Construction Collaboration: A QFD approach

By

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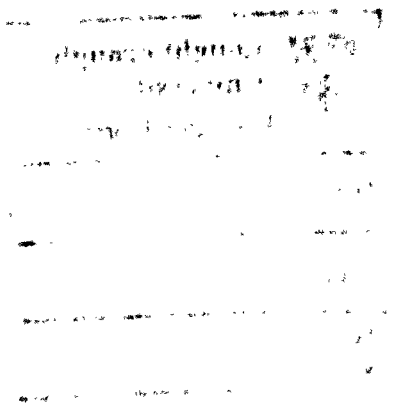

ABSTRACT

The UK Construction industry is a wide ranging complex environment with constantly evolving cultural, technical and organisational dynamics.

Collaboration systems are used within that environment to store information and aid construction professionals in dealing, manipulating and completing information vital to projects. There are many collaboration systems available to the construction market, but most are based on versions used in other less similar industries. As a result though the software packages available to work at a level acceptable to the major construction contractors, they are not fully satisfying the customers need. The quality of the software available currently could be improved.

Quality Function Deployment (QFD) is a Japanese product development tool developed in the 1960s. It is a quality system for strategic competitiveness; it maximises positive quality that adds value; it seeks out spoken and unspoken customer requirements, translates them into technical requirements, prioritises them and directs the process to optimise those features that will bring the greatest competitive advantage. QFD has been applied largely anonymously to software in the United States of America, and sparingly to construction within the UK.

Blitz QFD is a form of QFD that focuses specifically on the essential quality items of the customer. This method could be implemented within the construction industry creating a fully auditable transfer of customer needs to essential software design features. Blitz QFD would be a valuable development methodology in a construction industry that demands faster, user focused project collaboration software where the user's needs are not currently being satisfied.

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1.0 INTRODUCTION

Information technology has been widely applied across many economic sectors in order to increase competitiveness and reduce costs. The Internet has revolutionised the way in which information is stored , exchanged and viewed. It has opened up avenues for businesses, which were almost inconceivable. Recently many organisations have recognised the possibilities for increased productivity through the deployment of focused IT systems and have monitored the different developing information management philosophies.

This sudden recognition of the need to adopt new measures has had some immediate consequences. There has arisen a need for businesses to shift from their traditional, tried and tested methods and to radically alter these methods to embrace new technology. Such changes can prompt businesses to improve traditional business processes, innovate their products and services, and develop strategies that are flexible to incorporate new technologies as and when they emerge.

Collaboration is an idea that continues to develop and evolve at a fast pace. Within construction, software has been used to assist the construction process, but generally in a singular and disjointed manner. The 'user's voice' is not being captured from the construction organisations and then developed and embedded into the final product. Sectors other than construction have also faced similar problems as they strive for more efficient business processes; this has led to an array of business improvement techniques, tools and philosophies. These have been tried in some areas of construction but largely without success *(Fermi, 2005).*

Similarly the Egan report identified several problems with the construction industry:

- Under-achievement of the industry as a whole;
- Unacceptable level of defects;
- Lack of predictability within the industry as a whole;
- Lack of contractor profit;
- Need for customer feed-back;

- Lack of investment in capital, research, development and training; and
- Level of dissatisfaction amongst the industry's clients.

He identified four key drivers for change which would improve the industry:

- Committed leadership;
- A focus on the customer;
- Integrated processes and teams; and
- A quality driven agenda and commitment to people (Egan, 1998).

Four of the seven problems identified by Egan relate directly to understanding and delivering exactly what the client, or the customer, wants. It is a major problem within the industry and will not resolve itself. The four key drivers for industry change that Egan stated would help solve these problems demand a better concerted effort to working together and focusing on the customer and producing a product with assured quality.

Construction contracts exist because of the need to avoid risk, and have a clear train of responsibility for each of the construction participants. The basic disposition of risk on general contracting is extremely important *(Murdoch and Hughes, 2001).* The most important areas are:

- Money: The client is entitled to expect the building to be completed on time. Failure to achieve this would render the contractor liable to pay liquidated damages. These sums could be critical to the continuing survival of the client's organisation
- Default: The risk of default lies with the contractor. All work must comply with the contract documents. The contractor is responsible for the performance of every person on site, whether directly employed, sub contracted by the contractor or nominated by the client.
- Completion: This concept relates not to when the building is finished, but refers to when the contractor is entitled to leave the site and hand the building over to the client. This does not relieve the contractor of the liability for what

has been built, but rather imposes an obligation on the contractor to repair anything that may become apparent during the defects liability period

- Time: One of the main requirements, particularly of commercial clients but also equally important for public sector agencies, is to be able to predict the time for competition with some degree of accuracy essentially because buildings form very large parts of any client's investment in their business.
- Quality: There are many organisations looking to register with the British Standards Authority to become accredited firms under BS5750 or ISO 9000. The problem lies in that the standards define quality as 'conformance to requirements'. This means that if a client requires a cheap and nasty installation, and the contractor provides it, then conformance to the standard has been attained, but not necessarily the quality, hence disagreements can occur *(Murdoch and Hughes, 2001).*

In allocating a risk, the construction parties are concerned with the eventual payment and responsibility for the cost of the event, should it happen. The main issue regarding contractual risks is that the contract apportions these between the parties. Even if the contract is silent on a particular risk, that risk will still lie with one party or the other. The contract may also seek to transfer a risk by making one party financially liable should the eventually take place *(Murdoch and Hughes, 2001).*

This risk avoidance that is inherent in construction is one of the main factors that lead to adversarial relationships within the construction industry and between its clients. These adversarial relationships that result reduce the effectiveness of multi organisation communication, and satisfaction resulting from poor collaboration between partners. As a result many clients may find their voice unheard or ignored during the completion of construction contracts.

One technique which has potential to capture 'the customer's voice' is QFD. This thesis sets out to investigate the applicability of this technique to the early stage development of collaboration systems within construction, and as a possible solution to other construction industry problems.

1.1 Quality Function Deployment

Quality Function Deployment (QFD) is a quality system focused on delivering products and services that satisfy customers. To efficiently deliver value to customers, it is necessary to listen to the "voice of the customer" throughout the product or service development process. QFD has many different methodologies mixed in with different industry's culture and practices, from the use of the 4 phase ASI (American Supplier Institute) method of 4 houses of quality in manufacturing to quality control process charts and multiple deployment tables used in Service industries. Some major world organisations that use QFD are: 3M, Accenture, Boeing, Ford, IBM, Intel, Lockheed Martin, Microsoft, Motorola, NASA, Pratt & Whitney and Toyota *(QFD Institute, 2005).*

QFD was developed to bring a personal interface to modern manufacturing and business. It helps organisations seek out both spoken and unspoken needs, translate these into actions and designs, and focus various business functions toward achieving this common goal. QFD is designed to empower organisations to exceed normal expectations and provide a level of unanticipated excitement that generates value.

The QFD Institute defines QFD as *(QFD Institute, 2005)*:

1. Understanding customer requirements;
2. Quality systems thinking, psychology and knowledge/epistemology;
3. Maximising positive quality that adds value;
4. Comprehensive quality system for customer satisfaction; and
5. Strategy to stay ahead of the game.

QFD is used extensively in North America and Japan in manufacturing, with many uses now being seen in the services industry. QFD philosophies for developing software have been developed in the USA and applied on a limited scale. QFD used in AEC in the UK has been theorised within a limited number of published papers, but only applied in the manufacturing form on a few occasions.

1.2 Research problem

The construction process is an information intensive one during which huge amounts of information is generated and consumed by all professionals involved. The common types of information include site survey, cost analysis, design drawings, specifications, regulations, bills of quantities, project planning, job costing and estimates, etc. *(Duyshart, 1997).*

From the inception of the construction project through its design, construction, mobilisation, and operation, all parties involved with the project are dependent on information. The information may be commercial, such as a purchase order, financial, such as an instruction for payment or technical, such as graphical information on a drawing *(Cranfield School of Management, 1993).*

Over the last 30 years, the problems of information production and management have increased markedly along with the growing complexity of construction projects. Software vendors have proposed numerous tools to support the production and maintenance of information at a basic level (drawing editors, word processors, spread-sheet editors etc.) Such tools provide many helpful facilities, but they rarely handle any semantic aspects of the information being processed and in doing so, limit themselves in their support to the end user and promote information fragmentation/overload.

Any investment within any operating concern has to be financially viable by ultimately improving the performance or profitability of the organisation. The problem is that collaboration software for construction is costly and forces organisations to make strategic decisions on what to automate, how to automate, and when to automate or to leave it completely *(Marsh and Flanagan, 2000).*

In considering an IT investment within a construction organisation, or indeed within any organisation, consideration has to be given to costs, technical issues, means of implementation, risk assessment, procurement strategy and the likely benefits that will result. Typically, the benefits that will result are the most difficult to measure

(Andresen et al., 2000). Since the late 1960's, there has been a recognition that investments in IT are difficult to evaluate. Evaluation, considered difficult in the data processing era, has become even more problematic in the "information age" as IT systems have grown from those designed to perform specific tasks, i.e. those such as payroll, to those which extend across business processes and organisations. Viewed another way, the development of IT usage has moved from a purpose of aiming to automate processes to informate processes, to transformate processes.

The difficulty in evaluation centres on the fact that costs - particularly intangible costs - and benefits are difficult to quantify. In addition, there are usually always hidden costs and benefits, and the rapid change of pace in IT causes serious starting problems for any large investment *(Andresen et al., 2000).* Some construction organisations use evaluation techniques as a "ritual of legitimacy" and are considered as being more costly than the value that they generate *(Andresen, 1999).* This is also a significant argument that such techniques are only used to support business directions that have already been made.

A survey conducted towards establishing the attitudes around the application of data capture technologies among UK construction companies indicated a few interesting points *(Marsh, Flanagan, 2000).* The major barriers included a general lack of awareness about the technologies, coupled with an uncertainty about how to identify and measure potential benefits. Marsh and Flanagan go on to say that the problems of identifying benefits of IT investment are not unique to the construction industry. It is a problem experienced in all types of business sectors and organisations. The reason stated for the problem being accentuated within the construction sector is the industry's structure, fragmented supply chain and under capitalisation *(Marsh, Flanagan, 2000).*

Another area of difficulty is that not all organisations face an identical challenge. Their business sectors differ, the competitive forces they combat differ, their histories are not alike and they make different strategic choices. This can be amplified in the construction industry because the process is so complex and fragmented. In addition, construction organisations must be able to evaluate where in their evolution of IT developments they stand to ensure that they are able to make and manage the

appropriate degree of strategic change *(Andresen et al., 2000).* Where the construction industry fails is in not considering the implementation of a new system and when implementing that new system not understanding whether the organisation is seeking efficiency (productivity), effectiveness or overall business performance benefits, or a combination of these.

Most construction projects are organised as networks of supply and distribution organisations that procure raw materials, transform them into immediate and finished products, and distribute the finished products to customers. The simplest network consists of one site that performs both manufacturing and distribution. Most complex networks, such as those required to manufacture prefabricated window systems, span multiple sites that may be scattered around the world. We call these networks supply chains *(Lee and Billington, 1992).*

The construction supply chain also has barriers to investing in IT systems. 96.7% of firms employ 25 people or less and only 60 firms employ more than 1200 people *(Pottier, Achur and Price, 2005).*. Small to medium enterprises (SMEs) do not have the capital needed to implement electronic commerce technologies to support their business and project activities *(Anumba and Ruikar, 2001).* Payback from investing in such technologies can extend beyond a 12 month period. Consequently, the money invested for initial set up becomes dead investment for this period. Most SMEs are unable to sustain this investment. Essentially this means that the majority of the supply chain does not have ability to sustain any sort of IT investment, which would in turn benefit the overall productivity of any construction process they are involved in.

1.3 Research Aim and objectives.

The aim of this research is:

To determine whether Quality Function Deployment can be used to develop more user focused Collaboration systems in the Construction Industry.

To achieve this, this aim has been broken down into smaller objectives:

1. *To define a collaboration system and how is it used within a construction organisation?*

2. *To investigate and document the previous usage of Quality Function Deployment as a project management tool in its classical sense, software development form and how it is applied (if applied) in construction in general.*

3. *To evaluate the current Collaboration systems used within the top UK construction organisations, and to what extent are they used?*

4. *To develop a user requirements specification using QFD for a construction collaboration system, and assess QFD as a development methodology.*

5. *To assess QFD as a development methodology for construction collaboration systems*

1.3.1 Brief methodology

A thorough literature search will be conducted sourcing articles from international journal publications, books and conference papers. The main body of information collected within this thesis will be done through interviews. The interviews used to collect the information about the current collaboration systems in the UK construction industry will use a structured format to ensure equal comparison between the top 20 contractors interviewed.

For the QFD project in objective 4, unstructured interviews will be used to gather the information for the QFD process. Certain themes of information will be open for discussion within a time constraint with the aim of the interviewee leading the interview. The information gathered will be filtered through the 8 stage QFD process leading to a Collaboration system specification. That 8 stage QFD process will include the use of affinity diagrams, hierarchy diagrams, analytical hierarchy process and fishbone diagrams to manipulate the information and derive a specification. The

users themselves will also involved in processing their own information in the 8 stage QFD process.

1.4 Chapter Conclusions

The failure to identify and measure the full impact of IT within construction results in viable applications being erroneously dismissed as uneconomic. The potential application of IT can only be made when an informed decision regarding all potential costs and benefits associated with its application have been identified and quantified. In turn, this requires an understanding of the mechanisms through which IT influences the construction process, a detailed examination of the process the IT users complete.

The construction industry has an "arms length relationships" culture with other organisations that does not encourage unnecessary risk. For the most part, construction projects are teams from different organisations that are formed for the duration of the project and these last only as long as the project itself. The nature of their temporary relationship provides little incentive for investing in innovative technologies such as collaboration systems.

The vast majority of firms in the supply chain cannot sustain any sort of investment in IT, therefore any improvements to productivity as the result of IT implementation within the supply chain are hindered. It seems that the only manner in which the supply chain may improve productivity through IT is for the development costs of IT to be negated through continued development in cost effective flexible applications, like for instance, the Internet.

A solution to these problems is the ability to guarantee and deliver precise software systems/services to construction clients that do deliver value for money and provide tangible benefits to the users. QFD has a proven record of doing this in other industries in many different countries, but not within construction industry software. This thesis attempts to use QFD to develop a software requirements specification for a Construction Collaboration system.

1.5 Guide to this thesis

Each chapter of this thesis is presented as a discrete element of research. They are laid out in the same sequence as the line of enquiry followed for the entire project. Each one starts with a brief introduction as a navigational aid and concludes with a summary. These are provided for those readers who do not require the greater detail provided within the main part of the text. All references throughout each of the chapters can be found in the reference section at the end. An appendix section is used to contain much of the QFD process paperwork/tables used throughout the thesis. As such the QFD process chapters (6-7) will reference the appendices extensively.

Chapter one, 'Introduction', provides the reader with a generic background in the area where the thesis specialises. It also gives the main actions/aims of the study and provides an entry into the more detailed aspects of the thesis.

Chapter two, 'Research Methodology' provides an overview of the whole of the research as a further navigational aid to the thesis. It also describes the research methodologies used in each element of the work.

Chapter three, 'Information management in construction', profiles basic information management techniques and principles across different industries, focus's on information management strategy within constriction and then details the use of collaboration systems within the construction industry.

Chapter four, Quality Function Deployment, introduces QFD to the reader. It defines the background and development of QFD in its main conventional forms of manufacturing and service industry, describes its evolution within software development and searches for any previous applications within construction.

Chapter five, 'Current status of information management within construction', outlines a survey conducted examining the use of collaboration systems in the top 20 UK construction contractors. It also contains soft information regarding those systems implementation and success.

Chapters six and seven, 'QFD project stages 1-4' and 'QFD project stages 5-8', document the QFD project split into two sections. They present the project in a linear succinct manner consistent with the methodology.

Chapter eight, Conclusions and recommendations, sets out the inferences gained from the study, both of the QFD project and the application of QFD in developing a specification for a construction collaboration system. It also presents the results of a meeting with a top construction industry collaboration developer and their assessment of the QFD technique and its results.

The Appendices contain many of the excel files too large to include within chapters six and seven. These files will be minimised to fit within an A4 sheet.

2.0 INFORMATION MANAGEMENT IN CONSTRUCTION

2.1 Introduction

The nature of the AEC Industry is that of a collaborative activity involving multi-disciplinary teams, including the client, architect, engineer, consultant, and contractor. Each member of the team is responsible for certain aspects of the project. The different team members use their own unique processes to undertake their tasks, but inevitably, they rely on information supplied by others. Latham identified improving the communications link in his report Constructing the Team and stated that it was "crucial to further efficiency gain in construction" *(Latham, 1994).*

2.2 What is information and why is it important?

Information is an artefact, a way of describing the significance to a person of intrinsically meaningless events *(Dretske, 1981).* This information is then turned into knowledge through the investment of stimuli.

Take for instance a gifted Architect. This Architect could write a manual, an instruction for designing structures, but reading that manual would not make anyone an Architect. That is one of the differences between information and knowledge. The manual contains information, but knowing how to design a complex structure requires more than the instructions.

This is just one of many ways of thinking about information. It rests on the distinction between information and knowledge. Once this distinction is clearly understood, an individual or organisation is free to think about information, not knowledge, as an objective commodity, something whose generation, transmission, and reception do not require or in any way presuppose interpretive processes.

Modern interpretations of where information sits are all very similar. Figure 2.1 shows this theory.

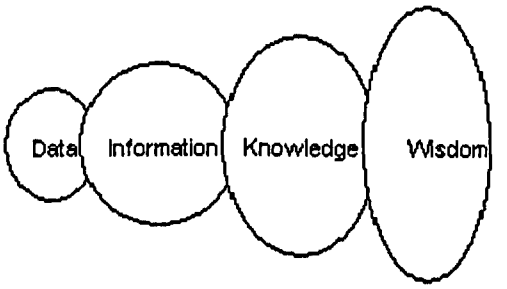


Figure 2.1 The value added hierarchy *(adapted from Cimtech 2002).*

2.3 Information management within construction

It is recognised that the modern AEC industry has more diverse types of participants than many other business sectors *(Duyshart, 1997).* Therefore we can state that the information types used throughout the construction process are as diverse as the process itself.

"...document management is a misnomer, a term of convenience, a link with the past. You should really think of document management as electronic transaction management" *(McKie, 1995).*

The aim of Information Management is to create an environment within which disparate forms of information can be linked together in the context of a project or organisation to achieve easy access and control *(Sun and Aouad, 1999).* The essential Information Management functions in AEC are the following:

- the system must allow the efficient location and delivery of documentation;
- the system must have the ability the manage documents and data regardless of the form from the original system or form;
- the system must have the ability to encompass and integrate with existing computer or paper based systems in the context of a construction project;

- as well as the previous, the system must control access, distribution and modification of documents, with the ability to mirror existing company procedures;
- the system must have the provision of tools to edit documents and add mark-up information whatever the source of the document *(Sun and Aouad, 1999).*

Essentially, the following list comprises the general advantages of using a correctly selected Information Management system for AEC projects

- Elimination of the need to pre-print forms;
- End to the need to transport and store blank forms;
- The saving of multiple data entries from being made throughout the organisation;
- The saving of the cost of transporting copies of the completed form to multiple destinations;
- Saved time in filing and retrieving the form;
- Faster searching through multiple records;
- Elimination of the use of expensive floor space for paper files; and
- The creation of a better records management system for long-term retention.

2.3.1 Information management strategy in the AEC industry

Many believe that more efficient information management within the AEC industry is a primary mechanism for increasing its productivity *(Egan 1998).* Indeed many think of the industry as backward in deploying technology, and that the application of IT has been piecemeal and only very few contractors have a comprehensive and integrated information system for its core business *(Mak, 2001; Marsh and Flanagan, 2000).*

Although there is growing interest in the role of innovation within the AEC sector and the diffusion of innovation within and across construction organisations, there has been little consideration of IT implementation in this context *(Whyte et al., 2002).*

The key to information strategy within the AEC industry is investment justification, or rather, the lack of it. The reason for this is that both business and project activities need to be costed. Even experienced accountants are often stymied by the problems they face when it comes to recording and calculating the costs of IT *(Love and Irani, 2001).* The result is organisations in the AEC industry that have little knowledge of how to evaluate both their future IT investments and their current IT systems *(Andresen, 2002).*

The combination of the above result in construction projects with software systems that are perfectly good in a generic sense, but whose systems are ill equipped to leverage support to the construction end-user and the project team to enough of an extent to contribute a good return on investment. Problems such as lack of clear audit trails, on-site versioning control, interoperability between software systems, quality of information, and information overload result.

2.3.2 Problems effecting Information Management in AEC

Effective Information Management can be looked upon and used as a strategic weapon *(Earl, 1989; Porter and Millar, 1985).* A multi-national, cross sector study conducted by Unisys shows that construction does not lag behind other sectors in its implementation of IT systems, but does in the impact of IT to its business *(Unisys, 1996).* 78.9% of those who responded to the survey within AEC felt that IT does not allow profit generation, against an average of 54% for senior managers within other industries answering the same question.

"The opportunity for a big-bang in construction exists. Our problem is not the lack of technology but more a lack of awareness of how to exploit it." *(Atkin, et al.1999).*

A survey based on interviews of more than 200 managers and heads of IT departments in some the UK's leading organisations (manufacturing & retail) supported the need for organisations to develop a "Corporate Knowledge Management Strategy" *(Allcock, 2002).*

Users of information management software were asked how long they spent on an average workday retrieving documents they had written or a colleague had sent them. 60% said they had wasted an average of a quarter of an hour per day searching for the information they required, 15% spent an average of 30 minutes per day, 7% spent an hour or more. For UK organisations this equates to £17bn annually wasted by companies navigating the information "black holes" *(Allcock, 2002).* The uptake and use of Information Management technology within the AEC sector is much lower than manufacturing or retailing. Therefore the figures quoted above are a better representation of what would be found within AEC.

2.4 Types of information and documents used within construction

Information within construction is usually given the autonomous label of a document. In terms of modern information medium development this term is obsolete, but since this is the common standard, understood and qualified across the industry, it is the term of choice in defining the existing standard.

Construction Information can be split into four categories:

Project Documents: These documents may be organised under the four main stages of a project, namely: Pre-design, Design, Contract and Contract Administration.

Office Management Documents: These include Quality Management, General Office, and Archives. Encompasses documents which are used in day-to-day management and operation.

Communication Documents: Drawings Letters Memos, and Instructions.

Reference Documents: these include Standards, Codes, Regulations and trade literature *(Duyshart, 1997).*

2.4.1 Multimedia documents

Information Management systems are designed not to just work with electronic text but can encompass the whole meaning of the "electronic document". Electronic documents can best be described as electronic information objects, which can include any of the following:

- A Word processing document
- A Spreadsheet document
- A Computer aided drafting (CAD) drawing
- A Computer Output to Laser Disk (COLD) file
- A Scanned or faxed image
- Microfiche and microfilm
- Sound file
- Video clip
- Database information
- A sequence of events – workflow

2.5 Underproductive information management.

In the business environment, the analysis of specific business processes as information systems has led to a wider recognition of information as a resource. This view has been promoted in some quarters of management education. There has been a reorientation of teaching concept from management information systems technology to management of information in general *(Middleton, 2002).*

2.5.1 Information overload

There are three terms that have been used to describe Information overload in current literature. These are, data smog *(Shenk, sited in Edmunds and Morris 2000),* analysis paralysis *(Stanley, Clipsham, sited in Edmunds and Morris 2000),* and information fatigue syndrome *(Oppenheim, sited in Edmunds and Morris 2000).* Information overload is frequently mentioned in the literature of a range of disciplines such as

medicine, business studies, and the social sciences, and the social sciences, as well as in computing and information science. It has rarely been mentioned within the AEC industry. Information underload is exactly the opposite; organisations are capturing so much data that it is increasingly difficult to extract any meaningful information from it.

2.5.2 Information overload survey

In 2003 a study was conducted as part of this research investigating information overload in construction project teams. 60 project team members from 17 projects totalling £953 million where interviewed.

The main findings of this study were:

- 60% of Project Managers surveyed directly admitted to experiencing information overload.
- 87% of Project Managers believe that they work regularly work with colleagues who are information overloaded.
- Overall 38% of all personnel surveyed admitted to experiencing information overload
- In comparisons to other research of the same topic in other industries, the results indicate the Construction Industry has a substantially greater problem with Information Overload

The results suggest that the Project Managers on the sites are acting as a filter to most incoming information on-site. They collect the non-specific information and then distribute it accordingly. Those who admitted to experiencing information overload received a greater amount of information than those who disagreed. This correlated with the Project Managers receiving a relatively large amount of information, compared with the overall values. These amounts are not of substantial value to display an individual reason for information overload, but provide a demonstration that the volume of information is only part of the problem.

In the same way that many organisations seem to ignore the Information in Information Technology when buying solutions, the Information in information overload does not simply mean volume, but many dynamics, some of which are extremely difficult to measure and change on a rapid basis. The key issue that must be described is a detailed examination of the information process within construction projects, and the reaction to that information flow affected by the users. Information Overload is not the problem; it is only the result of many problems.

The Architecture, Engineering, and Construction industry is an information intensive industry. So much so that information overload is common and increasing in many key areas. The result of information overload is stress, poor decision making, bad moral, and an overall negative impact on an individual's performance. There are many other reactions and results of information overload, many having yet to be measured.

Technology is constantly changing, but human nature is not. Therefore IT and Information Management Systems (including collaborative systems) need to be better designed and facilitated around the construction professional and not just the processes are needed to minimise impact of information overload. Additionally, more focused training and support on this issue needs to be implemented so that the individual/Project Director can identify the symptoms and effect change. Above all, the impact of information overload on AEC operations and its effects has to be identified as a problem by AEC organisations.

2.6 Types of solution/system documents

There are many different types of information management systems available to the construction industry across different industries. Table 3.1 presents a taxonomy of the main solutions. There are many definitions for each of the specific software/disciplines available across different industries, adding to the potential confusion to a non IT literate organisation.

Table 2.1 Taxonomy of Information management

Information management system	Definition
Records management. Known else as: RM, ERM, ERMS	A record is evidence of an activity or transaction, and demonstrates accountability. Records are created by the day to day activities that take place in organisations and government. They need to be captured, managed and safeguarded in an organised system in order to retain their value. With the rapid shift of paper to electronic processing and net-based solutions there is going to be a greater dependence on records management *(Waldron, 2002).*
Enterprise Relationship Management, (ERM)	Enterprise Relationship Management (ERM) is software that analyses data it has about an organisation's customers to develop a better understanding of the customer and how the customer is using its products and services. This kind of application may use data mining of its data warehouse or existing sales, marketing, service, finance, and manufacturing databases to generate new information about its customer relationships *(SearchCIO.com, 2002).* Enterprise Relationship Management is the integrated information system that serves the "front office" departments within an organization, which are sales, marketing and customer service *(TheSupplyChain.com, 2002).*
Electronic Document Management System, (EDMS)	In 1989 most of the information management systems available were called DIP (document image processing) because they held static documents as fixed images. The leading systems were then developed to manage both scanned images of paper documents and digital documents created on a range of PC application software including text documents. These more flexible systems were designed to manage active, changing documents as well as static images of existing documents and were referred to as Electronic Document Management Systems (EDMS), or just document management systems *(Hendley, 2002b).* At the time these systems could be divided into simple systems capable of managing documents as single files, and more sophisticated systems capable of managing compound or complex documents made up of components or a range of content files. A compound document management system would manage a compound document as a container document plus a number of component content files where each content file may have been created on a separate application and would have a separate identity *(Hendley, 2002b).* EDMS focus on facilitating the management of documents pertinent to particular enterprises, projects and work groups in computer networks and treats the document as a black box as they are shuffled around *(Bjork, 2002).*

	Early EDMS used dedicated networks and user interfaces. It was often very difficult to get hardware infrastructure in place. Since the proliferation of the internet in the second half of the 1990's almost all EDMS have migrated to using the general Internet as their physical network, web servers as storage medium and web browsers as the user interfaces *(Bjork, 2002).*
Content Management (CM)	EDMS is concerned with the external classification of a document, the index fields and keywords chosen to describe it and its relationship to other documents. Content Management goes further by taking into account the internal content of the document, and the metadata associated with it – author, date and time of creation *(Sutcliffe, 2002).* EDMS have evolved into "Content management" *(Sutcliffe, 2002).* Some vendors have achieved this transformation by simply re-badging their products although most have developed genuine added value capabilities that enable further business opportunities to be exploited.
Enterprise Content Management (ECM)	ECM (Enterprise content management) is a market that is formed by the convergence of several existing markets including the document management market, the media asset management market and the web content management market *(Zimmer, 2001).* The AIIM (The Association of Information and Image Management) describe ECM as "the technologies used to create, capture, deliver, customise and manage content across the enterprise in support of the business process" *(Mancini, 2001).* The Gartner group broadens this definition to include archives *(Sutcliffe, 2002).*
Knowledge Management (KM)	KM (Knowledge management) is not a single technology, but a combination of techniques that are drawn together to solve clearly defined business problems *(Howlett, 2002).* Daniel Rasmus of industry analysts Giga Information Group emphasizes the importance of aligning technology to strategic initiatives: "The success of KM depends on the selection of initiatives that align with organisational strategy and deployment of supporting tools and practices in areas that demonstrate a high likelihood of rapid adoption. " *(cited in Howlett, 2002).* KM is the process through which organisations generate value from their intellectual and knowledge-based assets. In the majority of cases generating value from such assets involves sharing them among employees, departments and even with other companies in an effort to devise best practices. It is important to note that this definition says nothing about the technology, while KM is often facilitated by IT, technology itself is not KM *(Santosus, Surmacz, 2002).* Knowledge management deals with the organisational optimisation of knowledge to achieve enhanced performance, increased value, competitive advantage and return on investment,

	through the use of various tools, processes, methods and techniques *(Anumba et al., 2002)* . Content management is the key platform on which organisations are building to develop a corporate "knowledge management" culture. Hence a successful knowledge management strategy depends in part on successful content management because it is the content and the document that packages and effectively delivers useable knowledge edge *(Hendley, 2002b).*
Collaboration systems	Collaboration systems are systems for enabling people to work collaboratively, even when separated by space and/or time. These include systems for audio and video conferencing, application and data sharing, and meeting and lecture recording, summarization, archival, and retrieval. These tools are usually hosted by an Application Service Provider, and being mostly internet systems are often regarded as extranets, or project extranets Solutions can be classified in three categories: 1. Team Communication and Document Management Tools. 2. Work Flow and Process Automation Tools 3. Process and Project Management Tools *(Becerik, 2004).*

An evolution from basic image scanning, through main organisation storage, organisation process management, and then organisation process improvement and finally to corporate information systems can be seen in Table 2.1. These systems represent not only a construction organisation's willingness to explore the possible IT solutions available, but the software development organisations evolving ideas of how IT can influence and drive industry forward more efficiently, and at a better pace.

