Co-ordination of building services and procurement methods for highly serviced buildings

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CO-ORDINATION OF BUILDING SERVICES
AND
PROCUREMENT METHODS
FOR
HIGHLY SERVICED BUILDINGS

by

KAM – CHUEN LAM

A doctoral thesis submitted in partial fulfillment of the requirements
for the award of
Doctor of Philosophy
of Loughborough University

April 2003

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Preface

This study has been completed only because of the support, advice and participation of a large number of people. Regrettably, it is not possible to identify some of them because of reasons of confidentiality and etiquette.

The thesis was originally submitted in December 2001 and has been amended to its present form. The help provided by way of comments on the shortcomings of the original text by my supervisors, Mr. Alistair Gibb and Mr. Willy Sher is gratefully acknowledged. Without their expertise and cajoling this work would never have been completed.

I would also like to express my sincere thanks to Dr. A N Baldwin, Dr. A D F Price and Dr. P Stephenson for their opinions and guidance in my research.

On a personal note, I would also like to express my gratitude to my wife for having the belief in me to complete a PhD, and for the thankless task of typing this text.

K. C. Lam
April 2003
This research explores the impact of both traditional and non-traditional procurement methods on the performance of the management of building services integration and co-ordination in Hong Kong and other countries. It examines those variables thought to be present in the building services co-ordination process (within the building process) which influence the performance of the building team and the outcome of the building project. Five propositions are addressed by the work which are:

1. Coordination of services is influenced by the management of design.
2. Coordination of building services is influenced by the management of construction.
3. Coordination is not only a technical issue but an exercise in management. It is also influenced by the construction professional’s working practices.
4. Coordination of services is influenced by the chosen project procurement method.
5. Project success is influenced by effective building services co-ordination and the use of an appropriate procurement method.

The problem of determining an appropriate procurement method for the management of a building services integration and co-ordination has been surrounded by controversy and strongly held opinions. The work reported here attempts to indicate some rational basis for choice in this decision by identifying those factors which significantly affect project performance, with particular reference to the distinctions between traditional and non-traditional procurement methods.

Modelling of the management of the co-ordination process based on rich data gathered from surveys and pilot studies help the development of two research models for this research. Case studies are then analysed to explore the co-ordination process in a real life situation. The variables given in the models and the propositions are tested. Analysis of 25 case studies and the survey results suggest that co-ordination of building services can be affected by both technical and managerial issues as well as the organizational structure selected for a complex project. The results from this research support the argument that successful co-ordination can be as readily achieved by a traditional building team as by a fully integrated design and construction organization. The conclusion to be drawn is that procurement form is not a good predictor of performance. Moreover, procurement method is not the only variable affecting project performance, rather the combined effect of a number of variables is the major determinant. In general, the level of managerial control is found to be more strongly associated with performance. Specifically, the factors of quality of design and co-ordination of services, integration of the building team, management of site co-ordination works and control of services contractors are found to affect more the performance of co-ordination of building services when the project is highly serviced.

Keywords: Co-ordination, Building process, Procurement methods, Building Team, Management.
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CHAPTER ONE

INTRODUCTION TO THE STUDY

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CHAPTER ONE: INTRODUCTION TO THE STUDY

1.1 Introduction

It is an accepted general truth of construction management that a project is regarded as successful if the building is delivered at the right time, at the right price and quality standard, as well as achieving a high level of client satisfaction. Obviously, the achievement of these criteria in association with the use of a particular procurement method has significantly increased the pressures on the design and construction teams.

1.2 Nature of the problems

The growing complexity of modern buildings and their building services in a highly competitive market-place has also increased the difficulty in getting the stated project success criteria especially for complex and highly serviced buildings. The increasing importance of building services in terms of its cost package size relative to the total cost plan is evident in all commercial and healthcare buildings. Indeed there are now very few projects where the management of the design and installation of services does not have a major impact on the overall programme and final account. Building services are engineering orientated, and necessitate special planning and management techniques. However, teambuilding, communication, integration and co-ordination between members of the building team, and their working can be influenced by the procurement method adopted. In short, the selection of an appropriate method can shape the performance of a project.

Good management is a key factor in promoting efficiency and systematic methods of working in the whole building process. As buildings grow in size and complexity, their building services are becoming more and more sophisticated and more specialist building services contractors have to work together with main-contractors. The increase in the number of members of the building team has made the co-ordination of their efforts much more difficult than before.
It is becoming apparent that the design phase, as well as the construction phase, requires more effective management to ensure the requirements of clients are met satisfactorily. However the extra demands on both design team and contractors caused by the drive for greater efficiency, have been compounded by traditional procurement techniques which divorce design activity from construction, making the management of the overall project more difficult. Increasingly, the building team is also experiencing more problems associated with non-traditional procurement methods too.

Broadly speaking, the problems facing the construction industry can be established under the following categories. These are by no means exhaustive nor ranked or selected in any particular manner other than they could be regarded as the key factors which are relevant to this research development. These are:

- Increasing project complexity with sophisticated building services.
- Increasing client sophistication.
- Fast-tracking pressures on design and construction.
- The changing environment.
- Separation of design from construction.
- Lack of full integration of building services by the design team.
- Lack of effective communication and co-ordination between members of the building team.
- Difficulty in managing a large number of specialist contractors by the building work contractors for highly serviced buildings.
- Inappropriate procurement path for building services.
- Working relationships between members of the building team.

All these factors are interrelated. Besides, they also have a direct impact on the performance of a project.

Having set out the general problems, it is clear that an investigation of the manner in which the building process operates should start and continue in the context of management of design and construction and in the organizations which design and construct/install the building and its building services.
Many of the general problems outlined above were reinforced by the author's own experience while working for several M&E services contractors, consultants and a large multi-disciplinary design organization specializing in the development of technically complex buildings. The procurement of complex and highly serviced buildings is often fraught with expensive problems of unsatisfactory co-ordination of building services in many large building projects. At the same time, the building industry is still experimenting with different procurement methods in the hope of identifying the most appropriate organizational form for the most efficient management of co-ordination of building services.

Much of the focus of the industry's research over the last two or three decades have been dedicated to improving performance both in terms of management and construction techniques. Studies on building procurement with particular reference to building services design and installation are scarce. They tend to be limited in depth, either concentrating on procurement issues and forms of contract or reviewing the management of building services and installation in a general way. Previous research also does not look in detail at the combined effect of a particular procurement path and its effect on the complex issue of co-ordination of building services within the temporary multi-organization system formed by the design and construction teams for a building project. The author was keen to find the missing linkage between a procurement method and its influence on the performance of building services design and installation.

A research project was therefore set up in Hong Kong in 1995 to analyse the performance of building services integration and co-ordination with different procurement methods and to develop more efficient techniques to aid management of building services.

1.3 This study

This study was inspired by the apparent lack of in-depth study of the selection of the most appropriate procurement path for highly serviced buildings. These projects demanded more efficient and effective management of the diversity of participating building services and building works organizations as transient design and construction teams with multiple goals, and yet interacting within a limited time span to construct a one-off product under specific project and dynamic conditions.
This study does not exactly fall within either the domain of dynamic construction management or the more static building services management sectors as perceived by the construction and building services professionals. Despite the development of improved techniques of design and construction management, little attention was paid to the evaluation of the impact of the different building procurement methods on the performance of building services integration and co-ordination which could shape the success of a project. The need for a critical analysis of the relationship between the building team (in particular, the M&E services contractor and the main-contractor), the procurement method and the project performance was therefore perceived as necessary.

It is the author’s belief that this study has contributed to the construction industry a better understanding of the management of building services co-ordination. The apparently neglected area as covered in this study has filled the gap of the present construction and building services management, and deeper study of particular services or buildings can be launched in future based on the techniques and framework developed in this study.

1.4 Aim of the research

The problem of determining an appropriate procurement method with due regard to effective and efficient co-ordination of building services in highly serviced projects has been surrounded by controversy and strongly held opinions in Hong Kong and elsewhere as there are conflicting views, which, on the one hand, indicate that procurement method is a major determinant of project performance, on the other hand, some proclaim that the non-traditional procurement methods can be used to solve all the ills in construction procurement, whilst some consider that the management of the building process is far more important than the procurement form.

In view of the importance of building services co-ordination in the building process, this research was aimed at determining the different effects of both traditional procurement method and the commonly used non-traditional methods on the performance of the management of building services design and co-ordination for projects that are large, complex and highly serviced.
1.5 Objectives

Clearly, the abovementioned aim is a statement of what the author attempted to investigate and further detailed statements expressed as objectives were necessary. These objectives describe what the research attempted to achieve or discover through a research.

Basically, the following two principal objectives were identified for this study:

i. To investigate and analyse the management of building services co-ordination from the design to construction stages under different procurement methods.

ii. To investigate and analyse any linkages or relationships between the performance of building services co-ordination and the procurement method adopted for a project.

Based on the two principal objectives, eight major objectives were derived and outlined as follows:

1. To identify all important factors affecting effective co-ordination of building services in the design and construction processes.

2. To develop and test two research models for investigating:
   - Co-ordination of building services, and
   - Procurement of building services.

3. To determine whether the characteristics of
   - The client
   - The project
   - The procurement method selected
   - The contract procedures employed
   - The design team
   - The construction team
   have a significant effect on the management of building services co-ordination for a highly serviced project.
4. To evaluate the performance of building services co-ordination under both traditional and non-traditional procurement methods.

5. To find out whether in certain circumstances a particular procurement method will be more appropriate and achieve a higher level of project success for a project that is large and highly complex.

6. To identify whether a particular procurement method chosen for a project is a major determinant of the project performance in terms of efficient management of building services co-ordination.

7. To propose and formulate a framework for the purpose of evaluating any procurement method for managing building services co-ordination.

8. To develop suitable methods and systems for improving building services co-ordination.

1.6 The propositions

The intention of this thesis is to utilize system variables as a basis for this research to examine and compare the effects of different procurement methods on building services design and installation.

By stating propositions, important theoretical issues can be made explicit. The position for the argument or investigation pertaining to building services integration and co-ordination and its relationship between the building team, the procurement method and the project characteristics can be clearly and specifically stated. The intention was that the tentative propositions would then be verified through this research and the conclusion would either support, reject or amend the proposed statements.

The propositions of this research were as follows:

- Co-ordination of building services will be influenced by the management of the design process.
Co-ordination of building services will be influenced by the management of building construction and building services installation.

Co-ordination of building services is not only a technical issue but also an exercise in management and both will be influenced by the contract procedure and the working practices of the project participants of a project.

Co-ordination of services will be influenced by the procurement method adopted for a project.

Project success will be influenced by effective building services co-ordination and the use of an appropriate procurement method.

The propositions given formed the focus of the study and they were also seen as the guide to the author in studying all important data.

Evidence for each of the propositions was then to be found, examined and analysed for this research commencing from the design stage to the completion of a building project.

1.7 Methodology of study

The methodology adopted is summarised in this section and discussed in more detail in Chapter 2.

The stages of the research methodology were:

Stage 1 – literature review and pilot study.
Stage 2 – main study.
Stage 3 – writing up.

Stage 1: literature review and pilot study

A review of available publications was undertaken to assess previous work in this field in order to have a clearer understanding of the building process.

This study reviewed relevant literature on the subject of:
• Building organization.
• Management of building services.
• Management of building construction.
• Procurement of buildings.
• Evaluation of project performance.

Intensive literature reviews were mainly carried out in Hong Kong and the UK. Specific publications of relevance were followed up and further information obtained where possible.

This included all the preliminary work required to prepare the aims, objectives and key questions of the study. During this stage, another major activity was reviewing previous process models which studied the performance of the procurement method in order to find the most suitable way of constructing models of co-ordination/building procurement. Models were also verified by subjecting them to the scrutiny of practising engineers and experts in the construction industry. The literature reviews were followed by a pilot study which took the form of structured interviews with industry experts — different members of the building team. Interview questionnaires were also used for this pilot study in order to validate the appropriateness of the main study questionnaire.

Postal surveys were undertaken of major clients, architects, engineers and contractors to investigate their management of services and building construction (see Appendix II). This also provided useful threads from theory and practice.

Another survey was conducted at The Hong Kong Polytechnic University to gain more knowledge of the problems of co-ordination of services from more than 300 building services designers, draftsmen, site co-ordinators and M&E services practitioners. The thread from theory and practice was drawn together.

A survey of the UK/USA and Australian experience in the field of management of building services was also carried out to collect different views and practices about the co-ordination issues and the use of procurement methods.
Between 1995 and 1999, the author also visited his research supervisors and the director of research in the UK for detailed discussions of the development of the research and the exploration of research tools. During these five years, the author presented aspects of this study at various national conferences held in Hong Kong, UK, Canada and SE Asia to obtain more feedback from other researchers (see Appendix I for a list of papers submitted and presented by the author).

**Stage 2: main study**

The pilot studies, surveys and questionnaires prepared the ground for designing the main study questionnaire which was used to evaluate the performance of more than 25 projects (see Appendix III). It was also intended to adopt both qualitative and quantitative data, which meant obtaining facts and figures from previously completed (and on-going) projects and not solely taking opinions or views of the respondents. It was also the intention to obtain a large sample of cases, but it was later concluded that a few large, highly serviced projects would give more useful and sufficient data for detailed analysis. The number of cases was determined by proceeding to the point where no more new data could be found from similar building projects.

The case studies produced much useful information (e.g. management of building services by the building team, selection of procurement method and project result). It was obvious that most project practitioners recognised the existence of problems from poor co-ordination, and the need for better teamworking. They also provided practical guidance and constructive advice regarding more efficient management of building services. Data obtained from stages 1 and 2 were fully organized, analysed and discussed. Models were also verified by the results obtained from in-depth case studies. Selection of an optimum procurement path for any highly serviced building was also explored. Finally, recommendations were made.

**Stage 3: writing up**

This stage involved writing up the content of the thesis and covered the chapters as given in the thesis outline.
1.8 Scope of the study

After a preliminary survey of 25 (see Appendix III) construction projects in Hong Kong and the literature in Hong Kong and the UK; the breadth of the detailed study was restricted to highly serviced buildings such as hospitals, hotels, a large complex exhibition centre and high-rise intelligent buildings, so as to focus on an ‘useful’ and ‘related’ domain. A narrow survey on one particular type of building was precluded by the dangers of being distracted by distortions peculiar to that building type and of excluding general characteristics of the construction industry in the context of highly serviced buildings in which the cost of building services are about 25 to 45% of the building cost (excluding land cost). Nevertheless, a still deeper study of some large hospital buildings with very sophisticated M&E services and employing different procurement methods for the same client was also added for this study.

1.9 Structure of thesis

Figure 1.1 shows what the various components of the research and how the material was organized into ten logically related chapters.

Figure 1.1 illustrates the thesis structure, tracing the main connections between chapters. This thesis is structured to reflect the methodology of the study, and the approximate stages of development of the investigation. Although the chapters are not independent, a certain degree of repetition of common principles or findings have been necessary to substantiate the chapter theme. However, the detail is developed in one chapter only in such cases, with appropriate cross-referencing in other chapters. There is a necessary interaction in drawing together the threads towards the formulation of a framework for a complete evaluation of the impact of a procurement method on building services coordination.
Figure 1.1: Thesis Structure
Below is a summary of the content and purpose of each of the ten chapters.

**Chapter One – Introduction**

The first chapter is a general introduction to the research and outlines the aim and objectives, propositions, research methodology, structure of the thesis and a summary of the research results and the achievement of this research.

**Chapter Two – Methodology**

This chapter presents the research design, methodology and limitations; it describes the methods used to achieve the aim and objectives. The chapter explains the methodology (literature reviews, surveys, interview questionnaire / pilot study, case studies, project data, comparison, propositions testing and conclusion) adopted to obtain and analyse the data obtained for this research study.

This chapter identifies the following:

- Qualitative research is the main strategy.
- Quantitative research will also be used (but not as the major component).
- The use of survey, case study and action research.
- The use of secondary data from other descriptive documents.

**Chapter Three – Overview of the construction industry to the research problem**

This chapter is concerned with giving an introductory background to the building construction industry and its problems. Attention is thence turned to the working of the project participants before examining the management of building services design and installation.
Chapter Four – The building process and research model

This chapter examines details of the building process, the building team and the relevant research models developed by other researchers for investigating the building organizational forms. This work is essential for developing suitable research models for this research study especially there is no previous research work on the combination of procurement method and management of building services.

Chapter Five – Building services integration and co-ordination

This chapter presents a detailed study of the co-ordination of building services contractors within the building process and the problems of inadequate building services integration and co-ordination so that the impact of building services procurement on project performance can be fully analysed in a systematic manner. This also allows the objectives of the research to be narrowed from the general aim of understanding of the building process and its organization forms to that of specifically identifying a better procurement method for highly serviced buildings.

Chapter Six – Models of the co-ordination of building services and procurement systems

This chapter draws together relevant findings from previous chapters and discusses the use of system thinking and system variables for investigating the performance of building services work under traditional procurement method. The relationship between these variables is then postulated in the form of useful models. This chapter also examines how the two models (Building Services Co-ordination Model and Co-ordination-Procurement Model) developed can be used to analyse the impact of a procurement method on building services design and installation.

Chapter Seven – Questionnaire survey and analysis of results

This chapter presents the outcome of a literature search and the results obtained from the qualitative and quantitative data collected from the surveys relating to the propositions of this research. In particular, this chapter compares and explains the impact of each procurement method on the project performance.
Chapter Eight – Case studies

This chapter discusses details of all case studies. Case studies provide useful data which will be used to analyse the effects of different procurement methods on the project performance and the management of building services design and installation by using the two research models and the research propositions.

This chapter also discusses the application of the research models in conjunction with the case studies and the discussion of results presented in chapter seven. Use of the rating method for evaluating procurement method is also given.

Chapter Nine – Findings and Conclusions

This chapter gives the main conclusions of the study based on the evidence obtained from this research and detailed examination of all data analysis and discussions. Furthermore, verification of the propositions through the investigation is given and detailed appraisal of the relationship between the procurement method adopted and the project performance of a project is made.

Chapter Ten – Recommendations and Contributions

This last chapter gives useful recommendations for the improvement to the effectiveness of the building services co-ordination process. Furthermore, possible directions for further research on the subject matter and the contribution of this research are included.

1.10 Results of research

Overall, the work has shown that the problem of poor co-ordination of building services still exists and that the separation of the design and construction processes perpetuate this situation.
The study has provided a new and better understanding of the complex issue of building services integration and co-ordination and the impact of a procurement method on the management of building services by bringing all cross-disciplinary systems (i.e. M&E services design / installation and building construction and management) together.

The main results of this work can be summarized as follows:

1. Establishing through empirical evidence and analysis the applicability of qualitative techniques for investigating the complex building services procurement. The research has clarified and cleared all controversy and strongly held opinions concerning the management of building services and the problem of determining an appropriate procurement method.

2. Research results also showed that co-ordination of services should start from the design team first, the contractors can only continue the co-ordination process smoothly and systematically when all services are fully integrated and co-ordinated between all members of the design team. Procurement method will not and cannot solve co-ordination problems that are design issues, but a procurement method can influence the management of co-ordination by all project participants. The research result proved that a particular procurement method selected for a project can influence the building team, in particular, the integration and co-ordination between all members, and therefore, will have a direct bearing on the outcome of a building project. Hence, procurement method as an intervening variable can be a factor assisting in optimising project performance and will affect building services co-ordination.

3. The results produced better knowledge of building services co-ordination demonstrated that the performance of building services co-ordination is a function of the characteristics of the client, the nature of the project, the working of both designers and contractors, the contract procedure employed and the procurement method adopted for their projects.

4. Analysis of the results confirmed that:
• The presumption that the choice of an appropriate procurement method can lead to a successful project outcome is an implicit assumption only as project can still fail if other essential requirements are not provided. Procurement method is not the only variable affecting project performance, but the use of good project management and effective integration of the building team will improve coordination of building services.

• A procurement method with greater interaction and synergism of the constituent parties, effective communication, efficient project management and greater control of all project participants can achieve a higher level of success for projects that are large and highly complex. The traditional system is still a workable system. The study confirmed that the traditional method without a central integrating mechanism is not suitable for large and complex building project. However, in certain circumstances, the non-traditional methods can achieve better project performance due to improved teamworking and additional project management.

• No particular procurement method is better than other, rather it is the combined effort of a number of variables which influence the success of a project.

5. The research results gave better knowledge of building services co-ordination and produced a rational framework which can assist the choice or evaluation of procurement methods based on the factors shown in the two research models (Building Services Co-ordination Model and Co-ordination—Procurement Model) which added new knowledge of modelling building services co-ordination. A number of attempts have been made to provide a more objective deterministic device for comparing different procurement methods.

6. Identifying areas in which future research was needed in order to extend the study of building services integration and co-ordination.

1.11 Summary of research achievements

The achievements of this research can be summarized as follows:
1. Establishing that failure to effectively manage building services co-ordination was due to:

- Incomplete design integration and co-ordination
- Client’s change of design
- Unsuitable contract procedures
- Inadequate management of co-ordination of building services by the construction team
- Poor teamworking
- Inappropriate procurement method

2. Establishing that both time and cost overruns of a project is one the consequences of ineffective approach to the management of building services co-ordination by the building team.

3. Identifying from theory and practice the essential criteria for effective management of building services co-ordination and the development of two research models and the procurement path decision chart using utility factors (for investigating building services co-ordination) that can be used under all circumstances by practitioners who need to be able to test in advance the various procurement options available to them before making a final choice of which procurement method to use for a particular project.

4. Identifying some significant shortcomings in the existing approaches to the management of building services co-ordination during both design and construction stages.

5. Identifying that procurement form is not a good predictor of performance. In general, the management, organization of a fully integrated building team, complete design and properly prepared contract procedures are found to be more strongly associated with good project performance. The important finding is that different procurements can be employed. However, it is clear that non-traditional methods which have less
differentiation, greater familiarity and better teamwork should give better performance than a traditional procurement system.

6. Providing a simple and effective approach for good management of building services co-ordination. The research gives a modified contractual arrangement to overcome co-ordination problems. The recommended system attempts to bring building services consultants and services contractors together without completely revolutionizing existing practices and procedures. It puts the contractors very much in control of the co-ordination of building services. This system introduces a new stage to the design process called the co-ordination stage, directly after the tendering stage. In this system, tenders are still based upon drawings and bills of quantities as is the case in current practice. However, the contract document must be revised to suit this new system. The detail design which shows the co-ordinated services could now be arranged between the contractors and the consultant at this new stage. This can help the industry to improve the co-ordination process.

This would greatly improve the co-ordination issue for projects based on a traditional procurement path as the percentage of traditional contracting is still greater than other forms of building procurement method in Hong Kong. Furthermore, the suggested new stage can also be used in other design-led procurement systems.
CHAPTER TWO

RESEARCH METHODOLOGY

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CHAPTER TWO: RESEARCH METHODOLOGY

2.1 Introduction

The research undertaken can be described as objective research in that it is directed towards a specific issue, the impact of different building procurement methods on the performance of the management of building services element of construction projects. It also aims to explore the root causes of inefficient co-ordination of building services with particular reference to the use of traditional procurement method and the comparison of this path with other alternative approaches.

2.2 The research wheel

A theory is simply an explanation of the reasons about some facet of reality, or as in the case of this study, of the impact of a procurement path on the outcome of implementing co-ordination of services. For this theory to be drawn, the best approach is to use the research wheel (Rudestam and Newton 1992) as illustrated in Figure 2.1.

![The Research Wheel](image)

*Figure 2.1 The Research Wheel (From Rudestam and Newton)*
The research wheel shows that the research process is not linear but a recursive cycle of steps that are repeated over time. By expanding the research topic to a broader context, propositions of the research are developed in a process of inductive logic. The developed proposition is a statement of an established relationship within a conceptual or theoretical framework. By stating propositions, important theoretical issues can be made explicit and suggestions formulated as to what relevant evidence must be collected. Clearly, each proposition should direct attention to something that needs to be examined within the scope of the study. Indeed, as cited by Yin (1989), the more a study contains specific propositions, the more it will stay within feasible limits. The researcher must clarify this relationship.

A conceptual framework, which is simply a less developed form of a theory, consists of statements that link abstract concepts to empirical data. Whilst a theory is the language that allows the researcher to move from observation to observation and make sense of similarities and differences. Moving forward around the research wheel, the researcher uses deductive reasoning to move from the larger context of theory to generate a specific question. The research question is the precisely stated form of the researcher's intent and may be accompanied by one or more specific suppositions. The researcher will seek to discover or collect the data that will serve to answer the research question.

The data collection process is essentially another task of empirical observation, which then initiates another round of the research wheel. Generalizations are made on the basis of the particular data that have been observed, and the generalizations are tied to a conceptual framework, which leads to the elucidation of further research questions and implications for additional study. Finally, the conceptual framework is fully developed, becoming a well established theory or logical explanation (i.e. the performance of building services co-ordination is a function of the characteristics of the building team, the management issues and the procurement method selected for a project).

Having identified the research design and methodology, the author made use of the research wheel and the following steps to execute his research.

- Establishing the focus of the study – the impact of procurement methods on co-ordination of building services.

22
- Establishing the preliminary questions.

  - What is management of building services integration and co-ordination in theory and practice?

  - How important is building services integration and co-ordination?

  - What are the essential requirements for effective building services integration and co-ordination?

  - Is co-ordination of building services affected by:

    - The size of a project
    - The complexity of a project
    - The management of building construction
    - The management of building services design and installation
    - The effect of the temporary multi-organizational structure on the integration of the building team.
    - The contract procedure.
    - The procurement method adopted.

  - Whether the means of procurement influence project performance?

  - How a building procurement method influences or determines the performance of building services co-ordination?

  - What is the logical method of choosing as suitable procurement method for building services?

  - Will the context of the building services project determine the most appropriate procurement form for best performance?

  - Is the traditional procurement method an unsatisfactory organizational form for managing building services co-ordination?
- Will a non-traditional procurement method achieve better project performance?
- Is the procurement method a good indicator of project performance?
- Is the level of managerial control for a project the important indicator of project success?
- What is the best method to improve the management of building services co-ordination without changing too much the existing practice in the construction industry?
- What is the best objective way to evaluate the performance of a procurement method with due regard to the management of building services co-ordination?

- Deciding on the research approach and the research techniques.
- Reviewing existing knowledge and the viewpoint of the building team concerning building process (building design and construction and building services design and installation), contractual issues and building organizations, problems within the construction industry and the integration and co-ordination of M&E (i.e. mechanical and electrical) services.
- Investigating cases concerning good and bad co-ordination of building services for providing an in-depth analysis of the management of building services co-ordination.
- Collecting data for this research.
- Reconciling all propositions and revising the research models as needed.
- Drawing conclusions in relation to the propositions proposed, the objectives and the overall aim of the research.
2.3 The research methodology

The sequence of research is outlined diagrammatically in Figure 2.2. The main subjects of the research are co-ordination of building services, the contract procedures, the building team and the procurement method.

- **Literature**
  - The building team
  - Co-ordination of building services
  - The contract and procurement method

- **Analysis**
  - Main questionnaire survey
  - Forum and workshop
  - Case studies
  
  **TRIANGULATION**

- **Data**
  - Comparison of data with two research models
  
  **Propositions test**

- **Conclusions**

*Triangulation* means the combination of different survey techniques to investigate the co-ordination process.

Figure 2.2: Research Sequence
Starting with the formulation of what were regarded as problems of poor building services co-ordination due to the selection of an inappropriate procurement method, the research formulated specific and empirically meaningful aim and objectives (see Chapter 1), and attempted to realize them in the light of existing knowledge and investigation evidence. The theoretical knowledge that formed the basis for assessing the investigation evidence, proposals, and preliminary research models arising from the research was obtained by reviewing available literature in construction and related disciplines such as construction management, building services design and installation and management science as well as previous research works related to the subject matter. The evidence, on the other hand, resulted from a study of current approaches to managing building services co-ordination by both designers and contractors was obtained through questionnaire surveys, oral interviews with top construction and M&E services companies in Hong Kong via their staff who are directly involved in project management. The evidence collected was analysed and interpreted against the background of existing knowledge from reviewed literature, previous research findings and some preliminary case studies carried out by the author.

The results and deductions from the analysis of these important data together with the author’s understanding of building services management led to the development of two research models. These models were used to facilitate further investigation of the research in conjunction with further data obtained from the main questionnaire survey and over 25 case studies carried out in Hong Kong. All data was fully analysed, systematically evaluated and thoroughly discussed and concluded. Data from one sample (e.g. questionnaires and interviews) was collected and analysed and then compared with what was known from another sample such as case studies. The data was used to test the research propositions. Based on the analysis of data, the Building Services Co-ordination Model was also slightly revised in the light of the research findings. The Co-ordination-Procurement Model, was, nevertheless, proved to be logical and valid. Finally, a critical review of the conclusions was drawn from the research.

In short, the work undertaken for the research can be summarized according to the stages shown in Table 2.1.
### Table 2.1: Methodology and work undertaken

<table>
<thead>
<tr>
<th>Stage</th>
<th>Method</th>
<th>Aim</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Existing research works in areas related to construction management and building services design and installation were reviewed.</td>
<td>To formulate a clear research problem.</td>
</tr>
<tr>
<td>2</td>
<td>A postal survey of some UK and Hong Kong institutions and research organizations was carried out.</td>
<td>To know extend of research on problem.</td>
</tr>
<tr>
<td>3</td>
<td>Books, journals and conference materials were reviewed. Discussions were held with practitioners and professionals in industry and academics.</td>
<td>To establish a firm theoretical basis for the research.</td>
</tr>
</tbody>
</table>
| 4     | a. A pilot study of basic questionnaire.  
b. A preliminary questionnaire survey of clients, professional consultants and contacting companies regarding their approaches to their management of building services was carried out. | To ensure proper questions are given.  
To determine and assess the current approaches to management of building services. |
| 5     | Interviews were carried out with project staff from some of the companies that took part in the preliminary survey. | To verify the findings and deductions from questionnaire survey. |
| 6     | Forums of building services co-ordination between the author and over 500 part-time building services students (most were working as client’s agents, consulting engineers and contractors) were undertaken. | To assess different ways of handling building services co-ordination.  
To provide more data about good and bad building services co-ordination. |
| 7     | Development of two theoretical research models. | To assist investigation of this research. |
| 8     | Co-ordination data from both construction and building services industries based on a main survey. | To seek new data.  
To test model based on detailed questionnaires, interviews and direct observations in one design offices and two building sites. |
| 9     | Data from past and on-going construction projects was collected. | To give deeper study.  
To collect and analyse data on co-ordination.  
To test model based on actual projects. |
| 10    | Analysis of all data was carried out. | To evaluate all results and give research findings.  
To review models.  
To draw conclusions.  
To give recommendations. |
2.4 The research propositions

A research should have suppositions and these will be used for reasoning or investigation. Both hypotheses and propositions are commonly used as research suppositions.

According to Bryman (1989), hypotheses should not only be derived from theory, but should also be formulated in such a manner that they can be tested. Nathan (1991) however cites that the findings from a test may not sustain the hypothesis and the theory in question. Instead, it is designed for feedback into our stock of knowledge and to revise the general theory. Hypotheses and the associated data collection and analysis techniques are really instruments that allow for theory to be refined.

A proposition, however, should not be confused with a hypothesis. A hypothesis is suggested in order to test the validity of the research (Popper 1992). It does not matter if the hypothesis is proved or refuted, both assist in the validation of the research. A hypothesis will generally be a statement which suggests a relationship between given variables. Research is then undertaken to test this relationship. Chems & Bryant (1984) suggest that propositions are not definitive statements but are subject to modification in the light of further evidence. As seen from the research wheel, propositions are used in an inductive process of a working hypothesis. If a proposition is refuted during the course of the research it may be changed to more accurately reflect the emerging data. Any modification of a hypothesis would invalidate the research as critical testing could not be performed (Popper 1992). Therefore, for this research, propositions are preferred to hypotheses as propositions may be changed in the light of further data. Of course, a research must be designed to test/validate these propositions.

The previous chapter gave some thought to the preliminary propositions and they were further extended as follows:

Proposition 1

"Co-ordination of building services is influenced by management of design"

This proposition allows the author to investigate the complex issue of managing co-ordination of services in the building industry.
Proposition 2

"Co-ordination of building services is influenced by management of construction"

This proposition facilitates the author's exploration of this variable to determine whether there is a close link between co-ordination of services and management of construction for the building work contractor and building services contractors.

Proposition 3

"Co-ordination of services is not only a technical issue but an exercise in management. It is influenced by the construction professionals' working practices."

This allows a closer investigation of the complex issue of this technical and managerial issue and determines its relationship with different building procurement methods.

Proposition 4

"Co-ordination of services is influenced by the building procurement methods"

This allows investigation of the impact of different building procurement methods on the implementation of co-ordination of services since each procurement method has associated with its particular managerial and organizational factors that can affect the co-ordination process.

Proposition 5

"Project success is influenced by implementation of effective co-ordination of services and the use of an appropriate procurement path"

This proposition allows the author to relate the importance of effective procurement method and management of co-ordination of services.

For these five propositions, data has been collected from an extensive review of the literature and building projects allowing each of these statements to be studied, and these propositions have also been used to examine selected building projects and the management and co-ordination of building services. Finally, all the propositions must be
tested so that each may be supported or rejected from empirical evidence obtained from this research.

2.5 Approaches in methodologies

The strategy for the research is developed by considering the data that needs to be collected to support the propositions stated in chapter one and this chapter. Therefore, techniques used by the author in collecting and interpreting data must be addressed.

Techniques in data collection and analysis are usually broadly classified as qualitative (content analysis) and quantitative (statistical analysis). This has brought about debate among proponents of these two divisions. According to Van Maanen (1983) and Das (1983), increased interest in qualitative research in organizations has lent this approach more credibility but also contributed to the general belief that both (qualitative and quantitative) approaches are mutually exclusive. The author will, however, examine the two schools of thought with the objective of establishing that a qualitative tool can be combined with that of a quantitative tool providing the selection and application processes are carried out with care and due regard to the phenomenon being investigated.

Das (1983) suggests that qualitative research is a mix of interpretive techniques which include participant observation, case studies, role plays, contrived and unobtrusive observations and focus group interviews. As such, the objective of the researcher is to describe, decode or translate the meaning not the frequency of certain more or less naturally occurring phenomena in the real world. Obviously, this requires a methodology sensitive to rich, contextual data (McGuire, 1986). Much qualitative analysis is in fact quasi-quantitative. According to Miles (1979), such characteristics of data are attractive to researchers because they feel the rich, full and real data that can be used to present a true picture of unimpeachable validity. Researchers have also recognised the approach as being better designed in the production of serendipitous findings (Das, McGuire). With the view of investigating the complex and multi-dimensional co-ordination of services and procurement method as found in a building organisation i.e. the TMO (Temporary Multi-Organisation), it was felt that a qualitative technique for capturing data should be included in this study.
But qualitative approach is not without difficulties. Because a less structured approach is used when compared with the quantitative technique, it also lends itself to data overload, sometimes referred to as an attractive nuisance (Miles 1979), since everything that can be observed can be potential data. Unlike most statistically orientated studies, there are no fixed rules or techniques for analysing qualitative data. A common approach is to identify patterns or themes after an attempt to impose some loosely framed structure. One other approach is grounded theory (Glaser and Strauss, 1967) where more emphasis is placed on the data. This involves studying the data to form some theoretical notions and then moving back to the data and further data collection to refine the notions. The researcher then examines the kinds of phenomenon that can be subsumed.

Quantitative methodology relies on a systematic and quantifiable approach in conducting research. According to Bryman (1989), the starting point is a theory of some aspect of a subject from which a proposition (or set of propositions) is derived. This proposition is designed in a manner conducive for a pre-determined test, the results of which are then fed back to the body of knowledge on the phenomenon studied. Although the process could well be applied in qualitative methodology, it is the manner in which the data and the propositions are generated that differentiates quantitative studies from other work.

Data generation in quantitative methodology emphasises the collection of numeric data using well-structured instruments and then classifies them into specific categories. This then leads to selective statistical evaluation aimed at proving propositions or hypotheses.

A significant feature of the quantitative approach is that it involves translating abstract concepts into concrete questions or variables which make it possible to take measurements relating to these concepts.

One of the main advantages of quantitative research and an often quoted reason for rejecting qualitative methods relates to its ability to replicate, i.e. it should be possible to use the procedures of one study to check the validity of another. Replication can also be used as a means of comparing and verifying the findings of a study. But more significantly, it should allow for examining whether the original research was carried out in an unbiased manner. However, it must be borne in mind that experiments and surveys carried with slight differences in technique could produce dissimilar results.
The rigidity of structure and emphasis on statistical techniques have probably contributed towards the claim by authors such as Giddens (1989) that quantitative research is infused with positivism. According to them because of the use of a natural science model, the investigation has a narrow perspective, but worse, it tends to give little attention to context.

Thus the difference between these two modes of research is not simply embedded in the use or non-use of numerical techniques. The manner in which the problems are conceptualised and then the approach used to establish findings are significant discerning factors. Whereas quantitative research is propelled by a prior set of concerns, usually derived from a literature review. Data collection in qualitative studies focuses on what is important to the individual (not the researcher) as well as the interpretation of the research problem. The difference in emphasis on the perspective of the individual studied often means that theoretical reflection occurs during or at the end of data collection for the researcher employing qualitative techniques. Finally the two approaches often differ in techniques of data collection. Interpretative research requires open-ended methods such as semi-structured interviewing for in-depth investigation, while the objective of generalisation in quantitative studies directs the researcher to such methods as surveying.

The present study, however, will use these two approaches in order to obtain more useful data. If the limitations of each are acknowledged, then the complementary nature of qualitative and quantitative techniques can be exploited.

Mixing qualitative techniques with those of quantitative is not new in social sciences. Such a methodology process is often referred to as “triangulation”, a term adopted by Campbell (1957) according to Mann (1983). Most authors (Jick, 1979; Brewer and Hunter, 1989; Bryman, 1989) agree that triangulation is a strategy for overcoming any particular method’s limitations and weaknesses by combining different techniques within the same investigation. More significantly, if the same conclusions can be reached using dissimilar methods, then it follows that the confidence in the validity of the research increases. The argument is more succinctly phrased by Jick (1979), quoting the work of Campbell and Fiske (1959), contending that multimethods should be used in the validation process to ensure that the variance reflected is that of trait and not of method.
Also, the use of multi-sources may yield valuable insights in a phenomenon where any single source is restrictive (Giddens, 1989).

This study adopted triangulation to investigate issues concerning the impact of building procurement method on co-ordination of building services. The main reason for applying the multimethod approach was directed at adding towards the strength of the evidence. Another objective was to compensate for the inherent limitations of the survey technique (imposed by its rigid framework) with the flexibility offered by the interview technique and case study. Similarly, it was also hoped that the promise of generalisation through a survey would help overcome the criticism of lack of representativeness and reactive interaction imposed by the interviews.

2.6 Approaches to data collection

The purpose of any analysis is to illuminate or to make possible inferences about something that is not otherwise apparent. To do this analysis, sufficient reliable data are required.

The strategy for this research is developed by considering the data that needs to be collected to support the propositions as stated in this chapter. An examination and discussion of social science research strategies of surveys, experiments and case studies suggests that the latter will provide the necessary high level of inter-related detail required to meet the needs of the research.

The research design is the logical sequence that connects the empirical data produced by research to the study’s initial research questions and ultimately to its conclusions (Yin 1989). One of the principal purposes of the design is to help avoid the situation in which the collected data does not address the initial research propositions. Research design in the social sciences typically consists of either a survey, experiment or case study (Robson 1993). The processing of data must therefore incorporate a system which is capable of being defined, measured and ultimately analysed to provide relevant results.

Surveys collect data in a standardised form from samples of a population will allow the researcher to carry out statistical inferences on the data. This statistical inference, moving
from the particular observations of the sample to the wider generalisations of entire populations, is a major reason why surveys are popular with researchers (Oppenheim 1992). One criticism of surveys is that only standardised data can be collected. The data cannot easily be linked to other pieces of information which may have had a bearing on the response; as Diesing (1972) states;

Statistical generalisations tell us that certain regularities occur a certain part of the time, but say nothing about the actual inner or interpersonal transactions that bring them about. To see why a regularity appears in one case and not another, one must enter into the two cases and see how the particular perceptual and cognitive processes produced the two results.

It was for this reason that the use of a postal survey was rejected as the only source of research data which were collected and given by others, but would be used in conjunction with data collected and generated by the author's case studies. The influences of procurement method on the co-ordination issue were considered to be so diverse that a remote, standardised form of data collection would not identify them adequately. It would be necessary to make enquiries of individuals directly. This could be achieved by using either an experiment or case study approach.

Experiments are undertaken to measure the effects of manipulating one variable on another variable and for finding causal relationships between variables (Robson 1993). It was thought that an experiment to investigate the influences on co-ordination of building services could not be achieved in real life situations as it was not feasible to manipulate the variable. Furthermore, an approach was required where the influences would present themselves without any bias from the researcher or the research subjects. The strategy of case studies stood out as being particularly appropriate for this research.

2.7 Data collection methods

With both qualitative and quantitative approach, there are a number of data collection techniques. As stated earlier, there were four main stages (e.g. literature search, questionnaire survey, interview with key personnel and case studies) in the fieldwork for the research project.
It was considered by the author that the data collection strategy for this study had to take into account:

- The need for a broad based investigation involving a large number of organizations.
- The need to address a reasonable number of samples on specific issues.
- The learning process (the data collection stage presented an opportunity to test and even learn from the industry).

2.8 Literature search and review

There are very few pieces of work on sociological and natural science research which do not involve some scrutiny of documentary materials and this study is no exception. It typifies the approach of most – beginning with an in-depth examination of literature on directly and indirectly related subjects pertaining to this research work.

Documentary research gives useful data from previous work on the research topic and can be very constructive in particular for the construction of the five propositions given in this research. However, all information obtained should be used with caution, in particular, the validity and reliability of the data obtained from others.

A literature search and review was carried out at the beginning of this research project. This was an important research tool which not only identified the areas of concern (e.g. integration and co-ordination of building services and its relationship with project management) that had been addressed in the building services and construction management technical and learned journals, but it was a useful vehicle for the purpose of identifying the key factors affecting the management of building services element of construction projects.

The previous chapters have highlighted the limitations and inadequacies of past research in procurement of building services. Much of it is fragmented, many have focused on the co-ordination of building services by either the building services design team or the construction team. In-depth studies on the impact of the building procurement path on the co-ordination of building services throughout the design and installation stages within the
Temporary Multi-Organization is hardly available. Nevertheless, an in-depth examination of literature on directly and indirectly related subjects could define the phenomenon and identify aspects of it that needed more detailed study. Also, a review of literature serves another positive function – a critical evaluation of existing work on the subject can prevent over-hasty research design and is also valuable in designing new work.

A review of the literature concerning construction procurement also revealed many different approaches to the procurement of building projects in the UK and Hong Kong.

Hong Kong like many other places of the world was also going through a phase whereby the so-called traditional method was no longer the only answer for the procurement of large and complex building projects.

These works coupled with some preliminary case studies in the UK and Hong Kong provided a good foundation from which the author developed two research models based on data gathered with particular reference to:

- Management of building services design and installation by the building design team
- Management of building services detailed design and installation by the building construction team members.
- Procurement of building contracts and performance of procurement methods including the key factors in contractual relationships.

It was established by the author that many factors were influencing the management of building services and the selection of the procurement path. The factors were of varying degrees of significance and these important factors were discussed in detail in Chapter 5.

2.9 Questionnaire survey

Chapter 7 gives details of questionnaire survey. Survey methods using questionnaires have long since been widely accepted as practical tools in eliciting information for decisions and for research by academics. The greatest advantage of this quantitative technique concerns its applicability to generalization through the feature of collecting
large quantities of data from considerable numbers of people. More significantly, the technique offers a means of gathering data not just across an organization but also across industries for comparison purposes. More importantly, this method eliminates bias.

Questionnaires can take the form of standardized or open-ended questions. For this research, only standardized questions were used and sent to a selected group of people or given directly in interviews. However, these standardized questions were still flexible enough to obtain further views.

For this research, a questionnaire was therefore prepared with the objective of obtaining basic or further information relating to the integration and co-ordination of building services and its relationship with project management; procurement choice, the use of forms of contract and the evaluation of the approach adopted.

The author had to decide upon the type of people who were relevant to the survey. All the data, views and comments gathered from the surveys would be perceived by the actual participants (i.e. the respondents) in the real world as they were inside the building world, they knew the problems; they learnt from experiences; and they had pragmatic solutions based on the particular project environment variables.

The identification of suitable organizations and firms who were able to provide relevant data and who were also willing to do so was most difficult. This research required the identification of two separate lists, namely: the client / consultancy / designer list; the building work contractor list and the M&E services contractor list.

Selecting the research sample is very important and a great care must be taken when choosing the type of sample design.

To be realistic, working within the time constraint, the selection process was based on only large and experienced organizations as they:

- should be reasonably representative of the option expressed by the professionals in the building/building services industries;
- were known to have commissioned large buildings for many years;
• had previous problems with clients, designers and various contractors, and understood co-ordination problems and solutions;
• had time and people to respond to questionnaires; and
• saw themselves as actively involved in procurement of building services and contract choice.

In many cases, the selection was based on a personalized process (e.g. firms where a contact name was known to the researcher or where a name could be ascertained) in order to achieve a good percentage of returns and a reasonable spectrum of views. But this was done with extreme caution as the researcher had to ensure no bias.

The questionnaire was developed from close and detailed reference to the literature relevant to this research project. Its development was also based on the author’s own experience in building services design and installation with the building work contractors in Hong Kong and elsewhere. Like any research, the precursor to successful research is the effectiveness of the questionnaire. A pilot study in order to validate the best form and content of the questionnaire before the main survey was undertaken.

One big issue causing concern was the interpretation of questions by the respondents. All questions should therefore be specific, simple, clear and precise. Most importantly, each question could be answered easily and without ambiguity. Furthermore, the wording and format of questions would not present any difficulties when interpreting or analyzing the data by the correspondents as well as the researcher. Pilot studies or pre-testing did help in improving the quality of some of the questions. These were constructive in simplifying the language and the terminology used in the questionnaire, ensuring that the statements were more easily understood by respondents. Furthermore, the questionnaire should be designed in an unbiased manner.

The draft questionnaire was initially tested and amended in response to comments made by other researchers, selected M&E services consultant firms (large and small) and two M&E services contracting firms (also one large and one small). The pilot study prepared the ground for conducting the main questionnaire survey. The final questions were ordered in such a way as to allow the respondent to commence by answering simple
questions before responding to those requiring more complex responses. The questionnaire was then customized for the respective client/consultancy list, and the two contractor lists but nevertheless still sought the same basic information.

The questionnaire is attached as questionnaire No. 1 in Appendix H. As this survey method was directed at eliciting the views or perceptions of all project participants, the most appropriate form of obtaining this was the use of a semantic differential scale (Churchill, 1987). This method gave a five or seven point scale on each question and the respondent had the option of selecting one of these points to express the view. In this study, the five point scale was selected as potential information would not be lost and gave a better spectrum of possible responses.

The author had to ensure that the characteristics of the sample were the same as its population and acted as representative of the population as a whole. A particular issue in sampling found during the research was the determination of a suitable size of sample. The sample size should give sufficient consistent and reliable data. In theory, as many as large and small organizations should be utilized. However, in view of the smaller size of the building industry in Hong Kong, only those reputable and experienced firms were considered as good representatives of the population. Besides, these organizations were capable of providing the research data that the author required. However, several (4 nos.) small but well established designers and contractors were also included by the author in the survey, and special attention was given to their views as the sizes of their projects were usually much smaller and less complex in term of the management of the building services design and installation.

The sample was therefore obtained by approaching appropriate clients, designers and contractors in the industry, asking for their co-operation. In this respect, the selection process was not entirely random. In this study, a randomly selected sample was thought to be more appropriate than a pure random sample as all selected firms were of similar sizes. They were very experienced with the building process and, most importantly, they all undertook different types of work under different procurement methods for both simple and complex projects. Furthermore, the objective of this survey was not only to obtain generalized impressions of the industry, but very specific data concerning co-ordination (for which a selected sampling is imperative).
A total of one hundred questionnaires were sent to the identified organizations, and the rate of response was 67%. Most organizations responded by completing questionnaires in a useable form, but a small number of responses (8 No.) had to be discarded as a result of incomplete information. The views of all valid respondents were analysed.

A summary of the organizations identified were as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>No. of organizations</th>
<th>%</th>
<th>No. of Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>10</td>
<td>(10)</td>
<td>8</td>
<td>(13)</td>
</tr>
<tr>
<td>Architect</td>
<td>20</td>
<td>(20)</td>
<td>10</td>
<td>(17)</td>
</tr>
<tr>
<td>M&amp;E services consultancy</td>
<td>16</td>
<td>(16)</td>
<td>12</td>
<td>(20)</td>
</tr>
<tr>
<td>Quantity surveyor</td>
<td>10</td>
<td>(10)</td>
<td>5</td>
<td>(8 )</td>
</tr>
<tr>
<td>Building works contractor</td>
<td>22</td>
<td>(22)</td>
<td>12</td>
<td>(20)</td>
</tr>
<tr>
<td>M&amp;E services contractors</td>
<td>22</td>
<td>(22)</td>
<td>13</td>
<td>(22)</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>100</td>
<td>60</td>
<td>100</td>
</tr>
</tbody>
</table>

The most daunting task is to ensure that the response rate is good enough to give confidence that the respondents are reasonably representative of the total population sampled.

Fowler (1984) notes there is no agreed-upon standard for a minimum acceptable response rate. Opinions regarding acceptable response rate vary from around 15% (Harper, 1971; Masterman, 1994) to over 70% (Dillman, 1983). But Naoum (1998) suggests a response range between 40 and 60%. Both authors acknowledge that these will differ according to the characteristics of the sample (whether it comprises the public, the private sector, etc.). Hodgekinson (1986), however, believes a target of 25-30% is adequate. For this research, the percentage of response rate (67% based on selected sampling) was therefore considered to be a valid base for further examination and analysis.

Data sought from the clients

i. Organization
• Type (public/private, developer, commercial, other).
• Size (no. of employers).
• Provision of individual project manager(s) for each project.

ii. Procurement process used

• Most used method.
• Other method.
• Satisfaction with the method.
  (Rating from Low (1) to High (5))
• Who selects/recommends the method.
• What are the most important key factors (from Low (1) to High (5)).
  Factors are accountability, predictable cost, speed in commencement/completion,
  transfer of risk, knowledge of process, quality, control of design, changes and
  cost, single point responsibility, management of building services and clear
  responsibility between client/designer/contractor.

iii. Problems arising from inadequate co-ordination of building services (from Low (1) to High (5)). Problems are delay in construction, claims/disputes between designer/contractor/services contractors, additional costs to overcome co-ordination problems and unsatisfactory services installations.

iv. Solutions to the problems in (iii) above.

To be objective, only some suggestions were given:

• Management of design.
• Management of contract.
• Management of construction.
• Selection of organizations and people.

Again, rating from Low (1) to High (5) was used.
The respondents were invited to give their comments on this issue.

**Data sought from the designers**

i. **Organization**

   - Type (architect, engineer in-house consultancy and other).
   - Size (no. of employers).

ii. **Procurement process used** (details identical to those provided for the client)

iii. **Provision of integration and co-ordination of building services and who is the leader.**

   (The existence of a co-ordination manager)

iv. **Problems from inadequate co-ordination** (same as for those provided for the client).

v. **Solutions to the problems in (iii) above** (details are the same as those provided for client).

vi. Apart from the above solutions, respondents were asked about possible ways to improve the integration and co-ordination of building services? Some factors are clear responsibilities between designer and contractors, provision of combined services drawings by both designers and contractor, improved site management by the contractors, improved site management by the consultancy, use of non-traditional procurement systems. Again, rating from Low (1) to High (5) was used.

**Data sought from the contractors**

i. **Organization**

   - Type (builder, M&E services, D&B).
   - Size (no. of employers, in-house design section).
ii. Experience in
   • Traditional procurement.
   • Non-traditional procurement.

iii. Satisfaction with
   • Traditional procurement.
   • Non-traditional procurement.
      Rating from Low (1) to High (5)

iv. How co-ordination of services was managed (details were requested).

v. Problems arising from inadequate co-ordination of building services (same as given to the designer).

vi. Solutions to the problems (same as given to the designer, but also co-ordination to be provided by the consultant in addition to that provided by the contractors).

vii. Possible ways to improve co-ordination of services (same as given to the designer, but also co-ordination to be provided by the consultant in addition to that provided by the contractors).

Additional surveys with building services personnel

To supplement this questionnaire survey based on non-random sampling, the author also conducted other surveys (e.g. workshops and forums) at the Hong Kong Polytechnic University between 1995 and 1999. The surveys were based on some 500 part time final year degree students which represented a reasonably large spectrum of views as they all worked in different organizations such as clients (5%), architects (7%), building services contractors (30%), main-contractors (20%) and building services contracting firms (38%). These students were mostly active participants in the construction industry and therefore their views would be of great value to this research project. These surveys offered a means of gathering data not just across an organization but also across industries for comparison purposes. More significantly, the surveys were successful in collecting, presenting and confirming data concerning efficient and poor co-ordination of services as
seen by the whole building team. Many useful and constructive comments were received
and discussed and some interesting new areas were opened up for improving co-
ordination of building services during the brainstorming sessions.

All these personnel were asked to provide:

- Building project details with particular reference to the management of integration
  and co-ordination of M&E services.
- The use of traditional and non-traditional procurement methods in terms of ease of
  management of services design and installation.
- Causes of poor co-ordination.
- Co-ordination problems and the effects on a project.
- Solutions to co-ordination problems (from design to construction of building).
- Working relationship between the main-contractor and M&E services contractors.

In addition, between 1995 and 2000 the author had found considerable inspiration from
discussion with many professionals from all sections of the building services and hospital
engineering industries when presenting some technical papers of the research subject at
some internationally attended launching conferences. This activity not only provided
valuable feedback and, occasionally, new dimensions on the research problem which had
all been considered and incorporated into the thesis.

2.10 Interviews

In order to compensate for the inherent limitations of the survey technique as imposed by
its rigid framework, the author saw that interviewing was a very useful interpretive
method that would allow for the flexibility required to extract factual information from
various people and many different groups of people, explore questions in depth and in
general, seek the 'rich' information in building up a valid, holistic picture of the
management of building services. But more importantly, concepts and words used by the
interviewer could be clarified. The author could also ensure that the correct respondent
was being interviewed, and thus improve the validity and reliability of data provided.
There is an element of personal interaction between the researcher and the respondent not present in other forms of data collection. Interviewing is really a compromise between structured method such as questionnaires and the more in-depth method such as participant observation.

The format of questions asked in interviews were categorised in four ways; totally structured, structured questions with open responses, open questions with structured answers, and totally unstructured. The categories depended on the type and depth of data being collected. It was also possible to use several categories within the same interview. This particular technique was used for this research by the author.

Interviews were used both as a primary and secondary source of data. As a primary source, the management of co-ordination of services and the effects of procurement method on integration and co-ordination of services were all discussed. This involved asking the construction professionals about these issues in their working practices. As a secondary source, information about the research topic was also checked with reference to the data obtained from the interviews. This meant the interviews contained far more useful data and a great deal of inter-related and complex data that could not possibly be obtained from other research tools.

But while the interview allows for considerable flexibility and good participation and control by the researcher, there are contextual and other problems. For example, it is difficult to ensure validity or reliability with the masses of information retrieved. The personal influence of the researcher could introduce bias. This could simply be in the way that the researcher poses the questions (Whyte, 1984; and Brenner, 1978) or in form of “cues” used in process if the questions are standard (Nachmias and Nachmias, 1996). As with all research techniques, when used correctly interviews are very powerful source of data, when used badly they produce worthless data. The interviews carried out for this research were therefore to be used with considerable dexterity and care.

As many as possible of the respondents from the large clients, architects and engineers, M&E services contractors, builders and quantity surveyors were interviewed further to determine data in more detail and ascertain the possibility of being able to extend the survey into a meaningful case study if there were still some on-going projects (or just
completed projects) available for the researcher's detailed analysis together with the associated building team members.

2.11 Case studies

Chapter 8 gives details of case studies. This research also used a combination of structured case studies for selected projects and personal interviews as case studies can be selected on the basis of their being representative with similar conditions to those used in statistical sampling to achieve a representative sample (Fellow 2000).

Surveys used to gather data from a relatively large number of respondents are without doubt a favoured research methodology. Surveys collect data in a standardized form from samples of a population and allow the researcher to make inferences on the data. This inference usually gives standardized data. The data, however, cannot easily be linked to other pieces of information which may have had a bearing on the response. Inference produces generalizations which of course may tell us that certain regularities occur, but say nothing about the actual inner or interpersonal transactions that bring them about. To see why regularity appears in one case (a case is a project; the construction of a building) and not another, one must enter into two or more cases and see how the particular perceptual and cognitive processes produced the two results.

Case studies are an important form of learning. They provide the receiver with a concentrated glimpse of the real world and offer organizations a mechanism to achieve new learning experiences from the successful or unsuccessful experiences of others. Case studies therefore represent a very useful source of research data which can be used to help develop and test theories or the research propositions and in the generation of further questions and answers. As case studies focus on one aspect of problem, the conclusion drawn will not be generalized but, rather, related to one particular event. This is not to say that the case study approach is of limited value. On the contrary, it provides an in-depth analysis of a specific problem.

Detailed case studies were prepared for selected projects in Hong Kong as the author could ascertain all relevant details of each project. Whilst the identities of the case study projects and the participants are confidential, the case studies are reviewed in context in
The principal objective of the case studies was to collect detailed information about the procurement strategies employed for each project in order that an assessment could be made of the success of the procurement strategy in terms of meeting the time and cost targets and the management of building services. The case studies were prepared on the basis of structured interviews conducted with key personnel involved in each project. These typically included the project manager, architect, quantity surveyor, contractor and consultant engineers.

Projects chosen for study in Hong Kong were selected by the author to represent a wide spectrum of highly serviced projects (e.g. hotels, high-rise office buildings, hospitals, exhibition center) using a variety of different procurement methodologies spread over an extended period of time. A total of twenty-five detailed case studies were undertaken in the period July 1995 to July 1999. These were based on companies who had responded to the main questionnaire and were a mixture of completed and current projects. This allowed the author to add to the richness of the factual data collected by actually observing some of the building teams in operation.

The principal requirement in performing case studies is to maintain a balance between flexibility and selectivity. Flexibility allows issues to be explored as they develop in the data collection phase. This could mean that more time is spent on a case study than was originally envisaged at the research design stage. Selectivity is concerned with deciding at the research design stage which features will be covered. For this research, a balanced research design was developed to ensure that important features would not be ignored as they were outside the research design or data was misinterpreted due to a lack of understanding at the research design stage.

A primary methodological concern with case studies was determining how many were required for this research. In theory, as many as possible would be ideal. However, the author had to face constraints like time and resources and even energy of the researcher. A pertinent suggestion made by Glaser and Strauss (1967) is that the number of cases obtained should be such that data saturation is reached. Richard Fellows (2000) also advised the author that even two good cases would be more than adequate if no further influences were identified in further case. In other words, saturation of data had been achieved when no more new data could be found in the next case study or put simply,
new data also confirm previously collected data. For this research, the author did consider the wide range of building procurement methods used by the construction industry and decided to have at least 2 or 3 projects for each commonly used procurement method. Nevertheless, the samples would be good enough to give adequate data in a meaningful way so that solid conclusions could be drawn from the rich data provided.

Finding projects to act as case studies was not easy at all. In the work undertaken by the author, it was necessary to identify suitable projects which could be used as the basis for the research. The criteria which were considered crucial in identifying the projects were as follows:

- They had to give data that the researcher was looking for.
- The projects had to be comparatively large and large and highly serviced. The projects should also have a large number of specialist services contractors (simple residential buildings and office buildings would not be considered as appropriate cases).
- The projects had to be practically completed so the full project span could be analysed (on-going projects could be very useful as action research might be used and therefore give deeper understanding of the problems in the real world).
- The projects had to be recently completed so the construction professional still had a clear recollection concerning the project and useful project documentation was still available.
- The projects had to be fully documented as arbitration reports since these should give unbiased information.

Most importantly, the projects selected should give rich data concerning good or bad management of building services from design to the end of the construction stage in different building procurement systems, otherwise, the projects would not help the fieldwork research.

For this research, the projects selected would have the following essential characteristics:

- Highly serviced facilities in Hong Kong and other countries.
• Large complex building projects with and without standard layouts.
• Reasonably tight schedules.
• Involving many multi-organizations and interfacing requirements.
• With or without co-ordination problems, claims and arbitrations of services delay and conflict, etc.
• Employing different building procurement methods from traditional path to partnering.
• Different project characteristics.
• Different degree of client involvement and influence.
• Different contractors' involvement and co-ordination process.
• Different management of design and construction.

All these characteristics were evaluated with the two models developed for this study. Additionally, two projects in the UK were studied since a broader sample of project performance results would be considered essential in order to see the differences between the two worlds - East and West, particularly, in the aspects of culture, attitude, business relationship, environments surrounding the projects and services / construction technologies.

Initiating new research can often be a complex problem in itself requiring learning from others. The following steps, derived from Easton (1992), were characteristic of the case study method and were congruent to the line of inquiry required for this research. The researcher had to become familiar with the information, before building a descriptive, qualitative model of the situation. Not all the information was valid, precise, or relevant. There was a need to diagnose problem areas, to identify symptoms and underlying causes of problems, and how they were related. Finally, there was the detailed discussion of the data collected in relation to research questions and the propositions. As such, the use of case studies allowed a naturalistic enquiry to be undertaken. This type of enquiry allowed the research findings to be intrinsically linked to the data and the data was then interpreted ideographically in terms of the particulars of the case.
It was anticipated that the information obtained from the case studies could be used to test the propositions, and solid conclusions would be drawn in relation to the impact of procurement path on management of building services.

The process of investigating the case studies was:

- Gathering information in relation to:
  - details of client, design team and construction
  - form of contracts, conditions of employment of the whole team and allocation of design responsibilities for building services and co-ordination process.
  - type of procurement strategy if available.
  - project characteristics such as complexity, constraints and special requirements, etc.
  - details of management of co-ordination.
  - details of construction management.
  - project success/failure factors with special emphasis on co-ordination of services.
- Interviewing key persons involved in the project being examined.
- Provision of new data not previously covered.
- Analysis of data.
- Comparing individual case studies based on the research models.
- Testing the validity of the propositions developed for this research.

2.12 Summary

This chapter has given details of the author’s research methods for the purpose of obtaining data pertaining to this research.

This is a significant chapter explaining the approaches to research methodologies, data collection and analyses. At the outset of the fieldwork, it was realized that the application of triangulation was not going to be a simple task, given that both methodologies would differ in the manner in which a problem was conceptualized and the approach taken to
establish significant findings. However, after a careful analysis, it was concluded that a multi-method approach, designed principally to add to the strength of the evidence could be carried out more appropriately by using all of the following:

- The survey approach.
- The survey with additional interview.
- The case study approach.
- Participant observation in design office and building sites.

As far as the qualitative versus quantitative debate was concerned, the researcher has tried to combine both qualitative and quantitative techniques. Although the complementary nature of postal surveying and interviewing may not represent a perfect symbiotic relationship, it did address the majority of criticisms levied against the individual techniques. Furthermore, structured case studies for selected projects and personal interviews had also been used to examine how the industry would manage the integration and co-ordination of building services in the real life situation.

Compared to other areas of research, to the author's knowledge, little attempt had previously been made to the analysis of building services co-ordination and the use of a particular procurement method. The proposed research methods should give a systematic approach to a more detailed examination of the research subject. Although the research had been primarily based on Hong Kong practice (similar to UK), nevertheless, the concept and methodology adopted could be used in other countries providing discernment to be exercised on matters of details such as contract form, structure of the industry and professional practices, etc.

The next chapter will give an overview of the background to the problems of construction management in the construction industry as the subject matter of management of the integration and co-ordination of building services cannot be treated in isolation and this research must be examined throughout the construction process.
CHAPTER THREE

OVERVIEW OF THE CONSTRUCTION INDUSTRY TO THE RESEARCH PROBLEM

3.1 Introduction
3.2 The construction industry: background, views and problems
3.3 Review of reports pertaining to the research problem
3.4 Constructing the team with integration
3.5 Appraisal of the traditional approach
3.6 Use of non-traditional procurement methods
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CHAPTER THREE: OVERVIEW OF THE CONSTRUCTION INDUSTRY TO THE RESEARCH PROBLEM

3.1 Introduction

This chapter discusses the work performed during the early stages of this project, covering a generic study of the building industry and the problems in relation to building services design and installation. The aim of this study is to investigate and appreciate fully the challenges and difficulties encountered when managing the building construction process as building services integration and co-ordination is a sub-system within the building process system. This allows the objectives of the research to be narrowed from the general building procurement system to that of specifically improving the management of building services integration and co-ordination in the entire building process.

3.2 The construction industry: background, views and problems

All the case studies undertaken by the author are based on projects in Hong Kong. It is felt necessary to present an historical background to the Hong Kong construction industry for better understanding of the industry in general and the inherent problems in the traditional form of contracting. This overview also facilitates a comparison between the author's research data and those data gathered from other countries.

Before 1997, Hong Kong was a British colony. Naturally, Hong Kong has been following the technologies and systems of the British construction industry (even after 1997). There have been many studies of the British and Hong Kong construction industries which suggest that the traditional separation of the design and construction processes is primarily responsible for the problems of construction projects and for their unsatisfactory performance (Anglo-American Council on Productivity, 1950, NEDO 1976, Laing 1979, Gray 1983, Nahapiet & Nahapiet 1985 and Smith and Wilkins, 1995).

Concern has been expressed for many years in Hong Kong about the organization and effectiveness of the building team. Particularly, the effectiveness of traditional procurement system has been challenged by the construction industry. The traditional
method of contracting is one where the client appoints an architect and other professionals to design a building and prepare necessary tender documentation. A main contractor and some nominated sub-contractors will then be appointed, under a certain form of contract, to actually construct the building. The purpose of this building team (i.e. designers and contractors) is to produce a satisfactory building for the client.

The traditional approach has come under increasing pressure, apace with the increasing complexity of building project and its building services. Whilst technology and complexity has forged ahead in the construction process, the approaches to its management have lagged behind. Obviously, this has an adverse effect on project performance.

Any building project will involve a variety of aspects of success. Each member of the building team have their criteria for success which may differ from one another. Sidwell (1984) notes that a client may regard completion of a project on time and within budget as a success. However, client satisfaction may differ in respect of an owner, an occupier or a tenant, or the general public. In many cases, client satisfaction will depend upon the degree of conformity between expectations, interpretation of the brief and the realization of the project. For building design professionals the criteria for success can be a successful interpretation of the client’s needs and a smooth-going project but must be also concerned with financial return. The contractor may also regard a conflict free contract as a means to secure future work with the client and to obtain reasonable profit margins.

The construction industry is essentially a service industry, it combines many organizations. Not only is the industry very large, it is also characteristically diversified and heterogeneous. A significant feature of the industry is its fragmented nature and the division which exists between the design and production functions.

The various processes that are involved in providing a building are generally managed by a team of people brought together for that one project and disbanded thereafter. All organizations contain individuals whose personal objectives may diverge from corporate ones. Also, different organizations have different objectives. Critics of the traditional approach point to the conflicting interests in the building team, maintaining that conflicts act against the client’s interest. The proliferation of organizations and specialisms has
aggravated the problem of integration, co-ordination, communication, motivation and control.

The manner in which these organizations are co-ordinated and integrated will affect the efficiency and effectiveness of the construction process. As the construction supply chain has become increasingly fragmented, each supplier/organization has become less trusting, more self-interested and adversarial. Effectively, each party attempts to pass risks down to the next party in the supply chain in order to minimize their own exposure. The net result is an industry structure with many interfaces, points of tension and conflict, which ultimately leads to increased cost and reduced efficiency. It is clear that clients should seriously consider their approaches to procurement in an attempt to improve the situation. Of course, the construction industry should also rethink, reengineer and revalue best practice and construction project management too.

The main aim of the building process is to satisfy the client. In general, the level of satisfaction on the important criteria can be design and planning, construction, defect rectification, final cost, time from design to completion, and quality of building. This satisfaction may be a subjective opinion of the client but it is this opinion which the design and construction teams seek to influence. It would be impossible to enumerate all the diverse factors clients may require from a project but there are a number of primary factors that must be considered. They include:

- Suitability of the building for the purpose for which it was commissioned.
- The price and value for money to the client.
- Completed on time.
- Problem free.
- The project is aesthetically pleasing to the client.
- The building is equipped with necessary environmental services for the users and equipment.
- Reasonable life cycle costs.
- Good project relations.
It is the duty of all members of the building team to work in the interests of the client, then the responsibility to create a satisfactory product must ultimately lie with the team. If the client is dissatisfied, it may be that the team has both failed to work as a team and other reasons as well.

The volume and complexity of building has increased rapidly. Increasingly the achievement of a successful project has been affected by the complexity of building design and construction. Society and environmental concerns have placed more constraints, not only in the form of legislation specifying minimum standards to which the finished product has to comply, but also in the maximum standards that it desires owing to our increasingly more sophisticated way of life. Solutions to building problems must meet these requirements and are inevitably more complex. A greater amount of scientific and technological knowledge will be used to achieve these complex solutions with the result that an increasing number of specialists are required at various stages of the building process.

This increase in the number of members of the building team has made the co-ordination of their efforts much more difficult than before. The fact that the majority of these new members are specialists often means that they have had a different training and education from the existing members of the building team. They therefore have difficulty in appreciating other areas of the building process and they also have their own specialist language. Communication between individual members of the building team is thus often fraught with misunderstandings; this only serves to exacerbate the problems involved in co-ordinating their efforts.

The above situation is typified by the emergence of building engineering services as a specialism in the building process caused by society's increased demand for the improvement of the internal environment and safety of buildings. The result has been an increased need for a specialist knowledge of building services in the design and production of most buildings. This specialism is normally contributed by a building services consultant at the design stage and many specialist subcontractors during the production stage. Although some large organizations do undertake responsibility for both design and production. The very nature of their work requires them to be 'engineer-orientated' and the different languages that result from these different backgrounds can be
The traditional construction process separates design from construction through professionalisation demanded by contractual forms. It creates an environment in which parties defend and uphold their rights, concentrating on apportioning the blame for deficiencies rather than encouraging team work (Griffith, 1984). While every member of the building team is pursuing their own objectives individually, they do not realize that they have to work together to achieve their goals, accepting the fact that a building is an unique project which demands efficient and effective teamworking.

With the increasing problems of delay in construction, over budget, disputes between design and construction teams, and poor building performance, clients become increasingly dissatisfied with the construction industry. At the same time many clients also wish to have more control of their projects. The consultants are also not satisfied with the traditional approach too as their projects are no longer “conflict free” and they also cannot satisfy their clients needs of:

- completion on time;
- within budget;
- to the required standards and quality; and
- minimum risks, e.g. disputes and claims.

Also, contractors are dissatisfied with low profit margins and the increasing confusion of responsibilities for design and construction/installation (for building services contractor).

It is considered by many professionals that the existing fragmented and dysfunctional construction supply chain could be overcome using more collaborative and teamwork approaches, but they did not address the fact that such approaches are difficult and are only possible when there is a long-term relationship between two parties. Again, the actions of clients, through their intelligent procurement practices (e.g. partnering and integrated procurement system), can substantially influence the nature of the supply market, which will align itself to meet and satisfy client needs and demands.
It is likely that when design and production are combined and under a single control, then good relationship and greater co-ordination and co-operation between the parties involved can be developed (Phillip, 1950, Emmerson, 1964, Banwell, 1964 and Naoum, 1989) and better project performance can be achieved.

3.3 Review of reports pertaining to the research problem

Since the Second World War there have been many studies of the UK construction industry which are also applicable to Hong Kong.

The vast majority of construction projects prior to the Second World War (1939-1945) were implemented by conventional methods of procurement that had remained unchanged for over 150 years. Since that time, however, the availability of different procurement systems has substantially increased, often as a result of importation from the USA. More significantly, the willingness of an increasing number of client organizations to sponsor and use these new methods with the hope of achieving better project performance.

Broadly speaking, three phases in the development of contemporary procurement systems can be identified. The first was a period of sustained economic growth when the use of conventional methods of procurement still prevailed; the second was a period of recession characterized by an increased use of non-conventional procurement systems; and the third period which was a time of post-recession recovery during which the most experienced clients of the industry designed and implemented their own procurement systems and more generally, although conventional systems still predominated, design-and-build and management-orientated procurement methods increased their share of the available workload.

1. The Simon Report (1944)

Between 1945 and 1972, the use of conventional method of procurement still prevailed. This pattern of organization of projects remained largely unaltered, particularly in the public sector even though the Simon Report had strongly recommended the use of selective bidding, and pointed to the shortcomings and fragmentation in the professions and in the construction industry.

The Phillips Report reiterated Simon’s recommendation and in addition highlighted the need for greater co-operation between all of the parties involved in the construction process although some innovations in procurement systems, such as negotiated tenders and design and build, had begun to be used to a very limited extent by the construction industry.


The Productivity team report on building (Anglo-American Council on Productivity, 1950) gave a detailed study of high productivity in the US building industry.

The report highlighted the following factors which were not thoughtfully considered by the UK construction industry.

- The complete pre-planning of the job by building owners, architects and contractors.
- The proper co-ordination of sub-contractor’s work and the effective collaboration between them and the general contractor.
- The adequacy of supplies of labour and materials and the absence of restricting controls.
- The preparation of designs which have regard to ease of construction and saving of cost.
- The completion, before the tender stage, of all essential drawings, specifications and schedules, and the issue to tenderers of such drawings and other details as are necessary to enable them to price the job quickly and accurately.

4. The Emmerson report (1962)

The Emmerson report (1962) expressed concern for the division between the construction and design processes. It commented that, “in no other important industry is the responsibility for design so far removed from the responsibility for production”.
Emmerson also highlighted that the “efficiency in building operations would depend on the quality of relationship between the building owner, the professions and the contractors and subcontractors.” The report also identified a number of problems as contributory factors to the inefficiency of the construction industry.

These included:

- Inadequate preparation of design drawings and specifications before contracts are put to tender.
- Lack of communication and co-ordination between the design team and construction team members.
- The need for competent management emphasizing that modern methods of training must be developed to cover the complexities of modern building technology and human relations.
- The need to reform the organization approach to building projects.

Emmerson also came to the conclusion that there was still a general failure to adopt enlightened methods of tendering in spite of the recommendations of earlier reports. His recommendations in this respect led directly to the establishment of the Banwell (1964) committee to consider this issue in more detail.


The Banwell report (1964 & 1967) called for greater attention to pre-contract planning and design formulation, particularly in defining the user’s requirements. Professionalism was criticised for being too widely perpetuated giving rise to unnecessary and inefficient construction practices. The report expressed concern at the failure of the industry and its professions to think and act together. Banwell emphasized the following points:

- The client must have a good brief.
• The complexities of modern construction design, requiring specialized construction techniques, demands that the design process and construction phase should not be regarded as separate fields of activity.

• A review of traditional contractual practices is needed to ascertain the roles of the professional parties and their codes of conduct to improve interdisciplinary relations.

Banwell also expressed the need to reform the organizational approach to building process, and he commented that: “design and construction must be considered together and that in the traditional contracting situation, the contractor is too removed from the design stage at which his specialist knowledge and techniques could be put to invaluable use”

The 1967 Action on Banwell Report found that some progress had been made since the original Banwell report was published, although the building professionals had done little to de-restrict their practices.

The Emmerson and Banwell Reports had emphasized the need to reform the organizational approach to building projects. Building project management was seen to be a passive procedural activity.

6. The Tavistock Institute (1963)

The Tavistock Institute of Human Relations undertook a study of communications in the building industry (Higgin & Jessop, 1963). The attention of the research team was drawn to the statement in the Emmerson Report concerning the need for co-operation and cohesion in the building industry, and they were asked to bear in mind that better communication could be an important factor in bringing about this general improvement. Higgins and Jessop identified that the problems of communication in the building industry were created to a large extent by the attitudes and perceptions about the values of contributors to the building industry. The most important drawback to the traditional approach as noted by the research team was the lack of effective communication and co-ordination. In other words the nature of the
relationships between the communicators which created the difficulties for communication structures. Five problems were outlined, namely:

- Communication with client.
- Communication between client and advisors.
- Communication with the design team.
- Communication within the construction team.
- Communication related to contract.

Higgin and Jessop also highlighted three main functions in any building process. Two were obvious: design and construction. The third would be called co-ordination which was almost equivalent in meaning to ‘control’, ‘planning’ or ‘management’. They also commented that: “It is the architect who exercises the main co-ordinating function before the contract is signed, and the builder afterwards.”

Furthermore, two propositions were put forward by the research team for improving communications:

- A co-ordinating function exercised over both design and construction functions by a single person or single group is better than one where functions have different co-ordinators.
- If design and construction functions must have separate co-ordinators, then the best system of this kind is one where there is an early exchange of relevant information.

[The first proposal bears a resemblance to management contracting and design and build procurement systems whereas the second is applicable to the traditional form of construction].

Higgin and Jessop then went further and commented that a building could be seen as a chain of interdependent operations – briefing, designing, estimating, billing, manufacturing supplying, assembling, etc. To undertake these operations a wide
variety of resources of materials and skill would be required, and must be co-
ordinated.

They also noted that the central problem arose from the fact that the basic relationship which existed among resources controllers had the character of interdependent autonomy. These resources controllers should co-operate with others for their activities as none of them (except in rare instances of large contractors) had all the resources called for. A first task, therefore, in the building process was the development from these relationships of interdependent autonomy of a team which was the primary tool of the building process.


Between 1973 and 1980, there was an increased use of non-conventional procurement systems. The Wood Report (1975) recognized improvement in the design-construction relationship. It commented that:

“The traditional separation between design and construction was found to have diminished with consequent advantage all round ... Contractors have much to offer at the design stage, especially by way of advice on construction implications of design solutions and decisions ... Yet, methods of procurement are still such that they are brought in too late for their advice and experience to be of practical use ... The original problems still exists.”

Wood showed that the majority of the public contracts in the UK were still let by traditional methods. The Wilson report (1975) found the same to be true for private sector.


Constructing the Team (Latham, 1994) said little which was new, apart from the 30% target for reduced construction costs.
The main recommendations of Latham’s report relating to the author’s study are summarized as below:

- Formulation of a project strategy by the client is the first building block to a successful and cost effective scheme.
- Clients should choose the procurement route which best suits their purpose, and use the appropriate form of contract.
- Effective management of the design process is crucial for the success of a project.
- There must be integration of the work of designers and specialists. However, there must be clear allocation of design responsibilities for building engineering services.
- Improve selection/tendering procedures. Quality judgement is recognized as an essential part of good procurement practice.
- Change the industry culture; foster teamwork and partnering.
- Reduce conflict and litigation.
- Adopt a target of 30% cost reduction by year 2000.

The Latham Report set challenging goals for improving the performance of the construction industry, and also the measures taken to ensure its implementation. Latham also commented that the British construction industry was fragmented and adversarial and changes were necessary.

Latham (1997) also criticised the slow response to change in the UK construction industry. He pointed out that very few of the many excellent recommendations and proposals given in reports by Simon (1944), Emmerson (1962) and Banwell (1964) were implemented. This was despite widespread agreement on these reports.

The UK government tried again with Latham’s report – “Constructing the Team” with the hope that his recommendations would be implemented this time around, as the construction industry had recognized that the building process could no longer go on as before if they still wished to remain in the competitive world.

9. The Egan Report (1998) and follow-up to this publication
The most recent initiative published is ‘Rethinking Construction’ by the Egan Construction Task Force.

Egan’s challenge to the industry is to raise the average performance to its best in quality and improved value for money. The conclusions of the report were built upon the basis of the Latham report. The main aims set by the report can be summarized as follows:

- Year-on-year financial improvements consisting of 10 per cent cut in construction costs, 10 per cent improvement in productivity, 10 per cent boost in profits and turnover.
- Greater integration of the design and construction processes.
- Increased standardisation of built forms.
- Improvements in timescale by the use of the ‘lean production’ techniques.
- End of competitive tendering based on price evaluation only.
- Phasing out of formal contracts in favour of partnering arrangements.

All these reports point out that the construction industry is still not doing its best. Otherwise, there is no need to have these new reports but with old reminders for the construction industry.

3.4 Constructing the team with integration

From Banwell through to Egan the construction industry has been criticised for the adversarial nature of its operations and constantly contrasted with the integrated team based approach of the Japanese and more recently UK car/manufacturing industry. Clearly, the problem is difficult team-building in the construction industry. Indeed, Emmerson (1962) stated the following comment in his survey report:

“Efficiency in building operations depends on the quality of relationship between the building owner, the professions – architect, surveyor, engineer – and the contractors and sub-contractors”...”There is a good deal of criticism of lack of cohesion between the architect and his professional colleagues and the builder”
Critics of the traditional approach point to the possibility of conflicting interests in the building team maintaining that internal conflict acts against the client's interest. The three dimensions described by the Tavistock Institute (1965 and 1966) of complexity, uncertainty and interdependency had a great impact for the introduction of the new management methods in an attempt to achieve a better co-ordination and control of the building process. Different groupings of members of the building team have centred upon modified contractual arrangement or organizational form. They tend to seek an organization which can harmonize and integrate the team.

It is the author's belief that even the most efficient business cannot survive, let alone succeed, if they are efficient at doing the wrong things, that is, if it lacks effectiveness. Efficiency is concerned with doing things right and effectiveness is doing the right things. Construction in the UK and Hong Kong has often been accused of being inefficient, it is probably more accurate to say that it is ineffective. Sir Michael Latham's 'Constructing the Team' (1994) criticised the industry for its adversarial attitudes. It is such behaviour which makes the industry, which employs many talented professionals and craftsmen, ineffective by working in an inappropriate manner. Improving integration of project teams can allow the process to be effective so that efficient work can be exploited.

When attempting an initiative to improve integration amongst participants on construction projects a number of issues need to be considered in order to provide appropriate measures. The greatest likelihood of success will come from studying existing theory and techniques and adopting them to suit the construction situation.

To begin with the attributes of integration should also be considered, to gain a better understanding of a modern building process.

