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A METHODOLOGY FOR SELECTING THE CONSTRUCTION TEAM

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ABSTRACT

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Achieving partnering in the public sector is difficult since most projects are one-offs and hence there can be no long term commitment, the option of providing incentives such as pain-gain sharing to contractors and consultants is not possible and contracts need to be awarded by competitive tendering. In a study of a project at Hurst Spit in Hampshire a partnering way of working was achieved with no partnering agreements, no long term commitments and no incentives.

It is proposed that a partnering way of working can be achieved using competitive tendering if a pre-qualification methodology can be developed which will eliminate parties that have not embraced a culture of co-operation.

This thesis describes a methodology that eliminates those companies that attempt to succeed in the pre-qualification stage by second guessing what the client wishes to hear and hence disguising the fact that the culture for co-operative working is not present and prefer to use litigation rather than co-operation. The solution to the problem required a methodology that is specific to project and client, and able to identify and eliminate companies having a culture inappropriate to co-operative working.

Initial trials of the methodology were undertaken with Gosport Borough Council to select consultants and contractors for the construction of a £2m bridge as part of the Millennium scheme for the regeneration of Portsmouth Harbour. The approach was to allow the client to identify all the success criteria that were important to the project. The client was then required to prioritise these criteria using analytical hierarchy process (AHP). Consultants and contractors were then asked to prioritise these same criteria and explain how they would deliver the project on these criteria.

In addition, the consultants and contractors were required to work together to value engineer the design prior to any construction works.

This research focuses on the development of a consultants and contractors selection process which will enable co-operative working between all participants and permit early contractor involvement.

The results of the trials were highly successful and the methodology described in this thesis is now being widely adopted.

Contents

1. Introduction

1.1 Background

Construction accounts for approximately 8% of the Gross Domestic Product of the UK and holds a similar position in the world's other industrialised nations (Tradepartners UK[1]). The construction industry is highly fragmented and is characterised by the need to assemble temporary teams of designers and contractors for the execution of any given project. In addition, the current nature of construction means that there is little repetition and every project has its own unique set of circumstances and problems.

As a result of the highly fragmented nature of construction, the industry is blighted by adversity, poor quality and cost and schedule overruns. It has been recognised that construction costs need to be reduced, together with construction schedules and generally provide better value for money (Egan[2]). In particular, greater certainty of cost and schedule outcome must be delivered. The Audit Commission found that in Local Government projects, which account for some 40% of the construction industry workload, two out of five projects had cost escalations of greater than 15% and two thirds of projects were completed late with half of all projects more than 15% behind schedule (Audit Commission[3]).

The reasons for these failures can be directly attributed to a lack of co-operation between the parties to a construction project. It is estimated that 30% of project costs can be attributed to failures in the design, construct and manage interfaces (Brown and Beaton[4]). This belief is reinforced by a study of a construction project where all parties co-operated which led to a cost saving in excess of 30% (Brown and Riley[5]). There is, therefore, a clear need to develop a selection process which ensures that co-operative working occurs between all parties to a project.

Various new contract strategies have been proposed and tried in an effort to achieve this (Egan[2]). In the UK partnering is being strongly promoted. Partnering was initially defined as:-

"*The creation of a special relationship between contracting parties in the design/construction industry. This relationship encourages the parties to change their traditional adversarial relationships to a more co-operative, team based approach, which promotes the achievement of beneficial goals, including the prevention of major disputes.*" (Larson[6])

This approach would appear to provide a panacea for the construction industry's ills. However, this conceals the fact that this relationship can only truly come about as a result of a philosophical and cultural shift by the parties involved. Too frequently, companies enter into partnering arrangements without any change from the traditional adversarial stance and thus project failure still results through non co-operation. It was also recognised that without trust, even with partnering, project failures would still occur (Brown et al[7]). Trust in this context has been defined as follows:-

"Trust is the reliance by one person, group or firm upon a voluntarily accepted duty on the part of another person, group or firm to recognise and protect the rights and interests of all others engaged in a joint endeavour or economic exchange" (Lazar[8]).

To overcome this problem partnering has been redefined to embrace the concept of trust as follows:-

"A long term commitment between two or more organisations for the purpose of achieving specific business objectives by maximising the effectiveness of each participant's resources. The relationship is based upon trust, dedication to common goals and an understanding of each other's expectation and values. Expected benefits include improved efficiency and cost effectiveness, increased opportunity for innovation and the continuous improvement of quality products." (Weston and Gibson[9])

This definition highlights two problems. Firstly, the majority of construction projects are one off and so no long term business relationship can be established. Secondly, probity issues in the public sector and E.C. legislation require selection of parties to a construction project to be based on competitive tendering rather than negotiation.

The traditional sequential method of construction procurement in which the design is finalised before a contractor is appointed prevents value engineering taking place to maximise the buildability of a project. It was the traditionally held view that the client would obtain better value for money through competitive tendering based on a completed design (Nam and Tatum[10]). However, when contractors are able to take part in value engineering before the design is finalised both cost and schedule reductions are possible (Brown and Riley[5]).

Projects can be considered unsatisfactory by clients because they fail to meet their expectations. However, this is frequently a result of the client having failed to rigorously analyse the project objectives prior to the start of the project and failing to communicate the objectives to the designers and contractors (Latham[11]). Whilst designers and contractors will make every effort to ensure a project meets the objectives that they believe the client would want, attempting to guess what the client expects is no substitute for the client specifying what is expected (Brown et al[12]).

1.2 Research Objectives

This research aims to develop a methodology for the selection of consultants, architects and contractors which ensures that only those that have the culture for co-operative working are selected. This methodology must allow selection to be made by competitive tendering whilst still permitting the benefits of co-operative working to be realised. In addition, the selection methodology must ensure that congruency of expectations and objectives exists between all parties to the project. The research will centre on integrating the success criteria for the project with the expectations of the client using a hierarchical structure.

The methodology will also be developed to allow early selection of the contractor to provide constructability knowledge during the design process. This will also permit trust and teamworking to develop from an early stage in the project.

To distinguish this co-operative working arrangement for single projects from the partnering arrangements described above, the term Project Partnering has been adopted for this new methodology. The long term relationships are now referred to as Strategic Alliancing (CIC[13])

The overall aims of this research are to provide a mechanism for assembling project teams that can work together without conflict, thus promoting trust, common objectives and to produce value engineering and continuous improvement in quality. Assembling a team with common objectives and mutual trust should also prevent cost and schedule overrun and achieve the client's objectives for the project.

1.3 Research Methodology

The research methodology adopted is action research. Action research was developed during the 1940s independently in the US and UK by Kurt Lewin[14] and the Tavistock Institute[15] respectively. Both Lewin and the Tavistock Institute applied action research to address problems in industry. The purpose of action research is to implement, change and generate new knowledge (McNiff[16]). Lewin's[14] original definition of action research included practitioners in a cyclic process of four stages:

1. plan
2. act
3. observe
4. reflect

More recent definitions of action research generally characterise it as (Carr and Kemmis[17]):

- focusing on change and improvement
- involving practitioners in action research
- being educational for those involved
- looking at questions that arise from practice
- being a cyclic process of collecting, feeding back and reflecting on data
- being a process which generates knowledge

Action research has been described as a form of collaborative research in that it involves practitioners in the research process rather than simply being researched upon (McNiff[16]).

The adoption of action research can raise several areas for concern (Baskerville and Wood-Harper[18]). However, these are more likely to be generic problems with the research approach rather than being peculiar to action research, for example:

1. The lack of impartiality of the researcher has led to the rejection of the action research method by a number of researchers. However this is not necessarily a problem singular to the action research method. A similar criticism could be made of research investigating

some phenomenon using an opinion-based questionnaire. The lack of impartiality or objectivity would lead to the rejection of the knowledge by some researchers.

2. Some of the action research conducted lacks rigor, which makes it difficult for the work to be assessed and also undermines the credibility of the method. Rigor relates to fitting the research methods to the problem in order to produce valid scientific explanations (Straub[19]). The lack of scientific discipline is a reasonable complaint about liberal action research, but similar complaints are also directed at other research methods (Baroudi and Orlikowski[20]).

3. Action research is sometimes branded as 'consulting masquerading as research'. At least four factors differentiate action research and consulting (Gummesson[21]):

   (i) researchers require more rigorous documentary records than consultants

   (ii) researchers require theoretical justification and consultants require empirical justification

   (iii) consultants operate under tighter time and budget constraints

   (iv) the consultation is usually linear; engage: analyse: action: disengage, whilst the action research process is cyclic

   Jonsson[22] suggests that these differentiations are not widely known and that even seasoned action researchers sometimes have trouble delineating action research from consulting. Baskerville and Wood-Harper[18] note that this dilemma may arise from sloppy action research, action research that loses its scientific focus and finally converts entirely into consulting.

4. Action research is context bound and not context-free. It is, therefore, difficult to determine the cause of a particular effect that could be due to the environment, researcher or methodology. This means that action research produces narrow learning in its context because each situation is unique and cannot be repeated. This is, in fact, no different from other scientific methods and further testing is required before generalisation by confirming or falsifying any causal links suggested by action research theories. In this

regard an action research study is no less effective and credible than most cross-sectional statistical survey methods (Baskerville and Wood-Harper[18]).

Action research can, therefore, achieve scientific rigour provided that certain strategies are adopted. Firstly, an ethical client-system infrastructure and research environment must be established. Data collection must be carefully planned. The iterative phases which formulate the theory must be strictly observed by planning the action, taking action and evaluating the action. Throughout the process collaboration with the practitioners must be promoted and they must be supported in the learning cycles. Finally, reports of the research must disseminate the scientific knowledge obtained from the work to allow future work to confirm or refute any casual suggestions or claims of the generalised theory. When this approach is adopted action research provides a research methodology of equal scientific rigour to any other.

1.4 Research Progression

The research began by studying the literature available on project procurement, selection of designers and contractors and measurement of project success.

A search was made for a project to analyse that was performing better than would normally be expected. A suitable project was identified and investigated to identify the factors influencing the enhanced project performance. The project selected was Hurst spit Stabilisation scheme and is described in detail in chapter 3.

The understanding of this project was essential for developing a methodology for selecting the designers and contractors for a construction project which ensured that the objectives identified as being key to project success were achieved.

Suitable construction projects were found for which the client was prepared to allow the methodology to be tested. The research was undertaken by using Gosport Borough Council's Millennium projects for the trials. These are civil engineering construction projects which are part of a scheme with a total value of £15M. The first of these projects was Forton Lake Opening Bridge. This is a bridge of approximately 150m length, with a lifting section across a navigable channel and built across a Site of Special Scientific Interest (SSSI) at a cost of £2.0M. The second project was a harbour promenade scheme, approximately four miles long, costing approximately £2M and providing a walkway along the entire harbour frontage. The third scheme was the construction of pontoons and interconnecting walkways in the harbour itself at a cost of approximately £2M. As a consequence of Millennium Commission funding for these and the other projects used as controls, there could be no cost or time overrun or any significant underspend. The timescale for Gosport's projects is shown in Table 1.1.

Similar projects were identified as control projects which would permit comparisons of project performance to be made as closely as possible on a like for like basis. Portsmouth City Council's Millennium projects were selected as control projects. These projects provided a near unique opportunity to compare almost identical projects but with Portsmouth using the traditional procurement route.

Project team performance was measured until final completion of the project. This was measured using the degree of interaction method developed by Pocock[23].

The methodology was evaluated by comparison with the control projects and by evaluating how closely the project met the client's objectives and expectations. For this purpose three client groups were identified and surveyed. These were: the Council members; the Council officers and the local residents. In addition, a new process to validate the effectiveness of the methodology by assessing quality was developed and tested on the Forton Lake Bridge Project.

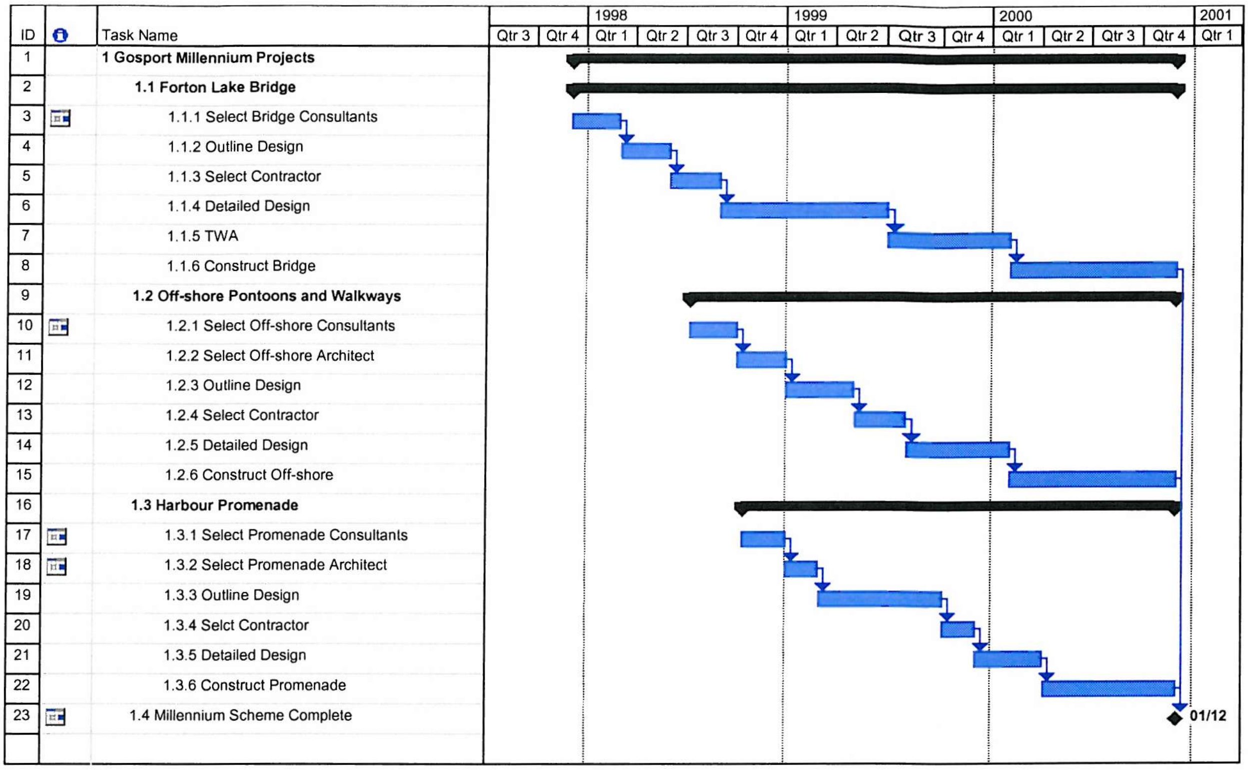

Table 1.1 Gosport Borough Council's Millennium Programme

1.5 Research Theory

The research utilised multiple criteria optimisation and multiple criteria prioritisation tools to identify project objectives and to investigate congruency of goals between the parties. The analytical hierarchy process (AHP) was identified as the most suitable tool and has been used as the principal tool in the research. This is a method of prioritising multiple criteria quantitatively and relies on a pairwise comparison of the individual criteria. In addition, it provides the means of measuring the consistency of the results. Unfortunately, unexpected problems have arisen, such as how to compare consistent and inconsistent priorities. Part of the research therefore focused on creating a clearer understanding of AHP. One of the advantages of AHP is its ability to provide a measure of the consistency of responses. However, as a result, the principal area for concern was inconsistency and the following questions needed to be addressed:-

1. Is it meaningful to compare inconsistent and consistent results?

2. Do inconsistent results really represent the prioritisation of criteria by an organisation?

3. Would a methodology which encouraged a respondent to provide consistent results present a distorted view?

These issues were addressed by the following means:-

1. Use of Monte Carlo simulation to establish the probability of inconsistent results occurring by chance.

2. Monitoring the progress of Gosport's Millennium projects to determine whether or not AHP provided a true representation of the objectives of project, client, contractor and consultant.

3. Studying the differences in results of AHP when a respondent is encouraged to be consistent and when they are not.

1.6 Justification for the Research

The need for construction without conflict has been recognised for some considerable time. In the private sector partnering has shown considerable success. However, in the public sector, where issues of probity dominate, few advances have been made. The need for a partnering type of working in the public sector has been promoted and research in this area recommended (Latham[11]). As a result of the perceived difficulties of achieving this, very little work has been directed at this problem.

The need for and value of this work can best be summarised by quoting from two companies who assisted in this research:-

"This is an important area of research which should help change culture to create a "level playing field" for all parties to a contract. It will help create a partnering way of working and eliminate the contractor that relies on claims during the contract to achieve a profit. We feel the research method proposed will achieve the aims and objectives stated." (Maunsell)

"This is a vitally important area of research which addresses the need to eliminate, from the construction industry, competition that undercuts tender prices by relying on claims during the contract. This research offers a far greater potential for a significant improvement in

construction than any other research currently in progress or already completed that is known to us." (Westminster Dredging)

1.7 Layout of Thesis

Chapter 2 presents a literature review of the problems associated with adversity in the construction industry. It investigates the causes for this adversity and looks at various strategies that are available to combat this adversity. The section of this literature review which discusses conflict is the substance of a paper (Brown et al[7]) and the definition of trust developed (section 1.3) is now the accepted norm.

Chapter 3 provides a review of Local Government procurement practice and legislation.

Chapter 4 presents a case study describing how a co-operative way of working developed on a contract set up in the traditional "adversarial" strategy. This chapter also highlights the fact that it is people having the culture for co-operation and not the contract that removes adversity from construction. The full details of this project are published in a paper of which this chapter is an extract (Brown and Riley[5]).

Chapter 5 describes the theoretical approach to the selection methodology. It includes a comparison of a number of multiple criteria decision making tools.

Chapter 6 researches the problems of using the Analytical Hierarchy Process (AHP) as a one of the principal tools in Selecting The Team.

Chapter 7 describes the proposed new project procurement strategy which includes the process called Selecting The Team (STT). It explains how it differs from partnering and why it presents a better option, particularly in the public sector.

Chapter 8 describes the method used to identify the objectives of the project and the client's expectations. It also describe mark distribution and explains why it was developed.

Chapter 9 details the methodology used for selecting the design consultants and describes the outcome of the first trial of the methodology.

Chapter 10 details the contractor selection process and describes the value engineering procedure.

Chapter 11 evaluates the performance of the methodology by comparison with other construction projects and by using an approach developed for the purpose of evaluating project outcome called quality issue analysis.

Chapter 12 summaries the selection methodology and concludes the research.

2. Literature Review

2.1 Overview

This literature review begins by presenting a general statement on the state of the construction industry. There then follows a review of the mechanisms available for contract procurement. A discussion of the causes of adversity in construction is then given, followed by methods for minimising conflict within the project delivery process. Finally, partnering as means of providing construction without conflict is discussed.

2.2 The Construction Industry

The construction industry contributes a significant proportion to the economies of all industrial nations. In the UK the construction industry provided 8% of the Gross Domestic Product (GDP) in 2002 (Tradepartners[1]). Similarly, in the USA the construction industry contributes 10% of Gross National Product (GNP) (Clough[24]) and in Italy 10% (Pietroforte[25]), whilst in Japan it rises to 24% of GNP (Paulson[26]).

In most countries the majority of construction is procured by the public sector. In 1993 about 66% of domestic construction in the UK was provided for the public sector (DTI[27]), in spite of over a decade of privatisation.

The vast majority of construction industry companies are small businesses. There are more than 200,000 contracting companies competing for the UK construction market (DTI[27]), 500,000 contracting companies in the USA (Barrie[28]) and 400,000 contracting companies in Japan (Paulson[26]). These construction companies are in intense competition between themselves as required and expected by a free enterprise system. In addition they compete in an industry which has a high level of variability. A wide range of professions and trades are involved in the planning, design, procurement and construction of any given project, and with new contract strategies such as Design Build Finance and Operate, involvement can be extended into the operational stages of a project. Every project is delivered by assembling a varied range of professions and trades into a virtual team under a unique combination of physical, environmental, regulatory, political, economic and other conditions. As a result of this and of the complex and dynamic nature of construction projects, risks and uncertainties can and frequently do arise in all phases of a construction project.

Unlike manufacturing, construction has little repetition or standardisation, as each project is different in design, layout, materials and geographical location. The inherent problems of producing a bespoke project are compounded further by differing construction methods, varying timescales and changes of labour and management. In addition, the construction environment is full of uncertainties particularly with respect to availability of suitable labour, plant and materials, unpredictability of production rates, design changes and unforeseeable ground conditions. Furthermore, construction productivity is always vulnerable to weather and geographical conditions.

These features of the construction industry, to a great extent, encourage project clients to seek to delegate the risks associated with their project onto other participants in the project, usually the contractors. Risk delegation to contractors is notable in public projects (Crowley[29]) as a result of project funding being limited to the estimated project budget with any overspend being the subject of public scrutiny. Strict guidelines exist for procurement of public projects to ensure that the issue of probity is not compromised and to ensure that the procurement process utilises public funds without bias. This is of particular concern to Local Authorities where breaches of standing orders or failure to exercise probity can result in the council members themselves being obliged to meet any shortfall in budget. The current contract awarding procedure in the public sector is, therefore, based solely on competitive bidding with the contract being awarded to the lowest bidder. The reasons for accepting the lowest price bid are the need for the client to satisfy the requirements of public accountability and probity and to demonstrate that "value for money" is being obtained as a result of fair competition.

2.3 Construction Improvement

There is a world wide effort to create significant improvements in the construction industry. To this end, ambitious but achievable targets and deadlines have been established to drive this process forward

CONSTRUCTION SECTOR PERFORMANCE METRIC	YEAR 2003 TARGET IMPROVEMENT	RANKING (*) IN IMPORTANCE
Total Project Delivery Time.	Reduce by 50%	First
Operation, Maintenance and Energy Lifetime Costs	Reduce by 50%	Second
Productivity and Comfort Levels of Occupants	Increase by 50%	Fifth =
Occupant Health and Safety Costs	Reduce by 50%	Sixth
Waste and Pollution Costs	Reduce by 50%	Fifth =
Durability and Flexibility in Use Over Lifetime	Increase by 50%	Third
Construction Worker Health and Safety Costs	Reduce by 50%	Fourth

(*) Ranking in Industry Importance Obtained from White House Construction Industry Report Workshop Participants Representing the Residential, Commercial, Institutional, Industrial, and Public Works Construction Sectors (Wright et al[30]).

Table 2.1: US Construction Sector Performance Improvement Targets to be Achieved by Year 2003.

Performance Metric	Improvement
Cost	30% reduction
Duration	25% reduction
Defects	zero
User benefits	20% improved

Table 2.2: The EPSRC IMI "Construction as a Manufacturing Process" Key UK Objectives

The emphasis has been on adopting processes which have proved successful in the manufacturing industry. Technical methods such as just in time (JIT), business process re-engineering (BPR), pre-fabrication and standardisation are beginning to produce benefits in the construction industry.

Although technical issues are important and need to be improved, the real problem is that of culture. Quantum improvements in the construction industry, as required by the improvement targets, will not be attained purely by technology transfer from manufacturing. Significant improvements can only occur by a process change coming from within the construction industry and dedicated to encompassing the whole culture of construction.

The need for a new contract strategy is clearly evident when it is recognised that the profit margins of construction lawyers specialising in litigation are far in excess of the construction companies that they represent. Adversarial working is being replaced by new ways of working in other industries (Towill[31]) and has shown great improvements.

The scenario for a paradigm shift in UK construction culture was proposed by Sir Michael Latham[11] in his report that proposed working in partnering arrangements. This proposed long term partnering relationships with mutually agreed and measurable targets for productivity improvements.

The major drawback of the Latham approach to partnering is the creation of long term relationships between partners, typically lasting 3-5 years and with a continuous stream of work being carried out during the lifetime of the partnering arrangement. Unfortunately this does not address the majority of construction projects in this country where more than 85% are still single one off projects, and the requirement, in the public sector, of a need to satisfy probity by competitive tendering (Audit Commission[3]).

In projects where the client and engineer have embraced the philosophy of non-confrontational working, the goal is then to create a partnering way of working after competitive selection of the Contractor whilst still fulfilling three basic requirements:-

- A method of contractor selection that achieves the best value
- A guarantee that the contractor selected will adopt the partnering philosophy

- A method of allocating risk and profit after the contract has been awarded.

2.4 Contract Award Systems

Two methods exist for selection of a contractor (Smith[32]) which are

1. By competitive tender
2. By negotiation

In both methods the major criterion commonly used for selection is price. In the UK public sector competitive tendering is still used almost exclusively and it is invariably the bidder with the lowest tender price that is awarded the contract. Due to the issues of probity, negotiated contracts are rare in the public sector.

As a result of the predominance of competitive tendering in the UK public sector further investigation is considered appropriate. Competitive tendering can be divided into two categories:-

1. Open tendering
2. Selective tendering

2.4.1 Open Tendering

The open tendering system permits any construction company to submit a tender for a project if they feel that they are capable of undertaking the proposed project and that they wish to be considered for the project (Merna[33]). Invitations to tender for the proposed project are brought to the attention of all construction companies, large and small, and good, bad or indifferent by advertising in journals and the press. By this means, the client hopes to gain the largest possible number of tenders thereby maximising competition and almost certainly obtaining the lowest price.

The disadvantage of open tendering is the large number of tenders which significantly affect the time and cost of the evaluation process. In addition, when an unlimited number of companies are permitted to tender for a given project there is a probability that the company submitting the lowest tender may be unsuitable to undertake the work resulting in considerable waste of time and effort. To reduce the number of tenders and to discourage unsuitable companies from tendering , some clients require a deposit to be lodged with them which is returned on award of contract (Smith[32]). The size of the deposit, however, must be high enough to discourage unsuitable companies from tendering but not so high that genuine bidders are put off.

2.4.2 Selective Tendering

Selective tendering is the most popular and straightforward method of eliminating unsatisfactory tenders. This requires that some form of qualification of the contractor be conducted before or after tenders are invited. Some project clients may require the contractor to be approved prior to obtaining tender documents (pre-qualification), while other clients may allow anyone to bid and only qualify companies submitting the lowest or lower bids (post-qualification).

Qualification criteria are well documented and include not only financial status, but also past performance, current performance and experience (Russell[34]). Qualification can occur on a project to project basis or can be an ongoing process by which contractor performance is monitored and recorded for future reference. Post-qualification often uses similar criteria to pre-qualification, although it may be more project specific.

There is some debate over the relative merits of post-qualification and pre-qualification. A post-qualification system requires less effort by the project clients because they only qualify the lowest or a few of the lower bidders, whereas a pre-qualification system necessitates the qualification of all prospective bidders. This effort is particularly relevant to any client with an ever changing list of prospective bidders (Rankin[35]). A negative aspect of post-qualification is that contractors have wasted time and effort in the bidding process. The advantages of pre-qualification include (Jaafari[36]):-

1. Saving unqualified contractors the cost associated with bid preparation
2. Encouraging competent contractors to bid with confidence as they are only competing with a few others of similar standard
3. All contractors who are allowed to bid will be qualified and hence the client can concentrate on evaluating the bids rather than evaluating the contractors

4. Saving in the time and effort of tender evaluation by reducing the number of tenders

5. Although any qualifying programme will be as objective as possible, there is an element of subjectivity which in the case of post-qualification could lead to conflict if a bid other than the lowest is accepted.

2.4.3 Selection by Lowest Bid

In reality there is no guarantee that selection by the lowest bid provides the best value for money (Gore[37]). Three main problems are associated with this procedure:-

1. There is no established relationship between a low tender price and a low final project cost.

2. The lowest bid might be based on a suicidally misconceived understanding of the project.

3. The lowest bid may not be the most realistic bid.

This presents the problem of being able to anticipate the probability of a bid being simultaneously the lowest, reasonable and acceptable (Gore[37]). The subsequent analysis by Gore[37] produced no firm conclusions as to whether or not the lowest bid will probably be the best bid. Accepting the wrong bid is a problem routinely faced by the public sector (Ashley[38]). If a bid is in error, either by accident or design, is it unfair to exclude another bid which may, more accurately represent the price of the project?

2.4.3.1 Reducing the Risk Associated with Lowest Bid

Two methods of reducing the risk associated with contract award based on the lowest bid are in common usage.

A) In order to overcome some of the problems associated with selection of contractors by acceptance of the lowest bid, some clients require a bond to be provided. There are two principal aspects of a bond:-

    1. A guarantee of the financial capacity of a contractor

    2. Protection against bankruptcy of the contractor during the project

This provides no guarantee to the project client of the contractor being able to achieve the objectives of the proposed project and does not address the problem of whether or not the lowest bid represents the best value for the client (Rankin[35]).

B) Liquidated damages provide some protection for the project client but even these will not fully compensate the client for contractor defaults. Awarding a contract on the basis of lowest price with the provision of a bond and liquidated damages provides no protection to the client if there are subsequent delays or other unsatisfactory performances leading to additional costs.

Both of these methods fail to address the most important issue. It is important that a project client is interested not only in the financial health of a potential contractor, but also in the contractor's capacity to successfully complete the project (Russell[34]).

In order to overcome the problems associated with selection of contractors using lowest bid various alternative strategies have been introduced.

2.4.4 Alternative Bidding Strategies

Each of these systems use competitive tendering but either have a structure which does not evaluate the bid on price alone or explicitly do not accept the lowest bid.

2.4.4.1 Non Lowest Bid Systems

A few countries, such as Italy, Peru and Portugal, are using a system in which the successful bidder is not the lowest one (Herbsman[39]). The philosophy behind this concept is that the best bid is the most reasonable one, not the highest and not the lowest, but the one closest to some average. There are many variations of this concept. The Peruvian Government bidding system provides an example of one such variation (Henriod[40]). The procedures are as follows:-

1. When three or more bids have been received:

   a. The average of all bids will be calculated.

   b. All bids that are greater than 10% above this average or less than 10% below will be eliminated.

   c. The average of the remaining bids will then be calculated.

d. The contract will be awarded to the bid that is immediately below the second average.

2. If fewer than three bids are received, the process may be cancelled and the contract awarded to the lowest bidder.

Another variation is bracketing. In this system only bids that lie within a certain range above and below the estimated cost are considered. The contract is awarded to the lowest bidder within this range.

Countries such as France and Portugal try to disqualify what they consider to be abnormally low bids (Henriod[40]). They define abnormal as "any bid whose price appears abnormally low and consequently may cause implementation problems." This, however, appears to be a very subjective approach and may eliminate valid bids and be open to legal challenge. In addition, this method may eliminate bidders who have devised a more efficient and cheaper method of construction.

2.4.4.2 A + B Bidding

The USA, the Federal Highways Administration has adopted a bidding method called A+B or bidding on cost/time which is used principally for road construction (Herbsman[41]). In this system the first part, called the A part is a conventional bid price by the contractor and is used as the base for cost reimbursement for constructing the project. Part B is the time period in which the contractor states the project will be constructed. The client of the project determines the cost of a time unit to the client, which, in the case of roads, is road user cost. The bids are evaluated by using the following formula:-

$$\text{Project price} = \text{Bid price} + \text{Project duration} \times \text{Owner time cost}$$

The bidder offering the lowest price after this calculation is awarded the contract. If the contractor is late finishing the project then the client is reimbursed at the client cost rate, if the project is finished early the contractor receives an incentive. A similar system is in use by the Highways Agency in the UK which is called lane rental. In this system the contractor pays rent to the Highways Agency for the road that is being worked on. The contractor thus has an incentive to complete the work in the minimum time.

Harp[42] investigated the legal aspects of the A + B method and concluded that it is within the competitive bidding concept and hence suitable for use within the public sector.

2.4.4.3 Multiple Parameter Bidding

An extension of this system has been used in the USA and Singapore (Herbsman[39]). In this system, the additional parameters of quality and safety are added, together with their relative weightings. This information is provided to potential bidders for a project including the way in which the parameters are to be quantified as shown in Table 2.3.

Number	Description	Weight (%)	Quantification Method
1	Cost	60	Actual cost value
2	Time	20	£s/calendar day
3	Quality	15	Past performance
4	Safety	5	Historical accident records

Table 2.3 Bid Parameters

The most complex and difficult parameter to quantify is quality. Quality in this context is not quality of design but solely quality of construction. There are essentially two approaches to the problem: past performance and future performance.

The past performance method relies on using subjective opinions to evaluate past performance on some measurement scale. The details of the evaluation process vary in different organisations. In Florida, the Department of Transportation uses the resident engineer as an evaluator. A better quantification method for past quality performance can be based on past test results, such as tolerance, number of defects and durability. In this way the evaluation will be less subjective. The Construction Quality Assessment System (CONQUAS) now in use by the Construction Industry Development Board in Singapore provides such a method. The CONQUAS system consists of a structured programme for inspecting, measuring and recording the quality performance of contractors. Under this system, contractors are assigned a quality performance score on past projects. A contractor's quality record becomes an essential part of the contractor's performance record. For public projects, contractors with superior quality scores are given a pricing advantage on competitive bids.

The future performance method relies on contractors bidding on quality in the same way that they bid on cost and time (Yarbrough[43]). In this method the contractor will bid on the quality of various parameters such as tolerance. This system has the merit that it is completely non-subjective. This approach is also used by BP in the petrochemical industry.

2.5 Adversity in Construction

The fierce competition generated by competitive bidding based on lowest price, as described above, has led to contractors bidding as low as possible to obtain work, but looking to contractual aspects of the work to obtain additional payment. Pursuing these objectives leads to adversity. The level of adversity in the construction industry is reflected in the anecdote that by the 1980s, the two main products of heavy construction were claims seminars and new attorneys firms specialising in construction litigation (Lazar[8]). In the UK in 1997 the top ten law firms specialising in construction litigation made higher profits than the top ten construction companies but with less than 0.1% of the turnover (Brown et al[12]).

2.5.1 The Roots of Adversity

There is a tendency for clients and contractors to assume an adversarial posture with each other as a result of the conflict between clients' costs and contractors' profits. This is essentially a no win situation since one party's gain is another party's loss (Larson[44]). This dynamic is further complicated since it permeates the supply chain between contractor and sub-contractor and contractor and supplier.

Designers and contractors are often adversarial, inefficient and resistant to innovation (Tarricone[45]). Consensus estimates that 30% of the cost of a project can be attributed to failures in the design - construct - manage process (Brown[46]). A significant proportion of these failures can be attributed to incongruent goals and the consequent divergence of the various organisations participating in a construction project (Nam[10]). This situation has been named divergence and is at odds with the convergence of objectives needed for a successful project.

Management of the trade-off between the goals of cost, quality and schedule has been one of the central concerns of project management (Puddicombe[47]). Research undertaken by Puddicombe[47] in the USA showed that these goals were ranked similarly by architects and contractors as shown in Table 2.4.

Goals	**Architect's Weighting**	**Contractor's Weighting**
Quality	0.54	0.49
Cost	0.27	0.30
Schedule	0.19	0.21

Table 2.4 Ranking of Goals (Puddicombe[47])

Similar research undertaken in the UK by the author for the Construction Industry Research and Innovation Strategy Panel (CRISP) casts doubt on these findings (CRISP[48]). Contractors were shown to respond to the survey by providing results that they thought would present themselves in the most favourable light and not how they really ranked these three goals. It was found that contractors would consistently inform clients that their principal goal was maximising quality in order to be entered on tendering lists, whilst admitting to the author that their real objective was to minimise cost.

Sanvido[49] extended these goals to incorporate specific success criteria for clients, designers and contractors. These are as follows:-

- Meeting the schedule
- Meeting contractor's profit goal
- Meeting sub-contractor's profit goal
- Cost savings to client
- Meeting quality specifications
- No claims by contractor
- No claims by client
- Safety

- Minimal surprises

Differing prioritisation of cost, quality and schedule as well as non-congruent success criteria will cause conflict as to the definitions of a successful project. This can lay the foundations for conflicting courses of action and adversity between the project participants. Puddicombe[47] showed that designers and constructors have different goals and success criteria for a project as shown in Table 2.5.

Success Criteria	Architect's Rankings	Contractor's Rankings
Meeting quality specifications	1	2
Meeting schedule	2	1
Minimal surprises	3	8
No claims by client	4	6
Safety	5	4
No claims by contractor	6	7
Cost savings for client	7	5
Meeting contractor's profit goal	8	3
Meeting sub-contractor's profit goal	9	9

Table 2.5 Success Criteria Rankings (Puddicombe[47])

This table shows that the only objective that both architects and contractors agree on is that the sub-contractor's goals are bottom of the list. This differing prioritisation of objectives lays the foundation for conflict between the participants of a construction project.

2.5.2 Conflict Due to People

Investigation of construction projects in the UK show that the occurrence and effect of dysfunctional conflicts in projects remain a cause for concern despite changes in project management organisational design (Gardiner[50]). Conflicts in construction projects all too often persist or remain hidden until a large proportion of the budget has been expended, by which time the client must either accept that the end result is not what had been hoped for or engage in an expensive, wasteful and time consuming course of corrective action (Abudayyeh[51]).

Gardiner[50] identified a variety of people centred mechanisms as the root cause for the common dysfunctional conflicts found in a construction project Table 2.6.

Cause of Conflict	Summary
Task Interdependency	Conflict resulting from dependency upon others (e.g. for information, feedback or completion of a task)
Organisational differentiation	Conflict due to different groups of people perceiving the same thing differently
Values, interests and objectives	Conflicts arising from misalignment of personal goals with the project goal
Tension	Conflict resulting from unresolved and mounting interpersonal tensions
Personality traits	Conflict escalation due to lack of understanding or inability to manage personalities encountered

Table 2.6 Causes of Organisational Conflict

2.5.2.1 Conflict Due to Task Interdependency

The entire structure of a project organisation is based on multiple social interdependencies that are established at the beginning of a project between the client, users, designers and construction companies. These interdependencies grow in strength and complexity during the detailed design and construction phases. Hundreds and usually thousands of tasks have to be undertaken by different sub-groups to achieve the finished project. When client and project providers are communicating at cross purposes, either due to simple misunderstanding or because of prior assumptions or beliefs or when they are just failing to communicate at all, the seeds are sown for costly conflict at a later stage.

2.5.2.2 Conflict Due to Differentiation

The fact that most construction project organisations are created from functionally separate, geographically separate and, nowadays, often culturally separate organisations, means that high differentiation exists for even quite small project organisations. The result of this high differentiation is that members often regard those members from "the other camp" with a natural wariness and a degree of caution. This has been shown by depicting the same project from the differing viewpoints of the various contributors: the architect, the client, the safety inspector, the engineer etc. (Walker[52]).

2.5.2.3 Conflicts Due to Differing Values, Interests and Objectives

Project organisations are composed of and influenced by a diverse range of people with competing as well as common organisational and personal interests. The interests of the participants and their organisations are based on values that may or may not have direct relevance to the project organisation. The need for a common goal is one of the requirements for successful organisational teams (Adair[53]). Research by Gardiner[50] found a lack of agreement between project participants regarding a common goal. Many contributors were only briefed on their particular input and were not provided with a more holistic picture of the client's goals and expectations. This resulted in misunderstandings and avoidable conflicts.

2.5.2.4 Conflict Due to Tension

In any organisation, anxieties may result from inconsistent demands from the organisation, identity crises or from extra-organisational pressures. Project organisations are more likely to cause higher levels of tension than non-temporary organisations due to the inherently higher degree of uncertainty that accompanies them. Whilst many contributors thrive on stress and derive satisfaction from the pressures of the job, tension can result in a lack of communication leading to conflict between the participants.

2.5.2.5 Conflict Due to Personality Traits

Project organisations are frequently formed from individuals who have been assigned to the project with no consideration of their suitability to the project organisation. Certain personal attributes can increase conflict in an organisation (Walton[54]). Most relationships involve fixed motives, and therefore require a high degree of behavioural flexibility if they are to be managed optimally. Project members who are unable to adopt this flexibility when appropriate may be drawn into and cause an escalation of unnecessary conflict (Gardiner[50]).

2.5.2.6 Ingredients of Conflict

All of these sources of conflict stem essentially from lack of communication. If the environment can be created which is conducive to communication, then many of the conflicts which arise in construction can be avoided. Gardiner[50] recommends developing project organisations as social units. Greater integration between project participants should improve communication and reduce conflict, and focus the minds of the participants on the project.

2.6 Integration Between Designer and Constructor

Many of the problems highlighted in Section 2.5.2 have been attributed to lack of team building. The only numerical evidence to support this is provided by Pocock[23]. In a study of 38 projects in the USA, he showed that the degree of interaction between designer and builder had a beneficial impact on project performance. Pocock[23] defined a numerical value for the degree of interaction (DOI) during the design and construction phases of a project given by:-

$$\mathrm{DOI} = \frac{1}{\mathrm{CD}} \times \sum_{k=1}^{n} P_k \times \left[\sum_{i=1}^{m_k} \left(\frac{t_{ik}}{160} \right) \times D_{ik} \right]$$

where DOI = degree of interaction based on man hours

CD = construction duration in months

n = number of project phases

P_k = weighting factor for each interaction phase for k = 1,2,3.....n

m_k = number of persons participating in the interaction for each phase (k)

t_{ik} = hours/month each person spent in interaction

160 = approximate work hours per month

Pocock[55] found that comparing the results of projects with a DOI of less than 0.4 and projects with a DOI of greater than 0.4 showed a significant difference in project performance as shown in Table 2.7.

Metric	**DOI < 0.4**	**DOI > 0.4**
Cost Growth %	8.89	6.50
Schedule Growth	31.19	11.85
Number of Modifications per million $	8.43	4.26
Modifications Due to Design Deficiencies (%)	29.21	22.55
Average User Satisfaction Rating (1 - 10)	6.83	8.27

Table 2.7 Performance of Projects with DOI score above and below 0.4

These results clearly demonstrate the value in achieving integration between designer and constructor.

An example supporting the above argument is provided by Nam and Tatum[10] in a pier project in the USA.

> The piers original design used 900mm diameter piles in an extremely complex configuration, including many batter piles. A general contractor formed a strategic alliance with a marine dredging company that had a large capacity crane. The contractor won the job and submitted a redesign as a value engineering proposal which called for 1400mm diameter piles. This redesign simplified the pile configuration because no batter piles were required.
>
> The designer engaged by the contractor commented on the original design:
>
> *"The original design, which specified a forest of piles at various angles, looked like a nightmare for the contractor. But it was not the original designers fault; it was because of the competitive bidding system that had a built in fault. If I had been asked to design it using a conventional pile I would have produced the same design."*
>
> *"Professionally, the original designer did what was expected under the circumstances, wherein the piles needed to be small enough to attract as many*

contractors as possible. They used 900mm piles as this was the limit of normal contractors' capabilities."

This example clearly demonstrates the need for greater integration between designer and contractor. With no integration between designer and contractor, the designer seeks to benefit the client by maximising contractor competition. The designer usually considers the prevailing construction practices in the design and avoids setting specific methods that may benefit particular contractors.

If this integration process can be extended to involve the client then further improvements in project performance should be possible.

In manufacturing, product and process design are becoming integrated, whereas in construction product design is often completely separated from production process management. Separating the two functions has significant effects on the use and development of construction technology. The low degree of integration between design and production function in the fragmented construction industry appears to be a major factor in limiting the size and rate of innovation (O'Connor[56]).

2.6.1 Consequences of Disintegration

A designer is traditionally selected by the client principally on the basis of professional reputation, although increasingly clients are asking designers to tender for work (Latham[11]). It is still, however, professional reputation that causes them to be invited to tender. The actual construction of a building is performed by a contractor who is usually selected by competitive tendering. Once the contract is awarded on a fixed price basis, the contractor may have incentives to reduce production cost by using innovative construction methods or equipment, but there is little to induce the contractor to improve quality (Nam and Tatum[10]).

The two key players in a construction project are living in different worlds: the designers world of reputation and the contractors world of price competition and cost reduction. This divergence of goals typically leads to a lack of co-operation or even an adversarial relationship between contractor and designer. Although new ideas in design can often be introduced with new materials and new methods of construction, continued co-operation between designer and contractor in the whole process is difficult. This helps make a potentially dynamic industry technologically rigid (Nam and Tatum[10]).

2.6.2 Early Contractor and Designer Integration

The benefits of early integration of designer and contractor to the buildability of a project are generally accepted and clearly demonstrated by the example in Section 2.6.

Constructability input is hindered by the partial understanding of construction requirements by designers, the fragmented project delivery process, contracting practices, diverging goals between design and construction professionals and changes in construction methods and materials (Fischer[57]). Constructability input is needed because of the high technical complexity of today's projects and the ever increasing demands for faster and lower cost delivery of finished projects (Fischer[57]).

Considerable engineering input is needed to back up construction staff on site, because of the fact that the method of construction is generally an assumed feature of the design (Gee[58]). The conflict between design and construction lies between the need to base the design of structures on an assumed method and sequence of construction and the desire, contractually, to leave the contractor as much freedom as possible to determine the preferred method and sequence, thus making the contractor totally responsible for all aspects of construction.

Designers are often only partially knowledgeable about and sometimes not aware of the construction methods chosen by contractors. Therefore, they do not consider the impacts of construction restraints on design in a systematic way (Fischer[57]).

A constructability knowledge base provides the opportunity for the design of a more constructable project. Integration of contractors in the design process would generate this knowledge base and enable designers to become more knowledgeable team members. There is a need for constructability knowledge that provides designers with the right knowledge at the right time (Fischer[57]).

Fisher provides an example of a bridge in the USA being redesigned with the contractor's direct input to take advantage of more efficient construction methods. This resulted in significantly lower costs than the original design. Clearly, had the contractor been involved at the start of the design process much wasted design effort, time and money would have been avoided.

The improved constructability achieved by involving the contractor during the design phase of a project is shown in the study of the Hurst Spit stabilisation project (Brown and Riley[5]). Early involvement of the contractor in this project led to improved constructability resulting in both schedule and cost reduction. In addition, this project demonstrated that co-operative working can take place extremely effectively in the public sector.

2.6.3 Sub-contractor and Supplier Integration

The integration process provides benefits when extended to include sub-contractors and suppliers. This is shown by a study of the construction of a control building for British Gas (Baird[59]) and a study of the stabilisation of Hurst Spit in Hampshire (Brown and Riley[5]), as described in chapter 3. Both of these projects were completed successfully by involving suppliers and sub-contractors in the decision making processes.

The British Gas project involved daily meetings between designers, contractors, sub-contractors and suppliers. The co-operation between all of these parties was essential to delivering a complex project to satisfactory completion on time (Baird[59]).

At Hurst Spit, site meetings were held weekly and involved all parties to the contract. These meeting not only served to progress the project but also provided a forum for team building, thus preventing the problems detailed in Section 2.5.2.

These two examples demonstrate the importance of integrating suppliers and sub-contractors into the project team.

2.7 Strategies for Integration

Planning, design, procurement, construction, operation, maintenance and reuse or disposal are all phases in what should be a continuous process in the delivery of a construction project. Nevertheless, clients, designers, consultant, contractors and sub-contractors have isolated these into separate processes. Each have their own project objectives and their own criteria for measuring success (Pocock[23]). Some criteria, however, are common to all parties, and include: delivery on time; delivery on budget; satisfying profit or cost goals; delivery without claims. The criteria which are not common, such as adoption of particular construction methods or specification of unworkable standards of workmanship, can lead to divergence and conflict.

A study of 16 successful projects (Sanvido[49]) identified four critical success factors:-

1. A cohesive team to plan, design and construct the project
2. Contracts that encourage team behaviour and allocate risk fairly
3. Experience in all project phases
4. Designability, constructability and operability information from and available to the project team in a timely manner

These four factors will only be achieved through integration of all the participants in a construction project. Four major means of achieving this essential construction integration have been identified as (Nam and Tatum[10]):-

1. Contractual
2. Organisational
3. Information
4. Non-contractual

Pocock[23] suggests that there are three alternative strategies by which to do this:-

1. Use of partnering
2. Use of design and build
3. Focus on constructability

Each of these approaches helps improve integration in a different way. Partnering attempts to change the nature of the often adversarial relationship between clients, contractors, consultants, architects and other team members by getting them to commit to common objectives, formalising improved communications and preventing disputes. Design and build combines the contractor, consultant and architect into one organisation. This environment enables communication between the participants to begin early and become routine throughout the project. However, design and build still does not integrate the client into the project delivery process. The authors experience in two major projects of this type showed that the client's expectations were not met by this form of contract. Constructability can take a number of forms, but principally it aims to get construction knowledge and experience into the early stages of planning and design. The same disadvantage exists with this strategy as with design and build; the client is not integrated into the project delivery process. In addition both constructability and design and build do not integrate the whole supply chain in the project delivery process and there is no culture change to prevent adversity between the client and the project providers. The only contract strategy that should encourage a culture change is partnering.

2.8 Partnering

Larson[6] defines partnering as :-

"The creation of a special relationship between contracting parties in the design/construction industry. This relationship encourages the parties to change their traditional adversarial relationships to a more co-operative team based approach, which promotes the achievement of mutually beneficial goals, including the prevention of major disputes."

Hancher[60] qualifies this further by defining partnering as follows:-

"A long term commitment between two or more organisations for the purpose of achieving specific business objectives by maximising the effectiveness of each participant's resources. The relationship is based upon trust, dedication to common goals and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost effectiveness, increased opportunity for innovation and the continuous improvement of quality products and services."

2.9 Partnering Structure

The advantages of working together have been strongly promoted by Latham[11]. Many clients are now users of partnering arrangements, but this is primarily for building work rather that civil engineering. It is more feasible to develop long term relationships in this sector of repetitive work loads but considerably more difficult for single one-off projects that predominate in the civil engineering sector. The earlier NEDO report[68] "Partnering: Contracting Without Conflict" also provides a good basis for partnering but again this does not support single one-off projects.

Hellard[67] investigated partnering on a world-wide basis and suggested that partnering is the master key that will unlock the techniques and principals of total quality management (TQM) to improve customer satisfaction. He highlighted some of the problems of partnering, including the danger of no true commitment, those pre-conditioned to adversity, top management paying lip service, the myopic thinking of some to win every battle every day, not bringing all the key players in at an early stage, skimping the early activities or the workshops, culture change not being easy and the use of old standard approaches.

Weston and Gibson[9] defined partnering as a long term commitment based on trust, dedication to common goals and an understanding of each other's individual expectations and values. Weston and Gibson[9] studied 139 contracts with the US Army Corps of Engineers, of which 39 were partnered and 100 of which were not. They show clearly partnering producing significant improvements for all parties to the project.

Partnering projects of all sizes was reported by Bates[61], who suggested the principals should include shared goals arrived at through consensus, mutual trust and respect, new attitudes and behaviour, new means of communication and commitment from top to bottom. Weston and Gibson's[9] view is reinforced by Larson[6], who states that "Whether the contract is awarded on a competitive basis or not, does not appear to affect the success of partnering efforts and is not a serious impediment to success". Schmader and Gibson[65] carried out a major study of over 200 contracts awarded by the US Naval Facilities Engineering Command (NVAFAC) and again the results reinforce the general advantages of partnering. The paper by Rankin et al[35] confirms that pre-qualification remains a key mechanism and this should provide an initial source of variables for any partnering selection process.

Although long term partnering is likely to produce the largest benefits there are a considerable number of projects where this approach is not possible. This is particularly true of either "one-off" civil engineering contracts or where the client is a public body. Although recent Government legislation has led to a large reduction in the amount of Government funded work from about 90% to about 60 % (Survey of Civil Engineering Workload Mix

1991/92, FCEC) the figures are still large. The new enlarged private sector is more able to adopt new procurement methods and contract strategies and hence take advantage of the potential savings from partnering, but probity in the public sector means that they have considerably less freedom to do this. EC law can also prohibit long term partnering. Thus a very large amount of construction work will still be awarded by competition. Latham[11] does little to address this problem.

A key document from The Royal Academy of Engineering, A Statement on the Construction Industry[62] urges the construction industry to address several factors including the following.

- Focus on customer satisfaction - it cannot be assumed they will know precisely what is wanted at the outset
- Attention to process as well as to product - research must focus on user friendly guides for clients
- Meaningful involvement of the client requires mutual co-operation, recognition of objectives, willingness to be open and free agreement to share risks and rewards to produce a successful project
- Alignment to a common goal to create a win-win environment.

2.9.1 Benefits of Partnering

Partnering has been in use in the manufacturing industry for some time with significant benefits (Womack[63]). Partnering centres on team building, conflict management, trust and mutual goal and objective development between the contracting parties (Wilson[64]). A study of the Corps of Engineers in the USA reveals that partnering projects have less cost and schedule growth, fewer claims and change orders and more value engineering (Weston[9]). Weston proposed that partnering does not require legally binding contracts but does require formal agreements. A study of 280 projects in the USA (Larson[6]) showed that for six project performance criteria partnering projects outperformed all others as shown in Table 2.8.

Client-Contractor relationship	Sample size	Meeting schedule	Controlling cost	Technical performance	Customer needs	Avoiding litigation	Satisfaction of participants
Adversarial	78	2.19	1.99	3.20	2.95	2.47	1.91
Guarded adversarial	66	2.86	2.95	3.75	3.48	3.56	2.62
Informal partners	77	3.92	3.50	4.05	3.90	4.46	4.28
Partners	59	4.41	4.17	4.55	4.57	4.80	4.28

Table 2.8 Results for Success Criteria by Client-Contractor Relationship

A further study of over 200 contracts awarded by the US Naval Facilities Command (NVAFAC) (Schmader[65]) reinforces the findings of Weston and Gibson[9] and Larson[6] and demonstrates the advantages of partnering.

However, in each of these studies partnering was limited to client and contractor. The full benefit of partnering can only occur when all parties to a construction project integrate in a partnering way (Sillars[66]).

Hellard[67] investigated partnering worldwide and suggested that partnering is the master key that will unlock the techniques and principals of TQM (Total Quality Management) to create customer satisfaction.

Rankin[35] recommends, however, that prequalification remains a key mechanism for selection of potential partners.

The advantages of working together have been strongly promoted by Latham[11]. Many clients in the UK are already users of partnering arrangements including BAA, Sainsbury, Marks and Spencer and Stanhope. These companies have the capacity to enter into long term partnering arrangements because of their continuous requirements for new construction. An earlier report by NEDO[68] also provides sound reasons for partnering but does not assist in providing guidance for one off projects. A report by the University of Reading[69] suggests that project specific partnering can create savings of between 2 and 10% at a cost not exceeding 1%. This is at odds with the study by Brown and Riley[5] which showed cost savings of 30%. The only published documentation supporting project specific partnering is report from the European Construction Institute[70] and proposes a methodology for partnering in the public sector.

The petrochemical industry has established its own initiative, Cost Reduction in the New Era (CRINE), which encourages a more open partnering way of working for one off projects. To date only large projects have been addressed but the success has been considerable. Tuft[71] states that the success of CRINE has been so great that the UK needs to explain to the rest of the world what had been done, otherwise the results would not be believed.

The approach to CRINE adopted by BP is reported by Cross[72]. Six suppliers were invited to a one week long interactive workshop. The six companies were asked to form alliances of at least two and no more than five companies and submit proposals for a project with challenging cost and performance targets. At the end of the week five different proposals were submitted representing a range of alliances.

Alliances in the petrochemical industry are offered a share in any improvement made on project performance targets and penalised for not achieving them. The share is calculated by a pre agreed formula.

Partnering centres on team building, conflict management, trust and mutual goal and objective development between the contracting parties(Wilson[64]). In the USA this is achieved through workshops with an outside facilitator and this approach is gaining popularity in the UK. Partnering represents a significant divergence from past and current practice. Culture changes of this magnitude require comprehensive and strategic planning. Project partnering agreements are single events and do not provide the cultural change mechanisms required to initialise the partnering process. Appropriate change must occur at the core of organisational design and functioning(Blake[73]).

Rethinking Construction (Egan[2]) compared the construction industry in the UK with manufacturing. Seven improvement targets were set together with four recommended improvements in the project process and five drivers for change. The Rethinking Construction model, also known as the 5:4:7 model, is shown in Figure 2.1.

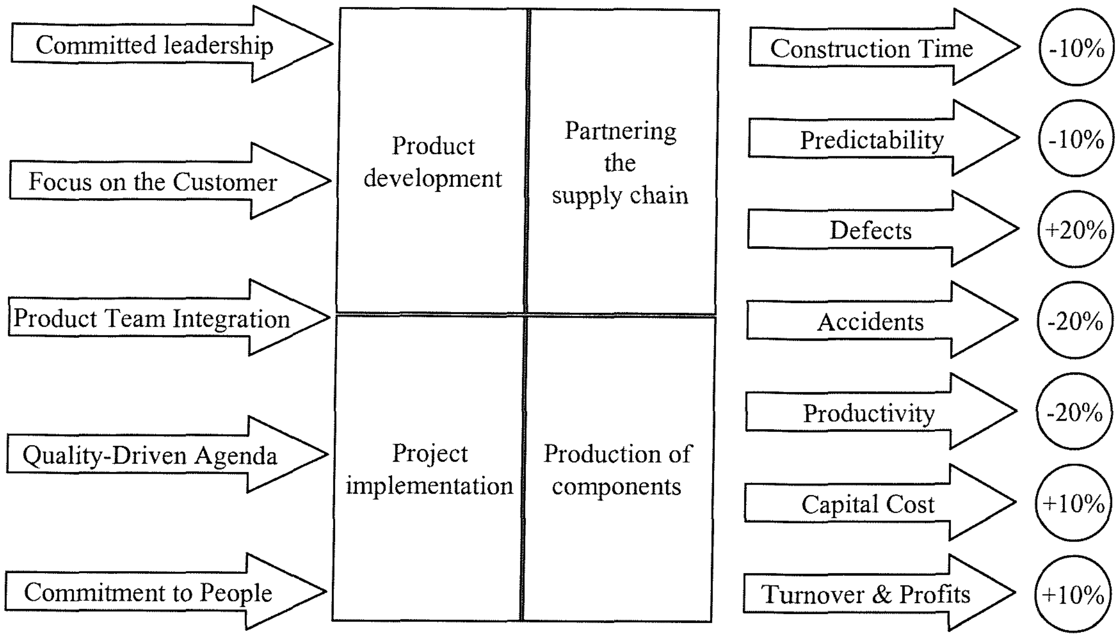

Figure 2.1: 5:4:7 Model

Long term partnering arrangements were recommended for achieving these improvements and key performance indicators (KPIs) proposed as a means of measuring performance.

The Construction Industry Council (CIC[74]) advocated the use of partnering on one off projects and published guidance on how this could be achieved. This was supported by a new form of contract specifically designed for project team partnering (ACA[75]) which uses partnering to refer to one off projects and strategic alliancing to long term arrangements. However, no guidance was available on how to select the designers and contractors to the team until the publication of Selecting the Team (CIC[76]) and many partnering projects failed to achieve the expected outcome.