Table 2.2 demonstrates the methods used to import information onto the system from both physical formats and other IT systems. These techniques can be/are used on all information management systems in Table 2.1.

Table 2.2 Data capture technologies

Data Capture technique	**Method**
Character Recognition	This is the process of automatic "reading" of the scanned data for storage in a computer. Specialised Intelligent Character Recognition (ICR) and Optical

	Character Recognition (OCR) engines can recognise numbers, typed data and to some degree, hand written data. OMR is the process used to detect the presence of indented marked responses.
Electronic Data Interchange (EDI)	EDI systems capture data directly from other systems across private networks or Value Added Networks (VANS). EDI is the computer-to-computer exchange of routine business information in a standard format, normally using a telecommunications network. For EDI to work, the parties using it must agree to the standard format for the information of select from a transaction set developed by a recognised standards body, e.g. ISO. Vendor specifications, CCITT standards, the ANSI X.12 standard, or the United Nations EDIFACT standard may define the form and format of such documents. EDI is also used in general to refer to electronic data interchange.
Fax Capture	Fax Software allows Faxes to be captured and stored as digital files
E-mail and electronic forms	These can directly support data capture in a digital format via the Internet or an internal telecommunications network
Voice capture	Within a construction project, it is common for decisions to be made across telephone lines, with no immediate documentation available to confirm and validate that the decision has been made. Voice calls can be recorded using today's technology, but the barriers remain, like which calls to record and which ones not to record? The system can not tell what are the important calls and which are personal, so it would record all of them, including all personal etc. It also asks the question of would the use of telephones on-site decline if the people knew that they where being recorded? This could have a serious effect of the communication throughout the site.
Bar Codes	Bar codes can be designed into a form and support the electronic identification of the form type as well as other form specific data *(New York state, 2002).*
Scanners	Scanners look and operate much like personal copiers and share much of the same technology. The most common types of files are the following: • PG JPEG (Joint Photographic Expert Group) • PCD Kodak Photo CD • TIF TIFF (Tagged Image File Format) • GIF CompuServe Graphic Interchange Format • IMG GEM Paint • CGM Computer Graphics Metafile • BMP Windows / OS/2 bitmapped graphic Format • MPG MPEG-1 (Moving Pictures Experts Group) and MPEG-2
Image processing	This is the term used for the processing software that is designed to capture digital images of the content of a single page on a document. The focus is on the

	speed of capture and on capturing a true facsimile of the original content which can be used as legally admissible proof if required. This is done through high quality scanning. Preparation is a time consuming activity that must be considered includes unfolding, distilling, guillotining the spines from the pamphlets if permitted, batching up documents and placing barcodes or header sheets at the front of each document *(Hendley, 2002a).* The higher the resolution of the scanner the better the quality of the image. However larger files can cause problems later when it comes to moving it around a network. Many scanners are supplied with built-in image enhancement software to try and improve the quality of images produced from poor quality originals *(Hendley, 2002a).*

The main method for importing documents within a construction project is by scanning paper copies of relevant files and saving them as an image file. All other files can be imported from other file formats into searchable files on system.

2.7 Collaboration

The term "Collaboration system" changes as the technology continues to evolve. Throughout the 1990's huge steps were taken in hardware and software available. Consequently, differing Information Management philosophies have evolved to suit differing industry environments, industry technology and industry processes along with collaboration.

2.7.1 Collaboration software

Organisations across many industries are increasingly no longer seeking specific technology "fixes" such as EDMS. Instead, they are concerned with end-to-end e-business solutions that can completely transform their business models so that they can compete in the digital economy *(Kakabadse, et al., 2004).* The result is a move from a focus on product/service and process innovation to solutions innovation, i.e. the introduction of new solutions that combine product and process supported by the required skills, competencies and capabilities *(Shepherd and Ahmed, 2000).*

The latest development is the collaborations system. A collaboration system is a project extranet/web based technology hosted and developed by an Application Service Provider (ASP) that allows for document management functions on projects across multiple projects/organisations with multiple organisations as primary partners *(Becerik, 2004).* The ASP's involvement with the product does not finish with its sale and therefore is part of the overall product.

The fundamental difference between ASP delivered service and conventional software applications is where each is stored. The internet has made it possible to provide remote services located away from the organisation within the surroundings of the services developers organisation, making servicing, upgrading and customer care of both IT software and hardware part of the service.

It should demand nothing more than a web browser on each device (PC, laptop, handheld, mobile phone, etc.) to access the desired service, meaning the AEC organisation does not pay for the costs and associated costs for the design of the in-house application servers or database servers to support the particular collaboration system *(McKie, 1999).*

The term ASP is a relatively new concept in IT terms but has been made complicated by the media. A good way to understand ASPs is to look at non-IT ASPs, which have been in operation for centuries. A good example of which is a shipping organisation. Instead of maintaining their own distribution networks for packages, organisations pay other organisations a fixed fee to ship a package with the post office, FedEx or UPS. Though shipping is a good metaphor, ASPs are generally referred to as:

"Application service providers (ASPs) are third-party service firms that deploy, manage and remotely host software applications through centrally located services in a rental or lease agreement." *(Ekanayaka, Currie and Seltsikas, 2003).*

Customers of the collaboration software supplied by the ASPs have the advantage of access to technical expertise, achieve cost benefit, and access to better services and new technology at a far lower cost of ownership.

Among other advantages for the customers are:

- scalability of applications over time;
- access to better IT expertise;
- state-of-the-art technologies;
- rapid implementation time;
- reduced downtime; and
- free upgrades *(Tao, 2001).*

Some of the disadvantages of utilising an ASP for collaboration software are:

- ASPs lack customisation of other in-house proprietary applications;
- Various ASP companies have gone bankrupt and others, although still in business, may be experiencing financial instability;
- Speed, bandwidth and reliability issues;
- Infrastructure issues (a company's existing network must be suitable to utilize an ASP); and
- Some ASPs aggregate or broker their services to other ASPs *(Ticehurst, 2000).*

The pricing models of ASPs provide a predictable cash flow because the pricing is typically based on per user per month. It also provides a scalable solution in a market place where rapid changes occur in terms of technology as well as within business *(Ekanayaka, Currie and Seltsikas, 2003).*

There are various types of ASPs available to modern business practices, including but not limited to, the following:

- EASP (Enterprise ASP) provides enterprise-class software and applications such as CRM (customer relationship management) and e-procurement and B2B (business-to-business) exchanges.

- FSP (full-service provider) provides full service systems integration and IT management services in addition to ASP service.

- VASP (vertical ASP) targets a vertical industry such as a financial services industry *(Smith and Rupp, 2002).*

Typical manufacturing or industrial supply chain models do not capture the reality of the AEC industry and its fragmented processes, this added to the complexity of the building process which is difficult for non-AEC observers to understand, means AEC has been slow to warm to the ASP technology *(Unger, 2002).* Another essential difference is that in manufacturing collaboration mainly takes place prior to assembly, where as construction project teams collaborate prior to, during, and after assembly the process.

Application Service providers in a construction non IT context could refer to any organisation involved in a construction process but who does take over responsibility for the process. For example a crane organisation is employed on a project where the main contractor has no expertise. They provide the specialised service or use of their equipment onsite for a designated period of time. Every organisation except the main contractor and client organisation would fit into this category from construction consultants to small building firms. Major IT ASPs within construction include BIW, 4Projects, Buildonline, Business Collaborator, IBM and Microsoft.

Core benefits include access to crucial knowledge without the capital investment or responsibility for developing or maintaining that knowledge internally and the flexibility to access that knowledge only when needed. Limitations are the cost of accessing that knowledge being high, and the potential differences between organisation values creating an adversarial relationship.

2.8 Chapter conclusions

This chapter investigated and presented a literature review on information management within the Construction Industry. The information was gathered from relevant construction and information management journals as well as relevant published books.

Information is a form of intellectual capital. It conveys meaning, understanding and intent to others through a form of communication. An effective communication system allows that information to spread intact to others who can use it constructively within an organisation.

Information management within construction is a philosophy which enables the construction information required to build and maintain a project effectively to reach anyone within a project who needs it. It also allows a transparency of process, enabling the transmitter to know when, where and how a person has received particular construction information and what actions has resulted from it. Information management strategy in the Construction Industry has developed to the stage where the use of intellectual property effectively has a sustaining and positive influence on the organisations utilising such strategy and the construction industry as a whole. An effective information management strategy within a construction organisation can act as driver for quality, value and for liberating the tacit information contained within the personal of an organisation.

Problems effecting Information management in construction include a lack of uptake or interest in the systems as a means of improving the construction process. Opinion within construction is sceptical of the potential improvements an effective information strategy can provide, and organisations are hence reluctant to invest the required resources to instigate a strategic information management system. Underproductive information management leads to problems such as information overload where construction project teams are receiving or having to deal with simply too much information. As a result they cannot handle the levels of drawings, bids, method statements, RFIs etc that is needed for their working responsibility and the information chain is broken.

There are multiple types of information management solutions available to the Construction Industry, including:

- Records management;
- Enterprise Relationship Management;
- Electronic Document Management System;
- Content Management;
- Enterprise Content Management;
- Knowledge Management; and
- Collaboration systems.

Collaboration software enables document management on a remote scale, enabling people to work together when separated by distance or time, within the confines or a project or organisation. Collaboration systems are provided by Application Service Providers who provide access to the software on their own servers via the internet and a browser interface. This allows organisations flexibility in out sourcing their information management needs and not having to accept the capital investment of operating and maintaining their own systems within the organisation.

The present level of development has seen one of the top 20 UK contractors take the first steps into using a collaborations system as a corporate information system, leveraging IT and the power of information manipulation into their core business processes, and not just the core construction processes.

3.0 QUALITY FUNCTION DEPLOYMENT

3.1 Introduction

QFD is a method for bringing the voice of the customer into the product development process as a customer orientated approach to quality *(Paulo and Cauchick 2003).* The unique characteristic of QFD is that the primary focus is on the customer requirements, specifically, the process is driven by what the customer wants, and not by innovations in technology *(Bossert, 1991).*

It is a key strategic link in the total quality management chain, and is one of the group of Japanese management tools that mixes awkwardly with an often natural desire for quick action *(Dickinson, 1995).* Unfortunately, like TQM, there are many incorrect impressions on what QFD is and how it is applied.

QFD was conceived in Japan in the 1960's during an era when Japanese industries broke from their post-World War II mode of product development based on imitation and copying and moved to product development based on originality *(Akao, 1997).* QFD was developed in this environment as a method or concept for new product development under the umbrella of Total Quality Control.

Between 1960 and 1965, Akao first presented his concept of QFD. The Japanese automobile industry was in a period of rapid change and growth, going through endless new product development and model changes. At that time the following two points became the seeds out of which QFD grew.

1. People started to recognise the importance of design quality, but how it was done was not available in any books at that time.
2. Companies were already using Quality Control charts, but the charts were produced at the manufacturing site after the new products were being churned out of the line *(Akao, 1997).*

The concepts of QFD began to formulise in 1966 in Japan when Oshiumi of the Kurume Mant plant of Bridgestone Tyre produced a processing assurance chart containing some of QFD's main characteristics and Ishihara developed the ideas of

"functional deployment of business" similar to those of QFD and applied them to Matsushita (electronics manufacturer) in the late 1960's *(Chan and Ming, 2002).*

It was Akao who first realised the value of this approach in 1969 and applied its power during the product design stage so that the product design characteristics could be converted into precise quality control points in the manufacturing quality control chart. A brief history can be seen in Figure 3.1.

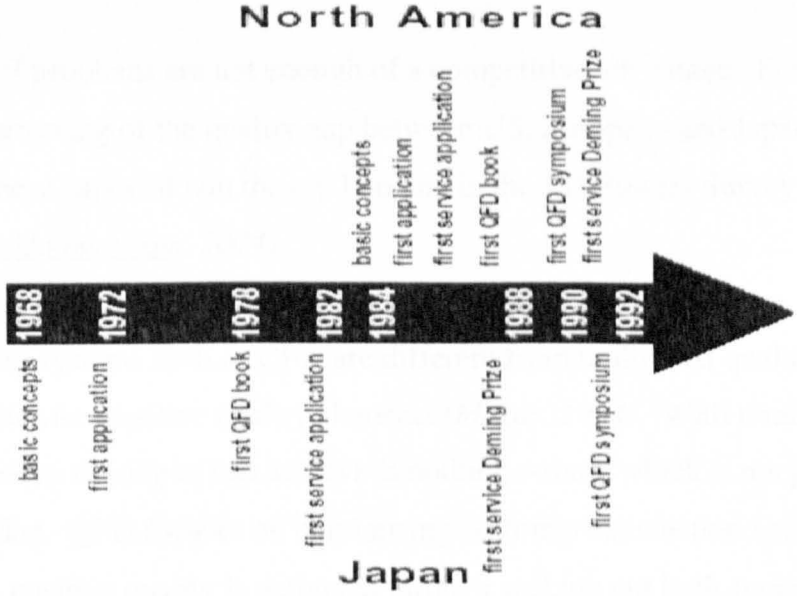


Figure 3.1 History of QFD *(Mazur, 1993).*

The first two reported applications of QFD were in the shipbuilding and electronics industries. QFD's early applications focused on industries such as automobiles, electronics and software. The fast development of QFD has resulted in its applications to many manufacturing industries. As QFD itself evolved, it became clear to QFD practitioners that it could be used to support service development *(Cohen, 1995)* and has been introduced to sectors such as government, banking and accounting, health care, education and research *(Chan and Ming, 2002).* From 1975 to 1995 this tool/process has been integrated with other improvement tools to generate a rich basis for product development *(Terninko 1997).*

QFD should be customised to suit each and every different project it is applied too. However, certain industries have been using skeleton templates of QFD for a number of years. One of the main barriers for application is the apparent complexity of the

process and the lack of ability for the novice individual to strip back the evolved versions to the original QFD and understand what is useful to apply and not apply.

To help understand how QFD works, it is useful to contrast the differences between modern and traditional quality systems. Traditional quality systems often focus on work standards, automation to eliminate people, or in more enlightened organisations, quality improvement teams to empower employees to resolve problems *(Mazur, 1995).*

The absence of problems are not enough of a competitive advantage. For example, despite the narrowing of the quality gap between US, European and Japanese car makers, Japanese cars still win the top honours in the J.D Powers Survey of new car quality *(www.jdpower.com, 2004).*

Modern quality systems such as QFD are different from traditional quality systems that try to minimise negative quality elements *(Mazur, 1994).* With traditional systems the best a developer can achieve is nothing wrong, which is not good enough in a tight market. QFD focuses on maximising customer satisfaction i.e., positive quality. This positive quality is delivered through seeking out both spoken and unspoken needs, and then translating those needs into actions and designs.

3.2 The deconstruction of QFD

To understand how the QFD process works, the basic aims of QFD must be examined:

1. Prioritise spoken and unspoken customer wows, wants, and needs;
2. Translate these needs into actions and designs such as technical characteristics and specifications; and
3. Build and deliver a quality product or service by focusing various business functions toward achieving a common goal and customer satisfaction *(QFD Institute, 2004).*

To achieve these goals there are various tools and techniques that can be used. The foundation set of tools for QFD are the Seven new planning tools, but there are other more advanced tools such as Value analysis, Experimental Design, AHP and SPC tools that can be used in more advanced QFD studies *(Bossert, 1991).* Table 3.1 shows how the basic Seven new planning tools can be utilised in the QFD process.

Table 3.1 Basic deployment of QFD tools.

1. Prioritise spoken and unspoken needs	2. Deployment of translated needs/designs	3. Focus business functions toward common goals
Affinity diagram	Matrix diagrams	
Tree diagram	Process decision program chart	
Interrelationship diagraph	Matrix data Analysis	
Arrow diagrams		

Most of the new tools are not new at all. Most of them have their roots in post World War 2 Operations Research Work. From the mid 1970's the Japanese have combined them with other tools to form a powerful planning cycle *(Bossert, 1991).*

Which tools are used and to what extent they are used is the difference between most QFD projects. For example, in software development, the emphasis in using QFD is loaded into the initial development of the requirements specification, not the software manufacturing stage. This is because the most quality gains in software development can be made where the traditional software development stage is unfocused, supporting the needs of the stakeholders *(Krogstie, 1999).*

Many books, articles and case studies describe what QFD is or could be. The QFD experience itself has largely been glossed over, as if it was self evident. The possibilities for wasting time and leading a team into a cul-de-sac are endless. Many QFD failures have at their source the uninformed decisions of an in-experienced QFD facilitator.

One of the key myths about QFD is that the House of Quality is QFD. The House of Quality is commonly associated with QFD and those who have briefly looked

at comprehensive QFD, such as the 4 phase method, it seems to be the only thing that needs to be completed. In technology driven QFDs and cost reduction driven QFDs, the House of Quality may not even be created *(QFD Institute, 2004).*

Dr. Akao, the founder of QFD states "The House of Quality (alone) does not make QFD." *(QFD Institute, 2004).*

Depending on the benefits a QFD team needs or is willing to work for, they will construct just the house of quality, or a collection of interrelated matrices/tables, or something in-between. Cohen's view is that this is all QFD. He applies the adage, "Science is what scientists do", and states that "QFD is what QFD practitioners do" *(Cohen, 1995).* Therefore, the QFD process used in software development appears different from the format used by the American Suppliers Institute's (ASI) 4 phase matrix system but the aim of the process is the same.

How a QFD project is launched is critical to its success. Poor job preparation can place at risk the outcome and success. The QFD team cannot be cold started by immediately constructing the house of quality. QFD cannot be started by brainstorming customer needs and a team of people cannot be just put together and expected to understand or agree on content and work smoothly with each other *(Shillito, 1994).*

The team will not rediscover focus on their own if the team mission and scope is poorly stated or non-existent from the beginning. Figure 3.2 demonstrates what events and activities and in a sequential order of events for a successful QFD project launch from the point of view of a QFD consultant *(Shillito, 1994).*

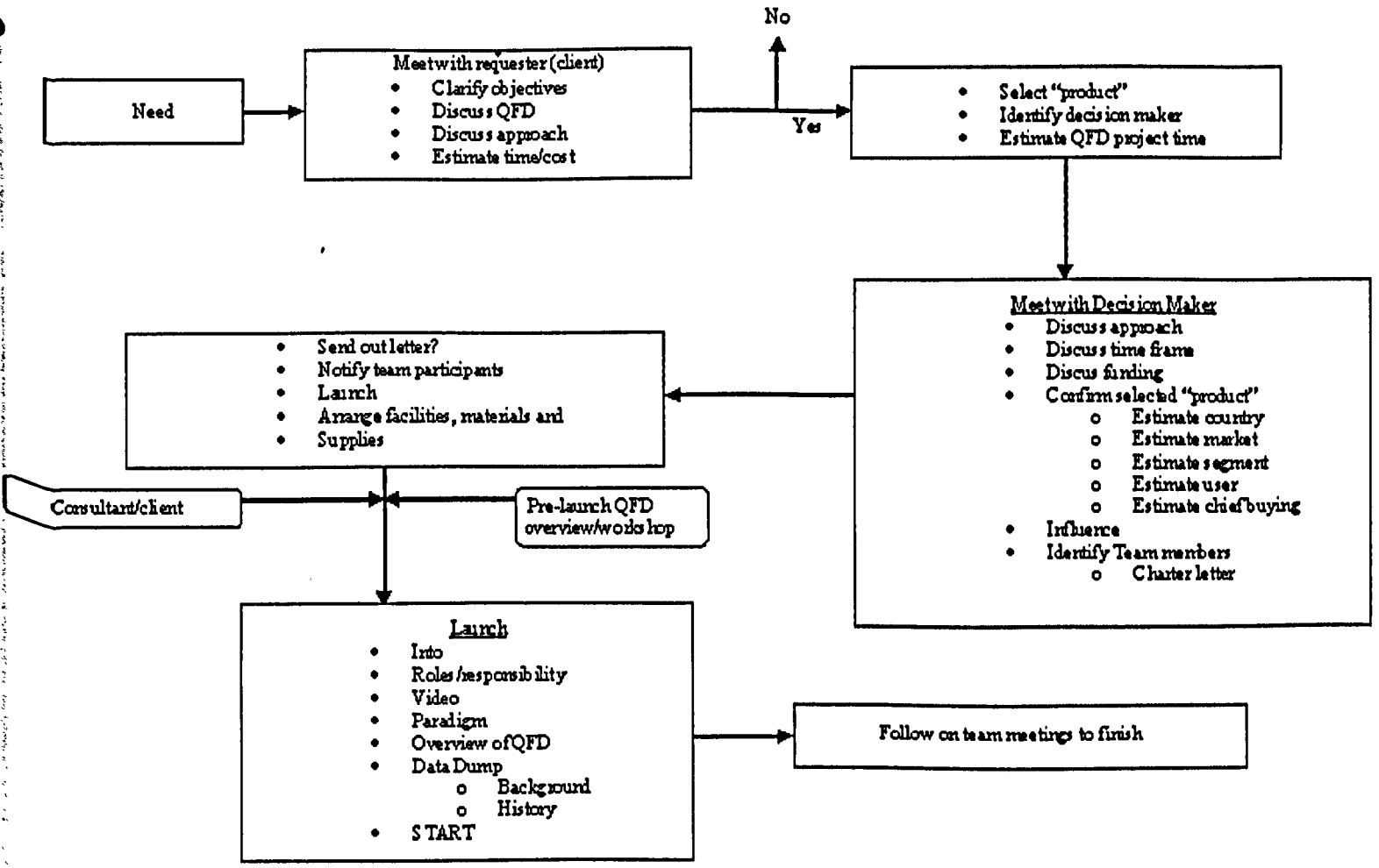


Figure 3.2 QFD project launch model *(Adapted from Shillito, 1994).*

QFD is a key strategic link in the total quality management chain, and a Japanese management tool that mixes awkwardly with a desire for quick action *(Dickinson, 1995).* There are a lot of common misconceptions around QFD:

- QFD is not a quick fix, and is not going to help short-term cash flow, and is not going to drive down costs in a couple of months. QFD is a long haul operation.

- QFD is not just the development team's tool. Kodak used QFD to great success but the biggest problem they found was the lack of senior management support. If that is one of the organisation's challenges, then the whole organisation should be involved.

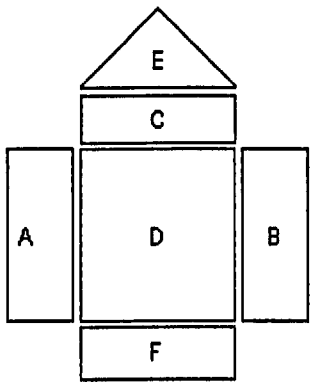
- QFD off the shelf and onto an organisation does not work. This requires creating hybrid customised models of QFD. It calls for using language that is natural to the company, and dealing respectfully with scepticism about jargon and "program of the monthism" *(Dickinson, 1995).*

3.3 The House of Quality

The House of Quality (HOQ) chart is the principal tool for QFD in manufacturing. An HOQ chart facilitates the translation of the requirements of one design phase into the design characteristics of the subsequent design phase. The structure of an HOQ chart depends on the objective, stage, and scope of the QFD project, and thus different HOQs can have different components. However, there are a set of standard components of an HOQ chart, including

- Customer attributes;
- Customer importance ratings;
- Engineering characteristics;
- Relationship matrix between customer attributes and engineering characteristics;
- Roof matrix among engineering characteristics; and
- Computed absolute/relative importance ratings of engineering characteristics *(Shin, et al., 2002).*

The HOQ chart suggested by Cohen can be seen in Figure 3.3 with the basic features.



A - Customer needs and Benefits

B - Planning Matrix (Market Research and strategic planning)

C - Technical Response

D - Relationships (Impact of Technical Response on Customer needs and benefits.

E - Technical Correlations

F - Technical Matrix (Technical Response Priorities, Competitive Technical Benchmarks, Technical Targets)

Figure 3.3 The House of Quality *(Cohen, 1995).*

The customer needs and benefits section (A) indicates the "voice of the customer". These are called the "whats" and indicate the requirements of the customer, i.e., "what" they think are important in the product *(Delano, et al., 2000).* The Planning Matrix (B) contains the customer perceptions where the relative importance of the different customer attributes are indicated. It also contains the customer's evaluation of the possible alternatives.

The technical response section (C) records the technical aspects of designing a product. They indicate how the customer's wants can be met. The Technical correlation's section (E), contains the positive and negative relationships between the technical characteristics. This section of the HOQ is used to balance engineering trade-offs and helps to generate new alternatives by highlighting areas for improvement in current products *(Delano, et al. 2000).* The Technical matrix (F) indicates the relative importance of the differing engineering characteristics and also indicates target levels or measures of effectiveness for each *(Delano et al., 2000).*

The center of the house describes the correlation between the Technical response and the customer attributes. The strength and direction of each relationship is represented by a graphical symbol creating a matrix of symbols indicating how well each Technical response meets each customer attribute.

The HOQ is one small part of the QFD methodology. Based on the ASI model, the mechanism consists of a series of four connected matrices. This can be seen below in

Figure 3.4. Table 3.2 also represents the relationship between "whats" and "hows" in the classical model of QFD.

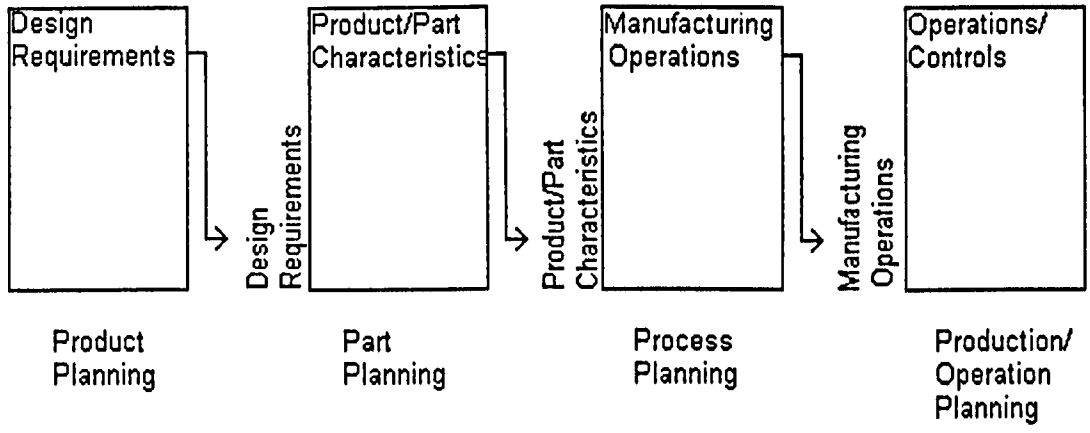


Figure 3.4 The ASI 4 phase QFD process *(Shillito, 1994)*.

Table 3.2 Classical Model for QFD *(Cohen 1995)*.

Matrix	What	How
House of Quality	Voice of the customer	Technical Performance Measures
Subsystem Design Matrix	Technical Performance Measures	Piece-Part Characteristics
Piece Part Design Matrix	Piece - Part Characteristics	Process Parameters
Process Design Matrix	Process Parameters	Production Operations

3.4 QFD applied to software development

From 1982-1987 using software QFD the 1000 person software development division of NEC was able to reduce first year post-shipments software defects from 45 to 0.5 defects per million lines of executable code. Besides increasing their market share 20% to 60% they were able to increase their productivity five-fold on key measures. Sales increased by five times, and profits by four times in this period *(Zultner, 1993)*. Software QFD is clearly a viable and successful method for developing software.

Traditional information management systems development methodologies are treated as a façade necessary to present an image of control or to provide a symbolic status, and are too mechanistic to be much use in the day to day organisation of software developer's activities *(Nadhakumar and Avison, 1999)*.

Software engineering and information engineering (IE) have long advocated the application of engineering like discipline to the software development activity. Integrated computer aided software engineering (I-CASE) represents an attempt to use automation to increase developer productivity. These advances provide improved methods for carrying out the software development process. However, there is no accompanying improvement in the understanding of this process. The adaptation of the philosophy of total quality management (TQM) from the manufacturing quality literature has been proposed by some as a possible guide for introducing quality into the software development activity *(Barnett and Raja, 1995).*

The usual practice of designing software appears irrational. Programmers start without desired behaviour and implementation constraints. A long sequence of design decisions is made with no clear statement of why they do things the way they do, and the rationale is never explained *(Parnas and Clements, 1986).*

Customers buy or accept software for the following reasons:

- to solve problems;
- to seize opportunities;
- to look good to significant others; or
- to feel good

The first two are crucial for most software products. Any software that does not help the customer in at least one of these four ways is valueless *(Zultner, 1993).*

3.5 Software Quality

The term quality means conformance to requirements and customer satisfaction. It also means "fitness for use" *(Chin et al., 2001).* According to the definition from the BS EN ISO 8402:1995, quality is the "totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs" *(BSI, 1995).*

The quality of the software product and process used by an organisation affects the competitive position of the business organisation. Poor quality systems consume additional resources and contribute to the two to three year backlog of development projects that exists in most companies *(Barnett and Raja, 1995).*

In order to satisfy the customer within the schedule and resource constraints that all projects face, it is necessary to concentrate the best efforts on those things of greatest importance to the stakeholders of the system *(Krogstie, 1999).* To achieve this, before the design stage, the project team must obtain all the requirements specifications and the customer's priorities and ensure they are passed onto the next stage before it starts. This principle is illustrated below in Figures 3.5 and 3.6.

