AN ANALYSIS OF BUILDING PROCUREMENT FACTORS AFFECTING COORDINATION OF BUILDING SERVICES

K.C. Lam, A.G.F. Gibb and W.D. Sher

Department of Civil & Building Engineering Loughborough University. UK

The procurement of complex and highly serviced buildings is always fraught with expensive and complex problems of inadequate coordination of building services. These problems are detrimental to the success of building projects, and must be resolved by rational and professional management from design to construction. Preliminary results of our research study have indicated that the success of complex coordination of building services is dependent on the appropriateness of a particular procurement system for a particular project. This paper presents two models which can be used for managing the coordination of building services and in the selection of an appropriate procurement path with due regard to the coordination of complex building services.

Keywords: case studies, coordination model, coordination-procurement model, propositions, services coordination.

INTRODUCTION

This paper stems from research at Loughborough University, into consideration of the effects of different procurement methods on coordination of complex building services for highly serviced buildings. This paper is a continuation of our paper (Lam, Gibb and Sher, 1996) presented in the ARCOM 96 Conference, and presents further improvements to our coordination model and the development of a coordination-procurement model based on surveys, in-depth case studies and further analysis of other literature on project performance and selection of building procurement systems. In this paper we also discuss the application of these two models as a framework for examining several building projects in conjunction with five central propositions proposed in our research. In the authors' opinion, the models can be used to evaluate the impact of a particular procurement method on the management of building services design and installation. Conversely, the models provide a unique framework to enable the objective identification, comparison and appraisal of procurement systems for new building projects in a systematic manner.

BACKGROUND TO THE RESEARCH

During the ARCOM 96 Conference, we highlighted the limitations and inadequacies of previous research in coordinating building services and the effects of building procurement methods on the management of building services design and installation, and building construction. Much of this past work is fragmented, and some has focused either on design issues or services installation issues. Studies on building

Lam, K C, Gibb, A G F and Sher, W D (1997) An analysis of building procurement factors affecting coordination of building services. *In:* Stephenson, P (Ed.), *13th Annual ARCOM Conference*, 15-17 September 1997, King's College, Cambridge. Association of Researchers in Construction Management, Vol. 1, 83-92.

procurement with particular reference to building services design and installation are scarce, and tend to be more limited in depth, either concentrating on procurement issues and forms of contract or reviewing the management of building services design and installation in a general way. To date, researchers have neglected the implications of the combined effect of a particular procurement path and the complex nature of coordination of building services within the Temporary Multi-Organisation system formed by the design and construction teams for a building project. We have, therefore, taken a wider perspective in investigating the management of building services. We have therefore addressed the impacts of a procurement path on the coordination issues; the working of all professionals in the Temporary Multi-Organisation; and the factors of project characteristics altogether.

It follows that the principal objective of this study is to determine the relationship between building procurement methods and the management of the coordination of building services. It is anticipated that our research results will redress the present illogical approach to the selection of procurement method, and this should lead to more effective guidelines for selecting building services procurement route for highly serviced buildings, and for the building industry to make use of these findings to implement the management of building services more effectively. The lack of documented research in this area makes comparison with other researchers findings difficult. Also, our research involves a considerable amount of data which is often in a qualitative format. Any attempts to quantify the evidence quantitatively would be difficult and not appropriate for this qualitative research project.

AIM OF RESEARCH

This research reflects the authors' experience, continuing investigation and research in management of the coordination of building services. The research project aims to:

- explore the inherent problems in the management of specialist contractors, design and construction for M&E works.
- identify the root causes of poor coordination of building services associated with unsuccessful procurement of highly serviced buildings.
- determine the impact of building services procurement on the coordination of building services within a Temporary Multi-Organisation, i.e. the project team-architect -engineers-contractors.
- identify the factors that influence the decision making process of selecting an appropriate procurement path with emphasis on attaining effective coordination of services.
- develop a methodology so that the most appropriate procurement path can be selected for the most efficient management of coordination of building services.

PROBLEMS IN HIGHLY SERVICED BUILDINGS

By their very nature building services cannot be designed and installed independently as this vital element has to be fully integrated with other elements in a building and requires a high level of coordination. Hence, close working between all designers and contractors is necessary to produce an integrated building in which building services, structural and building elements are fully planned, systematically organized and

combined and brought to fruition as required by a client, (i.e. a perfect building with good design, high quality, short completion time and last but not least, reasonable cost). As buildings grow in size and complexity, building services also tend to be more sophisticated and difficult to manage from design to installation. Furthermore, coordination problems have become particularly acute if services and other building elements are not properly planned, managed and coordinated.