2.9.2 Partnering for Improved Collaboration

It has been suggested that construction performance, particularly with regard to cost, time quality and buildability, can be improved if the project participants adopt more collaborative ways of working (Bennett et al[77]). In fact, Bennett and Jayes[78] suggest that performance can be dramatically improved with more collaborative ways of working, and present a number of case studies to illustrate how partnering can develop to yield these benefits. However, these benefits only accrue after a period of evolution giving rise to what Bennett and Jayes[78] refer to as the three generations of partnering. This, therefore, implies that the full benefits of partnering will not be realised on one-off projects.

Although partnering has been proposed as the means to improve collaboration, Barlow et al[79] suggest that the term partnering is frequently used to capture a spirit of co-operation that may occur on any type of project. Consequently, considerable effort has been focused on examining the conditions which encourage or inhibit collaboration between clients and contractors (Bennett and Jayes[80]). Various tools and techniques are available to support partnering and foster collaboration, including new forms of contract, alternative pricing formulae, partnering charters and partnering workshops, but Bresnen and Marshall[81] question whether collaboration can be actively engineered by applying these techniques. Bresnen and Marshall[81] also raise the question as to whether trust and collaboration can fully develop in a relationship that may be affected by imbalances in economic power and widely varying economic conditions.

The use of incentives in partnering have been seen as an important way of reinforcing collaboration in the short term and helping to build trust between clients and contractors in the long term (Bresnen and Marshall[82]). These incentive are referred to commonly as 'risk-reward' or 'gainshare-painshare' arrangements (Bennett and Jayes[80]). However, research by Bresnen and Marshall[82] found that incentives were not necessarily a source of motivation to the construction operatives and only impacted at company level. This is at odds with the lessons learnt from other industrial sectors where the need for motivation throughout all levels of the organisation is recognised as essential. Bresnen and Marshall[82] found that in the projects they studied many staff were unaware of any financial incentives and that there was little direct connection between project incentives and the systems for appraisal and reward of individual members of staff. In fact, in one case company policy was to ensure that incentive arrangements were not divulged below management level because of a belief that it would encourage demands for increased wages, bonuses and benefits. The exclusion of construction operatives from the partnering process was also evident in the teambuilding sessions for a number of projects observed by Bresnen and Marshall[83]. They also observed that key team members from designers and subcontractors were rarely involved in teambuilding and that teambuilding sometimes failed to diffuse organisational or professional differences or to integrate those with having a negative attitude. There was however, a view that senior management support was vital in giving a collaborative approach legitimacy and that in the projects studied partnering had been championed at the highest levels. From this study Bresnen and Marshall[83] concluded that there are many potential positive benefits for clients developing more collaborative approaches, not only with regard to key project processes and in particular design-construction integration, but also with regard to hard performance outcomes especially in the areas of time, cost and quality. However, Bresnen and Marshall[84] suggest that there is no one strategy or template for successful partnering and that successful partnering will involve a variety of different mechanisms which may or may not be systematically developed. It also appears unlikely that successful partnering can simply be engineered by formal means or, alternatively, that it simply evolves purely on the basis of informal relationships. Instead, partnering involves a combination of formal and informal processes and any attempt to develop a partnering approach must recognise the potentially complex and dynamic interplay between them.

2.9.3 Limitations of Partnering

In spite of the benefits of partnering espoused previously, as the use of partnering has spread, there have been more reports of mediocre or failed partnering projects (Lazar[8]). Lazar[8] attributes this to failure of the project participants to embrace the cultural change needed for successful partnering. Many companies regard partnering as simply another selection process and on award of contract continue with business as usual with the partnering agreement having no meaning.

Brown and Riley[5] quote the client for the Hurst Spit project as saying: "as soon as you write down a formal partnering agreement you lose the element of trust which drives the whole set-up. If the will is there you don't need the formal arrangement, if the will is not there you won't create it by writing it down".

Friedland[85] suggests that failed partnering projects happen when there has been an inability to distinguish between trust based relationships and reciprocation based relationships. Pahre[86] poses the question; is a partnering relationship always trust based, or can it be held together by a much more fragile bond that mimics trust until the relationship suddenly evaporates?

Lazar[8] identifies two groups of participants from within the construction industry that have used partnering successfully:-

1. Early adopters

2. Those with a pent up demand for a better way to manage projects

Early adopters always want to be first on the bandwagon: they always want to try the latest innovations first. Pent up demand includes managers who have wanted strongly to conduct business between client and contractor as an ethical trust based relationship for some time, but were either prevented from doing so or could not find the right way to start the process. In both instances, the financial success resulting from partnering provided a justification, rather than a primary motivating force for trying partnering.

As the news of successes with partnering spreads, other clients and contractors also want to try it. However, both their motivation and preparedness for partnering are different and the results are likely to be different.

Early adopters who are willing to pay the high price for the risk associated with innovation tend to link with the potential purchasers who are pent up, awaiting the availability of the demanded item, in this case a partnering relationship (Stiglitz[87]). If the pattern holds true, the supply of early adopters and pent up demand for partnering will run down and the percentage of clients and contractors who are attracted primarily by the promise of better economic outcomes will increase. Both their motivation and preparedness for partnering are different and the results are likely to be unsatisfactory.

Lazar[8] proposes that there are four barriers to partnering which can be grouped into one external and three internal categories:-

Intrusions from the outside world (external)

Organisational climate (internal)

Organisational culture (internal)

Organisational structure (internal)

Intrusions from the outside world can be overcome by championing from senior management. Where this is the case both the project and partnering relationship can have extremely successful outcomes (Chakraborti[88]).

The internal barriers arise as a result of the mind set of the organisations involved. Of these the primary barrier is culture. Short term changes to culture frequently arise from radical solutions such as a massive infusion of new personnel or the creation of a new division (Denison[89]).

Organisational climate is subjective and often subject to direct manipulation by people with power and influence. Therefore, executive decisions and policies can affect climate in the short term.

Clients and contractors working together in a co-operative environment with their interaction guided by the mutual goal of successful project completion provides a promising alternative to the industry malaise of excessive claims and litigation. Identifying processes that can defuse disputes before they become job stopping or relationship eroding problems is a tremendous step towards improving contract performance (Lazar[8]).

The greatest limitation of partnering is that it is difficult to utilise in the public sector where there is requirement for some form of competitive tendering process to satisfy probity, and also due to non-available of a continuous work load, although this still accounts for some 66% of construction procurement. Brown and Riley[5] showed that with a culture change, the advantages of partnering can be realised even in the public sector and for one-off projects. Significant improvement in project delivery was achieved with no partnering agreements, but with a true change in culture leading to trust and co-operation.

2.9.4 Value Engineering

Although there are numerous reasons for poor value in construction, the following are most frequently reported (Zimmerman and Hart[90]):

1. Lack of time

2. Lack of information

3. Meaning not clear

4. Misconceptions

5. Temporary circumstances that inadvertently become permanent

6. Habits

7. Attitudes

8. Politics

9. Lack of fee

Contractors influence value with the quality of their workmanship. Their skill in construction and the integrity of their production affects the cost of the facility for many years in the future. The resources and talents of the suppliers and contractors carrying out the work offer the potential for cost savings when effectively integrated into the project (Assaf et al[91]). Unnecessary cost is not a reflection on the abilities of the designer as a professional but a management issue that needs to be addressed.

Value engineering was developed by Lawrence D. Miles after World War II when many of the materials used by industry were in short supply and difficult to obtain. Companies were forced to look for substitute materials and found that in many cases substitute materials were performing as well, if not better than, the original ones. This led many companies to conclude that, in some cases, productivity and quality could be improved by changing materials (Elias[92]).

Although value engineering was first used on manufactured products, it was soon realised that the methodology was just as applicable to the design and service processes as it was to manufactured products.

Value engineering is distinguished from other cost reduction programmes by the use of functional analysis (Elias[92]). By considering the function of a product new alternatives to design, engineering and manufacture may be found to improve efficiency, reduce cost or increase performance. Value engineering has been strongly advocated by Egan[2] as a means of improving construction performance and facilitating the process through closer co-operation brought about by partnering.

2.10 Conclusions

It has been shown that the construction industry makes a significant contribution to the Gross National Product of most industrialised nations. However, in spite of the size of the construction industry, inefficiencies, litigation and cost and schedule overruns have been endemic. This has been attributed to a lack of integration and conflict between the client, designer and contractor for a given project, which ultimately accounts for approximately 30% of project costs. Many of these problems are caused by a lack of common goals and expectations, arising from the necessity to assemble project teams, in a very short time, with no experience of working with each other. The situation is aggravated further by the nature of construction, with its lack of repetition and its need for projects in geographically and culturally different environments. The selection of an appropriate designer and contractor who will embrace the expectations of the client and the project, and having the culture to work together in a non adversarial way is considered to be a key factor that has a direct impact on the success or failure of any construction project. This co-operative method of working is not being achieved with the traditional method of selection by competitive tendering.

To generate an environment for construction without conflict various alternative contract strategies have evolved. Of these, partnering has been strongly promoted. Partnering is a long term commitment between two or more organisations based on trust, with mutually agreed and measurable targets for productivity improvements. Partnering has been reported to have achieved considerable success, but this is based largely on anecdotal evidence, and reports of failed partnering projects are becoming more frequent. These project failures have been attributed to organisations entering into partnering arrangements without having undergone the culture change required to work co-operatively, with trust, for the benefit of the project. Most importantly, partnering as defined cannot operate for single one-off projects or satisfy the need of the public sector for competitive tendering.

The majority of construction projects, particularly in heavy civil engineering, are one off projects, which prevent the client from entering into long term partnering arrangements. Additionally, within the public sector, negotiated contracts and performance improvement incentives would transgress the issues of probity.

The ability for organisations to work co-operatively in the public sector for the benefit of the project has been clearly demonstrated. It has been shown that this is brought about by achieving mutual trust between all the parties to the project, working towards common goals, involving all parties in the decision making process, involving the contractor at the design stage and providing prompt and fair payment of interim and final valuations.

The key problem facing the public sector is how to achieve the benefits of co-operative working without any long term agreements and satisfying the issues of probity. This will only be achieved by adopting a structured pre-selection process that is capable of identifying those organisations that have common goals and that have embraced the culture of working in a co-operative manner without conflict. In addition designers need to be selected that recognise the benefits of involving the contractor in the design stage to improve buildability and enabling this to happen whilst still using competitive tendering.

3. Review of Local Government Procurement Practice

3.1 Introduction

For the purposes of legislation the Government has defined public procurement, of which Local Government procurement is a part, as the process of the acquisition, usually by means of a contractual arrangement after public competition, of goods, services, works, and other supplies by the public service. This process spans the whole life cycle from initial conception and definition of the needs of the public service through to the end of the useful life of an asset or the end of a contract. Both conventionally funded and more innovative types of funded projects (for example PPP/PFI arrangements with the private sector) are included, as are the use of the private sector to deliver services previously delivered directly by the public sector ("contracting out") and in-house consortia bidding in a public procurement process.

3.2 Best Value

In developing a policy on public procurement, the principles that should guide public bodies in carrying out procurement need to be agreed first. The concept of "best value for money" is central to public procurement policy, but it is often misunderstood. Sometimes it appears to be used as reflecting only "effectiveness" or "efficiency". It needs to be understood in a wider, more encompassing sense as summing up the twelve principles outlined below. When a procurement process results in these principles being satisfied to an acceptable extent, it can be considered that the process has resulted in "best value for money". Central Government has recommended, therefore, that "best value for money" should be defined as "the optimum combination of whole life cost and quality (or fitness for purpose) to meet the customer's requirement." This definition allows for the inclusion, as appropriate, of social, economic and environmental goals within the procurement process. Government further recommends that best value for money thus defined should be the primary objective of procurement policy. It also recommends that procurement staff in general should work with audit to establish criteria for and identify methods of evidencing best value for money, as thus defined.

3.3 First Principles for Procurement Policy

The Government recommends that the following twelve principles should be adopted as the basis for any public procurement policy.

1. Transparency: openness and clarity in policy and its delivery.

2. Integrity: no corruption, no collusion with suppliers or others.

3. Competitive supply: normally this will be best achieved by acquiring goods and services by competition unless there are convincing reasons to the contrary.

4. Effectiveness: meeting the commercial, regulatory and socio-economic goals of Government in a balanced manner appropriate to the requirement.

5. Efficiency: ensuring that procurement processes are carried out as cost effectively as possible.

6. Fair-dealing: treating suppliers fairly and without unfair discrimination, including protection of confidentiality where required, and without imposing unnecessary burdens or constraints on suppliers and potential suppliers.

7. Responsiveness: meeting the aspirations, expectations and needs of the community served by the procurement.

8. Informed decision-making: basing decisions on accurate information and monitoring to see that requirements are being met.

9. Consistency: suppliers should, all other things being equal, be able to expect the same general procurement policy across the whole public sector.

10. Legality: conformity to EC and other legal requirements.

11. Integration: joined-up Government, meaning that procurement policy should pay due regard to other local economic and social policies, rather than cut across them.

12. Accountability: effective mechanisms must be in place in order to enable Accounting Officers and their equivalents in other bodies to discharge their personal responsibility on issues of procurement risk and expenditure.

3.4 Legislation

UK Local Government procurement is regulated by both domestic and European legislation. The European market is covered by a number of Directives, secondary European legislation, which has to be implemented by each of the 15 Member States into their own legislative framework, and give detailed instructions on tendering procedures. Statutory Instruments implement the UK regulations. The level of legislation fully in force varies across the member states.

The Directives set out the principles for Works, Supplies, Services and Utilities contracts which are above specified financial threshold levels. The levels are much lower for supplies and services than for works. The rules specify procedures for advertising and awarding depending on the type of contract which contracting authorities must comply with.

Contracts above the threshold levels affected by the EC procurement rules must be advertised in the Supplement to the Official Journal of the European Communities (OJEC) before being notified elsewhere.

The table below shows the current EU Procurement Directives and the corresponding Statutory Instruments which implement the legislation in the UK, along with amending legislation.

EU Procurement Directive	UK Implementation
The Works Directive 93/97/EC as amended by Directive 97/52/EC	SI 1991 No 2680 Public Works Contracts Regulation 1991 as amended by: • Utilities Supply and Works Contracts Regulations 1992 (SI No. 3279) • Public Supply Contracts Regulations 1995 (SI No. 201) • Utilities Contracts Regulations 1996 (SI No, 2009)
The Supplies Directive 93/36/EC as amended by Directive 97/52/EC	SI 1995 No. 201 Public Supply Contracts Regulations 1995 as amended by: • Utilities Contracts Regulations 1996 (SI No. 2911) • Public Contracts (Works, Services and Supply (Amendment) Regulations 2000 92/50/EC as amended by Directive 97/52/EC
The Services Directive 92/50/EC as amended by Directive 97/52/EC	SI 1993 No. 3228 Public Services Contracts Regulations 1993 • Public Supply Contracts Regulations 1995 (SI No. 201) • Utilities Contracts Regulations 1996 (SI No. 2911) • Public Contracts (Works, Services and Supply (Amendment) Regulations 2000 (SI No, 2009)
The Utilities Directive 93/38/EC as amended by Directive 98/4/EC	SI 1996 No. 2911 Utilities Contracts Regulations as amended by: • Utilities Contracts (Amendment) Regulations 2001 (SI No. 2418)
The Public Sector Remedies Directive 89/665/EC as amended by Directive 97/52/EC	SI 1991 No 2680 Public Works Contracts Regulation 1991 SI 1995 No. 201 Public Supply Contracts Regulations 1995 SI 1993 No. 3228 Public Services Contracts Regulations 1993 as amended by: • Public Contracts (Works, Services and Supply (Amendment) Regulations 2000 (SI No. 2009)
The Utilities Remedies Directive 92/13/EC	Utilities Contracts Regulations 1996 (SI No. 2911)

The Directives are intended to ensure that where public funds are to be used for the purchase of supplies (goods), services or building works, there will be full, fair and transparent competition throughout the EU and beyond. All Contracting Authorities are legally bound to comply with these Regulations. Where a contract covers a combination of goods and services then the Directive for whichever element has the higher value applies to the whole contract. Even in cases where the EU Procurement rules do not require competition, the Contracting Authority must comply with EU Treaty obligations, in particular not to discriminate against suppliers or contractors on the grounds of their nationality or the Member State in which they are based.

3.5 Enforcement

The principal means of enforcement for a breach of the Regulations are:

- Action by suppliers or contractors against individual purchasers in the High Court (England, Wales and Northern Ireland) or in the Court of Session (Scotland).
- Action by the Commission against the member state in the European Court of justice.
- In either event, the result may be:
    - A suspension of an incomplete contract award procedure.
    - The setting aside of a decision in an incomplete contract award procedure.
    - An award of damages by the High Court/ Court of Session where a contract has already been entered into.

3.6 Action Required by European Law

The means laid down in the Directive to ensure full and fair competition is to place a Notice concerning tenders in the Supplement to the Official journal of the European Communities. There are three kinds of Notice:

1. Annual Prior Information Notice (PIN) also known as a Prior Indicative Notice. This is a notice which should be placed soon after the beginning of the Local Authority's financial year containing advance information of all contracts for goods or Part A services over £560,000 and all works contracts over the threshold which are likely to be let during the year.

2. Contract Notices. These are placed for each contract to which the Directives apply. In essence they advertise the fact that tenders will be sought and ask potential suppliers to express their interest.

3. Contract Award Notices. These must be placed after the award of every contract which has been subject to the Directives. Again there is a set format and UPS will provide all necessary assistance. Local Authority's are required to check all notices for compliance and record them so that they have the necessary information to enable them to complete a Statistical return which has to be sent to HM Treasury for onward transmission to the Commission. This occurs every two years at present but is likely to be an annual requirement in the near future.

3.7 Alternative Procedures

The Contract Notice must make it clear which of three different kinds of Procedure will be followed for the tendering process. These are:

1. Open Procedure, under which all potential suppliers who express an interest must be invited to tender.

2. Restricted Procedure, under which the Contracting Authority may restrict the number of interested suppliers to which it sends Invitations to Tender. There must, however, be genuine competition of no less than five participants and no discrimination between suppliers on grounds of Nationality or Member State.

3. Negotiated Procedure, under which the Contracting Authority may negotiate the terms of the contract with one or more potential suppliers selected by them. There are very strict rules concerning the use of the Negotiated Procedure and extremely few contracts qualify. Moreover, every time this Procedure is applied, a full report justifying its use must be prepared for examination by the EU Commissioners.

3.8 Time Requirements

The Directives lay down minimum time requirements to allow potential suppliers to express their interest and put in their tenders. The time limits are basically the same for both the Supplies and Services Directives but vary according to the procedure used. The Open Procedure requires at least 52 days between dispatch of the Notice and receipt of tenders; the Restricted Procedure requires a minimum period of 37 days for receipt of responses from companies and a further period of 40 days minimum for receipt of tenders from the selected companies.

There is also an upper limit of 48 days for the time allowed for publication of a Contract Award Notice under any of the three procedures. In situations where, because of the kind of contract, tenderers are given the opportunity to inspect the premises, the time limit for submission of tenders must be extended to allow for such inspection.

3.9 Press Advertisements

The Directives forbid the placing of a contract advertisement in the press or similar publications before the date on which the Notice is dispatched to the Official journal. If an advertisement is placed elsewhere it must not contain any information which was not included in the OJEC. All enquiries and expressions of interest received from prospective tenders, no matter how they learn of the contract, must be treated in the same way and in accordance with the Directive Rules.

3.10 Aggregation Of Requirements

In determining whether the threshold has been reached the rules require aggregation of the value of separate contracts for meeting a single requirement and, in certain circumstances, for the aggregation of a series of contracts or a renewable contract for supplies of the same type. Conversely, single requirements must not be broken down for the purpose of taking the value below the threshold.

3.11 Specification Of Requirements

The Directives set out detailed criteria for the technical specification of requirements. In general, these must refer wherever possible to relevant European specifications and must avoid references which would have the effect of favouring or eliminating particular suppliers, contractors, products or services. This forbids, for example, the use of brand names unless absolutely essential and even in these circumstances, the description must be accompanied by the term or "equivalent".

3.12 Selection Of Tenders

The Directives set out detailed criteria for the selection or rejection of tenders based on the evidence of their economic and financial standing, their technical capacity and, for services, their ability.

3.13 Criteria For The Award Of Contracts

Contracts may be awarded on the basis of either lowest price or the most economically advantageous offer. Various criteria may be applied to determine which offer is the most economically advantageous including price, delivery, technical merit, technical support, aesthetic and functional characteristics and operating costs. The criteria must be given in the invitation to tender and should also be given in the contract notice, preferably in descending order of importance.

3.14 Design Contests

Design Contests are procedures for obtaining plans or designs, which involve, a jury which is autonomous in making its decisions and offers prizes or payments which may lead to the award of a Public Services contract. The rules apply to contests where the value of prizes or payments equals or exceeds £150K.

The intention to hold a design contest has to be advertised in the Official Journal. The number of participants may be restricted but they must be selected on the basis of clear and non-discriminatory criteria. Where the rules of the contest require a services contract to be awarded to the successful contestant, the Negotiated Procedure may be used without a further notice being issued, providing all the successful contestants are invited to negotiate the contract.

3.15 Current Thresholds

	Supplies	Services	Works
Contracts	£154,477 (SDR 200,000) (Euro 249,681)	£154,477 (SDR 200,000) (Euro 249,681)	£3,861,9323 (SDR 5,000,000) (Euro 6,242,028)o
Indicative Notices	£464,024 (Euro 750,000)	£464,024 (Euro 750,000)	£3,093,491 (Euro 5,000,000)
Small Lots	£123,740 (Euro 200,000)	£49,496 (Euro 80,000)	£618.698 (Euro 1,000,000)
For subsidised works contracts under regulation 23 of the Public Works Contracts Regulations 1991 the threshold is £3,093,491 (Euro 5,000,000)			

3.16 Contract Standing Orders

Contract Standing Orders are made for the purpose of securing competition and regulating the awarding of contracts in accordance with section 135 of the Local Government Act 1972 They aim to promote good purchasing practice, public accountability and deter corruption. Following the rules set out in the standing orders is the best defence against allegations that a purchase has been made incorrectly or fraudulently. Local Government officers or employees responsible for purchasing or disposal must comply with Contract Standing Orders. These Standing Orders lay down minimum requirements, therefore a more thorough procedure may be appropriate for a particular contract.

By law, Local Authorities must make standing orders with respect to contracts for the supply of goods or materials or for the execution of works which provide for:

1. Securing competition

2. Regulating the manner in which tenders are invited.

Contract Standing Orders form part of a Local Authorities Constitution. Compliance by all staff is therefore mandatory and contravention is a serious matter. Contract Standing Orders set out the administrative procedure that must be followed in seeking tenders and letting contracts for the supply of services and work

Contract Standing Orders have three main purposes:

1. To ensure that the Local Authority obtains Best Value in the way it spends money, so that in turn it may offer Best Value services to the public

2. To comply with the laws that govern the spending of public money; and

3. To protect individuals from undue criticism or allegation of wrongdoing.

Local Authorities are required to monitor the performance of Contract Standing Orders and amend them if necessary to ensure compliance with new or changing legislation.

3.17 Conclusions

Local Government procurement is regulated by extensive domestic and European legislation which is implemented through the use of standing orders. Because of the protection afforded by Contract Standing Orders against breach of law any new procurement method adopted has to comply with existing Contract Standing Orders. Whilst domestic legislation requires Local Authorities to procure on the basis of best value there is considerable reluctance to procure on any basis other than lowest cost to ensure compliance with probity. In addition, whilst the Forton Lake Millennium Bridge Project which was central to this research, was below the European threshold value for design services and construction works the procurement method adopted had to be capable of being used for projects which exceeded the threshold value. Therefore, the whole of the research was constrained by domestic and European legislation and Gosport Borough Council's existing standing orders. However, although Contract Standing Orders are Local Authority specific they all address the same legislation which results in the procurement method pioneered with Gosport Borough Council being transferable to any other Contracting Authority.

4. Investigation of a High Performing Project

4.1 Introduction

The first stage in the research was to identify and analyse a project which had performed better than expected. The criteria used for selecting the project were that it was a one off project offering no possibility of further work and that it was procured by a public sector organisation. The project selected met these criteria but in addition started with the most adversarial conditions and yet was still performing better than would be expected in a typical project. The project was over six months late in starting through central Government delays and as a result the tender validity period had expired. The project therefore had all the trappings of a claims and litigation focused project. This project was constructed prior to the publication of Rethinking Construction and therefore comparisons are made with the prevailing improvement targets of the time.

4.2 The Hurst Spit Project

Hurst Spit is a shingle spit formed at the end of the Pleistocene period and located at the eastern end of Christchurch bay on the south coast of England (Figure 4.1). It is approximately 2km long and at its seaward end reaches a point approximately 1250m from the Isle of Wight. The spit now protects the coastal areas of the Solent to the east, both on the mainland and the Isle of Wight from Atlantic storms. The Spit also protects the salt marshes in its lee, a Site of Special Scientific Interest.

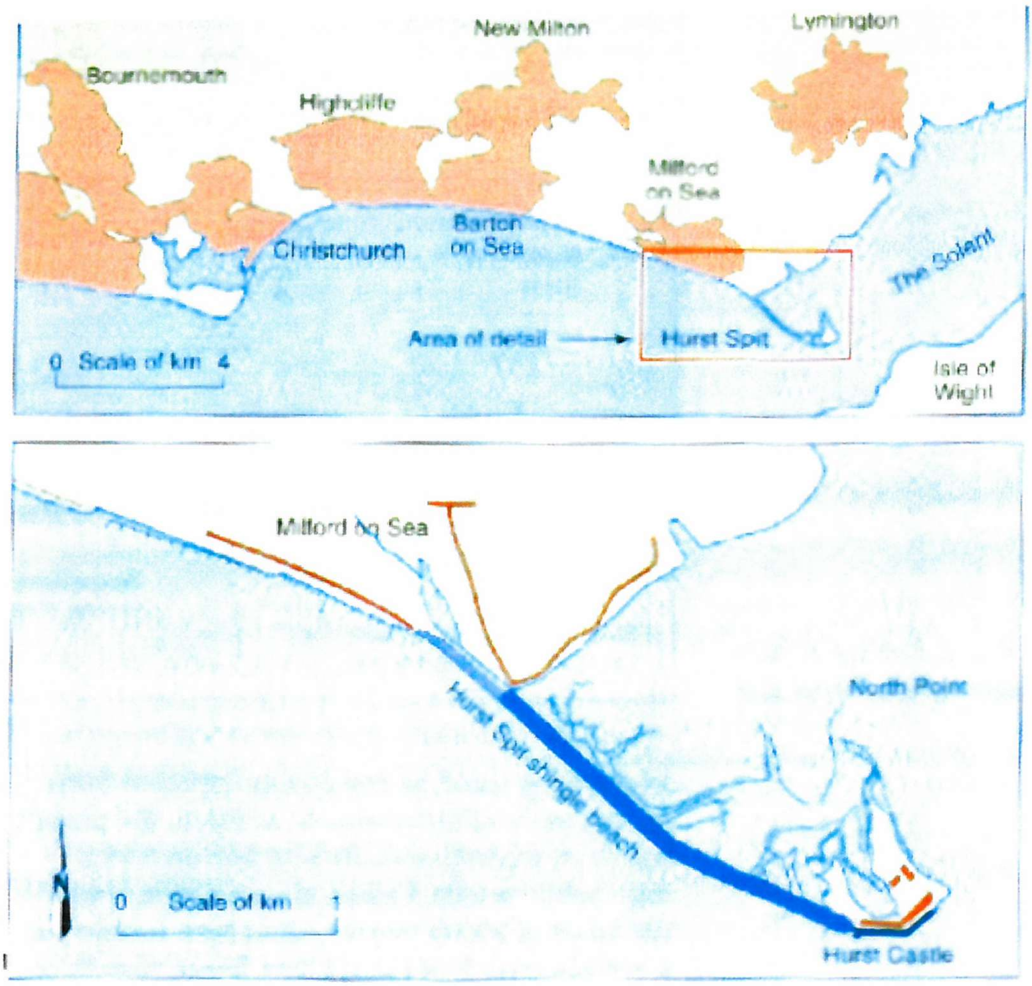

Figure 4.1: Location and Plan of Hurst Spit

Historically the spit was nourished by littoral drift from the west. However, as early as 1609 repairs became necessary due to storm damage. Coastal protection works to its west, which began some 100 years ago, severely reduced the shingle supply for re-nourishment of the spit. In 1974 New Forest District Council took over responsibility for coastal protection from the Borough of Lymington and in 1981 started a programme of annual re-nourishment.

Due to the threat of extensive damage to property and the salt marshes that would occur as a result of the spit being breached, a more permanent stabilisation scheme was developed (Figure 4.2).

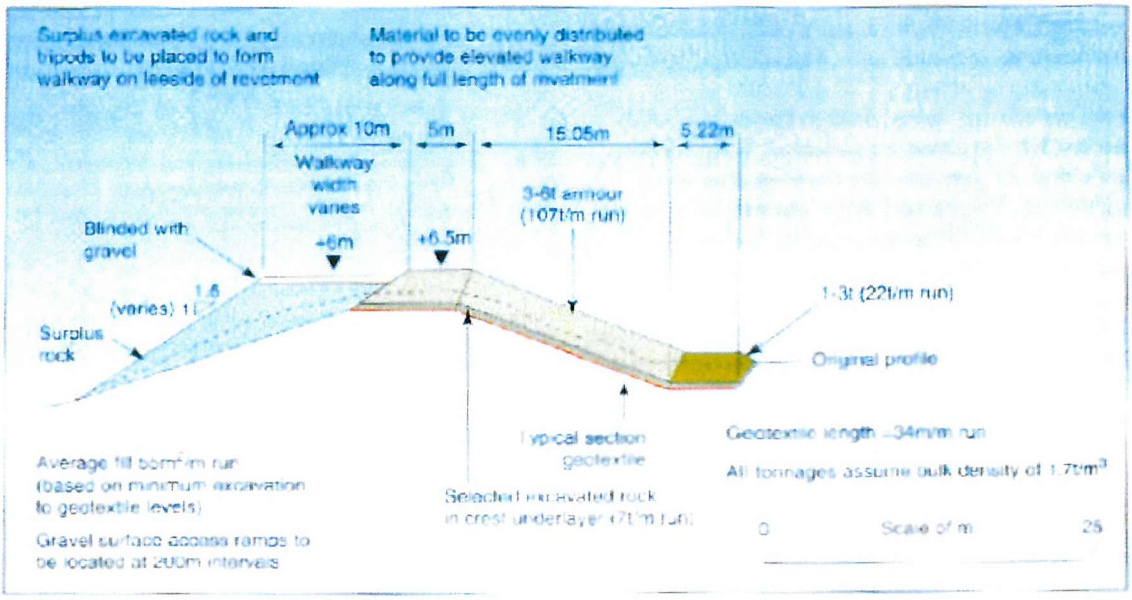

Figure 4.2: Cross Section of New Stabilisation Scheme

New Forest District Council was the Client for the stabilisation works and the engineer was the assistant director of the council's engineering services department. The resident engineer was also a member of the same department.

The design was carried out in-house by the New Forest District Council's Engineering Department in Lymington. Research for the design was undertaken jointly by New Forest District Council and HR Wallingford Ltd. at their laboratories in Oxfordshire. The contract drawings, specification and bill of quantities were all produced in-house by New Forest District Council. The method of measurement used was the ICE Standard Method of Measurement.

The main contractor appointed to undertake the works was Westminster Dredging Company Limited of Fareham in Hampshire. The contract was let under the ICE Conditions of Contract 5th edition with amendments. The contract tender price was £5 million with a contract duration of 30 weeks.

The project was expected to take the form of a traditional civil engineering contract, which often results in adversarial confrontations arising between the contractor, engineer and client. The project was both land-based construction and maritime, involving marine dredging for gravel and placing it both on and off-shore. It was thus anticipated by the engineer that the main contractor would be either a marine contractor with a land based sub-contractor or vice versa. In either case the sub-contract value was to be in the order of 50% of the tender sum. In order to give the engineer greater control over the selection of sub-contractors, the ICE Conditions of Contract 5th edition was adopted, rather than the current 6th edition.

The project was further complicated as a result of being a new and untried design and it was not possible accurately to predict the standards of work which could be reasonably expected from certain parts of the works. In addition, the project was in an environmentally sensitive area with a high public profile. Delays in completion before the onset of winter storms could have resulted in a serious breach of the spit and hence catastrophic consequences both to commerce and the environment. A breach in the Spit would have led to flooding of the nearby low-lying areas with consequent disruption to agriculture and business as well damage to residential property.

The client was concerned with the outcome of the project and therefore asked contractors interested in tendering. Surprisingly, several large contractors failed to respond correctly to the request and were removed from the tender list.

In order for the employer to obtain a dredging licence from the UK Government for the preferred source of gravel, the cost of two alternative sources of sea dredged gravel had to be compared. Tenderers were therefore asked to submit prices for each of the alternate sources. The contractor which was ultimately successful submitted the lowest prices for each of the alternative gravel sources and, in all tenders received, the client's preferred source was the cheapest.

The contractors tendering for the project had, as usual during the tendering process, asked the client for clarification of certain areas where it was thought that there was ambiguity or where errors or conflicting information occurred in the tender documents. The successful contractor had, however, sought clarification of substantially more points than the other tenderers.

The contractor was duly identified as being the preferred tenderer, with the tender price having a validity period of six months. The contractor was keen to commence the works but due to delays in obtaining dredging licences, the start was delayed.

As a result the contractor became involved with the design and advised the design team on changes which would improve buildability and reduce construction costs and duration all at no cost to the client, but purely due to the desire of the contractor to provide value engineering. The chance event of the delay led to a situation where a contractor had been selected by competitive tendering but was able to suggest changes to the design to enhance buildability. This process was made possible because the design team and engineer were part of the clients organisation and value engineering was able to take place at no additional cost to the client. Had the designers been outside consultants it is unlikely that this process would have taken place as a result of the cost implications for the client.

When construction eventually started cautious optimism existed between the parties for a non-confrontational project which, over time, developed into a high degree of trust which all parties strove to maintain throughout the contract.

Evidence of the success of the partnering which evolved can be found in the fact that during the entire project no contractual letters were written by any of the parties. Furthermore, site meetings were not used for resolution of problems, as these were routinely sorted out on site, but principally for maintaining contact between all of the parties. As a result, meetings rarely lasted more than one hour.

4.3 Setting the Stage

The contract was prepared with the expectation that it would be a traditional adversarial contract, but the individuals named in the contract were keen to work in a non-confrontational manner. The main contractor was of similar mind and had already adopted the philosophy of treating others in the way they would wish to be treated themselves, and wished to tender on an equal basis. This philosophy was evident at tender stage when the main contractor raised 20 queries concerning the contract documents, a few being in connection with errors or matters of interpretation, but most were directed at ensuring that no tenderers made incorrect assumptions on key requirements, for use perhaps for claims later. The result of these points being raised was the responses being circulated to all tenderers thereby ensuring a "level playing field", which was the original intention of raising the query.

One area in particular is worth mentioning is that the contract prohibited the use of local roads for delivery of materials, except for small quantities. The main contractor was concerned that some tenderers would price on the basis of significant quantities of rocks being delivered to site by road, likely to be a considerably less expensive option than delivery by sea. The response from the engineer to this query was circulation to all tenderers conforming the original specification.

This example demonstrates two important points

- the tender price offered allowed for providing exactly what the client required
- the contractor, which wished to provide a genuine service to the client, wanted to tender on an equal basis.

The main contractor stated in comments relating to the project

" Our actions at tender stage, in respect of the queries raised, were to seek clarity in order to be able to price what the client actually wanted; to avoid disputes and misunderstandings should we win the contract; to create a 'level playing field'".

One further point demonstrates the motives of the contractor in the project. Due to delays in obtaining dredging licences, the tender validity period expired and the main contractor was asked if the validity period of the tender price could be extended. The contractor agreed to do this even though the tender sum could have been increased whilst still providing the lowest tender.

Before the start of the contract the client, engineer and contractor had all displayed openness and integrity and all were confident of a successful outcome to the project. The relationship developed fully when all parties to the contract, including suppliers and sub-contractors, realised they could trust each other and work together. The fact that the main contractor's culture and policy was not to act as a "traditional" main contractor may have accelerated the development of a partnering approach.

4.4 Building the Team

The client and engineer had already established a good basis for the contract to work with the minimum confrontation and were keen to build on the approach demonstrated by the main contractor. The project had the benefit of well written amendments to the conditions of contract, which clearly expressed the degree of risk sharing. It had, for example, been recognised that a possible area for dispute could be sea conditions that prevented working; however, inclement conditions were defined unambiguously by using wave height, leaving no grounds for misunderstanding.

The attitude of the main contractor to its own sub-contractors was also investigated. The most fundamental difference from traditional adversarial contracts was the policy adopted by the main contractor of paying their sub-contractors when payment was due instead of the commonly adopted "pay when paid" policy.

It was further stated in an interview with the project manager that company policy at all times was to assist their sub-contractors whenever possible, and such measures could include increasing the frequency of payments, the provision of a quick and easily agreeable method of assessing interim payments and helping with engineering services and plant and labour where required.

Two other factors were considered to be important for the success of the contract. Site meetings were held with all interested parties present, including sub-contractors and suppliers. Second, it was agreed that the resident engineer could work with the sub-contractors, thus avoiding any defective work being continued whilst instructions were relayed through the main contractor.

The client also demonstrated the ability readily to adopt different procedures, such as with regard to re-measurement. The difficulties of producing test panels of rock in order to re-measure rock placement was recognised and this method was discarded in favour of measuring the weight of rock delivered to site. This was possible because both contractor and client were prepared to agree the weight of rock delivered and the client was satisfied that the rock was placed in accordance with the contract. Interim valuations were agreed by considering the percentages of work complete.

The resident engineer stated during an interview that in his opinion the main contractor had always undervalued the amount of work done, and in one instance, the resident engineer suggested that the contractor should increase his application for payment. The overall result of this system was that valuations were agreed on the spot and because of the clients accounting procedures the contractor was paid early in every case.

The final observation made by both client and contractor concerns the issuing of instructions relating to unforeseen conditions and variations. There is often a reluctance by engineers to issue instructions relating to unforeseen conditions for fear of being thought of as negligent by the client. This frequently leads to disputes with attempts to cover the situation with variation orders. Where the situation is truly unforeseeable no stigma can be attached to an engineer treating it as such, since by definition it could not have been foreseeable. Where variations occur, instructions should be issued promptly so that the contractor is not left with the dilemma of whether or not to proceed with the works at its own risk.

4.5 Contract Analysis

Analysis of this project suggests a framework for partnering working using traditional forms of contract, as follows.

- Contractors need to be prepared to tender for a project with no hidden agenda and clients need to produce comprehensive and fair documents for the contractor to work from

- The client needs to be vigilant in ensuring that the tender prices received reflect the scope of the work expected and are not based on misunderstanding of the requirements of the contract which may result in a claims situation

- There must be commitment from client, engineer, contractor and sub-contractors to work together as a team, agree interim valuations and ensure prompt payment. The old approach of pay-when-paid has no place in the modern construction industry

- Care must be exercised in preparation of tender documents to ensure that the works are buildable and any onerous conditions are highlighted at tender stage

- All parties to the contract must be proactive and prepared to implement change for the benefit of the project

- A project team must be built up based on mutual trust and elimination of the "us and them" attitude.

The project contained a large element of risk, which was increased by a delayed start. The contractor, at the start of the project, recognised the need for acceleration in order to complete the offshore works before winter.

Two barges were employed, rather than the planned one, to ship rocks at double the rate which had two results. First, the client may have incurred some re-handling charges and, second, the contractor's plant was utilised at a level not originally envisaged.

The acceleration was achieved with no additional costs to the client but with a large reduction in the risk associated with failing to complete the offshore works during the good weather. The final result was a project completed on time, with high quality workmanship and to budget.

4.6 The Outcome

The key performance targets set for the UK construction industry are in the following categories:-

- Cost reduction
- Time reduction
- Defect reduction
- User benefits

Analysis of the project suggests that the project has achieved considerable advances in all of these categories and that they are directly attributable to co-operative working. The actual performance of the project against the key performance targets are as follows:-

- significant savings of additional costs as a result of completion before the onset of winter weather
- a significant compression of the contract programme
- No defects have been reported
- User benefits are difficult to quantify but completion of the project before the winter has prevented environmental damage to the adjacent Sites of Special

Scientific Interest (SSSIs) and flooding of the surrounding areas amounting to benefits in excess of 1000% of the project value.

Questionnaires were completed by the Client, Engineer, Main Contractor and principle sub-contractor to assess the benefits that they had experienced as a result of co-operative working in the areas of :-

1. Administration
2. Contract duration
3. Cost
4. Workmanship

The common benefits cited by all of the respondents are summarised below:-

1. Administration
   - Improved supervision and problems addressed corporately
   - Head office based inputs to project reduced
   - Significant improvement in contract planning
   - Improved health and safety procedures
   - Agreement of valuations simplified and quicker payment resulted
   - Supervision of sub-contractors improved as a result of being part of the site team
   - Selection of construction methods by consensus.
2. Contract Duration
   - A substantially compressed programme achieved without significant problems
   - Delays reduced
   - Improved buildability through teamwork

- Variations caused minimal delays to introduce
- The project completed well within the contract period allowed by the Contractor.

3. Cost

- More efficient and appropriate use of plant
- Reduced costs as a result of less head office input
- Variations cost less to introduce
- The project completed within budget.

4. Workmanship

- The quality of workmanship and materials higher than average
- Quality assurance properly implemented.

4.7 Co-operative Culture

The effectiveness of having a management team drawn from different parties to the contract but having mutual trust and common purpose has been clearly demonstrated in this project. The spirit of the management team can be best expressed in the words of a comment added to the bottom of a questionnaire: "weekly site meetings provided a forum for discussing what was already happening on site. They were important, if only to maintain contacts - they hardly ever lasted more than one hour. Problems were rarely kept for meetings - they were routinely sorted out on site".

Traditional contracts are supervised by a project team drawn from the various parties but operating in name only as a team. Each team member will follow their own agenda dictated by the party that they represent, the global project requirements being lost in a political melée.

This project shows the step change which can be achieved when the vision for co-operative working is applied with sincerity and trust. Political brinkmanship and mutual distrust were entirely absent from this management team making the beneficiaries the Client, Engineer and Contractors and the losers the litigation lawyers and the banks' profits from interest charges.

All the team members have recognised the advantages of working in this manner and would actively attempt to emulate this type of co-operative working on future projects.

4.8 Conclusions

The Hurst Spit project shows the step change improvement in efficiency which can be achieved when the vision for partnering working is applied with sincerity and trust. Political brinkmanship and mutual distrust were entirely absent from this management team making the beneficiaries the client, engineer and contractors.

All project team members have recognised the advantages of a partnering approach on the project and would actively attempt to emulate this type of working on future projects.

The motivation for a partnering way of working is a philosophy not an agreement. There is no need for special forms of contract or agreements, especially as these will not necessarily satisfy the requirements of public accountability. However, it is of absolute importance that the philosophy of co-operation be augmented by prompt and fair payment throughout the supply chain.

However, although the organisations involved provide support and a framework, it is not the organisations which set the agenda on site but the character and attitude of the individual members of the teams. Selecting the right people is the key.

Partnering can provide a step improvement in construction even in single projects. In order to provide maximum benefits it is necessary to involve the contractor at the design stage. Partnering is a mechanism specifically developed for the construction industry and as such will provide greater benefits than technology transfer from manufacturing.

This project provides evidence of the benefits to the construction industry of a co-operative way of working. The requirements for a cultural change in the attitudes of the construction players has been identified and the importance of mutual trust and common purpose highlighted.

The motivation for a co-operative way of working is a philosophy not an agreement. There is no need for special forms of contract or agreements, especially as these will not necessarily satisfy the requirements of public accountability. However, it is of absolute importance that

the philosophy of co-operation be augmented by prompt and fair payment throughout the supply chain.

The Client for the project investigated stated that: "as soon as you write down a formal partnering agreement you lose the element of trust which drives the whole set-up. If the will is there you don't need the formal arrangement, if the will is not there you won't create it by writing it down".

However, one of the main points to make is that, although the organisations involved provide support and a framework, it is not the organisations which set the agenda on site but the character and attitude of the individual members of the teams. Selecting the right people is the key.

Co-operation can provide a step improvement in construction even in single projects. In order to provide maximum benefits it is necessary to involve the Contractor at the design stage. Co-operation in the construction industry can provide greater benefits than technology transfer from manufacturing.

5. Theoretical Approach to Selection Methodology

5.1 Introduction

The overall approach to the designer and constructor selection process was to provide a transparent procedure for selection of both parties prior to any detailed designs being produced but capable of delivering best value for money to the client. Selection of constructors before the design process had begun would enable value engineering to take place and the study of the Hurst Spit project had demonstrated the benefits of this. However, at Hurst Spit the time made available for value engineering came about by accident as a result of delays in obtaining dredging licenses whereas any new selection process would require value engineering to occur by design. Furthermore, all parties to the project had to understand the project objectives and work towards achieving them. It was therefore decided that the initial stage in the selection process would be to establish and prioritise the project objectives. To this end the following procedure was postulated, developed and trialed.

5.2 Identification of Project Objectives

In order to identify the project objectives it was considered necessary to engage the client in a rigorous process to ensure that all outcomes be considered. This also posed the question, particularly with public bodies, who really is the client? Typically there are four interested parties: the elected representatives; the civil servants; the end users and the taxpayers. The method adopted to identify the project objectives, therefore, had to be simple enough to be used by everyone and capable of aggregating the views of all interested parties.

Exploratory research indicated that the most appropriate way of achieving this was to use a variation of the Delphi Method (Sackman[93]). The Delphi Method is an iterative process which has been used for a variety of applications ranging from business and education to science and medicine. The aim of the Delphi method is to combine expert opinion, by facilitating the exchange of ideas and information but enabling each participant to have an equal input by preventing bias due to position, status or dominant personalities. The method involves a panel of experts who each respond separately to a specific enquiry via a series of questionnaires. Their responses are anonymous in the sense that none of the others know who is included in the group or where a particular response originated from. As responses are made separately, new ideas may be introduced by individuals which other members of the panel have not previously considered. Material may be provided to the panel to provide a focus to the enquiry and to accelerate the process providing this does not constrain the ensuing discussion or steer consensus in a particular direction.

Responses obtained from the panel are collated by a central co-ordinator and fed back to the respondents in a synthesised form. The respondents are then asked for a further response allowing them to revise their initial position if they so wish. The process is then repeated. The aim of each round or iteration is to gradually produce a consensus amongst the group, or alternatively for responses to become stable. Since there is ultimately no guarantee that a consensus will result and a range of opinions or responses may be produced instead of a single answer this approach elicits a set of criteria for which there is general agreement. However, due to the time constraints of a construction project, the full rounds of iterations were considered to be unnecessarily protracted to be use with all parties and the use of one round of questionnaires to all interest parties with the objectives refined by the client's advisers was considered adequate. Thus for the trial projects, the full Delphi Method was only conducted with the council officers and not with the members and other interested parties.

5.3 Prioritisation of Project Objectives

In order to prioritise the set of project objectives obtained by the Delphi Method some form of multiple criteria decision making (MCDM) tool was required. For this purpose six tools were evaluated. These were:

- Analytical Hierarchy Process (AHP)
- Simple Multi-Attribute Rating Technique (SMART)
- Simple Additive Weighting (SAW)
- Preference Ranking Organisation Method for Enrichment Evaluations (PROMETHEE)
- Elimination Et Choix Traduisant la Réalité (ELECTRE)
- Technique for Order Preference By Similarity to the Ideal Solution (TOPSIS)

5.3.1 Analytical Hierarchy Process

One of the popular MCDM methods is the Analytical Hierarchy Process (AHP) which was developed by Thomas Saaty[94] in the early 1970s whilst advising the US Government.

AHP is a decompositional method which breaks a decision problem down into a hierarchy of interrelated decision elements. At the top of the hierarchy is a statement of the most general objective of the decision problem. The process of decomposing attributes then continues until all the essential criteria for making the decision have been specified. The alternative courses of action are added to the hierarchy below each of the lowest level attributes.

The fundamental approach of AHP is similar to other MCDM methods, which involve establishing a decision hierarchy. The main difference is that the alternative courses of action also appear on the hierarchy at its lowest level. The major innovation of AHP is the introduction of pairwise comparisons. These processes are used to determine the relative importance of attributes and also to compare how well the alternatives perform on different attributes. In AHP, the rating of alternatives and weighting of attributes are performed using pairwise comparisons. These pairwise comparisons are converted into sets of numbers, which are then transformed into a matrix. Afterwards, an eigenvector method is used to solve the matrix for determining the attribute importance and alternative performance.

The Analytical Hierarchy Process is a popular method for solving multi-criteria decision problems involving qualitative data, and has been applied to many decision situations including influencing the Strategic Arms Limitation Talks in both SALT 2 and SALT 3 (Saaty[94]). AHP offers a number of advantages over other tools, such as consistency checks on the decision maker's judgements, but complexity in use has discouraged many decision makers from adopting AHP as a decision making tool.

5.3.1.1 Strengths of AHP

The AHP provides a method for formally structuring almost any decision analysis problems. It allows a complex problem to be decomposed into sets of simpler judgements and also provides a documented rationale for the choice of a particular alternative. It is this feature of AHP that has made it appear particularly attractive for use by those involved in construction procurement.

The use of pairwise comparisons means that the decision-maker can focus in turn on each small part of the problem. Only two attributes or two alternatives have to be considered at any one time so that the decision-maker's judgmental task is simplified.

The AHP process requires more comparisons to be made than are needed to establish the relative weightings. Thus, by entering redundant information, AHP allows a consistency check to be made on the decision-maker's judgements. This is a good practice in decision analysis because the inputs are questioned in several ways. Any inconsistencies in the judgements will be reflected in the decision model and this is inherent in the AHP.

The wide range of applications of the AHP is evidence of its versatility. In addition to judgements about importance and preference, the AHP allows judgements about the relative likelihood of events to be made. This has allowed it to be applied to problems involving uncertainty as mentioned earlier, and also to be used in forecasting major events (Saaty[94]).

5.3.1.2 Weaknesses of AHP

In some problems, the restriction of pairwise comparisons to a 1 to 9 scale will produce inconsistencies in the results. This will frequently be the case when there are a large number of alternatives.

The eigenvector method for obtaining weights is not transparent to most decision makers and is not easily calculated by hand.

The addition of new alternatives can reverse the rank of some of the existing alternatives. This reverse ranking arises from the way in which the AHP normalises the weights to sum to one giving results which do not appear to be intuitively reasonable.

The redundancy built into the AHP is an advantage, however, it requires a large number of judgements from the decision maker. This method can be very time consuming if a large number of attributes or alternatives have to be compared. The requirement to answer a large number of questions may reduce the attraction of the AHP to the potential user, even though the questions themselves are intrinsically easy.

5.3.2 Simple Multi-Attribute Rating Technique

An alternative approach for tackling qualitative multi-attribute problems is SMART. SMART was developed by Edwards[95] in 1971 and it is strongly favoured by decision makers who are distrustful of a mathematical 'black box' approach. Since the analysis is very transparent, many decision makers prefer using SMART instead of AHP.

SMART and AHP have a common feature, in which both methods involve setting up a decision tree to structure a problem, but their rating and weighting techniques are totally different. In AHP the rating of alternatives is achieved using eigenvectors, however, in SMART, rating of alternatives is assigned directly in terms of the decision-maker's preference, and hence called direct rating. In some conditions involving quantitative data, value functions can be adopted instead of direct rating. The simplest choice of a value function is a linear function, and it is sufficient in most cases.

In SMART, the weighting of attributes is carried out using 'swing weighting procedure', for which a decision maker will simply be asked for the relative importance of attributes with reference to some fixed scale.

5.3.2.1 Strengths of SMART

SMART provides a formal structure to a MCDM problem. SMART helps the decision-maker to gain a better insight into the problem, which may also reduce a large number of alternatives to a few.

SMART employs a simple method to obtain judgements from the decision-maker. The questions are very simple and straightforward, and there are fewer questions involved in the SMART analysis compared to the AHP approach.

SMART uses direct rating for the decision-maker to assign a value to an attribute according to the strength of preference. The value is intuitively obvious and lies between 0 and 100, where 100 is most important and 0 is least important.

A swing weighting procedure is used to allow the decision-maker to rank the alternatives. No complex mathematical calculations are involved in assigning weights to attributes, unlike AHP.

The scores of the original alternatives will not change when new alternatives are added. Because of the use of direct rating, the rating of alternatives are measured with reference to their own scales, so that changing the number of alternatives will not change the decision scores of the original alternatives. Hence reverse ranking will not happen in SMART making this technique extremely robust.

SMART can handle very complex problems and can be applied to problems involving large numbers of attributes and alternatives.

5.3.2.2 Weaknesses of SMART

SMART requires that the performance of an alternative on one attribute must be judged independently of its performance on other attributes. SMART is not suitable for hierarchies of alternatives or attributes and where this occurs the alternatives will need to be regrouped in order to apply SMART.

If two attributes actually represent the same thing, this is clearly redundancy. The danger of redundancy in SMART is that it may lead to double counting, which may cause certain objectives to have undue weight when the final decision is made. One way of identifying redundancy is to establish whether the decision would be affected if a given attribute were eliminated from the tree. If the deletion of the attribute would not make any difference to the choice of the best course of action, that attribute should be excluded from the tree.

5.3.3 Simple Additive Weighting

The SAW method[96] is known by a variety of different names including weighted summation, weighted linear combination, and scoring method. It is used to evaluate an alternative according to its score. The score of an alternative is calculated as the weighted sum of its attribute scores. This score expresses the preferences of the decision-maker. This is an additive method since the final appraisal score is calculated by summing across the evaluation criteria the combined effects of decision alternative outcomes and criteria weights. The best alternative is that with the highest score.

Before applying the SAW method the decision-maker needs to define the problem, identify the alternatives and define the criteria. This gives a decision statement and a decision consisting of making a choice amongst a number of alternatives. The alternatives are subject to a number of criteria or attributes.

5.3.3.1 Strengths of SAW

The method is simple and therefore easy to use and implement. Given the weights and standardised ratings in matrix form only a single matrix multiplication operation is required to evaluate all of the alternatives. Its simplicity makes it quick to implement. This would be useful in situations where there is a time constraint to find a solution or where there are a large number of alternatives.

The procedure of standardising the attribute scores removes the problems of incommensurable units. The range of values across the alternatives for each attribute is 0 to 1. Therefore alternatives with attribute values of the order 10^m can be compared with attributes having values of magnitude 10^n.

5.3.3.2 Weaknesses of SAW

The method assumes that the attributes are independent. Any change in any of the attributes for a given alternative should not affect any other attribute for that alternative. In reality the attributes might be in conflict. This would be the situation with the attributes of quality and price. If the quality is increased then so should the price to cover the cost of improved quality.

The method assumes that all of the attribute weights have a fixed relationship. A change in one attribute weighting should result in a change to the weight of another attribute. Instead, any value can be attached to the weight, regardless of the weights of other attributes.

5.3.4 Preference Ranking Organisation Method for Enrichment Evaluations

The PROMETHEE method[97] is used to evaluate problems in situations where there are many alternatives but no optimal solution. None of the alternatives will be the best on each criterion. In addition, the criteria are often conflicting and compromise solutions have to be found. The decision-maker needs to define the problem, find the alternatives and define the criteria. This gives a decision statement and a decision consisting of making a choice amongst number of alternatives. The alternatives may also be subject to a number of criteria.

5.3.4.1 Strengths of PROMETHEE

PROMETHEE enables conflicting criteria to be considered. The method automatically calculates the robustness of the current classification for each criterion.

PROMETHEE allows the decision-maker to directly use the original problem data specified in a simple multi-criteria table. The data can be readily separated from the underlying method.

The decision-maker is able to define the scales of measure. These can be tailored to indicate their priorities and preferences for every criterion. The decision-maker can specify the problem in terms familiar to themselves rather than the underlying method. This makes the method easy to use and efficient.

The criteria can be specified as maximum or minimum value preferred. For example, cost would ideally be minimised whilst quality should be maximised.

The weights are bounded. This means that they have to be distributed amongst criteria from a single total value. The decision-maker's preference for an alternative can be clearly represented as a proportion of the overall weight.

5.3.4.2 Weaknesses of PROMETHEE

The method requires a lot of effort to calculate manually and there is no straightforward way of computer implementation. For any application involving large problems it would require the purchase of bespoke software.

The method is prone to rank reversal when additional alternatives are added. This occurs mainly because differences in criteria values are not taken into account totally.

5.3.5 Elimination Et Choix Traduisant la Réalité

ELECTRE[98], which translates as elimination and choice reflecting reality, was developed by Roy in 1968. ELECTRE is a set of decision making methods that can be applied to many different problems, including multiple-criteria decision making. ELECTRE I is designed for selection problems, ELECTRE TRI for assignment problems and ELECTRE II, III and IV for ranking problems. ELECTRE III is used when it is possible to quantify the relative importance of criteria and IV when quantification is impossible. Therefore, ELECTRE III has been considered as this is the most appropriate for addressing the problem of project objectives.

5.3.5.1 Strengths of ELECTRE

This method deals well with hierarchical data and has well defined methods of inputting this data into the process.

The choice of indifference, preference and the veto thresholds gives the user a huge amount of control over the method and allows the user to easily tweak the method to suite their particular needs. The indifference and preference threshold are very useful in decision making. In many methods, one alternative will be classed better than another if it is slightly better. In ELECTRE, if one alternative is different by less than the indifference threshold, they will be considered as being the same. This is very important when many criteria are being considered. Thus, when using ELECTRE, if a set of projects has ten criteria and project A outperforms project B in nine criteria but the difference in performance in each of these criteria is less than the threshold, but project B outperformed project A by a significant score in the final criterion, then project B would be preferable. This is the more intuitive answer. In other decision making methods however, this may not be the case, and project A may be ranked the same as B or better, which may not be the best solution.

ELECTRE can be applied to large complex problems with the use of ELECTRE software[99]. Once the data has been input into the software, the ranking is calculated automatically.

The choice of the thresholds is not complex and relies on the intuition of the decision-maker. This enables decision-makers to quickly create a ranking using ELECTRE software.

5.3.5.2 Weaknesses of ELECTRA

This method is very complex to implement. Although it could be implemented in a spreadsheet it would not be a trivial exercise. This means that the commercial software is the only viable option to use.