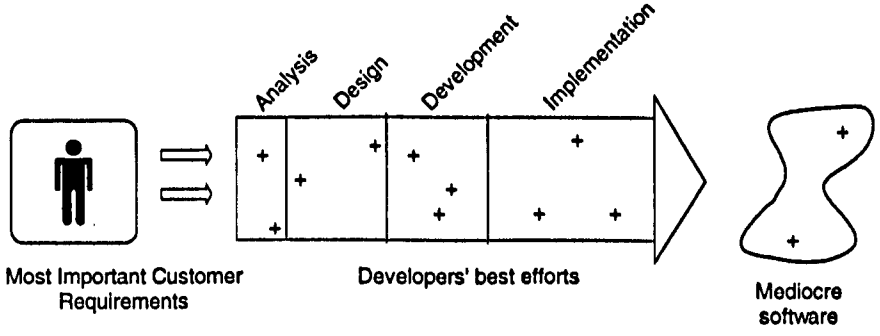


Figure 3.5 Unfocused development process *(Krogstie, 1999).*

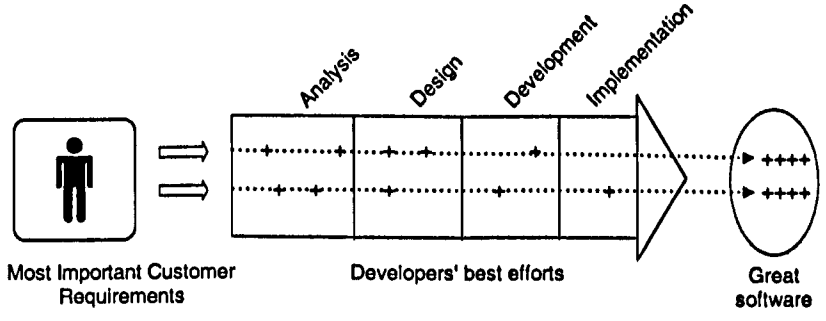


Figure 3.6 Focused development process *(Krogstie, 1999).*

3.6 Software QFD

Software QFD is the generic term for QFD that has been adapted for the application in the software industry. The QFD process is shaped around the process or product it is developing, and therefore, it has to be customized for each application. Two

essential differences, however, have to be taken into consideration when transferring QFD to software development:

1. Software is identified not by its physical characteristics but by its behavior *(Herzwur and Mellis, 1999).*

"Software [...] is valued not for what it is, but for what it does" *(Zultner, 1990).*

2. The production process of the software industry in the strictest sense is a duplication process. Therefore in a higher sense than in manufacturing the problem lies in the early stages of the development. The application of QFD has therefore to focus on the ability to prioritise the engineering activities and pay less attention to the deployment down to the software's last line of code *(Herzwurm and Mellis, 1999).*

There has been a number of different software QFD methodologies developed in the last decade:

3.6.1 Software Quality Deployment

In the early 1990s Richard Zultner has developed a framework of how to apply Akao's comprehensive QFD to software development, including quality deployment according to the ASI four-phase deployment. The framework presented is a general one which should be customised for each application

This methodology utilises an altered Subdesign matrix (2nd house of quality) and can be seen in Figure 3.7. After the initial fundamental deployments (what for and for whom), customer deployments (determination of the types of customers the team is trying to provide for) and quality deployments (exploration and specification of high value customer requirements) which lead up to and are contained as a part of the House of Quality have been made, the quality deployment matrix at the top of the HoQ is used in the subsystem design matrix.

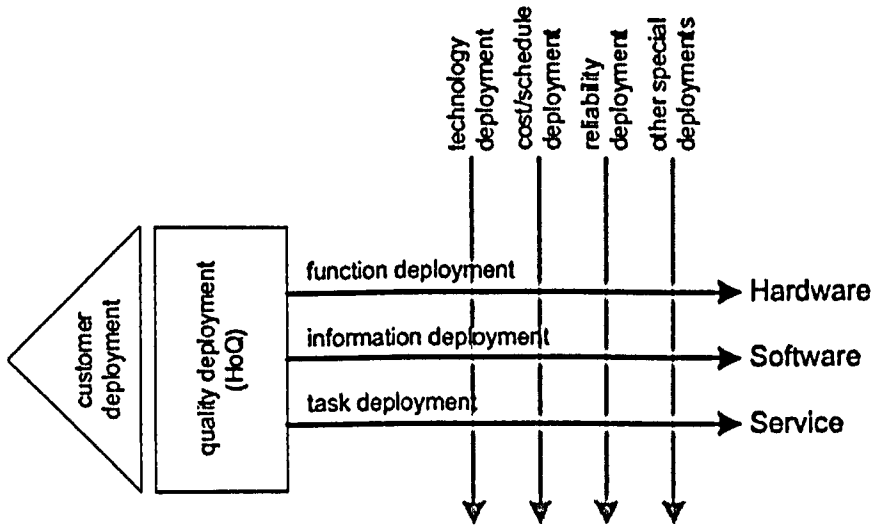


Figure 3.7 Zultner's comprehensive software quality deployment *(Zultner, 1993).*

At this point various vertical deployments are used. The three common vertical deployments for software teams are technology, cost/schedule, and reliability *(Zultner, 1993).*

- Technology deployment: aims to deploy new technologies into the design and development of new products/services.

- Cost/schedule deployment: sets customer-derived cost/schedule targets and seeks the necessary reduction in time spent during the project to meet those targets. For software, costs derive primarily from labour hours expended.

- Reliability Deployment: this looks at failure models and faults to prevent or improve the effects of failures. Standard reliability engineering tools and techniques are integrated into the design and development process.

- Other special deployments: this section is used to address specific concerns of customers of the organisation. For example in embedded software projects with tight memory constraints, memory deployment may be found useful.

3.6.2 Ohmori's Matrix of Matrices approach

Similar to Zultner's approach the basic structure of Ohmori's Software QFD process uses the manufacturing set methodology, i.e., the ASI 4 phase QFD shown in figure 3.8. The difference is in the complex approach using 14 different matrix-matrix-diagrams, and it covers only the first 2 main matrices in the ASI method.

In this approach there are several activities for analysing a comprehensive business system that combines all the tasks necessary to reach the organisation's goals. Once these high-level functions are known, the customer requirements (here called software quality requirements) are identified and set against the product functions (software additional functions) in the Software-HoQ and (software) quality elements in the classic HoQ *(Herzwurm and Mellis, 1999)*. The great number of matrices, shown in Figure 3.8 is a result from vigorously taking into account the quality elements concerning the business as well as the business software.

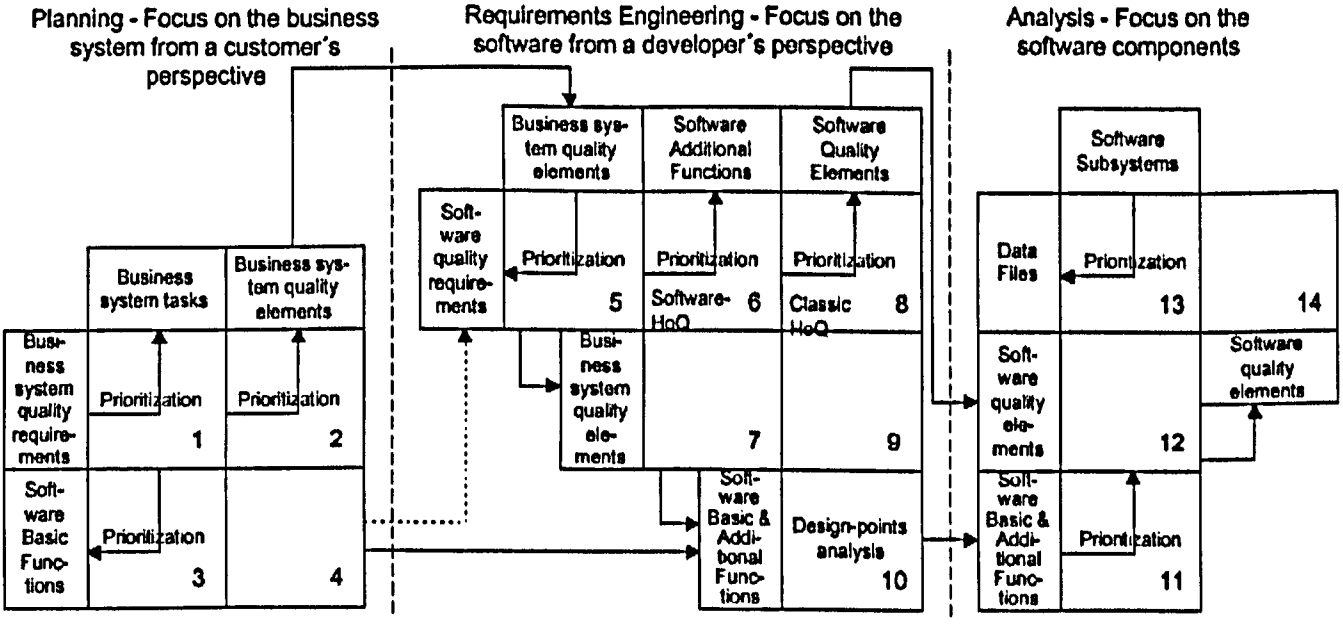


Figure 3.8 Ohmori's Matrix of Matrices approach *(Herzwurm, Mellis, 1999)*.

3.6.3 Andersen Consulting (now Accenture) Method/1: version 11.0

Method/1 is the Software QFD method used by Accenture. The main difference between this method and the last two Software QFD methodologies is that it is not an altered form of the manufacturing QFD methodology stream. The majority of activities associated with Accenture's Software QFD methodology occur during planning and analysis where the projects scope and value are determined. The methodology is displayed in Figure 3.9.

The matrices to the right of Figure 3.9 are similar to the House of Quality matrices found in other QFD-techniques, although not including the HoQ roof, where it is impossible to relate different functional requirements to indicate to what extent they are consistent or inconsistent *(Krogstie, 1999).*

The Accenture SQFD process in Mehtod/1 is achieved in 6 steps:

1. Determine stakeholder types and characteristics: Identify the stakeholders of the project, and their importance relative to the goals of the project *(Krogstie, 1999).*

2. Evaluate stakeholder inputs: the stakeholder Input table is used to organise the input collected during requirements gathering. The organisational problems and the opportunities the stakeholder wants to address are found in the business needs category *(Krogstie, 1999).*

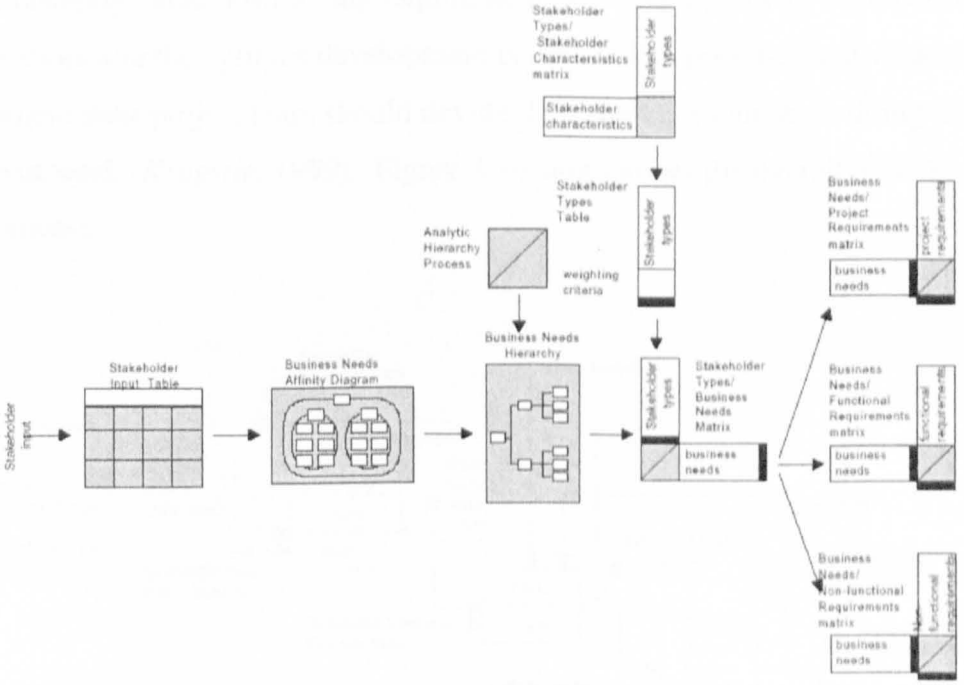


Figure 3.9 An SQFD roadmap *(Krogstie, 1999).*

3. Define business needs: The stakeholders business needs represent problems and/or opportunities the solution could address. These needs require thorough examination in order to determine the structure and level of business benefits the project can deliver *(Krogstie, 1999).*

4. Assigning business needs to stakeholder types: Once the business benefits have been structured and evaluated, the project team has to evaluate how important the fulfillment of the business needs is to the stakeholders. The level of stakeholder satisfaction provides means of prioritising the business needs *(Krogstie, 1999).*

5. Align requirements to needs: the Business Needs/Functional Requirements Matrix prioritises the systems functional requirements based on their contribution to the business needs. After the evaluation, the judgments are weighted and the requirements priorities are then calculated. This identifies the functional requirements alignment with the business needs. The same procedure can be used to align non-functional and project requirements *(Krogstie, 1999).*

6. Managing value: Prioritising requirements serve as a guide to the downstream activities in the systems development process. The priorities and value define where their project team should devote their scarce resources to doing their best work *(Krogstie, 1999).* Figure 3.10 summarises the overall SQFD process.

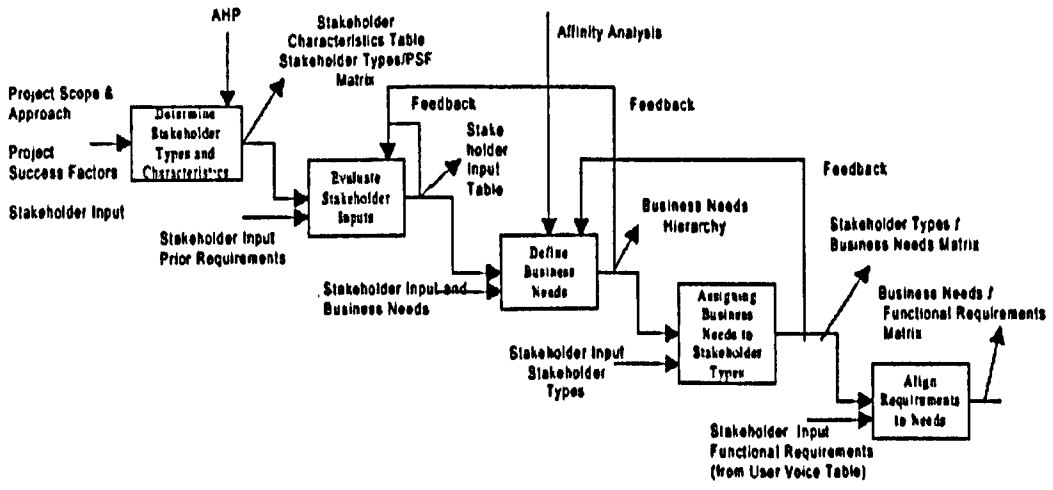


Figure 3.10 The SQFD process *(Krogstie, 1999).*

3.6.4 Blitz QFD

Blitz QFD was developed in the 1990's after responses and feedback from both software and non-software organisations. A group of experienced practitioners at the QFD institute applied QFD *to* the QFD process to develop a better way to begin using QFD *(Zultner, 2000).*

"some have stagnated at the level of "Kindergarten QFD" and are failing to get the full benefits that QFD for Software can deliver" *(Zultner, 1996)*

As a result of their limited success they blame QFD for poor results. Blitz QFD can be described as an "essential minimum method" for QFD. It is a streamlined and controllable method that in its simplest form uses no matrices, although it includes an overall process that can evolve into any number of matrices (such as the HoQ).

Blitz QFD can support development projects using a spiral or evolutionary strategy. Object-oriented approaches, business process reengineering and rapid application development projects can all benefit from QFD when Blitz QFD is used *(Zultner, 1996).*

Blitz QFD steps:

1. *Go to Gemba.* In order to gather the "voice of the customer", their verbatim/statements, Gemba (location of the customers) must be observed first hand.
2. *Sort the verbatim.* Requirements are not sourced from the customer. Verbatim are. These customer statements have to be sorted out by type, distilling the observations, verbatim, and notes into verified needs.
3. *Structure the needs.* An affinity diagram is used to structure the needs. This process aims at discovering the natural structure of the customer needs, by using the customers themselves to complete the affinity diagram.
4. *Analyse the customer needs structure.* The affinity diagram is transformed into a hierarchy diagram (HD) that is used to analyse the structure and uncover additional, non-stated needs. The structure of the HD is used to analytically identify needs that no customer mentioned, but which every customer finds important.
5. *Prioritise the customer needs.* The next step is to take the customer's needs on the hierarchy diagram and let them be prioritised by actual customers so that the important needs are known, by what degree and by whom. AHP (Analytic Hierarchy Process) is the method used to prioritise the needs.
6. *Deploy Prioritised Customer needs.* The maximum value items for the project have been identified through the relationships between the high value needs and related items. It is at this point, where on every dimension of the project what are the most important things for the project to succeed in, and so therefore satisfying the customer. The value for the customer within the project has now been identified *(Zultner, 1996).*

3.7 QFD usage in construction

QFD is used in many other industries such as automobiles, electronics, banking, insurance, healthcare, utilities, and food processing *(Eldin, 2003).* The practical

application of QFD to AEC has so far been used only in Japan although there are positive signs showing that the USA may follow.

One of the first QFD investigations in AEC was completed in Japan in the late 1980's by a group of QFD practioners *(Shiino and Nishihara 1990).* Their reaction to the AEC industry was the realisation of the complexity and variety of the processes and structures/infrastructures that were constructed. The system they composed has three sub systems in an attempt to deal with that complexity:

1. Demanded quality deployment flow;
2. Technology study flow; and
3. Construction control flow.

With the recognition that AEC can encapsulate many different project types this system is designed to be adaptable with the three subsystems described above allowing the accommodation of multiple project types *(Shiino and Nishihara 1990).*

For a number of years AEC professionals have been trying to apply QFD. The main barrier lies in what type of QFD they have been applying. The majority have tried to use the ASI (American Supplier Institute) 4-phase method. This technique is tailored for manufacturing existing designed models and maximising deployment on a mass production scale, and deploying that quality in the controlled synchronised and duplicating environment of the production line, not on the vastly scaleable alternating and individual environment of an AEC project. AEC and manufacturing industries have been described as similar, with AEC a form of manufacturing with the stations moving through a fixed product *(Ballard and Howell, 1998)* but in many respects, their characteristics differ.

As a result, the attempts so far of utilising the manufacturing stream of QFD have been met with mixed results, from bland outcomes to encouraging but not quite successful practical projects. A key development factor of QFD that is overlooked in many AEC QFD studies is that the method being applied should be tailored to the project itself. Otherwise, any competitive edge from using it would essentially be lost *(Gargione, 1999).* The primary difference between QFD and other conventional

quality management tools is that quality is being built into a product and not inspected out of it *(Gargione, 1999)*. Therefore the QFD process itself must reflect characteristics of the industry/product it is being applied. Stated simply, there is no stock QFD process that can be transferred across industries.

Construction Industry Institute (CII) is a consortium of leading owners, engineering and construction contractors, and suppliers who have a singular mission: to improve the cost effectiveness of the capital facility project life cycle, from pre-project planning through completion and commissioning. By collaborating on important industry issues and by providing guidance on best practices discovered through research, the CII members are collectively an industry forum for the engineer-procure-construct process.

This research was commissioned by the CII to determine the feasibility of adapting QFD for use in the project management process of the engineering and construction industry. They have determined the possibility of adapting QFD for use in the Project Management process of AEC and indicated the following points:

- Quality function deployment has definite value as a tool for improving the project definition process.
- It has step change potential for use by both Clients and Contractors

The benefits are concentrated in the areas:

- Enhanced identification of, and responses to, customer requirements.
- More complete up-front planning
- Reduced cycle time through less redesign
- Better cross-functional communication *(Oswald, Burati, 1992)*

These points suggest the focus of QFD should be mainly in the front end of a project in areas such as the design and feasibility stage. These conclusions are mirrored in other work were it has been found that AEC can be improved through looking at its ability to accurately determine client's requirements and successfully transform these

requirements into plans and specifications *(Gargione, 1999)*. In addition, customer satisfaction has been identified as one of the most important challenges facing AEC businesses over the last decade. As industries and companies worldwide face increasing competition, slower growth rates, and price pressures, greater attention continues to be placed on customer satisfaction *(Syed, et al., 2003)*.

3.8 QFD in Construction design stages

The design stage in AEC is where the requirements of the client are identified sorted, items of value and quality are designated through specifications, drawings and design plans

One of the key problems identified in the design stage is little interaction between design and construction and among the specialists were the majority of the design of buildings is completed, which results in the following phases working on incomplete designs, and as a result, a large amount of change orders *(Alarcó and, Mardones, 1998)*. These design changes can have a huge effect on the overall project and have been estimated to take 40 to 50% of the work hours in certain projects *(Alarcón and Mardones, 1998)*.

QFD in AEC has gained new impetus with the increasing trend to adopt project procurement using the Design and Build method. As the organisation assumes full responsibility for design and construction in a D/B contract, the ability to identify and respond to the client's needs will have a vast impact on the delivery *(Pheng and Yeap 2001)*.

The use of a correct QFD methodology in AEC has been recognised as having benefits across the sphere of control on a project, and specifically design. Integrating a tailored QFD system would result in the contractor experiencing following benefits though only if they were working with a QFD knowledgeable client *(Oswald and Burati, 1992)*:

- A standard approach to obtaining and using the clients' requirements;

- A more complete set of owner requirements, and a more complete understanding of them;
- Fewer conflicts in design requirements;
- Less rework, leading to lower costs and shorter project execution time; and
- Greater opportunity to integrate constructability concepts into the design.

Clients would also experience benefits, such as *(Oswald and Burati, 1992)*:

- Optimum internal definition of project requirements, coordinating such diverse considerations as market timing and financial, technical, production, and maintenance inputs;
- More efficient communication of the requirements to design/construction contractor/s;
- Shorter cycle time for project concept to start-up; and
- Greater conformance of project execution to project requirements.

Simply put, it has been recognised for a number of years that the integration of design and construction during the early stages of a project provides the potential for designers to give the clients better value for money designs *(Yang et al., 2003)*.

Previous work such as the Construction Industry Institute correctly target the front end of the construction process as that with the most potential for improvement of the over result, and that which needs an overall improvement compared with similar industries.

The potential for QFD to be of great use in AEC increases with the size of the project. Capital project delivery in AEC is a complex process and often takes many years to complete. There are often multiple changes across several rounds of design evolution, leading to the basic and original customer's requirements being sidetracked *(Ahmed, Sang, Torbica, 2003)*. As a result, customer's needs and their equivalent functional requirements may be ignored and unfulfilled.

There is a limited number of documented uses of QFD in construction, Table 3.3 shows the limit of the Construction QFD library.

Table 3.3 Construction QFD: published papers

Author/year published	Synopsis
Architecture Planning Committee of the Japan, 1968.	Housing design.
Shiino, Nishihara 1990.	A paper examining QFD application in general construction, civil engineering and factory-manufactured multiple-family housing.
Construction Industry Institute (CII), Oswald, Burati, 1992.	A series of reports examining the possibility of adapting QFD for use in the project management process of the AEC industry.
Mallon, Mulligan 1993.	A paper examining the hypothetical renovation of a computer workroom facility was investigated.
Laurikka, Lakka, Vainio, 1996.	A paper presented at the 8th Symposium on QFD in Michigan USA presented the findings of QFD applied to three different AEC projects.
Huovila, Lakka, Laurikka, and Vainio, 1997.	A paper examining the use of QFD in AEC design, specifically the structural design of an industrial building.
Serpell and Wagner 1997.	A paper on the determination of design characteristics for the internal layout of a building complex
Abdul-Rahman, Kwan., Woods, 1998.	A paper investigating the application of QFD in low-cost housing design was conducted.
Alarcón,, Mardones, 1998.	Improving the design-construction interface
Kamara, Anumba, 1999.	A paper investigating the use of QFD in requirements processing in concurrent life-cycle design and AEC.
Gargione, 1999.	A paper investigating the application of QFD to the design phase of an apartment construction project.
Kamara, Anumba, 2000.	A paper extending the previous published work examining the use of QFD based software for the definition, analysis and translation of client requirements into solution-neutral design specifications
Pheng, Yeap, 2001.	A paper examining the awareness and applicability of the QFD in Design and Build contracts
Sommerville, Craig, 2002.	A paper investigating the application of Quality Function Deployment in the IT/Construction Industries
Eldin, Hikle, 2003.	A paper documenting a pilot study in which QFD was implemented in the design of a modern sized classroom for college students.
Syed, Sang , Torbica, 2003.	A paper examining the use of Quality Function Deployment in Civil Engineering Capital Project Planning

3.9 Chapter conclusions

This chapter investigates and presents a literature review on Quality Function Deployment. The information was gathered from relevant construction and information management journals as well as relevant published books.

QFD was developed in Japan within the shipping and electronics industry at the end of the 1960s. It was developed to extract quality from customer information and build that information into an effective and efficient production process. QFD is a method currently used mainly in manufacturing for deploying and refining products and production methods through the use of a number of management and process tools.

QFD in its purest form uses the seven Japanese management and planning tools:

- Affinity Diagrams;
- Relations Diagrams;
- Systematic Diagrams;
- Matrix-Related Tools;
- Process Decision Program Chart;
- Arrow Diagrams; and
- Other Japanese-Origin Tools.

These tools derive from the United States military occupation and rebuilding of Japan after World War Two, and have been in widespread use in Japan since the mid-1970s. It is a measure of their effectiveness that those tools became of interest to American organisations in the 1980s and 1990s.

The House of Quality is commonly associated with QFD, and through misconception many organisations who apply QFD have the impression it is the only action involved within the process. The House of Quality should only be seen as an interchange between the voice of the customer and the voice of the engineer, with much work needed on either side of these facets needed to complete a successful QFD process.

There are different variations of QFD that have been developed to apply to producing a software system. They are:

- Software QFD;
- Software Quality Deployment;
- Ohmori's Matrix of Matrices approach;

- Andersen Consulting (now Accenture) Method/1:version 11.0; and
- Blitz QFD.

They range from Software QFD to Blitz QFD, with each version from the former to the latter moving away from the formalised manufacturing deployment focused style of the House of Quality to a user focused development style of searching, focusing, extracting unspoken user needs and building them into an effective system specification.

The use of QFD in construction has been sparse but there is a continued interest in applying a tool that has proven very successful in manufacturing. There have been various studies within the Construction Industry into applying various types of customised QFD templates but the continued focus on deployment and the use of the House of Quality instead of a more customer focused QFD methodology like Blitz QFD has produced unambiguous results.

Finally, the greatest advantage of the QFD method is the flexibility inherent through allowing integration of special, company or project-specific peculiarities into the procedure, which within construction, would provide a powerful decision making and development method.

4.0 RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

This chapter introduces and discusses the philosophical background to the design of the research methodology employed to complete this research. It also introduces the methods of data collection and analysis together with their strengths and limitations.

The Concise Oxford Dictionary *(The Concise Oxford Dictionary of current English, 1995)* describes research as:

1) the systematic investigation into and study of materials, sources, etc., in order to establish facts and reach new conclusions; and
2) an endeavour to discover new or collate old facts etc. by the scientific study of a subject or by a course of critical investigation

Research is therefore concerned with the *what* (facts and conclusions) and *how* (scientific, critical) components. Two types of research exist: quantitative and qualitative. Quantitative research is seen as the stream where numbers and statistics are used and a scientific method adopted in which an initial study of theory results in precise aims and objectives with hypotheses to be tested. With qualitative research an exploration of the subject is undertaken without prior formulations, the object is to gain understanding and collect information and data such that theories will emerge *(Fellows, Liu, 1997).*

4.1.1 Quantitative research

A survey design provides a quantitative or numeric description of some fraction of the population – the sample – through the data collection process of asking questions of people. This data collection, in turn, enables a researcher to generalise the findings from a sample of responses to a population. An experiment tests cause and effect relationships in which the researcher randomly assigns subjects to groups. The researcher manipulates one or more independent variables and determines whether these manipulations cause an outcome *(Creswell, 1994).*

The design of a survey method section follows a standard format. Below are five typical components:

- The survey design: All the reasons why a survey is being completed, and why the preferred type of data collection method is being used.
- Population and sample: Specific characteristics of the population and sample, including discussions on clustering, sample selection, stratification and the method used to identify the demographic.
- Instrumentation: If an established instrument is used, its validity and reliability must be discussed, and a pilot/field test should be confirmed with appropriate rational.
- Variables in the study: Relations between the survey variables and the instrument, e.g., a table could be used to cross reference the variables, and the questions or hypotheses.
- Data analysis: A summary of the techniques used in a step by step method *(Creswell, 1994).*

4.1.2 Qualitative research

Qualitative research is interpretative research and as such the bias and values of the researcher should be stated explicitly in the research approach. Being open is useful and is seen as a positive quality *(Creswell, 1994).* Table 4.1 shows a table of data collection approaches in qualitative research available to the researcher and highlights the wide approaches available:

Unlike quantitative designs, few writers agree on a precise procedure for data collection, analysis, and reporting of qualitative research. Qualitative research seeks to describe and explain the particular phenomenon under investigation *(Marshall and Rossman, 1989).* The questions and problems are usually derived from real world observations, dilemmas and questions and take the form of wide-ranging inquiries *(Marshall and Rossman, 1989).*

Additionally some qualitative researchers have argued that the term validity is not applicable to qualitative research and have at the same time realised the need for some kind of qualifying check or measure for their research *(Wolcott, 1990)*.

Table 4.1 Data collection approaches *(Creswell, 1994)*.

