (Huovila and Gray, 2005).

THE WEAKNESS IN CURRENT APPLICATIONS OF QFD TO CONSTRUCTION

Conventional or paper based approaches require that the user is able to list all of the requirements from the outset to achieve the goal. The list may be very long, but even to be comprehensive for a problem so large as a building the list would be extremely long. This is even if the user could specify all of the requirements. Many users are not familiar with specifying buildings so are limited by their knowledge. This is largely why the existing briefing processes fail; the problem is too big and beyond most peoples' comprehension. So briefing is done in short bursts largely informed by proposals of what could be achieved in the form of drawings or sketches etc.

There is a temptation to require everything to the highest standard, whilst not being able to articulate what the standard is nor whether there is a possibility of trading one requirement against another.

The user has little way of becoming informed other than by using consultants who may have a vested interest, or only local information sources and experience.

It is very difficult to capture the reasoning and subsequent decision in the briefing process. This limits the transferability of the process to others and the subsequent stages in the chain.

THE DEVELOPED QFD APPLICATION

This application has been developed to overcome the limitations in existing applications. It is computer based which enables an integrated approach to both the calculations, access to information sources on the WWW and a reporting structure based on a continuous record of decision making through the process using a connected data base. The overall building project has been subdivided based on conventions of design, e.g. spaces and then within each space a definition of the performance can be developed and the priorities be set. The user has available a database which consists of structured tables of: building spaces that define the possible functions; possible indoor performance and possible actions or technologies to achieve a required performance (Table 1). The database tables are the result of rigorous search and analysis of the design literature and industry classification systems such as CI/SfB, Co-ordinated Project Information (CPI), Common Arrangement of Work Sections (CAWS), Uniclass, etc. These tables were reviewed and modified by experts in the construction industry using a Delphi approach. Samples from the database tables below show that buildings might be office, school, factory, etc. with specific interior spaces such as working area, meeting room, canteen / kitchen or plant rooms. Building spaces and functions should meet a specific set of requirements and/or performance criteria in order to fulfil human needs such as physical, psychological, sociological or economic (Rush, 1986). On the other hand a building can be seen as four main systems or parts. These main systems are:

structure, envelope, interior and building services. Each of the main systems can be divided into an hierarchy of sub-systems. The integration among the sub-systems is critical to the delivery of building integrity through its visual: acoustical, air quality and spatial performance.

Table 1: Interrelationship between spatial data bases

	Small office		**Working area**	**Server room**
	Large office		Meeting room	Communication room
	Multi family house		Canteen / kitchen	Photo copier room
	Single family house		Technical room	Switch board room
	Stores		Plants and equipment room	Lifts and escalator motors room
	Shopping centre		Gallery area	HVAC plants room
	Hotel	Enclosed space	Display area	Tea / Coffee point
	Motel		Library room	Warm up kitchen *
	Elementary school		Storage	Warm up kitchen ***
	Secondary school		Post room	Warm up kitchen *****
	Warehouse		Secondary circulation	Kitchen *
	Assembly		Miscellaneous	Kitchen ***
SPACES	Clinic		Entrance	Kitchen *****
	Nursing house		Reception	Desk
	Hospital		Core	Hot desk
	Theatre		Primary Circulation	Touch down desk
	Cinema		Basement	Quiet working area
	Museum	Open plan space	Externals	Meeting area (2-4 persons)
	Gallery		Bedroom	Meeting area (4-8 persons)
	Library		Academic	Meeting area (8-12 persons)
	Sport centre		Administration	Meeting area (12-16 persons)
	Recruiting Offices		Aerobics studio	Meeting area (16-24 persons)
	Stables		Anteroom Areas	Resting area (4-8 persons)
	Petrol station		Bathroom	Resting area (8-12 persons)
	Public Toilets		Cold rooms and freezers	Resting area (12-16 persons)
	Crèche		Concessions	Resting area (16-24 persons)
	Public house		Dining Room	Conference room (15-20 persons)
	Recording studio		Main Hall	Lecture room (50-100 persons)

ENTRY TO THE DECISION-MAKING FRAMEWORK

The House of Quality (Figure 1) is the main menu of the database where by clicking on the different areas a user would trigger the required function and open its form. Users start by creating a new project or selecting an existing one and selecting a building space and function.