The result, although giving a ranking, does not show how much better one alternative is than another. The only way to distinguish would be to change the indifference, preference and veto thresholds to help understand how closely the projects are ranked against each other

The method as a whole is not very intuitive. The method is difficult to understand at a superficial level and could make users anxious about using it.

As the choice of thresholds is intuitive, first time users may make mistakes and misunderstand the implications of their choices.

5.3.6 Technique for Order Preference By Similarity to the Ideal Solution

Technique for Order Preference By Similarity to the Ideal Solution (TOPSIS)[100] is based on the concept that alternatives should be chosen on the basis of having the shortest distance from a positive ideal solution and the furthest distance from a negative ideal solution. The ideal solution is the alternative having the greatest collection of maximum attributes for each criterion. An ideal solution is rarely attainable when solving real-world problems. TOPSIS, however, looks for the closest alternative to the positive ideal solution and furthest from the negative ideal solution.

5.3.6.1 Strengths of TOPSIS

This is a very easy method to implement. A user can immediately understand the principles behind this method and can quickly understand what the method is doing. A spreadsheet can easily be made that will calculate all the values needed and give the user the final ranking.

The method does not require much subjective input into the model. The only subjective inputs are the weighting values.

TOPSIS produces an easily understood result with no room for misinterpretation. The ranking also has a value which shows how much better one alternative is than another. This is very useful if there are other factors that may influence the decision. If, for example, the second project in the ranking gave other rewards, such as future work, it may be useful to know how close the second project is to the first.

TOPSIS can also be applied to large problems with the use of an easily produced spreadsheet.

5.3.6.2 Weaknesses of TOPSIS

Although the method takes in only a small amount of subjective data, a change in this can drastically affect the results. Therefore careful thought must be put into the selection of the weighting values.

There is no formal method for choosing the weights. This can lead to problems if the user is unsure how important one criteria is compared to another.

It is difficult to map hierarchical problems with this method. The only way is represent a hierarchy is by weighting the values chosen. This is not ideal and doing it this way is not suggested in the method.

5.3.7 Conclusions

All six of the multi criteria decision making tools considered are able to provide a ranking of alternatives. They differ in the complexity of use and the need for introducing additional subjective variables such as weights and thresholds. SMART was considered to be too simplistic as it relies essentially on judging criteria against some arbitrary scale. SAW is easy and quick to use but involves identifying some common attributes of the criteria being considered and using them to make a judgement. Both PROMETHEE and ELECTRE are complex to use and require bespoke commercial software for implementation. TOPSIS is easy to implement but highly subjective and not suitable for hierarchical problems. AHP was considered to be the most appropriate tool to use for the following reasons:

1. It is the only method that provides a check on the decision maker's consistency is AHP
2. It allows pairwise comparisons
3. The method is mathematically opaque so that the respondent cannot predict the results
4. The analysis does not require any bespoke commercial software
5. The method can handle hierarchical data
6. The method yields ranking and magnitude.

AHP was therefore, the tool used for ranking and prioritising the project objectives.

6. Analytical Hierarchy Process

6.1 Introduction

The use of AHP produced a number of anomalies which required investigation. AHP as developed by Saaty[94] uses a scale from one to nine where a judgement of one to one represents equal importance. It was decided that ranking any of the project objectives as equally important to another one would not be permitted for the reasons given in section 9.1 and hence a one to one judgement was not permitted. This required research to find how this affected the consistency ratio and to determine the random index for a two to nine scale. It was also necessary to investigate how inconsistent results should be managed. Because early trials produced a large number of inconsistent results it was decided to investigate the effect of using a two to five scale instead of a two to nine scale.

6.2 Random Index Calculation

Saaty[94] defined a consistency ratio (CR) to measure the consistency of judgements. The consistency ratio is defined as:

$$CR = \frac{CI}{RI}$$

Where RI is the random index and $CI = \frac{(\lambda_{max} - n)}{(n-1)}$

Where λ_{max} is the largest eigenvalue of the judgement matrix and n is the number of criteria.

Originally Saaty[94] used a batch of 500 questionnaires with random data entered to determine the random index. The average consistency index (CI) that resulted was then called the random index (RI). Only one batch of 500 was generated for each number of factors. This was probably due to computer limitations at the time. The processor speed of an up to date PC is roughly equivalent to a supercomputer 25 years ago, which was around the time Saaty was first working on AHP. This means the processing power available for use in this research was considerably greater than that available to Saaty.

The RI values shown in Table 6.1 and Table 6.2 were created using a bespoke AHP Matlab program. A random batch of 500 responses was initially run 6 times for each number of properties and the average CI taken. This was done for the four scales: 1-9; 1-5; 2-9 and 2-5. Where the 2-5 and 2-9 equate to not allowing 1-1 comparisons in the 1-5 and 1-9 scales respectively.

Scale of 9	With 1 to 1 excluded									
	Number of Properties	CI (run 1)	CI (run 2)	CI (run 3)	CI (run 4)	CI (run 5)	CI (run 6)	RI (Scale 2-9)	Saaty's RI (Scale 1-9)	Difference
	3	0.578	0.611	0.501	0.55	0.593	0.577	0.56833	0.58	-0.0117
	4	0.95	0.941	0.954	0.955	0.893	0.964	0.94283	0.9	0.04283
	5	1.206	1.171	1.222	1.182	1.187	1.204	1.19533	1.12	0.07533
	6	1.313	1.338	1.343	1.324	1.327	1.354	1.33317	1.24	0.09317
	7	1.47	1.437	1.432	1.44	1.408	1.442	1.43817	1.32	0.11817
	8	1.503	1.477	1.493	1.505	1.502	1.493	1.4955	1.41	0.0855
	9	1.574	1.553	1.548	1.54	1.554	1.549	1.553	1.45	0.103
	10	1.582	1.588	1.577	1.59	1.583	1.579	1.58317	1.49	0.09317
	11	1.606	1.62	1.624	1.61	1.608	1.61	1.613		1.613
	12	1.63	1.646	1.646	1.649	1.643	1.646	1.64333		1.64333
	13	1.659	1.668	1.659	1.642	1.66	1.652	1.65667		1.65667
	14	1.676	1.669	1.668	1.678	1.674	1.674	1.67317		1.67317
	15	1.68	1.687	1.685	1.69	1.689	1.687	1.68633		1.68633
	With 1 to 1 permitted									
	Number of Properties	CI (run 1)	CI (run 2)	CI (run 3)	CI (run 4)	CI (run 5)	CI (run 6)	RI (Scale 1-9)	Saaty's RI	Difference
	3	0.535	0.586	0.528	0.492	0.564	0.48	0.53083	0.58	-0.0492
	4	0.884	0.867	0.911	0.859	0.891	0.944	0.89267	0.9	-0.0073
	5	1.065	1.104	1.081	1.127	1.134	1.115	1.10433	1.12	-0.0157
	6	1.255	1.229	1.22	1.261	1.242	1.253	1.24333	1.24	0.00333
	7	1.32	1.351	1.357	1.34	1.356	1.328	1.342	1.32	0.022
	8	1.39	1.408	1.396	1.416	1.407	1.395	1.402	1.41	-0.008
	9	1.455	1.443	1.453	1.447	1.452	1.458	1.45133	1.45	0.00133
	10	1.496	1.468	1.488	1.452	1.489	1.488	1.48017	1.49	-0.0098
	11	1.508	1.515	1.523	1.501	1.511	1.508	1.511		1.511
	12	1.539	1.539	1.543	1.534	1.542	1.542	1.53983		1.53983
	13	1.551	1.555	1.543	1.551	1.542	1.555	1.5495		1.5495
	14	1.566	1.567	1.572	1.56	1.565	1.575	1.5675		1.5675
	15	1.585	1.593	1.583	1.579	1.586	1.581	1.5845		1.5845

Table 6.1: Random Index for Scale of 9

Scale of 5

With 1 to 1 excluded									
Number of Properties	CI (run 1)	CI (run 2)	CI (run 3)	CI (run 4)	CI (run 5)	CI (run 6)	RI (Scale2-5)	Saaty's RI	Difference
3	0.29	0.27	0.27	0.26	0.259	0.289	0.273		0.273
4	0.482	0.475	0.462	0.478	0.472	0.479	0.47467		0.47467
5	0.56	0.584	0.58	0.585	0.563	0.569	0.5735		0.5735
6	0.648	0.646	0.641	0.638	0.639	0.648	0.64333		0.64333
7	0.696	0.697	0.694	0.689	0.676	0.694	0.691		0.691
8	0.723	0.725	0.724	0.718	0.716	0.724	0.72167		0.72167
9	0.74	0.745	0.741	0.753	0.744	0.743	0.74433		0.74433
10	0.759	0.767	0.762	0.759	0.759	0.759	0.76083		0.76083
11	0.778	0.777	0.778	0.774	0.774	0.773	0.77567		0.77567
12	0.79	0.784	0.795	0.79	0.786	0.787	0.78867		0.78867
13	0.801	0.802	0.796	0.795	0.796	0.798	0.798		0.798
14	0.807	0.802	0.808	0.803	0.808	0.811	0.8065		0.8065
15	0.813	0.813	0.815	0.812	0.815	0.817	0.81417		0.81417
With 1 to 1 permitted									
Number of Properties	CI (run 1)	CI (run 2)	CI (run 3)	CI (run 4)	CI (run 5)	CI (run 6)	RI (Scale 1-5)	Saaty's RI	Difference
3	0.292	0.235	0.252	0.242	0.255	0.26	0.256		0.256
4	0.41	0.426	0.421	0.407	0.388	0.415	0.411		0.411
5	0.504	0.501	0.502	0.516	0.502	0.501	0.50433		0.50433
6	0.562	0.556	0.579	0.553	0.555	0.559	0.56067		0.56067
7	0.605	0.615	0.602	0.6	0.599	0.604	0.60417		0.60417
8	0.635	0.638	0.634	0.64	0.627	0.632	0.63433		0.63433
9	0.652	0.654	0.654	0.661	0.644	0.648	0.65217		0.65217
10	0.671	0.682	0.681	0.673	0.672	0.68	0.6765		0.6765
11	0.688	0.689	0.693	0.687	0.681	0.689	0.68783		0.68783
12	0.692	0.695	0.694	0.696	0.698	0.701	0.696		0.696
13	0.712	0.706	0.703	0.708	0.702	0.713	0.70733		0.70733
14	0.716	0.717	0.715	0.713	0.711	0.712	0.714		0.714
15	0.719	0.722	0.72	0.72	0.716	0.721	0.71967		0.71967

Table 6.2: Random Index for Scale of 5

The RI was found to change when not allowing 1 - 1 comparisons. Table 6.1 and Table 6.2 show that the RI decreases with a decreasing scale. They also shows that not allowing 1 - 1 comparisons increases the RI. The difference between any two scales increases as the number of factors increase asymptotically towards a maximum value as shown in Figure 6.1.

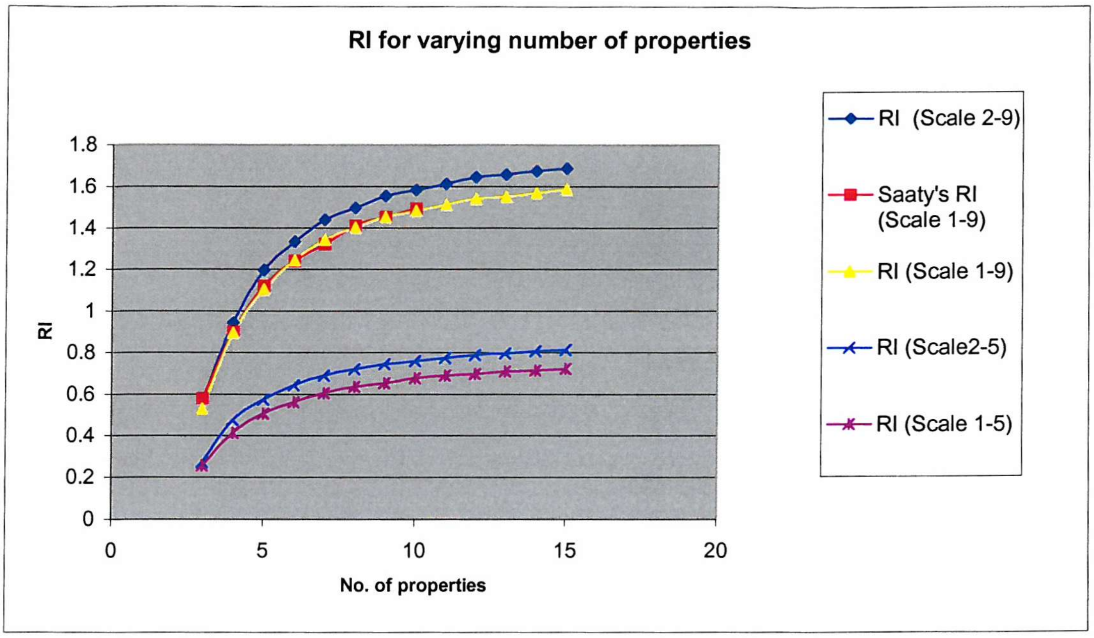

Figure 6.1: Graph of RI Values

Table 6.3 shows the data produced for a scale of 2-9 for 3 factors. The average RI is 0.531 but the individual data entries range from 0.480 to 0.586.

CI (run 1)	CI (run 2)	CI (run 3)	CI (run 4)	CI (run 5)	CI (run 6)	Average CI	Saaty's RI
0.535	0.586	0.528	0.492	0.564	0.480	0.531	0.580

Table 6.3: RI Values for 3 Factors

This indicates that the random CI for a batch of 500 is distributed over a range. The distribution was thought likely to be Gaussian. The RI for a number of factors was equal to the mean of the RI distribution. To find a more accurate value for the mean more than 6 batches needed to be run. A few test runs showed that 80 batches would give a good distribution and did not require too much processing time as the number of factor increased. A typical histogram of 80 batches can be seen in Figure 6.2. The histogram clearly suggests a Gaussian distribution.

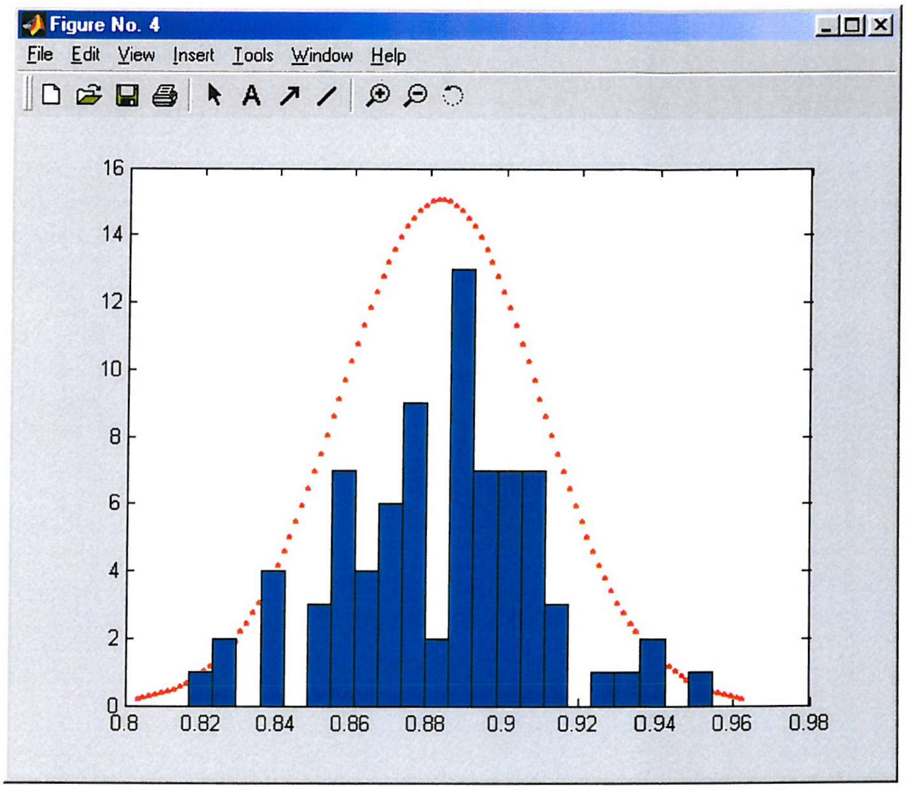

Figure 6.2 : Distribution of RI Results for 80 Batches

The dotted line shows the Gaussian distribution calculated from the standard deviation and the mean of the data. Table 6.4 shows the mean and two standard deviation for each number of factors from running 80 batches of 500 for each number of factors and each alternative scale. The results are displayed graphically in Figure 6.3.

	Scale 1 - 9		Scale 2 - 9		Scale 1 - 5		Scale 2 - 5	
No. of factors	Mean	Std Dev x2	Mean	Std Dev x2	Mean	Std Dev x2	Mean	Std Dev x2
3	0.528888	0.064889	0.567738	0.065356	0.249511	0.030659	0.287194	0.034178
4	0.882930	0.053069	0.952512	0.059030	0.407933	0.022356	0.465658	0.027371
5	1.112129	0.046095	1.188525	0.052879	0.501290	0.020897	0.573561	0.022048
6	1.250483	0.034397	1.337513	0.036917	0.564145	0.015037	0.643626	0.016300
7	1.340407	0.030345	1.433017	0.029046	0.604811	0.013634	0.688067	0.013973
8	1.405265	0.026561	1.500728	0.026440	0.634775	0.010464	0.719186	0.009504
9	1.450187	0.017553	1.547996	0.020868	0.655709	0.009452	0.742896	0.011612
10	1.485933	0.018134	1.585554	0.019331	0.673409	0.008797	0.762879	0.007735
11	1.514385	0.014705	1.613864	0.015546	0.686869	0.007853	0.776768	0.007771
12	1.533799	0.013767	1.636856	0.014250	0.697751	0.007039	0.788374	0.006904
13	1.556069	0.013439	1.655717	0.014491	0.707063	0.006064	0.798598	0.005907
14	1.568597	0.012137	1.672641	0.011670	0.714534	0.005259	0.807097	0.006063
15	1.583102	0.009631	1.685813	0.012243	0.720993	0.004995	0.814650	0.005267

Table 6.4: Mean and Standard Deviation for 3 - 15 Factors

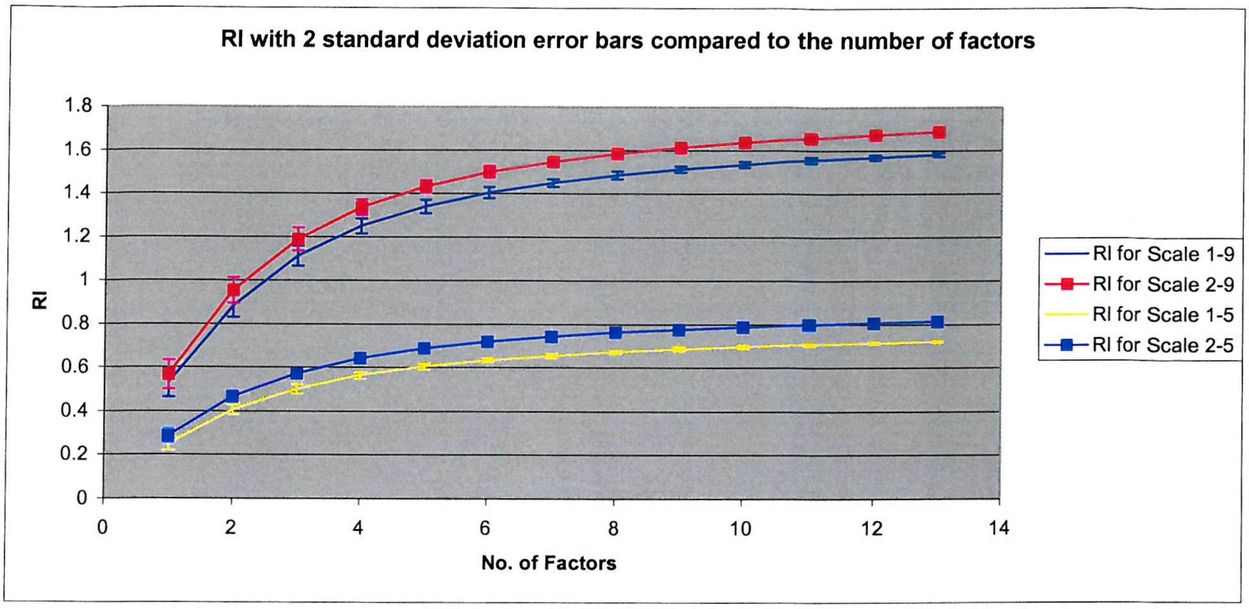

Figure 6.3: RI using 80 Data Sets

The error bars show two standard deviations above and below the mean for each of the factors. It can be seen that there is greater variation from the mean for lower factor quantities. It also shows that the larger scales have a larger distribution than the smaller scales.

6.3 Investigation of Impact of Scale Range

This section of the research investigated the effect that the choice of scale range has on consistency. In addition it also investigated whether respondents used the full range of values possible or whether there was any preference for particular ranges of values such as even numbers or odd numbers or restricted ranges. This research was carried out using questionnaire packs given to students. Each pack contained four questionnaires as follows:

1. Distance from the Southampton University Student Union bar to various locations in Southampton using a 2-9 scale
2. Preferred features of the Southampton University Student Union bar using a 2-9 scale
3. Distance from the Southampton University Student Union bar to various locations in Southampton using a 2-5 scale
4. Preferred features of the Southampton University Student Union bar using a 2-5 scale

Questionnaires 1 and 3 require decisions to be made on factual information whereas questionnaires 2 and 4 elicit opinions. Fifty-two completed questionnaire packs were returned of which approximately 20% had to be discarded as a result of being incorrectly completed. This left 168 individual questionnaires for analysis. Data from the questionnaires was analysed using a dedicated Matlab program. The data was analysed with a view to discovering potential trends so as to be able to ensure, as far as possible, that when AHP is used in live situations there is a reasonable expectancy that the results will be consistent.

In addition, the magnitude and range of numbers used in the response was recorded. This was to allow investigation of the possibility of correlation between consistency and the range of the scale used by the respondents.

6.3.1 2-9 Scale Consistency

Questions using the 2-9 scale produced 3 values relating to consistency. The CI values and two CR values, based on Saaty's original RI for a 1-9 scale and the newly calculated values relating specifically to a 2 – 9 scale. These three measures of consistency were analysed across the entire set of questionnaires and are shown in Table 6.5.

		Bar AHP 2-9 Scale			
Consistency Index		1-9 Consistency Ratio		2-9 Consistency Ratio	
Mean	0.253848218	Mean	0.204716305	Mean	0.190863322
Median	0.174313725	Median	0.140575585	Median	0.131062951
Standard Deviation	0.243152696	Standard Deviation	0.196090884	Standard Deviation	0.182821576
Range	1.09841169	Range	0.885815879	Range	0.825873451
Minimum	0.04163831	Minimum	0.033579282	Minimum	0.031307
Maximum	1.14005	Maximum	0.919395161	Maximum	0.857180451
Confidence Level(95.0%)	0.075771756	Confidence Level(95.0%)	0.061106255	Confidence Level(95.0%)	0.056971245

Table 6.5: Results 2-9 Bar Features

Distance AHP 2-9 Scale					
Consistency index		1-9 Consistency ratio		2-9 Consistency ratio	
Mean	0.11329216	Mean	0.101153714	Mean	0.094805154
Median	0.060971	Median	0.054438393	Median	0.051021757
Standard Deviation	0.132544246	Standard Deviation	0.118343077	Standard Deviation	0.110915687
Range	0.5755909	Range	0.513920446	Range	0.481666025
Minimum	0.016632	Minimum	0.01485	Minimum	0.013917992
Maximum	0.5922229	Maximum	0.528770446	Maximum	0.495584017
Confidence Level(95.0%)	0.041303717	Confidence Level(95.0%)	0.036878319	Confidence Level(95.0%)	0.03456378

Table 6.6: Results 2-9 Distances

When using the 2 – 9 scale the distance questionnaire produced more consistent results. This is consistent with the expectation that a question with a definable answer would yield better consistency as an AHP problem. Not only is the mean value of the CI lower a smaller range of values leads to a closer confidence limit.

The difference made by introducing the 2-9 RI to the distance question is significant as it takes the CR below 0.1, considered by many to be a cut-off point for consistency. This can be seen in Table 6.6.

6.3.2 2-5 Scale

No RI has been previously defined for this scale and therefore only one CR is generated.

Bar AHP 2-5 Scale			
Consistency index		2-5 Consistency Ratio	
Mean	0.124495188	Mean	0.234896581
Median	0.0909404	Median	0.17158566
Standard Deviation	0.092110148	Standard Deviation	0.173792733
Range	0.3916548	Range	0.738971321
Minimum	0.0297662	Minimum	0.056162642
Maximum	0.421421	Maximum	0.795133962
Confidence Level(95.0%)	0.028703559	Confidence Level(95.0%)	0.054157658

Table 6.7: Results 2-5 Bar Features

Distance AHP 2-5 Scale			
Consistency index		*2-5 Consistency ratio*	
Mean	0.066805162	Mean	0.126047475
Median	0.0516815	Median	0.097512264
Standard Deviation	0.078899034	Standard Deviation	0.148866102
Range	0.513215	Range	0.968330189
Minimum	0.016785	Minimum	0.031669811
Maximum	0.53	Maximum	1
Confidence Level(95.0%)	0.024586683	Confidence Level(95.0%)	0.046389969

Table 6.8: Results 2-5 Distances

As with 2-9, the 2-5 scale results confirm that the factual answer, distance question, produces more consistent results.

Comparing scales it can be seen that that on average the CI of the 2-5 scale is significantly lower than that for 2-9. For example in Table 6.8, Results 2-5 Distance, the average CI is 0.067 whereas in Table 6.6: Results 2-9 Distance, the average CI is 0.113. This was expected based on earlier work that showed that the CI of random data is much lower for the 2-5 scale. When the CI values are normalised using the appropriate RI the situation is reversed. For example in Table 6.8: Results 2-5 Distance, the CR is 0.126 where in Table 6.6: Results 2-9 Distance, the CR is 0.095. This shows that in comparison with random data a 2-9 scale has proven more consistent in both types of questionnaire. This result is significant and points towards the preferred scale for AHP use.

Considering the 2-9 scale of the Bar question; CR confidence limits are 0.191±0.57 (2 d.p). Over 95% of the responses can be expected to exhibit a CI below 0.25. The distance question produces a similar result at a CR of 0.13.

6.3.2.1 Graphical Questionnaires

A graphical questionnaire form was introduced towards the end of the data collection period. This used a slider on a web page to make the comparisons instead of using numbers. The sample of this type of questionnaire was small with only 13 complete packs or 52 individual AHP results being collected. It was hoped this small sample would provide an idea as to whether or not the method is worth pursuing. This is of particular importance for a web based approach to selection.

The graphical questionnaires gave a considerably higher level of inconsistency when compared to the numerical type for each scale, as can be seen in Table 6.9. The difference is most pronounced in the distance question with over 50% increase in average CR. This raises serious concerns about the use of graphical style questionnaires and more work will be required before these can be considered viable. Due to these consistency concerns graphical questionnaire data has not been used to formulate recommendations on acceptable consistency ratios.

Scale	Mean Consistency Ratio for Numerical Type	Mean Consistency Ratio for Graphical Type
2-9 Bar features	0.191	0.290
2-5 Bar features	0.235	0.265
2-9 Distances	0.095	0.153
2-5 Distances	0.126	0.220

Table 6.9: Consistency for Numerical and Graphical Questionnaires

6.3.3 Differences in Weights

In addition to AHP questionnaires each pack contained mark distribution questionnaires to test the feasibility of using AHP as a means of validating mark distribution questionnaires. Just as post processing of factor weights is needed when using AHP methods, a comparable calculation is required to compare the weights of the different types of scale and question.

Scales 2-9 and 2-5 are compared for the bar features question and each is subsequently judged against the mark distribution method. This comparison is made using:

$$\sum_{1}^{n}(R_{scale1(n)} - R_{scale2(n)})^2$$

Where:

$R_{scale(n)}$ *is the weight of factor n produced by first scale*

$R_{scale2(n)}$ is the weight of factor n produced by second scale

N is the number of factors

Scales Compared	Average Difference Measurement
2-9 to 2-5	0.0337
2-9 to Mark distribution	0.0419
2-5 to Mark distribution	0.0471

Table 6.10: Bar Question Compared to Points

Table 6.10 shows that on average there is a greater difference between both of the AHP methods and the mark distribution method than between the two AHP methods. This strongly suggests that the AHP method does cause the respondent to think in a different manner when completing the question, this can only be positive since the AHP forces every factor to be considered.

In considering the distance results there is a 'perfect' or correct answer against which the methods can be compared. Table 6.11 shows the known distances of the places considered and a normalised result used to represent the perfect result.

Place	Distance (miles)	Normalised
Glen Eyre Halls	0.67	0.099
Montefiore Halls	0.91	0.135
Clowns Wine Bar	1.16	0.172
Parkway Station	1.83	0.272
West Quay Arcade	2.17	0.327

Table 6.11: Actual Distances for Corresponding Questionnaire

Table 6.12 shows the average difference measurement from the perfect result calculated by the same method as used for the Bar differences. The results produced an unexpected result because the points method recorded the smallest difference with the 2-5 scale second and 2-9 notably worse. The distances given as perfect are *'as the crow flies'* taken from an accurate map. One explanation is that the 2-9 scale caused respondents to think more deeply about the question and in comparing the factors they considered a *'by road'* distance.

These finding suggest that further investigation of mark distribution combined with AHP is needed.

Scale	Average Difference Measurement
2-9	0.051
2-5	0.028
Mark distribution	0.019

Table 6.12: Average Differences from Perfect Result

6.3.4 Data Trends

A correlation function was used to test for possible trends between certain components of the data available. It was hypothesised that there may be a link between the amount of the available scale range used and the consistency of results. For example the 2-9 scale has 8 possible levels so the range is 8, considering only magnitude. A person with highest comparison level 5 and lowest 2 is using 4 levels or half the available range. A correlation would indicate that the range of scale used affects consistency. However, as Table 6.13shows, the correlation is close to zero. A similar association between average magnitude of comparison and CI was made but also showed no significant correlation.

Data Set	Correlation
Bar 2-9	0.081
Bar 2-5	-0.141
Distance 2-9	0.143
Distance 2-5	-0.151

Table 6.13: Correlation Values

The correlation was measured for the differences between the weight results of each questioning method for the distance question. Table 6.14 shows some correlation between the two AHP methods. From this data it can be suggested that if a respondent is a good judge using one AHP scale they will be good when using another AHP scale and vice versa, but need not necessarily perform the same using the mark distribution scale.

Scale	2-9	2-5	Mark distribution
2-9	1		
2-5	0.591	1	
Mark distribution	0.45	0.516	1

Table 6.14: Correlations between scales

6.3.5 Testing Eysenck's Theory

Eysenck[101] conducted investigations into cognitive consistency. He suggested that people who use a large range of responses on one questionnaire will use a large range on all questionnaires and visa-versa. A small investigation was carried out with the data obtained from this investigation to test whether this theory applies to AHP.

The average range of all the 2-9 bar results were compared to the average range of all the 2-5 bar results. These produce a correlation of 0.7. When the average range of the distance questionnaires 2-5 and 2-9 were compared they produced a correlation of 0.46.

The above results show that Eysenck's theory holds moderately well for pure opinion questionnaires but when there is a true answer the correlation is low.

6.3.6 Odd or Even

During data collection the question was raised as to whether the respondents used only odd numbers when answering or only even numbers or a mixture of both. This was investigated by looking at the 2-9 bar questionnaire responses.

It was found that out of the 42 questionnaires studied only 3 were made up entirely of odd numbers or entirely of even numbers. The analysis also looked at whether the majority of respondents use more odd numbers or visa-versa. This split turned out even with 21 respondents using more odd numbers than even and 21 respondents using more even numbers than odd. This shows that having the table included in the questionnaire pack explaining the numbering using odd numbers does not influence the respondent into using more odd numbers than even. This also confirms that the population sample is totally random.

6.4 Results of AHP Investigation

6.4.1 Random Index Values

The RI is inversely related to the CR. Changing RI changes the CR and therefore the perceived consistency. There is a different RI table for each scale. It is fairly obvious that the RI for the scale 1 –5 should not be used for determining the CR for the scale of 1 – 9. The appropriate RI needs to be used for a particular scale. By excluding 1 – 1 relationships from comparisons a different scale is produced. Therefore, by excluding 1 – 1 comparisons from a 1 – 9 scale, the scale becomes 2 – 9. The 1 – 9 RI should not be used with the 2 – 9 scale.

A major conclusion is that the RI values given by Saaty are not applicable when the scale is modified to remove the 1 – 1 comparison condition. Each scale has a unique RI table. The new RI values calculated in this research should be used.

6.4.2 Optimum Scale

A trend has been shown of lower CI values when a smaller scale is used, this is highlighted as the difference between the CI 2-9 scale and 2-5 scale. However when used in a real scenario and normalised with the relevant RI value the 1-5 and 2-5 scales proved less consistent. This coupled with the extra range of judgements make the 1-9 and 2-9 scales preferable.
Disallowing 1-1 comparisons does not stop the weights of factors coming out equal but does reduce the decision range and raises the RI needed. Therefore greater consistency is expected from a 1-9 scale than a 2-9 scale.

6.4.3 Types of questionnaire

It has been shown from a small study that the graphical type questionnaires seem to perform worse than the traditional number scale questionnaires in terms of consistency. The time taken to complete the graphical questionnaire is however, considerably less, by at least a factor of two. However, the greater ease of completing the graphical questionnaires may actual contribute to the higher inconsistency as a result of less diligence being used. Nevertheless, the reduced number of unusable responses suggest that further consideration should be given to these type of questionnaires.

For use in small samples and particularly when the respondent has an element of buy-into the result of the process, the data available suggests using the traditional numerical scale questionnaires will yield better consistency

6.4.4 Expected consistency levels

From analysis of the consistency ratios of the AHP questionnaires comparing distance, using the 2-9 comparison scale, it can be seen that the mean CR using the 2-9 RI is 0.095. The 95% confidence limit is 0.035 showing that nearly all respondents will have a CR below 0.13. This ratio is higher than that originally suggested by Saaty but seems more representative of the type of results achieved in real problems. For the AHP questionnaires comparing bar features and again considering the 2-9 scale, the CR is much higher with a mean of 0.191 and a 95% confidence limit of 0.057. This result is particularly striking, as respondents would rarely be expected to return a result exhibiting a CR of below 0.1, identified by many sources as the cut-off point. Clearly this shows that in real scenarios immediately discarding results of above 0.1 consistency cannot be justified.

On average consistency is better where a factual answer exists. When soliciting a pure opinion the CR was far higher. From these results it is possible to draw some realistic guidelines for the application of AHP to designer and constructor selection. When looking at the AHP returns of respondent companies there is no single correct answer that can be provided, however it would be expected that the company would have a well defined culture and details of that culture would appear within the AHP response. This culture will go a long way to defining the AHP comparison answers. It is therefore reasonable to expect a company to have a consistency ratio below that seen for respondents of a pure opinion questionnaire. It is shown, to 95% confidence, that any respondent to the bar questionnaire will exhibit a CR, of less than 0.248. It is therefore proposed that this value represents a cut-off point above which a designer or constructor would not be considered for the next round of the tender process. In contrast a well-defined answer can expect a CR below 0.13. Ideally any potential partners would produce responses below this value and these can realistically be considered consistent results. This raises the question of what should be done with results that exhibit moderate inconsistency, now defined as CR 0.13 to 0.25.

6.4.5 Handling of Inconsistent Results

The general consensus among academic papers written on the use of AHP (eg[102,103,104]) is that if results are inconsistent the problem should be reconsidered to improve consistency. This method is feasible for an individual comparing a number of items with a view to defining the best, because the decision belongs to that individual. The author has serious reservations as to the benefit of returning to an inconsistent constructor and asking them to reconsider their answers. It is highly likely that any interaction between the client and potential designers and constructors in this way would lead the respondent towards the answer the client wants and not necessarily the true view of the potential partner.

This provides some insight into the question as to whether the inconsistent constructor can, in fact, be simply removed from the tender list. The answer to this question falls into six categories of AHP result and can be seen in Table 6.15.

		Consistency		
		Consistent (CR<0.14)	Moderate Inconsistency (0.14<CR<0.25)	Inconsistent (0.25<CR)
Requirements Match	Good	Keep	Repeat	Discard
	Poor	Discard	Discard	Discard

Table 6.15: Categories for Consistency

If the result is consistent and does not represent a close match to the requirements of the client it can be deemed correct to remove that respondent from consideration. On the other hand if the respondent is consistent and closely matches requirements then that respondent would be carried forward to the next stage of the selection process.

This leaves the cases of inconsistent and moderately inconsistent respondents to be considered. Those that offer poor matches and poor or moderate consistency should be removed from consideration. Either they don't match requirements or do not really understand their own business or the aims of the client, hence the poor consistency. In any case they are likely to represent a poor choice of partner since they are unable to make a consistent assessment of what objectives are important.

The final category is made up of those respondents who appear to match the requirements but fall into the region of moderate inconsistency, as defined above. Only for this category of respondents would it be useful to return to and ask them to reconsider the answers they have provided. In doing this there is no risk of the respondent gaining an unfair advantage since they already seem to match the requirement. If on return of the reconsidered answer the respondent is still a good match and is now consistent they should be taken forward to the next stage, otherwise they would be removed from consideration.

Using this 6-zone approach ensures fairness by removing the opportunity for poorly matched respondents to gain an advantage in any reconsideration process but also does not discard potentially viable partners for being inconsistent initially.

6.4.6 Involving multiple people in decision

People in a company have a range of skills and experience. It is quite sensible to involve more than one person in a decision and the AHP can take account of this. Individuals should complete the AHP separately with an aggregation performed on the weights. The geometric mean should be used to average the weights.

6.5 Conclusions

The Analytical Hierarchy Process (AHP) has been found to be a valid decision making tool but is not universally applicable. It is particularly useful when the survey population is small and the respondents have a vested interest in the outcome such as the parties to a construction project.

It has been shown that the modified version of AHP used in this research is fundamentally different in approach to other uses. By distributing the questionnaires among the constructors being compared the relative point for comparisons is no longer held by the client, nor is it constant.

Analysis of Random Index (RI) values given by Saaty and used for this work has shown that they are not applicable when the scale is modified to remove the 1-1 comparison condition. Each scale has a relevant RI table and by removing 1-1 comparisons the scale is changed. The values required for a range of scales has been accurately calculated and should be used in future work.

From the results collected and analysed in this report, a 6-zone approach to deal with the range of responses anticipated when using AHP to select parties for a construction project is presented. Additionally, a firm cut off consistency ratio (CR) of 0.25 has been justified.

Not all issues have been definitively answered. Despite proving definite differences between AHP and points decision methods it has not been possible to categorically state that AHP provides a closer image of the respondents' real views, although this is expected to be the case.

AHP is a robust approach to decision making. Whilst concerns have been addressed over consistency it should be recalled that alternative methods have no mechanism to either measure such factors or provide traceability of results. This makes AHP ever more pertinent as decision makers are increasingly called upon to justify their choices.

7. Transferring Theory to Practice

7.1 Introduction

Gosport Borough Council (GBC) saw the Millennium scheme for the regeneration of Portsmouth Harbour as an ideal platform from which to develop an innovative method of construction project delivery. Gosport decided that they wished their projects to be delivered in a manner emulating the way in which the Hurst Spit project proceeded. The formal partnering approach was rejected by Gosport as being unsuitable for the following reasons:-

1. There could be no long term commitment
2. Procurement had to be by competitive tender
3. One of Gosport's officers had been involved with a failed partnering project
4. It was recognised that any contract that contained the word trust would be unenforceable
5. Standing orders prohibited the use of target costs or financial incentives.

The issues that Gosport considered vital to the success of their project reinforce the findings by the author at Hurst Spit and are given below:-

1. Companies that embraced Gosport's cultural values.
2. Companies that would work in co-operative manner
3. Consultants that recognised the value of the other participants being involved with the design process
4. Constructors that would wish to make an input to the design process
5. Integration of client and project objectives.

To satisfy the above issues, GBC recognised that a completely new procurement strategy was required. To make it completely clear to the council members, and to all participants that would subsequently become involved with the project it was necessary to distinguish this new contract strategy from partnering.

7.2 Details of the Methodology

The methodology was developed from the theoretical approach described previously. The new procedure involves five key phases as shown in Figure 7.1 and can be described as follows:

1. Analysis of client's objectives
2. Designer selection
3. Stage one constructor selection
4. Concurrent engineering phase
5. Stage two constructor selection

Within each of these stages, there are further integrated levels of analysis, measurement, evaluation and feedback. The project delivery process therefore involves an intrinsic co-operative method of working which also embraces some of the most crucial elements that multi-partner projects need to agree on. According to the latest report from the Construction Industry Council (CIC[13]), these success factors are namely; openness, clearly articulated mutual objectives, problem resolving structures, and commitment to continuous improvement.

Adopting a structured pre-selection process has enabled companies that share mutual objectives and embrace a co-operative working culture to be identified. Consequently the project is more likely to achieve or exceed the performance targets.

The five stages of the process, mentioned above, are described in this chapter as they were expected to operate for GBC's Millennium Bridge. The full details of the iterations and the final form of the process used are described in the following three chapters. A process map of initial methodology showing each key stage is shown in Figure 7.1. A general overview of each key stage will be explained followed by details of the mechanisms involved.

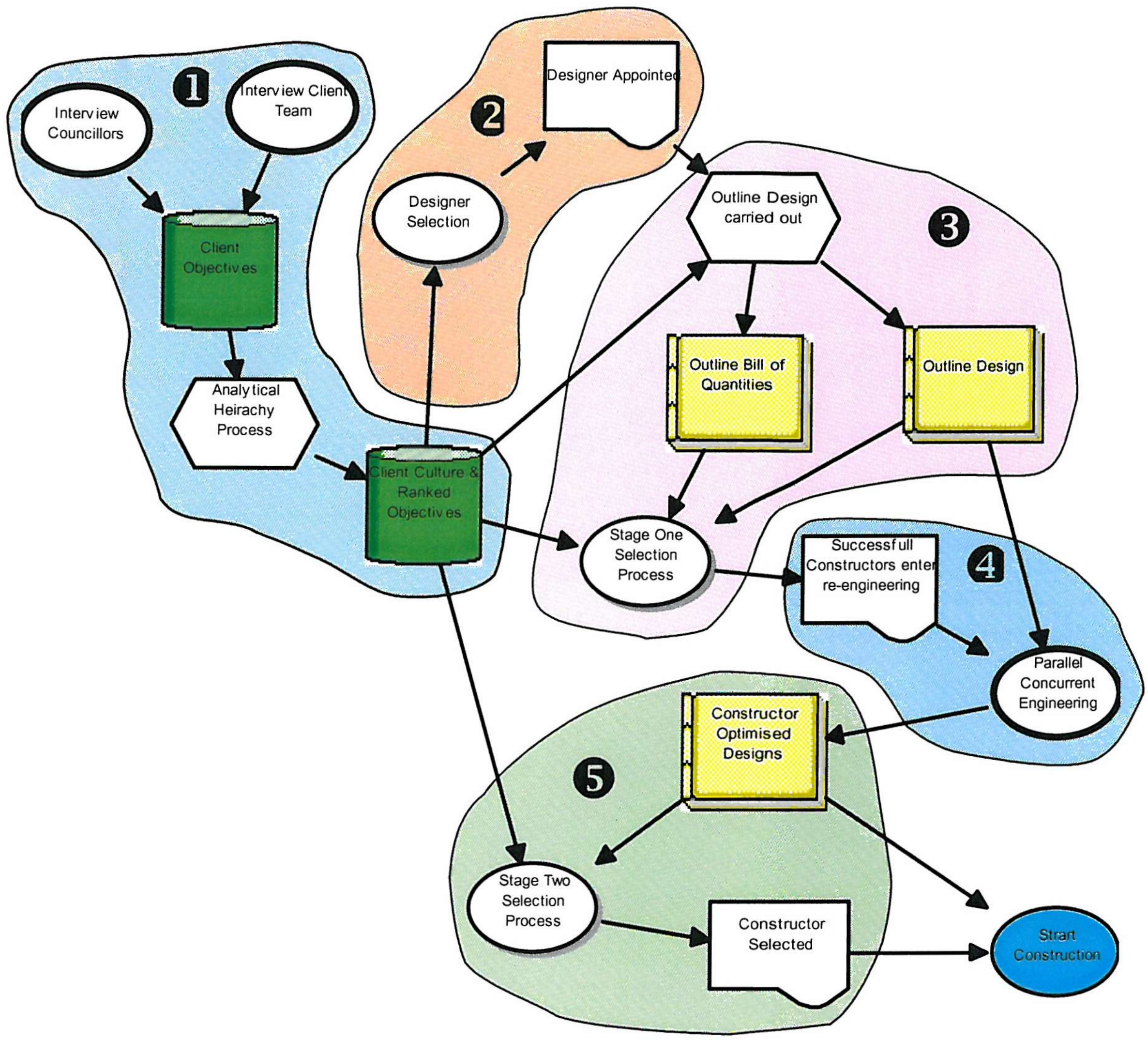

Figure 7.1: Systems View of Procurement Process

7.3 Phase 1: Analysis of Client's Objectives

This stage allows the true expectations and objectives of the project to be determined. For the project in question the council officers, the elected council members and the Millennium project team all had individual aspirations for the project. To identify the objectives the

Delphi method, as described in section 5.2, was used and all interested persons were invited to respond. This process identified 32 objectives, which were assembled into a hierarchy with 8 super-objectives. The next step was to prioritise the 8 super-objectives. It was expected that the analytic hierarchy process would be used to achieve this, but the Council Members were unhappy with using a method of prioritisation with which they were unable to understand how the process worked. The only respondents to use AHP were the GBC Millennium project manager and engineering advisor.

It was therefore necessary to adopt or devise an alternative method for prioritising the objectives by the Council Members. Five alternative methods had already been considered and rejected as described in chapter 5, therefore, an alternative method for prioritising the objectives was designed by the author. This method requires the respondent to assign 100 marks across the objectives according to their level of importance. This method was called Mark Distribution and the decision table for the Forton Lake Bridge Project is shown in Table 7.1.

Objective	Score
Quality	
Design	
Cost	
Culture	
Political	
Time	
Working Relationship	
Experience	
Total	100

Table 7.1: Mark Distribution Table for Bridge Objectives

The raw data forming the responses from the Millennium Project manager and the engineering advisor are given in Table A.1 and Table A.2 of Appendix A respectively. The raw data is assembled into a judgement matrix to enable the largest real eigenvector to be calculated to yield the priority rankings. The assembled data for the Millennium Project manager is shown in Table 7.2 and there follows an example of the calculations to determine the ranking of the criteria.

	Time	Culture	Experience	Political	Cost	Quality	Design	Working
Time	1	1/5	2	1/3	1/3	1/7	1/9	1/2
Culture	5	1	5	3	1/5	1/5	1/5	5
Experience	1/2	1/5	1	1/5	1/7	1/9	1/7	1/5
Political	3	1/3	5	1	1/7	1/9	1/7	2
Cost	3	5	7	7	1	1/5	1/3	3
Quality	7	5	9	9	5	1	2	9
Design	9	5	7	7	3	1/2	1	9
Working	2	1/5	5	1/2	1/3	1/9	1/9	1

Table 7.2: Assembled Data for Engineering Advisor

Formulating for an eigenvector solution gives:

$$\begin{bmatrix} 1.0000 & 0.2000 & 2.000 & 0.3333 & 0.3333 & 0.1429 & 0.1111 & 0.5000 \\ 5.0000 & 1.0000 & 5.0000 & 3.0000 & 0.2000 & 0.2000 & 0.2000 & 5.0000 \\ 0.5000 & 0.2000 & 1.0000 & 0.2000 & 0.1429 & 0.1111 & 0.1429 & 0.2000 \\ 3.0000 & 0.3333 & 5.0000 & 1.0000 & 0.1429 & 0.1111 & 0.1429 & 2.0000 \\ 3.0000 & 5.0000 & 7.0000 & 7.0000 & 1.0000 & 0.2000 & 0.3333 & 3.0000 \\ 7.0000 & 5.0000 & 9.0000 & 9.0000 & 5.0000 & 1.0000 & 2.0000 & 9.0000 \\ 9.0000 & 5.0000 & 7.0000 & 7.0000 & 3.0000 & 0.5000 & 1.0000 & 9.0000 \\ 2.0000 & 0.2000 & 5.0000 & 0.5000 & 0.3333 & 0.1111 & 0.1111 & 1.0000 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \\ x_8 \end{bmatrix} = \lambda \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \\ x_8 \end{bmatrix}$$

Solving using Matlab gives eigenvectors of:

$$\begin{bmatrix} -0.0567 & 0.0173 - 0.0517i & 0.0173 + 0.0517i & 0.0244 + 0.0076i & 0.0244 - 0.0076i & 0.0323 + 0.0886i & 0.0323 - 0.0886i & -0.4293 \\ -0.1835 & -0.1776 + 0.1204i & -0.1776 - 0.1204i & 0.0577 - 0.1836i & 0.0577 + 0.1836i & -0.0036 + 0.1419i & -0.0036 - 0.1419i & 0.4146 \\ -0.0379 & 0.0184 - 0.0375i & 0.0184 + 0.0375i & -0.0353 - 0.0390i & -0.0353 + 0.0390i & 0.0057 - 0.0256i & 0.0057 + 0.0256i & 0.1117 \\ -0.0972 & -0.1139 - 0.0097i & -0.1139 + 0.0097i & -0.0118 - 0.0043i & -0.0118 + 0.0043i & 0.0034 - 0.0995i & 0.0034 + 0.0995i & -0.4138 \\ -0.3221 & 0.1576 + 0.4473i & 0.1576 - 0.4473i & -0.4239 + 0.2634i & -0.4239 - 0.2634i & -0.0682 + 0.0029i & -0.0682 - 0.0029i & -0.2028 \\ -0.7366 & 0.7343 & 0.7343 & 0.7401 & 0.7401 & -0.7440 & -0.7440 & 0.4321 \\ -0.5474 & 0.3140 + 0.2602i & 0.3140 - 0.2602i & 0.3906 - 0.0240i & 0.3906 + 0.0240i & 0.6204 - 0.1212i & 0.6204 + 0.1212i & -0.0324 \\ -0.0791 & -0.0512 - 0.0555i & -0.0512 + 0.0555i & 0.0150 + 0.0959i & 0.0150 - 0.0959i & -0.0427 - 0.0295i & -0.0427 + 0.0295i & 0.4809 \end{bmatrix}$$

And corresponding eigenvalues of:

$$\begin{bmatrix} 9.0748 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ 0.0000 & 0.0870+2.8222i & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.0870-2.8222i & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & -0.5766+1.1866i & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 & -0.5766-1.1866i & 0.0000 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & -0.0827+0.3905i & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & -0.0827-0.3905i & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0698 \end{bmatrix}$$

The largest real eigenvalue is 9.0748 and the corresponding eigenvector is:

$$\begin{bmatrix} -0.0567 \\ -0.1835 \\ -0.0379 \\ -0.0972 \\ -0.3221 \\ -0.7366 \\ -0.5474 \\ -0.0791 \end{bmatrix}$$

giving the normalised eigenvector

$$\begin{bmatrix} 0.0275 \\ 0.0890 \\ 0.0184 \\ 0.0472 \\ 0.1563 \\ 0.3575 \\ 0.2657 \\ 0.0384 \end{bmatrix}$$

This gives the ranking of the alternatives as

TIME	3%
CULTURE	9%
EXPERIENCE	2%
POLITICAL	5%
COST	16%
QUALITY	36%
DESIGN	27%
WORKING RELATIONSHIP	4%

$$CI = \frac{(\lambda_{max} - n)}{(n-1)}$$

$$CI = \frac{(9.0748\ \text{-}8)}{(8-1)}$$

CI =0.1535

Number of Criteria (n)	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table 7.3: Values of Random Index (Saaty[94])

Using RI = 1.41 for 8 criteria

$$CR = \frac{0.1535}{1.41}$$

Giving a consistency ratio of:

$CR = 0.1089$

This value is slightly more than the value of 0.1 suggested by Saaty[94] but considerably less than the threshold level established by the research detailed in Chapter 6. Therefore this result was deemed to be acceptable. The calculations to determine the results from all other respondents were identical to those shown above.

The raw data provided by the five Gosport Borough Council Members who responded is given in Table A.3 to Table A.7of Appendix A. The average scores calculated from the raw data is given in Table 7.4.

TIME	34%
CULTURE	25%
EXPERIENCE	14%
POLITICAL	5%
COST	4%
QUALITY	9%
DESIGN	5%
WORKING RELATIONSHIP	4%

Table 7.4: Average of Members' Scores

The average scores from the Council Officers using AHP were very similar to the average scores from the Members using Mark Distribution. It was agreed with the Officers and Members that, as AHP has greater mathematical rigour than Mark Distribution, the average of the officers' scores would be used for the project. The final ranking of the objectives is shown in Table 7.5.

Super Objective	Importance	Sub-objective
Quality	32%	To ensure that design quality translates effectively into physical quality To provide a structure with low maintenance and operating costs To engage designers with formal QA type procedures To provide a structure that will be of a quality worthy of being referred to as a "Millennial structure"
Design	29%	To engage designers who have a proven record of flair and initiative To engage designers who are able to show a grasp of a Millennial brand and concept To produce a structure that is sympathetic to environmental and planning issues To produce a design that is both individual and intellectually challenging
Cost	17%	The need to ensure that budgets are not exceeded or significantly underspent The need to balance capital expenditure against operational and maintenance costs of the structure The desire to examine options to enable choices to be made about costs The need to ensure a balance between the cost of any solution and its effectiveness
Culture	7%	A desire to work with organisations which understand the Local Government culture including issues such as probity A willingness to embrace new ideas and concepts A desire to work with others in a co-operative manner The need to work with others who are for flexibility in thinking and working methods
Political	6%	To meet the valid expectations of Bodies such as English Heritage and English Nature To meet the requirements of the Millennium Commission To reconcile the potentially different needs of the County Council and the Borough Council To recognise that any Gosport project is part of an overall Portsmouth Harbour wide scheme
Time	3%	The length of the overall design and construction period including any period required for a Public Enquiry Ability of Designers to forecast programmes accurately Completing works by dates agreed with the Millennium Commission The desire to examine options to enable choices to be made about the length of the overall programme.
Working Relationship	3%	To engage designers who will be able to communicate easily and effectively with the Council To engage designers who will be able to assist the Council throughout the project in its dealings with various parties To engage designers who are sympathetic to the Councils requirements To engage designers who are compatible with the Councils culture
Experience	2%	To engage designers who are able to demonstrate a record of building structures of proven quality To engage designers who can demonstrate a successful record at Public Enquiries To engage designers who have a proven record of producing structures that are adopted by the Highway Authority To engage designers who have been proven to produce designs with flair and imagination

Table 7.5: Ranking of Objectives for Designers

It was considered necessary to investigate the meaning of these results. The funding for the bridge was being provided by the Millennium Commission, but this funding would only become available following completion of a bridge of Millennial quality. However, there no guidelines as to what constitutes Millennial quality and therefore, quality and design were considered to be the key elements in ensuring receipt of the funding. The next most important objective was cost. Gosport is a relatively poor Local Authority and additional funding for any cost overrun would be difficult to obtain. Political and cultural issues were thought to be an issue because of the number of organisations having an interest in the project. There was considered to be ample time for the project to be completed and the Millennium Commission was flexible on completion dates. The only issue was that once deadlines were agreed they had to be met. It was expected that project progress would be better if a good working relationship between the Council and designers existed, although this was desirable rather than essential. The experience of the designers was not considered to be an issue because the Council's standing orders would prevent engagement of any designers without suitable experience. In this case, standing orders required the designers to have a track record of designing moving bridges.

Undertaking this process caused the exact expectations and objectives for the project to be investigated. This enabled all parties subsequently engaged on the project to be provided with a clear statement of the expectations and objectives for the project.

7.4 Phase 2: Designer selection

A detailed process map of this stage in the process is shown in Figure 7.2. Only designers with an established track record of designing bridges were accepted onto the pre-qualification list.

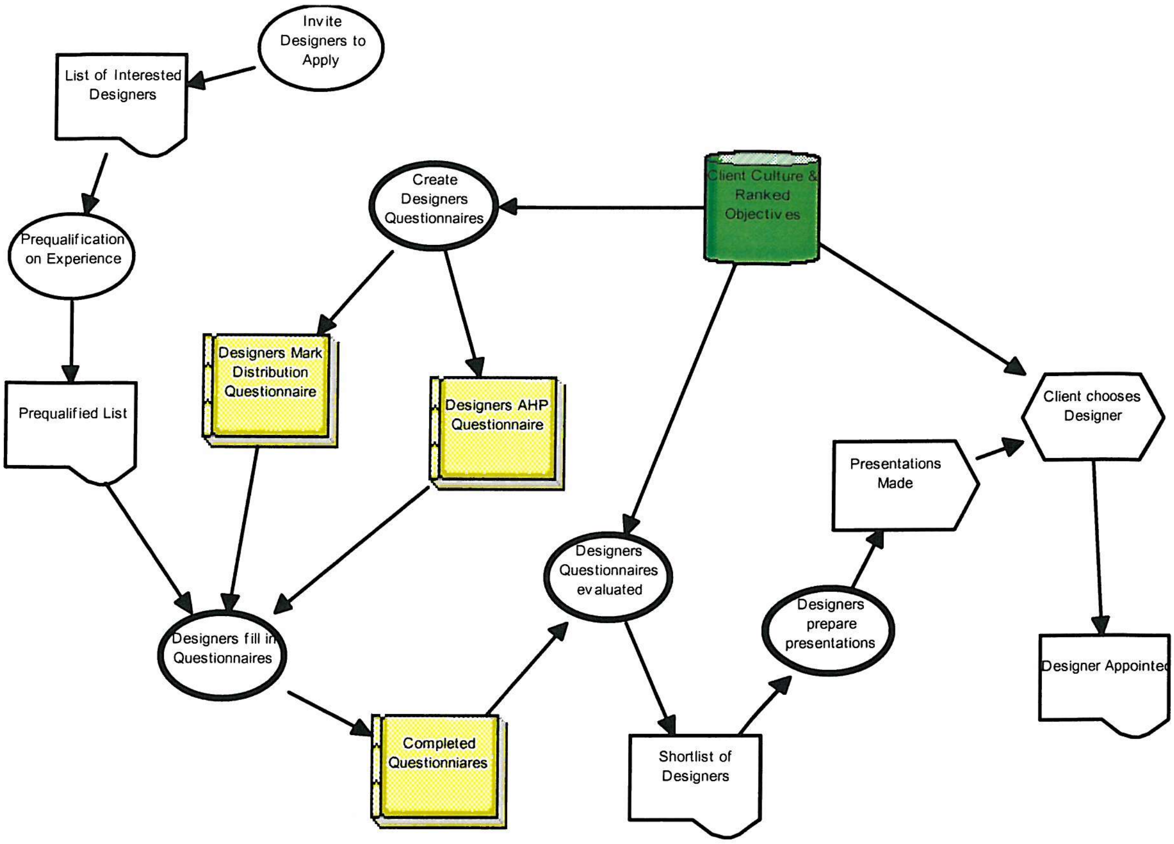

Figure 7.2: Designer Selection Process

Two questionnaires were designed in order to investigate four issues which were ranked in the order shown below:-

1. The attitude towards the involvement of constructors in the design process
2. Areas of concern for the client
3. The organisational culture of prospective designers
4. The long-term benefits to the client.