Data collection approaches
Gather observational notes by conducting an observation as a participant
Gather observational notes by conducting an observation as an observer
Conduct an unstructured, open ended interview and take interview notes
Conduct an unstructured, open ended interview, audiotape the interview, and transcribe the interview
Keep a journal during the research study
Have an informant keep a journal during the research study
Collect personal letters from informants
Analyse public documents (e.g., official memos, minutes, archival material).
Examine autobiographies and biographies
Examine photographs or videotapes
Have informants take photographs or video tapes
Collect sounds)e.g., musical sounds, a child's laughter)
Videotape a social situation of an individual/group
Examine physical trace evidence (e.g., footprints in the snow)

4.2 Research Paradigms

PhD research should be an "original contribution to knowledge". Yet PhD research has its limits. The Theory of Relativity was not Einstein's PhD thesis, a contribution to Brownian motion theory was. Das Kapital was not Marx's PhD. That was on the theories of two little known Greek philosophers.

Research seeks to measure reality. It is the definition of that reality which forces the different perceptions of the existing research paradigms of today. According to Positivism, reality can be measured without the observer influencing the observed facts *(Fellows and Liu, 1997)*. Essentially there is one reality and it is fixed at the point where the facts are being measured and will continue without the observer unchanged. Interpretivism says that reality is constructed by the facts involved and not fixed *(Saunders's, Lewis and Thornhill, 2000)*. Therefore the facts reality is derived by the observations and perceptions of the observer and is possibly different for other observers. Reality is only fixed at the observer's point because they are a part of the reality that is being created through the observation. Hence the saying 'beauty is in the eye of the beholder'. This project will use an interpretivitist

methodology where the observer applied a project management tool in the field of software development. The observer was thus an integral part of the research process.

4.3 Research Aims and Objectives

The principle aim and objectives of the research are restated here to help provide a clear comparison with the adopted methodology and its design. The principal aim is:

To determine whether Quality Function Deployment can be used to develop more user focused Collaboration Systems in the Construction Industry

The Research Objectives can be summarised as follows:

1. *To define a collaboration system and how is it used within a construction organisation?*

2. *To investigate and document the previous usage of Quality Function Deployment both as a project management tool in its classical sense and in it's software development form and how it is applied (if applied) in construction in general.*

3. *To evaluate the current Collaboration systems used within the top UK construction organisations, and to what extent are they used?*

4. *To develop a user requirements specification using QFD for a construction collaboration system.*

5. *To assess QFD as a development methodology for construction collaboration systems.*

4.4 Research Methodology

Essentially, this research asks if a project management tool (QFD) can help to develop a better project management tool (Information Management Software). This research

looks at whether QFD can develop better Information Management systems, the chosen method to investigate this is a case study. As QFD is both a time consuming, and very rigorous method, only one project will be completed due to time constraints.

4.4.1 Limitations

It is important to critically evaluate the results and the overall study. This thesis has certain limitations that need to be taken into account when considering its contributions:

- The system specification will depends on the breadth of the people interviewed; they will be the key to how complete the specification of the system will be. Therefore throughout the interviews a broad spectrum of collaboration system users must be sought for the interviews.
- The users within this study are sourced from 3 top 20 UK construction contractors. With the construction industry being disparate and varied the results would mean the system would be specifically tailored to those three organisations, and not the construction industry as a whole. Therefore the Collaboration system requirements developed from this project can only be presented in the sense of 3 top UK contractors, and not industry wide. For this reason discussions of the results have been made with a UK Collaboration system manufacturer to assess its overall competency as a construction industry software specification.
- QFD studies are mainly completed by a fully trained QFD practioner with experience and training. In this case the QFD methodology was designed and completed by the researcher with minimal QFD training and no previous industrial QFD application experience.
- Collaboration systems are produced by software developers with a grounding in software development methodologies and experience in writing software requirements specification. With this project the researcher had neither.

4.4.2 Validation

Validity asks whether the research measured what it intended to. Validity is necessary to give the research and its findings the basis to be used outside the studies specific circumstances.

This will be done through taking the requirements specification and QFD methodology to a major collaboration system developer for the construction industry and have them examine the results and the development methodology. Three forms of validation will be addressed:

Technical validity: This refers to the results of the QFD process. The functional specification of the collaboration system must be viable for the construction industry.

Economic validity: This refers to the ability and economic viability of construction software or generic software developer to use QFD in developing a software requirements specification. This will involve examining at the QFD process to see if the costs/resources of using the process would be at an acceptable and usable level.

Operational validity: This refers to the tools and the structure of the QFD process used including the team focused methodologies and the stepped program.

4.4.3 Surveys

The main body of information collected within this thesis will be done through interviews. It was felt that a postal survey/questionnaire would not give the quality and offer the flexibility to collect sensitive or dynamic information that the QFD process needs. This was based on the belief that a questionnaire is most suited to surveys where *(Fellows and Liu, 1997)*:

- The questions must be simple and straight forward to be understood.
    - o There is no direct format of questions as each system users experience and process will be different. Different aspects of how

a user interacts with a system will be explored as they appear in the interview.

- The answers have to be accepted as final, there is no opportunity to probe
  - One of the essential parts of the data collection method is the ability to probe answers for additional information or further areas to investigate.

- Questionnaires are inappropriate where spontaneous answers are wanted
  - The interviews will be conducted in the users work to encourage spontaneous experiences and reminders of how they work and what effects their interaction with the system.

- The respondent can see all the questions before answering any of them, and therefore different answers cannot be seen as independent.
  - The questions in the interview would start off with a basic grounding to explore how the users interact with the system, after which probing questions regarding answers given by the user would be done on the spot.

- The researcher can not be sure the right person completes the questionnaire
  - With the interview technique, all users will be identified before they are interviewed for their appropriateness and place within the study.

- There is no opportunity to supplement the respondent's answers by observational data *(Fellows, Liu, 1997).*

  - Part of the data collection/manipulation within QFD relies on the use of observational data, this is essential to the process.

4.4.4 Interviews

This project will use Interviews as the primary source of information. Interviews can vary in nature and can be one of the following:

- Structured;
- Semi-structured; or
- Unstructured.

All data gathering within this project will use two types of interview. Structured interviews will be used for an initial study of existing software systems used, and then unstructured interviews for the information gathering on the QFD project. Some essential points when conducting the interviews are:

Structured: An interview with a set of structured questions will be completed as part of the initial research into Collaboration systems. These interviews will not seek to probe the responses given to a great extent, but if necessary or pertinent to the study this shall be done.

Unstructured: The inputs of the researcher are critical, especially probing, as the questions asked will influence the response obtained. Any probing done throughout the research will be an indirect response to areas that may be useful to the overall aims of the study. Also any body language or 'non verbal communication' will be captured under observations in the Gemba visit tables. All interviews will be recorded for transcription and further analysis.

4.5 Layout of Thesis

Table 4.1 is a quick reference navigational aid to each element of the research. It states the objective of each item contained in the thesis with a reference to the location.

Table 4.2 Locational guide to the research

Element of research	Objective	Chapter	Page #
Introduction	• Introduction to this thesis including basics of research and main results	1	
Research Methodology	• Present a concise and complete album of the forthcoming research	2	
Information Management Literature review	• Consolidate the existing Information Management theory	3	
Classic QFD and Software QFD Literature review, Construction QFD Literature Review	• Present the founding philosophy of QFD as used in manufacturing in Japan and USA • Review the alternate QFD methodologies used to develop software. • Outline the research completed into applying QFD in AEC	4	
Survey of existing site Information Management systems in the top 10 UK Contractors (6)	• Evaluate the different Document Management Systems used on site and trace their development.	5	
QFD Project: Gather the customer needs	• Project goals + Customer segments. Investigate the QFD project goals and the identify and define the customers. • Visit Gemba: Visit the value face of the customer and investigate and collect information about the customer characteristics/process • Discover the customer needs: Take the information gathered from the visit to the gemba and clarify customer needs	6	

QFD Project: Deploy gathered information through task development stages	• Structure the customer's needs using management and process tools and then examine them for unstated needs. • Prioritise the customer needs using AHP and the customers themselves. • Deploy the Project Tasks by driving the prioritised customer needs forward through customer/solution/design/and project issues.	7	
Conclusions and Recommendations	• This chapter will conclude the thesis and contain conclusions to over study and thesis	8	

4.6 Literature review

Published literature constitutes the most accessible font of peer reviewed knowledge from which to start any investigation. The core of the literature review was sourced from a selection of peer reviewed journals and conferences such as the CIBW78 generations of meetings. The literature review commences by reviewing the literature within the construction management discipline, and then diversifies out to manufacturing and project management disciplines where QFD is more established.

The official source of QFD literature is the QFD Institute based in Michigan, USA (www.qfdi.org). The QFD Institute has regular symposiums where some of the founders of QFD itself review papers. The topics at these symposiums are generally concerned with service/manufacturing sectors though there have been some construction orientated studies presented there.

There are very few references to QFD applied to construction, and those that are available are generally theoretical studies or administered on a small scale.

The literature review consists of a review of Collaboration software followed by a review of the different types of QFD methodologies and a section relating to QFD material in construction.

The critical review of the literature will:

- Help spot gaps in contemporary knowledge;
- Make sure that the most current thinking and theories were considered and included within the thesis; and
- Ensure this research is not a duplication of other works.

4.7 Current status of Information Management in UK Construction

This survey was designed to tap into as many top UK contractors as possible and find out what Information Management Systems they were using for their projects, and to discover information about how they replace/update and choose/develop that software. The survey took the form of a short interview of the Business Systems Manager or equivalent of each of the construction arms of the contractors. The primary aim/objectives were:

A1. Investigate project software used and related IT strategy that was implemented throughout the UK by the top construction contractors.

O1. Evaluate what software is being used for projects under each contractor's umbrella;

O2. Investigate the replacement updating strategy used by each of the organisations for their software;

O3. Gain the key features as looked for by the Business Systems Managers when they are looking to develop or buy the software;

O4. Compare the different types of software used by each of the organisations who take part.

The survey was targeted at the top 20 UK contractors in terms of size. All of the interviews took place in situ at the contractor's office and took a maximum of an hour to complete. The interviews were conducted at the user's work place because that is where the user interacts with the software and realises their problems and successes.

The questions covered includes what systems are used on projects, their key features, the replacement strategy for the software, how much contact there is between the software suppliers/contactors in terms of software development/support.

This chapter is aimed at giving a presentation of the existing software systems used, by whom, how the system features compare, and how they are updated/replaced, and presenting all the information one place.

4.8 Methodology – QFD project

4.8.1 Introduction

This project assessed QFD's ability to develop Information Management Systems in the construction environment. Therefore the best way to test this was to attempt to use it in a practical sense.

QFD is a product development methodology that has no fixed path. From conception each QFD project uses the available tools in a different manner and to a greater/lesser degree with the result that each QFD project process is unique.

QFD used in the traditional sense can be a time consuming activity designed to implement a solid long term manufacturing project, for example the manufacture of a car. For these projects, development time can be extensive. For software development, the development time is significantly less, and the product is a one off and replicated automatically. These factors indicate that the traditional form of QFD is not suited to fast development processes and individual projects. Therefore, Blitz QFD, a shorter more potent form of QFD is being used in this project. It was developed for the use on software development and places a lot of emphasis on the initial gathering of the customer requirements. This method was decided after an

extensive literature search and a review of its origins and method can be found in the literature review.

4.8.2 Chapter 6 - QFD project: Project inception to discovering the user benefits

Project goals: For QFD to have a long-term impact, it must address the key problems facing the users of the collaboration systems today and in the future. The project goals in this case refer to the goals of the QFD project, and not the PhD project.

The cause and effect diagram (C &E) was used to explore the potential or real causes (or inputs) that result in a single effect (or output). Causes are arranged according to their level of importance or detail, resulting in a depiction of relationships and hierarchy of events. This can help search for root causes, identify areas where there may be problems, and compare the relative importance of different causes.

The C&E diagram is also known as the fishbone diagram because it was drawn to resemble the skeleton of a fish, with the main causal categories drawn as "bones" attached to the spine of the fish. For the project goals stage, the QFD project is only concerned with the main goals. The bones of the fish diagram will be dealt with later. If more information was needed at this stage then an affinity diagram and Analytical Hierarchy Process (AHP) could have been used to prioritise data and examine it more carefully.

Identify customer segments: The Identify customer segments step is used to identify which users will help the project be most successful. This process will define the users based on characteristics of use. These may well be different from existing demographic attributes whose purpose is advertising and promotion. The purpose here is software design, and so usability, functionality, integration, and longevity issues need to be understood.

Some questions about the users that will be answered in this stage are:

- Which users will help achieve the project goals?

- Are all users equally important, or are some more valuable to us than others?
- Are there limited resources? (time, people, money) to visit customers?
- If so, how should they be visited?

The QFD at this stage will define the user by how they interact with the system, for example the level of computing experience for on-site operatives will affect the design of the software system. This step will be particularly helpful when exploring unspoken needs, since the user may only reveal them in the process of using the product. Some of the information needed for this exercise:

- Who will buy the software?
- Who will use the software?
- Which are most useful to understand in order to achieve the business goals already identified?
- How will the software be used?
- How else could the software be used?
- How should the software not be used?

Visit Gemba: In Japanese manufacturing, the word gemba means the shop floor. When there is a problem, the engineers go directly to the work area and use their own eyes to see, their own ears to hear, their own hands to touch, etc. They rely on their own experience, not reported data, to understand the situation.

In QFD, the gemba is where the product or service becomes of value to the customer, that is, where the product really gets used and delivers real value to the customer. An analysis in the gemba can clarify unspoken opportunities for new products and services.

Analysis at the gemba starts with the user walking through his business processes under consideration. The document capture and transmission stage will be mapped using a basic process map to aid discussion of the process. Modelling and process mapping methods are two powerful ways to understand the context of the user in more detail. They allow the QFD process to hear and see what is going on. After the

processes have been mapped and the user visited, the Gemba visit table will be used to document the customer's experience of the system they use and focus all the relevant information recorded in each interview and notes taken into one space.

The upper section of the table gathers data regarding the customer, the team, and the visit. The lower section will contain the information gathered from various media types on the gemba visit. Explanatory notes from the scene may be added. Finally, this data is reduced to single issue statements that clarify what the user means.

The Gemba can be divided into three steps.

1. Visit onsite; spend time with the project team talking about their job and how they interact with the software on a daily basis. Spend time with as many people on the project team on-site for up to 2 hours each. Complete this on as many sites as possible.
2. With the information gathered, meet with 3-4 project managers and discuss the information topics gathered, seek explanation and additional information on specifics identified by the project team
3. Analyse information and conduct short interviews on specific information areas accessed in first step.

Discover the customer needs: To satisfy any user, a software developer must understand how meeting their requirements affect satisfaction. There are many specification approaches for gathering user requirements. If the product in question has users who are completely knowledgeable about all their requirements and able to articulate them, they work, but in almost every occasion, customers are untrained at giving their requirements.

QFD takes a different approach to exploring and then engineering requirements. It asks the user to define value by telling the QFD practitioner, or demonstrating important problems they face that prevent them from achieving their personal or business goals, by identifying opportunities they cannot currently seize, and by revealing things that make them look good to others or feel good about themselves.

The following become the starting point for further analysis:

- Problems (negative statements of what is wrong or what needs to be changed) can be reworded into positive needs or benefits
- Opportunities and image issues which are usually positively stated can be reworded into needs or benefits.

The information gathered at Gemba in the last step is entered appropriately in the CVT (Customer Voice Table). If for example the user data comes in the form of a software feature, an attempt will be made to identify the underlying benefit that would be satisfied by the inclusion of the feature. The CVT is started with the benefits and features. If needed additional categories can be applied in the table. Typical categories are technical performance and quality characteristics, functions, processes, tasks, reliability, technology and cost. This concept is especially useful to understand true user needs that underlie customer's spoken comments.

The user needs entered in this table should be stated in positive words. Resolving positive needs is more powerful than eliminating negatives; nothing wrong does not mean that there is anything right. From the gemba visit table, and the clarified item column containing the distilled customers voice, the following will be deployed:

- Customer opportunities directly to the customer needs column,
- Customer characteristics and scenes into the customer section and look for corresponding benefits go in the customer needs column.
- Customer image and esteem issues can have their own column in the customer section, and then look for corresponding customer needs.

4.8.3 Chapter 7 - QFD project: User needs to a software specification

Structure the customer needs: The KJ (Jiro Kawakita) Method is a means of organising diverse observations and qualitative information into useful documented facts.

It was developed for creative activity support and uses cards for making a conceptual map from brainstorming. Using this KJ Method produces the affinity diagram which shows the natural structure of the customer's requirements. This is a "right brain" method, as most people are not aware of what cognitive structure they use for their requirements. It was developed by anthropologist Dr. Jiro Kawakita to surface the cognitive structure of group samples. This method is also unique because the grouping categories come after the groups are made, not before. This allows for breaking the paradigms that existing information places on data.

For this step, the customer needs discovered in the CVT in the previous step are used. The users are the people the process wants to explore so they must silently place the items where they "belong". After this headings are created for the groups. There may be several levels of grouping nested within each other. Some data may actually become the header. It is important to note that there are no right or wrong groupings, only different points of view.

This process can be shown using the following animals: cat, pig, horse, sheep, dog, grizzly, lion, buck, tiger, and rabbit. A group of people, move the animals into groups. If any one person disagreed with a choice, then they could move it where they thought it should go, and then place headings on those categories. The result is demonstrated in the following affinity diagram.

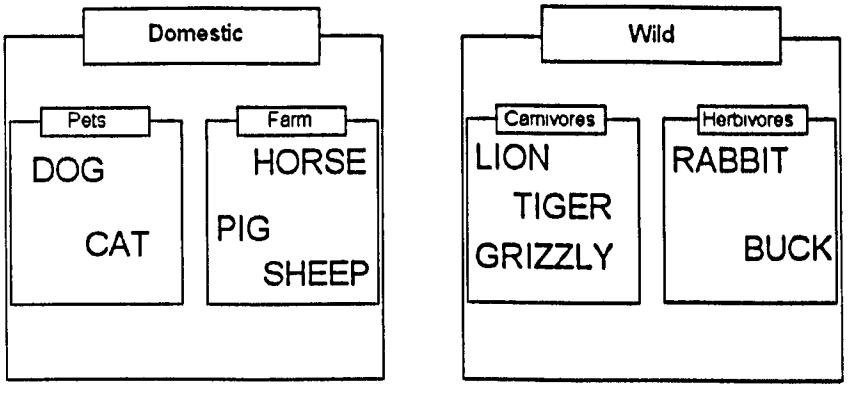


Figure 4.1 Example of an affinity diagram

The affinity diagram was not originally intended for quality management. Nonetheless, it has become one of the most widely used of the Japanese management

and planning tools. The affinity diagram was developed to discover meaningful groups of ideas within a raw list. In doing so, it is important to let the groupings emerge naturally, using the right side of the brain, rather than according to preordained categories.

This step sets up the next step, where the exciters (un-stated needs) are uncovered and promoted.

Discover the un-stated needs: The structure uncovered by the KJ method is used to find missing, implied and other possible needs. A complete set of needs is not required, just enough to see the structure.

The Hierarchy diagram provides a more analytic perspective on the data, by rotating affinity diagram from a top-bottom to left-right orientation. The Hierarchy Diagram performs three tasks:

1. Starting at the left most "column", confirm that the level of detail or granularity of the items agree. In this example, domestic and wild are the same level of detail, and so they pass this test. If some items are less detailed, they should be moved to the left; if more detailed, moved to the right.
2. Next, for that level determine if there are any missing members of the set. Here, using the classifications of domestic and wild animals. Is there another member of this set, such as "semi-domesticated" which might include animals such as llamas?
3. These two steps are then repeated for each of the columns to the right.

Figure 4.2 is an example of this Hierarchy diagram working for the simple animals example used in the previous step. This is a tool to uncover unspoken needs which should be confirmed with the user.

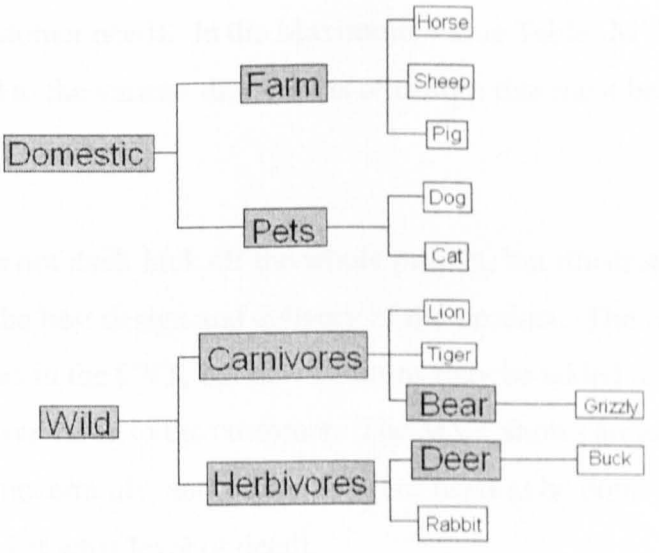


Figure 4.2 Hierarchy diagram

Prioritising the customer needs: The user needs on the hierarchy diagram must be prioritised by actual customers so we know which needs are important, how much, and to whom. Analytic Hierarchy Process (AHP) is a procedure which provides accurate ratio scale priorities based on natural language comparisons. There are other ways to do this, but they are not as accurate, nor do they yield ratio-scale numbers. Unlike other ranking or rating techniques like Pareto analysis, Scenario analysis, Decision trees and Strategic planning tools (SWOT etc.), AHP does not require rational responses. An inconsistency check quantifies this by looking for instances of a>b, b>c, c>a. AHP uses the human ability to compare single properties of alternatives. It not only helps decision makers choose the best alternative, but also provides a clear rationale for the choice.

A properly organised and prioritised hierarchy can tell if there are sufficient needs to satisfy the users. In other words, are there enough needs that the customer would be satisfied with the product, if they were delivered?

To start with, the most abstract level of detail is used (1st level of the hierarchy diagram) and the criteria is arranged in both the rows and columns. Working row by row, determine whether the row is more important than the column and if so, how much more important.

Deployment: In the Customer Voice Table (CVT) all columns were driven back to explore the customer needs. In the Maximum Value Table (MVT) key user needs are driven forward to the various dimensions of design that must be aligned in order to assure customer value.

The MVT does not itself kick off the whole project, but illustrates areas where there is need to focus the best design and delivery of the product. The columns in the MVT start the same as in the CVT, but new columns may be added to assure end-to-end activity to deliver value to the customer. The MVT shows areas that have great complexity or uncertainly, and where matrices need to be done between two design dimensions and at what level of detail.

In the CVT, the aim is to understand what the customers are saying through their own words, so it is worked from right to left. On the MVT, the aim is to plan the delivery of the benefits to the customers, and is therefore worked from left to right.

The MVT shows everything on the project that is most important to the customers, what the project must apply best efforts too. For this reason, it is the single most important piece of paper/software produced throughout the development process.

This is the end of the Blitz QFD process. Though if more detail is needed, the best known matrix in QFD, the house of quality, can be used. This matrix deploys the "voice of the customer" into solutions characteristics and capabilities.

4.9 Chapter conclusions

This chapter investigates and presents a research methodology for achieving the previously stated aims and objectives. It seeks to complete an effective and sound methodology consistent with current standards and practices.

PhD Research has to be a contribution of original work that seeks to measure reality depending on which research paradigm is chosen:

- Positivism; and

- Interpretivism.

An interpretivitist approach was chosen assuming that the researcher would be an integral part of the process being researched. Certain Limitations surrounding the study were recognised as:

- The breadth of the people interviewed;
- The number of organisations involved;
- The lack of industrial experience in QFD; and
- No experience in developing a software specification.

These limitations were noted, and steps were taken to limit any impact they would possibly have. Those limitations were considered the overall impact of the study in the conclusions. A validation strategy was constructed which involved presenting the software specification and overall results to a leading Collaboration system developer and requesting their opinion of the project in terms of three crucial factors:

- Technical validity;
- Economic validity; and
- Operational validity.

The main body of information in this project will be collected using interviews. A survey of the current status of information management in UK construction will be completed by interviewing prominent personnel in the IT department of each of the top 20 UK Main contractors. The interview will revolve around 10 main questions with the flexibility to follow different lines of conversation if appropriate.

Chapters 2 and 3 will comprise of the literature review of the two main subjects, Information Management within the Construction Industry and Quality Function Deployment, with Chapter 4 being the research methodology chapter. Chapter 5 will investigate the current status of information management in UK Construction with chapters 6 and 7 recounting the QFD project. Chapter 8 will comprise of the conclusions and further recommendations of the overall study.

5.0 CURRENT STATUS OF INFORMATION MANAGEMENT IN UK CONSTRUCTION.

5.1 Introduction

Chapter 3 described the theoretical framework of information management within the UK construction industry. This chapter presents the current practice of information management within the UK construction industry.

Approximately 1.5 million people work in AEC in the UK *(Morton, 2002).* These personnel are split into many professions that come together and contribute their skills and expertise to complete a building project. The four main professions are the Architect, Civil Engineer, Surveyor and Builder. These are not only professions, but also distinct identities that have developed over the last 300 years *(Morton, 2002).* This culture of individualism has led the architects, civil engineers and surveyors to often work in isolation in their own organisations separate from the other main partners in a construction project. This means that contemporary construction is operated by a group of essentially different organisations, with different identities, all working towards the same goal in different ways on multiple and individual projects. Added to this confusing work method is the varying contributions made by the client or the client organisation, contractors, sub contractors, and supply chain organisations.

Bowley sums up the result as:

"It is difficult to see how any system more wasteful of technical knowledge, intellectual ability and practical and organising experience could have been invented"

(Bowley, 1966)

5.2 Organising the Information

The sharing of information between the key stakeholders in a construction project is not a new concept, it has been the focus of study and research for many years. Prior to the use of computers all communication was mainly achieved using paper forms. The integration of IT into AEC can be seen so far in three broad stages.

The first stage (prior to 1980) used computers to help streamline manual tasks like bookkeeping, typing and number crunching. The second phase started with the advent of the personal computer where construction computing became more application focused and specific stand-alone programs such as estimating, scheduling and design were developed *(Anumba et al., 1997).* The third phase, which dates from 1990, has seen the development of IT as a communication medium capable of establishing favourable supply chain relationships *(Thorpe et al. 1998).*

This third stage is still active, and the subsets of the stage have moved from basic document scanning technologies, to EDMS where the scanned information can be manipulated, to internet based systems such as intranets and extranets, and then finally collaborative internet based systems that allow multiple organisations and stakeholder access to project specific information.

5.3 Sharing the information

Good communication is vital to the construction process. Previous research completed by the Royal Institute of Chartered Surveyors (RICS) has shown that there has been a poor take-up of electronic communication as part of the procurement process in AEC. 30% of Bills of Quantities were prepared in digital form, less than 30% were made available to the contractor as an electronic document and less than 10% of priced bills were submitted electronically *(Breetzke, Hawkins, 2003).*

5.4 Aim/Methodology

Contractors were used for this survey as it was felt they are the largest group of users of collaboration software within the UK construction industry. They are also the prime users of those systems as designed by the ASPs themselves.

AIM: To survey and present the current document management/collaboration systems used by the top construction organisations in the UK from a contractor perspective focusing on what is being used, by whom, where why and what experiences with information management they have had.

OBJECTIVES:

1. Interview each of the top 20 organisations in the NEC Contractors file "top 20 firms" concerning their contemporary collaboration strategy.

The semi structured interview consists of ten questions. Those questions were chosen to examine which collaboration system each contractor uses, were they use it, how long they have been using it for, what they think are its good/poor features, how they chose the software and how they intend to replace it in the future.

2. Present that information with a concise type on each organisation, and a rundown of the main features of its chosen system.

The majority of surveys/reports that exist about recent AEC industry trends and applications have been lead/commissioned from a technology organisation perspective, focusing on the functional specifications of the software available, stating what AEC organisations are using what software and sourcing that from the technology organisations themselves. This can almost be looked on as a sales measure, if not, a biased account.

The aim of this survey is to examine the collaboration systems used by UK main contractor organisations by contacting the organisations themselves, and not their technology suppliers. The interview was designed as a semi structured interview, or a structured conversation with 10 stipulated waypoints. The result is not only the answer to the basic 10 questions asked, but also a more complex picture on the relationships between contractors, technology organisations, and the systems they both use.

5.4.1 Limitations

- The survey was limited to the top 20 UK contractors as reported by the New Civil Engineer *(NEC, 2003)*.

- The survey is aimed at discovering what is being used by main contractors, not smaller niche sub industries within the construction industry that may use various forms of information management.

5.4.2 Survey type: interviews

The survey was completed using a structured interview. A questionnaire could have been used but it was felt that potential for a response would be greater if personal contact where made with the contractors and the effort spent in travelling to meet them. Also the use of an interview facilitated a more in detail response to questions, allowed the interviewer to encourage extensive answers for each of the questions and allowed various answers to be probed for more pertinent answers. Also with the extent of different IT implementation throughout large organisations, an interview setting allowed the questions to be directed at the right systems.

The use of fixed date interviews also allowed the interviewee time to source specific information about the information management systems used by their organisation and approach the interview with a balanced opinion of their employers systems.

5.4.3 Questions

The survey consisted of 10 questions. These were aimed at gaining a topographic viewpoint of the systems used within the top UK contractors. The questions were developed round the following:

- What systems are being used?
- Where are they being used?
- When are they being used, and since when?
- How are they being used?
- With what are they being used?
- Why are they being used?
- Has your organisation been able to use those systems as desired?

5.5 Introduction to NEC civil engineering lists

The NEC (New Civil Engineer) publishes a Contractors file in July of each year. Within the Contractors file, they detail a list of the top 20 UK Contractors on a turnover basis. This list was used as the sample for the survey.