Lawrence and Lorsch (1967) defined integration as the:

"process of achieving unity of effort among various sub-systems in the accomplishment of the organizations tasks."

or as:-
"the quality of the state of collaboration that exists among departments that are required to achieve unity of effort by the demands of the environment"

They identified a number of mechanisms used by companies to integrate these differentiated departments:

- The use of managerial hierarchy.
- Integrating committees and teams.
- Individual integrators (i.e. co-ordinator).
- Routine control and scheduling procedures.
- Direct contact with individual managers outside official channels.

But sub-systems or departments reflect the degree of differentiation within an organization since the system concept views the organization as a unitary whole composed of many interdependent sub-systems that interact with each other.

Lawrence and Lorsch also defined differentiation as the:

"state of segmentation of the organization system in sub-systems, each of which tends to develop particular attributes in relation to the requirements posed by its external environment."

They extended their definition of the differentiation of sub-systems to include:

- Variation in formality of structure.
- Differences in members' orientation toward particular goals.
- Difference in members' orientation to time and technical achievement.
- Members' interpersonal orientation.

They also concluded that:

"the states of differentiation and integration are inversely related. The more differentiated an organization, the more difficult it is to achieve integration."
To overcome this problem, the effective organization has integrating devices consistent with the diversity of the environment. The more diverse the environment, and more differentiated the organization, the more elaborate the integrating devices.

The complexity of modern day buildings has caused the structure of the design and construction teams to change. Building construction has progressed from the single master builder, responsible for the design and construction of a building in the nineteenth century, into a process that involves many highly specialized groups. Design and construction problems are now of such magnitude and complexity that no individual is capable of addressing all aspects of building construction. The result has been the gradual crystallization of individual disciplines, each responsible for certain parts of the building work. Specialization has obvious benefits, but if the many individual groups are not co-ordinated properly the design and construction work still remains fragmented, resulting in problems and inefficiency. Large numbers of designers and contractors per project, each with narrower specialities and responsibilities are now the norm of modern day projects.

Obviously, this effect has made the integration of their efforts much more difficult than before. This is not conducive to co-ordination and communication within the entire building team as both are needed across the disciplines to reach a satisfactory working suitable to all.

The concept of the formation of a project team will have a beneficial effect upon the performance of that team and ultimately the success of the project. However, the characteristics of construction projects make the formation of a project team difficult. Team building is considered to be an ideal; the integration of the project organization is a more realistic aim.

Tatum (1987) recognized the need for design and construction integration, and reported the following finding: -

- Effective integration requires that construction experts participate in conceptual development and planning for the project.
• There are barriers that prevent integration, such as resistance by owners because of perceived costs; traditional role of construction people which makes them unaccustomed to working in the design office; reluctance of architects and engineers to accept input from construction personnel; lack of qualified personnel, training programmes and incentives; and unawareness of potential benefits.

In a nutshell, integration of all members of the building team is an essential requirement for a successful project. Lawrence and Lorsch (1967) established a correlation between integration and performance. Good performance was found to lie in the achievement of an adequate level of integration. Both team building activities and integration have a positive effect on organizational performance. The concept of integration is used to replace team building within construction organizations. Child (1984) concludes that effective integration can contribute substantially to high organizational performance. The author had also experienced that the greater integration could enhance project performance while working in two contracting organizations. The benefits were increased productivity, efficiency and also the increased motivation of the members of a team.

Conventional building team is too complex. The process for a construction project is also lengthy. In essence a construction project relies on the collective action of a number of groups. Integration has to be applied for construction project with the following problems:

• Principally, the changing building and building services technologies, contract procedures, materials and components, increasingly sophisticated client, and complexity of the whole building process are such that the sequential approach of independent professional to the formation of design and construction solution is unable to provide an efficient service and high integration is seen as a necessary solution to the interdependence and uncertainty involved.

• The training and experience of the members of the building team creates problems of communication and co-ordination. Integration can reduce the inherent differentiation and weld the members of the team to work more co-operatively and effectively.
Organizational relationships are of prime importance for the successfully run project. For organizational relationships to work more effectively, interpersonal relationships must likewise operate in an effective way. But organizational relationship depends on the characteristics of a particular organizational form. It is also true that each building procurement system gives a particular organizational form and each system would have an impact on the working of the building team. In other words, when the building team and project procedures are appropriate to client and project characteristics as a result of using the most appropriate organizational form, higher levels of success will be attained.

So a relatively uncomplicated project, regardless of monetary value, should, in theory, require only a simple organizational form. However, a highly complex project may need a more integrated system. The level of integration is thus increasing from a traditional approach through management contracting and project management.

3.5 Appraisal of the traditional approach

The traditional approach can produce a useful set of contract documents which will ensure that the client requirements are fully understood by the contractors. Thus forming a common basis for tender evaluation, and eliminating the possibility of any misinterpretation of client criteria. Under this particular characteristic, traditional procurement provides competitive pricing and offers a high degree of certainty of building cost.

The traditional approach concentrates more on the link between the professionals and the client, emphasising the importance of this relationship and claiming that it provides the best advice and service to the client. Furthermore, only those contractors with the necessary experience in the type of work, reputation, resources, financial stability and technical know-how would be selected. Therefore in theory, the most effective building team can be put together for each project in recognition of the client's needs, since this method gives access to a wide range of specialist knowledge and experience from the design and construction teams. This is seen to be in the client's interest.

Judging from these facts, the initial indications are that the use of best professional designers, properly chosen and well integrated and the use of the best contractors by
competitive tender has the potential to provide the client with a better building. However, as buildings grow larger and when the building services are getting more and more complicated, the use of the traditional approach is not wholly satisfactory. Where there is dissatisfaction with the service provided by the construction industry it may arise from problems associated with the quality of the building product, the performance of the building product, the effectiveness of the production/delivery process, or the cost of the product.

3.6 Use of non-traditional procurement methods

If there is one main reason for the growth of the many procurement methods it is surely the inadequacies of the traditional method and the adversarial working relationships between members of the building team (that become brittle during the construction process). These are seen to be the cause of the increase in cost and delays in completion. Developers could no longer afford to pay the high prices which resulted from this time honoured method which is not efficient at all.

Observations of the industry and coupled with the many publications and reports indicate that there are problems in the traditional approach such as:

- A large number of separate parties and multiplication of the responsibility pattern.
- The division between the construction and the design process. The contractor is too removed from the design stage at which his specialist knowledge could be put to invaluable use.
- The comparative isolation of many designers from the practical construction process.
- Lack of communication and co-ordination between design and construction team members.
- Inadequate preparation of design drawings and specifications before contracts are put to tender.
- Inadequate building services and integration and co-ordination.
- Inefficient project management and difficult teamworking.
- Adversarial working relationship between the members of the building team.
- Inappropriate contract and contract procedures.
Suggestions have been made by both construction and building services industries and academics in Hong Kong and abroad to overcome the problems of organizing and controlling design and production in the construction industry. The important suggestions are:

- Put design and construction teams together under one umbrella if feasible – a true building team with a commitment to meet project objectives.
- Bring construction aboard early, contribution from specialist consultants, the contractor, sub-contractors and suppliers must be obtained within sufficient time for effective co-ordination and input to the design function.
- Introduce a project co-ordinator, concentrating control and integration of the design and construction team.
- Effective building services integration and co-ordination.
- Increase involvement of the designer in the construction stage.
- Improve quality by:
  - Providing complete design information.
  - Ensuring clear responsibilities for design and construction.
  - Teamwork and partnering.
  - Improved project management.

A further factor for consideration of the problems facing the building process is the organization environment, which can vary between stable and dynamic. Mintzberg (1979) considered the dynamic environment as being the cause of uncertainty within the work of an organization. It is important for the organization to respond quickly to this environment and more efforts in project management would be needed.

Broadly speaking, many clients in Hong Kong were not satisfied with the traditional procurement system for both building construction and M&E services installation. Therefore, the professional and the industry responded by introducing various organizational forms as an alternative to the traditional approach. These were namely:

- Traditional system with domestic sub-contractor.
• Traditional system with principal M&E services contractor.
• Building works contractor, Principal M&E services contractor plus project management consultant.
• Design and Build.
• Management contracting/construction management.
• Project management.

A number of researchers (e.g. Hewitt (1985); Turner (1990); Masterman (1996) and Morledge (1996)) have investigated the characteristics, advantages and disadvantages of this wide range of organizational forms. The industry had also responded to the increased use of these alternative forms by conducting investigations and publishing guidelines for members of the industry and clients for selecting procurement methods for their projects, for example:

• NEDO report, Faster Building for industry, 1983.
• The RICS report, "Key Factors in Contractual Relationship" (Hibberd, Merrifield and Taylor, 1991).
• The RICS report, "The Procurement Guide" (Morledge and Sharif, 1996).

However, these guides were intended as a primer for discussion with the client before making procurement decision. White (1978) suggested that a building consultant would have to advise the client on the choice of the form appropriate to the client's needs. The consultant would be a professional with knowledge and experience of a wide range of organizational forms which could analyse the client's needs and select or develop an organizational form which would give the best results for the clients. In general, there are sufficient guidance notes on the selection of procurement methods, charts and information on which to base such a service, but subjective advice would seem to be the usual practice. The selection process is not straightforward as a result of the continuing proliferation of different methods of procuring building projects.
The major difficulties in selecting procurement methods have been identified by Masterman (1994) as:

- No single person, or knowledge "czar", has been found who is fully conversant with all the main procurement arrangements.
- No consensus has been found between experts which easily systemises procurement selection.
- No mutually exclusive sets of criteria uniquely and completely determine the appropriate procurement arrangements for a specific project.

Despite these strictures, methods have been devised by various researchers such as Skitmore & Marsden (1988), Frank (1984), Hibberd, Merrified & Taylor (1990), Bennett & Grice (1990) Turner (1990), Morledge (1991) and Masterman (1992) which partially overcome these difficulties or in the case of the simpler approaches, ignore them entirely.

None of these reports had critically considered the building services element which only became an important part in the building process when building design started to change between 1960 and 1970. Only the Latham Report recognized the building services design and installation could shape the success of a project.

3.7 The research study

At the centre of the building process is the building team which supplies all the design, managerial, and constructional skills necessary to realise a building project.

In order to investigate how co-ordination of building services within the building process was carried out, it was necessary to study the following issues.

1. Building services integration and co-ordination under two parts - technical and managerial issues undertaken by both designers and contractors with all building procurement methods.
2. The principal variables which are present in the building process and which are thought to be most relevant to the performance of the building team and the outcome of the project are:

- The client characteristics.
- The designer characteristics.
- The construction team characteristics.
- The project characteristics.
- The contract procedure.
- Co-ordination management.
- The procurement method.
- The influence of the environment.
- The success achieved.

This research pursued this particular point and aimed to clarify the relative merits of the different procurement methods with a view to providing some indication of how they may be matched to particular circumstances and the effects of these different organizational forms on the management of building services integration and co-ordination. It had proved to be an extremely complex task and controlled comparisons would be needed. Previous research had been largely fragmented and, though it had examined certain areas, it had not examined the problem as a whole – the impact of building procurement on building services integration and co-ordination (two separate, but closely related issues). As a vehicle for this examination two models (Building Services Co-ordination Model and Co-ordination-Procurement Model) had to be developed which attempted to show the relationships between the variables presented in the building process. The objective of the models was that they should assist in the selection of those organization forms and project procedures that are appropriate to individual client, project characteristics, building services integration and co-ordination, and that would therefore result in project success. Also, other assessment methods would be developed to help both subjective and objective analyses when designing organization form.
3.8 Reconciliation of official reports

The examination of the historical background to procurement plainly shows that all important official reports and previous studies conducted by the author have emphasized:

- The drawbacks of the traditional systems.
- Poor communication between project participants.
- Poor working relationships between members of the building team.
- Design is separated from construction. There is no contractor involvement in the design process.
- The need for clients and the industry to embrace the use of other procurement methods and good project management in order to maximize the likelihood of ensuring the clients’ needs were met.
- The co-operation and co-ordination of the building team for better integration of the design and construction processes.
- A major change in the culture of the industry and its clients.
- Use of better Forms of Contract with fair contractual arrangements of risk and award.
- Unsatisfactory buildings in terms of cost, time and quality.

Having examined the inherent problems in the construction industry, it is essential to consider the construction industry in detail. The construction industry is essentially a service industry. It combines the skills of many professionals and material and component producers. Not only is the industry large, it is also characteristically diversified and heterogeneous. A significant feature of the construction industry is its fragmented nature and the dichotomy which exists between the design and construction functions. The various processes that are involved in providing a building are generally managed by a team of people brought together for that one project and disbanded thereafter. This team usually comprises individuals from various professional and specialist firms who are responsible to the client for the design, management and construction of the building project. In general, a building team comprises:

- Architect
- Quantity surveyor
• Structural/civil engineer
• Building services engineer
• Building works contractor
• Specialist trade contractors
• Building services contractors

The building process can be considered as a matrix of conflicting professional and commercial groups combining to contribute particular specialist skills in order to achieve a desired objective, namely the production of a one-off project. The contributions are made on a part-time basis (for the duration of the project) and the interests of the various contributors are often found to be different and conflicting. It is clear that what is thought to be a team is really a coalition, “a temporary combination for special ends between parties that retain distinctive principles” (Rowlinson, 1988). The coalition needs to be managed as the unified effort of a team is likely to be more efficient and effective. The organization and management of a building project, therefore, requires greater co-ordination and co-operation between a large number of highly differentiated operating units.

The fragmentation and complexity of the industry, and the unique nature of its projects, must place great dependence on the competence of the building team in setting up the building process and bringing the project to a successful completion.

3.9 Summary

The construction industry and its clients know the industry is fragmented and adversarial. Changes and rethinking construction are necessary to create successful procurement methods for the construction industry.

In the UK many excellent recommendations of changes to procurement and related activities have been offered in the past fifty years – since the first publication of the Simon Report in 1944 to the Egan Report in 1998. Even in the Egan Report, there is nothing new (intended to be the “how” in response to Sir Michael Latham’s “what”) in
his recommendations. It is clear that the industry is still fraught with the old problems such as:

- Inefficient teamwork and difficult integration.
- The construction is too removed from the design process and the comparative isolation of many designers from the practical construction process.
- Unfair contracts with problematic allocation of responsibilities and more and more design duties have passed to the contractors by the designers.
- Inefficient project management.
- The need for developing modern methods of training to cover the complexities of modern construction technology/building services and human relations.

All these problems also apply to building services.

The literature which has examined the building industry, has concluded that change is required in procuring buildings. In particular, both Latham (1994) and Egan (1998) reports have suggested significant changes for the benefit of the construction industry in UK. Some of these changes or key factors (Moir, 1988) for successful building procurement include:

- Proactive client with good management and a well defined client brief.
- Team selection and structure of roles and responsibilities, with fair contractual arrangements of risk and award.
- Adequate time and resources for the project.
- Greater integration of the design and construction process.
- Early involvement of specialist contractors.
- Clear allocation of design and construction responsibilities for building and building services development.
- Clear and effective programming and construction management.
- A culture of team co-operation and trust.
- Best practice procedures.
- End of competitive tendering based on price evaluation only (Quality is essential).
- Use of suitable procurement method.
The changes have a profound effect on all involved in the design and construction industry. These changes are also needed in Hong Kong.

In general, there is still a significant divide between the design and construction teams in the construction industries in the UK and Hong Kong. Changes are necessary in relation to the procurement and contractual arrangements with the construction industry. The use of non-traditional procurement, better project management and working methods can improve the integration of these two teams. This will optimise the opportunities and achievements for the client’s benefit. Furthermore, all project participants will also gain benefits.

Building services installation becomes an important part of the building process and accounts for a significant amount of the building cost. The management of the engineering services is as important as the construction element. Indeed there are now very few projects where the management of the design and installation of services does not have a major impact on the overall programme and final account.

Nevertheless, to date no major report has studied the effect of building procurement on building services integration and co-ordination. Hence, there is no clear understanding of the relationship between the building team, the procurement method and the performance of building services integration.

The thesis will therefore concentrate on the area ignored by other researchers, which is the impact of procurement method on the performance of the management of building services integration and co-ordination.

The next chapter examines the construction process with previous research results and research models before embarking on a detailed study of procurement methods for building services design and installation.
CHAPTER FOUR

THE BUILDING PROCESS AND RESEARCH MODEL

4.1 Introduction
4.2 Project success
4.3 Measuring project success
4.4 Project success measures
4.5 The conceptual model
4.6 Requirements of a model to represent the building process
4.7 The chosen research model
4.8 The organization forms
4.9 Details of the variables within the model
   4.9.1 Client characteristics
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   4.9.6 The project performance
   4.9.7 The project environment
   4.9.8 Importance of organizational form
4.10 Summary
CHAPTER FOUR: THE BUILDING PROCESS AND RESEARCH MODEL

4.1 Introduction

It is necessary at this stage to examine the client’s needs, project success, and its measurement, the building process and the participants and the way in which the project is handled so that the modelling of building services procurement can be carried out. This chapter also examines the models which have been used by previous researchers to investigate the organization and operation of the building team.

It then discusses the development of a preliminary model used in pursuit of this research to investigate the important variables within the building process. With this model, the procurement of a building services can then be analysed in a systematic manner by using the identified variables as discussed in this chapter.

4.2 Project success

Any building project will involve a variety of aspects of success. For the client, a successful outcome might be completion of a building on time and within budget. For the professionals involved, success might be represented by a satisfied client and a trouble free project. The contractor will also be interested in a smooth running project. All in all, all project participants must be also concerned with financial return.

4.3 Measuring project success

Judgement of the success of construction project is fraught with difficulty because of the nature of the work. Such judgement must necessarily be based on some assessments of:

- Client satisfaction.
- Aesthetics, function and quality.
- Cost.
- Time.

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However, the first two are based on subjective opinion and even cost and time are not reliable indicators since the expression of success in terms of cost and time overrun must be weighted against the accuracy of the forecast.

A considerable amount of research has been directed towards investigation of alternative procurement systems. As these comparisons inevitably compare time, cost and building performance then similar attention should also be directed towards evaluation of project success.

Clearly, in our rapidly changing and highly competitive environment, success must be defined in much wider and more comprehensive terms than the classical cost, schedule and technical objectives.

Tuman (1986) highlights that project success also means satisfying the goals and aspirations of many different project participants or project stakeholders. In other words, a project is considered an overall success if the project meets the three major objectives, i.e. time, cost and quality, and if there is a high level of satisfaction concerning the project outcome among key people in the building team and key users of the building. Hence, success in building services procurement should have a significant impact on the three major objectives.

4.4 Project success measures

The three labels cost, time and quality and the organizational forms are interrelated.

1. Cost

Essentially the client is interested in an early prediction of the total amount that would be paid and the variance between this prediction and the actual final sum. Though the fact that predicted cost is not exceeded may give client satisfaction there is no guarantee that it was the right cost. There is the suspicion that one reason for the success of alternative procurement methods is that they are more positive about the final cost to the client or the use of better project management.
2. **Time**

Design and construction duration will, to an extent, be a function of the cost, size and complexity of the project. The time taken for the design and construct stages will also depend on the abilities of the people involved and the techniques and resources devoted to the project. Furthermore, the effect of good project management is paramount.

Judgement of project time performance also has its problem since there is no effective benchmark to indicate how long a project should take, as compared to the numerous published cost data for various buildings.

It is also noted from the NEDO report – Faster Building for industry (1983) that alternative procurement methods produce quicker results at competitive prices and with no resulting loss of quality.

3. **Quality**

Quality is difficult to define and compare, perhaps it is better to consider it as being an amalgam of client satisfaction, architectural excellence, efficient building and high standard of finish and building services. Judgement is extremely difficult. Besides, objective measurement is almost impossible.

However, in summary, the main aim of the building process must be to satisfy the client. This satisfaction may be a subjective opinion of the client but it is this opinion which the building team seeks to influence. There must, however, be rational grounds for the judgements made by the client. It would be impracticable to enumerate all the diverse factors clients may require from a project but there are a number of primary categories that may be considered. These may include the general suitability of the building for the purpose for which it was commissioned, the price and whether this represented value for money to the client, whether the project was on programme or not and the degree to which the project is aesthetically pleasing to the client. Further considerations might be related to life cycle costing and performance/use of building.
The construction industry is diversified, heterogeneous in structure and complex in product type. These characteristics have a significant effect on the response of the building team and the performance of the project. It is the duty of all members of the building team to work in the interests of the client, then the responsibility to create a satisfactory product must ultimately lie with the team. If the client is dissatisfied, it may be that the team has both failed to work as a team, and that it has failed to make its members individually accountable for their actions.

4.5 The conceptual model

A model is a key element in determining the scope of any research. It points to those areas which must be considered in data collection and analysis.

Having examined the project success variable, the second area of this research was the development of a framework (e.g. the model shown on page 91) for evaluating the effect of the organization form of a building project on the project success.

To start with, it was necessary to define the meaning of a model.

Models are descriptions of systems (Pritsker 1979). The descriptions can take one of three forms: physical, mathematical, or graphical.

Hagget and Chorley (1967) discussed the function of a model, which should provide a framework for the definition, collection and ordering of information. It should therefore enable phenomena to be visualized and comprehended and assist in explanation and comparison. Finally, a model should communicate ideas.

Models have become widely accepted as tools for studying complex phenomena. The value of a model arises from its effective improvement of the understanding of system characteristics especially based on ‘System Thinking’ approach. Cleland and King (1968) in their study of system analysis and project management adopted a system approach, and they defined:
'A system approach by its very nature is made up of interdependent elements, actions which affect one element must affect others also, and actions of one element cause reactions on the part of others. The recognition of such interactions and interdependencies both within and without the organization is the essence of the system viewpoint.'

Therefore, the system approach embraces the essential features of model building process. The system model emphasizes wholeness and the existence of a set of interdependence. In this respect, a system model is appropriate to the study of building team organization. With this tool, the complex building process can be examined and analysed more systematically.

The research process should encompass the identification of the problems and the development of a model, which is then tested against reality (in this study, 25 projects would be used to validate the models and in conjunction with the data obtained from the author's questionnaire/interview survey results because these represented the views from the industry and therefore these were also evidence but obtained in another way, though not all objectively). The modelling techniques should therefore include all important variables and sub-systems, show clearly the degree of inter-relatedness and interdependency and remain valid and useful across the required range of situation.

Before setting out the research framework due consideration would be given to previous research in this and related fields.

The building process is seen as a series of interdependent parts which operates within a system comprising of people who manage and supervise it and have their own goals. The management of building services is only a part or sub-system of the building process systems. Therefore, models used successfully by other researchers must be examined first.

Since 1960 many building process models had been developed to investigate the effectiveness of the building team and the operation of the building process.
Among the most relevant models for this research, the following models though not many are considered relevant and useful (even they did not consider building services work in the construction process) and they were detailed in Table 4.1.

1. Higgin and Jessop (1965)
2. Morris (1972)
5. Rowlinson (1988)

Table 4.1: Detail of models used by other researchers

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Details of their model</th>
<th>Common variables</th>
<th>Adoption for the author’s work</th>
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<tbody>
<tr>
<td>Higgin and Jessop</td>
<td>They saw the building process as the development of the relationship among three functions: design, construction and co-ordination. They also listed 7 phases of the building process.</td>
<td>Design, Construction, Co-ordination</td>
<td>✓</td>
</tr>
<tr>
<td>Morris</td>
<td>He studied design and construction process. He used the RIBA (The Royal Institute of British Architects) model and studied the differentiation and integration necessary at each phase of the construction process. His three main process sub-systems include design, design realization and construction. He also emphasized differentiation and co-ordination.</td>
<td>Design, Construction, Coordinating/integration and differentiation</td>
<td>✓</td>
</tr>
<tr>
<td>Sidwell</td>
<td>He compared procurement methods for construction. He saw the principal variables in the construction process as client and project characteristics, the building team and project procedures. These variables can shape the dependent variable of project success. All these variables are subject to the influence of the sixth element of the model, the environment.</td>
<td>Client, Project, Building team, Project, procedure</td>
<td>✓</td>
</tr>
<tr>
<td>Nahapiet</td>
<td>The work by Nahapiet in comparing project performance, proposed that the selection of contractual arrangement is a function of:  • Client attributes and requirements.  • Project delivery processes (contractual arrangements, project management processes and design and construction methods). Again all these variables are subject to the influence of the environment.</td>
<td>Client, Contract procedure, Contractual arrangement, Management</td>
<td>✓</td>
</tr>
</tbody>
</table>
Table 4.1 – continued

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| **Rowlinson** | He compared procurement methods for buildings. He used the following variables to investigate their effects on the building process and the aspect of project performance.  
- Client variable.  
- Project variable.  
- Organization variable.  
- Management variable.  
The primary conclusion to be drawn from his research is that procurement form is not a good predictor of performance. In general, the management and building team organization variables are found to be more strongly associated with performance. Specifically, increased client complexity is found to be associated with reduced performance, as are increased project complexity and uncertainty. | **Client** | ✓ |
|   |   | **Project** | ✓ |
|   |   | **Organization** | ✓ |
|   |   | **Management** | ✓ |
| **Newcombe** | Newcombe’s anatomy of a construction project illustrates the components, context and characteristics of a typical project. His model included the following important variables.  
- Building team – client, designers and contractors.  
- Project management – strategic and co-coordinative.  
- Building process in detail.  
- Environment.  
He has highlighted the interactions between the parts of the model. However, the application of this model is difficult when compared with the models proposed by Sidwell (1982), Nahapiet (1985), Rowlinson (1988) and Naoum (1989). | **Building team** | ✓ |
|   |   | **Management** | ✓ |
|   |   | **Interaction** | ✓ |
| **Naoum** | He compared procurement methods. He developed a model which has five main variables:  
- Client characteristics.  
- Project characteristics.  
- Designer characteristics.  
- Contract procedure.  
- Procurement method.  
These variables together with the system environment can shape the project performance of a building project. | **Client** | ✓ |
|   |   | **Project** | ✓ |
|   |   | **Design team** | ✓ |
|   |   | **Contract** | ✓ |
|   |   | **Procurement** | ✓ |
|   |   | **method** | ✓ |

The study of these research models provided a clearer understanding of modelling.

- The graphical model is informative.
- The system approach is useful for examination of the building process.
- The construction industry is not one single industry but a composite of diverse sectors. However, for research purposes, many models only cover the important project participants including clients and the appointed design and construction teams.
- Appropriate relationships between the variables involved can/should be shown.
Most models show that the client and project characteristics are primary determinants of procedures and control mechanisms adopted. These then influence the organization and operation of the building team.

The model given by each of the researchers is the conceptualisation of one comprehensive model of the building process embracing all system relationships and identifying the underlying principal elements of these systems so that the form of the organizational system and the relationships and procedures involved may be rationalised to achieve effective management of the building process.

Many factors, other than those already discussed, have the opportunity to affect project performance. Some important factors such as human aspects (communication, administrative ability, attitude to cooperation and coordination) and the changing environment are not necessarily less important. A reduction in the number of systems, and variables, included in the model is quite reasonable as long as it is recognised that some important variables may be excluded and that the model so produced may not predict performance fully if the missing variables present themselves.

The various models already discussed were attempts to illustrate the building process, to show the functions, interrelationships, responsibilities and so on. The study of these research models also assisted the author to develop a preliminary model employed in this research.

4.6 Requirement of a model to represent the building process

In considering the development of a building process model the following questions were addressed: -

1. What should be represented in the model and to what level of detail?
   
   i. The model will need to represent the process of design and construction.
   ii. The model should be able to be re-used in a generic way and the model is not project specific.
iii. The level of detail to which the elements/variables are to be represented will need to be salient. If too much detail is provided, the model would be excessively large, making it cumbersome and complicated to use. On the other hand, the model should not be vague.

2. What will be the use of the model?

The model will form an integral part of this research methodology that can be used to investigate the complex building services co-ordination process systematically.

3. Who will be represented in the model?

The various disciplines within the building team.

4. What is the boundary of the system to be modelled?

The system to be modelled is the building process starting from the inception of the project, through design, documentation, construction and completion of a building.

5. What will be the format of the model?

A graphical format will be most suitable and it should facilitate model construction and modification.

6. What is the salient aspect of the model?

The constructed model will need to be tested, verified and further modified to reflect the outcomes of the case studies to be carried out later. The model must therefore reflect both management of building construction and M&E services.

In view of the complexity of the building process and the building services integration and co-ordination, it was considered necessary to have two models. One would study the important details of managing building services design and installation and the other would be used to study building services procurement.
4.7 The chosen research model

The review of previous published and unpublished research and opinions expressed publicly and privately, lays the foundation for the presentation of the preliminary research mode. Having examined the requirements of a research model, it would be seen that a model should consist of components which represent the constants or variables in the physical reality to be studied. The model set out to illustrate the relationships between the variables in the building process. The objective of the model is:

- To stimulate the development of possible theory.
- To assist in the selection of a procurement path that is appropriate to a highly serviced project through better understanding of the interrelationships among various variables.
- To help management of building services integration and co-ordination.

Based on the author's own understanding of building services management and other researchers' work, the proposed model for this research would therefore include the following variables as expected in a building project.

- Client characteristics – type, sophistication, criteria, ability, people.
- Project characteristics – type, complexity, constraints, risk.
- Design team characteristics – experience, ability, organization/people.
- Construction team characteristics – experience, ability, organization/people.
- Project/control procedures – contract, documentation, control mechanisms.
- Procurement form – organizational form, differentiation, proximity, co-ordination.
- Project environment – general level, specific level.

The aforementioned items would be considered as systems within any organizational form (i.e. procurement method). Project success is outside the organizational form but located within the building process system boundary. The project environment of course exists in every system and is to be situated just outside the system boundary, i.e. an external influence.

Figure 4.1 shows the author's research model which was based on the concept of system concept and the variables identified above.
FIGURE 4.1 - THE CONCEPTUAL MODEL
According to Cleland and King (1968), this system approach could illustrate the interaction and interdependence between the identifiable variables. This suggests that an action of one variable can cause reaction on the part of others.

There are seven elements or variables in the researcher's proposed model. The elements client characteristic, project characteristic are seen as primary or independent variables. To operate the model one would start with an assessment of the characteristics of these two variables. Project / control procedures, design team and construction team characteristics are considered as the intervening or moderator variables which are then selected or adapted to achieve optimum result on the seventh dependent or end-result variable of project success. All these variables are subject to the influence of the eighth element of the model, the environment.

According to Hughes (1989) this environmental influence would be divided into two levels:

- Macro-environment-cultural, economic, political, social and physical.

The environment of the project is changing all the time. Influences from the macro-environment place demands upon the project. These have to be mitigated through the utilization of expertise in the micro-environment.

For this research, in order not to complicate the investigation, this environmental factor would have to be assumed unaltered for all organizational forms. However, this would not be the case in reality. Even with this factor in mind, the proposed research model is still considered useful and comprehensive for the purpose of this research. Nevertheless, the model will be revised to accommodate the environmental factors.

4.8 The organizational forms

Two major elements in the building process are the organization and management of the building team.
Invariably the construction of a building requires the formation of a project team comprising representatives of all sides to co-ordinate and control the building process.

The success of this team is a critical element in the performance of the project and represents the combination of diverse skills and technical activities. Examination of the team reveals that it exhibits the characteristics of an organization — this is, specificity of purpose, employment of skilled personnel, formality of communications, formal rules, procedures and controls, hierarchy of authority of specialization and division of labour (Khandwalla, 1977).

The manner in which the building team is organized is termed organizational form and represents in the set of functional specialisms grouped together as a building team. This building team operates within the building process (= the building system) which includes all processes from the inception of the project through design and construction to completion. The building process may be obtained by a number of routes and each utilizes basic processes of design, documentation and construction. However, a number of organizational forms may be adopted (e.g. traditional method, design and build, management contracting and construction management, etc.).

Strictly speaking, an organizational form is a component of procurement form. In a temporary organization such as the building team which jointly or singly contracts to provide a building, the logical method of describing the organization authority form is through the formal structure vested in the building team members by the client.

The building industry is unique in its methods of working which allow the responsibility for design to be far removed from that for construction. This division of responsibility between the designers and the builder has cultivated a wide variety of procurement methods.

In the traditional system, the authority for design and that for construction are vested in the architect and builder separately. The architect does not have any responsibility for the construction process: responsibility is divided. On the other hand, the design and build system vests authority, and so responsibility with one organization. This represents single point responsibility.
The management contracting system is different from the traditional system. There are still separate design and construction responsibilities, but the management contractor is also involved in the design process.

The construction management system is similar to the management contracting system, but this management consultant will not carry out any physical construction, but is responsible to the client for monitoring both design and construction works. However, the architect still acts as the design co-ordinator.

From these organization forms, it is possible to distinguish all systems by the division of responsibility and delegation of formal authority for the design and construction process.

With so many procurement systems, it is naturally important to select a building team using the most appropriate organizational form, and with the capabilities, resources and experience commensurate to the task.

Building project teams are invariably composed of representatives from various functional and organizational sources. The building team can be seen as highly differentiated, facing a problem in its own integration. In any team constituted from disparate organizations there is always danger of conflict (more especially a characteristic of fragmented, traditional patterns) between the team’s objectives and those of the operating units or the various professions. Morris (1972) points to the danger of entrenched attitudes being adopted under situations of disharmony and stress. A balance must therefore be maintained between the various operating units within building project teams. Lawrence and Lorsch (1967) have proposed that as different parts of an organization encounter different task environments they will be differentiated in their behaviour. However in order for the system to behave as a whole each differentiated sub-system must be effectively integrated. It is clear that the need for integration is greater when organizations are more specialised and differentiated. The question now becomes that of determining the pattern of differentiation and integration of the parts of an organization that gives better performance in a particular task environment, i.e. the team work between the main-contractor and the building services contractor as part of this research.
The model proposed in figure 4.1 shows the principal sub-systems within the building process. The model operates by first considering the client, project characteristics and contract strategies which act as constraints on the project team and should be a primary influence on the choice of organizational form. Project and control procedures may then be adopted which will govern the operation of the project, the documentation, form of contract, management systems etc. Finally the building project team is organised by co-ordination management to provide the desired balance and performance. Operation of the model to design appropriate organizational form has three necessary stages.

1. The characteristics of organizational forms and their components as they operate within the building process must be established so that correct selection may be made.

2. The organizational form must be designed with due consideration of the interaction of the constituent elements, i.e. the design and construction teams.

3. Project success must be measured adequately to monitor and control the project.

4.9 Details of the variables within the model

This section seeks to discuss the principal variables which are present in the building process and which are thought to be considered important in the selection of procurement systems.

These variables (as identified in section 4.7) are to be discussed under the following main headings:

- Client characteristics.
- Project characteristics.
- Building team (designers and contractors) characteristics.
- Project/control procedures.
- Procurement form.
- Project success.
- Project environment.
This study uses these variables as a basis for the examination of the selection of procurement method and management of building services integration.

Each variable also has its sub-variables as follows:

4.9.1 Client characteristics

‘The Client’ is a complex system of different interests and the client’s relationship is seldom with a single member of the building industry (Crichton, 1966). A client can be classified as:

- Client type – public/private.
- Client criteria – cost/time/quality, expectation.
- Client experience – experienced/inexperienced.
- Client specialization – developer/purpose built.

The client is the sponsor and initiator of the building. The characteristics of the client organization will differ in relation to the type of business activities and the organizational structure of the corporation. This will generate different expectations and criteria for achieving satisfaction with respect to cost, time and quality. Furthermore, different client characteristics will influence the building process, the selection of the procurement method and the resulting success of the project in different ways.

Clients of the construction industry have traditionally been categorized as ‘public’ or ‘private’ organizations as a reflection of the ownership, or source of funding, of the establishment. The public sector client, because of public accountability, will need to ensure that the expenditure of taxpayer’s money is safeguarded by the adoption of conservative policies in all areas of their activities and being risk averse. On the other hand, perceived wisdom suggests that private organizations are concerned to maximise profits and are prepared to adopt more aggressive policies and take higher risks to achieve their objectives.
The level of the client’s experience of the construction industry and project implementation is a critical characteristic in terms of client behaviour when dealing with the industry and in particular when deciding which procurement system is most appropriate for their project.

Clients with considerable previous experience of building should be familiar with the building process. They may have their own team of experts, depending on the scale of their activities, and may be considered ‘sophisticated’ clients. Generally, communications and relationships between experienced clients and other members of the building team are likely to be good as a result of better understanding of the project; continuing involvement during the life of the project and with a detailed knowledge and understanding of the construction industry and its procedures. One would expect such clients to achieve a higher success rate and more readily achieve satisfaction than inexperienced clients. Inexperienced clients on the other hand often exhibit much less positive characteristics which may include:

- Little knowledge or understanding of the construction industry and its procedures.
- A lack of expertise in managing and controlling projects.
- The inability to produce a comprehensive brief or prioritize objectives without substantial assistance from an external consultant.
- A lack of continuing or regular involvement with the implementation of construction projects.
- A desire to make changes to the project throughout its duration and a lack of understanding of, or unwillingness to accept, the consequence of such action.

It thus follows that communications and relationships between the building team and inexperienced clients are often less perfect.

Closely linked with the idea of sophistication is the concept of specialization which is intended to account for the client who has a repeat need for a particular type of building (e.g. hospitals) and may develop a highly specialized knowledge and expertise. Also, they have better understanding of their requirements and will contribute more to the project.
Thus, this will influence the selection of the procurement method for the project and subsequently the performance of the project.

Many studies (NEDO, 1983, 1985; Naoum, 1989; Franks, 1990; Turner, 1990; Morledge, 1991 and 1996 and Masterman, 1996 for example) of the needs of clients have been carried out over the past two decades. From this published material three primary factors emerge, which are stated most frequently: time, cost and quality. Typical client’s requirements were defined by Bennett and Flanagan (1983) and some of the important points can be summarized as:

- Functional building at the right price.
- Quality at the right price, i.e. value for money.
- Speed of construction.
- Recognition of the risks and uncertainty associated with the project.
- Accountability in the public sector.
- Balance between capital cost and long-term ownership costs.
- Flexibility to change the design during construction.
- The building should reflect the client’s activities and image.
- A desire to be actively involved in and kept informed about the project throughout its life.
- Innovative design.
- Minimizing future maintenance.

Building is about getting it right for the client. Thus the clients do not want any surprises during the implementation of their projects and require certainty of performance in the time-honoured triumvirate of time, cost and quality. But these performance requirements would be influenced by many aspects of the building process and the client’s selection of the procurement method.

Having examined the details within the client characteristic, it is contended by the author that:
• The project characteristic is a function of the client characteristic as clients' needs dictate the building design and requirements.
• The procurement method is a function of the client characteristic as clients influence the selection of the organizational form.
• Project success/performance is a function of client characteristic which shapes the project performance as a result of the client's management of the project.

4.9.2 Project characteristics

A building project may have characteristics which will influence the building process and the resulting success of the project. These characterises include:

- building type.
- technology, range of services, expertise needed.
- new/refurbishment.
- area/cost/building rate.

Building projects can be distinguished by their functions and designs, conditions, level of constructional complexity or technology. The more complex the building, the wider the range of services and expertise needed.

These characteristics can therefore impose a greater managerial pressure upon the building team. As the procurement process revolves around the characteristics of the individual project and may require a specific procurement method to optimise:

• Integration of all members.
• Project success.

Thinking about Building (NEDO 1985) defined complexity as technical advancement or high levels of servicing and included this as an important factor affecting the choice of procurement method. Sidwell and Ireland (1978) noted that complex, high value projects required special attention in determining appropriate procedures and organization to be successful. Morris (1983) also cited that speed of the project, the project’s complexity and the scale of the works would affect the choice of procurement method and ultimately, the
success of the project. Hence, large capital projects will obviously need different types of project organization to relatively simple and low cost projects. In contrast, a relatively uncomplicated project, regardless of monetary value and size, should, in theory, require a simpler organizational form.

Simplicity and standardization of design of course can contribute to good performance (Nahapiet 1983) and Aram and Javian (1973) found that high complexity projects required direct and effective communications between organization units for successful outcome.

In general, most large complex projects would take longer to design and longer to build, and it is obvious that the factor of complexity will have a significant effect on the project process-design and construction, i.e. the organizational form in building project. Objective measurement of complexity is not easy, but the cost and physical space occupied by the project can be a measure of the size of the building and to some extent of its complexity.

In this research, the complexity of building services in relation to its procurement method and the following factors are examined and discussed further in detailed case studies. It is also contended that:

- The procurement method is a function of the project characteristics in which the complexity of building services could be an important factor.
- Project success/performance is a function of the project characteristics as large and complex projects are difficult to manage both in design and construction.
- The building team is a function of the project characteristics as this may influence the specific organization of the building team required.
- Project procedures are a function of the project characteristics as no two projects are the same and special attention in determining appropriate procedures would be required for each project.
4.9.3 Building team characteristics

The building team is a group of building industry professionals and personnel from one or more organizations who combine together to fulfil the necessary design and construction functions comprising the building process.

Each member of the building team contributes a particular expertise and is generally concerned with a special functional area in the building process. The design and construction teams are, therefore, an association of specialists from different disciplines with inherent problems of co-ordination and communication (Higgin and Jessop, 1965). Integration of the different operating units may thus be a very important factor in this temporary multi-organization — an organization of organizations (Stocks, 1984).

Where projects are complex, there are clearly difficulties of contact and communication. This can create problems of co-ordination and information and particular organizational forms may have to be used to provide situations which encourage and enhance integration. Of course, the independence of the individual team members is still present and considered necessary in view of the technical complexity of a building.

The traditional arrangement of independent professionals working from separate practices (or the operating units) and coming together for the duration of a project would represent a low level of integration.

A building team should be a group of people working together toward a common goal and their combined efforts are organized into a co-operative whole. The traditional approach does not wholly support this view, as Banwell (1964) pointed out:

'The most urgent problem which confronts the construction industry is the necessary of thinking an acting as a whole.'

On the other hand a system where all services, from design to construction (building works and building services) are provided and managed by a single body should afford a high level of integration. Apparently, building a team from a wide variety of organizations and motives is a difficult and complex task. As stated earlier, any system
which moves away from the conflicting goals of a coalition of project participants, and towards the unified effort of a team is likely to be more efficient and effective. It is clear that effective integration will obviously have a significant impact on the working of the building team, and will influence the selection of the procurement method and consequently project performance.

As the building team is made up of two teams, it was necessary to discuss these teams one by one to gain a clearer understanding of integration of members within the building process.

1. The design team characteristics

The architect is considered to be the leader of the building team and the adviser of the client organization, it is to be expected that the designer characteristics will influence the selection of the building team and consequently project performance.

The design team can also be seen as highly differentiated (e.g. individual designers for architecture, structural engineering, building services and cost planning) and facing a considerable problem in its own integration. Lawrence and Lorsch (1967) found that the need for integration was greater when organizations became more specialized and differentiated.

Integration in this context is structural and organizational, and is not identical to co-ordinated and co-operative working relationships.

According to Walker (1996), the most positive approach has been the creation of multidisciplinary practices that employ within the one firm all the professional skills associated with projects. If, within such practices, specialists were created in project-dedicated teams, then one would expect that conditions would be created in which a high level of integration could occur. However, if such practice continues to organize in ‘departments’ of specialist skills, a great integrating opportunity will have been lost. Nevertheless, such a practice still has a better opportunity of overcoming problems created by differentiation and of generating better integration for individual projects than if projects are designed using independent practices. A parallel situation
would exist if all the design contributors were in-house to the client’s organization. A major advantage in this situation would be the potentially high level of integration with the client, as client and design team would be under the same organizational umbrella.

Closely linked with the designer characteristics is the attitude of designers to appreciate the changing construction procurement scene and use their experience with adoption for new procurement methods. The move away from the conventional procurement procedures has also meant that organizations have to change to match this new market. The designers should change their attitude towards new procurement methods in order to accept the input from the contractor. Furthermore, the designers’ role in construction and building services supervision is reduced but still has to be responsible for quality control.

The design team characteristics will obviously have a direct impact on:

- The complexity of building design and construction.
- The provision of quality information which will facilitate smooth building construction and building services installation.
- The maintenance of a harmonious building team relationship. This may be less visible when the project is finished but is thought to be an important component as far as project success is concerned.
- The management of quality design.
- The management of the construction process in conjunction with the construction team.

Therefore, the following statements are generated for this research:

- The procurement method is a function of the designers’ professional characteristics as the designers will influence the selection of the building team.
- Project performance is a function of the designers’ professional characteristics as the quality of their services will influence project results.
2. The construction team characteristics

Similar to the design team, the construction team is made up of different operating units. Hence, differentiation will exist and the problem of integrating various subcontractors by the main-contractor is always present.

But integration of these contractors will also depend on the selection of the procurement method and the contract procedures. It must be noted that the integration is structural and should not be confused with co-ordinated and co-operative working relationships. These could be attained by all procurement methods.

Co-ordination between design and construction phases and participants is a prerequisite for success had been cited by many research reports including Morris (1972) and Walker (1996). Obviously, the organization of many different operating units and their management of a particular building project will have a direct bearing on the outcome of the project success.

Rowlinson (1988) contended that an increase in familiarity, proximity and co-ordination and a decrease in the technological differentiation would be expected to improve the efficiency of the design and construction processes and contribute to a consequent improvement in performance. Hence, the split between design and construction in the traditional procurement path will not help the ‘real’ integration of the building team and there is a great need for the contractors’ contributions.

The working of all contractors will definitely have a significant effect on the performance of a project. The following project success factors (Rowlinson 1988) have been identified to be relevant to the construction team characteristics.

- The contractor: size and staff, experience and capacity, familiarity with the rest of the team.
- Size of the construction team.
- Differentiation among team members.
• Team leadership.
• Management of works and sub-contractors’ work.
• Co-ordination and control of construction team members.
• Management of design-construction interface.
• Management of people.
• Management of information flows.
• Building contract.

This list is by no means exhaustive, but the factors are considered sufficient for this research.

For the purpose of this study, it is contended that:

• The procurement method is a function of the construction team characteristics as the integration of contractor can make use of different organizational forms.
• Project procedures are a function of the construction team as specific procedures would be needed for a particular pattern of organization of contractors.
• Project success is a function of the construction team characteristics as the efficiency of the construction team can shape the outcome of a project.

The aim of this research is to investigate the impact of building procurement method on the management of building services integration and co-ordination by the building team. It was, however, intended to leave the detailed study of management of building services to the next chapter which discusses co-ordination of building services at both design and installation stages by the design and construction teams with special reference to the traditional and non-traditional procurement methodologies.

4.9.4 Project/control procedures

Project/control procedures embrace:

1. Procedures adopted for selection of the members of the building team.
2. Managerial control for effective co-ordination, co-operation and communication.
In conducting their research Sidwell (1982) and Rowlinson (1988) both used the concepts of building team selection, contract procedures and managerial actions to compare different procurement methods. It is contended that these components will define the approach that any client will adopt to the process of building procurement and making the choices during the building process or before it commences.

This variable embraces the procedure adopted for selection of the members of the building team, in particular the contractor. In most cases the professional members will be appointed in accordance with professional codes, e.g. RIBA, RICS and ACE (i.e. Royal Institute of British Architect, Royal Institution of Chartered Surveyors and Association of Consulting Engineers, all in UK) and on agreed fees. The construction team may be appointed by competition using open and selective tendering or negotiation. Occasionally, the design and construction can be offered as a package by the contractor. The building team selection is therefore by no means always the same. The construction industry opinion is that the method of selection will vary according to the organization form.

The method of building team selection is found to affect project performance significantly. Latham (1994) cited that consultant selection should be based on quality and cost for best result. Egan (1998) also supported Latham’s ideas. Morris (1986) noted that competitive bidding can adversely affect the outcome of major projects and the number of separate contracts is related to the chances of success (as few as possible for best management purpose). Warszawski (1975) did in fact conclude that a major problem facing non-conventional contracting system was the objective selection of the most suitable contractor.

The conditions of contract documents, the apportionment of risk and responsibilities for performance between the participants are also seen to be important issues as they are directly influencing the financial and organizational bases of the project and so the likelihood of success or failure (Morris 1986). Rubin (in Smith et al, 1975) also sees the legal framework as apportioning risk and legal responsibility for: adequacy of design; cost of construction; liability to sub-contractors; indemnification; financing; co-ordination of the work. One may therefore consider that the framework also provides a safety net.
Contract procedures can influence the selection of the appropriate building team, and determine the working of the various parties as well as the degree of differentiation and integration and subsequently affect the performance of the project. It is also thought that, when the building team and project procedures are appropriate to client and project characteristics, a higher level of success will be attained.

Ireland (1984) states that there are ‘virtually meaningless distinctions between (these) nominally different procurement forms’ and goes on to argue that managerial actions during the construction process, rather than the procurement form, are the determinants of performance.

Managerial control, during design and construction is also identified by Sidwell (1982) as being the most important factor affecting success. Baker et al (1983) also cite inadequate control procedures as a determinant of cost and schedule overruns. The use and control of sub-contractors were seen to be areas requiring attention by NEDO (1983) and Barton (1983). Bromilow (1977) also identifies that faulty programming, poor documentation and tardy decisions are factors affecting performance. Might (1984) contends that technical planning, perceived difficulty of the project and generation of project team support as important factors and Morris (1986) also sees comprehensive project definition and planning, design and technology management as maxims for project success.

The building process relies on effective co-ordination, co-operation and communication. If objectives are to be achieved satisfactorily then an element of managerial control is necessary. The design team must then produce adequate documentation to communicate to the construction team for the various members to make use of this documentation to plan and manage their individual activities. The degree of managerial control is reflected in the range and type of control mechanisms set up for the particular problem. At one end of the range would be a ‘low control’ situation and the other end a ‘high control’ situation would obviously exist if detailed documentation was administered through a system of monitoring systems, instructions, reports, regular meetings (long and short-terms and emergency), reviews, inspections and feed back system.

For this research, the project/control procedure is contended to have the following properties:
• Project procedures are a function of the client characteristics as the procedures reflect the client’s needs.

• Project procedures are a function of the project characteristics as the procedures would be related to the complexity of the project.

• Project procedures are a function of the building team as the procedures are based on the selected organization’s form.

• Project success is a function of the project procedures.

4.9.5 Procurement form

After the client has established the special needs and priorities, decision on the most suitable method to procure the project will be made. The decision of procurement method will be based on:

1. Key factors in selection of procurement.

2. Type of arrangement that best fits the project.

This variable was discussed briefly under the building team characteristics.

The fragmented nature of the building industry particularly the separation of design and construction, the uniqueness of construction projects and the resulting ephemeral nature of the project organization places great dependence on the project team in setting up the building process and bringing the project to a successful conclusion (Sidwell, 1982). That is to say, the performance of a project depends on the appropriateness of the procurement system selected.

One fundamental aspect of the building process that requires early and particular attention if success is to be achieved is the selection of the most appropriate organization for the design and construction of the project (Masterman, 1996).

A review of current practices revealed many different approaches to the procurement of building projects. The choice of building procurement systems available to clients is now so wide that the need to carry out the selection process in a disciplined and objective manner should be self-evident.
From a general review it was established that the following procurement paths are the ones most frequently encountered.

- Conventional/traditional.
- Management contracting.
- Construction management.
- Design and build.
- Joint-venture or partnering.

Project management has not been referred to as it is considered not to be a procurement path, but rather a very useful role which can be applied to a number of the procurement routes.

As an aid to adopting a more logical approach to the selection of the most appropriate method from the proliferation of systems currently available it is thought that the different methods needed to be categorised for proper analysis of organization form.

The NEDO report, Thinking about Building (1985) adopts a practical approach and identifies four different basic procurement systems, or paths/methods, i.e. traditional, design and build, management, and design and manage, each of which have a number of variants, but makes no attempt to establish a grouping of systems based upon common characteristics.

Perry’s (1985) approach categorizes all procurement methods as:

- Divided management of design and construction, i.e. conventional system.
- Co-operative management of design and construction, i.e. variants of the conventional system such as negotiation and serial contracts.
- Special emphasis on management, e.g. management contracting, construction management and design and manage.
- Integrated management of design and construction, e.g. design and build system, develop and construct and package deals.
Classification is considered necessary for the purpose of assisting in the simplification of the selection of procurement systems, the most appropriate categorization relating as it does to the critical interaction between the design and construction processes.

A review of the literature reveals a wide range of reasons put forward for using a particular procurement path. If these can be accepted as genuine all that would be required is for these reasons to be matched with the specific project requirements in order to establish a procurement path.

Hibberd, Merrifield and Taylor (1990) have conducted a detailed study of key factors in contractual relationships and the following conclusions are drawn by them.

Factors affecting the selection of the procurement path are:

- Supposed benefits of a particular procurement route, this includes certainty of cost and time.
- Previous selection of a form of contract.
- Type of client.
- Size of project.
- Personal preference.
- Design input.
- Continuity of project.
- Single point responsibility.
- Management team.
- Availability of resources.
- Desire to change approach.
- Previous problems.
- Level of risk.
- Time available for development of the design.
- Time available until completion.
- Standing orders/company policy.
- Need to change design.
- Phasing requirements.
The above items are of varying degrees of significance.

However, there are other factors which by themselves should not determine the choice of procurement path.

- Supposed benefits of a particular procurement route.
- Previous selection of a form of contract – personal preference.
- Desire to change approach.
- Company policy.

Nevertheless, the following factors which may by themselves, or more likely when considered in connection with other factors, influence or determine the choice of procurement path.

- Size of project.
- Continuity of project.
- Previous problems.
- Time available until completion.
- Need to change design.
- Phasing requirements.

However, the selection of procurement path can be looked from another angle, i.e. the client objectives as identified in “Thing about Building (NEDO report, 1985). These objectives include:

- Early completion of the project.
- Need to make variations during construction.
- Level of quantity in design and workmanship.
- Price certainty before commitment to proceed.
- Price competition in choice of building team.
- Division of contractual and professional responsibility.
- Risk avoidance.
Another important point of high level of satisfaction from the parent, client, users and project team as raised by Morris (1986) must also be seriously considered. Masterman (1996) emphasizes that the selection process needs to be carried out in a disciplined and objective manner and within the framework of the project strategy and project brief. He further states that there is no best buy among procurement systems, and client organizations are complex and different categories of client require discrete solutions to their procurement needs, added to which the prevailing economic climate often influences the choice of the procurement method. It therefore follows that the choice must be made by matching the criteria and objectives of the project brief with the most suitable characteristics of the various procurement methods.

Alternative procurement systems are useful. Sidwell’s thesis (1982) also points out that there are advantages in the integrated organizational forms as they tend to promote integration, co-operation, co-ordination and good communications.

NEDO (1983) has identified projects that have site times 30 to 50 percent shorter than average and has also found these to have used design build, management contracting or construction management methods.

Franks (1984) rates six alternative building project management systems on five scale (complexity, aesthetic, economy, time and size) and concludes that use of a project manager is best closely followed by contractor’s design. The traditional method falls into bottom place.

Morledge (1996) in ‘The Procurement Guide’ concludes that the selection of an appropriate procurement strategy has been identified as a key decision in terms of achieving client objectives. Conversely, an inappropriate choice can be a key factor in performance failure, resulting in cost and time overruns and poor building performance. He also sees that there will be no single procurement strategy suitable for all projects and all clients.

Thus, it can be concluded that an appropriate organizational form including elements of proper project management, flexibility, effective communication and integrative
mechanisms will improve the working of the building team, and, subsequently the performance of the project.

For this research, the following statements have been proposed and would be examined further in the author’s case studies.

- Procurement is a function of the project characteristics.
- The building team is a function of the procurement form selected as this forms determines the assembly of the building team, and in particular, the contractors.
- Project/control procedures are a function of the procurement method adopted as the controls are based on the organization of the building team.
- Project performance is a function of the procurement method adopted as the particular method selected can shape the outcome of a project.

4.9.6 The project performance

Project performance is an assessment or evaluation of project delivery. It is generally seen as some combination of three factors: final cost, speed and the time taken from inception to completion and the standard of design and construction attained.

The success of a project is a subjective assessment as well as an objective measure. Whether or not a project is regarded as successful depends on whether it achieves what is required or expected. Therefore, success is a function of the needs and expectations of the relevant parties.

By and large, project performance is a function of the procurement method adopted and all performance measures (cost, time, quality, satisfaction) are interrelated with one another.

Furthermore, it is contended by the author that:

- Project success is a function of client characteristics.
- Project success is also a function of project characteristics.
• Project success can further be seen as a function of project procedures.
• Project success is a function of building team and procurement method.

4.9.7 The project environment

The term 'environment' describes all external influences on the building process. The process of designing and constructing a project can be analysed as an open adaptive system. As such it needs to respond to its environment.

The term environment describes all external influences on the building process. Broadly speaking, these influences may be grouped (Hughes, 1989) as:

- Political – government policy and the effect of national and international political decisions.
- Legal – legislation, laws and building regulations.
- Institutional – influence from professional institutions.
- Cultural – modes of behaviour by society as a whole.
- Social – social environment within which the project is operating.
- Technological – technology available to do the work.
- Economic – general economic activity and economic competition.
- Physical – physical environment.
- Aesthetic – aesthetic influence around a project.
- Policy – the translation of these total environmental influences.

As discussed earlier, there are two levels of environmental influence. On the level of the macro-environment, there are essentially five categories of interest which are cultural, economic, political, social and physical. Each of these can be viewed in a world context as being general, prescriptive and widely applicable. They each have a 'soft' effect upon the construction project and often may not be perceived as problem areas. At the level of the micro-environment, the remaining environmental factors surround and define the project. Influences from the macro-environment places demands upon the project. These have to be mitigated through the utilization of expertise in the micro-environment. Each
of the five facets of the micro-environment can interact with the other. This means that wherever a problem occurs in one of the facets, it has consequences for each of the others.

An open system is dynamic and adapts to events and occurrences (environment) outside the system by changing its structure and processes. Perhaps the most important aspect of the environment variable is that of change. Building projects with their complexity and timescale are particularly vulnerable to change in environment. The timing of an environmental influence may moderate or enhance its disruptive effect (Sidwell, 1982). The changing environment can create uncertainty, hence, the building team requires an immediate action to cope with the changing environment as this environment will have effects on the client and the construction process. The building team works within their own micro level constraints and the entire building process, building industry and client are influenced by the macro environment (Sidwell, 1978).

The idea developed here sees the process of construction as a sub-system of the client's system. As such, it is influenced by the client's environment as well as by the particular environment of the process. Recognition of the construction process as a sub-system of the client's system identifies a boundary between the process and the client's organization which needs to be integrated. The need for integration has as great an implication for the client as it has for the construction team (Walker, 1996).

During the past twenty to thirty years there have been dramatic changes in attitudes to the environment. These changes can create uncertainty, not only with regard to prices, but also in terms of investment within the work of an organization which will affect the demand for building. The demand depends on the needs and priorities of the client and in certain cases the needs may not have been forecast. In these circumstances, the client may require immediate action to meet the production programme, which in turn could influence the procurement method to be selected and, consequently, the performance of the project, but may be less visible when the project is finished.

4.9.8 Importance of organizational form

Invariably the construction of a building requires the formation of a project team comprising representatives from all parties to co-ordinate and control the building
process. The success of this team is a critical element in the performance of the project and represents the combination of diverse skills and technical activities.

Examination of the team reveals that it exhibits the characteristics of an organization. What is thought to be a team is really a coalition of people, i.e. a temporary combination of the building team for special ends but with different goals and objectives. The coalition needs to be managed so that all parties are harmonized and dissenting views are avoided. The implications for procurement method are manifest. Any system which moves away from the conflicting goals of a coalition and towards the unified effort of a team is most likely to be more efficient and effective. The problems of individuals having their own particular goals within any organization will always exist but a system which allows organizations to co-operate with one another is obviously advantageous. That is to say, appropriate organization form can improve the performance of a project.

The author has proposed a systematic study of the intrinsic principal components of the building process. Following the disciplines of system thinking, the author has also identified a number of these principal elements and proposed a conceptual model of the building process which allows the relationships of the building project team and organizational form within the process to be shown and enables further investigation of the significant determinants of project success/performance.

The conceptual model provides a framework for the definition and ordering of data on organization form within the building process. It points to those variables which must be considered or controlled in data collection and analysis. The model contributes to understanding of the procurement process, whilst being open to revision and amendment in the future. The model is flexible and allows incorporation of other variables into the contextual (client and project characteristics) and process domains. These new variables may be additional to or a replacement of the variables used in the research.

This model is considered to be useful and gives sufficient variables for further detailed study of building services integration and co-ordination in the following chapter.
4.10 Summary

This chapter firstly discussed project success and performance and secondly examined the need for an integrated building team to satisfy clients’ needs.

Following the disciplines of system theory the author had identified a number of principal elements and proposed a conceptual model. The author went further and critically examined these important elements relevant to effective management of the building process. The principal elements were also examined in conjunction with the detailed examination of the building services integration and co-ordination in Chapter 5.

The main achievements of the conceptual model were:

- An increased understanding of the complex organization form.
- Assistance in understanding the complexity of variables within the process which can be used to investigate the performance of a project.
- Providing a framework to compare different procurement systems.

The model required an additional component – building services integration and co-ordination in order to give a more complete framework for detailed evaluation of different procurement systems. However, at this stage, the conceptual model (Fig. 4.1) was considered to be comprehensive enough.

The author also identified that previous research did not address the integration of the building services designer and contractor in the organization form or the selection of procurement systems with due consideration for building services design and construction. The author had, therefore, considered the development of an additional model specially for building services integration. It was envisaged by combining these two models, more fruitful discussion of the effect of procurement method on building services could be achieved. This was seen as a major step towards the more comprehensive study of the complex building process in today’s construction industry.
Research needs to be bounded and to concentrate on a specific domain. Therefore, detailed study must be undertaken to examine the following statements in relation to the management of building services co-ordination within the building process.

1. Co-ordination is a function of client characteristics.
2. Co-ordination is a function of project characteristics.
3. Co-ordination is a function of procurement method adopted.
4. Co-ordination is a function of project procedure and managerial issues.
5. Co-ordination is a function of design professional characteristics.
6. Co-ordination is a function of construction professional characteristics.

It is also deduced from these statements that:

When the building team, project procedures, project management and quality of design and the project participants are appropriate to client and project characteristics, higher levels of success will be attained.

Hence, for efficient and effective management of building services co-ordination, the above deduction should be considered in optimising success in building services procurement.

It is important to realise that the impact of a particular procurement path on the building of an effectively integrated building team for a particular project. However, it must be stressed that the organization form is not the only factor which can influence the success of a project, the combined effect of a number of those variables within the building process model can also shape the performance of a project.

The next chapter looks at the management of building services as exemplified by the traditional system in operation in Hong Kong. This will give the necessary background and further data pertaining to co-ordination of services.
 CHAPTER FIVE

BUILDING SERVICES INTEGRATION AND CO-ORDINATION

5.1 Introduction
5.2 Integration and co-ordination of building services
5.3 Detailed study of co-ordination of building services
5.4 Integration of the four distinct building systems
5.5 Objectives of integration
5.6 Objectives of co-ordination of building services
5.7 The building services industry
5.8 The building design process
5.9 The process of building services integration and co-ordination
   5.9.1 The feasibility stage
   5.9.2 The sketch plan stage
   5.9.3 The working drawing stage
   5.9.4 The construction stage
5.10 Installation co-ordination by services sub-contractors
5.11 The results of poor co-ordination
5.12 Appraisal of building services integration and co-ordination
5.13 Summary
5.1 Introduction

Chapter 4 discussed the broad spectrum of building process, the organizational forms and the variables affecting the overall performance of a project. It is clear that specialist building services procurement of modern day buildings should be taken into consideration as the performance outcome of a project would also depend on the working of the building services contractors. Large and highly serviced buildings are usually complex projects and therefore are technically more complex in design and construction (see Figure 5.1). Obviously, successful project performance of large multidisciplinary projects would require an enormous amount of co-ordination to ensure that all cross discipline interactions are efficiently facilitated and all parties must be constantly aware of the ever-changing state of the project. Undoubtedly, effective management of building services design and installation is one advance that would facilitate the pursuit of a fully integrated and co-ordinated building.

![Figure 5.1: Co-ordination problems in the building delivery process](image-url)
This chapter presents a detailed study of the co-ordination of building services contractors within the building process and the problems of inadequate building services integration and co-ordination based on literature, reports on services and the author's surveys carried out in Hong Kong so that the impact of any building services procurement on project performance can be fully analysed in a systematic manner. This also allows the objectives of the research to be narrowed from the general aim of an understanding of the building process and its organizational forms to that of specifically, the identification of a better* procurement method for highly serviced buildings with much complex building services systems.

* This aspect has been addressed in order to contribute to the debate about best practice in building services procurement. At the outset it should be made plain that the author does not subscribe to the view that there is any such thing as best practice. The main argument is that there can never be a best practice, only better practice, in construction procurement.

5.2 Integration and co-ordination of building services

Before one can discuss any subject meaningfully one must be sure that the words that are used are understood in the same way by both the writer and the reader. Integration and co-ordination are terms frequently used in relation to building services on building projects to mean the same thing. Often these two terms are considered synonymous. But is this correct?

The Oxford English Dictionary provides the following definitions:
Integration: To combine parts into a whole; to complete by adding parts.
Co-ordination: To bring (or put) parts into proper relationship

It is suggested therefore that the word integration should be used in construction to describe the state of incorporation of all building parts, i.e. the building services, the structure, the building elements such as interior and external fabrics and the architecture of the whole building. Indeed, every building that has ever been built has been integrated. Building services integration occurs in every building, adequately or not. The integration of building services concerns the relationship between building services and the
remainder of the building (Barton, 1983). Whereas co-ordination implies the process of achieving the state of incorporation. Conversely, the co-ordination of building services concerns the interrelationship of the building services themselves (Barton, op cit.). Again, co-ordination of building services occurs in every building, adequately or inadequately.

Turner (1990) however states that “co-ordination is a balanced and effective interaction of separate actions. An act of producing a complete and integrated solution of design, of construction, or design and construction”. He also postulates that co-ordination responsibility is an inescapable part of construction procurement and a decision must be taken on how, if at all, responsibility is to be placed for co-ordination of the process of design and construction on to an organization or between a number of organizations.

Hartley (1993) however defines co-ordination differently as follows:

Co-ordination means to ‘bring together’ into a proper relationship and cause to function efficiently.

The traditional procurement system separates the two main disciplines of design and construction. The design is carried out by a consultant and the construction is carried out by the contractor. Thus the architect integrates the work of the building services consultant into the design of the project. Therefore, it may be presumed that an architect will bring together members of the design team to co-ordinate the design and that, as designers, the relevant components will fit together to function efficiently. Whereas the building services consultant co-ordinates the mechanical and electrical (M&E) engineering services. During this process, it is the engineering consultant’s responsibility to ensure that the building services will fit the space available and that the services design is integrated with the building. This is a design function within the building process. As far as the construction function is concerned, traditionally, the construction process will be co-ordinated by the main contractor. It is the builder’s responsibility, acting in the capacity of the project main contractor, to bring together the services sub-contractors and that, by planning their respective activities with other trades in an agreed programme, the various services will fit together to function efficiently.

It is clear that a co-ordinating function has existed in both design and construction for many years (Higgin and Jessop, 1965). Therefore, building process for building services is the combination of design, construction and co-ordination.
The third function of co-ordination is a descriptive of the relating together of separate activities and their concerted direction towards a common purpose (Higgin and Jessop, 1965). In their ‘Communications in the Building Industry’, they also postulate that:

- A co-ordinating function exercised over both design and construction functions by a single person (or group) is better than one where the functions have a different co-ordinator.
- If design and construction functions must have separate co-ordinators, then the best system is one where there is an early exchange of information.

They also see that different parties to the building process all have a role with respect to the co-ordination function. However, this role changes as the design/construction interface is crossed, thus indicating the dynamic nature of the building process.

Michie (1981) as a building services engineer views things differently and he breaks down the definitions of integration and co-ordination for application in the building services industry in more detail.

a. Functional integration
   “This term is used to describe a state of total design harmony, where the building fabric and the environmental services are combined to provide a space, ideally suited to its purpose or function…”

b. Spatial integration
   “This term is used to describe the state of physical harmony, service to service and service to building fabric.”

c. Functional co-ordination
   “The establishment and control during the design/build process of objectives and procedures aimed at achieving functional integration.”

d. Spatial co-ordination
"The establishment and control during the design/build process of objectives and procedures aimed at achieving spatial integration."

Clearly the sooner one can decide upon both functional and spatial integration, the sooner the co-ordination procedures can be determined and implemented in order to achieve the objectives and consequently the more likelihood that good integration will be achieved.

These definitions of co-ordination contain the words ‘establishment and control of objectives and procedures’ which are managerial issues. Butler’s definition (1977) of co-ordination is quite straightforward, i.e. the placing of items in their correct positions relative to each other and to the system of which they form a part. But he goes on and stresses that co-ordination of services should be carried out by all sectors of the design and construction team and co-ordination is necessary at technical, managerial and site operative level. Danto (1980) also defines co-ordination as putting items in their correct position relative to one another and to the system of which they form part. He also sees that management of design and construction is of vital importance. Michie (1981) goes on to emphasize that co-ordination is an important part of project management and should therefore take place throughout the project life (i.e. from design to construction). Barton (1976a & b) however contends that co-ordination is neither wholly technical nor wholly managerial but a combination of both. Kwok (1988) postulates that co-ordination is a management process which allows each trade to organize the necessary materials and labour for timely delivery to site for construction according to an agreed plan. He also contends that co-ordination of building services should have two components, namely:

- design co-ordination; and
- installation co-ordination.

Kwok further stresses that co-ordination is a complex and complicated task which requires the joint effort from all the building team members. Pasquire (1994) emphasizes on early incorporation of specialist M&E design capability for good co-ordination. Price and Gibb (1996) also see that efficient management of specialist contactor design for M&E works is an important ingredient for the integration of building services into construction projects.
The above-mentioned definitions are not exhaustive, but they highlight the following important messages within the process of co-ordination of building services.

- Co-ordination is a technical issue and co-ordination efforts must be exerted by the project design and construction teams throughout the life-cycle of the project.
- Co-ordination is also a managerial issue as this process revolves around the management of design and construction with many project participants.
- The more complex the building services, the greater the need for integration and co-ordination of design and construction.

5.3 Detailed study of co-ordination of building services

Having clarified the meanings of integration and co-ordination of building services, the author continued to look into the relevant studies before conducting detailed examination of the effect of procurement paths on the management of building services integration and co-ordination.

The relevant studies were:

- Integration of building services and its relationship with other parts of a building.
- The necessity for integration.
- The objectives of co-ordination.
- Design co-ordination of building services.
- Installation co-ordination of building services.
- Co-ordination problems.
- Effects of co-ordination problems on project performance.

5.4 Integration of the four distinct building systems

A building has four main systems or parts: structure (S), envelope (E), building services (B) and interior (I). If the interrelationships between the integration of these building systems or elements are not logical, the building will fail to perform.
Traditionally, the architect has total responsibility for the integration of these four systems. In practice, the architect relies more heavily on consultants in the area of structure and building services systems than for interior and envelope decisions, although the architect may make use of an interior designer or a curtain wall consultant.

Each system can be conceived as a distinct entity, i.e. as separate and autonomous parts. Nevertheless, in modern building design, the four systems will combine more often than not in different levels of integration.

According to Rush (1985), there are five levels of integration: remote, touching, connected, meshed and unified. All of the levels are based on an identifiable physical relationship.

- Remote: When two systems are remote from each other, they do not physically touch. (e.g. a curtain wall and an internal sunshade device).
- Touching: This relationship involves contact without a permanent connection between the systems. (e.g. surface conduit mounted on wall).
- Connected: This category applies when two systems are permanently attached directly to each other. (e.g. bed-head trunking mounted on hospital ward wall).
- Meshed: The meshed category refers to systems that interpenetrate and occupy the same space. (e.g. raised floor and under floor A/C system).
- Unified: When two systems are unified, they are no longer distinct (e.g. masonry chimney and structure).

The five levels of integration serve as a conceptual model for understanding the way integration takes place. There are two fundamental decisions to make about system integration – what systems are being considered for integration, and what level of integration will exist between or among the systems chosen.

The four building systems i.e. Structure (S), Envelope (E), Building Services (B), and Interior (I) could be combined in different ways and the task of sorting out the correct resulting integration would appear enormously complex. The versions of these combinations are:
Four-system combination
S+E+B+I

Three-system combinations with four different sets of design
1. S+E+B or S+E, S+B, E+B.
2. S+E+I or S+E, S+I, E+I.
3. E+B+I or E+B, E+I, B+I.
4. S+B+I or S+B, S+I, B+I.

Two-system combinations with six sets of design
S+E, S+B, S+I, E+B, E+I, B+I.

These combinations show how buildings can be designed in pieces or, more accurately, by separate systems. This also illuminates the complexity of integrating building systems.

From the complex realm of integration possibilities, it has been identified by the author that the following combinations occur in each of the combination modes:

- Structure + Building Services (S+B)
- Envelope + Building Services (E+B)
- Interior + Building Services (I+B)

These are by no means simple combinations as it is necessary to consider the five levels of integration altogether. The interplay of the many system combinations has meant the design of the whole is much more complex than the sum of the four systems. A change in one system or part can therefore have a serious effect on other portions of the design and construction. To help understand the complexity of the issue, a detailed combination matrix developed by Rush (1985) would give an indication of the possible combinations of the four building systems as shown in Table 5.1.
Table 5.1 Relationships among systems

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<thead>
<tr>
<th></th>
<th>remote</th>
<th>touching</th>
<th>connected</th>
<th>meshed</th>
<th>unified</th>
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<tbody>
<tr>
<td>S+E</td>
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<tr>
<td>S+B</td>
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<td>S+I</td>
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<td>E+B</td>
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<td>B+I</td>
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</table>

This basic study of integration had illustrated that:

1. Modern building design involves a great deal of building integration and satisfactory design performance requires an enormous amount of integration and co-ordination to ensure that all the four building systems are fully planned, organized and arranged by the four main professions: architect, engineer, services engineer and quantity surveyors to form a whole (perfect building). This also infers that the cross-disciplinary interactions (Services with Structure; Services with Enclosure; Services with Interior and even Services with Services) must be facilitated and managed throughout the building process.

2. Building design problems are now of such magnitude and complexity that no individual is capable of addressing all aspects of building design (Newton 1995). The result has been the gradual crystallization of individual disciplines, each responsible for certain parts of the design work. Specialization has obvious benefits, but if the many individual groups are not co-ordinated properly the design and construction processes remain fragmented, resulting in problems or errors and inefficiency.

3. The functional decomposition of a building design into individual disciplines if not managed properly may not always be conducive to co-ordination and communication within the design team. Each specialist works within their own well established paradigms, each with its own view on the most suitable solution (Rzveski 1993). For instance a wall can be a structural component (a load bearing element), an architectural component (an envelope or for aesthetical value) or a mechanical services component (an insulator). Each discipline will have its own viewpoint on the most suitable solution for their requirements; efficient co-ordination and
communication is needed across the disciplines to reach a compromise suitable to all in such a situation. Obviously, problems can be heightened if disciplines do not have an understanding of the technology, terminology and philosophy of other discipline’s work. It is also essential that team members know how others use cross-discipline information and how and in what form they require it to be structured.

4. Initial considerations for the space required for building services should take place at the inception stage, but this decision heavily depends on:

- Full understanding of client’s needs which are often not clear or given at this stage.
- Completion of a detailed evaluation of the whole building design. However design never has a single optimum solution (Greorgy 1966). Furthermore, design is never a single problem but as a series of sub-problems (Cross 1989) and design is an interactive process (Eppinger 1991). During this stage, the architect has not yet developed the design and this adds difficulty in evaluating the design of building services systems and their space requirements.
- The experience and judgement of the building services engineer. During this stage, sufficient spaces for services will be quickly allowed for and this exercise must avoid over provision which is a waste of scarce space resources, or under provision, which certainly creates difficulties for further design and the services installation. Studies of how designers actually work undertaken by the author have shown that design activity is an iterative process whereby an initial conjectured solution to one part of the design is progressively refined and checked for compatibility with other emerging aspects of the design. This iterative process can therefore affect building services designs.
- Special requirements such as:
  - Flexibility of building design to cope with present and future needs of the building users.
  - Minimum interference with various architectural and structural elements.
  - Constraints due to building design and its construction method and the need for early use of part of the building.
- Maintenance of services and possible future development of the building.
- Cost effectiveness of the services systems.

Indeed, this initial integration is the most important part of a building design process. A properly integrated design with adequate spaces for the M&E services would obviously give better quality of a building and consequently, resulting better and smoother integration and co-ordination of services to be followed after this initial design. It is clear that individual competence does not lead to collective competence, but team effort is by far the most crucial factor.

5.5 Objectives of integration

Having examined the complexity in integrating all building systems, it was felt necessary to define the objectives of this task so that the relevant studies could be examined for a complete analysis of building services procurement.

Designing buildings with a degree of servicing is rather like assembling a hi-fi system. The components and subsystems need to be ‘balanced’ to obtain the desired performance without unnecessary expense. Poor performance of one component is likely to drag the overall system performance down, thereby wasting the expensive high performance of the other components. Therefore, building services must be carefully integrated with other building elements.

In a preliminary study of integration and co-ordination of building services, Danton (1980) from a building services engineer’s viewpoint suggests the basic requirements of integration are that:

- The building fabric, as designed, minimizes thermal and energy conservation problems, normally presented to the services engineer.
- The complete integration of building services and structure be entirely feasible in view of the complexity of modern buildings.
- The design should be suitable for the practical realization of the necessary building routines.
• The design and subsequent construction can be properly monitored.
• The design team is properly motivated.
• The client's demands are to be met.

Most importantly, the design and subsequent construction can be properly carried out smoothly and without co-ordination problems.

It was sufficient to say from Danton's work that the performance of integration and co-ordination of building services would have a direct bearing on the client's demands/needs. It is necessary to achieve a balanced design and possibly smooth building construction, Danton also contends that the following factors could affect co-ordination of services:

- The conditions of engagement for services engineers and the related fee structure.
- Communication between the disciplines.
- Design procedures and practice.
- Management structure.
- Cost effectiveness.
- Site organization.

These factors correspond with those suggested by Butler, (1977) and Vincent & Happold (1977). The two important additions are those of management structure and site organization. All these factors will have to be analysed after the completion of the study of detailed design co-ordination and installation co-ordination.

5.6 Objectives of co-ordination of building services

A building client requires his/her building to be:

• Functionally satisfying.
• Aesthetically.
• Completed on time.
• Completed within budget.
Good value for money.

These are seen to be the objectives of most building projects. As discussed earlier, co-ordination of building services is almost equivalent in meaning to control, planning or management of both technical and managerial issues pertaining to building services design and installation. Thus, this implies that the objective of co-ordination of building services is to satisfy the client’s needs in terms of cost, time and quality of building services and the overall project and performance. In the building process, the different members of the building team all have a role with respect to this co-ordination function.

Co-ordination must be carried out within the various M&E services disciplines first. By virtue of the nature of building services, the various building services systems and sub-systems are interconnected. The action on one system affects the other and therefore there is a need to co-ordinate all these systems and sub-systems. At the same time, all services must be co-ordinated with the architectural and structural elements. Again, failure to integrate all disciplines together can lead to many design, construction and co-ordination problems.

In order to gain a greater understanding of the relationship between the objectives of co-ordination and the need for co-ordination of building services, the author had to review all literature and reports pertaining to the co-ordination process.

Crawshaw (1976) undertook a comprehensive study of poorly co-ordinated working drawings with special reference to building services based on 25 projects. He identified that:

- The co-ordination process is vital to the smooth running of any project.
- Poor co-ordination results in cost and project overrun.
- Low standard of workmanship as a result of poor co-ordination.
- Co-ordination faults cause friction between the contractors and the designers.

In his conclusion, he highlights that co-ordination faults can be expensive and disruptive and that the co-ordination problems can have serious effects on the organization and
management of a project. In other words, the project would not meet the client’s satisfaction in terms of cost, time and quality.

Butler (1977) carried out a preliminary study of co-ordination of building services and concluded that the co-ordination of services is a desirable part of the design/construction process and that the lack of it can lead to additional contract costs and delays in the construction phase. These views are supported by Crawshaw (1976) and the statistical evidence provided in his paper. Furthermore he added that effective co-ordination of building services would permit practical, economic and aesthetic building services installation within the building structure, providing also for reasonable access and maintenance facilities.

In an Institute of Building Occasional Paper entitled “Co-ordination of Mechanical and Engineering Services” Barton (1978) cites that problems on site caused by poor co-ordination of services are common to most projects and are usually the most disruptive and expensive to deal with. Any improvements in co-ordination within both the design and construction teams should therefore play a significant part in improving the co-ordination of services work within the overall building process. Barton does not give many details about the objectives of co-ordination, but by referring to several of his articles on services co-ordination on sites (Barton, 1976, a & b), it appears that Barton contends that expensive co-ordination problems associated with the integration of building services within a building during its design and construction can be tackled by better management of design and construction. This not only improves the co-ordination of services on site but can also shape the performance of a project. In other words, effective co-ordination of building services can offer a higher chance of better project outcome and should therefore be pursued by the whole building team if they wish to serve their clients well.

Monaghan (1978) describes the procedure developed for the co-ordination of services and states that there is a need for effective co-ordination if the project is to be successful, he sees that the orderly organization of the M&E systems from inception to installation is a must in order to ensure that:
• No conflict occurs between the various services.
• No physical interference between services elements and the building structure or finishes.
• A correct installation sequence is established and followed by all contractors.

Hence, one might agree that the effective co-ordination of building services would minimize conflicts and associated co-ordination problems so that the construction of building would be smoothly carried out within the time specified.

Spiers (1978) also sees that it is the effective co-ordination of building services with greater use of management skills that will ensure satisfactory project performance in terms of cost, time and quality.

All that is written in the three papers supports the author’s contention. The smooth running of a contract during the installation of M&E services would be the most demanding test of management expertise, not just for the main contractor and the specialist sub-contractors involved but also for the client, architect, quantity surveyor and consultants.