The two questionnaires were in the form of an AHP questionnaire and a mark distribution questionnaire. The AHP questionnaire was used to validate the responses to the mark distribution questionnaire. This was to ensure that the responses were the genuine views of the organisation and not simply responses that it was thought the client might like to hear.

An example of how this worked comes from the questions relating to involving constructors in the design process. It was clear from the responses, that of the sixteen organisations responding to these questionnaires, two considered that constructors had nothing to input to the design process. This was not in agreement with the view of the client.

Four organisations were short listed by using the questionnaire responses and asked to make a half-day presentation of their scheme design to the council. They were instructed that the presentations should be made by people who would be involved in the project and not by marketing departments. The successful company had assembled a team consisting of a structural engineer, an architect, an environmental consultant and a mechanical engineer. This proved to be the most balanced team and, in presenting their scheme, and able to address all of the concerns of GBC. The designers were then asked to prepare an outline design and bill of quantities.

7.5 Phase 3: Stage one constructor selection

This process is shown in Figure 7.3. The initial part of the process is similar to that of the selection process for the designers. The same combination of mark distribution and AHP questionnaires were used but the individual questions were redesigned for constructors.

Again, as an example of the effectiveness of the process, analysis of the responses revealed that three of the thirteen constructors responding to the questionnaires felt that they had nothing to contribute to the design process.

Following analysis of the questionnaires four constructors were short listed. The constructors shortlisted by this process were required to submit a tender based on the bill of quantities and a quality submission which addressed the specific issues detailed in the tender documents. Constructors were obliged to satisfy the quality requirement for the project in their tender submissions before their cost submissions were evaluated. One constructor was rejected for the project based on their quality submission alone without their cost submission being opened. Constructors who were successful were then invited to enter the second phase of the selection process.

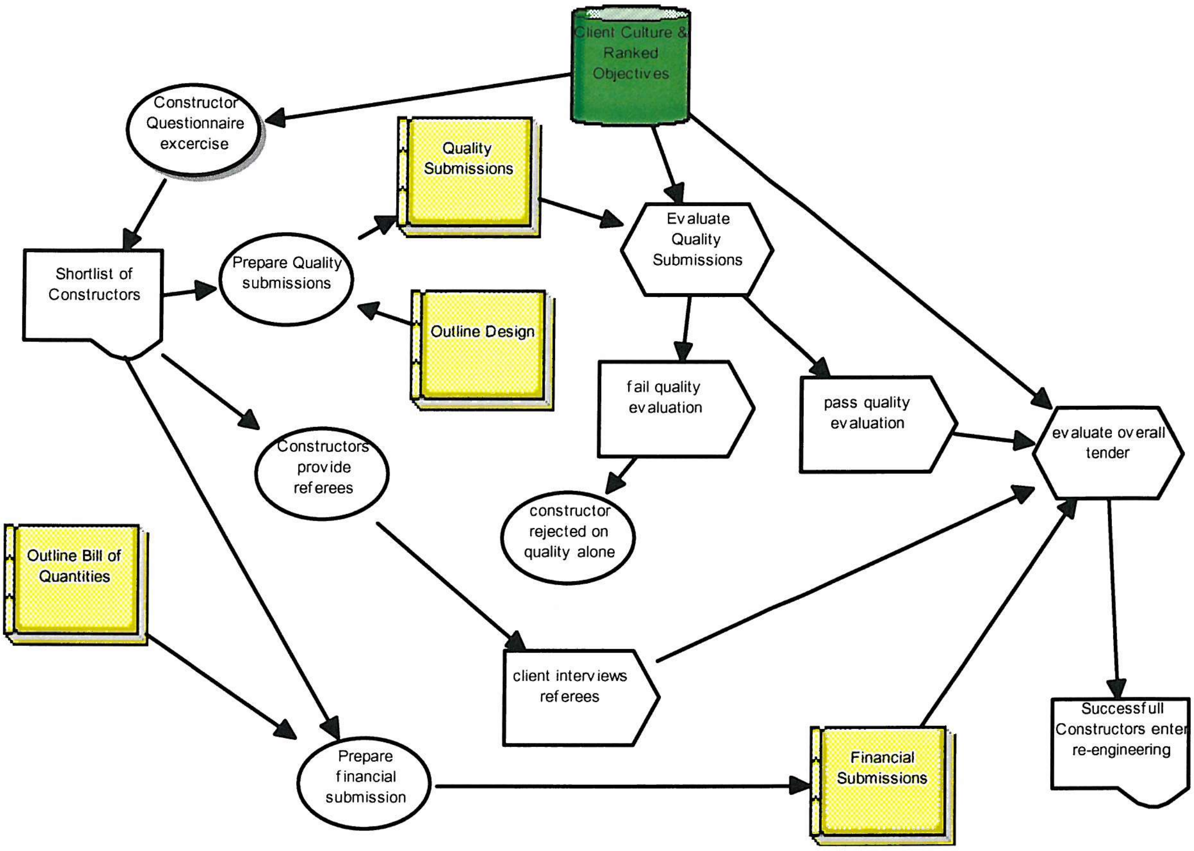

Figure 7.3: Stage 1 Constructor Selection

7.6 Concurrent engineering phase

This process involved each of the constructors working independently with the designers to improve the buildability of the project, improve the quality and reduce the risk to all parties. This results in a bespoke design for each constructor suited to their own particular expertise and preferred method of working. GBC agreed that unsuccessful constructors could claim reimbursement for the time spent working on the project once the final selection had been made. However, no applications for payment were received. Investigation of why none of the unsuccessful constructors claimed the payment offered revealed that it was considered that this was just a tendering process in a different guise and incurred the same cost as traditional tendering. More significantly, the two companies which undertook the value engineering process successfully felt that this was an opportunity to engage in exciting and rewarding engineering.

7.7 Stage two constructor selection

The overall process is shown in Figure 7.4. Following completion of the previous task the constructors were required to make a revised quality and price submission. The final selection was made on the basis of 60% cost and 40% quality. Cost was calculated by the reduction from the scheme budget expressed as a percentage of the maximum reduction offered. Quality was assessed by a 1 – 5 scoring system on 20 separate issues previously identified and shown in Appendix M.

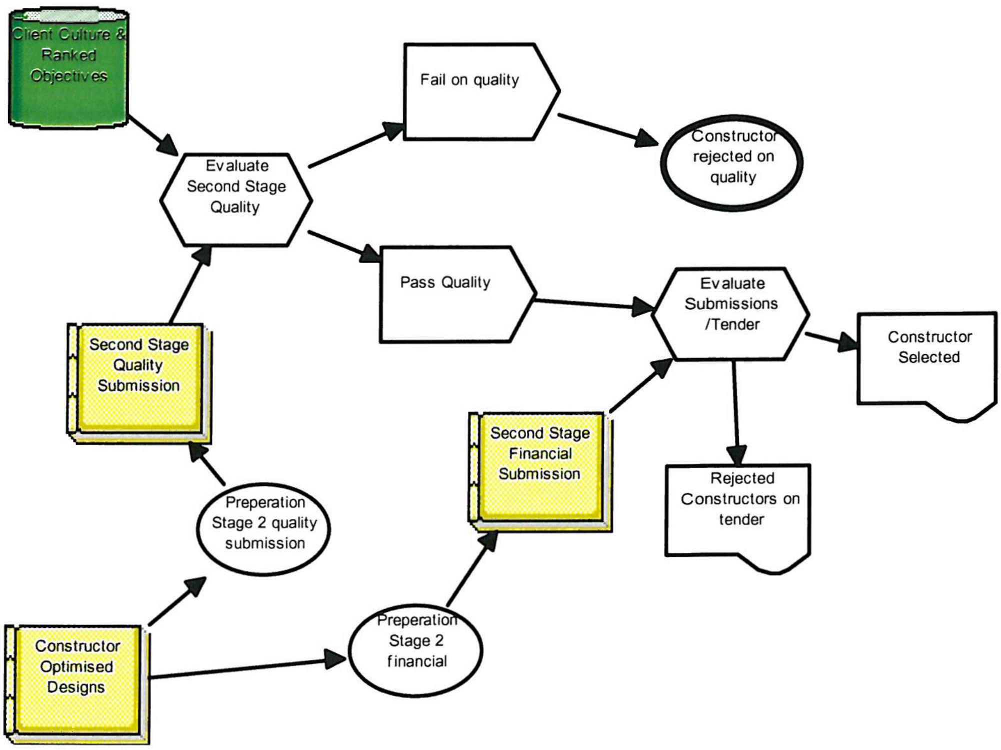

Figure 7.4: Stage 2 Constructor Selection

7.8 Conclusions

The process detailed in this chapter provided great assistance to Gosport Borough Council in selecting the parties for the construction of Forton Lake Bridge. However, a number of unexpected problems were encountered. The Analytical Hierarchy Process had been selected as the main tool to use for prioritising the project objectives and it had not been expected that the Council Members would not wish to use AHP because of the opacity of the process. In deed, this was one of the reasons for selecting this method. The Mark Distribution questionnaire which was designed to overcome this problem worked well and gave results similar to those produced by AHP.

The value of conducting a rigorous analysis of project objectives was demonstrated by the results of the process. The significantly greater importance attached to quality and design than cost and time is in contrast to conventional thinking (eg Audit Commission[3]). It is likely, therefore, that without this process the project could have been undertaken with a different set of goals.

The problem of inconsistent results from the AHP questionnaire was also an issue which needed to be addressed. In particular, should results which were inconsistent be accepted or should companies submitting inconsistent results be rejected by Gosport Borough Council? Secondly, was the value of 0.1, as proposed by Saaty[94], the most appropriate maximum value to use to judge inconsistency or should another value be considered? These issues were investigated and are reported in chapter 6. Following this investigation companies submitting results with a consistency ratio greater than 0.25 were rejected.

The final point of interest was that the results for prioritisation of the objectives by the Council Officers were very similar to those from the Council members. The reasons for this were thought to be that although Council members are likely to have different agendas to officers, such as re-election, members are regularly briefed by officers, so the members' results are likely to be a reflection of the officers' briefings. Subsequent discussions with some of the officers and members confirmed that this was probably the case and that as members are likely to defer to the views of officers, it probably not necessary to involve members in the detailed decision making process.

8. Details of the Refined Selection Process as Implemented

8.1 The Project

The first project used to develop and refine the methodology was a bridge that was built as part of Gosport Borough Council's Millennium scheme. The bridge was built across Forton Lake and was to replace an existing bridge that had been constructed by the Ministry of Defence and had collapsed. The new bridge was to be approximately 6m wide and 150m long with a moveable section in order to maintain a navigable channel. The project was further complicated by being located in a Site of Special Scientific Interest (SSSI).

The methodology was further refined and tested on two more of Gosport's Millennium projects which are not described in detail in this thesis although the outcomes are discussed in chapter 11.

8.2 The Client

The project was commissioned by Gosport Borough Council (GBC). The client was defined as a sub-committee of council members representing the full council. The council appointed two officers to a project management team who were responsible for the day to day running of the project. However, the project will eventually be funded by the Millennium Commission, which will only reimburse GBC if the bridge is of "Millennial Quality" and completed by June 2001. This has necessitated GBC insuring against non-payment by the Millennium Commission. In addition, the term "Millennial Quality" is not defined, and hence the expectations and goals of the financiers are unknown. As a result of previous work undertaken by the Business Engineering Group (BEG) with New Forest District Council, GBC approached BEG to enlist their assistance in developing a new method of project procurement. The client's objectives were to achieve the benefits of a partnering way of working but without offering any incentives or long term commitment. For this reason the procurement process is referred to as "Project Delivery Process" (PDP), to distinguish it from partnering.

8.3 Project Objectives

The first stage of the process was considered initially to consist of asking the client to rank the following project success criteria:-

1. Project delivery in minimum time
2. Project delivery at minimum cost
3. Project delivery with Millennial quality

Initial discussions with the two council officers on the project management team showed that these three objectives were an over simplification of the client's objectives and expectations. Although these discussions were held with only two of the officers, the members were briefed by the officers and it was agreed that this was a correct assessment.

It was decided that the project objectives needed to be determined by all members of the council that wished to have an input with no prior constraints or limitations on what the objectives could be. The result was the objectives already mentioned and shown in Table 7.5. This shows eight key objectives with each objective being divided into sub-objectives. The objectives were grouped into the eight key objectives because it was felt that there were too many objectives to work with.

8.4 Prioritising of Objectives

It was anticipated that the Analytical Hierarchy Process (AHP) would be used to prioritise the objectives and hence provide quantitative rankings. However, due to the large number of council members and officers who wished to make an input to the PDP an alternative method of prioritisation which would be less time consuming and more transparent was used. This consisted of a mark distribution questionnaire as shown in Figure 8.1. Respondents were required to assign a score to each objective, so that the total of all scores was 100. The scores for each objective from every completed questionnaire were summed and the objectives ranked according to their total score. Ultimately, only five members completed this questionnaire, far fewer than originally expected. Questionnaires of this generic format have been developed and used throughout this research.

Objective Explored	Marks Awarded
Cost (The need to ensure that budgets are not exceeded or significantly underspent)	
Culture (The desire to work with organisations who understand Local Government culture)	
Design (To engage designers who are able to show a grasp of a Millennial brand and concept)	
Experience (To engage designers who have a proven record of flair and initiative)	
Political (To meet the requirements of the Millennium Commission)	
Quality (To provide a structure that will be of a quality worthy of being referred to as a "Millennial structure")	
Time (Completing works by dates agreed with the Millennium Commission)	
Working Relationship (To engage designers who will be able to communicate easily and effectively with the Council)	
Total	100

Figure 8.1 Mark Distribution questionnaire

AHP analysis of the objectives was undertaken by the two Gosport officers on the project management team and the results are shown in Appendix A. The results of the mark distribution questionnaires and AHP were very similar. The major surprise coming from these results was that cost was ranked in third place by both officers. This issue was investigated in depth as it was considered to be of importance. Discussions with the client revealed that there was concern that if the project was not of suitable quality the Millennium Commission might withhold funding, and also if a quality project could be produced then additional funds could be obtained if necessary to cover any shortfall in Millennium Commission funding.

It was decided the project objectives would be taken as the mean of the two results provided by officers of the project management team and are shown in Appendix B. These results then produce a set of objectives unique to this project and to GBC. These objectives formed the basis for selecting the consultants and constructor for the project, by ensuring congruency of objectives.

Ultimately it is anticipated that AHP will be used to prioritise the sub-objectives. However, at this stage interest lay in establishing a proof of concept of the use of AHP for establishing congruency of objectives. It was also considered that whilst the prime objectives appeared to be a comprehensive representation of GBC's expectations, further work was required to compile a comprehensive list of sub-objectives. Work to date suggests that several of these sub-objectives will themselves require sub-dividing. It also became clear that the principle objectives were client specific rather than client and project specific. This was identified as being a result of the GBC members focusing on the process of project delivery rather than creating an integrated set of product and process objectives. This phenomenon was to evince itself at the consultants' interviews when it became clear that the council had a different prioritisation of objectives for the product. The council officers suggested that the reason for this was that council members are elected for relatively short periods so their immediate concern is for re-election at the next election, so that rather than take a long term view they tend to focus on the issues that will give rise to more votes from the electorate.

It was clear that this problem had to be addressed. It is proposed that two sets of success criteria were established: one for the process and one for the product. These two sets of criteria can then be prioritised using AHP and some method of assessing the relative contributions to the project as a whole from process and project be utilised. This will enable an integrated set of criteria to be established which includes product and process. This approach was used for the next Millennium project; the off-shore pontoons and walkway.

The pontoon and walkway project differed from the bridge in three aspects. Firstly, it was of much smaller value, only £300,000 rather than £2,000,000 for the bridge. Secondly, the design was carried out in-house and the selection methodology was only used for the selection of the constructors. Thirdly, Gosport Borough Council had experience of delivering similar projects. Just as with the bridge, the overwhelming concern was to deliver a project of 'Millennial Quality' and so ensure release of the funds by the Millennium Commission. Because of this, it was agreed with both officers and members that the objectives for this project were identical to those for the bridge. Therefore, the process of identifying and prioritising the project objectives was not repeated for this project. As a result of confidence in the selection process and the small scale of the project, the final selection was made prior to carrying out value engineering. Therefore, the value engineering process was only conducted with one constructor.

The selection process performed well and the constructor selected worked well with the Gosport Borough Council's engineers. All of the AHP questionnaire responses received had been complete correctly and there were no consistency ratios greater than 0.25. The project was completed ahead of schedule and to budget and the Millennium Commission duly made the funds for the project available.

8.5 Conclusions

The process of identifying and prioritising the objectives worked well and clearly showed the overriding importance given to ensuring that the Millennium Commission realised the funds for the projects. Given the initial enthusiasm for the process and the number of who initially returned data for the process the final response of only five questionnaires from members was disappointing. Investigation suggested that most members were happy to accept and follow advice from officers and that it was considered the role of members on the Millennium Project Committee to undertake the more detailed tasks. There were apparent discrepancies between the prioritisation of objectives given by the questionnaires and those stated later by members, particularly during the consultants' interviews. The true reason for this was never fully discovered but it was possible that because of overspending by the Council at that time, the possibility of cost savings on the Millennium projects was being considered. A subsequent interview with two of the Council members provided confirmation that the project objectives were still as identified and prioritised by the selection process.

9. Designer Selection

9.1 Methodology

The approach to consultant selection was to attempt to identify those consultants that had the greatest congruency of understanding of the success criteria with GBC. In appraising consultants cognisance was to be given to congruency of sub-objectives as well as the super objectives.

It was anticipated that the main tool for selecting consultants would be AHP. To simplify presentation of the prioritisation process, the pairwise judgements required for AHP were presented in the form of a table rather than a matrix. A slight variation from traditional AHP was introduced which prevented any of the success criteria being assigned equal weightings. This was to ensure that, for example, equal importance could not be placed on lowest cost, shortest time and maximum quality. However, the large number of sub-objectives would make an AHP questionnaire too long and an addition selection method needed to be added. After discussions with the project officers it was decided to adopt a form of the mark distribution questionnaire to explore in detail the designers' views on the issues that were important to Gosport. Selection was made by first considering the AHP results and then using the mark distribution results to shortlist four companies.

Fourteen mark distribution questions were assembled which addressed the issues that GBC considered to be most important and required addressing in the project delivery process. There was no requirement for any particular number of questions and fourteen came about through being the number of questions required to adequately address all of the issues. Every question was given seven possible answers which were structured to investigate the issues of time, culture, experience political, cost, quality and design shown in Table 7.5. Having compiled the questionnaires, the two officers of the project management team were asked to assign marks as they felt appropriate and the results are shown in Appendix C. Selection of consultant was based on the theory that the companies whose scores most resembled those provided by GBC would probably have the most similar culture. It was also considered that the results of these questions would be valuable for the interview stage of the selection process.

One other factor was considered to be important. GBC were keen to engage consultants that would work as part of a team and not behave as prima donnas. To investigate this, a second AHP investigation was used. In this question the consultants were asked to rank the relative importance of the client, consultant and constructor in producing a prestigious project. The complete questionnaire is shown in Appendix D.

It was recognised that company culture was a significant factor, and an insight into this culture could be gained by finding out who filled in the questionnaire and why they were chosen. The people answering the questionnaire were either architects or engineers ranging from graduates to partners except for one who was a marketing manager with no apparent engineering experience.

It was also thought important to ask the companies responding to describe their own culture, essentially as a means of comparing the way in which they thought of themselves with the outcome of the questionnaire results. None of the companies responding were able to adequately describe their culture. The most common response was a list of previous projects or details of company structure. The reasons for the inability to describe culture are not clear but are outside the scope of this research.

In addition, the consultants were advised that any answers provided either in the questionnaire or during the interview may be incorporated into the contract. At the time it was thought that this would ensure that the company selected would perform in the manner they had described. However, it was agreed later with the project officers and Council's auditor that this was inconsistent with the trusting relationship expected to develop and was likely to be counter productive. Furthermore, this would results in a bespoke contract which might not be enforceable.

9.2 The AHP Results

To maintain anonymity and to respect commercial confidentiality , the responding companies are numbered from 1 to 16.

Analysis of the results revealed an unexpected problem. Ten of the sixteen results were shown to be inconsistent in prioritising of the project objectives as shown in Appendix E. These results had a consistency ratio of greater than 0.1, the maximum value suggested by

Saaty[94], with some being more than double this value. This posed the questions: can a company be accepted or rejected on the basis of inconsistent results and what is the meaning of inconsistency. This problem led to a complete change in the selection process. There was sufficient uncertainty in the results to cast doubt on the reliability of selection based on a comparison with GBC results.

It was decided that the eight project objectives could be place into two broad categories: hard and soft issues. Culture, political and working relations were classed as soft issues, the others were considered hard issues. The companies were ranked by taking the sum of the percentage scores given to the soft issues. The reasoning for this was that all of the companies were assumed to be technically competent and so the difference between them lay in the soft issues.

The second AHP questionnaire also had a problem with inconsistency: seven of the sixteen companies returned inconsistent results as shown in Appendix E. This was even more surprising since there were only three criteria to prioritise. Initially the companies were ranked in the reverse order of how much importance they placed on the role of the consultant. It was reasoned by Latham[11] that the greater the level of importance attached to the consultant, the lesser the importance was attached to team work. However, after discussions with the project officers it was decided that little information could be gained from this questionnaire, particularly given the level of inconsistency, but the results could be investigated further at the interview stage.

9.3 Mark Distribution Questionnaire

The results of the mark distribution questionnaire are given in Appendix F. Several companies gave marks which did not sum to one hundred. Where this happened the marks were scaled to add to one hundred and this would be addressed further if the companies were selected to proceed to the second stage.

After detailed discussions with the project officers and three of the Council members it was decided that the most vital questions were 5, 8 and 13 and that the answers to the other questions should be ignored initially. These remaining questions would be explored in more detail in interviews. The answers to questions 5, 8 and 13 are addressed in more detail below.

The responses to one question are of particular interest. Question 13 (Table 9.1) asked "why do you believe your organisation can best deliver the concept of a Millennium project" with one possible answer being "We will be able to devote sufficient time and resources to the scheme to ensure that the Millennium concepts are fully addressed".

Question - 13 Why do you believe that your organisation can best deliver the concept of a Millennium project ?		**Marks Awarded**
Answer 1	We will be able to devote sufficient time and resources to the scheme to ensure that the Millennium concepts are fully addressed	
Answer 2	We will work closely with the client to capture the local character and culture in order to incorporate its spirit into the project	
Answer 3	Our experience on prestige projects is such that the Millennial concept is well within the scope of the organisation	
Answer 4	We are ideally suited to working with the client to understand the concepts and interrelationships they have with other parties to the overall project delivery	
Answer 5	I will ensure that design costs are minimised in order to maximise funding for the construction costs	
Answer 6	Our office procedures will ensure that a high quality product with low maintenance costs is delivered	
Answer 7	We will bring individual design flair to produce a scheme that is Millennial in terms of quality	

Table 9.1 Question 13

At the time of compiling the questionnaire this answer was almost removed, because it was considered that every company would be prepared to and see the need to devote sufficient time and resources to the project and so there was little point in asking the question. It is interesting that the two companies that gave zero marks to answer 1 assigned over two thirds of their marks to answers three and four. These two answers were considered to be contradictory, with answer three being an arrogant response. Ultimately these two companies were not invited to the next stage of the selection process and this was predominantly as a result of assigning zero marks to answer 1.

Question 5 (Table 9.2) addresses the issue of involving the constructor during the design stage. It had been decided that any companies not assigning marks to answers 4 and 5 of this question would not be selected for the next stage. These are the only two answers to this question which suggest that the consultant answering this question sees benefit in involving the constructor during the design stage.

Question - 5	**Would the buildability of the project be enhanced by appointing a constructor during the design stage ?**	**Marks Awarded**
Answer 1	Possibly but only at the risk of lengthening the design process	
Answer 2	It is difficult to see what meaningful advantage could be gained by this since working with a constructor at the design stage would be difficult to achieve	
Answer 3	There would only be a minimal advantage in view of our experience on project of this nature	
Answer 4	Yes but such a procedure could be difficult for a Local Authority to achieve	
Answer 5	There would be advantages to this but overall the cost of the project could increase	
Answer 6	Buildability is closely linked to the quality of the finished product but quality can best be achieved by appropriate levels of site supervision	
Answer 7	Buildability relies essentially on good design and so little advantage is seen in this	

Table 9.2 Question 5

Question 8 (Table 9.3) considers the issue of integration and team building. Answer 1 is the only answer which takes a positive view on this issue. It was therefore decided again, that any companies assigning no marks to this answer would be not be selected for the next stage as this was seen as a key issue.

Question - 8 How relevant is it in a project of this nature to involve the client, the Consultant, the constructor, sub-contractor and suppliers in all decision making processes ?		**Marks Awarded**
Answer 1	This would be a suitable goal if sufficient time is available	
Answer 2	There are inherent difficulties in undertaking this type of exercise which limits its value	
Answer 3	A good designer has sufficient experience in projects of this nature such that they do not need any significant input from other "players" in the construction industry	
Answer 4	It is best to clearly differentiate the respective roles of all the parties to a project if contractual difficulties are to be avoided	
Answer 5	If time permitted the additional hidden cost of this is difficult for a public body to justify	
Answer 6	For a Millennial project it is more important to concentrate on supervision in order to achieve a quality product	
Answer 7	If a Millennial quality structure is to be produced it is dangerous to embark on a process of "design by committee"	

Table 9.3 Question 8

Using the above criteria the following companies were selected:-

- 2, 7 16
- 5,8
- 9
- 12
- 14

Companies 2,7,16 and 5,8 had assembled themselves into teams. These companies were then invited for interview. However, company 14 declined to come to interview and withdrew from the project.

A company that had been rejected telephoned the client and advised the client that an unwise decision had been made. This company told the client that they were the best bridge designers available and could not possibly be rejected. The attitude of this company suggests that the methodology had correctly eliminated this company who appeared to have no interest in working as part of a team. Subsequently this company spoke with the author to request assistance with working in a later partnering contract.

9.4 The Interview

The companies that were invited for interview were instructed to attend with a team that they felt was most appropriate for the project and make a presentation using the personnel that would actually be working on the project. In addition, they were asked to present some outline designs for the bridge. A set of questions was compiled to address the issues already identified as important. The answers to these questions were used to assist in ranking the companies. A copy of the questions is shown in Appendix G.

The approach of the companies attending the interviews is summarised as follows:-

1. Only two companies used people that were actually going to work on the project to make the presentation

2. Only one company had assembled a team that addressed the key issues of the project

3. Two companies could not embrace the concept of partnering without providing a financial incentive

4. One company saw no benefit in early constructor involvement.

The client's principal areas of concern were the need to build a bridge of Millennial Quality, as discussed in section 7.3. The task was made difficult because, firstly, the bridge was to be constructed across a Site of Special Scientific Interest (SSSI). Secondly, in order to complete the construction within an acceptable timescale the need for a public enquiry had to be avoided and thirdly, there was the requirement to construct a bridge with a moveable section. At this time no decision had been made by the client concerning the moveable section and designers were free to suggest lifting, rotating or sliding sections. The original bridge used a novel sliding section.

The company that was ultimately selected were instructed that as a condition of appointment they would be expected to assist in working towards avoiding a public enquiry to which they enthusiastically agreed. This company had assembled a team consisting of:-

1. Two civil engineers
2. One mechanical engineer
3. One architect
4. Two environmental consultants

This in itself gave the client confidence in the ability of the company to successfully deliver the project as the team appeared well balanced with specialists in what were expected to be the difficult disciplines. This company had also carried out an in-house competition to produce the best designs for the bridge and the winning entry was the one presented at the interview. Additionally, this company was able to present a detailed analysis of the estimated cost of constructing this bridge.

The company also stated that it was normal practice for many consultants to merely produce a specification for the mechanical aspects of the design and rely on a sub-contractor to carry out the detailed design. In their experience, this had led to problems of inadequate or unsuitable design, and it was now their policy to carry out detailed mechanical engineering design in-house. This was a critical aspect since the moveable section of the bridge caused concern over operability and reliability as a survey of moving bridges in public ownership, undertaken by GBC had highlighted recurring problems and expense arising from moveable bridge sections.

Each company was assessed by the council members and officers using a set of criteria shown in Appendix H. The results of this assessment are given in Table 9.4. The soft issue score is the score arising from questions 5, 8 and 13 of the designers' questionnaire as detailed in sections 9.2 and 9.3. The complete questionnaire is shown in Appendix D.

Company Number	Designer Assessment Score %	Soft Issue Score %
9	78.25	77
2, 7 & 16	70.125	30
12	55	18
5 & 8	31.25	10

Table 9.4 Comparison of Assessment Score and Soft Issue Score

This shows that both of these scores rank the companies in the same order. Analysis of the data gives a correlation coefficient between the two sets of data of 0.81433. This provides some validation for the selection process used.

The first task for the company selected was to prepare an outline bill of quantities to be used for the constructor selection process as described in chapter 10.

9.5 Conclusions

The selection process provided a clear distinction between the shortlisted consultants and the remainder of the applicants. However, the issue of consistency of results again gave problems. It was primarily the problem of consistency that led to the results of questionnaire 3 being ignored prior to the interview stage. It is worth noting that the consultants that were ultimately successful were one of only three companies to rank the client as being more important than the other parties and, in fact, gave the client the highest ranking of the three. This may be significant because it was only this company that, at the interview, addressed in detail the concerns of the client. It was this which made the decision on final selection a straightforward task and there was unanimous agreement across the whole panel.

The actual scores awarded in questionnaire 2 (Table E.1 to Table E.16) are also worth noting. Five of the companies used no scores greater than 3 with no companies using a score of greater than 9. The company that was finally selected used the largest range of scores which resulted in culture and working relationships being ranked far higher than all other objectives. These results were entirely consistent with their scores in questionnaire 1 and with their performance at the interview. This helps provide some confidence in the validity and rigour of the selection process used for the consultants.

10. Constructor Selection

10.1 Methodology

The initial method of constructor selection took a similar form to that of selecting consultants. In the constructors questionnaire the AHP question used for prioritising the project's objectives remained the same. A new mark distribution questionnaire was designed for constructors using ten questions. The AHP question asking the relative importance of client, consultant and constructor was deleted because analysis of the responses to this question from consultants had shown that no confidence could be placed in the answers received. In addition, each constructor was asked to provide three referees one of whom was to be a domestic sub-contractor. A questionnaire was designed to be completed by the sub-contractor and is shown in Appendix I. This questionnaire was used to determine if a co-operative and trusting relationship extended down the supply chain.

The major difference in the new mark distribution questionnaire is the assigning of a multiplicative weighting factor to each question. This was introduced as a result of the experience with the consultants questionnaire as described in section 9.3. It was decided that rather than making a judgement using only the most important questions and ignoring the remainder, the answers to all questions would be considered by using a weighting system to adjust their contribution according to their relative level of importance. The weighting factor for each question was between 1 and 4 and individual answers are weighted in the range of +2 to -2. The weightings were established through discussions with the project officers. The key issues addressed by the questionnaire are innovation, teamworking and early integration and the approach to quality.

As a trial the questions were sent to the consultant's project manager who attempted to complete the questions from a constructor's perspective. The results of this trial are given in Appendix J. This led to extensive discussions between GBC, the Business Engineering Group and the consulting engineers selected by the earlier process. The outcome of these discussions was a modification to the questionnaire to ensure greater differentiation between prospective constructors. The final questionnaire is shown in Appendix K. In the final version, the answers to the questions have been arranged to be mutually exclusive and the answers that are of positive value to Gosport were assigned a positive weighting, those that had no impact received a zero weighting and those which were detrimental to Gosport's objectives were given a negative weighting.

As a preliminary test of the validity of the answers, Monte Carlo simulation was carried out on question 2. After 2000 trials the results showed with 95% certainty that the score of 70 attained by the consulting engineers would not have occurred by chance.

In addition the sub-objectives for the project were amended to represent the input to the project that was expected from the constructor. These objectives are presented in Table 10.1. The main objectives remain the same but some of the sub-objectives reflect the different inputs that the constructor will bring to the project. The changes were made through discussions with the project officers and a draft was circulated amongst the Council members for comment. The mark distribution questionnaire was again designed so that the questions explored the objectives and sub-objectives identified for the constructor's input and set out in Table 10.1.

The members wished to introduce a political sub-objective to the effect of 'to employ a significant proportion of local labour'. The auditor advised that this may compromise EU legislation (chapter 3) and the statement 'to promote the employment of trainee labour' was added as a compromise. This recognised that as a result of the withdrawal of the Royal Navy from Gosport a significant proportion of training provision had been lost and any new provision was desirable.

Factor	Description
Cost	The need to ensure that budgets are not exceeded or significantly underspent. The need to balance capital expenditure against operational and maintenance costs of the structure. The desire to examine options to enable choices to be made about costs. The need to ensure a balance between the cost of any solution and its effectiveness.
Culture	A desire to work with organisations which understand the Local Government culture including issues such as probity. A willingness to embrace new ideas and concepts. A desire to work with others in a co-operative manner. The need to work with others who are for flexibility in thinking and working methods.
Design	To engage constructors who have the ability to assist the bridge designers with their task. To engage constructors who are able to demonstrate a grasp of a Millennial brand and concept. To produce a structure that is sympathetic to environmental and planning issues. To produce a design that is both individual and intellectually challenging.
Experience	To engage constructors who are able to demonstrate a record of building structures of proven quality. To engage constructors who can demonstrate a record of assisting clients at Public Enquiries. To engage constructors who have been proven to assist in the design of structures with flair and imagination. To engage constructors who are able to demonstrate sensitivity to the needs of building structures in sensitive environmental locations.
Political	To meet the valid expectations of Bodies such as English Heritage and English Nature. To meet the requirements of the Millennium Commission. To promote the employment of trainee labour. To recognise that any Gosport project is part of an overall Portsmouth Harbour wide scheme.
Quality	To ensure that design quality translates effectively into physical quality. To provide a structure with low maintenance and operating costs. To engage constructors with formal QA type procedures. To provide constructors a structure that will be of a quality worthy of being referred to as a "Millennial structure".
Time	The length of the overall design and construction period including any period required for a Public Enquiry. Ability of constructors to forecast programmes accurately. Completing works by dates agreed with the Millennium Commission. The desire to examine options to enable choices to be made about the length of the overall programme.
Working Relationship	To engage constructors who will be able to assist the Council throughout the project in its dealings with various parties. To engage constructors who are sympathetic to the Councils requirements. To engage constructors who are compatible with the Councils culture. To engage constructors who are able to demonstrate a positive working relationship with all parties involved in a project.

Table 10.1 Objectives for Constructors

These objectives for constructors are the equivalent of the objectives for consultants shown in Table 7.5 but focusing on the qualities of constructors that would assist in achieving the project objectives.

The questionnaires were sent to constructors and the factored results are shown in Appendix L. As quality had already been identified as the most important factor, it was decided to identify those companies that had ranked quality highest in the AHP questionnaire and of those select the four companies scoring highest on the mark distribution questionnaire to go through to the next stage. The mark distribution score was the sum of the scores to individual answers multiplied by the weighting factor for that answer. As some answers had negative weighting factors it was possible for a constructor to achieve a negative score although no constructors did. Therefore companies 5,7,10 and 11 were selected.

During this time the designers were asked to prepare an outline bill of quantities for their design. The four constructors selected were required to submit a fixed price tender based on the bill of quantities and a quality statement in separate envelopes. The quality tender evaluation is shown in Appendix M. The envelopes containing the quality tenders were opened before the envelopes containing the price submission and companies were required to score over 75% on quality to be acceptable. It can be seen that company 7 failed on quality and the envelope containing the price submission was returned unopened.

The three successful constructors were now required to engage in value engineering workshops with the designers and hence amend their price submissions to reflect the design modifications incorporated. The constructors were given the opportunity to spend up to one week with the consulting engineers to investigate design issues which could lead to higher quality, reduced cost and construction time and lower maintenance costs. The constructors were advised that any proposals made would not be communicated to the other constructors prior to award of contract but that their ideas might be incorporated in the final design. In consideration of this, unsuccessful constructors were permitted to claim up to £10,000 for their input.

Companies 5 and 10 were extremely successful at this process and suggested a number of changes to improve buildability, reduce cost and ensure final quality. Company 11 were unable to embrace this process and withdrew from the project.

The contract was finally awarded to company 5 on the basis of their revised tender submission. However, Company 5 were also the most proactive in the value engineering process and the company both made suggestions to the designers and listened to ideas from the designers.

The most significant results of the value engineering process are as follows:

1. Because of the sensitive location of the bridge, white concrete had been specified for the bridge deck. The cost of white concrete and the problems of maintaining colour consistency in site conditions are well known. The constructor proposed using a pre-cast concrete shell of white concrete to form permanent shuttering and infilling with normal concrete. This had the benefits of ensuring a high quality external finish and colour consistency as a result of factory manufacture. It also means that the need for shuttering was eliminated thereby reducing cost and time and as a result of the significant reduction in the volume of white concrete required considerable savings in the cost of concrete were made.

2. As a result of the use of permanent shuttering Efco table-forms could be used for the temporary works again giving cost and time savings.

3. The consultants suggested using Zem drain lining as shuttering for the bridge columns as this achieves a finish of a similar standard to that of steel shutters but at a much reduced cost.

4. The use of flexible piles was proposed which would eliminate the need for bridge bearings. This would have a significant impact on the cost of maintaining the bridge as bearing replacement is the largest cost involved in bridge maintenance.

All of these ideas were implemented in the project and although there was no overall cost saving in the project the client was able to additional parapets and bridge lighting for the same total cost.

10.2 Conclusions

The selection methodology again worked well and the constructor that was finally selected not only submitted the most attractive tender but also scored highly in the AHP and mark distribution questionnaires. In addition, this constructor performed well in the value engineering process and produced valuable contributions for both design and construction. The ideas investigated from the other constructors during the value engineering process were not incorporated into the project.

Once again some unexpected results were received. Companies 4, 9 and 12 each submitted answers to one question in questionnaire 1 which did not total 100 as shown in Table L.1, Table L.9 and Table L.10. Companies 1 and 4 completed the AHP questionnaire incorrectly as shown in Table L.21 and Table L.24. This resulted in considerable discussion between the Council members and officers. Some held the view that any companies that were unable to provide numerically correct answers should automatically be rejected. Others held the view that only those companies that had completed the AHP questionnaire incorrectly should be eliminated as there was a clear example and set of instruction with the questionnaire. It was argued that if companies could not follow a simple set of instructions then they were not suitable companies to construct a bridge. It was pointed out by the auditor that the designers that had made mistakes in completing the questionnaire had not been automatically rejected and it was decided that the incorrect results would be normalised and entered into the selection process. None of these companies went through to the next phase of the selection process as a result of their overall scores.

There followed some discussion as to whether or not a warning should be included in the questionnaire pack that incorrect answers would be rejected. It was decided that this was unnecessary and this problem did not arise again during the research.

Overall this trial was considered to be very successful. The only changed suggested was that only one company should undertake the value engineering process and that company would be the one selected from the quality and price submission.

11. Evaluation of Performance of the Project Delivery Process

11.1 Introduction

The opportunity to compare the performance of identical construction projects has probably not occurred since the construction of the Mulberry Harbours during 1943 and 1944 and evidence of the improvement in performance as a result of new ways of working is largely anecdotal (Bresnen and Marshall[81]). The most widely used tools for comparison of project performance are the DTI Key Performance Indicators (KPIs). These attempt to compare projects by normalising the results of different projects. However, the use of KPIs fails to take into account project specific obstacles and problems and client instructed variations. This chapter presents the KPIs for the Forton Lake Bridge project but also investigates how the project team selected by the Project delivery Process performed when problems and changes arose.

11.2 Key Performance Indicators

Key Performance Indicators are calculated using the published DTI conversion curves and by comparison to a similar project. The project selected for comparison to calculate the KPIs for Forton Lake Bridge was the York Millennium Bridge. The main details of the two projects are shown in Table 11.1.

		York Bridge	Forton Lake Brideg
Cost		£4,200,000	£2,017,721
Time	Start Date	01 June 1999	13 Sept 1999
	Period	97 weeks	90 weeks
Size	Total Length	150 m	140 m
	Clear Span	150 m	25m
Construction Type		Steel and composite static cable stayed arch.	White concrete and steel bascule opening bridge.
Conditions of Contract		New Engineering Contract	New Engineering Contract (Option C)
Gross Disposable Household Income (£ per capita)		£105	£87
Employment Rate (all persons)		79%	80%

Table 11.1: Comparative Details of Projects

Apart from the construction details there are other similarities between the projects as detailed below:

- both projects are Millennium funded pedestrian bridges
- both clients are Local Authorities
- both projects required approval under the provisions of the Transport and Works Act 1992
- Both project teams were bound by Millennium Commission regulations
- Both projects are infrastructure linkage over water
- Both projects were quality driven, iconic projects

The KPIs for Forton Lake Bridge are shown in Figure 11.1

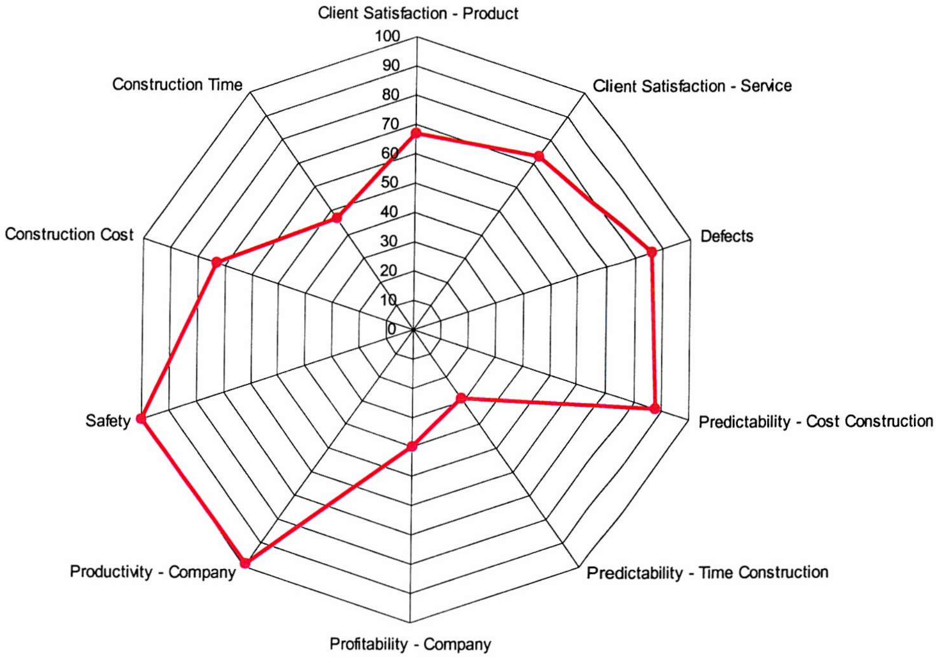

Figure 11.1: KPI Radar Chart for Forton Lake Bridge

The KPI radar chart shows that the project performed better than the national average in all the KPI benchmarks except in predictability of construction time, company profitability and construction time. The project performance in all of the benchmark scores will be discussed in detail because these scores provide a distorted picture of the project performance.

The KPI score for company profitability of the constructor is 40% which is below the national average of 50%. However, this is a measure of company performance and not project performance. In fact, on this project, profits exceeded expectations for two reasons. Firstly, the scope of the works was increased with associated increase in profits and secondly, the structural steelwork sub-contractor recommended changing the design of the lifting section of the bridge to enable in situ construction using land based cranes rather than an expensive heavy lifting crane barge. Therefore, the KPI score does not reflect project performance.

Both construction time and predictability of construction time score worst than the national average with scores of 47% and 29% respectively. However, these scores both include the project delay brought about by almost nine months delay in approval under the Transport and Works Act and granting of a MAFF licence. Central Government guidelines suggest that granting of approval and licences takes between 3 and 6 months, but for Forton Lake Bridge it took over one year even though applications were uncontested. Not only did this delay the start of the main works, some enabling works had already started, but the project was now starting in the middle of September rather than February or March. This resulted in the project sub-structure being constructed during the period of shortest daylight and the most adverse weather conditions. In addition, the original constructor's team, that had been involved in the value engineering process and that had established a close working relationship with the consultants, had been moved to different projects. Thus the teambuilding process had to start again from scratch and this was to have further consequences later.

Safety and company productivity scored 100% and 99% respectively and effectively cannot be improved. However, safety is only a measure of reportable incidents and not truly a measure of safety performance and is therefore not a proactive measure.

Cost and cost predictability scored better than average but again no allowance is made for the increased scope of works or unavoidable and unnecessary delays by central Government. These scores, therefore, are again not a true reflection of project performance.

The score for defects was also good at 86%, however the project was still not defect free. This resulted in the client's scores for satisfaction with the product and with the service being less than 100% at 67% and 73% respectively. This is probably a somewhat harsh reflection of the project as the finished bridge won three awards and the main cause of dissatisfaction with the service related to time for which the delays were beyond the control of the constructor or designers.

11.3 Quality Issue Analysis

11.3.1 Introduction

The Quality Issue Analysis is a central part of the evaluation of the Project Delivery Process as used at Forton Lake Opening Bridge. The analysis is described in two parts, firstly an outline of the technique and secondly the way this technique was used on Forton Lake Bridge and the results found.

An approach has been developed to assess the various elements of the bridge construction and evaluate the outcome to these events with the adoption of the key process inputs. A quantitative assessment is then made in order to gain an insight into the impact of adoption, or lack of, the Value Enhancing Practices on the entire project. The impact is assessed in terms of cost to the project and other parties. The term "Quality Issue Analysis" is used to refer to this approach. This approach uses information collected by questionnaires and interviews at regular intervals throughout the projects from all parties involved in the project.

11.3.2 The Quality Issue Analysis Technique

The concept of the analysis is to investigate each important issue that has shaped the project outcome, both positive and negative. By looking in depth at these issues it will be possible to ascertain which areas of PDP could be improved in future implementations.

The Quality Register from the Movement for Innovation (M4I*) forms a start to the framework for the technique. In the Quality Register, quality issues are listed with summarised details. These are then categorised by source of problem. The source categories are shown in Table 11.2

Workmanship	Defective material
Design & Specification	Damage on site

Table 11.2: Quality Source Categories

By taking a bigger picture view of what a quality issue is, a much broader range of sources can be used. The issues themselves will also be greater, not just issues that have resulted in physical defects, but both positive and negative outcomes that have shaped the project outcome for each party to the project.

11.3.3 The Quality Issue Analysis of Forton Lake Bridge

The important issues arising during the Forton Lake Bridge project are shown in Table 11.3.

* Details available at http://www.m4i.org.uk

	Event	Cause	Effect
1	Re-design of bridge deck to use precast concrete shells	Value engineering process	Certainty of quality Reduced cost Reduced time
2	Use of Zem drain to shutter columns	Value engineering process	Certainty of quality Reduced cost
3	Use of Efco table forms	Value engineering process Re-design of bridge deck	Reduced cost Reduced time
4	Use of flexible piles	Value engineering process	Reduced maintenance costs
5	Delay	TWA and MAFF	Disintegration of integrated team Increased cost Increased time
6	Re-alignment of bridge	Late information from MoD	Increased cost Increased time
7	Flooded pile borehole	Lack of integrated team	Increased cost to constructor Increased time
8	Pile out of position	Lack of checks and supervision	Increased cost to constructor Increased time
9	Column out of plumb	Pile out of position	Increased cost to constructor Increased time
10	Re-design of lifting section	Recommendation by structural steelwork sub-contractor - Kent Structural Marine (KSM)	Reduced cost Increased time Erection not dependent on weather conditions
11	Structural steelwork fabrication not approved	Lack of quality documentation Failure to adhere to specification Lack of supervision	Increased time for KSM Increased cost for KSM
12	Possible omission of Corbel stiffeners	Lack of quality documentation Lack of supervision Site staff unable to read steel fabrication drawings	Increased cost to constructor Remedial works
13	KSM ceases trading	Unrelated to construction	KSM staff employed by constructor
14	Torsion shaft seizure	Lack of buildabiliy in design	Re-design of torsion shaft Increased time Commissioning delays
15	Introduction of bridge lighting	Budget surplus as a result of lower cost	Increased time
16	Electrical operation failure	Poor electrical design	Commissioning delays

Table 11.3: Important Events during the Project

The numbering system refers to the numbers in Table 11.3.

1. This is discussed in detail in chapter 10.

2. This is discussed in detail in chapter 10.

3. This is discussed in detail in chapter 10.

4. This is discussed in detail in chapter 10.

5. This is discussed in detail in section 11.2 but the largest impact of the delay was the disintegration of the project team through the constructor's staff being diverted to other projects.

6. Re-alignment of the bridge was necessary due to the presence of a high voltage submarine cable owned by the MoD and supplying the radar installation controlling Portsmouth harbour. Although the MoD were aware of the proposed route of the bridge from the start of the project they did not inform the project team of the existence of the cable until after detailed design had been completed. The presence of the cable was not revealed during the hydrographic surveys because it was a standby cable carrying no power at the time of the surveys. This resulted in additional time and cost being incurred by the designers will the bridge was re-aligned. These costs were passed on to the client.

7. The pile bore hole flooded because the piling auger jammed in the hole and could not be extracted without dismantling the piling rig. Because of the time taken to do this, the tide came in and flooded the borehole. The auger jammed because the causeway used as the piling mat collapsed under the piling rig. The consulting engineers had requested a method statement for the construction of the causeway for just this reason as the seabed had a very low bearing capacity. The constructor had not recognised the significance of the need for a method statement and had not submitted one for approval since temporary works design is the responsibility of the constructor. In addition, the consulting engineers had raised the issue of the need for protection of the boreholes against flooding and asked for a method statement, but the constructor proposed that boring would start immediately after high tide so that there was no risk of flooding and no need for protection. The roots of this problem lie in the disintegration of the team caused by the delay. The possibility of these problems occurring had been discussed prior to the delay and the consulting

engineers were trying to help the constructor by requesting method statements. However, the constructor's staff were new to the project and trust had not built up with the consulting engineers. At the time they considered submitting method statements for these activities unnecessary as they had not appreciated the need for them. Flooding of the borehole potentially reduced the pile skin friction and a re-design pile had to be installed at the constructor's expense.

8. The out of position pile was due to poor setting-out. However, whilst mistakes do occur, this was such a critical element of the works that the setting-out should have been checked by another engineer. In addition, no post construction survey was carried out and the incorrect position of the pile was not noticed until a later stage.

9. The out of plumb column was caused by constructing the column on the out of position pile. The top of the column was correctly located but the base was out of position making the column out of plumb. This was not noticed until after the shuttering had been struck. This resulted in the column being demolished, a new pilecap designed and installed and the column recast. This was all at the constructor's expense.

10. The use of a heavy lift crane barge had always been a risky operation for the project. Crane barges are expensive to hire and availability is limited. They are also vulnerable to tide and weather conditions. KSM suggested modifying the design of the lifting section to allow for final fabrication on site rather than in a fabrication shop. This enabled a land based crawler crane to be used, eliminating the need for a crane barge. This resulted in a substantial cost saving and reliance on weather conditions, although there was a slight increase in time. KSM's motives for this suggestion were probably financial rather than altruistic as they could charge higher rates for site fabrication than factory fabrication. However, this is still an example of a win-win situation and of the readiness of the consulting engineers to consider design changes for the benefit of the project.

11. Difficulties in approving the structural steelwork fabrication were due to KSMs refusal to adhere to the specification. The specification required various percentages of welds to be tested and certified. Although KSM claimed that this had been done, they were unable to produce the certification. It is likely that the majority of the testing and certification had not been carried out because of the cost of employing a company to carry out the works. Eventually the constructor had the testing and certification carried out.

12. There was concern after the corbels had been cast in whether of not the stiffeners had been fitted. This was impossible to ascertain after installation as the corbels had been filled with concrete. KSM lacked any quality documentation to establish whether they had been fitted and the corbels had not been inspected prior to delivery to site. The site staff were unable to read steel fabrication drawings and they were accepted and installed on the basis of an external dimension check. As the constructor was unable to prove the existence of the stiffeners remedial works were carried out at the constructor's expense.

13. KSM ceased trading due to circumstances unrelated to this or any other construction project. This had potentially serious implications for the project in terms of delays while a new fabricator was found. The problem was overcome with the help of the integrated team which had now emerged. The client and consulting engineer agreed that the constructor could employ the fabrication staff from KSM to enable the project to be completed without the need for finding a new fabrication company. The fabrication was completed successfully although there was a cost to the constructor.

14. The torsion shaft was designed to connect the two gearboxes on either site of the bridge to ensure equal rates of lifting on both sides of the bridge and to enable the bridge to operate in the event of failure of one of the lifting motors. The shaft had been designed to couple the two gearbox shafts after they had been precisely aligned coaxially. This is standard, but not good, practice at ground level, but virtually impossible to achieve at high level on a structure which is being buffeted by the wind and with gearboxes suspended from cranes. Every attempt to achieve this resulted in seizure of the shaft through incorrect alignment of the gearboxes. It was quickly recognised that the torsion shaft needed to be re-designed as a cardin shaft with a universal joint at each end. Again the integrated team helped overcome the problem. The shaft was re-designed, fabricated and installed before any blame was attributed, resulting in minimal delay.

15. Architectural lighting was introduced as a result of the lower overall cost of the bridge arising mainly from the value engineering process. This not only enhanced the project but meant that there was no underspend on the budget. This led to an increase in project duration but improved the overall quality of the finished product.

16. Late appointment of the electrical contractor resulted in a poorly designed control system, which although it functioned was not sufficiently robust to be commissioned. The reason

for the late appointment was due to the difficulty that the constructor had in finding a contractor that would undertake the works for the price allowed for in the tender price. Ultimately the delays in commissioning and the extra site visits required by the commissioning company cost more than the original preferred contractor.

11.4 Conclusions

Calculation of the key performance indicators for Forton Lake Bridge show that the project performed better than the national average, however, there is some doubt as to whether they are a true reflection of the project. In particular, significant delays to the project were caused by Government departments which were outside of the control of the project team and do not reflect on the performance of the project team. They delays do, however, have an effect on the KPI scores.

Problems were encountered during construction of the bridge but analysis of these only reinforces the effectiveness of the selection methodology used. The integrated team carried out a very effective value engineering process enhancing value to the client. The delay brought about by through late approvals by Government caused disintegration of the project team with consequences for the project. However, once integration developed, the team worked well, overcoming a number of problems.

A number of problems arose as a result of lack of sub-contractor and specialist designer integration into the team. As a result of this, the constructor is now using a similar selection process to select sub-contractors for future projects.

The difficulties of integrating various engineering disciplines into one project caused problems. The project lacked having a multi-skilled engineer both on site and in the design office. This is a recurring problem in construction projects and one which was not addressed by the selection process. This is an issue which needs to be addressed in the future.

Forton Lake Opening Bridge is now complete and was built to budget and delivered on time. The Millennium Commission have agreed that the bridge is of Millennial quality and have agreed to fund the project. In addition, the bridge and those involved in its construction, including the University, have received three awards for excellence. Two of the certificates of award are shown in Appendix N, the third award from the Solent Protection Society is in the form of a plaque attached to the bridge.

12. Conclusions

12.1 Introduction

The need for this research arose from a recognition, both in literature and from the author's own experiences in the construction industry, that the construction industry was dramatically failing in delivering construction projects in all aspects but particularly with regard to cost, schedule and quality. The research began by identifying a construction project which was performing well and meeting the client's expectations. A project was identified which, against the odds, appeared to be performing well in all areas and especially in cost, schedule and quality. The project was investigated and monitored and on completion the project was delivered below budget and within a substantially shortened construction period. The investigation revealed that the reasons for this success were:

1. A culture for co-operative working existed in all participants to the project
2. A willingness for all participants to trust each other
3. Involvement of the constructor at the design stage
4. Prompt and fair payment by client to constructor and constructor to sub-contractor.

The research then focus on identifying and developing suitable tools to create a methodology for project procurement that would ensure that these factors were present in the whole project delivery team.

12.2 Overview of Selection Methodology

The selection process begins by rigorously establishing the project objectives. This is achieved by the Delphi method. All interested parties are invited to list their objectives for the project including both product and process objectives. The individual lists of objectives so obtained are then compiled into a single list which is then circulated to the respondents. Respondents are then asked to add or remove objectives form the list and, ideally, this process is repeated until consensus is reached. For most projects this process will end after compilation of the first list.

The objectives so established are grouped under suitable headings, with the objectives now forming a description of each heading. The research suggests that eight headings is the maximum number that can be effectively worked with. The headings can now be considered the project super objectives.

These super objectives can now be prioritised using, preferably, AHP. Alternatively mark distribution can be used. The super objectives are assembled into either an AHP or mark distribution questionnaire and the original respondents are asked to complete the questionnaire. When using AHP, a consistency ratio from a respondent of greater than 0.25 should not be accepted. Responses that have a consistency ratio of greater than 0.25 should either be rejected or the respondents asked to redo the questionnaire. The final ranking is the average of all scores. Where a mixture of AHP and mark distribution is used the mark distribution responses may be used as a check of the AHP responses and not included in the overall average. The result gives the overall prioritisation of the project objectives.

A questionnaire pack is then compiled for designers, which includes a description of the project and an AHP and mark distribution questionnaire. The mark distribution questionnaire contains a number of questions each focusing on one of the project objectives. A series of answers is presented for each question addressing various aspects of achieving that objective which can be delivered by the designers. It is important that some of these aspects are essential or desirable whilst others are of little or no value or completely undesirable. Each answer is given a weighting of between -2 and +2 with essential aspects weighted 2 and totally undesirable aspects weighted as -2. Each question is also given a weighting depending on its focus with the weighting reflecting the priority of the objective it is focused on. It is recommended that the questions, answers and weightings are established by a selection panel through consensus rather than by an individual.