Table 5.1. Top 20 contractors 2003 *(NCE , 2003)*

Position	Company	Civil engineering turnover (£m)	Profit margin (%)	Total staff	Work undertaken
1	Balfour Beatty	1121	n/a	10660	Ai B C Df G M P PH Ra Ro T WW
2	Carillion	645	n/a	n/a	B C Df G Ra Ro Wa
3	Mowlem	480	2.9	n/a	Ai B C D Df G M P PH Ra Ro T Tu Wa WW
4	Edmund Nuttal	438.5	4.2	3513	Ai B C D Df G M P PH Ra Ro T Tu Wa WW
5	Skanska	404.6	3.0	4008	B G Ra Ro T Tu WW
6	Amec	312.5	n/a	1889	Ai C Df G M P PH Ra Ro T Tu WW
7	Morgan Est	281	2.3	2000*	Ai B C P Ra Ro Tu WW
8	Costain	237	n/a	915	Ai B C G M P PH Ra Ro Tu WW
9	Alfred Mcapline	233.7	4.3	814*	Ai C D Df G Ra Ro T WW
10	Ringway Group	233	3.6	1888*	Ai Df Ro
11	JMurphy & sons	220	3.8	3100	B C D G P Ra Ro T Tu WW
12	May Gurney	213	2.5	1400	B C G Ra Ro WW
13	AWG Construction services	196	1.5	700*	B D Df P Ra Ro Wa WW
14	MJ Gleeson Group	180	n/a	1381	B C G M P Ra Ro Wa WW
15	Jackson Civil Engineering	153.4	9.1	n/a	B C Df G PH Ra Ro T WW
16	Dean & Dyball Construction	139	0.7	1270	Ai B C P Ra Ro T WW
17	Birse Civils	131	n/a	317*	C Ra Ro WW
18	Sir Robert McAlpine	130	n/a	300*	Ai B M P PH Ra Ro
19	Fitzpatrick Contractors	124	4.8	1603	Ai B Df M PH Ra Ro
20	Kier Constriction	124	n/a	493*	B df G P PH Ra Ro Tu WW

* Permanent staff only

Table 5.2 Types of work, *(NCE , 2003)*

Abbreviation	Type of work
Ai	Airports
B	Buildings
C	Coastal/Flood defences/Irrigation
D	Dams/reservoirs
Df	Defence
G	Geotechnical
M	Manufacturing
PH	Ports & Harbours
P	Power/energy
Ra	Rail/Rail bridges
Ro	Roads/Road bridges
T	Telecommunications
Tu	Tunnelling
Wa	Waste handling/treatment
WW	Water/wastewater

5.6 Survey results

Fourteen out of the top twenty contractors agreed to be interviewed. For illustrative purposes, the non-participating contractors were left in the results.

Each of the ten questions are presented in order with the specific answers from each of the organisations, with additional more detailed answers from each of the participating organisations contained within Appendix B on the accompanying disk.

Q1. What collaboration system/s is your organisation using at the moment for AEC projects?

Organisation	
Balfour Beatty (^)	Business Collaborator, Build Online
Carillion	ProjectNet, Project Eagle (intranet)
Mowlem	
Edmund Nuttal	Business Collaborator
Skanska	Skandocs, BuildOnline, EDDA (Electronic Document Drawing and Archive system)
Amec	docs open (Construction services)
Morgan Est	Build Online, Bespoke server & CD, Informatix
Costain	Business Collaborator (customised and named Icosnet)
Alfred Mcapline	Laserfiche, QDMS (Quality Document Management System)
Ringway Group	None, consultant's software: IBM suite
JMurphy & sons	
May Gurney	
AWG Construction services	Projectwise (on occasion). Mainly Project Management Assistant
MJ Gleeson Group	DOCS, DocsPro, Project Extranet
Jackson Civil Engineering	None, use basic folder system
Dean & Dyball Construction	

Birse Civils	
Sir Robert McAlpine	
Fitzpatrick Contractors	Project Net, BIW information channel
Kier Constriction	Currently deploying a document management system

Q2. Does your organisation use different systems between the head office and project sites and over different regions of the UK?

Organisation	Answer
Balfour Beatty	At times yes, but preferably no
Carillion	Not for construction work
Mowlem	
Edmund Nuttal	Yes, staff members allowed to use which system they like
Skanska	Yes though EDDA is used on all sites
Amec	All the same, except on smaller sites were a bespoke system may be used.
Morgan Est	Yes, different systems used
Costain	No
Alfred Mcapline	Yes, Laser Fish and QDMS
Ringway Group	No
JMurphy & sons	
May Gurney	
AWG Construction services	Yes
MJ Gleeson Group	The different Divisions use different systems, but within each Division the same systems are used.
Jackson Civil Engineering	No (file system in use on main server)
Dean & Dyball Construction	
Birse Civils	
Sir Robert McAlpine	
Fitzpatrick Contractors	No, all standardised
Kier Constriction	Some sites on the insistence of the client

Q3. When did you start using those systems?

Organisation	Answer
Balfour Beatty	2000-2001
Carillion	2000-2001
Mowlem	
Edmund Nuttal	2002
Skanska	EDDA,1990 Skandocs, 2004
Amec	1996-1997
Morgan Est	CD & Scanning, 2001-2002 Buildonline, 2002, Informatix, 2005
Costain	2003
Alfred Mcapline	2000-2001
Ringway Group	IBM, 2004. Scanning software, 2003
JMurphy & sons	
May Gurney	
AWG Construction services	Projectwise 1999, PMA 2001

MJ Gleeson Group	DOCS, 1998 DocsPro – 2003 BIW, 2003
Jackson Civil Engineering	N/A
Dean & Dyball Construction	
Birse Civils	
Sir Robert McAlpine	
Fitzpatrick Contractors	Project Net, 2000 BIW, 2004
Kier Constriction	1999-2000 (client specified software only)

Q4. What in your opinion are top five benefits of using collaboration software on projects?

Organisation	Answer
Balfour Beatty	1. Versioning 2. Audit trails 3. Viewing tools 4. Email notification functionality
Carillion	1. Accessibility 2. Ease of use 3. Set up and speed 4. Drawing register 5. Archiving
Mowlem	
Edmund Nuttal	1. The ability to communicate to a number of parties simultaneously, 2. record of who's received what and when 3. Ability to tracking down for who is responsible for holding up the process. 4. Work delay warning facility 5. Effective storage & filing
Skanska	1. Retrieval 2. Versioning 3. Auditing
Amec	1. search facility 2. Good quality document storage/manipulation 3. Personal storage limits. 4. Integration with Outlook
Morgan Est	1. Ease of access, 2. Capture of live data, 3. Ability to access records from a process that can be used to measure the effectiveness of that process, 4. Ability to capture the record in 3 at the end, giving a complete workflow, 5. Complete workflow from beginning to end for that processes
Costain	1. Multiple uploads 2. Edit feature (when editing doc in word/excel file on system is read only) 3. Price
Alfred Mcapline	1. Archiving facility 2. Savings on Photocopying costs
Ringway Group	1. Remote access 2. Price 3. Speed of access 4. Document viewer 5. Mark-up facilities
JMurphy & sons	

May Gurney	
AWG Construction services	1. Current information 2. metadata 3. Auditing attributes 4. Remote access
MJ Gleeson Group	1. Efficiency, 2. Consistency, 3. Control, 4. Summary reports 5. Accessibility to info
Jackson Civil Engineering	N/A
Dean & Dyball Construction	
Birse Civils	
Sir Robert McAlpine	
Fitzpatrick Contractors	1. Clear User interface 2. Flexibility of Process Management 3. Viewing technology 4. Searchable of comments 5. Reliability
Kier Constriction	1. Accessing documents. 2.Tracking movement of documents through their various approval routes. 3. Revision management. 4. Issuing documents 5.Data and document storage

Q5. What in your opinion are the top five problems with the collaboration systems?

Organisation	**Answer**
Balfour Beatty	Varies from product to product
Carillion	1. Dealing with faxes and paper correspondence 2. Working with the way the people still seem to work on a construction site. 3. Have to be careful not to improve the process that actually should not be a process in the long run. 4. Finding a better way of integrating the non-electronic information. 5. The interface between the printing facilities and reprographics
Mowlem	
Edmund Nuttal	1. Biggest problem with any system the hardware 2. Time periods for getting internet connections onto site 3. Speed of internet connection 4. Complexity and inherent staff training problems
Skanska	1. Optical Character recognition 2. Bugs in software 3. Not a lot of systems that can be used in construction
Amec	1. Not able to publish straight from Docs open to internet
Morgan Est	1. Culture 2. Training 3. Trying to sell people the benefits

Costain	1. Speed
Alfred Mcapline	1. Time taken to fill in document fields in DM software
Ringway Group	1. Will people use it? 2. Lack of trust in electronic copies
JMurphy & sons	
May Gurney	
AWG Construction services	1. Viewing drawings on screen is extremely difficult 2. Some of them (systems) are very bandwidth-intensive 3. The cost of the infrastructure to support the software 4.
MJ Gleeson Group	1. Inconsistency of operator performance 2. Inappropriateness
Jackson Civil Engineering	N/A
Dean & Dyball Construction	
Birse Civils	
Sir Robert McAlpine	
Fitzpatrick Contractors	Mostly just tweaks, nothing enough to need a re-design of the software
Kier Constriction	1. Sub contractors having the systems or ability to fully partake in the system. 2. Learning curve of using and the change in mind set. 3. Unease of companies to be prepared to release information electronically. 4. Resources to input and keep system running

Q6 How many projects is your organisation using this software at the moment?

Organisation	Answer
Balfour Beatty	25 to 30
Carillion	40-50
Mowlem	
Edmund Nuttal	6
Skanska	Skandocs, 6 Edda, 12
Amec	12
Morgan Est	23
Costain	15
Alfred Macapline	16
Ringway Group	3
JMurphy & sons	
May Gurney	
AWG Construction services	6
MJ Gleeson Group	25
Jackson Civil Engineering	0
Dean & Dyball Construction	
Birse Civils	
Sir Robert McAlpine	
Fitzpatrick Contractors	6
Kier Constriction	4

Q7 Has your organisation ever been approached by a software development organisation for requirements specifications or do you buy directly off the shelf?

Organisation	Answer
Balfour Beatty	Yes, consultation takes place on existing software used and its strengths
Carillion	No
Mowlem	
Edmund Nuttal	Yes, numerous
Skanska	Yes, but not wanting to reveal organisations
Amec	Yes, a lot.
Morgan Est	Yes, mostly organisations trying to sell though
Costain	No
Alfred Mcapline	No
Ringway Group	No
JMurphy & sons	
May Gurney	
AWG Construction services	No
MJ Gleeson Group	No. Gleeson did however work with the developer of DocsPro to add some features
Jackson Civil Engineering	No
Dean & Dyball Construction	
Birse Civils	
Sir Robert McAlpine	
Fitzpatrick Contractors	Yes, a few of them were not serious though
Kier Constriction	No

Q8. Has your organisation ever considered developing its own software?

Organisation	Answer
Balfour Beatty	
Carillion	Yes, but not an option for the future unless the environment changes from present.
Mowlem	
Edmund Nuttal	Yes, but only specialised inhouse databases, not full systems
Skanska	SKANDOCS
Amec	No
Morgan Est	No
Costain	Yes (Customised BC)
Alfred Mcapline	No
Ringway Group	No
JMurphy & sons	
May Gurney	
AWG Construction services	No
MJ Gleeson Group	No, though helped investigate improvement features for DocsPro
Jackson Civil Engineering	No
Dean & Dyball Construction	
Birse Civils	
Sir Robert McAlpine	
Fitzpatrick Contractors	Yes. The intranet used is in house
Kier Constriction	No

Q9. What process does your organisation use to select the collaboration software that your are using?

Organisation	Answer
Balfour Beatty	Group investment in Business Collaborator. Three of Balfour's operating companies have made investments in build online.
Carillion	Working group with an "implementation of tender". Detailed check list of functional requirements. Some of the supply chain has been bought to do financial negotiation. Detailed report for senior management approval produced.
Mowlem	
Edmund Nuttal	IT Development Committee
Skanska	Statement of requirements constructed and sent to software developers for a quote. Resulting applicants are then scored through a set process.
Amec	Director level assessment of software/ change reports
Morgan Est	Number of vendor checks: Financial/certifications. Background check.
Costain	Interviewed 60 users throughout country, from this constructed a 10 page pre-qualification questionnaire and sent to 30 companies identified.
Alfred Mcapline	Assessment workgroup of seven or eight people from the two regions.
Ringway Group	One experienced person tasked with assessing options and presenting report on the systems available.
JMurphy & sons	
May Gurney	
AWG Construction services	Discussing across divisions and construction of a business case for the software.
MJ Gleeson Group	Our IT department review the requirements of the system (in consultation with the users) and procure the appropriate cost effective system.
Jackson Civil Engineering	Assessment by IT section of organisation
Dean & Dyball Construction	
Birse Civils	
Sir Robert McAlpine	
Fitzpatrick Contractors	Examination of on shelf products
Kier Constriction	Mainly by client preference

Q10: What is the updated/replacement strategy for the collaboration software you use?

Organisation	Answer
Balfour Beatty	No formal strategy as yet
Carillion	An annual IS strategy review which looks at all the corporate systems in place
Mowlem	
Edmund Nuttal	IT development committee
Skanska	Monthly meetings were the business systems managers from the Skanska group come together for progress meetings. Once a year strategy meeting.

Amec	Driven by companies coming together. If nothing happens then it tends to be the same. Tends to be driven by decision to standardise across the business. Though constant reviews of Docs open are being done.
Morgan Est	Long term agreement with current supplier
Costain	None, just update the current product.
Alfred Mcapline	We have used the Laser fish for about four years and as far as I know there is no plan in the future to change. We are reasonable happy with it.
Ringway Group	Currently none
JMurphy & sons	
May Gurney	
AWG Construction services	Update as projects are completed (only used on a project basis)
MJ Gleeson Group	An 'as required' basis
Jackson Civil Engineering	Currently none
Dean & Dyball Construction	
Birse Civils	
Sir Robert McAlpine	
Fitzpatrick Contractors	Monitor the market place. Look to develop good relationships with vender and then grow with their tool set as it is develop. Interact with suppliers at Partner levels
Kier Constriction	Not considered as the systems used are site based and hence are only for the duration of the site. (client required systems)

5.7 Summary of results

The most popular system used is Business Collaborator. The system is used as a corporate system for Costain who had the system customised to suit and renamed Icosnet. The version developed was then re-released by Business Collaborator as a new version of the software. Other Collaboration software in use for the top 20 main contactors are Build Online, ProjectNet, IBM suite, Projectwise and BIW.

The use of collaboration software as an organisation policy is limited to the top 10 contractors, with the rest using collaboration software as part of the client's preference (the client's system) on their contracts and then basic document/image management systems such as Laserfiche and Docs Pro as a corporate system. The use of multiple software systems used to do the same thing within single organisations suggests there is confusion either with the best/original application of the software or the configuration of the software itself is not suited to the applied function.

There are 7 different systems all from different organisations used by the top ten main contractors, not including systems used as part of client preference. These

collaboration systems were implemented between 2000-2003 therefore the usage of these systems is still in the very early stages.

The usage onsite of these software packages ranges from less than 5 project sites from Kier Construction and Fitzpatrick to 40-50 sites with Carillion and Balfour Beatty. There is a threshold between the top ten contractors and contractors listed from 10th to 20th of above/below 10 projects at once. These projects offer varying percentages of the total projects being carried out by each of the contractors.

The primary features/functions that were mentioned by more than one contractor as desirable functions of collaborations systems were:

- Create versions of documents;
- Create/track an audit trail of a document;
- The ability to view various file types without having the specific file compatible viewer; and
- The speed and the ability to remotely access the documents.

Secondary features/functions that were mentioned include:

- ability to archive;
- price of the system/access time;
- drawing register;
- adequate personal storage limits;
- ability to upload multiple documents; and
- clear user interface.

These primary and secondary features clearly describe the essential functions of a collaboration system. The important factor in considering these software features is that including them all is not the key to successful system, more so the key is looking at these functions as a core set of system responsibilities and realising the driver for a successful collaboration is knowing how to present those core functions in a manner

so they will all be accessible and fully useable for the average construction industry worker. Without that usability the system is worthless.

Problems with the software were more varied and will be directly related to experiences with the software. The major soft issues raised included dealing with the inconsistency of the operator performance/mind set and trying to sell the people the benefits, "working with the way people work on a construction site", the complexity and inherent staff training problems, the unease of companies prepared at releasing information electronically and lack of trust in electronic documents.

Issues regarding a more technical nature revolved around:

- The speed of the internet connection/bandwidth needed to run system;
- Timescale for getting bandwidth onsite;
- Bugs in the software;
- Viewing large documents on small screens;
- Sub contractors having the ability to partake in the system;
- The resources needed to input and keep the system running;
- Dealing with the unchanged paper processes (faxes/paper correspondence);
- The quality of the optical character recognition; and
- The interface between printing facilities and reprographics.

These points are essential issues that need to be addressed before considering taking on a collaboration system. Without those addressed, even the best designed collaboration system would fail. Aligned with the primary and secondary software functions discussed previously, these provide a basic template of issues that need to be considered as a roadmap for success.

Only the top contractors have been approached by software developers looking to examine their construction processes, and this was only in the attempt to sell them their products, an examination and customisation of the product to suit the specific contractor is only done after the sale is complete.

The majority of the organisations would not consider developing their own collaboration software because of the costs associated with developing the sophisticated IT operation needed, the non-guarantee that the investment will produce an acceptable solution compared with the products on the shelf. Also developing software in-house creates a dependency on certain personnel with difficult circumstances arising if they should decide to move on or realise their worth to the organisation, and hardware/software moves on so fast it would not a be a good enough investment to consider. It is simply more cost effective and less risky for the organisation to seek a product from a number of IT specialists. The only organisation that has developed it own collaboration software is Skanska with its Skandocs system.

Many of the organisations have however developed various smaller applications such as in-house access databases for drawing management, basic Intranet systems with folder systems based on an in-house server

The Collaboration systems used have been selected by assessing the organisations information needs and then contacting various software developers for an invite to tender their software. The major differences can be seen in how the contractors assess their own needs, which can be split into carrying out a survey on the intended end users of such a system and relying on the knowledge of one/several persons to stipulate and articulate the needs of the organisation from personal experience and expertise.

Several of the contractors including Balfour Beatty (Business Collaborator) and Fitzpatrick (BIW) have made investments in specific software developers and have senior members of the contractor on the development boards of the software developer. Once the functional requirements of the contractor have been self assessed the most common method for selecting the software is for a team of 2-8 people to conduct background checks on each of the software developers, attend various software developer's proposals/presentations and write a report with recommendations for board approval.

There are mixed results regarding the update and replacement strategy of the software systems. Some of the contractors have not thought about this stage so far, while

others are using the same process as for the other long standing IT software systems they use. The remainder are happy to leave the software to be developed and updated by the software developers, and have no formal replacement strategy.

5.8 Chapter conclusions

This chapter investigated the current use of collaboration systems within the UK construction industry. Interviews were carried out with 14 out of the top 20 UK constructor contractors looking at what systems were currently being used, how, where, by whom, and their most important and disappointing features (in their opinion).

Collaboration systems are generally only in use in the top ten main contractors, smaller contractors tend to work with large main contractors and gain experience of such systems from them but do not actually use them as a direct decision.

The systems that are available have been adapted from other industries with the result that much of the functionality of the systems are not used. There are approximately ten software functions that are used 90% of the time. The difference between the main software providers is how well they accomplish this basic functionality.

The majority of contractors use their IT personnel to decide on what system they use. These IT personnel have a sophisticated knowledge of what the software is used for on a project but they lack the experience of the day to day usage of the systems from an AEC perspective and therefore tacit issues that pervade and heavily influence AEC personnel's use of such systems.

It is a contradictory attitude for a contractor to put a large effort and use valuable resources to choose a collaboration tool for their organisation and then agree with a client to use their preferred software on their projects.

The contractors started using collaboration systems between 2000-2003 and the top ten contractors use seven different systems, and all have used most of the other systems at some stage. This suggests that the market is still in early development and

has yet to become stable with two or three main suppliers. With the market in this condition, there is an opportunity for a well-developed system to become the Market leader.

There were a number of unfilled user requirements that became evident from speaking to each contractor. Each contractor used the systems slightly differently and had a different view on how they wanted to use the system within their own organisation. These unfulfilled user requirements ranged from the system dealing with non-electronic faxes and paper correspondence, to publishing from systems directly onto the internet, training issues and user/system interaction.

6.0 QFD PROJECT: PROJECT INCEPTION TO DISCOVERING THE USER BENEFITS

Chapter 5 described the present configuration of collaboration systems used in the UK construction industry. That survey explored and discussed the various characteristics of the systems available, their advantages, features and failings.

This chapter is the start of the QFD project where the requirements for a better collaboration system than what exists currently is explored.

6.1 Project Goals

Every project must have a focal start point. This start point is used to access the basic qualities that will make the process a success, and clarify the overall aims and objectives.

To do this the first stage in the QFD process is to examine the project goals. A cause and effect diagram is used with four different bones. While these categories can be anything and customised to suit, typical cause headings can be:

- Manpower, methods, materials, and machinery (manufacturing)
- Equipment, policies, procedures, and people (administration and service).

For this project the values are: how measured, time frame, who judges success, and means to achieve it. Table 6.1 was constructed to show the basic project goals that this QFD project would target if completed within an industrial setting.

Table 6.1 Project goals table

Goal Statement, including target.	How measured?	Time frame	Who judges success?	Means to achieve it (Basics)
Develop user focused system	Level of user support needed, topics needing help with	6 monthly reporting	Clients	1 Long term partner relationship with client to Develop and re-Develop software 2 Educate software designers in construction processes 3 Continually investigate software development strategies and compare to current process
Deliver a system able to be used by the entire construction industry	Construction industry uptake/dispersion of software	1 year	Industry (types of clients interested in software)	1 Included wide range of potential users within software development process. 2 Investigate the needs of more obscure construction partners. 3 Actively search for uncommunicative-exposed industry clients for software eyes
Improve the satisfaction of customers and associates	Quarterly meetings with senior client staff	Every 3 months	Clients	1 Examine customer service routines and look for improvements 2 Enable feedback from grass roots to be heard and acknowledged
Improve profits and win/retain contracts with new software	Increased sales/contracts	6 months	Clients	1 Develop better systems (see goals). 2 Improve sales techniques, and breadth of clients targeted
Be seen as an innovating software house always looking for new techniques	Success of dynamic attempts to access the customers point of view	1 year	Industry (interest in software/methods)	1 Investigate method of software development 2 Be vocal about these investigations and their results in sales materials/demonstrations

The first step in the QFD project is concerned with the main project goals. The bones of the fish diagram will be dealt with later. If it needs to be taken further then an affinity diagram and AHP can be used to prioritise data and expand it for further understanding. The fishbone diagram is mainly used as a mechanism to discuss the goals and underlying business plans being considered.

The primary aim of this stage is to understand the origin of the project goals to be dealt with and to give a constant reference throughout the project of the overall project goals.

6.2 Identify customer segments

Once the basic project goals have been identified, the software users have to be targeted. The purpose here is software design, and so usability, functionality, integration, and longevity issues need to be understood. The user segments table shown will be used to focus all data collected.

At this stage some specific questions about the users were asked

- Which users will help achieve the project goals?
- Are all users equally important, or are some more valuable to us than others?

- Is there limited resources? (time, people, money) to visit users?
- If so, how should they be visited?

This step is used to identify which users will help the project be most successful. This process will define the users based on characteristics of use. These may well be different from existing demographic attributes whose purpose is advertising and promotion. The main point is to set up the rest of the QFD process with the main users of the software identified and their characteristics clarified.

The QFD at this stage will define the user by how they interact with the system, for example, the level of computing experience for on site operatives will affect the design of the software system. This step will be particularly helpful when exploring unspoken needs, since the user may only reveal them in the process of using the product.

Some of the information needed for this exercise is:

- Who will buy the software?

This is usually split between main contractors and large client organisations. Only large main contractors have the resources to run collaboration systems, and client organisations such as Tesco who project manage their own projects.

- Who will use the software?

This is dependent on the project. Typically it can be split into four groups.

  - Project staff on site, e.g., Project managers, engineers, site administrators. This group is primarily located in site.
  - Project Partners, e.g., all subcontractors involved within a project such as lift contractors, structural engineers. Any organisation who works onsite, but is based remotely.

- Project design staff, e.g., Contractor design staff, Consultants, Architects that are involved remotely on multiple projects providing/reviewing design information.
- Clients. Project owners accessing the system remotely often or at intervals.

- Which users are most useful to understand in order to achieve the project goals?

An examination of the project goals and the customer segments is completed to investigate what users are most important to a collaboration system. There are endless possibilities for different people to access collaboration across the participating project organisations. The key is identifying the most important users.

- How will the software be used?

In what surroundings will the software be used? Where? When? What level of IT experience will the users have?

- How else could the software be used?

Other possible uses of the software within the organisation. Is existing collaboration software used only as a project tool or as a corporate information tool? Do the users have their own uses for the software that it was never designed for.

The customer segments table takes much of this information and gathers it in one place for consideration and reference later in the QFD process.

Table 6.2 Customer segments table

Who uses product?	What is product used for?	When is product used?	Where is product used?	Why is product used?	How is product used?
Project staff. Project managers, QS, Site Admin, Engineers, Anyone that is site based and uses the system	Accessing general project information/ uploading HR information/ sending correspondence/ Editing information	Daily	On project site	To save time, and have a fully auditable information and communication source	Depends on culture. Often reluctantly, sometimes with enthusiasm. Benefits of using the system onsite need to be demonstrated to the staff, and training/support comprehensive
Project Partners Any Subcontractors providing materials, labour, plant, specialist services or prefabricated items to the site	Uploading correspondence information/ sending & receiving product information	Occasionally for pertinent information	Remote to site/client in offices	To upload invoices/drawings for site/clients to view Also used to review information placed there by other project participants	Often stipulated in contracts by client/contractor that a specific system must be used Training generally lacking since staff get moved and replaced mid-project without having the proper training
Project Design staff: Consultants, main contractor design staff, architects,	Sending design information to project partners & site/ receiving design information back	From occasionally to daily depending on design job	Remote to site/client offices	To upload/download drawings to be sent to contractors for review, or site for action	Often the most IT literate and knowledgeable about advantages of using IT Good attitude towards systems but worried about usage from project partners
Project Clients	Accessing general information on the project	Occasionally	In client offices remote to designs/site/project partners	Depending on client sophistication general overview of project to full participation in design confirmation and project site monitoring	Depending on sophistication of client organisation can range from non-existent to organisations like Iesco who use the system as a corporate management system, and is extensively used on all its projects

6.3 Visit the Gemba

6.3.1 Introduction

The QFD project started with contacting various organisations with the aim of getting access to multiple projects and access to the people on the project that use project management software. Appendix A shows a detailed diagram used during these meetings. Two approaches were used to gain access to the projects:

- Technology organisation: Gain the interest of software developer in the QFD methodology and use them to facilitate contact and organise project visits for two of their client contractors in return for a detailed report on their systems performance written from the QFD results/process.
- Construction Organisation: Gain interest from a number of construction contractors in the QFD methodology for access to an agreed number of their projects in return for a detailed report on the organisations information needs/performance cherry picked from the QFD results/process

6.3.2 Initial challenges

The initial strategy was to approach a number of collaboration system developers. One organisation was particularly interested and used their contacts to approach several of their clients. Initially the contractors contacted through the software developer were interested but this dissolved due to various time/resources impact issues.

The second strategy was then applied. Various main contractors from the NCE (New Civil Engineer) Contractors File 2003 were approached through the Business Systems Manager or equivalent. Two contractors stated interest in the project and the resulting report that would be provided. Their companies were met and the QFD projects aims and objectives were discussed. Both organisations agreed to take part. The project visits for contractor A were organised by a senior project manager within the organisation and best dates for visits provided. Contractor B's project visits were organised by making contact with the various project leaders through email initiated by the senior contact who agreed to take part.

After the first visit to contractor A, an accident forced the contact within the organisation off work for 8 weeks. There was no other members of staff willing to take over, and contact with contractor A was broken. At this time Contractor C was contacted, and after a meeting to discuss targets, an agreement to contribute towards this research was made.

To help understand the organisations involved, a short profile of each has been constructed:

Contractor A: A is one of the largest privately-owned construction organisations in the UK. Turnover for 2006 is anticipated to exceed £290m, with most work being repeat business. Founded in 1921, Contractor A has a successful track record within the Building, Civil Engineering, Highways Services, Rail and Facilities management sectors.

Contractor B: B dates back to 1865 when a 26 year old jobbing builder from the Isle of Man founded the original construction business in Liverpool. For more than 140 years B has been at the forefront of UK and international construction. With an order book of £1,900 million for 2006 contractor B is a major organisation within construction.

Contractor C: C is the world's leading airport company, and own and operate seven UK airports. They also manage contracts or stakes in airports outside the UK and are also a world-leading developer and manager of airport retailing. C will spend an average of £2 million a day in investment on new airport facilities over the next decade, and are one of the UK's principal developers of infrastructure and one of the construction industry's largest clients

Through discussions with the participating Contractors a list of projects were drawn up with easy access, a wide range of situations and participants. The 17 Participants included within the data gathering stage were:

- Project manager
- Quantity surveyor
- 3 site administrators
- Site engineer
- Project planner
- Document controller
- 2 sub contractors
- Main design consultant
- Design co-ordinator
- Main contractor
- Architect
- Oil and gas sector project manager
- Information management administrator
- Health and safety manager

6.3.3 Gathering the information

All the information was gathered using un-structured interviews. Un-structured in the sense that certain conversation themes were discussed but with no formal itinerary or order of discussion. The themes were:

- A walk through of their main job processes.
  - What they do?
  - With whom?
  - Where?
  - When?
  - How?
- How their job interfaces with IT tools
  - A demonstration of the user using IT in their work place to complete their job.
  - Step by step walk through of the exact processes used with commentary from the user.
- A discussion on how their current system meets their needs
  - How much the current system used by the user meets their job needs?
  - Where the potential for improvement is.
  - What the best parts of existing system is.

All interviews were held where the user accesses the system. Contractor A's interviews took place at their regional headquarters where the users were based. Contractor B's interviews took place in the site offices of a project, their oil and gas head quarters where engineers were based, and the design offices where the design co-ordinators were based. Contractor C's interviews took place during a monthly design meeting onsite. All the project partners were present and permission was given for/from them all to spend twenty minutes being interviewed each. Each of the project partners were excused during the morning and the interviews conducted in the site offices. The interviews took place between February and April 2005. On all projects the interviews took place when the site was live.