Danton (1980) and Michie (1981) have investigated the integration and co-ordination of building services and its relationship with project management from the services engineer’s point of view and both contend that the benefits of effective co-ordination of building services could be enormous. The benefits are:

• To meet client’s demand (Danton).
• To provide a fully integrated final building (Michie).
• To avoid additional contract costs and delays in construction (Danton).
• To reduce tender figures and site works orders, programme delays and contractual claims (Michie).
• To improve maintenance and replacement of services (Danton).
• To reduce building cost-in-use (Michie).
Both Danton and Michie recognize the long lasting problem of integration and co-ordination of building services. They all consider that improvements in design procedures and management structure are needed to achieve better project performance.

As the author's research was based on building projects in Hong Kong, it was necessary to see whether the previous research results discussed would be similar to the situations found in the projects in Hong Kong.

Kwok (1988) as Assistant Director (Building Services) of the Hong Kong Government's Department of Electrical and Mechanical Services, contends that with better planning, organization and co-ordination by the building team, the following overall objectives of co-ordination should be achievable:

- To complete the project on time.
- To complete the building with the allowable costs.
- To complete the project with high quality of services.

Kwok adds that the objectives of co-ordination of building services are:

- An orderly construction programme.
- Reduction of obstruction between different trades.
- Reduction of congestion in each space.
- Improvement of human relations on site.
- Improvement of safety on site.

Kwok advocates the great need for co-ordination of building services and project management from a client oriented viewpoint since the performance of many highly serviced modern government hospitals and some intelligent office buildings are not wholly satisfactory. The most frequent complaints are:

- Projects are late and not to budget as a result of lack of efficient and effective management of building services on site.
• Excessive claims for loss and expense by contractors as a result of co-ordination problems.
• Inadequate space to fit building services and difficult maintenance of services in congested spaces.
• The lack of communication between the client and the design team.
• The lack of teamworking between the design team and the contractors.
• The failure of the design to meet the client’s requirement in terms of provision of building services.

Woods (1987) investigated building services co-ordination in Singapore. He also notes that co-ordination of building services can result in:

• Ease of construction leading to prompt completion of construction work.
• Minimal variations which maximize profit for contractor and minimize potential additional costs to the client.
• Effective design and construction teamwork between professionals tending towards a product of greater quality.
• Anticipation of space requirements preventing either gross over-provision or under-provision of service areas.
• A better aesthetic appearance of the service element.

The author of this study also identified the following findings from his discussions with all professionals and case studies both conducted in Hong Kong.

• Problems associated with the integration of building services within a building during its design and construction are the most disruptive and expensive. The problems are mainly due to inadequacies in management of both the design and construction phases.
• Lack of co-ordination does have a definite and adverse effect on the construction process.
• It is vital that building services installations are adequately designed, integrated and co-ordinated from design through construction and that if this is done, significant
improvements in project performance in terms of cost, time and quality will be realised.

- It is quite clear that co-ordination of M&E services should have been managed by the building team in view of the adverse effect of poor co-ordination on project performance. It is also clear that management of specialist building services procurement would not be an easy task.

Having reviewed the objective of co-ordination of services. It is necessary to examine the following issues in order to gain a clearer understanding of building services procurement:

- The practice and management of building services co-ordination in the design and construction phases under the traditional approach.
- The shortcomings of the traditional approach.

5.7 The building services industry

The building services industry is not a single entity (O’Hea, 1996). It is made up of a diverse number of active participants, namely:

- The customers, developers and end users who are served by the industry and who have an influence on it.
- The specifiers and consultants who design the services.
- The manufacturers which supply the components that give physical form to the designs.
- The M&E contractors who take responsibility for integrating and installing the building services equipment on site.

In particular building types, a substantial proportion of the construction work and building cost is associated with the provision of building services. Building services now account typically for 15-25% of the total construction cost of a new building although for special buildings this can be as high as 50-60%. The quality of building services design and installation would therefore shape the performance of a project. A very important
influence on the industry is the need to achieve first class customer satisfaction. Therefore, to satisfy clients, building services would have to be adequately designed, integrated, co-ordinated and installed by the building team and, in particular, the building services consultant and the various specialist services contractors, all working together as an effective construction team to produce the best solution.

Construction clients have become more commercially minded, more discerning and more demanding of better performance, better value for money and faster construction (Smith et al, 1995). As large buildings such as hospitals, hotels and commercial office developments become more technologically complex, their M&E services have also become more complex and sophisticated. Clients now require a higher standard of M&E services performance and provision; and generally have higher expectations of quality. These changes in M&E services requirements, together with shortening of design periods and the increase of specialist subcontractor design and co-ordination of services, have resulted in complications in the design and procurement of M&E services. In other words, it implies that quality management of design and installation of building services should exist in building procurement. How is this good design and construction achieved? To answer this question, a review of the design process and the building services integration of co-ordination is required.

5.8 The building design process

The central issue is: how does the management of building services design and installation processes operate? An understanding of this is considered essential if the concept of procurement forms and their differences are to be investigated. The construction process is the framework within which the procurement form is situated and according to which the procurement form can be analysed.

Pugh (1990) defines the ‘total design process’ as the systematic activity necessary from the identification of user needs to the realization of information to create the final product. Pugh’s total design process definition can be applied to the building design process: the need is the client’s wish to have a suitable building and the information produced allows the construction phase to proceed efficiently.
Newton (1995) adds that a building design process is a multi-disciplinary process, performed in a series of iterative steps, to conceive, describe and justify increasingly detailed solutions and costings to meet the needs of the client. He also sees that a building design describes the ideas and philosophies of the building designer produced at any time during the building design process. This may take the form of an option sketch produced during a feasibility study, a set of calculations, specifications or construction drawings.

A study of literature from all construction and building services professions, backed up by interviews with various building design professionals and from the author’s own personal experience, gave an insight into the strengths and weaknesses of current design practice in Hong Kong. From this it was concluded that:

a) In general, the RIBA (Royal Institute of British Architects) Plan of Work for design team operation is the normal framework for design of buildings.

b) There are problems in the management of building design. The problems are inter-related, and they can be attributed to one of the following six categories:

- Increasingly sophisticated clients.
- Fast-tracking pressures on design for early completion of buildings.
- Increasing building complexity.
- Difficult and insufficient information management.
- Difficulty in planning design work as a result of many design organizations/designers and an enormous amount of co-ordination.
- Modern buildings are so technically complex that all the design processes involved in a multi-discipline design project cannot be understood by an individual.

c) During construction it is commonplace for problems to occur between building services and other components of the building. These have three main causes:

- Design-related problems.
- Installation-related problems.
- Procedural and data co-ordination problems.
At the outset of any project it is essential that the client’s project team define an overall plan of work within which individual activities can be placed. This will help to focus the team on the activities required and the order in which they must be completed. The RIBA plan of work is a document accepted throughout the construction industry.

The RIBA Plan of Work, originally published in 1964, is a prescriptive model procedure for the methodical working of a multi-disciplinary team on a typical project. Although the RIBA plan of work is written for application to the building as a whole, the plan is now generally viewed as inadequate for building services design.

An outline view of the model is shown in Table 5.2

<table>
<thead>
<tr>
<th>Stages</th>
<th>Parties</th>
<th>Client</th>
<th>Architect</th>
<th>Quantity Surveyor</th>
<th>Civil/Structure Engineer</th>
<th>M&amp;E Engineer</th>
<th>Main-contractor</th>
<th>Sub-contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Inception</td>
<td>xxx</td>
<td>xxx</td>
<td>xx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Feasibility</td>
<td>xxx</td>
<td>xxx</td>
<td>xx</td>
<td>xxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Outline proposals</td>
<td>xx</td>
<td>xxx</td>
<td>xx</td>
<td>xxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Scheme Design</td>
<td>xxx</td>
<td>xxx</td>
<td>xx</td>
<td>xxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Detail Design</td>
<td>xx</td>
<td>xxx</td>
<td>xx</td>
<td>xxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Production Information</td>
<td>xxx</td>
<td>xxx</td>
<td>xx</td>
<td>xxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Bill of Quantities</td>
<td>xxx</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. Tender Action</td>
<td>xx</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
</tr>
<tr>
<td>I. Project Planning</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td></td>
</tr>
<tr>
<td>K. Operations on site</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td></td>
</tr>
<tr>
<td>L. Completion</td>
<td>xxx</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
</tr>
<tr>
<td>M. Feed-back</td>
<td>xx</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
</tr>
</tbody>
</table>

N.B. The main body of the RIBA Plan of Work that lists the duties and actions for each design function for each stage of the design.

xxx = main participant (primary responsibility)
xx = secondary participant (secondary responsibility)

Table 5.2: The RIBA Plan of Work Structure
The RIBA plan of work is a framework of stages describing all the management tasks and design work in a project programme, from the initial contract between client and architect to the point when the building is completed and in use, as can be seen in Table 5.3 with details of work to be carried out by the services consultant.

**Summary of Plan of Work Stages with Building Services Work**

<table>
<thead>
<tr>
<th>Plan of work stage</th>
<th>Purpose of work and decision to be reached</th>
<th>Task to be done by building services engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Inception</td>
<td>To prepare general outline of requirements and plan future action.</td>
<td>Establish clear project intent</td>
</tr>
<tr>
<td>B. Feasibility</td>
<td>To provide the client with an appraisal and recommendation so that he may determine the form in which the project is to proceed ensuring that it is feasible functionally, technically and financially.</td>
<td>Undertake a preliminary appraisal of all building services systems, built form and construction standards. Establish cost.</td>
</tr>
<tr>
<td>C. Outline proposals</td>
<td>To determine general approach to layout, design and construction in order to obtain client's approval of outline proposals.</td>
<td>Develops and agree the brief. Select most suitable systems. Produce cost plan. Basic integration.</td>
</tr>
<tr>
<td>D. Scheme design</td>
<td>To complete the brief and decide on particular proposals, including planning arrangement, appearance construction method, outline specification, and cost, and to obtain all approvals.</td>
<td>Final development of the brief, provide preliminary design and integration of building services. Prepare revised estimate.</td>
</tr>
<tr>
<td>E. Detail design</td>
<td>To obtain final decision on every matter related to design specification, construction and cost.</td>
<td>Full design of services including integration and co-ordination of services. Complete cost checking of design.</td>
</tr>
<tr>
<td>F. Production information</td>
<td>To prepare production information and make final detailed decisions to carry out work.</td>
<td>Complete drawings, schedules and specification. Complete detailed co-ordination.</td>
</tr>
<tr>
<td>G. Bills of quantities</td>
<td>To prepare all information and arrangements for obtaining tender.</td>
<td>Preparation of bills of quantities and tender documents.</td>
</tr>
<tr>
<td>H. Tender action</td>
<td>To obtain tenders and negotiate for agreements on costs.</td>
<td>Preparation of tender documents. Evaluation and award of tenders.</td>
</tr>
<tr>
<td>J. Project planning</td>
<td>To establish the programme and to make arrangements to commence work on site.</td>
<td>Project management with contractors and further co-ordination of services.</td>
</tr>
<tr>
<td>K. Operations on site</td>
<td>To follow plans through to practical completion of the building.</td>
<td>Site supervision. Cost control. Co-ordinate work by all.</td>
</tr>
<tr>
<td>L. Completion</td>
<td>To hand over the building to the client, remedy any defects, settle the final account, and complete all work.</td>
<td>Testing and commissioning. Final account.</td>
</tr>
<tr>
<td>M. Feedback</td>
<td>To analyse the management, construction and performance of the project.</td>
<td>Not usually provided.</td>
</tr>
</tbody>
</table>

Table 5.3: Tasks of building services designer
There are twelve stages shown in the Plan of Work, represents the logical sequence of design work; passing from stage A: Inception through to stage M: Feedback. For each stage there are design functions performed by the various participants involved in the project. It is assumed the architect is responsible for leading the client and the design team, and therefore, has two functions within the Plan of Work, a management function and a design function. Within the body of the Plan of Work the actions and duties of each participant are listed for each stage of the work. The typical functions described include:

- Design studies/work to be performed.
- Proposals and options to be considered.
- Decisions and actions to be taken.
- Discussions and meetings to be accomplished.
- Information to be elicited and provided.

Although the architect is the lead designer, in accordance with the ‘wheel of dominance’, the lead of the whole design process at any one time can change in emphasis, and the organization and people within it should have a flexible attitude to their leadership role (e.g. building services engineer is the leader for M&E system design, but other design team members are secondary designers).

These duties represent an outline method of working on a general project and need adapting to the specific needs of individual projects.

The RIBA Plan of Work has been frequently used to provide a systematic framework within which design can be managed and has gained wide recognition as a benchmark within the building industry. However, the plan is only a checklist describing what should be done at which stage of the design life cycle. It is not detailed enough to schedule individual activities nor define task durations to produce workable design programmes. The Plan of Work also describes the complete project life cycle from Inception through to Handover and Feedback, making parts of the model redundant for the purpose of planning design. From the surface of this framework, the important issue of building services integration and co-ordination is not evident.
However, The design functions within the Plan actually dictate many management functions, such as overseeing design work and co-ordination task. Tasks such as these would be deemed to be ongoing throughout the design. As far as building services is concerned, the co-ordination task should form part of an inherent part of the design process.

In all the RIBA Plan of Work is an accurate representation of the design process for the level of detail shown. However, the basic Plan of Work (including the new Plan of Work), as it stands, is too generic to plan the individual participants’ work on a day-to-day basis.

Although the design stages of the RIBA Plan of Work fit well with architectural design, they are not always well matched to building services design appointments. The major problems generally stated with regard to building services management are usually given in the context of work carried out under traditional procurement as detailed by the RIBA plan of work. Examination of the plan of work shows that the system of managing the building services elements of a project is in fact different from that used for managing the building work (or main construction work). For example, for the architect, briefing proceeds through the scheme design stage concluding with a consolidated brief. This then forms the basis for detailed design before going out to tender. However, for many building services design appointments, design activities may end after the Scheme/Detail design stages, as detailed design being carried out by the installing contractor when appointed. It is this arrangement which complicates the co-ordination process because the consultant’s design is not the final one and all previous co-ordination works require double-checking. Arguably the building services element of construction projects does not even exist within this RIBA plan, but is outside of it and to some extent independent of it.

The author’s research into the co-ordination of design revealed significant misunderstandings over responsibility for design and co-ordination arising from the terms and conditions of appointment promulgated by the professional bodies.

The design and construction functions in the building process have become too separated as the consultant and the sub-contractor are paid to carry out distinct stages of the process.
with a minimum of overlap and yet design should anticipate space, access, maintenance and operational problems.

There is no doubt that most clients expect the architect to take responsibility for bringing the different parts of the design into order and combining them as a whole. The architect is normally engaged under the RIBA Conditions of Engagement and the appointment says: “The architect will have the authority to co-ordinate and integrate into the overall design the services provided by any consultant, however employed”. But the architect will not be responsible for their detailed designs, inspection and performance of the work entrusted to them. Although ill-defined it is clear that the responsibility for functional and spatial co-ordination lies firmly with the architect who will base sequence of working on the RIBA plan of work. Because of the architectural background and training, it is not uncommon that many architects have difficulty in fulfilling the co-ordination role given the increasing content and complexity of services in many buildings.

The building services consultants normally undertake commissions in accordance with the ACE (Association of Consulting Engineers) Conditions of Engagement. Under the ACE conditions, design information is normally limited to the production in sufficient details of drawings and specifications in order to obtain tenders. Preparation of detailed drawings, co-ordination drawings and builder’s work drawings are specifically excluded from the normal fee agreement, and would attract additional fees. This is clearly not satisfactory from the client’s point of view and therefore not generally carried out. Evidence exists to suggest that the additional fees charged can vary from 1½ to 4 per cent of the service’s tender.

So it is seen that the architect is responsible for co-ordination but requires support in this from the consultants who are not obliged to give it, as they are not normally paid to do so. In this circumstance therefore it is not surprising that co-ordination of services suffers and is not usually completed.

The duties to be performed by the building services consultant under the Association of Consulting Engineers three schedules of duties may be:

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a) Full Duties (renamed to Additional Services)

All duties are grouped under stages which may be equated to those of the RIBA Plan of Work. The duties listed in Stages 1 to 6 (1 to 2 for Pre-design and 3 to 6 for Design) are intended to harmonize with those performed by the architect under Plan of Work Stages A to F.

b) Abridged Duties (renamed to Normal Services)

All duties are grouped under stages which may be equated to those of the RIBA Plan of Work. The duties listed in stage 1 to 4 (1 to 2 for Pre-design and 3 to 4 for Design) are intended to harmonize with those under Plan of Work stages A to D only. A Sub-contractor would then be appointed to develop the Tender Drawings further, i.e. Plan of Work stages E to F.

N.B. For the full duties and normal services already described. The consultant is required to ensure that all building services are developed in a manner compatible with the structural and architectural concepts. The preparation of co-ordination drawings is outside the scope of the engineer’s service. For any project the degree of detailed inter-service co-ordination will be decided, based on the consultant’s perceived need for this function. Less complex installations would require a minimal level of co-ordination.

c) Performance Duties

All duties are grouped under stages which may be equated to those of the Plan of Work. The duties listed in stages 1 to 3 are intended to harmonize with those performed by the Architect under Plan of Work stages A to C only. A sub-contractor will be appointed to develop the Sketch Drawing during Plan of Work stages D to F.

N.B. The designer must be very experienced to be capable of visualizing all the services systems in order to describe the requirements for design development well, with the minimum of documentation. Obviously, most of the building services
integration and co-ordination would be left to the specialist contractor in this particular circumstance.

Under the ACE Agreement, an engineer is only required to prepare and draw up such designs, drawings and specifications as may be necessary for placing a contract for the execution of the works. The use of drawings is one of the principal methods by which the information is conveyed to an installing contractor. The designer’s drawings will therefore form the basis on which the installer will tender for the installation works.

In practice, building services design is not a discrete activity with neatly defined boundaries of responsibility carried out by a single company or individual, but is more typically an evolving process to which professional designers, specialist designers, manufacturers and installation engineers may contribute. The more enlightened consulting firms consider that they should be responsible for all aspects of design and that this includes what is called design development as carried out by the services contractor, i.e. the preparation of installation details after final selection of plant and equipment. However not infrequently the onus for this work is placed on the nominated services sub-contractor and the responsibility for it is also placed on the main-contractor. Because the final selection of plant and equipment is left to be carried out by the services contractor upon appointment there is a break in the flow of detailed services information. The break occurs at the tender stage when other members of the project team are settling final arrangement details. It is therefore not compatible with the objectives of co-ordination as services information is out-of-step with the rest of the project. Clearly, this practice does not make effective and timely co-ordination.

Design influences the speed of projects in two ways (NEDO, 1988): firstly the co-ordination of design affects the coherence of the design information and its timely communication; secondly the buildability of the design is linked to speed on site. As far as building services were concerned, the author would also add the “building services co-ordination” as the third factor.

Increasingly more people from different autonomous organizations are involved in the design process, including consultants, specialist subcontractors and suppliers. With traditional procurement, continuity in the development of design can therefore be severely
affected by the sequence in which the design and building services contractors are appointed. The author had identified that inconsistencies and delays in the production of design documentation were common in Hong Kong and usually a source of aggravation on sites. Clearly, the traditional method of management of building services design would not easily produce conditions conducive to effective co-ordination. On the other hand, where clients had established a firm and well-defined context for co-ordinating the contributions and responsibilities of all the main participants (architect/services consultant/services contractors and main-contractor), including their own, project outcomes would be more satisfactory (Phillis, 1988).

5.9 The process of building services integration and co-ordination

As mentioned earlier, building services co-ordination is a very complicated task which requires joint effort from all the design team members since:

- The job of determining optimum solution of a particular building services system, for a list of given constraints, demands effective communication and co-ordination within the design team because design:
  - is an interactive process;
  - never has a single optimum option; and,
  - is never a single problem but as a series of sub-problems.

- The interplay of the many components within a building has meant the design of the whole is much more complex than the sum of the parts. For instance the fabric, structure and thermal dynamics of a building are so interdependent that although a clearer understanding has evolved of the science of these components, their combined design has become more complicated. Design problems are now of such magnitude and complexity that no individual is capable of addressing all aspects of building design. Another consequence of the increasing integration of components is the effect of changes or revisions, with a change in one part having a ‘domino effect’ on other portions of the design (Crabtree et al. 1993).
• The functional decomposition of a building design into individual disciplines is not always in empathy with the requirements of individual parts of the building. Each specialist works within their own well established paradigms, each with its own view on the most suitable solution. Specialisation has obvious benefits, but if the many individual groups are not co-ordinated properly the design work remains fragmented, resulting in errors and inefficiency. As each discipline will have its own viewpoint on the most suitable solution for their requirements: co-ordination and communication is needed across the disciplines to reach an integrated design.

• The complexity of modern buildings, both in their content and construction, has dramatically increased the pressure on the design team to satisfy the information requirements of the site process, including:

  - a fully developed architectural solution that would complement all building elements.
  - a fully developed structural solution that would complement the architectural and building services.
  - fully developed, integrated and co-ordinated building services solutions complementing the architectural and structural elements.
  - complete information for contractor’s further design development, physical installation and subsequent operation and maintenance of all building services systems.

From the author’s surveys in Hong Kong, the design and installation co-ordination of building services would normally be implemented through the following stages throughout the life cycle of a building project (also applied internationally): -

• the feasibility stage;
• the sketch plan stage;
• the working drawing stage;
• the construction stage; and
• the occupation stage.
This design process assumes that the design team is appointed first and designs the building and its building services. Tender documents are then prepared as the basis by which a contractor is chosen, who then continues the design and constructs it. This is only one way of procuring a building and of course, there are many other procurement methods where the relationship between the design team, the client and the contractor varies.

Before 1970, the project architects in Hong Kong assumed the co-ordinating role between disciplines. Now that building services have become sophisticated and complicated, coordination is reassigned to the building services consultant. Nevertheless, the architect is still responsible for the overall co-ordination task.

5.9.1 The feasibility stage

Since the building services form an integrated part of a building, integration and co-ordination of the building services would have to be started at the initial stage, i.e. the sketch plan stage.

The client’s design brief is the main working target for the design team. With the traditional procurement approach the architect, as manager of the building team, has conventionally assumed the task of attempting to control and co-ordinate the client body and of achieving compromise and consensus in the design briefing and, subsequently, the requirements of the design of buildings. The quality of a design briefing would therefore have a significant impact on the completeness of a building design and the integration of building services as poor briefing and incomplete design information could result in substantial changes in designs and as a consequence, difficult integration of services.

The purpose for carrying out feasibility studies is to ensure that the client’s objectives are technically viable and can be achieved within the specified limits of cost and programme. Based on the author’s research results and experience gained while working in several consultants, the building services consultant will aim to:

- evaluate building design;
• identify estimated building loads from scarce information of building layout and access impact on the selection of building services systems;
• discuss likely space requirements for equipment and options for location of plantrooms and service ducts/cores;
• commit spatial requirements for building services systems. This design information is usually required at this stage in order to enable architectural and structural designs to proceed. Initially this information is likely to be an approximation based on a notional allowance for plant space. The adequacy of the services together with their space allocation is a very important design process which would only be determined by an experienced engineer;
• perform appraisal of building services feasibility study;
• advise on limits of cost;
• provide rough design sketch;
• prepare a broad outline of project programme;
• decide the management approach; project policy; procedure and process; and
• review/agree the brief.

The feasibility studies must be conducted with input from other members of the design team. Spaces, plantrooms, services routes and special needs for M&E services must also be agreed in principle in order to avoid spending time examining options which are not practical due to other building constraints. The author identified from his surveys in Hong Kong that, in practice, space allowances are always difficult to assess at this critical stage as:

• The layout of the building is only in a rough form and services loads can only be estimated based on rules of thumb and previous job experience.
• Building height and floor-to-floor height are not yet fully determined but spatial requirements especially for the critical ceiling void must be given to the architect to enable the building design to progress. This requires an engineer’s preliminary and yet reliable judgement based on the rough area of certain preliminary architectural floor plans and the anticipated services system design as well as installation and maintenance requirements.
• M&E services plant rooms and service ducts cannot be fully determined at this stage, and rough ideas in terms of sizes and ideal locations must be made and recommended for the architect’s consideration.

The author also identified from his surveys in Hong Kong that:

• For typical buildings like high-rise residential buildings and some office buildings, the determination of spatial requirements required for M&E services can be managed by most services consultants without severe problems.

• The design co-ordination of building services in connection with spatial requirements would be a very difficult task for highly serviced buildings such as hospitals, institutional buildings, large hotels and complex facilities.

• This design co-ordination can only be carried out when the preliminary architectural drawings are available and the client’s requirements have all been clearly identified by the services consultant.

• The success of this vital functional and spatial integration has a direct bearing on the quality of the M&E services design which can seriously affect the distribution of services and their co-ordination.

5.9.2 The sketch plan stage

The design solutions accepted in principle at the feasibility stage now form the basis of a more detailed examination of the selected systems and how they will fit into the building.

At this stage detailed discussions would be taking place with the other members of the design team to ensure that the systems proposed are properly integrated and co-ordinated with other building elements.

From the author’s surveys based on some large consulting engineers in Hong Kong, he identified that the building services consultant will:

• Incorporate client’s requirements.

• Refine building loads.
• Review spatial requirements based on detailed load assessments together with more
detailed layouts prepared by the other members.
• Provide basic service layouts and schematic diagrams.
• Undertake services integration and co-ordination exercises between the various
services engineers and the other members.
• Consult specialist suppliers/contractors for engineering data, i.e. building automatic
system, sophisticated fire controls, water treatment, etc.
• Appraise scheme design.
• Develop alternatives.
• Update cost estimate.
• Perform technical feasibility analysis of project.
• Review/agree the design.
• Complete basic design.
• Seek approval from client and authorities before carrying out further design.

Building Services integration and co-ordination is a continuing process during this stage.
Each team member would seek to avoid over provision of spaces for services which is a
waste of the scarce space resource, or under provision which could create difficulties for
installation, testing and commissioning and operation and maintenance of the systems.

When more detailed designs become available from the architect and structural engineer,
more elaborate and detailed building services integration and co-ordination would have to
be undertaken by the services engineer. At this stage, changes or re-designs of any one or
all of the building elements to facilitate effective integration and co-ordination of services
are still feasible. Obviously, this demands a joint effort from all the design team members
and the use of effective communication and co-operation across the disciplines to reach a
compromise suitable to all.

Based on the author’s surveys in Hong Kong, during this intermediate stage, the services
consultant would:

• Determine the capacities of the various systems based on the architect’s input and
advise on possible modification of the building design.
• Select the most optimum M&E services and integrate them into building with the architect and structural engineer.

• Plan the most optimum pipe/duct runs in conjunction with the designs of the other members of the design team.

• Confirm size and location of:

  - M&E services plant room.
  - services ducts.
  - special enclosures for services.
  - ceiling voids (based on preliminary segregation of services by zoning within the service space, i.e. ceiling and lighting zone, clearance, ducting zone and piping zone).
  - major builders work for M&E services.

• Co-ordinate all M&E services based on basic system layouts between all services engineers.

• Identify all works by trades and establish a sequence of construction in each space.

At this stage, detailed co-ordination of services is not yet feasible as detailed working drawings have not yet been prepared by the various services disciplines. However, as long as the scheme design is thoughtfully planned, conflicts would be minimized at later stages.

Survey results also indicated that design co-ordination among the architectural, structural and building services is a task requiring effective communication and management. Therefore, for effective design co-ordination, most consultants would assign the lead services engineer to be the building services co-ordinator to:

• Co-ordinate all M&E services first among M&E services engineers.

• Co-ordinate services with architectural and structural services.
With this arrangement, the architect only needs to deal with one services engineer and this single-point communication greatly improves the communication and co-ordination process.

5.9.3 The working drawing stage

This stage involves preparation of design drawings and specifications suitable for obtaining tenders for the work. From the author’s detailed surveys amongst some large M&E consulting engineers, the building services engineer is to:

- Obtain final decision on every matter related to design, specification, installation and costs.
- Complete fully integrated and co-ordinated building services drawings.
- Confirm all relevant details passed to architect and structural engineer regarding plant weights, space requirement, structural openings, access, etc.
- Produce complete technical and non-technical information for the construction team (i.e. the main-contractor and sub-contractors).
- Update estimate for cost control purpose.
- Carry on management of design.
- Review design.
- Carry on management of tendering.

This is the final stage of building services integration and co-ordination of the design phase. Building services engineers will have to ensure that all finalized building services systems and sub-systems are free from interference with various architectural and structural components/elements.

In theory, designs should have been fully completed by all members of the design team. Technically, all necessary design drawings and detailed design information should be made available to all designers and contractors and it is possible to make use of all drawings to check whether the proposed M&E services systems are fully integrated and co-ordinated, i.e.
• Sufficient space for each of the M&E services.
• Services will not conflict with services when they are grouped together.
• Services will not conflict with the structural frame.
• Services are free from interference with the architectural element.
• Services can be properly fixed and installed in accordance with a logical sequence of works.

Between 1970 and 1980, the majority of building designs in Hong Kong were not so complex as today’s buildings, building services co-ordination was not a problem area in the building construction industry (Banham, 1983). The factors identified by the author during his surveys were:

• Compared to modern buildings, building services design was not complicated.
• Adequate spaces for building services had been provided as building height was not a critical factor, floor to floor height would not be tight and large plant-room spaces were available enabling contractors to install services without too much conflict between systems.
• A small number of building services contractors who could still maintain reasonable profit margins.
• Similarly, fewer large main contractors who could also maintain reasonable profit margins.
• All these services and building work contractors were practical people with the ‘good will’ factor still in their minds and they tended to co-operate quite satisfactorily, based on a long-term business approach.
• Clients and consultants also worked quite well with contractors. More often than not problems were solved between the parties concerned without the mountains of letter writing that we all indulge in today. In simple terms, this meant the existence of non-adversarial relationships and an atmosphere of trust between all.
• Co-ordination of services was mainly carried out on site by different services contractors without relying too much on the use of co-ordinated services drawings. Detailed co-ordination would be carried out verbally on site by all contractors’ site staff. It was altogether a far more informal approach than that of today. The co-ordination process was usually quite effective as all contractors wished to complete
their parts as early as possible in order to avoid unnecessary labour costs due to possible disruption of his works.

- Most services contractors and main contractors maintained good formal and informal communication which was conducive to effective co-ordination of services.
- Most consultants were prepared to accept services contractor's proposals regarding solutions to co-ordination problems and the resulting variations were usually dealt with fairly and quickly by both parties.

To sum up, co-ordination of services was not a big problem during this period as the whole building team prepared to tackle the problems jointly providing the basic design was workable and the contractors were able to make reasonable profit margins. The above findings seem to be too good to be true, but they are the solutions suggested by many people and reports and, in particular, the Latham (1994) and Egan (1998) Reports.

Today's projects are very much bigger, many of them being multiple buildings. These buildings contain engineering services which are more extensive and sophisticated, accounting for anything up to 50 per cent of the total construction cost. As buildings services are becoming more sophisticated, large building spaces are getting scarce as a result of commercial pressures such as cost of building and maximum useful space. Furthermore, profit margins have been trimmed down for both consultants and contractors as a result of fee-cuts and keen competition amongst much larger number of contractors and professionals. At the same time, clients are concerned more about lower tender costs and quicker completion of projects and with more design changes. Hence, the previous harmony in the industry no longer exists (Phillis, 1983). For large scale complex projects, management of services design and installation would be very difficult with a large number of designers and contractors on each project, each with narrow speciality and responsibility; different expectations, involvement and organizational structure. In other words, the organization and management of a building project requires a much higher degree of co-ordination of a large number of highly differentiated operating units. It is the architect who exercises the main co-ordinating function before the contract is signed and the contractors afterwards. Thus, the main-contractor, having accepted the responsibility for construction, will be the construction co-ordinator.
Survey results gathered by the author in Hong Kong between 1995 and 2000 however revealed that in many complex projects, the M&E services designs are usually not fully integrated and co-ordinated mainly for the following main reasons:

- Unless otherwise agreed between the client and advisers, the M&E services consultant is not responsible for the preparation of detailed co-ordination drawings. Usually, this unfinished design work is passed to the specialist contractors by spelling out this services co-ordination requirement in the contract document.
- Incomplete design information on the “interface” data between various services systems due to incomplete details of all M&E services equipment and plant before the appointment of all services contractors.
- Lack of adequate integration between services and the architectural and structural elements.
- Lack of adequate co-ordination of services by the various M&E services design engineers.
- Conflicts between architects structural engineers and building services engineers drawings.
- Poor management of information flow at the design stage between the various members of the design team.
- For successful co-ordination a full awareness of space implications and a full practical knowledge of different service requirements is required. The availability of such practical experience is always a problem to design office managers.
- It is often felt by architects that engineers tend to exaggerate these space requirements and very tight spaces would usually be allowed for the services. Furthermore, architects tend to concentrate more on the architectural element than other elements of a building.
- The pressures exerted by clients for fast project completion together with high workloads on consultants also limit the time for full co-ordination between disciplines. Furthermore, with low profit margins, most consultants cannot afford the provision of a large number of detailed co-ordination drawings.
• Client's changes in requirements and design changes by the design team could complicate building services integration and co-ordination and this may seriously affect the progress of the already co-ordinated services, architectural and structural elements.

Information gathered by the author from consulting practices in Hong Kong also revealed that because the final selection of plant and equipment is left to be carried out by the services contractor upon his appointment there is a break in the flow of detailed services information. Clearly this factor makes effective and timely co-ordination impossible to achieve, the outcome being the spatial integration is left to the M&E services contractors. The selection of major plant and equipment items and the design of the building services systems which connect to them are interdependent. However, responsibility for the design tasks involved in linking plant and systems is often the cause of confusion between consultant and services contractors.

In order to prepare the initial design, the services consultant has to select certain manufacturers' equipment provisionally and plan their layouts around these items. This is the only way that physical space requirements can be determined, pipe and ductwork routes planned, and budget costs prepared. By so doing, the consultant could carry out the spatial integration and co-ordination.

Regardless of the designer's provisional plant selections it is usually the services contractors who have the final say since it is they who are best placed to agree optimum buying conditions and delivery times. The client is usually in favour of the services contractor making the decision since they perceive that this will ensure that the most competitive price is attained. Some public clients actually prohibit the mention of manufacturers' names within design specifications. If the installer selects an alternative to that identified in the designer's specification even having obtained the designer's approval, the installer is in effect changing the design and is therefore potentially accepting responsibility for any consequences which arise as a result of their alternative plant selection. Most likely, the offered plant and equipment would differ from the consultant's selection and therefore it is necessary to continue the design development so that further co-ordination is needed and be carried out with other members of the design team. If the contractor's offers differ too much from the consultant's selected equipment
and plant, more co-ordination and possible changes in design would be necessary as the physical sizes of the contractor’s equipment and plant may not be compatible with the consultant’s design and the allocated spaces. Clearly, it is evident that the system used to protect the client (e.g. competition between equipment suppliers and lower price) is costing more as a result of this second design co-ordination falling on the services contractor. The contractors of course would have included this co-ordination task in their tenders.

Central to the traditional form of building procurement is the idea that the contractor merely installs and that it is up to the client’s appointed design engineer to provide the necessary design information. In practice, this is not the case as the services contractor has to carry out further detailed design and all expensive co-ordination details.

Producing a tender bid for installation works based on a set of drawings can also result in risk for the services contractor. The tendering contractor must estimate the amount of work needed to produce installation details for use by site operatives. The work involved in this process can vary significantly depending on the quality of information provided on the designer’s drawings. Disputes can arise when the services contractor makes an over-optimistic assessment of the quality of the tender drawings.

There are two common situations in which conflict might arise. The first occurs when the consultant has produced detailed design drawings (sometimes referred to as “general arrangements”) showing the routes of distribution systems. The contractor might expect that the routes indicated are feasible, albeit with some planning of the precise positions of individual services. If this turns out not to be the case, additional work and expense may be incurred in planning and agreeing new routes. This also holds up the progress of the M&E services installation as well as the builder’s work.

The second example arises when the consultant has been employed to produce co-ordination drawings to demonstrate that adjoining services do not clash and how they relate to the building structure and fabric. Asked to tender on the basis of such drawings, the services contractor might reasonably assume that the installation details can be confined primarily to the planning of fixings, supports and the sequencing of activities. If, having won the contract, the contractor finds that there are physical clashes which
necessitate re-routing of the services, it can become uncertain whose responsibility it is to complete this work. The contractor may not have priced for such a detailed drawing exercise, whilst the consultant may argue that the resolution of such problems is a legitimate part of the installation planning process.

Previously acceptable ambiguity over design responsibilities can become the cause of serious conflicts resulting in project delays, increased contractual claims and increased litigation. In order to restore the situation to one in which client interests are best served, there is a need for a more robust, clearly defined division of responsibilities between the parties. Hence, in many cases, to avoid confusion the requirement of detailed co-ordination of M&E services based on the consultant’s design intent becomes the norm in the services sub-contracts. Of course, this responsibility has to be adequately priced and allowed for in the contract sum. Contractually, the responsibility for resolving spatial clashes should still remain with the consultants and, therefore, a very detailed design integration and co-ordination must still be provided.

Where there are to be several services contractors a “lead” contractor is normally named by the employer (client) in the tender documents who will have overall responsibility for co-ordination. Alternatively, the building services co-ordination would be provided by the main-contractor.

5.9.4 The construction stage

Co-ordination is an integral part of the total design and construction process.

Kwok (1988) states that co-ordination on site during construction is an audit on the degree of completeness of design co-ordination. Theoretically, good design co-ordination should eliminate or reduce co-ordination problems at construction stage. On the other hand, inadequate design co-ordination leads to a lot of corrective efforts.

Because design responsibility, in varying degrees, is split between various parties; the architect, contractor, nominated sub-contractors, specialists and public utility companies; a requirement exists to ensure that there is no conflict between any of the various services either of one service with another or with the structure or finishings of the building.
Under a regime of open tending where the contractor is free to offer a choice of equipment to meet a performance orientated specification, detailed information on many items of plant, equipment and materials can only be obtained after the award of both main and sub-contracts.

If conflict-free working is to be achieved in a situation where much final detailed information is only available after the main contract and various sub-contracts/specilist contracts have been let, it will be necessary to establish an organization within the contract/contracts. Functionally, this organization is capable of managing and co-ordinating the final detail and installation sequence of all M&E services. To be effective, the organization must be authoritative, competent, experienced, able to respond with the necessary speed and contractual acceptability to all parties involved in the project.

Of the various parties involved on a complex serviced project, the main-contractor would initially seem best placed to undertake this role. Hence, a requirement is to be written into such contracts for the main-contractor to undertake final ‘on-site’ co-ordination responsibility for the smooth installation of building services into the building structure.

Contractually, installation co-ordination is also usually the responsibility of the various services contractors. Under the traditional procurement system, the sub-contractor’s work will be the main-contractor’s responsibility. Also, from the viewpoint of effective management of the construction process, the main-contractor will best be responsible for the main co-ordination function (Higgin & Jessop, 1965). Nevertheless, the design aspects will still be the responsibility of the consultant.

Based on the author’s surveys in Hong Kong, when buildings are small and do not have complex M&E services, the main-contractor would co-ordinate the building and M&E services works without many problems.

For highly serviced buildings, engineering services are usually more extensive and sophisticated. The main-contractor is no longer equipped with the necessary knowledge of such complex building services. Naturally, there will be great difficulty in managing the specialist trades contractors. However, the main-contractor has full responsibility for the performance of its sub-contractors in all respects (except design). This includes
scheduling of works, co-ordination between trades and general attendance. To carry out this managerial task of controlling the sub-contractors effectively, it is best to have an experienced site-based building services engineer managing the engineering installations (Banham, 1983; Phillis, 1984) rather than a general building technologist who normally would have a limited understanding of building services works. Therefore, in many large projects, the main-contractor would have to employ a qualified M&E services engineer (in the capacity as the main-contractor’s building services co-ordinator) with the necessary supporting co-ordinating team to undertake the management of services installation together with the building project manager on site. Thus, the building services co-ordinator is, in fact, an integrator who is given the authority, and is held accountable, for the co-ordination of services and associated building works.

Large and complex projects usually demand detailed planning of building services co-ordination once the building and building services contracts have been let. From the survey data gathered by the author in Hong Kong, under most contracts in Hong Kong, the builder (main-contractor) is fully responsible for the complete co-ordination of the building works including works executed by all nominated sub-contractors and domestic contractors (Kwok, 1988). This responsibility includes but is not limited to:

- Co-ordination of all trade sections or components one with the other for the compatible integration of the work.
- Liaison with all services sub-contractors and specialists undertaking the various M&E services and specialist installations.
- Ensuring that the construction is in accordance with the specification and the details shown on all construction and building services drawings.
- Ensuring that the building services can be properly installed within the timescale of the construction programme and that adequate space for maintenance is provided.
- Ensuring that specialist contractors including public utility companies are allocated their required amount of time to complete their works.
- Establishment of detailed logical sequence of work or erection schedules.

Phillips (1988) stated in his report that, notwithstanding the client has spelled out the requisite co-ordination requirements described above to the contractors, most builders do
not yet fully comprehend what is required from them under the task “co-ordination of building services”. Co-ordination of services however costs money who ever does it, it is therefore necessary to define this work clearly and leave no tendering main-contractors and sub-contractors in any doubt about what to price for.

The author’s survey carried in Hong Kong indicated that in many cases, the vital work of integration and co-ordination of M&E services is usually inadequately covered by many contractors. Inadequate provision of the right building services co-ordinator and supporting technical staff is the main factor. Secondly, adequate resources are usually not allowed for proper preparation of expensive co-ordination drawings. Thirdly, the management of building services co-ordination is not as high on the main-contractor’s agenda as their own building works. Fourthly, it is difficult to manage all sub-contractors.

The building services co-ordinator plays an important role in the co-ordination process (Phillips, 1988). As a key player, the building services co-ordinator is to manage all services contractors’ works in conjunction with the construction management to be carried out by his colleague. The author identified from many contracts and building projects that the services co-ordinator will:

- Liaise with the design team in connection with all M&E services works.
- Plan all services installations in conjunction with the construction manager.
- Identify all the building work requirements associated with all building services installations.
- Convene co-ordination meetings.
- Prepare co-ordination drawings based on sub-contractors’ drawings so that each contractor is fully aware the space allocated to each trade.
- Manage and control the preparation of final installation drawings (by all services contractors) based on their final co-ordination drawings/details so as to allow their drawing works to be efficiently and continuously proceeded with.
- Arrange detailed logical sequence of services installation by each trade at each space.
- Formulate a priority list of areas requiring close co-ordination of the various services installed therein.
• Control and monitor all M&E services works to ensure that the co-ordination procedures are followed to enable the expeditious completion of the works within the time scale of the construction programme.
• Resolve site co-ordination problems with M&E services consultant.
• Arrange testing and commissioning with sub-contractors.
• Arrange handover of M&E services works.

To sum up, as a team leader of a task group, the building services co-ordinator is required to obtain all design drawings from the architect, plus working and shop drawings from the parent organization, nominated sub-contractors, specialists, and public utility companies and to check that all services can be installed in their appropriate location without conflict of service with service or with the structure and finishings. Furthermore, all services can be properly maintained.

The process of co-ordination will require the proper installation of services into the building spaces provided for them and the establishment of a detailed sequence of installation. Conflicts between the requirements of different parties will, at times, inevitably result and the building services co-ordinator will be required to negotiate a satisfactory arrangement and to see that it is enforced. Solving simple and routine space conflicts of an inter contractual nature will be the sole responsibility of the building services co-ordinator and will not be referred to the architect who will not normally expected to be involved in such matters.

In those instances where a conflict cannot be reasonably resolved the co-ordinator shall request the architect to resolve the conflict. Co-ordination checking must take place sufficiently in advance of the work to enable serious or significant conflict situations to be referred to the architect and for solutions to be devised by the architect and notified to the main contractor (as variations) in good time to suit the construction programme and without delay or disruption of the works. Wherever possible, the building services co-ordinator will suggest possible conflict solutions to the architect.
The final result of the co-ordination would be the production by the building services co-ordinator of all necessary co-ordination drawings, sketches and instructions incorporating all co-ordination solutions showing the integration of all services to be executed by the relevant contractors.

In a nutshell, the building services co-ordinator is responsible for co-ordinating the various M&E services installations to ensure that all services are installed correctly, cost effectively and quickly. The co-ordinator must therefore plan and manage all services contractor’s works well before constructing the building. Most importantly, detailed co-ordination drawings must be fully developed from the partially completed design provided by the consultants.

Obviously, in order to satisfactorily undertake the co-ordination work, the services co-ordinator would be a competent services engineer as well as a project manager. Besides, the individual should have the right personality which can weld all sub-contractors together to carry out the installation co-ordination with the construction management team.

5.10 Installation co-ordination by services sub-contractors

In the context of ‘traditional’ procurement, whenever sub-contractors are appointed, regardless of whether these are nominated by the employer or chosen by the main-contractor, the main-contractor has full responsibility for the performance of the sub-contractors in all respects. Sub-contracting in any form still places the responsibility for co-ordination, day-to-day management, scheduling of works, firmly with both main-contractor and services contractors.

Whilst the main-contractor is responsible for the overall co-ordination of the specialist contractors’ works, the services contractors will be fully responsible for the co-ordination of M&E services design and installation which are both technical and managerial issues. It is clear that without the sub-contractor’s adequate input, it is not feasible for the main-contractor’s building services co-ordinator to manage all M&E services works on site. So it is necessary to examine what a services contractor will do during the installation stage.
As far as building services co-ordination is concerned, the specialist services contractor will:

- Review project information including:
  - the building and project phases.
  - building programme (from pre-construction to the handover date).
  - the content of M&E services.
  - the technical complexity of services.
  - the number of sub-traders and specialist.

- Plan and programme all M&E services works with the main-contractor’s building services co-ordinator/construction manager.

Planning is a strategic activity implemented by programming. It involves thinking through all the stages of a project and identifying:

- the task to be performed.
- the method to be used.
- the information required and their sequence.
- the resources required.
- the timescales to be allowed.

It is essential that all contractors do their best to ensure that their programmes are realistic and well thought out. This will avoid the following problems commonly associated with the building services installation:

- The main-contractor’s programme cannot be complied with, or that the logic is flawed.
- Inadequate planning and programming of services installation.
- An over simplistic approach to building services due to a failure to appreciate their scope, context and impact on other building elements.
• The adoption of illogical programme without understanding the consequences for building services.
• Inadequate interfaces between services, and services and building works.

Interview results indicated that failure to assimilate the building services contractor’s programme into the main-contractor’s programme will almost certainly lead to conflict and possible failure later on. Therefore, effective planning and programming will have significant impact on the smoothness of the building services co-ordination process. The main problem is that under many forms of contract, the main-contractor is required to produce a master programme within 21 days of accepting of the tender. This has the disadvantage that input from services contractors may not be readily available even if the services contractor has already be appointed by the client. Hence, the original master programme will have to be discussed re-examined and revised by all parties concerned for a realistic planning of services works.

Apart from the programming of services, the services contractor will also undertake the following tasks:

• Check design and confirm selection of M&E services plant and equipment with consultant and manufacturers.
• Develop consultant’s design into detailed design in conjunction with the input from specialist equipment suppliers and installers.
• Complete technical submission.
• Prepare preliminary working drawings based on the consultant’s design drawings and the selected plant and equipment which have been accepted and approved by the consultant. These drawings will then be used by the main-contractor’s building services co-ordinator to prepare the requisite co-ordination drawings.
• Liaise with the building services co-ordinator and revise preliminary working drawings in conjunction with the main-contractor’s detailed co-ordination drawings (often called combined services drawings, CSD) including all necessary interface details.
• Prepare builders’ work requirements in connection with the M&E services. The building work requirements include marking out, reservation of openings through structural walls, floors, beams, machine foundation details, special requirement for hangers, access panels, etc. All these details will be incorporated into a composite drawing to be provided by the building services co-ordinator in order to show all building work requirements required for the proper installation of building services.

• Finalize design with consultant.

• Review project master programme and update managing programme for M&E services.

• Prepare detailed installation programmes for each of the building services.

• Check resources for services installation.

• Plan services installation.

• Liaise with main-contractor and other specialist contractors and carry out M&E services installation in accordance with the agreed sequence of work and time allocated to the services including any necessary “second fixing” e.g. ceiling diffusers after erection of ceiling grids.

• Manage interface works between all M&E services and builder’s activities in advance.

• Resolve co-ordination problems with building services co-ordinator.

• Complete services installation including additional work instructed by the architect.

• Liaise with the building services co-ordinator for carrying out testing and commissioning of services.

• Carry out final inspection and handover the services to client.

If all services contractors would follow these tasks in a professional way, building services co-ordination would be more straightforward. However, this is not the case in practice. The author’s survey results indicated that the co-ordination process will invariably break down especially when effective project management is not implemented by all project participants. This can be due to a number of reasons including unwillingness on the part of the main contractor and/or not possessing the required expertise in the services field. Other reasons are that both the main and services contracts do not adequately specify the resources and management needed for co-ordination of services. Furthermore, insufficient provision is often made in the bill of quantities by the
contractor to cover this heavy liability, unprofessionally assumed the costs involved for building services professional/technical/admin staff and high expenditures for the coordination task are to be lost in the other rates.

Another problem identified by the author is the working relationship between the main-contractor and M&E services contractors which could hinder good co-operation needed for effective co-ordination of services.

Co-ordination demands tremendous effort in planning and programming. If either the main-contractor’s master plan or the services contractor’s installation programmes is not realistic, it would be impractical for all sides to evaluate all co-ordination processes realistically and this would further affect the progress of all works.

To sum up, as far as site co-ordination work is concerned, the author’s survey results based on projects in Hong Kong revealed that in many projects, there were still inadequacies in:

- Team building.
- Provision of detailed co-ordination drawings by the building services co-ordinator and the services contractors.
- Co-operation between all parties.
- Planning and programming of building services co-ordination and installation.
- Provision of adequate and accurate ‘interface’ between all trades.
- Efficient control and monitoring of building services installation on site.
- Adequate resources for carrying out the co-ordination task as well as sufficient resources for services installations.
- Sufficient spaces for M&E services installations.
- Proper sequence of works.
- Involvement of the design team to resolve co-ordination problems which are in fact their own design problems.
- Control of variations arising from client’s changes, late design input or improvement in design.
All these root causes of poor M&E co-ordination would definitely affect the cost, time and quality of a project. Obviously, prevention is needed, not cure. The best place to address a co-ordination problem is on the drawing board, but effective site co-ordination must also be carried out by all.

5.11 The results of poor co-ordination

This chapter would be incomplete without discussing the effect of the lack of co-ordination of building services. The effects identified by the author from his preliminary case studies and interviews conducted in Hong Kong (before embarking on his questionnaire surveys and the detailed case studies as given in Chapters 7 and 8) could be categorized as:

a) Delay during construction as a result of conflicts between two or more services, or services with the structural and building elements. These result in disruption of the critical master building programme since all works could not be carried out and completed on time. Extension of time is needed to:

- Resolve the design/co-ordination problems in addition to the down time.
- Reschedule all working programmes and delivery schedules for equipment, materials and resources.

b) Ineffective working, loss of productivity and extra costs due to co-ordination problems such as:

- Improper arrangement for the sequence of works.
- Inadequate spaces for proper installation of services.
- Re-designs (to overcome co-ordination problems) with abortive works and additional labour and materials for the modifications of the partially completed installations.
- Frustration of the labour force as they have to do work more than twice, when there is nothing apparently wrong with it (this can generate confrontation between different trades on site).
- Poor communication between different trades.

c) The quality of design co-ordination varies substantially from project to project. Contractors are left to guess. This leads to higher tendered sum as all contractors have to cover the high costs incurred in co-ordinating M&E services based on incomplete services designs with little or no integration whatsoever between the members of the design team.

d) Difficult building services installation in congested spaces can cause:

- Inefficient design.
- Operational problems.
- Difficult maintenance as a result of inadequate access and working space.
- Unsightly services.

e) Poor working relationship between the design and construction teams, with each member of the building team blaming each other for poor building services design and co-ordination. This creates arguments and conflicts between project participants. As such, teamworking is hard to achieve for the essential requirement of co-operation and co-ordination of the building construction and its M&E services.

The overall results are:

- Increase in contract sums due to additional costs as allowances for co-ordinating services by all contractors.
- Extra costs due to variation orders for solving poor co-ordination problems.
- Extension of time due to delay during construction as a result of poor management of co-ordination of services, down time and ineffective working.
- Claims for financial cost due to abortive works, waste of materials and labour resources, additional management and associated overheads for re-co-ordination of services.
- Inefficient services co-ordination and probably downgrading the quality of services.
• Poor project performance as no one is satisfied. Obviously, the client will suffer most in terms of time, cost and quality of building.

• Adversarial working relationship between the design and construction teams.

Much of the literature (Crawshaw, Barton, Butler, Spiers, Monaghan, Danton and Michie) confirms the author’s findings based on surveys carried out in Hong Kong. Also, all researchers contend that effective co-ordination of services is vital to the smooth running of any project. Taken as a whole, co-ordination faults can be expensive and disruptive and they can have serious effects on the organization and management of a project.

5.12 Appraisal of building services integration and co-ordination

The author identified from his surveys in Hong Kong that the causes of ineffective or poor building services integration and co-ordination would be one or the combination of several of the following sources:

a) Client side

• Frequent changes of design even during the construction stage.

• Employment of services consultant for incomplete design, i.e. abridged duties without preparation of co-ordination drawings.

• Selection of consultants and contractors based on price only.

b) Designer side

• Incomplete integration of services design.

• Inadequate co-ordination details such as combined services drawings and sectional views identifying provision of adequate spaces for services.

• Incomplete interface data.

• Unclear design and co-ordination responsibilities.

• Unrealistic construction programme and inadequate time for contractor’s preparation of details.

• Poor management of services integration and co-ordination.
c) Construction team

- Unclear co-ordination requirements and procedures.
- Lack of professional approach to management of co-ordination of services on site.
- Main-contractor is not willing to undertake the overall responsibility of co-ordinating M&E services with the specialist services contractors even this is a contractual requirement.
- Likewise, each M&E services contractors cannot co-ordinate other contractor’s works as there is no contractual link between them.
- Inadequate preparation of co-ordination of services (e.g. preparation of combined services drawings).
- The usual ‘father-son’ contractual relationship between the main-contractor and the nominated services contractor is not conducive to effective co-ordination of services. Not least to mention, poor communication flow also has a direct bearing on the formation of a coherent working team.
- Unfair sub-contract conditions for the sub-contractors and the onerous responsibility for the risky co-ordination of services imposing on the main-contractor which should be the consultant’s work.
- Lower tendered sums encourage claim situation due to inadequate design co-ordination as this is the only way to recoup low profit margin or even losses.
- Inadequate techniques for managing, controlling and integrating sub-contractors.

d) Procurement path

- The use of an inappropriate procurement system which does not cultivate teamworking.
- The incorrect choice of an organization form which does not fully utilize the contractor’s contribution.
- The suitability of main contractor (in all procurement paths) in effectively co-ordinating the more technically sophisticated work is questionable.
To sum up, all these factors are not conducive to effective co-ordination of services, and it is also clear that the traditional procurement path employing separate main-contractor and nominated sub-contractor does not easily cultivate the requisite teamworking which is considered of paramount importance as far as co-ordination of services is concerned.

5.13 Summary

This chapter has detailed how the design and construction teams managed the problematic building services integration and co-ordination based on the traditional procurement system.

Based on literature review and the author’s detailed surveys (interview with different people in the construction industry and site visits) and the author’s own experience in the building services industry, the author had determined the main causes of poor co-ordination of services and the subsequent results which were due to the lack of effective management of building services integration and co-ordination.

It is also concluded that integration and co-ordination of building services are:

- Deficiency in design.
- Technical issues related to the design of building services with other elements of a building.
- Management issues related to the management of project and project participants within the building process.
- One of the key factors in the selection of the best procurement path for a project but not always given high priority by many project participants.
- One of the factors that can shape the project performance of a project.
- Indicator of good project management.

Based on the analysis of the research data gathered by the author (with assistance given to the author from many organizations in the building services industry in Hong Kong and UK), it is apparent that the co-ordination of building services sub-contractors is an exercise in management and not an exercise in solving technical problems for the
designers. From the research data, the following important inferences had been drawn by the author. Each of these inferences would also be examined in the 25 case studies to be carried out later.

- Co-ordination between design and construction phases and participants is a prerequisite for success. High levels of co-ordination improve performance and increase satisfaction.
- Increases in familiarity, proximity, co-ordination and a decrease in differentiation will improve the efficiency of the design and construction processes and contribute to a consequent improvement in project performance.
- Increased project complexity (e.g. highly serviced building) can reduce project performance and satisfaction. But high levels of administrative/management ability in the project team can improve project performance.
- The more interdependent the task (e.g. M&E services installation and building construction), the greater the integration and control is necessary.
- The more complex the task of the sub-contractor, the greater the integration is required and the more control must be exerted by the main-contractor.
- The greater the intensity (rate of change) of the services sub-contract, the greater the integration and control is needed.
- The larger the sub-contract value relative to the main-contract, the greater the integration and control is required by the main-contractor.
- Nominated services sub-contractors are less integrated into the project system and more control should be provided by the main-contractor.
- Any system which allows organizations to co-operate with one another is advantageous. Therefore, the greater the familiarity between the sub-contractor and the main-contractor, the greater integration achieved and the unified effort of this team is likely to be more efficient and effective. This also leads to high levels of performance and satisfaction.
- The complex task of integrating into a viable whole large numbers of highly differentiated operating units (i.e. contractors) is a management problem of the first order. However, the more differentiated an organization (i.e. main-contractor and subcontractors), the more difficult it is to achieve integration. High levels of differentiation can lead to low levels of project performance and co-ordination.
Therefore, integrating devices must be given and these mechanisms are related to contract procedures and requirements. Higher level of project management ability in the project team will therefore improve performance and satisfaction.

- Different organization forms exhibit differing degrees of co-ordination and integration. Any organization located appropriately in terms of co-ordination and integration will exhibit higher project performance.

Because of the lack of adequate relevant research literature in this subject in the UK and Hong Kong, much of the evidence in this chapter had been anecdotal, based on detailed case studies, supplemented by the industry comments and the structured interviews with key persons of design and construction teams in Hong Kong. The findings were nevertheless similar to the previous research carried out in UK and other countries. Hence, co-ordination of services would therefore be considered as a universal problem and the management techniques would be inferred to be similar in the context of ‘traditional’ procurement. However, cultural and local conditions are different between Hong Kong and abroad and might influence the management of this important issue in different degrees and this factor would be examined later in this study in the light of emergence of further evidence.

Other unconventional procurement paths are further development of the traditional approach but with modifications in roles and responsibility and the organizational structure of each of the members of the building team. Hence, it is important to investigate all these procurement paths as each path will have different impact on building services integration and co-ordination.

The next chapter combines the study of the integration of services contractors into the construction project systems with different procurement paths. Before embarking on the detailed analysis of the case studies and other survey data, a Building Services Co-ordination Model is established first in order to examine the co-ordination issues systematically. Another model (Co-ordination-Procurement Model) is further developed from the conceptual model (Fig. 4.1) to assist in the analysis of the selection of an appropriate procurement method.
#CHAPTER SIX

##MODELS OF THE CO-ORDINATION OF BUILDING SERVICES AND PROCUREMENT SYSTEMS

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CHAPTER SIX: MODELS OF THE CO-ORDINATION OF BUILDING SERVICES AND PROCUREMENT SYSTEMS

6.1 Introduction

The previous chapters have reviewed the activities of integration and co-ordination of building services involved in the process of procuring a building in the context of 'traditional' procurement in Hong Kong. Factors contributing to inadequate integration and co-ordination of services and their likely effects upon the construction process have also been discussed at length.

The next stage is to develop suitable models which can be used to allow questions about the effect of procurement systems on the complex co-ordination of building services to be answered systematically. By using these models, detailed appraisal of each of the commonly used procurement paths can be applied systematically based on the details depicted in the models. Of course, all results will further be tested, verified or disproved based on further in-depth case studies, detailed surveys and interviews with major clients and participants within the construction industry. These are covered in Chapters 7 and 8. This chapter discusses:

- The development of two models and how they can be used to investigate the answers to be pursued for this research work.
- The need for carrying out case studies in conjunction with the application of the two models developed for the investigation of the impact of procurement systems on the management of building services. Particular reference is made to the co-ordination of M&E services between the building work contractor and all M&E services specialists (domestic or nominated contractors) and the special principal services contractor.

6.2 Models

This section discusses the development of two models and how they are used in the pursuit of this research to investigate the important variables concerning the management of building services co-ordination within the building process.
As discussed in chapter four, a model is description of a system (Pritsker 1979) and it can thus be seen as a representation of reality. This also infers that a model would allow questions about a system to be raised and answered. Hence, a model not only communicates ideas or concepts, it will also provide a framework for the definition, collection and ordering of rich and useful data on a subject. Furthermore, it enables phenomena to be visualized and comprehended, assisting in explanation and comparison. Finally a model should communicate ideas. Thus a model is a key element in determining the scope of any research, as it points to those areas which must be considered.

The research objective is to analyse the performance of co-ordination of building services with particular reference to the effect of building procurement and the organizations of the whole building team. The research process should therefore encompass the identification of the co-ordination process, the impact of the building procurement path on the management and co-ordination of services and the continuing development and refinement of the models employed in this research.

The various models of previous researchers were studied in Chapter 4. None of these models were specifically derived to include the installation of building services. The author also produced a conceptual model (Figure 4.1) for this research. The simple model was based purely around the notion of building procurement plus management of building services. Though simple, the model had all important subsystems and was found very useful during the early stage of the research. Nevertheless, this conceptual model was still not detailed enough to explore the complex issues of both building services co-ordination and building procurement.

The conceptual model (Fig. 4.1 in Chapter 4) adopted in this research is based on a system approach which is considered to be the most appropriate strategy. The system approach by its very nature is made up of interdependent elements and the associated subsystems within the building process. This approach can illustrate the interaction and interdependence between the identified variables and the system model will embrace the essential features of co-ordination of building services and building procurement if all important variables can be grouped together. The system approach is therefore appropriate to the study of complex building team organization in the initial stage of this research and gives better understanding of the configuration and casual relationships
among postulated elements or variables in the physical reality of building services integration and co-ordination, with particular reference to the influence of a particular building procurement system.

As discussed earlier, all the variables such as those technical and managerial issues which have been identified in the previous chapters are related to each other. In the system approach, a variable may be independent so that when varied, it can induce change in other variables. Furthermore, there will also be one or more dependent variables (e.g. successful co-ordination and project performance) in the same model. The outcome of this dependent variable must also be changed or affected in response to any changes in the independent variables which can be depicted as follows:

- An independent variable affects other independents

Figure 4.1: The conceptual model (reproduced for reference)
Changes in independent variables can affect dependent variables.

Also, a model should consider those moderator variables that exist and help achieve the optimum level of the dependent variable. On the whole, the usefulness of the chosen system model is that it not only emphasizes wholeness and existence of a set of interdependencies or variables within the building process, it also allows for complexity to be reasoned. This is the result of examining the effect or action of one variable on the others (e.g. the impact of co-ordination of services on project performance) since the system thinking recognizes such interactions and interdependencies within a system boundary.

To improve the usefulness of the conceptual model, the following two more sophisticated models were further developed:

- Building services co-ordination model (BSC model); and
- Co-ordination - procurement model (CP model).

The BSC model is based purely around the notion of aspects affecting co-ordination of building services in the building process, the CP model concentrates on the context of the building process and its management and organization.

These two models are to be tested against the reality in the building industry. Hence, the modelling techniques have been selected to encompass all possible significant components, constants or variables. Each of the models has been designed to show the relationships between the variables, e.g. their interaction, as well as interdependency. To be useful the models must also remain valid and applicable across the whole range of commonly used building procurement systems. This modelling process is iterative, bringing necessary modifications to initial models after testing against reality. Creating a model is to present a simplified version of the reality of what is happening in the industry.

Obviously, if models are to be re-used they must be not project specific so that they can be used globally with some modifications to suit the local conditions. Research needs to be bounded and to concentrate on a specific domain if resources are not limitless. Given
the aim of improving understanding of the procurement process and the co-ordination of building services, models must be meaningful. To be meaningful, it is of vital importance that a model will include just sufficient details for easy manipulation. However, it should not be too simplistic, otherwise some important aspects of the procurement and co-ordination processes might be excluded resulting in the invalidity of the model. On the other hand, a large and complicated model would make it cumbersome and difficult to manipulate, it would not help to understand the co-ordination problem and could not achieve the objective for having a model in the first place. Formalizing a model is therefore a matter of striking a balance between simplicity and complexity. Furthermore, a model should be open to revision and amendment at a later date.

6.3 Key issues raised from preliminary research results

Based on preliminary research results, the procurement of complex and highly serviced buildings is always fraught with expensive and complex problems of inadequate coordination of building services as a result of inadequately designed and coordinated building services. To further complicate this coordination issue, previous research (Barton, 1978; Michie, 1981; Kwok, 1988; Loosemore & Davies, 1994; Parsloe, 1994; Pasquire, 1994; Wilkins & Smith, 1994; Price and Gibb, 1996 and many others) and some of the findings based on the author's case studies have identified that, although "complete" design is of paramount importance, this single factor 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, approach attitude and operation of each the project participants, communication between individual members of the building team, allocation of risks, early incorporation of specialist services contractors, forms of contract, conflicts, quality of design and construction management by both design and the construction teams and the external environmental conditions surrounding the overall building system must all be considered together.

Many variables in relation to the coordination of building services and the effects of a procurement path on building services have been identified by this research. All the data can be shown in the proposed research models. The data should generate adequate
background information for further analysis and validation of data in conjunction with detailed study of additional case studies and surveys.

It was established by the author that many factors were influencing the management of building services and the selection of the procurement path in Hong Kong. These factors or variables must be incorporated in the two research models. The factors were, however, of varying degrees of significance and the identified important factors were:

a) Management of building services design and installation by the building design team

1. **The client**
   - Management within the client organization.
   - Proximity to project and building team.
   - Control of project and building team.
   - Client objectives and understanding of the risk of inadequate integration and coordination of building services and its relationship with project management.

2. **The project**
   - Complexity of the project.
   - Sophistication and specialization.
   - Budget and time constraint.
   - Technical uncertainty.
   - Environmental variables such as the building economy and political influences.

3. **The Designer**
   - Size of the project team.
   - Competence of firm and design personnel.
   - Co-ordination and control of design team members, and team leadership.
   - Quality of service and buildability.
   - Responsibilities between design team and construction team.
   - Contractor input during design.
   - Completeness of design.
   - Completeness of documentation.
b) Management of building services detailed design and installation by the building construction team members.

1. **The Contractors**
   - Size of the project team.
   - Competence of personnel.
   - Use of sub-contractors.
   - Use of domestic contractors.
   - Differentiation among team members.
   - Co-ordination and control of team members.
   - Planning of co-ordination of services.
   - Completeness of contract documentation.
   - Responsibilities between various contractors with particular reference to coordinating M&E services.
   - Team leadership.
   - Proximity to design team.
   - Budget and time constraints.
   - Site conditions and site supervision.
   - Contract procedures and information flows.
   - Relationship with the client organization.
   - Project management.

c) Procurement of building contracts and performance of procurement methods including the key factors in contractual relationships.

1. **Procurement form**
   - Consultant and contractor selection method and procedures.
   - Contract documentation and conditions of contract.
   - Risk taking.
   - Organizational forms, differentiation, proximity/familiarity, co-ordination and integration mechanisms.
2. **Key factors in relation to co-ordination of M&E services**

- Type of project.
- Previous problems.
- Design input.
- Accountability (competition and price).
- Quality of design.
- Quality of contractors.
- Management of project by the design and construction teams.
- Time available until completion.
- Need to change design and control of variations.
- Level of risk.
- Client and contractor satisfaction.
- Teamworking based on the concept of the temporary multi-organization to the building team.

6.4 **Building services co-ordination model**

The social sciences exploit modelling techniques to represent or explain phenomena and relationships in the real world. A model is therefore a substitute for some real system. The value of a model arises from its improving our understanding of obscure behaviour characteristics more effectively. Higget and Chorley (1967) discuss the function of a model, which should provide a framework for the definition, collection and ordering of information. It should enable phenomena to be visualized and comprehended, assisting in explanation and comparison.

The review of previous published and unpublished research, opinions expressed publicly and privately and the results of the author’s own action 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 6.1 (i.e. Building Services Coordination Model). Firstly, the conceptual model adopted in this research is intended to stimulate the development of theory. Secondly, the model is considered to be a useful tool for better understanding the complex issue of the coordination of building services between the design and construction teams. To be useful, the model must also remain open to revision and
amendment if necessary following further research in conjunction with more in-depth case studies. The model developed by the author should encompass all relevant variables/factors or sub-systems within a "co-ordination system". The model should also show clearly the interrelationships and interdependence between all possible variables or sub-systems. Lastly, the model selected should be useful for carrying out detailed study of the co-ordination of building services in each of the procurement methods commonly used in the building industry.

In constructing the building services co-ordination model, the following points must be recognized.

1. Co-ordination of building services is a technical issue. The process requires contribution from both design and construction teams.

2. Co-ordination of building services is also a managerial issue. The process requires good project management. Both design and construction teams have to provide adequate design and construction management.

3. Co-ordination of building services requires a team of specialists working co-operatively. As co-ordination problems can be aggravated by the number of parties being co-ordinated, this team needs to be managed so that dissenting views are avoided and roles are harmonized. Any system which moves away from the conflicting goals of a coalition and towards the unified effort of a team is likely to be more efficient and effective. The problem of individuals having their own peculiar goals within any organization will always exist but a system which allows organizations to co-operate with one another is obviously advantageous.

4. The role of both designers and contractors may change with different procurement methods. This can change the management of building services co-ordination by each party of the building team. Hence alternative organizational forms can have different impacts on the performance of a project.

5. Based on the literature review and the author's survey results (see Chapter 5), the co-ordination process of system should encompass:

- Management of design.
- Conceptual integration of building services by the whole design team.
• Full integration and co-ordination of building services by the M&E designer with other members of the design team.
• Management of construction.
• Integrating all services contractors into the construction team by the main-contractor.
• Co-ordination of building services by the construction design.
• Co-ordination of building services by both design and construction teams.
• Managing people and organizations in both design and construction team.

The structure of the building services co-ordination model should therefore incorporate the following sub-systems:

• Technical difference system.
• Structural difference system.
• Management difference system.
• Social difference system.
• Co-ordination system.
• Environmental system.

The conceptual model can be used to study the management of building services by either the design team or the construction team.

6.4.1 Development of building services co-ordination model (BSC model)

Based on the sub-systems or variables identified (as stated above) by the author, the development of the BSC model was followed and this was based on four main stages.

Stage 1
Each member of the building team contributes a particular expertise and is generally concerned with a discrete functional area in the building process. Teams are, in essence, an association of specialists from different disciplines with different practices, needs and goals. These different operating units create inherent problems of integration, co-ordination and communication. Great differentiation between project participants must
exist in the building team and it is not conducive to effective co-ordination of the building services.

The differentiation (i.e. technical, structure, management and social) of the operating units is the principal constraint on the project team and should be a primary influence on the co-ordination process. These four differentiation sub-systems are independent variables and they are shown in Figure 6.1.

Stage 2
In order for the whole building system to behave as a whole each differentiation must be effectively managed. The model further illuminates the requirement of a suitable co-ordination system (see Figure 6.1) for managing both technical and managerial issues in designing and constructing a building (Of course, consideration must also be given to the choice of organizational form since the characteristics of organizational forms and their components operating within the building process can affect both the design and construction processes). This co-ordination organization system is an intervening variable that helps to achieve satisfactory co-ordination of building services.

Stage 3
The environment within the building process is also a major influence on the building process and its outcome. This independent variable must, therefore, be seen as a system and is shown in Figure 6.1.

Stage 4
To complete the system model, relevant inputs must be included for attaining the dependent variable in a system model—satisfactory co-ordination and project success. These are all shown in Figure 6.1.

The model employed in this research based on the four stages is presented in Figure 6.2. This figure includes the main sub-systems such as technical difference, structural difference, management difference, social difference, co-ordination organization and environment. Necessary inputs are also included to produce the output. Explanation is given in 6.4.2 of this chapter.
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<td>Stage 2</td>
<td>The provision of an intervening variables. The four differentiation systems are to be modified and controlled by the “Coordination Organization” system which is therefore located over the four difference systems as given in Stage 1.</td>
</tr>
<tr>
<td>Stage 3</td>
<td>The addition of the environmental factors. All variables can be affected by the environmental factors. Hence they will be located within this environmental envelope.</td>
</tr>
<tr>
<td>Stage 4</td>
<td>The incorporation of all inputs and outputs. Based on the system thinking, all inputs are to be incorporated for managing the co-ordination of building services. The output will be the dependent variable—project success.</td>
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</table>

**Legends**
- $V$ = variable
- $C$ = co-ordination organization
- $E$ = environment
- $I$ = inputs
- $O$ = outputs

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**Figure 6.1: Development of building services co-ordination model**
Complete Design by Competent Designers

Combined Services Drawings

Proper Tender Document and Programmes

Technical Difference System - builder and engineer

Effective Communication

Planning & Monitoring

Use of Computer

Systematic Coordination Procedures

Clear Installation/Coordination Responsibility

Structural Difference System - 'organic' builder & bureaucratic services contractor

Coordination Organization System - Design Team, Main Contractor and Sub-contractors

Sufficient Time and Resources

Clear Client's Brief

Proper Procurement Method

Managerial Difference System - involvement

Effective Site Management

Good Project Manager & Leadership

Good Building Services Coordinator's Management

Sufficient Experience and Resources

Commitment to Coordination

Social Difference System - integration of builder and services workers

Figure 6.2: Building Services Co-ordination Model
6.4.2 Explanation of the model

The model proposed is the conceptualization of one comprehensive model of the co-ordination process within the building process. To operate the model, one would start with an examination of:

1. The characteristic of various operating units (e.g. designers and contractors) and the integrative mechanisms required to achieve team working.
2. The execution of co-ordination of building services during the design and construction stages.
3. The variables of client and project characteristics.

All these three variables are primary influences of the co-ordination system. Each variable is working as an intervening variable that has linkages between the dependent and independent variables and can cause the relationship between them to change.

Finally appropriate project and control procedures are to be adopted which will then govern the operation of the projects, the documentation, form of contract, management systems etc required for effective co-ordination of services.

The characteristics of organization form can influence the working of the different operating units. Therefore, the organizational form must be carefully designed with due consideration of the interaction and synergism of the various operating units within the co-ordination system.

The co-ordination of building services within the building process can be considered as a matrix of conflicting professional and commercial groups (Architect v M&E services engineer and main-contractor v services sub-contractor) combining together to contribute their particular specialist skills in order to achieve a desired objective, namely the production of a building. It is, therefore, viewed as an organization and consequently subjected to organizational analysis. The co-ordination model is used to show the variables within the design and construction functions of the building process affecting the co-ordination of building services.
This co-ordination model is based on the assumption that:

- All M&E services have been integrated and coordinated by the design team.
- The main-contractor is the chief construction coordinator who will also co-ordinate all M&E services with the specialist contractors.
- All operating units are competent professional and commercial groups.
- The co-ordination of building services on the building project is affected by technical, organizational and managerial factors, and operates within contractual constraints. Also, these factors are themselves interrelated.
- Sufficient time and resources have been allocated to the building process for constructing the building and installing all M&E services.
- The client's changes or design changes are kept to the minimum, otherwise, these changes can affect the progress of the building process.

Based on the foregoing, the co-ordination model can be purposely used to investigate the working of the construction team. Basically, the co-ordination model consists of five sub-systems:

1. **Technical difference system**
   Most main contractors are builder-orientated and M&E services contractors are engineer-orientated. There will be sharp differences in design, construction, installation, testing and commissioning, languages/communication, practices and tolerance between these two organizations. The states of differentiation and integration are inversely related. The more differentiated an organization, the more difficult it is to achieve integration. These differences can often create problems of co-ordination. A mechanism is needed to reduce the differentiation, i.e. by means of integrating devices such as communication, adequate details for construction/installation, interface, direct supervision and standardization of work processes.

2. **Management difference system**
   With the exception of some large and unusual projects, M&E services contractors are only involved with their projects for relatively short and intermittent periods, whereas the main-contractor is involved with the project for its entire life span. These
differing degrees of involvement and responsibility will have a direct impact on the complex co-ordination of services with the construction of the building. The solution is good planning, programming of works and more full-time involvement of the building services contractors.

3. Structural difference system
Based on the organization structures in relation to performance of works, the differences would exist between the main-contractor adopting an organic structure and the services contractors employing a mechanistic structure and these differentiations would create differences in working. Thus, these structural differences can often limit effective co-ordination of services as the specialist services contractors (bureaucratic structure) tend to organize themselves in a more rigid way contrasting with the main-contractor who has to manage the overall building work which is subjected to rapidly changing conditions. These differences can only be resolved by mutual understanding, better team working and effective project management and control.

4. Social difference system
Main-contractors and engineers are viewed as two different groups of professionals and yet they have to work very closely. The attitude of “them and us” is the norm in the industry. Unless they are properly welded together by means of both formal and informal relationships to work as a team, it is difficult to co-ordinate all works effectively. This is particularly the case in the relationship between the main-contractor’s casual and part time labour and the M&E services contractor’s highly skilled and well-integrated labour.

5. Co-ordination organization system
This represents the combined integration and co-ordination work between the design and construction teams. It is also seen to be the most important part necessary for effective co-ordination of building services. Undoubtedly, the first line of defence against poor co-ordination is a fully integrated design with adequate co-ordination drawings and details. The last line must be the good management of further co-ordination between the main-contractor and the services sub-contractors.
These five sub-systems would be found in nearly all building projects irrespective of the type of procurement path chosen. These factors are themselves interrelated and therefore can affect the building project in complex manner. Consequently, if building services are to be successfully integrated on building projects, then their relationships with the remainder of the building project must be considered in terms of technical, managerial, structural and social factors and the overall management of co-ordination of services undertaken by the building team.

The model developed by the author is capable of illustrating the dynamic nature of the coordination process and the essential elements in relation to the integration of all technical, social, organization/structural and managerial components as well as their interactions with the environment. In order not to overload this model, the effects or impacts of any procurement path will be separately discussed in another model, i.e. Coordination - Procurement Model (CP model). Briefly, the BSC model illustrates that effective coordination of building services demands the following inputs:

- Intensive inputs from clients (comprehensive briefing, sufficient time and funding for design and coordination of services), design team (complete design information, fully integrated and coordinated building services and clear contract) and all contractors (complete working drawings for 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.
- Use of an appropriate procurement path and contract conditions (i.e. proper 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 organization and management of the building process 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 organizational system used to acquire a building can
shape the success of a project. Though simple, the BSC model is considered to be detailed enough to assist evaluation during the 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 BSC model. It is, however, not advisable to make an arbitrary selection of a procurement path based on this 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, therefore, needed to facilitate a systematic evaluation of possible procurement paths in a disciplined and objective manner.

6.5 Procurement of building services and building construction

Many unsatisfactory projects have suffered 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 a detailed literature search, little has been said about the logical selection of a procurement method with particular reference to coordinating building services in past research.

This research into procurement methodologies has focused on both project organization systems and the implication of building services elements. From the preliminary research finding and the development of the BSC Model, the author has identified that the 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, project characteristics and project management in a procurement process.

The functional approach is based on all common factors to all construction projects, namely:

- The main functions and the responsibilities of those involved in a building project.
- The project characteristics.
- The management of design and construction.
- The contract form selected.
- The allocation of responsibilities for design and construction.
The integration of designers and contractors.

The project environment (external factors).

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 an evaluation of surveys and case studies, eight major functional factors have been identified as follows:

<table>
<thead>
<tr>
<th>Key function</th>
<th>Requirements for coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Client</td>
<td>Experience, briefing, decision-making, sophistication/complexity, funding and involvement.</td>
</tr>
<tr>
<td>2. Project characteristics</td>
<td>Nature and complexity, cost, time, design, quality and change of needs, constraints and uncertainty.</td>
</tr>
<tr>
<td>3. Organization</td>
<td>Procurement form, familiarity and proximity, differentiation and coordination.</td>
</tr>
<tr>
<td>4. Design team</td>
<td>Multi-organizations to single organization, excellence in design, integration and supervision, completeness of services design and project information, project management and teamworking.</td>
</tr>
<tr>
<td>5. Construction team</td>
<td>Multi-organizations to single organization, excellence in planning construction and coordination, project management and teamworking.</td>
</tr>
<tr>
<td>7. Project environment</td>
<td>Meteorological, economical, political and technological factors.</td>
</tr>
<tr>
<td>8. Project performance</td>
<td>Cost, time and quality.</td>
</tr>
</tbody>
</table>
6.6 Co-ordination - procurement model

Having established the requirements for each of the functions, it is logical to view building procurement as being based on “System Thinking” and devise a Co-ordination - Procurement (CP) Model (for selection of procurement path with emphasis on improving the coordination of building services).

6.6.1 Development of co-ordination - procurement model (CP model)

The objective of the model proposed is the conceptualization of one comprehensive model of the building process embracing all system relationships and identifying the underlying principal elements of these systems so that the key issues of management of building services, the organizational system and the relationships and procedures involved can be rationalized to achieve effective management of the building process.

Based on the functional factors discussed in this chapter, it was logical to plan and develop a co-ordination procurement model. The development of the model is given in Figure 6.3.

The development of the model was based on five main stages.

Stage 1
The client and the project are primary determinants of procedures and control mechanism adopted. These then influence the organization and operation of the building team. These are independent variables and must be located above all variables.

Stage 2
The procurement method selected will determine:

- the structure building project team;
- the working of all project participants; and
- the project and control procedures which will govern the operation of the project, the documentation, form of contract, management systems etc.
The procurement method is an intervening variable.

Stage 3
The organizational form must be designed holistically with due consideration of the interaction and synergism of all project participants.

Therefore, the characteristics of the design and construction teams must be fully examined together with the co-ordination model developed by the author. The co-ordination characteristic is working as an intervening variable which will modify other independent variables.

Stage 4
All variables are selected or adopted to achieve optimum results on the dependent variable of project performance/success.

Stage 5
All variables including project success are all subject to the influence of the environment.

After this basic development, this model was finalized as shown in Figure 6.4. In this model, all inputs for the co-ordination characteristics would be identical to those shown in Figure 6.2: Building Services Co-ordination Model.
### Stage 1
Consideration of the primary variables.
- **Project characteristics**
- **Client characteristics**
These independent variables must be examined first which are hypothesized to be influences in the selection of the building team and management of the building process.