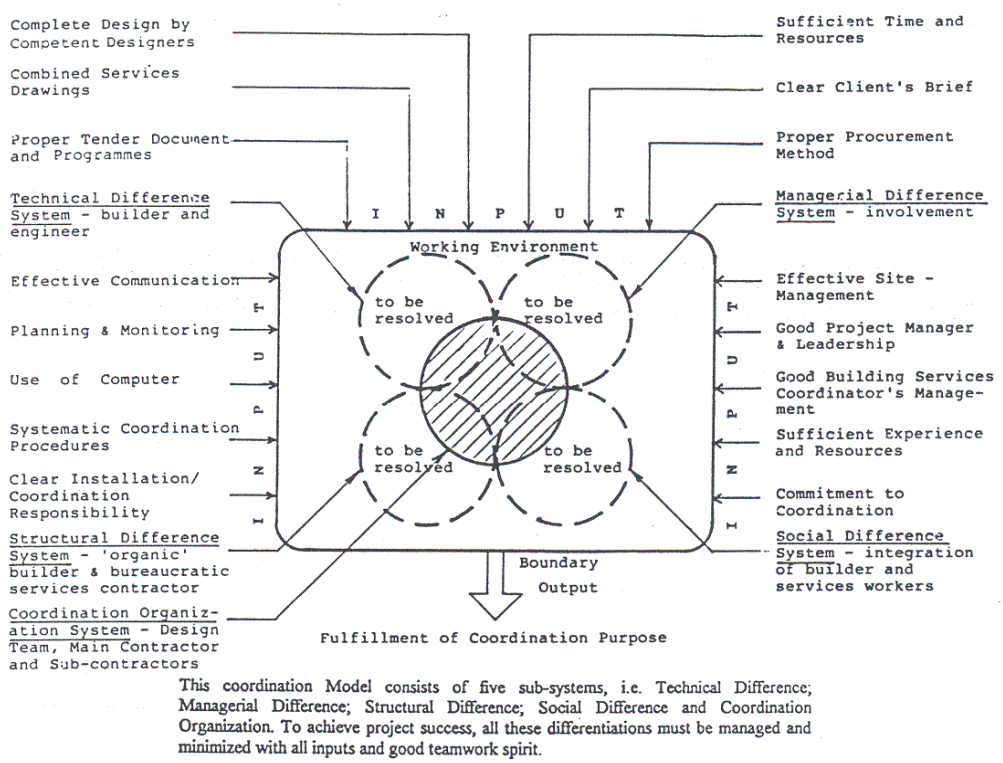
Based on our research results, we have found that the procurement of complex and highly serviced buildings (i.e. large hospitals, hotels, infrastructures and large office complex developments) is always fraught with expensive and complex problems of inadequate coordination of building services. These problems are detrimental to the success of any building project, as the results of inadequately designed and coordinated building services can cause: delay during construction, major monetary claims, unsightly services, and potentially difficult maintenance. Hence, it is necessary to re- engineer the present approaches to the management of design and construction. To complicate this complex coordination issue, from previous research (Barton, 1978: 6-10; Michie, 1981; Kwok, 1988; Loosemore & Davies, 1994; Parsloe, 1994; Pasquire, 1994; Wilkins & Smith, 1994; Gibb, 1995; Lam, et.al., 1997 and many others) and our findings based on in-depth case studies, we have also identified that although "Complete" design is of paramount importance, this cannot and will not completely solve poor coordination problems. Issues relating to a client's brief, changes of design, conditions of engagement of designers and contractors, division of design responsibilities, allocation of risks, early incorporation of specialist services contractors, forms of contract and quality of design and construction management must all be considered together. As a procurement path determines the organisation for the design and construction of a project, and the ways the design and construction teams work together, it is, necessary to use an appropriate procurement system which is conducive to effective coordination of building services.

KEY ISSUES RAISED FROM PRELIMINARY RESULTS FROM THE RESEARCH STUDY

During the second stage of this research, we have identified many variables in relation to the coordination of building services and the effects of a procurement path on building services. All the data are shown in the coordination model and coordination-procurement model. The data generate adequate background information for further analysis and validation of data in conjunction with detailed Study of additional case studies.