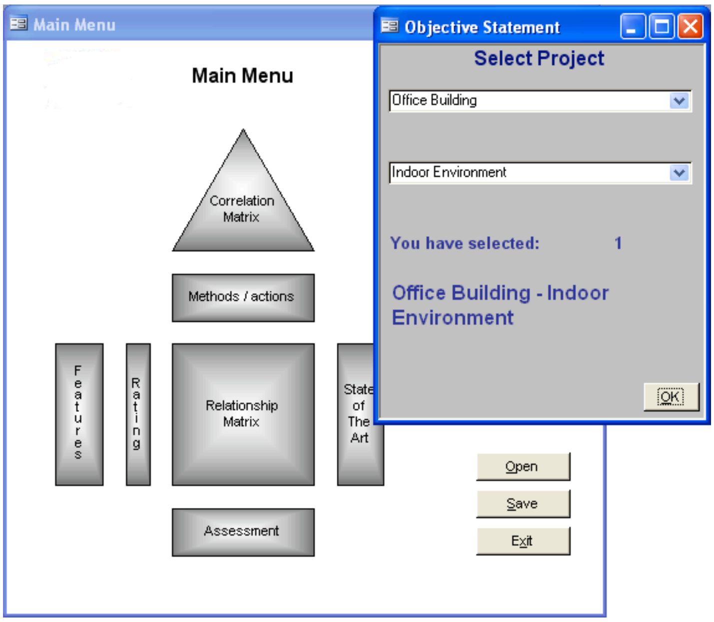

Figure 1: Entry to the system via the main menu

CHOOSING THE REQUIRED FEATURES (FEATURES)

The required indoor environment features are grouped into six performance criteria as follows: spatial performance, acoustical performance, thermal performance, air quality, visual performance and building integrity. Each of these performance criteria is defined by physiological, psychological, sociological and economic needs. Users can select, deselect or add new features to the default list of features. When the user clicks on a feature a relevant list appears, on the right hand side of the form, of links to pages that provide information from relevant literature and websites. Through the links the user can surf these websites to build their knowledge base. They will be in a better position, when their knowledge is enhanced, to make informed judgements and selections. The normal practice of setting requirements is that all relevant people meet together and develop the list of requirements. The decision support tool in this case not only facilitates the process, but can set an order. It also becomes the record of the discussion and agreements. Agreement is reached by consensus and the advantage of this tool is that all can be informed of the current state of knowledge via the website access, whatever their background, so ensuring a fully informed decision process.

RANKING THE REQUIRED FEATURES (RATING)

Once the required indoor features are identified, an importance rating is set for each feature. The importance rate is set on a five-point scale from very low to very high. The ranking is subjective and will vary according to the user's perceptions and criteria. This step requires consensus from those taking part and it is not a ranking of order but a reflection of the importance of each aspect in the final solution. Again when a feature is selected, the relevant list of links appears at the bottom of the form so that the user can always access more information or refresh their previous thinking.

The text box to the bottom right of the form is refreshed each time the user clicks a feature. This is to record the reasoning behind the decision-making and is collected in a data base to produce the reports and can be used to develop the performance specification.