### Stage 2
Consideration of the intervening variables.
The procurement method is to match the attributes of the client body and project itself.

### Stage 3
Incorporation of the variable which can influence the working of project participants.
Contract characteristics including management tools as moderator variables which are selected to achieve optimum level of the management of the building team.

### Stage 4
Provision of the co-ordination intervening variable.
This important variable is to assist efficient co-ordination amongst and between the design and construction teams. This variable is a moderator which is used to achieve optimum level of the last dependent variable, project success.

### Stage 5
Completion of the model.
All variables are to be bounded by the environment within which the building process takes place.

**Legends**
- PC = project characteristics
- PM = procurement method
- D/T = design team
- CLC = client characteristics
- CC = contract characteristics
- C = co-ordination
- PS = project success
- E = environment

Figure 6.3: Development of the co-ordination - procurement model
ORGANISATIONAL FORM

PROJECT CHARACTERISTICS

CLIENT CHARACTERISTICS

PROCUREMENT CHARACTERISTICS

CONTRACT CHARACTERISTICS

CONSTRUCTION TEAM CHARACTERISTICS

COORDINATION CHARACTERISTICS

DESIGN TEAM CHARACTERISTICS

PROJECT PERFORMANCE

BUILDING TEAM RELATIONSHIP

PROJECT ENVIRONMENT

Figure 6.4: Co-ordination - Procurement Model
6.6.2 Explanation of the model

The CP model developed for this research is based on the discussion about organizational forms with the building process given in Chapter 4. The model proposed shows the principal elements identified within the building process. The model operates by first considering the project and client characteristics which act as constraints on the project team and should be a primary influence on the choice of procurement method and management of building services. Project and control procedures and systems are then adopted which govern the operation of the project, the documentation, form of contract, management systems etc. Finally, the building team is organized to provide the desired balance and performance in the context of co-ordination of building services. The project team works within their micro level constraints and the entire building process and client are influenced by the macro environment.

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

<table>
<thead>
<tr>
<th>Sub-system</th>
<th>Characteristics for coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Client</td>
<td>Comprehensive brief, decisive, and efficient communication.</td>
</tr>
<tr>
<td>2. Project characteristics</td>
<td>Avoidance of complexity; realistic budget and time; certainty in construction activity; minimum changes in design and favourable project environment.</td>
</tr>
<tr>
<td>3. Procurement</td>
<td>Organizational form for best coordination of services.</td>
</tr>
<tr>
<td>4. Contract/risk</td>
<td>Unambiguous design and construction responsibilities, obligations and rights/sharing of risk; adequate time and resources for design, coordination and construction.</td>
</tr>
<tr>
<td>5. Integration and co-ordination</td>
<td>Design of rapid team integration for multi organizational form plus effective co-ordination of services.</td>
</tr>
<tr>
<td>6. Design team</td>
<td>Experienced and knowledgeable in integrated design and coordination of services; appointment for full service, i.e. complete design information; good site supervision and cooperative team.</td>
</tr>
</tbody>
</table>
7. Construction team
Experienced and knowledgeable in construction and coordination of specialist contractors; professional project management; good interfacing, coordination and effective resolution of conflicts; coherent and interdependent organizations 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. The object of the model is that it can be used to assist in the selection of the best organizational form for the management of coordination of services and help improve the outcome whatever the procurement strategy.

The development of this CP 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 attempt to use it in this way (i.e. direct or absolute answer) as procurement is a complex issue and necessitates detailed evaluation of each scenario. Most importantly, each procurement form has associated with its particular managerial and organizational factors. Also, no single procurement path can be suitable for every project on all occasions. Procurement is a complex issue and needs detailed evaluation for 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 consider all the stakeholders needs such as (i.e. clients, designers and contractors) and the particular project constraints. This is obviously a difficult task since no single procurement path can fully 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.
6.7 Testing of models

The models developed were useless if the design of the model was not suitable. The design of a model must give the right variables and the questions/points to which answers are to be sought from the model. Besides, a model should capture the reality being modeled as closely as is practical – the complex issue of building services co-ordination in the construction and building services industries. To this end, the author therefore carried out a pilot evaluation for testing the two models on three projects and made some changes (e.g. management of building services co-ordination on site) before conducting the detailed analysis of all case studies. Furthermore, the author also discussed the suitability and applicability of the research models with many professionals working in the real world and scholars when attending some local and overseas conferences and forums on building services. Case studies were also used to show how/where/to what extent they supported or represented (see Chapter 8 for details) the models. The models should give sufficient inputs which would present or occur in a typical building project but the author would check these inputs in each case very carefully in conjunction with all variables as given in the model. The feedback from the professionals and some researchers on the two models was that, in general, the models were very comprehensive but the building services co-ordination model seemed to have many subsystems and minor modification might be needed.

6.8 The propositions of the research

Data drawn together from literature, surveys, discussions, observations and the author's own experience in Hong Kong can be stated as propositions of this 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. The research results and the two models developed for this research stimulate five central propositions, which are:

Proposition 1

"Co-ordination of building services is influenced by management of design"
This proposition points to the investigation of the complex issue of managing co-ordination of services in the building industry.

**Proposition 2**

"Co-ordination of building services is influenced by management of construction"

This proposition points to the linkage between the management of co-ordination of services and the management of construction for the building work contractor and building services contractors.

**Proposition 3**

"Co-ordination of services is not only a technical issue but an exercise in management. It is influenced by the construction professionals’ working practices."

This points to a closer investigation of the complex issue of this technical and managerial issue and determines its relationship with different building procurement methods.

**Proposition 4**

"Co-ordination of services is influenced by the building procurement methods"

This points to the investigation of the impact of different building procurement methods on the implementation of co-ordination of services since each procurement method has associated with its particular managerial and organizational factors that can affect the co-ordination process.

**Proposition 5**

"Project success is influenced by implementation of effective co-ordination of services and the use of an appropriate procurement path"

This points to the impact of an appropriate procurement method on the management of co-ordination of services.

All these propositions were analysed in conjunction with those inferences given in Chapter 5 (Section 5.13) and also tested by means of detailed case studies as shown in Chapters 8 and 9.
6.9 Summary

The lack of previous research in building services co-ordination and building services procurement compelled the author to develop a detailed study of both building and building services industries and factors affecting the co-ordination of M&E services contractors within the building process in Hong Kong and abroad. The detailed studies gave useful and sufficient data for the development of two models. The two models contributed to deeper understanding of the co-ordination issue whilst being open to revision and amendment for a specific type of building and building procurement path.

This chapter has presented a Building Services Coordination model and a Co-ordination - Procurement model based on surveys, case studies and analysis of other literature on project performance and selection of building procurement systems. Both models set out to illustrate the relationships between the variables in the integration and co-ordination of building services and its relationship with building project procurement. The objective of these two models is that they will be used to act as a framework for examining highly serviced building projects in conjunction with the propositions. In the author's opinion, the models should be used to evaluate the impact of a particular procurement method on the management of building services design and installation. Conversely, the models also provide a unique framework to enable the objective identification, comparison and appraisal of procurement systems with the author's assessment method (see Chapter 8) for new building projects in a systematic manner. The two models developed for this research are sufficient to investigate this research work. However, further improvement in this modelling would be given, particularly around the notion of co-ordination/procurement.

The two models can be applied reasonably successfully and can also be extended and revised at a later date to incorporate other variables into the contextual and process domains after completing all analyses of questionnaire data and case study data for major projects. The new variables may be additional to or a replacement of the variables used in this research. More detailed studies of the management of building services design and installation serviced based on the identified variables depicted in the research models will be dealt with in Chapter 7.
# CHAPTER SEVEN

## QUESTIONNAIRE AND ANALYSIS OF RESULTS

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7.3 Summary of client responses
7.4 Evaluation of returns and in-depth interviews with clients
   7.4.1 Performance of management of co-ordination
   7.4.2 Responsibility for carrying out co-ordination
   7.4.3 Impact of inadequate co-ordination
   7.4.4 Procurement method
   7.4.5 Understanding management of co-ordination
7.5 Summary of design team responses (i.e. Architect, Engineer and Quantity Surveyor)
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   7.6.1 Performance of management of co-ordination
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   7.6.3 Impact of inadequate co-ordination
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7.7 Summary of main-contractor's responses
7.8 Evaluation of returns and in-depth interviews with main-contractors
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   7.8.2 Responsibility for carrying out co-ordination
   7.8.3 Impact of inadequate co-ordination
   7.8.4 Procurement method
   7.8.5 Management of co-ordination of services
7.9 Summary of services contractor's responses
7.10 Evaluation of returns and in-depth interviews with the services contractors
   7.10.1 Performance of management of co-ordination
   7.10.2 Responsibility for carrying out co-ordination
   7.10.3 Impact of inadequate co-ordination
   7.10.4 Procurement method
   7.10.5 Management of co-ordination of M&E services
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7.14 Use of case studies
7.15 Short summary
CHAPTER SEVEN: ANALYSIS OF RESULTS

7.1 Introduction

As discussed in Chapter Two: Research Methodology, the overall research methodology adopted by the author can be described as follows:

a) Literature search and review of relevant materials including books, technical papers, research reports, technical and learned journals in relation to the building and building services industries, project management, design and construction and installation of services based on various procurement methods in order to get sufficient data.

b) Interviews with some key building and building services professionals and project participants in order to obtain more qualitative data.

c) Discussions with other researchers in construction management in order to know more management of the research.

d) Use of questionnaires and further interviews for the purpose of obtaining data, views and comments.

e) Use of case studies to gain deeper and clearer understanding of the research area.

f) Analysis of all data obtained from the above techniques.

This chapter examines the author's detailed study of the responses from various members of the building team based on the questionnaires sent to each category of the various organizations such as clients, consultants, quantity surveyors, building contractors and M&E services contractors. The analysis is also based on semi-structured interviews with selected firms who not only returned the questionnaires, but also agreed to be interviewed and gave further clarification of their responses to the questionnaires. The questionnaire also included open sections, where respondents could discuss their particular problems and add their own comments, observations or insights into the management of integration and co-ordination of M&E services.

Figure 7.1 outlines the questionnaire construction and the process of evaluation of the research data.

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Preliminary survey of theory and practice relating to construction management and management of building services

Evaluation of theory and practice related to the management of building services design and installation

Development of research models and construction of questionnaires and other techniques

Collecting real data by means of questionnaires from the client, designers, building works contractor and services contractors

Analysis of data plus further interviews for deeper understanding of the research

Explanation and inferences and discussion with propositions

Figure 7.1: The Methodology Map (questionnaire and interview)
This chapter also discusses the use of case studies from more than twenty-five building projects in Hong Kong and abroad after this questionnaire survey. This is to ascertain what happens in the industry and this can also help to eliminate or reduce the bias of individuals in the questionnaire/interview results. At the same time, the correspondent’s perceptions or responses can be double checked against the realities that occur in the industry. These cases provided further evidence which would be used to verify the results obtained from the questionnaire surveys and the interview results.

7.2 Questionnaires and survey results

In Section 2.9 of this thesis, the author discussed the application of the questionnaires and the personal interview in detail. In executing the research, the author used a selected sampling which was thought to be most appropriate rather than a random sample. This was:

- To ensure that the chosen sample would provide a good representation of the population, i.e. the design and construction teams.
- To ensure that the selected sample (i.e. design and contracting firms and people) was suitable for this research. These organizations must be homogenous and shared similar characteristics. They were all large organizations, were very experienced with the building process and the co-ordination of building services, and, most importantly, they all undertook different types of large project work under different contractual arrangements. There were, however, differences in that some clients were private organizations and others were public types. Moreover, due to the nature of their business or services, some clients had complex organizational structure while other had simple ones. With this non-random sampling design, quality of information should be deep and more reliable.
- To ensure that useful information would be obtained from reliable respondents. The sample was obtained by approaching clients, professional practices and contractors in the industry, asking for their co-operation. In this respect, the sample could not be said to be random. In fact, it was necessary to use the selected sampling for this research as randomly selected organizations might not give the requisite research data because many of the small design and contracting firms might not have the necessary
experiences of large and highly serviced projects. Of course, there would be exceptional cases, hence, the author did not exclude these smaller organizations but a great care was taken when choosing a small number of these firms if they had the knowledge and experience in the management of building services co-ordination.

Whatever technique for collecting data is selected, it should always be examined critically to assess to what extent it is likely to be reliable and valid.

A pilot study test was necessary. After testing the draft questionnaires, the preliminary questionnaires were fully revised in order to facilitate good capturing of research data. The questionnaire was then customized for the respective client, consultancy and contractor lists but nevertheless still sought the same basic information.

A total of one hundred questionnaires were sent to the identified organizations in Hong Kong. The questionnaires elicited from the respondents their perceptions of how co-ordination of building services related to procurement methods and project performance and canvassed their opinions on a range of issues which were important to effective management of building services co-ordination. Responses between the groups of clients, designers and contractors were analysed and compared.

The rate of response was 67%. Most organizations responded by completing questionnaires in a useable form, but a small number of responses (8 No.) had to be discarded as a result of incomplete information.

A summary of the organizations identified were as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>No. of organizations</th>
<th>%</th>
<th>No. of Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>10</td>
<td>(10)</td>
<td>8</td>
<td>(13)</td>
</tr>
<tr>
<td>Architect</td>
<td>20</td>
<td>(20)</td>
<td>10</td>
<td>(17)</td>
</tr>
<tr>
<td>M&amp;E services consultancy</td>
<td>16</td>
<td>(16)</td>
<td>12</td>
<td>(20)</td>
</tr>
<tr>
<td>Quantity surveyor</td>
<td>10</td>
<td>(10)</td>
<td>5</td>
<td>(8)</td>
</tr>
<tr>
<td>Building works contractor</td>
<td>22</td>
<td>(22)</td>
<td>12</td>
<td>(20)</td>
</tr>
<tr>
<td>M&amp;E services contractors</td>
<td>22</td>
<td>(22)</td>
<td>13</td>
<td>(22)</td>
</tr>
</tbody>
</table>

100 100 60 100 210
The issue of response rates was important and must be taken into account when evaluating the research data. As explained in Section 2.9, for this research, the percentage of response rate (67% based on selected sampling) was considered to be adequate as these were mostly large and experienced professional practices and contractors. These organizations and the people not only represented the views of the construction industry but they were also able to provide informed and competent information based on many highly serviced projects with which they were associated.

Before discussing the questionnaires in detail, it is necessary to mention the rating scale used by the author. The numerical number system is a good choice as the respondent has the choice to express his/her degree of significance or seriousness (or the degree of agreement or disagreement) for a question. This is in fact a ranking system based on the scores given by the respondents. The score is actually a weighting factor.

The “Total Weighting” factor given for each question is the product of the rating on a scale of 1 to 5 (where 1 is the minimum/low level of effect or recognition and 5 is the maximum/high effect) and the number of responses provided by the respondents. A score of 2 or less represents a very weak effect; a score of 2.5 - 3 represents a moderate effect and a score above 3.5 indicates a strong effect. The total weighting factor is also expressed in terms of a percentage of the maximum score of each question. A high percentage indicates a high effect or very significant. With reference to Hibberd’s work (1991) and many other researchers, an index of a score (i.e. position) is given to each of the calculated “Total Weighting” factors. This provides a useful measure of seriousness, importance or significance and the highest score is assigned a rank of 1.

To determine the position of importance, it is necessary to compare the actual score of each question with the total score obtained from a set of questions. This is in fact a simple calculation of importance index. The question which gets the highest percentage or index is given the highest position (1 (one) being the top and also means the most important one). Each set of questions included in a main question (there are five main questions in each questionnaire) is independent and therefore cannot be combined for ranking. This method is considered sufficient enough to evaluate the subjective responses obtained from both questionnaires and interviews.
It is stressed that the ranking exercise is based on a respondent’s perception, not an objective assessment. This subjective assessment based on the scores is used to analyse the perceived relative importance of factors. The fact that this subjective assessment does not provide any absolute value on the ranking position is recognized. Emphasis is not only given to factors that are placed as the most important and the least important but other factors between these two will also be examined since all factors can be main attributes or sub attributes that may influence the co-ordination process.

Propositions help to identify boundaries of the study in this qualitative work which seeks immersion in the subject matter to collect all possible data for analysis to see what, if anything, emerges. The author gave five propositions (see Section 2.3) and they all pointed to the seeking of the following information from various project participants by using a structured questionnaire as one of the research tools and this was augmented by interviews.

- Management of co-ordination of services and the inherent problems.
- Contractual issues pertaining to implementation of building services co-ordination.
- Use of different procurement methods and the impact of each procurement method on building services co-ordination.
- Other factors influencing building services co-ordination and project performance.
- The best means to optimize success and achieve better co-ordination services.

The following tables summarize the survey responses from:

- The client
- The design team
- The main-contractor
- The M&E services contractors

Analysis of each summary was also provided to bring out the important issues which were considered significant and relevant to the management of the building services element of construction projects.
7.3 Summary of client responses

Table 7.1 was prepared with the objective of obtaining basic but important information relating to the co-ordination of M&E services and the procurement methods normally used from the viewpoint of a client.

The table gives an indication of the score for each of the sub-questions within the main questions. With these scores or weighting factors, the relative importance of all relevant factors could be determined. These importance factors based on the percentage of the actual score should, however, not be seen as an absolute precise measure, and should not be used as the only source of information. As such, the data must be used in conjunction with other information (e.g. interview data and case studies, etc). It was considered by the author that with this percentage / position data, the reader would see the relative importance of each of the sub-questions under the five main questions 1 – 5.

<table>
<thead>
<tr>
<th>Responses</th>
<th>Average Rating &amp; Max. Scores (40)</th>
<th>Total Weighting &amp; % Actual Score</th>
<th>% of Score &amp; Position of Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Performance of management of co-ordination of building services by:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Architect</td>
<td>4</td>
<td>32 (80)</td>
<td>(29) 1</td>
</tr>
<tr>
<td>b. Services engineer</td>
<td>3.5</td>
<td>28 (70)</td>
<td>(25) 2</td>
</tr>
<tr>
<td>c. Building services contractor</td>
<td>3.25</td>
<td>26 (65)</td>
<td>(24) 3</td>
</tr>
<tr>
<td>d. Main-contractor</td>
<td>3</td>
<td>24 (60)</td>
<td>(22) 4</td>
</tr>
<tr>
<td></td>
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<td>110</td>
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<td><strong>2. Responsibility for carrying out co-ordination of M&amp;E services:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Design team</td>
<td>4.5</td>
<td>36 (90)</td>
<td>(35) 1</td>
</tr>
<tr>
<td>b. Main-contractor</td>
<td>4.25</td>
<td>34 (85)</td>
<td>(33) 2</td>
</tr>
<tr>
<td>c. Building services contractor</td>
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<td>32 (80)</td>
<td>(32) 3</td>
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<tr>
<td></td>
<td></td>
<td>102</td>
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<tr>
<td><strong>3. Impact of inadequate co-ordination on:</strong></td>
<td></td>
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<td></td>
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<tr>
<td>a. Contract time performance</td>
<td>4.75</td>
<td>38 (95)</td>
<td>(24) 1</td>
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<td>b. Cost control</td>
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<td>(21) 2</td>
</tr>
<tr>
<td>c. Management of contract</td>
<td>4.75</td>
<td>30 (75)</td>
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<td>d. Project success</td>
<td>3.5</td>
<td>28 (70)</td>
<td>(18) 4</td>
</tr>
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<td>e. Quality of services</td>
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<td>28 (70)</td>
<td>(18) 4</td>
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</table>
Table 7.1 – continued

4. *Procurement method:*

<table>
<thead>
<tr>
<th>Method</th>
<th>a. Most used</th>
<th>b. Level of satisfaction</th>
<th>c. Important factors in determining the choice of procurement method given due regard to the co-ordination of building services:</th>
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</tr>
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<tbody>
<tr>
<td></td>
<td></td>
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<td>Predicable cost</td>
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</tr>
<tr>
<td>Conventional</td>
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<td>Develop and Construct</td>
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<td>24 (60)</td>
<td>(28) 2</td>
<td></td>
</tr>
<tr>
<td>Management Contracting</td>
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<td>8 (20)</td>
<td>(9) 3</td>
<td></td>
</tr>
<tr>
<td>Construction Management</td>
<td>1</td>
<td>8 (20)</td>
<td>(9) 3</td>
<td></td>
</tr>
<tr>
<td>Design and Build</td>
<td>1</td>
<td>8 (20)</td>
<td>(9) 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>86</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Method</th>
<th>b. Level of satisfaction</th>
<th>c. Important factors in determining the choice of procurement method given due regard to the co-ordination of building services:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Predicable cost</td>
<td>4.25</td>
</tr>
<tr>
<td>Develop and Construct</td>
<td>4</td>
<td>32 (80)</td>
<td>(29) 1</td>
</tr>
<tr>
<td>Conventional</td>
<td>3</td>
<td>24 (60)</td>
<td>(21) 2</td>
</tr>
<tr>
<td>Management Contracting</td>
<td>3</td>
<td>24 (60)</td>
<td>(21) 2</td>
</tr>
<tr>
<td>Construction Management</td>
<td>3</td>
<td>24 (60)</td>
<td>(21) 2</td>
</tr>
<tr>
<td>Design and Build</td>
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<td>8 (20)</td>
<td>(7) 3</td>
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<tr>
<td></td>
<td></td>
<td>112</td>
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5. *Understanding of importance of management of co-ordination of M&E services:*

<table>
<thead>
<tr>
<th>Factor</th>
<th>a. Costly co-ordination problems as a result of inadequate management of co-ordination</th>
<th>b. Quality of design coordination</th>
<th>c. From previous experiences</th>
<th>d. From other projects</th>
<th>e. Need good project management by all parties</th>
<th>f. Costly client's contribution to avoid problems</th>
</tr>
</thead>
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<tr>
<td>Predicable cost</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
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<tr>
<td>Completion on time</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Smooth management of building team</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>4</td>
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<td>Quality of design</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Dissatisfaction with previous procurement</td>
<td>4.25</td>
<td>1</td>
<td>4</td>
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<td>3</td>
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<tr>
<td>Single point responsibility</td>
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<td>1</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Project complexity</td>
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<td>1</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Control of contract work/contractor</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Knowledge of method</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Transfer of risk</td>
<td>3.5</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Working relationship</td>
<td>3.25</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

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7.4 Evaluation of returns and in-depth interviews with clients

Relevant remarks drawn from the survey summary and the information derived from interviews with senior personnel by the author were:

- Performance of management of co-ordination.
- Responsibility for carrying out co-ordination.
- The impact of inadequate co-ordination.
- Procurement method.
- Understanding of management of co-ordination.

7.4.1 Performance of management of co-ordination

Clients (80% response) were normally satisfied with the lead designer’s performance, but gave lower ratings to other project participants. A significant issue was that lower ratings were given to the construction team which indicated that many clients (over 70%) were still not fully satisfied with the performance of the main-contractor and the services subcontractor in many construction projects using the traditional procurement method.

The interview results also indicated that a substantial number of experienced and public clients (over 85% response) strongly considered that all services design engineers, building contractors and services sub-contractors could make more contribution to the complex co-ordination process. Many experienced clients also understood the dependence of services engineers/services sub-contractors on information from the architect/main-contractor and this dependence tended to make them feel less responsible for their work. Most importantly, the author found that many clients also felt that both services consultants and contractors should improve their performance.

7.4.2 Responsibility for carrying out co-ordination

Many clients (over 80%) put much emphasis on the effort of the design team. Most experienced clients felt that better integration and co-ordination of services should be provided by the design team during the design stage as this was the first line of defence
preventing poor co-ordination later. From the interview results, many clients also realized the importance of the second stage of the co-ordination work which must be carried out by the various contractors on site. Naturally, in order to reduce the contractual conflicts and problems in relation to co-ordination of services, many clients would delegate the main-contractor to be the lead building services co-coordinator working with all services sub-contractors. In this case, they would all be paid to do the job if the projects were large and complex.

Some clients also asked the building services consultant to provide extra service with regard to the provision of detailed co-ordination details and drawings, but this practice mostly applied to large building projects especially procured by the government/public clients.

7.4.3 Impact of inadequate co-ordination

Many clients (over 85%) knew that extra costs, expensive claims, disputes between members of the building team and costly arbitration would be the result of inadequate co-ordination of M&E services in many highly serviced buildings. They also realized the consequences of inadequate integration and co-ordination of building services. The consequences mentioned to the researcher are listed below in order of importance:

1. Delay to building programme.
2. Increase in project cost due to abortive work and solutions for resolving the co-ordination problems.
3. Serious effect on the management of services sub-contractors.
4. Serious effect on the management of the building construction.
5. Effect on quality of building and its services.
6. Effect on project success.

As expected, high cost and delay in construction were viewed as the serious impacts. Project success and quality, perhaps somewhat surprisingly, fell to the bottom of the order of importance. This point was further raised and discussed with the respondents by the author and their reasons were:
There were other priorities that might shape the success of a project. If the co-ordination processes did not seriously affect the contract time, slight increase in construction cost due to the co-ordination problems could still be tolerated. Of course, sufficient contingency should have been allowed for the extra costs involved. In many commercial projects, the M&E services were not very complex and the performance of building services sub-contractors would not affect the overall project performance. Furthermore, the root cause of project failure could be other issues.

In short, most clients expressed their views that they did not wish to have problems in their projects and M&E services was one of the many problems that they had known. Most clients however, considered that the serious effects of poor co-ordination of services were delay in construction and extra costs as a result of contractors' claims.

7.4.4 Procurement method

Based on the questionnaire results, the traditional procurement path was still the most common method (over 87%). Only a small number of the client respondents indicated low satisfaction with this conventional process. The responses to those using non-conventional processes as the main procurement path was very small but some experienced clients (30%) indicated that the Develop and Construct (not Design and Build) method was another much used procurement process. Clients were also very satisfied with other non-conventional methods.

It was established from the questionnaire results and in-depth interviews that many factors influenced those responsible for the selection of the procurement path. The factors had varying degrees of significance and could be classified under three headings, namely:

a. Factors which by themselves should not determine the choice of procurement path:

• Supposed benefits of the procurement path.
b. Factors which by themselves when considered in connection with other factors, could influence or determine the choice of procurement path:

- Size of project.
- Previous problems.
- Phasing requirements.
- Need to change design.
- Time available for development of design.
- Time available until completion.

c. Key factors in determining the procurement path and the contractual relationship

The most important factors were:

- Apportionment of risks - less risks if possible (87%).
- Overall project cost - within budget (85%).
- Single point responsibility - main-contractor to do all works (85%).
- Time performance - no overrun (75% respondents).
- Ease of project management - client to look after design and contractor to look after construction (70%).
- Quality of project - control of design and quality of building (60%).

All in all, all the factors under the three headings would be considered when deciding the selection of procurement path. In general, there was little evidence of the combination of a disciplined, systematic and objective approach to the selection of their procurement systems, but attention appeared to have been paid to market conditions in the construction industry, past experience, advisors' advice and policies of the client's organizations. The interviewee's feedback was that, in practice, the choice of the most appropriate building procurement route could be considered as an unstructured, ill-disciplined approach of adjudication between alternatives found in the real world. Besides, the selection process
could only be a satisfying process, rather than providing a definite answer to the procurement system question.

As far as the management of co-ordination of building services was concerned it was established from the interview results that a suitable procurement path should:

- Enhance better management of integration and co-ordination of services with clear responsibility of design and installation.
- Cultivate team working and a high degree of co-operation between project participants.
- Give satisfactory level of risk.
- Facilitate effective project management for the overall project based on the concept of single point responsibility.

The interview results indicated that non-conventional procurement paths tended to be used for large, complex and highly serviced building projects, and there was also a move towards the Develop and Construct method for the following reasons:

- Single point responsibility with regard to design and construction.
- Greater certainty with regard to time and cost.
- Better working relationship.
- Reduction of client’s management and risks associated with the provision of complete and fully integrated and coordinated M&E services design.
- Good record of this procurement path.

7.4.5 Understanding management of co-ordination

Based on the questionnaire / interview survey results, with the exception of some inexperienced and private clients, many clients (over 85%) fully understood and realized the importance of good management of co-ordination of M&E services. In general, many clients were advised by their consultants about the co-ordination issues which were based on previous project results and the consultant’s experiences. Clients understood the following:
• The effect (e.g. high cost involved by both contractors and client, time overrun and contractual conflicts/problems) of inadequate management of co-ordination of M&E services on project performance in particular for large and highly serviced building projects.

• The need for good integration of M&E services in design and the use of experienced contractors to avoid inadequate co-ordination.

Based on in-depth interview results, the author found that not many clients fully appreciated their contribution to the process of effective co-ordination and, they often created problems like:

• Ineffective management of design input (e.g. poor design brief, multi-headed client confusion and poor supply of information) resulting in either design problems or incomplete design and also late design changes which could seriously affect integration and co-ordination of M&E services.

• Employment of the services consultant in many projects was still based on standard service in which full co-ordination of services was not included and therefore the design would not be fully completed and co-ordination problems could easily occur (Some experienced clients however claimed that they would ask the consultants to provide more co-ordination details if there was such a need in some large and complex projects. Incidentally, the contractors would also be paid to carry out the co-ordination work on site, as this was the only way to have a smooth project. Some clients further paid the consultant to assist the contractors on site, but this practice was very rare and only limited to unusual projects).

• Costly management of contractors’ co-ordination work was not fully realized.

In short, clients had tried nearly all procurement methods. Still, the conventional method was the preferred selection. Some clients, however, were not fully satisfied with the conventional method (e.g. more co-ordination problems and risks) and had shifted their attention to the construction management system for large and complex projects. But still, there was a separation between design and construction. Besides, the client had to take up more risks and responsibilities for the completion of a project. The Design and Build (D&B) method offered a single point of responsibility and therefore the system should
give greater integration and co-ordination of services. However, clients did not have full control of design and quality. The Develop and Construct path was more acceptable from the viewpoints of greater control of design and quality; better integration and co-ordination of services and building works due to the combination of design and installation teams; high reliability of cost and time control; and once the contract had been signed, the contractor would be fully responsible for the entire design and construction so that delay would be minimized.

7.5 Summary of design team responses (i.e. Architect, Engineer and Quantity Surveyor)

Table 7.2 relates to the co-ordination of M&E services and the procurement method selected.

Table 7.2

<table>
<thead>
<tr>
<th>Responses</th>
<th>Average Rating &amp; Max. Scores (135)</th>
<th>Total Weighting &amp; % Actual Score</th>
<th>% of Score &amp; Position of Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Performance of management of co-ordination of building services by:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Architect</td>
<td>4</td>
<td>108 (80) (26) 1</td>
<td></td>
</tr>
<tr>
<td>b. Building services engineer</td>
<td>3.7</td>
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<td></td>
</tr>
<tr>
<td>c. Building services contractor</td>
<td>3.5</td>
<td>95 (71) (23) 3</td>
<td></td>
</tr>
<tr>
<td>d. Main-contractor</td>
<td>3</td>
<td>81 (60) (20) 4</td>
<td></td>
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<tr>
<td>e. Quantity surveyor</td>
<td>1.04</td>
<td>28 (21) (7) 5</td>
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<tr>
<td>2. Responsibility for carrying out co-ordination of M&amp;E services:</td>
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<td></td>
</tr>
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<td>a. Main-contractor</td>
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<td></td>
</tr>
<tr>
<td>b. Building services contractor</td>
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<td></td>
</tr>
<tr>
<td>c. Building services engineer</td>
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<tr>
<td>d. Construction project management team</td>
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<td>e. Architect</td>
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<td>3. Impact of inadequate co-ordination on:</td>
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<td></td>
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<tr>
<td>a. Cost control</td>
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<td>135 (100) (25) 1</td>
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</tr>
<tr>
<td>b. Contract time performance</td>
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<td></td>
</tr>
<tr>
<td>c. Project success/business</td>
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<td>e. Quality of services</td>
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</table>
### Table 7.2 – continued

#### 4. Procurement method:

<table>
<thead>
<tr>
<th>Method</th>
<th>Most used</th>
<th>Level of satisfaction</th>
<th>Important issues in determining the choice of procurement method with due regard to co-ordination of building services.</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dissatisfaction with previous procurement method used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single point responsibility</td>
<td>Completion on time</td>
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<tr>
<td>Conventional</td>
<td>5</td>
<td>135 (100)</td>
<td>(11) 1</td>
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<tr>
<td>Develop and Construct</td>
<td>3</td>
<td>81 (60)</td>
<td>(23) 2</td>
</tr>
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<td>Construction management</td>
<td>3</td>
<td>81 (60)</td>
<td>(23) 2</td>
</tr>
<tr>
<td>Management contracting</td>
<td>1.1</td>
<td>30 (22)</td>
<td>(9) 3</td>
</tr>
<tr>
<td>Design and Build</td>
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<td>(9) 3</td>
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#### 5. Management of co-ordination of M&E services.

<table>
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<th>Most used</th>
<th>Level of satisfaction</th>
<th>Important issues in determining the choice of procurement method with due regard to co-ordination of building services.</th>
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<td>a. Responsibilities for co-ordination in contract</td>
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<td>135 (100)</td>
<td>(12) 1</td>
</tr>
<tr>
<td>b. Full integration of services into design by consultant</td>
<td>5</td>
<td>135 (100)</td>
<td>(12) 1</td>
</tr>
<tr>
<td>c. Full co-ordination of services with building works by main-contractor</td>
<td>5</td>
<td>135 (100)</td>
<td>(12) 1</td>
</tr>
<tr>
<td>d. Preparation of preliminary services co-ordination drawings and relevant details by consultant</td>
<td>5</td>
<td>135 (100)</td>
<td>(12) 1</td>
</tr>
<tr>
<td>e. Preparation of detailed services co-ordination drawings and builder’s work drawings by main-contractor and services contractors</td>
<td>5</td>
<td>135 (100)</td>
<td>(12) 1</td>
</tr>
<tr>
<td>f. Solving problems by all parties on site</td>
<td>4.81</td>
<td>130 (96)</td>
<td>(11) 2</td>
</tr>
<tr>
<td>g. Preliminary co-ordination of services by consultant</td>
<td>4.26</td>
<td>115 (85)</td>
<td>(10) 3</td>
</tr>
<tr>
<td>h. Detailed co-ordination of services by individual services contractors</td>
<td>4</td>
<td>108 (80)</td>
<td>(9.5) 4</td>
</tr>
<tr>
<td>i. Good site management by all contractors</td>
<td>4</td>
<td>108 (80)</td>
<td>(9.5) 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1136</td>
<td></td>
</tr>
</tbody>
</table>
Table 7.2 – continued

6. Performance of employment of:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Principal services contractor covering all M&amp;E services</td>
<td>5</td>
<td>135 (100)</td>
<td>(23) 1</td>
</tr>
<tr>
<td>b. Building services co-ordination team in main-contract</td>
<td>5</td>
<td>135 (100)</td>
<td>(23) 1</td>
</tr>
<tr>
<td>c. Building services co-ordination team in sub-contractor</td>
<td>5</td>
<td>135 (100)</td>
<td>(23) 1</td>
</tr>
<tr>
<td>d. Domestic sub-contractor</td>
<td>4</td>
<td>108 (80)</td>
<td>(18) 2</td>
</tr>
<tr>
<td>e. Nominated sub-contractor</td>
<td>3.15</td>
<td>85 (63)</td>
<td>(14) 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>598</td>
<td></td>
</tr>
</tbody>
</table>

7.6 Evaluation of returns and in-depth interviews with design team

Relevant remarks drawn from the survey summary and the information derived from interviews with senior personnel by the author were:

- Performance of management of co-ordination.
- Responsibility for carrying out co-ordination.
- Impact of inadequate co-ordination.
- Procurement method.
- Management of co-ordination.
- Performance of contractors.

7.6.1 Performance of management of co-ordination

The questionnaire results indicated that:

Architect – highest rating
Building services engineer – below architect
Building services contractor – third position
Main-contractor – below services contractor
Quantity surveyor – lowest

It was not surprising to see that the quantity surveyor (QS) obtained the lowest score as this particular project participant would not normally be involved in the actual process of
design, integration and co-ordination of services. However, the QS still played an important role in the preparation of contract documents which should cover all essential details of management of co-ordination in both the main-contract and all sub-contracts (or other forms of contract). The details should cover:

- Responsibility for co-ordination by each party.
- Scope of management of co-ordination.
- Minimum requirements pertaining to resources and co-ordination team required for satisfactory execution of co-ordination.
- Obligations and rights with regard to co-ordination issues.

Discussions between the author and some large quantity surveyor practices also revealed that M&E Bill of Quantities (BQ) should reduce some co-ordination problems since the level of information for services BQ should be much more comprehensive than the information a services consultant provided to contractors adopting the drawings and specification route. Given the greater degree of detailed information required to prepare a full BQ the main overriding advantage rested not so much in the bill itself but in the fact that the installation should be better designed and co-ordinated before tender. The quantity surveyor should therefore have an effective role to play in the tendering and installation of building services works although the score was the lowest.

The results did reflect a low performance of the main-contractor and the interview results also revealed that the construction team (e.g. all contractors) could do more to improve the co-ordination process.

The author’s discussions with the designers also revealed the following points:

- Architects should give more considerations to M&E services design and installation, in particular, the provision of adequate spaces to facilitate better integration and co-ordination. This was said to be the first line of defence against clashing or conflict of M&E services. Normally, spaces provided were barely adequate and it was difficult to accommodate all M&E services satisfactorily.
• Building services engineers should do more and the indicated performance rating was far from perfect. Most consultant engineers felt that they could do better if they were be paid by the client to carry out the extra work of co-ordination details during the design stage and perhaps even during the construction process for some large projects. But they further added that the architect should also work with them hand in hand for more effective integration and co-ordination of services. Some project management consultants commented that, ideally, someone from the architectural practice and the services engineer would together go through the design with necessary co-ordination checks in order to avoid many co-ordination problems later. This need was very much allied to the quality assurance system. However, not many architects and engineers carried out this work.

• All designers agreed that they were satisfied with the large and experienced contractors as they were fully aware of the consequences of inadequate site co-ordination. However, there were still many building work and services contractors whose performances were still less satisfactory especially in:

  - Programming of M&E services with building work.
  - Setting up adequate site co-ordination teams.
  - Adequate preparation of combined services drawings.
  - Control of sub-contractor's works.
  - Communications between contractors with regard to co-ordination.

7.6.2 Responsibility for carrying out co-ordination

Based on the questionnaire/interview survey results, the author identified that the services professions and the main-contractor should be fully responsible for this task for the good of a project.

Interview results showed the following:

• Co-ordination of services must be managed by the whole building team. The design team should concentrate on the integration of services first in their designs
and the construction team should follow the design and fully co-ordinate the services on site.

- The consulting engineer, as services designer, should be the lead project manager when handling services co-ordination. The architect should then support the engineer in this respect as much as possible. The structural engineer should take a more pro-active approach to help improve the co-ordination process as many co-ordination problems were closely related to space constraint and awkward structural design.

- An additional construction project management team would certainly do a better job than just relying on the main-contractor and services contractors.

- Over 90% of respondents from the design team stressed that members of the construction team should take up the site co-ordination duty and provide adequate management for the co-ordination process. They should execute works like:

  - Planning of services and building construction.
  - Preparatory work such as co-ordination details, schedules and programme of services and building construction.
  - Control of co-ordination work.
  - Solving co-ordination problems with the design team.

7.6.3 Impact of inadequate co-ordination

Most returns considered that the critical problems of extra cost, time, overrun, contractual disputes and unsatisfactory project performance were the significant impacts.

The interviews carried out by the author identified that co-ordination problems created adversarial relationships between all contractors and designers and this poor working relationship was not helpful in the difficult co-ordination process. This also explained its ill-effect on the management of the whole construction process because of:

- Poor team working with “Them and Us” or “Builder and Engineer” attitudes.
- Distrust of members among the building team.
• Disrupted installation/construction programmes due to suspension of works as a result of clashing of services or other co-ordination problems.
• Disputes between main-contractor and sub-contractors (this can generate antagonism between the parties leading to serious contractual disputes).

The design team also noted that poor-coordination of services could also result in:

• Lower quality of services and building elements.
• Lower performance of services.
• Difficult maintenance of services.
• Effect on aesthetics.

However, all these points were difficult to quantify. Furthermore, their effects were not seen for some considerable time after project completion and subjective assessments would obviously be employed by individual researcher.

The results of the survey showed that co-ordination problems existed in almost all projects. When these problems were not significant and could be resolved quickly by the whole building team, the effect on the overall project performance was small (cost and short delay). It was also commented by many interviewees that when the co-ordination problems were out of control (e.g. large number at the same time and slow resolution by all parties), the knock-on effect on construction progress could seriously affect the project success, and often the services installation would delay the progress of the construction work, leaving the client at great risk.

7.6.4 Procurement method

With the exception of the higher rating given to construction management, the results were similar to those given by the clients. Obviously, most designers were the client’s advisers and it would be quite reasonable to expect similar responses.
Based on the interview results, it was interesting to note that the use of construction management was gaining more and more consideration. Many interviewees expressed the merits of this procurement path with regard to co-ordination of services:

- To strengthen the management applied on behalf of the client.
- To apply construction and services expertise to early planning, building construction and installation of M&E services.
- To give greater control of both the building work contractor and services contractors, and therefore should achieve greater co-ordination of M&E services and builder's work if the technical issues of the co-ordination process were satisfactory.
- To be able to accommodate design changes (but should be avoided).

The surveys also gave a strong indication in the increase of design and build type contracts (e.g. develop and construct) over the period of the author's research study since 1995 for many highly serviced hospitals and special buildings. As far as co-ordination of services was concerned, the argument put forward by some of the large architects and consulting engineers who recommended this unconventional approach were:

- No more separation of the responsibility for design and construction.
- Better communication between the designers and contractors.
- Greater co-ordination and integration of the building team as a result of better working relationship of the project team.
- Inherent buildability is achieved.
- Greater control of services contractors by the D&B contractor.
- Services contractors' co-ordination problems would become the D&B contractor's own problem, and this tended to force resolution of the problems instead of making claims etc.

The interview results based on in-depth discussions amongst the author and many M&E services consultants also highlighted the following:
• Co-ordination problems still exist in all procurement methods, but to a lesser extent in the D&B method, as there was less separation between members of the building team.

• Contractually, the services consultant was responsible for the provision of a more workable design and had to take up the role of the leading services co-ordination right from the beginning. The consultant would also work closely with the services contractors during the early design stage and therefore, most of the co-ordination problems would be eliminated first.

• The whole building team would solve co-ordination problems much quicker since both architect, services engineer and the contractors involved were members of the D&B organization (either employed or owned), and therefore, the complex task of integrating large numbers of differentiated operating units into a viable whole was easier and could be managed more efficiently.

• Even with difficult problems, the whole team would provide better provision for alternative solutions in order not to affect the construction programme.

• Easy project management from the viewpoint of the client and consultants. Problem with nomination would not occur and contractual claims would be diminished due to single point responsibility of the contractor.

Interview results indicated that the design team members still favoured the traditional procurement method. However, there were strong suggestions that they showed great interest in other non-conventional methods as these unorthodox systems would improve the complex task of co-ordination of building services as a result of:

• Greater project management provided by experienced experts.

• Greater integration and co-ordination.

• Better team working than the conventional method.

• Higher level of managerial control for both of the design and installation of building services.

• Early involvement of the services contractor in the design process.
Most importantly, the design team could concentrate on the design issues whilst the project management consultant and the team of various experts would look after the management of the whole building construction. All these views were reflected in the rating given to the item of level of satisfaction.

When they were asked what would be the preference for employment of the contractor, most returns gave the use of nominated services contractors because the designers could pick up the best specialist contractors to complete a special design and installation. However they knew quite well that this would also be the root cause of the co-ordination problem if these contractors and the main-contractor could not form an effective building team even they were capable of doing the work.

Many designers also had no objection to the use of domestic sub-contractors as this approach was very close to the concept of single point responsibility. However, they had great concern about the quality of M&E services if the services contractors were neither named nor pre-qualified by them. Interview results also indicated that the use of domestic contractors would greatly improve the management of the co-ordination process, but installation was still separated from design.

In-depth interviews with building services designers and several project management consultants together with questionnaire results supported the preference of a “Principal Services Contractor” to a large number of nominated M&E services organizations. The principle was that a main-contractor would be employed to look after the building construction aspects of the project and a main building services contractor covering all specialist services works including the overall services co-ordination. In this case, the main-contractor would only co-ordinate with a single building services contractor who agreed to have full contractual responsibility for spatial co-ordination of all services and all interfaces with its own sub-contractors and the main-contractor. Therefore, the task of managing a large number of services contractors would be greatly reduced. To enhance this system, an independent project management consultant and its team members would often be employed to cover all aspects of construction planning, programming, site supervision and co-ordination of the building services. In other words, both the building works contractor and the Principal Services Contractor would concentrate more on the technical issues and therefore, the project could be constructed more efficiently.
As far as building services works were concerned, the merits of this approach as raised by the interviewees were:

- Single point responsibility for services installation would reduce the usual complex management and communication problems that the main-contractor would face especially during the overall services co-ordination process.
- Co-ordination problems could still exist, but greater co-ordination and integration of the building services designer and contractor would be expected due to the single point responsibility of the principal contractor.
- The Principal Services Contractor must manage its co-ordination duties before carrying out the various services packages which were under its contract. As the PSC was fully responsible for all M&E services, it would take the project management seriously. More effective co-ordination would be achieved when all services packages were under the control of one body. If this specialist body was an engineering specialist, it could do better than the builder who knew very little about complex building services.
- Further reduction of problems with nomination as there was only one principal contractor rather than many services contractors.
- With proper construction management, an experienced principal contractor would form a better building team and achieve better project performance.

The level of satisfaction with a particular procurement process was not unduly affected by the discipline of the respondent or interviewee. Most replies and interview results gave higher ratings to non-traditional procurement methods which were perceived to give better co-ordination of building services as a result of the application of additional project management and the change of the organizational structure of the contractor from multiple contractors of high differentiation to a single organization with less differentiation.

However, many designers cited that they were also quite satisfied with the traditional system for many projects as long as they had the right contractors and all contract documents including the design were fully complete. Furthermore the management of co-
ordination must be clearly spelled out for the main-contractor’s pricing for all resources needed for good co-ordination of services.

When determining which procurement process would be chosen in relation to co-ordination of services, most members of the design team indicated that, in general, they would consider most of the points given in the questionnaire, however, the most important criteria were:

- Previous experience.
- Full responsibility for co-ordination of services by the main-contractor/services contractors.
- Transfer of risk and co-ordination problems from the client/designer to the contractors.
- Other factors would be technical complexity, size of project, time, cost control and control of design.

Generally speaking, consultants were more influenced than clients in the choice of the procurement process by their experiences of dissatisfaction and the transfer of co-ordination responsibility to the contractors. This would mean that consultants were more likely to adopt an alternative procurement process.

Again, the choice of the most appropriate building procurement system would be considered as unstructured, many interviewees indicated that they had sufficient knowledge about all of the available procurement systems of the construction industry and they had done their best in advising their clients.

In general practice, they would adopt the following approaches:

a. Residential building - Traditional method  
b. Standard office building - Traditional method  
c. Complex building - Traditional method plus project management consultant or construction management system
d. Very complex building  -  Traditional method and Develop and Construct  
e. Special building  -  Both conventional and un-conventional methods

The interviewees also cited that the above-mentioned should not be viewed as rigid rules since each project would demand special considerations and the final choice would be made to match the client’s need and the project characteristics as close as possible.

7.6.5 Management of co-ordination

Most returns, together with interview results, indicated that a large number of client’s consultants gave serious consideration to the suggested management techniques/tools to help improve co-ordination of services. In particular, most gave high priorities to:

- Complete design by consultants and the design must be fully integrated and co-ordinated by the whole design team. The services consultant would produce sufficient co-ordination details first. But sole reliance on the building services engineer would not give effective co-ordination.
- Contract documents must clearly define all responsibilities, obligations and rights in relation to management and co-ordination of services. Settlement of co-ordination problems within a simple framework must also be covered to avoid exacerbation of further problems.
- Both building work contractor and services sub-contractors should provide comprehensive coordination of services (e.g. planning and programming of all M&E services installations in conjunction with the building construction, programming building services co-ordination, organizing and preparing all co-ordination details and information and managing the co-ordination of services), and the main-contractor should be the key services co-coordinator working with each sub-contractor’s site engineer.
- Contractors must carry out their co-ordination duties prior to the installation of services and use an effective quality control and assurance system. Combined services drawings / builder’s work drawings together with effective site management would be essential for satisfactory management of services.
• Good teamwork with commitment to completing the works based on either short-term or long-term partnering approach must exist in the building team.

• Most quantity surveyors supported the use of Bills of Quantities which would improve the co-ordination process as the design would be more detailed and fully completed. At the same time, contractors could price all co-ordination efforts more accurately.

• It was also mentioned by some design team members that the services consultant could do more by providing extra services such as preparation of co-ordination drawings with the contractor and the offer of advice on site and in particular, the resolution of problems with contractors. These extra services were practical but very costly (at least one to two percent of the cost of the building series). Of course, the additional fees must be paid by the client to the consultant.

7.6.6 Performance of contractors

This question was deliberately raised to draw the consultant’s view on the use of the best type of contractor for carrying out the complex M&E services installation.

The answers correlated well with most of the replies/views discussed earlier. The salient points were:

• Nomination needed greater attention since this was difficult to achieve better co-ordination but many large and reputable contractors could perform very well if they also had a good main-contractor and the design was reasonably complete.

• Domestic contractors would give, in theory, higher performance than the nominated sub-contractors, but this would depend on the quality, experience of the contractors and the use of good management for the co-ordination of services.

• The principal services contractor received very high favour from the services consultant as a single engineering services organization could often lead a team of specialist contractors more effectively to execute the co-ordination process and the main-contractor would only have one big services contractor to administer.
Data collected from the design team also shown high ratings were given to the building services co-ordination team. The author was informed on many occasions that this team was essential for trouble-free co-ordination of M&E services and both main and sub-contractors must allow for this in their project management whether the project was complex or not.

7.7. **Summary of main-contractor's responses**

Table 7.3 relates to the co-ordination of M&E services and the procurement method used.

<table>
<thead>
<tr>
<th>Responses</th>
<th>Average Max. Score (60)</th>
<th>Total % of Score &amp; % Weighting</th>
<th>% of Score &amp; Position of Importance</th>
</tr>
</thead>
</table>
| 1. **Performance of management of co-ordination of building services by:**
| a. Main-contractor | 4 | 48 (80) | (29) 1 |
| b. Building services contractor | 3.54 | 43 (72) | (26) 2 |
| c. Architect | 3.45 | 41 (68) | (25) 3 |
| d. Services engineer | 3 | 36 (60) | (21) 4 |

2. **Responsibility for carrying out co-ordination of M&E services.**

| a. Building services engineer | 5 | 60 (100) | (24) 1 |
| b. Building services contractor | 4.58 | 55 (92) | (22) 2 |
| c. Construction project management team | 4.5 | 54 (90) | (21) 3 |
| d. Architect | 3.7 | 45 (75) | (18) 4 |
| e. Main-contractor | 3 | 36 (60) | (15) 5 |

3. **Impact of inadequate co-ordination on:**

| a. Cost control | 5 | 60 (100) | (21) 1 |
| b. Contract time performance | 5 | 60 (100) | (21) 1 |
| c. Management of contract | 4 | 48 (80) | (17) 2 |
| d. Project success | 3.64 | 44 (73) | (16) 3 |
| e. Reputation/business | 3 | 36 (60) | (13) 4 |
| f. Quality of work | 3 | 36 (60) | (13) 4 |

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### Table 7.3 – continued

#### 4. Procurement method:

**a. Most used**

<table>
<thead>
<tr>
<th>Method</th>
<th>Number</th>
<th>Percentage</th>
<th>(Rank)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>5</td>
<td>60 (100)</td>
<td>(45) 1</td>
</tr>
<tr>
<td>Develop and construct</td>
<td>3</td>
<td>36 (60)</td>
<td>(27) 2</td>
</tr>
<tr>
<td>Design and build</td>
<td></td>
<td></td>
<td>(11) 3</td>
</tr>
<tr>
<td>Management contracting</td>
<td>1</td>
<td>12 (20)</td>
<td>(9) 4</td>
</tr>
<tr>
<td>Construction management</td>
<td>1</td>
<td>12 (20)</td>
<td>(9) 4</td>
</tr>
</tbody>
</table>

**b. Level of satisfaction**

<table>
<thead>
<tr>
<th>Method</th>
<th>Score</th>
<th>Percentage</th>
<th>(Rank)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction management</td>
<td>4.45</td>
<td>54 (90)</td>
<td>(26) 1</td>
</tr>
<tr>
<td>Develop and construct</td>
<td>4.27</td>
<td>51 (85)</td>
<td>(25) 2</td>
</tr>
<tr>
<td>Conventional</td>
<td>4</td>
<td>48 (80)</td>
<td>(23) 3</td>
</tr>
<tr>
<td>Management contracting</td>
<td>3</td>
<td>36 (60)</td>
<td>(18) 4</td>
</tr>
<tr>
<td>Design and build</td>
<td>1.33</td>
<td>16 (27)</td>
<td>(8) 5</td>
</tr>
</tbody>
</table>

**c. Preference of employment of:**

<table>
<thead>
<tr>
<th>Employment</th>
<th>Score</th>
<th>Percentage</th>
<th>(Rank)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic sub-contractor</td>
<td>5</td>
<td>60 (100)</td>
<td>(29) 1</td>
</tr>
<tr>
<td>Principal services contractor</td>
<td>4.54</td>
<td>55 (92)</td>
<td>(26) 2</td>
</tr>
<tr>
<td>Building services co-ordination team in main-contract</td>
<td>4</td>
<td>48 (80)</td>
<td>(23) 3</td>
</tr>
<tr>
<td>Nominated sub-contractor</td>
<td>3.82</td>
<td>46 (77)</td>
<td>(22) 4</td>
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</table>

**d. Important issues relating to the use of a particular procurement method.**

<table>
<thead>
<tr>
<th>Issue</th>
<th>Score</th>
<th>Percentage</th>
<th>(Rank)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost within budget</td>
<td>5</td>
<td>60 (100)</td>
<td>(13) 1</td>
</tr>
<tr>
<td>Completion time</td>
<td>5</td>
<td>60 (100)</td>
<td>(13) 1</td>
</tr>
<tr>
<td>Control of contract work</td>
<td>5</td>
<td>60 (100)</td>
<td>(13) 1</td>
</tr>
<tr>
<td>Dissatisfaction with previous method</td>
<td>5</td>
<td>60 (100)</td>
<td>(13) 1</td>
</tr>
<tr>
<td>Working relationship</td>
<td>4.91</td>
<td>59 (98)</td>
<td>(12) 2</td>
</tr>
<tr>
<td>Transfer of risk</td>
<td>4.54</td>
<td>55 (92)</td>
<td>(11) 3</td>
</tr>
<tr>
<td>Single point responsibility</td>
<td>3.64</td>
<td>44 (73)</td>
<td>(10) 4</td>
</tr>
<tr>
<td>Quality of building</td>
<td>4</td>
<td>48 (80)</td>
<td>(9) 4</td>
</tr>
<tr>
<td>Knowledge of method</td>
<td>3.64</td>
<td>44 (73)</td>
<td>(9) 5</td>
</tr>
</tbody>
</table>

#### 5. Management of co-ordination of M&E services

**a. Clear responsibility for design, installation and co-ordination.**

b. Adequate design information and co-ordination details from the design team.

c. Chief services contractor to manage co-ordination work.

d. Co-ordination as an itemized cost

e. Services consultant to assist site co-ordination with quick response

<table>
<thead>
<tr>
<th>Issue</th>
<th>Score</th>
<th>Percentage</th>
<th>(Rank)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less change by client</td>
<td>5</td>
<td>60 (100)</td>
<td>(11) 1</td>
</tr>
<tr>
<td>Good teamwork</td>
<td>4.36</td>
<td>53 (88)</td>
<td>(10) 2</td>
</tr>
<tr>
<td>Competent project participants</td>
<td>4.09</td>
<td>49 (82)</td>
<td>(9) 3</td>
</tr>
<tr>
<td>Independent construction project</td>
<td>4</td>
<td>48 (80)</td>
<td>(8.7) 4</td>
</tr>
<tr>
<td>Main-contractor to manage site coordination work</td>
<td>3.64</td>
<td>44 (73)</td>
<td>(8) 5</td>
</tr>
</tbody>
</table>

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7.8 Evaluation of returns and in-depth interviews with main-contractors

Relevant remarks drawn from the survey summary and the information derived from interviews with senior personnel by the author were:

- Performance of management of co-ordination.
- Responsibility for carrying out co-ordination.
- The impact of inadequate co-ordination.
- Procurement method.
- Management of co-ordination of services.

7.8.1 Performance of management of co-ordination

Analysis of the questionnaire results together with information obtained from interviews indicated that:

Contracting organizations seemed to give lower ratings to the design team, but many of these contractors (over 70%) did give higher ratings to their own performance with regard to the management of building services as many of them felt that they had done more than the consultants in this respect.

Interview results revealed that most contractors felt that the co-ordination of building services could be achieved more effectively if the design team could provide more integration and co-ordinate services first. Contract documentation or procedures alone could not resolve the many co-ordination problems that would arise during installation. In other words, quality of design and design information became a high priority and many contractors considered that the performance of the design team could be improved if they put more effort into this aspect.

Many building work contractors also felt that they had done more than their services contractors in the co-ordination process, and again, they also considered the services contractors could improve their performance of co-ordination as this was the best way to have smooth M&E installations.
7.8.2 Responsibility for carrying out co-ordination

As expected, many contractors (over 75%) strongly felt that the important task of building services co-ordination should be the responsibility of the design team and the building services contractors. Interview results also supported their views and some comments from these building work contractors were:

- If they had a choice, they would let others do the co-ordination work.
- A major improvement could be to have M&E engineers managing the engineering installations, rather than builders (main-contractor).
- Building services contractors should have full responsibilities for the majority of co-ordination of building services as they were more suited and capable for the task.
- The main-contractor would be fully responsible for all builders' works and interfaces associated with the M&E services and they were willing to cooperate to the fullest extent required by his building services contractors. To do this, the building services designer as well as the services contractors must provide adequate co-ordination information.
- The main-contractor staff would usually have little knowledge of building services design and installation. They would have to employ a qualified building services engineer and a team of people experienced in the various disciplines involved to act as their own building services co-ordination team. This team would play an important role in the project and this provision must be adequately covered in the tender, otherwise, it would be difficult to manage the services contractors if the main-contractor did not have the right people and the necessary resources to support this expensive duty. Alternatively, some main-contractors would hire a small services consulting engineering firm to carry out all the co-ordination work but this was found not to be a good solution and this practice was not be suitable for complex building projects requiring continuing integration and co-ordination on site.
Many contractors felt that if the building services co-ordination work would be managed independently by a project management consultant, together with the design team, they could then concentrate on their building works and the performance of the overall project could be much improved.

7.8.3 Impact of inadequate co-ordination

Most responses gave high ratings to cost, time and management of the project

Interestingly, few put much emphasis on quality and reputation.

Interview results also revealed:

- The most important factor was the time factor as some services co-ordination problems could delay the progress of the construction and this would result in loss and additional expenses by all contractors.
- Quality of building and building services could be affected by other factors, but co-ordination problems would often be related to the root cause of some maintenance problems.
- Reputation was in fact very important and most contractors knew that the performance of their management of services could affect their businesses, but there were other things which might determine their reputation. By and large, the building work contractors realized that if they had done a good job, they would get another job requiring good management of services.

7.8.4 Procurement method

The questionnaire returns indicated that the conventional method was still used mostly by many contractors, but the Develop and Construct method would also be used more and more.
Interview results revealed that many large contractors could work as building work specialists in any one of the common procurement methods, but they had to change from a conventional builder to a special D&B contractor or a builder in a construction management system in order to suit the trend in the local building industry.

As far as level of satisfaction was concerned, many main-contractors gave high ratings to the conventional and some un-conventional methods.

Most of the large contractors informed the researcher that they had been using the conventional method for many years and, in general, they were quite satisfied with this method as:

- Procedures were well known.
- Contractors would only look after the construction aspect, the design would be the design team's "baby".
- Building services works would be the responsibility of the services contractors as well as the services consultant. Although the main-contractor would still have to manage this work which would be covered in the tender.
- Risks and problems would be shared by all project participants, thus offering some protection to the main-contractor.

Many contractors showed greater satisfaction with the method of Construction Management as the provision of a construction project management team did help the main-contractor concentrate on the construction work.

Few large and well-established contractors expressed great satisfaction with the D&B method as this gave a higher profit margin and more business with some special clients (e.g. Hospital Authorities). However, the contractors would undertake the design to meet a client's performance specification and cost limit etc. and higher responsibility and burden would be placed on the contractor in view of the single point responsibility of the D&B contractor.

When talking about the performance of the project participants. The questionnaire surveys and interview results both gave:
• Higher rating for the use of domestic contractors instead of nominated services sub-contractors for the reason of greater control of contractors and greater integration and co-ordination as a result of the reduced differentiation and greater familiarity between the members of the building team.

• The second choice would be the use of the principal building services nominated sub-contractor as the inter-services co-ordination could better be provided by a large engineering contractor than by the building contractor. This approach would relieve much of the main-contractor's duty and responsibility with regard to co-ordination of services to an engineer.

• As far as the provision of a building services co-ordination team within the main contract was concerned, most main-contractors felt that this was only essential for large and complex projects. Most interviewees were satisfied with the performance of this team, but they added that they could do a better job if the preparation of all co-ordination design drawings were passed back to the design team or the major services contractor (e.g. HVAC), and therefore they could spare more time on site co-ordination and management of services contractors.

With regard to the important issues on the use of a particular procurement method for managing co-ordination of services, the questionnaire surveys gave serious consideration to:

• Previous experience
• Cost control
• Completion on time
• Control of contract
• Working relationship
• Balanced risk

However, it was pointed out by many main-contractors during the interviews that, in practice, they were not involved in the selection of the procurement method as this vital decision making was supposed to be the client's responsibility. But through years of practice in the industry, they had found out the key factors in procurement. All in all, most respondents cited their own important criteria such as:
• Full control of services contractors.
• Clear division between design and installation and the preparation of any detailed M&E co-ordination drawings would be a design issue.
• Project participants were able to work as a team.
• Fair contract.
• Reasonable reward.
• Reasonable construction time and adequate time to be allowed for all preparatory works.
• Fair risks.

Incidentally, many of these might not be provided by the client. Some interviewees also cited that the chosen route was very rarely best for the building services, but for the project overall.

7.8.5 Management of co-ordination of services

Lastly, when the main-contractors were asked to identify the factors which they considered important, many gave high priorities to:

• Clear responsibility of design and installation.
• Complete design data.
• A chief services contractor to manage all M&E services.
• Services consultant carry on the co-ordination work with the M&E services contractors.
• Once agreed, the master programme should go as planned, any design change resulting in co-ordination and construction problems should be avoided as much as possible.

Many of the interviewees also opined that the existence of a good working team and the employment of suitable project participants with solid experience in planning and procuring building construction and building services installation would be needed. As most builders are project management orientated, many interviewees also stressed the great need of good project management in addition to the provision of complete design
and necessary co-ordination details, incidentally, this need had been repeated by many large contractors to be crucial for a successful project.

### 7.9 Summary of services contractors’ responses

Table 7.4 relates to the co-ordination of M&E services and the procurement method used.

<table>
<thead>
<tr>
<th>Responses</th>
<th>Average Rating &amp; Max. Scores</th>
<th>Total Weighting &amp; % of Actual Score</th>
<th>% of Score &amp; Position of Importance</th>
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<tr>
<td>1. Performance of co-ordination of building services by:</td>
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<tr>
<td>a. Building services contractor</td>
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<td>2. Responsibility for carrying out co-ordination of M&amp;E services</td>
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<td>c. Construction project management team</td>
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</tr>
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<td>d. Architect</td>
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<td>e. Building services contractor</td>
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<td>3. Impact of inadequate co-ordination on:</td>
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<td>a. Quality of work</td>
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<td>b. Cost</td>
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<td>e. Reputation/business</td>
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<td>f. Project success</td>
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Table 7.4 – continued

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<td>c. <strong>Preference of employment</strong></td>
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<td>d. Important issues relating to the use of a particular procurement method</td>
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<td>Cost within budget</td>
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<td>Completion time</td>
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<td>Working relationship</td>
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<td>Knowledge of method</td>
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<td>Single point responsibility</td>
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<td>5. <strong>Management of co-ordination of M&amp;E services</strong></td>
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<td>Clear responsibility for design, co-ordination and installation</td>
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<td>Adequate design information and co-ordination details from the design team</td>
<td>5</td>
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<td>Services consultant to assist site co-ordination with quick response to problems found</td>
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<td>Co-ordination as an itemized cost in a contract</td>
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<td>Good working relationship with the main-contractor</td>
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<td>Independent construction project management team to co-ordinate services</td>
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<td>Competent and professional building services co-ordination team members</td>
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<td>Quality and experience of contracting organizations</td>
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<td>Main services contractor (HVAC) to manage co-ordination work</td>
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<td>47 (72)</td>
<td>(8) 5</td>
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<td>582</td>
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7.10 Evaluation of returns and in-depth interviews with the services contractors

Relevant remarks drawn from the survey summary and the information derived from interviews with senior personnel by the author were:

- Performance of management of co-ordination.
- Responsibility for carrying out co-ordination.
- Impact of inadequate co-ordination.
- Procurement method.
- Management of co-ordination of M&E services.

7.10.1 Performance of management of co-ordination

The questionnaire results obtained from the large services contractors indicated the following:

- Low rating for the architect and interview results revealed that this was because the integration process carried out by the architect was not fully noted by many. Secondly, most of the management task of co-ordination of services would be perceived as the services consultant’s domain.
- Although the services contractors had been selected by the services consultant, most M&E services contractors still considered that the preliminary co-ordination work carried out by the design team was still far from perfect and therefore, the rating given was only slightly higher than the one awarded to the architect.
- The main-contractor would be requested to carry out the co-ordination work and in many cases there were significant improvements in the co-ordination process. Therefore, it was quite reasonable for the large services contractors to give a higher rating to the main-contractor in the context of co-ordination. It was also learnt from the interviewees that, still, many services contractors were not fully satisfied with the main-contractor’s performance, namely:
  - Inadequate preparation of combined services drawings by many even there was reasonable provision of a co-ordination team.
• Realistic programming (e.g. scheduling of both M&E and building works. This has nothing to do with the use of IT programming. The key point is that all schedules must considered all constraints, site conditions, logistics and the relationship of interdependency between various activities) of services installation was not provided by the main-contractor.

• Main-contractors were not fully committed to the co-ordination process and, in many cases, builder's work would take precedence over the M&E services work even where the latter was far more critical in nature.

7.10.2 Responsibility for carrying out co-ordination

The responses from most of the respondents (over 85%) concurred that the building services consultant should undertake the design co-ordination first and then they could carry out the co-ordination process on site more effectively. During the interviews, most services contractors considered that the co-ordination work should also be performed by the architect, in order to provide more realistic spaces for the services. However, the co-ordination process should best be the services consultant's responsibility.

Many respondents also advised that the main-contractor and any construction project management team if employed should also take up the overall responsibility for the management of the co-ordination process on site. This is because the M&E services must form part of a building and usually the construction work must be carried out first and the services would follow before the return to complete the construction work.

From the interview results, many services contractors would accept their duty of carrying out the co-ordination process with all contractors, but most of them would disagree that they should carry out the preparation of all co-ordination drawings which they considered, should be the design team's responsibility. They also added if all these co-ordination drawings had been completely done and provided by the services consultant, this would greatly reduce most of the time, energy and cost that would be incurred in the preparation of the designer's unfinished work. What the contractors would do was merely the general revision of the designer's drawings based on the actual equipment or plant that they had selected for the project and any installation details required.
7.10.3 Impact of inadequate co-ordination

Similar to those obtained from the main-contractors, in terms of seriousness, the order was:

First - Cost (e.g. abortive work, extra labour, resource and overhead).
Second - Contract time (e.g. delay in construction and disrupted installation programme).
Third - Management of contract (e.g. extra management work, deployment of resources to accommodate co-ordination problems and solution, and possible preparation of claims).

Reputation – this was difficult to quantify by the sub-contractors, but the interviewees informed the author that poor performance of management of services co-ordination could affect their business, as many experienced and large clients/designers would look into this aspect during selection of tenderers/contractors. As such, most sub-contractors also gave a high rating to this criterion.

As far as project success was concerned, many interviewees cited that various things could affect the project performance. Serious co-ordination problems would definitely affect the outcome of a project in particular, time overrun, extra cost and poor working relationship between the project participants would be borne by each party. However, usually contractors would suffer most as many tendered prices were already very low and that any extra work, cost plus unavoidable contractual conflicts/disputes and possible claims would further eat up the thin profit margin and ultimately this could also cause serious loss.

7.10.4 Procurement method

The questionnaire surveys gave similar results to those obtained from the main-contractors. Many services contractors still gave the conventional method as the most commonly used method. Most of the services contractors informed the researcher that they also had experience in various non-conventional methods. However, the current
trend in the local industry had pushed the contractors to join the D&B contractor for some large and highly serviced projects in order to have a share in this market.

As far as level of satisfaction was concerned, most survey and interview results indicated that many services contractors were quite satisfied with the methods that they had been using for years e.g. conventional, management/construction management as they could still act as nominated sub-contractors. Many contractors did not like the idea of working as a contractor for the pure design and build for large projects as there were problems of payment and more design responsibility. When jobs were scarce, many services contractors would work as a services contractor for the Develop and Construction contractor as in many cases, the services design would still be provided by a services consultant. In this case, the integration and co-ordination of services would be shared between the services designer and the contractor in a more workable manner. Hence, many responders also gave a high rating to the D&C system.

All questionnaire results and interview results further revealed that most services contractors still preferred the nomination system as this type of contractor offered many advantages (close relationship with client/designer; better payment system and protection in relation to contractual issues). With these advantages, it was not difficult to see why the contractors did not favour the domestic contractor system because this system would not give what the specialist services contractors wanted. Besides, the main-contractor would usually impose greater constraints on the domestic contractor. At the same time, there would be greater control of the services contractor by the main-contractor with a relationship of ‘Father and Son’.

Nevertheless, it did not mean that all services contractors would not wish to act as domestic contractors. Some interviewees opined if they had worked satisfactorily with a particular main-contractor before, providing the contract conditions were acceptable, they would be prepared to change to domestic contractors for getting more business.

Many contractors (75% of respondents) favoured the use of principal services contractor since they could change to a much larger and more powerful services organization. They could co-ordinate much better with their own specialist contractors. Besides, this system could offer them higher profit margin and better business opportunity. However, some
contractors felt that this system was only beneficial to the large contracting organizations and the system would certainly hamper some contractors if they had not engaged in HVAC, electrical services and fire protection engineering altogether.

Incidentally, the interview results also supported the questionnaire results with regard to the use of a building services co-ordination team in each of the services contracts. Many respondents cited that this team had already been allowed for in many of their previous projects. However the size of the team was much smaller and in general, there was no need to prepare many combined services drawings as all co-ordination would take place on site between the individual services contractors.

The services contractors further commented that, in the present arrangement, the size of the co-ordination team would be larger and they had no problem in carrying out all co-ordination duties (e.g. preparation of combined services drawings etc. as spelled out in the tender document). However, they added that the cost of this co-ordination was very high and also difficult to price for large and highly serviced projects. One thing was sure that this team overcame many co-ordination problems and this was extremely helpful for the smooth progress of the M&E installations.

As far as the key factors in determining a particular procurement method were concerned, most contractors gave similar replies to those offered by the main-contractors. In terms of rating of importance, the important factors were:

- Cost control.
- Time management.
- Control of contract management work, risk transfer, quality of services and working relationship.
- Previous experience.

During the interviews, many contractors stressed that they would wish to complete a good job, and to receive reasonable reward but without much risks and troubles like co-ordination problems and poor working with other members of the building team. Most contractors also expressed their dislike of the pure D&B and their employment as domestic contractors as they were not entirely satisfied with these arrangements. The
requirement of single point of responsibility did not receive much consideration from the majority of the interviewees. Of course, those favoured the principle services contractor and D&C method would be those large contracting organizations. Many contractors cited that, although the factors given in the questionnaire were important to them, in reality contractors would not have the opportunity to advise their clients on the selection of procurement method for a project.

7.10.5 Management of co-ordination of M&E services

The questionnaire/interview results indicated the consensus from the majority of the respondents. With the exception of the item of using the HVAC services contractor to manage the overall co-ordination of services, all items listed received serious consideration. The most important issues as expressed by the interviewees were:

- Clear responsibility for design and installation because this was the most problematic area. In many cases, the root cause of most co-ordination problems was the result of incomplete design which had to be undertaken by the contractors. Effective co-ordination could never be carried out if there was inadequate integration and co-ordination during the design stage. In fact, the co-ordination process could be viewed as a test of a design. A good design would achieve better co-ordination and an incomplete design would definitely create co-ordination problems on site, no matter how good the construction team’s site management was.

- Adequate co-ordination details from the design team were considered very important as no one could co-ordinate the services better than the services consultant and other members of the design team. However, in practice, not many co-ordination drawings would be given to the contractors.

- Incidentally, services consultants would be in the best position to solve co-ordination problems on site since only the consultant could solve the problem in conjunction with other designers in the most effective way. Other people could of course solve the same problem but it would take much more time and much effort.
• As co-ordination of services requires many resources, this item should be priced by all tenderers and any unrealistic submission should be rejected by the consultant. Only good and experienced contractors with adequate allowance for the co-ordination process should be selected. Furthermore, this co-ordination was accepted as not being cheap.

• As projects are getting larger and larger, it would be extremely helpful to have a project management consultant to plan and manage all building works and M&E services installations together with the design and construction teams. This practice was seen to be very effective in many highly serviced projects.

• Many contractors also pointed out the need of a good working team with competent project participants. Most importantly good communication between all members of the team should exist. Without all these, even with complete design and an appropriate contract, the project might not be executed satisfactorily.

• Last but not least, from many discussions with the interviewees, in order to have a successful management of M&E services installations, it was necessary to have sufficient resources and manpower. In plain English, it was a good tender price with reasonable profit margins. Without this essential requirement, it would be difficult to carry out the contract in a satisfactory way.

7.11 Feedback from project participants studying at the Hong Kong Polytechnic University

As stated earlier, the author wanted to obtain as much information as possible from the project participants who were actually carrying out building services co-ordination in both drawing offices and building sites. A large number of part-time students (over 300) during the past few years provided very informative data concerning how the clients, consultants and contractors managed the process of co-ordination of building services. With this special large group of project participants, they still had some inherent bias. Most of these biases would be neutralized or challenged by other participants having different roles and responsibilities during the discussions and debates. Hence, the conclusions drawn from these people were factual and practical. Much of the data would be similar to the results obtained from the questionnaire surveys and interviews. However, there were some atypical data such as:
a. Client

- Many clients in the commercial sector did not consider the issue of co-ordination of building services for standard buildings which were not complex in design. Furthermore, selection of building procurement was primarily based on previous experience and use of un-conventional procurement methods were not often favoured.

- Experienced public clients (e.g. Government, Hospital authority, Mass Transit) paid much attention to the management of integration and co-ordination of building services as they did not wish to have problems in the M&E services installations. They were also fully aware of the adverse effects on the project performance, in particular the completion date and extra cost. All these clients actually emphasized the need of good management for design co-ordination and the installation of services on sites.

- Multi-headed client problems must be solved and allowed for in the design of a building. Building layout and provision of services should be flexible so that minor changes could be accommodated easily.

- Too many projects go out to tender before the design process had reached the degree of completion required by the conditions of contract being imposed.

b. Design of M&E services

Complete design and provision of fully coordinated services drawings by the consultants would be the best means to minimize site co-ordination problems. But it was rare to have this.

The reasons were:

- Consultants normally offered standard service.

- Additional service for carrying out co-ordination drawings was not usually allowed for by the client.

- It was impossible to provide 100% complete design as M&E services design would be affected by the plant, equipment, components and systems finally
selected by the contractor. There would be revisions of spaces, clearances, installation requirements and interfaces between systems.

• For complex hospital buildings, there were many highly serviced areas requiring co-ordination.

In theory, all these areas would have been coordinated and adequate sectional drawings and details should have been provided. Nevertheless, in many cases, only critical or congested areas would be provided with just sufficient data and sections and all other areas would be checked by calculations to ensure that sufficient spaces would be available for ordering installation.

• The use of quality assurance systems existed in many design offices. However, with the exception of some large consultants, not many firms could afford the employment of a quality team to check design and co-ordination of services. Such teams were highly recommended by many project participants as this was the first line of defence against poor co-ordination of services.

• Consultants would check contractors’ installation drawings, combined services layouts and builders’ work drawings, but the responsibility for proper installation still rested on all contractors.

• Consultants did not normally carry out co-ordination work on site as this was an extra service and the contractors were contractually responsible for this work.

• Some smaller consultants would be employed by the main-contractors to work as building services coordinator, but this consultant would mainly provide all co-ordination drawings and details.

• The best place to coordinate services was the building site, and many consultants preferred all contractors to work in a central site office.

c. The contractors

• Many large main-contractors could manage the co-ordination work especially as they had their own building services co-ordination teams. But smaller contractors might not carry out the work satisfactorily.
• As design was not always completed and co-ordination drawings were scarce, most main-contractors would need to provide all co-ordination details, drawings, co-ordination meetings and site control of M&E services works, all at high cost to them and the owners. Co-ordination of services in large and complex buildings was now recognized as of equal importance to the building works and more and more project management and resources would be allocated to M&E services installations.

• As far as the co-ordination process was concerned, there were not many differences between nominated services contractors and domestic services contractors. However, it was much easier to communicate and work with ones 'own people' as the services contractor was "part of the family" when using domestic contractors. Some large main-contractors had already set up an independent M&E services contracting section in their organization and this would increase business opportunity as well as strengthening the co-ordination process.

• Even with the use of a principal services contractor, the main-contractor would still retain its building services team (much smaller in size as drawing works would not be required) to ensure proper management of the services installation.

• Main-contractors would like to work with construction project management consultants / contractors, but responsibility for co-ordination must be made absolutely clear. In this procurement system, it would be sensible and logical to leave the services co-ordination work including the preparation of co-ordination drawings to the project management consultant team and the main-contractor would concentrate on the building works.

• Not many main-contractors could provide good D&B service. There were only a small number of large building work contractors who had the necessary resources and experience. They could provide good management of co-ordination of complex M&E services for some hospital projects and clients were quite satisfied with the Develop and Construction system.

• Co-ordination of services is best carried out by the services contractors and the M&E consultant. The main-contractor should be relieved of all technical issues such as preparation of fully coordinated services drawings with all M&E
services. The main-contractor, however, would work with the services team and complete the project.

- Procurement pattern was only a name in today's industry, quality and experience of both the main-contractor and its services contractors would shape the outcome of the co-ordination process. The procurement method selected for the project would affect project performance but not by itself was the only determinant. Furthermore, the design team should be more involved in the management of co-ordination of services on site with all contractors.

The data obtained from the practicing students gave further insights into the co-ordination process. As these people were the actual players in the construction field, their opinions and views not only supported the survey results, but also helped the researcher's examination of cases later. A further workshop and forum on co-ordination of building services was conducted by the author in 2003 with 30 MSc students/practitioners also gave similar data and suggestions. Furthermore, many of these engineers claimed that the co-ordination process as given by the author could be handled very effectively.

7.12 Reconciliation of survey results

Before examining the survey results, the author considered that the different viewpoints from all project participants should be summarized first. The reader should therefore get a better picture of the discussions followed this table.

The data had been analysed into two distinct way. Firstly, by setting down the problems/issues identified from the project participants in the building team (e.g. client, designers and contractors). Secondly, by giving a weighting to the seriousness rating for each of the problem/issues. For example, very important or serious will be equated to 5 and less important is 1. This weighting was the weighted importance given by the respondents. The method was identical to the technique that the author adopted in preparing Table 7.1.

The table 7.5 was prepared following the analysis of all questionnaire and interview data by the author.
<table>
<thead>
<tr>
<th>Details</th>
<th>Client</th>
<th>Design Team</th>
<th>Main-contractor</th>
<th>Services Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding of importance of building services co-ordination</td>
<td>Yes, but not all. Large clients know more than inexperienced ones</td>
<td>Yes, fully and yet passing the technical issue to the contractors</td>
<td>Yes, fully but does not wish to handle the technical issue of the co-ordination process</td>
<td>Yes, fully but does not wish to do more (i.e. designer's co-ordination work)</td>
</tr>
<tr>
<td>Responsibility for carrying out co-ordination</td>
<td>By the design and construction teams as they are paid to do design and construction</td>
<td>By all members of the design team, but M&amp;E consultancy should responsible for this task and be the chief co-ordinator</td>
<td>By the design team and all services contractor Main-contractor will carry out relevant co-ordination tasks but not design co-ordination.</td>
<td>By the design team and particularly the services consultant and all contractors. Main-contractor should be the chief integrator.</td>
</tr>
<tr>
<td>Level of satisfaction</td>
<td>Not for all projects, some are o.k. but some are low.</td>
<td>Not wholly as the services consultant and all contractors can do much better</td>
<td>Not wholly as the design team and all services contractor have not done their best. The builder has done enough work.</td>
<td>Not completely as the design team and the main-contractor can do much better. Some BS contractors have not done enough work.</td>
</tr>
<tr>
<td>Preferred procurement method</td>
<td>Still traditional system but other systems are also used D&amp;B seems very good</td>
<td>Traditional first and other systems next. D&amp;B can give more effective management</td>
<td>Still traditional with domestic contractors for best result and other systems as adopted by the client.</td>
<td>Traditional path with nomination and principal services contractor Domestic contractor is not good.</td>
</tr>
<tr>
<td>Factors relating to effective co-ordination</td>
<td>Complete design and good selection of firms Allocation of sufficient resources for carrying out adequate co-ordination of services by the whole building team Suitable contractors</td>
<td>Complete integration and co-ordination of services with other elements of a building by the M&amp;E consultant Comprehensive/clear contract procedures concerning management of co-ordination of services by all contractors Better site management/supervision</td>
<td>Services design is complete and detailed co-ordination has been carried out by all designers. Clear contract document pertaining to management of co-ordination of services. Good services contractors Good management of services contractor Support from the design team</td>
<td>Services design is complete and must be fully co-ordinated by all designers Clear contract relating to co-ordination of services Good management of building construction and services installation by the main-contractor Good management of building and services Support from the design team</td>
</tr>
<tr>
<td>Effect of procurement on co-ordination</td>
<td>Can have significant effect</td>
<td>Yes, but not very significant</td>
<td>Yes, but the process is still the same.</td>
<td>Not much as the co-ordination process is nearly the same.</td>
</tr>
</tbody>
</table>

Table 7.5: Reconciliation of important responses from the building team (Based on data obtained in Chapter 7)
Based on the questionnaire responses and the interview results and by adopting Hibberd’s work (1990) on the use of seriousness rating, the key factors as identified by the author were:


- Services clashing with each other or with other elements of the building (V).
- Downtime and delays (V).
- Abortive work (V).
- Ineffective working and possible knock on effects to other trades (V).
- Disputes (F).
- Adverse effect on working relationship (V).
- Claims for loss and expense (V).
- Failure of the design to meet performance (F).