COORDINATION MODEL

The review of previous published and unpublished research, opinions expressed publicly and privately and the results of our research in engineer's offices and surveys conducted in Hong Kong have laid the foundation for the development of the research model shown in Figure 1 (i.e. Coordination Model). This conceptual model is considered to be a useful tool for better understanding the complex issue of coordination of building services whilst remaining open to revision and amendment if necessary following further research in conjunction with more in-depth case Studies.



This coordination Model consists of five sub-systems, i.e. Technical Difference; Managerial Difference; Structural Difference; Social Difference and Coordination Organization. To achieve project success, all these differentiations must be managed and minimized with all inputs and good teamwork spirit.

Figure 1: Coordination Model

The model is capable of illustrating the dynamic nature of the coordination process and the essential integration of all technical; social; organisation/structural and managerial components as well as their interactions with the environment. The effects or impacts of a procurement path will be separately discussed in another model, i.e. Coordination- Procurement model. Briefly, the model illustrates that effective coordination of building services demands;

- Intensive inputs from clients (comprehensive briefing, sufficient time and funding for design and coordination of services), design team (complete design information and fully integrated and coordinated building services) and all contractors (effective site coordination of services);
- Effective project management of design and construction by all parties;
- Teamworking in the design and construction teams. All social structural and technical differences are to be overcome as much as possible; and
- Use of an appropriate procurement path and contract conditions (i.e. allocation of risks, responsibility of coordination and terms, etc.) to facilitate the abovementioned input requirements.

It can be clearly seen from this model that coordination of building services will be influenced by the working of the client, design and construction teams. However, their workings can be affected by the procurement path selected for a particular project. Hence, for a complete study of the coordination issue, it is necessary to study the characteristics of procurement methods commonly used in the building industry, and see how the organisational system used to acquire a building can shape the success of a project. Though simple, this coordination model is considered to be detailed enough to assist evaluation during selection of an appropriate procurement path for a particular project. If project success is to be achieved, the procurement path chosen

would have to incorporate all the inputs as identified in the model. It is, however, not advisable to make an arbitrary selection of a procurement path based on this coordination model alone as the characteristics of each procurement path and the special needs of clients will affect the coordination of services differently. A framework is needed to facilitate a systematic evaluation of possible procurement paths in a disciplined and objective manner.

PROCUREMENT OF BUILDING SERVICES AND BUILDING CONSTRUCTION

From our research results, we have identified that many projects suffer from inadequate or inappropriate procurement decisions. Therefore, the most useful protection that can be offered to a client is a logical and sensible policy for choosing a procurement strategy for each building project. However, based on our studies, little has been said about the logical selection of a procurement method with particular reference to coordinating building services in past research.

Our research into procurement methodologies has focused on both project organisation systems and the implication of building services elements. From our preliminary results - and the development of the Coordination Model, we have identified that selection of the best procurement path for a highly serviced building is in each case largely a function of the key functional factors such as client, design, construction, contract, I project characteristics and project management in a procurement process. '

The functional approach is based on all common factors to all construction projects. That is; (1) the main functions and the responsibilities of those involved in a building project; (2) the project characteristics; (3) the management of design and construction; (4) the contract form selected; (5) the allocation of responsibilities for design and construction; (6) the integration of designers and contractors; (7) the project environment (external factors); and (8) time and resources provided for design and management. This functional approach is considered to be a useful tool which can be used in studying different forms of procurement globally in any given country (other than Hong Kong). The functional approach to building procurement is also applicable to coordinating services since all these eight functional factors influence the setting up of the coordination process.

Based on our evaluation of surveys and case studies, at least eight major functional factors have been identified as follows:

Key function	**Requirements for co-ordination**
• Client	Experience, briefing, decision making, funding and involvement.
• Project characteristics	Nature and complexity, cost, time, design, quality, change of needs.
• Organisation	Procurement form, familiarity and proximity, differentiation coordination.
• Design team	Multi-organisations to single organisation, excellence in design, integration and supervision, completeness of services design and project information, project management, teamworking.

- Contract/risk — Fairness, clear responsibilities and balanced allocation of risks.
- Project environment — Meteorological, economical, political and technological factors.
- Project performance — Cost, time, quality.