When approaching the Contractors to participate in the project a significant amount of emphasis was made that the interviews would need to be made with the users/internal users, since in some occasions contractors tended to direct any research questions to their IT staff and not their project staff. Additionally, a good representation of the different users would have to be found. For example, completing a QFD study of *10 project sites* only accessing information from site personnel would result in a very good specification for a document management system, and not a collaboration system. A wide range of project participants was therefore required.

6.3.4 Organising the information

Each interview was recorded on a PDA and then transferred to a laptop as a Windows media file. Those files were then transcribed and information inserted into a Gemba visit table and customer process model for each interviewee.

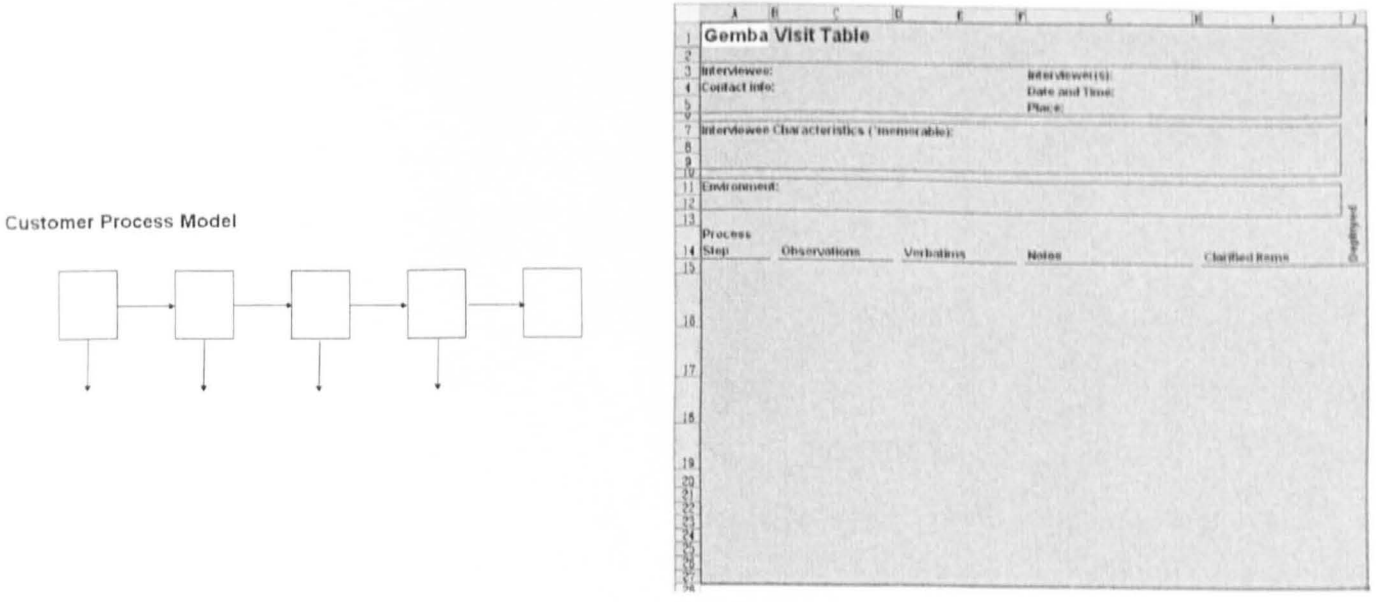


Figure 6.1 Customer Process Model and the Gemba visit table

After each interview, a basic process map of the user's interaction with the system was constructed. These steps were then taken and inserted into the 'Process step' column on the Gemba visit table. The interview was then reviewed and specific items

of customer/process intent or dissatisfaction were inserted word for word into the Vertabims column. Once this was completed all three columns were examined to 'clarify' the user's voice into short precise statements that can be taken further in the QFD process. An example of one section of one of the completed Gemba tables can be seen in Figure 6.2. All of the completed Gemba tables are contained in Appendix C on the accompanying disk.

This process is time consuming, but allows different issues to be placed in line with the process they are involved in and examined as an issue in a process, and not a problem with the user.

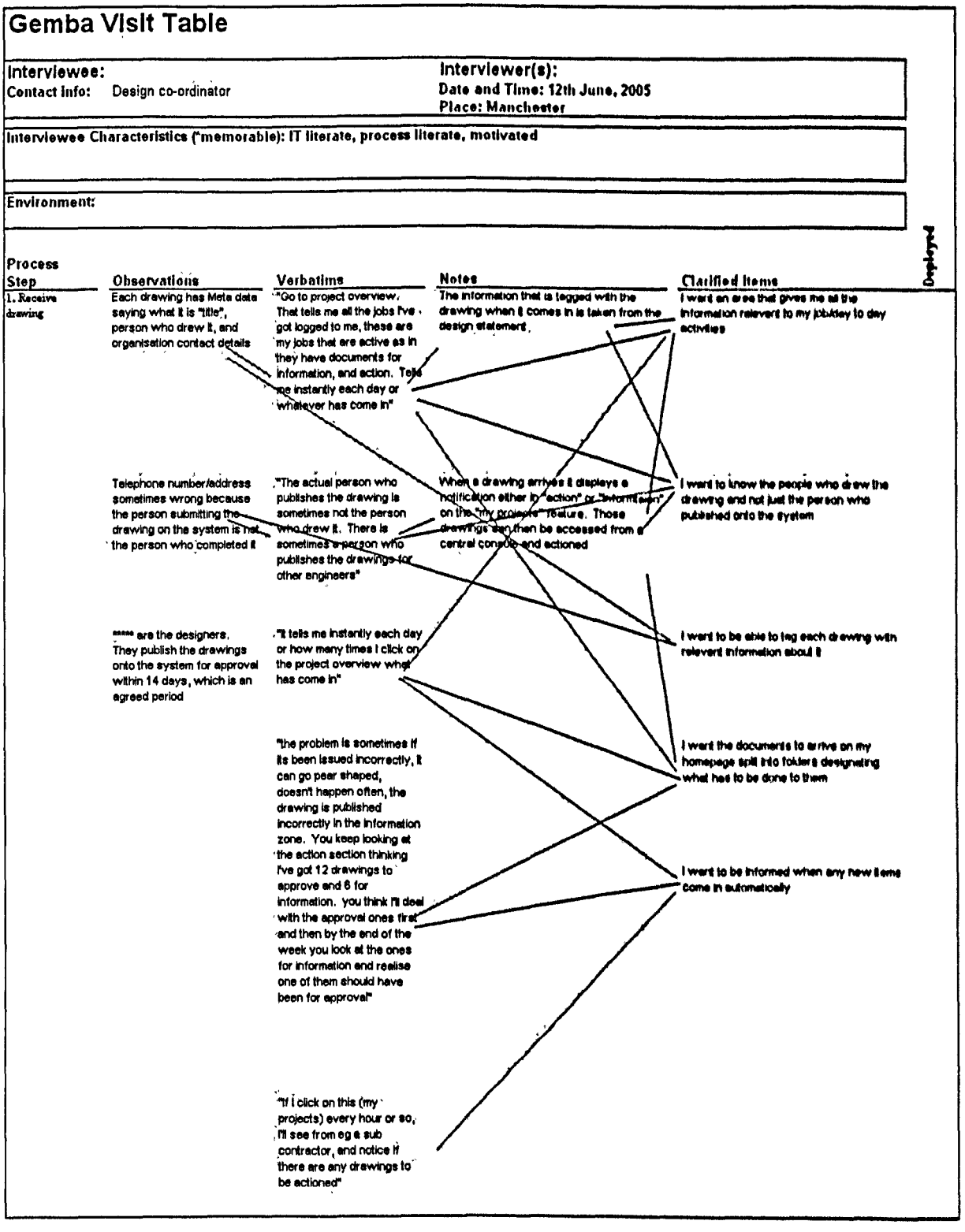


Figure 6.2 A section of the Design Co-ordinator Gemba visit table

6.4 Discovering the customer needs

The 17 interviews from the Gemba visits resulted in the clarified items in Table 6.3 These clarified items are mixture of generic benefits and software features and are unsorted, unstructured, and non-prioritised.

Table 6.3 Unsorted Clarified items

Clarified Items		
I want to use the system to comment on all drawings easily and quickly	I want to be able to access to drawings I need easily and quickly	I want to be able to use the system as a drawing register
I want the system to announce to the site system administrator at regular points what files have arrived from the suppliers for distribution	I want the main functions to be simple to use and in the event of an update in the software be as similar to the previous method as possible	I want to be able to upload drawings to the server
I want the system to be compatible with all site/contractor/organisation systems	I want to have a filing system that is in order or is policed	I want to be able to batch upload drawings
I want to be able to access the system externally and be able to use it fully	I want to be able to upload my own templates I have created for use on the system in my own folder.	I want the CAD team to be trained up in the software
I want to be able to use the system for all forms of construction document like variations, instructions, technical queries	I want to be able to print out a document using only one window	I want the people who actually use the system to be trained in it, and not just the bosses
I want to have support: easily contactable, quick to respond and able to solve problems	I want to be able to get back to where I was before I decided to print a document instantly	I want a qualified trainer to be part of the on site team
I want one person assigned to look after a set number of projects/organisations and that person to be known to the senior site personnel	I need to have basic IT training before I get training for the actual Collaboration software	I want training to be given to all personnel, not just one or two and then they are expected to train the rest of the team
I want to be able to give access to other organisations from site, and not have to contact support	I want to be able to colour and shade over parts of drawings and save them as different files	I want to be able to upload multiple file formats/drawings/documents easily
I want the notifications to tell me more about what I am being notified about	I want to be able scan and then upload drawings that have been notated/coloured onto drawings back onto the system	I want the system to be policed and have a maximum amount of actions allowed before notification goes to an administrator
I want the notification title to tell me what is in the notifications	I want to be able to create layers onto of existing drawings so I can shade areas, annotate onto them	I want a "drawing in sheet" shown in a window at the start of everyday detailing the recent documents to have been uploaded
I want to use the system for commenting on drawings but it is not easy enough right now	I want a system that is good enough to work on low speed connections in a stripped back manner	I want to be trained in the best way to manage information management and information flow
I want a back up system running so that if the system goes down/is having problems I can access a basic file server for the documents I need	I want to be able to track the approvals on the drawings, who has approved it, when and where	I want a mark up system that is easy to use and is simple to add customer symbols/comments
I want everyone to have comprehensive training on the software	Help format information management strategies for the customers, detailing best practice with the system and pitfalls to avoid	I want to be able to view multiple drawings on one screen easily.
I want a system that can compress automatically everything that is stored on it to save space	I want all relevant file types to be compatible with the system viewer	I want to be able to move files between folders after I have put them there, just encase of a mistake
I want to be able to publish documents to specific lists of people.	I want to be able to see who has downloaded a file, when, where, when it was saved, and see any comments/changes.	I want the screen to return to the point immediately before a function is used, after a chosen function is completed
I want to be able to batch publish drawings	With every new version that is added I want the old versions to be locked, but available for viewing	I want a search function that finds things I want to find
I want a fast method of publishing documents	When a file is published, I want it to be read only	I want a folder system on the system that is not confusing and simple of figure out what goes where, and what will be where

I want to have a draw package in the mark-up facility that is easy to use, and provides all the hand written symbols that would be used if using pen/paper	I want all employees of a firm to be added to the system log in automatically	I want to have automatic coding of documents, not site individual that makes the storage and retrieval of documents less problematic
I want to be able to track RFIs for their completion status	I want to know exactly where I am on the system, and what is infront of me, and where I have come from	I want to be able to use my email on both the system and an external program like outlook encase of a system problem.
I want to be able to upload saved files from a computer onto the system	I want a back button within the system	I want to be able to load up folders in one batch, not file by file
I want a backup system/server that I can access the essential files if the main system goes down	I want to be able to distribute documents and drawings to the other members of the project team/project partners	I want to have tailored training in line with my job
I want a list/link of/to favourite folders that are accessed regularly to be displayed for easy access on my homepage	I want to have support for the system that is efficient, easy to contact and have the ability for fix problems fast	I want an area that gives me all the information relevant to my job/day to day activities
I want to be able to archive all the drawings in a systematic order in a folder system	I want a customisable folder system to store the various documents	I want to know the people who drew the drawing and not just the person who published onto the system
I want to be able to access the drawings easier than from the hardcopy rack/in a good format on the small screen	I want to use the system essentially as a document store and archive	I want to be able to tag each drawing with relevant information about it
I want to be warned when a package is not on time and is running close to the limits	I want to be able to print out the drawings/documents quickly and easily	I want the documents to arrive on my homepage split into folders designating what has to be done to them
I want early warnings to be sent to the different contractors for each package if it is going to run late	I want to have a homepage where all informed concerned with my part in the project is stored/accessed	I want to be informed when any new items come in automatically
I want early warnings to be posted onto the internet so anyone concerned can access them	I want to be able to open the drawings/documents easily from my homepage/start page	I want to be able to view multiple file formats easily
I want to be able to send a notification to users on the system that a document/drawing has arrived	I want a timer with a countdown on the drawings with alerts telling me how long I have left to action the drawing	I want to know who has looked/edited the drawing previously and when/how/where they did this
I want to be able to set up different distribution lists for group notifications to be sent out	I want a separate marker telling how many unseen/viewed drawings I have that have been distributed to me	I want to be able transfer meta information about a documents
I want the process of notifying persons about a document to be quick and easy	I want to be able to mark up those drawings using the viewer, and not have to open specific software to change it	I want to be able to search for the drawing number/ file name/ project status and drawing coding
I want to have a customisable distribution list enabling me to add companies/persons instantly easily whenever I wish to send out a notification	I want to know where/to who the drawings have to go to before they are completed	I want the customer's organisation to be able to configure/customise the search engine
I want the system to show me more of a world view in terms of site activity and statistics	I want to be able to use tablet/stylus equipment to mark up drawings digitally	I want to be taught how to use the system/service to its fullest degree by the system developer
I want to be able to use the system to send correspondence to all the project partners	I need a good desktop PC	I want to be able to manipulate the file meta data
I want the client to be able to use the system to examine the project documents	I need a good Internet connection	I need a good desktop PC
I want to be able to access the system away from site for project documents	I want to use a management system	I need a good Internet connection
I want the contractors involved on the project to use the system	I want an environment where I can concentrate on using the system	I want to use a management system
I want to be able to search image files	I want to be able to access RFIs and send them off using the system	I want an environment where I can concentrate on using the system
I want to be assessed as to my IT competence	I want to be able to audit the drawings and find out the history of the drawing/s	I want all drawings that have been redlined to be saved immediately as updated versions of the original documents
I want a document controller to controller a distribution list, enabling him to notify specific people of when a document regarding them has arrived	I want to use the system to access any drawings/files I need	I want to be trained onsite where I will be working
I want to receive an email with notification telling me a document has arrived	I want the drawing/file names to be descriptive of the contents of the file	I want training to be comprehensive and on going if needed

I want that notification to tell me what document has arrived, who sent it, and when it has to be actioned by	I want a small box/view when the title of the document is highlighted to appear and give a small description of the contents	I want to have the upload process compatible/customisable with the CAD checking process of the designer
I want a system that is well supported and in the event of a problem, the suppliers are instantly contactable	I want a section in my/my organisation homepage in the system that tells me all the drawings that are directly related to me/my organisation	I want all the categories in the file storage centre to be available for sorting the documents
I want all common/major software systems used onsite to be compatible with the system	I want a software system that is reliable and doesn't crash regularly	I want to have support that is quick, efficient and experienced at dealing with my inquiries
I want one person on each site to be highly trained in the use/maintenance of the software	I want a system that is compatible with all drawing file formats, so I don't have to convert any before an upload	I want to be able upload drawings/models/documents/files onto a central system
I want the contractor to set guidelines of use, a protocol for best practice	I want to be able to access any drawing in a viewer from anywhere in the system, and not have to go through a process of downloading it first	I want to be fully trained by an official software systems personnel
I want to be able to write comments on existing documents saved on the system	I want the system to have an "essentials" mode for firms that only access the system on few occasions where only specific actions/areas can be viewed to give a simpler direct interface	I want a search engine that is effective and finds what I want
I want to be able to track previous revisions of a drawings, seeing who did them where and when.	I want there to be an Instant messaging service, allowing those online to see the other project staff that are online, and be able to send instant messages to them	I want a warning to go off to an administrator when the number of actions outstanding reaches a certain level
I want to be able to track the history of the comments made on the drawing, who made them, where and when	I want to be able to layer drawings on top of each other to compare them	The actions outstanding should only be able to be deleted by a site administrator
I want to know what has been done about the comments that have been written on the drawings	I want to be sure every time I download a file that it is the most up to date version	I want actions to have a "sell by date", if that date is reached, then a message is sent to the project leader
I want to be able to open the drawings/regenerate them quickly with no short time delay	I want the project administrator to be able to add users on the spot without needing authorisation.	I want to be able to change the issue status of the drawing
I want to be able to manipulate the drawings onscreen easily and naturally	I don't want to have to fill out forms to create users on the system, nor do I want a time delay	I want to be able to batch publish multiple files to the system
I want notification on emails status	I want to be able to create subfolders and main folders instantly, without needing permission from ASP	I want to be able to notify people when I publish drawings to them
I want a simple notification system	I want a preset filing structure/suggestions built into the system	I would like to given instruction on basic IT systems, as well as the management system being used
I want to have notification on all correspondence as to when it was received, what was done, and warnings for lack of response	I want a simple filling system with no overlap with other folders	I want to be trained inline with my jobs IT requirements
I want to be able to tell that that notification has been read	I want to be able to notify people of an uploaded drawing	I want to know what actions have been taken as a result of reading the message
I want to be able to upload and manipulate electronic documents to the system.	I want to be able to link my email to the system	I want to see when someone has read the action message I have sent them
I want to be trained on project in the situations where I will use it	I want an Instantly viewable audit trail	I want function that tells me about actions that have not been completed
I want a Summary page setting down the actions taken/access made on documents I have published to people	I want to be able to load different versions of the same drawing onto the system	I want to have a strategy document detailing methods of information strategy
I want to be able to re-trace my steps on the system easily to where I started from	I want a fast system	I want every action on every document registered and available for audit
I want to be able to access the search engine on every page	I want to be able to access the system/documents whether ever I can access an internet connection	I want to be able to scan documents
I want a one page at the front that tells me everything I need to know: documents, communications, etc.	After I have downloaded the document from the system I want it locked while I alter it	I want to be able to save the scanned document as various file types
I want large storage space to store all the documents	I want the document to be automatically uploaded and added as a new version when I save my version	I want a user guide that is friendly and easy to access

I want the one page that tells me everything to have a headlines page detailing broad information regarding the project	I want to be notified of any changes to any project documents on any projects that I am involved in	I want a quick/automated uploading method/function
I want the system to be able to use tabs to open multiple pages in the one window	I want the system to be able to handle all common types of file, especially the Microsoft file types	I want to be able filled out the RFI forms electronically
I want a search engine	I want a vendor area giving articles/news on projects for an external point of view	I want to be able to store/register drawings on the system
I want the system to log me out after a certain amount of time not used	I want to be able to use the system to complete requisitioning/purchasing	I want to be able to access older files to be accessible on new system
I want all prices/buying material to be kept on the system	I want better performance of the system at set times related with system load	I want to have one person on each site that has been specifically trained to use the system to a high degree
I want a mark-up system	I want a protocol/automatic function for naming documents	I want a filing system designed specifically in mind for construction
I want to be able to use the mark-up system directly from the viewer	I want the use of the system spread out over the day, maximising the useful bandwidth and minimising the mass use at one time	I want to be able to use the system for all forms documentation onsite
I want all of the organisations standard forms online	I want the system to default back to the previous upload meta data	I want a report telling me actions made as the result of sending someone a document to read. i.e., feedback on the results of sending out H&S manuals to site
I want the folder system to be more representative of its contents	I want to be able to fill out RFIs electronically on a form straight onto the system	I want to be able to navigate to the main areas of the site from wherever I am
I want to be able to find the doc I need easily through the folder system	I want to upload folders and have them be in the same folder structure as in the original format	I want a to be warned when someone hasn't completed a set action
I want the system to accessible for low IT standard organisations	I want a search engine that will find documents I need	Better organised/extended folder system
I want a filing system that is compatible with construction	I want a wider/more effective search criteria available	Separate folder for toolbox tools
I want a filing system that uploads drawings faster	I want to be able to find the document I am looking for easily	I want a system that can deal with the rail regulation audits

In this form they comprise of a mixture of software functions, and customer needs. The mixture the software functions and user benefits in the clarified items are then examined for greater breadth and depth, and the benefits that are the result of the functions are brought forward and identified to find the underlying benefit that would be satisfied by the inclusion of the function. The reasons the benefits rather than the features are examined in the QFD process are:

- The user can relate to them easier than specific features, making it easier for them to examine and sort.
- Once a benefit of a feature is discovered, cheaper/more effective methods of fulfilling that benefit than the original basic feature can be assessed.
- In QFD, the Voice of the Customer (benefits) is later translated into the voice of the Engineer (features), so it is important to distinguish between them at this early stage.

Defining a customer need/benefit from a product feature is an essential part of the QFD process and the easiest way to do this is to look for the following when assessing a clarified item.

- Is the statement of benefit to the user?
- Does it talk about the user, not the product?
- Is the statement technology and product independent?
- Does it define value to the user?
- Does it talks about solving problems (positively reworded), opportunities, look/feel good?

The Customer Voice Table (CVT) is split into benefits and features. If needed additional categories can be applied in the features section to correspond with the application, and un-used sections can be deleted. Typical categories are technical performance and quality characteristics, functions, processes, tasks, reliability, technology and cost. Essentially the CVT is a multiple intermingling Fishbone diagram with the benefits at the head (the desired results or outcome) and the features as the bones, or casual factors that contribute to that outcome.

A single CVT was not completed for each individual Gemba visit table, but the users were grouped into three categories, site staff, project partners, and main contractor design staff that were identified in the customer segments table. Site staff included all personnel that were directly related to onsite activities, project partners consisted of all sub-contractors and main contractor design staff included design co-ordinators acting as intermediatories between site and project partners.

The generic CVT can be seen in Figure 6.3

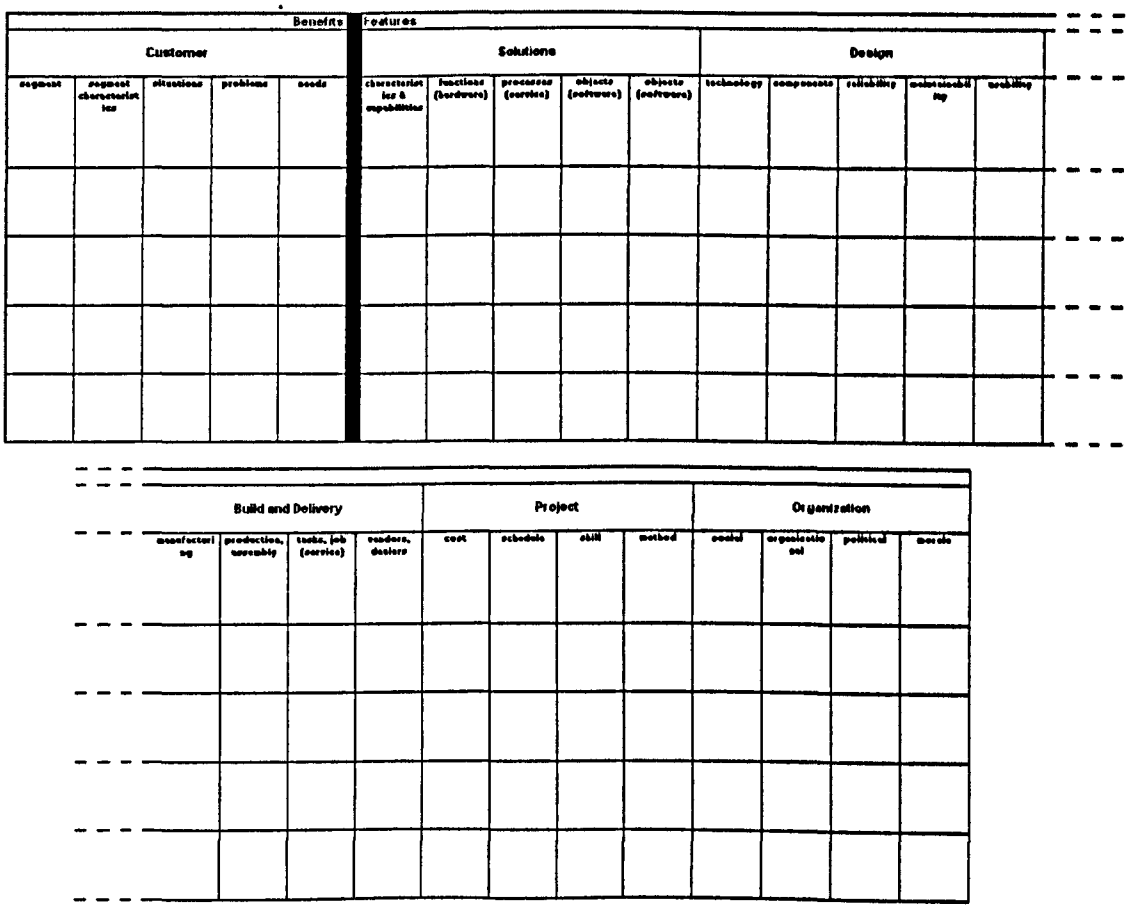


Figure 6.3 A Generic CVT

The CVT was taken and customised to suit this particular usage. Three different CVTs were used, corresponding to the customer segment table. A section of the CVT table for the Project Partners can be seen in Figure 6.4. All 3 CVT tables can be seen in the Appendix D. The Clarified items taken from the Gemba visit tables can be seen in the shaded boxes. Features were distinguished from the benefits and placed in the right side of the table, and then extrapolated back to their basic benefits on the left side. Other features, observations, situations relevant to the benefit were also identified and inserted into the CVT. The lines crossing the table provide the links between the Fishbone head and its bones, which in turn can be related to other features or benefits. Some of the clarified items were benefits, and were entered straight into the customer needs column.

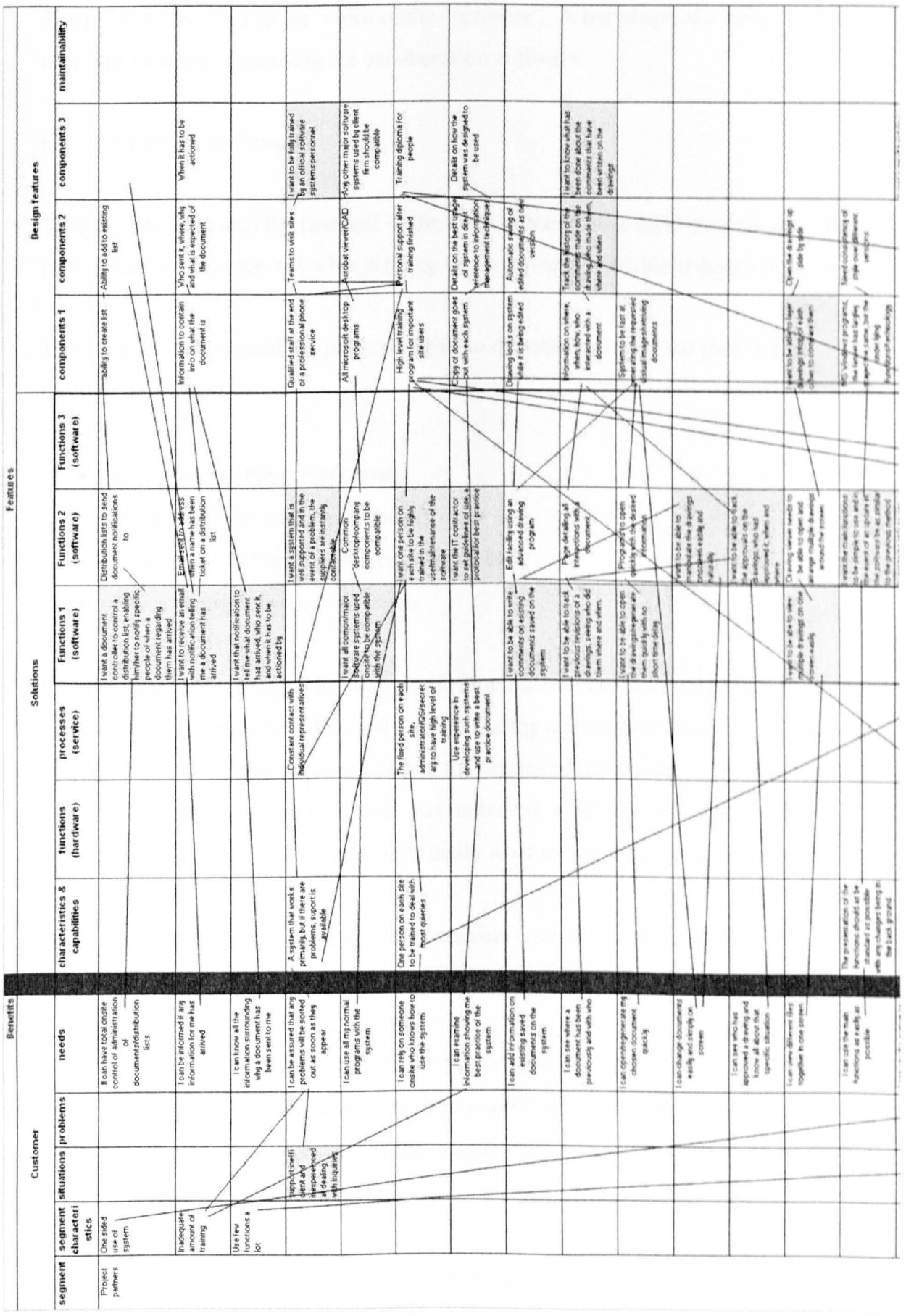


Figure 6.4. A section of the Project Partners CVT

The result of the CVT is the 'voice of the customer'. A list of specific benefits that a user will look for when using the collaboration software.