- Need to change design by client (V).
- Large size and high complexity of project (V).
- Poor quality of design (V).
- Inadequate design input, integration and co-ordination by design team (V).
- Lack of co-ordination details from the services consultant (V).
- Unclear responsibilities for design and installation (V).
- Inexperienced building work and services contractors (V).
- Inadequate management for co-ordination of services by the whole building team (V).
- Inadequate client input (F).
- Inadequate contract documents (F).
- Poor working relationship between project participants (V).
- Ineffective communication and lack of site control by contractors (F).
- Low tendered sum (V).
c. Improvement in integration and co-ordination of services with “Seriousness Rating” of Very (5), Fair (3) and Minor (1).

- Good project management (V).
- Complete design with proper integration and co-ordination of services by the design team (V).
- Sufficient co-ordination details to be provided by building team (V).
- Proper contract documents incorporating all co-ordination requirements (V).
- Adequate time and cost for construction together with adequate resources for coordinating services (V).
- Single point responsibility for management of co-ordination (V).
  - By main-contractor with all sub-contractors
  - By main-contractor with all domestic-contractors
  - By principal services contractor with main-contractor
  - By D&B contractor
  - By project management consultant with main-contractor and sub-contractors
  - By construction management with main-contractor and sub-contractors

All the above must consist of a building services co-ordination team

- Design team to work on-site (V).
- Good team spirit and high degree of co-operation between project participants (V).
- Effective working by all (F).
- Use of standard design/installation (F).
- Selection of competent contractors (V).
- Adequate time and data for a quality design (F).

d. Contract arrangement for building services

In the case of highly serviced construction requiring a high degree of inter-discipline coordination (hospitals, institutions and large hotels in particular), the effectiveness of the contractual linkage became an important issue.
All procurement methods could be used but there was no one contract arrangement which was ideal. The key finding was:

“Let engineers manage engineering installations, rather than builders”

In general, one must note and consider the following factors:

- Characteristics of project.
- Complexity of M&E services.
- Type of client and his needs and requirements.
- Design and construction time.
- Cost and price certainty.
- Quality and performance characteristics required from the completed building.
- Responsibility (client’s management, designers’ designs and contractors’ construction / installation).
- Management of the design team and responsibility for integration and co-ordination of services.
- Management of the construction team and responsibility for co-ordination of services on site.
- Risk avoidance and level of risk.
- Need to change design.
- Contractor selection process.
- Organizational form and team building.
- Project environment.
- Previous selection of a form of contract.
- Advantages and disadvantages of a particular procurement route.

7.13 Special comments

Having identified the important data in relation to integration and co-ordination of services from the research surveys, the author felt that it was logical to examine the needs of the various project participants and the main factors causing poor co-ordination of
services of each of the project participants before embarking on the next step – the investigation of real projects in the context of management of co-ordination of services.

The questionnaire surveys and interview results both gave:

a. **Client**

**Needs**
- A successful project completed on time and within budget.
- The building should fit the intended purpose.

**Factors affecting co-ordination with “Seriousness Rating” of Very (5), Fairly (3) and Minor (1).**
- Inefficient management of design input (V).
- Design change throughout the project cycle (V).
- Reluctance of giving additional fees for consultant’s preparation of co-ordination details (V).
- Inappropriate building contract with vague co-ordination issues and requirements (V).
- Inefficient project management (F).
- Unrealistic building programme (V).

With the exception of the first problem which is a technical issue, the rests are managerial issues.

b. **Design team**

**Needs**
- Excellent design.
- Problem – free construction ad installation.
- Short/long-term partnering with client and members of design team.
- Reasonable payment.
- Enhanced reputation.

**Factors affecting co-ordination with “Seriousness Rating” of Very (5), Fairly**
- Late designing of building services (V).
- Inadequate design and integration (V).
- Inadequate co-ordination due to standard service and short time element for detailed design (V).
- Incomplete design and co-ordination of complex projects (V).
- Inadequate management of co-ordination (V).
- Unclear responsibilities for design and installation (V).
- Slow response to resolution of co-ordination problems (F).
- Poor site management and supervision (M).

All these problems are both technical and managerial issues.

c. **Main-contractor**

<table>
<thead>
<tr>
<th>Needs</th>
<th>Factors affecting co-ordination with</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>“Seriousness Rating” of Very (5), Fairly (3) and Minor (1).</td>
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<tr>
<td></td>
<td>Good quality building.</td>
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<tr>
<td></td>
<td>Completed on time.</td>
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<td></td>
<td>Problem – free construction.</td>
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<tr>
<td></td>
<td>Enhanced reputation.</td>
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<td></td>
<td>Reasonable profit margins.</td>
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<tr>
<td></td>
<td>Project construction complexity (V).</td>
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<td></td>
<td>Inadequate budget for coordinating service (V).</td>
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<tr>
<td></td>
<td>Insufficient provision of manpower and resources for carrying out proper co-ordination of services (V).</td>
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<tr>
<td></td>
<td>Unclear responsibility for co-ordination of services installation (V).</td>
</tr>
<tr>
<td></td>
<td>Insufficient time to do co-ordination (V).</td>
</tr>
<tr>
<td></td>
<td>Unwilling to co-ordinate services (V).</td>
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<td></td>
<td>Inadequate management of building services works (V).</td>
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<tr>
<td></td>
<td>Poor communication between project participants (V).</td>
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<td></td>
<td>Difficult interface management (V).</td>
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<tr>
<td></td>
<td>Unrealistic building programme and illogical services installation programme (V).</td>
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<tr>
<td></td>
<td>Poor site management and supervision (F).</td>
</tr>
<tr>
<td></td>
<td>Complexity of building services installation (V).</td>
</tr>
</tbody>
</table>
Many services contractors (V).
- Client-initiated variations (F).
- Adversarial working relationship (V).
- Low tendered price and claim situation (V).

All the identified problems are managerial issues.

d. Services-contractor

Needs

- Excellent services installation.
- Completed on time and within cost.
- Problem – free contract.
- Enhanced reputation.
- Reasonable profit margins.

Factors affecting coordination with “Seriousness Rating” of Very (5), Fairly (3) and Minor (1).

- Inadequate budget for co-ordination (V).
- Insufficient provision of manpower and resources for co-ordination (V).
- Unclear responsibility for co-ordination of services installation (V).
- Unrealistic services installation programmes (V).
- Poor management of co-ordination of services and slow response to co-ordination problems (V).
- In sufficient experience (F).
- Poor working relationship with project participants (V).
- Poor project management (F).
- Inefficient communication between project participants (F).
- Different trades have different cultures with different attitudes to tolerances, installation and interface responsibility (F).
- Low tendered price and claim situation (V).

The identified problems are both technical and managerial issues.
The problems created by each project participant clearly illuminated both of the technical and managerial issues as discussed by the author in his development of the two models proposed for this research (see Chapter 6 for BSC Model and CP Model). All these problems were related to a particular procurement method.

To overcome any possible co-ordination problems, it would be necessary to sort out the best solutions to each of the problems listed under each of the four project participants. It was quite clear that there was no simple solution and it was impossible to satisfy all people. The problems could be resolved by good engineering and effective management, when all project participants were working together. However, this teamworking was affected by the procurement method selected for a project. Documentation procedures and drawings alone could not resolve the many co-ordination problems that would arise. It was absolutely essential for each party to look to harmonize its relationship with all other groups involved in the construction process, not least with respect to design, co­ordination and quality of the services being installed.

An analysis of the evidence gathered from the questionnaire response together with many lengthy interviews results gave the following important facts:

- **Co-ordination of building services will be affected by the management of services design.** This is particular relevant to the approach adopted by a services consultant and the quality of the design, integration and co-ordination of service. This proves the first proposition given in Section 2.3.

- **Co-ordination of building services will be influenced by the management of construction and building services.**
  Co-ordination of building services is a project within a large project (i.e. building). Project must be managed, the more complex the project, the greater the managerial pressure will be imposed upon the building team to optimize project success. The key players (e.g. main-contractor and services contractor) must manage their projects by using appropriate resources, procedures and managerial techniques to enhance the complex issue of co-ordination of building services. This proves the suitability of the second proposition.
Co-ordination of services will be affected by the working practices of the different professionals.
Co-ordination is not only a technical issue but also an exercise in management. The co-ordination will be affected by the effort and contribution from each of the project participants which are considered as temporary multi-organizations. These different groups have different objectives, skills, expertise, characteristics and practices or tasks, but are drawn together in the achievement of a project. Team building is essential and should have a beneficial effect upon the performance of the team and ultimately the success of the project.

The research data suggested that the team relationship required is difficult to form. The influence of a good team of experts on the complex issue of building services co-ordination is clear during the construction process but is less visible when the project is finished. The influence is considered to be so diverse and complex that a remote, standardized form of data collection would not identify them. It would be necessary to make further enquires of individuals directly by using case study approach.

This research information supports the third proposition but further study is required to confirm the respondent's replies based on real cases.

Co-ordination of services can be affected by various procurement methods.
The conclusion drawn is that procurement method is an important variable in affecting project performance. A procurement method determines the organizational form of a building team, and the form also governs the integration of the services designer and contractors into the construction project team. Thus the design and co-ordination of services can be affected by the project participants working under different procurement methods. All methods can be used for achieving good building services co-ordination. However, procurement is not the only determining factor, other variables as given in the two research models all have their relative effect on the project performance. An appropriate procurement method combined with the right team, people, procedures, and quality of design and construction will perform better.

The evidence supports the fourth propositions but additional case study may give more data and reinforce the reasons.
• Building services are becoming more complex and the costs now account for 10-50% of the whole building costs (excluding land cost). The management of building services co-ordination can affect both the design and construction time, cost of M&E services and the building works and the quality of a project. Hence the failure or success of the management of services installation can shape the outcome of a project.

Project success is therefore closely related to the provision effective co-ordination of building services. However, the selection of an appropriate procurement method and the organization form so formed to execute the project can shape the success of the co-ordination process.

The evidence supports the fifth proposition.

All these propositions would also be tested by the author by using case studies.

7.14 Use of case studies

The study revealed very useful information and perhaps a few number of anecdotal stories by both clients, consultants and contractors given to the researcher during the interviews. Some of the data might be biased or distorted by individual project participants and it was necessary to ensure their factual accuracy by using further case study and the author’s own experience and analysis of all data available.

To support the findings of the questionnaire surveys and in-depth interviews results, it was considered necessary to borrow the data obtained from the project participants and making use of the BSC and CP models to give a more comprehensive study. A case study could yield deep but narrow results and the use of two or more research methods (i.e. triangulation) would assist the author to obtain accurate data and therefore improving the reliability of the research findings.

Therefore, the principal objective of the case studies (over 25 numbers) was to collect detailed information about the management of integration and co-ordination of building services and the procurement strategies employed for each project in the real world. These case studies would then facilitate a more practical assessment of the success of a procurement method in relation to the management of building services and the goals of the project. The case studies are covered in Chapter 8.
7.15 Short summary

The questionnaire surveys and in-depth interview results provided rich information about management of building services and selection of building procurement method in Hong Kong. The information obtained supported the preliminary research data gathered from the literature search and the author’s investigation of building services design and installation.

It was observed by the author that the survey results would expose a possible bias by individuals, according to their role in the construction industry. Each sector tended to blame the other sector for inadequate co-ordination of building services. The apparently role-centred subjectivity in the perceptions of the three main parties (i.e. client, consultant and contractor) in the construction industry as to the reasons for inadequate co-ordination should therefore be considered very carefully in this context. The data obtained was fully analysed and compared by the author with different clients, designers and contractors. The data was deemed to be factual but each of the project participants still alleged that they had done the right things and that the other parties had done something wrong or they had done not enough work for the co-ordination process.

The data provided were opinions and views of the project participants in the local building industry. The rich information explained and answered the research questions. Indeed, conclusions could have been drawn from the data alone. However, it was considered by the author that this would not be the best way to carry out this research without exploring some real cases of highly serviced building projects in Hong Kong and elsewhere if possible. The case studies are presented in next chapter.

The important achievement is that the author’s findings should be used by the services/construction industries to improve the co-ordination process. In so doing, higher project performance using all procurement methods can be achieved.
CHAPTER EIGHT

CASE STUDIES

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CHAPTER EIGHT: CASE STUDIES

8.1 Introduction

The guiding principal for developing any research methodology is that it must completely address the research questions. Any academic subject requires a methodology to reach its conclusions; it must have ways of producing and analyzing data so that research results or findings can be tested, accepted or rejected. Hence, in-depth investigation of co-ordination of services based on selected building projects must be carried out.

It was strongly felt by the author that the findings obtained from all questionnaire survey results and in-depth interview data would not be complete in themselves, and some of the results might be dismissed as anecdotal stories, general views or facts. Since most of the survey results came from standardized data, the results could not easily be linked to other pieces of information which might have had a bearing on the research questions. Furthermore, the views expressed by the interviewees might not fully represent the whole picture in reality. Quite often, views might have also been distorted with bias from the researcher or the respondents or interviewees. Obviously, many views and opinions would be both subjective as well as objective. Nonetheless, to ensure factual accuracy of the data obtained from the project participants, additional surveys based on real-life projects would be needed so that the necessary high level of inter-related detail required to meet the need of the research and useful inferences about management of co-ordination of building services within the building industry would be possible. Furthermore, these cases would be used to test the research models and the propositions.

As discussed in Chapter Two, owing to the qualitative nature (rather than quantitative) of this research, the case study approach would be more appropriate. The key reasons behind using this mode of data enquiry and analysis was that of holism, the study of the whole picture of the co-ordination process in the real world rather than relying on the data obtained from the respondents and the interviewees; the relation of factors to each other and to the wider picture that the researcher might not observe. Furthermore, it was possible to identify new things; to illuminate or to make possible inferences about something that was not otherwise apparent from the questionnaire survey and the interviews.
8.2 Methodological concerns with the case studies

Figure 8.1 illustrates the methodology used for conducting the case study and the important points to be investigated.

![Methodology Map (Case Study)](image)

- Case study for deep and narrow data
- Identification of suitable highly serviced building projects (> 25 nos.)

**Data to be sought and detail of analysis**
- Client characteristics
- Project characteristics
- Procurement method/team building
- Design team characteristic
- Construction team characteristic
- Management of building services co-ordination
- Project performance relating to building services co-ordination

- Research models to investigate cases
- In-depth study of specific cases
- Broadly-based questionnaire survey as reference

- Analysis, findings and discussions of cases
- Conclusion

Figure 8.1: The Methodology Map (Case Study)
The cases had been identified as a project; the construction of a building with due regard to installation of building services. Therefore, it was necessary to identify relevant projects which could be used as a basis for the research where the researcher could seek useful data which should be real and rich in nature. Several criteria as listed below were considered crucial in identifying the project.

- Ideally, all the project participants had to be present on the project and be able to furnish their individual views and information pertaining to a project, in particular, issues relating to management of building services.
- The projects had to be highly serviced and comparatively large and complex (Simple buildings were not included as co-ordination problems would be less acute).
- Buildings had to have been recently completed so that people could recall the details. Old buildings would also be useful if data was available. Indeed, there was a need to examine these old buildings together with the traditional procurement method which had been used for a long time.

As explained in Chapter Two, it was not necessary to have a large number of cases as long as the few cases selected (6 in this thesis) produced adequate and useful data and that any additional case studies would give no new categories of data, i.e. no further influences or data could be identified or drawn. The 25 projects chosen for study in Hong Kong (see Appendix III for more details) were selected by the author to represent a wide spectrum of projects using a variety of different procurement methodologies spread over an extended period of time. The 6 cases presented were owned by the Hospital Authority. The projects had similar characteristics in terms of client involvement/management and influence, project complexity, and different management of design/construction using different designers and contractors. For all these projects, the author had a good understanding of these projects first and ample information about the projects was available from the project participants and the services industry. The element of reliability of the data could be checked easily from trade journals and symposia. All the 25 cases and questionnaire survey results were also used to validate the model. Table 8.1 shows the case investigated by the author. The table illustrates brief details of the procurement method used and the details relating to the management of building services co-ordination.
Table 8.1 Details of Case Studies

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Type of building</th>
<th>Degree of complexity</th>
<th>Procurement method</th>
<th>Performance of building services co-ordination</th>
<th>Adequacy of co-ordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (SHT)</td>
<td>Hospital</td>
<td>Very</td>
<td>T &amp; NSC</td>
<td>Poor</td>
<td>Inadequate</td>
</tr>
<tr>
<td>2. (TMH)</td>
<td>Hospital</td>
<td>Very</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
</tr>
<tr>
<td>3. (QMH)</td>
<td>Hospital</td>
<td>Very</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
</tr>
<tr>
<td>4. (EDH)</td>
<td>Hospital</td>
<td>Very</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
</tr>
<tr>
<td>5. (CPH)</td>
<td>Hospital</td>
<td>Very</td>
<td>T + DSC</td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td>6. (HOOH)</td>
<td>Hospital</td>
<td>Very</td>
<td>T + NSC</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>7. (HCD)</td>
<td>Hospital</td>
<td>Very</td>
<td>T + DSC</td>
<td>Good</td>
<td>Adequate</td>
</tr>
<tr>
<td>8. (SH)</td>
<td>Hotel</td>
<td>Complex</td>
<td>T + PM + NSC</td>
<td>Good</td>
<td>Adequate</td>
</tr>
<tr>
<td>9. (UCH)</td>
<td>Hospital</td>
<td>Complex</td>
<td>T + DSC</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>10. (NDH)</td>
<td>Hospital</td>
<td>Very</td>
<td>T + PM + NSC</td>
<td>Adequate</td>
<td>Good</td>
</tr>
<tr>
<td>11. (TKOH)</td>
<td>Hospital</td>
<td>Complex</td>
<td>D &amp; B</td>
<td>Very good</td>
<td>Good</td>
</tr>
<tr>
<td>12. (CEC)</td>
<td>Exhibition centre</td>
<td>Very</td>
<td>D &amp; B</td>
<td>Very good</td>
<td>Very good</td>
</tr>
<tr>
<td>13. (CP)</td>
<td>High-rise office</td>
<td>Normal</td>
<td>JV</td>
<td>Good</td>
<td>Adequate</td>
</tr>
<tr>
<td>14. (BOC)</td>
<td>High-rise office</td>
<td>Normal</td>
<td>T + PM + NSC</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>15. (HKB)</td>
<td>High-rise office</td>
<td>Complex</td>
<td>T + PM + WPC</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>16. (KCRC)</td>
<td>Railway station</td>
<td>Very</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
</tr>
<tr>
<td>17. (TSKH)</td>
<td>Hospital</td>
<td>Complex</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
</tr>
<tr>
<td>18. (POH)</td>
<td>Hotel</td>
<td>Normal</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
</tr>
<tr>
<td>19. (HB)</td>
<td>High-rise office</td>
<td>Normal</td>
<td>T + NSC/DSC</td>
<td>Very good</td>
<td>Very good</td>
</tr>
<tr>
<td>20. (HI)</td>
<td>Office</td>
<td>Complex</td>
<td>T + NSC</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>21. (MTRC)</td>
<td>Underground station</td>
<td>Very</td>
<td>T + NSC</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>22. (HKEC)</td>
<td>Office</td>
<td>Normal</td>
<td>T + DSC</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>23. (CH)</td>
<td>Hospital</td>
<td>Normal</td>
<td>T + NSC</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>24. LTCH</td>
<td>Hospital</td>
<td>Complex</td>
<td>D &amp; B</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>25. (SESH)</td>
<td>Hospital</td>
<td>Complex</td>
<td>D &amp; B</td>
<td>Adequate</td>
<td>Good</td>
</tr>
</tbody>
</table>

Legend:

T = Traditional  
NSC = Nominated Sub-contractor  
DSC = Domestic Sub-contractor  
PM = Project Management  
PSC = Principal Services Contractor  
D&B = Design & Build  
JV = Joint Venture  
WPC = Work Package Contractor  

N.B. Case no. 1 – 16 are included in the Appendix. Case 17 – 25 were used as references to substantiate the evidence found in cases 1 – 16.
8.3 Collecting evidence

A case study was seen to be an empirical inquiry by the author that would investigate a contemporary phenomenon or problem within its real-life context. To do this study, data or facts must be sought in a systematic way.

For this research, evidence for case studies came from documents, archival records, interviews and observations. All these sources of evidence would be used to give an in-depth investigation of the co-ordination process within the research subject – management of co-ordination of services in relation to different organizational forms. For this research, the evidence/data gathered were:

1. Project complexity and its relationship with building services integration and co-ordination.
2. Client’s project management in relation to management of building services design and installation.
3. Selection of a procurement method based on procurement assessment criteria and with due regard to building services installation.
4. Provision of adequate management of building services design by the design team. Was adequate integration and co-ordination of services provided? If not, what were the reasons and anticipated problems?
5. Provision of adequate management of building services design and installation by the construction team. Had adequate co-ordination been allowed for and provided? What did they do? How successful was the co-ordination process? Any problems found and what were the reasons?
6. The impact of the procurement path on the management of co-ordination by the building team.
7. Satisfaction with the co-ordination process.

The following principles of data collection were used for this research:

a. Using multiple sources of evidence, as case studies were not limited to a single source of evidence. All sources of evidence were reviewed and analyzed together, so that the case study’s findings were based on the convergence of information from different
sources, not quantitative or qualitative data alone. Evidence was used carefully and was not just accepted as a literal recording of events that had taken place. Some documents (e.g. memoranda, minutes of meetings and other written reports) could be deliberately edited and therefore due regard was given to the actual validity of a document. Most importantly, a researcher should not be misled by documentary evidence and must be correctly critical in interpreting the contents of any evidence. For case studies, the most important use of documents (e.g. contract, specifications, schedules, drawings, architect’s instructions, etc.) was to corroborate and augment evidence from other sources, and finally, inferences could be made. Besides, new questions could be raised from the evidence from time to time.

b. Creating a case study database for systematic organization of information. The database would be:

- Notes as a result of an investigator’s interviews, observations, or documents analysis.
- Documents relevant to a particular case study, e.g. contract, drawings, specification; bills of quantities, schedules, programmes, letter, minutes of meetings, claims, etc.
- Additional data collected from the site being studied by the investigator.

c. Maintaining a chain of evidence.

To increase the reliability of the information, it was necessary to base on a notion similar to that used in criminological investigations. In other words, the author would follow the derivation of any evidence from initial research questions to ultimate case study conclusions. The research models had proven to be a useful vehicle that enabled the co-ordination issues and mechanisms executed in each project to be examined. The author used the two research models to form a guide for defining the unit or detail of analysis – making explicit what should be studied and analysed (i.e. all elements such as all the independent, intervening and dependent variables shown in the models).
8.4 Analyzing evidence

Data analysis for case studies was more complex than the processes used in other research strategies and data manipulations had to be done carefully, fairly, analytically to rule out alternative interpretations. For this research, the best strategy that the author selected was the one relying on the five research propositions. The propositions shaped the data collection plan (e.g. sub-systems within the two research models based on all sources of information, conferences, dissertations / theses, reports / occasional papers, academic research journals, textbooks, magazines and trade journals) and the already completed questionnaire survey results. Data analysis consisted of examining, categorizing, tabulating or otherwise recombining the evidence, to address the proposed propositions of this study.

8.5 Mode of analysis and targets

For this case study, the 'Pattern-Matching' mode was used. This analytic strategy compared an empirically based pattern with a predicated one or with several alternative predications (such as “The majority of problems associated with building services are caused by inadequate design integration and co-ordination on site”). Where the patterns coincided (e.g. inadequate design information yielded difficult site co-ordination for unsatisfactory project as in Case 1 and adequate design gave better co-ordination and higher project performance in Case 2, 3, 5 and 6. the pattern matching mode was also shown in Tables 8.13 and 8.14 on page 337 and 338), the result increased the validity of the case study. To improve the overall analysis process, the author also adopted the strategy of explanation – building which tried to find the best explanations together with a set of causal links. This explanation was the result of comparing the findings of an initial case against the research propositions together with revision of any one of the five propositions if necessary.

The evidence was also examined once again from a new perspective, in an iterative mode. Finally, a satisfactory explanation was developed. In short, the case studies were intended to analyze the following data:

- Details of services co-ordination problems.
• Root cause of the problems (technical/managerial).
• Effect on project performance.
• Selection of procurement method by the client.
• Impact of procurement path on management of building services design and installation.
• Ways to achieve greater integration and co-ordination between participants involved in complex projects in order to improve project performance.
• The best procurement path for effective management of building services.
• Changes in building procurement for attaining better management of building services in the local building industry.

8.6 Analysis of case studies

The author carried out a large number of case studies (over 25 cases) in Hong Kong since 1996. All the case studies are shown in Table 8.1. All these 25 cases were fully examined and analysed and covered in Appendix Three. The remaining 19 cases gave no further new detail. 6 cases were used for presented with detailed analysis. However, they all supported the evidence as obtained from the 6 cases. The research design was to help avoid the situation in which the collected data did not address the research question. Based on the rich data obtained from the questionnaire/interview survey results and the author's own knowledge, a systematic approach was used. it was necessary for the author to concentrate on certain specific areas and in conjunction with the important issues as depicted in the two research models developed by the author. The case studies in this chapter present the following items concisely for each project.

• Details of the project.
• Client.
• Procurement method.
• Management of design.
• Management of building services installation.
• Team working.
• Project result.
• Project success or failure factors.
A consistent format for each of the case studies was adopted in order to facilitate comparison between any two projects in this study. Six cases are presented to illustrate the management of co-ordination of building services (The remaining 19 cases were also analysed in the same way). The first case has been elaborated to show how the researcher examined the technical and managerial issues together with the selected procurement method. For the remaining cases, only important data and shorter discussions have been given for easy appraisal of the extensive data. It was thought that with this format, the reader could still see the co-ordination processes as occurred in the real world.

8.7 Case study 1

Table 8.2: Analysis of case study 1

<table>
<thead>
<tr>
<th>Item</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. The project</strong>&lt;br&gt;A very large and complex 1400-bed regional/teaching hospital</td>
<td>Highly serviced building with modern hospital facilities. Should require special attention to design and construction that was not fully appreciated by the building team.</td>
</tr>
<tr>
<td><strong>b. The client</strong>&lt;br&gt;The Medical and Health Department backed up by the Architectural Services Department</td>
<td>This was an experienced client but with little experience in this first modern hospital</td>
</tr>
<tr>
<td>Structure</td>
<td>Bureaucratic. Longer planning/approval time, and rigid procedures were the norm.</td>
</tr>
<tr>
<td>Control of multi-headed client problems (e.g. many users)</td>
<td>Not fully recognized. Created many problems such as late decision making, changes in design and additional works which seriously affected design and construction.</td>
</tr>
<tr>
<td>Management of briefing</td>
<td>Inadequate. Affected design integration of building and services seriously.</td>
</tr>
<tr>
<td><strong>Working with design team</strong></td>
<td>Good</td>
</tr>
<tr>
<td><strong>c. The procurement method used</strong>&lt;br&gt;Traditional path was chosen as a standard building procurement for government projects</td>
<td>Previous performance of this path was good, but the project team did not take the complexity of this teaching hospital and its complex M&amp;E services into consideration.</td>
</tr>
<tr>
<td>Contract document</td>
<td>Inadequate and with flaws. Responsibilities for design, construction and installation were ambiguous. Management of co-ordination of services by contractors was not covered in detail. Allowance for co-ordination works was not clearly identified.</td>
</tr>
<tr>
<td>Selection of contractors</td>
<td>Lowest price was the first priority.</td>
</tr>
<tr>
<td>d. Management of design</td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td></td>
</tr>
<tr>
<td>Structure of the consultant</td>
<td></td>
</tr>
<tr>
<td>Management of integration and co-ordination of services</td>
<td></td>
</tr>
<tr>
<td>Co-ordination between members of the design team</td>
<td></td>
</tr>
<tr>
<td>Management of multi-headed client problems</td>
<td></td>
</tr>
<tr>
<td>Design information</td>
<td></td>
</tr>
<tr>
<td>Drawing</td>
<td></td>
</tr>
<tr>
<td>Involvement in construction stage</td>
<td></td>
</tr>
</tbody>
</table>

| A multi-disciplinary firm from overseas won the job working with a local quantity surveyor. Greater integration and co-operation should have been expected from the coherent design team. However, the architect dominated most of the design, and the architectural aspects tended to influence other building elements. |
| Far from perfect. Basic integration had been carried out, the integration and co-ordination of services was considered inadequate and incomplete by the design team. |
| Members did not fully integrate and co-ordinate all the M&E services with the building design. Co-ordination of services was left to a coordinator in the architect's section who was employed at a very late stage and changes were difficult when designs were completed. There were co-ordination checks for the M&E services layouts by an independent overseas consultant, but there was no properly organized quality control system to manage the resolution of co-ordination problems before construction started. |
| Not fully recognized in the beginning. But the design team had done the best to manage additional designs later. Numerous variation orders for installation of hospital equipment and additional works created numerous problems and had to be postponed to the completion of the main contract works. |
| Incomplete in general, but good for plantrooms. Co-ordination details embracing all M&E services were scarce. Interface points were not shown. |
| The major obstacle to smooth co-ordination was the use of single line drawings for the M&E services systems. |
| Inadequate in the beginning. Designers assumed the main-contractor to co-ordinate the services. As problems arose, there was still no immediate action given to reduce the conflicts between the builder and their services sub-contractors. Consultant took a proactive role in solving co-ordination problems on site. Improvement began in progress of construction. Architect and the client came to realize the acute co-ordination problems and prepared to help as much as possible. Co-ordination of M&E services was mainly provided by the M&E services consultant, government site staff in joint venture with the builder and the services contractors. The system emphasized proper site management, identification of problems, quick provision of solutions to co-ordination conflicts, good control of contractors and close monitoring of progress. This special task force improved the progress of the construction and the hospital was not unduly delayed. |
### Table 8.2 - continued

<table>
<thead>
<tr>
<th>e. Management of installation</th>
<th>The main-contractor and the services sub-contractors did not fully realize the full extent of co-ordination of services, due to the poorly defined and implicit details of management of co-ordination in the contract documents. Evidence indicated that all contractors were not aware of the amount of work required for managing their services with other contractors and inadequate allowance was therefore made for the contract work. Most still thought that the work could be managed on site as in simple buildings and there was no need to produce adequate co-ordination details for this complex building.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td></td>
</tr>
<tr>
<td>f. Overall management of the co-ordination process</td>
<td>Greater integration and co-ordination of services should be expected, but the result was not good.</td>
</tr>
<tr>
<td>Design team</td>
<td>Overall, poor management. Putting aside the absence of production of co-ordination drawings, site control of services installation was inadequate and very weak. Immediate action was not taken for services co-ordination problems even when the progress of the building works was affected.</td>
</tr>
<tr>
<td>The main-contractor</td>
<td></td>
</tr>
<tr>
<td>Services sub-contractor</td>
<td>For the problematic contractor (responsible for the HVAC and steam plant), the management of site work and co-ordination of services was very poor in the beginning as a result of poor project management given by the project manager. Services had been installed but without any co-ordination at all, this created many serious co-ordination problems, resulting in knock-on effects on all services installations. Also, the progress of the building works was affected. Later, the project management was changed and site management was then much improved. However, the contractor was still taking an attitude which was not conducive to good co-ordination of services with all project participants. Team working was hardly seen from this contractor with the main-contractor.</td>
</tr>
<tr>
<td>Later work for improvement</td>
<td></td>
</tr>
<tr>
<td>Client/designer</td>
<td>After many long debates, reluctantly, all contractors agreed to work under the management of the consultant/client co-ordination team. They completed the services works which were fully planned, monitored and controlled by the special co-ordination team which tackled most technical and managerial problems left by the construction team.</td>
</tr>
<tr>
<td>Design team</td>
<td></td>
</tr>
<tr>
<td>Architect/main-contractor (MC)</td>
<td>Good</td>
</tr>
<tr>
<td>M&amp;E services consultant/all contractors</td>
<td>Good, but members of the services team can work better to avoid co-ordination problems first in design and the architect to give room for services installation.</td>
</tr>
<tr>
<td>MC and services contractors</td>
<td>Fair team working</td>
</tr>
<tr>
<td></td>
<td>Better co-operation</td>
</tr>
<tr>
<td></td>
<td>Reasonable with most contractors but adversarial with the HVAC services contractor.</td>
</tr>
</tbody>
</table>
h. Project result

<table>
<thead>
<tr>
<th>Overall</th>
<th>Unsatisfactory. Project was not completed on time. Co-ordination problem was identified to be a major factor causing delay in construction. Of course, these were other factors such as too many design changes as well as the main-contractor’s own problems too. Contract costs exceeded, as there were many variations and claims as a result of co-ordination problems by the services contractor and the main-contractor. Quality of services and construction was acceptable, but some installations would be difficult to maintain as a result of co-ordination problems. Client was not satisfied. In particular the costly claims submitted by the contractors and the extra management needed for arbitration in relation to co-ordination of services. Consultants were also not satisfied and experienced financial loss as a result of protracted construction period. Reputation was also seriously affected as a result of the unfavourable outcome of this project. All suffered high loss in the context of narrow profit margins and the problematic contractors lost business opportunity in the local building industry.</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Critical project performance factors</td>
<td></td>
</tr>
<tr>
<td>Client</td>
<td>Higher cost and late completion of project and more work to do before providing service to the community. Major problems were: Incomplete brief. Too many changes due to late decision-making and the problems of the multi-headed client were not properly controlled. Unclear contract document in relation to management of co-ordination of M&amp;E services by the main-contractor and the nominated services contractors.</td>
</tr>
<tr>
<td>Design team</td>
<td></td>
</tr>
</tbody>
</table>
| Contractors | Unsuccessful project overall although the building would still be completed and functioned quite well. Major factors were:  
- Inadequate management of briefing.  
- Incomplete integration and co-ordination.  
- Incomplete design information and co-ordination details.  
- Unclear contract in relation to detailed responsibilities for design and co-ordination by the contractors.  
- Late involvement in management of co-ordination problems.  
- Poor working relationships between contractors.  
Also not successful. No one was satisfied with the bad name and the loss in profit margins. Main factors were lack of management of services co-ordination coupled with poor site management with the main-contractor. Poor working relationships between contractors. |
8.7.1 Postscript

This was not a successful project. The client, consultants and contractors were all dissatisfied with the project results although the completed project was functioning well. This project also became a good example of bad co-ordination of services and poor working relationship between contractors along with problems of a multi-headed client.

The procurement path selected should have worked if the design had been complete and every contractor had known their duties well. Furthermore, the contractors should have been co-operative and willing to work as a team. Good project management should also exist.

However, in this case, the project was quite complex and the design was not fully complete. There was also unclear responsibility for the important management of co-ordination of services in each contract. Furthermore, the main-contractor did not manage and control the co-ordination work effectively, rather allowing many co-ordination problems to hold up the progress of the construction work. As co-ordination problems increased in number, they caused disputes between members of the design and construction teams. In particular, there was serious adversarial working relationship between the main-contractor and the problematic services contractors who also did not manage the services installation properly. The co-ordination problems continued to exist for months in many parts of the building without any action by the building team.

The project participants sensed the “smoke” of the co-ordination “fire” and realized the knock-on effects of the co-ordination problems. Contractors became aware of the serious impact on the building construction and services installations. The client and design teams started to clear all co-ordination problem, in the hope of getting the building completed on time. A special task force was set up by the M&E services consultant in order to ensure smooth and orderly completion of the problematic services installation since both the main-contractor and HVAC contractor would not sit together to do the right co-ordination and both were rather occupied by their preparation of claims for the delay in contract work as a result of the co-ordination problem created by the design team and poor management of services installation by the construction team (including main-contractor and sub-contractors).
The co-ordination hurdle was, however, subsequently resolved and minimized by adequate identification of installation problems, quick resolution of problems for each trade by the co-ordination task group, together with improved project management for carrying out M&E services installation and builder’s works with some changes in project controllers with the main-contractor and the HVAC sub-contractor. This was further coupled with good control of contractor’s work, all based on careful planning of building zone, continuing motoring of contractors’ works and the provision of decisive action if there were further problems and actions required by all project participants. In general, both technical and managerial issues were extremely important when one was discussing good management of co-ordination of services and the co-ordination chaos.

Good team working is also an important element too, without working co-operatively in harmony, it is difficult to have good co-ordination. This factor was obviously missing in this project and was affected by the selected procurement path. In this case, nomination appeared to jeopardize the good working relationship needed between the main-contractor and the nominated services sub-contractors, creating many battlefields throughout the construction stage. However, the provision of a good services coordinator and co-ordination team members, using the most effective co-ordination tools such as co-ordination drawings, communication skill and cultivation of good working relationships for building a temporary working team was found to be very useful and effective for coordinating all services in the later part of this building’s construction. Therefore, people and project management would all have a great effect on the co-ordination process.

In short, this project result was unsatisfactory. Later arbitration results and other information indicated that:

- The design was not complete and co-ordination details were scarce during the tender stage.
- Co-ordination problems found before tender out were not addressed.
- Responsibility for carrying out the design, installation and co-ordination had been stated, but important details were missing and contractors therefore did not allow sufficient resources for carrying out the co-ordination process.
- There was poor project management by the contractors.
There was a poor working relationship between contractors.

The selection of experienced and co-operative contractor was significant. Apparently, judging from the management of the construction, the main-contractor and HVAC sub-contractor were not the best candidates (They were not the best but they were the lowest tenderers only).

Action by the design team should be taken earlier and before the escalation of co-ordination problems.

Team working was hardly seen in this construction team.

Multi-head client problems caused problems, in this case producing significant ill effects on the co-ordination of services and the planned building programme.

The results supported the validity of the author’s models in terms of the essential variables and the logical framework of the whole system.

8.8 Case study 2

The detailed analyses follows the format used in case study 1.

This was a 1656-bed government district hospital. The design of this large hospital was carried out by reputable U.K. architect and M&E services engineer. Both consultants had been advised on the co-ordination problems in case study 1 by the government project engineer (same as for case 1). They were reminded that better design and more co-ordination of building service should be exercised. To prevent co-ordination problems the M&E services consultant was also asked to provide extra service at additional cost for the provision of more co-ordination details and the employment of senior resident engineers and necessary supporting site staff for more efficient management of the services installation together with all nominated sub-contractors. The government project engineer also strengthened the site supervision team, and co-ordination of services was high on the agenda. Again, this practice was based on the lessons learned from case study 1.

The procurement method was again the traditional system as the government still believed that this was the right system. All services contractors were experienced local specialists and they had to work with a large Japanese Main-contractor. Interview results
suggested that these nominated services contractors worked and co-operated quite well with the main-contractor, although both still encountered numerous co-ordination problems in several critical areas.

The government had learnt a lot from case study 1 (also from other projects) and re-drafted all contract documents for both main contract and nominated services sub-contracts used for this project. The contract documents clearly spelled out details of the management of co-ordination, resources and manpower needed for proper co-ordination of all M&E services and hospital engineering systems. Most importantly, this time, the main-contractor was fully responsible for the preparation of all co-ordination details, drawings, planning and overall management of the M&E services installations with all services contractors and they were all controlled and managed by the main-contractor's special building services co-ordination team. This firstly prevented any disputes pertaining to scope of work in relation to co-ordination of services in all contracts, and secondly, allowed efficient and orderly installation of services together with the building works by the main-contractor.

The main-contractor also had to set up a site office for all M&E services contractors so that the main-contractor's building services co-ordination team could work together with the M&E services contractors and the design team on site. This not only improved site communication but also enhanced overall management of service installation and co-ordination due to a team working approach.

The services in this hospital were very complicated and extensive and co-ordination of services demanded great efforts from all contractors and the design team. The Japanese contractor applied modern management techniques (e.g. critical path analysis, detailed programming, installation meeting, etc.) to control the progress of all building works and M&E services. This significantly improved the management of building services installation.

All services works had been carefully planned, coordinated, controlled and monitored by the construction team. Inadvertently there were still many co-ordination problems found in this hospital project, but these were quickly resolved because of the proper working of the centralized building services co-ordination team.
As far as the multi-headed client problem and design changes were concerned, these were still the problematic areas, although much work had been done to avoid unnecessary effects on M&E services and building construction by the government project manager.

In short, the client was quite satisfied with the traditional system used for the management of the installation of building services and the hospital equipment.

Using the format for case study 1 the following details depict the main points concerning the successful management of building services co-ordination in conjunction with the building procurement system used for this project.

Table 8.3: Analysis of case study 2

<table>
<thead>
<tr>
<th>Item</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The project</td>
<td>Complex and highly serviced. High cost and comparatively short construction time.</td>
</tr>
<tr>
<td>b. The client</td>
<td>Same as case study 1. The client learnt a lesson and improved the management of multi-headed client problems. Still, there were many unexpected changes which all affected the co-ordination process.</td>
</tr>
<tr>
<td>c. The procurement method used</td>
<td>Same as case study 1, traditional method was still favoured by the client, but other methods had indeed been considered before making the final decision.</td>
</tr>
<tr>
<td>Responsibilities for co-ordination of services</td>
<td>Standard contract documents had been revised to give adequate details regarding co-ordination of services by the contractors. Any co-ordination problems would now be the main-contractor's own problems that must be solved quickly.</td>
</tr>
<tr>
<td>Selection of contractor</td>
<td>Still based on price, but quality of contractors was taken into account.</td>
</tr>
<tr>
<td>d. Management of design</td>
<td>Individual specialist consultants had been selected, and the M&amp;E consultant had a greater say than in case 1.</td>
</tr>
<tr>
<td>Structure of the consultant</td>
<td>As a first priority in M&amp;E services and building designs.</td>
</tr>
<tr>
<td>Management of co-ordination</td>
<td>Greater integration and co-ordination as they all knew the problems and outcomes from case study 1. The M&amp;E consultant also did more co-ordination work but there were still some unforeseen problems in some congested areas.</td>
</tr>
<tr>
<td>Co-ordination between members of design team</td>
<td>Better than case study 1 as comprehensive information was given to the contractors. Still, there were some late changes which affected the co-ordination process.</td>
</tr>
<tr>
<td>Improvement in multi-headed client problems</td>
<td>More co-ordination details and drawings given to contractors as instructed by the client. Comprehensive information provided.</td>
</tr>
<tr>
<td>Design information</td>
<td></td>
</tr>
</tbody>
</table>

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| **Drawings** | Large-scale double line drawings for both plan and sections to be used thus facilitating better co-ordination. |
| **Involvement in construction** | The resident engineers were fully responsible for all engineering and co-ordination issues. |
| **Management of installation** | Overall performance was good as good contractors had been employed and the main-contractor adopted the Japanese system for both construction and installation of services. |
| **Management system for building services installation** | Very effective for preventing serious co-ordination problems by introducing the main-contractor’s building services co-ordination team working with all services contractors with effective management and planning of services works. |
| **f. Management of co-ordination** | In general, this was deemed to be very good. |
| **Responsibility for co-ordination** | Very clear for all designers, main-contractor and all services contractors. |
| **Management and planning of co-ordination of services** | Covered by each party in accordance with the details of management of co-ordination stipulated in the contract. Drawings and staff had been allowed for. |
| **g. Teamworking** | Good |
| Client/designer | Good and less communication gap than Project 1. |
| Designer/contractor | Good, co-operative. |
| Main-contractor/sub-contractor | Very co-operative. |
| Between sub-contractors | |
| **h. Project result** | As far as building services installation was concerned, the result was very satisfactory for this large hospital (from the perspective of the client’s project management). Co-ordination problems did affect progress of construction but this was not the main cause of delay in construction. |
| **i. Critical performance factors** | |
| Client | Comprehensive design brief and better management of multi-head clients. |
| Designers | Clear responsibility for co-ordination of services was allocated to each party. |
| Contractors | More involvement with regard to management of design and co-ordination of services and hospital equipment. |
| | Higher integrated M&E services design with adequate space for services installations. |
| | Design information as complete as possible. |
| | More co-ordination details for services. |
| | Involvement in management of co-ordination on site with all contractors. |
| | Improved communication with contractors. |
| | Better working relationships with contractors. |
| | Experienced and competent people |
| | Good team working and effective communication between contractors and consultants. |
| | Business-minded contractors. |
| | Good site project management and the unique provision of a dedicated building services management system developed by the client for managing co-ordination of services on-site. |
| | No one wished to suffer as they had learnt the mistakes in case study 1. |
This project demonstrated that both technical and managerial issues as included in the author's Building Services Co-ordination Model for attaining effective co-ordination of services did exist in this project. As far as any adverse effects of the traditional procurement method on this project performance were concerned, the researcher must admit that he did not see much effect from this project as the method gave quite satisfactory results. However, the only concerns were:

- The nominated contractors must be welded into the construction team. Otherwise the co-ordination process would be difficult.
- Above all else this nomination system would perpetuate the divide between services and building work. The divide would still create distrust and hamper cooperation between the specialist sub-contactors and main-contractor. This would not be the best way to achieve successful procurement of a building.
- Furthermore, the main-contractor would be protected by the nomination process. Too frequently, the main-contractor's default could be passed to the nominated sub-contactors and this would relieve them of their contractual obligations, and the client could suffer.

The result also validated the models.

8.9 Case study 3

This was an extension to an existing 1295-bed government regional hospital. The details were similar to case 2 and the following short conclusions were given:

1. The traditional method had been used but again the working between the Japanese main-contractor and the nominated services sub-contractors (from local contracting organizations) was deemed to be quite satisfactory.

2. The designers of the hospital again had given special consideration to the complex M&E services installation as they had heard the saga of case 1 from the client's project manager. They also learnt some critical co-ordination problems and the successful management of building services from case 2.
Greater integration and co-ordination between all members of the design team were reflected from the overall layout of the building. The good design of the building obviously helped smooth the installation of services.

3. Same as case 2, the design team had also assigned individual resident architects and engineers to assist the contractors on-site. This further reduced generation of co-ordination problems, like other hospitals, full or complete design and co-ordination was difficult to achieve, and there would still be some unforeseen co-ordination problems. With the involvement of the designers, most problems could at least be resolved together if the main-contractor’s services co-ordination team and the contractors could not overcome the problems themselves.

4. As practised in case 2, the main-contractor’s services co-ordination team played a very important role in the management of building services installation with the nominated services contractors.

The management of building services was similar to the second case study. The performance was considered quite acceptable by the government project manager for a complex project like this. Although there were still many minor co-ordination problems found (especially due to client’s design changes), most could be tackled quickly by the consultants and the main-contractor. Hence, co-ordination problems were insignificant in relation to the main-contractor’s claim submitted to the client.

5. Teamworking was deemed to be quite satisfactory. All project participants were fully aware of the importance of working as a single team. Even with the traditional procurement method using nominated services sub-contractors, the working relationship between the project participants was in harmony.

6. Briefly, the main project success factors were:

Client
- Better briefing.
- Better management of multi-headed client problems.
• Clear contract in relation to co-ordination of services.
• As usual, a good site supervision team had been used.

**Designer**
• Better design with greater integration and co-ordination.
• Additional co-ordination details for the contractors.
• Involvement in co-ordination on site.
• Good working relationships with contractors.

**Contractor**
• Business – minded contracting firms.
• Better construction management (Japanese style).
• Effective management of services installation.
• Good management of co-ordination of services.
• Good working relationship with all project participants.

The result also supported the models.

### 8.9.1 Postscript

This project was very similar to case study 2. The project was delayed and claims (mainly due to design changes by client) had been submitted by the main-contractor. As far as co-ordination of services was concerned, the result was very satisfactory. Again, the traditional procurement system was still seen to be workable system for complex hospital project.

### 8.10 Case study 4

The use of the traditional procurement path employing nominated sub-contractors for highly serviced hospitals had been examined and discussed in cases 1 to 3. Depending on the circumstances and the quality of design, contract documents, quality of contractors, working relationship and management of project, the conventional path would achieve satisfactory co-ordination of building services (Lee, 1984). This method, however, under unfavourable conditions, would also give unsatisfactory result.
The traditional system also employed domestic sub-contractors and it was necessary to see how and in what ways this method might affect the management of the building services installation.

Based on a report submitted by the Government Chief Building Services Engineer. The use of domestic contractor was based on:

1. The human aspects were important influences on project performance. Inflicting an unknown specialist contractor upon a main-contractor prevented the normal working relationship between the main-contractor and his own sub-contractor.

With domestic sub-contractors, the main-contractor was able to enter into a contract with a chosen specialist contractor, with whom a good working relationship should exist. As the main-contractor would form better business relationships with their own sub-contractors, this should lead to more effective co-ordination, control, progress, prices and quality.

2. The main-contractor was fully aware of the scope of the entire works at tender stage. Programmes and attendance items were more likely to be clearly identified and agreed between the parties reducing the likelihood of future disputes.

3. Nomination was risky. The sub-contract performance significantly affected the main contract progress. This often allowed the main-contractor an extension of time for delay on the part of nominated sub-contractors. Claims were also submitted by the main-contractor. Not least to mention, there were unavoidable arguments disputes too. Obviously, the client must bear all costs.

4. This was one possible way of spreading the co-ordination risk to the main-contractor, and this also became a single point responsibility as all responsibilities and liabilities were channeled through one party under one contract.

5. A greater responsibility and pressure was placed on the design team in achieving a full design prior to inviting main contract tenders.
6. The design team had to concentrate on project management with one big contractor who was fully responsible for all works.

The report also gave one important issue regarding careful selection of suitable specialist domestic contractors, and that a list of names of pre-qualified contractors must be included in the main-contract document from which the contractor was able to select their preferred specialist contractors.

The project

This was a 1752-bed government regional hospital. This hospital was designed by two large local consultants each working with an UK specialist consultant experienced in hospital projects. The UK architect had already designed a high-rise hospital before this project. The project was let on a traditional procurement method and with the intention that domestic sub-contractors be used as the client did not wish to have claims and arbitrations as had happened previously in some recently completed hospital projects (Case 1 to 3).

The reasons against nomination by the client are:

1. Co-ordination of services requires the formation of good team. Nomination does not give good team working in general.
2. Elimination of nomination can improve the overall management process from the viewpoint of the client.
3. The main-contractor can work with their ‘preferred’ services sub-contractors and therefore should give better teamworking and good working relationship.
4. The reduction in differentiation or the greater familiarity from the use of the domestic form of procurement should lead to more effective co-ordination, progress, prices and quality.
5. The main-contractor is now wholly responsible for the entire project as services is now becoming an integral part of a building contract.
The contract was awarded to a large New Zealand contractor in joint venture with a reputable local firm. Building services work on this project amounted to 40-45% of the total cost.

The project completion date was delayed and a substantial claim (mostly from design change and some co-ordination problems as a result of incomplete design) for additional costs by the contractor had to be settled by the client. The problems associated with this project were:

- The brief and conceptual design were developed out of a poorly co-ordinated group of end-users.
- Design changes arising largely from an inadequate briefing process and poor management of the complex multi-headed client problems.
- Inadequate consideration of building and medical services provision as a result of the local designer’s own problems.
- Lack of co-ordination of building services in design and installation.
- Local building services contractors boycotted the tender procedure. The boycott arose from the client decision to use domestic contractors rather than to nominated sub-contractors, thus depriving bidding contractor of expertise in the special services and contributing the extended tender period. The successful contractor subsequently experience difficulties in managing the various M&E services subcontractors and in achieving an appropriate quality of work.
- Ineffective project management by the building services contractor coupled with the use of inexperienced services contractors (e.g. Electrical services, HVAC) for this complex project.
Table 8.4: Analysis of case study 4

<table>
<thead>
<tr>
<th>Item</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The project</td>
<td>Complex and highly serviced</td>
</tr>
</tbody>
</table>
| b. The client | Same as case study 1.  
Client still not managing the critical multi-headed client problems adequately.  
Inadequate briefing process.  
Still many design changes during the construction stage. |
| c. The procurement method used | Traditional with domestic sub-contractors for better project management and greater integration and co-ordination between contractors.  
Clear, with single point responsibility by using domestic contractors for all M&E services.  
Experienced services contractors boycotted the tender.  
Main-contractor had to select some inexperienced contractors and this created difficulties in coordinating the building services and in achieving an appropriate quality of work. |
| Responsibilities for co-ordination |  |
| Selection of contractors |  |
| d. Management of design | Complex. First with inexperienced local architect and M&E services consultant.  
Secondly, each was working with a different specialist consultant.  
Communication would be a bit complicated.  
Design was prepared by the expatriate designers and local architect and engineer to complete design. This complicated the integration and co-ordination of M&E services.  
Insufficient as there were critical co-ordination problems which were apparently caused by the lack of co-ordination between service needs and space provision. This was also linked to the working of each of the two key designers with their design partner.  
Not improved much since case study 1 by the client.  
It was a culture in government organization, deviation from standard procedure was difficult.  
Many hospital users still made changes even when design was complete.  
Design team did not manage this professionally. |
| Structure of the consultant |  |
| Co-ordination between members of design team |  |
| Improvement in multi-headed client problem |  |
| Design information | Basic layouts were adequate but co-ordination drawings were still scarce.  
Use of double-line drawings for plan and elevations. Good for development of co-ordination details. |
| Drawings |  |
| Involvement in construction | There was a resident architect and engineer on site, but involvement in the co-ordination work was considered just sufficient. |
Table 8.4 – continued

<table>
<thead>
<tr>
<th></th>
<th>Management of installation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>e.</td>
<td>Management system for building services installation</td>
<td>Management system for building services installation was adopted from case 2 to 3. The established system should work. Underestimate of co-ordination requirements (e.g. experience, staffing levels, no. of drawings). Inadequate coordinated production information for services and construction and as a consequence work started slowly and remained behind schedule. Inefficient resolution of co-ordination problems between contractors coupled with tight space provision for complex services.</td>
</tr>
<tr>
<td>f.</td>
<td>Overall management of co-ordination</td>
<td>For a complex project like this, the design and construction team must give special consideration to the co-ordination of services but the performance was not entirely satisfactory. There were flaws in design as well as in construction management and management of services works by the building services coordinator.</td>
</tr>
<tr>
<td>g.</td>
<td>Teamworking</td>
<td>Good. Satisfactory but with gaps in completing the design. Satisfactory. Fair as some sub-contractor were difficult to manage.</td>
</tr>
<tr>
<td>h.</td>
<td>Project result</td>
<td>Not completely satisfactory for both co-ordination of services and construction compared with case study 2.</td>
</tr>
<tr>
<td>i.</td>
<td>Critical project performance factors</td>
<td></td>
</tr>
<tr>
<td>Client</td>
<td></td>
<td>Sufficient brief. Clear contract document regarding co-ordination of services. Use of domestic contract for single point responsibility. Poor management of multi-headed client problems and too many changes again.</td>
</tr>
<tr>
<td>Designer</td>
<td></td>
<td>Owing to the designer’s organizational structure, these were incomplete design information which caused problems in design and construction. Inadequate integration and co-ordination of services and building. Involvement on site could have been more. Communication with project participants was satisfactory.</td>
</tr>
<tr>
<td>Contractor</td>
<td></td>
<td>Not all were experienced contractors. Management of co-ordination of services was deemed to be not very successful, as construction work had been delayed by services. Main-contractor did not effectively organize the management system developed by the client for the co-ordination process and created problems when installing some M&amp;E services in some critical/congested areas. Apparently, there were flaws in overall planning and programming of the services installation and construction. Team working existed but main-contractor did not form the best working team with some of his sub-contractors.</td>
</tr>
</tbody>
</table>
8.10.1 Postscript

Even with a single point responsibility, the main-contractor still had problems with the M&E services. The case study displayed:

- Inadequate integration and co-ordination by the designer would definitely create contractor's co-ordination problems. Still, the building services consultant did not design the building services fully with other members of the design team.

- Without adequate resources, planning and management of building services for highly serviced buildings like this project would still be chaos, even with domestic sub-contractors and co-ordination of building services.

- The lack of consideration given to proper co-ordination and integration and the management of multi-headed client problems still remained the most common cause for delay and contractual claims.

- Good co-ordination of building services is only possible if the project participants are experienced and co-operative. Selection of sub-contractors was of paramount importance. Price was not the only factor to be considered by the main-contractor. By far, good working relationships and high competence in running large contracts for complex building like this would be the essential requirement for a successful project. Local working experience was also important.

- The consultant still did not provide sufficient co-ordination drawings for many critical areas. Furthermore, the consultant also did not offer proactive help for solving some of the poorly designed and coordinated services (To avoid involvement in the main-contractor's co-ordination problems and possible dispute).

Overall, the project was delayed but the hospital was functioning quite well. Although this procurement approach was the traditional route using domestic services contractors, the performance of management of building services was similar to cases 2 and 3. Again, there was submission of claim from the main-contractor as a result of design changes and some co-ordination problems. By and large, the co-ordination process was deemed to be more than acceptable as one had to consider the complexity of this building and the
massive design information left to the contractors’ further development into full co-ordination drawings.

The results also validated the usefulness of the models. The co-ordination model was found, in particular, very helpful in identifying the issues concerning the complex management of building services.

8.10.2 Eliminating nomination

In matters where a great deal of co-operation was required from both main-contractor and sub-contractors in the integration and co-ordination of building services, it would make sense to let the main-contractor choose the specialist building services contractors who must all be approved, qualified and experienced contractors.

In purely contractual terms there was also a considerable advantage to the client in removing the act of nomination (e.g. less risk to time and monetary claims from the main-contractor) and all responsibilities and liabilities were channeled through one party under the main contract.

Since the completion of this hospital, the government was quite satisfied with the domestic contractor arrangement and many hospital projects (see hospital projects such as CPH and HOHH in Appendix Three) adopted this procurement method. The performance of the co-ordination of services on these other projects was quite satisfactory.

Table 8.5 gives a summary of the comparison of nominated and domestic contractor systems based on the chief government engineer’s decision marking.

This summary was also confirmed by the author’s detailed analysis of the six cases in conjunction with the data obtained from the questionnaire/interview survey results. It was clearly seen that the higher the differentiation, the more the co-ordination and integration would be required by the construction team. On the other hand, the higher the familiarity or proximity between two operating teams/units, the easier the integration and co-ordination would be found.
### Table 8.5: Comparison of nominated and domestic contractors in the context of management of coordination of building services

<table>
<thead>
<tr>
<th>Traditional</th>
<th>Traditional with domestic contractors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Organization</strong></td>
<td></td>
</tr>
<tr>
<td>Separation of design from construction</td>
<td>Still with separation.</td>
</tr>
<tr>
<td>- Harder integration &amp; coordination of various designers</td>
<td>- No change.</td>
</tr>
<tr>
<td>- Difficult to weld the design and construction teams together</td>
<td>- Still difficult but with less contractors to work with.</td>
</tr>
<tr>
<td>- Services contractor is not involved in design and services will have to be coordinated based on contractor’s selection of equipment and plant.</td>
<td>- No change.</td>
</tr>
<tr>
<td>- There are multiple responsibilities for coordination (designers and contractors) and allocation of design and construction responsibilities are not always clear.</td>
<td>- No change for design but there would be better co-ordination due to single point responsibility with domestic contractors.</td>
</tr>
<tr>
<td><strong>2. Managerial issues</strong></td>
<td></td>
</tr>
<tr>
<td>- Management of separate design and construction teams is difficult.</td>
<td>- No change in design team. Better performance in construction team.</td>
</tr>
<tr>
<td>- Management of coordination during design stage is essential, but not fully completed based on normal condition of employment of consultant.</td>
<td>- No change.</td>
</tr>
<tr>
<td>- Difficult to manage coordination on site with the builder and all sub-contractors.</td>
<td>- This problem would still exist but would be diminished due to greater co-operation as a result of single point responsibility of the main-contractor.</td>
</tr>
<tr>
<td><strong>3. Design</strong></td>
<td></td>
</tr>
<tr>
<td>- Fully integrated services and detailed coordinated M&amp;E services drawings are essential, but design is often incomplete.</td>
<td>- Design should be fully completed for domestic sub-contractors as consultant cannot pass the responsibility to the main-contractor so easily if design is incomplete.</td>
</tr>
<tr>
<td>- Response to problems and provision of solutions will usually be slow due to separate design and construction teams.</td>
<td>- The problem could still occur but with domestic contractor, the main-contractor would solve the problems much quicker.</td>
</tr>
<tr>
<td><strong>4. Contract</strong></td>
<td></td>
</tr>
<tr>
<td>- Contract for services consultant is a problem, coordination of services is additional duty.</td>
<td>- Detailed co-ordination of services is always required to avoid contractual problem.</td>
</tr>
<tr>
<td>- Architect is the lead designer, but coordination of services is passed to his M&amp;E consultant and the main-contractor.</td>
<td>- No change in theory, but the main-contractor would have to do more co-ordination work.</td>
</tr>
<tr>
<td>- Site coordination by all sub-contractors but managed and prepared by the main-contractor.</td>
<td>- This is still necessary but the main-contractor would be fully responsible for the co-ordination work.</td>
</tr>
<tr>
<td>- Fosters confrontational attitudes and adversarial working relationships due to conflict of interest.</td>
<td>- Better working relationship with own people.</td>
</tr>
<tr>
<td><strong>5. Risk</strong></td>
<td></td>
</tr>
<tr>
<td>- In the context of coordination of services, the risk is high as the client is responsible for design and coordination is a design problem at large.</td>
<td>- Less risk to the client if the design was completed, but the main-contractor takes more risk if it does not co-ordinate its services works.</td>
</tr>
</tbody>
</table>

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8.11 Case study 5

This project involved the phased development of an existing 640-bed hospital. The first phase consisted of the addition of new staff quarter, the second phase the construction of 858-bed new hospital building.

The method of procurement was traditional with full Bills of Quantities, nominated subcontractors, and the use of an independent project management team appointed from the private sector.

The project was regarded successful and the co-ordination of services was good.

The presentation of this project starts from the determination of the original architect but the reader can find more details from Appendix Three.

Table 8.6: Analysis of case study 5

<table>
<thead>
<tr>
<th>Item</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The project</td>
<td>Complex and highly serviced plus connection to an old hospital building.</td>
</tr>
<tr>
<td>b. The client</td>
<td>Semi-government hospital client, still very rigid and bureaucratic. Also with multi-headed client problems.</td>
</tr>
<tr>
<td>c. The procurement method used</td>
<td>Traditional with nominated services sub-contractors coupled with project management consultant.</td>
</tr>
<tr>
<td>Responsibility for co-ordination</td>
<td>Clear, based on the well-established building services co-ordination management system developed by the government.</td>
</tr>
<tr>
<td>Selection of contractors</td>
<td>No problems. All contractors were good contracting firms, and most understood building services co-ordination.</td>
</tr>
<tr>
<td>d. Management of design</td>
<td>Local architect working with very experienced M&amp;E services consultant and with additional project management consultant employed by the client.</td>
</tr>
<tr>
<td>Structure of the consultant</td>
<td>As a first priority by the consultant.</td>
</tr>
<tr>
<td>Management of co-ordination</td>
<td>Good integration and co-operation since the design team treated this as an important element in design.</td>
</tr>
<tr>
<td>Co-ordination between members of design team</td>
<td>Yes, but with more efforts with the users in this hospital project as many users were not experienced in development of good briefing.</td>
</tr>
<tr>
<td>Improvement in multi-headed client problems</td>
<td>Adequate.</td>
</tr>
<tr>
<td>Design information</td>
<td>Adequate.</td>
</tr>
<tr>
<td>Drawings</td>
<td>Involvement in construction</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Management system for building services installation</td>
<td>Quality drawings plus sufficient co-ordination details and based on a quality assurance system by the M&amp;E consultant.</td>
</tr>
<tr>
<td></td>
<td>Some as the project management consultant would undertake this task with all contractors on site.</td>
</tr>
<tr>
<td>Overall performance was very good as the use of project management consultant provided better planning and management of the whole project.</td>
<td></td>
</tr>
<tr>
<td>The use of a well-established co-ordination management system plus extra project management gave smooth progress of works.</td>
<td></td>
</tr>
<tr>
<td>Good preparation of all works in relation to co-ordination of building services by all contractors and the project management team on site.</td>
<td></td>
</tr>
<tr>
<td>f. Management of co-ordination</td>
<td>Very satisfactory as most project participants gave early recognition of potential problems relating to the co-ordination of building services.</td>
</tr>
<tr>
<td></td>
<td>Very clear responsibility and details regarding co-ordination, and all contractors worked together to ensure early completion of coordinated drawings.</td>
</tr>
<tr>
<td></td>
<td>Contractors also planned and managed the works very efficiently and professionally.</td>
</tr>
<tr>
<td>g. Teamworking</td>
<td>h. Project result</td>
</tr>
<tr>
<td>Client/designer</td>
<td>Critical project performance factors</td>
</tr>
<tr>
<td>Designers/contractors</td>
<td>Client</td>
</tr>
<tr>
<td>Contractors/project management consultant</td>
<td>Typical government structure but managed by the project management consultant.</td>
</tr>
<tr>
<td></td>
<td>Should give better design brief and properly handle multi-headed client problems in the beginning.</td>
</tr>
<tr>
<td></td>
<td>Appropriate contract documents with clear responsibilities and requirements for co-ordination of services were given to contractors.</td>
</tr>
<tr>
<td></td>
<td>Using professional project management to enhance project success was a wise decision for inexperienced client.</td>
</tr>
<tr>
<td></td>
<td>Sufficient design information.</td>
</tr>
<tr>
<td></td>
<td>Good integration and co-ordination of services.</td>
</tr>
<tr>
<td></td>
<td>Involvement in management of co-ordination on site with contractor and management consultant.</td>
</tr>
<tr>
<td></td>
<td>Good working relationship with all project participants.</td>
</tr>
<tr>
<td>Contractor</td>
<td>All were experienced contractors.</td>
</tr>
<tr>
<td></td>
<td>A very good working team on site with good working relationships between contractors and consultants.</td>
</tr>
<tr>
<td></td>
<td>Sufficient resources for managing co-ordination of services on site. The use of the co-ordination team was very effective in co-ordination of services, and in particular, the resolution of problems between contractors concerned.</td>
</tr>
<tr>
<td></td>
<td>Good project management under the guidance of the project management consultant.</td>
</tr>
<tr>
<td></td>
<td>Win-win approach by most contractors as they wished to do a good job for better business opportunity.</td>
</tr>
</tbody>
</table>
8.11.1 Postscript

This case showed the use of the traditional method was still feasible for highly serviced building, but good project management should be added to strengthen the management of the whole building construction. Services were only a part of the product.

Additional project management coupled with good contractors would definitely improve project management in coordinating the efforts of large number of contractors on complex project like this hospital.

In essence, the success of the management of building services installation could be summarized as follows:

- Adequate design with sufficient design information and co-ordination details.
- Good project management by the project management, and all contractors fully aware the co-ordination duty and adequate resources had been allowed for the works.
- Good working relationship between members of the building team.
- Good teamwork and co-operation.
- Co-ordination of services was high on the agenda and the whole team worked together with the help of the special co-ordination team. All in all, all the parties must have a will to win, and apply this to the fullest extent. Problems found were quickly resolved by the co-ordination team and the contractors concerned.
- Multi-headed client problems did occur but were under the control of the management consultant, so that design changes were fully addressed and managed to reduce effect on the planned construction and services installation.

Lessons learnt from other projects (See case studies in Appendix Three) also confirmed the merit of the employment of professional management for compensating the weakness of the traditional procurement method, and the performance of co-ordination of building services in each case was also very successful.
As explained earlier, to solve the co-ordination problems, one must tackle all technical and managerial issues as depicted in the co-ordination model. The cases mentioned supported the researcher’s view. It appeared that the traditional procurement system coupled with good project management could achieve remarkably good project results. However, before making the final comment on this modified traditional procurement path, other cases using different procurement approaches are examined as follows.

The results also supported the usefulness and suitability of the two models.

8.12 Case study 6

The lack of integration and co-ordination of building services into the construction work was often argued as the root of building services problems in the traditional procurement system. Where alternative systems were used, then these problems either did not exist, or existed but to a greater or lesser extent.

The most obvious alternative system is design and build (D&B) as it is the fastest growing procurement route for hospital projects.

The project

This was a 618-bed government district general hospital.

The enhanced D&B (develop/construct, D&C) procurement route was selected by the new Hospital Authority. The contractor was responsible for design development, working details and construction. The reasons for the choice were:

- To avoid the lengthy traditional procurement process because of overlapping activities with D&C method.
- To provide a single point contact and responsibility for design and construction.
- To provide a high degree of public accountability.
- To better integrate design and construction thus minimizing building services co-ordination problems because of better team working and co-operation.
• To provide a high level of buildability due to involvement of the contractor at the optimum point in the design process to maximize potential buildability and constructability.

• To ensure that the hospital in-house project manager finalized all users needs and requirements before the completion of the design, thus, reducing later design changes (N.B. all users should have been advised the effect of late decision and changes, and the penalty of late completion).

However, the client had to accept that:

• Relatively fewer firms would offer the design and build service so there would be less completion, and the contract price may be higher than the traditional method.

• Difficulties could be experienced in preparing an adequate brief and details of hospital users’ requirements.

• Bids would be more difficult to compare since each design and cost will vary.

• Client changes to project scope could be expensive.

The basic design of the hospital was carried out by the client’s project team and a local health planner together with a building services consultant. A scope design was finally completed and four contractors were invited to tender. After detailed tender analysis, the contract was finally awarded to a large and very experienced local building works contractor.

Subsequent to the award of the contract, the client had also reached an agreement with the contractor to use a partnering approach on this project.

The contractor appointed another health planning architect and a large M&E services consultant to develop the scope design. Basically, the scope design was up to stage D, based on the RIBA Plan of Work, and performance standards and technical specifications were very comprehensive, and the final design deviated little from the original design concept.
As it was the contractor’s first fast track design and build hospital project, the contractor had fully committed to this project as this would provide a good entry into this special construction field which could yield good future profit margins and reputation.

The hospital was again a complicated project requiring a high degree of co-ordination in both design and construction. The methodology and approaches employed for the successful completion of this building and its building services in a tight programme included the following:

- Provision of a good comprehensive functional brief and a very detailed scope design by the client.
- Experienced contractor good at construction management.
- Most M&E service contractors were contracting divisions within the construction firm’s parent company. As such, both contractors should work more effectively and co-operatively. After all, they had the same project goal.
- Experienced architect and M&E services consultants were working very closely with the contractors. The construction team therefore understood the design concept and provided input at early stages to any design activities which would be beneficial to their subsequent execution of the site work.
- Design team prepared complete design information and adequate co-ordination details. Furthermore, design would be flexible for changes. The main-contractor also provided good management of M&E services installation with the construction works. Most importantly, both had accepted the significance of building service co-ordination right from the beginning of the project.
- Reduction of multi-headed problems and changes by the client.
- Effective management of client’s brief and good communication between designers and users during the development of the detailed design.
- Overall, there was a good building team with experienced designers and contractors all working together with a greater spirit of co-operation.
Table 8.7: Analysis of case study 6

<table>
<thead>
<tr>
<th>Item</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. The project</strong>&lt;br&gt;A complicated project to be completed within a 30-month contract period.</td>
<td>Highly serviced with tight construction time. The project completion data should be late but accepted by the client.</td>
</tr>
<tr>
<td><strong>b. The client</strong>&lt;br&gt;The new Hospital Authority</td>
<td>With new concept of project procurement and management of project.</td>
</tr>
<tr>
<td>Structure</td>
<td>Less bureaucratic and would accept changes from standard practice.</td>
</tr>
<tr>
<td>Management of multi-head client problems</td>
<td>Still existed, but had been taken into consideration. Changes were minimized and carefully controlled.</td>
</tr>
<tr>
<td>Management of briefing</td>
<td>Good and comprehensive by the project team.</td>
</tr>
<tr>
<td>Working with design team and contractors</td>
<td>Professional with good additional project management.</td>
</tr>
<tr>
<td><strong>c. Procurement method</strong>&lt;br&gt;Fast track but with control of design and cost</td>
<td>Develop and Construct was selected because of the need of single-point-responsibility.</td>
</tr>
<tr>
<td>Contract documents</td>
<td>Clear management of co-ordination of services was given in the contract documents. Other contractual requirements were also comprehensive.</td>
</tr>
<tr>
<td>Selection of contractor</td>
<td>Still based on price but the quality of contractor and design team was also given serious consideration.</td>
</tr>
<tr>
<td><strong>d. Management of design</strong>&lt;br&gt;Scope design</td>
<td>Comprehensive by the project team.</td>
</tr>
<tr>
<td>Contractor’s design team</td>
<td>Professional by the two experienced consultants working with the reputable building work contractor.</td>
</tr>
<tr>
<td>Management of co-ordination</td>
<td>Effective for this fast track construction. Good integration and co-ordination provided.</td>
</tr>
<tr>
<td>Co-ordination between members of design team</td>
<td>Good but there were still some unforeseen problems which however, were quickly resolved by the construction team.</td>
</tr>
<tr>
<td>Quality of drawings</td>
<td>Sufficient for parallel design and construction.</td>
</tr>
<tr>
<td>Involvement in site co-ordination</td>
<td>Provided by design team. Design team worked with contractors to solve site problems as and when required.</td>
</tr>
<tr>
<td>Management of multi-headed client problem</td>
<td>Good and effective based on good communication and project management.</td>
</tr>
<tr>
<td><strong>e. Management of installation</strong>&lt;br&gt;Management of M&amp;E services installation</td>
<td>Good with adequate planning and management. The main-contractor had planned all works and the building services co-ordination team had provided sufficient co-ordination with all services contractors and the building works contractor for the fast track construction.</td>
</tr>
<tr>
<td>Management system for building services installation</td>
<td>With the well-established building services co-ordination system developed for case study 2.</td>
</tr>
</tbody>
</table>
Table 8.7 – continued

<table>
<thead>
<tr>
<th>f. Overall management of the coordination process</th>
<th>Co-operative and effective for this fast track construction.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The main-contractor</td>
<td>Understood the co-ordination chaos and was prepared to avoid the problems from design to construction (e.g. integrated and co-ordinated design with due regard to services installation, and good planning and management of the site co-ordination process with adequate details, information and schedules). Also with good project management for services installation.</td>
</tr>
<tr>
<td>The M&amp;E services contractors</td>
<td>As members of the construction company, better working was the rule. However, there were still some co-ordination problems but these were quickly resolved by the building team.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>g. Teamwork</th>
<th>Good working relationship.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client/contractor</td>
<td>Very good based on long-term partnering relationship.</td>
</tr>
<tr>
<td>Main-contractor/designer</td>
<td>Very good as members of the same company.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>h. Project result</th>
<th>Very satisfactory even the actual project completion date could not be met. Cost had been closely controlled and there were no serious co-ordination problems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>All project participants were satisfied with the project performance. The D&amp;C contractor did a good job and became a specialist in hospital construction.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1. Critical project performance factors</th>
<th>Good project management provided based on the lessons learnt form previous hospital projects.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>Good monitoring of project with appointed management consultant.</td>
</tr>
<tr>
<td>Design team</td>
<td>Good control of multi-headed problems and design changes for the first time in hospital project.</td>
</tr>
<tr>
<td>Contractors</td>
<td>A successful design team with new role in design and build business.</td>
</tr>
<tr>
<td></td>
<td>Professional service provided within time constraint.</td>
</tr>
<tr>
<td></td>
<td>Greater integration and co-ordination of M&amp;E services with building and structural elements.</td>
</tr>
<tr>
<td></td>
<td>A good construction team with high degree of cooperation and understanding.</td>
</tr>
<tr>
<td></td>
<td>Good working relationship with all project participants.</td>
</tr>
<tr>
<td></td>
<td>Professional construction project management for this project.</td>
</tr>
<tr>
<td></td>
<td>Involvement in the design process.</td>
</tr>
<tr>
<td></td>
<td>Commitment to the design &amp; build route with win-win approaches.</td>
</tr>
<tr>
<td></td>
<td>Use of building services co-ordination team and effective on-site management for all M&amp;E services works.</td>
</tr>
</tbody>
</table>

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8.12.1 Postscript

A number of the case studies illustrated the problems caused by the inadequate co-ordination of the building services design and the main architectural work. With the Design and Build system the management of building services installation was seen to be different from the traditional procurement system as:

- The design team employed by the contractor worked closely with the main-contractor to provide practical solutions for fast track construction. This led to better integration and co-ordination of M&E services.
- Participation of the contractor at the design stage and also during the preparation of detailed design drawings was conducive to better co-ordination of M&E services.
- Owing to the single point responsibility the D&B contractor must solve the co-ordination problems as they were responsible for both design and construction.
- The D&B contractor had greater control of their domestic contractors and services installations.
- Problems of design liability are greater under design and build so the contractor would try hard to eliminate problems from design to construction.

The results obtained from this case also validated the suitability of the two models.

Judging from the data collected and some comparison made as depicted in Table 8.8, it was clear that D&B could solve some of the problems of traditional procurement for the client, main-contractor and sub-contractors. This also demonstrated the effectiveness of the building services co-ordination model in examining the management of the complex co-ordination issues as the model would cover all important points/issues.

From the author’s research results, the differences between the two methods are summarized in Table 8.8 and this gives a better understanding of the characteristics of the two procurement paths in the context of M&E services.
Table 8.8: Comparison of the traditional path and D&B in the context of management of coordination of building services

<table>
<thead>
<tr>
<th>Traditional</th>
<th>D&amp;B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Organization</strong></td>
<td><strong>Integrated design and construction team</strong></td>
</tr>
<tr>
<td>Separation of design from construction</td>
<td>- Enhanced integration &amp; coordination as all members work under one umbrella.</td>
</tr>
<tr>
<td>- Good integration &amp; coordination is possible but difficult to achieve with separate design and construction teams.</td>
<td>- Better teamwork and control.</td>
</tr>
<tr>
<td>- Difficult to weld the design and construction teams together.</td>
<td>With potential long term partnering for future hospital projects.</td>
</tr>
<tr>
<td>- Services contractor is not involved in design, and services will have to be coordinated based on contractor's selection of equipment and plant.</td>
<td>- Consultant works with contractors, second coordination after design is not necessary, and both are involved for detailed design and installation.</td>
</tr>
<tr>
<td>- There are multiple responsibilities for coordination (designers and contractors) and allocation of design and construction responsibilities are not always clear.</td>
<td>- Single point responsibility, contractor must manage all coordination works.</td>
</tr>
<tr>
<td><strong>2. Managerial issues</strong></td>
<td></td>
</tr>
<tr>
<td>- Management of separate design and construction teams is difficult.</td>
<td>- Management is easier due to the integrated team approach.</td>
</tr>
<tr>
<td>- Management of coordination during design stage is essential, but not fully completed.</td>
<td>- Coordination must still be managed, but is carried out by both design and construction teams and the work must be fully completed to ensure speedy construction.</td>
</tr>
<tr>
<td>- Difficult to manage coordination on site with the builder and all sub-contractors.</td>
<td>- This problem could possibly still occur, but the D&amp;B contractor directly controls the contractors who work much closer and more efficient together.</td>
</tr>
<tr>
<td><strong>3. Design</strong></td>
<td></td>
</tr>
<tr>
<td>- Fully integrated services and detailed coordinated M&amp;E services drawings are essential, but design is usually incomplete.</td>
<td>- Design must be complete for construction, and both design and construction teams will understand better.</td>
</tr>
<tr>
<td>- Response to problems and provision of solutions will usually be slow due to separate design and construction teams.</td>
<td>- Quicker response to coordination problems and solutions as the contractor is wholly responsible for design and construction.</td>
</tr>
<tr>
<td><strong>4. Contract</strong></td>
<td></td>
</tr>
<tr>
<td>- ACE contract for services consultant is a problem, coordination of services is an additional duty.</td>
<td>- D&amp;B consultant must provide workable drawings, or assist the contractor as much as possible.</td>
</tr>
<tr>
<td>- Architect is the lead designer, but coordination of services is passed to his M&amp;E consultant and the main-contractor.</td>
<td>- Both architect and engineers will provide coordinated design and solve coordination problems quickly.</td>
</tr>
<tr>
<td>- Site coordination by all sub-contractors but managed and prepared by the main-contractor.</td>
<td>- Similar but will be assisted by the M&amp;E consultant and all services contractors.</td>
</tr>
<tr>
<td>- Fosters confrontational attitudes and adversarial working relationships due to conflict of interest.</td>
<td>- This problem could possibly still occur, but may be diminished due to the main-contractor's own selected contractors.</td>
</tr>
<tr>
<td><strong>5. Risk</strong></td>
<td></td>
</tr>
<tr>
<td>- In the context of coordination of services, the risk is high as the client is responsible for design, and coordination is a design problem at large.</td>
<td>- The D&amp;B contractor takes all risks, but services contractors also take higher risk as the system requires the D&amp;B contractor to co-ordinate all designs, construction works and services installations.</td>
</tr>
</tbody>
</table>
Other case studies revealed that enhanced D&B could be used for other sophisticated buildings because of the creation of a fully integrated design and construction team having adequate resources and good project management for all design and construction.