Having established the requirements for each of the functions, it is logical to view building procurement as a system based on "System Thinking" and devise a Coordination-Procurement System Model (for selection of procurement path with emphasis on improving the coordination of building services) as illustrated in Figure 2.

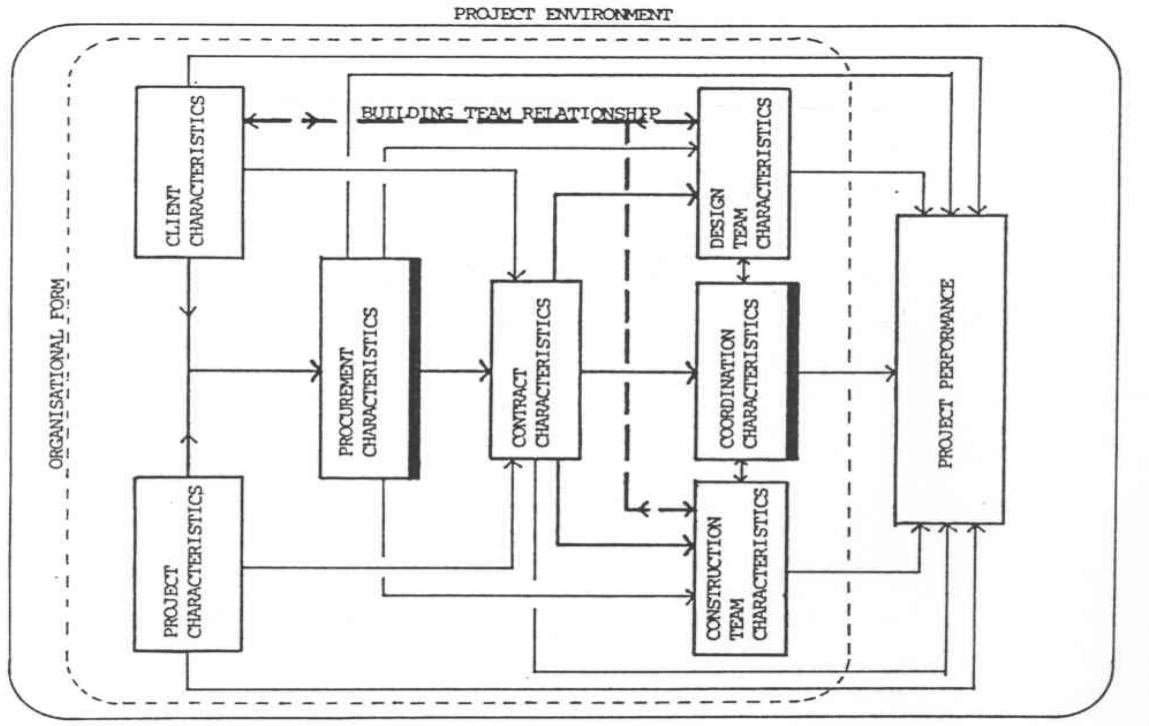


Figure 2: Coordination-Procurement Model

The model comprises six major sub-systems which are detailed below:

SUB-SYSTEM CHARACTERISTICS FOR COORDINATION

Sub-system	**Characteristics for co-ordination**
• Client	Comprehensive brief, decisive, and efficient communication.
• Project characteristics	Avoidance of complexity; realistic budget and time; certainty in construction activity; minimum changes in design; favourable project environment.
• Procurement	Organisational form for best coordination of services
• Contract/risk	Unambiguous design and construction responsibilities, obligations and rights/sharing of risk; adequate time and resources for design,

coordination and construction.

- Design team — Experienced and knowledgeable in integrated design and coordination of services; appointment for full service, i.e. complete design information and site supervision; cooperative team; Total Quality Management (TQM) is important.
- Construction team — Experienced and knowledgeable in construction and coordination of specialist contractors; professional project management; good interfacing, coordination and effective resolution of conflicts; TQM is important; coherent and interdependent organisations with effective integration, mutual trust and cooperation.

The client and project characteristics are seen as primary independent variables. The other elements are selected or adapted with modifications in order to serve the needs of the primary variables, the objective being to achieve optimum results of the dependent variable of project success. All these variables are subject to the influence of the project environment. The model illustrates the relationships between the variables in the building process, and the object of the model is that it can be used to assist in the selection of the best organisational form for the management of coordination of services. Also, the model can be used to improve the outcome whatever the procurement strategy.