Expressions of interest are invited from designers by the appropriate method and in the case of Local Government, by the procedures outlined in chapter 3. Designers expressing interest and meeting any pre-qualification criteria are sent a questionnaire pack.

The completed questionnaires are analysed. Designers submitting AHP responses with consistency ratios of greater than 0.25 may be rejected at this stage. Initial selection is made using the AHP questionnaire. These are assessed by considering the response to the one or two most important criteria. Final selection uses the total scores from the mark distribution questionnaire and those designers scoring highest are short-listed. Those designers selected at this stage are invited for interview and detailed instructions given as to what is required from them at interview. The final selection is made following the interview using a pre-established set of criteria. The successful designer is then required to produce an outline design and approximate quantities sufficient to obtain a tender price.

A questionnaire pack is assembled for constructors using the same process as above but investigating how the constructor can deliver the project objectives. It may be helpful to involve the designers in assembling the questionnaires. Expressions of interest are invited from constructors using company procedures or the procedure required by standing orders in the case of Local Government. Evaluation of the completed questionnaires is carried out in an identical way to that described for designers. The required number of constructors can now be short-listed.

The constructors that have been short-listed are asked to price the outline bill of quantities and make a quality submission in accordance with details set out by the client. Constructors should be advised of the relative contributions of the price and quality submissions. The constructor can now be selected form the tenders submitted. It is a requirement that the successful constructor engaging in a value engineering process with the constructor and it may be appropriate to allow a provisional sum for this task. Detailed design can now proceed and the final tender price fixed. Construction can then proceed in the usual way.

12.3 Use of the Selection Process in Public Procurement

Whilst the selection process developed is not exclusive to procurement in the public sector, it was developed with the public sector and the process was closely monitored by Gosport Borough Council's auditor and District Audit to ensure that procurement legislation or probity were not compromised.

The whole selection methodology is focused on delivering best value for money which is central to public procurement policy as described in section 3.2. The process completely aligns with the principles that are expected to be adopted for procurement policy, as set out in section 3.3. In particular the process has the following attributes.

The process is transparent and uses mathematical tools to select construction parties by evaluating their alignment to a set of project objectives. All prospective parties are provided with the project objectives and the method of assessment.

There is no collusion between the client and prospective service providers and the evaluation process is based entirely on a pre-established set of criteria. These criteria have been established through a rigorous mathematical process involving a wide range of people and so cannot be compromised.

Final selection is by competition although not just competition on price but including quality as well. At all stages in the process the focus is on selecting the best organisations to deliver a construction project.

The process is more efficient than the traditional bill of quantities tender process. The client does not have to evaluate a large number of tender documents. The questionnaires can be evaluated using a spreadsheet. If questionnaire responses are submitted electronically the whole process can be automated.

The whole selection process fully complies with EU procurement policy. It has now been scrutinised by a number of other auditors from Local Authorities including Brighton and Hove, West Sussex and Dorset and found to be totally compliant with all legislation.

When the process was developed with Gosport Borough Council it was a requirement that there was to be no change in standing orders to accommodate a new procurement process. Although contract standing orders are Local Authority specific they all address the same legislation. Therefore, the process which was developed to comply with Gosport's standing orders will be transferable to any other public body.

12.4 Concluding Remarks

This thesis describes the development of a methodology, using action research, to select parties to a construction project with the goal of increasing the probability of a successful construction project. The methodology was developed on the procurement of Gosport Millennium Bridge which, in spite of significant delays brought about by Central Government through taking an additional nine months to grant approval for the scheme under the Transport and Works Act, was completed on time and budget and has received three awards for quality. Whilst the project was a success, this in itself does not prove that this was due to the selection methodology developed in the course of the research and other procurement methods could achieve the same results. However, as analysis of important events in during the construction of the project showed the use on the project of the selection methodology had an impact on the final outcome. In fact, the analysis was made easier as a result of the delay arising from the Transport and Works Act and it was shown that every factor addressed by the methodology worked towards ameliorating the impact of the delay.

It was therefore concluded that adoption of this methodology can contribute significantly to project success and delivering projects which meet the client's expectations. However, the method requires considerable time and costs to be expended in the selection process and is therefore not suitable for all projects. The methodology, as described in this thesis, is particularly suited to larger complex projects. A simplified version is being developed for use on smaller projects.

In a speech at the official opening of the bridge, the leader of Gosport Borough Council said that without the new procurement method and the support from Southampton University it is likely that the bridge may never have been built. The benefits of using the methodology are, therefore, clearly recognised by those involved in its development and first use.

The methodology is now an accepted procurement route for construction projects by a number of public and private organisations and a guide[76] to its use is to be published by the Construction Industry Council and launched by Sir John Egan in October 2003.

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Appendix A. Prioritisation of Objectives

Table A.1 shows the AHP questionnaire responses given by the engineering advisor. Table A.2 shows the AHP responses provided by the Millennium Project manager. Figure A.1 shows the results for prioritisation of the project objectives by Gosport Borough Council's engineering advisor. Figure A.2 shows the results for prioritisation of the project objectives by Gosport Borough Council's Millennium Project manager. There is a small inconsistency in the results given by both the engineering advisor and the Millennium Project manager with the consistency ratio being greater than 0.1.

Factor	Weight	Weight	Factor
Time	1	4	Culture
Time	2	1	Experience
Time	1	4	Political
Time	1	3	Cost
Time	1	6	Quality
Time	1	8	Design
Time	2	1	Working
Culture	4	1	Experience
Culture	1	3	Political
Culture	1	7	Cost
Culture	1	6	Quality
Culture	1	5	Design
Culture	3	1	Working
Experience	1	2	Political
Experience	1	7	Cost
Experience	1	8	Quality
Experience	1	6	Design
Experience	3	1	Working
Political	1	7	Cost
Political	1	4	Quality
Political	1	7	Design
Political	4	1	Working
Cost	1	4	Quality
Cost	1	4	Design
Cost	5	1	Working
Quality	1	1	Design
Quality	8	1	Working
Design	8	1	Working

Table A.1: Response from Millennium Project Manager

Factor	Weight	Weight	Factor
Time	1	5	Culture
Time	2	1	Experience
Time	1	3	Political
Time	1	3	Cost
Time	1	7	Quality
Time	1	9	Design
Time	1	2	Working
Culture	5	1	Experience
Culture	3	1	Political
Culture	1	5	Cost
Culture	1	5	Quality
Culture	1	5	Design
Culture	5	1	Working
Experience	1	5	Political
Experience	1	7	Cost
Experience	1	9	Quality
Experience	1	7	Design
Experience	1	5	Working
Political	1	7	Cost
Political	1	9	Quality
Political	1	7	Design
Political	2	1	Working
Cost	1	5	Quality
Cost	1	3	Design
Cost	3	1	Working
Quality	2	1	Design
Quality	9	1	Working
Design	9	1	Working

Table A.2: Response from Engineering Advisor

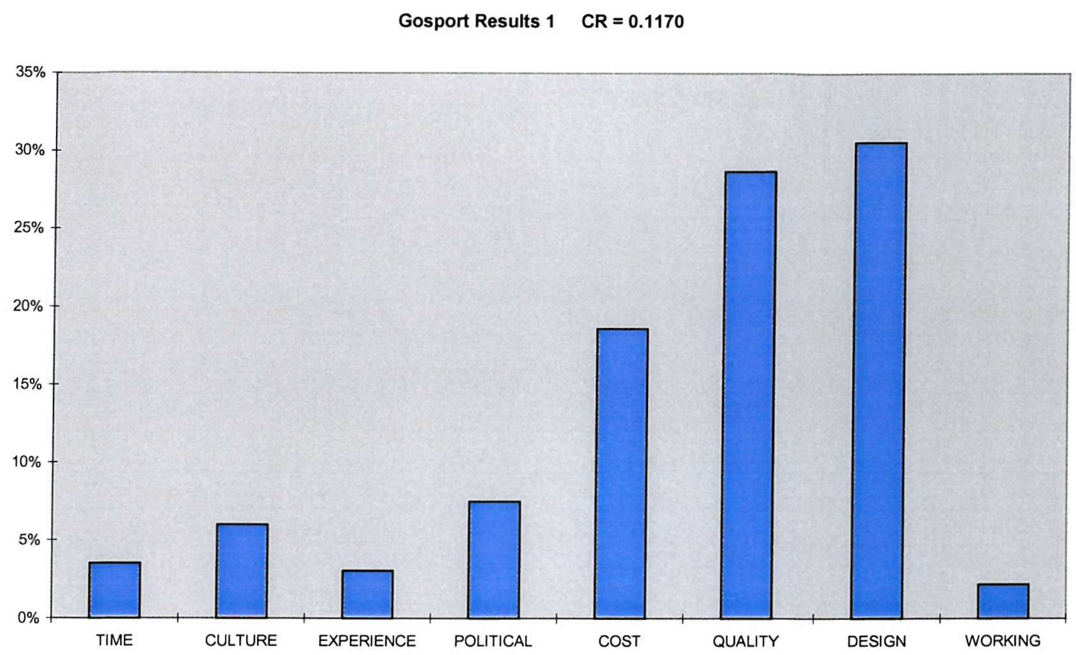

Figure A.1: Prioritisation of Objectives by Millennium Project Manager

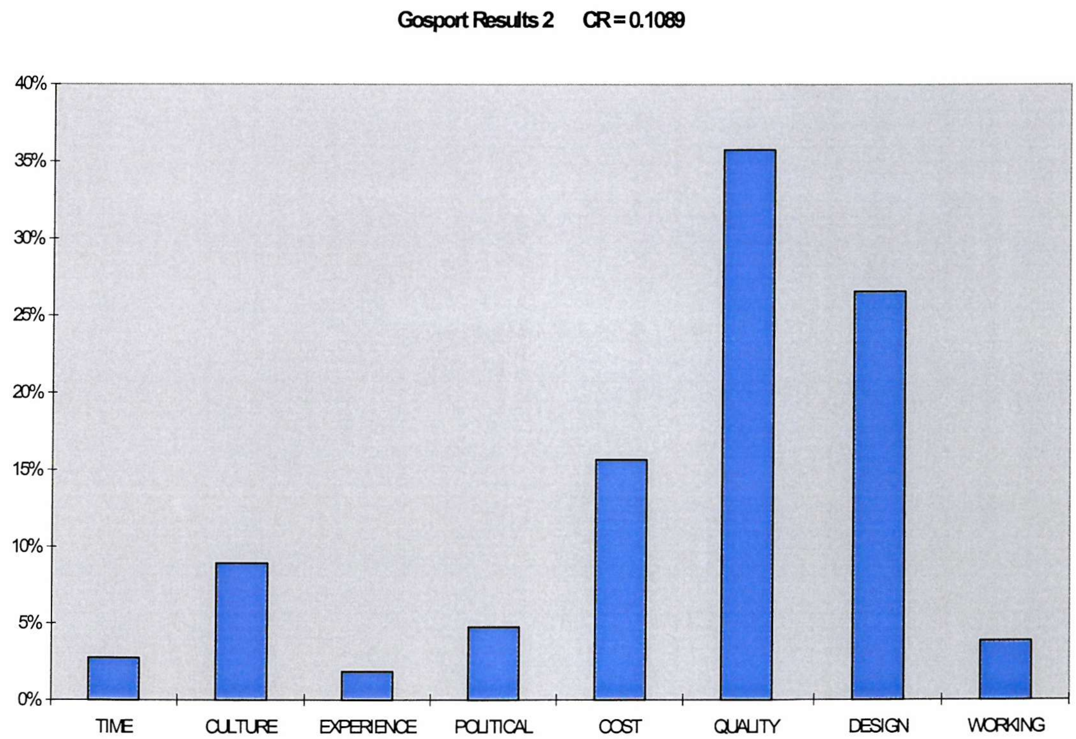

Figure A.2: Prioritisation of Objectives by Engineering Advisor

Objective	Score
Quality	33
Design	29
Cost	15
Culture	8
Political	6
Time	3
Working Relationship	2
Experience	3
Total	100

Table A.3: Prioritisation Scores from Council Member 1

Objective	Score
Quality	36
Design	25
Cost	10
Culture	1
Political	3
Time	10
Working Relationship	12
Experience	2
Total	100

Table A.4: Prioritisation Scores from Council Member 2

Objective	Score
Quality	30
Design	25
Cost	15
Culture	5
Political	5
Time	10
Working Relationship	5
Experience	5
Total	100

Table A.5: Prioritisation Scores from Council Member 3

Objective	Score
Quality	40
Design	20
Cost	10
Culture	5
Political	5
Time	10
Working Relationship	5
Experience	5
Total	100

Table A.6: Prioritisation Scores from Council Member 4

Objective	Score
Quality	33
Design	25
Cost	19
Culture	4
Political	2
Time	12
Working Relationship	2
Experience	3
Total	100

Table A.7: Prioritisation Scores from Council Member 5

Appendix B. Overall Project Objectives

Figure B.1 shows the overall prioritisation of the project objectives. These were obtained by taking the mean of the results produced by the engineering advisor and Millennium Project manager which are shown in Figure A.1 and Figure A.2.

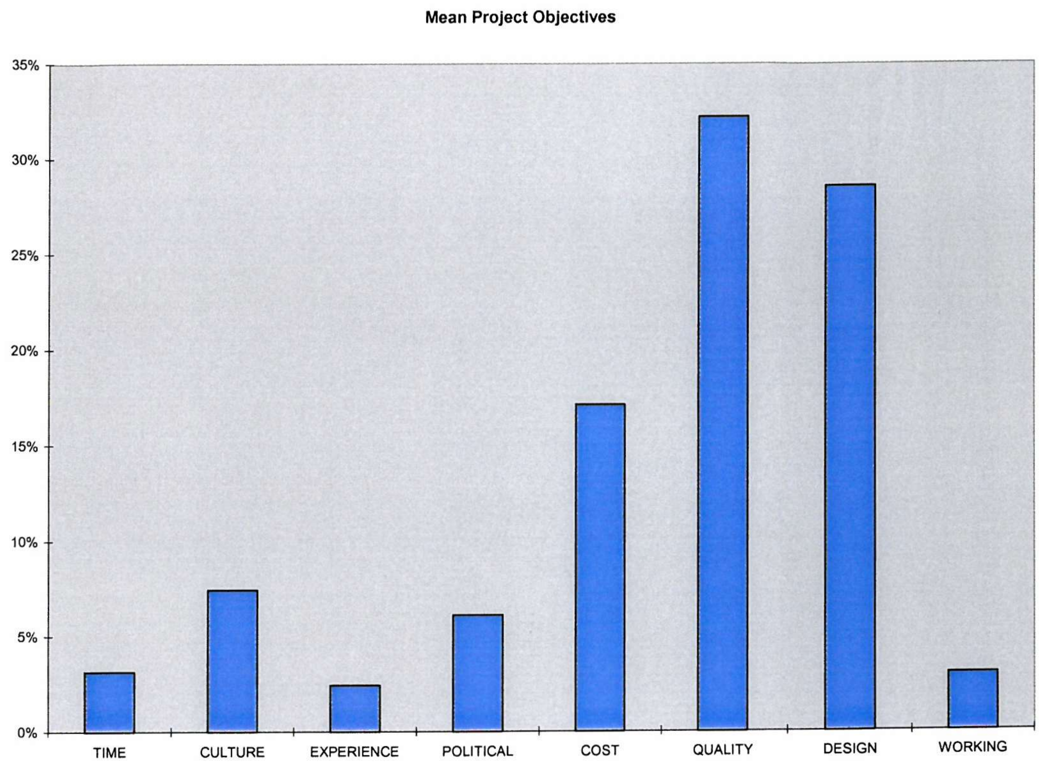

Figure B.1: Overall Prioritisation of Project Objectives

Appendix C. GBC's Mark Distribution Answers

The following tables are the draft mark distribution questions with the average of the scores assigned by the engineering advisor and the Millennium Project manager.

Value Explored	**Question - 1 What measures would you take to ensure completion by the due date ?**		**Marks Awarded**
Time	**Answer 1**	"Fast track" methods may be needed to complete on time	20
Culture	**Answer 2**	Construction methods may need to explored in order to reduce construction times	26.5
Experience	**Answer 3**	Our track record on projects of this nature is good and we have demonstrated an ability to accurately programme the overall process thereby ensuring completion on time	10
Political	**Answer 4**	It may not be possible to achieve the due date but this should be capable of extension by negotiation if a quality scheme is to be produced	15.5
Cost	**Answer 5**	Additional resources could be employed and construction times reduced	5.5
Quality	**Answer 6**	If a quality product is to be achieved it may not be possible to meet completion dates	17.5
Design	**Answer 7**	Design times may need to be reduced	5
		Total	100

Value Explored	**Question - 2 How will you be able to accurately forecast the programme ?**		**Marks Awarded**
Time	**Answer 1**	By allowing sufficient time initially to allow for unforseen difficulties that may occur	3
Culture	**Answer 2**	By discussion with the client at regular intervals	25.5
Experience	**Answer 3**	By virtue of our experience on projects of this nature	16.5
Political	**Answer 4**	By discussion with all the interested parties at an early stage	27
Cost	**Answer 5**	By allocating sufficient staff at regular stages in the design process	15.5
Quality	**Answer 6**	Our office practices require us to update programme forecasts at fixed stages in the design process	6.5
Design	**Answer 7**	By using traditional designs levels of uncertainty can be minimised	6
		Total	100

Value Explored	**Question - 3** *(modified question)* **What difficulties do you see in embracing the cultural values in local government ?**		**Marks Awarded**
Time	**Answer 1**	Local authorities are often bureaucratic and this can lead to difficulties when quick decisions are required	10
Culture	**Answer 2**	We treat each client as an individual and try carefully to identify his particular requirements	25
Experience	**Answer 3**	We are very used to working for local authorities and see little difficulty in adapting to Gosport's needs	17.5
Political	**Answer 4**	We only work for clients where we a happy that we understand the values of all the "players" in the project	27
Cost	**Answer 5**	Local authorities tend not to be prepared to pay for quality designs	6
Quality	**Answer 6**	To much emphasis may be placed by local authorities on the quality of the finished product as against the quality of the design	6.5
Design	**Answer 7**	Local authorities tend to be conservative and this can cause design conflicts	8
		Total	100

Value Explored	Question - 4 How does your organisation adapt to embrace new concepts ?		Marks Awarded
Time	**Answer 1**	We tend to wait to see how relevant these are before adopting them	5.5
Culture	**Answer 2**	We seek out suppliers, contractors and specialist sub-contractors to introduce us to new ideas and concepts	24
Experience	**Answer 3**	New concepts are carefully considered at a senior level before being introduced in a systematic way	16.5
Political	**Answer 4**	We easily adapt when external considerations require this	6
Cost	**Answer 5**	These are carefully evaluated in order to demonstrate proven cost benefit before introduction	12
Quality	**Answer 6**	New ideas need to be carefully considered if quality is not to be compromised	11.5
Design	**Answer 7**	We are innovative designers and therefore our organisation is constantly adapting as part of its normal culture	24.5
		Total	100

Value Explored	**Question - 5 Would the buildability of the project be enhanced by appointing a contractor during the design stage ?**		**Marks Awarded**
Time	**Answer 1**	Possibly but time only at the risk of lengthening the design process	12.5
Culture	**Answer 2**	It is difficult to see what meaningful advantage could be gained by this since working with a contractor at the design stage would be difficult to achieve	3.5
Experience	**Answer 3**	There would only be a minimal advantage in view of our experience on project of this nature	14
Political	**Answer 4**	Yes but such a procedure could be difficult for a local authority to achieve	26
Cost	**Answer 5**	There would be advantages to this but overall the cost of the project would increase	21.5
Quality	**Answer 6**	Buildability is closely linked to the quality of the finished product but quality can best achieved by appropriate levels of site supervision	11.5
Design	**Answer 7**	Buildability relies essentially on good design and so little advantage is seen in this	11
		Total	100

Value Explored	**Question - 6** *(modified question)* **How appropriate any innovative procedures, designs and construction methods to this Millennium scheme ?**		**Marks Awarded**
Time	**Answer 1**	Innovation may lead to delays in overall programmes and should therefore be avoided	10.5
Culture	**Answer 2**	A Millennial scheme should provide an ideal opportunity to try new ideas and concepts	19.5
Experience	**Answer 3**	We have tried new ideas and concepts but found that traditional well proven methods are usually best	11
Political	**Answer 4**	Although considerable potential benefits may be found the number of parties involved in a project of this nature does not make this a practical proposition	5.5
Cost	**Answer 5**	The construction industry is conservative by instinct and innovation usually equates to increased cost to cover the increased risk	11
Quality	**Answer 6**	Improvements in the quality of products only come about if innovation is encouraged	18
Design	**Answer 7**	Innovative design flair is vital to a successful Millennial scheme	24.5
		Total	100

Value Explored	**Question - 7** *(modified question)* **How will your experience be relevant should a Public Enquiry be necessary ?**		**Marks Awarded**
Time	**Answer 1**	Experience has shown that if programmes are to be met then Public Enquiries should be avoided	6
Culture	**Answer 2**	We would hope to avoid this by attempting to identify and overcome potential difficulties during the design process	16
Experience	**Answer 3**	If an Enquiry is unavoidable then our experience and expertise should see a successful outcome	12.5
Political	**Answer 4**	If an Enquiry is unavoidable then it is important to ensure that bodies such as English Nature and English Heritage are "onside"	19.5
Cost	**Answer 5**	It is usually better to spend more on the design processes than to meet the cost of an Enquiry	13.5
Quality	**Answer 6**	A well presented demonstrably high quality product minimises the Enquiry process	11
Design	**Answer 7**	If a Millennial quality design is to be produced an Enquiry may be unavoidable but this quality should ensure a successful outcome	21.5
		Total	100

Value Explored	**Question - 8** *(modified question)* **How relevant is it in a project of this nature to involve the client, the Consultant, the contractor, sub-contractor and suppliers in all decision making processes ?**		**Marks Awarded**
Time	**Answer 1**	This would be a suitable goal if sufficient time is available	25
Culture	**Answer 2**	There are inherent difficulties in undertaking this type of exercise which limits its value	2
Experience	**Answer 3**	Experience has shown that other "players" in the construction industry are not sufficiently willing to participate at the early stages of a project so as to make this a viable exercise *or A good designer has sufficient experience in projects of this nature such that they do not need any significant input from other "players" in the construction industry*	12.5
Political	**Answer 4**	It is best to clearly differentiate the respective roles of all the parties to a project if contractual difficulties are to be avoided	21.5
Cost	**Answer 5**	If time permitted the additional hidden cost of this is difficult for a public body to justify	10
Quality	**Answer 6**	For a Millennial project it is more important to concentrate on supervision in order to achieve a quality product	14
Design	**Answer 7**	If a Millennial quality structure is to be produced it is dangerous to embark on a process of "design by committee"	15
		Total	100

Value Explored	**Question - 9** *(modified question)* **What do you think the most important considerations are to Gosport Borough Council, Hampshire County Council and The Millennium Commission in the successful delivery of the project**		**Marks Awarded**
Time	**Answer 1**	Completing the structure by the June 2000	3
Culture	**Answer 2**	Being prepared to work in innovative ways with the organisations involved in the project	8
Experience	**Answer 3**	Employing a Consultant with a proven track record in projects of this nature	3
Political	**Answer 4**	Understanding the differing cultures, needs, obligations and requirements of the organisations	6
Cost	**Answer 5**	Delivering the structure within agreed budgets	16
Quality	**Answer 6**	Producing a high quality low maintenance structure	34
Design	**Answer 7**	The design should be of a quality appropriate to a landmark Millennium project	30
		Total	100

Value Explored	Question - 10 How will you be able to accurately forecast costs ?		Marks Awarded
Time	**Answer 1**	Sufficient time should be allowed in the overall design period to allow for regular reviews of cost to be undertaken as the design progresses	12.5
Culture	**Answer 2**	We will discuss cost reviews with the client in order to agree modifications to the Brief to accommodate cost changes should these be necessary	17.5
Experience	**Answer 3**	In view of our experience on structures of this type we foresee little difficulty in accurately forecasting costs	5
Political	**Answer 4**	We will liase with the County Council throughout the design process in order to ensure that their requirements in relation to adoptability are fully incorporated into the design	19
Cost	**Answer 5**	Sufficient estimating staff will be employed during the design process to ensure that costs are regularly reviewed	30
Quality	**Answer 6**	Our office practices require us to regularly review anticipated construction costs at fixed stages in the design	9
Design	**Answer 7**	By using proven technology and construction methods	7
		Total	100

Value Explored	Question - 11 *(modified question)* **How relevant do you see "value engineering" being to this project ?**		**Marks Awarded**
Time	**Answer 1**	The clients timescales may well preclude this exercise being undertaken	21
Culture	**Answer 2**	The extent to which this is required will be determined by the detail contained in the Brief	6.5
Experience	**Answer 3**	Our experience of this concept limits our ability to assess its relevance	13.5
Political	**Answer 4**	This is of little relevance on a project such as this. Value means different thing to different people. Given the number of interested parties it is difficult to see how this concept can be applied in a worthwhile way	7.5
Cost	**Answer 5**	If the client has a clear Brief the involvement of the Consultant in this process would only add an unnecessary cost onto the project	13
Quality	**Answer 6**	If a Millennial structure is to be of outstanding quality value issues do not necessarily apply	27.5
Design	**Answer 7**	If a Millennial quality structure is to be designed it is difficult to see how this concept is relevant to the project	11
		Total	100

Value Explored	**Question - 12** *(modified question)* **What measures will you employ to ensure low lifecycle costs and adoption by Hampshire County Council as the Highway authority**		**Marks Awarded**
Time	**Answer 1**	Time constraints may inevitably mean that considerations of this nature will need to be addressed towards the end of the design process and that the time for design may have to be extended if this aim is to be achieved	14
Culture	**Answer 2**	We will ensure that the County Council are fully aware of the clients financial constraints and that on a Millennial project the lifecycle equation may need to be reconsidered	16.5
Experience	**Answer 3**	In view of our experience with structures of this type we envisage few difficulties in securing adoption	6
Political	**Answer 4**	We will regularly liase with the County Council to ensure that all their requirements for adoption are fully addressed	22.5
Cost	**Answer 5**	Reconciling low lifecycle costs may not be compatible with the need for a Millennial structure and different options will need to be explored	20.5
Quality	**Answer 6**	the use of well proven traditional materials should minimise maintenance costs and maximise the adoptability of the structure	4
Design	**Answer 7**	Design considerations for a Millennial structure should not be constrained by considerations of adoptability if an appropriate bridge design is to be achieved	16.5
		Total	100

Value Explored	Question - 13 *(modified question)* **Why do you believe that your organisation can best deliver the concept of a Millennium project ?**		Marks Awarded
Time	**Answer 1**	We will be able to devote sufficient time and resources to the scheme to ensure that the Millennium concepts are fully addressed	14
Culture	**Answer 2**	We will work closely with the client to capture the local character and culture in order to incorporate its spirit into the project	15
Experience	**Answer 3**	Our experience on prestige projects is such that the Millennial concept is well within the scope of the organisation	8
Political	**Answer 4**	We are ideally suited to working with the client to understand the concepts and interrelationships they have with other parties to the overall project delivery	18
Cost	**Answer 5**	I will ensure that design costs are minimised in order to maximise funding for the construction costs	7
Quality	**Answer 6**	Our office procedures will ensure that a high quality product with low maintenance costs is delivered	10
Design	**Answer 7**	We will bring individual design flair to produce a scheme that is Millennial in terms of quality	28
		Total	100

Value Explored	**Question - 14** *(modified question)* **What special measures need to be taken for the environmental issues ?**		**Marks Awarded**
Time	**Answer 1**	Sufficient time should be allowed to ensure that the fullest consultation take place with interest groups	27
Culture	**Answer 2**	Proposals should be modified in order to gain as broad a consensus to the scheme	22
Experience	**Answer 3**	Few. My past experience in projects of this nature will minimise this difficulty	9
Political	**Answer 4**	The clients role is to identify the need for these and to incorporate any special requirements in the Brief	5
Cost	**Answer 5**	Special precautions are usually costly to provide and measures to mitigate their need should be pursued	15
Quality	**Answer 6**	A high quality product will usually minimise the need for these	10
Design	**Answer 7**	The design concept should have identified these at an early stage and incorporated them into the design	12
		Total	100

Appendix D. Consultants Questionnaire

This appendix contains the actual questionnaire that was sent to consultants that had expressed interest in designing Forton Lake Opening Bridge. It was the responses to this questionnaire that produced the short list of consultants.

GOSPORT
the millennium town

FORTON LAKE BRIDGE
CONSULTANTS QUESTIONNAIRE

Renaissance of Portsmouth Harbour

Millennium Scheme

Element G4
June 1997

Contents

FORTON LAKE BRIDGE

Introduction

It is important to the Borough Council, and we believe to any organisation with whom we work, that wherever possible the two parties should have as closer fit as possible in regard to their cultural values and norms. The Council has determined the profile of the type of organisation with which it would like to work on this project and the attached questionnaires are designed to assist in this process. I am sure that you would agree that if your organisation and the council are not compatible this would not naturally lead to the type of harmonious relationship that is considered essential for a project of this nature.

The Council is aware that projects of this nature are outside the normal scope of its operations and has therefore determined to follow a different process from that which it would normally use to appoint Consultants. The answers that you give will all be assessed by experienced. senior professionals in the construction industry. These results will be used to select organisations whose work will be visited and who will be invited to meet with members of the Council's project team. After this process it is intended to invite three organisations to submit design concepts and to tender for the design work for this project.

A period of approximately two weeks has been allowed for you to complete the questionnaire. It should therefore be returned to me, in both paper and electronic formats, by Monday 7th July1997 at the latest.

During the period allowed to complete the questionnaire I do not consider it appropriate to directly answer any queries that you may have. These should be directed to Karen Newman (Direct dial 545270) who will arrange for an appropriate answer to be given.

If you are a joint applicant your partners have been sent the same questionnaires. You are both expected to complete and return them.

The information contained with these questionnaires should be read in conjunction with that previously supplied to you. This is listed below. Should you require further copies of this please contact Karen Newman.

List of papers

1. Letter dated February 1997 enclosing questionnaire for expressions of interest.
2. Description of element - Project Details.
3. Statement of the viability of Forton Lake Bridge proposals.
4. Schedule of details identifying "project purpose" in relation to an agreement with the
   Millennium Commission.
5. Ordnance Survey map exhibit identifying the position of Forton Lake Bridge.

FORTON LAKE BRIDGE
Factors Important to Gosport Borough Council

The following factors have been identified by the Council as being of importance, either in a positive or negative manner, in relation to this project. We appreciate that compromises will need to be made and that some of these factors will have a greater weighting than others. The factors are set out below in alphabetical order in order to assist you with the completion of the questionnaires.

Factor	Description
Cost	The need to ensure that budgets are not exceeded or significantly underspent The need to balance capital expenditure against operational and maintenance costs of the structure The desire to examine options to enable choices to be made about costs The need to ensure a balance between the cost of any solution and its effectiveness
Culture	A desire to work with organisations which understand the Local Government culture including issues such as proberty A willingness to embrace new ideas and concepts A desire to work with others in a co-operative manner The need to work with others who are for flexibility in thinking and working methods
Design	To engage designers who have a proven record of flair and initiative To engage designers who are able to show a grasp of a Millennial brand and concept To produce a structure that is sympathetic to environmental and planning issues To produce a design that is both individual and intellectually challenging
Experience	To engage designers who are able to demonstrate a record of building structures of proven quality To engage designers who can demonstrate a successful record at Public Enquiries To engage designers who have a proven record of producing structures that are adopted by the Highway Authority To engage designers who have been proven to produce designs with flair and imagination
Political	To meet the valid expectations of Bodies such as English Heritage and English Nature To meet the requirements of the Millennium Commission To reconcile the potentially different needs of the County Council and the Borough Council To recognise that any Gosport project is part of an overall Portsmouth Harbour wide scheme
Quality	To ensure that design quality translates effectively into physical quality To provide a structure with low maintenance and operating costs To engage designers with formal QA type procedures To provide a structure that will be of a quality worthy of being referred to as a "Millennial structure"
Time	The length of the overall design and construction period including any period required for a Public Enquiry Ability of Designers to forecast programmes accurately Completing works by dates agreed with the Millennium Commission The desire to examine options to enable choices to be made about the length of the overall programme.
Working Relationship	To engage designers who will be able to communicate easily and effectively with the Council To engage designers who will be able to assist the Council throughout the project in its dealings with various parties To engage designers who are sympathetic to the Councils requirements To engage designers who are compatible with the Councils culture

Questionnaire One

In the following questions you are required to award 100 points in total across the seven answers indicated. Your highest score should be given to the answer that you most agree with and your lowest (including zero score) to the answer(s) you agree with least. You must answer all questions.

Example

Question -In your opinion which means of transport causes most environmental damage ?		**Marks Awarded**
Answer 1	Aeroplane	
Answer 2	Ferry	
Answer 3	Train	
Answer 4	Bus/Coach	
Answer 5	Car	
Answer 6	Cycle	
Answer 7	Walking	
	Total	100

Explanation

Most people would probably agree that walking and cycling are the least environmentally damaging.

A simple question can however often be quite complex.

ie what exactly is meant by “environmental”?, what is meant by “damage”?, is a vehicle running full more or less damaging that one running empty?, do walkers destroy areas of outstanding natural beauty ?

These are matters where, given the limited information available, you will need to form your own judgements.

Depending on your view point your answers could look like this.

Question -In your opinion which means of transport causes most environmental damage ?		**Marks Awarded**
Answer 1	Aeroplane	35
Answer 2	Ferry	10
Answer 3	Train	15
Answer 4	Bus/Coach	18
Answer 5	Car	20
Answer 6	Cycle	2
Answer 7	Walking	0

Question - 1 What measures would you take to ensure completion by June 2000 ?		Marks Awarded
Answer 1	"Fast track" methods may be needed to complete on time	
Answer 2	Construction methods may need to be explored in order to reduce construction times	
Answer 3	Our track record on projects of this nature is good and we have demonstrated an ability to accurately programme the overall process thereby ensuring completion on time	
Answer 4	It may not be possible to achieve the due date but this should be capable of extension by negotiation if a quality scheme is to be produced	
Answer 5	Additional resources could be employed and construction times reduced	
Answer 6	If a quality product is to be achieved it may not be possible to meet completion dates	
Answer 7	Design times may need to be reduced	
	Total	100

Question - 2 How will you be able to accurately forecast the programme ?		Marks Awarded
Answer 1	By allowing sufficient time initially to allow for unforeseen difficulties that may occur	
Answer 2	By discussion with the client at regular intervals	
Answer 3	By virtue of our experience on projects of this nature	
Answer 4	By discussion with all the interested parties at an early stage	
Answer 5	By allocating sufficient staff at regular stages in the design process	
Answer 6	Our office practices require us to update programme forecasts at fixed stages in the design process	
Answer 7	By using traditional designs levels of uncertainty can be minimised	
	Total	100

Question - 3 What difficulties do you see in embracing the cultural values in local government ?		Marks Awarded
Answer 1	Local authorities are often bureaucratic and this can lead to difficulties when quick decisions are required	
Answer 2	We treat each client as an individual and try carefully to identify his particular requirements	
Answer 3	We are very used to working for local authorities and see little difficulty in adapting to Gosport's needs	
Answer 4	We only work for clients where we a happy that we understand the values of all the "players" in the project	
Answer 5	Local authorities tend not to be prepared to pay for quality designs	
Answer 6	Too much emphasis may be placed by local authorities on the quality of the finished product as against the quality of the design	
Answer 7	Local authorities tend to be conservative and this can cause design conflicts	
	Total	100

Question - 4 How does your organisation adapt to embrace new concepts ?		Marks Awarded
Answer 1	We tend to wait to see how relevant these are before adopting them	
Answer 2	We seek out suppliers, contractors and specialist sub-contractors to introduce us to new ideas and concepts	
Answer 3	New concepts are carefully considered at a senior level before being introduced in a systematic way	
Answer 4	We easily adapt when external considerations require this	
Answer 5	These are carefully evaluated in order to demonstrate proven cost benefit before introduction	
Answer 6	New ideas need to be carefully considered if quality is not to be compromised	
Answer 7	We are innovative designers and therefore our organisation is constantly adapting as part of its normal culture	
	Total	100

Question - 5 Would the buildability of the project be enhanced by appointing a contractor during the design stage ?		**Marks Awarded**
Answer 1	Possibly but only at the risk of lengthening the design process	
Answer 2	It is difficult to see what meaningful advantage could be gained by this since working with a contractor at the design stage would be difficult to achieve	
Answer 3	There would only be a minimal advantage in view of our experience on project of this nature	
Answer 4	Yes but such a procedure could be difficult for a local authority to achieve	
Answer 5	There would be advantages to this but overall the cost of the project could increase	
Answer 6	Buildability is closely linked to the quality of the finished product but quality can best be achieved by appropriate levels of site supervision	
Answer 7	Buildability relies essentially on good design and so little advantage is seen in this	
	Total	100

Question - 6 How appropriate are any innovative procedures, designs and construction methods to this Millennium scheme ?		**Marks Awarded**
Answer 1	Innovation may lead to delays in overall programmes and should therefore be avoided	
Answer 2	A Millennial scheme should provide an ideal opportunity to try new ideas and concepts	
Answer 3	We have tried new ideas and concepts but found that traditional well proven methods are usually best	
Answer 4	Although considerable potential benefits may be found the number of parties involved in a project of this nature does not make this a practical proposition	
Answer 5	The construction industry is conservative by instinct and innovation usually equates to increased cost to cover the increased risk	
Answer 6	Improvements in the quality of products only come about if innovation is encouraged	
Answer 7	Innovative design flair is vital to a successful Millennial scheme	
	Total	100

Question - 7 How will your experience be relevant should a Public Enquiry be necessary ?		Marks Awarded
Answer 1	Experience has shown that if programmes are to be met then Public Enquiries should be avoided	
Answer 2	We would hope to avoid this by attempting to identify and overcome potential difficulties during the design process	
Answer 3	If an Enquiry is unavoidable then our experience and expertise should see a successful outcome	
Answer 4	If an Enquiry is unavoidable then it is important to ensure that bodies such as English Nature and English Heritage are "onside"	
Answer 5	It is usually better to spend more on the design processes than to meet the cost of an Enquiry	
Answer 6	A well presented demonstrably high quality product minimises the Enquiry process	
Answer 7	If a Millennial quality design is to be produced an Enquiry may be unavoidable but this quality should ensure a successful outcome	
	Total	100

Question - 8 How relevant is it in a project of this nature to involve the client, the Consultant, the contractor, sub-contractor and suppliers in all decision making processes ?		Marks Awarded
Answer 1	This would be a suitable goal if sufficient time is available	
Answer 2	There are inherent difficulties in undertaking this type of exercise which limits its value	
Answer 3	A good designer has sufficient experience in projects of this nature such that they do not need any significant input from other "players" in the construction industry	
Answer 4	It is best to clearly differentiate the respective roles of all the parties to a project if contractual difficulties are to be avoided	
Answer 5	If time permitted the additional hidden cost of this is difficult for a public body to justify	
Answer 6	For a Millennial project it is more important to concentrate on supervision in order to achieve a quality product	
Answer 7	If a Millennial quality structure is to be produced it is dangerous to embark on a process of "design by committee"	
	Total	100

Question - 9 What do you think the most important considerations are to Gosport Borough Council, Hampshire County Council and The Millennium Commission overall for the successful delivery of the project		Marks Awarded
Answer 1	Completing the structure by the June 2000	
Answer 2	Being prepared to work in innovative ways with the organisations involved in the project	
Answer 3	Employing a Consultant with a proven track record in projects of this nature	
Answer 4	Understanding the differing cultures, needs, obligations and requirements of the organisations	
Answer 5	Delivering the structure within agreed budgets	
Answer 6	Producing a high quality low maintenance structure	
Answer 7	The design should be of a quality appropriate to a landmark Millennium project	
	Total	100

Question - 10 How will you be able to accurately forecast costs ?		Marks Awarded
Answer 1	Sufficient time should be allowed in the overall design period to allow for regular reviews of cost to be undertaken as the design progresses	
Answer 2	We will discuss cost reviews with the client in order to agree modifications to the Brief to accommodate cost changes should these be necessary	
Answer 3	In view of our experience on structures of this type we foresee little difficulty in accurately forecasting costs	
Answer 4	We will liase with the County Council throughout the design process in order to ensure that their requirements in relation to adoptability are fully incorporated into the design	
Answer 5	Sufficient estimating staff will be utilised throughout the design process to ensure that costs are regularly reviewed	
Answer 6	Our office practices require us to regularly review anticipated construction costs at fixed stages in the design	
Answer 7	By using proven technology and construction methods	
	Total	100

Question - 11 How relevant do you see "value engineering" being to this project ?		Marks Awarded
Answer 1	The clients timescales may well preclude this exercise being undertaken	
Answer 2	The extent to which this is required will be determined by the detail contained in the Brief	
Answer 3	Our experience of this concept limits our ability to assess its relevance	
Answer 4	This is of little relevance on a project such as this. Value means different things to different people. Given the number of interested parties it is difficult to see how this concept can be applied in a worthwhile way	
Answer 5	If the client has a clear Brief the involvement of the Consultant in this process would only add an unnecessary cost onto the project	
Answer 6	If a Millennial structure is to be of outstanding quality value issues do not necessarily apply	
Answer 7	If a Millennial quality structure is to be designed it is difficult to see how this concept is relevant to the project	
	Total	100

Question - 12 What measures will you employ to give low lifecycle costs and ensure adoption by Hampshire County Council as the Highway authority		Marks Awarded
Answer 1	Time constraints may inevitably mean that considerations of this nature will need to be addressed towards the end of the design process and that the time for design may have to be extended if this aim is to be achieved	
Answer 2	We will ensure that the County Council are fully aware of the clients financial constraints and that on a Millennial project the lifecycle equation may need to be reconsidered	
Answer 3	In view of our experience with structures of this type we envisage few difficulties in securing adoption	
Answer 4	We will regularly liase with the County Council to ensure that all their requirements for adoption are fully addressed	
Answer 5	Reconciling low lifecycle costs may not be compatible with the need for a Millennial structure and different options will need to be explored	
Answer 6	The use of a well proven traditional approach should minimise maintenance costs and maximise the adoptability of the structure	
Answer 7	Design considerations for a Millennial structure should not be constrained by considerations of adoptability if a quality design is to be achieved	
	Total	100

Question - 13 Why do you believe that your organisation can best deliver the concept of a Millennium project ?		Marks Awarded
Answer 1	We will be able to devote sufficient time and resources to the scheme to ensure that the Millennium concepts are fully addressed	
Answer 2	We will work closely with the client to capture the local character and culture in order to incorporate its spirit into the project	
Answer 3	Our experience on prestige projects is such that the Millennial concept is well within the scope of the organisation	
Answer 4	We are ideally suited to working with the client to understand the concepts and interrelationships they have with other parties to the overall project delivery	
Answer 5	I will ensure that design costs are minimised in order to maximise funding for the construction costs	
Answer 6	Our office procedures will ensure that a high quality product with low maintenance costs is delivered	
Answer 7	We will bring individual design flair to produce a scheme that is Millennial in terms of quality	
	Total	100

Question - 14 What special measures need to be taken for the environmental issues ?		Marks Awarded
Answer 1	Sufficient time should be allowed to ensure that the fullest consultation take place with interest groups	
Answer 2	Proposals should be modified in order to gain as broad a consensus to the scheme	
Answer 3	Few. My past experience in projects of this nature will minimise this difficulty	
Answer 4	The clients role is to identify the need for these and to incorporate any special requirements in the Brief	
Answer 5	Special precautions are usually costly to provide and measures to mitigate their need should be persued	
Answer 6	A high quality product will usually minimise the need for these	
Answer 7	The design concept should have identified these at an early stage and incorporated them into the design	
	Total	100

Questionnaire Two

Using the judgement criteria provided, please use your experience to rank the importance of the pairs of factors in the table below to this project. A "1" should be entered into the column adjacent to the factor of least importance and a rank in the other. A ranking of 1 : 1 is not permitted.

Intensity of Importance	Definition	Explanation
1	Reference number.	Identifies the lesser rank..
3	Weak importance of one over another.	Experience and judgement slightly favour one over another.
5	Essential or strong importance.	Experience and judgement strongly favour one activity over another.
7	Demonstrated importance.	An activity is strongly favoured and its dominance is demonstrated in practice.
9	Absolute importance.	The evidence favouring one activity over another is of the highest possible order of affirmation.
2, 4, 6, 8	Intermediate values between the two adjacent judgements.	When compromise is needed.

Example

Which means of transport causes most environmental damage?

Train	1	3	Aeroplane
Ferry	1	5	Train
Aeroplane	7	1	Ferry

Explanation

In the example the respondent has judged that:-

1. The aeroplane has weak importance over the train
2. The train has strong importance over the ferry
3. The aeroplane has demonstrated importance over the ferry

Please complete these tables

Success Factor 1			Success Factor 2
Cost			Quality
Cost			Design
Cost			Working Relationship
Culture			Experience
Culture			Political
Culture			Cost
Culture			Quality
Culture			Design
Culture			Working Relationship
Design			Working Relationship
Experience			Political
Experience			Cost
Experience			Quality
Experience			Design
Experience			Working Relationship
Political			Cost
Political			Quality
Political			Design
Political			Working Relationship
Quality			Design
Quality			Working Relationship
Time			Culture
Time			Experience
Time			Political
Time			Cost
Time			Quality
Time			Design
Time			Working Relationship

Using the same criteria, please rank the importance of the members of a construction team in producing a prestigious project on time and to budget.

Client			Consulting Engineer
Consulting Engineer			Contractor
Contractor			Client

Questionnaire Three

Tell us more about your organisation

Name of Contact Person

Position in Organisation

Names and Positions of persons who contributed to the answers

Why were these people chosen ?

Briefly what do you think are the most significant aspects to the Council on this project (Answer in not more than 50 words)

The Council wishes to restore the historic link across Forton Lake. Briefly describe the range of different options that you may feel appropriate at this early stage in the projects development. (Answer in not more than 50 words)

Please describe the culture of your organisation

Appendix E. AHP Responses from Consultants

The raw data received from the consultants in response to questionnaires 1 and 2 is shown in Table E.1 to Table E.32. Figure E.1 to Figure E.32 are the AHP responses, converted to percentage scores, from prospective bridge consultants to questionnaires 2 and 3 of the consultants questionnaire. Odd numbered figures are the responses to questionnaire 2 and even numbered figures are the responses to questionnaire 3. The responses are considered consistent when the consistency ratio is less than 0.1.

Factor	Weight	Weight	Factor
Time	6	1	Culture
Time	3	1	Experience
Time	4	1	Political
Time	1	2	Cost
Time	1	2	Quality
Time	3	1	Design
Time	5	1	Working
Culture	1	5	Experience
Culture	2	1	Political
Culture	1	6	Cost
Culture	1	5	Quality
Culture	1	5	Design
Culture	3	1	Working
Experience	3	1	Political
Experience	1	6	Cost
Experience	1	6	Quality
Experience	1	4	Design
Experience	5	1	Working
Political	1	4	Cost
Political	1	5	Quality
Political	1	5	Design
Political	1	3	Working
Cost	3	1	Quality
Cost	3	1	Design
Cost	5	1	Working
Quality	3	1	Design
Quality	6	1	Working
Design	4	1	Working

Table E.1: Questionnaire 2 Response from Company 1

Factor	Weight	Weight	Factor
Time	3	1	Culture
Time	2	1	Experience
Time	2	1	Political
Time	2	1	Cost
Time	1	2	Quality
Time	2	1	Design
Time	3	1	Working
Culture	3	1	Experience
Culture	1	3	Political
Culture	1	3	Cost
Culture	1	3	Quality
Culture	3	1	Design
Culture	3	1	Working
Experience	1	3	Political
Experience	1	3	Cost
Experience	2	1	Quality
Experience	1	2	Design
Experience	3	1	Working
Political	3	1	Cost
Political	3	1	Quality
Political	3	1	Design
Political	3	1	Working
Cost	1	3	Quality
Cost	1	3	Design
Cost	3	1	Working
Quality	1	2	Design
Quality	3	1	Working
Design	3	1	Working

Table E.2: Questionnaire 2 Response from Company 2

Factor	Weight	Weight	Factor
Time	5	1	Culture
Time	5	1	Experience
Time	5	1	Political
Time	3	1	Cost
Time	3	1	Quality
Time	3	1	Design
Time	5	1	Working
Culture	1	3	Experience
Culture	5	1	Political
Culture	1	5	Cost
Culture	1	5	Quality
Culture	1	5	Design
Culture	1	2	Working
Experience	5	1	Political
Experience	1	5	Cost
Experience	1	2	Quality
Experience	1	2	Design
Experience	3	1	Working
Political	1	7	Cost
Political	1	7	Quality
Political	1	7	Design
Political	1	7	Working
Cost	1	2	Quality
Cost	1	2	Design
Cost	2	1	Working
Quality	2	1	Design
Quality	5	1	Working
Design	2	1	Working

Table E.3: Questionnaire 2 Response from Company 3

Factor	Weight	Weight	Factor
Time	2	1	Culture
Time	2	1	Experience
Time	2	1	Political
Time	1	2	Cost
Time	1	2	Quality
Time	1	3	Design
Time	1	2	Working
Culture	1	2	Experience
Culture	4	1	Political
Culture	1	2	Cost
Culture	1	3	Quality
Culture	1	4	Design
Culture	2	1	Working
Experience	2	1	Political
Experience	1	4	Cost
Experience	1	5	Quality
Experience	1	6	Design
Experience	1	3	Working
Political	1	3	Cost
Political	1	4	Quality
Political	1	5	Design
Political	1	3	Working
Cost	1	3	Quality
Cost	1	3	Design
Cost	1	2	Working
Quality	1	3	Design
Quality	3	1	Working
Design	4	1	Working

Table E.4: Questionnaire 2 Response from Company 4

Factor	Weight	Weight	Factor
Time	7	1	Culture
Time	7	1	Experience
Time	7	1	Political
Time	1	3	Cost
Time	1	5	Quality
Time	1	5	Design
Time	7	1	Working
Culture	1	4	Experience
Culture	3	1	Political
Culture	1	7	Cost
Culture	1	7	Quality
Culture	1	3	Design
Culture	1	5	Working
Experience	5	1	Political
Experience	1	5	Cost
Experience	1	5	Quality
Experience	1	5	Design
Experience	1	7	Working
Political	1	7	Cost
Political	1	7	Quality
Political	1	7	Design
Political	1	7	Working
Cost	1	5	Quality
Cost	1	5	Design
Cost	5	1	Working
Quality	1	3	Design
Quality	5	1	Working
Design	7	1	Working

Table E.5: Questionnaire 2 Response from Company 5

Factor	Weight	Weight	Factor
Time	2	1	Culture
Time	3	1	Experience
Time	3	1	Political
Time	1	2	Cost
Time	2	1	Quality
Time	1	3	Design
Time	3	1	Working
Culture	1	2	Experience
Culture	1	3	Political
Culture	2	1	Cost
Culture	3	1	Quality
Culture	1	3	Design
Culture	1	2	Working
Experience	3	1	Political
Experience	1	2	Cost
Experience	2	1	Quality
Experience	1	3	Design
Experience	3	1	Working
Political	1	3	Cost
Political	2	1	Quality
Political	1	3	Design
Political	3	1	Working
Cost	1	2	Quality
Cost	1	2	Design
Cost	1	3	Working
Quality	2	1	Design
Quality	1	2	Working
Design	2	1	Working

Table E.6: Questionnaire 2 Response from Company 6

Factor	Weight	Weight	Factor
Time	2	1	Culture
Time	2	1	Experience
Time	2	1	Political
Time	2	1	Cost
Time	2	1	Quality
Time	2	1	Design
Time	2	1	Working
Culture	1	2	Experience
Culture	1	2	Political
Culture	1	2	Cost
Culture	1	2	Quality
Culture	1	2	Design
Culture	1	2	Working
Experience	2	1	Political
Experience	1	2	Cost
Experience	1	2	Quality
Experience	1	2	Design
Experience	1	3	Working
Political	2	1	Cost
Political	2	1	Quality
Political	2	1	Design
Political	1	2	Working
Cost	1	2	Quality
Cost	2	1	Design
Cost	3	1	Working
Quality	2	1	Design
Quality	2	1	Working
Design	2	1	Working

Table E.7: Questionnaire 2 Response from Company 7

Factor	Weight	Weight	Factor
Time	7	1	Culture
Time	7	1	Experience
Time	7	1	Political
Time	1	3	Cost
Time	1	5	Quality
Time	1	7	Design
Time	7	1	Working
Culture	1	4	Experience
Culture	3	1	Political
Culture	1	7	Cost
Culture	1	7	Quality
Culture	1	7	Design
Culture	1	3	Working
Experience	5	1	Political
Experience	1	7	Cost
Experience	1	7	Quality
Experience	1	7	Design
Experience	1	5	Working
Political	1	7	Cost
Political	1	7	Quality
Political	1	7	Design
Political	1	5	Working
Cost	1	3	Quality
Cost	1	5	Design
Cost	7	1	Working
Quality	1	5	Design
Quality	7	1	Working
Design	7	1	Working

Table E.8: Questionnaire 2 Response from Company 8

Factor	Weight	Weight	Factor
Time	1	7	Culture
Time	1	5	Experience
Time	1	5	Political
Time	3	1	Cost
Time	3	1	Quality
Time	1	3	Design
Time	1	7	Working
Culture	7	1	Experience
Culture	7	1	Political
Culture	7	1	Cost
Culture	7	1	Quality
Culture	7	1	Design
Culture	1	2	Working
Experience	1	2	Political
Experience	5	1	Cost
Experience	5	1	Quality
Experience	5	1	Design
Experience	1	7	Working
Political	5	1	Cost
Political	5	1	Quality
Political	5	1	Design
Political	1	7	Working
Cost	1	3	Quality
Cost	1	3	Design
Cost	1	7	Working
Quality	1	3	Design
Quality	1	7	Working
Design	1	7	Working

Table E.9: Questionnaire 2 Response from Company 9

Factor	Weight	Weight	Factor
Time	5	1	Culture
Time	5	1	Experience
Time	5	1	Political
Time	1	2	Cost
Time	3	1	Quality
Time	3	1	Design
Time	5	1	Working
Culture	1	5	Experience
Culture	1	3	Political
Culture	1	5	Cost
Culture	1	5	Quality
Culture	1	5	Design
Culture	3	1	Working
Experience	5	1	Political
Experience	1	5	Cost
Experience	1	5	Quality
Experience	1	5	Design
Experience	5	1	Working
Political	1	5	Cost
Political	1	5	Quality
Political	1	5	Design
Political	1	3	Working
Cost	5	1	Quality
Cost	5	1	Design
Cost	6	1	Working
Quality	1	3	Design
Quality	4	1	Working
Design	5	1	Working

Table E.10: Questionnaire 2 Response from Company 10

Factor	Weight	Weight	Factor
Time	6	1	Culture
Time	5	1	Experience
Time	6	1	Political
Time	1	2	Cost
Time	1	2	Quality
Time	3	1	Design
Time	5	1	Working
Culture	1	4	Experience
Culture	3	1	Political
Culture	1	7	Cost
Culture	1	5	Quality
Culture	1	5	Design
Culture	3	1	Working
Experience	4	1	Political
Experience	1	6	Cost
Experience	1	5	Quality
Experience	1	4	Design
Experience	5	1	Working
Political	1	7	Cost
Political	1	5	Quality
Political	1	5	Design
Political	1	3	Working
Cost	5	1	Quality
Cost	5	1	Design
Cost	6	1	Working
Quality	3	1	Design
Quality	6	1	Working
Design	4	1	Working

Table E.11: Questionnaire 2 Response from Company 11

Factor	Weight	Weight	Factor
Time	5	1	Culture
Time	3	1	Experience
Time	5	1	Political
Time	3	1	Cost
Time	3	1	Quality
Time	3	1	Design
Time	3	1	Working
Culture	1	3	Experience
Culture	3	1	Political
Culture	1	2	Cost
Culture	1	3	Quality
Culture	1	3	Design
Culture	1	2	Working
Experience	3	1	Political
Experience	1	2	Cost
Experience	1	3	Quality
Experience	1	3	Design
Experience	1	2	Working
Political	1	2	Cost
Political	1	3	Quality
Political	1	3	Design
Political	1	2	Working
Cost	1	5	Quality
Cost	1	3	Design
Cost	2	1	Working
Quality	2	1	Design
Quality	2	1	Working
Design	3	1	Working

Table E.12: Questionnaire 2 Response from Company 12

Factor	Weight	Weight	Factor
Time	5	1	Culture
Time	4	1	Experience
Time	1	2	Political
Time	1	2	Cost
Time	1	3	Quality
Time	1	6	Design
Time	3	1	Working
Culture	1	5	Experience
Culture	3	1	Political
Culture	1	3	Cost
Culture	1	7	Quality
Culture	1	7	Design
Culture	1	5	Working
Experience	1	2	Political
Experience	5	1	Cost
Experience	1	4	Quality
Experience	1	4	Design
Experience	3	1	Working
Political	1	2	Cost
Political	2	1	Quality
Political	1	2	Design
Political	2	1	Working
Cost	1	3	Quality
Cost	3	1	Design
Cost	2	1	Working
Quality	3	1	Design
Quality	4	1	Working
Design	4	1	Working

Table E.13: Questionnaire 2 Response from Company 13

Factor	Weight	Weight	Factor
Time	3	1	Culture
Time	1	4	Experience
Time	4	1	Political
Time	2	1	Cost
Time	1	3	Quality
Time	1	5	Design
Time	1	2	Working
Culture	1	6	Experience
Culture	2	1	Political
Culture	1	2	Cost
Culture	1	5	Quality
Culture	1	7	Design
Culture	1	4	Working
Experience	7	1	Political
Experience	5	1	Cost
Experience	2	1	Quality
Experience	1	2	Design
Experience	3	1	Working
Political	1	3	Cost
Political	1	6	Quality
Political	1	8	Design
Political	1	5	Working
Cost	1	4	Quality
Cost	1	6	Design
Cost	1	3	Working
Quality	1	3	Design
Quality	2	1	Working
Design	4	1	Working