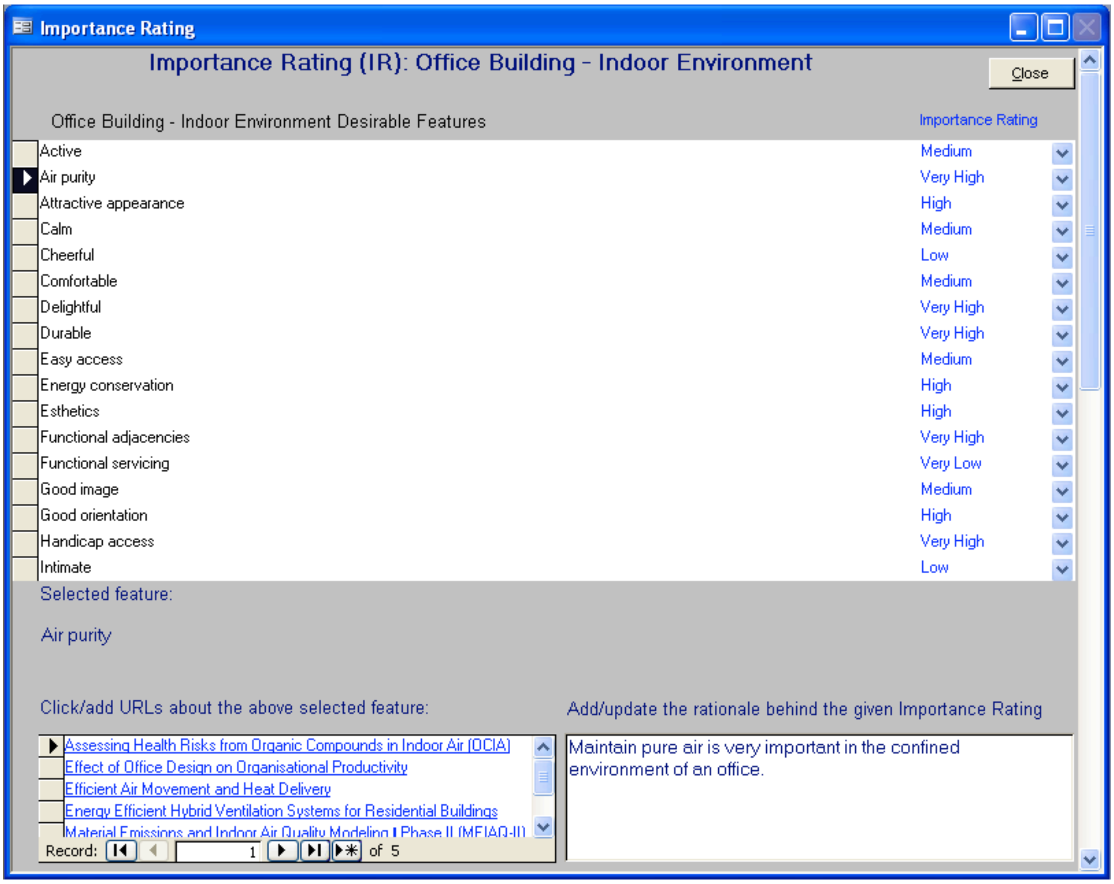

Figure 2: Rating the Required Features

SELECTING ACTIONS TO MEET THE REQUIRED FEATURES (METHODS / ACTIONS)

For each of the required features selected above there will be number of ways of providing a solution in terms of actions. These actions form the basis of the performance specification. The user chooses the actions by clicking on the selection box. Again when an action is selected, the relevant list of links appears at the bottom of the form so that the user can always access more information or refresh their previous thinking.

The relationship matrix allows the user to determine how well each of the actions that have been selected meets the criteria of each required feature (see figure 3). For each feature selected in the left of this form the list of selected actions appears to the right of the form so that a row in the relationships matrix is established. The strength of the usefulness of the action is expressed by (scale 0 is weak through, 1, 3 to 9 as very strong). The strength of the relationship between the features and the actions is subjective and according to the user's understanding of the issues. By double-clicking on a feature or an action, a pop up window appears to show the relevant list of links to literature and websites. In the text area labelled "Rationale", users record the decision-making reasoning for the strength given to the relationship between each feature and action to help managing the evaluation and feedback process.