The development of this Coordination-Procurement System Model based on a qualitative approach gives a unique and structured framework of reference which allows at least an objective appraisal, identification and comparison of various procurement methods for highly serviced building projects. It must be noted that the model does not attempt to give an absolute answer to the selection of a procurement path, and in fact, it would be ill-advised to have this concept (i.e. direct or absolute answer) as procurement is a complex issue and necessitates detailed evaluation of each scenario. Also, no single procurement path can be suitable for every project on all occasions. Procurement is a complex issue and needs detailed evaluation of each project. As seen from the sub-systems in the model, the procurement path for a particular project is an important strategy as the selected path must satisfy all, i.e. clients, designers, all contractors and the particular project constraints. This is obviously a difficult task since no single procurement path can satisfy all parties in a contract. Furthermore, the selection of procurement methods for any but the simplest project is difficult owing to the many options available. There is no short cut to the selection of an appropriate path and all criteria affecting decision making must be fully established and evaluated in relation to the complexity of the highly serviced project.

THE PROPOSITIONS OF THE RESEARCH

Data drawn together from literature, surveys, discussions, observations and our experience can be Stated as propositions of our research. By Stating propositions, important theoretical issues can be made explicit and suggestions formulated as what relevant evidence must be collected. Each proposition directs attention to something that needs to be examined within the scope of the study. Our research results and our two models stimulate five central propositions, which are:

- Coordination of services is influenced by the management of design.

- Coordination of building services is influenced by the management of construction .Coordination is not only a technical issue but an exercise in management. It is influenced by the construction professional's working practices.
- Coordination of services is influenced by project procurement methods.
- Project success is influenced by implementation of effective coordination of services and the use of an appropriate procurement path.

All these propositions will be analysed and tested by means of detailed case studies. Since this research is still on-going, it is considered more appropriate not to give the authors' findings of these propositions during this presentation as more information is still required for carrying out detailed analysis.

PRELIMINARY STUDY OF PROCUREMENT PATH

To test the models, we have examined several large hospital projects using various traditional procurement paths with nominated services sub-contractors. For this paper, only two hospitals in Hong Kong (Case 1 and 2) are to be discussed. Coordination of services in Case 1 is unsatisfactory, but the result in Case 2 is considered very satisfactory. The analyses can be summarized with reference to the Coordination-Procurement Model as detailed below:

Case 1 (traditional path)	**Case 2 (traditional path)**
Client characteristics	
Inexperienced client; multi-headed client problem; unclear brief and requirements; late decision and too many changes; no feed back from previous projects.	Experienced client; effective organisation of multi-headed client; good brief and detailed requirements; changes had been managed; with feedback from Case 1.
Project characteristics	
Complicated building, building services and hospital engineering systems; construction period was unrealistic; many uncertainties in construction.	More complicated than Case 1; construction period again was very tight; site condition had been predicted and allowed for.
Contract	
Unclear contract document and ambiguous requirements of coordination of services; resources needed for coordination were inadequately covered;	Improved contract document based on lesson learnt from Case 1; special requirements of coordination of services had been spelled out in detail and to be treated as priced item.
Procurement characteristics	
Conditions of engagement was based on normal service; coordination drawings were not provided by designers.	Special conditions with provision of detailed coordination drawings, information and coordination.
Design team	Experienced hospital architect with M&E services consulting engineer; good working relationship with equal status; a special coordination team had been set up on site.
Experienced hospital planner and engineers from a single organisation, powerful architect overrode services engineers; inadequate site coordination initially but improved later.	
Construction team	

Inexperienced and lack of management of services; no provision of coordinated services drawings; adversarial attitudes between designers and HVAC contractor; bad team building.	Experienced Japanese contractors; sub-contractors had no experience in hospital projects, but they had good management of services; plus provision of detailed coordinated services drawings; very good team building.