6.5 Chapter conclusions

This chapter described the first half of the QFD process. The QFD process itself is part of the results since it is what is being investigated within this research project.

This chapter investigated the project origins to the emergence of the user needs through four steps:

- Investigating the project goals;
- Identifying the customers (users);
- Gathering the 'voice of the customer'; and
- Discovering the customer needs.

Investigating the project goals: An investigation into the project goals was primarily used within industry where there may be conflicting agendas within an organisation or project. Once these goals were identified the origins of these goals were investigated specifically looking at how each goal was measured, what time frame is involved, who judges the success of the goal and finally what means were needed to achieve it.

Identifying the customers (users): The customers (users) were then identified using the following questions as a guide:

- Which users will help achieve the project goals?
- Are all users equally important, or are some more valuable to us than others?
- Is there limited resources? (time, people, money) to visit users?
- If so, how should they be visited?

These questions helped build a profile on who used the software systems, provided initial incite to plan the information gathering strategy in the next step, and enabled

the interviewer to understand fully what users use the software for before going to interview them.

Gathering the 'voice of the customer': 17 users were then visited across 3 organisations. Those users had a wide range of activities and responsibilities on construction projects, but all relied on the collaboration system. Each user was interviewed where they used the systems, with the user walking through the process of how they used the system, giving a constant commentary. From this, different patterns of usage emerged depending on job responsibility though many had common core points. The interviews were recorded using a PDA. The files were synchronised onto a Laptop in media player file form for processing. Each interview was transcribed and information from the transcription inserted into a column on the Gemba visit table. Statements were then created (clarified items) summarising the user's position and opinions taking into account and observations and notes. There was a total of 173 clarified items after the 17 interviews were completed.

Discovering the customer needs: The clarified items were split into three sections depending on employee and inserted into three different Customer Voice Tables. These CVT tables extracted the generic customer benefits behind the clarified items which mostly contained software functions and service characteristics. The 70 generic customer benefits discovered in the CVTs were then used in the next section of the QFD process where they are taken on and transformed into a software specification.

7.0 QFD PROJECT: USER NEEDS TO A SOFTWARE SPECIFICATION

7.1 Introduction

Chapter 6 dealt with the project goals, identification of the users of the software system, the gathering of the user needs, and the investigation to discover the benefits behind those needs. The last 4 steps of the QFD process will find a natural structure for those needs, identify any holes within that structure (missing customer benefits), prioritise those needs by the users themselves, and then deploy the high value benefits into a software requirements specification for a construction collaboration system.

7.2 Structuring the customer needs

7.2.1 Introduction

The KJ-Method was introduced by the Japanese and has become one of the seven new management tools of modern Japanese quality management *(Mazur, 2004)*. This is a "right brain" method, as most users are not aware of what cognitive structure they use for their requirements. This method is unique because the grouping categories come after the groups are made, not before. This allows for breaking the paradigms that existing data place on data.

The KJ method was used to produce an affinity diagram which shows the natural structure of the user's requirements. The users are the people the process wants to explore so they placed the items where they "belong". After this headings are created for the groups. There may be several levels of grouping nested within each other. Some data may actually become the header. It is important to note that there is no right or wrong groupings, only different points of view.

Table 6.3 was printed, and the requirements cut into individual cards. Those cards were then taken to a meeting room where two users spent 45 minutes taking the pile of user requirements from the middle of the table and placing them within groups and then deciding on the group description.

The advantages of using the KJ Method are rooted in its simplicity. No expensive software tools are needed, and the process takes around an hour to complete. The only resource needed is the time of the users themselves.

The groups identified by the KJ method were: drawings; documents; files and folders; information management; training; system supplier support and system capabilities with user control, system functionality and user interaction as system capability sub-folders. The following groups, Tables 7.1 to 7.7, were the result of the KJ Method:

Table 7.1 Drawings

Drawings	I can store drawings on the server	I can use the system to register drawings
	I can know exactly what drawings are mine and what I have to do with them, without having to search for the information	I can upload multiple drawings at once
	I can see who has approved a drawing and know all about that specific situation	I can access the drawings I need easily and quickly
	I can save different versions of the same drawing onto the system	I can be told how much time I have left to work on a drawing
	I can up-load my customised drawings/measure sheets onto the system	I can know who did the changes to a drawing
	I can see instantly what new drawings have been recently uploaded	I can change the status of a drawing that has been published
	I can mark each drawing with information about it	I can alter drawings and be able to add our clients symbols in our drawings
	I can make sure one person on site knows everyday what drawings have been distributed to who	

Table 7.2 Documents

Documents	I can easily use the system for all types of construction documents	I can edit existing documents stored on the system
	I can know all the information surrounding why a document has been sent to me	I can view and store/retrieve documents on the system
	I can inform people a document requiring their attention has arrived	I can add information on existing and saved documents on the system
	I can find out all information on the history of any document in the one place	I can be informed of any changes to projects on a project I am involved with
	I can audit every document to see how it has been modified	I can upload various documents and not have to type the same meta-data in every time
	I can open/regenerate my chosen document quickly	I can let colleagues know I have uploaded a document for their viewing
	I can upload/create my own document templates	I can make sure when I save a document it is saved as a new version and uploaded automatically
	I can change documents easily and simply on screen	I can use the system for all forms of site documentation
	I can be sure all documents are named correctly	I can see the history of every document on the system
	I can upload documents to the system	I can see where a document has been previously and with who

	I can let a colleague know when a document has been uploaded for them	

Table 7.3 Files and folders

Files and folders	I can sort all the documents in the folder in multiple ways	I can be informed of any new files that are uploaded
	I can see who has had access to a file	I can find out the history of the files on the system
	I can use a filing system that is compatible with the construction industry	I can search the system for any file
	I can upload folders and have them keep their own subfolder structure	I can line up multiple files to publish automatically
	I can open any file instantly from the page it appears on	I can alter folder contents and configurations after upload
	I can create subfolders/folders without needing system supplier notification	I can view different files together in one screen
	I can make sure every time I download a file that it is the most up-to-date version	I can only edit the latest version of a file, the rest are read only
	I can easily find documents in the filing system	I can clearly see any information regarding the modification of a file

Table 7.4 System supplier support

System supplier support	I can rely on the support services to fix any problems quickly	I can rely on the ASP to be able to solve any system problems as soon as possible
	I can be assured that any problems will be sorted out as soon as possible	

Table 7.5 System capabilities

System capabilities	User control	I can use search without having to go to the search page	I can grant permanent access to the system project partners instantly from a site portal
		I can purchase items and place requisition orders using the system	I can use the mark-up system directly from the viewer
		I can have total onsite control of administration of documents/distribution lists	I an see if a colleague has not looked at or actioned a notification that was sent
		I can use the system to examine any file type	I can see what has happened as the result of sending a notification to a colleague
		I can alter users details/existence on the system instantly	I can use a system that is compatible with different types of industry/company audit
		I can read articles regarding my project partners activities/company profile	I can use a mark up system that has all the symbols/icons that are used in the paper process
		I can track all forms of communication	I can copy meta data instead of having to type it in every time
		I can alter users details/existence on the system instantly	I can search using a wide and informed criteria
	System functionality	I can use all my normal programs with the system	I can access the system externally from any internet connection
		I can make sure no two people are editing the same document at the same time	I can access the system on a limited IT set up
		I can have a software system that is reliable and doesn't crash regularly	I can be sure all the older file databases can be read on the system
		I can be sure I will never run out of storage space	I can know more about a notification without having to open the document it

			refers to
		I can store as much as I like on the system	I can have a central point where all my information is stored
		I can use different hardware to make marking up easier	I can make sure the system is compatible with all the other site software systems
		I can be sure all employees can log onto the system	I can be sure all older file databases can be read using the system
		I can find out what the contents of a file are without having to download and open it first	I can use the system on a low speed connection
		I can make sure no-one can access my account if I leave the work station	I can access the files stored on the system if the system goes down
	User interaction	I can use a search engine that is effective and finds what I want	I can access my email separately from the main system
		I can use a tabs feature instead of opening multiple browsers	I can complete all major functions very simply
		I can contact any of the project staff immediately	I can use an effective search engine
		I can use the system as normal in times of high load	I can customise the search criteria available
		I can access a simple, limited functions version of the software	I can see my steps through the system to my current point where I started
		I can know exactly where I am in the system at all times	I can use the main functions as easily as possible
		I can make sure I don't get over loaded with actions I haven't completed	I can make the system easy to use for distant project partners

Table 7.6 Information Management

	Information Management	I want to be able to access all the information I need from one area	I can access all the information I need to do my job from the system
		I can be informed when work on the project is running late	I can notify colleagues easily that information for them has arrived
		I can access all organisation documents, forms, information online	I can access all the information I need from a central location
		I can upload any information I see as relevant to the project onto the system	I can have a central location where I can access all my information from
		I can be informed if any information for me has arrived	I can send information to anyone working on the project
		I can notify colleagues in a simple manner that information for them has arrived	I can input information (e.g. RFIs) directly onto the system
		I can send design information, questions to multiple people	I can access all the information I need from one place
		I can change the upload process to suit my own companies procedures	I can learn how to handle information better
		I can access information to help me use the systems best	I can access articles on the various other projects being completed by the other organisations present
		I can examine information showing me best practice of the system	

Table 7.7 Training

Training	I can be trained in the scenarios that I will be using the system, and not just generic training modules	I can be trained by the people who developed the system
	I can get basic IT training apart of the main system training course	I can be trained in the best way to manage information management and information flow
	I can be trained onsite where I will be working	I can have a user guide that is friendly and easy to access
	I can have tailored training to suit my job responsibilities	I can use basic IT before I am trained for the main system
	I can make sure all my colleagues can use the system	I can make sure all staff using the system have been officially trained
	I can rely on someone onsite who knows how to use the system	I can have the people who actually use the system trained in it
	I can be assured the most appropriate people on site are trained	I can speak to someone who is trained in the system instantly
	I can rely on one person on each site that is trained to a high degree in the system	I can have the most experienced persons deal with the system

7.3 Discovering the un-stated needs

The structure uncovered by the KJ method is used to find missing, implied and other possible needs. A complete set of needs is not required, and not expected, just enough to see the structure.

Once the user benefits had been organised into groups, they were printed and arranged in their groups in table. They were then rotated from a top-bottom (affinity diagram layout) to left-right orientation into a hierarchy diagram so the group descriptions/headings were facing the left with the groups that contained the user benefits on the right. This layout provides a more analytic perspective on the data, and allows 'holes' in the information to be spotted.

At this point a three step process was used to examine and manipulate the information in the hierarchy diagram.

- Starting at the left most "column", confirm that the level of detail or granularity of the items descriptions agree. If some items are less detailed, they should be moved to the left; if more detailed, moved to the right.
- Next, for that level determine if there are any missing members of the set.

- These two steps are then repeated for each of the columns to the right.

The results of this can be seen in Tables 7.8 to 7.12. The gray boxes mark the shifted levels /added levels added groups. The first column on the left hand side is the Primary column, the second from the left is the secondary and the final column on the right is the tertiary column.

Table 7.8 Project Documents

Project documents	Drawings	I can store drawings on the server	I can use the system to register drawings
		I can know exactly what drawings are mine and what I have to do with them, without having to search for the information	I can upload multiple drawings at once
		I can see who has approved a drawing and know all about that specific situation	I can access the drawings I need easily and quickly
		I can save different versions of the same drawing onto the system	I can be told how much time I have left to work on a drawing
		I can up-load my customised drawings/measure sheets onto the system	I can know who did the changes to a drawing
		I can see instantly what new drawings have been recently uploaded	I can change the status of a drawing that has been published
		I can mark each drawing with information about it	I can alter drawings and be able to add our clients symbols in our drawings
		I can make sure one person on site knows everyday what drawings have been distributed to who	
	Documents	I can easily use the system for all types of construction documents	I can edit existing documents stored on the system
		I can know all the information surrounding why a document has been sent to me	I can view and store/retrieve documents on the system
		I can inform people a document requiring their attention has arrived	I can add information on existing and saved documents on the system
		I can find out all information on the history of any document in the one place	I can be informed of any changes to projects on a project I am involved with
		I can audit every document to see how it has been modified	I can upload various documents and not have to type the same meta-data in every time
		I can open/regenerate my chosen document quickly	I can let colleagues know I have uploaded a document for their viewing
		I can upload/create my own document templates	I can make sure when I save a document it is saved as a new version and uploaded automatically
		I can change documents easily and simply on screen	I can use the system for all forms of site documentation
		I can be sure all documents are named correctly	I can see the history of every document on the system
		I can upload documents to the system	I can see where a document has been previously and with who
		I can let a colleague know when a document has been uploaded for them.	
	and folder	I can sort all the documents in the folder in multiple ways	I can be informed of any new files that are uploaded

		I can see who has had access to a file	I can find out the history of the files on the system
		I can use a filing system that is compatible with the construction industry	I can search the system for any file
		I can upload folders and have them keep their own subfolder structure	I can line up multiple files to publish automatically
		I can open any file instantly from the page it appears on	I can alter folder contents and configurations after upload
		I can create subfolders/folders without needing system supplier notification	I can view different files together in one screen
		I can make sure every time I download a file that it is the most up-to-date version	I can only edit the latest version of a file, the rest are read only
		I can easily find documents in the filing system	I can clearly see any information regarding the modification of a file

Table 7.9 System Capabilities

System capabilities	User control	I can use search without having to go to the search page	I can grant permanent access to the system project partners instantly from a site portal
		I can purchase items and place requisition orders using the system	I can use the mark-up system directly from the viewer
		I can have total onsite control of administration of documents/distribution lists	I an see if a colleague has not looked at or actioned a notification that was sent
		I can use the system to examine any file type	I can see what has happened as the result of sending a notification to a colleague
		I can alter users details/existence on the system instantly	I can use a system that is compatible with different types of industry/company audit
		I can read articles regarding my project partners activities/company profile	I can use a mark up system that has all the symbols/icons that are used in the paper process
		I can track all forms of communication	I can copy meta data instead of having to type it in every time
		I can alter users details/existence on the system instantly	I can search using a wide and informed criteria
	System functionality	I can use all my normal programs with the system	I can access the system externally from any internet connection
		I can make sure no two people are editing the same document at the same time	I can access the system on a limited IT set up
		I can have a software system that is reliable and doesn't crash regularly	I can be sure all the older file databases can be read on the system
		I can be sure I will never run out of storage space	I can know more about a notification without having to open the document it refers to
		I can store as much as I like on the system	I can have a central point where all my information is stored
		I can use different hardware to make marking up easier	I can make sure the system is compatible with all the other site software systems
		I can be sure all employees can log onto the system	I can be sure all older file databases can be read using the system
		I can find out what the contents of a file are without having to download and open it first	I can use the system on a low speed connection
		I can make sure no-one can access my account if I leave the work station	I can access the files stored on the system if the system goes down

	User interaction	I can use a search engine that is effective and finds what I want	I can access my email separately from the main system
		I can use a tabs feature instead of opening multiple browsers	I can complete all major functions very simply
		I can contact any of the project staff immediately	I can use an effective search engine
		I can use the system as normal in times of high load	I can customise the search criteria available
		I can access a simple, limited functions version of the software	I can see my steps through the system to my current point where I started
		I can know exactly where I am in the system at all times	I can use the main functions as easily as possible
		I can make sure I don't get over loaded with actions I haven't completed	I can make the system easy to use for distant project partners

Table 7.10 Information Management

Information Management	Project based information/Manipulation	I want to be able to access all the information I need from one area	I can access all the information I need to do my job from the system
		I can be informed when work on the project is running late	I can notify colleagues easily that information for them has arrived
		I can access all organisation documents, forms, information online	I can access all the information I need from a central location
		I can upload any information I see as relevant to the project onto the system	I can have a central location where I can access all my information from
		I can be informed if any information for me has arrived	I can send information to anyone working on the project
		I can notify colleagues in a simple manner that information for them has arrived	I can input information (e.g. RFIs) directly onto the system
		I can send design information, questions to multiple people	I can access all the information I need from one place
		I can change the upload process to suit my own companies procedures	
	External Information on Company/best practice	I can access information to help me use the systems best	I can learn how to handle information better
		I can examine information showing me best practice of the system	I can access articles on the various other projects being completed by the other organisations present

Table 7.11 Training

Training	Personal training	I can be trained in the scenarios that I will be using the system, and not just generic training modules	I can be trained by the people who developed the system
		I can get basic IT training apart of the main system training course	I can be trained in the best way to manage information management and information flow
		I can be trained onsite where I will be working	I can have a user guide that is friendly and easy to access
		I can have tailored training to suit my job responsibilities	I can use basic IT before I am trained for the main system
	training	I can make sure all my colleagues can use the system	I can make sure all staff using the system have been officially trained

		I can rely on someone onsite who knows how to use the system	I can have the people who actually use the system trained in it
		I can be assured the most appropriate people on site are trained	I can speak to someone who is trained in the system instantly
		I can rely on one person on each site that is trained to a high degree in the system	I can have the most experienced persons deal with the system

Table 7.12 System supplier support

System supplier support	Problem resolution	I can rely on the support services to fix any problems quickly	I can rely on the ASP to be able to solve any system problems as soon as possible
		I can be assured that any problems will be sorted out as soon as possible	I can let the IT support examine the system remotely
	Contact methods	I can email a supplier representative	I can request a visit from the supplier
		I can send an enquiry through a project rep to the supplier	I can telephone the supplier
		I can have a support team in my organisation	I can have an IT implementation team within my organisation

The first point that became clear in the analysis of the hierarchy diagram was the relationship between 'Files and Folders', 'Documents' and 'Drawings'. These were all shifted into the secondary column and collected under 'Project documents'. The next group's title, Information management, was the same granularity as 'Project documents' therefore needed no changes. However the benefits in the second column were too detailed and had to be moved into the third column. Therefore they needed to split into relevant group headings that would slot into column two. The two secondary group headings are 'Project based information' and 'External/company information'. The next heading in the primary column, 'Training', is of the same level as the previous headings within the primary column and was acceptable. The secondary items for training were too detailed and where moved into the tertiary column. The tertiary group was then split into groups and the group descriptions slotted into the secondary column. The new group headings were: 'My training' and 'My colleague's training'. A large area of discussion in the Gemba visits centred round the training of colleagues working on site, essentially, if some of the project team was not confident in their colleagues from other organisations using and being trained in the system to the same standard as themselves, there was a large drop in confidence in using the system for essential tasks. Therefore the QFD process will seek to confront that problem from the user perspective.

The last group to be organised into the hierarchy diagram was 'collaboration system supplier support'. The primary heading in this group was consistent with the level of detail shown by the other primary column group headings. The secondary items were too detailed so were therefore shifted to the right into the tertiary column and given a group heading. At this point a missing requirements section was identified. Another group on the secondary column titled 'Contact methods' was created and a number of contact methods/solutions were introduced to the tertiary column under this group.

The result of this step in the QFD process is a set of organised, structured customer needs that can be prioritised and then deployed into a software specification.

7.4 Prioritising the customer needs

The user needs on the hierarchy diagram must be prioritised by the users. Analytic Hierarchy Process (AHP) is a procedure which provides accurate ratio scale priorities based on natural language comparisons and which is used widely in QFD methodologies.

Using AHP on the hierarchy diagram seemed the ideal method of prioritising the customer needs but one of it's drawbacks that became clear is how complex it can become when applying AHP to more than 10 items at once. The original plan was to apply AHP to the primary and secondary column group names and then apply it within the tertiary groups enabling the prioritisation of the groups and well as the needs within the tertiary groups, but the limitations of applying AHP meant it would only be practical to use it on the primary and secondary columns of the hierarchy table. The AHP for these sections was done using Expert Choice software and undertaken with one user. In Tables 7.13 to 7.17 the first 2 columns (primary/secondary) the higher the number the more important the item. This AHP process was undertaken not as the main prioritisation process but to add greater depth to the tertiary level prioritisation that is described below.

For the tertiary or highest level of detail of the customer requirements, a questionnaire was constructed to keep with the planned methodology and enable the users to prioritise the customer needs, but in a more conventional manner compared with

AHP. Contractor B was contacted and agreed to have a number of their users complete the questionnaire in a group exercise. They examined each tertiary group individually and picked out the most important half of each and then prioritised them from 1-x depending on the size of the group.

The result at this point is a complex set of user requirements that have been sorted into natural groups by the user, then examined for the missing user needs, and then given an importance rating by the users themselves. The result of this can be seen in Tables 7.13 to 7.17

Table 7.13 Project documentation prioritised

Project documents 0.249	Drawings 0.117	I can store drawings on the server	*I can use the system to register drawings* **2**
		I can know exactly what drawings are mine and what I have to do with them, without having to search for the information	*I can upload multiple drawings at once* **1**
		I can see who has approved a drawing and know all about that specific situation	*I can access the drawings I need easily and quickly* **6**
		I can save different versions of the same drawing onto the system **4**	I can be told how much time I have left to work on a drawing
		I can up-load my customised drawings/measure sheets onto the system	*I can know who did the changes to a drawing* **7**
		I can see instantly what new drawings have been recently uploaded **3**	*I can change the status of a drawing that has been published* **5**
		I can mark each drawing with information about it **8**	I can alter drawings and be able to add our clients symbols in our drawings
		I can make sure one person on site knows everyday what drawings have been distributed to who	
	Documents 0.53	*I can easily use the system for all types of construction documents* **3**	I can edit existing documents stored on the system
		I can know all the information surrounding why a document has been sent to me	I can view and store/retrieve documents on the system
		I can inform people a document requiring their attention has arrived **9**	*I can add information on existing and saved documents on the system* **7**
		I can find out all information on the history of any document in the one place	*I can be informed of any changes to projects on a project I am involved with* **8**
		I can audit every document to see how it has been modified **4**	I can upload various documents and not have to type the same meta-data in every time
		I can open/regenerate my chosen document quickly	I can let colleagues know I have uploaded a document for their viewing
		I can upload/create my own document templates **6**	I can make sure when I save a document it is saved as a new version and uploaded automatically
		I can change documents easily and simply on screen	*I can use the system for all forms of site documentation* **10**
		I can be sure all documents are named correctly	*I can see the history of every document on the system* **2**

		I can upload documents to the system **1**	I can see where a document has been previously and with who
		I can let a colleague know when a document has been uploaded for them **5**	
	Files and folders 0.78	I can sort all the documents in the folder in multiple ways	*I can be informed of any new files that are uploaded* **4**
		I can see who has had access to a file	*I can find out the history of the files on the system* **8**
		I can use a filing system that is compatible with the construction industry **6**	*I can search the system for any file* **3**
		I can upload folders and have them keep their own subfolder structure	*I can line up multiple files to publish automatically* **2**
		I can open any file instantly from the page it appears on **5**	I can alter folder contents and configurations after upload
		I can create subfolders/folders without needing system supplier notification	I can view different files together in one screen
		I can make sure every time I download a file that it is the most up-to-date version	I can only edit the latest version of a file, the rest are read only
		I can easily find documents in the filing system **1**	*I can clearly see any information regarding the modification of a file* **7**

Table 7.14 System capabilities prioritised

System capabilities 0.119	User control 0.12	I can use search without having to go to the search page	*I can grant permanent access to the system project partners instantly from a site portal* **2**
		I can purchase items and place requisition orders using the system	*I can use the mark-up system directly from the viewer* **1**
		I can have total onsite control of administration of documents/distribution lists **5**	*I can see if a colleague has not looked at or actioned a notification that was sent* **7**
		I can use the system to examine any file type **8**	I can see what has happened as the result of sending a notification to a colleague
		I can alter users details/existence on the system instantly	*I can use a system that is compatible with different types of industry/company audit* **4**
		I can read articles regarding my project partners activities/company profile **6**	I can use a mark up system that has all the symbols/icons that are used in the paper process
		I can track all forms of communication	I can copy meta data instead of having to type it in everytime
		I can alter users details/existence on the system instantly	*I can search using a wide and informed criteria* **3**
	System functionality 0.114	I can use all my normal programs with the system	*I can access the system externally from any internet connection* **2**
		I can make sure no two people are editing the same document at the same time	*I can access the system on a limited IT set up* **1**
		I can have a software system that is reliable and doesn't crash regularly **7**	I can be sure all the older file databases can be read on the system
		I can be sure I will never run out of storage space **6**	I can know more about a notification without having to open the document it refers to
		I can store as much as I like on the system **5**	*I can have a central point where all my information is stored* **3**

		I can use different hardware to make marking up easier	*I can make sure the system is compatible with all the other site software systems* **4**
		I can be sure all employees can log onto the system **9**	I can be sure all older file databases can be read using the system
		I can find out what the contents of a file are without having to download and open it first	*I can use the system on a low speed connection* **8**
		I can make sure no-one can access my account if I leave the work station	I can access the files stored on the system if the system goes down
	User interaction 0.103	*I can use a search engine that is effective and finds what I want* **5**	*I can access my email separately from the main system* **4**
		I can use a tabs feature instead of opening multiple browsers	*I can complete all major functions very simply* **3**
		I can contact any of the project staff immediately **1**	I can use an effective search engine
		I can use the system as normal in times of high load	*I can customise the search criteria available* **6**
		I can access a simple, limited functions version of the software	I can see my steps through the system to my current point where I started
		I can know exactly where I am in the system at all times **2**	*I can use the main functions as easily as possible* **7**
		I can make sure I don't get over loaded with actions I haven't completed	I can make the system easy to use for distant project partners

Table 7.15 Information management prioritised

Information Management 0.46	Project based information/Manipulation 0.87	I want to be able to access all the information I need from one area	*I can access all the information I need to do my job from the system* **6**
		I can be informed when work on the project is running late	I can notify colleagues easily that information for them has arrived
		I can access all organisation documents, forms, information online **7**	*I can access all the information I need from a central location* **5**
		I can upload any information I see as relevant to the project onto the system	I can have a central location where I can access all my information from
		I can be informed if any information for me has arrived **5**	*I can send information to anyone working on the project* **1**
		I can notify colleagues in a simple manner that information for them has arrived **4**	*I can input information (eg RFIs) directly onto the system* **2**
		I can send design information, questions to multiple people **3**	I can access all the information I need from one place
		I can change the upload process to suit my own companies procedures	
	External Information on Company/best practice 0.52	*I can access information to help me use the systems best* **1**	*I can learn how to handle information better* **2**
		I can examine information showing me best practice of the system	I can access articles on the various other projects being completed by the other organisations present

Table 7.16 Training prioritised

Training 0.319	Personal training 0.123	I can be trained in the scenarios that I will be using the system, and not just generic training modules	*I can be trained by the people who developed the system* ***1***
		I can get basic IT training as part of the main system training course	I can be trained in the best way to manage information management and information flow
		I can be trained onsite where I will be working ***2***	*I can have a user guide that is friendly and easy to access* ***4***
		I can have tailored training to suit my job responsibilities ***3***	I can use basic IT before I am trained for the main system
	Colleague training standards 0.054	*I can make sure all my colleagues can use the system* ***2***	*I can make sure all staff using the system have been officially trained* ***3***
		I can rely on someone onsite who knows how to use the system	*I can have the people who actually use the system trained in it* ***1***
		I can be assured the most appropriate people on site are trained	*I can speak to someone who is trained in the system instantly* ***4***
		I can rely on one person on each site that is trained to a high degree in the system	I can have the most experienced persons deal with the system

Table 7.17 System supplier support prioritised

System supplier support 0.267	Problem resolution 0.72	I can rely on the support services to fix any problems quickly	*I can rely on the ASP to be able to solve any system problems as soon as possible* ***1***
		I can be assured that any problems will be sorted out as soon as possible ***2***	I can let the IT support examine the system remotely
	Contact methods 0.028	*I can email a supplier representative* ***2***	*I can request a visit from the supplier* ***3***
		I can send an enquiry through a project rep to the supplier	*I can telephone the supplier* ***1***
		I can have a support team in my organisation	I can have an IT implementation team within my organisation

7.5 User specification deployment

7.5.1 Introduction

In the Customer Voice Table (Chapter 7.4) all columns were worked to the left to explore the user needs and expose the benefits behind the features. In the Maximum Value Table (MVT) key user needs are worked to the right to various software features that must be aligned in order to assure user satisfaction.

The MVT does not itself start the whole project, but illustrates areas where there is need to focus the best design and delivery of the product. The columns in the MVT

start the same as in the CVT, but new columns may be added to assure end-to-end activity to deliver value to the customer. The MVT shows areas that have great complexity or uncertainly, and where matrices need to be done between two design dimensions and at what level of detail.

In the CVT, the aim is to understand what the customers are saying through their own words, so it is worked from right (user features/clarified items) to left (user benefits). On the MVT, the aim is to plan the delivery of the benefits to the users, and is therefore worked from left (prioritised user benefits) to right (user features).

7.5.2 Maximum Value Table (MVT)

The 72 ranked tertiary user needs were taken from the Prioritised Hierarchy and placed in the empty MVT table. The MVT table was customised to contain the information shown in Table 7.18.

Table 7.18 MVT table contents

Main sections	Sub headings	Software features	Notes
Benefits	Situations		This section presents any detailed customer notes that need to be considered specifically when considering the solution
	Problems		
	Solutions		
Features	Solutions	Characteristics	This section describes the specific functions that the software will aim to complete, related to hardware, general characteristics, service functions and various software functions.
		Hardware functions	
		Service functions	
		Software functions 1	
		Software functions 2	
		Software functions 3	
	Design considerations	Components 1	The components represent any specific notes about any of the software functions in the solutions section
		Components 2	
		Components 3	
		Components 4	
		Components 5	
	Project Investigations	ASP service tasks	This section describes the service requirements that the ASP and not the software must complete
		ASP service tasks	

The benefits section of the table contained any specific user problems or situations gathered across the QFD investigation, and the Needs columns contain the Prioritised Hierarchy diagram. The Prioritised Hierarchy diagram has been altered with the most important primary/secondary/tertiary groups/items in order.

The Features section of the MVT is where the User benefits have been deployed into the user specification. The Characteristics & capabilities column is used to place any limits or targets on the feature. The Functions (hardware) column represents any hardware needed to deploy the user needs, and Processes (service) column is used to deploy any service characteristics needed.