Table E.14: Questionnaire 2 Response from Company 14

Factor	Weight	Weight	Factor
Time	1	2	Culture
Time	2	1	Experience
Time	1	3	Political
Time	4	1	Cost
Time	3	1	Quality
Time	5	1	Design
Time	1	4	Working
Culture	3	1	Experience
Culture	1	2	Political
Culture	5	1	Cost
Culture	4	1	Quality
Culture	6	1	Design
Culture	1	3	Working
Experience	1	4	Political
Experience	3	1	Cost
Experience	2	1	Quality
Experience	4	1	Design
Experience	1	5	Working
Political	6	1	Cost
Political	5	1	Quality
Political	7	1	Design
Political	1	2	Working
Cost	1	2	Quality
Cost	2	1	Design
Cost	1	6	Working
Quality	3	1	Design
Quality	1	6	Working
Design	1	8	Working

Table E.15: Questionnaire 2 Response from Company 15

Factor	Weight	Weight	Factor
Time	2	1	Culture
Time	2	1	Experience
Time	3	1	Political
Time	2	1	Cost
Time	2	1	Quality
Time	2	1	Design
Time	3	1	Working
Culture	2	1	Experience
Culture	2	1	Political
Culture	1	3	Cost
Culture	1	3	Quality
Culture	1	3	Design
Culture	1	2	Working
Experience	1	2	Political
Experience	1	2	Cost
Experience	1	2	Quality
Experience	1	2	Design
Experience	1	2	Working
Political	1	3	Cost
Political	1	3	Quality
Political	1	3	Design
Political	1	2	Working
Cost	1	2	Quality
Cost	1	2	Design
Cost	2	1	Working
Quality	2	1	Design
Quality	3	1	Working
Design	3	1	Working

Table E.16: Questionnaire 2 Response from Company 16

Factor	Weight	Weight	Factor
Client	1	7	Consultant
Client	1	7	Contractor
Consultant	4	1	Contractor

Table E.17: Questionnaire 3 Response from Company 1

Factor	Weight	Weight	Factor
Client	2	1	Consultant
Client	1	2	Contractor
Consultant	1	2	Contractor

Table E.18: Questionnaire 3 Response from Company 2

Factor	Weight	Weight	Factor
Client	1	2	Consultant
Client	1	2	Contractor
Consultant	1	2	Contractor

Table E.19: Questionnaire 3 Response from Company 3

Factor	Weight	Weight	Factor
Client	3	1	Consultant
Client	1	3	Contractor
Consultant	1	5	Contractor

Table E.20: Questionnaire 3 Response from Company 4

Factor	Weight	Weight	Factor
Client	1	7	Consultant
Client	1	7	Contractor
Consultant	1	5	Contractor

Table E.21: Questionnaire 3 Response from Company 5

Factor	Weight	Weight	Factor
Client	2	1	Consultant
Client	2	1	Contractor
Consultant	1	2	Contractor

Table E.22: Questionnaire 3 Response from Company 6

Factor	Weight	Weight	Factor
Client	2	1	Consultant
Client	2	1	Contractor
Consultant	1	2	Contractor

Table E.23: Questionnaire 3 Response from Company 7

Factor	Weight	Weight	Factor
Client	1	5	Consultant
Client	1	7	Contractor
Consultant	1	5	Contractor

Table E.24: Questionnaire 3 Response from Company 8

Factor	Weight	Weight	Factor
Client	4	1	Consultant
Client	4	1	Contractor
Consultant	4	1	Contractor

Table E.25: Questionnaire 3 Response from Company 9

Factor	Weight	Weight	Factor
Client	1	7	Consultant
Client	1	6	Contractor
Consultant	5	1	Contractor

Table E.26: Questionnaire 3 Response from Company 10

Factor	Weight	Weight	Factor
Client	1	9	Consultant
Client	1	7	Contractor
Consultant	4	1	Contractor

Table E.27: Questionnaire 3 Response from Company 11

Factor	Weight	Weight	Factor
Client	1	3	Consultant
Client	1	3	Contractor
Consultant	2	1	Contractor

Table E.28: Questionnaire 3 Response from Company 12

Factor	Weight	Weight	Factor
Client	1	5	Consultant
Client	1	7	Contractor
Consultant	5	1	Contractor

Table E.29: Questionnaire 3 Response from Company 13

Factor	Weight	Weight	Factor
Client	1	6	Consultant
Client	1	4	Contractor
Consultant	4	1	Contractor

Table E.30: Questionnaire 3 Response from Company 14

Factor	Weight	Weight	Factor
Client	1	2	Consultant
Client	1	3	Contractor
Consultant	1	2	Contractor

Table E.31: Questionnaire 3 Response from Company 15

Factor	Weight	Weight	Factor
Client	1	3	Consultant
Client	1	3	Contractor
Consultant	1	2	Contractor