ANALYSIS OF CASE-STUDIES

The case studies have also been examined with the characteristics of the procurement path used. Inherently, traditional building procurement does not create a spirit of team work and therefore discourages integration and coordination of various participants. In Case 1, because of the adversarial nature of the traditional contractual path, the construction team did not work in harmony. As seen from the analysis, the obvious causes of project failure are inadequacy in a) client's involvement, b) detailed design information, c) site management of all contractors, d) contractors' cooperation and e) overall project management in all technical and managerial issues. In Case 2, owing to the feedback from Case 1, the same client had learnt a painful lesson and planned to rectify all coordination problems from the briefing stage to the construction stage. Significant improvements in all technical and management issues as depicted in our coordination model had all been adopted and managed quite successfully. The most important factors of project success were good teamworking and excellent management offered by all the parties. Obviously, special attention was given to coordination of services right from the beginning to the end of this project.

These two case studies (and nevertheless many others) have demonstrated the applicability of the model, which, is bound to be influenced by subjective judgement. This should not be seen as a weakness, as human experience is a form of useful feedback and should help select a particular procurement path. It has also illustrated an important fact that the same procurement path can be unsuccessful in one project, but can also be successful in another case.

To sustain this study, we have also studied another large hospital again using a traditional procurement path. Initially, the result was totally unsatisfactory in terms of planning, design and management. To rectify the problems, the client had re-selected the project architect and an additional project management team was introduced as the client's project manager. This project manager used a total quality management system to manage the project and the outcome was a high quality hospital completed on time and within budget. The services again were fully integrated and coordinated during the design and construction stages and this project success demonstrated that coordination could be managed technically and managerially.

From all our case studies (only three cases are reported in this paper), we have identified that the procurement pattern is not the most critical factor. However, a procurement path can influence teamworking which can affect the outcome of a project. From the three case studies, it is encouraging to see that the data obtained support the five central propositions in our research. However, more case studies and surveys will be required to validate these with different procurement paths and project characteristics.

For new projects, the model can be used to analyse each of the sub-systems in relation to the characteristics of a particular procurement path and the most appropriate path can be determined after the evaluation process. However, the use of both qualitative and quantitative approaches (i.e. a weighting system) may be necessary to overcome a

particular method's limitations and weaknesses. Based on our research findings, 'it has been identified that no single method of procurement is suitable for every project for all time as the project characteristics and the members in the design and construction teams vary from project to project; the use of a particular procurement route however can achieve a higher level of project success and more efficient coordination of services.

CONCLUSION

Coordination of building services has a direct bearing on the success of a building project. Services must be fully integrated and coordinated. The way in which many clients and their advisors select the methods used to control the design and construction of their highly serviced building projects, can be haphazard, ill-timed and lacking in logic and discipline. Selection of a procurement path is difficult. There is a need for re-engineering present approaches to the selection of procurement paths. Models developed by the authors can be used to select a procurement method with due regard to coordination of complex engineering services. However, further improvement in this modelling is required from the viewpoint of quantitative analysis. It is anticipated that the outcome of the research will allow better advice to be provided to the building industry.

REFERENCES

Barton, P.K. (1978) The coordination of mechanical and electrical engineering in building production. *Special paper: coordination of mechanical and engineering services*, CIOB.

Gibb, A.G.F. (1995) Maintain control or delegate responsibility? The design development dilemma at construction interfaces. In: *ARCOM 95*, 202-211.

Kwok, P.K. (1988) Coordination of building services in tall building. *Building Journal Hong Kong China*, 98-104.

Lam, K.C., Gibb, A.G.F. and Sher, W.D. (1996) Impact of building procurement methods on coordination of building services. In: *ARCOM 96*, 150-159.

Lam, K.C., Gibb, A.G.F. and Sher, W.D. (1997) Selection of procurement paths for highly serviced hospital buildings. In: *CIB W92 Symposium on Procurement*, Montreal, Canada, 345-355.

Loosemore, M. and Davies, M.G. (1994) Hospital development briefing. *CIBW92, Conference on Procurement Systems*, Hong Kong, 179-186.

Michie, A. (1981) Integration and coordination of building services and its relationship with project management. *BSER&T*, **1(**1), 15-26.

Pasquire, C. (1994) Early incorporation of specialist M&E design capability. *CIBW92, Conference on Procurement Systems*, Hong Kong, 57-75.

Parsloe, C.J. (1994) The allocation of design responsibilities for building engineering services. *BSRIA Report Nr 77420/2*, U.K.

Wilkins, B.W. and Smith, A.J. (1994) Procurement of major publicly funded health care projects. *CIBW92, Conference on Procurement Systems*, Hong Kong, 307-313.