8.13 Other cases studies

The author carried out many case studies (25 nos.) for this research in Hong Kong. All these cases provided sufficient data to test the propositions and the studies displayed:

- The traditional path has been used for many years. The performance of this procurement strategy was found to be acceptable even for many highly serviced hotel buildings. The main reason was teamworking based on ‘win-win’ business thinking rather than complete design.
- The use of principal services contractor is still not popular. This procurement strategy has been used for some very large building projects and Railway projects in Hong Kong. The performance of the management of building services was very satisfactory.
- The use of the joint-venture approach (with building work contractor and M&E services contractor) also proved to be a workable system. Again, this system is seldom used.
- The use of construction management system was a good procurement strategy for many complex buildings. From observations, the performance of the management of co-ordination of M&E services was very satisfactory. The outstanding performance is a result of good integration of contractors and the provision of very effective project management. The use of this procurement path is still low. As many clients realized the importance of good project management, many clients turned to the employment of a project management consultant. In many cases, this consultant would be expanded to a management team in charging all planning and management of the contraction and M&E services works with all contractors on site. The project performance was very good for many projects.

All details of these cases can be found in Table 8.1 and the Appendix Three.
8.14 Identification of key issues from the case studies

The objective of this research was to attempt to identify the impact of building procurement on the process co-ordination of building and whether traditional method would be workable or other methods could improve the project outcome.

Before examining the key issues concerning co-ordination of building services and building services procurement, it was helpful to reconcile the findings from all the cases carried out by the researcher. The important facts were:

1. Case study 1 (Traditional procurement)

Based on the evidence, the project was not successful (with late completion, claims and arbitration). Co-ordination of M&E services was badly treated and became an example of inadequate co-ordination in the local building industry.

Reasons:

- Inadequate client management with serious multi-headed client problems.
- Low quality of design drawing and inadequate integration and co-ordination during design stage.
- Unclear control documents concerning responsibilities for design and co-ordination.
- Inadequate project management by the main-contractor and the HVAC subcontractor. Both did not provide adequate management of co-ordination of building services.
- Poor working relationships between the design and construction teams.

Remarks: If the contractors had worked together with the design team right from the beginning of the co-ordination chaos, the co-ordination process would not have been so bad and the project result would have been a different one.
2. **Case study 2 (Traditional procurement)**

From the evidence obtained, this project was considered to be very successful by the client.

Co-ordination of M&E services was good.

**Reasons:**

- Better client management.
- Very clear contract documents regarding management of co-ordination for the design and construction teams.
- Good quality of design drawing and greater integration and co-ordination during design stage.
- Co-ordination details provided by the services consultant.
- Good project management by the design team.
- Involvement on site co-ordination by the services consultant.
- Adequate project management by all contractors.
- Good management of co-ordination of building services provided by all contractors and the main-contractor’s co-ordination team performed very satisfactorily.
- Good working relationship.

**Remarks:** Both technical and all managerial issues had all been planned and managed to achieve a successful project. But problems were still created by client design changes. The Japanese main-contractor provided good construction management (programming and planning and supervision).

3. **Case study 3 (Traditional procurement)**

Critical project performance factors were similar to case 2. Based on the analysis of all data and the evidence arrived produced, the co-ordination of building services was considered successful by the project team.
Remarks: Greater integration and co-ordination of M&E services had been provided for this high-rise hospital. The main-contractor was a Japanese contractor and provided good construction management.

There were still many design changes ordered by the client and these changes affected the overall construction.

4. Case study 4 (Traditional with domestic contractors)

This complex hospital was not so successful by the client. From the evidence, co-ordination of services was deemed to be barely satisfactory as the client’s services project manager expected to have better performance when compared with cases 2 and 3.

Reasons:

- Client design changes were not properly controlled by the design team.
- Design was incomplete, and services were still not fully integrated and coordinated. There were also flaws in the design of services.
- Inadequate project management by the contractor.
- Inadequate professional management of co-ordination of services by the main-contractor in the beginning of the project.
- A good working team did not exist in the main-contractor’s organization.
- The employment of in-experienced services contractors.

Remarks: The performance of this project would have been much improved if control of services contractors, management of co-ordination of services and more involvement of the design team on site activities were strengthened. Furthermore, co-ordination of services could also be further improved if the main-contractor had employed experienced services contractors with adequate resources and staffing levels. The building services coordination also spent too much time on too many (30,000) drawings which in fact created the problem of difficult management of 'too much' information. Time and efforts should
be well spent and just sufficient drawings would be all right when good control of installation was available.

5. Case study 5 (Traditional with project management)

This was an interesting project. The client knew its weakness and employed a project management consultant to look after this hospital project. Based on the author’s research results and the evidence, the project result was considered very good and the coordination of services was deemed to be very satisfactory.

The main reasons were:

- Good client management by the project management consultant.
- Comprehensive design information plus co-ordination details by the experienced services consultant.
- Clear contract documents in relation to management of building services installation and co-ordination.
- Good project management by the contractors and the project management consultant.
- Good management of building services installation by all contractors, and, in particular, the special services co-ordination team.
- Good working relationships between contractors and consultants.

Remarks: This was a typical case of business minded contractors working together. They certainly would do better with help from the building services co-ordination team.

The use of good professional procurement and project management for the traditional procurement route was seen to be a major determinant of project success. Other case studies also displayed the advantages of project management consultant. Project success was also enhanced by engendering a team spirit and a high degree of co-operation between project participants, based on shared goals. Both good nominated and domestic
contractors could be good partners in a construction team, but selection of right people was difficult.

6. Case study 6 (Develop and Construct)

Based on the available data and the evidence identified by the author, this was a very successful project but with higher tender price. Both construction and services installations were very satisfactory.

The main reasons were:

- Commitment of the client and the project team to a successful design/build route.
- Good client management and briefing.
- Full responsibility for design and construction firmly with one contractor.
- Good design with greater integration and co-ordination of M&E services with building.
- Involvement of the contractor in the design process.
- Comprehensive design and installation information and good management of building services installation.
- Good working relationships between client, consultants and contractors.

Data obtained from detailed evaluation of all the projects included for this research project give a better insight into all common building procurement methods and the management of co-ordination of building services in the real world.

The data confirm that:

- A significant proportion of the surveyed clients left the matter of the choice of the most appropriate procurement system until a stage in the building process when any possibility of making an appropriate decision has been removed. Hence, a substantial proportion of all clients were likely to be adopting an incorrect approach to the selection of procurement systems and that their satisfaction was thus very often misplaced.
The lack of a clear-cut decision making system means that the selection of building procurement is still based on managerial judgment which is a combination of subjective and objective decisions. The management of building services in a highly serviced building project is not often fully considered during the decision making process.

The choice of an appropriate procurement methodology emerges clearly from this research as a major determinant of project success. Success in managing building services installations does not imply an overall success. Those projects procured (case studies 2 to 4) using a traditional route all fail to achieve the client's objectives in terms of time or cost or both.

On the other hand project success is much improved on those projects employing either modified traditional procurement technique (case study 5) with additional project management or the D&B method (case study 6).

In principle, an effective management system for managing building services co-ordination can be used for different procurement methods. Case studies 2 to 6 all adopted the same co-ordination system (as developed by the Building Services Branch, Architectural Service Department). The only changes are leadership, resources, managerial techniques, team working and control of services contractors.

Tables 8.9, 8.10 and 8.11 give some detailed comparisons of the six case studies. The method is based on the principle of allocating a weighting factor (Franks, 1990) to each of the items or factors which are related to the performance of the co-ordination process and the effectiveness of a particular procurement method in relation to the management of building services.

The weighting factors (1 to 7) were initially determined by means of a method of scoring. These factors were further adjusted by referring to the opinions of the project participants in each of the six case studies. Although there are no mutually exclusive sets of criteria uniquely and completely determine the appropriate procurement methods for a specific project. This method is sufficiently sophisticated to enable a decision to be taken as to the most appropriate method of designing and constructing the project being examined.
Table 8.9: Adequacy of co-ordination of building services based on a scale of 1 (Lowest) to 7 (Highest)

<table>
<thead>
<tr>
<th>Item</th>
<th>Case Study No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1. Quality of design</td>
<td>4</td>
</tr>
<tr>
<td>2. Adequacy of consultant's co-ordination</td>
<td>3</td>
</tr>
<tr>
<td>3. Contract document</td>
<td>3</td>
</tr>
<tr>
<td>4. Site co-ordination details and management</td>
<td>4</td>
</tr>
<tr>
<td>Score</td>
<td>14</td>
</tr>
<tr>
<td>% of total score (28)</td>
<td>50</td>
</tr>
</tbody>
</table>

Case study 1 has the lowest score which explains why this project failed to achieve effective management of building services installation. Cases studies 2, 3 and 4 both have higher scores (over 70%) and give co-ordination of services. Cases studies 5 and 6 have much higher scores and higher performance in the co-ordination process.

Table 8.10: Performance of building services co-ordination process based on a scale of 1 (Lowest) to 7 (Highest).

<table>
<thead>
<tr>
<th>Item</th>
<th>Case Study No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1. Integration of services into building</td>
<td>4</td>
</tr>
<tr>
<td>2. Consultant's co-ordination</td>
<td>3</td>
</tr>
<tr>
<td>3. Control of design change</td>
<td>4</td>
</tr>
<tr>
<td>4. Main-contractor's co-ordination</td>
<td>3</td>
</tr>
<tr>
<td>5. Effectiveness of the main-contractor's co-ordination</td>
<td>3</td>
</tr>
<tr>
<td>6. Consultant's involvement</td>
<td>4</td>
</tr>
<tr>
<td>7. Building services progress performance</td>
<td>3</td>
</tr>
<tr>
<td>8. Building construction progress performance</td>
<td>3</td>
</tr>
<tr>
<td>9. Working relationships between project participant</td>
<td>3</td>
</tr>
<tr>
<td>Score</td>
<td>30</td>
</tr>
<tr>
<td>% of total score (63)</td>
<td>48</td>
</tr>
<tr>
<td>Ranking</td>
<td>6</td>
</tr>
</tbody>
</table>

It can be seen from Table 8.10 that case study 6 using a non-traditional procurement technique gives the highest performance. However, the results obtained from case studies 2 to 5 also reflect that reasonably good co-ordination can be obtained by using the traditional procurement route. Nevertheless, the traditional method must be used with
great care and effective management of building services design and co-ordination must be provided. Case study 5 also illuminates that higher performance can be attained by employing a separate project management consultant to improve the weakness of the traditional procurement system.

Table 8.11: Effectiveness of the procurement process based on a scale of 1 (Lowest) to 7 (Highest).

<table>
<thead>
<tr>
<th>Item</th>
<th>Case Study No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Client's management</td>
<td>4  6  6  6  6  7</td>
</tr>
<tr>
<td>2. Management of multi-headed client</td>
<td>3  5  5  5  6  7</td>
</tr>
<tr>
<td>3. Management of building services design</td>
<td>4  6  6  5  6  7</td>
</tr>
<tr>
<td>4. Management of building services co-ordination</td>
<td>4  6  6  5  6  7</td>
</tr>
<tr>
<td>5. Management of overall project</td>
<td>4  6  6  5  6  6</td>
</tr>
<tr>
<td>6. Team working</td>
<td>3  6  6  5  6  7</td>
</tr>
<tr>
<td>7. Contract time performance</td>
<td>4  5  5  5  6  7</td>
</tr>
<tr>
<td>8. Building services cost performance</td>
<td>4  6  5  5  6  7</td>
</tr>
<tr>
<td>9. Client's satisfaction</td>
<td>4  6  5  5  6  7</td>
</tr>
<tr>
<td>10. Building services contractor's satisfaction</td>
<td>4  6  6  5  6  6</td>
</tr>
<tr>
<td>11. Main-contractor's satisfaction</td>
<td>4  6  6  5  6  7</td>
</tr>
<tr>
<td>Score</td>
<td>42  64  62  56  66  74</td>
</tr>
<tr>
<td>% of total score (77)</td>
<td>54  83  81  73  86  96</td>
</tr>
<tr>
<td>Ranking</td>
<td>6  3  4  5  2  1</td>
</tr>
</tbody>
</table>

The results obtained from Table 8.11 for case studies 1 to 6 also confirm that the non-traditional method (case study 6) gives the best result. Cases 2, 3 and 5 adopting a traditional procurement have good results. Case study 1 gives the lowest score and mirrors serious co-ordination problems in this project whilst using the traditional procurement route. But case study 5 gives very good result when additional project management consultant is used to compensate the weakness of the traditional route.

The author also used the utility factor method (see Table 8.12) for Table 8.11. The method is based on the systems developed by Skitmore and Marsden (1988) and Bennett and Grice (1990). On the evidence of the trial data using all projects included for the case studies, the author's two research methods also give similar or intuitively satisfactory answers to those obtained by Bennett and Grice.
The 'utility factor' method is based on the fact that all of the listed criteria (or items) are not of equal importance to the client, but each procurement method may have a different degree of relevance to each item relative to the other procurement methods. Therefore, suitable 'client’s priority rating factor' (1 to 5/minimum to maximum) are necessary for this requirement in the light of the characteristics of both the client and the project. The total of all the priority ratings should be equal to 1. All of the priority ratings are then multiplied by each of the 'weighting factor' for the various procurement methods (or cases). The results for each procurement methods are then totalled and ranked on the basis that the most appropriate method has the highest total results.

This method is a useful objective aid to the selection of procurement method. However the highest rated procurement method may still be not the most appropriate method for a particular project with special requirements, and there is a need for caution even if the method is ranked first.

Table 8.12: Procurement – system selection

<table>
<thead>
<tr>
<th>Items</th>
<th>Client’s priority rating</th>
<th>Priority rating</th>
<th>Procurement system</th>
<th>Score</th>
<th>Utility factor</th>
<th>Score</th>
<th>Utility factor</th>
<th>Score</th>
<th>Utility factor</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Client’s management</td>
<td>2</td>
<td>0.046</td>
<td>Traditional</td>
<td>6</td>
<td>0.276</td>
<td>7</td>
<td>0.322</td>
<td>6</td>
<td>0.276</td>
<td></td>
</tr>
<tr>
<td>2. Management of multi-headed client</td>
<td>5</td>
<td>0.111</td>
<td>Traditional &amp; PM</td>
<td>5</td>
<td>0.555</td>
<td>7</td>
<td>0.777</td>
<td>6</td>
<td>0.666</td>
<td></td>
</tr>
<tr>
<td>3. Management of building services design</td>
<td>5</td>
<td>0.111</td>
<td>Develop and construct</td>
<td>6</td>
<td>0.666</td>
<td>6</td>
<td>0.666</td>
<td>6</td>
<td>0.666</td>
<td></td>
</tr>
<tr>
<td>4. Management of building services coordination</td>
<td>5</td>
<td>0.111</td>
<td></td>
<td>6</td>
<td>0.534</td>
<td>6</td>
<td>0.534</td>
<td>6</td>
<td>0.534</td>
<td></td>
</tr>
<tr>
<td>5. Management of overall project</td>
<td>4</td>
<td>0.089</td>
<td></td>
<td>6</td>
<td>0.555</td>
<td>7</td>
<td>0.777</td>
<td>6</td>
<td>0.666</td>
<td></td>
</tr>
<tr>
<td>6. Team working</td>
<td>3</td>
<td>0.067</td>
<td></td>
<td>6</td>
<td>0.402</td>
<td>7</td>
<td>0.469</td>
<td>6</td>
<td>0.402</td>
<td></td>
</tr>
<tr>
<td>7. Contract time performance</td>
<td>5</td>
<td>0.111</td>
<td></td>
<td>6</td>
<td>0.666</td>
<td>7</td>
<td>0.777</td>
<td>6</td>
<td>0.666</td>
<td></td>
</tr>
<tr>
<td>8. Building services cost performance</td>
<td>5</td>
<td>0.111</td>
<td></td>
<td>6</td>
<td>0.534</td>
<td>6</td>
<td>0.534</td>
<td>6</td>
<td>0.534</td>
<td></td>
</tr>
<tr>
<td>9. Client’s satisfaction</td>
<td>3</td>
<td>0.067</td>
<td></td>
<td>6</td>
<td>0.402</td>
<td>7</td>
<td>0.469</td>
<td>6</td>
<td>0.402</td>
<td></td>
</tr>
<tr>
<td>10. Building services contractor’s satisfaction</td>
<td>3</td>
<td>0.067</td>
<td></td>
<td>6</td>
<td>0.402</td>
<td>6</td>
<td>0.420</td>
<td>6</td>
<td>0.402</td>
<td></td>
</tr>
<tr>
<td>11. Main-contractor’s satisfactory</td>
<td>3</td>
<td>0.067</td>
<td></td>
<td>6</td>
<td>0.402</td>
<td>7</td>
<td>0.469</td>
<td>6</td>
<td>0.402</td>
<td></td>
</tr>
<tr>
<td>Total score</td>
<td>43</td>
<td>1.00</td>
<td></td>
<td>5.526</td>
<td></td>
<td>6.457</td>
<td></td>
<td>5.748</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rank order</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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It can be seen from Table 8.12 that the highest rated methods are the non-conventional procurement methods. Based on this disciplined and objective approach, it also appears that the traditional system is not a good choice. Nevertheless, it does not show the whole picture as the management of building services co-ordination can be implemented satisfactorily in all procurement methods. The only difference found between the various methods is the degree of teamworking, integration of project participants and to some extent, the management of the co-ordination process.

The selection of procurement methods in connection with building services co-ordination proposed by the author would provide a most accessible and useful guidance although the system is still heavily conditioned by the project participants (a must for the adviser as selection is based on both subjective and objective decision – makings and no straightforward solution is possible). The approach will reduce the number of possible alternatives to be considered.

8.15 Factors hindering team formation

It was important to understand the perceptions and attitudes of the project participants before attempting to re-engineer any team process. It was identified from the case studies that the success of the co-ordination process was directly related the formation of a good team. The author also obtained additional data from the project participants involved in the cases surveyed. The data was the provision of the opinions on a range of issues which were important to successful project team formation and working relationships within the team. Results between the groups of clients, consultants and contractors were compared and as shown below.

a) As perceived by clients

<table>
<thead>
<tr>
<th>Rank</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Communication shortcomings between members</td>
</tr>
<tr>
<td>2</td>
<td>Inadequate contract documentation/administration by all members</td>
</tr>
<tr>
<td>3</td>
<td>Unrealistic tender pricing and inappropriate contractor selection</td>
</tr>
<tr>
<td>4</td>
<td>Inadequate/incomplete design documentation and delayed design information or slow response by consultants</td>
</tr>
<tr>
<td>5</td>
<td>Inadequate project management and slow response by contractors plus unrealistic information expectations</td>
</tr>
<tr>
<td>6</td>
<td>Contract conditions</td>
</tr>
<tr>
<td>7</td>
<td>Industry culture</td>
</tr>
</tbody>
</table>
b) As perceived by consultants

<table>
<thead>
<tr>
<th>Rank</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Members operating on tight profit margins</td>
</tr>
<tr>
<td>2</td>
<td>Selection of a contractor who has tendered too low</td>
</tr>
<tr>
<td>3</td>
<td>Unrealistic time/cost/quality targets by contractors and clients</td>
</tr>
<tr>
<td>4</td>
<td>Adversarial industry culture and communication shortcomings between members</td>
</tr>
<tr>
<td>5</td>
<td>Lack of competence of project participants and lack of professionalism of project participants</td>
</tr>
<tr>
<td>6</td>
<td>Slow contractor response/action and interest on claim</td>
</tr>
<tr>
<td>7</td>
<td>Quality of design data and slow consultant response</td>
</tr>
<tr>
<td>8</td>
<td>Contractors low regard for design issues</td>
</tr>
</tbody>
</table>

The project team participants’ perceptions of factors which hindered team formation provided an insight into the basic question as to what could affect the formation of an effective team. These factors might be regarded as related to four broad issues, money/interest, performance and quality, communication and industry culture. These was considerable common ground in terms of what the project participants regarded to be major obstacles to team formation. Probably the most important of these were those associated with the money issue since profit level would affect the service which the team members could provide and therefore their ability and willingness to perform. This factor affected:

- Client’s contribution towards the resources needed for carrying out effective co-ordination by all members and the single-mindedness of clients towards a cost minimization is a significant cause triggering a chain reaction of the co-ordination process and this can create big problem.
- Completion of design and building services co-ordination work by all consultants.
• Management of co-ordination work by all contractors.

Performance issues were also perceived to be significant to team formation. The ability of the team to perform would depend on individual team members to perform to expectation. Problems such as incomplete design and inadequate co-ordination by the consultant, and the poor management of the co-ordination process were seen to be major problems. These would trigger variation claims and adversarial tensions within the project team.

Two other factors identified by all the project participants as being significant obstacles to team forming were communication shortcomings within the team and unrealistic deadlines set by the team members. Construction is an industry based on human activities and therefore people are needed. Project participants have to communicate in order to execute their work. Communication problems within the construction industry have long been identified. Good communication within the project team are an important ingredient of successful team performance and conversely, poor communication related problems generate and exacerbate many of the problems and conflicts with the team working such as:

• Effect of inferior quality of design information, contract documentation and requirements on the co-ordination of services process.
• Main-contractor's inadequate construction information and details can impede satisfactory co-ordination of building services tasks with the services contractors.
• Inadequate services contractor's information can hinder the progress of the construction process.

Communication problems often began at the start of a project and their effect on the team formation could no longer be underestimated.

The factor of unrealistic deadlines set by the team members must also be examined from the temporary nature of the building team which gives little incentive for the project participants to move too far from their organizational goals in favour of common project goals. The various project participants are fragmented in their objectives, procedures practices, methodologies and mechanisms, and each one would have their priorities
independently. Obviously, the promotion of self-interests and the lack of concern for other team member's activities are important contributors to team failings. As such, the construction industry continues to exhibit a strong adversarial culture with a track record of participant shaving a low regard for each other.

While the needs of the project participants may be independent, there is a high level of interdependency on each other for the co-ordination process to perform well. All participants who come from different organizations and who have strong commitments to the objectives of those organizations must be fully integrated to form an integrated collaborative team by means of:

- Appropriate procurement method to form a suitable organization for the project
- Team building mechanisms and strong project management
- Business-minded construction concept
- Application of TQM concept.

8.16 Factors affecting co-ordination of building services

Having studied all the 25 cases, this section identifies and describes some key issues which emerged from the case studies in conjunction with the two models:

The key issues affecting integration and co-ordination of building services are:

1. The client's management of:

   - Production of clear, comprehensive and coordinated briefing documents for ensuring a complete design and construction to be achieved by his consultants and contractors.
   - Co-ordination of end-user requirements (i.e. multi-headed client problem) through brief development and design.
   - Use of professional project management to manage design, construction and commissioning of a project.
   - Control of design changes during construction.
• Provision of clear and detailed contract documents which clearly define responsibilities for design and installation of building services for all designers and contractors.

• The use of suitable procurement methodologies for greater integration and co-ordination by the design and construction team.

• Co-ordination of services has a price but the award will outweigh the cost incurred.

Therefore, co-ordination performance is a function of client characteristic.

2. The design team's management of:

• Clear design brief and user requirements from the very beginning of a project.

• Provision of a fully integrated and coordinated building design.

• Provision of complete design information giving due consideration to the spaces required for proper installation of all services.

• Provision of adequately designed and coordinated M&E services layouts from design through construction is the first line of defence against poor co-ordination problems.

• Provision of properly integrated and coordinated building services at design stage by the whole design team based on a quality assurance system. This co-ordination should best be managed by an integrating unit or integrator.

• Time and resources required for preparing adequate coordinated information for the contractors.

• Communication with client and contractors.

• Formation of a good working team with high degree of co-operation. The 'Them and us' attitude should be eliminated and all contractors and design team members are equal in standing.

• The use of good professional procurement and project management in coordinating the efforts of large numbers of people on complex building projects.

• Under an ideal design procedure the consultant should commence the design and co-ordination of services with the specialist contractor (this is not however in practice).
As such, co-ordination performance is a function of the design team.

3. The contractor’s management of:

- Project planning and management of construction and building services.
- Time and resource for preparing and coordinated details for construction and installation of services.
- Co-ordination of building services with all contractors based on a good organized co-ordination management system and in accordance with the requirements pertaining to good co-ordination of services as laid down in the contract document.
- The use of an integrating unit or integrator with sufficient resources for managing service installation is the second line of defence against inadequate co-ordination.
- The use of good professional project management for the construction and building services installations.
- A team approach with a high degree of co-operation between project participants based on shared goals and have a vested interest in achieving them (e.g. chance of success).
- Involvement in design if possible with a particular procurement path, contractors and designers should work together to enhance quality of construction and services installation.

Hence, co-ordination performance is a function of the characteristics of the construction team.

It can also be deduced that:

- Co-ordination performance and project success is a function of the procurement method adopted.
- The contract procedure adopted based on the procurement method selected will also affect the performance of building services co-ordination.
The project characteristic has a direct bearing on the complexity for a building and will therefore affect the management of building services which can affect the performance of a project.

8.17 Procurement system, conflict, claims and dispute relating to the co-ordination process

Construction conflict was worth re-examining in the context of the procurement method since the temporary multi-organization was found to be a significant contributor to conflicts, claims disputes and unsatisfactory project performance by the author.

The centre of this research study is to examine the impact of building procurement method on the management of building services and vice versa. The study would not be completed without examining the co-ordination process in conjunction with the causes of conflict, claims and disputes on construction and the procurement method adopted for a project.

Analysis of claims data from several large hospitals (case 1 to 4) and other projects indicated a pattern of common claims as a result of inadequate co-ordination.

An opinion survey of a cross-section of clients, consultants and contractors in Hong Kong, as to the common causes of claims relating to co-ordination of services conducted by the author in 2003, also yielded similar significant factors such as:

a) As perceived by contractors

<table>
<thead>
<tr>
<th>Rank</th>
<th>Causes of claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inaccurate/delayed design information</td>
</tr>
<tr>
<td>2</td>
<td>Inadequate design/co-ordination</td>
</tr>
<tr>
<td>3</td>
<td>Slow consultant response</td>
</tr>
<tr>
<td>4</td>
<td>Ambiguities in contract documents</td>
</tr>
<tr>
<td>5</td>
<td>Variations due to client changes and design errors</td>
</tr>
<tr>
<td>6</td>
<td>Inadequate contract administration</td>
</tr>
</tbody>
</table>
7 Lack of professionalism of project participants
8 Other disruptions (by Employer or others)
9 Increased time and cost

b) As perceived by clients and consultants

<table>
<thead>
<tr>
<th>Rank</th>
<th>Causes of claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inadequate contract administration and management of co-ordination</td>
</tr>
<tr>
<td>2</td>
<td>Slow contractor response and suspension of work</td>
</tr>
<tr>
<td>3</td>
<td>Delay in completion</td>
</tr>
<tr>
<td>4</td>
<td>Inadequate resources and delayed construction/M&amp;E installation</td>
</tr>
<tr>
<td>5</td>
<td>Lack of competence of project participants</td>
</tr>
<tr>
<td>6</td>
<td>Unrealistic information expectations from contractors</td>
</tr>
<tr>
<td>7</td>
<td>Other disruption by contractors</td>
</tr>
</tbody>
</table>

Claims and disputes could be considered as a detrimental drain on project resources that should therefore be averted in full. Most significantly, they all affect project performance.

All the causes of claims were related to:

- The management of a building design by all designers
- The management of a building construction by all contractors
- Poor communication between project participants and a lack of team spirit among participants
- The method of construction project procurement as the method adopted sets the framework and the boundaries within which project members function

While the choice of procurement system could not be based merely on the potential to minimize unhealthy conflict and disputes. This can be incorporated as one of the criteria to be considered in selecting an appropriate choice and proper management of the project procurement system.
From the evidence in the author's study, most of the causes of conflict were found in all procurement methods. However, most of the causes of conflicts were found to be more common and more frequent in traditionally procured contracts. Because of the arrangement of the non-traditional procurement systems, unsurprisingly, fewer conflicts and disputes were found and this could be the result of the ingredients of better teamwork and project management found in this organization form. Apparently, it could be concluded that there should be a good correlation between the type of procurement system and the types and frequencies of conflicts which were related to the co-ordination process.

8.18 Selection of procurement method

As stated earlier, the issues that would determine the procurement path were not consistent, for it would appear that strong personal and or organizational preferences often override other factors. Indeed, the issue of management of co-ordination of building services was not the main one in many commercial building projects. However, from the author’s findings, this was not the case when procuring highly serviced hospitals and other complex buildings.

Nevertheless, certain issues emerged as important determinants of the procurement path chosen with due regard to attaining effective management of building services installation in the real world. The following list identifies these issues from the analysis of all the data (Cases studies and interview results). An attempt had also been made to prioritize their significance in the selection process.

- Supposed benefits of a particular procurement route, including certainty of cost, time and changing requirements.
- Project complexity.
- Level of risk.
- Client input into project development.
- Time available for development of the design.
- Organization of design team.
- Management of design and integration of M&E services, building and structure.
- Quality of tender information and tender documents in co-ordination of services.
- Choice of contractors.
- Organization of construction team – single point responsibility or individual specialists with or without additional project management function.
- Management of construction and services installation by the project participants.
- Working relationships between project participants.

Although the management of building services is an important part of a building contract, in practice, most of the surveyed clients put much emphasis on the following objectives:

- Lowest possible tender (95% of interviewees).
- Certainty of completion date (97%).
- Certainty of final cost (95%).
- Elimination of risk (90%).
- Elimination of contractual problems (95%).

This, of course, does not mean that the management of co-ordination of building services is not important. The procurement method selected for a particular project should attain a successful or at least a satisfactory project performance. This project outcome must also include satisfactory performance of building services design and installation and therefore, effective management of building services must also be taken into account during the selection of the most appropriate organization for the design and construction of the project.

One of the fundamental needs to ensure the successful delivery of a building project is the correct choice of procurement method for managing the relationships between the different organizations and specialists that will form the project team. To ensure that the client's needs are satisfied, it is necessary to evaluate the M&E services design and installation.

In practice, the process of selecting the most appropriate procurement method for the implementation of a highly serviced building project involves additional considerations such as:
Based on the research data, it has been identified by the author that for best management of co-ordination of building services, the procurement method should achieve greater integration and co-ordination between participants involved in complex construction projects in order to improve project performance.

While team building was the ideal way to achieve integration during construction, the pre-requisites (willingness to be a member of the temporary multi-organization (TMO), mutual trust and respect, common goals) were, in fact, not usually present in the real world. Integration of tasks and activities (as covered by the management system developed for managing co-ordination of services, i.e. building services co-ordination team, preparation of combined services drawings and builder’s work details for services installations, co-ordination on-site, planning, programmes and scheduling site meetings, control and monitoring of works, etc.) was seen as a more realistic goal rather than trying to build an ideal team which was usually easier said than done.

There was an inter-relationship between integration and co-ordination. Integration and co-ordination were different entities which should applied to the same dimension. Integration is concerned with establishing common objectives for the organization as a whole (i.e. at a strategic level) whilst co-ordination is concerned with the inputs of tasks and individuals.
The overall effectiveness of the co-ordination process therefore depends on the combination of the coordinated efforts of all services contractor and all are managed and integrated by the building services coordinator with the support from the design team.

Apart from team building, there were other important factors that should be considered:

- How to get the best contractors to complete the job?
- Could the contractors be appointed much earlier for preparing co-ordination details with the design team?
- How to ensure the provision of a flexible design which could accommodate changes (must satisfy client’s need)?
- How to ensure the provision would be fully integrated and coordinated? And could the quality assurance system be useful for checking design and co-ordination?
- Would the client consider the benefit of additional cost for preparing all coordinated design information and adequate combined services drawings and associated builder’s work details by the consultant?
- Should the M&E consultant and the architect be employed to carry on the co-ordination work with the contractors on site?
- Could the contractor work out the co-ordination details with the consultant after the tendering stage and before the construction stage?
- Could a main/Chief building services contractor (e.g. principal services contractor) be used to simplify all co-ordination works?
- Should domestic contractors be more helpful in coordinating M&E services?
- Could nominated services contractors work with the main-contractor under the management of a project management team in this flatter structured procurement? Would this reduce the levels of contractual hierarchy within the organization and give better project performance?
- Were the contractors fully aware of the management of co-ordination of services in their contract? Was the cost adequate?
- Was there any incentive to encourage contractors to do a good job? Liquidated damage was bad, should payment be related to progress of work?
It had been identified by the author that there would be more than one-way to achieve the requirements of the project, and also for co-ordination of building services. From the research data, the common procurement methods would address the co-ordination process to a different extent.

1. **Traditional path**

   - Design-led, facilitating high level of quality in design.
   - Good level of integration and co-ordination of services with experienced designers.
   - There was a break in the progress of the co-ordination process as contractor’s equipment and plant would be different from the designer’s basic design.
   - Problem with nomination construction.
   - Separation of design and construction, thus creating problems like responsibilities for design and co-ordination between designer and contractor.
   - Difficult integration of the construction team and therefore team working for co-ordination was not easy.
   - The method was unfortunately open to a level of abuse if any attempt was made to let the work before the design and co-ordination was complete.
   - Depending on the working of the construction team, the performance of management of building services could range between poor to good.

2. **Traditional path with domestic contractors**

   - Same as traditional path in general.
   - Design should be fully complete, otherwise, main-contractor would claim for any problems due to incomplete design and its ill effect on construction.
   - Greater integration of various contractors as the problem of differentiation was overcome by the use of domestic contractors. Therefore, co-ordination should be easier.
   - Single point of responsibility for the management of co-ordination of services.
   - In theory and practice, the performance in relation to management of building services should be higher than the traditional path as a result of improved
communication between the main-contractor and the domestic contractors, and better control of services contractors.

3. **Traditional path with additional project management consultant**

- Still based on the traditional path.
- Additional project management (PM) added improved design. But this team had to be of the highest quality.
- PM consultant to plan and manage the building construction works and services installation with all contractors.
- Co-ordination of services would be managed by a central body (PM consultant) together with all contractors and designers on site.
- The system would break down traditional adversarial barriers, thus, enhancing the co-ordination process.
- The performance of this system was much better than the traditional systems employing either nominated or domestic services contractors.

4. **Traditional path with principal services contractor, main-contractor and project management consultant.**

- Similar to the traditional path with additional project management consultant.
- The fundamental change was one big services organization to manage and co-ordinate all M&E services with the building works contractor, and both had to work with the PM consultant.
- Greater integration of various building services contractors under a large engineering contractor. Co-ordination of services was under one single organization first. The contractor had full contractual responsibility for co-ordination.
- The performance on management of co-ordination was very good for many large projects.

5. **Construction management (CM)**
The system demanded a good team of designers and contractors.

The use of good professional procurement and project management would be considered as a major determinant of project success.

M&E designs and co-ordination of services were as complete as possible, and contractors were also involved in the design stages to improve site work.

Greater integration of project participants under a dedicated management system by the CM would improve the co-ordination process.

The system had been used for some large and very complex fast track building projects in Hong Kong. The project performance was excellent.

6. Design and Build

- Single point responsibility for design and construction by one contractor. Greater integration of project participants and more effective working was found.
- Develop and Construction is a better choice since the client can still control the design and performances required. To be effective, the client’s requirements must be stated clearly and accurately and delivered on time.
- The D&B contractor is fully responsible for the design, co-ordination and installation of M&E services, and therefore, cannot claim for any co-ordination problems that he creates.
- Design changes are expensive.
- D&B is seen as a fast track strategy. The use of a separate team of consultant and a project manager is needed to monitor the contractor’s design and construction works.
- The performance of this system was very good. The client did not have to worry about the co-ordination problems any more, but had to pay a high price for the project.

There are many other factors that influence the selection of a procurement path for particular project. The case studies have shown no one procurement path would be the best in all circumstances. Any procurement path could be employed as long as the technical and managerial issues had been overcome, and together with the employment of
a team of good people who could all form a cohesive group in a temporary multi-
organization.

8.19 Summary

The use of questionnaires and interviews is useful but often do not produce good explanations and clear evidence. Case study can give deeper information and help the author to have a better understanding of the research subject. The research models were applied over 25 case studies to examine the evidence of the five propositions. The collection of survey data from diverse groups of people has been shown to be worthwhile and contributes much to the understanding of the facts and issues in relation to managing co-ordination of building services. Based on the author’s research data analysis presented, the propositions are also supported by the research findings (see Table 8.13 and 8.14 p. 337 – 338). More discussions will be given in Chapter 9.

A number of case studies illustrate the problems caused by inadequate co-ordination of the building services design and installation and the main architectural work. Similar problems have also been found in other countries (Pasquire, 1994, Price and Gibb, 1996). There is a need to take a fresh look at these problems which are neither wholly technical nor wholly managerial but a combination of both.

The methodology for the research was a case study format that enabled the problem experienced in each project to be reviewed based on a simple “pattern matching” logic. The sample based on the 25 cases provided sufficient data to analyze and test the propositions with confidence. This case study adopts a system approach by viewing the co-ordination process as a system consisting of three main technical, organizational and managerial subsystems (as detailed in models) which themselves are interrelated and subject to contractual constraints and procurement of building services work. The two research models had been proven to be a useful vehicle from which derived the data needed from the 25 projects.

The conclusions drawn from all case studies conducted by the author show that good co-ordination of building services is only attained when all project participants share the work needed for a successful project from design through construction.
The data obtained matched those gathered from the questionnaire surveys and interview results. The most important conclusions drawn were:

1. Co-ordination is a balanced and effective interaction of separation actions from a temporary team of specialists. An act of producing a complete and integrated solution of design of construction and of design and installation of mechanical and electrical services. The importance of good team functioning is fundamental to the success of the project construction process. Projects displaying high level of value and complexity require special attention to integration and co-ordination. The more complex the work, the more interdependent the task and the greater the rate of change, the greater the integration, co-ordination and control should be provided. The level of co-ordination is significant in terms of project performance. Good co-ordination is essential if construction conflicts are to be avoided.

2. Lack of co-ordination does have a definite and adverse effect on the construction process. The cost implications of co-ordination should be included in the various forms of contract and agreement for the design and construction teams.

3. Inherent design and co-ordination problems are concentrated in congest areas and combined service areas and where the services designed do not fit into the space/zones provided. The main causes of these problems were identified as incomplete design or inaccurate/inadequate design information; inadequate integration, interface and co-ordination of services and other elements in a building; project complexity; lack of experience of designers and contractors; inadequate funds and resources for carrying out co-ordination information by the design and construction teams; unclear definition of responsibilities for co-ordinating services; inadequate contract administration and site management; and ineffective communication between project participants and lack of teamwork.

4. It is vital that building services design and installation are adequately managed and co-ordinated from design through construction, and that if this is done, significant improvements in project performance will be realized. This important task should best be managed by a co-ordinator/integrator (or a central integrating unit) with sufficient resources as a single point of co-ordination responsibility for both the design and
installation phases of M&E services. Nevertheless, in addition to the use of the best integration mechanisms or devices, the importance of a good team functioning is fundamental to the success of the co-ordination process.

Also, the following requirements are essential if effective co-ordination is to be achieved:

- It is best executed over both design and construction by a single body.
- It must be planned, managed, monitored and controlled.
- It must start in the early stages of both the design and construction processes.
- It must have early exchange of relevant information.
- It must be continuous throughout the contract.
- It must be brought about by direct contact between all responsible/relevant people/parties.
- It must be integrated with those of the rest of the building team.

5. During the production stage of the building process, the co-ordination problems can be aggravated by the main-contractor and the nominated services sub-contractors. Therefore, co-ordination of services must rely on the resolution of both technical and managerial issues as depicted in the Building Services Co-ordination Model. The relationship between the co-ordination of M&E services contractors and the main-contractor within the building process must be appraised in terms of the technical, structural/organizational, managerial and contractual factors as shown in the Building Services Co-ordination Model. Promoting team formation and improvement team performance is of vital importance to the co-ordination process. However, improved teamwork is difficult to achieve and effective management of project coupled with adequate integration and co-ordination mechanisms must be provided to compensate this weakness.

6. The method of construction project procurement sets the framework and the boundaries within which project team members function. The development of project teams and the behaviour of the team participants is therefore very much a function of the procurement approach adopted. The form of a contract is a primary determinant of
how the project team will function and consequently have a bearing on the project’s success.

The development of alternative procurement methods to the traditional approach is responding to the need for better and more effective processes. The responses to these alternatives also give an indication to the complex and difficult problems associated with teamwork, adversarial relationships between the project team members and the compartmentalization of the design team and the construction team.

The traditional method of procurement will still continue to be preferred procurement method although this system produces an adversarial climate for project team members. The use of traditional and non-traditional procurement paths give satisfactory project results but to differing degrees. Non-conventional methods, however, appear to give better results. Where the contractor is able to provide a link between design and construction through early appointment, the project performance can be further enhanced. Nonetheless, both procurement approaches must be supported by the use of good professional procurement and project management as this study found that the essential element which brought about success was the level of managerial control. A high level of managerial control designed for the co-ordination process performed much better and gave a higher level of performance of the building services co-ordination.

From the evidence in the author’s study, unsurprisingly, neither the traditional method nor the non-traditional contracting is the solution to all of the problems facing the co-ordination process. Not least to mention, in addition to an integrated collaborative design in which the building services are fully co-ordinated, a good working team of designers and contractors employing short-term or long-term partnering arrangements and based on mutual trust and business minded approaches must exist. Team building as a continuous exercise, lasting for the duration of the project. All appropriate opportunities for team building should be exploited for the good of the project. This is far more important than just relying on the provision of detailed contract procedures and strict control of people or organizations. Furthermore, a continued commitment by all project participants to do a good job is vital to project success.
7. Adequate contract documentation relating to the execution of the co-ordination process and better links between the design and construction teams should be provided to facilitate the co-ordination process. Co-ordination problems could be aggravated by the number of parties being co-ordinated. A large number of nominated services contractors should be replaced by fewer contractors (M&E only).

8. Greater use of both principal building services contractor managing the M&E services and a dedicated project management team should be considered on major projects.

9. All parties to a project should follow a process of continuous quality improvement with an enhanced customer – focus for each participant.

10. Accepting the lowest price bid does not always provide value for money and more consideration needs to be given to the quality of the building team. Co-ordination of services is a very expensive task. Improvements will not be achieved unless the needs of the individual participants (e.g. M&E consultant and contractors) can be met in terms of reasonable profit margins and realistic time frames for each participant to do a good job. Hence, the client’s focus on the lowest tender as an approach for selecting consultants and contractors should be changed.

11. Success in building services co-ordination does not necessarily imply that a building project is wholly satisfactory as there are other factors which can influence the project outcome. However, improved building services design co-ordination should reduce cost, time and abortive work and significant improvements in the project performance will be realised.

12. Appropriate working environment and proper attitude of the personnel within the co-ordination process should give more effective co-ordination.

The data gathered should support the five propositions and the next two chapter give the author’s comments on the propositions; personal recommendations as to what should be done and should not be done; limitations of the research and further research needed.
<table>
<thead>
<tr>
<th>Case No. abbreviation</th>
<th>Type of building</th>
<th>Degree of complexity</th>
<th>Procurement method</th>
<th>Performance of building services coordination</th>
<th>Adequacy of co-ordination</th>
<th>Factors affecting project performance</th>
<th>Client/designer satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Management of design &amp; construction</td>
<td>Teamwork</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adequate</td>
<td>Inadequate</td>
</tr>
<tr>
<td>1. (SHT)</td>
<td>Hospital</td>
<td>Very</td>
<td>T &amp; NSC</td>
<td>Poor</td>
<td>Inadequate</td>
<td>-</td>
<td>v, poor</td>
</tr>
<tr>
<td>2. (TMH)</td>
<td>Hospital</td>
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<td>T &amp; NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>3. (QMII)</td>
<td>Hospital</td>
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<td>T &amp; NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v</td>
<td>-</td>
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<tr>
<td>4. (EDH)</td>
<td>Hospital</td>
<td>Very</td>
<td>T &amp; NSC</td>
<td>Fair</td>
<td>Inadequate</td>
<td>v, fair</td>
<td>-</td>
</tr>
<tr>
<td>5. (CPH)</td>
<td>Hospital</td>
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<td>T &amp; DSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v</td>
<td>-</td>
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<tr>
<td>6. (HOHI)</td>
<td>Hospital</td>
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<td>T &amp; DSC</td>
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<td>Adequate</td>
<td>v</td>
<td>-</td>
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<td>7. (HCD)</td>
<td>Hotel</td>
<td>Complex</td>
<td>T &amp; PSC</td>
<td>Very good</td>
<td>Good</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>8. (SH)</td>
<td>Hotel</td>
<td>Complex</td>
<td>T &amp; PM + PSC</td>
<td>Very good</td>
<td>Good</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>9. (UCH)</td>
<td>Hospital</td>
<td>Very</td>
<td>D &amp; B</td>
<td>Very good</td>
<td>Good</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>10. (NDD)</td>
<td>Hospital</td>
<td>Complex</td>
<td>D &amp; B</td>
<td>Good</td>
<td>Adequate</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>11. (TKOH)</td>
<td>Hospital</td>
<td>Very</td>
<td>D &amp; B</td>
<td>Good</td>
<td>Good</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>12. (CEC)</td>
<td>Exhibition centre</td>
<td>Very</td>
<td>D &amp; B</td>
<td>Very good</td>
<td>Adequate</td>
<td>v, very good</td>
<td>v</td>
</tr>
<tr>
<td>13. (CP)</td>
<td>High-rise office</td>
<td>Normal</td>
<td>JV</td>
<td>Good</td>
<td>Good</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>14. (BOC)</td>
<td>High-rise office</td>
<td>Normal</td>
<td>T &amp; PM + NSC</td>
<td>Very good</td>
<td>Good</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>15. (HKB)</td>
<td>High-rise office</td>
<td>Complex</td>
<td>T &amp; PM + WPC</td>
<td>Very good</td>
<td>Good</td>
<td>v</td>
<td>-</td>
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<tr>
<td>16. (KCRG)</td>
<td>Railway station</td>
<td>Very</td>
<td>T &amp; PM + WPC</td>
<td>Good</td>
<td>Adequate</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>17. (TSKH)</td>
<td>Hospital</td>
<td>Complex</td>
<td>T &amp; NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>18. (POH)</td>
<td>Hospital</td>
<td>Normal</td>
<td>T &amp; NSC</td>
<td>Poor</td>
<td>Inadequate</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>19. (JH)</td>
<td>Hotel</td>
<td>Complex</td>
<td>T &amp; NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>20. (JH)</td>
<td>Hotel</td>
<td>Very</td>
<td>T &amp; NSC/NSC/DSC</td>
<td>Very good</td>
<td>Good</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>21. (MTRC)</td>
<td>Underground station</td>
<td>Normal</td>
<td>T &amp; NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v</td>
<td>-</td>
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<tr>
<td>22. (HKEC)</td>
<td>Office</td>
<td>Normal</td>
<td>T &amp; DSC</td>
<td>Very good</td>
<td>Good</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>23. (CH)</td>
<td>Hospital</td>
<td>Complex</td>
<td>T &amp; NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>24. (LTCI)</td>
<td>Hospital</td>
<td>Complex</td>
<td>T &amp; DSC</td>
<td>Very good</td>
<td>Good</td>
<td>v</td>
<td>-</td>
</tr>
<tr>
<td>25. (SESH)</td>
<td>Hospital</td>
<td>Complex</td>
<td>D &amp; B</td>
<td>Very good</td>
<td>Good</td>
<td>v</td>
<td>-</td>
</tr>
</tbody>
</table>

Legend:

T = Traditional
NSC = Nominated Sub-contractor
DSC = Domestic Sub-contractor
PM = Project Management
PSC = Principal Services Contractor
D&B = Design & Build
JV = Joint Venture
WPC = Work Package Contractor

N.B. Case no. 1 – 16 are included in the Appendix. Case 17 – 25 were used as references to substantiate the evidence found in cases 1 – 16.
### Table 8.14: Comparison of the six cases

<table>
<thead>
<tr>
<th>Hospital Project</th>
<th>No. 1 (STH)</th>
<th>No. 2 (TMH)</th>
<th>No. 3 (QMH)</th>
<th>No. 4 (EDH)</th>
<th>No. 5 (UCH)</th>
<th>No. 6 (NDIH)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Client</strong></td>
<td>Hospital Authority</td>
<td>Hospital Authority</td>
<td>Hospital Authority</td>
<td>Hospital Authority</td>
<td>Hospital Authority</td>
<td>Hospital Authority</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td>Complex</td>
<td>Complex</td>
<td>Complex</td>
<td>Complex</td>
<td>Complex</td>
<td>Develop and construct by single contractor</td>
</tr>
<tr>
<td><strong>Procurement Method</strong></td>
<td>Traditional NSC</td>
<td>Traditional NSC</td>
<td>Traditional NSC</td>
<td>Traditional but all DSC</td>
<td>Traditional plus Project Management</td>
<td>Good designers</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>Experienced Master Consultant</td>
<td>Experienced health planner with M&amp;E consultant</td>
<td>Experienced health planner with M&amp;E consultant</td>
<td>Experienced overseas designers and local large M&amp;E consultant</td>
<td>Local designer with experienced M&amp;E consultant</td>
<td>Good designers</td>
</tr>
<tr>
<td><strong>Coordination of services in design</strong></td>
<td>Limited coordination</td>
<td>Proper coordination provided, but not full</td>
<td>Fully coordinated with more details</td>
<td>Not full coordination</td>
<td>Proper coordination provided, but not full</td>
<td>Adequate coordination details</td>
</tr>
<tr>
<td><strong>Details of contractor</strong></td>
<td>Main-contractor without experience in hospital project, poor site management with experienced services contractor</td>
<td>Japanese main-contractor with good services contractors</td>
<td>Japanese main-contractor and very cooperative services contractors</td>
<td>Large overseas main-contractor and new services contractors</td>
<td>Good PM with cooperative main-contractor and services contractors</td>
<td>Experienced contractors having its own building services division outsourcing</td>
</tr>
<tr>
<td><strong>Pre-construction work</strong></td>
<td>Required coordination drawings are missing</td>
<td>Satisfactory preparation of coordination drawings by main-contractor</td>
<td>Satisfactory coordination drawing are prepared by main-contractor</td>
<td>Coordination drawings are prepared by main-contractor but not adequate</td>
<td>Good management of coordination drawings by PM &amp; main-contractor</td>
<td>Coordination drawings are prepared by D&amp;B contractor and consultant</td>
</tr>
<tr>
<td><strong>Site coordination</strong></td>
<td>Poor, due to unclear contract conditions, poor site management</td>
<td>Good work due to clear contract and effective site management</td>
<td>Good, due to clear contract conditions &amp; effective site management</td>
<td>High level of site management but with poor control of services contractor</td>
<td>Good site management with additional PM</td>
<td>Good site management, effect cooperation due to single point responsibility</td>
</tr>
<tr>
<td><strong>Claim</strong></td>
<td>Major</td>
<td>Minor</td>
<td>Minor</td>
<td>Major</td>
<td>Nil</td>
<td>Not known</td>
</tr>
<tr>
<td><strong>Status of the project</strong></td>
<td>Fail</td>
<td>Success</td>
<td>Success</td>
<td>Satisfactory</td>
<td>Success</td>
<td>Success</td>
</tr>
<tr>
<td><strong>Consideration of coordination of services</strong></td>
<td>Yes, but inadequately managed</td>
<td>Yes, adequate and well organized</td>
<td>Yes, adequate but not well organized</td>
<td>Yes, adequate but not well organized</td>
<td>Yes, well organized</td>
<td>Yes, well organized</td>
</tr>
<tr>
<td><strong>Effective site coordination</strong></td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Site management</strong></td>
<td>Loose and poor</td>
<td>Good</td>
<td>Stringent but effective</td>
<td>Good and systematic</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Control of services contractor</strong></td>
<td>Poor and not organized</td>
<td>Good</td>
<td>Very good, well organized</td>
<td>Fair</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td><strong>Team working</strong></td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Working relationship</strong></td>
<td>Adversarial</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Contract terms regarding coordination</strong></td>
<td>Unclear</td>
<td>Clear</td>
<td>Clear</td>
<td>Clear</td>
<td>Clear</td>
<td>Clear</td>
</tr>
<tr>
<td><strong>Attitude of contractor</strong></td>
<td>Negative</td>
<td>Positive (For reputation and business)</td>
<td>Positive (For reputation and business)</td>
<td>Positive (For entry into Asian market and reputation)</td>
<td>Positive (For business and reputation)</td>
<td>Positive (For D&amp;B company’s business strategy)</td>
</tr>
<tr>
<td><strong>Client’s changes during installations</strong></td>
<td>Too many</td>
<td>Still many</td>
<td>Many</td>
<td>Too many</td>
<td>Controlled</td>
<td>Some but finally controlled</td>
</tr>
</tbody>
</table>

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CHAPTER NINE

FINDINGS AND CONCLUSIONS

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<td>9.2</td>
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CHAPTER NINE: FINDINGS AND CONCLUSIONS

9.1 Introduction

This chapter discusses the overall findings of the research investigation.

Examination of the management of building services co-ordination and the impact of the procurement method on the co-ordination process has been the subject of this research.

The majority of the problems encountered on many complex and highly serviced facilities are due to incomplete or inadequately integrated and coordinated design by the design team, and inadequate management of the building construction and installation of building services by the construction team. Commonly, such problems involve building services and result in highly detrimental effects on quality of building and building services, construction time and final project cost of many building projects. Clearly, the construction industry is still not doing the best for its clients.

The construction industry must serve its clients to the best of its ability. The organization of the building team and the way the team works through the building process is a central element of this service. It is essential that the design and installation of building services is carried out as effectively and efficiently as possible, including sufficient provision for later incorporation of improved, upgraded and new service elements. Hence, the design and installation of building services needs to be effectively co-ordinated and controlled and all construction professionals engaged in these tasks need to collaborate in achieving the same goal – successful project.

Concern of improvement in the management of building services has resulted in a series of thorough reviews of the current practices of the construction industry by the author. These reviews have identified potential areas for change (e.g. organization of the design of M&E services, quality of design, contract documents, management of M&E services by the building team and the selection of procurement method) in each of the temporary multi-organizations formed by many heterogeneous groups of professionals and specialists who combine together to fulfill the necessary design and construction functions comprising the building process.
Given the increasing significance of the building services element in a modern building (up to 50% of the construction cost of highly serviced hospitals and over 50% of the occupation costs), it is imperative that special attention is given to building services to ensure optimal project performance through design and its realization. This research pursues this point and aims to clarify whether the means of building procurement method influence building co-ordination performance while recognizing that the characteristics of the client, the design team, the construction team and the project can play a significant role in shaping success.

At the centre of the building services co-ordination process is the building team which supplies all design, managerial, and installation/construction skills necessary to realize a building project. The objectives of this research are, therefore, to examine:

- The management of building services co-ordination from the design to construction stages under different procurement methods by the building team.
- The working of the building team for the design and installation of M&E services.
- The various forms (i.e. procurement methods) in which it may be organized.
- The linkages or relationships between the performance of building services co-ordination and the procurement method adopted for a particular project.
- The performance of building services co-ordination under both traditional and non-traditional procurement methods and to find out whether in certain circumstances a particular procurement method will be more appropriate and achieve a higher level of project success.
- Whether a particular procurement method chosen for a project is a major determinant of the project performance in terms of efficient management of building services co-ordination.

Previous research by others on the management and procurement of building services works had been scarce and largely fragmented and also not based on Hong Kong construction industry. Though it had examined certain areas, it had not examined the co-ordination problem as a whole. This research was an attempt to fill the gap in the study of the processes of building services co-ordination and its procurement. This research adopted the holistic approach, seeking to examine the building services co-ordination...
process in Hong Kong, and to determine appropriate mechanisms for improvement to promote problem avoidance and, hence, increased efficiency and effectiveness of the management of building services co-ordination and procurement of building services work.

In view of the importance of building services co-ordination in the building process, this research was aimed at determining the different effects of both traditional procurement method and the commonly used non-traditional methods on the performance of the management of building services design and co-ordination for projects that were large, complex and highly serviced.

The area of research is complex as it embraces many intricate variables, but this thesis has developed a methodology which is a multi-method (triangulation) approach designed principally to add to the strength of the evidence and may be replicated by others.

This research explored the inherent problems of poor co-ordination of building services in the design and construction stages and the variations in the organization of a building team when undertaking a building project. It then examined those variables in the building process which could influence the performance of the building team and the outcome of the building services co-ordination and installation. Based on intensive literature search and in-depth interview data, two models had been developed to analyse the co-ordination process and to assist in the selection of an appropriate procurement method for a particular building project.

The results of additional in-depth interviews and case studies were then analysed to explore the relationships given in the models. The propositions had also been examined, tested and discussed.

9.2 Research findings and appraisal of the five propositions

The questionnaire/interview surveys and the 25 cases conducted by the author provided a means of deepening understanding of the management of co-ordination of building services processes and the following important points were identified:
The co-ordination problems caused by the design and construction teams.

The need for management of the design process by the design team with due regard to the integration and co-ordination of building services.

Clear responsibilities for carrying out co-ordination of building services during the design and construction stages by the project participants.

Better contract issues in relation to building services co-ordination.

The use of both traditional and non-traditional procurement methods and their effects on the management of building services co-ordination in Hong Kong. Both will give satisfactory as well as unsatisfactory project performance.

Construction and building services contractors' working practices.

Improvement in the co-ordination process with higher managerial controls.

Difficult teambuilding to be tackled by better teamwork based on practical integration/co-ordination mechanisms.

To facilitate easy appraisal, the author also combined and linked all results obtained from all sources (literature / reports / people, questionnaires / interviews and all case studies) which are shown in Table 9.1.

Based on the evidence in the author's study, all the aforementioned points were further discussed in conjunction with the five propositions:

- **Proposition 1** – Co-ordination of building services will be influenced by the management of the design process.

- **Proposition 2** – Co-ordination of building services will be influenced by the management of building construction and building services installation.

- **Proposition 3** – Co-ordination of building services is not only a technical issue but also an exercise in management and both will be influenced by the contract procedure and the working practices of the project participants of a project.

- **Proposition 4** – Co-ordination of services will be influenced by the procurement method adopted for a project.

- **Proposition 5** – Project success will be influenced by effective building services co-ordination and the use of an appropriate procurement method.
<table>
<thead>
<tr>
<th>Evidence</th>
<th>1. Literature, reports &amp; key persons in the industry in Hong Kong</th>
<th>2. Questionnaire &amp; interview</th>
<th>3. 25 case studies</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>In Chapter 5, 7 and 8, Kwok, Phillips, Banham and many practitioners and publications in UK</td>
<td>In Chapter 7</td>
<td>In Chapter 8</td>
<td>(1), (2) and (3) must combined together to draw a conclusion.</td>
</tr>
<tr>
<td>Influence on co-ordination by client</td>
<td>Yes, important</td>
<td>Yes, importance given by correspondents</td>
<td>Yes, important but this problem can be solved by giving more advice to client by the design team</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Briefing can affect design information</td>
<td>Good brief can avoid problems, designers should manage this</td>
<td></td>
<td>Combining (1), (2) and (3) shows that client does not directly involve in the co-ordination process but must manage the project well as factors listed can affect the design and construction teams.</td>
</tr>
<tr>
<td></td>
<td>Design changes can affect completed design and complicate co-ordination</td>
<td>Changes are norm and have significant effect, must be managed by client</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inadequate resources allowed for co-ordination can be a big problem</td>
<td>Fees for designer and contractor to do co-ordination</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unrealistic programs and targets</td>
<td>Targets must not hinder progress of design and construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Influence on co-ordination by designer</td>
<td>Yes, important</td>
<td>Yes, very important</td>
<td>Yes, extremely important</td>
<td>Combining (1), (2) and (3) shows that design is the most important factor and design co-ordination will be shared between designers and contractors</td>
</tr>
<tr>
<td></td>
<td>Completeness of design is the key factor</td>
<td>Complete design and good design co-ordination will avoid many problems</td>
<td>Design will never be complete</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inadequate integration and co-ordination will create site problems</td>
<td>Design co-ordination will have to be carried out by contractors</td>
<td>Spaces must not tight for services</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor communication with project member</td>
<td>Consultant should provide sufficient site management</td>
<td>Good site management is very important, will solve problems quickly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inadequate site management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Influence on co-ordination by all contractors</td>
<td>Yes, very important for the 2-stage of the co-ordination process</td>
<td>Yes, important</td>
<td>Yes, important</td>
<td>Combining (1), (2) and (3) shows that contractors have to work together to manage the complex co-ordination process. Team work is essential for satisfactory co-ordination.</td>
</tr>
<tr>
<td></td>
<td>Good teamwork and working relationship</td>
<td>To start with consultant's design must be right</td>
<td>Good construction team can do a good job even co-ordination details are not provided</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adequate preparation of co-ordination details</td>
<td>Sufficient time and resources are required for all relevant parties to do the co-ordination work as a team</td>
<td>In most project, good team building is difficult but good management of co-ordination must be provided by all contractors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sufficient planning management and site control</td>
<td>Good site management</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effective communication</td>
<td>Effective communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Influence on project characteristics</td>
<td>Yes, important especially for large, complex and highly serviced building</td>
<td>Yes, but good design and effective management can improve project performance.</td>
<td>Complex projects do have more problems especially when design is complex, spaces are tight and poor site management of co-ordination</td>
<td>All (1), (2) and (3) indicate the effect of complexity on building services co-ordination. Simple building with simple designs do have fewer problems.</td>
</tr>
<tr>
<td>Influence on procurement form</td>
<td>Can have an effect but no 'Best Buy' procurement and less attention given to building services procurement</td>
<td>Some effect especially the formation of a building team to work together is affected by the organizational form used.</td>
<td>Yes, with moderate effect on project results, all methods can be used for co-ordination but integrated procurement has less problems.</td>
<td>All (1), (2) ad (3) indicate that procurement method will have an effect on the complex co-ordination process, but all procurement methods can be used.</td>
</tr>
</tbody>
</table>

Table 9.1: Summary of information obtained from literature, questionnaires and case studies
9.2.1 Proposition 1 – Co-ordination of building services is primarily influenced by the management of design

The case studies provide ample confirmation for the earlier studies discussed in this research study and there is sufficient evidence to support this first proposition. The main findings of this research study are:

1. General summary of the management of design

<table>
<thead>
<tr>
<th>Findings</th>
<th>Conclusions</th>
<th>Evidence</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management of design</td>
<td>Is a function of design and construction team,</td>
<td>Chapter 7 &amp; 8 and other</td>
<td>Complex technical and management issues, all can</td>
</tr>
<tr>
<td></td>
<td>project complexity and client's needs and</td>
<td>references</td>
<td>affect the final outcome of a project.</td>
</tr>
<tr>
<td></td>
<td>organizational form</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Influenced by the management of</td>
<td>Can shape project performance</td>
<td>Ditto</td>
<td>Complete design to be provided</td>
</tr>
<tr>
<td>design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem from designer</td>
<td>Incomplete design and co-ordination</td>
<td>Ditto</td>
<td>Contractors to management development of design</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and co-ordination</td>
</tr>
<tr>
<td>Problem from contractor</td>
<td>Incomplete co-ordination details</td>
<td>Ditto</td>
<td></td>
</tr>
<tr>
<td>Effects from other variables</td>
<td>Project characteristics</td>
<td></td>
<td>More effort for large and complex project</td>
</tr>
<tr>
<td></td>
<td>Procurement path adopted</td>
<td></td>
<td>Right organization based on integrated</td>
</tr>
<tr>
<td></td>
<td>Contractual issues and</td>
<td></td>
<td>collaborative team approach</td>
</tr>
<tr>
<td></td>
<td>professional working practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Co-ordinated design is a pre-requisite for project success. In theory as well as in practice, a complete design of building services should eliminate most of the co-ordination problems. Firstly, services should be fully integrated, coordinated and interfaced. Secondly, adequate spaces should be allowed for all M&E services. Most significantly, the spaces must also be verified by the design team for proper installation of services. The research results show that a design completed before tender is preferential in theory, in reality no design is ‘complete’. Quite often, inadequate spaces for services installation, poor integration of services and building fabrics, design faults, accidental omissions of details, conflicts between drawings and documents are repeatedly found in many projects. Furthermore, the essential combined services drawings including associated builder’s works are not normally
provided by many M&E consultants as a result of the normal consultant fee agreement. The complexity of a project also adds more difficulties in the design and co-ordination process. Nevertheless, proper design is the first line against the co-ordination problem.

Design details, according to the projects surveyed, are drawn in isolation with little thought given to the incorporation of all M&E services into the construction process. In many cases, adequate consideration is not given to the practicality of installation detail and the effect it may have on the complex co-ordination process cannot be underestimated. Quite often, most designs are still not flexible enough to facilitate easy installation and co-ordination in many highly serviced projects.

The research results reinforce the fact that inadequate designs and over-complex designs often affect construction time and make co-ordination of building services difficult. Therefore, quality of designer is very important. Clearly, a higher degree of designers’ experience (also for contractors) will achieve better designs, integration and co-ordination of services. Hence, project performance is a function of the design organizations.

3. The research findings show that the design process has a significant impact on the subsequent co-ordination and installation of services. With traditional procurement approach the specialist services contractor has no major influence at the design stage because the system prevents this involvement. From the case study results, early involvement of contractors in the design process (e.g. Principal Services Contractor and D&B) will often give fewer co-ordination problems and smoother installation of services. However, it does not mean that the traditional contracting cannot give good co-ordination especially with 2-stage traditional system.

4. The research results also confirm that incomplete design and inadequate coordinated design information are the mostly cited factors in delaying construction and causing productivity to fall. For example, in traditional contracting, detailed M&E design work is devolved to services sub-contractors by the consultant. But there is a hiatus (i.e. a break in the flow of detailed services information) in the design process. Because the final selection of plant and equipment is left to be carried out by the
services contractors. This break occurs at the tender stage when other members of the project team are settling final arrangement details. It is therefore not compatible with the objectives of co-ordination as building services information is out-of-step with the rest of the project. Clearly, this makes effective and timely co-ordination difficult to achieve.

5. The survey results have also revealed that useful feedback of co-ordination problems and solutions to the design team for improvement of design is rare. If the information can be given to the designers, there will be significant improvement in design and co-ordination.

6. Most architects and building services engineers are fully aware of the effects of their designs on the co-ordination of services. However, the involvement of the structural consultant in the integration and co-ordination process is still considered inadequate. Quite often, there are serious conflicts between the M&E services and the structural element in many projects.

7. This research identified that the development of the consultant's design into working details for smooth installation by each services contractor has a direct bearing on the co-ordination process. In fact, it is the second line of defence against the co-ordination problem. Failure to complete this task will certainly lead to poor project performance. The quality of this detailed design and the working drawings produced will dictate the performance of the co-ordination process and the smoothness of the installation of services. Effective communications amongst relevant contractors on site can also solve many co-ordination problems. Clearly, failure in managing this second-stage co-ordination by the contractors can affect the outcome of a project.

8. As observed from the 25 cases, effective co-ordination will lead to better project performance. However, the following points as identified from the research results are common to most projects and will improve the problematic co-ordination process:

- Clients must accept responsibilities for managing design and construction.
• Design must be as complete as possible. Timing of the design of building services is critical. In common practice, the design of M&E services occurs in the later stage of the design phase, services are required to be fitted into the spaces allocated which is often a difficult task. This is indeed an inappropriate design development. To improve a design, the M&E services consultant should not lag behind the completion of the architect’s preliminary design. Both project designers should work together to achieve the most optimum integration and co-ordination of building services. In particular, the M&E consultant can give:

- Preliminary segregation of services by zoning (spaces for layers of services) to achieve effective spatial co-ordination.
- Optimum locations of plant.
- Innovative arrangements of M&E services.
- Simplification of distribution of services.

• Adequate co-ordination details should firstly be provided by the M&E consultant. For effective co-ordination, the consultant should also carry out the co-ordination work with all the services contractors. The client must understand the benefit of this additional work and meet the additional costs incurred.

• Design should not be separated from the construction process and all consultants should take this point into consideration in order to reduce problems on site.

• Designs will still be innovative. The important ingredients such as standardization, simplification and practicability must be incorporated by all designers. This can improve design integration and reduce difficulty during the physical installation of the services.

• Contractor’s specialist knowhow and practical experience should be fully utilized to improve the design and co-ordination processes.

• Feedback from previous projects is valuable. Design should eliminate all possible co-ordination problems learnt from previous projects.

• All contractors must accept the fact that adequate working drawings and details and combined services drawings are essential for a smooth installation.

• All parties to a project should follow a process of continuous quality improvement, with an enhanced customer-focus for each project participant.
• Higher managerial controls of the design and construction processes.

The main conclusion to be drawn from this research is that the performance of co-ordination of building services is dependent on the design of M&E services. It is vital that building services design is adequately designed and co-ordinated from design through construction. Adequate design with sufficient co-ordinated information can reduce many avoidable co-ordination problems, and significant improvements in project performance will be realized. To certain extent, the design process can also be affected by the procurement method selected for a particular project. In general, non-traditional systems with early involvement of services contractors, better team work and with the use of effective project management can lead to better design and more effective co-ordination of the M&E services. However, the research results show that there is no major difference in the management of building services design and co-ordination between the traditional contracting and the non-traditional procurement systems. The only difference is that complete design and co-ordination will be carried out by a design team and by the contractors during the construction stage in traditional contracting. Whilst a D&B contractor has a cohesive design and construction team which is fully responsible for both design and construction.

Based on the evidence obtained from all cases and the questionnaire surveys, other closely variables such as the characteristics of the client/project; quality of designers and contractors; contractual arrangements between client/designers and client/contractors and contract procedures are also important. The selected organizational form to build up the building team is also found to have significant impact on design performance which can lead to differing levels of project performance. Nonetheless, design completeness and its management is a factor identified as being influential.

9.2.2 Proposition 2 – Co-ordination of building services is influenced by the management of construction process

Based upon all data gathered by the author and the results presented in Chapter 7 and 8, the evidence also supports this proposition, and the findings of this second proposition are:
1. General summary of the management of construction process

<table>
<thead>
<tr>
<th>Findings</th>
<th>Conclusions</th>
<th>Evidence</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management of construction</td>
<td>Is a function of the characteristics of project/client, contract procedures, construction team and procurement path.</td>
<td>Chapter 7 &amp; 8 and other references</td>
<td>Complex managerial issues but can be managed by proper contract documents, procedures, information communication and good teamwork with good people.</td>
</tr>
<tr>
<td>Influenced by the management of construction</td>
<td>Will affect co-ordination of services which is part of a building process</td>
<td>Ditto</td>
<td>Building services cannot be isolated from the construction process, all must be managed in parallel</td>
</tr>
<tr>
<td>Problem from designer</td>
<td>Inadequate involvement Inadequate information</td>
<td>Ditto</td>
<td>Continuous management to completion and complete data</td>
</tr>
<tr>
<td>Problem from main-contractor</td>
<td>Inadequate project management and difficult co-ordination with many contractors</td>
<td>Ditto</td>
<td>Effective project management and adequate resources for co-ordinating all services</td>
</tr>
<tr>
<td>Problem from services contractors</td>
<td>Not well planned and managed by many Inadequate management of co-ordination</td>
<td>Ditto</td>
<td>Effective management and adequate work for the co-ordination process</td>
</tr>
<tr>
<td>Effects from other variables</td>
<td>Size and complexity of project, organization form and difficult team building</td>
<td>Ditto</td>
<td>More effort and right organizational form and integrated collaborative team approach</td>
</tr>
</tbody>
</table>

2. Building services is an unique part of a building project. The management of M&E services installation should be handled and managed with great care by all project participants.

As identified from the research surveys, in many cases, the root cause of poor co-ordination of building services is the results of incomplete design, poor working relationship, inadequate and ineffective project management.

Even with complete design and sufficient tender documents, the co-ordination process is still only partly completed, as co-ordination must be continuously executed, and the contractors involved must be brought together to complete the second half of the co-ordination process. This means that either the building works contractor or a lead (or main) building services contractor is appointed to manage the co-ordination process before and during the construction process with appropriate
integrative mechanisms. Clearly, all contractors should carry out the co-ordination as early as the pre-construction period.

3. Based on the research findings, one can look at the management issue from two angles, namely: the design and physical construction of the building.

The design issue has been discussed and this will also be elaborated during the discussion of the working of the project practitioners. As far as the management of building services installation in the building process is concerned, the critical problems found in the industry are:

- Inadequate management of building services installation by the building works contractors. This includes:
  - Poor co-ordination planning and management.
  - Unrealistic programming of services installation in conjunction with the construction programme.
  - Inadequate resources and people to carry out the co-ordination task.
  - Inadequate management of the co-ordination information required for both construction and services installation.
  - Inadequate control of services contractors.
  - Poor working relationship.
  - Too many parties to be co-ordinated at the same time.

- Inadequate management of the co-ordination process by individual services contractors.

This involves:

  - Poor programming of services installation with the construction organization.
  - Inadequate planning of co-ordination work, in particular, the production of co-ordination details and interfacing requirements.
- Inadequate resources and staff.
- Inadequate logistics.
- Inadequate involvement in the co-ordination process.
- Poor site supervision.
- Inadequate involvement of the design team to help improve the contractor’s co-ordination process.
- Poor working relationship and communication shortcomings between project participants.
- Many services systems to be co-ordinated with the building work contractor.

4. The research results provide ample confirmation that good project management given to the co-ordination process can improve project performance. To effectively manage the co-ordination process, it is necessary to complete as much co-ordination work as possible during the pre-construction period. The building team should pay attention to the following requirements which are often not adequately provided:

- Planning of construction and services installation with comprehensive details.
- Organizing services installation and building construction works well before construction by an independent co-ordination body or team (e.g. the building services coordinator).
- Integrating the construction personnel to work as a team and in accordance with appropriate management techniques such as:
  - Setting up a co-ordination team within each contracting organization but with the main-contractor or the principal services contractor acting as the chief building services coordinator.
  - Setting up necessary co-ordination procedures and methods.
  - Obtaining sufficient co-ordination information from all contractors at the right time and under the control of the coordinator.
  - Detailed programming of services installation with the construction organization.
- Planning of installation with due regard to logistics and proper sequencing of various services installations.
- Coordinating contractors to do work in accordance with programmes and planned areas/zones.
- Directing contractors to execute works based on plans, schedules and locations/zones.
- Controlling co-ordination problems if found on site.
- Solving co-ordination problems with all parties concerned.
- Monitoring progress of works and take additional actions and controls if required.

5. Based on the evidence available, there are other factors which can seriously affect the effectiveness of the above management system. The author’s observations are:

- Lack of appropriate leadership for managing the co-ordination process and poor working relationships between project participants.
- Inadequate experience of the project practitioners.
- Inadequate support from each parent organization of the project participants.
- Management of logistics is important as M&E services materials, plant and equipment are all imported items, and they usually have a long delivery period. To add the complexity, logistics can complicate the building construction as access and spaces must be allowed for while the construction is under way. This point must therefore be carefully managed by all parties.
- Efficiency of solving problems by the consultants as well as the construction team.
- Management of vast amount of information and drawings required for good co-ordination of services can be problematic if not careful thought about, planned and handled as too much information to be prepared and disseminated can hamper effective co-ordination.

6. The use of additional professional project management consultant has a significant impact on the overall project management.
The results of this research support those of Ireland (1983) and Rowlinson (1988) who have both stated that the management variable of the project rather than the procurement form has the most effect on project performance.

From the evidence available, it can be concluded that the performance of building services co-ordination is determined by the quality and effectiveness of the management of building construction and its building services installation throughout the construction stage. The multiplication of highly differentiated services sub-contractors, with attendant management responsibility for main-contractor is a management problem of the first order, especially when talking about managing, planning, supervising, controlling, co-ordinating and bringing these M&E specialists together. This problem adds extra elements to the management chain and the level of management resources provided to co-ordinate the project and to direct and supervise work on site must be commensurate. Factors affecting management of building service identified by the author include the characteristics of client, project, organizational structure of the building team, quality of design and team work and completeness of contract documents are important influences on management performance. Based on the evidence, the managerial issues has more significant impact than the organization form. In general, non-traditional procurement paths give higher management performance as a result of the proximity of the members of the team and better teamworking. The author’s research study produces enough evidence to show that the management process is essentially the same whichever procurement path is chosen. Clearly, any method with strong project control and efficient managerial actions, higher integration of project participants, higher familiarity and better communication is likely to lead to better project management and therefore better co-ordination. Hence, the management system adopted for a particular project by the building team has a direct bearing on project success and is seen to be an important variable in affecting co-ordination, but the management system will be influenced by the project procedures which are related to the selected procurement method.

9.2.3 Proposition 3 – Co-ordination of building services is not only a technical issue but also an exercise in management. It is influenced by the construction professionals’ working practices
The findings of this research do suggest a relationship between the co-ordination process and the professional working practices, and also support this proposition and the author’s comments are:

1. General summary of the construction professionals’ working practices

<table>
<thead>
<tr>
<th>Findings</th>
<th>Conclusions</th>
<th>Evidence</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working practice</td>
<td>Is a function of specialization structure/technology, complexity and size of project.</td>
<td>Chapter 7 &amp; 8 and other references</td>
<td>Give problem of integration and co-ordination</td>
</tr>
<tr>
<td>Multi-participants, and multi-disciplinary with multiple objectives in TMO</td>
<td>Differentiation and conflicts. Difficult integration</td>
<td>Ditto</td>
<td>Differentiation must be resolved and integration is necessary</td>
</tr>
<tr>
<td>Different working practices and human aspects</td>
<td>Inherent characteristic can affect teambuilding, need integration and co-ordination</td>
<td>Ditto</td>
<td>Managerial actions with managerial hierarchy, integration mechanisms procedures, integrators, formal and informal controls</td>
</tr>
<tr>
<td>Effect on project</td>
<td>Can create adversarial conditions and shape project performance</td>
<td>Ditto</td>
<td>Need better organizational form and contract procedures. Formation of an integrated collaborative team by changing attitude.</td>
</tr>
<tr>
<td>Integrative mechanisms</td>
<td>Will help integration Rules/procedures, plan/schedules, mutual adjustment, control/contact.</td>
<td>Ditto</td>
<td>Use right information, integrating committees and teams, individual integrators/central integrator, formal and informal interactions.</td>
</tr>
</tbody>
</table>

2. A building project is procured using a design team and many specialist contractors. The design team develops an optimum design first and the construction team translates the design into a final product – the building that the client wants.

A building project involves a high level of organizational complexity. This arises because there are many specialized skills and professions required and each has a useful contribution to the construction process. The formation of an integrated collaborative project team will have a beneficial effect upon the performance of that team and ultimately the success of the project. On the other hand, the management of
this team is very difficult. If not carefully managed, the combined efforts of each of the project team members might not be achieved and the project will have problems.

3. Increasing building complexity has resulted in a large numbers of designers per project, each has particular interest with narrower specialisms and responsibilities is now the norm on many large and highly serviced projects. All these professional designers and specialist contractors have differences in terms of commission, task involvement, organizational structure, technical knowledge and professional practices and sophisticated human aspects (e.g. alliance). This requires a great deal of team building and integration and co-ordination. Specialization has obvious benefits, but if these individual groups are not successfully integrated (to ensure that the tasks of all members add up to the total task or requirement of the whole building), the design and installation of the M&E services still remain fragmented, resulting in problems and inefficiency.

The involvement of several different professional experts, each working for their own firm and brought together for the purpose of a building project, creates a temporary organizational structure. The building team can thus be seen as highly differentiated, facing a problem in its own integration. This can also have an impact on project success. Due to the one-off nature of the building project and the use of temporary organizations to produce a building, team building is the ideal way to achieve integration during both design and construction stages. However, the formation of a real team is difficult as the pre-requisites for team building are not present due to the nature of the TMO, a great deal of effort is therefore required in coordinating the activities of these people or organizations. As such, the project team members have to be brought together by using appropriate integration/co-ordination mechanisms (formal and informal) or devices to achieve the co-ordinated efforts of individuals working in groups as a single organization.

4. The design of M&E services cannot be treated in isolation and must be fully integrated with both architectural and structural elements. All members of the design team should contribute their efforts to the integration and co-ordination of services. Based on the case studies and questionnaire data, in general, the project architect will be responsible for the direction and integration of the whole building project including
the M&E services. The responsibility for functional and spatial co-ordination always lies with the architect. But the architect will pass this duty to the M&E services consultant. The M&E services consultant will be responsible for the integration of services, but the co-ordination work is not fully completed and most of the co-ordination work will be assigned to the services contractors. In this circumstance, therefore, it is not surprising that co-ordination suffers. It is clear that the ACE agreements need reviewing relative to design responsibility if better co-ordination is to be achieved.

5. Each member of the construction team also contributes a particular expertise and is generally concerned with a discrete functional area in the building process. The building team is, in essence, an association of specialists from different disciplines with inherent problems of professional practice, technical language, communication, project management and involvement. As mentioned earlier, a high level of integration is required to bring all these heterogeneous organizations to work together for the duration of a project while retaining their individuality.

From the research results, it is clear that the co-ordination of M&E services is best brought about by direct contact between all responsible contractors. Therefore, the integration of contractors through the hierarchy (under a central authority), the administrative system (procedures, etc) and possibly voluntary activities (individual contractors see a need to complete work) must improve the co-ordination process.

6. The next consideration is how to manage and achieve a complete design and satisfactory installation of services. The survey results based on real life projects and literature search have confirmed that the design and installation of building services must be carefully managed by the building team and good management often gives better project results.

Nonetheless, the management of the integration and co-ordination of services carried out by the building team is still far from perfect. Some of the crucial findings are:
i. Design issues

- Conflicting needs between “Wheel of Dominance” in design team and team leadership.
- Poor communication, co-ordination and control of the multi-head client can seriously affect the design of M&E services and the co-ordination process. Firstly, inadequate management of the client’s brief often results in incomplete design. Secondly, changes to the design can seriously disrupt the development of an integrated design and the contractors’ works. (N.B. This is a client’s practice/problem)
- Different working practices amongst designers based on conventional design team can affect the management of integration and co-ordination of services unless an integrated collaborative design team (with mutual respect, understanding and co-operation for the good of the project) is used.

An integrated collaborative design team does not exist in many projects. Architect still tends to dominate other members of the design team (i.e. problem of wheel of dominance), thus, affecting the design of a building which is not conducive to smooth co-ordination. Similarly, seldom does the structural engineer play special attention to the need of building services (e.g. deep beams in ceiling void can affect smooth installation and also reduce spaces).

ii. Construction

Co-ordination must be continuous in the construction stages. But there are problems like:

- Large number of project participants with different goals, objectives, priorities, structure, social relationship/human aspects, managerial characteristics and driving forces.
- Differences in task, involvement and working of different members (i.e. builder and M&E services contractor) of the construction team.
• Difficult integration of all members of the construction team based on contractual arrangement only.