Table E.32: Questionnaire 3 Response from Company 16

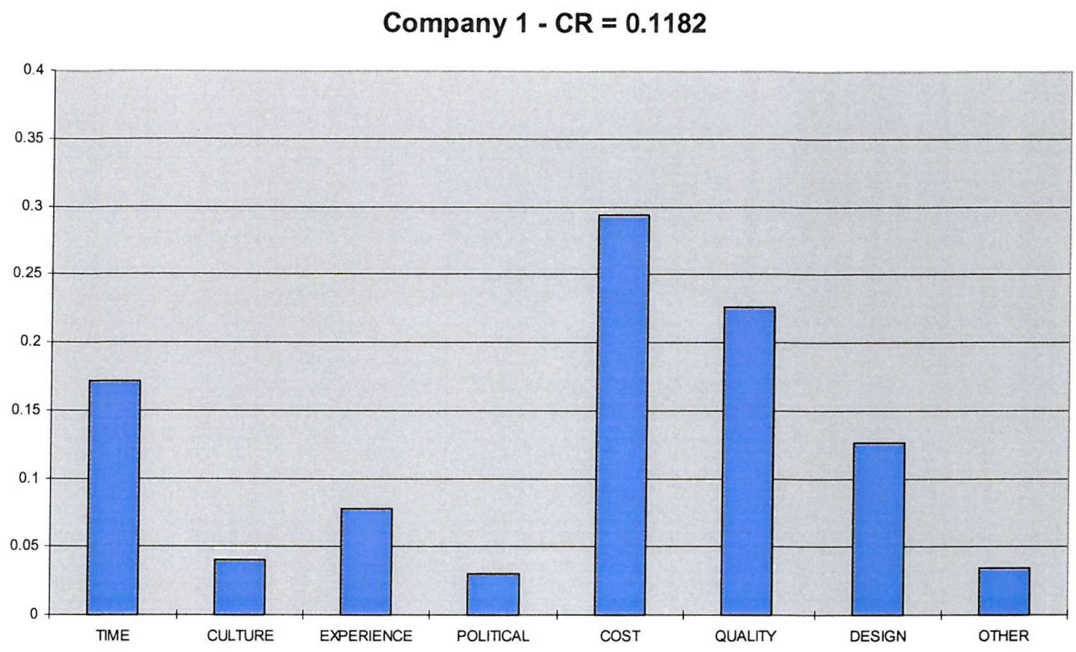

Figure E.1: Company 1 Project Objective Ranking

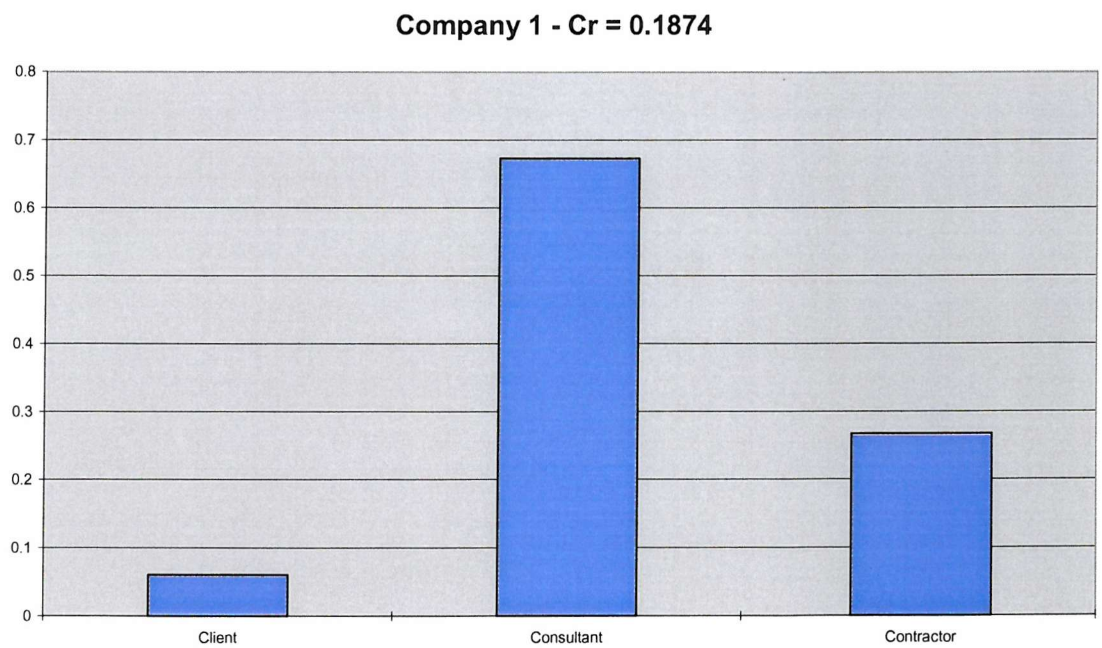

Figure E.2: Company 1 Project Participant Ranking

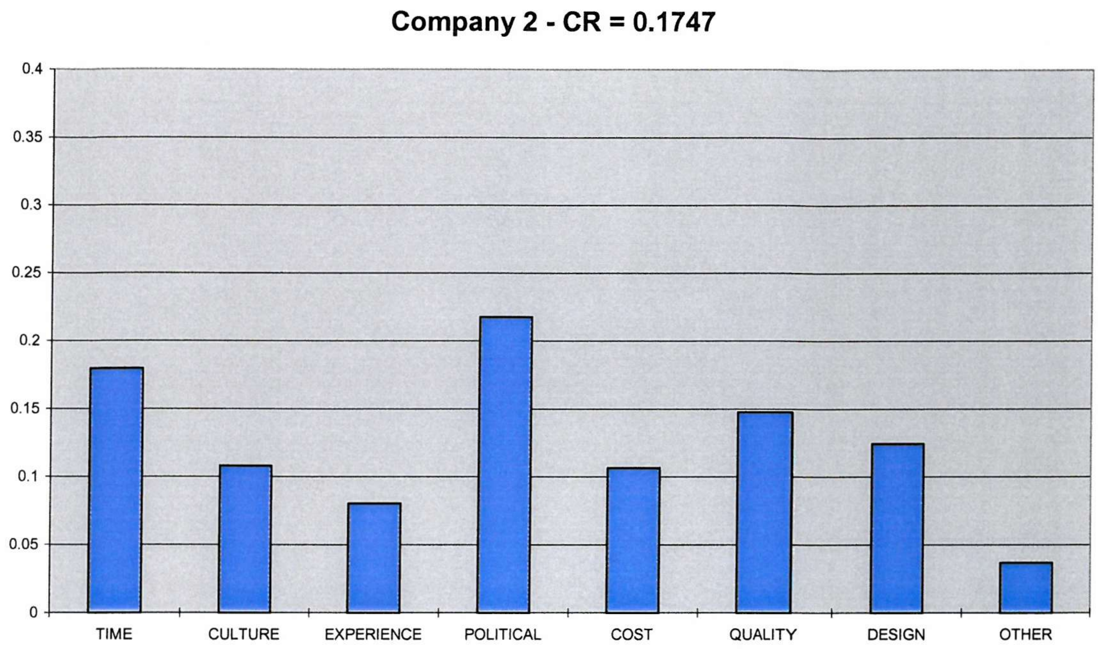

Figure E.3: Company 2 Project Objective Ranking

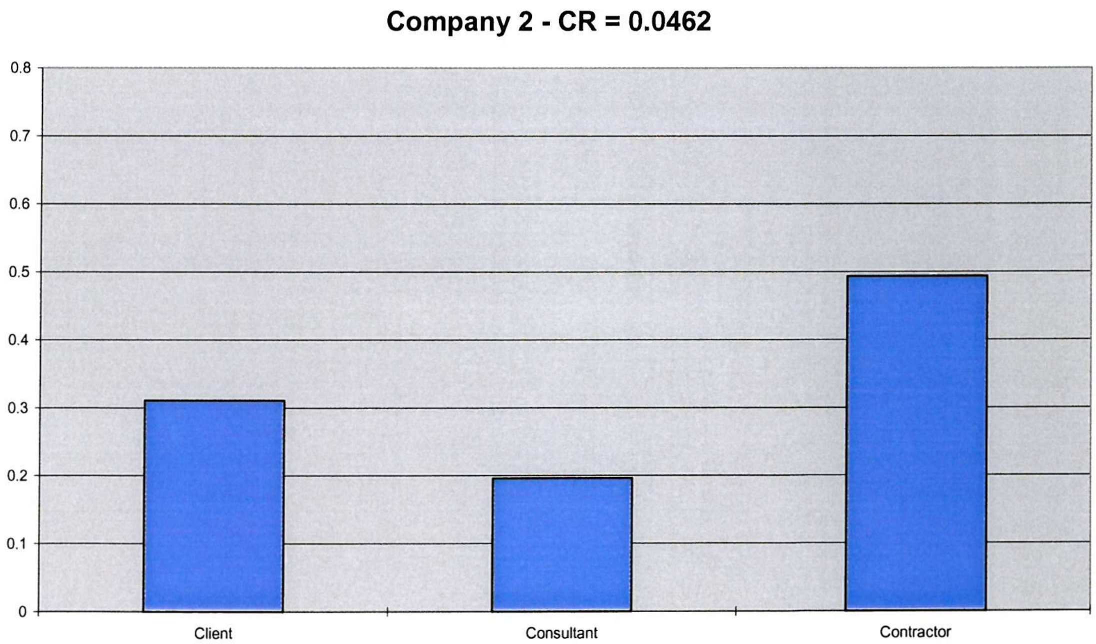

Figure E.4: Company 2 Project Participant Ranking

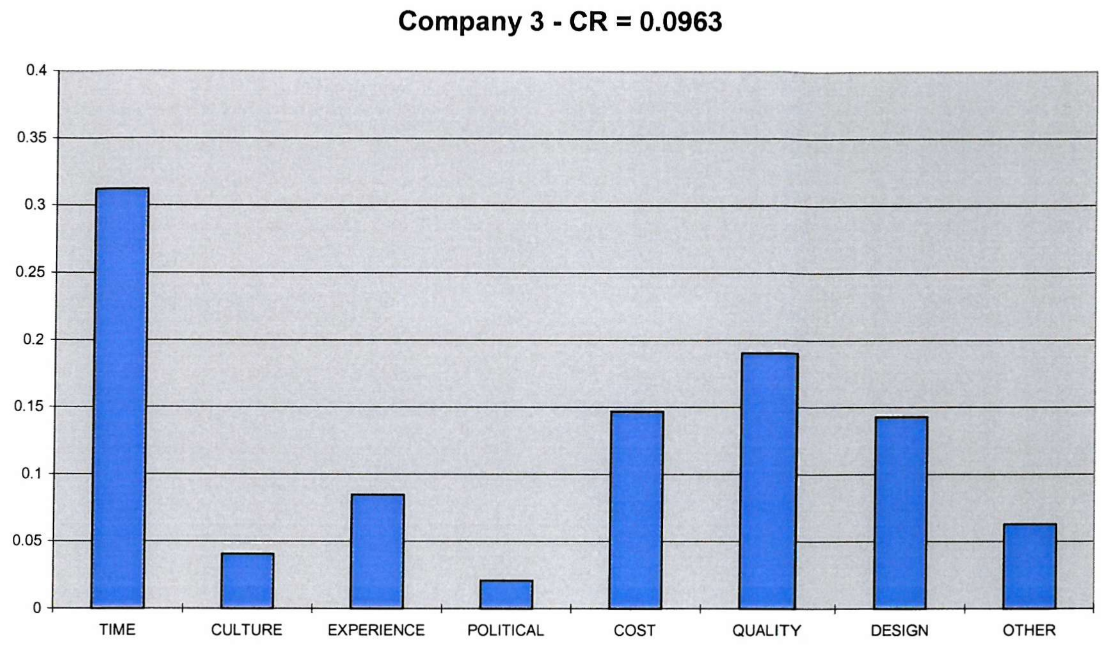

Figure E.5: Company 3 Project Objective Ranking

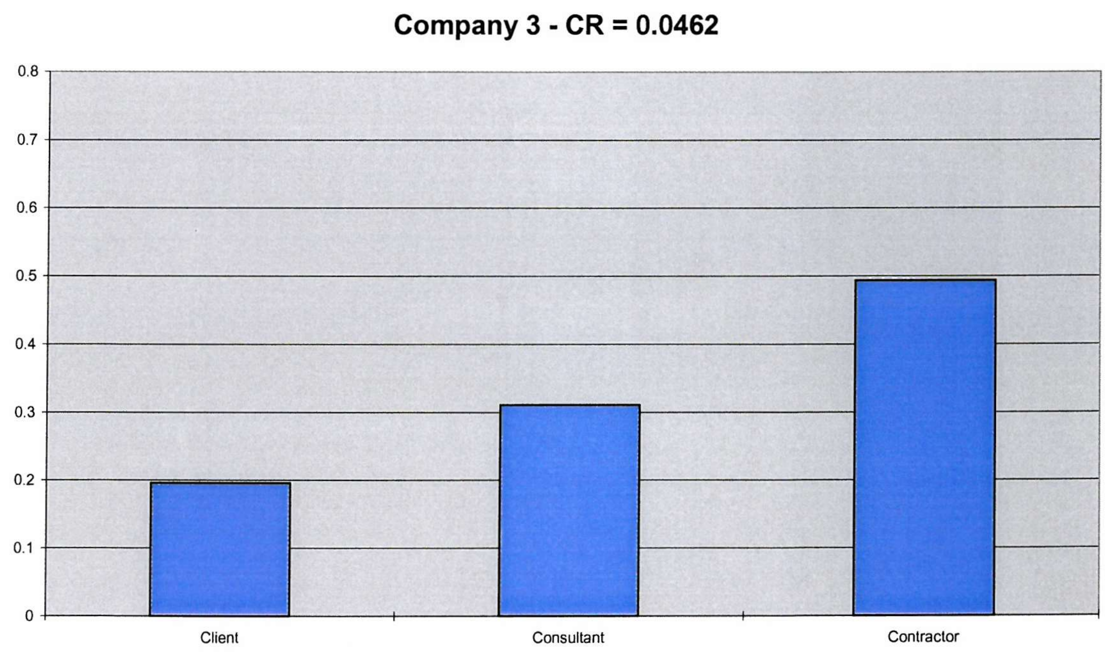

Figure E.6: Company 3 Project Participant Ranking

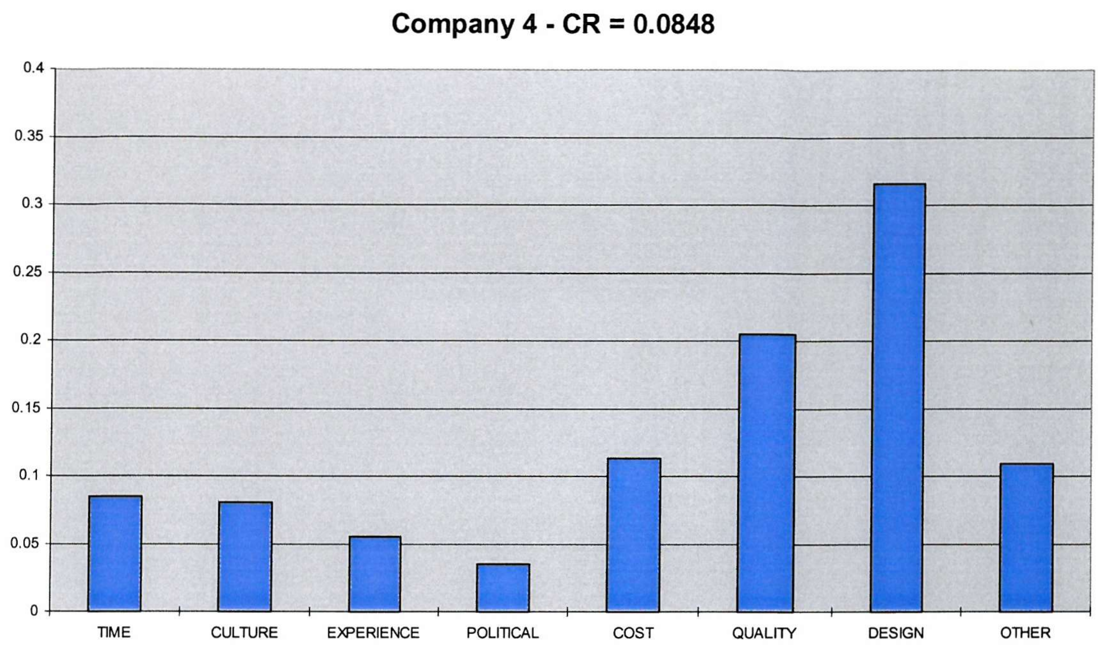

Figure E.7: Company 4 Project Objective Ranking

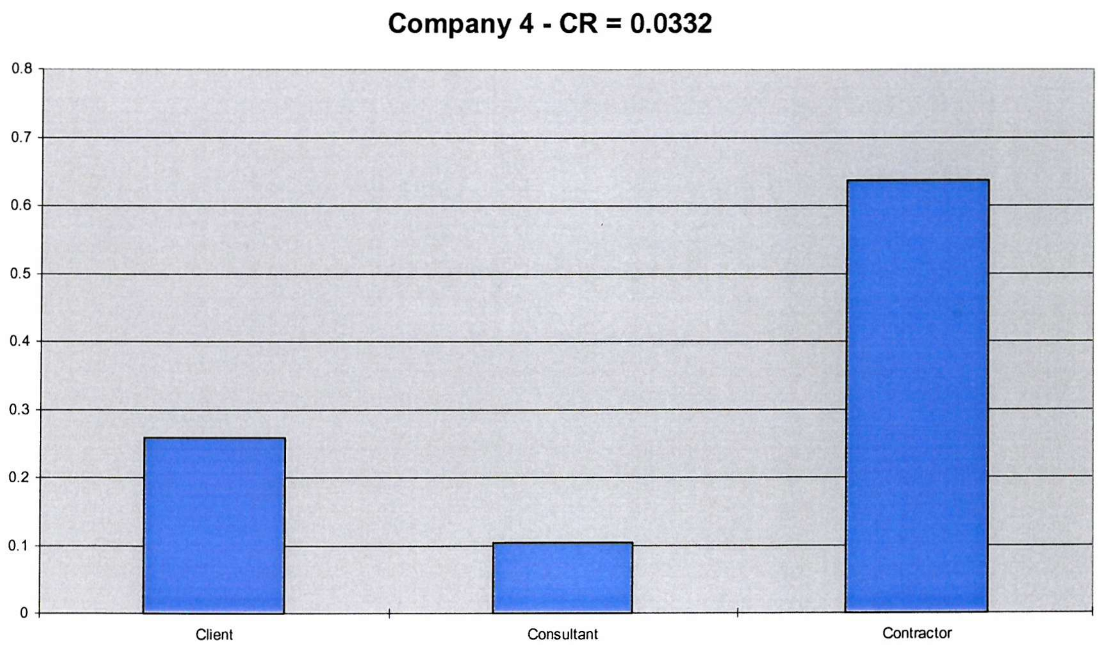

Figure E.8: Company 4 Project Participant Ranking

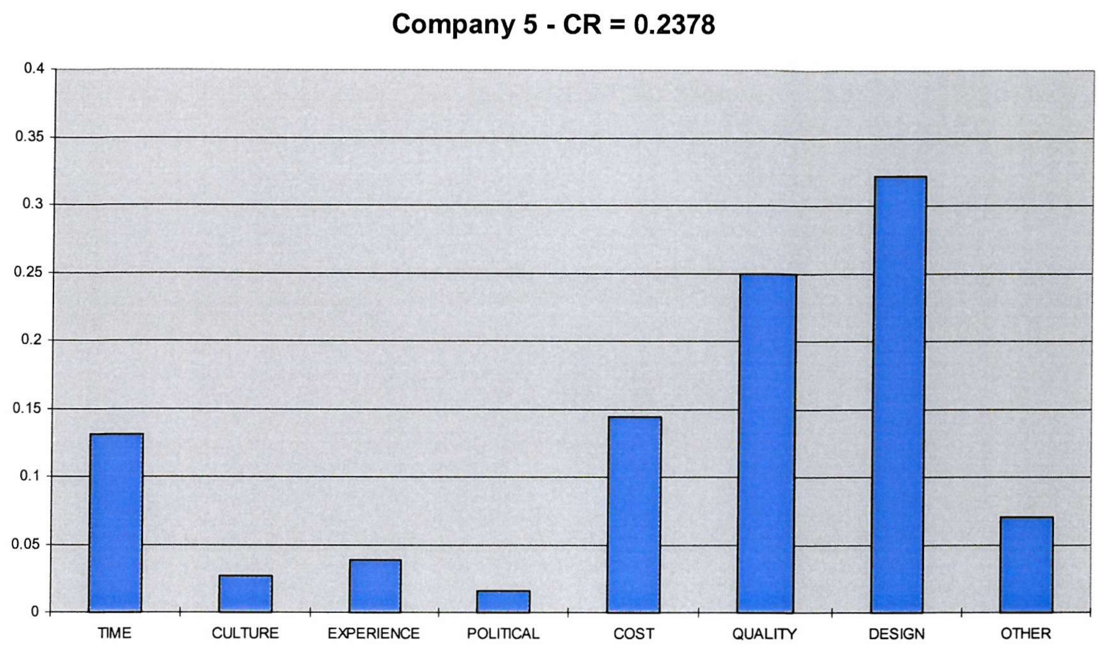

Figure E.9: Company 5 Project Objective Ranking

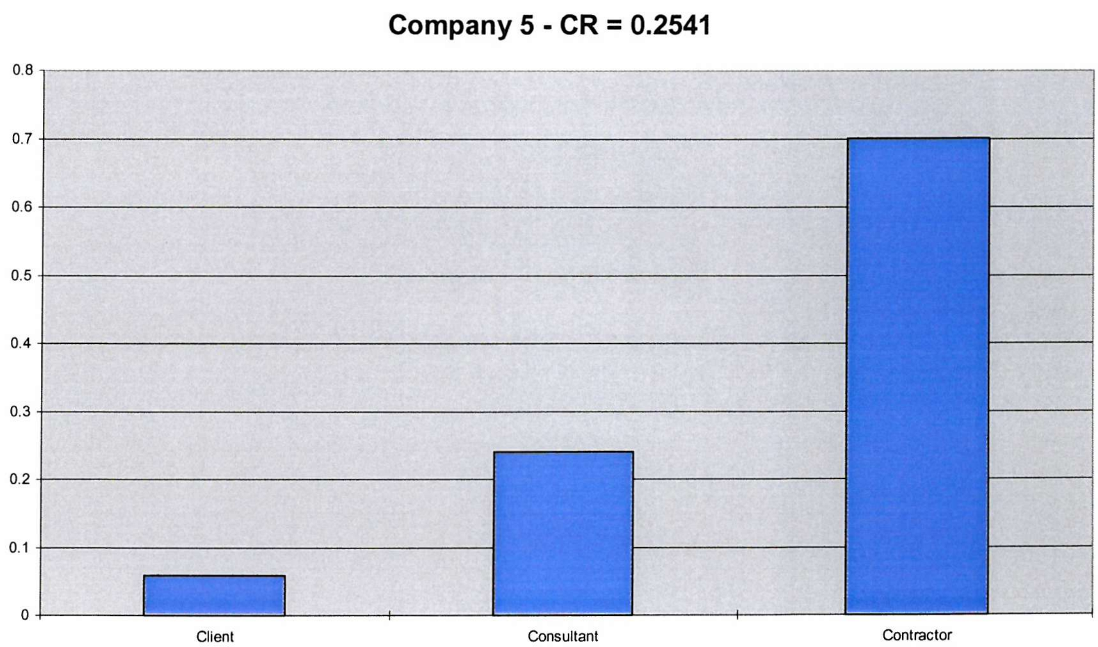

Figure E.10: Company 5 Project Participant Ranking

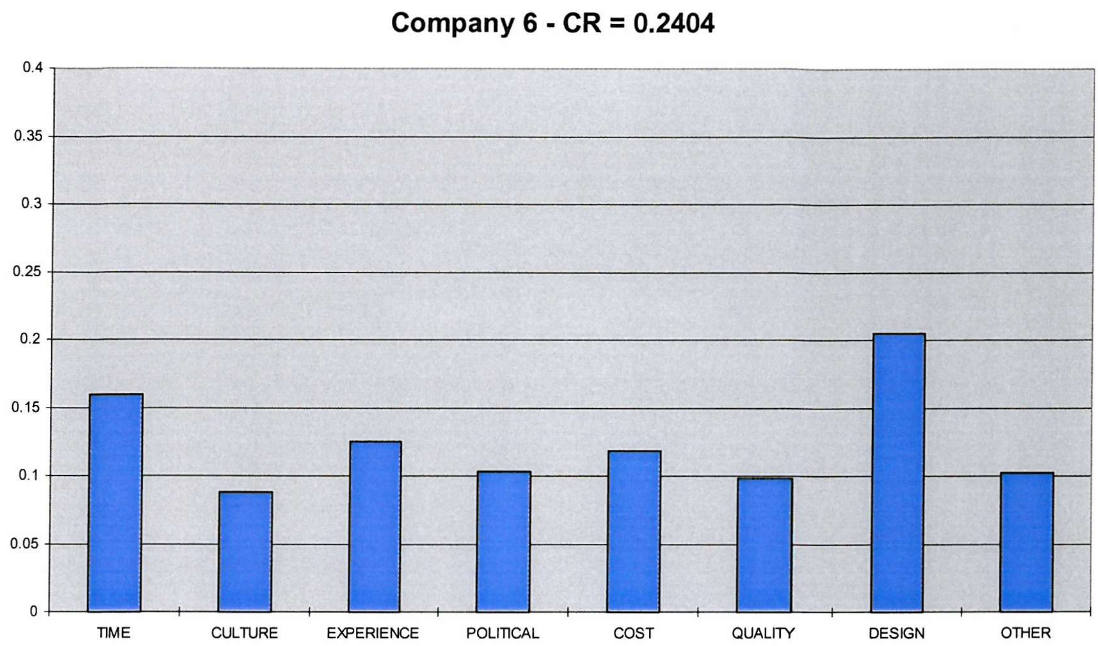

Figure E.11: Company 6 Project Objective Ranking

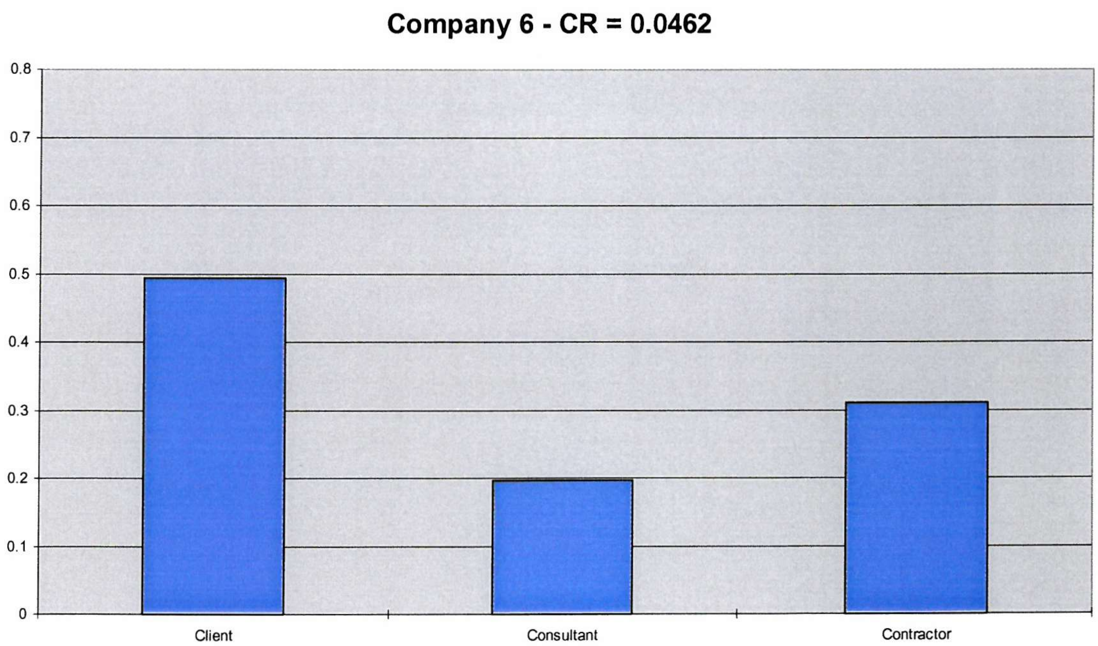

Figure E.12: Company 6 Project Participant Ranking

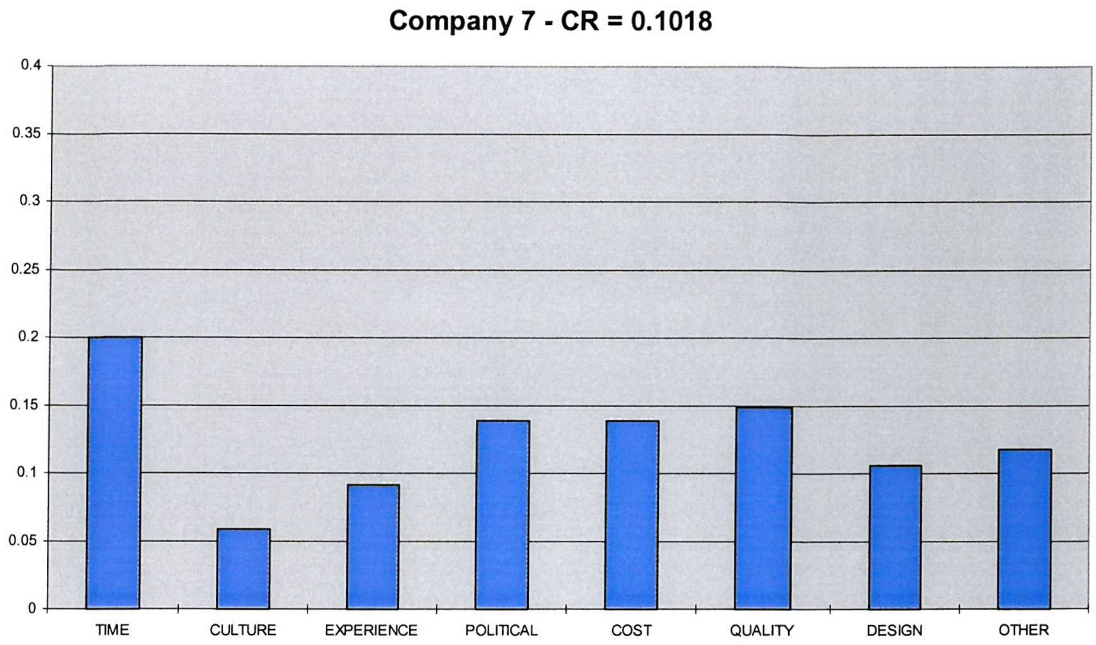

Figure E.13: Company 7 Project Objective Ranking

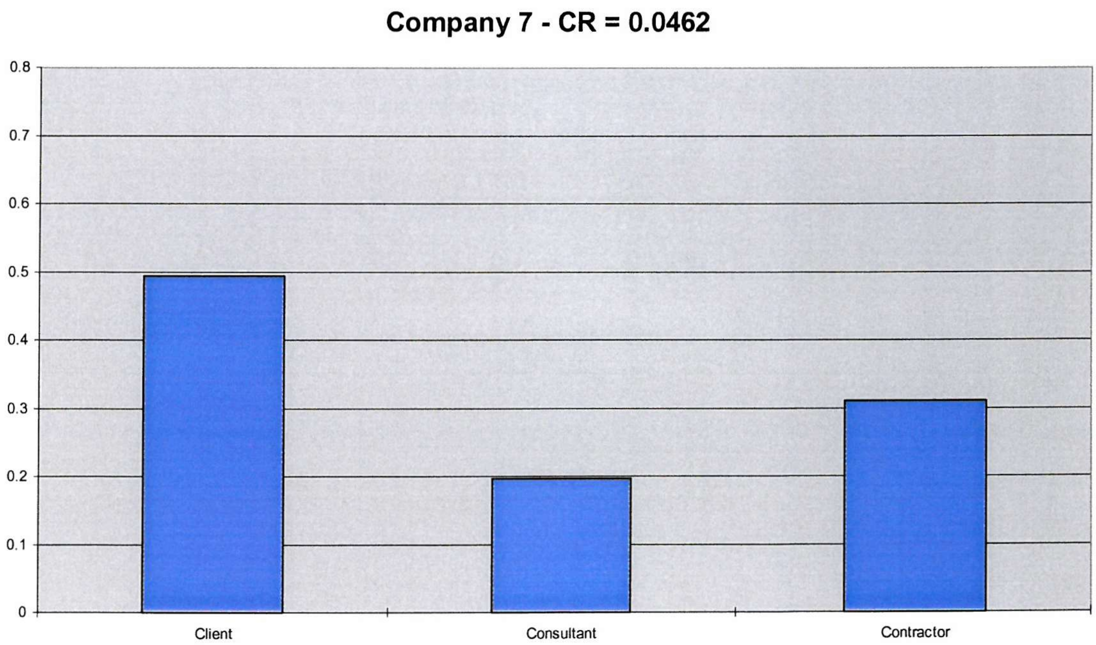

Figure E.14: Company 7 Project Participant Ranking

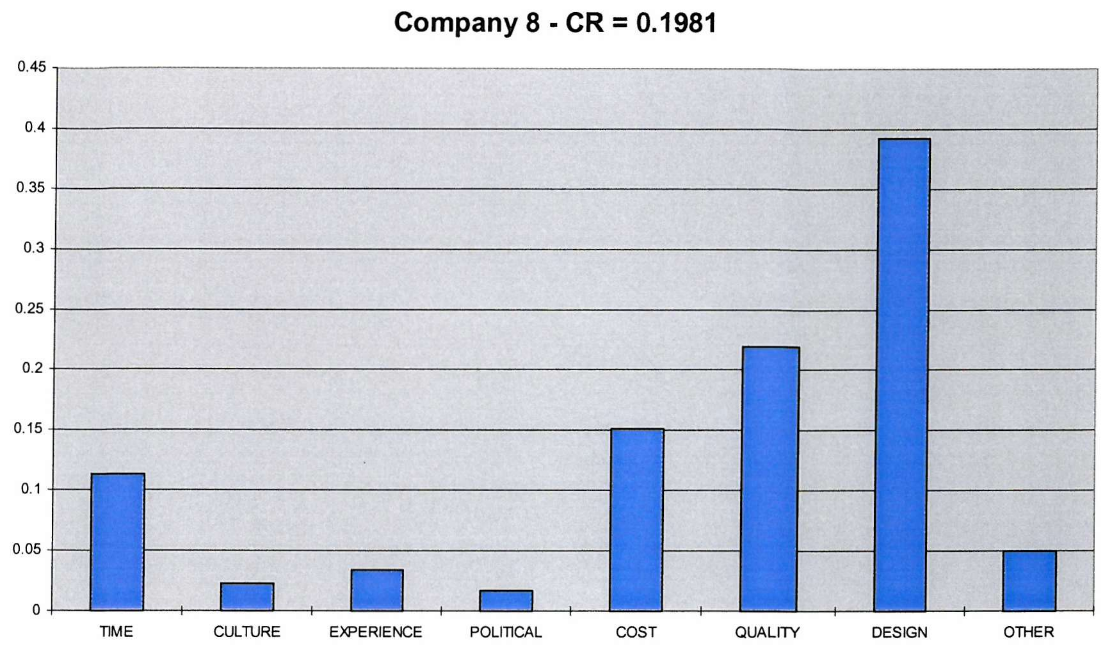

Figure E.15: Company 8 Project Objective Ranking

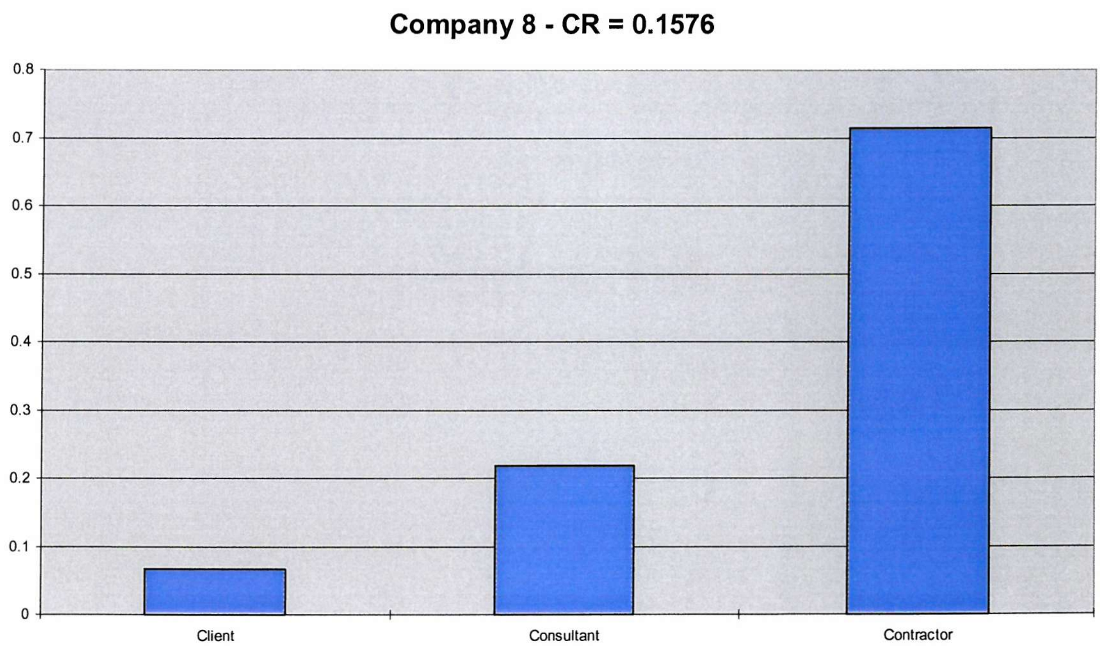

Figure E.16: Company 8 Project Participant Ranking

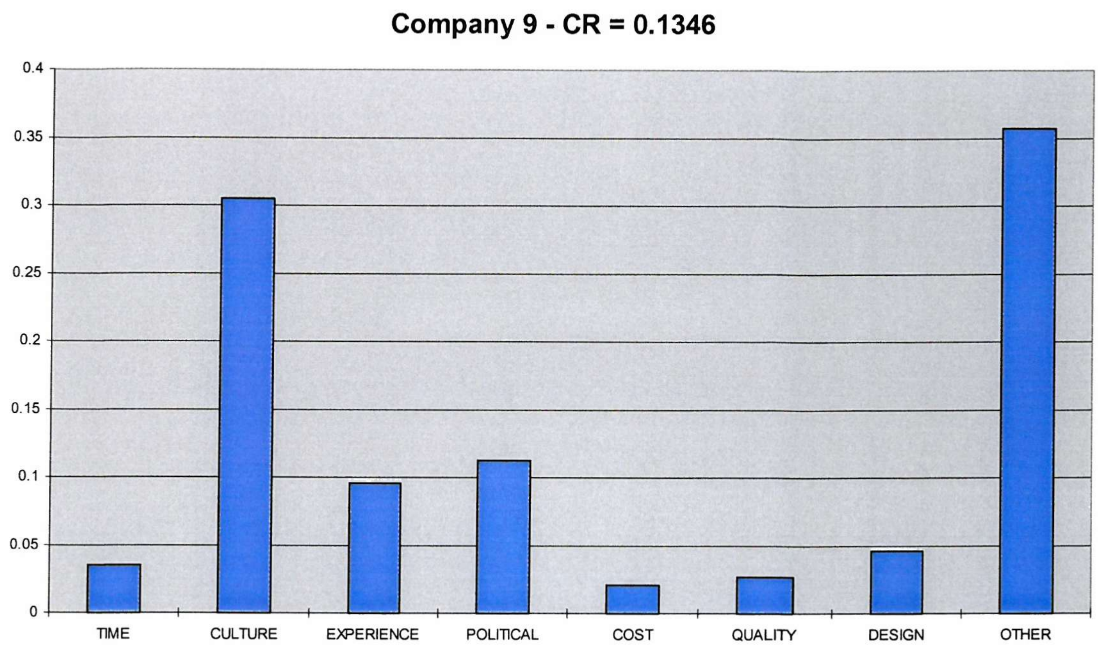

Figure E.17: Company 9 Project Objective Ranking

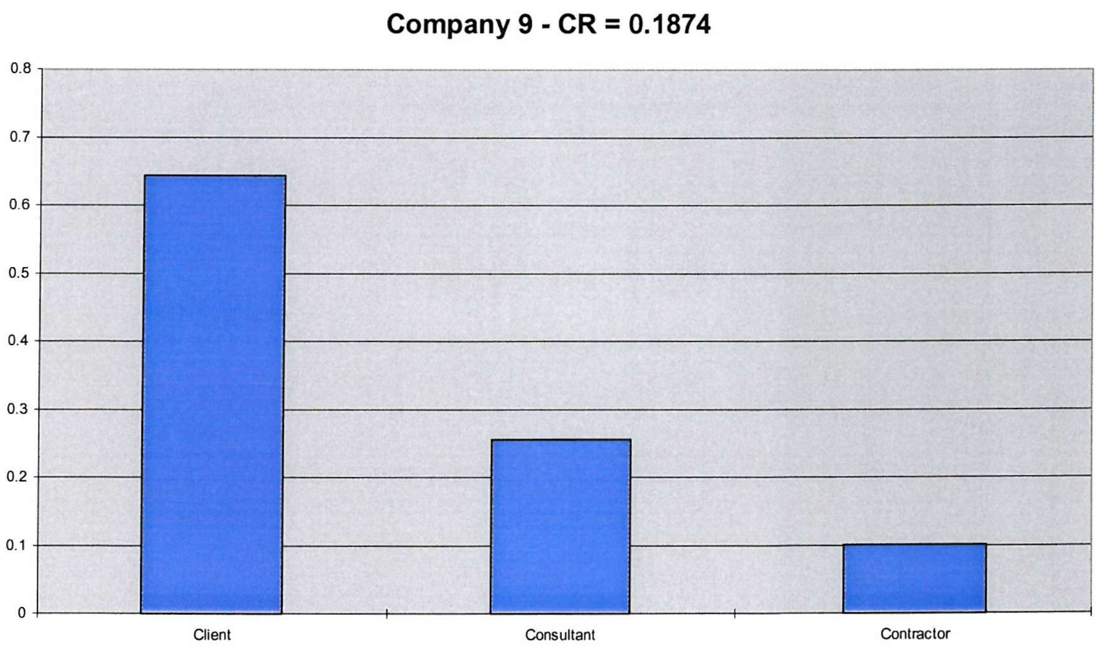

Figure E.18: Company 9 Project Participant Ranking

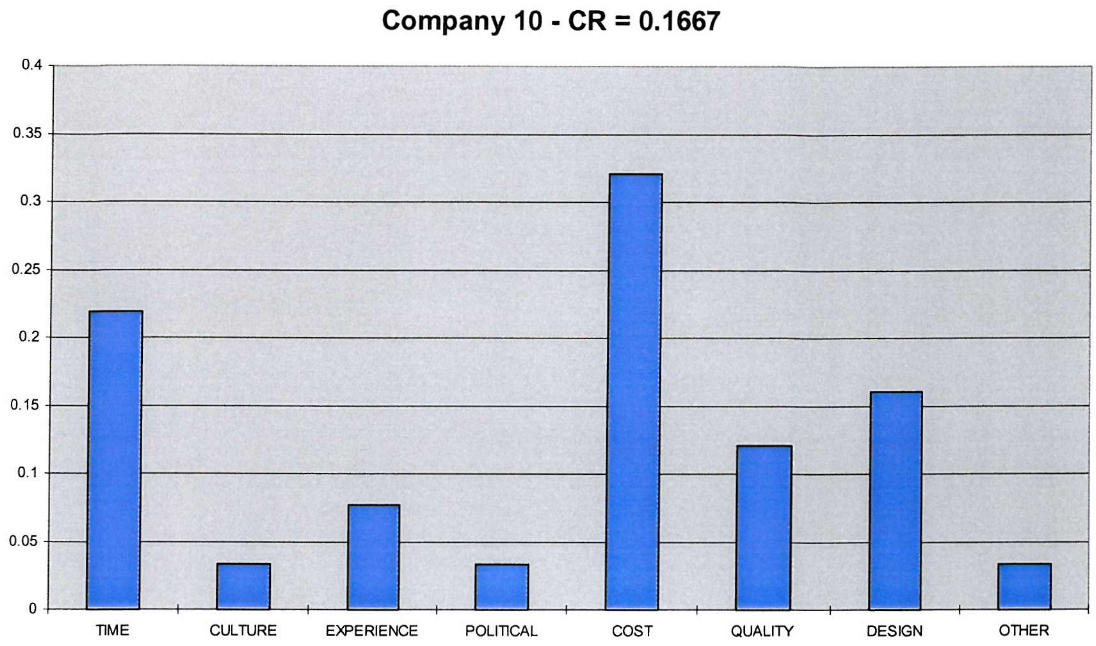

Figure E.19: Company 10 Project Objective Ranking

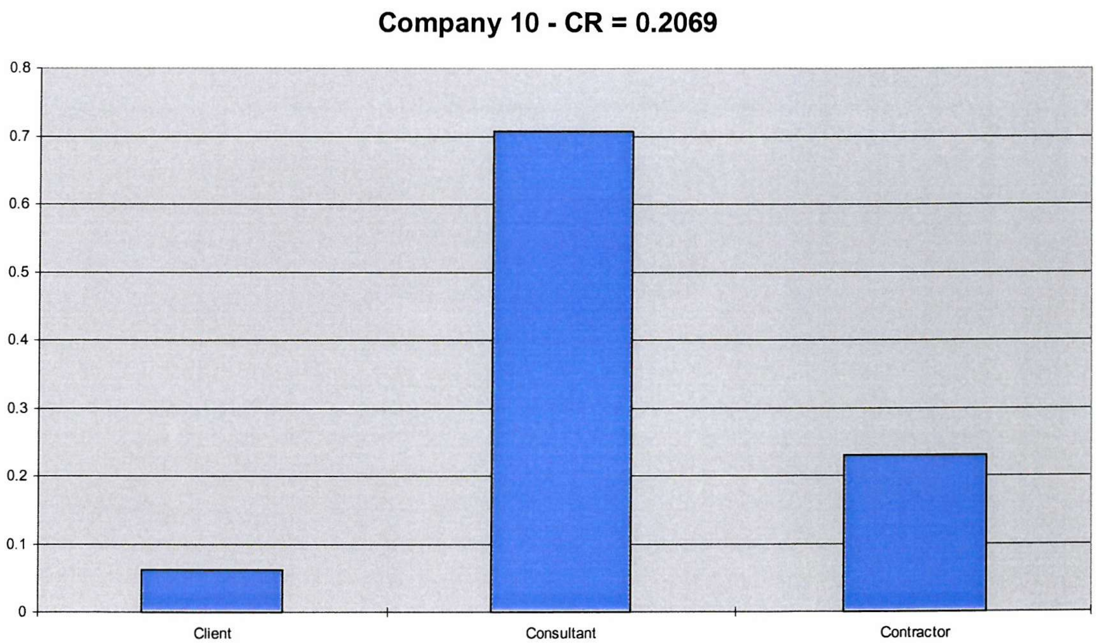

Figure E.20: Company 10 Project Participant Ranking

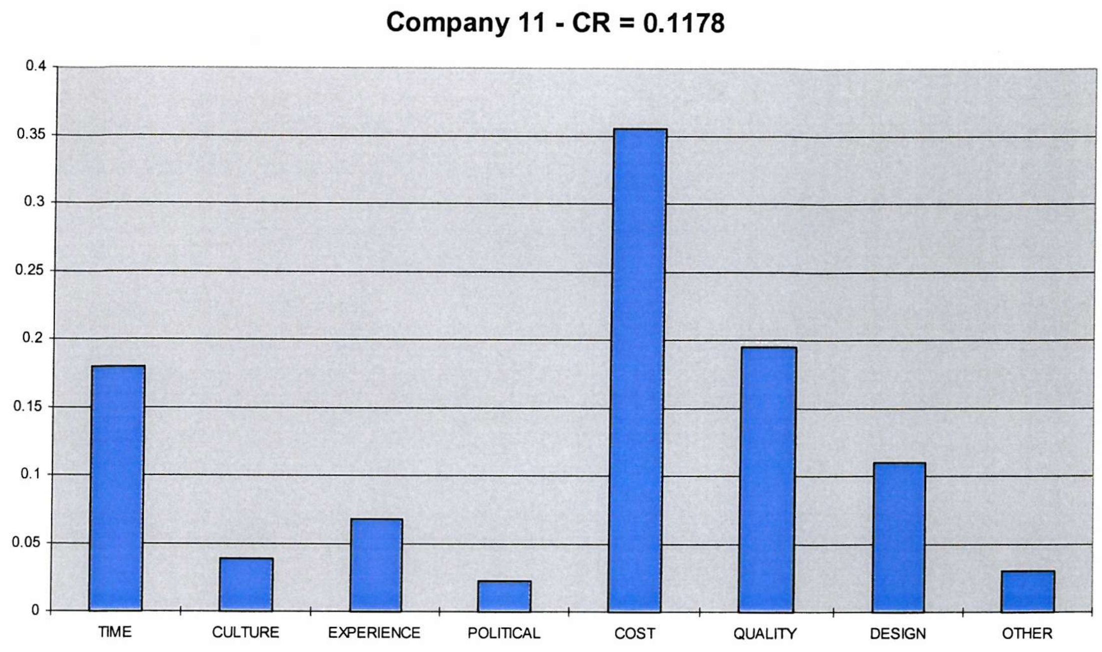

Figure E.21: Company 11 Project Objective Ranking

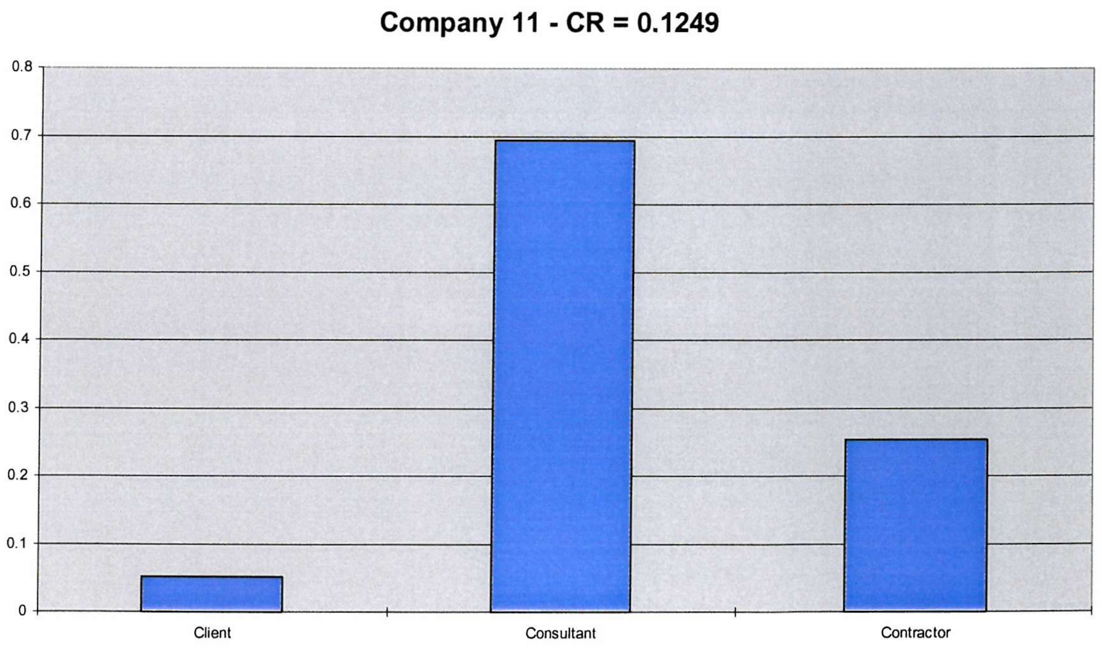

Figure E.22: Company 11 Project Participant Ranking

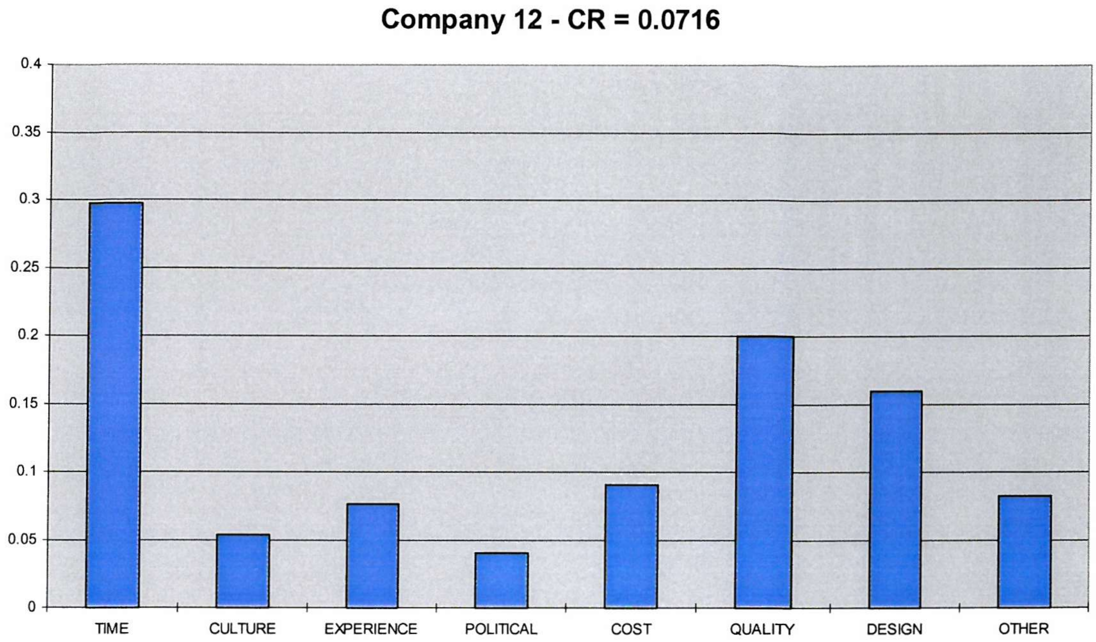

Figure E.23: Company 12 Project Objective Ranking

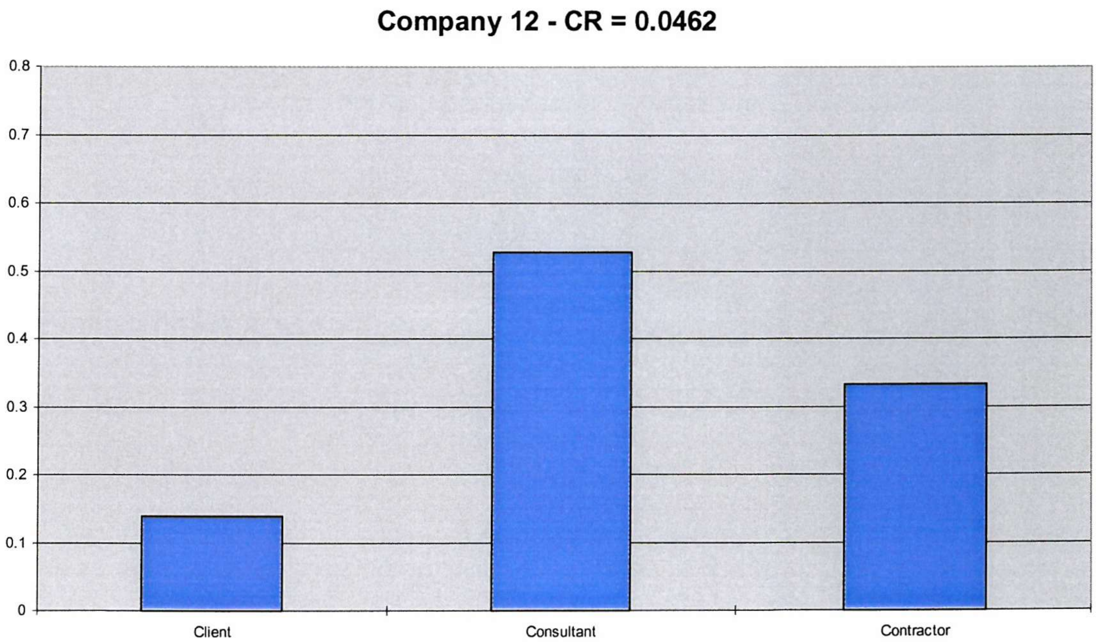

Figure E.24: Company 12 Project Participant Ranking

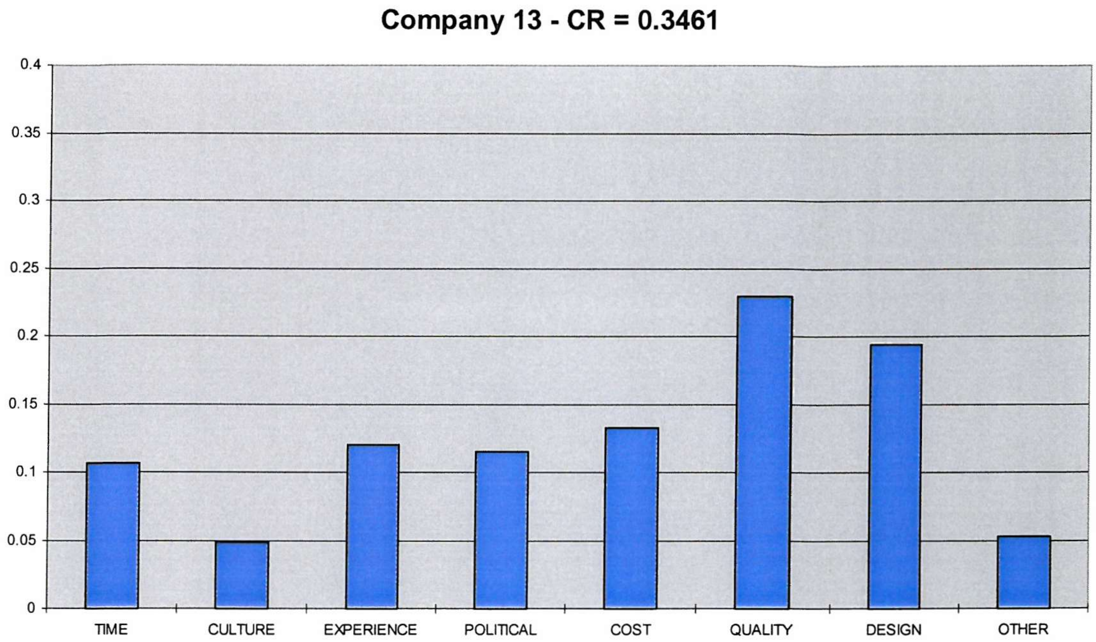

Figure E.25: Company 13 Project Objective Ranking

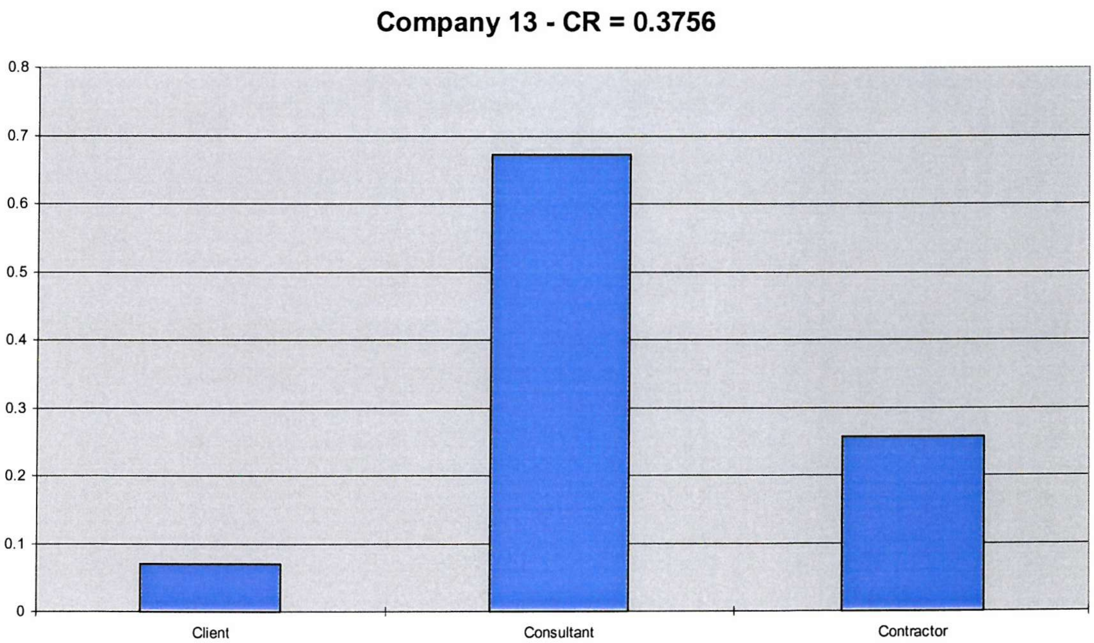

Figure E.26: Company 13 Project Participant Ranking

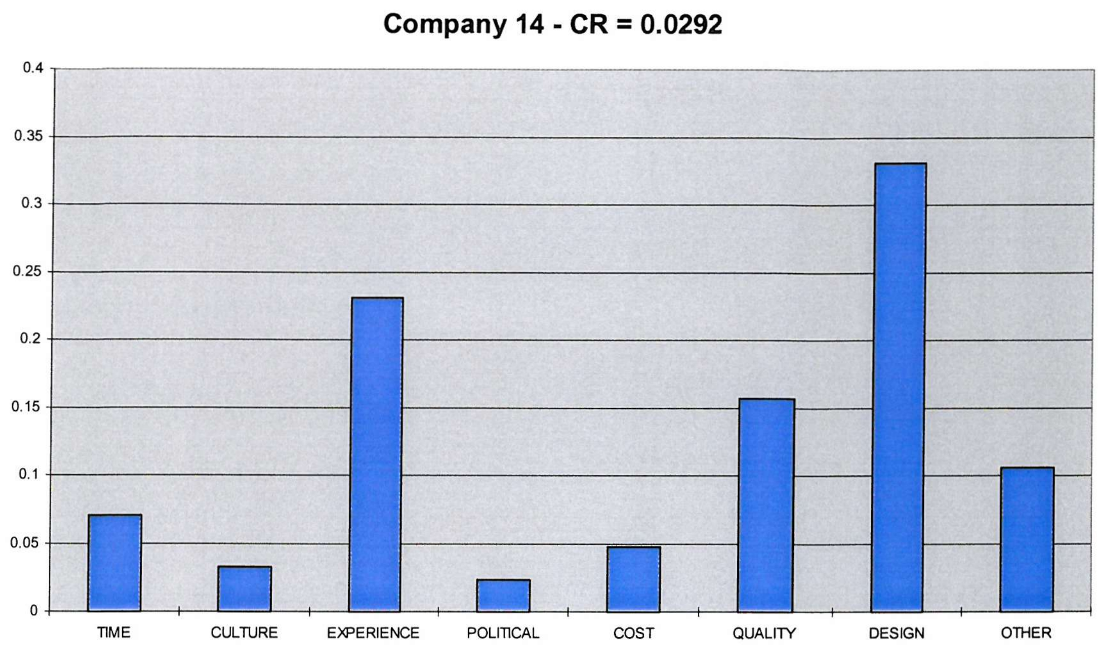

Figure E.27: Company 14 Project Objective Ranking

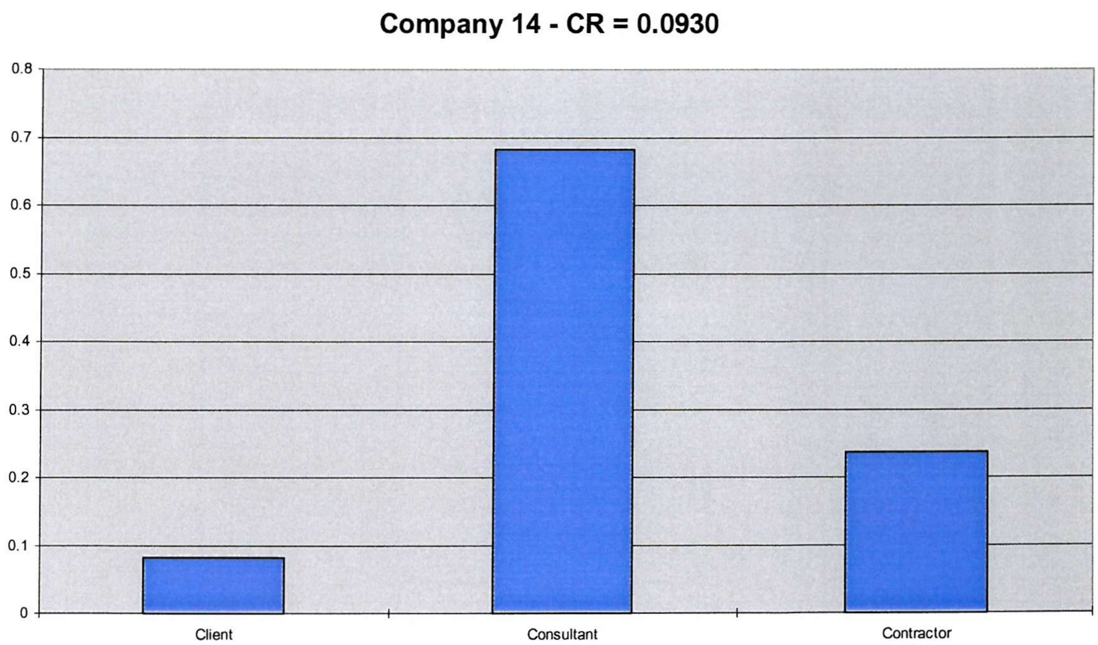

Figure E.28: Company 14 Project Participant Ranking

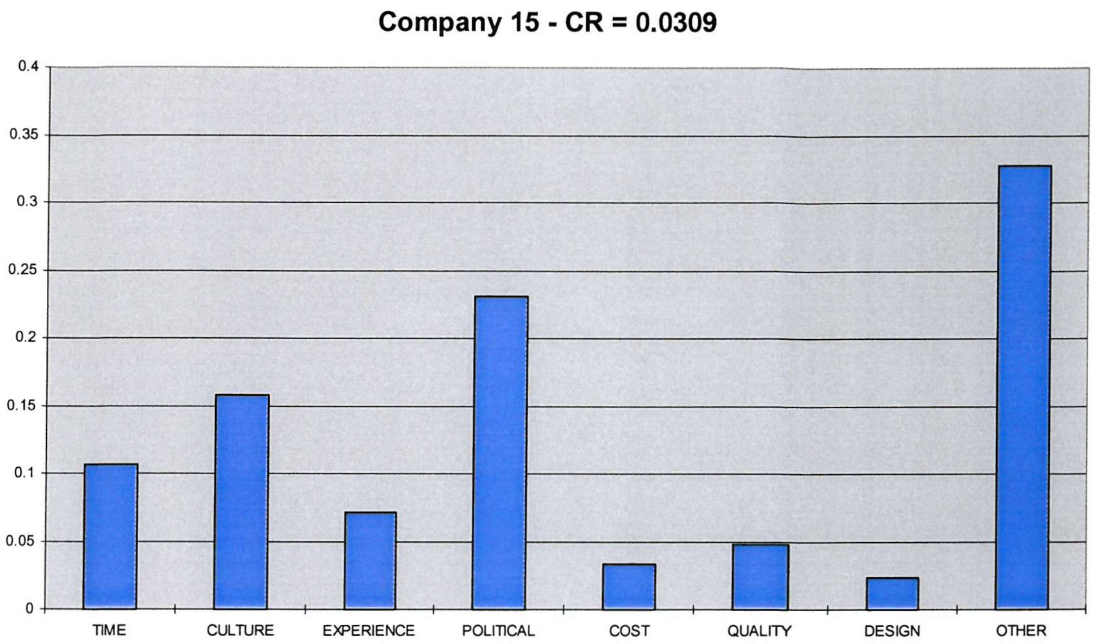

Figure E.29: Company 15 Project Objective Ranking

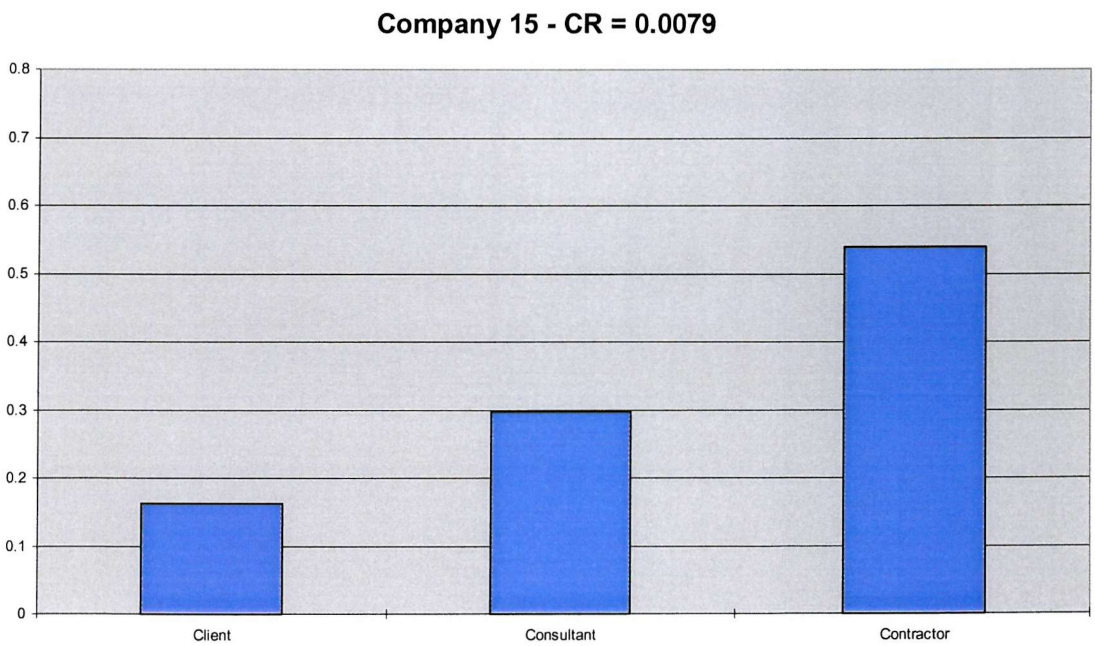

Figure E.30: Company 15 Project Participant Ranking

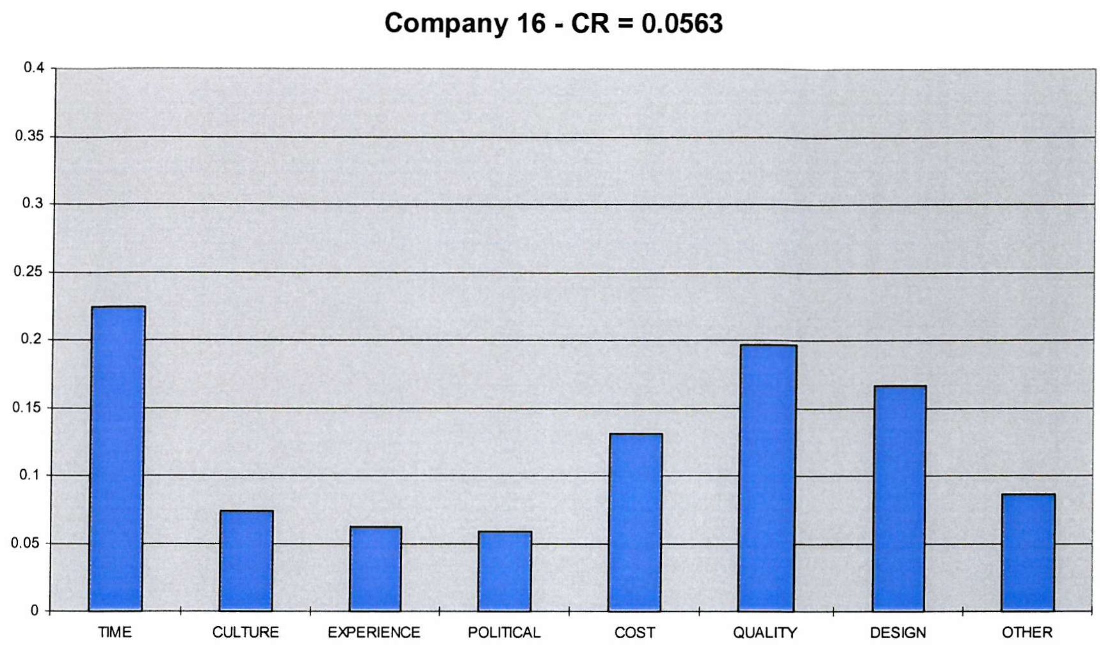

Figure E.31: Company 16 Project Objective Ranking

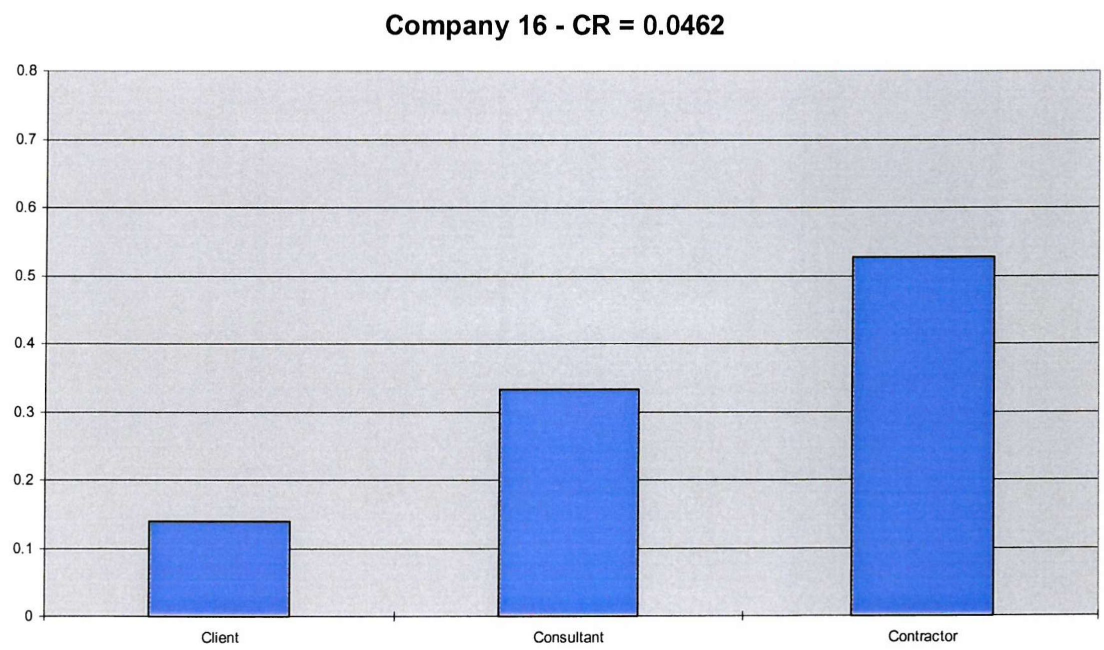

Figure E.32: Company 16 Project Participant Ranking

Appendix F. Consultants Mark Distribution Responses

The following tables are the marks awarded to each answer of the mark distribution questionnaire by the consultants. Non integer marks indicate that the marks awarded did not total 100.

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	10	20	60	0	10	0	0
Co 2	10	15	55	0	5	0	15
Co 3	24	26	26	0	4	0	20
Co 4	20	30	50	0	0	0	0
Co 5	20	20	35	0	10	0	15
Co 6	10	20	30	0	20	0	20
Co 7	21	19	39	0	8	0	13
Co 8	15	25	35	0	15	0	10
Co 9	15	35	25	0	15	0	10
Co 10	10	50	30	0	10	0	0
Co 11	10	40	40	0	10	0	0
Co 12	20	25	20	5	20	5	5
Co 13	0	0	100	0	0	0	0
Co 14	15	25	40	0	10	0	10
Co 15	23.9316	23.9316	35.8974	0	23.9316	0	0
Co 16	25	25	25	0	15	0	10

Table F.1: Consultants Responses to Question 1

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	12.5	50	12.5	12.5	12.5	0	0
Co 2	13	15	30	10	15	15	2
Co 3	12	12	19	13	18	18	8
Co 4	10	20	30	30	5	5	0
Co 5	10	15	30	15	20	5	5
Co 6	10	20	25	20	15	5	5
Co 7	9	23	22	24	17	5	0
Co 8	10	13	30	15	18	8	6
Co 9	20	15	15	15	15	15	5
Co 10	20	20	10	20	30	0	0
Co 11	10	20	30	20	10	10	0
Co 12	24	12	19	15	10	15	5
Co 13	0	20	50	20	10	0	0
Co 14	15	18	25	20	12	7	3
Co 15	16.1538	21.5385	26.9231	10.7692	10.7692	21.5385	0
Co 16	15	10	10	30	15	15	5

Table F.2: Consultants Responses to Question 2

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	0	70	30	0	0	0	0
Co 2	5	35	35	20	0	0	5
Co 3	10	40	40	10	0	0	0
Co 4	0	55	20	25	0	0	0
Co 5	15	30	45	10	0	0	0
Co 6	10	40	40	0	10	0	0
Co 7	14	25	42	15	4	0	0
Co 8	10	30	45	15	0	0	0
Co 9	5	45	15	30	0	0	5
Co 10	0	60	40	0	0	0	0
Co 11	0	70	30	0	0	0	0
Co 12	10	20	25	5	10	20	10
Co 13	10	50	40	0	0	0	0
Co 14	5	40	25	15	5	5	5
Co 15	0	53.8462	53.8462	0	0	0	0
Co 16	5	45	50	0	0	0	0

Table F.3: Consultants Responses to Question 3

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	0	10	5	5	20	0	60
Co 2	0	5	10	15	10	10	50
Co 3	5	10	17	12	18	18	20
Co 4	0	0	15	15	15	0	55
Co 5	0	10	15	15	15	15	30
Co 6	0	10	20	20	5	20	25
Co 7	0	11	5	27	18	8	31
Co 8	0	20	15	15	15	15	20
Co 9	0	5	15	5	30	15	30
Co 10	0	0	0	0	0	0	100
Co 11	0	5	10	5	20	0	60
Co 12	5	15	15	20	10	15	20
Co 13	0	0	15	20	15	10	40
Co 14	5	10	15	10	15	15	30
Co 15	0	16.1538	16.1538	16.1538	26.9231	16.1538	16.1538
Co 16	0	15	15	15	15	15	25

Table F.4: Consultants Responses to Question 4

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	0	0	30	0	0	0	70
Co 2	25	0	0	20	25	20	10
Co 3	12	14	11	14	11	18	20
Co 4	0	0	25	0	0	0	75
Co 5	0	0	25	40	30	5	0
Co 6	0	10	5	65	0	0	20
Co 7	5	0	0	55	10	25	5
Co 8	0	0	30	40	30	0	0
Co 9	0	0	30	30	30	5	5
Co 10	0	0	0	0	0	0	100
Co 11	0	0	30	0	0	0	70
Co 12	10	5	5	20	5	20	35
Co 13	0	0	100	0	0	0	0
Co 14	10	5	10	10	5	15	45
Co 15	0	10.7692	10.7692	21.5385	0	43.0769	21.5385
Co 16	25	0	0	20	20	30	5

Table F.5: Consultants Responses to Question 5

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	0	40	0	0	0	20	40
Co 2	0	10	0	0	10	40	40
Co 3	5	35	0	0	10	15	35
Co 4	0	10	0	0	0	0	90
Co 5	0	20	5	0	15	20	40
Co 6	0	30	0	0	0	30	40
Co 7	0	34	0	0	2	23	41
Co 8	0	20	5	0	15	20	40
Co 9	0	15	0	0	5	30	50
Co 10	0	40	0	0	0	20	40
Co 11	0	30	0	0	0	30	40
Co 12	5	25	15	5	10	15	25
Co 13	0	30	0	0	0	30	40
Co 14	5	15	5	0	20	25	30
Co 15	0	21.5385	0	0	0	43.0769	43.0769
Co 16	0	20	0	0	5	30	45

Table F.6: Consultants Responses to Question 6

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	0	75	10	5	0	10	0
Co 2	10	20	25	20	5	15	5
Co 3	20	20	10	20	10	20	0
Co 4	0	40	30	0	0	30	0
Co 5	5	5	25	20	10	15	20
Co 6	0	30	10	25	10	25	0
Co 7	5	20	20	20	10	18	7
Co 8	4	4	20	25	12	15	20
Co 9	0	15	15	15	0	30	25
Co 10	0	100	0	0	0	0	0
Co 11	0	85	5	5	0	5	0
Co 12	13	12	17	17	10	17	14
Co 13	5	30	30	20	5	5	5
Co 14	5	15	20	15	5	25	15
Co 15	32.3077	32.3077	21.5385	21.5385	0	0	0
Co 16	10	15	10	25	10	20	10

Table F.7: Consultants Responses to Question 7

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	10	0	50	10	0	0	30
Co 2	40	5	5	25	10	0	15
Co 3	0	20	20	20	10	10	20
Co 4	0	40	20	40	0	0	0
Co 5	22.2222	11.1111	0	44.4444	0	0	22.2222
Co 6	0	20	20	20	10	10	20
Co 7	30	20	3	35	0	2	10
Co 8	30	10	0	40	0	0	20
Co 9	30	0	5	30	0	5	30
Co 10	0	0	20	0	0	0	80
Co 11	0	5	50	5	0	0	40
Co 12	25	15	10	10	10	10	20
Co 13	5	5	30	10	5	5	40
Co 14	10	5	25	10	5	15	30
Co 15	16.1538	21.5385	16.1538	16.1538	0	21.5385	16.1538
Co 16	40	20	0	40	0	0	0

Table F.8: Consultants Responses to Question 8

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	20	0	10	0	20	25	25
Co 2	16	10	16	10	16	16	16
Co 3	18	10	15	10	17	15	15
Co 4	15	5	0	10	20	20	30
Co 5	20	5	10	5	20	20	20
Co 6	16	15	12	15	15	12	15
Co 7	22	10	10	10	23	10	15
Co 8	17	11	14	13	15	12	18
Co 9	15	15	10	15	15	15	15
Co 10	20	0	10	10	20	20	20
Co 11	20	5	15	0	20	20	20
Co 12	18	10	7	7	18	22	18
Co 13	10	10	0	5	10	25	40
Co 14	10	25	20	15	10	10	10
Co 15	21.5385	0	21.5385	0	21.5385	21.5385	21.5385
Co 16	25	10	10	5	15	10	25

Table F.9: Consultants Responses to Question 9

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	20	10	20	20	10	10	10
Co 2	15	20	15	20	15	10	5
Co 3	5	20	15	15	18	17	10
Co 4	15	15	15	15	15	10	15
Co 5	20	10	10	10	20	15	15
Co 6	5	20	15	20	20	20	0
Co 7	11	22	7	30	15	13	2
Co 8	20	10	5	20	15	15	15
Co 9	10	15	15	15	15	15	15
Co 10	10	10	10	0	30	30	10
Co 11	10	10	20	5	30	15	10
Co 12	10	10	15	15	17	16	17
Co 13	0	10	50	20	0	10	10
Co 14	10	15	10	25	5	25	10
Co 15	16.1538	16.1538	16.1538	16.1538	16.1538	16.1538	10.7692
Co 16	20	20	10	20	10	20	0

Table F.10: Consultants Responses to Question 10

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	0	100	0	0	0	0	0
Co 2	0	100	0	0	0	0	0
Co 3	25	40	0	25	10	0	0
Co 4	0	50	0	30	0	10	10
Co 5	0	100	0	0	0	0	0
Co 6	45	10	0	45	0	0	0
Co 7	0	100	0	0	0	0	0
Co 8	0	100	0	0	0	0	0
Co 9	0	100	0	0	0	0	0
Co 10	0	100	0	0	0	0	0
Co 11	0	100	0	0	0	0	0
Co 12	10	30	0	20	15	10	15
Co 13	8	12	0	5	10	30	35
Co 14	0	25	0	0	0	50	25
Co 15	0	0	0	0	0	0	0
Co 16	0	100	0	0	0	0	0

Table F.11: Consultants Responses to Question 11

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	0	0	85	15	0	0	0
Co 2	0	5	50	30	5	5	5
Co 3	0	0	50	50	0	0	0
Co 4	0	20	30	50	0	0	0
Co 5	0	15	25	25	15	10	10
Co 6	0	0	50	50	0	0	0
Co 7	0	21	36	36	0	5	2
Co 8	0	15	25	25	15	10	10
Co 9	0	0	15	70	15	0	0
Co 10	0	0	90	10	0	0	0
Co 11	0	0	85	15	0	0	0
Co 12	0	10	25	30	10	20	5
Co 13	0	25	50	25	0	0	0
Co 14	0	5	10	65	5	5	10
Co 15	0	35.5385	35.5385	36.6154	0	0	0
Co 16	0	15	20	50	5	0	10

Table F.12: Consultants Responses to Question 12

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	0	25	25	50	0	0	0
Co 2	15	15	15	15	10	15	15
Co 3	16	16	16	16	4	16	16
Co 4	20	15	15	15	0	0	35
Co 5	15	15	15	15	10	15	15
Co 6	15	15	15	15	10	15	15
Co 7	12	22	15	26	5	5	15
Co 8	17	17	15	15	6	15	15
Co 9	10	10	10	10	10	10	40
Co 10	20	10	10	10	0	20	30
Co 11	20	10	20	5	0	20	25
Co 12	10	15	15	18	10	15	17
Co 13	0	0	40	30	0	0	30
Co 14	20	20	15	15	0	10	20
Co 15	21.5385	21.5385	21.5385	16.1538	0	16.1538	10.7692
Co 16	20	20	10	10	10	15	15

Table F.13: Consultants Responses to Question 13

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	10	10	0	15	15	0	50
Co 2	25	10	5	0	5	20	35
Co 3	10	10	0	15	15	0	50
Co 4	0	0	0	0	0	25	75
Co 5	21.0526	15.7895	10.5263	10.5263	5.26316	5.26316	31.5789
Co 6	15	15	0	0	20	20	30
Co 7	27	7	1	0	8	20	37
Co 8	20	15	10	15	5	5	30
Co 9	30	10	10	0	20	10	20
Co 10	0	0	0	0	0	0	100
Co 11	10	15	0	10	15	0	50
Co 12	25	20	5	5	15	5	25
Co 13	25	15	10	20	10	5	25
Co 14	15	10	20	5	5	20	25
Co 15	26.9231	26.9231	0	0	26.9231	0	26.9231
Co 16	22.2222	16.6667	11.1111	5.55556	5.55556	11.1111	27.7778

Table F.14: Consultants Responses to Question 14

Appendix G. Interview Questions for Designers

FORTON LAKE BRIDGE DESIGNER INTERVIEWS
QUESTIONS FOR PDP SESSION

1. The Council is keen to ensure that all parties who will work on the project are involved at an early stage in the design process. Assuming you are appointed who do you see being involved initially and how will you set about building a project team?
2. Once the team has been established how will you ensure that it is able to successfully incorporate new members?
3. How will you ensure that a project team is able to effectively communicate. How much of a problem is the physical distance between the parties offices and how would you set about trying to overcome this?
4. Why do you believe that the Council wishes to introduce a new method of working (PDP) in respect of its Millennium projects?
5. The concept of partnering in the construction industry is claimed to have significant advantages for all parties involved in a project. Because of public accountability and probity related issues the Council has decided that PDP is more appropriate. What processes do you envisage using to ensure that the PDP properly accounts fully for the expenditure of large sums of public money?
6. Would the buildability of the project be enhanced by appointing a contractor during the design stage?
7. What processes would you envisage following to obtain contractors and suppliers who would be willing to actively participate in this project on the PDP basis?
8. What are your preliminary views on the most appropriate Conditions of Contract to use in the main contract?
9. How would you define 'quality' as applied to bridge design?
10. The Council has used the term 'Millennial quality' in respect of the proposed bridge.

    What do you think this means?

    What do you think the Council means?

    What do you think the public will think this means?

    How would you ensure that the Millennial quality of your design could still be appreciated in say 20 years time?

11. How relevant is it in a project of this nature to involve the client, the Consultant, the contractor, sub-contractor and suppliers in the decision making process?

12. The Council has said that it wishes to appoint a bridge designer for this project not select a bridge design. You have submitted an outline design proposal. If you are appointed what processes do you see being used to develop a final design concept? How wedded are you to indicative design that you have already submitted?

13. How important do you believe it is to get public acceptance for the final bridge design? What methods would you suggest employing to achieve this?

14. How realistic do you consider it to believe that a Public Enquiry could be avoided? What processes should be followed to avoid one? If a Public Enquiry is to be held how would you envisage that its timing arid duration could be influenced? What experience do you have of similar Public Enquiries.

15. The materials chosen for the construction of the bridge will represent a balance between capital cost and ongoing revenue expenditure. Given the Council's wish to have the bridge adopted how do you see the balance applying to this scheme?

16. How would you set about ensuring that an adoptable bridge is constructed?

17. Do you have an Environmental Policy?

18. The Council would be embarrassed by a cost overrun on this project. What processes would you employ to minimise the possibility of this occurring?

19. What do you consider to be the interrelationship between the level of site supervision required, Quality Assurance by the contractor and the Project Delivery Process?

Appendix H. Designer Assessment Guidelines

MILLENNIUM PROJECT - FORTON LAKE BRIDGE
DESIGNER ASSESSMENT CRITERIA

OVERALL EXPERIENCE AND FACILITIES - Weighted

GENERAL EXPERIENCE

Has the consultant got sufficient breadth and depth of experience in the general area in term of projects:-

of a similar size and complexity
of a similar quality

What is the consultants track record in terms of delivering the services required
Are the consultants senior managers/partners sufficiently experienced
Are they available to work on the commission

Who will ultimately be responsible for the commission

TECHNICAL FACILITIES

Are the necessary methods and procedures in place for the delivery of the service ie

procedures for planning programming and management
procedures for cost control

INTERNAL MANAGEMENT SYSTEMS

Has the consultant implemented sound procedures for quality management

RELEVANT EXPERIENCE AND EXPERTISE

PROJECT MANAGER/TEAM LEADER

Do they have sufficient experience in managing/leading services in terms of projects:-

for similar (or the same) client
of a similar type, size and complexity
of a similar quality
within similar constraints of time
within similar constraints on cost
under similar contractual/procurement arrangements

What is their track record on their most recent and directly related projects
What proportion of their time will they devote to the proposed commission
What will they be like to work with

PROPOSED STAFF

How relevant is their experience and expertise

SPECIAL SERVICES

What services will be provided from external sources
What arrangements are made for sub-contracting, including responsibilities and liabilities
Will the consultant be able to successfully control and manage the delivery of any sub-contracted service

APPROACH

OVERALL CONCEPTUAL APPROACH

Are the consultants proposals right for the client, their needs and constraints in terms of:-

quality
cost
practicality

UNDERSTANDING OF CLIENT OBJECTIVES

Does the consultants proposals demonstrate a clear understanding of the clients objectives in terms of :-

function (ie quality and adoptability)
operational efficiency aesthetics
cost
time

Are all particular client requirements met

DETAILED APPROACH

What is the consultants technical approach to the commission in term of:-

the techniques to be used
any special procedures to be followed (ie for the appointment of sub contractors)

How will the consultant manage the commission
What is the consultants programme for the commission

Note :-
Marks to be awarded on the following basis :- 4 Excellent, 3 Good, 2 Satisfactory, 1 Poor, 0 Unsatisfactory

Appendix I. Sub-contractor Reference Form

These are the sheets which were sent to the sub-contractors named as referees by the short listed contractors.

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FORTON LAKE BRIDGE – SELECT LIST OF CONTRACTORS

REFERENCE IN RESPECT OF

Please circle the most appropriate answer

1. How many years have you worked with this firm?	<1	1-2	2-5	>5
2. On how many schemes?	1	2-3	4-5	>5
3. Please comment on the overall quality of their work.	Poor	Satisfactory	Good	Excellent
4. Please comment on their contract management and site supervision efficiency.	Poor	Satisfactory	Good	Excellent
5. How would you describe the effectiveness of their management support?	Poor	Satisfactory	Good	Excellent
6. Overall how well would you describe their management of contracts with you?	Poor	Satisfactory	Good	Excellent
7. How would you describe the firms attitude to predicting and preventing delays to the works?	Poor	Satisfactory	Good	Excellent
8. If delays occurred how co-operative were they ion seeking to work with you to find mutually beneficial solutions?	Poor	Satisfactory	Good	Excellent
9. How would you describe the firms attitude in not seeking to exploit delays for their own advantage?	Poor	Satisfactory	Good	Excellent
10. Please comment on the firms ability to co-operate at all levels without undue dispute.	Poor	Satisfactory	Good	Excellent
11. How would you describe the firms willingness to make constructive suggestions about the project and to share any mutual benefits?	Poor	Satisfactory	Good	Excellent
12. How would you describe your working relationship?	Not prepared to	Reluctant to	Prepared to	With pleasure
13. Please describe your attitude to working with this firm again.	Poor	Satisfactory	Good	Excellent

14. Do you have any informal or formal policies in respect of "local labour" that the firm were expected to comply with?	YES	NO
15. If applicable did they comply to your requirements	YES	NO

16. Please give dates and values of contracts which you consider relevant and, if possible, a brief description of the work.

17. Any other comments that you wish to make.

Thank you for completing this questionnaire

Signed... Date......................................

Company...

Designation...

Appendix J. Trial Results of Constructors Questionnaires

Question - 1		Marks Awarded	Weighting	Revised Score
Answer 1		15	0	0
Answer 2		20	6	120
Answer 3		20	3	60
Answer 4		10	0	0
Answer 5		20	-6	-120
Answer 6		5	-6	-30
Answer 7		10	0	0
	Total	100		30

Table J.1: Trial Results for Constructors Question 1

Question - 2		Marks Awarded	Weighting	Revised Score
Answer 1		5	-2	-10
Answer 2		35	4	140
Answer 3		30	0	0
Answer 4		10	2	20
Answer 5		5	-4	-20
Answer 6		15	-4	-60
	Total	100		70

Table J.2: Trial Results for Constructors Question 2

Question - 3		Marks Awarded	Weighting	Revised Score
Answer 1		10	-4	-40
Answer 2		10	4	40
Answer 3		15	2	30
Answer 4		15	-2	-30
Answer 5		15	2	30
Answer 6		15	2	30
Answer 7		20	4	80
	Total	100		140

Table J.3: Trial Results for Constructors Question 3

Question - 4		Marks Awarded	Weighting	Revised Score
Answer 1		15	4	60
Answer 2		10	-8	-80
Answer 3		15	0	0
Answer 4		20	8	160
Answer 5		20	0	0
Answer 6		10	-8	-80
Answer 7		10	-8	-80
	Total	100		-20

Table J.4: Trial Results for Constructors Question 4

Question - 5		Marks Awarded	Weighting	Revised Score
Answer 1		10	-4	-40
Answer 2		10	4	40
Answer 3		15	-2	-30
Answer 4		10	-4	-40
Answer 5		15	0	0
Answer 6		20	2	40
Answer 7		20	2	40
	Total	100		10

Table J.5: Trial Results for Constructors Question 5

Question - 6		Marks Awarded	Weighting	Revised Score
Answer 1		30	4	120
Answer 2		5	-4	-20
Answer 3		5	-8	-40
Answer 4		30	8	240
Answer 5		5	-8	-40
Answer 6		5	-8	-40
Answer 7		0	0	0
	Total	100		220

Table J.6: Trial Results for Constructors Question 6

Question - 7		Marks Awarded	Weighting	Revised Score
Answer 1		10	6	60
Answer 2		10	3	30
Answer 3		5	-6	-30
Answer 4		20	-6	-120
Answer 5		20	-3	-60
Answer 6		10	6	60
Answer 7		25	-6	-150
	Total	100		-210

Table J.7: Trial Results for Constructors Question 7

Question - 8		Marks Awarded	Weighting	Revised Score
Answer 1		10	-1	-10
Answer 2		15	2	30
Answer 3		10	0	0
Answer 4		10	1	10
Answer 5		20	-2	-40
Answer 6		10	2	20
Answer 7		25	-2	-50
	Total	100		-40

Table J.8: Trial Results for Constructors Question 8

Question - 9		Marks Awarded	Weighting	Revised Score
Answer 1		20	3	60
Answer 2		30	-3	-90
Answer 3		10	6	60
Answer 4		40	0	0
Answer 5		0	-3	0
Answer 6		0	-6	0
Answer 7		0	-3	0
	Total	100		30

Table J.9: Trial Results for Constructors Question 9

Question - 10		Marks Awarded	Weighting	Revised Score	
Answer 1		0	-2	0	
Answer 2		20	2	40	
Answer 3		15	-1	-15	
Answer 4		15	2	30	
Answer 5		15	-2	-30	
Answer 6		20	1	20	
Answer 7		15	1	15	
	Total	100		60	
				TOTAL	**Possible TOTAL**
				290	**5000**

Table J.10: Trial Results for Constructors Question 10 and Totals

Appendix K. Constructors Questionnaire

This appendix contains the actual questionnaire that was sent to constructors that had expressed interest in constructing Forton Lake Opening Bridge. It was the responses to this questionnaire that produced the short list of constructors.

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FORTON LAKE BRIDGE CONSTRUCTORS QUESTIONNAIRE

Renaissance of Portsmouth Harbour Millennium Scheme

Element G4
February 1998

Contents

FORTON LAKE BRIDGE

Introduction

It is important to the Borough Council, and we believe to any organisation with whom we work, that wherever possible the parties should have as close a fit as possible in regard to their cultural values and norms. The Council has determined the profile of the type of organisation with which it would like to work on this project and the attached questionnaires are designed to assist in this process. I am sure that you would agree that if your organisation and the council are not compatible this would not naturally lead to the type of harmonious relationship that is considered essential for a project of this nature.

The Council is aware that projects of this nature are outside the normal scope of its operations and has therefore determined to follow a different process from that which it would normally use to appoint Constructors. The answers that you give will all be assessed by experienced senior professionals in the construction industry.

A period of approximately two weeks has been allowed for you to complete the questionnaire. It should therefore be returned to me, in both paper and electronic formats, by Monday 23rd February1998 at the latest.

During the period allowed to complete the questionnaire I do not consider it appropriate to directly answer any queries that you may have. These should be directed to Karen Newman (Direct dial 545270) who will arrange for an appropriate answer to be given.

FORTON LAKE BRIDGE
Factors Important to Gosport Borough Council

The following factors have been identified by the Council as being of importance, either in a positive or negative manner, in relation to this project. We appreciate that compromises will need to be made and that some of these factors will have a greater weighting than others. The factors are set out below in alphabetical order in order to assist you with the completion of the questionnaires.

Factor	Description
Cost	The need to ensure that budgets are not exceeded or significantly underspent. The need to balance capital expenditure against operational and maintenance costs of the structure. The desire to examine options to enable choices to be made about costs. The need to ensure a balance between the cost of any solution and its effectiveness.
Culture	A desire to work with organisations which understand the local government culture including issues such as proberty. A willingness to embrace new ideas and concepts. A desire to work with others in a co-operative manner. The need to work with others who are for flexibility in thinking and working methods.
Design	To engage constructors who have the ability to assist the bridge designers with their task. To engage constructors who are able to demonstrate a grasp of a Millennial brand and concept. To produce a structure that is sympathetic to environmental and planning issues. To produce a design that is both individual and intellectually challenging.
Experience	To engage constructors who are able to demonstrate a record of building structures of proven quality. To engage constructors who can demonstrate a record of assisting clients at Public Enquiries. To engage constructors who have been proven to assist in the design of structures with flair and imagination. To engage constructors who are able to demonstrate sensitivity to the needs of building structures in sensitive environmental locations.
Political	To meet the valid expectations of Bodies such as English Heritage and English Nature. To meet the requirements of the Millennium Commission. To promote the employment of trainee labour. To recognise that any Gosport project is part of an overall Portsmouth Harbour wide scheme.
Quality	To ensure that design quality translates effectively into physical quality. To provide a structure with low maintenance and operating costs. To engage constructors with formal QA type procedures. To provide constructors a structure that will be of a quality worthy of being referred to as a "Millennial structure".
Time	The length of the overall design and construction period including any period required for a Public Enquiry. Ability of constructors to forecast programmes accurately. Completing works by dates agreed with the Millennium Commission. The desire to examine options to enable choices to be made about the length of the overall programme.
Working Relationship	To engage constructors who will be able to assist the Council throughout the project in its dealings with various parties. To engage constructors who are sympathetic to the Councils requirements. To engage constructors who are compatible with the Councils culture. To engage constructors who are able to demonstrate a positive working relationship with all parties involved in a project.

Questionnaire One

In the following questions you are required to award 100 points in total across the answers indicated. Your highest score should be given to the answer that you most agree with and your lowest (including zero score) to the answer(s) you agree with least. You must answer all questions.

Example

Question -In your opinion which means of transport causes most environmental damage?		**Marks Awarded**
Answer 1	Aeroplane	
Answer 2	Ferry	
Answer 3	Train	
Answer 4	Bus/Coach	
Answer 5	Car	
Answer 6	Cycle	
Answer 7	Walking	
	Total	100

Explanation

Most people would probably agree that walking and cycling are the least environmentally damaging.

A simple question can however often be quite complex.

For example what exactly is meant by "environmental"?, what is meant by "damage"?, is a vehicle running full more or less damaging than one running empty?, do walkers destroy areas of outstanding natural beauty?

These are matters where, given the limited information available, you will need to form your own judgements.

Depending on your view point your answers could look like this.

Question -In your opinion which means of transport causes most environmental damage ?		**Marks Awarded**
Answer 1	Aeroplane	35
Answer 2	Ferry	10
Answer 3	Train	15
Answer 4	Bus/Coach	18
Answer 5	Car	20
Answer 6	Cycle	2
Answer 7	Walking	0

Question - 1 What measures could be adopted to ensure completion of the bridge by June 2000?		Marks Awarded
Answer 1	"Fast track" construction methods may be needed to complete on time.	
Answer 2	We can assist the designers and suggest design changes which should improve construction times.	
Answer 3	Our track record on projects of this nature is good and we have a proven record of meeting target completion dates.	
Answer 4	If a quality scheme is to be produced it may not be possible to achieve the due date but this should be capable of extension by negotiation.	
Answer 5	Additional resources could be employed and construction times reduced but at an increased cost.	
Answer 6	It may be difficult to achieve "Millennial quality" within the timescale.	
Answer 7	Design times may need to be extended in order to produce a scheme which is practicable to build quickly.	
	Total	100

Question - 2 What difficulties do you see in embracing Gosport's cultural values?		Marks Awarded
Answer 1	Local authorities are often bureaucratic and this can lead to difficulties when quick decisions are required.	
Answer 2	We treat each client as an individual and try carefully to identify his particular requirements.	
Answer 3	We have worked in Partnering arrangements with other clients and see little difficulty in adapting to Gosport's needs.	
Answer 4	Local Authorities often have aspirations for the economic benefits of the work to be returned to the local economy and this is difficult to achieve on specialist works.	
Answer 5	Persuading the client to release cash early in the construction cycle to enable the contractor to pay suppliers and sub-contractors at an early stage.	
Answer 6	Quality is achieved by the engagement of experienced bridge builders and allowing them the freedom to exercise their own judgement.	
	Total	100

Question - 3 How does your organisation adapt to embrace new concepts?		Marks Awarded
Answer 1	We tend to wait to see how relevant these are before adopting them.	
Answer 2	We seek out suppliers and sub-contractors to introduce us to new ideas and concepts.	
Answer 3	New concepts are carefully considered at a senior level before being introduced in a systematic way.	
Answer 4	We adapt when external considerations require this.	
Answer 5	These are carefully evaluated in order to demonstrate proven cost benefit before introduction.	
Answer 6	New ideas need to be carefully considered if quality is not to be compromised.	
Answer 7	We actively seek to work with the design team to improve the overall quality of the finished product.	
	Total	100

Question - 4 Would the buildability of the project be enhanced by appointing specialist sub-contractors during the design stage?		Marks Awarded
Answer 1	Yes but this may lengthen the overall project programme.	
Answer 2	It is difficult to see what meaningful advantage could be gained by this since working with a sub-contractor at the design stage would be difficult to achieve.	
Answer 3	In our experience there would only be a minimal advantage on a project of this nature	
Answer 4	Yes but sub-contractors may be reluctant to provide their expertise.	
Answer 5	There would be advantages to this but overall the cost of the project could increase.	
Answer 6	No. Buildability is closely linked to the quality of the finished product and quality can best be achieved by close control of the sub-contractors on site.	
Answer 7	Buildability relies essentially on the engagement of good designers and so little advantage is seen in this.	
	Total	100

Question - 5 How appropriate are innovative procedures in the design and construction methods of this Millennium scheme?		Marks Awarded
Answer 1	Innovation may lead to delays in overall programmes and should therefore be avoided.	
Answer 2	The scheme should provide an ideal opportunity to try new ideas and concepts.	
Answer 3	We have tried new ideas and concepts but found that traditional well proven methods are usually best.	
Answer 4	Although considerable potential benefits may be found the number of parties involved in a project of this nature does not make these a practical proposition..	
Answer 5	The construction industry is conservative by instinct and innovation often equates to increased cost to cover the increased risk.	
Answer 6	Improvements in the quality of products only come about if innovation is encouraged.	
Answer 7	Local knowledge of the marine environment may be more important than specialist skills.	
	Total	100

Question - 6 How relevant is it in a project of this nature to involve the client, the consultant, the contractor, sub-contractor and suppliers in the design process?		Marks Awarded
Answer 1	This would be a suitable goal if sufficient time is available.	
Answer 2	There are inherent difficulties in undertaking this type of exercise which limits its value.	
Answer 3	A good designer has sufficient experience in projects of this nature such that they do not need any significant input from other “players” in the construction industry.	
Answer 4	It may be relevant but the respective roles of all the parties to a project would need to be clearly defined if contractual difficulties are to be avoided.	
Answer 5	The additional hidden cost of this is difficult for a public body to justify.	
Answer 6	For a Millennial project it is more important to concentrate on supervision in order to achieve a quality product.	
Answer 7	It would be difficult for us to assist the designers since we have no direct design capability.	
	Total	100

Question - 7 What special measures need to be taken to assist in safeguarding the environment throughout the project?		Marks Awarded
Answer 1	Sufficient time should be allowed to ensure that the fullest consultation take place with interest groups.	
Answer 2	The environmental impact needs to be judged over the whole life of the structure and not just during its construction.	
Answer 3	Few. My past experience in projects of this nature will minimise this difficulty.	
Answer 4	The need for these should have been incorporated into the design brief and therefore there is little role for the contractor to play.	
Answer 5	The choice of materials and constructional methods can have significant effects on the overall environmental impact of the bridge.	
Answer 6	The contractor should have a substantial responsibility for ensuring that environmental safeguards are built into the design process.	
	Total	100

Question - 8 How do you believe that the client can best achieve a bridge that will retain "quality" throughout its life?		Marks Awarded
Answer 1	This can only be achieved if the client allows sufficient time in the design and construction stages.	
Answer 2	Ways to ensure that sufficient funding is safeguarded for future maintenance should be explored.	
Answer 3	By employing contractors with extensive experience of building similar structures.	
Answer 4	If local "ownership" of the bridge can be achieved then problems such as vandalism may be reduced.	
Answer 5	This can best be achieved by the designer specifying the highest quality materials and standards of construction.	
Answer 6	Quality should be more important on a Millennium project than meeting target dates.	
Answer 7	By ensuring that this requirement is fully understood by the designers.	
	Total	100

Question - 9 Generally what difficulties do you believe exist that prevent contractors from actively participating in the design processes?		**Marks Awarded**
Answer 1	This can be achieved but only if the projects timescale is adjusted to suit an integrated design process.	
Answer 2	Normal local government processes and cultural factors make this difficult to achieve.	
Answer 3	This should be achievable but limited experience of this by both clients and contractors make this difficult.	
Answer 4	Where the client may be constrained by the requirements of other public bodies.	
Answer 5	The contractors involvement at an early stage has cost implications that could increase the overall cost of the project and can therefore be difficult for the client to justify.	
Answer 6	If the contractor is to protect his best interests he may not be able to give advice.	
Answer 7	A lack of design expertise.	
	Total	100

Question - 10 How can a construction company help contribute to the public acceptance of a Millennium project?		**Marks Awarded**
Answer 1	It is an idealised concept to believe that public acceptance can be achieved without the risk of delaying the project.	
Answer 2	By actively promoting the project in the area.	
Answer 3	Our reputation is such that our name will naturally contribute to enhancing the project and its public acceptance.	
Answer 4	By maximising training opportunities.	
Answer 5	The cost of promotion is effectively borne by the client and the contractor should have little role to play.	
Answer 6	By adopting construction methods that will minimise public inconvenience.	
Answer 7	By seeking, with the designers, to enlist public involvement in appropriate details of design.	
	Total	100

Questionnaire Two

Using the judgement criteria provided, please use your experience to rank the importance of the pairs of factors in the table below to this project. A "1" should be entered into the column adjacent to the factor of least importance and a rank in the other. A ranking of 1 : 1 is not permitted.

Intensity of Importance	Definition	Explanation
1	Reference number.	Identifies the lesser rank.
3	Weak importance of one over another.	Experience and judgement slightly favour one over another.
5	Essential or strong importance.	Experience and judgement strongly favour one activity over another.
7	Demonstrated importance.	An activity is strongly favoured and its dominance is demonstrated in practice.
9	Absolute importance.	The evidence favouring one activity over another is of the highest possible order of affirmation.
2, 4, 6, 8	Intermediate values between the two adjacent judgments.	When compromise is needed.

Example

Which means of transport causes most environmental damage?

Train	1	3	Aeroplane
Ferry	1	5	Train
Aeroplane	7	1	Ferry

Explanation

In the example the respondent has judged that:-

1. The aeroplane has weak importance over the train
2. The train has strong importance over the ferry
3. The aeroplane has demonstrated importance over the ferry

Please complete these tables

Success Factor 1			Success Factor 2
Time			Culture
Time			Experience
Culture			Experience
Time			Political
Culture			Political
Experience			Political
Time			Cost
Culture			Cost
Experience			Cost
Political			Cost
Time			Quality
Culture			Quality
Experience			Quality
Political			Quality
Cost			Quality
Time			Design
Culture			Design
Experience			Design
Political			Design
Cost			Design
Quality			Design
Cost			Working Relationship
Culture			Working Relationship
Design			Working Relationship
Experience			Working Relationship
Political			Working Relationship
Quality			Working Relationship
Time			Working Relationship

Questionnaire Three

Tell us more about your organisation

Name of Contact Person ________________________________

Position in Organisation ________________________________

Names and Positions of persons who contributed to the answers

Name ________________________________

Position ________________________________

Name ________________________________

Position ________________________________

Name ________________________________

Position ________________________________

Name ________________________________

Position ________________________________

Why were these people chosen ?

Briefly what do you think are the most significant aspects to the Council on this project?
(Answer in not more than 50 words)

How do you think your experience could assist in avoiding a public Enquiry?

Please describe the culture of your organisation

Appendix L. Constructors Questionnaire Responses

Table L.1 to Table L.10 are the marks awarded to each answer of the mark distribution questionnaire by the constructors. Three companies (4, 9 and 12) submitted marks which did not total 100 (Table L.1, Table L.9 and Table L.10). Table L.11 to Table L.20 are the weighted scores from the constructors. Table L.21 to Table L.33 are the AHP scores given by the constructors.