The equal most important section of the MVT with the Project investigations section is the three Functions columns, where the main software features of the user benefits are deployed. The design considerations section is used to mention any important specifics about the Functions. Both of these are highlighted.

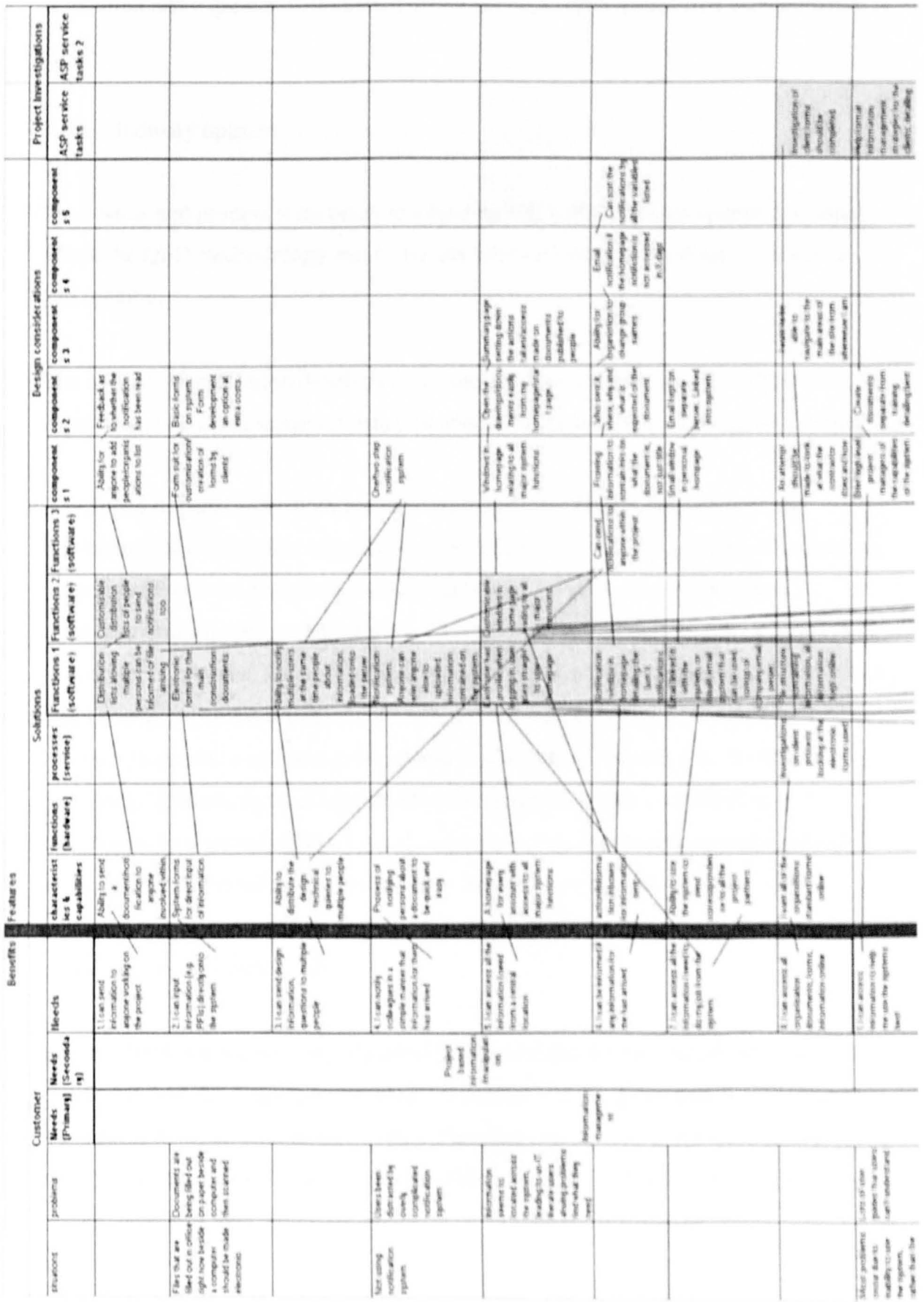
The final section of the MVT is the Project investigations columns. This column represents any user deployments that are not software functions, such as training/support issues that have to be planned and dealt with.

Taking each tertiary user need one by one:

1. If there was a specific user problem or situation it was entered in appropriate column.
2. Each user benefit was expanded into various software features or project tasks for training schedules/plans. Main design considerations if any were inserted.
3. Any links to other user features were then sought and links created.

The result is a large Excel table containing the main user value features of collaboration systems which a section of can be seen in Table 7.19. The complete MVT can be seen in Appendix E.

Table 7.19 A section of the MVT



This is the end of the Blitz QFD process. The user specification can be taken forward if required and a greater examination of the user functions discovered and deployed further.

7.6 Industry opinion

The results and process were taken to a leading UK collaborations system developer where the QFD methodology and its results were presented for industry evaluation and opinion.

The industry organisation develops collaboration systems that enable professionals to communicate and exchange information about built assets securely over the internet.

Developed in partnership with industry organisations, the UK government and universities, the validation organisation services have been proven in the construction, property and utilities industries by thousands of users from client, consultant, contractor and supplier organisations. The industry organisation developed the UK's first project 'extranet' through an investigation into projecting project drawings onto a web browser. Combining the notion of a project database with new web-based browser programs, a solution evolved and was tested on two projects, for BAA and Sainsbury. Internet technology provided the means to enable coordination and integration, to improve efficiency and communication, and to reduce costs and risks, to the benefit of the industry. The industry organisation system creates a central repository of information about the built asset, and allows users to access information exactly tailored to their needs.

In early 2004, the industry organisation announced that it now hosted over one million documents and drawings, plus another 2-3 million system-generated process items (eg: transmittals, RFIs, comments, etc). The total number of log-ins continued to grow rapidly, passing the four million mark in February 2004 and adding a further million before the end of July.

The person chosen to validate the system specification has worked in construction industry PR, marketing and publishing since 1987, working with professional services

businesses, predominantly in the construction and ICT industries. He worked for the Halcrow consulting group for seven years before taking up senior in-house marketing and PR posts at Tarmac Professional Services (now part of Carillion). Before joining his current organisation as a Director, he established his own successful independent consultancy, with clients including HBG Construction, the Construction Best Practice Programme, the Building Centre Trust and construction consultant PCM. Writing about construction IT, he has produced a guide on website development for Construct IT in 2000, and has contributed technology chapters to books on construction business development and on partnering and collaborative working. His book "Construction Collaboration Technologies: The Extranet Evolution" was published by Taylor and Francis in September 2005.

A set of themes where discussed:

Technical feasibility: This refers to the results of the QFD process and whether the specification is a viable collaboration system specification for the construction industry.

Chosen comments
Comment on user need: "I want to access my email separately from the system" "We run an email-less system so if something goes wrong they can rely on email and there's a protocol for people to bring everything from email back into the system afterwards" "What we do have is the concept of team mail within the system which is an email like function except we will capture project related communications between team members that are conducted in an email type fashion. They will be captured in the system and subject to the same audit trail."
Comment on user need: "I can input information directly onto the system, e.g. RFIs" "One of the enhancements we got out this summer was specifically aimed at designers but could also impact on many engineers and site staff. If they have got a drawing and they need some information about, they can kick off an RFI from the viewing of the drawing so they don't need to come out of the viewer. In the same way you could previously mark a comment on a drawing you can now issue an RFI, change order, instructions and any one of a multitude of processes that might be started from a drawing environment"
Comment on the substantial amount of software supplier conduct information gathered "The quality of a service is all important, ASPs know with a low initial expenditure, customers can easily swap to competitors, all you have to do is get back information, which is usually part of the project contact" "I'm encouraged there is a push for system supplier support, because it is potentially a very good differential between us and the conventional software vendors, and that will also tie into the training

side of it as well. This area is something we are rather keen on; we are establishing a BIW training academy, where previously it was done by consultants.

All the fundamental features of a collaboration system were apparent within the specification. Additionally some of the prioritised elements described above were part or similar to some of the improvements the developer were attempting or had recently deployed in their system. The QFD process managed to define the factors that software vendors have spent resources and time finding out through experience. One of the aspects that QFD excelled at was providing an additional layer of information detailing how the user liked the functional requirements of the system to be presented, or how they wanted the main functional aspects of the system to tie together. These aspects are part of the final Maximum Value Table and show the product developer not only the product fundamentals, but how those fundamental qualities of software can fail or succeed through their application, or how exactly they are applied, by the user.

Economic feasibility: This refers to the ability and economic viability of construction software or generic software developer to use QFD in developing a software requirements specification. This will involve looking at the QFD process to see if the costs/resources of using the process would be at an acceptable and usable level.

Comments
"We have things like user focus group forums, there can be different levels or user groups, we have done designer users, project manager users and many more. There might be an opportunity to capture the feedback that comes out of those situations or use QFD beforehand in interviews and discuss the results in the groups, or use the groups to do the grouping/prioritisation actions"
"I can see me going into the next new project meeting and saying what about using this technique for getting and specifying requirements earlier than we normally do."
"We have got people who write specification but they often emerge from some sort of osmosis, I don't think there is a structured what about doing it."
"We have a business analysts who will sit and analyse a process but that might not capture some of the other end user stuff that QFD might do, so I can see it being valuable in that respect"

Time is the most costly resource within the QFD process, specifically client time where their users take part within the QFD process. These teams are the users that can function as the QFD team itself or as the workshops that manipulate the information and the prioritise it. Within BIW there are already user workshops in existence. These workshops could easily be used within the QFD project to achieve its information gathering and manipulation tasks.

The developer stated they don't have a fixed product development methodology. Using a technique such as QFD could evolve their systems further and create a more focused user requirements specification.

Operational feasibility: This refers to the tools and the structure of the QFD process used including the team focused methodologies and the stepped program.

Comments
"As a market research tool it's exciting, I like the process, my mind is racing away about it"
"I can see all sorts of use for this kind of information just from a reality check point of view for us. This kind of research/technique could be very valuable if it was undertaken across our user group, looking at how good our software is, how well it meets the end user requirements or what gaps or opportunities it might have identified, but also as a quality check on what their actual experience has been"
"If you read the trade press about other ASP products you will find a company called XX. They are making serious inroads into the big CRM giants in the SME markets and within the construction industry there are huge amounts of SMEs. I think XX are going to grow on the basis of offering a good product in a competitive way at a competitive price, in a way the big giants can't do."

Currently very few organisations out of the top 20 main UK contractors use collaboration software. The developer recognises that the construction industry is mainly made up of SMEs. If they could develop a system dynamic enough to exploit this area a large untapped market would be accessible. A small IT organisation in the USA has recently been taking market share from some of the major market leaders in CRM. The reason for this is that they have been developing quality, customer focused software systems for their clients. QFD being a process that focuses completely on user needs has the potential to develop a solution for this unopened market.

The developer sees QFD as a methodology that can give them access to previously unattainable levels of user information/user requirements. It can do so in a methodology that is easily applied, auditable and focused on building the voice of the customer into a robust software specification.

7.7 Chapter conclusions.

This chapter described the second and final half of the QFD process. It investigated the project origins to the emergence of the user needs through four steps:

- Structuring the customer needs;
- Discovering the un-stated needs;
- Prioritising the customer needs; and
- Software specification deployment.

Structuring the customer needs: The customer needs discovered from the CVT were individually written onto single cards and randomly placed on a table. Two users then sort them into rational grouping, placing a heading for those groups after the groups had been formed. The result was an affinity diagram of the customers needs.

Discovering the un-stated needs: The affinity diagram of needs was then turned into a hierarchy diagram with three levels of granularity. The different levels of granularity were then matched equally amongst each other, moving the different needs up or down depending on their circumstances.

The hierarchy diagram was then examined for holes where there was obvious information lacking in certain topics and topics all together missing. This is the method where QFD discovers the unspoken needs of the customer.

Prioritising the customer needs: The top 30 out of the 70 customer needs have to be discovered, allowing the high value items more focus when the software specification is deployed. AHP was initially intended to be used to do this, but applying AHP to 70 different factors proved to big a task, and instead a focus group of users were used to choose the top 30, in order within their preordained groups.

Software specification deployment: The MVT was then used to deploy the top 30 customer needs into a user specification for a collaboration system. The MVT took

the generic user benefits and turned them into either software functions or service/training functions.

The final result is the MVT table. It is an interrelating table of software functions and training/service characteristics. The collaboration software specification was then taken to a Director of a leading UK developer of collaboration software for the Construction Industry. He assessed the specification itself examining it for

- Technical feasibility;
- Operation feasibility; and
- Economic feasibility.

The Director was impressed by the technical specification paying particular attention to the support and training issues mentioned they are an issue they are trying to focus on. QFD process itself is a sound method for delivering a customer focused product to the market, and requested more information in view of a presentation to the organisations production team.

Economically the Director could not think of a reason where the QFD could not use existing methods and resources to collect the information it needed. In some situations less information would be need to be collected, but with the QFD process the information could be leveraged better for a user specification.

8.0 CONCLUSIONS AND RECOMMENDATIONS.

This chapter draws conclusions to the thesis by discussing the findings from Chapter 5, Chapter 6 and Chapter 7, in light of the previous research discussed in the literature review in Chapter 2 and 3. The chapter begins with summarising the research findings in relation to the research questions.

8.1 Main research findings

The principle aim and objectives of the research are restated here to help a clear comparison with the adopted methodology and its design. The principal aim is:

To determine whether Quality Function Deployment can be used to construct more user focused Collaboration Systems in the Construction Industry

The Research Objectives were summarised in four key stages:

1. *What is a collaboration system and how is it used within a construction organisation?*

2. *Investigate and document the previous usage of Quality Function Deployment both as a project management tool in its classical sense and in it's software development form and how it is applied (if applied) in construction in general.*

3. *What are the current Collaboration systems used within the top UK construction organisations, and to what extent are they used?*

4. *Develop a user requirements specification using QFD for a construction collaboration system.*

5. *To assess QFD as a development methodology for construction collaboration systems.*

8.1.1 Research objective 1: *What is a collaboration system and how is it used within a construction organisation?*

This objective was completed through a detailed literature search looking at the following in this order:

1. Information
2. Information management
3. Information management strategy within construction
4. Information management systems
5. Collaboration systems

A literature review was then constructed utilising journal publications, government construction statistics and published books to present a succinct narrative surrounding collaboration systems within construction.

A Collaboration system is a type of digital information management system based on the internet and run by ASP. That collaboration system seeks to store and provide access to all the information needed throughout the construction process to all the relevant people. It also seeks to provide a high level of control and hindsight over the information which is stored on it.

There are multiple types of information management systems available to the UK construction industry including collaboration systems, most of which are existing systems that have been converted to be used in construction from other industries. They are all essentially electronic filing cabinets. The main advantages between manual and electronic file storing and manipulation could be stated as:

1. The ability to track and audit file movements and updates.
2. The ability to access and manipulate files remotely using the internet.
3. The ability to file and store information in a fraction of the time and space.

These basic advantages form the basis of many of the features that make using collaboration systems cost effective and efficient from a process standpoint, but are not the essential items that make a collaboration system successful with the *users*, which is a key driver for the collaboration systems overall success.

Problems in using collaboration systems arise when organisations are not able to understand how to apply these software tools in the correct manner, or the systems design means they have to be applied with a substantial amount of training. An understanding of how these systems are used best is often as valuable as applying the system itself. The result of applying a system without any basic knowledge of information management strategy can lead to a situation worse than without using any electronic aids in the first place.

Problems such as information overload, are the result of poorly implemented information management systems are, and very common on UK construction sites. This leads to many project staff being 'turned off' to electronic aids, and makes it harder to achieve the certain initial buy in that is required when applying something which has results that cannot be physically evident.

With collaboration systems being operated and supported by organisations completely separate from the client construction organisations certain features such as the system technical support and reliability (in terms of connectivity and day to day usage) have become increasingly influent on the decision making process of construction organisations where previously information management systems where bought on a functional basis with technical support/reliability the responsibility of the client organisations and not the software provider. Essentially some aspects of the service industries have begun influencing software development within construction.

8.1.2 Research objective 2: *Investigate and document the previous usage of Quality Function Deployment both as a project management tool in its classical sense and in its software development form and how it is applied (if applied) in construction in general.*

This objective was completed through a detailed literature search looking at the following in this order:

1. Current QFD practices
2. The historical perspective and development of QFD
3. Misconceptions and weaknesses surrounding the method
4. The use of QFD in developing software
5. A review of QFD's use within construction

A concerted literature search was conducted across the American manufacturing project management and construction journals for published material in the last 20 years. There is plenty of information and articles describing QFD applied in various streams of manufacturing and service industry situations, but within construction and software development the selection is limited. From these various sources a literature review was constructed.

Quality Function Deployment is a real world technique developed, refined and extended in industry. It has a successful record in shipbuilding, software, automotive, service industries across the world but mainly in Japan and the USA. QFD could be adapted and used successfully in construction in the United Kingdom.

QFD should be customised to suit each and every different project it is applied too. However, certain industries have been using skeleton templates of QFD for a number of years, which creates the impression that stock QFD methodologies can be used with guaranteed success in different sectors.

Time taken to customise a QFD system would depend entirely on the project, participants and the QFD facilitator, though an initial starting point would be a one hour meeting with the project participants for the facilitator to understand the processes involved and then another hour meeting a week or so later for the QFD facilitator to present the QFD process and consult with the project participants.

The core barriers to its use in construction include:

- Lack of foundation knowledge in manipulating various QFD tools to suit construction circumstances
- Perception of QFD "adding" to the workload required on a construction project
- Lack of trained facilitators in QFD
- Lack of realisation that existing methods can be improved significantly

The majority of practical QFD research in construction conducted from the early 1980s has been in deployment, i.e., applying the house of quality in the 4 phase ASI (American Suppliers Institute) method. The ASI method was developed from QFD in America in the 1980s to deal with existing and confirmed customer needs, aligned separately from the 4-phase method. Also, it was aimed at constant process which evolved over a number of years. This is not construction. The ASI 4 phase method of QFD is not suited to construction.

Egan identified four key drivers for change which would improve the industry:

- Committed leadership;
- A focus on the customer;
- Integrated processes and teams; and
- A quality driven agenda and commitment to people (Egan, 1998).

QFD is successful in areas such as uncovering, focusing and aligning un-stated customer needs, up-front planning, and reduced cycle time through less redesign and better cross-functional communication. They are real world benefits that can be delivered from a correctly constructed front end Blitz QFD application.

Contrary to most management techniques Blitz QFD is not added onto existing techniques, but replaces the existing processes utilising the existing teams, creating a methodical/auditable pattern that is specifically designed to discover and build into the project the core areas of design in the initial stages that are extensive and expensive to alter in the construction stages, or not noticed at all using the previous methods. As such it offers real benefits to construction practioners.

8.1.3 Research objective 3: *What are the current Collaboration systems used within the top UK construction organisations, and to what extent are they used?*

This objective was completed by interviewing a leading individual within the business systems department in 14 of the top 20 UK main contractors. Questions were asked regarding what is used, where, when, if there are problems, what are the successes, what points would you like to see changed.

The survey discovered that in the top 10 UK contractors use 9 different collaboration systems. The majority of the 10 contractors started using the collaboration systems between 2001-2002. These two facts suggest the application/development of collaboration systems for construction is in the early stages. With 9 systems being used over the top ten contractors the market is still fluctuating, and the best systems have not yet emerged to control the majority of the market. There is no market leader, or perceived market leader, and a lack of awareness from contractors of what's available.

Collaboration systems are not software products bought off the shelf and forgotten about. They are a service, not just a software product. Therefore post software sale contact with the supplier must be seen as an essential part of the product sold. Many of the contractors were not happy with the contact/support service provided by the software suppliers. When the service/support provided was acceptable it was understood there were areas where this could be improved.

The contractors were not aware of the systems available. They each had several senior IT experienced individuals, but there still seemed to be a lack of understanding at Board level as to what exactly information management could do, and where their organisation could deploy it. This resulted in a few of the top 20 UK contractors choosing the cheapest system (usually image storage/basic document management features) available after their investigations of various systems. Essentially organisations are not sure what they want, and not wanting to pay for something they lack in knowledge about.

Only the top 15 use the collaboration systems through choice. The rest can't afford the systems but do come in contact with them through clients such as ASDA who stipulate in their contracts a specific system will be used in any of their projects.

The use of the current systems within the top 10 contactors varies from most of them using the document storage and recall functions and ignoring the drawing retention and transmission functions to one organisation using collaboration as a corporate information system throughout all of its core information processes.

The opportunity exists for a construction specific system to dominate the market. The information needed to develop a system is available. With the right development methodology a system could be developed to match the user's expectations and surpass them.

8.1.4 Research Objective 4: *To develop a user requirements specification using QFD for a construction collaboration system.*

A QFD green belt course was attended, run by the QFD Institute, where a basic 2 day course on applying QFD was instructed. This balanced with a thorough literature search enabled the researcher to construct a QFD project. The QFD project took 6 months to complete from the initial meetings with the involved contractors to the complete software specification presentation to the Collaboration system developer.

The Maximum Value Table resulted in 78 software functions and 23 training and support functions being specified. Each of those functions has a clear audit path back through the prioritisation and grouping stages to the CVTs where again each user benefit can be traced directly to their origins of who said what and in what situation the input was made.

This transparency allows a full auditing of *where* each software or support/training function derives, enabling the organisation to understand *how* their employees and partners try to solve their information needs, and *what* existing actions add value or create waster within their information management process.

30% of the functions derived from the users related specifically to training and support issues. This is an area with a large potential for development. Currently these issues are not being given enough priority. They are, and will continue to have a large influence on the construction industry's choice of system, whether recognised by the ASPs or not.

The functions were examined by the Director of one of the market leading UK construction ASPs, who requested an extended meeting after the presentation of results to the organisations product development team.

8.1.5 Research Objective 5: *To assess QFD as a development methodology for construction collaboration systems*

The QFD process and resulting specification was taken and presented to the Director of a leading collaboration systems developer for construction. The Director had spent time reading through the methodology prior to the visit, and after the presentation of the results and the method questioned various aspects of the QFD method. In particular aspects of technical, economic and operational feasibility were examined for a thorough and industry applicable method of software development.

There is a big difference between the QFD most professionals have heard of and the type that should be applied to developing software. Most applications of QFD that have gone wrong attempt to use a manufacturing style house of quality to develop a service/software/construction. Construction is similar in some aspects to manufacturing, but the applications in construction are usually directed towards developing customer requirements and developing them into a design specification, not as QFD is used in manufacturing, to deploy the chosen solution in the most efficient manufacturing process available. This if often why a 4 phase House of Quality process, which is seen as 'conventional' QFD, is applied. The House of Quality 4 phase method was developed in the early 1980s for car manufacturing by the American Suppliers Institute, not in Japan as the foremost QFD method. Other QFD methods are better suited, even specifically developed for certain situations but are rarely used through lack of exposure.

The resources needed to gather the user information are not prohibitive. Half the interviews completed in the QFD project took approximately 10 minutes to complete, and were more akin to a brain dump of information than a structured interview, and were completed in one morning at a bi monthly design meeting on site with minimal disruption. Software development organisations like BIW already use focus groups made up of representatives of their customers/users, meaning the steps within the QFD process that need to use the users to manipulate the information gathered could easily be combined with an existing process. With the correct process there is no reason for a QFD process to be used each time a new software system need is identified. The process does not take up too many resources and can open up areas of value and customer satisfaction that previously was not accessible.

Software developer's existing methods for developing a specification do not involve manipulating the information from the users to find additional developmental information that can be constructive within the software development process. They do not involve the users themselves in defining their own customer needs. One of the crucial parts of the QFD process is having the users themselves manipulate their own user requirements within the QFD development process. This method is essential for accessing the meta information surrounding the users needs and how they interact and additional user needs that were not stated by the users themselves.

There is a huge expectation or want for a better level of customer service from the ASPs. Currently ASPs simply do not provide the level of support and customer service that is expected by the construction organisations. This is an opportunity. One of the biggest areas where users wanted additional functionality with the software is the support service applied from the software developer. This is a prime example where a service orientated organisation could deliver a support service far exceeding any of the current applications, and gaining value in their product, but not altering the software system. It is a very important aspect that has not been correctly deployed by the current system developers that can have a huge effect on how their clients perceive the software. Simple solutions like training client personnel in system troubleshooting allows client professionals to contact a familiar face before contacting an external organisation. That trained team/individual will have a greater investment in solving the problem since they are part of the same organisation. A simple

technique such as this could reduce the load to the ASPs helpdesk by solving all the basic enquiries that happen on an everyday occurrence, saving the developer money at the same time increasing the perceived value of the service/software. There are extensive possibilities on how service can be provided, all of which are easily accessible from the users themselves.

The QFD method is simple to use, flexible with what it does, for example steps can be missed out if they are deemed in a particular situation to not be of use. The QFD process demonstrated within this thesis is an example of how one can be constructed and delivered, not a rule book to exact application. Hence the tools within the QFD process can be added to with other techniques or replaced completely of better techniques are found, or seen to be more effective in any particular situation.

The results in this situation were gained through examining 3 different construction organisations working methods and construction professionals currently using 5-6 different systems regularly. A software developer could use the QFD technique, but aim it specifically at their product and use QFD to improve on an existing system, rather than develop an entirely new generic system. QFD can be applied to existing systems in use to gauge their success and any improvements that could be made just as easily as applying it to a new situation.

Additionally, this QFD method could be adapted to be used across to develop a software specification for other types of construction software and could be used for generic software development across other industries.

The result of the Blitz QFD process is a software specification. If desired this specification can be taken forward and a House of Quality used to compare the specification to competitors specification/service, and further detail the limitations and expectations of the functional specification discovered.

8.2 Study Limitations

This study was based round the following limitations that were detailed in the initial Methodology:

- The system specification will depend on the breadth of the people interviewed; they will be the key to how complete the specification of the system will be. Therefore throughout the interviews a broad spectrum of collaboration system users must be sought for the interviews.

Stage two of the QFD process investigated the users of collaboration systems, split them into four categories and investigated various aspects including how they use the system; what they use the system for; when they use the system and where they use the system. Table 6.2 demonstrates this. A wide range of personnel were interviewed, including the following roles: Project manager; Site engineer; Health and safety manager; Quantity surveyor; Project administrator; Oil & gas manager; Architect; Design consultant; Contractor designer; External sub-contractor; Organisation trainer.

The only key role not interviewed was the client organisation. One of the contractors used in the study was the client organisation within the project examined, but declined to be interviewed because they had no interaction with the system and received information regarding progress only through weekly progress meetings. This is an example of varying client participation within projects, which cannot be simply defined for as a 'role' which needs considered as an information source such as 'Project manager', and would need to be defined on a project by project basis.

- The users within this study are sourced from 3 top 20 UK construction contractors. With the construction industry being disparate and varied the results would mean the system would be specifically tailored to those three organisations, and not the construction industry as a whole. Therefore the Collaboration system requirements developed from this project can only be presented in the sense of 3 top UK contractors, and not industry wide. For this

reason discussions of the results have been made with a UK collaboration system manufacturer to assess its overall competency as a construction industry software specification.

A leading UK Collaboration system developer was consulted with the results. They where impressed with the results and method and further contact was requested. This validated the results as effective across their targeted customer base of the top UK construction organisations.

- QFD studies are mainly completed by a fully trained QFD practioner with experience and training. In this case the QFD methodology was completed by the researcher with minimal QFD training and no previous industrial QFD application experience.

A complete literature search was completed and constantly referred to, with information gained from a QFD basic course from the QFD Institute and a completed Masters degree dissertation, the risks of a failed QFD process were minimised. Ideally a QFD team made up the users lead by a QFD facilitator would work as a team to complete the CVT (Customer Voice Table) and MVT (Maximum Value Table) but the resources needed were not available from the contractors.

- Collaboration systems are produced by software developers with a grounding in software development methodologies and experience in writing software requirements specification. With this project the researcher had neither.

A lack of experience in developing a software specification was countered with a robust software QFD process. That process enabled users to manipulate their own information throughout the fixed specification development process without the input or influence of the researcher, therefore reducing the potential negative aspects of a lack of experience to a minimum. The QFD process and its results were validated through consultation of the methodology and results by a UK leading collaboration software developer.

8.3 Recommendations for further study

An investigation to examine exactly what construction professionals use collaboration software for would give a definitive user list that would help the software developers target more cleanly their software. Existing systems fail largely to take into account small issues of user incompatibility that greatly affect the user's likelihood to use the system. Mapping out the characteristics of the users would help define what is precisely needed.

Using a QFD team (made up of industry professionals) within the QFD process to complete the MVT and CVT combined with support from a major contractor and software developer would enable the QFD process to have an extensive assessment with industry audibility and create a better environment for increased exposure of the method to industry. Also the use of QFD team to complete the manipulation of the customer needs would lead to a better specification. Their experience and understanding of the user's needs would allow a more precise understanding of how the needs interacted and affected each other.

QFD has the potential to gather a vast amount of information. The use of QFD software would enable the data sets to be manipulated digitally, and not manually. This would speed up the overall process and increase the amount of information accessible with limited resources.

The user needs discovered in this process highlight what the system should be satisfying. A study investigating the extent each of those needs are currently being satisfied may lead to information on how certain groups of users are not being satisfied, while others are being over focused on.

8.4 Implications of QFD applied across the Construction Industry

The effective application of QFD throughout construction would significantly increase the focus on the client in an industry where financial and operational factors often come before client satisfaction. In doing so construction could have a system where it can measure and trace the development and evolution of their client's needs

across a set period. Consistent use of QFD in this respect could help organisations interact and satisfy their clients requirements to a much higher degree than currently, helping to develop longer term relationships to mutual benefit to all the organisations involved. This would lead to an increased awareness and understanding of the client/customer satisfaction problems within construction of which symptoms include a fragmented and disassociated industry supply chain and low profit margins.

8.5 Personal development

During my PhD I have learned how to create and manage an extended research project, setting aims and objectives and developing a methodology to fulfil those aims and objectives.

Additionally I have learned to create a structured work program and a set of procedures and work through those procedures within the overall research project, timescales, and predefined boundaries.

8.5 Implications of QFD applied across the Construction Industry

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