• Communication shortcomings among project participants (i.e. too much or too little).

• Inadequate involvement in the co-ordination process because of different attitudes, needs, involvement and interests/benefits.

• Co-ordination and integration of large team with different working practices is difficult.

To achieve a harmonious and collaborative team for achieving effective co-ordination, the industry must change their existing methods/behaviour or even practices to form a project team which will have a beneficial effect upon the performance of the team and ultimately the success of the project. The research results show that the level of managerial control with appropriate integration mechanisms for the project is the single most important indicator of success. This also supports the views expressed by other researchers that it is when projects become more complex in size that greater emphasis is needed on integration, management and control of the project participants.

To summarize, the performance of building services co-ordination is also dependent on the efficient working of the temporary multi-organization (TMO). Integration of the project participants during the design and construction processes has been identified as being the most important means for improving project performance and the working of the TMO. From the evidence available, it can be concluded that an integrated team as opposed to non-integrated team if used for large and complex projects tends to perform better than other team. The integration of this TMO must be managed by an integrative administration system with adequate procedures, formal and informal communication, direct and indirect contacts (e.g. regular meetings, ad-hoc meetings and site-walks, etc.) and managerial controls. It is difficult to obtain voluntary team building for managing the coordinating process. Furthermore, the elimination or reduction of all differences in each member of the building team is either difficult or impossible. However, procurement method as an intervening variable can be a useful factor for optimizing project management with the large number of project participants within a project.
9.2.4 Proposition 4 – Co-ordination of services is influenced by the building procurement methods

The findings of this research study give sufficient evidence to identify that the procurement form has a moderate effect on building services project performance, and the author’s comments are:

1. General summary of the building procurement methods

<table>
<thead>
<tr>
<th>Findings</th>
<th>Conclusions</th>
<th>Evidence</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procurement method</td>
<td>Is a function of the characteristics of client, project, contract procedures and building team.</td>
<td>Chapter 7 &amp; 8 and other references</td>
<td>Direct bearing on the formation of the building team and the co-ordination process.</td>
</tr>
<tr>
<td>Effect of procurement method</td>
<td>Can shape overall project performance</td>
<td>Ditto</td>
<td>Careful selection of organizational form to optimize the co-ordination process</td>
</tr>
<tr>
<td>Other important variables considered more important</td>
<td>Quality of design, site co-ordination, team work, managerial controls and team integration mechanism</td>
<td>Ditto</td>
<td>Procurement method can be an important variable in affecting project performance but not by itself is the only determinant</td>
</tr>
<tr>
<td>Best procurement method for co-ordination</td>
<td>No simple answer, all methods can work</td>
<td>Ditto</td>
<td>Provided we have incorporated all the key factors as given in this research</td>
</tr>
<tr>
<td>Difficult choice of procurement</td>
<td>Both subjective and objective systems can be used</td>
<td>Ditto</td>
<td>Need both subjective and objective decisions Use author's method for objective selection</td>
</tr>
</tbody>
</table>

2. The procurement method selected for a project determines the organization of the building team i.e. the client, designers and the contractor. Provided the design is complete and the contract documents, contract conditions are complete, clear, precise and fair. The remaining factors to be considered are:
The efficiency of the overall construction management.

The human aspects of the building team.

The will and the commitment of each project participant.

Co-ordination of building services is a combination of technical and managerial issues. The procurement method selected for a project under particular conditions has a direct bearing on:

- The production of design and co-ordination information.
- The integration of the building team.
- The working of the contractors.
- Communication between project participants.
- The managerial issues for managing the project by the building team.
- The formation of an integrated collaborative building team.

Selection of an appropriate procurement path is not a straightforward decision making. Both subjective and objective decision making methods can be used. In the industry, the method is mainly subjective and not scientific at all. The author’s findings can be used to improve the suitability of the organizational form for a particular project.

3. The choice of an appropriate procurement methodology emerges clearly from this research as one of the major determinants of successful management of integration and co-ordination of building services in Hong Kong.

However, the results from this research also support the argument that success in management of co-ordination of services can be as readily achieved by the traditional building team as by the fully integrated design and construction organization.
The key variables are:

- Provision of fully integrated and coordinated design and efficient co-ordination depend on the working of both design and construction teams.
- Greater emphasis is given to the integration of the project participants of the building team.
- Higher managerial control must be provided by the designer and construction teams.
- Greater control of the co-ordination process by a dedicated management structure which clearly defines appropriate roles and levels of authority, procedures and resolution of disputes in relation to co-ordination of services in a clear and precise contract document.
- Co-operation between project participants can be enhanced by engendering a team spirit through the use of partnering arrangement.
- Selection of experienced designers and contractors. Bid should not just be based on the lowest tender as the quality of the project participants can shape the project performance.

4. The author’s study confirm that without a central integrating mechanism for managing building services installation, the use of a traditional route is not suitable for large and complex building projects and can easily fail to achieve effective co-ordination of services. However, the use of good professional project management provided by a management consultant can improve the co-ordination process.

The aggregate performance in the traditional building process is primarily affected by:

- The sufficiency of design information and working drawings and details (i.e. Co-ordination drawings) provided by the design and construction teams.
- The extent of tasks interdependence requires a high degree of co-operation and close working between the builder and the building services contractors.
The traditional building process does not have a central integrating mechanism is not suitable of large, complex and highly serviced building projects. Effective management of a large number of specialist contractors must be provided by the main-contractor.

5. Through the use of non-traditional procurement paths, project success is much improved, especially when the design and construction teams are working together. Case studies in Hong Kong and aboard display that early involvement of the services contractors and a high degree of co-operation between project participants is important factors. Nevertheless, effective management of co-ordination of building services must still be carried out by the building team. All in all, the selection of the most appropriate procurement strategy to form a best building team structure is paramount if clients wish to achieve optimal cost, time, quality and performance of building services co-ordination.

Admittedly, the complexities of multi-headed clients, multi-participant, multi-disciplinary, large and complex projects with multiple objectives make the selection of a procurement path very difficult. Hence, one should select a procurement method based on all variables which can affect the outcome of a project. The author's two research models provide a useful framework for the evaluation of the most appropriate path based on the characteristics of the client, the project and the contract procedures. The construction team and the requisite organization form are then matched to these characteristics. Of course, the environmental factors must also be fully examined. Furthermore, human aspects should not be neglected as procurement methods have been blamed even where human relationship problems have contributed to the problems.

6. The criticisms of the traditional method are that the method tends not to promote integration, co-operation, co-ordination and communication where projects are complex. These are clearly difficulties in project management unless there are managerial techniques or systems to weld the different project participants together. Generally speaking, this procurement path is not conducive to co-ordination. However, based on the author's study, there are many cases with successful co-ordination. One of the advantages argued for some of the non-traditional
organizational forms is that they tend to promote integration, co-operation, co­
ordination and good communication. Most importantly, high synergy exits between
the design and construction teams and this success factor can often lead to better
integration and co-ordination of services.

As mentioned earlier, procurement method is an intervening variable (see Building
Services Procurement Model) which can be seen as an important factor in optimizing
project performance. From the evidence available, it can be concluded that building
services co-ordination has a very close relationship with the use of a particular
procurement method. However, the research results do not give enough evidence to
conclude that traditional procurement method cannot give high performance of the
co-ordination process. Neither traditional contracting nor alternative procurement
methods is the solution to all of the problems facing the co-ordination process.
Factors such as human aspects/team work project management, contractual issues,
quality of designers/design and contractors/construction are also important. The
research results also show little difference between the various procurement methods
as they all have to employ nearly the same mechanisms in the co-ordination process.
The essential difference, however, is the responsibility for design, construction and
co-ordination (e.g. traditional path with separate design and construction functions
versus D&B method with combined design and construction). The procurement path
selected for a project can and will affect the management of building services design
and installation. However, it is by no means the only factor which determines the
success or failure of the co-ordination process.

9.2.5 Proposition 5 – Project success is influenced by the implementation of
effective co-ordination of services and the use of an appropriate procurement
path

The findings of this research strongly support the claim in this final proposition and the
author's comments are:

1. General summary of the co-ordination & procurement path
<table>
<thead>
<tr>
<th>Findings</th>
<th>Conclusions</th>
<th>Evidence</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>The combined variables</td>
<td>Is a function of project complexity, client's needs, design, management, building team and contract procedures.</td>
<td>Chapter 7 &amp; 8 and other references</td>
<td>Very complex issues but human relationship, attitude of the parties and team building cannot be overlooked.</td>
</tr>
<tr>
<td>Project success is not just based on M&amp;E services</td>
<td>Project performance will include all client's needs although services is important</td>
<td>Ditto</td>
<td>M&amp;E cost is over 45% in highly serviced building, can shape project performance</td>
</tr>
<tr>
<td>Ineffective co-ordination can affect project success</td>
<td>Need improvement</td>
<td>Ditto</td>
<td>Effective co-ordination is essential</td>
</tr>
<tr>
<td>Use of appropriate procurement can shape project success</td>
<td>True, but not the only factor and difficult to select the best method</td>
<td>Ditto</td>
<td>Right procurement method help improve organizational form. All methods are acceptable but attention must be given to the project characteristics and management of project.</td>
</tr>
<tr>
<td>Combined effect of effective co-ordination and proper organization form</td>
<td>Best answer for the construction process</td>
<td>Ditto</td>
<td>Gives highest project performance but 'form' is not the solution, only the details of the organization of the building team and their integration.</td>
</tr>
</tbody>
</table>

2. A significant feature of the construction industry is its fragmented nature and the dichotomy which exists between the design and production function:

Through analysis to projects, the research results confirm that the complexity of building design and construction and the ephemeral nature of a project do place great dependence on the competence of the building team in setting up the building process and bringing the work to a successful completion. However, ineffective management of building services design, integration, co-ordination and installation is one of the concerns of the industry as this co-ordination matter can significantly influence the outcome of a building project.

The research findings have also identified that ineffective co-ordination of building services due to inadequate design and management of the construction process can lead to many serious consequences such as:
• Effect on progress of works.
• Increase in cost.
• Time overrun.
• Disputes.
• Claims, arbitration and lawsuit.
• Unsatisfactory building.
• Client/contractor satisfaction.
• Loss of profit and business.
• Adversarial working relationship.

The research results show that the aforementioned items will definitely affect the performance of a project. Essentially, good management of design and installation of M&E services is the first line of defence against all these ill effects.

3. As discussed earlier, when the building team and project procedures are appropriate to the client and project characteristics, higher levels of success can be attained. As a procurement method determines the working and organization of the project participants, the selected procurement path can shape the performance of the co-ordination process which, in turn, would have a direct influence on the outcome of a project.

The research results also show that depending on the circumstances, some building teams and project procedures are more likely to provide a successful outcome to a project than others by using the same procurement path. Based on the evidence obtained from the questionnaire/interview surveys and 25 case studies, the author conclude that no particular procurement path is better than another path rather it is the combined effect of a number of variables (e.g. characteristics of the building team, quality of design, management of co-ordination and the working of the project participants) which can significantly influence the outcome of a project. However, procurement method as an intervening variable can be a factor assisting in optimizing project performance.
Based on the evidence available, to sum up, the performance of a project can be affected by the effectiveness of the co-ordination process and the procurement path chosen for a project. Effective and systematic co-ordination of services combined with the optimum organization of designers and contractors will enhance the whole construction process and therefore has a significant impact on project performance. Conversely, poor co-ordination and inappropriate organization of team members will give inferior project performance. The effect of this procurement path on the project is not the most significant one as there are also other factors such as client/project characteristics, quality of design and co-ordination, provision of good project management with the right contract procedures, etc. which all can affect teambuilding and the co-ordination process.

9.3 Highlights from the findings and conclusions

Examination of the performance of the management of co-ordination of building services within the building process employing different procurement methods has been the theme of this research. Taking the research objectives and all the research findings into account, this result supports the following conclusions.

1. Poor co-ordination of building services are mainly caused by:

- Incomplete design of building services with responsibility gap between architect and M&E consultant.
- Fuzzy demarcation of responsibilities for design and co-ordination between designers and contractors.
- Inadequate management of building construction and building services installation by the building team coupled with work execution gap between the building work contractor and the M&E services contractors.
- Poor teamworking due to differences in task, involvement, structure, social relationships and managerial characteristics.
- Inappropriate procurement method selected for the project.
- Unhealthy pricing of the contract (i.e. cut-throat low tender sum).
2. Successful co-ordination of building services needs better management of both technical and managerial issues as identified in this research.

3. Based on the evidence obtained from the cases studies and questionnaire surveys, to improve the co-ordination process, the following important requirements are essential:

- The best place to address a co-ordination problem is on the drawing board. A full design with adequate co-ordination details must therefore be provided by the design team. The client should employ the M&E consultant in the capacity of the lead building services coordinator and be fully responsible for the integration and co-ordination of all M&E services. The head of the design team – normally the architect – is no longer the natural leader throughout the life of a project. The services consultant needs to predominate at appropriate times for the integration and co-ordination of services in the course of the design process. To do this, the consultant should be paid to provide the ‘missing’ additional co-ordination details. Furthermore, there must be some ways of measuring and validating co-ordination – so quality assurance system and processes ought to be included by the consultant. Again, it is far cheaper to rub out a co-ordination problem on a drawing than to sort it out on site. Another important point is that the designer should no longer pass the co-ordination down the line, as co-ordination is a design issue. Consultants are experts and are trained to manage building services design and installation. The designer’s ability in coordinating site installation has been found to be very professional.

- The allocation of design responsibilities and complete scope of works should be made very clear in the contract documents to all designers and contractors. The M&E services contractors and the building works contractor should be paid for all costs for managing the management of the building services co-ordination.

Research findings reveal that many competent contractors can and will develop the consultant’s design into more detailed co-ordination drawings if the design is reasonably complete or even considered to be barely sufficient. But sufficient time
must be given for this work. If the M&E contractors were also brought into the
design team early on the problems with design co-ordination should disappear in
theory, and with better project planning, site management and the right
construction team - all the things which, when added up, make co-ordination
more effective and less problematic.

- Site management of co-ordination work by a special co-ordination task unit either
  provided by the main-contractor or the project management consultant can
definitely help and improve the co-ordination process as identified from the case
  studies.

- Many things can go wrong on site, but the hinge on which nearly all turns is the
  quality of site management. Careful planning and management of a project before
  and during the construction phases should be practiced by all parties.

- Elimination of a large number of specialist services contractors by the
  employment of a principal building services contractor can improve the co-
  ordination process and the chance for project success.

- Under favourable conditions, the ‘partnership’ principle can result in teamwork
  between the client, the builder and the various M&E services contractors. The use
  of this principle is still not common as it is difficult to build trust and mutual
  understanding.

- Good information dissemination and communication.

- Incentives to complete on time - the conditions of engagement and forms of
  contract and management systems should have this in mind.

- The procurement path selected for a project has a direct bearing on the working
  of a building team. None of the procurement methods can solve the problems
  facing the construction industry. To achieve project success the parties need to
  match the various organization forms to the needs of the client and the project,
and to a certain extent, the characteristics of the professionals need to be matched. The best method is the one which engenders a team spirit and a high degree of co-operation between all project participants. Whatever form of procurement method is selected, there need to be effective project management and co-ordination throughout the design – construction process.

The choice of an appropriate procurement is still not treated with sufficient care by many clients. Indeed, it is an old problem which has been debated for more than 50 years since the publication of the Simon report in 1944. The assumption that non-traditional procurement methods will give better project performance should not be taken for granted. The results of 25 cases studies suggest that when projects are complex and highly serviced the most successful projects are those that have organizational forms designed to cope with the client, the project and the building team. The organizational forms and the management of the building project identified as being most successful are those including elements of good quality of people, design, and construction, strong project management, effective communications and good integrative mechanisms.

The tendency to concentrate on the organizational form has led to the omission of a number of important variables in the process of selection of a suitable procurement system. From the evidence available, it is clear that a procurement system is indeed a complex system, and therefore, cannot be adequately analysed by using a simple diagram/table or an algorithm merely showing the major variables or factors in relation to the client and the project. Basically, an effective contract strategy is one which is appropriate to the client and the project, and an appropriate organization is then created to procure this project.

4. There are a series of different routes leading to a successful project all starting from the same point but following different courses. Good management of building services co-ordination and installation can therefore be readily achieved by the traditional building team as well as the integrated design and build method.

From the evidence in the author's study, it is clear that both technical and managerial issues required for attaining successful co-ordination of services remain the same in
all procurement methods. However, the following project success attributes should improve the co-ordination process.

- Single-point responsibility.
- Better communication, co-operation and team working.
- Involvement of the contractor during the design process for better co-ordination with other members of the design team.
- Reduced differentiation with increasing integration of design and construction teams.
- Emphasis in project management and control of contractors.

9.4 Short summary

Analysis of the five propositions shows that the research results based on the questionnaire/interview surveys and the case studies conducted in Hong Kong do strongly support the propositions 1, 2, 3 and 5. However, from the evidence identified from the 25 case studies, the proposition 4 is not strongly supported although it cannot be denied that a procurement method adopted has a direct bearing on the organization of the building team, and in particular, the formation of an integrated collaborate construction team which is appointed to carry out the second part of the building services co-ordination assuming that the first part of the co-ordination is fully completed by the design team.

The author's research results answer the five propositions with these verified statements, the author is able to confirm the linkages between these propositions and the use of different procurement methods for procuring building services. Through this process, the objectives of this research (i.e. the evaluation of the management of building services in various procurement paths and the relationship between the building series co-ordination process and the procurement method adopted) are then concluded in conjunction with the author's discussions and comments. Furthermore, the aims and objectives of this research have been studied, tested and verified and the author's research questions are also properly and adequately answered.
The two research methods have proven to be a very useful vehicle from which were derived the conclusions mentioned in this chapter. The models are also validated by all 25 cases and the questionnaire/interview survey results. Though the Building Services Co-ordination Model has fulfilled its function adequately, some of the input details do add complexity in its application and these inputs can be omitted for clarity (also suggested by some key persons in the industry). To this end, the author also re-examined the model and built a more user-friendly model as shown in Figure 9.1 which can still be used under all circumstances by all practitioners.

The problem of determining an appropriate procurement method with due regard to effective and efficient co-ordination of building services in highly serviced projects has been surrounded by controversy and strongly held opinions in Hong Kong and elsewhere as there are conflicting views, which, on the one hand, indicate that procurement method is a major determinant of project performance, on the other hand, some proclaim that the non-traditional procurement methods can be used to solve all the ills in construction procurement, whilst some consider that the management of the building process is far more important than the procurement form.

The results suggest that, depending on the circumstances, the quality issues of both design and contract documents and the level of managerial control for the M&E services installation provided by the building team are important. When both the building team and project procedures are appropriate to the project characteristics of a particular project, higher levels of success can be attained.

The important conclusion to be drawn from the research is that procurement form is not a good predictor of project performance. The results from this research also support the argument that successful co-ordination of building services can be as readily achieved by the traditional procurement method as by the fully integrated design and build method. Ironically, though the procurement method selected for a project can affect the project outcome, it is by no means a strong determinant as project performance can also be affected by other factors. Furthermore, in the author's opinion, no particular organizational form is better than another, per se, rather it is the combined effect of a number of variables or factors (e.g. project management, choice of right people with right attitude to do the job, proper contract, quality of design and co-ordination information,
pricing, site management and control of contractors, etc.) which can strongly influence the success of a project. Based on the data gathered from the 25 cases, project success can be enhanced by engendering a team spirit and a high degree of co-operation between project participants, based on shared goals. This can be made more effective through the use all procurement methods, but the use of non-traditional procurement arrangements appears to give better project performance as a result of higher collaboration/co-ordination, least differentiation, closer proximity or familiarity between the project participants and strong management.

The research results also support the view expressed by many researchers (Ireland, 1984; Naoum, 1988 and Rowlinson, 1988) that when building projects are larger, more complex and highly serviced, greater emphasis is needed on the integration of all project practitioners. Furthermore, more effective management and control of the entire process of integration and co-ordination of services must be given by all relevant project participants.

The selection of the most appropriate procurement strategy is paramount if clients are to achieve optimal solutions in terms of cost, time, quality and project performance. It is easier said than done. As far as selection of the best method is concerned, there is no exact answer, as both traditional and non-traditional methods can be used. The procurement method chosen for a particular project only forms the structure of the building team and gives the foundation of all contract procedures as well as the general management required. The organizational form nevertheless must be designed holistically with due consideration of the interaction of many construction activities and the synergism of the constituent parties. Based on the evidence, the success of a project relies upon the building team and the performance of the management of each of the project participants. To satisfy the client, all the project participants should work together and follow the findings presented in this chapter. In so doing, effective co-ordination can be achieved in all procurement methods.

The next concluding chapter summarizes the main conclusions and usefulness of this research and incorporates some useful recommendations and future research.
NOTE

The variables in Figure 9.1 are related in such way that the four independent variables, resolution of differences, provision of adequate technical support, provision of efficient management actions and the essential team work all can influence the central organization designed for managing the co-ordination process, which in turn affects the dependent variable – fulfillment of efficient co-ordination. Hence, the central co-ordination organization is working as an intervening variable which has linkages between the dependent and independent variables. The more effective is the management of building services co-ordination by this co-ordination organization or unit, the higher chance the complex co-ordination process can be smoothly completed. The central organization for co-ordinating the M&E services can be affected by the selection of procurement method which in turn can affect the dependent variable – successful co-ordination which is one of the important attributes influencing project performance.
CHAPTER TEN

RECOMMENDATIONS

10.1 Introduction
10.2 Summary of main findings, conclusions and recommendations
10.3 Detailed recommendations for implementing the research findings
10.4 Further research and actions
10.5 Contributions of the thesis to knowledge on co-ordination of services
CHAPTER TEN: RECOMMENDATIONS

10.1 Introduction

This final chapter gives some of the important recommendations pertaining to:

- Improvement in the co-ordination process based on the existing building construction practice.
- Recommendations for further research work on the subject matter.

10.2 Summary of main findings, conclusions and recommendations

Findings without recommendations are useless and recommendations without findings and conclusions are also useless and irresponsible.

This condensed and structured summary is a useful device to project the relationships between the perceived highlights of the many facts, analyses, the five propositions, findings and conclusions that emerged during this study. The summary is not sequential as there is considerable overlap and interaction between the various findings and conclusions during different stages of the study.

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<td>Use of traditional and non-traditional procurement methods.</td>
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10.3 Detailed recommendations for implementing the research findings

Co-ordination of building services as one aspect of project management, should be carried out throughout the design/construction/installation process, and if done properly will lead to the full integration of building services. Particularly important is co-ordination in the early stages of a project.

To improve the co-ordination process, the following recommendations should be considered and implemented by the industry.

1. Improvement in design

The best way to avoid many of the co-ordination problems should be a good design which takes proper integration and co-ordination of services into consideration during the various design stages.

The M&E consultant acting as the lead building services coordinator must be fully responsible for the whole process of co-ordination of services. The co-ordination must be fully completed before tender – the production of fully coordinated services drawings, and builder’s work drawings.

A Quality Assurance (QA) system should be provided and used to ensure completeness of the co-ordination details by the M&E consultant during the various design states. Figure 10.1 indicates a QA system designed for a consultant. This system relies on the design critiques and project management reviews, and therefore can be used to incorporate the planning and checking of the integration and co-ordination of all M&M services into the ‘design critique’ by a QA manager. Of course, the project team project manager is still fully responsible for the preparation of all co-ordination details with all relevant parties of this project. The co-ordination process will also be continued in the construction stage.
Figure 10.1: QA in Consulting Engineering Practices for co-ordinating M&E services
2. Change to existing contractual arrangements

Improvement in building services co-ordination can be achieved by a different working practice from the one currently in use, without introducing a complete revolution in the existing practices and procedures for the local industry, the following advice should be considered:

As the percentage value or importance of the services increases, so do the problems of design co-ordination and integration. Since letting the different M&E services as separate packages means more problem of co-ordination, a principal services contractor (a lead M&E contractor co-ordinating numerous domestic specialist contractors) is then recommended to be appointed in sufficient time (i.e. much earlier than normal) so that the co-ordination process can be carried out with other members of the design team before the construction stage. This situation requires no change in the involvement of the consultant. Early incorporation of M&E services contractor will lead to cost and time savings. A further consequence is likely to be improved working relationships between the various members involved combined with a desire to find solutions rather than problems.

The system will put the consulting engineer and the contractors very much in control of the working drawings and even the design content of the detailed installation.

This services constructor will then manage all M&E services works with the building work contractor before construction starts.

The consultant continues to have a technical input (as adviser and coordinator in the design team) to the site-coordination process whilst the services contractor (as the chief site coordinator) is working with the main-contractor.

To be successful, the main-contractor has to employ its own building services coordinator and a small number of supporting M&E staff. But the M&E services co-ordinated working drawings and builders' work drawings, and all managerial exercises are the responsibilities of the services main-contractor and the consultant.
This system probably provides the best compromise, gets the consultant to complete the design, brings the services contractor involved at the earliest possible time to complete the co-ordination information and gives the client protection by ensuring the consultant’s fully committed controlling role. With this method, the traditional fee structure will have to be modified but the additional cost incurred can reduce the extra costs due to poor coordination and possible claims from the contractors.

This system provides the opportunity for better co-ordination. This system can also be used for all procurement methods.

3. A new stage called the co-ordination stage can be added after the tendering stage for the traditional procurement path as show in Figure 10.2. This is a major variation from normal practice where the co-ordination is left to the main-contractor and subcontractors and to be carried out at soon as possible, but the emphasis is towards allowing the designers and M&E services contractor(s) to review and finalize all co-ordination issues well before the construction stage.

![Diagram of the new co-ordination stage in traditional contracting](image)

Figure 10.2: The New Co-ordination Stage in Traditional Contracting

Fundamentally, it is essential that all parties are fully committed to the successful co-ordination of building services. Of course, greater emphasis is needed on team building with effective managerial control.
4. The next proposal is to use partnering and joint venture system for a single M&E services contractor, working together and sharing the risks and rewards with a building contractor of comparable size and reputation. The great advantage is that the client gets better project performance due to the enhanced integration of the two project participants working as an integrated collaborative construction team.

5. Design/construction team co-location can also be used to have improved communication; co-operation; faster decision making achieved through the immediacy of contact (e.g. design/co-ordination meetings); improved team building achieved by developing a common project culture and identity that is associated with the sharing of site office (or even design office); and finally a more efficient and quicker method of integrating the provider’s and receiver’s processes (e.g. the design/construction supply chain management). Development in virtual teamworking may reduce some of the need to physically co-locate while still facilitating the personal contact necessary for collaborative working. However, the author’s recommendation is still the co-locating - having all project participants responsible the co-ordination process physically near to each other. This is the best way to accelerate team building and has been confirmed by the author to be a very effective system to bring individuals and organizations together on a project.

6. The use of computer-aided design has a profound effect on the quality of drawings and information. Contractors can make use of the designer’s drawings to produce their co-ordination drawings. This practice not only saves time but eliminates avoidable delays due to the long time element required for the preparation of a new set of drawings for site co-ordination purpose.

7. The biggest cost savings result from early and careful planning of building services but its effect may be reduced if a proper programme is not produced. Therefore, the lead designer should provide a comprehensive master programme for the entire building construction and M&E services installation. Both main-contractor and services contractor would then extend the master programme to facilitate their actual programming of works with necessary modifications. Incentive such as improved payment system based on milestones as shown on contractor’s programmes would also improve the co-ordination process.
8. The architect should no longer be the project manager for many large and complex projects. As identified from the case studies, a project management consultant with adequate experience and experts is the best person to help both designers and contractors. The client should have less problems with this arrangement. However, it would require a substantial increase in fees. From a rational viewpoint, the system appears to be ideal, but technically and economically viable. The system can avoid many construction problems and most significantly, the higher level of managerial control can give better management of building services work on site.

9. Building engineering services are highly specialized and advances in technology are rapid. A compounding factor is that the trend for modern buildings to incorporate more services is likely to continue and this further exacerbates the co-ordination process. It is therefore essential that the area of expertise of both designers and contractors match the services required.

10. The proliferation of client changes is no longer acceptable and this must be controlled and arranged as post contract work for the best compromise. Alternatively, the design should be more flexible to cope with possible changes.

10.4 Further research and actions

Further research work should concentrate on the following nine directions:

1. The area of research is complex, but this research has developed a methodology which is essentially qualitative and relatively straightforward and which may also be replicated by others. However, attempts have been made to quantify the evidence whenever possible. Further co-ordination studies can be both quantitative and qualitative. Hopefully, meaningful indicators, indexes, weighting factors client/contractor satisfaction benchmark can be established to indicate the impact of each of the variables (see BSC and BSP model) on building projects having different complexities (e.g. residential, office and hospital projects). In so doing, this would be extremely valuable in building up a body of an empirical knowledge concerning the subject. It can be postulated that these technically complex projects do require
2. As human factors can affect team building, further study should examine the effect of culture and human relationship and behaviour. It is envisaged that case studies obtained from different countries (e.g. West and East) would give deeper understanding of this issue in procuring the M&E services.

3. The “invisible” effect of M&E services design, installation and co-ordination on maintainability as this is an important impact on building performance.

4. The development of specific design and co-ordination models for different complex building projects for the building services industry. Along side with this, it is recommended to consider the development of useful algorithms as part of a standardized approach to effective procurement choice.

5. The impact of design and co-ordination of building services on productivity should be taken into account in future study as this productivity factor indicates overruns in cost and time of a project.

6. The use of any procurement path for a particular type of building and managed by the same contractor, and incorporating all the research findings and recommendations provided by the author.

7. The research was essentially qualitative. This, however, did not necessarily detract from the findings. Further quantitative evidence would assist in adding research data. It is suggested that quantitative evidence (e.g. cost, time and production rate) should be considered in any further research in this area. However, careful thoughts should be given to the selection of ‘standard’ cost, time and rate of change.

8. Problems with management of building services co-ordination clearly remain, and more work is needed to develop a guide for those involved in managing this process.
To underpin the development of further models of co-ordination it is necessary to profile the education, skills and experience of those involved in designing building services and those responsible for managing the installation and commissioning of these services. Similar research has been completed for project managers of construction projects but no similar work currently exists for building services engineers. Dissemination of the findings through publications and workshops or seminars to foster awareness and implementation of performance improvement based on the author’s research models and the research results should be of more practical use to the industry.

The wide range of possible areas for future research clearly indicates the importance of co-ordination of building services and would be extremely valuable in building up a body of empirical knowledge concerning the subject. This will have a strong impact in future construction practice. The best way of carry out these further studies should be carried out as joint ventures between industry and academia. Possibly, action research by actual involvement and direct or indirect observations within the building process should be arranged for getting the best result.

10.5 Contributions of thesis to knowledge on co-ordination of services

This research study has direct and important implications in relation to clients, designers and contractors and those considering possible directions for further research in management of building services.

1. This research not only bridges the existing gap between design and construction but also provides an insight into the management of building services design and co-ordination using different procurement methods in Hong Kong. The research has identified that the procurement form will have some effect on performance only and the presumption that the choice of an appropriate procurement will lead to a successful project outcome is only an implicit assumption. The research results support that co-ordination performance is affected by both technical issues and managerial actions. This also indicates that the construction industry can accept different organizational forms for the same project as long as appropriate technical issues and managerial issues are fully incorporated into a project.
2. This research provides a deeper understanding of the influence of proper design and adequate co-ordination on the project success especially for highly serviced hospital projects and makes a contribution to the building economy by reducing unnecessary cost relating to ineffective co-ordination of building services based on the author’s recommendations. The study will promote awareness amongst clients, designers and contractors of the implications of their contributions and effects upon the construction process. The study also draws the attention of the project participants to the significant aspect of good management of M&E services and puts the findings of this research into practice so that the industry can provide better buildings not just in Hong Kong but also globally with or without major change to existing contractual arrangements.

3. This thesis concentrates on the neglected research into integration and co-ordination of building services and its relationships with project management and building procurement, and provides two pragmatic but theoretical models and useful data for other researchers and all practitioners.

There is a paucity of research related to the specific area of building services integration and co-ordination. What little building services research exists is dated and not necessarily directly relevant since it does not deal with procurement. Of those researchers who have investigated the general or a particular area of building services design or site management, the effect of the procurement form has not been examined or considered. If the trend towards the increased use of services continues, it is conceivable that building services contractors may take on the principal role in managing the construction process and there is currently no co-ordination model that supports this scenario. There is a need to evolve new models which address the problems of co-ordination and collaboration. To meet this need, the author developed two research models which will contribute to deeper understanding of the management of building services co-ordination, not only for the construction in Hong Kong, but globally.

The Building Services Co-ordination Model provides a general conceptual framework which allows the development of better management of design and co-ordination of M&E services. To be flexible the model is not specific to any one kind of building. The concept
and the variables identified by the author can be used to produce a specific design and construction protocol or logic for all building projects.

The variables or factors within this model affecting the co-ordination process have also been fully addressed and some practical solutions are given (see research findings) to help the project participants to improve the co-ordination process.

The Co-ordination - Procurement Model is a combination of the co-ordination system and selection of a procurement path. The model provides a conceptual framework which can be used to establish the design of an appropriate organizational form based on a careful consideration of all characteristics of a project, the client, the designers, the contractors, the contract procedures and the procurement method itself. To this end, this facilitates better management of the M&E services co-ordination.

The lack of previous research in this topic has given an opportunity to the author to explore this interesting subject from the viewpoints of the project participants and the academia. The research findings are useful and pragmatic. The results produced will have a strong impact on the construction industry practices. The results also show that the traditional procurement path can be a good organizational system under certain circumstances but this is not the best procurement methodology when buildings services are getting more and more sophisticated. For the best result, the traditional organizational form must be designed holistically with careful thought about effective interaction and synergism of the constituent project practitioners and the use of additional project management techniques and systems.

In the real world, even with the right organizational form, it does not guarantee a successful project. Many other considerations as given in this study must also be examined and evaluated. Most importantly, the requirements of a competent building team with complete design, sufficient resources, adequate project management and reasonable profit margins are required for effective management of building services. Finally, all project participants should re-engineer and re-value their work and take a new style of working from the old thinking of integrated collaborative team based on all-win-win concept.
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CO-ORDINATION OF BUILDING SERVICES AND PROCUREMENT METHODS FOR HIGHLY SERVICED BUILDINGS

By
K. C. Lam

A doctoral thesis submitted in partial fulfillment of the requirements for the award of Doctor of Philosophy of Loughborough University.

APPENDIX

April 2003
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APENDIX I

List of published paper by the author
LIST OF CONFERENCE/JOURNAL PAPERS (BETWEEN 1996 – 2001)

N.B. The author would like to express his gratitude to his supervisors for their invaluable advice and guidance in transforming some parts of this study to publication.

Prepared by: K. C. Lam
A. Papers published in 1996

1. Co-ordination of building services and the building procurement system, the 14th IFHE (International Federation of Hospital Engineering) Congress, Copenhagen, June 1996, p. 67-75.


B. Papers published in 1997


6. Modelling procurement methods for coordination of M&E services in highly serviced hospital buildings, International Conference on Construction Process Reengineering CPR-97, Griffith University, Australia (revised and accepted, but no publication due to “no registration”).
C. Papers published in 1998

1. Management of contractors by project/quality management system, p. 1065-1070.


3. Quality assurance and constructability in building services planning and procurement, p. 1173-1178.

The Sixth East Asia-Pacific Conference on Structural Engineering & Construction (EASEC-3), National Taiwan University, Jan. 1998.


D. Papers published in 1999


2. Quality maintenance management of building services – An integrated approach for Hong Kong and China, Hong Kong and Shanghai Symposium on Science and Technology, September 1999, Hong Kong, p. 110-120.


E. Papers published in 2000


F. Papers published in 2001


APENDIX II

Details of the questionnaires
DETAILS OF QUESTIONNAIRES

N.B. The attached questionnaires were used for this research study.

Prepared by: K. C. Lam
To: Organization

Dear Sir/Madam

I am currently undertaking a research under the supervision of Mr. A. Gibb and Mr. W. Sher of the Department of Civil and Building Engineering, Loughborough University in UK, into the effects of different building procurement methods on the management of building services design and installation for large and highly serviced buildings in Hong Kong.

As one of the long established architect/engineer/quantity surveyor/building works contracting firm/M&E services contracting firm, your views on this subject are particularly vital to my research and our local building industry. I would hope that you will feel able to arrange for the enclosed questionnaire to be completed and returned to me, in the prepaid envelope provided, and at your earliest convenience.

I would be much obliged if you would also allow me to seek your further views on the research subject. I will be available at any time which is convenient to you.

Your anonymity will be reserved during the currency, and in the final reporting of the research. Your information will remain confidential and only used in connection with my academic research. I will be happy to provide you with the results of my survey once it has been completed.

May I thank you in advance for your assistance.

Yours sincerely,

K.C. Lam
Dept. of Building Services Engineering
The Hong Kong Polytechnic University
(Tel. 2766 5845, Fax 2774 6146)
Questionnaire Survey Form

Form No. 1 – For Client

Form No. 2 – For Design Team

Form No. 3 – For Main-contractor

Form No. 4 – For Services Sub-contractor
A SURVEY OF THE IMPACT OF PROCUREMENT METHOD ON CO-ORDINATION OF BUILDING SERVICES

QUESTIONNAIRE

The answers to this questionnaire are confidential and are given, and received, on the understanding that they will be used solely for this research.

They will be aggregated with information from other respondents, analysed and summarized before publication or release to any third party and will therefore be completely anonymous.

By: Mr. K. C. Lam
From: Department of Building Services Engineering
The Hong Kong Polytechnic University
FORM NO. 1 : BUILDING SERVICES PROCUREMENT QUESTIONNAIRE – CLIENT

1. Name of organization

____________________________________________________________________________________

____________________________________________________________________________________

2. Type of organization/business activities

   a. Government
   b. Hospital Authority
   c. Property developer
   d. Other (please state)

____________________________________________________________________________________

3. Briefly describe the types of building that you commonly plan and procure

____________________________________________________________________________________

____________________________________________________________________________________

4. Which procurement method is the most used in your organization

   a. Conventional
   b. Two-stage
   c. Design & Build/Develop/Construct
   d. Management Contracting
   e. Construction Management
   f. Other (please specify)

____________________________________________________________________________________

5. Indicate your satisfaction with the procurement methods you have used. Please rate each on a scale of 1 to 5 (low to high)

   Procurement method
   a. Conventional
   b. Two-stage
   c. Design & Build/Develop/Construct
   d. Management Contracting
   e. Construction Management
   f. Other, please state

____________________________________________________________________________________

5a Indicate with a tick to the most important reason for the selection of the selected procurement method.
6. Who generally is the principal adviser upon the choice of the procurement method for your project?
   a. In-House expert
   b. Architect
   c. Quantity surveyor
   d. Building services consultant
   e. Construction Project Management Consultant
   f. Other, please specify

6a Are you satisfied with the expert advice you received on the selection of procurement method?
   a. Completely satisfied
   b. Reasonably satisfied
   c. Dissatisfied

7. Indicate what you believe to be the importance of the following issues in determining the choice of procurement method. Please rate each criterion from low (1) to high (5).
   a. Dissatisfaction with previous procurement method used
   b. Transfer of risk
   c. Single point responsibility
   d. Predicable cost
   e. Completion on time
   f. Smooth management of building team
   g. Project complexity
   h. Quality of design
   i. Control of contract
   j. Working relationship
   k. Knowledge of method
   l. Other, please specify

8. Please rate the various highlighted factors in relation to your understanding of the important management of co-ordination of M&E services based on a scale of 1 to 5 (from low to high).
   a. From previous experience
   b. From other project
   c. Essential for large and complex project
   d. Relating to quality of tender document:
      - Quality of design co-ordination
      - Requirements for co-ordination
   e. Need good project management by all parties
   f. Costly client's contribution to avoid problems
9. Please indicate on a scale of 1 to 5 (low to high) what you believe to be the serious impact of inadequate co-ordination of building services.

a. Quality of services
b. Cost control
c. Contract time performance
d. Management of contract
e. Project success
f. Other, please specify

10. Who should be responsible for carrying out the co-ordination of building services? Please indicate on a scale of 1 to 5 (low to high).

a. Architect
b. Services engineer
c. Quantity surveyor
d. Main-contractor
e. Building services contractor
f. Other, please specify

11. Indicate your satisfaction on a scale of 1 to 5 (low to high) with the following project participants in carrying out the management of building services co-ordination for your complex projects.

a. Architect
b. Services engineer
c. Quantity surveyor
d. Main-contractor
e. Building services contractor
f. Other, please specify

12. If you have any comments not covered by the questions, please make them here.

THANK YOU FOR COMPLETING THE QUESTIONNAIRE
FORM NO. 2: BUILDING SERVICES PROCUREMENT QUESTIONNAIRE – DESIGN TEAM

1. Name of organization

2. Type of organization/business activities

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>a. Architect</td>
<td></td>
</tr>
<tr>
<td>b. Building service engineer</td>
<td></td>
</tr>
<tr>
<td>c. Quantity surveyor</td>
<td></td>
</tr>
<tr>
<td>d. Main contractor</td>
<td></td>
</tr>
<tr>
<td>e. Building services contractor</td>
<td></td>
</tr>
</tbody>
</table>

3. Briefly describe the types of building that you commonly plan and procure

4. Which procurement method is the most used in your organization

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>a. Conventional</td>
<td></td>
</tr>
<tr>
<td>b. Design &amp; Build</td>
<td></td>
</tr>
<tr>
<td>c. Develop/Construct</td>
<td></td>
</tr>
<tr>
<td>d. Management Contracting</td>
<td></td>
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<tr>
<td>e. Construction Management</td>
<td></td>
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<tr>
<td>f. Other (please specify)</td>
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</tr>
</tbody>
</table>

5. Indicate your satisfaction with the procurement methods you have used. Please rate each on a scale of 1 to 5 (low to high)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Conventional</td>
<td></td>
</tr>
<tr>
<td>b. Design &amp; Build</td>
<td></td>
</tr>
<tr>
<td>c. Develop/Construct</td>
<td></td>
</tr>
<tr>
<td>d. Management Contracting</td>
<td></td>
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<tr>
<td>e. Construction Management</td>
<td></td>
</tr>
<tr>
<td>f. Other, please state</td>
<td></td>
</tr>
</tbody>
</table>

5a Indicate with a tick to the most important reason for the selection of the selected procurement method.
6. Who generally is the principal adviser upon the choice of the procurement method for your project?

   a. In-House expert
   b. Architect
   c. Quantity surveyor
   d. Building services consultant
   e. Construction Project Management Consultant
   f. Other, please specify

6a Are you satisfied with the expert advice you received on the selection of procurement method?

   a. Completely satisfied
   b. Reasonably satisfied
   c. Dissatisfied

7. Indicate what you believe to be the importance of the following issues in determining the choice of procurement method. Please rate each criterion from low (1) to high (5).

   a. Dissatisfaction with previous procurement method used
   b. Transfer of risk
   c. Single point responsibility
   d. Predicable cost
   e. Completion on time
   f. Smooth management of building team
   g. Project complexity
   h. Control of design
   i. Control of contract
   j. Working relationship
   k. Knowledge of method
   l. Quality of services
   m. Other, please specify

   -------------------------------------------
   -------------------------------------------
   -------------------------------------------

8. Please indicate on a scale of 1 to 5 (low to high) what you believe to be the serious impact of inadequate co-ordination of building services.

   a. Quality of services
   b. Cost control
   c. Contract time performance

   -------------------------------------------
   -------------------------------------------
   -------------------------------------------
d. Management of contract

e. Project success/business

f. Other, please specify

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9. Who should be responsible for carrying out the co-ordination of building services? Please indicate on a scale of 1 to 5 (low to high).

a. Architect

b. Services engineer

c. Main-contractor

d. Building services contractor

e. Construction project management team

f. Other, please specify

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10. Indicate your satisfaction on a scale of 1 to 5 (low to high) with the following project participants in carrying out the management of building services co-ordination for your complex projects.

a. Architect

b. Services engineer

c. Main-contractor

d. Building services contractor

e. Other, please specify

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11. Indicate on a scale of 1 to 5 (low to high) what you think to be the importance of the indicated issues in relation to good management of co-ordination of building services.

a. Responsibilities for co-ordination in contract

b. Full integration of services into design by consultant

c. Preliminary co-ordination of services by consultant

d. Detailed co-ordination of services by individual services contractors

e. Full co-ordination of services with building works by main-contractor

f. Preparation of preliminary services co-ordination drawings and relevant details by consultant

g. Preparation of detailed services co-ordination drawings and builder’s work drawings by main-contractor and services contractors

h. Good site management by all contractors

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12. How satisfied are you (based on a scale of 1 (low) to 5 (high) that the following project participants in performing co-ordination of M&E services.
a. Nominated sub-contractor
b. Domestic sub-contractor
c. Principal services contractor covering all M&E services
d. Building services co-ordination team in main-contract
e. Building services co-ordination team in sub-contractor

13. If you have any comments not covered by the questions, please make them here.

THANK YOU FOR COMPLETING THE QUESTIONNAIRE
1. Name of organization

2. Type of organization/business activities
   a. Building construction
   b. Building and civil engineering
   c. Building construction & M&E services
   d. Management contractor

3. Briefly describe the types of building that you commonly tender and build.

4. Which procurement method is the most used in your organization
   a. Conventional
   b. Design & Build
   c. Develop/Construct
   d. Management Contracting
   e. Construction Management
   f. Other (please specify)

5. Indicate your satisfaction with the procurement methods you have used. Please rate each on a scale of 1 to 5 (low to high)

<table>
<thead>
<tr>
<th>Procurement method</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td></td>
</tr>
<tr>
<td>Design &amp; Build</td>
<td></td>
</tr>
<tr>
<td>Develop/Construct</td>
<td></td>
</tr>
<tr>
<td>Management Contracting</td>
<td></td>
</tr>
<tr>
<td>Construction Management</td>
<td></td>
</tr>
<tr>
<td>Other, please state</td>
<td></td>
</tr>
</tbody>
</table>

5a Indicate with a tick to the most important reason for your preferred/selected procurement method in question 5.

   a. Familiarity
b. Suitability

c. Simplicity

d. Other, please state

6. Indicate what you believe to be the importance of the following issues in the use of a particular procurement method. Please rate each criterion from low (1) to high (5).

   a. Dissatisfaction with previous procurement method used
   b. Transfer of risk
   c. Single point responsibility
   d. Cost within budget
   e. Completion time
   f. Smooth management of building team
   g. Quality of building
   h. Control of contract work
   i. Working relationship
   j. Knowledge of method
   k. Other, please specify

    7. Please indicate on a scale of 1 to 5 (low to high) what you believe to be the serious impact of inadequate co-ordination of building services.

   a. Quality of services
   b. Cost control
   c. Contract time performance
   d. Management of contract
   e. Project success
   f. Reputation/business
   g. Other, please specify

   8. Who should be responsible for carrying out the co-ordination of building services? Please indicate on a scale of 1 to 5 (low to high).

   a. Architect
   b. Services engineer
   c. Main-contractor
   d. Building services contractor
   e. Construction project management team
   f. Other, please specify
9. Indicate your satisfaction on a scale of 1 to 5 (low to high) with the following project participants in carrying out the management of building services co-ordination for your complex projects.

a. Architect
b. Services engineer
c. Main-contractor
d. Building services contractor
e. Other, please specify

10. Indicate on a scale of 1 to 5 (low to high) what you think to be the importance of the indicated issues in relation to good management of co-ordination of building services.

a. Clear responsibility for design, installation and co-ordination
b. Adequate design information and co-ordination details from the design team
c. Main-contractor to manage site co-ordination work
d. Chief services contractor to manage co-ordination work
e. Independent construction project management team to co-ordinate services
f. Services consultant to assist site co-ordination with quick response
g. Co-ordination as an itemized cost
h. Good teamwork
i. Competent project participants
j. Less change by client

11. Use a scale of 1 to 5 (low to high) and indicate your preferred employment of the following project participants in managing the M&E services installation with you.

a. Nominated sub-contractor
b. Domestic sub-contractor
c. Principal services contractor
d. Building services co-ordination team provided by the Main-contractor

12. If you have any comments not covered by the questions, please make them here.

THANK YOU FOR COMPLETING THE QUESTIONNAIRE
FORM NO. 4: BUILDING SERVICES PROCUREMENT QUESTIONNAIRE -- BUILDING SERVICES CONTRACTOR

1. Name of organization

2. Type of organization/business activities
   a. Full M&E services
   b. HVAC
   c. Electrical services
   d. Other, please state

3. Briefly describe the types of building that you commonly tender and install your M&E services.

4. Which procurement method is the most used in your organization
   a. Conventional
   b. Design & Build
   c. Develop/Construct
   d. Management Contracting
   e. Construction Management
   f. Other (please specify)

5. Indicate your satisfaction with the procurement methods you have used. Please rate each on a scale of 1 to 5 (low to high)

   Procurement method
   a. Conventional
   b. Design & Build
   c. Develop/Construct
   d. Management Contracting
   e. Construction Management
   f. Other, please state

5a Indicate with a tick to the most important reason for your preferred/selected procurement method in question 5.
6. Indicate what you believe to be the importance of the following issues in the use of a particular procurement method. Please rate each criterion from low (1) to high (5).

   a. Dissatisfaction with previous procurement method used
   b. Transfer of risk
   c. Single point responsibility
   d. Cost within budget
   e. Completion time
   f. Smooth management of building team
   g. Quality of building
   h. Control of contract work
   i. Working relationship
   j. Knowledge of method
   k. Other, please specify

   7. Please indicate on a scale of 1 to 5 (low to high) what you believe to be the serious impact of inadequate co-ordination of building services.

   a. Quality of services
   b. Cost control
   c. Contract time performance
   d. Management of contract
   e. Project success
   f. Reputation/business
   g. Other, please specify

8. Who should be responsible for carrying out the co-ordination of building services? Please indicate on a scale of 1 to 5 (low to high).

   a. Architect
   b. Services engineer
   c. Main-contractor
   d. Building services contractor
   e. Construction project management team
   f. Other, please specify
9. Indicate your satisfaction on a scale of 1 to 5 (low to high) with the following project participants in carrying out the management of building services co-ordination for your complex projects.

a. Architect
b. Services engineer
c. Main-contractor
d. Building services contractor
e. Other, please specify

10. Indicate on a scale of 1 to 5 (low to high) what you think to be the importance of the indicated issues in relation to good management of co-ordination of building services.

a. Clear responsibility for design, co-ordination and installation
b. Adequate design information and co-ordination details from the design team
c. Main-contractor to manage site co-ordination work
d. Main services contractor (HVAC) to manage co-ordination work
e. Independent construction project management team to co-ordinate services
f. Services consultant to assist site co-ordination with quick response to problems found
g. Co-ordination as an itemized cost in a contract
h. Good working relationship with the main-contractor
i. Competent and professional building services co-ordination team members
j. Quality and experience of contracting organizations

11. Use a scale of 1 to 5 (low to high) and indicate your preferred employment as one of the following project participants working with the main-contractor.

a. Nominated sub-contractor
b. Domestic sub-contractor
c. Principal services contractor

11a As one of the listed contractor in question 11, do you favour the provision of the main-contractor's building services co-ordinator and his team to co-ordinate your services with others. Please give a tick to the appropriate answer.

a. Very desirable
b. Necessary
c. Not necessary

If you are no completely satisfied with this co-ordinator, please briefly describe the reasons for your dissatisfaction.
12. If you have any comments not covered by the questions, please make them here.

THANK YOU FOR COMPLETING THE QUESTIONNAIRE
APPENDIX III

Summary of the case studies
SUMMARY OF THE CASE STUDIES

N.B. Over 25 case studies had been examined by the author. As some were similar and only 25 projects were presented for discussion and reference.

Prepared by: K. C. Lam
<table>
<thead>
<tr>
<th>Case No. abbreviation</th>
<th>Type of building</th>
<th>Degree of complexity</th>
<th>Procurement method</th>
<th>Performance of building services co-ordination</th>
<th>Adequacy of co-ordination</th>
<th>Factors affecting project performance</th>
<th>Client/designer satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Management of design &amp; construction</td>
<td>Teamwork</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adequate</td>
<td>Inadequate</td>
</tr>
<tr>
<td>1. (SHT)</td>
<td>Hospital</td>
<td>Very</td>
<td>T &amp; NSC</td>
<td>Poor</td>
<td>Inadequate</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2. (TMH)</td>
<td>Hospital</td>
<td>Very</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v, good</td>
<td>-</td>
</tr>
<tr>
<td>3. (QMH)</td>
<td>Hospital</td>
<td>Very</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v, good</td>
<td>-</td>
</tr>
<tr>
<td>4. (EDH)</td>
<td>Hospital</td>
<td>Very</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v, good</td>
<td>-</td>
</tr>
<tr>
<td>5. (CPH)</td>
<td>Hospital</td>
<td>Not complex</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v, good</td>
<td>-</td>
</tr>
<tr>
<td>6. (HOHH)</td>
<td>Hospital</td>
<td>Normal</td>
<td>T + PM + PSC</td>
<td>Very good</td>
<td>Good</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>7. (HCD)</td>
<td>Hotel</td>
<td>Complex</td>
<td>T + PSC</td>
<td>Very good</td>
<td>Good</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>8. (SH)</td>
<td>Hotel</td>
<td>Complex</td>
<td>T + PM + NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>9. (UCH)</td>
<td>Hospital</td>
<td>Very</td>
<td>D &amp; B</td>
<td>Very good</td>
<td>Good</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>10. (NDH)</td>
<td>Hospital</td>
<td>Complex</td>
<td>D &amp; B</td>
<td>Very good</td>
<td>Good</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>11. (TKOH)</td>
<td>Hospital</td>
<td>Complex</td>
<td>D &amp; B</td>
<td>Very good</td>
<td>Good</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>12. (CEC)</td>
<td>Exhibition centre</td>
<td>Very</td>
<td>JV</td>
<td>Good</td>
<td>Adequate</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>13. (CP)</td>
<td>High-rise office</td>
<td>Normal</td>
<td>T + PM + NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>14. (BCD)</td>
<td>High-rise office</td>
<td>Normal</td>
<td>T + PM + WPC</td>
<td>Very good</td>
<td>Good</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>15. (HKKB)</td>
<td>Hospital</td>
<td>Complex</td>
<td>T + PM + WPC</td>
<td>Very good</td>
<td>Good</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>16. (KCRC)</td>
<td>Railway station</td>
<td>Very</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>17. (TSKH)</td>
<td>Hospital</td>
<td>Complex</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>18. (POH)</td>
<td>Hospital</td>
<td>Normal</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>19. (HB)</td>
<td>High-rise office</td>
<td>Normal</td>
<td>T + NSC</td>
<td>Adequate</td>
<td>v, good</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>20. (HI)</td>
<td>Hotel</td>
<td>Complex</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>21. (MTRC)</td>
<td>Underground station</td>
<td>Very</td>
<td>T + NSC/DSC</td>
<td>Very good</td>
<td>Good</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>22. (HKEC)</td>
<td>Office</td>
<td>Normal</td>
<td>T + NSC</td>
<td>Good</td>
<td>Adequate</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>23. (CH)</td>
<td>Hospital</td>
<td>Normal</td>
<td>T + DSC</td>
<td>Very good</td>
<td>Good</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>24. (LTHC)</td>
<td>Hospital</td>
<td>Complex</td>
<td>T + NSC</td>
<td>Very good</td>
<td>Good</td>
<td>v, very good</td>
<td>-</td>
</tr>
<tr>
<td>25. (SESH)</td>
<td>Hospital</td>
<td>Complex</td>
<td>D &amp; B</td>
<td>Very good</td>
<td>Good</td>
<td>v, very good</td>
<td>-</td>
</tr>
</tbody>
</table>

Legend:

T - Traditional
NSC - Nominated Sub-contractor
DSC - Domestic Sub-contractor
PM - Project Management
PSC - Principal Services Contractor
D&B - Design & Build
JV - Joint Venture
WPC - Work Package Contractor

N.B. Case no. 1 – 16 are included in the Appendix. Case 17 – 25 were used as references to substantiate the evidence found in cases 1 – 16.
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<th>No. 5 (UCH)</th>
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<tr>
<td>Client Authority</td>
<td>Hospital Authority</td>
<td>Hospital Authority</td>
<td>Hospital Authority</td>
<td>Hospital Authority</td>
<td>Hospital Authority</td>
<td>Hospital Authority</td>
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<tr>
<td>Services Method</td>
<td>Complex</td>
<td>Complex</td>
<td>Complex</td>
<td>Complex</td>
<td>Complex</td>
<td>Complex</td>
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<tr>
<td>Procurement</td>
<td>Traditional</td>
<td>Traditional</td>
<td>Traditional</td>
<td>Traditional but</td>
<td>Traditional plus</td>
<td>Develop and</td>
</tr>
<tr>
<td>Method</td>
<td>NSC</td>
<td>NSC</td>
<td>NSC</td>
<td>all DSC</td>
<td>Project Management</td>
<td>construct by single contractor</td>
</tr>
<tr>
<td>Design Client</td>
<td>Experienced Master Consultant</td>
<td>Experienced health planner with M&amp;E consultant</td>
<td>Experienced health planner with M&amp;E consultant</td>
<td>Experienced overseas designers and local large M&amp;E consultant</td>
<td>Local designer with experienced M&amp;E consultant</td>
<td>Good designers</td>
</tr>
<tr>
<td>Coordination of services in design</td>
<td>Limited coordination</td>
<td>Proper coordination provided, but not full</td>
<td>Fully coordinated with more details</td>
<td>Not full coordination</td>
<td>Proper coordination provided, but not full</td>
<td>Adequate coordination details</td>
</tr>
<tr>
<td>Details of contractor</td>
<td>Main-contractor without experience in hospital project, poor site management with experienced services contractor</td>
<td>Japanese main-contractor with good services contractors</td>
<td>Japanese main-contractor and very cooperative services contractors</td>
<td>Large overseas main-contractor and new services contractors</td>
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<td>Experienced contractors having its own building services division outsourcing</td>
</tr>
<tr>
<td>Pre-construction work required coordination drawings are missing</td>
<td>Satisfactory</td>
<td>Satisfactory</td>
<td>Satisfactory</td>
<td>Coordination drawings are prepared by main-contractor</td>
<td>Coordination drawings are prepared by main-contractor</td>
<td>Good management of preparation of coordination drawings by PM &amp; main-contractor</td>
</tr>
<tr>
<td>Site coordination</td>
<td>Poor, due to unclear contract conditions, poor site management</td>
<td>Good work due to clear contract and effective site management</td>
<td>Good, due to clear contract conditions &amp; effective site management</td>
<td>High level of site management but with poor control of services contractor</td>
<td>Good site management with additional PM</td>
<td>Good site management, effect cooperation due to single point responsibility</td>
</tr>
<tr>
<td>Claim</td>
<td>Major</td>
<td>Minor</td>
<td>Minor</td>
<td>Major</td>
<td>Nil</td>
<td>Not known</td>
</tr>
<tr>
<td>Status of the project</td>
<td>Fail</td>
<td>Success</td>
<td>Success</td>
<td>Satisfactory</td>
<td>Success</td>
<td>Success</td>
</tr>
<tr>
<td>Consideration of coordination of services</td>
<td>Yes, but inadequately managed</td>
<td>Yes, adequate and well organized</td>
<td>Yes, adequate but not well organized</td>
<td>Yes, adequate but not well organized</td>
<td>Yes, well organized</td>
<td>Yes, well organized</td>
</tr>
<tr>
<td>Effective site coordination</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Site management</td>
<td>Loose and poor effective</td>
<td>Stringent but effective</td>
<td>Good and systematic</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Control of services contractor</td>
<td>Poor and not organized</td>
<td>Good</td>
<td>Very good, well organized</td>
<td>Fair</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>Team working</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Working relationship</td>
<td>Adversarial</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Contract terms regarding coordination</td>
<td>Unclear</td>
<td>Clear</td>
<td>Clear</td>
<td>Clear</td>
<td>Clear</td>
<td>Clear</td>
</tr>
<tr>
<td>Attitude of contractor</td>
<td>Negative</td>
<td>Positive (For reputation and business)</td>
<td>Positive (For reputation and business)</td>
<td>Positive (For entry into Asian market and reputation)</td>
<td>Positive (For business and reputation)</td>
<td>Positive (For D&amp;B company's business strategy)</td>
</tr>
<tr>
<td>Client's changes during installations</td>
<td>Too many</td>
<td>Still many</td>
<td>Many</td>
<td>Too many</td>
<td>Controlled</td>
<td>Some but finally controlled</td>
</tr>
</tbody>
</table>

Table: Comparison of the six cases
Layout of Data

1. Project Number

2. Type of Project - function of building; size (No. of storeys/beds)

3. Project Characteristics - client's needs; complexity; services requirements

4. General Information - contract sum; cost of services (% of contract sum); contract period; extension of time; claims/arbitration; records of site instruction

5. Procurement Path - type; details of contract; design team; construction team; project management

6. Coordination of Services - requirements; management; problems/outcome

7. Project Result - failure/success; causes/attributes

8. Details of Survey - contract; key persons; interviews; survey
A.1. **Project Number** - 1 (STH)

A.2. **Type of Project**

A 1400-bed regional hospital. This also housed the clinical department of Hong Kong’s second medical school of the Chinese University of Hong Kong.

A.3. **Project Characteristics**

A modern and very large teaching hospital with extensive medical facilities. In addition to the complexity of this sophisticated project, it was also the first hospital fully equipped with complex air-conditioning. The client (Health Authority) therefore decided to use an overseas master health consultant for this hospital complex and wished to make use of this prototype hospital for future design of modern hospitals.

A.4. **General Information**

a) Total contract sum - $425 million Hong Kong Dollars (0.3 m/bed)

b) Cost of building services - $154 million (36.6% of (I) above; 0.11m/bed)

c) Design period - about tow years (from 1978)
     Construction period - five years (from 1979 to 1983)

d) Extension of time - more than one year

e) Claims/arbitration - Both were submitted by the Main-contractor and HVAC services contractor as soon as the building was completed. Main issues were client’s changes, inadequate information and building services coordination problems. Defences from client included Main contractor’s inadequate project management; poor attendance etc. on specialist contractors, and in particular, the lack of coordination of services and building works as a whole (from arbitration documents).

f) Records of site instructions - over 3000 instructions were issued; some 1600 instructions covered building services installations. Many building/building services site instructions were identical (confirmation of instruction/use by all contractors). For the services instructions, they could broadly be categorized as below:

- services information - 20% of total
- client/design change - 20% of total
- services coordination - 60% of total

*For services coordination, the detailed breakdown was:

- identification of problem 20%
- conflict - service with service 20%
- conflict - service with building 20%
- advice on coordination details 40%
A.5. Procurement Path

This was a traditional system. The architect was both lead-designer and project manager. The Form of Contract was similar to JCT80.

a) As this was one of the largest hospital in South East Asia, a large Australian master consultant (architect, structural and civil engineer and building services engineer) was appointed and worked in conjunction with a local quantity surveyor. The client was the Medical and Health Department/Building Development Department. The client’s representative was made up of professional architects and engineers and health specialists. With the exception of the client’s project architect, all other members of the client team did not have sufficient experience in modern hospital planning and design. The master consultant had no experience in construction management in Hong Kong and therefore adhered to the client’s quantity surveyor’s advice on the use of standard practice for Govt. project, i.e. traditional procurement system without considering the complexity of this project (This was the first large hospital, no one had experience).

b) The construction team was based on the traditional general contracting, i.e. The Main-contractor with his domestic sub-contractor as well as client’s nominated sub-contractors (most were building services specialist contractors). It was thought by the client that this complex project could be handled in the same way as a typical government project with “mutual trust and cooperation” (From Govt. file), and special attention was therefore not given to details of contractor’s project management. All contractors also treated this project as a very large Govt. project and thought they could manage the project in the usual ways.

c) The project management system was:

1. Client - bureaucratic with uncontrolled multi-headed users
2. Client representative - bureaucratic, typical government officer
3. Master consultant - bureaucratic, architect dominated the whole management of design and construction; management of design was well organized
4. Main-contractor - bureaucratic with inadequate project management
5. Services-contractors - lack of project management

A.6. Coordination of Services

a) Client - no previous project result of large and modern and highly serviced hospital, and they insisted on using standardized hospital design criteria (e.g. floor to floor height) which had cause serious coordination problem due to inadequate spaces for services installations, inadequate project management and too many changes

b) Designer - experienced professionals but with minimum detailed design coordination; because of the ACE contract, coordination drawings were not provided for this complex project and therefore resulting site coordination problems. The building design was not conducive to effective coordination of services (i.e. inadequate services ducts and headrooms for this highly serviced building; lack of close integration of services within the building structure. All services had been checked by an independent
consultant but due to management problem, identified coordination problems were not adequately followed-up.

c) Main-contractor - as responsibility for services coordination was not clearly defined in the contract, there was a lack of interest in managing services with all services contractors. Also, there was poor working relationships with some services contractors.

d) Services contractors - as responsibility for services coordination was not clearly defined in the contract, there was a lack of interest in coordination of services. Very traditional working was the norm. and coordination of services was not carefully organized and carried out systematically.

e) Client’s B.S. site staff - relied too much on the M&E consultant for solving all coordination problems probably due to their limited experience in hospital project. However, they took part in the day-to-day coordination group with the M&E consultant later and achieved significant improvement in clearing services conflicts, etc. and improved the coordination chaos a lot.

f) Main causes of inadequate coordinations are:

1) inadequate design coordination (from surveys in consultant’s office) for this complex project. Services had to be fixed in very tight spaces with unfavourable structural design. Drawings were mostly single lines for HVAC and electrical services. Fully prepared combined services drawings were not provided.

2) Poor contract details about responsibility for coordination No specific and clear information was given regarding:

   • Main contractor’s management of M&E services installation and preparation of fully coordinated services drawings (The main-contractor only provided one qualified BS engineer and a few assistants for this highly serviced building. However, responsibility for carrying out combined services drawings (CSD) left-out. Without CSD, it was not possible to achieve smooth building construction and services installation).

   • Sub-contractor’s management of M&E services installation with the Main-contractor’s preparation of CSD again had been left out. (from exam. of documents)

3) Poor main-contractor’s management of services installations such as no preparation of SCD; inadequate programming of services/sequencing of work; lack of monitoring of services installations and poor working relationship with the HVAC services sub-contractor.. (from surveys and interview with designers and services contractors)

4) Poor sub-contractors’ management of services installations i.e. lack of CSD, installation programmes and agreed sequencing of works (from discussions with project manager and exam. of documents and interviews)

5) Adversarial working relationship between the Main-contractor and the HVAC service sub-contractor and the architect.

6) Many late client’s changes causing re-designs, abortive works, re-coordination of services and disruption of progress.
A.7. **Project Result**

a) Delay in completion - about two years as a result of inadequate construction management and poor services coordination

b) There were claims from the Main-contractor and his HVAC services contractor. Result from arbitration revealed the following facts:

- Complex building with inadequate integration of services
- Inadequate services coordination from both parties, i.e. designers and contractors
- Inadequate construction management by the Main-contractor and his services contractors
- Too many changes from the client as a problem of multi-headed client
- Implicit contract document with regard to coordination of services
- Difficult control of nominated services sub-contractors
- Inadequate design and construction time

c) The Main-contractor won the case but he was awarded one million dollars only (as he should undertake the main coordinating role) and worked with all services subcontractors. The client had learnt a pain lesson from this project and he would take serious attention to services coordination in future projects. However, he saved 20 million which would be paid to the Main-contractor if there was no arbitration.

A.8. **Details of Survey**

a) From documents in consultant’s office
b) Study of arbitration reports
c) Discussions with services consultant and project personnel
d) Discussions with site agent, services engineer and contractors
e) Further discussion with client’s representative (services project engineer)
f) Observations of services installations during building construction and from site record book data
B.1. Project Number - 2 (TMH)

B.2. Type of Project

A 1656-bed district general hospital designed to cope with an ever-increasing demand for medical services in a new town and its adjoining areas.

B.3. Project Characteristics

A much larger hospital than Case 1 (Project Number 1), it was indeed a very complex project. Building and M&E services designs were even more sophisticated. The client (Health Authority) again selected overseas specialist consultants for this special project. Design/construction problems experienced in Case 1 were particularly noted and avoided in this project. However, the basic design of the hospital building was pretty much based on Case 1 in many aspects, e.g. design concepts, systems, etc. but with significant improvement in integration of services and accommodation of hospital equipment.

B.4. General Information

a) Total contract sum - $589 million Hong Kong dollars (0.36M/bed)

b) Cost of building services - $202 million (34.3% of (a) above; 0.12M/bed)

c) Design period - more than two years (from 1981)
Construction period - five years (from 1984 to 88)

d) Extension of time - more than one year

e) Claims/arbitration - There were claims from the Main-contractor (for extension of time). Details were treated as confidential. Unofficial information revealed that these claims were based on client’s changes, weather and some services coordination problems. However, services were deemed to be satisfactorily designed and installed.

f) Record of site instructions - Not available due to (e) above. However, it was reported by the project engineer that more than 2500 site instructions had been issued and about half of this issue was building services. Again, the building services instructions were categorized by the client as follows:

- services information 30% of total
- client/design change 25%
- services coordination, e.g. 45%*

N.B. In this case study, the client’s project engineer was quite satisfied with the abovementioned issuing as they were deemed to be reasonable for a project of this size, and contractually, all advice must be confirmed by S.I. in accordance to Govt. practice.

* For services coordination, the detailed breakdown was:
• identification of problem 19%
• conflict - service with services 34%
• conflict - service with building works 20%
• advice on coordination details 27%

B.5. Procurement Path

This was a traditional system. The architect was both lead-designer and project manager. The Form of Contract was similar to JCT80. The project was again based on a Main-contractor/Nominated B.S. Sub-contractor arrangement as in Case 1 (STH).

a) Similar to Case 1, but independent overseas hospital planner and building services consulting engineer were used. In this case, the services consultant had a equal status as the architect. This was conducive to the overall building design as any effects on services design/installation could be voiced for better integration of services into the architectural and structural designs (Case 1 did not have this benefit and the services engineer would have to work under pressure imposed on him by the architect partner). To improve coordination of services, in addition to the extra service of providing combined services drawings, the M&E services consultant was also requested to have a B.S. coordination team on site. Also, as an unusual arrangement, the client also assigned two additional resident building services engineer (one as senior) to lead a team of site engineering staff. Obviously, this team would work more closely with the Main-contractor in all B.S. installations than in Case 1.

b) The construction team was based on the traditional general contracting, i.e. Main-contractor/Nominated Services Sub-contractor. However, in view of the complex services installation, the Main-contractor was instructed to undertake the main coordinating role and coordinate his work with all services contractors (as a priced item). Within the contract documents, a minimum number of B.S. supervisory staff for the Main-contractor and each of the Nominated Sub-contractor was specified to facilitate sufficient management of services installations. This arrangement appeared to be working reasonably well (commented by the client).

c) The project management system could be viewed from the following investigations:

1) Client - still bureaucratic and multi-headed users, but with significant improvement due to lesson learnt in Case 1
2) Client’s project engineer - more concerned with the management of services design and coordination
3) Client site engineering staff - to avoid problems as in case study 1, they had provided a very good monitoring system for services and building construction
4) Design team - management of services and hospital equipment was treated as an important issue. There was also a special B.S. engineering team on site for managing services design and coordination matters with the Main-contractor
5) Main-contractor - Japanese style with strong B.S. coordination team and backed up by modern construction management (e.g. computerized programmes)
6) Services contractors - very cooperative team of well organized large contracting organizations.
B.6. Coordination of Services

a) Client - they learnt experience from Case 1, but there were still multi-headed problems (lack of control of hospital users) which still affected services and building

b) Designer - they had seen the Project No. 1 and identified the root causes of most of the design/coordination problems. However, as hospital design was very complex, there were still coordination problems in this complex building. As additional service, the services consultant would provide adequate coordination drawings and detailed design drawings for the Main-contractor’s site coordination work. Furthermore, communication was significantly improved in this project by the introduction of site project staff (assisting services contractors and Main-contractor)

c) Main-contractor - as requested in the contract, he had taken up the main coordinating role and provided a strong building services coordinating team (as a priced item). Efficient “Japanese style” construction management was provided. The Main-contractor would provide: a) all necessary combined services drawings; b) all associated building works; c) site coordination with all services sub-contractors, and d) solving coordination problems with consultants and all services contractors. Most importantly, it was the Main-contractor’s will to do a good job for future business growth.

d) Services Sub-contractors - all accepted services coordination responsibilities right from the beginning and prepared to cooperate with the Main-contractor. They also prepared their combined services drawings with the Main-contractor on site.

e) Client’s B.S. site staff - they provided good monitoring of the whole building services installation and liaised with all consultants, Main-contractor and services sub-contractors for effective coordination of services. (The key B.S. site staff had worked in the Project No. 1 and could therefore offer better management of services)

f) Main causes of effective coordination

1) Better brief; client noted flexible approach to planning of hospital equipment
2) Good project management from the client’s B.S. project engineer as he provided better control of client’s input and requirements into services designs. Besides, he initiated better management of design and construction as a result of his previous involvement in the Project No. 1 (i.e. coordination chaos were to be eliminated from design to contracting).
3) Building and building services were carefully integrated. Services had also been coordinated by the M&E services consultant. Though not completely free of services coordination problems, the designs were as complete as possible (high quality design drawings which could easily be converted into detailed combined services drawings), especially with the provision of coordination details and better design information.
4) Good project management from Main-contractor, especially the provision of a strong services coordinating team who provided all CSD, programming and monitoring of M&E services
5) Sub-contractors’ participation in services coordination at a price
6) A reasonably well organised management structure existed in each of the design and construction teams
7) Effective communication and good working relationships between all project participants. Besides, good control of services sub-contractors appeared to have a direct bearing on the project performance.

Of course, there were still some coordination problems, e.g. complex services within tight ceiling voids and Main Services Corridors which appeared to be a problem of design coordination rather than site coordination problems.

B.7. Project Result

a) Again, there was delay in completion as a result of adverse weather, change of designs, additional work and some disruptions due to services installations, etc. But on the whole, the project was deemed to be satisfactorily completed. The quality was also high. Claims submitted by the Main-contractor was subsequently settled between the Govt. and the claimant.

b) Coordination of services was fully implemented right from the beginning of this project, though not perfect, it was considered very satisfactory by the client and all parties. The introduction of the management of services appeared to work very well in terms of technical and managerial issues.

c) As far as coordination of services was concerned, the control of all services sub-contractors based on the traditional general contracting was considered quite satisfactory. The project success indicated quality of project management was important. Of course, cultivation of good working relationship as seen in this project was an essential attribute to this high project performance.

d) Selection of the best organizational forms and project participants was very satisfactory.

e) It appeared that both the design and construction times was inadequate and longer periods should be allowed for achieving better project results.

B.8. Details of Survey

a) From discussions with client’s project manager (B.S.) and the key site personnel
b) Inspection of drawings and contract documents from the design and construction teams

c) Discussions/interviews with services sub-contractors and Main-contractor coordination team member

d) Observations of services installations during building construction and from site record book data
C.1. Project Number - 3 (QMH)

C.2. Type of Project

This Govt. project consisted of extension to an existing 1295 bed regional hospital. The extension included the erection of two blocks of high-rise buildings, providing a further 750 beds. The main block basement would also house a central plant that could provide all engineering services to the entire hospital (new and existing). The design standard was at least equal to our case study 2.

C.3. Project Characteristics

Although this project had only 750 beds, it was indeed a very complex building for four reasons:

a) the main block was a 23-storey (with six basements) high-rise building, and one of the world’s tallest hospital buildings; the other block was 10 storey high

b) a new central plant was incorporated for the entire hospital. Therefore, the capacity of each service system would be based on 2045 beds - a very large regional hospital in reality

c) the new extension would be connected to the existing hospital buildings which would be re-developed later.

d) site constraint factor - not enough working space within the existing hospital site

The design standard was very high. Also, the building must cope with future requirements which could not be easily identified and incorporated into designs.

As this was again a very complex health building project, the designs were also provided by a U.K. hospital architect and a U.K./local M&E services consultant. They had visited both cases (1&2) in order to give the best designs and more effective coordination of building services.

C.4. General Information

a) Total contract sum - $400 million Hong Kong dollars (0.53M/bed)

b) Cost of building services - $253 million (63% of (a) above; 0.34M/bed)

For the 750 bed building, the approximate cost of M&E services was about 50% of the total cost of building

c) Design period - more than two years (completed in 1985)

Construction period - about five years (1985 to 1989)

d) Extension of time - about two years (completed in 1991)
e) Claim/arbitration claims had been submitted by the Main-contractor. Arbitration was also used. However, the claim was finally settled. The Main-contractors’ claim was based on the prolongation of the project as a result of client’s changes/redesign and additional services coordination problems (Not contractor’s coordination chaos). The contractor won the case, but the actual sum claimed was not know to outsider.

f) Record of site instructions - Not readily available due to (e) above. But it was advised by the resident B.S. engineer that over 2000 site instructions had been issued. Some 1300 instructions was building services element: From the engineer's records, these instructions could be grouped into the following categories:

- services information - 35% of total no.
- client/design change - 30% of total no.
- services coordination 35%

* For services coordination, the detailed breakdown was:
  - identification of problems 25%
  - conflict - service with service 30%
  - conflict - service with building works 20%
  - advice on coordination details 25%

Owing to the effective integration of services and adequate headrooms, conflict of services was not of significant effect in this project.

C.5. Procurement Path

Similar to case study 1 & 2, this was a traditional system. The architect was still the lead designer. He also acted as the project manager. The Form of Contract was similar to JCT80. The project was again based on a Main-contractor/Nominated B.S. Sub-contractor arrangement.

a) Both the architect and services consultant had never worked before. Importance of services and the problems of poor coordination were again highlighted by the client (Health Authority). Hence, the architect was very keen on services integration and provided very effective solutions in the overall building design.

b) As a typical Govt. project, the construction team was based on the traditional general contracting, i.e. Main-contractor/Nominated B.S. Sub-contractor. Since the client had stressed that services was a problematic area, similar to case study 2, the Main-contractor would have undertake the main coordinating role, and he would coordinate all services installations with the specialist services sub-contractors. Each of the sub-contractors also included element of coordination of services in his contract document.

c) The project management system was similar to case study 2. Again, a large Japanese Main-contractor was selected to work with a very reputable U.K. based HVAC services contractor. All other services sub-contractors were very experienced organizations.

1) Client - bureaucratic and multi-headed client problems still existed
2) Client’s project engineer - picked up experience from case study 1 & 2 and provided even better project management. But still had difficulties in coordinating the hospital users

3) Client site engineering staff - provided good monitoring of services and building construction. Prompt advice was given to Main-contractor for necessary “follow-up” action with due regard to overall building construction

4) Design team - very cooperative and provided good design management. Site management was adequate

5) Main-contractor - Japanese style with reasonable control of sub-contractors

6) Services contractors - very cooperative and managed work reasonably well

C.6. Coordination of Services

a) Similar to case study 2, i.e. a systematic approach had been given to this problematic area, i.e. management of design by designer first, i.e. services were fully integrated and the whole building design did consider the ease of services installations. (Adequate services ducts and strategically located plant room had been carefully planned for this objective)

b) Preliminary coordinated services drawings and sufficient information had been provided by the services consultant for Main-contractor’s further detailed coordination. Main-contractor would provide necessary combined services design, planning of services and building works, control of services installations and solving coordination problems with all sub-contractors and consultants.

c) In general, services were effectively coordinated by all sub-contractors with the Main-contractor. As usual, in certain critical areas, e.g. plant rooms, congested voids/spaces/corridors, there were still some major coordination problems. However, they were mostly managed by the sub-contractors themselves.

d) Reasons for effective services coordination were:

1) Adequate integration of services into building design

2) Services had been coordinated by the M&E consultant and adequate design information was available

3) Main-contractor and all services sub-contractors undertook coordination work together. Installations were fully programmed and monitored

4) Effective site communication and good working relationships between all project participants

5) Coordination work had been clearly specified and all contractors would have priced this work in each contractor’s contract, and therefore resources were allowed for and available for this expensive responsibility (clear contract)

6) Efficient site management by the consultant and client’s B.S./Building site staff

C.7. Project Result

a) There was delay in completion as a result of adverse weather and client changes, for uncoordinated end users. Of course, there were some areas where services did create some coordination problems, but this was reported to be insignificant compared with
the client’s re-design of building and frequent changes. Furthermore, the Main-
contractor’s tendered sum was HK$20 million below the second lowest tenderer,
hence, the contractor would recoup losses whenever opportunities existed during the
course of the complex construction process. Anyhow, the Main-contractor won the
case and the arbitrator awarded something over HK$30 million to the contractor
(compared to Case 1 with one million only).

b) As far as services coordination was concerned. For this sophisticated building which
was highly serviced, all project participants would consider that this project was a
successful one. It would be argued that it was still difficult to control the services sub-
contractors, and the Main-contractor had to execute the coordination work with
tremendous efforts. As contractually, they were still two separate parties, and the sub-
contractors still needed a lot of mothering. The Main-contractor would also make use
of the sub-contractor’s performance to claim for extension of time, etc. - as used in the
Main-contractor’s arbitration.

c) Construction time still appeared to be tight

C.8. Details of Survey

a) Discussions with client’s B.S. project manager and resident site engineer

b) Inspection of drawings and contract documents

c) Discussions/Interviews with major services sub-contractors and the Main-contractors’
coordination team

d) Observations of services installations
D.1. Project Number - 4 (EDH)

D.2. Type of Project

This was a 1752-bed regional hospital designed to meet the medical-care needs of half the population of Hong Kong Island. Again, this was a vertical hospital design. The hospital was sited on a hillside. The complex consisted of several components: the 14-storey main hospital, a 12-storey special block; a 9-storey pathology block; a 8-storey polyclinic; a plant building; a nurses’ training school and staff quarters. The complex had a total gross floor area about 188,000 square metres, and spread over a 10-hectare site.