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	30	12	10	20	8	0	20
Co 2	5	35	24	12	8	1	15
Co 3	10	30	40	10	0	0	10
Co 4	15	25	15	15	15	5	10
Co 5	20	40	30	4	3	0	3
Co 6	20	20	20	20	10	5	5
Co 7	10	40	30	0	10	0	10
Co 8	25	37	25	10	2	1	0
Co 9	20	30	30	5	5	10	0
Co 10	16	42	18	4	5	15	0
Co 11	7	30	36	5	12	5	5
Co 12	10	35	25	10	15	0	10
Co 13	20	35	20	5	10	0	10

Table L.1: Constructors' Responses to Question 1

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6
Co 1	30	5	10	20	15	20
Co 2	5	43	42	3	2	5
Co 3	0	90	10	0	0	0
Co 4	5	30	30	10	5	20
Co 5	10	40	37	4	2	7
Co 6	10	30	30	15	5	10
Co 7	5	40	40	5	0	10
Co 8	4	33	51	0	2	10
Co 9	10	30	50	0	0	10
Co 10	10	40	30	10	5	5
Co 11	5	32	34	10	3	16
Co 12	20	40	30	10	0	0
Co 13	5	40	30	10	5	10

Table L.2: Constructors' Responses to Question 2

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	5	10	5	5	5	5	65
Co 2	4	9	11	12	16	15	33
Co 3	0	20	0	35	0	20	25
Co 4	10	10	20	5	20	20	15
Co 5	0	10	10	5	20	20	35
Co 6	15	15	15	10	15	10	20
Co 7	0	20	10	5	15	10	40
Co 8	8	5	20	9	13	10	35
Co 9	8	0	20	5	12	25	30
Co 10	3	10	5	15	22	15	30
Co 11	3	12	15	2	15	15	38
Co 12	0	10	25	0	25	10	30
Co 13	3	20	15	0	15	7	40

Table L.3: Constructors' Responses to Question 3

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	70	5	5	5	5	5	5
Co 2	20	2	13	15	20	5	25
Co 3	0	0	0	0	0	50	50
Co 4	25	5	5	25	20	5	15
Co 5	30	10	15	15	10	0	20
Co 6	10	15	15	5	15	20	20
Co 7	15	5	15	35	15	0	15
Co 8	16	3	3	9	12	30	27
Co 9	20	5	20	10	25	10	10
Co 10	30	2	30	30	4	2	2
Co 11	15	0	0	50	20	10	5
Co 12	15	15	10	15	15	15	15
Co 13	20	5	20	15	20	10	10

Table L.4: Constructors' Responses to Question 4

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	5	10	5	5	10	50	15
Co 2	10	40	8	2	12	15	13
Co 3	0	45	0	0	0	45	10
Co 4	15	20	10	10	15	15	15
Co 5	0	60	5	5	5	10	15
Co 6	10	40	10	10	0	10	20
Co 7	5	40	10	5	10	15	15
Co 8	2	29	2	5	5	28	29
Co 9	0	40	5	0	20	30	5
Co 10	0	30	5	0	2	50	13
Co 11	20	15	3	25	2	15	20
Co 12	0	50	0	0	5	35	10
Co 13	5	30	5	5	5	35	15

Table L.5: Constructors' Responses to Question 5

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	75	0	0	10	5	10	0
Co 2	69	10	5	10	1	5	0
Co 3	100	0	0	0	0	0	0
Co 4	25	5	20	25	5	15	5
Co 5	30	5	5	45	5	5	5
Co 6	40	5	5	40	0	10	0
Co 7	50	5	10	25	5	5	0
Co 8	85	0	4	10	0	1	0
Co 9	65	5	0	25	5	0	0
Co 10	45	5	10	30	0	10	0
Co 11	37	10	5	33	5	10	0
Co 12	75	0	15	5	5	0	0
Co 13	45	5	5	25	10	10	0

Table L.6: Constructors' Responses to Question 6

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6
Co 1	10	20	10	0	40	20
Co 2	20	26	1	1	33	19
Co 3	25	25	0	0	25	25
Co 4	25	25	10	5	20	15
Co 5	20	30	5	0	30	15
Co 6	15	30	0	0	30	25
Co 7	25	15	10	0	30	20
Co 8	25	29	10	0	28	8
Co 9	15	40	0	5	25	15
Co 10	25	30	0	0	25	20
Co 11	13	27	10	0	25	25
Co 12	30	25	5	0	20	20
Co 13	20	25	0	0	35	20

Table L.7: Constructors' Responses to Question 7

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	20	20	20	20	5	5	10
Co 2	15	11	17	16	14	10	17
Co 3	10	10	20	20	10	10	20
Co 4	15	15	15	15	15	15	10
Co 5	15	10	10	10	20	10	25
Co 6	20	10	20	10	15	5	20
Co 7	10	10	25	15	20	5	15
Co 8	10	5	30	20	20	0	15
Co 9	20	15	10	10	10	0	35
Co 10	15	15	25	20	15	5	5
Co 11	9	10	25	23	22	1	10
Co 12	15	5	20	10	25	10	15
Co 13	5	10	5	20	20	20	20

Table L.8: Constructors' Responses to Question 8

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	75	5	5	5	10	0	0
Co 2	30	22	11	27	1	0	9
Co 3	70	10	10	10	0	0	0
Co 4	20	15	5	20	15	5	10
Co 5	20	30	10	35	0	5	0
Co 6	60	20	0	20	0	0	0
Co 7	25	25	20	25	5	0	0
Co 8	17	18	30	26	4	1	4
Co 9	15	20	15	30	15	5	0
Co 10	30	20	15	15	5	0	15
Co 11	40	15	18	20	2	5	0
Co 12	30	15	15	15	15	5	5
Co 13	20	20	15	35	5	0	5

Table L.9: Constructors' Responses to Question 9

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	0	25	10	25	0	20	20
Co 2	1	30	8	13	0	36	12
Co 3	0	30	0	10	0	30	30
Co 4	5	15	10	25	5	25	15
Co 5	0	20	0	20	0	30	30
Co 6	0	30	10	0	0	30	30
Co 7	5	30	15	15	0	25	10
Co 8	4	17	7	21	2	32	17
Co 9	5	30	5	15	0	25	10
Co 10	0	20	5	25	0	30	20
Co 11	0	10	15	25	2	30	18
Co 12	0	30	15	5	5	25	20
Co 13	5	30	20	15	0	15	15

Table L.10: Constructors' Responses to Question 10

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	0	72	30	0	-48	0	0
Co 2	0	210	72	0	-48	-6	0
Co 3	0	180	120	0	0	0	0
Co 4	0	150	45	0	-90	-30	0
Co 5	0	240	90	0	-18	0	0
Co 6	0	120	60	0	-60	-30	0
Co 7	0	240	90	0	-60	0	0
Co 8	0	222	75	0	-12	-6	0
Co 9	0	180	90	0	-30	0	0
Co 10	0	252	54	0	-30	0	0
Co 11	0	180	108	0	-72	-30	0
Co 12	0	210	75	0	-90	0	0
Co 13	0	210	60	0	-60	0	0

Table L.11: Constructors' Weighted Responses to Question 1

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6
Co 1	-60	20	0	40	-60	-80
Co 2	-10	172	0	6	-8	-20
Co 3	0	360	0	0	0	0
Co 4	-10	120	0	20	-20	-80
Co 5	-20	160	0	8	-8	-28
Co 6	-20	120	0	30	-20	-40
Co 7	-10	160	0	10	0	-40
Co 8	-8	132	0	0	-8	-40
Co 9	-20	120	0	0	0	-40
Co 10	-20	160	0	20	-20	-20
Co 11	-10	128	0	20	-12	-64
Co 12	-40	160	0	20	0	0
Co 13	-10	160	0	20	-20	-40

Table L.12: Constructors' Weighted Responses to Question 2

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	-20	40	10	-10	10	10	260
Co 2	-16	36	22	-24	32	30	132
Co 3	0	80	0	-70	0	40	100
Co 4	-40	40	40	-10	40	40	60
Co 5	0	40	20	-10	40	40	140
Co 6	-60	60	30	-20	30	20	80
Co 7	0	80	20	-10	30	20	160
Co 8	-32	20	40	-18	26	20	140
Co 9	-32	0	40	-10	24	50	120
Co 10	-12	40	10	-30	44	30	120
Co 11	-12	48	30	-4	30	30	152
Co 12	0	40	50	0	50	20	120
Co 13	-12	80	30	0	30	14	160

Table L.13: Constructors' Weighted Responses to Question 3

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	280	0	0	40	0	-40	-40
Co 2	80	-16	0	120	0	-40	-200
Co 3	0	0	0	0	0	-400	-400
Co 4	100	-40	0	200	0	-40	-120
Co 5	120	-80	0	120	0	0	-160
Co 6	40	-120	0	40	0	-160	-160
Co 7	60	-40	0	280	0	0	-120
Co 8	64	-24	0	72	0	-240	-216
Co 9	80	-40	0	80	0	-80	-80
Co 10	120	-16	0	240	0	-16	-16
Co 11	60	0	0	400	0	-80	-40
Co 12	60	-120	0	120	0	-120	-120
Co 13	80	-40	0	120	0	-80	-80

Table L.14: Constructors' Weighted Responses to Question 4

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	-20	40	-10	-20	0	100	30
Co 2	-40	160	-16	-8	0	30	26
Co 3	0	180	0	0	0	90	20
Co 4	-60	80	-20	-40	0	30	30
Co 5	0	240	-10	-20	0	20	30
Co 6	-40	160	-20	-40	0	20	40
Co 7	-20	160	-20	-20	0	30	30
Co 8	-8	116	-4	-20	0	56	58
Co 9	0	160	-10	0	0	60	10
Co 10	0	120	-10	0	0	100	26
Co 11	-80	60	-6	-100	0	30	40
Co 12	0	200	0	0	0	70	20
Co 13	-20	120	-10	-20	0	70	30

Table L.15: Constructors' Weighted Responses to Question 5

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	300	0	0	80	-40	-80	0
Co 2	276	-40	-40	80	-8	-40	0
Co 3	400	0	0	0	0	0	0
Co 4	100	-20	-160	200	-40	-120	0
Co 5	120	-20	-40	360	-40	-40	0
Co 6	160	-20	-40	320	0	-80	0
Co 7	200	-20	-80	200	-40	-40	0
Co 8	340	0	-32	80	0	-8	0
Co 9	260	-20	0	200	-40	0	0
Co 10	180	-20	-80	240	0	-80	0
Co 11	148	-40	-40	264	-40	-80	0
Co 12	300	0	-120	40	-40	0	0
Co 13	180	-20	-40	200	-80	-80	0

Table L.16: Constructors' Weighted Responses to Question 6

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6
Co 1	60	60	-60	0	240	120
Co 2	120	78	-6	-6	198	114
Co 3	150	75	0	0	150	150
Co 4	150	75	-60	-30	120	90
Co 5	120	90	-30	0	180	90
Co 6	90	90	0	0	180	150
Co 7	150	45	-60	0	180	120
Co 8	150	87	-60	0	168	48
Co 9	90	120	0	-30	150	90
Co 10	150	90	0	0	150	120
Co 11	78	81	-60	0	150	150
Co 12	180	75	-30	0	120	120
Co 13	120	75	0	0	210	120

Table L.17: Constructors' Weighted Responses to Question 7

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	-20	40	0	20	-10	10	-20
Co 2	-15	22	0	16	-28	20	-34
Co 3	-10	20	0	20	-20	20	-40
Co 4	-15	30	0	15	-30	30	-20
Co 5	-15	20	0	10	-40	20	-50
Co 6	-20	20	0	10	-30	10	-40
Co 7	-10	20	0	15	-40	10	-30
Co 8	-10	10	0	20	-40	0	-30
Co 9	-20	30	0	10	-20	0	-70
Co 10	-15	30	0	20	-30	10	-10
Co 11	-9	20	0	23	-44	2	-20
Co 12	-15	10	0	10	-50	20	-30
Co 13	-5	20	0	20	-40	40	-40

Table L.18: Constructors' Weighted Responses to Question 8

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	225	-15	30	0	-30	0	0
Co 2	90	-66	66	0	-3	0	-27
Co 3	210	-30	60	0	0	0	0
Co 4	60	-45	30	0	-45	-30	-30
Co 5	60	-90	60	0	0	-30	0
Co 6	180	-60	0	0	0	0	0
Co 7	75	-75	120	0	-15	0	0
Co 8	51	-54	180	0	-12	-6	-12
Co 9	45	-60	90	0	-45	-30	0
Co 10	90	-60	90	0	-15	0	-45
Co 11	120	-45	108	0	-6	-30	0
Co 12	90	-45	90	0	-45	-30	-15
Co 13	60	-60	90	0	-15	0	-15

Table L.19: Constructors' Weighted Responses to Question 9

	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6	Answer 7
Co 1	0	50	-10	50	0	20	20
Co 2	-2	60	-8	26	0	36	12
Co 3	0	60	0	20	0	30	30
Co 4	-10	30	-10	50	-10	25	15
Co 5	0	40	0	40	0	30	30
Co 6	0	60	-10	0	0	30	30
Co 7	-10	60	-15	30	0	25	10
Co 8	-8	34	-7	42	-4	32	17
Co 9	-10	60	-5	30	0	25	10
Co 10	0	40	-5	50	0	30	20
Co 11	0	20	-15	50	-4	30	18
Co 12	0	60	-15	10	-10	25	20
Co 13	-10	60	-20	30	0	15	15

Table L.20: Constructors' Weighted Responses to Question 10

Factor	Weight	Weight	Factor
Time	5	5	Culture
Time	5	1	Experience
Time	5	3	Political
Time	5	5	Cost
Time	7	9	Quality
Time	9	7	Design
Time	5	7	Working
Culture	5	9	Experience
Culture	7	5	Political
Culture	3	7	Cost
Culture	6	9	Quality
Culture	1	5	Design
Culture	3	9	Working
Experience	7	4	Political
Experience	9	7	Cost
Experience	6	9	Quality
Experience	5	7	Design
Experience	7	9	Working
Political	5	7	Cost
Political	3	9	Quality
Political	2	5	Design
Political	1	5	Working
Cost	8	9	Quality
Cost	1	5	Design
Cost	4	9	Working
Quality	7	9	Design
Quality	7	9	Working
Design	4	9	Working

Table L.21: Questionnaire 2 Response from Company 1

Factor	Weight	Weight	Factor
Time	2	1	Culture
Time	3	1	Experience
Time	2	1	Political
Time	1	4	Cost
Time	1	4	Quality
Time	1	2	Design
Time	3	1	Working
Culture	3	1	Experience
Culture	5	1	Political
Culture	1	2	Cost
Culture	1	3	Quality
Culture	2	1	Design
Culture	1	4	Working
Experience	5	1	Political
Experience	1	2	Cost
Experience	1	2	Quality
Experience	1	3	Design
Experience	1	3	Working
Political	1	5	Cost
Political	1	5	Quality
Political	1	4	Design
Political	1	5	Working
Cost	1	3	Quality
Cost	3	1	Design
Cost	1	4	Working
Quality	4	1	Design
Quality	3	1	Working
Design	1	4	Working

Table L.22: Questionnaire 2 Response from Company 2

Factor	Weight	Weight	Factor
Time	1	9	Culture
Time	1	3	Experience
Time	1	5	Political
Time	1	3	Cost
Time	1	5	Quality
Time	3	1	Design
Time	9	1	Working
Culture	3	1	Experience
Culture	1	9	Political
Culture	9	1	Cost
Culture	1	9	Quality
Culture	3	1	Design
Culture	1	9	Working
Experience	1	5	Political
Experience	3	1	Cost
Experience	1	9	Quality
Experience	3	1	Design
Experience	1	3	Working
Political	5	1	Cost
Political	1	3	Quality
Political	3	1	Design
Political	3	1	Working
Cost	1	5	Quality
Cost	1	3	Design
Cost	3	1	Working
Quality	3	1	Design
Quality	9	1	Working
Design	3	1	Working

Table L.23: Questionnaire 2 Response from Company 3

Factor	Weight	Weight	Factor
Time	4	7	Culture
Time	5	5	Experience
Time	4	8	Political
Time	5	7	Cost
Time	3	8	Quality
Time	5	5	Design
Time	5	5	Working
Culture	7	4	Experience
Culture	7	8	Political
Culture	6	6	Cost
Culture	6	7	Quality
Culture	6	5	Design
Culture	6	5	Working
Experience	6	8	Political
Experience	5	5	Cost
Experience	5	8	Quality
Experience	7	7	Design
Experience	5	5	Working
Political	7	3	Cost
Political	8	8	Quality
Political	7	6	Design
Political	7	5	Working
Cost	6	8	Quality
Cost	6	8	Design
Cost	5	5	Working
Quality	7	7	Design
Quality	6	5	Working
Design	6	6	Working

Table L.24: Questionnaire 2 Response from Company 4

Factor	Weight	Weight	Factor
Time	1	6	Culture
Time	1	3	Experience
Time	1	7	Political
Time	1	7	Cost
Time	1	7	Quality
Time	1	4	Design
Time	1	2	Working
Culture	1	2	Experience
Culture	1	3	Political
Culture	1	7	Cost
Culture	1	5	Quality
Culture	1	5	Design
Culture	1	2	Working
Experience	1	5	Political
Experience	2	1	Cost
Experience	1	4	Quality
Experience	1	2	Design
Experience	1	3	Working
Political	3	1	Cost
Political	1	2	Quality
Political	3	1	Design
Political	1	2	Working
Cost	1	5	Quality
Cost	5	1	Design
Cost	1	2	Working
Quality	4	1	Design
Quality	1	2	Working
Design	1	2	Working

Table L.25: Questionnaire 2 Response from Company 5

Factor	Weight	Weight	Factor
Time	1	3	Culture
Time	1	3	Experience
Time	3	1	Political
Time	1	3	Cost
Time	3	1	Quality
Time	1	5	Design
Time	1	5	Working
Culture	3	1	Experience
Culture	3	1	Political
Culture	1	3	Cost
Culture	5	1	Quality
Culture	1	5	Design
Culture	1	5	Working
Experience	3	1	Political
Experience	3	1	Cost
Experience	3	1	Quality
Experience	5	1	Design
Experience	1	3	Working
Political	1	3	Cost
Political	3	1	Quality
Political	1	5	Design
Political	1	5	Working
Cost	3	1	Quality
Cost	1	3	Design
Cost	1	3	Working
Quality	1	3	Design
Quality	1	3	Working
Design	3	1	Working

Table L.26: Questionnaire 2 Response from Company 6

Factor	Weight	Weight	Factor
Time	4	1	Culture
Time	1	4	Experience
Time	4	1	Political
Time	1	3	Cost
Time	1	6	Quality
Time	1	4	Design
Time	3	1	Working
Culture	1	6	Experience
Culture	2	1	Political
Culture	1	5	Cost
Culture	1	6	Quality
Culture	1	4	Design
Culture	1	5	Working
Experience	6	1	Political
Experience	4	1	Cost
Experience	1	4	Quality
Experience	3	1	Design
Experience	5	1	Working
Political	1	2	Cost
Political	1	6	Quality
Political	1	2	Design
Political	1	4	Working
Cost	1	4	Quality
Cost	1	3	Design
Cost	3	1	Working
Quality	5	1	Design
Quality	6	1	Working
Design	3	1	Working

Table L.27: Questionnaire 2 Response from Company 7

Factor	Weight	Weight	Factor
Time	1	2	Culture
Time	1	2	Experience
Time	4	1	Political
Time	1	2	Cost
Time	1	4	Quality
Time	1	2	Design
Time	1	3	Working
Culture	4	1	Experience
Culture	5	1	Political
Culture	1	2	Cost
Culture	1	2	Quality
Culture	2	1	Design
Culture	1	5	Working
Experience	5	1	Political
Experience	1	2	Cost
Experience	1	3	Quality
Experience	1	2	Design
Experience	1	2	Working
Political	1	5	Cost
Political	1	5	Quality
Political	1	4	Design
Political	1	4	Working
Cost	1	3	Quality
Cost	1	2	Design
Cost	1	2	Working
Quality	3	1	Design
Quality	2	1	Working
Design	2	1	Working

Table L.28: Questionnaire 2 Response from Company 8

Factor	Weight	Weight	Factor
Time	3	1	Culture
Time	1	5	Experience
Time	1	3	Political
Time	1	3	Cost
Time	1	4	Quality
Time	1	4	Design
Time	1	5	Working
Culture	3	1	Experience
Culture	3	1	Political
Culture	1	4	Cost
Culture	1	5	Quality
Culture	2	1	Design
Culture	1	5	Working
Experience	1	2	Political
Experience	1	2	Cost
Experience	1	5	Quality
Experience	1	3	Design
Experience	1	3	Working
Political	2	1	Cost
Political	1	4	Quality
Political	2	1	Design
Political	1	3	Working
Cost	1	4	Quality
Cost	1	3	Design
Cost	1	4	Working
Quality	2	1	Design
Quality	1	3	Working
Design	1	3	Working

Table L.29: Questionnaire 2 Response from Company 9

Factor	Weight	Weight	Factor
Time	2	1	Culture
Time	1	3	Experience
Time	4	1	Political
Time	3	1	Cost
Time	1	2	Quality
Time	3	1	Design
Time	1	3	Working
Culture	1	3	Experience
Culture	2	1	Political
Culture	2	1	Cost
Culture	1	3	Quality
Culture	2	1	Design
Culture	1	3	Working
Experience	5	1	Political
Experience	3	1	Cost
Experience	2	1	Quality
Experience	4	1	Design
Experience	1	2	Working
Political	1	2	Cost
Political	1	4	Quality
Political	1	2	Design
Political	1	5	Working
Cost	1	3	Quality
Cost	2	1	Design
Cost	1	4	Working
Quality	3	1	Design
Quality	1	2	Working
Design	1	4	Working

Table L.30: Questionnaire 2 Response from Company 10

Factor	Weight	Weight	Factor
Time	5	1	Culture
Time	5	1	Experience
Time	5	1	Political
Time	3	1	Cost
Time	1	3	Quality
Time	3	1	Design
Time	4	1	Working
Culture	1	3	Experience
Culture	3	1	Political
Culture	1	5	Cost
Culture	1	6	Quality
Culture	1	4	Design
Culture	1	4	Working
Experience	3	1	Political
Experience	1	5	Cost
Experience	1	5	Quality
Experience	1	4	Design
Experience	1	3	Working
Political	1	6	Cost
Political	1	7	Quality
Political	1	5	Design
Political	1	5	Working
Cost	1	3	Quality
Cost	3	1	Design
Cost	4	1	Working
Quality	4	1	Design
Quality	5	1	Working
Design	3	1	Working

Table L.31: Questionnaire 2 Response from Company 11

Factor	Weight	Weight	Factor
Time	1	5	Culture
Time	1	5	Experience
Time	1	2	Political
Time	1	2	Cost
Time	1	3	Quality
Time	1	3	Design
Time	2	1	Working
Culture	3	1	Experience
Culture	3	1	Political
Culture	5	1	Cost
Culture	1	3	Quality
Culture	2	1	Design
Culture	1	3	Working
Experience	1	2	Political
Experience	5	1	Cost
Experience	1	3	Quality
Experience	1	2	Design
Experience	1	3	Working
Political	2	1	Cost
Political	1	5	Quality
Political	1	3	Design
Political	1	2	Working
Cost	1	5	Quality
Cost	1	5	Design
Cost	1	5	Working
Quality	3	1	Design
Quality	3	1	Working
Design	1	3	Working

Table L.32: Questionnaire 2 Response from Company 12

Factor	Weight	Weight	Factor
Time	1	7	Culture
Time	3	1	Experience
Time	3	1	Political
Time	1	5	Cost
Time	1	2	Quality
Time	3	1	Design
Time	3	1	Working
Culture	5	1	Experience
Culture	3	1	Political
Culture	5	1	Cost
Culture	1	2	Quality
Culture	1	3	Design
Culture	1	3	Working
Experience	3	1	Political
Experience	1	4	Cost
Experience	1	3	Quality
Experience	1	3	Design
Experience	1	3	Working
Political	1	3	Cost
Political	1	5	Quality
Political	1	3	Design
Political	1	3	Working
Cost	1	2	Quality
Cost	3	1	Design
Cost	3	1	Working
Quality	3	1	Design
Quality	3	1	Working
Design	1	3	Working

Table L.33: Questionnaire 2 Response from Company 13

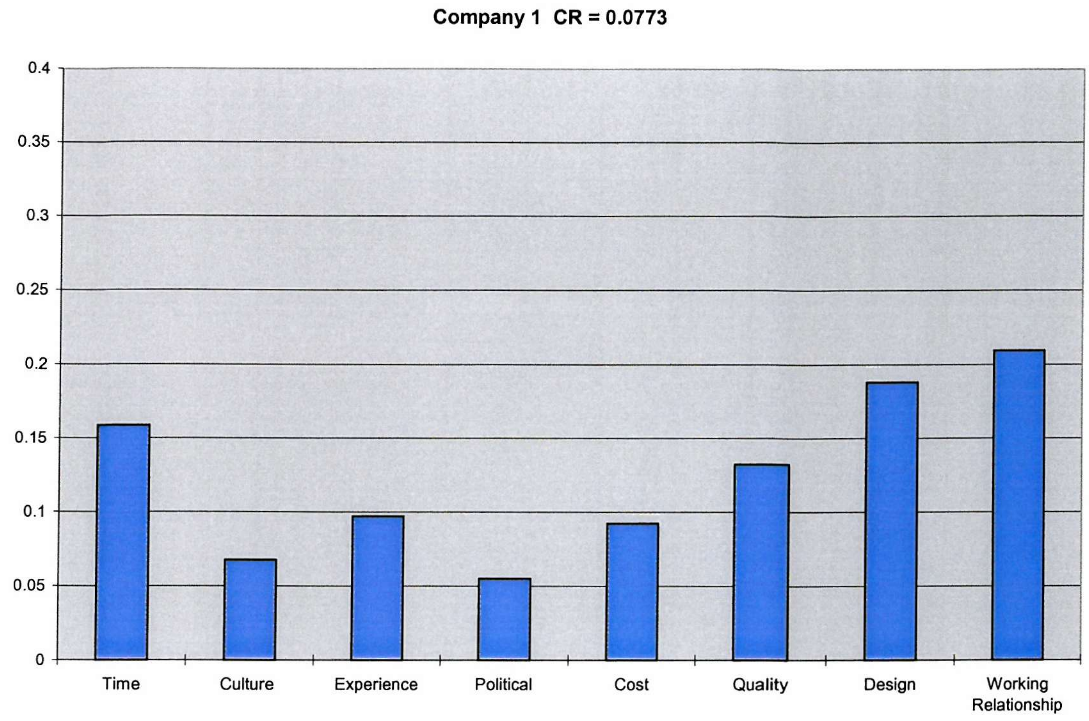

Figure L.1: Company 1 Project Objective Ranking

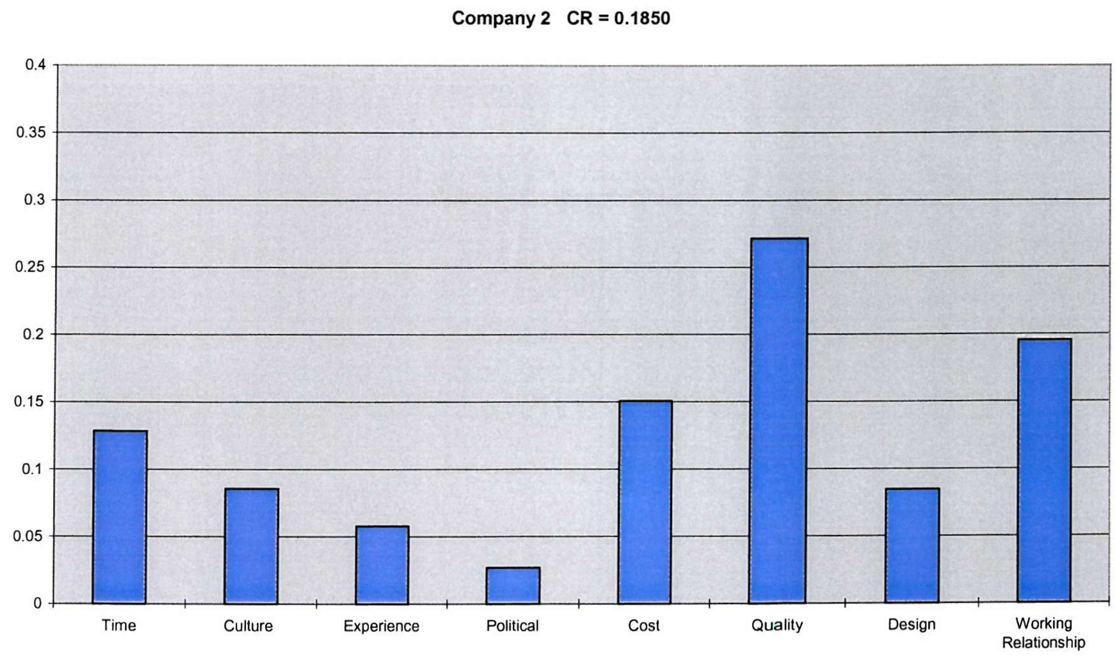

Figure L.2: Company 2 Project Objective Ranking

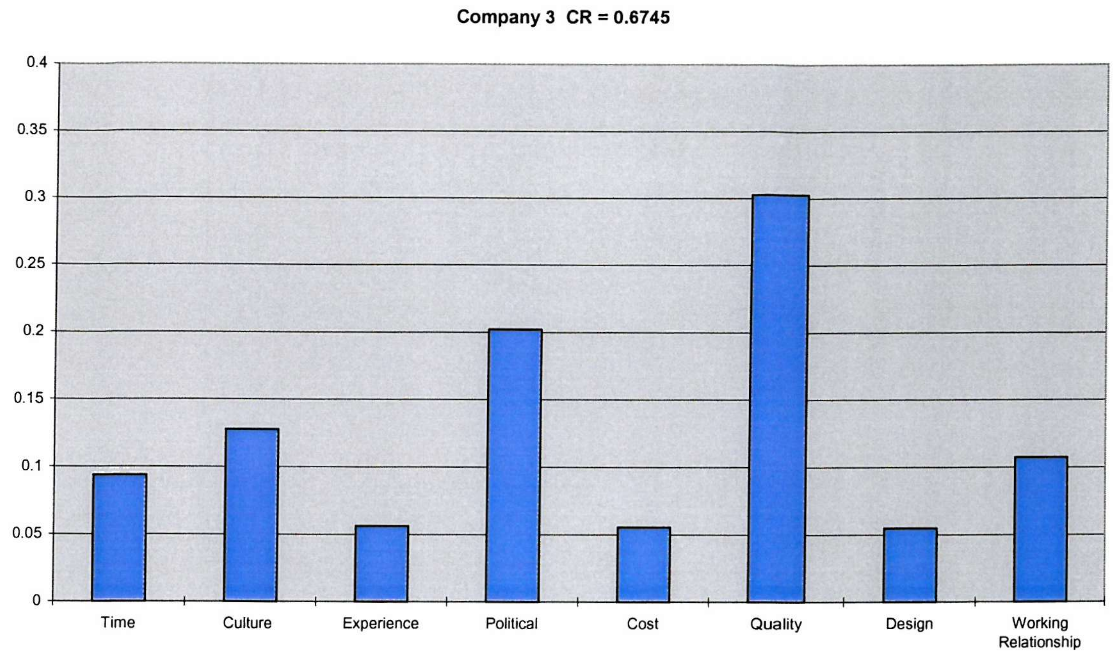

Figure L.3: Company 3 Project Objective Ranking

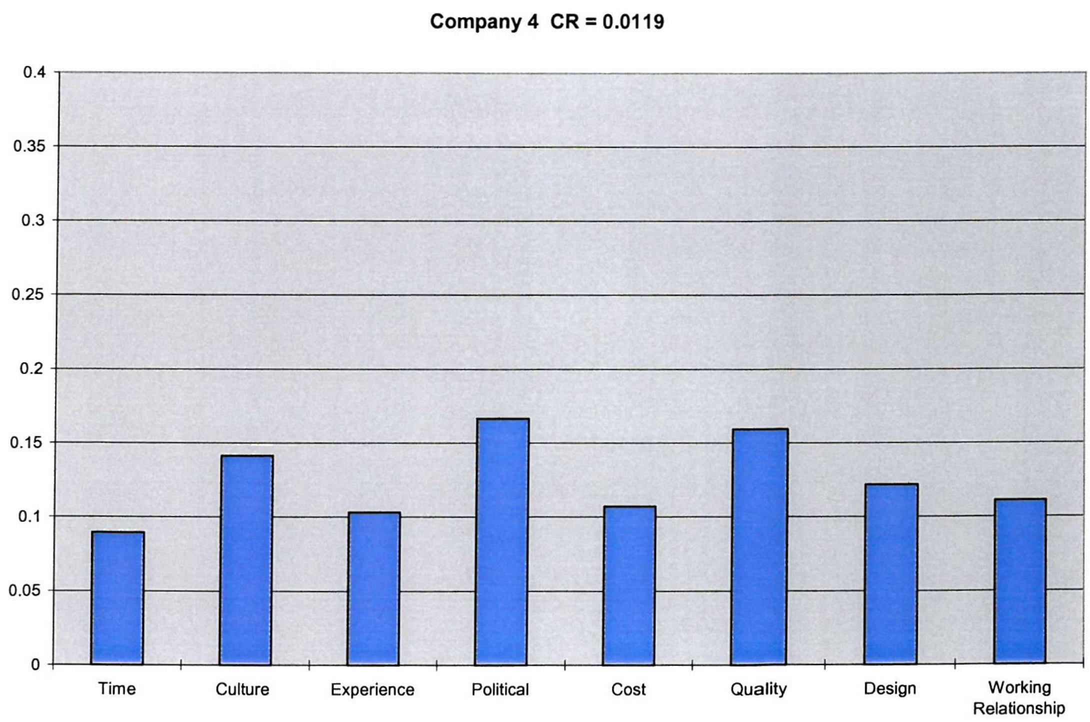

Figure L.4: Company 4 Project Objective Ranking

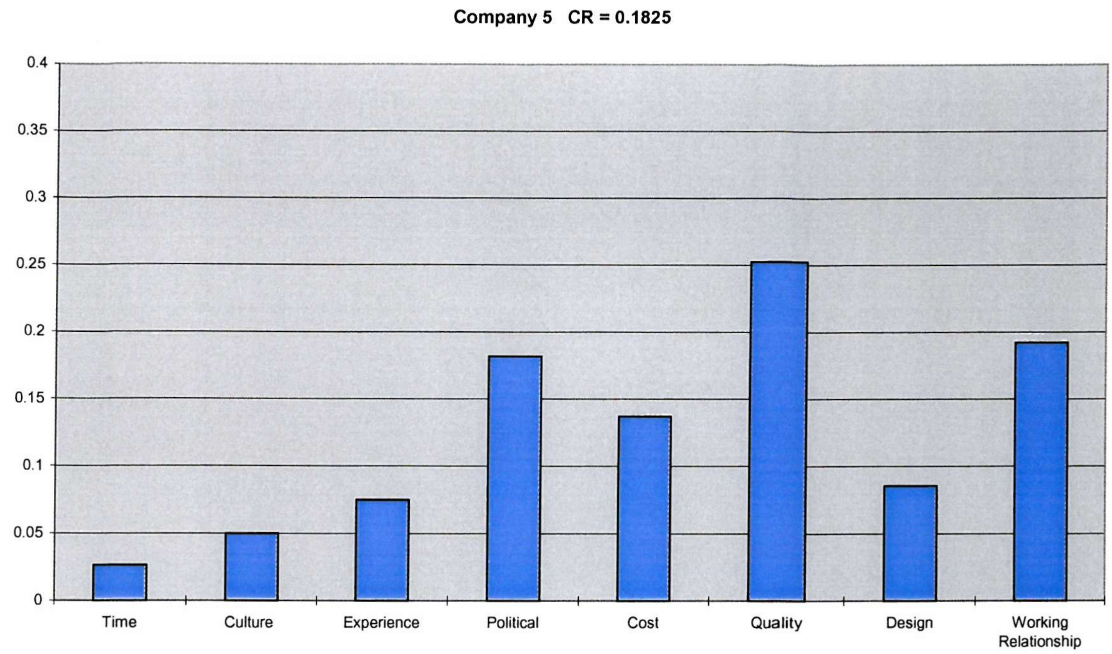

Figure L.5: Company 5 Project Objective Ranking

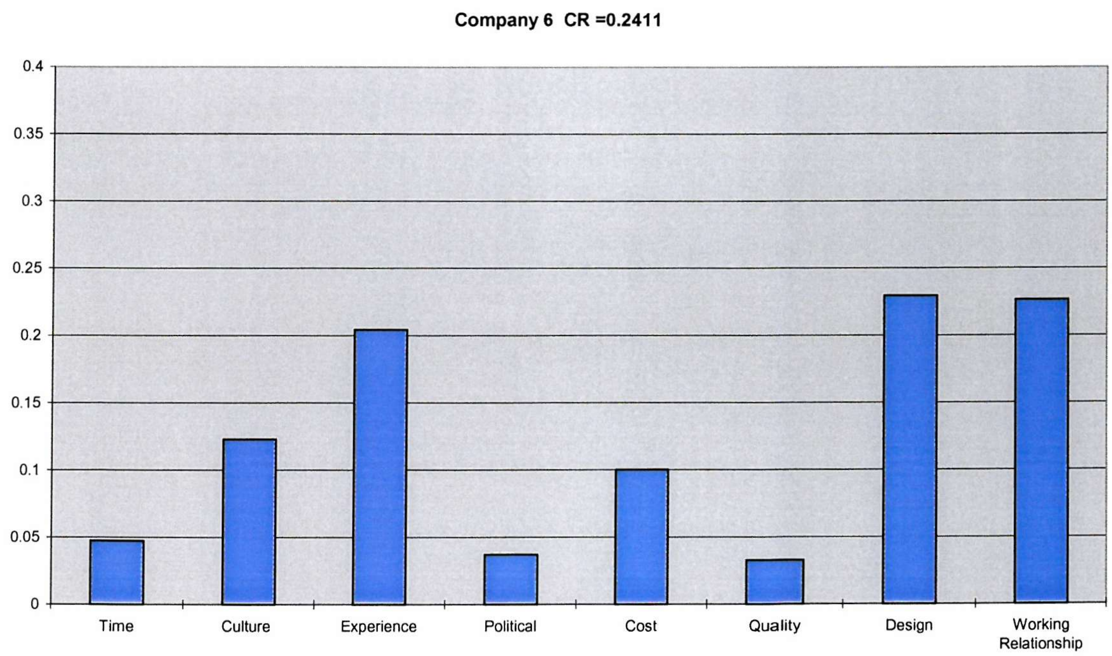

Figure L.6: Company 6 Project Objective Ranking

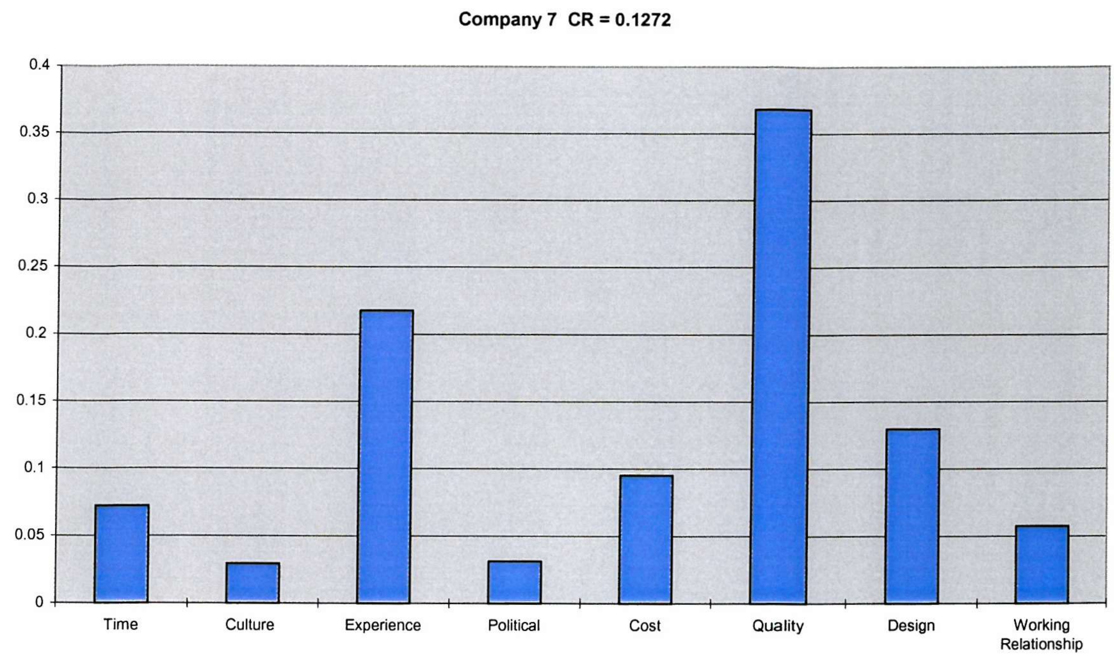

Figure L.7: Company 7 Project Objective Ranking

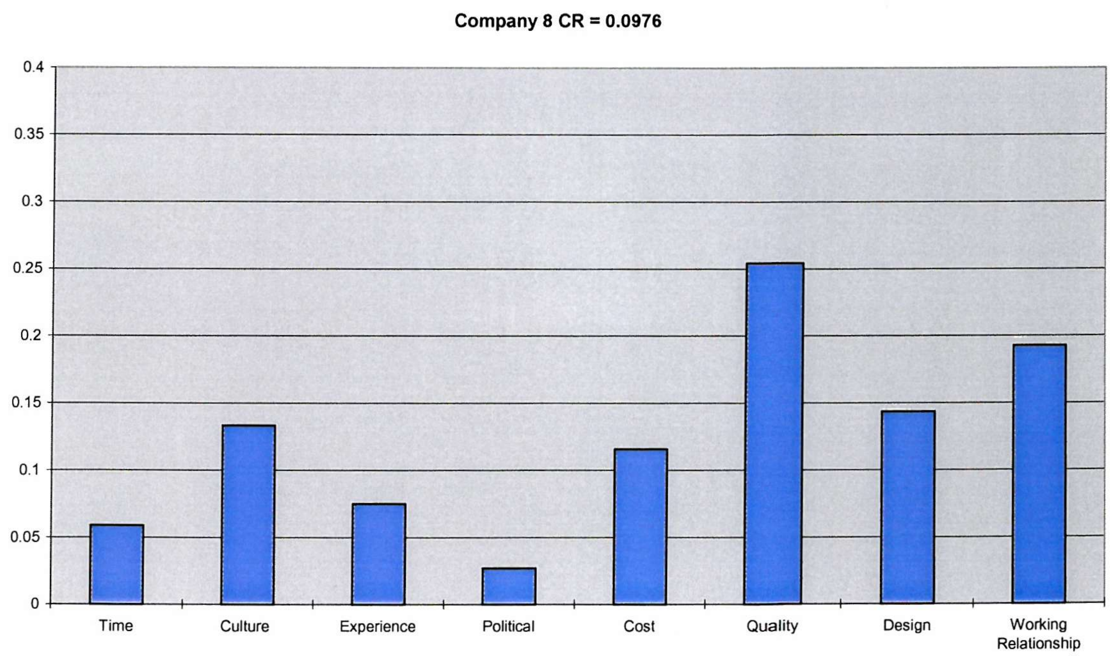

Figure L.8: Company 8 Project Objective Ranking

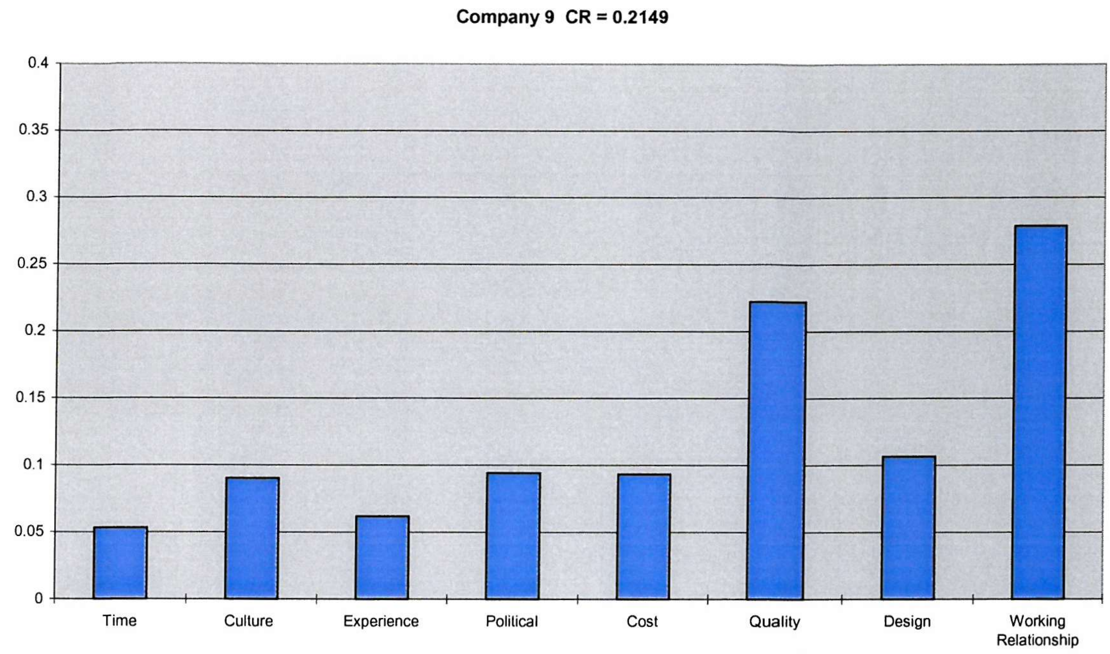

Figure L.9: Company 9 Project Objective Ranking

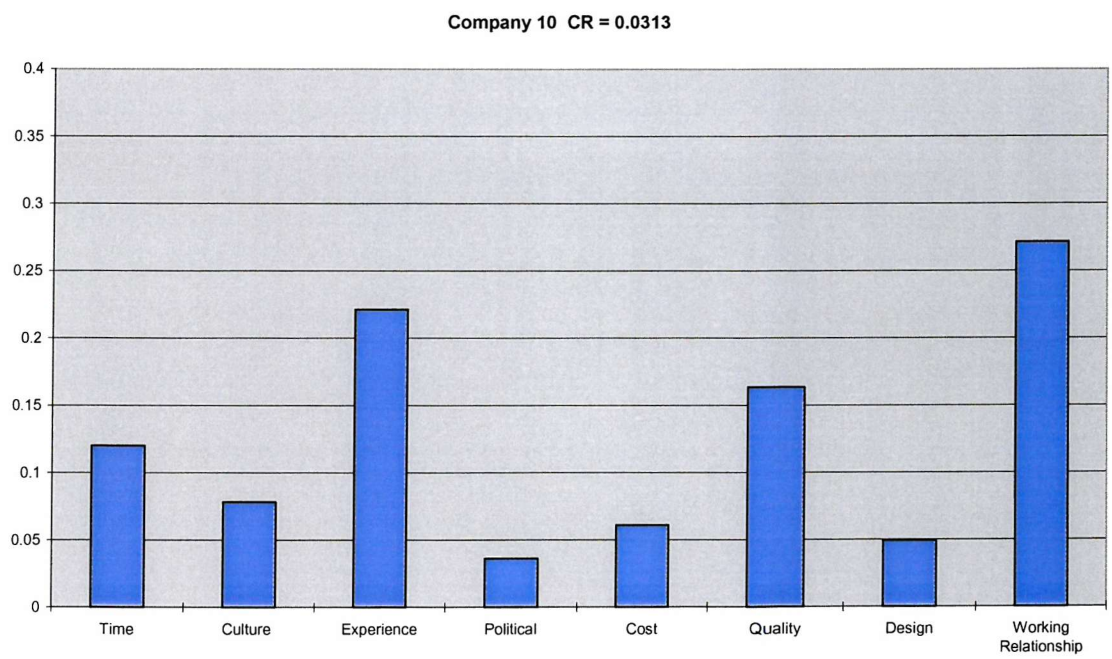

Figure L.10: Company 10 Project Objective Ranking

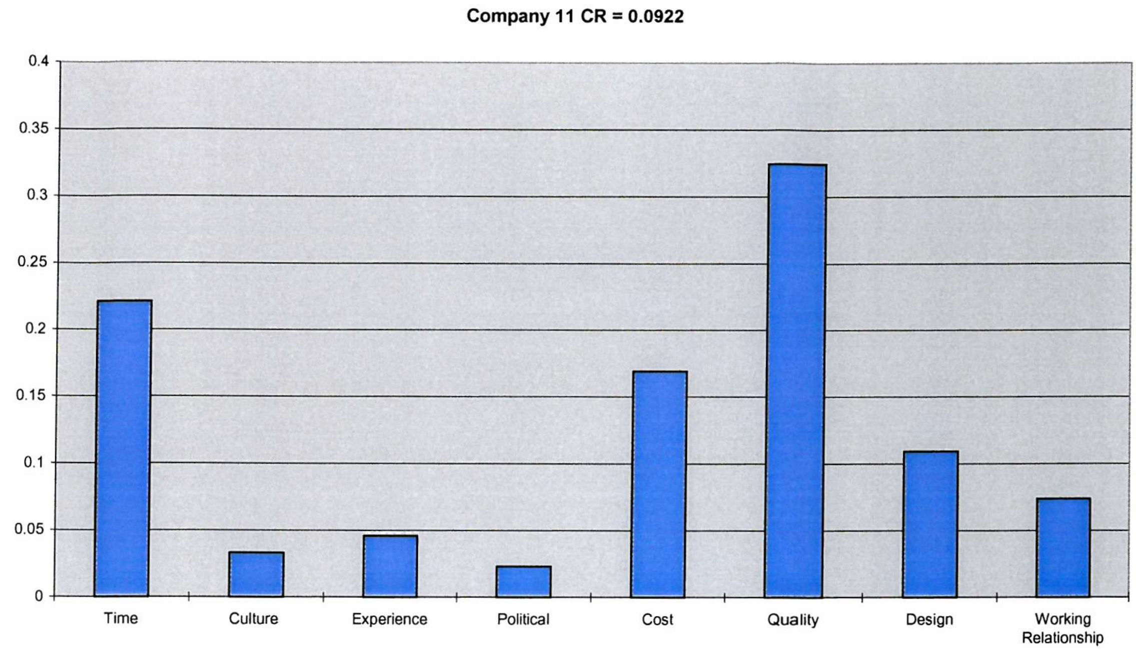

Figure L.11: Company 11 Project Objective Ranking

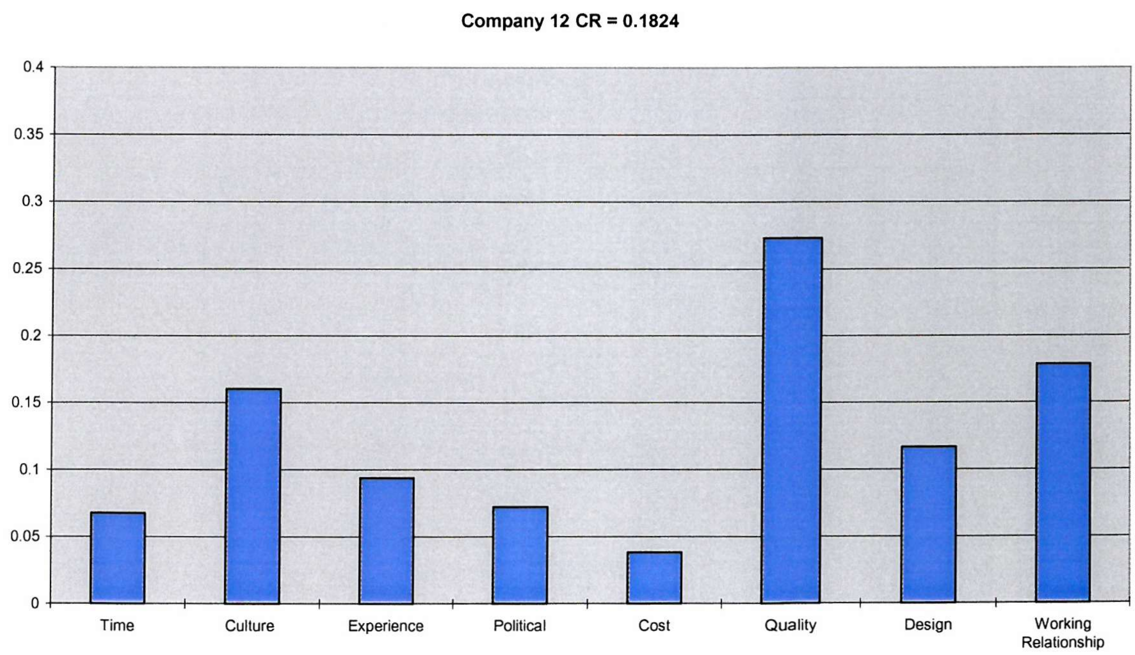

Figure L.12: Company 12 Project Objective Ranking

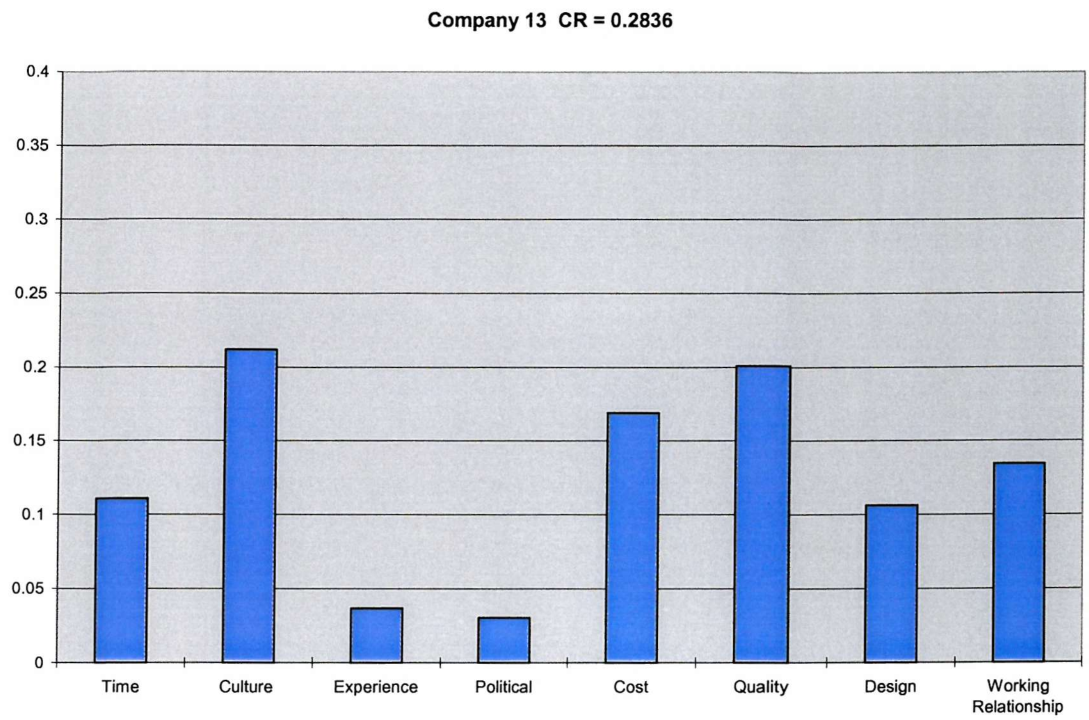

Figure L.13: Company 13 Project Objective Ranking

FORTON LAKE OPENING BRIDGE - QUALITY TENDER EVALUATION

Quality Aspect	Weighting	Marks awarded																Weighted Marks			
	%	Company 5				Company 7				Company 11				Company 10				Company 5	Company 7	Company 11	Company 10
		Terry	Jim	Ade	Average	Terry	Jim	Ade	Average	Terry	Jim	Ade	Average	Terry	Jim	Ade	Average				
Past experience on similar structures	15	5	9	9	7.67	0	0	4	1.33	5	10	9	8.00	6	8	9	7.67	115.00	20.00	120.00	115.00
Contract approach and methodology	15	8	9	8	8.33	4	6	4	4.67	5	8	7	6.67	6	7	7	6.67	125.00	70.00	100.00	100.00
Commitment to teamwork	15	7	10	9	8.67	0	6	4	3.33	5	8	8	7.00	6	9	9	8.00	130.00	50.00	105.00	120.00
Proposals for planning, managing and executing the works	10	7	10	9	8.67	5	6	5	5.33	5	7	6	6.00	5	6	8	6.33	86.67	53.33	60.00	63.33
Proposals for senior management involvement in the Contract	10	5	10	7	7.33	4	6	5	5.00	3	6	8	5.67	3	7	7	5.67	73.33	50.00	56.67	56.67
Management structure	Pass/Fail				0.00				0.00				0.00				0.00				
Key persons					0.00				0.00				0.00				0.00				
Experience					0.00				0.00				0.00				0.00				
Qualifications					0.00				0.00				0.00				0.00				
Head Office support facilities	5	6	7	7	6.67	5	5	7	5.67	7	6	8	7.00	6	8	7	7.00	33.33	28.33	35.00	35.00
QA policy					0.00				0.00				0.00				0.00				
H & S policy and records					0.00				0.00				0.00				0.00				
Staff training inc. NVQs					0.00				0.00				0.00				0.00				
Procedures and criteria for the selection and management of subcontractors	10	9	8	9	8.67	7	7	4	6.00	4	6	4	4.67	7	7	7	7.00	86.67	60.00	46.67	70.00
References from previous clients	10	9	0	8	5.67	4	0	4	2.67	7	0	8	5.00	7	0	8	5.00	56.67	26.67	50.00	50.00
Community involvement	5	7	8	9	8.00	9	10	7	8.67	4	6	4	4.67	6	8	8	7.33	40.00	43.33	23.33	36.67
Liason arrangements and managing interests of third parties and PR.	5	7	7	7	7.00	9	9	6	8.00	4	8	5	5.67	6	6	6	6.00	35.00	40.00	28.33	30.00
	100				76.67				50.67				60.33				66.67	781.67	441.67	625.00	676.67
																		100%	56.5%	80.0%	86.6%

Appendix N. Certificates of Awards

Figure N.1 shows the award certificate presented by The Southern Association of the Institution of Civil Engineers. At the award ceremony the judges commended the procurement method used.

Figure N.2 shows the award certificate for the Demonstration Project Award presented by the Movement for Innovation.

THE INSTITUTION OF
CIVIL ENGINEERS
Southern Association

Merit Award 2001

This is to certify that

Forton Lake Opening Bridge

has been awarded the Merit Award 2001 by

The Southern Association of
The Institution of Civil Engineers

for achieving excellence in

concept, design and construction.

Signed.................................	*Signed.................................*
Joe Dwyer, CEng, FICE	*John Henderson, C Eng, MICE*
ICE President	*ICE Southern Association Chairman*

Registered Charity No. 210252

Figure N.1: Institution of Civil Engineers Award

RETHINKING

Movement for
Innovation
M^4I

CONSTRUCTION

DEMONSTRATION PROJECT AWARD

The Movement for Innovation Board wishes to acknowledge the invaluable contribution made by:

University of Southampton
Business Engineering Group

As a member of the

Forton Lake Opening Bridge

Demonstration Project Team in identifying and measuring innovations and best practices and sharing that knowledge to help implement "Rethinking Construction" *across the industry.*

Alan Crane
Chairman of the M^4I Board

Figure N.2: M^4I Award