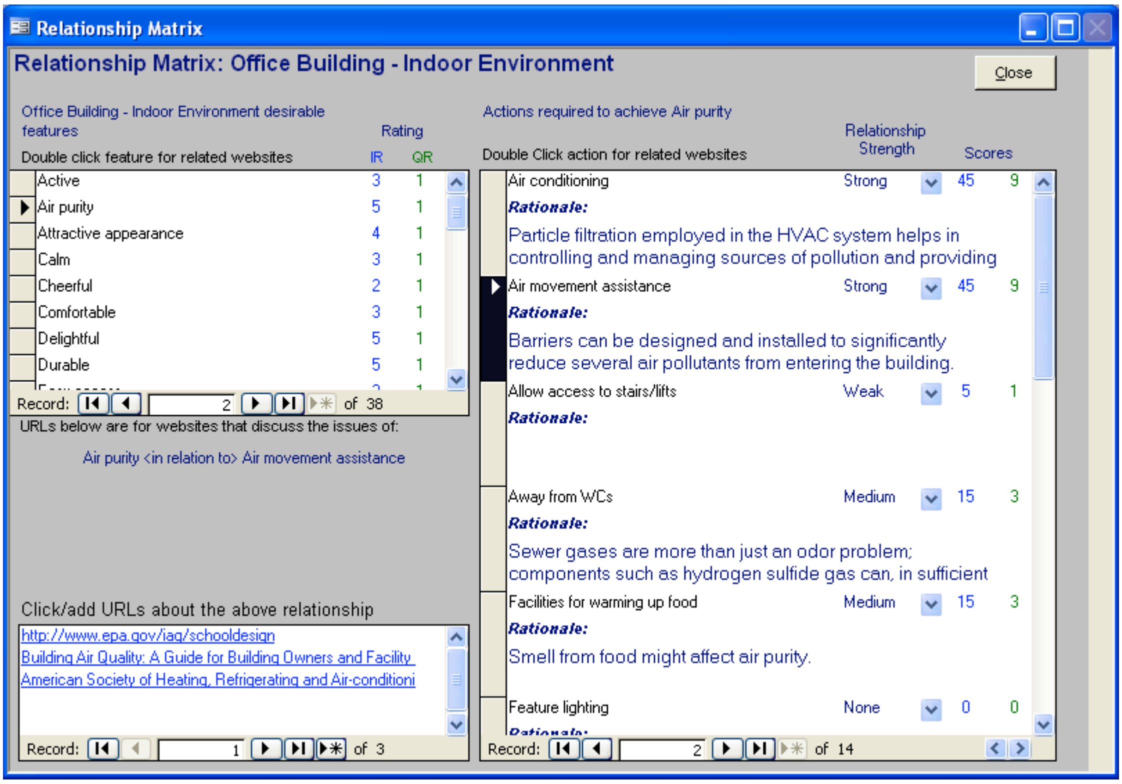

Figure 3: The Relationship Matrix

CORRELATION BETWEEN ACTIONS (CORRELATION MATRIX)

A Correlation Matrix is also available and indicates where there is either support from the actions working in concert with each other (the positive relationship) or where they are in conflict with each other (the negative relationship). For each action selected an identical list of the selected actions appears to the right of the form so that a row in the correlation matrix is established. Correlation strength could be in the range of: 9 = Very Positive, 3 = Positive, 0 = Neutral, -3 = Negative or -9 = Very Negative.

RESULTS REPORTS (ASSESSMENT)

The selected actions are scored in order to assess their feasibility and their importance in delivering the features to the required quality. Therefore, actions are scored taking into account the strength of their relationship to the required features and the feature's importance and quality rates. Actions are also scored according to their feasibility taking into account their correlation strengths. The Assessment Report (see figure 4) displays the actions in the order of their scores. The actions with highest importance scores and lowest feasibility rate are displayed first as these are the most problematic situations, which need more attention so that trade offs could be made and the conflict resolved.

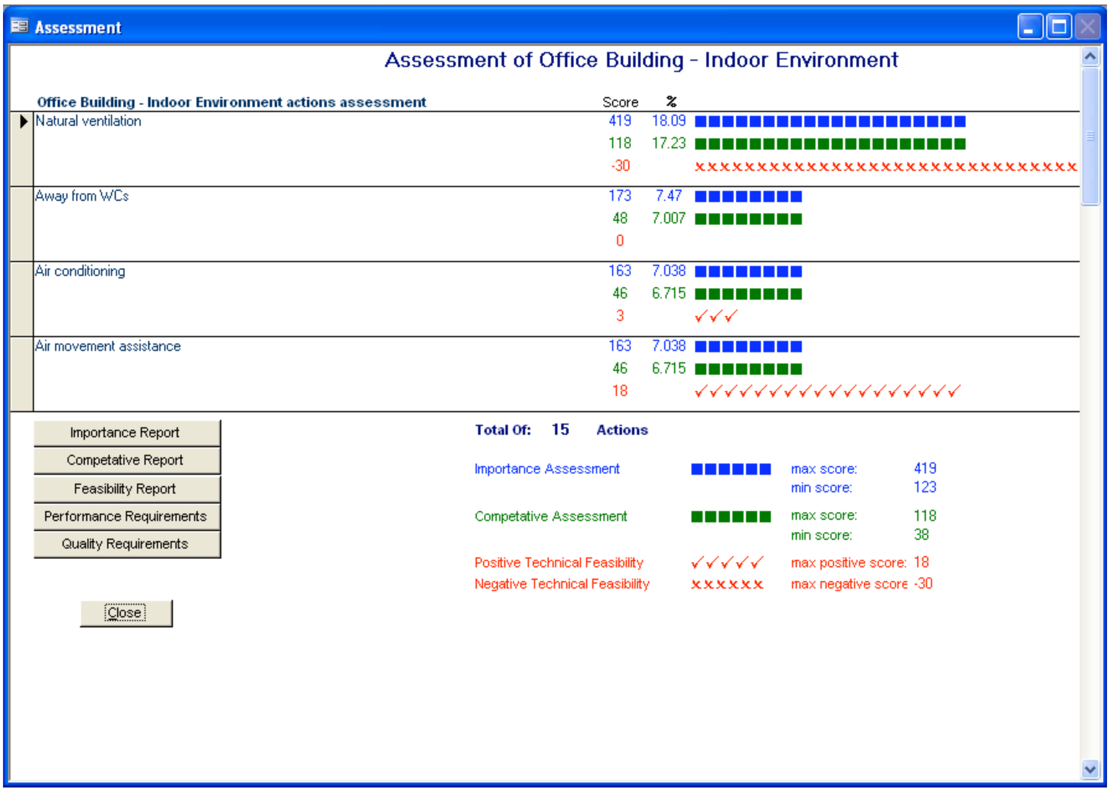

Figure 4: The Assessment Report

Five detailed reports can be viewed or printed:

Importance assessment report: Actions are scored taking into account the strength of their relationship to the required features and the features' importance rates (see relationship matrix above). Actions are listed in descending order of their importance scores and grouped with features that produce 45 importance points, i.e. very important feature with very strong relationship to the action in consideration.

This report shows as well the decision-making reasoning behind the high score of each relationship that was recorded in the text boxes of the rating form and the relationship matrix, i.e. why a feature is very important for the user (score 5) and why the relationship between an action and a feature is very strong (score 9).

Quality assessment report: Actions are scored taking into account the strength of their relationship to the required features and the features' quality rates in the relationship matrix. Actions are listed in descending order of their quality scores and grouped with features that produce 45 quality points, i.e. very high quality feature with very strong relationship to the action in consideration.

This report shows as well the decision-making reasoning behind the high score of each quality relationship that was recorded in the text boxes of the benchmarking form and the relationship matrix, i.e. why a feature has a high quality standard requirements (score 5) and why the relationship between an action and a feature is very strong (score 9).

Technical feasibility report: Actions are scored according to their feasibility taking into account their correlation strengths (see correlation matrix above). Actions are listed in ascending order of their technical feasibility and grouped with actions that have -9 very negative correlation.

Performance requirements report: Features are grouped and listed according to their importance rating starting with the very important features (score 5). This report shows as well the decision-making reasoning behind the ranks given.

Quality requirements report: Features are grouped and listed according to their quality targets starting with the very high quality features (score 5). This report shows as well the decision-making reasoning behind the selected quality standard.

CONCLUSION

QFD is a very powerful tool but needs to be modified and developed to meet the specific needs of construction briefing. This application has provided the necessary developments by taking a user perspective and providing information to meet the weaknesses in the existing methods. By adding access to information outside of the system through the WWW the user can be better informed. As advances in knowledge searches become available these could be substituted for the current links then the user could have automatic access to relevant information. The user can therefore provide a value judgement in terms of prioritization of their requirements. This can be cascaded down through levels of design process and the basis of the decision can be recorded, not only in numerical terms, but also in supporting text that describes the context and thinking behind the decision. This is probably the most useful feature as the majority of briefing decisions are subjective.

In conclusion this version of QFD brings structure and support to an often confused process of building briefing, a continuity of memory of the progressive development of the brief, a record of the decision and its context as well as a method of informing the user of leading practice via the WWW.

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