D.3. Project Characteristics

This was by far the largest hospital in Hong Kong. Hence, it would be a very complex and costly project. The complexity stemmed from:

a) highly serviced for this modern hospital

b) the largest medical facility equipped with the most sophisticated medical equipment/technology

c) again, a vertical building design for services, structural framework, medical equipment, hospital functions

d) a flexible design which could cope with possible future changes in layout and distribution of services

D.4. General Information

a) Total contract sum - $1333 million Hong Kong dollars (0.76M/bed including civil engineering works)

b) Cost of building services - $550 million (42% of (a) above; 0.31M/bed)
   Again, HVAC cost represented approximately half of this cost.
   The design standard was at least equal to our Case 3.

c) Design period - more than two and half years (completed in 1987)
   Construction period - about three and half years (1988 to 1991)

d) Extension of time - one year (completed in 1992)

e) Claims - again, claim had been submitted by the Main-contractor. This was based on increased construction cost of hospital overrun as a result of the client’s large number of changes, etc. The claim was finally settled, but details of the settlement were confidential.

f) Record of site instructions - some 3000 instructions had been issued. As identified in (e) above, there were over 3000 design changes (building layout and services) as a result of
changes in client requirements. Again, there were over 1300 building services site instructions covering the issues.

- services information 30% of total
- client/design change 35%
- services coordination 35%*

* For services coordination, details of the breakdown were:

- identification of problems 25%
- conflicts - service with service 35%
- conflicts - service with building 20%
- advice on coordination details 20%

The abovementioned conflicts were mainly due to difficulties in coordinating many services relating to tight space provision (about 50% of the summation of the above figures of 35% and 20%) within the plant building. With the exception of the operating theatre floors, conflicts in tower blocks were not particularly critical when compared with the podium floors (especially plant buildings) where extensive services had to run from various plant rooms and distribute to different tower blocks.

D.5. Procurement Path

The project was let on a traditional procurement method using the Hong Kong General Conditions of Contract (similar to JCT80) with fluctuations. The procurement path was different from usual practice, domestic services sub-contractors were used to procure building services. The architect was the lead designer. He also acted as the project manager.

a) Both of the project architect and services consultant were inexperienced in large hospital project, they therefore worked with a reputable U.K. medical planner and a U.K./Hong Kong services consultant. The U.K. health planner was the architect in-charge of the case study No. 2 and therefore versed in local practice and the importance of services integration for high-rise hospital. However, the local architect/M&E consultant would be the chief designers. The U.K. health planner and the U.K./H.K. services consultant were heavily involved in the planning of this project. All building and M&E services designs were mostly developed by these specialist consultants and the local designers would have to further develop the scheme designs into detailed designs. The client would still assume the role of team leader and project manager.

b) The construction team was formed by a joint venture of an international construction company versed in hospital construction and a well known local building contractor who had successfully constructed a general hospital some years ago.

As advised by the M&E services consultant, nominated services sub-contractors needed to be replaced by domestic services sub-contractors for better management of building services. All these services contractors would have to accept and use the Main-contractor’s own form of contract. And therefore, problems appeared as most local
services contractors boycotted this bidding as they would no longer be protected by the client as in the nomination mode. This had caused approximately 8 months delay in the tendering activity.

The Main-contractor therefore selected an overseas air-conditioning specialist contractor (as a family of the international company) and also managed to have some local services contractors (e.g. electrical services and plumbing) who were arguably not the most experienced contractors for this large and complex project. Other services contractors (e.g. fire, medical gases, boiler etc.) were however considered good contracting organizations.

c) From interview with the M&E services consultant (Also with reference to the Govt. Chief Engineer’s comment on contract arrangement for Govt. hospital projects), it had been identified that this special choice of domestic services sub-contractors was based on the following reasons:

1) The Main-contractor could entirely control all sub-contractors especially in the case of highly serviced construction requiring a high degree of inter-discipline coordination.
2) The domestic contractors’ problems would be the Main-contractor’s problems, and he must resolve the problems at once for their mutual benefits (as he selected his sub-contractors, he could work with them more efficiently).
3) The Main-contractor was made contractually responsible for coordinating his works with all building services.
4) The client was still not entirely satisfied with the use of nominated services contractors in case study 2 and 3, as the Main-contractors in these two projects still had difficulties in managing/controlling the nominated sub-contractors.
5) In theory, communication between the Main-contractor and the services contractors could be improved, this would be conducive to the coordination process.
6) Reduction of claims as the Main-contractor could no longer make use of the performance of his services contractors (except design problems). This was the major reason that the client initiated the change.
7) In theory again, there would be no loss to the client (except the increase in tender sum as the Main-contractor would take more risks and the need for more resources). But he must provide a more complete design to the Main-contractors.
8) Reduction of managerial problems as the client would have a single point of contact only, i.e. the Main-contractor and his building services coordinator.

d) The project management system was similar to case study No. 2 and 3. But in this case, services would be entirely managed and coordinated by the Main-contractor.

1) Client - bureaucratic and multi-head client problems still existed
2) Client’s project engineer - same as in case study No. 2/3 and provided good overall management. However, they still could not manage their client. i.e. the hospital users
3) Client site engineering staff - same as in case study No. 2/3 but mainly in site supervision and reporting.
4) Design team - both were Chinese firms and therefore very cooperative.
5) Main-contractor - mainly Western style. The Main-contractor was strong in construction and also backed up by the local partner. However, as far as
management of services was concerned, it was not so well organized and managed in the beginning. The Main-contractor even had difficulties in manoeuvring his own family - the A/C contractor. However, after a long learning period, the services engineer did organize his services department and managed the various services contractors together with the building up of a coordinating team.

6) Services contractors - worked well with the Main-contractor, especially those local services contractors. The A/C sub-contractor was however a bit difficult to manage (equal status with the Main-builder in overseas).

D.6. Coordination of Services

a) This was a highly serviced large hospital project demanding a high degree of management of services from design to construction. The building was considered satisfactorily completed but there were still some coordination chaos - inefficient services installations; conflicts, disruption of works and re-coordination of services etc.

b) Similar to case study No. 3, a systematic approach had been used (i.e. coordinating team and procedures). The Main-contractor in this case had however to fully coordinate all his domestic sub-contractors.

c) In general, services had been satisfactorily coordinated in all tower blocks. However, it was not the case for the podium floors designed to have very extensive building services within very congested spaces. Most local services contractors still used to coordinating services on site instead on drawings. Furthermore, there were about 30000 drawings to be produced for services. Owing to the large number of combined services drawings to be provided, the Main-contractor had encountered difficulties (lack of experience and adequate staffing) in producing fully coordinated services drawings with their services contractors on time (especially for the complex podium floors housing all service distribution mains). Also, most of the sub-contractors did not have adequate experience with regard to services coordination and so work had been started late and subsequently held up the building programme (Podium floors). In any event, there were serious services coordination problems as a result of lack of coordination between services needs and space provision - an obvious flaw in design integration.

d) Comments on services coordination

1) Though not entirely satisfactory and problem-free, the complex services were however at last all coordinated and installed in this complex building. As stated previously, this was the advantage of this domestic contracting system - the Main-contractor had to manage all his problems with all his contractors no matter how difficult the services and building designs were.

2) Design was incomplete and thus the contractors had experienced difficulties in coordinating the various building services. Design also appeared not to have buildability. Furthermore some services were inadequately coordinated by the consultant.

3) The electrical/plumbing contractor wanted to use this project as a foothold for entry into the building services market, and he would therefore prepared to work more cooperatively with others. This would improve the coordination process. The A/C contractor however required sometimes to adjust himself to work with the Main-
contractor notwithstanding that they were from the same organization. All other services contractors were typical good people who would work with others.

4) Initially, the Main-contractors coordinating team was not well organized and created some “services coordination chaos” (non-completion of combined services drawings, the podium floors were too large and fitted with non-standard layout of services; inadequate site coordination coupled with difficult sequencing of service installations). This was also partly due to inadequate experience and management in coordinating hospital services amongst all contractors. The coordination work could be better organized if the Main-contractor had picked up the experience gained in our case study 1 to 3.

D.7. Project Result

a) In general, services had been installed quite satisfactorily but not smoothly.

b) Again, there was one year delay in completion as a result of client changes. Inherently, there were also services coordination problems, but the service element was not a critical item in the claim. The claim was finally settled. Apparently, the client did accept his fault, i.e. too many changes and the necessary re-coordination of M&E services with building elements, but not services coordination problem as this was deemed to be the Main-contractor’s own responsibility - This demonstrated the merit of this domestic sub-contracting system (provided the design was complete). The domestic services contractor system appeared to be a workable system. Compared with our case study No. 2 & 3, it would also argue that the performance of the nominated services contractors were quite satisfactory, but they were difficult to be welded together with the Main-contractor’s organization. For best coordination of services, all M&E services would have been fully designed by the consultants. Apparently, service designs for this project were incomplete and thus imposing heavy burden on the Main-contractor and his services contractor. It was clear that quality of services design (integration and coordination) was the salient factor for achieving high project performance. Organizational form such as this domestic sub-contractor only improved integration of team members for smooth working.

c) From surveys, it was felt that adequate time and efforts had not been allowed for preparing coordinated services details by both designers and contractors. Furthermore, overall management of services by all contractors had a significant impact on the slow progress of the project during the early stage of the construction.

d) Again, the construction time appeared to be tight for this complex project. To improve project performance, it would not be unreasonable to allow more time for the contractor’s detailed planning and the complex coordination process.

D.8. Details of Survey

a) Discussions with the M&E services consultant and client’s project engineer
b) Discussions with the Main-contractors’ B.S. coordinator
c) Discussions with services sub-contractors
d) Inspection of drawings and contract documents
e) Observations of service installations

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E.1. Project Number - 5 (CPH)

E.2. Type of Project

The redevelopment of an existing psychiatric hospital (1740 patients). Two identical low-rise horse-shoe-shaped blocks (3-storey building) were designed and provided to accommodate a total of 752 patients. Each of the new block was to stand in a footprint of roughly 3,000 sq. m. The whole block would be air-conditioned.

E.3. Project Characteristics

A small hospital complete with special facilities for mentally ill patients. Service requirements would be similar to an infirmary (no complex medical gas, steam plant and sophisticated A/C systems). The project must be completed within twenty-two months.

E.4. General Information

a) The contract value - HK$238.6 million including services (0.317M/bed)

b) Cost of Services - HK85 million (about 40% of (a) above; 0.11M/bed)

c) Design period - within one year (completed in 1993)


e) Claims - nil

f) Record of site instruction - Totally, there were about 300 site instructions. About 165 was building services element

The services instructions could be broken down into the following categories:

- services information 57%
- client/design change 10%
- services coordination 33%*

For services coordination, the details were:

- identification of problem 40%
- conflicts - service with service 15%
- conflicts - service with building 10%
- advice on coordination 35%

N.B. Due to the effective management provided for services, coordination of services was not a problem in this contract.

E.5. Procurement Path
a) Same as project no. 4. This project was based on traditional system. Tender was arranged to have full Bills of Quantities including building services and domestic services sub-contractor arrangements as the Govt. thought this would be a better system.

b) The entire redevelopment was designed by the Govt. The Main-contractor was a large local contracting organization.

c) The Main-contractor would take up the main coordinating role in managing his construction with all domestic services sub-contractors.

d) The project management system was similar to case study No. 2 to 4.

1) Client - improved project management, multi-head client problem had been solved by effective project management using single point of administrative control.
2) Client’s project engineer - effective management
3) Design team - very cooperative; good management of design and construction (N.B. this is not a complex hospital project compared to case study 1 to 4).
4) Main-contractor - local construction firm with adequate project management, services would be looked after by a services coordinator and backed up by a team of technical staff.
5) Service contractors - Though worked under the Main-contractor, all services sub-contractors provided reasonably good management of their services installations.

E.6. Coordination of Services

The project was completed on time and with very few of the coordination problems highlighted in case study No. 4. Services were deemed to be satisfactorily coordinated and installed for the following reasons:

a) This was a psychiatric hospital building, and services were basic provisions and not sophisticated. Furthermore, services had been adequately integrated with the building and structural elements.

b) As identified in case study No. 4, more effective and direct control of all services contractors under the domestic sub-contractor mode was a norm as the Main-contractor was made contractually responsible for coordinating the works of the domestic sub-contractors.

c) Potential problems relating to services had been addressed by producing as near to a full design as possible prior to tender (Also due to the effect of full B.Q. for services). This was not a complex hospital building and the service systems were relatively simple. For a low-rise block, provided sufficient spaces had been allocated for service installations. Fully coordinated service installation can be achieved when services and construction had been planned, managed and monitored. Also, the use of combined services drawing was of great importance.

d) The Main-contractor fully comprehended what was required in relation to coordination of services and he priced this accordingly. Of course, he also acted accordingly -
management of service coordination with all sub-contractors by providing a full-time services coordinator on site.

e) Services contractors had priced coordination requirements and were also prepared to cooperate with the Main-contractor. Hence, they would work things out to their mutual benefit.

E.7. Project Result

a) As there were no critical client’s changes (due to the simple nature of this hospital function) and very few coordination problems, the project was deemed to be a very successful one.

b) Even for a low-rise block liked this project, as far as building service installation was concerned, the Main-contractor did provide good management of this vital element for his domestic services sub-contractors. There was good coordination of services as a result of good control of services contractors in managing services installations and this demonstrated that the domestic contracting was a workable solution especially when the design was detailed and fully completed. Of course, it was still necessary to base on a sound coordination system such as service coordination responsibilities and details, procedures, planning, preparation of combined services drawings, programmes of works, interface of services and monitoring and controlling. Furthermore, the designer had carried out effective services integration and provided the basic service coordination for the Main-contractor’s final site coordination work.

E.8. Details of Survey

a) Interviews/discussions with the Main-contractor/sub-contractors
b) Discussions with client’s building services engineer
c) Inspection of drawings and contract document
d) Observations of service installations
F.1. **Project Number** - 6 (HOHH)

F.2. **Type of Project**

This was a redevelopment of an existing small district hospital. The new buildings would have 316 beds (26,000 sq. m.) and situated in 70,000 sq. m. site.

F.3. **Project Characteristics**

Through small in terms of number of bed, it was still a very complex hospital buildings as it had to house all necessary medical facilities and service systems for exactly the same design as in a large regional hospital. Since land was a problem, the hospital could not follow the mainstream of low-rise, loose-fit building form, and the four main hospital buildings (6-7 storey), (3 nos.) had to stand on a two storey podium. The hospital had been subvented by the Hospital Authority. But the minimum design standards still needed to follow Govt. standard which was equivalent to the UKDHSS requirements.

F.4. **General Information**

a) The contract value - HK$408 million including services (1.29M/bed)

b) Cost of building services - HK$164 million (or 40% of (a) above; 0.45M/bed)

c) Design period - about two years

d) Construction period - over three years (1994 to 1997)

e) Claim - nil

f) Record of site instructions - totally 330 no. had been issued. Out of which, about 170 was M&E services element.

The breakdown of services instructions was shown below:

- services information 35%
- client/design change 25%
- services coordination 40%

Details of services coordination were:

- identification of problem 32%
- conflicts - service with service 20%
- conflicts - service with building 18%
- advice on coordination 30%

F.5. **Procurement Path**
a) Same as project no. 5, the traditional path was adopted. The architect was the lead designer and project manager. The Main-contractor had however to select and control all his domestic services contractors.

b) The architect was a local/overseas hospital planner. M&E services were designed by a large local services consultant.

c) The Main-contractor was a large and very experienced building/civil contractor who also had experience in hospital construction. The Main-contractor had selected very cooperative services contractors who however did not have experience in hospital engineering.

d) The project management systems in the design and construction teams were:

1) Client - inexperienced client; not bureaucratic and delegated as much as possible to the architect; multi-headed client problem still existed but not critical as the client needed to have the hospital on time and any changes would be seriously considered and avoided.

2) Client’s project representative - a small team of technical people who provided constant feedback to client about progress of work and the consultant’s project management. They also walked along the building site with open eyes and liaised with the client’s consulting architect/engineer with regard to quality of construction/services installations as well as identification of problems.

3) Design team - very cooperative; reasonably good management of design and construction.

4) Main-contractor - prepared to complete the project on time and managed to control his services contractors quite successfully.

5) Services contractors - a good working team and generally very efficient in managing services installations even without the mothering from the Main-contractor. The Main services contractor (AC&V contractor) had generally provided adequate planning and management with other services contractor on site.

F.6. Coordination of Services

a) The project was completed as scheduled. There were of course, some critical coordination problems for this complex buildings, but they had been resolved by the Main-contractor and his domestic services contractors.

b) The design team was experienced in hospital projects and they had produced an integrated building with adequate accommodations for services. Basically, services had been coordinated and sufficient details were available for contractor’s detailing of works.

c) In principle, the Main-contractor would take up the coordinating role and coordinate all service installations with his building construction. The Main-contractor would still provide a services coordinator and sufficient technical staff to manage the coordination process in order to satisfy the specified requirements as stipulated in the contract document. However, he had wisely made use of the domestic contracting system, and made special arrangement with the AC&V contractor to include the individual boiler
plant, electrical and fire services contractors, etc. in his contract, and prepared all combined services installation drawings and combined builder’s work drawings at an agreed cost. This, in fact changed the domestic service contracting mode into a domestic Main or Principal M&E services contractor, and achieved significant improvement in coordination as:

1) This AC contractor as an “engineering manager” would better coordinate all his works with other service contractors, and was able to provide more useful combined services drawings. This would be more efficient and quicker than by the builder’s B.S. coordinator who still did not involve in the actual services installations.

2) This AC contractor would effectively manage any coordination problems with other services contractors on site as he possessed more combined influence than the results achieved by individual services contractors. In this project he would seek solutions to speedily overcome conflicts or coordination problems for the Main-contractor’s service coordinator as he had paid to do this work.

3) This Main services contractor system could improve the communication between all engineering contractors and the Main-contractor. The Main-contractor’s services coordinator would only discuss any coordination problems with one single person and he would do the rest. This surely conducd services coordination.

4) With this “domestic” mode, obviously, the Main-contractor could better control his servants to execute the works as he wanted. (much would still depend on the degree of cooperation between them).

c) The service design was still not fully completed and detailed coordination works had to be checked and “designed” by the services contractors (covered in the contract - contractor to allow for the risks of changes in quantities of the works as a result of coordination process). Problems did exist, but it was the combined effect of the construction team and the client’s B.S./architect representatives that most of these problems were jointly checked and subsequently overcome. Had the design been fully integrated and coordinated, coordination problems would be much reduced and the contractors could provide better quality of installations. It was clear that if nominated services contractors was adopted, the Main-contractor would have much greater difficulties in coordinating the complex building services/hospital services with the large number of services contractors.

F.7. Project Result

a) The design and construction teams were satisfied with the performance of this project. The client got his building on time and within the planned budget. The contractors also completed the works and earned their credit.

b) The project was not coordination problem free, but the usual coordination problems were quickly tackled by the contractors. Probably, it would not be a bad thing to have a bureaucratic and yet powerful Main-contractor with a good team of services contractors who were committed to compete this project on time. The working relationships between the Main-contractor and his services contractors were considered reasonably good. Although there were serious arguments between them, however, adversarial attitudes had not been observed.
c) The Main services contractor system was a workable solution. This would reduce unnecessary workload of the B.S. coordinator and he would concentrate on the managerial issues such as detailed planning and interfacing with construction work etc.

F.8. Details of Survey

a) Interview/discussion with client's B.S. engineer
b) Discussions with service contractor
c) Inspection of consultant/contractors’ drawings and contract documents.
d) Observations of service installations
G.1. Project Number - 7 (HCD)

G.2. Type of Project

This was a continuation of a very large development of a commercial city. This consisted of 3 hotels (an eighteen-storey), offering more than 1,600 rooms, 200,000 sq. m. of office space (two linked fourteen-storey office blocks), 200,000 sq. m. of retail space and about 400 luxury compartments (two fifteen-storey residential blocks) with all sports and recreational facilities.

G.3. Project Characteristics

A very large and modern mixed-use complex in the hearth of the city. The sheer scale and complexity of what was one of the largest multi-use developments in Hong Kong was echoed by the scale and complexity of building services involved. Designs for the speculative tenant areas had to remain flexible to cope with present and further requirements. Each element of this particular project would have been considered a major building in itself. Most importantly, the entire development must be designed and constructed at the soonest possible.

G.4. General Information

a) Total contract sum - US100 million

b) Cost of building services - over 40 million (40% of the entire building cost)

c) Design period - about 1.67 years (600 days)

d) Construction period - less than 2 years (700 days, completed in 1985)

e) Claim - From the client, not construction or services, but utilisation of site area.

f) Records of site instructions - complete details were not available, but there were about 1000-1200 building services instructions. These instructions could broadly be categorised as below:

- services information - 35%
- client design change - 25%
- services coordination - 40%

Details of services coordination were

- identification of problems 30%
- conflicts - service with service 24%
- conflicts - service with building 16%
- advice on coordination 30%

G.5. Procurement Path
a) This was a traditional system with improvement. The architect was both lead-designer and project manager. The design team comprised a large architect/structural engineering firm; a U.K./Hong Kong based M&E services consultant and a local quantity surveyor. This was a very experienced team.

In the early phase of this commercial development (Phase 1 to Phase III), there were difficulties in administrating a large number of specialist nominated sub-contractors on a tight programme (In Phase III, similar to Project No. 6, the AC&V sub-contractor was also paid to control other services sub-contractor. The AC&V contractor also worked with a construction management team). For more than a year the M&E consulting engineer studied ways to improve on the traditional Nominated Sub-contractor system adopted in the early phases. They finally decided to adopt the Principal Services Contractor (identical to Main Service Contractor).

b) Basically, all engineering services was the responsibility of a single nominated building services sub-contractor. This was a major improvement, as services would be managed by engineers, rather than builder.

The principal services contractor was basically wearing two hats.

1) First he was a specialist installer for works which he was capable of undertaking himself, i.e. HAC&V, electrical services, fire services, etc.
2) Secondarily and very importantly, he was responsible for the project management and coordination of all engineering services installations, both his own and those which he was required to sub-let to specialists, i.e. security installations, etc. However, the Main contractor was still required to have building services staff on site.

In this case, the US$27 million Principal Mechanical and Electrical Services Contract was awarded to a famous U.K./Hong Kong based M&E services contractor after competitive tender, and before the appointment of the Main Building Contractor (so once the Main-contractor was appointed, he could incorporate all the M&E work into his Master Programme which was essential for proper management of services).

With this compromise arrangement, at least engineers would be managing the engineering installations and the Main-contractor would have only one Nominated Building Services Sub-contractor to administer. This arrangement would go a long way to relieving main contractors whose site staff had little knowledge and little enthusiasm for building services works as this single contract delegated responsibility to services engineer who was more suited and capable for the task.

c) The Main-contractor again was a very large civil engineer/building construction company. The modified role of the Main-contractor still left a high demanding task for this contractor in order to meet the tight building programme.

d) The project management system could be viewed from:

1) Client - experienced with good project management managed by in-house professional project managers.
2) Designer - very experienced and cooperative; good project management overall.
3) Main-contractor - very professional and systematic but with dynamic management approach.
4) Principal services contractor - again, very professional and systematic approach to management of engineering services.

A positive and constructive attitude was adopted from the very beginning in order to establish a good working relationship between all parties of the contract was the key success factor in this project management.

G.6. Coordination of Services

To adopt the approach of employing a Principal Services Sub-contractor was far-sighted and clearly it had contributed to the successful construction of this project.

Though the project was very complex (nearly identical to a large regional hospital), services was fully coordinated by the Main-contractor and the Principal Services Contractor (equal status) for the following reasons:

a) Though a very complex project, the designers had adequately integrated services into building design.

b) Cooperation between the Main Building Contractor, the Principal Services Sub-contractor and the Professional team was of the highest order resulting from mutual respect between all parties. Good working relationships were established at an early stage in the contract, with a continuous dialogue between the client, architect, consultant, Main building contractor and the Principal Services Contractor. This allowed for the rapid identification, analysis and resolution of any difficulties arouse during the construction period.

c) Provision of complete design information, services were adequately integrated and coordinated first by the services consultant. The Principal Services Contractor also heavily involved in the design stage, i.e. to assist in both the detailed development of services design and their cost effective implementation. This enabled the contractor to provide a service beyond its narrow contractual obligations; a mutually supportive approach that characterized the attitudes of all the team members and which was fundamental to the success of this project.

d) Services were also fully coordinated by the Principal Services Contractor (at a cost) with other specialist contractors. Combined services drawings were adequately provided and potential problems were resolved ahead of construction. Project teams were also used to solve day-to day problems found on site.

e) The Principal Services Contractor arrangement simplified the interfaces between the design team and the contractors and resulted in the proper allocation of responsibilities for construction and engineering activities.
A full planning and coordination team was set up on site to work with the Main-contractor. Within the Principal Services Contractor, project team were established to independently manage the apartments, offices, hotel and podium facilities (Zone-based strategy as stated in “Specialist Trade Contracting - a rev” by CIRIA, 1997). This
establishment of four teams enabled the day-to-day construction momentum to be maintained, whilst forward planning was implemented by the construction management team (formed by the Builder, Main Services Contractor).

f) The Main-services contractor was very experienced in services coordination and jointly worked with the services contractors for all overall planning, programming, coordination and construction activities of the entire development.

G.7. Project Result

a) The combination of technical, commercial and programme considerations was skilfully balanced by the design and construction team. They successfully established a constructive working environment based on mutual respect, goodwill and cooperation which was to the ultimate benefit of the project and all those concerned. The project was a successful one.

b) As far as services coordination was concerned, the Principal M&E Services Contract system was a very successful path. Though not entirely coordination problems free in this project, this single party did manage to predict and resolve the coordination problems very effectively and professionally mostly before the physical installation of services. In general, quality of services installations was high.

c) Selection of the right principal M&E services contractor who could skilfully executed engineering management was a salient factor as not all contractors could perform this task. In this case, it demonstrated that coordination of services was both technical and managerial issues. Indeed, from the evidence provided, management aspect (planning, organizing and controlling services installations) appeared to be the most important project success factor.

G.8. Details of Survey

a) Interview with services consultant and services sub-contractors.
b) Inspection of design and working drawings and contract document regarding services coordination.
c) Investigations based on Project Information published by the parties concerned.
H.1. **Project Number** - 8 (SH)

(For further reference as recommended by the services consultant)

H.2. **Type of Project**

A large eight hundred room hotel building

H.3. **Project Characteristics**

This luxury hotel incorporated bedroom floors, from the 5\(^{th}\) to 17\(^{th}\), comprised 800 bedrooms. The basement to the 4\(^{th}\) floor consisted of plant rooms, hotel facilities, shops and restaurants. The building had to accommodate ever more sophisticated services.

H.4. **General information**

a) Total contract sum - not available from the M&E services consultant

b) Cost of services - around 100 million and between, 40-45% of the entire building cost (about 0.125M/guestroom)

c) Design period - over one year

d) Construction period - about three years (completed in 1974)

e) Claim - nil

f) Records of site instructions - about 800 M&E services instructions had been issued to the Principal services Contractor. Coordination was to be resolved by the contractor and therefore only 10 to 20% of this 800 instructions would be required as a result of confirmation of changes for services coordination.

H.5. **Procurement Path**

a) This was a traditional system i.e. Design team plus Main-contractor and Services Sub-contractors.

b) The architect and services consultant were local designers, they were very experienced in hotel design.

c) The Main-contractor was a very well established and experienced building contractor.

d) Similar to project No. 6, the AC&V sub-contractor was fully responsible for other M&E services installations (at a cost) as a special requirement which had been deliberately written for this highly serviced project. (recommended by the consultant to the international hotel group for easy management)

Similar to project No. 7, the AC&V contractor would be managing all engineering installations and the Main contractor would have only one Nominated Main Building Services Sub-contractor to administer.

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The project management systems were:

1) Client - experienced hotel client. They understood their hotel requirements and gave good briefing. They also relied on the design team to manage the project. But they would monitor the project themselves.

2) Designers - very professional management of design and construction; a very good working team

3) Main-contractor - a good building construction company prepared to work things out with client and sub-contractors. They did not provide comprehensive management of services installations and relied on the main services sub-contractor’s (the AC&V contractor) expertise and cooperation.

4) Services sub-contractor - had established good working relationships with all services contractors, the main-contractor and the design team.

H.6. Coordination of Services

The project was a very complex hotel and required a high degree of integration of services during the design stage, and full services coordination on site. Detailed combined services drawings were, however, not fully prepared but most coordination problems were identified and resolved on site by the site engineering staff under the management of the Main-services Contractor (in this case, he was not involved in the design stage, and quite different from the Project No. 7).

Generally speaking building services installations were successfully coordinated on site.

Comments on the services coordination were:

a) A very good working team of services contractors who would plan and coordinate services on site for mutual benefits - to complete works for earlier payments. The Main Services Contractor did control the services contractors very effectively especially in connection with sequencing of works and giving due regard to the main-contractor’s building programmes.

b) In general, services had been coordinated by the consultant in those congested areas. For podium floors designed for the main M&E services distribution systems, sufficient headrooms would normally be allowed for. But details of services coordinations were completely left to the Main-services Contractor. Only minimum important sections had been provided for tendering purposes. For effective coordination of services, the Main services contractor therefore set up a site coordinating team in order to fully coordinate his works with other services contractors. As discussed earlier, the coordination was mainly achieved by management of services on site but also backed up by a large number of coordination details (detailed plan layouts and sectional details) for critical areas as prepared in the contractor’s head office.

c) Services consultant worked with the Main services Contractor and prepared to accept modified designs to suit coordination problems. (as long as design intent remained unchanged)
d) Good working relationships between the various services contractor from engineers, foreman to the permanently employed fitters. Apparently, there was effective site communication and all site personnel understood each other’s requirements and would compromise in order to facilitate completion of all services installations.

H.7. Project Result

Surprisingly, the complex services of this hotel project was satisfactorily coordinated and installed without the use of fully coordinated services drawings. The project was also completed on time. The overall quality was also considered reasonably good. The successful coordination of services was attributed to the extremely good working relationships between the various services contractors and the services consultant. Furthermore, there appeared to be a very satisfactory site management of building services. The usual coordination problems due to ‘first come, first install’ did not exist. However, there were still serious coordination problems as a result of inadequate design coordination and the lack of fully coordinated services drawings, otherwise, the main services contractor would not have to spend long hours on site coordination works and he could divert his energy to other aspects of his project management.

H.8. Details of Survey

a) Interviews of services consultant and the main services contractor.
b) Inspections of drawing sand tender document kept by the main services contractor
c) Observations from record photographs showing the various stages of the M&E services installations.
I.1. Project Number - 9 (UCH)

I.2. Type of Project

This was an extension of an existing 663 bed hospital and there would be a net addition of 745 beds. This would be achieved by construction of an extension block linked to the existing hospital.

I.3. Project Characteristics

The brief was to build a twelve-storey new block (64,587 sq. m GPA) opposite the existing 663-bed hospital, upon completion of which patients and staff would move in while the original block was knocked down and re-built. The new block was also designed above a six-storey podium. A full range of general hospital facilities had been constructed. The site area was 4305 sq. m. The result would be an all-services medical centre for 800,000 people.

In additional to the unusual high-rise hospital block, five high-rise staff quarter buildings were also included.

The design standards for this project were consistent with new government hospital. As the new building services systems would also serve (except AC&V system) the existing hospital (and its replacement), the services were considered highly sophisticated and complex in order to meet the 21st century.

I.4. General Information

a) Total contract sum - HK$776.6 million (1.04M/bed)

b) Cost of building services - HK$295 million (38% of (a) above; 0.39M/bed)

c) Design period - feasibility study between 1979 and 1982; final design completed in 1991
   Construction period - about 4 years (from 1991 to 1995)

d) Extension of time - nil

e) Claim - Nil, but the original architect was terminated in 1988

f) Record of site instructions - not available from the project management firm. However, the approximate number of B.S. instructions would be around 1000 as the project manager had provided a good control of the issuing of site instructions. In general, B.S. instruction was used to cover:

• service information 40%
• client/design change 20%
• services coordination 40%

For services coordination, the detailed breakdown would be:
I.5. Procurement Path

a) This was a traditional system with main-contractor and nominated services subcontractors. The architect was a lead designer but he would not be required to manage the construction. A project management consultant was appointed as Project Manager to manage planning, design and construction management with the design and construction team. The main-contractor however had to take up the coordinating role and manage all services sub-contractor.

b) The new hospital block was originally designed by an overseas/Hong Kong based hospital architect. He was commissioned to carry out a feasibility study between 1979 and 1982. The design was nearly completed in 1987. However, the employment of the architect was determined for reasons unknown to the public. Having discussed with the services coordinator in this architect practice, it was at least identified several key issues as follows:

1) There were problems in the budget and schedule completion dates as a result of ineffective project management.
2) There were communication gaps and continuing users’ requirements were not fully incorporated into design (as multi-headed client problem)
3) Disputes

c) When the original architect had been determined, an independent project manager was appointed to set up a new design team. The team included:

1) Project manager
2) A local architect with a very experienced Hong Kong based U.K. health planner as sub-consultant
3) A local M&E services consultant who was again very experienced in hospital engineering (as the original designer)
4) A local quantity surveyor - same as original design

The original design concept was adopted as much as possible, but the architect had to change the overall design within the time and budget constraints, and special client’s needs. The new design was finally completed and approved in 1991. The hospital was completed in 1995.

d) The project management systems were:

1) Client - bureaucratic and inexperienced, multi-headed client was still a serious problem
2) Client’s Project Manager - very professional project management
3) Original architect - a good professional health planner but appeared to be weak in project management
4) New design team - very cooperative team, most had worked before in other hospital projects. Under the guidance of the PM, they all provided effective management of design.

5) Main-contractor - typical Chinese style contractor but using modern techniques for construction management. Worked quite well with sub-contractors.

6) Sub-contractors - all were quite cooperative and worked well with the Main-contractor

I.6. Coordination of Services

a) In general, the complex services and hospital equipment were effectively managed and coordinated by the Main-contractor and his services nominated sub-contractors within the time and cost constraints. This result was achieved at a high cost.

b) Firstly, the architect’s sub-consultant appreciated the importance of services integration and the hospital building design had been designed in such a way that it would facilitate distribution of services and so to achieve significant improvement in services coordination. Secondly, the architect had previously worked with the M&E services consultants in other large project (Project No. 3 and others). They all knew the coordination chaos in the previous projects, and therefore would better integrate and coordinate all M&E services in the design. This was the best approach to managing services, and serious coordination problems would be reduced. In accordance with the contract, the main-contractor needed to set up a services coordinating team on site in order to ensure that all services were coordinated (preparation of combined services drawings), planned and programmed before the services installation began. This also included monitoring and controlling.

c) In all contract documents, both the main-contractor and each of his nominated services sub-contractor had to include all services coordination responsibilities and priced these in their tendered sums. So everyone would have to perform these duties.

   To cultivate team working, each sub-contractor had to set up a site office to accommodate his drawing office and the specially required coordination team in order to closely liaise and work with the main-contractor on site (rather than sending problem to head office) in the most effective way.

   All services sub-contractors would have to provide necessary details for the main-contractors’ preparation of combined services drawings, and they all worked quite cooperatively with the main-contractor/Project Management Team.

   Coordination problems did occur but they were quickly resolved mostly by the site engineers. It reflected that effective communication would be very conducive to services coordination. This also indicated that it was the contractors commitment to the project goal—completion of works with the least expenditure as cost-effective working could only be achieved by a smooth flow of installations.

d) In addition, good working relationships between all contractors and consultants were also found to be significant in progressing the post contract phase smoothly.
e) The project manager had planned and managed the construction work and the services installations with the main-contractor and sub-contractors. Client changes had been kept to the absolute minimum during the construction of the buildings and this was the main reason why the project could be completed on time.

f) Computer-aided design was adopted to help services coordination

I.7. Project Result

This was a successful project. Though very complex, this project was completed on time and within the very tight budget.

There were very few problem once this project started on site. Services were satisfactorily coordinated and installed by the services contractors as a result of:

a) Better brief and the problem of the multi-headed client had been recognized and managed from the very beginning of the project. Client was informed about this problem and changes were properly controlled.

b) Implementation of project management by an individual consultant for building construction and building services was found to be significant in progressing the post contract phase smoothly.

c) Proper integration of services into building and provision of sufficient design information in the first place.

d) Services were also effectively coordinated on site by all contractors. Solutions to conflicts had been promptly provided by the contractors/consultants.

e) Presence of team approach in the design and construction team - a high degree of cooperation between project participants based on shared goals and mutual respects. The adoption of a sophisticated method of coordinating services ensured that services were coordinated before completion of structure was important project success factor.

I.8. Details of Survey

a) Interviews of services consultant and services contractors
b) Discussions with the Main-contractor
c) Inspection of tender documents
d) Observation from photographs and selected services installations
J.1. Project Number - 10 (NDH)

J.2. Type of Project

This was a new district hospital with 618 beds.

J.3. Project Characteristics

This 7-storey, 63,000 sq. m. hospital basically consisted of five linked blocks providing all necessary medical facilities as a general hospital. The project was the first new hospital project to be entrusted to the new Hospital Authority (replacing the previous Medical and Health Dept.) to devise and manage from inception to completion. The project was announced in the March 1993 and to be completed by mid-1997.

As a government hospital, the design standard would be identical to other large regional hospital (e.g. Project No. 1 to 4). Again, the building was highly serviced. Most critically, the hospital must be completed on time and handed over to the users in 1997. Cost was only the second priority.

J.4. General Information

a) The contract value - HK$1000 million (1.6M/bed)

b) Cost of services - HK$450 million (45% of (a) above; 0.64M/bed)

c) Client’s design period - one year by the client (from 1993 to 1994)

d) Contractor’s design and construction period - less than four years (from 1994 to 1997)

e) Claim - nil

f) Record of site instructions - This is a Design-Build (actually a Develop and Construct) system. The Main-contractor would be responsible for all works. The number of site instructions issued was therefore comparatively fewer (about 200), less than one-third of these instructions was M&E services and they would cover client’s changes involving variations to the contract. Site information would be covered in the contract diary (for D&B contract’s action etc.). As far as services coordination was concerned, the details of the site information were:

- Identification of problem 40%
- Conflicts to be resolved 20%
- Advice related to coordination details 40%

Note: The abovementioned information was estimated to be around 45-50% of the total volume of the diary.

J.5. Procurement Path
a) As rapid delivery was required to obtain the project prior to the change in administration in 1997 (For political reasons rather than commercial pressures). An early decision was taken, therefore, to use a modified design and build (develop and construct) approach by the Hospital authority (HA). This required the production of tender documents to detailed design stage, based on a well developed brief by a team of professional consultants first.

The principal factors which led the client to follow the develop and construct route were as follows:

1) reduced total project time, fast tracking by commencing work on site prior to completion of documentation
2) single point contract and responsibility (avoidance of claims which occurred in most of the hospital projects using the traditional system as faults due to sub-contractor would be made use by the Main-contractor for alleged disruption of his works)
3) early firm price possible and some form of competition
4) inherent buildability
5) close intercommunication between the contractor’s design and construction teams (especially building services) promotes maximum cooperation in achieving smoother running of the contract and prompt resolution of site problems
6) the building design is highly specialised and could only be designed by a specialist consultant (i.e. contractor’s consultants) or the employer himself and his consultants.

The form of contract used was the standard Design and Build form developed by the Government (Based on U.K. system, i.e. JCT80 with contractor’s design (CD81)). But the form had been modified to achieve greater client control. A milestone payment system was also incorporated for both benefits - early completion and payment.

b) The basic designs were carried out by the client’s project team and a local health planner together with a M&E services consultant. A conceptual design and all requirements were issued to selected/pre-qualified Design and Build (D&B) contractors, and a large local contractor was finally awarded the contract after detailed analysis of his tender offer.

c) The building contractor appointed a local/U.K. based health planner as his design architect who had to further develop the client’s conceptual design into a workable solution. The contractor’s architect also worked with a large local M&E services consultant who had sufficient experience in hospital engineering.

The building construction work would be the contractor’s responsibility. All services would be managed by the D&B contractor’s owned M&E services company. Both of the construction and services departments were grouped under one roof and they had built up a very long working experience in many projects. All M&E services were either provided by the D&B contractor himself (i.e. electrical services) or contracted out for special services.

d) The project management systems for this project were:
1) Client - good management; multi-headed client problems had been recognized and controlled by the use of an effective administrative control, i.e. a single point of contact (with sufficient high level of authority) within the project implementation team.

2) Client's project management team - In order to closely monitor the design and construction of this project, the client had also employed a project management consultant to maintain tight control over time, cost and quality, and to supervise the construction on site. This project management team involved professionals who were very experienced in hospital projects.

3) D&B contractor - the main-contractor was a very professional building work contractor and provided good construction management. As highlighted earlier, this contractor's M&E services dept. was also experienced in large projects and had worked with the construction group for more than ten years. Hence, this partnering system had created a very good team which was essential for this complex project.

I.6. Coordination of Services

Very similar to project no. 5 and 6, services were in general properly integrated and coordinated. There were of course some coordination problems as a result of client changes and integration of services into a complex building liked this. By and large, the satisfactory services installations was due to:

a) A practical design was adopted for this hospital building. The building layout was also integrated with services.

b) Still, there were some critical coordination problems as a result of inadequate design integration between services, building and hospital functional requirements. These design problems were the most difficult to solve as these conflicts involved not only the design teams but also the hospital users. Hence, it appeared that D&B system was not entirely satisfactory for this complex hospital project which was highly serviced and needed to satisfy intricate hospital functions and designs which however could not be easily determined in a short span. It was clear that even in a D&B contact, sufficient time should be allowed for this problematic area in the contractor's Master Programme.

c) The D&B contractor was fully responsible for the building and all services, and he had to solve all services coordination problems. Otherwise, he would have to bear all consequential responsibility, i.e. penalty. This was an obvious merit of D&B system.

d) Though services were coordinated with the use of combined services drawings, services had in principal, been further coordinated by the D&B contractor's coordinator (and his technical staff) and the services sub-contractors on site based on cooperative spirit, possibly through the special relationship with the services dept. with the construction dept.

e) During the construction stage, the client had ordered some major changes and these did create some coordination problems (e.g. change of design and disruption of construction). However, this was subsequently rectified by the high level steering committee to avoid possible claims from the D&B contractor. To do this successfully, it
was necessary to have tight control over changes and changes would not be entertained during the rest of the contract period.

f) The D&B method is not a panacea for eliminating coordination problems, the Main-contractor and all services contractors still have to use the same coordination procedures used in the traditional procurement system. For project success, services must be properly coordinated at both design and installation stages. Nonetheless, project success could be enhanced by engendering a team spirit and a high degree of cooperation between project participants, based on common/shared goals - i.e. the construction and M&E services contractors.

J.7. Project Result

a) By using D&B system, the hospital was completed on time, and the cost was also within budget. In fact, there could be delay in this project as a result of client's change of design. But the problem was subsequently overcame and the client therefore avoided possible claims. The problem of the multi-headed client must be recognized and managed from the very beginning of the project and a dedicated management structure would be necessary which clearly defined, the procedures, roles, formulation of clear and agreed objectives and needs, particularly at inception stage.

Though the project was contractually completed, the contractor still had to design and construct new work to suit the hospital users finalized needs and the continuing changes in medical technology. Obviously a flexible approach to hospital design would be necessary for building and services (it is possible but very difficult)

b) It did not mean that D&B system was coordination problem free, it was still vital that all building services design and installation were adequately designed and coordinated from design through construction (as in all procurement methods). However, D&B system was conducive to services coordination as a result of a fully integrated design and construction team. Of course, it was still essential to have a good team of designers and contractors who all worked towards the same goal - completion of contract; good quality of building and services; a good profit margin and pride.

J.8. Details of Survey

a) Interviews with project management teams
b) Discussions with contractors involved
c) Inspection of tender documents
d) Observation from photographs and selected services installations on site.
K.1. Project Number - 11 (TKOH)

K.2. Type of Project

This is an acute general hospital with 458 beds and ambulatory care centre.

K.3. Project Characteristics

Though a small district hospital, this is certainly a facility for the next century. And therefore, the design standard is identical to those large modern government hospitals. Obviously, the hospital in a highly serviced building. Functional planning is a key. A standard, rectangular block (9-storey) stands at the head of a central core from which run four narrow arm (each arm is in fact a low-rise block of 3-7 storey). All blocks are linked together with this layout, the distribution of services is much simplified as each block has its service ducts and plant rooms.

K.4. General Information

a) Total contract sum - HK$1,161 million (2.53M/bed)

b) Cost of building services - HK$487.6 million (42% of (a) above; 1.064M/bed)

c) Design period - about one year by the client

d) Design and construction period - about four years (from 1996 to 1999)

e) Construction - in progress

f) Record of site instructions - no final figures yet; but the anticipated number would be around two to three hundreds based on experience gained from a 618-bed district hospital using develop and construct method.

Site instructions requested for client changes, etc. will be controlled and avoided as far as possible in order to avoid any possible claims from the Main-contractor, otherwise, site instructions will only be used to cover advice, confirmation of design data and requirement.

K.5. Procurement Path

a) The facility uses an enhanced design and build contract as it is required to enter service by the end of 1999. Again, building cost is not a problem.

b) Actually, develop and construct system has been used for this project, i.e.

1) A full project design (to stage D), performance standards and technical specification had been provided by the client, i.e. his U.K. based master building, structure and M&E services consultant employed for this project in association with the Hospital Authority’s project department.
2) Successful tenderer (a large local building contractor employed a local health planner as his architect and a large M&E services consultant for all hospital services) had provided all design development and production of all documents and construction drawings for construction and services installations.

3) The Hospital Authority also appointed his master consultant as project manager and consultant to maintain tight control of design and quality. A Project Manager will be assisted by his site architect and services engineer on site.

c) The principles of this approach where rapid project delivery and a high degree of public accountability are required, are as follows:

- This is not a very complex hospital project and this is the best way to complete a building on time and with competition
- Single point responsibility of the Main-contractor is needed for client’s project management.
- The aspect of contractor claim is diminished in design and build as the Main-contractor is responsible for design and cannot claim for design/coordination faults.
- Design and build system gives greater coordination and integration of the design and construction teams, and usual coordination problems will be diminished.

However this D&B contract is very costly (1,161 million Hong Kong dollars and equated to 2.53M/bed; when compared with the large hospitals using the traditional procurement system which has a cost of 1.37M/bed) and it is apparent that the contractor has included a large sum of money as “contingencies”.

d) The management system is:

1) Client - bureaucratic and multi-headed client problems still exist
2) Client’s project team - very experienced and professional; has provided good project management base on experiences obtained from previous hospital projects.
3) Client’s design/project consultants - all are professional and cooperative, and provide good control over design and construction. Multi-headed client problems have been controlled.
4) Design and build contractor - a good building contractor also experienced in large hospital construction. He also works quite well with the architect and M&E services consultant and provides all planning and programmes for the construction management. The overall project management is professional and efficient especially for this small hospital.

K.6. Coordination of Services

The project is still on-going, so far services have been well managed and the design team and the Main-contractor and services contractors have all carried out the necessary services coordination such as:

a) Services have been given due attention in the design of the building, and M&E services, etc. have been adequately integrated and coordinated by the services consultant.
b) Combined services drawings (CSD) are used for coordinating M&E services and will provided by the Main-contractor.

c) In addition to the CSDs, all contractors also carry out adequate site coordination work and overcome problems as soon as they arise.

d) Services have been incorporated into the Main-contractors’ construction programmes and progress of services installations are closely monitored and controlled.

e) Useful assistance from the client’s site engineer/architect who are very experienced in hospital projects.

Coordination problems have been created as a result of contractor’s design integration problems. However, most coordination clashes are subsequently resolved by the teams. Nonetheless, most conflicts have been quickly tackled by the services sub-contractors in order not to hold up the progress of works.

K.7. Project Result

a) It is premature to draw a solid conclusion for the overall performance of this project. However, based on the performance of the Main-contractor and his services contractors, it would not be unreasonable to say that the services installation would be satisfactory especially when there is adequate coordination of services amongst all services contractors on site.

b) Again, this project has a greater chance of success as all design and construction teams have vested interest in achieving satisfactory completion of project. Most importantly, the team building in this D&B contract avoids the usual confrontational attitude and this is conducive to services coordination. Project success obviously can be enhanced by engendering a team spirit by the use of non-traditional procurement arrangement, i.e. develop and construct. But the client has to pay more. Last but not least, effective management of services by the various participants also improves the building services installations.

K.8. Details of Survey

a) Discussions with client’s project management team

b) Site visits

c) Inspection of contract documents and drawings
L.1. Project Number - 12 (CEC)

L.2. Type of Project

This was an integrated building complex of over 400,000 sq. m. The complex comprised two parts; the Exhibition Centre Portion and the Commercial Portion.

L.3. Project Characteristics

The Exhibition Centre Portion had been specifically designed for the flexibility and functionality to meet the needs of both international and regional conventions and exhibitions. The two exhibition halls had over 18,000 sq. m. of prime exhibition space. Each hall was larger than a football field and enough to accommodate up to 600 exhibition booths or 8,000 people for a convention. Other exhibition and convention supporting facilities were also included and this project was considered as a highly serviced project. Above the Exhibition Centre were a super deluxe class 5-star hotel with 600 rooms; a 900 rooms business class hotel; a 70,000 sq. m. 40 storeys office/trade tower and a service apartment with 600 fully furnished apartment suites.

The entire complex was a highly service project. The construction of this complex was one of the most fast track projects in the Southeast Asia.

L.4. General Information

a) Overall cost of the project - in the order of HK$3 billion (approximately US$400 million at 1985 prices)

b) Cost of building services - 40 to 45% of (a) above

c) Design period - about 1 ½ years (from 12/1984 to 06/1986)

d) Construction period - about 3 years for convention centre (in 1988) and about 4 years for the entire complex (in 1989)

e) Claim - nil

f) Record of site instruction - was not available but the researcher was informed that about half (about 1500 no.) of the total number of site instructions issued was M&E services installation, and the details would be:

- services information 30%
- client/design change 40%
- services coordination 30%

For services coordination, the approximate breakdown was as follows:

- identification of problem 30%
- conflict -service with service 20%
- conflict - service with building 20%
• advice on coordination details 30%

L. 5. Procurement Path

a) This was an unusual project. The Hong Kong Government offered a large site to the Trade Development Council (TDC) free of charge on condition that the TDC would develop a Convention and Exhibition Centre at no further cost to the government.

The project was to be let as a design-and-build contract on a fast-track basis at no cost to the TDC. The successful bidder would be granted the space above and around the convention and exhibition to develop what they decided was necessary (i.e. hotels, office towers and apartment tower) in order to make the project viable. TDC finally awarded the contract to a large local developer (one of the nine bidders) in late 1984. Under the terms agreed between the two parties, the entire project would be financed by the developer under a Design Build Own Operate Transfer agreement.

b) The developer appointed:

• the scheme designer - a Hong Kong architectural firm as the architect and structural engineer
• his fully owned building construction company as the Main-contractor
• the main-contractor’s fully owned M&E services contractor
• his in-house professional management team as project manager to manage this project
• a large M&E services consultant who had been working extremely well with the developer and the architect in other large projects

The client (TDC) also employed the original project advisor to be his project manager.

c) Basically, the developer adopted the traditional contracting system with Main-contractor and sub-contractors. But all sub-contractors were in fact domestic sub-contractors and this greatly improved integration (to reduce differentiation). With the exception of all consultants, the contracts for the Main-contractor and his sub-contractor were based on a cost plus basis as they were in fact in-house contractors (being part of the developer’s group).

d) The management system was thus to be an unusual one:

• Client - inexperienced, but supported by a very strong project management team; very demanding client but very cooperative with the developer.
• Developer - very experienced in estate development; also supported by a strong project management team.
• Designers - both architect and engineers were very excellent professionals and they had good working relationships with all project participants. As professional service charge was not a problem to the developer, they had provided extremely good and responsive professional services.
• Main-contractor - very experienced and organised building contractor who provided quick responses to client’s changes and effective construct management. The Main-
contractor also worked cooperatively with all project participants. He would also prepared to complete the project at any cost as long as he could satisfy the group Director’s objective - completion on time and good qualify of building.

- Domestic services sub-contractors - were all large and professional M&E services contractors who had very good working relationships with the Main-contractors and the M&E services consultant. Again, they were very dynamic and prepared to make ways to suit the project’s requirements (cost was not a problem but they had to meet their Group Directors’ objectives - to satisfy the Developer).

e) For this project, what appeared to be a complex project, which theoretically could be expected to create a highly differential organisation structure, actually had an organisation structure which reduced differentiation and provided a high level of integration (i.e. Developer with good working relationships with designers; Developer’s owned groups as Main-contractor and sub-contractors; and adequate resources).

f) Overall, there was a systematic project management with detailed and extensive control, and management information systems.

L.6. Coordination of Services

This project had the largest air-conditioning plant and other M&E services systems in Hong Kong. In terms of designs and construction, this was a very complex and highly serviced building (buildings within building). However, services were satisfactorily integrated and coordinated by the design and construction teams. Of course, there would still be some serious site coordination problems as a result of client’s change of design or improvement in design, but they were promptly resolved by all parties concerned as they had to complete the project on time and at any reasonable costs. The successful coordination of services was a result of:

a) Building services consultant was one of the largest M&E services consulting engineer in Hong Kong. This firm had built up a very good working relationships with the client and the project architect. Integration of services with building during the design stage was very professional. Detailed information had been provided for contractor’s site coordination. The services consultant was also paid to assist the M&E services contractor in particular to some complex combined services drawings.

b) The architectural practice also offered structural engineering which also reduced differentiation and helped coordination of services.

c) The Main-contractor and his M&E services contractors were the developer’s group members, therefore, they all worked towards a common goal - completion of the project on time for their directors (and for the Developer). This was very conducive to coordination of services.

The M&E services contractors also worked very closely with the M&E services consultant (the contractors actually rented an office beneath the consultant’s office), and they worked together in order to improve the communication needed for coordinating detailed designs and services coordination. Additionally, a coordinating team had also been set up between Project Management Team, Main-contractor, all
M&E services contractors and the consultant on site so that comprehensive planning, scheduling and preparation of combined services drawings or details were prepared on time and ahead of construction/installation; Furthermore, any coordination problems, etc. which were identified would be resolved without passing back to head offices. Project participants and senior management would meet as when and required and sort out any problem areas. Problems were never allowed to hang unresolved (also as a result of a sound project management system implemented) for this project. However, most problems were still resolved by those sub-contractors concerned.

d) Both the client (TDC) and the Developer’s project management teams were experienced in large project management and they provided effective and strong project management for this project. Again, for a project of this size, “Zone-based” strategy and individual building (Convention centre, hotel, office, apartment building) group/unit had been utilized to facilitate effective management of construction and services for efficient control of planning and execution of works.

e) There was a very good team of designers and contractors and they all welded together to work efficiently and very cooperatively.

f) Sufficient resources were available for planning and preparation of services coordination (detailed information from consultant; contractor’s close working with consultant at additional expenses, extra service from consultant on site) and the professional but very pragmatic supervision of services installations.

L.7. Project Result

The construction of this complex was of the most fast track project in Hong Kong, both the building construction and the M&E installation programme was about 5 weeks ahead of schedule. The reasons why the project was successful had been analysed. It was a very successful project, though very complex in terms of size and sophistication, M&E services were fully integrated and professionally coordinated in a practical approach... The reasons for success:

a) Teamworking was the key factor, there was total commitment to project success. The architects, M&E and other consultants were brought together to work as a team.

b) The consultants played a major fact in achieving the fast track project. Their designs were accurate and fast. Their attitude to site problems was positive and flexible. Very little delay was caused by design delay which reflected enormous credit on their flair and ingenuity. With the quality designs and the right contractors, project success could therefore be enhanced.

c) The majority of consultants and contractors were Chinese. It was the Chinese culture to avoid confrontation (especially the contractors were part of the developer’s group). Form of contract was not important.

d) The client had a strong financial base, and money wisely spent for accelerated design and construction was endorsed by the Developer. Adequate resources were available for services designs and management of coordination of services on site.

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e) Adequate design information and assistance from M&E consultants

f) The procurement path was the most perfect one - one single organisation for construction and services installations, i.e. high integration of main-contractor with his selected services contractors and under a special relationship (as same group members all answered to their directors and the Developer). Services installation was of high quality. In the Convention and Exhibition Centre’s Extension (not discussed in here) which had a construction cost of 4.8 billion (US$619 million), nominated subcontractors had been avoided, the Main-contractor had to select his specialist subcontractors from the client’s list. Again, services were satisfactorily planned and coordinated by the joint efforts of the main-contractor’s coordinating team and his domestic sub-contractors. A systematic management system was also provided for this Extension project.

All contractors were fully committed to early completion of this project and they also provided practical and professional approach to managing building construction, services designs and installations together with the services consultant.

g) There was excellent project management in this technically demanding project, i.e. from client, Developer, Main-contractor and all his sub-contractors. Client’s change was again a serious problem (as in the hospital projects). However, all the client changes had been entertained by the Developer and managed quite successfully by the designers and contractors (quick design changes with practical solutions) of course at additional costs to the Developer.

L.8. Details of Survey

a) Discussions with client’s project management team
b) Discussions with M&E services consultant and the major M&E services contractor
c) Inspection of contract documents and drawings
M.1. Project Number - 13 (CP)

M.2. Type of Project

This was a 78-storey intelligent office building.

M.3. Project Characteristics

The building site had an area of 7,235 sq. m. and cost HK$3.55 billion (US$430 million). On a per square meter basis, this site set the recording of being the highest in Hong Kong. The total floor area was 173,000 sq. m. This project was a joint venture of three large estate developers. With interest payments topping HK$918,000 (US$120,000) per day, the consortium would have hammered a profitable scheme and got the project moving fast. To meet the clients’ requirement for the earliest return, the building had to be completed in three different phases. The complex M&E services was also arranged to match each phase of completion with the minimum amount of temporary connection work. Therefore the building was designed with three main mechanical zones each taking care of one phase of completion (i.e. 5-6, 44-45 and 69-70-71 storey). Unlike most of Hong Kong office developments, there was no commercial element included in the building. The client demanded an intelligent building of good quality and the construction would have to be the fastest of all fast track projects. However, the client insisted on a building cost of around HK$1,000 million but still had to maintain the prestige of the building.

The developers formed an in-house construction team at an early stage to participate in the design and ensure that economical and easy to build solutions were found.

M.4. General Information

a) Site cost - HK$3.35 billion

b) Construction cost - approx. HK$1.1 billion (approx. HK$6,400 per sq. m. of building area)

c) Cost of building services - about 35% of (b) above; this was equivalent to about HK$2,200 to 2,500 per sq. m.)

d) Design period - approx. one year

e) Construction period - about 3 years (from 1990 to 1992)

f) Claim - nil

g) Record of site instruction - Detailed information was not available due to the “in-house” construction team arrangement. However, the researcher was informed that most services were satisfactorily integrated and coordinated and therefore the number of site instruction needed for M&E services would be about a few hundreds only.

Basically, site instructions were issued to cover:
• services information 40%
• client/design change 15%
• services coordination 35%

For services coordination, the approximate breakdown would be:

• identification of problem 35%
• conflict - service with service 15%
• conflict - service with building 10%
• advice on coordination details 40%

M.5. Procurement Path

a) This was a joint venture project and the client consisted of three developers. A joint
venture company was set up to carry out the construction of this building (each of the
three partners had completed many high-rise buildings in Hong Kong and they also had
very experienced professional builders and M&E services contractors). Having an in-
house construction team would allow the contractor to come in at early stage to
participate in the design and to ensure that economical and easy-to-build solutions were
found.

As a matter of fact, this project was very close to a “construction management” system
as the project management team formed by the client acted as the construction manager
and he coordinated the design team; prepared programme of pre and post contract
activities; supervised the construction process and provided professional construction
expertise for this fast track project. Obviously, with this contract strategy, design and
construction could overlap and speeded up the project.

b) The client also employed:

• a large local architect
• a large U.K./local structural engineer
• a famous M&E services consultant who had just completed a 70-storey bank
  building
• a local quantity surveyor

c) In general, the design team would provide the detailed design information for the
client’s owned Main-contractor and services contractors. With this in-house
construction team, it was possible to allow the design period to extend well into the
construction stage (based on parallel/overlapping design and construction activities).
Furthermore, the project management team was also spared from the tedious and time
consuming negotiations with the “outside” contractors over claims for both costs and
extension of time. With an in-house team, the project management could communicate
directly with all members of the construction team.

d) The management system was thus to be an unusual one:
• Client - this was a short-term partnering system within this joint venture. The project was professionally managed by the three developers based on 'Chinese Businessmen' spirit. The clients also worked extremely well with the design team.

• Designers - all were very experienced and professional designers, they worked closely with their clients and provided efficient management of design to suit client’s constraints and demands. These professionals were also welded together with the in-house contractors to jointly develop an economic but prestigious skyscraper and under immense pressure (quick completion).

• Contractors - each of the three developers deplored their best resources and people for the in-house construction team. All the professionals were competent and experienced contractors, and they provided a dynamic approach to the construction management and worked as a team. They would work cooperatively with each other and the consultants for the pursuit of an ambitious goal - completion of this 78 storey high-rise building on time and within budget.

The in-house construction team had the least differentiation and maximum integration as a result of:

• the best construction contractors selected from the three estate developers
• a fully integrated M&E services contracting team owned by the developers

Overall, the clients, the design and construction teams were based on a win-win-win approach.

M.6. Coordination of Services

As a 78-storey high class office building designed for 21st century, the building services would be comparatively complex than normal office buildings. Nevertheless, the M&E services were satisfactorily integrated and coordinated, and services designs had met the fast track construction.

The reasons for success were:

a) Though a 78-storey skyscraper, basically, services designs and installations were considered straightforward and symmetrical. Apart from the lower podium floors, services layouts for office floors were more or less identical. With the right designs and good planning and close coordination of services installations for fast track. Hence, there would not be many coordination chaos as found in hospital and hotel buildings.

b) Services had been fully integrated with building design (structure and architecture) by the design team using the most cost effective systems and in consistent with the state of the art in building services engineering (based on well proven designs from another 70-storey office/bank building and that all major service distribution systems would run in their service ducts and plant rooms were centrally located resulting optimum duct runs etc.). There were project/special group meetings for close coordination of services between the architect, structural and services engineers.
c) Contractors were experienced in high-rise buildings and they were also involved in the detailed design of services with the services consultant. Furthermore, they also provided good management of services on site. As detailed design information and coordination details were available, services could therefore be easily coordinated.

d) With the exception of the plant rooms and some congested spaces, coordination of services would be easily tackled especially for the typical office floors (when mock-up installations had been prepared, difficulties and problems could be easily identified and resolved by the design and construction teams). Besides, there were little uncertainties about services requirements (not in hospitals) and there would be fewer design changes.

e) The main-contractor and all services contractors were in-house contractors of the clients. This obviously created a better working relationship than other form of procurement system (least differentiation and maximum integration of project participants) which was conducive to coordinating M&E services with building construction.

f) The three developers had provided an effective management system to manage both services installations and construction of the building.

M.7. Project Result

For a building project that bore such a high land cost and heavy interest burdens to developers, the fast-track programme based on an unusual joint venture system had met the project objective. Building services, amounting to 35% of the total construction cost, had satisfactorily been integrated and coordinated by the hardworking of the building team for the following reasons:

a) A good partnering system based on “Chinese businessmen” culture and trust rather than details of contract. Most importantly, the project organisation created a spirit of teamwork and a high degree of cooperation between all project participants.

b) A good design with adequate coordination information and adequate combined services drawings.

c) Competent designers and contractors all providing a truly integrated and coordinated building through professional project management and effective communication from ‘top to bottom’ and ‘bottom to top’.

d) Contractors were ‘in-house’ contractors and they would make ways to overcome site problems at the soonest possible in order to complete their works on time and with the cost constraint.

e) There was little client’s change.

M.8. Details of Survey

a) Discussions with client’s project management team.

b) Discussions with project participants, i.e. services designer and contractor.

c) Inspection of drawings.
N.1. Project Number - 14 (BOC)

N.2. Type of Project

This was a 70-storey first-class bank building second to none in Hong Kong. It was an office building containing a major banking hall and office spaces, of which about 40% would be occupied by the bank and its sister banks with the remainder to be leased on the open market.

N.3. Project Characteristics

The building would contain approximately 107,100 square meters of gross area excluding the basements. Office floors ranging from 2,576 to 745 square meters, and were designed to provide a wide variety of tenant choices and feature flexible layouts in addition to spectacular views.

This was a mega-structure. The owner placed emphasis on the aesthetics of the project, but also paid careful attention to the issues of initial cost and system performance. Particular concern was given to developing office technology to ensure that the building systems would be capable of meeting these evolving needs for the life of the building. The construction budget was set at HK$1 million (US$128.2 million). The building was the world’s sixth tallest building (315 m)

N.4. General Information

a) Cost of building - about HK$2.5 to 3 billion (no actual figure was known to the public)

b) Cost of services - would be around 35% of building cost

c) Design period - over 3 years (from inception to design)

d) Construction period - about 4 years (1986 to 1989)

e) Claim - nil

f) Records of site Instruction - not available from the client. But the researcher was informed that not many site instructions had been issued for building services, and less than 45% of all site instructions issued would be services elements for:

- services information 40%
- client/design change 20%
- services coordination 30%

For services coordination, the breakdown would be:

- identification of problem 30%
- conflict - service with service 18%
- conflict - service with building 10%
• advice on coordination details 42%

N.5. Procurement Path

Though a very costly and complex office building, the traditional contracting system had been selected, i.e. Main-contractor/Nominated B.S. sub-contractor arrangement but under client’s strong project management team’s management.

a) The building design was based on U.S. methods, and the basic designs were carried out by the American architect and services consultant.

b) The American designers also worked with their Hong Kong associates:

1) a small architect practice but had a special relationship with the American project architect
2) a large M&E services consultant

The Hong Kong associate regularly liaised with the U.S. firms to ensure constructability in Hong Kong; to jointly review the bids from the contractors; to assist in the preparation of all local submissions; and to furnish the primary point of contact with the contractors during the construction phase.

The process had been quite successful. The unique considerations in Hong Kong had been addressed and resolved within the project. The integration of local construction practice and alternative techniques developed in the United States had been completed to the point where the project was an amalgam of both to the enhancement of the overall project.

3) A local Japanese building contractor was employed as the Main-contractor.
4) Several large M&E services contractors were employed as nominated services sub-contractor and they had to work under the Main-contractor.
5) A specialist Hong Kong firm was also employed for ‘scheduling’.

c) The project management system was:

1) Client - inexperienced and relied much on the professional consultants and his own project management team. He had very good relationship with the project architect.

2) Designers - All were experienced architects and engineers. The U.S. architect had a good working relationship with the M&E services consultant in U.S. and his Hong Kong associate. The local architect had also worked with the project architect and the local M&E services consultant before. Overall, this was considered to be a very cooperative team.

3) Main-contractor - typical Japanese style and good at construction management but they had modified their management styles to suit the local conditions (a combination of Japanese/Western construction management).
4) Services sub-contractor - they were competent professionals and all had experience in high-rise buildings. Also, they prepared to work as a team with the Main-contractor, they were proud to be the contractors for this prestigious project.

N.6. Coordination of Services

This was a successful project. Services were adequately integrated and coordinated for the following reasons:

a) For this 70-storey high-rise building, all M&E services systems would appear to be straightforward (especially for the typical floors), but it was not the case as the superstructure frame was structural steel with reinforced concrete columns and slabs on permanent decking. This necessitated a very careful integration of services into the structural/building designs. Hence, the effect also complicated the building services systems. Services however had been carefully designed and integrated into the building design in the first place as all the principal designers were very experienced in the steel frame type high-rise buildings in the U.S.

b) Services had been fully coordinated by the design and construction teams, i.e. good designs, complete preparation of combined services drawings and detailed builder’s work drawings in relation to services installations (specially needed for a steel framed structure, missing hole was difficult to provide later). Furthermore, there would be numerous mock-up/prototype services installations to identify potential problems and further improvement to services installations before the actual installation.

c) The Main-contractor, as a Japanese organisation had adopted a well structured/organized construction management system for planning and controlling all M&E services installations together with his building construction work.

d) All contractors worked quite cooperatively but services contractors would find ways to overcome their coordination problems first and the Main-contractor’s coordinating team would follow up the rest of the coordination process.

e) The client’s management team not only acted as client’s representative but also assisted the Main-contractor to monitor the construction of the building in accordance to well-thought programmes.

N.7. Project Result

For this mega-structure, the traditional procurement system appeared to work pretty well. The building was constructed on time and within budget. Services were state-of-the-art technologies and fully integrated and coordinated. The success was thought to be:

a) There was a good building team - designers and contractors, all worked as a team even bonded by a traditional procurement system which could easily create an adversarial “them and us” attitude. Nevertheless, the differentiation had been reduced by the Chinese commercial pressure, i.e. - a “win-win-win” approach for this unusual project (owned by the Chinese Government).
b) Services had been carefully integrated and coordinated by the designers first, and
designs were also fully detailed (as in the American ways). The contract was clear,
details of management of services coordination were clearly spelled out and all
contractors had to allow for coordination of services. With these allowances, there
would be adequate resources for all coordination works.

c) There was effective construction management. The client’s management team had
constantly watched the progress of the works and took constructive actions with the
senior management of the various project participants. Likewise, the Main-contractor
had provided very systematic project management for the construction. Services had
been planned and managed in association with building construction. Besides, M&E
services installations would be closely monitored and controlled. Problems once
identified would be promptly resolved and never allowed to hang unresolved.

d) Most importantly, the major services sub-contractors were good “Chinese” contractors
and they were prepared to work with the Main-contractor and the consultants as a
team.

e) Overall, adversarial relationship did not exist as all these well-established contractors
wished to continue their businesses and they were proud to be the project participants
in the prestige project (Reputation for another job!)

N.8. Details of Survey

a) Discuss with the project participants
b) Inspection of drawings
c) Project data sheets provided by others
O.1. **Project Number - 15 (HKB)**

O.2. **Type of Project**

This was an unusual 47-storey bank building in the heart of the city.

O.3. **Project Characteristics**

This Bank Group (the client) was a major international financial institution. The client decided to redevelop their Headquarters, the simple brief was to create the “best bank building in the world” within a reasonable time. This involved the demolition of the old building and the erection of a new high-rise bank building on an extremely congested site.

The bank required many special facilities and services which would take time to research, design and install. Even by Hong Kong standards, the new building was very large and employed unusual construction techniques which had to be developed and absorbed by those responsible for erection. And this project was achieved in a design and construct period of about 5 years.

The building services designs and installation were very complex and innovative, and required a high degree of integration into the building and its structure. Furthermore, flexible building services could respond to a rapidly evolving banking technology and high departmental mobility.

There was no doubt that the client wanted something very special, not only to perpetuate the bank” symbolic image but also to provide a building that would embrace the latest technology.

The building had a gross total floor area of 99,000 square metres.

O.4. **General Information**

a) Total cost - over HK$5,227 million

b) Cost of services - about 40% of the building cost

c) Design period - about two years (from 1980 to 1981)

d) Construction period - three and half years (from 1982 to 1985)

e) Claim - nil

f) Records of Site Instructions - full details were not available, site instructions issued for building services covered:

- services information 40%
- client/design change 30%
- services coordination 30%
For services coordination, the detailed breakdown would be:

- identification of problem 30%
- conflict - service with service 15%
- conflict - service with building 10%
- advice on coordination details 45%

As a matter of fact, owing to the effective integration of services and adequate coordination, conflict of services was insignificant in this project.

O.5. Procurement Path

a) This project adopted a management contracting system which offered:

- time saving potential for overall project time (fast track construction)
- buildability potential
- parallel working
- competitive tendering by leading specialist sub-contractors
- efficient/strong project management for complex building
- late changes (design) easily accommodated

b) The client employed a famous U.K. architect for the scheme in 1980; together with a large U.K./local structural engineer; a reputable U.K./local firm as consultant mechanical and electrical engineer; and one of the largest quantity surveyor in associate with a U.K. firm.

c) The project would be fast-track construction where an outline design was produced and then construction commenced; detail design then continued a few paces ahead of construction.

d) The management contractor was appointed in 1981 (but until the final building design concepts were formulated by the designers). This contractor was a joint venture of a large local construction management firm and a large U.K. construction specialist. In the management contract that emerged, the management contractor’s principal responsibility was to organise the execution of the works through a series of sub-contracts and secure its completion to programme in an economical manner and in accordance with the designs. In this project, the management contractor however had no control over design progress, variations, alternations or additions. The management contractor’s aims were to make available to the project pre-construction management services - technical; commercial and contractual - to influence the construction techniques during the development of the design, the organisation and coordination of design development process, to monitor pre-construction manufacture, the implementation of quality assurance, to provide continuity from this stage during construction and commissioning and the coordination of activities to reduce the chance of delays and claims.

e) The project management system included:
1) Client - good organiser with in-house professional, but relied much on the project architect.

2) Designers - very professional design managers, they all worked as a team under the strong leadership of the project architect.

Design was to be carried out in the UK with client organisation in Hong Kong. Hong Kong Design offices provided design development and details during the construction stages.

3) Management contractors - very professional project manager with local construction experience and western construction management techniques. This team consisted of the following major sections:

- commercial
- pre-construction project
- project construction QA/QC
- M&E services

4) Works package contractor - all were carefully selected; experienced and competent specialists. They worked cooperatively with the management contractor. The management contractor would:

- plan and program all sub-contractors' works
- coordinate all sub-contractors' works
- monitor, control, record and report progress

O.6. Coordination of Services

The complex nature of the project involving high technology, research, prototyping, design development and the complexity of the organization that would be required to coordinate the many construction packages. Nevertheless, services were considered professionally integrated and coordinated for the following main reasons:

a) M&E services had been seriously considered during the design stages by the project architect and his services consultant. Design of services was fully integrated with building, structure, interior decoration and use of building.

b) Adequate spaces had been carefully planned and allowed for all services (the architect actually had produced man prototype installations in his UK design office). Furthermore, mock-up installations would be carried out on site prior to physical installation on all floors.

c) Services coordination was detailed and spelled out in the contracts and all contractors had to allowed for this work. Services had been satisfactorily coordinated by the management contractor and his sub-contractors. They provided:

1) a very systematic system for managing preparation of design and shop drawings.
2) combined services detail (based on the design team but using actual equipment selected by the contractors)
3) planning, programming and sequencing of M&E services works with others. Logistical plan for services and building construction would also be included.
4) good site management to ensure early completion of works
5) different packages for effective management of services installations; i.e. central services (main A.C plant); sub-floor systems with all M&E services; air handling unit service modules, etc. (each contractor would concentrate on his work in his working space).
6) zone-based strategy with day-to-day management. This would give:

- completion of each work area
- good interfaces between zones
- bring together the contractors involved in the zone and ensure they have a common understanding of the sequence and details of work

d) Site coordination was also monitored and assisted by the design team. Any coordination/installation problems would be investigated and resolved without being left out.

e) Adequate resources from the management contractors and his services contractors. Most of the services were carried out by the Japanese contractors and they were very professional organizers, and exhibited a high degree of teamworking.

O.7. Project Result

The bank building was a successful project. It was completed on time and within budget (not known to the public).

The bank took building services very seriously, and employed world class architect and services consultant to provide the best building in the world but at a very high cost (over HK$5,000 million. Though not coordination problems free, services had been well coordinated and matched the progress of the building construction.

The success factors were:

a) using the best procurement and project management structures - Independent designers, management contractor and specialist sub-contractors (works package contractors).

b) Competent design team with quality design information (well-thought, fully integrated, tested, prototype installations and detailed drawings) coupled with experienced management contractor and good specialist sub-contractors. The management contractor also removed the contractor design team barrier (both are on the same side) and improved communication between project participants. Hence “them and us” attitude could be reduced. With reduced differentiation, integration of the design and construction teams would be increased.
c) Close control of sub-contracts and suppliers and the provision of comprehensive construction management and good management of services installations. Most importantly, contractors were prepared to cooperate with the management contractor.

d) Use of combined services drawings and prototype installations together with effective communication during installation stage.

e) Use of off-site prefabrication to ease coordination work “Building in use” had been analysed by the project architect and there was good control of multi-headed client problem (by client’s management; planning of user requirements and project control so there were few critical client changes, thus avoiding disruption to progress of work).

O.8. Details of Survey

a) Discussion with M&E services consultant member
b) Discussion with the major services contractors
c) Observation from site photographs
P.1. Project Number - 16 (KCRCS)

P.2. Type of Project

This was a central railway station renovation and expansion in Hong Kong.

P.3. Project Characteristics

The project objective was to renovate and extend the existing station to accommodate future domestic and international passenger demands and provided a world class train station facility.

It comprised an elegant new pavilion structure at concourse level adjacent to the existing station built on both the existing and extended podium structure and would include the complete refurbishment of the existing station concourse, walkways and platforms. The gross floor area was approximately 45,000 sq. m. (present size - 20,000 sq. m.).

The construction of the project would take place while the station was still operating. The work was phased in such a manner that the disturbance to the normal and efficient station operation would be kept to a minimum.

The phasing of construction activities on site was a particularly complex process as a result of the following factors:

a) the station would continue in operation (and all the associated facilities and building services)
b) to limit the construction time as short as possible
c) the complex relationship of the four levels of the station - platform, walkway, concourse and mezzanine.
d) the need to undertake much of the platform level works during periods of isolation (between train arrivals and departures)
e) the station was a highly serviced building and all new services had to serve the renovated building.

P.4. General Information

a) Project value - approximately HK$1,000 million (1 billion)
b) Cost of building services - about 450 million (equate to 45% of the contract value)
c) Design period - about 2 years
d) Construction period - three years (1995 to 1997)
e) Claim - nil

f) Records of site instruction - not available from the client, but the researcher was informed that for this special project, a large number (over 1500) of B.S. instructions
for a renovation project was quite understandable as it was extremely difficult to construct such complex buildings with so many constraints. Basically, the S.I. covered:

- services information 40%
- client/design change 20%
- services coordination 35%

For services coordination; the breakdown would be:

- identification of problem 20%
- conflict - service with service 25%
- conflict - service with building 20%
- advice on coordination details 35%

As this was an existing building, it would anticipate more problems in coordinating existing M&E services than in a new project. Hence, there would be more conflicts or clashes amongst new/existing/temporary M&E trades and other trades.

P.5. **Procurement Path**

a) This was believed to be the second management contract to be let in Hong Kong; the redevelopment of the Hong Kong Bank in the 1980’s was the first one. A management contract was particularly suitable for a project of this complexity of the station expansion.

The main advantages of a management contracting strategy perceived by the client was:

1) time saving potential for overall project time
2) parallel working was essential
3) late changes easily accommodated
4) work package let competitively
5) can be applied to a complex building
6) central management, the client deals with one firm only and this firm must be a professional project manager.

b) From the client’s point of view the management contract approach allowed a specific construction planning to be incorporated within the final design. Various alternatives could be assessed with the practically oriented construction team who would have the responsibility to build. The management contract approach was therefore based on procuring the management team and site organisation expertise and using it to its full extent in finalizing the design and agreeing the strategy in tendering and pricing, and managing the subcontract works packages (65 nos.)

c) A joint venture between local contractor and British contractor was awarded a management contract to manage and supervise the construction work. Both were large building construction organisations. The management contractor provided specialist and experienced management personnel (project, construction, programme, procurement and building services) for this project with multiple phasing and coordination.
d) The professional design team comprised large local architect, a multi-disciplinary consultant as structural and M&E services consultant and a quantity surveyor.

e) All works package contractors were pre-qualified specialist contractors and building construction contractor. They all had direct contractual links with the management contractor.

f) The project management system was follows:

1) Client - a Government Department with typical central control system but considered as an experienced client with good in-house project management personnel.

2) Designers - all were professional and experienced consultants, and demonstrated good management of design. The working relationship with the management contractor was good.

3) Management contractor - very professional construction and project management team, and worked together with the design and construction teams.

4) Work contractors - a cooperative construction team with adequate site management.

P.6. Coordination of Services

The project had not been completed yet. However, the researcher was informed that so far all M&E services had been satisfactorily installed in accordance to the tight schedule. As this was an existing building of complex design., there were of course many small coordination problems. It was also accepted that because of the unusual nature of this project, there were many client changes and unforeseen phasing problems which also generated critical coordination chaos which had nevertheless been picked up by the construction team and subsequently resolved by the contractors.

The success of services installation was due to:

a) Adequate coordination at design state and continued through construction by all designers together with the management contractor. In addition to the provision of detailed design, the M&E consultant also carried out an extensive site surveys for the existing building and provided useful information for the services contractors' coordination of services (this was reported to be very useful but still needed contractor's further investigation as soon as they obtained access to the existing building).

b) Comprehensive project management provided by the management contractor and all works package contractors (i.e. pre-construction and post-construction planning and monitoring of services installations. Most importantly, the management contractor had provided an efficient services coordinating team on site).

c) Building services work on this project amounted to 45% of the total cost. Problems in this area, and they were significant, were inevitably going to have a significant impact on the progress of the project. Therefore, responsibility for coordination of services had been specially noted and clearly specified in all contractors’ contract documents. Coordination would have been adequately allowed for in the tendered sums. The client
also acknowledged the necessity of additional building services personnel in his project
department, and provided a coordinator for managing all matters relating to all M&E
services in the existing building.

d) Through a very complex building (with few typical layouts), building services were still
adequately coordinated by using properly prepared shop drawings, combined services
drawings and builder’s work drawings, coupled with effective site communication, site
meetings and day-to-day problems solving group. There was also a spirit of cooperation
amongst the project participants guided under the leadership of the management
contractor (by a very experienced B.S. site engineer good at services installations).

P.7. Project Result

A very complex building with tight programme, and the need to keep the station fully
operational during construction while maintaining firm control of project costs, led the
client to adopt the management contracting method of procurement. This was a right
choice.

So far so good, the project was considered satisfactorily constructed. If the project had
been let on a traditional form of contract, one could imagine the magnitude of the claims
that would be submitted by the Main-contractor and the possible time delays to the
project. The reasons for this project success were:

a) Both the design and construction teams acknowledged the complexity of the M&E
works and allowed adequate resources for managing services installations (especially
for the existing station)

b) The design team had finalised their designs with greatest confidence because of the
buildability input by the management contractor.

c) The design team had more direct contact and control over the work package
contractors thus guaranteeing the practicality of their designs.

d) The packages were designed to suit the operation needs and to the most cost effective
solutions for the station.

e) Good control of work package contractors (65 nos.) by the management contractor
using an organised management system but fully integrated with the design team.

f) Effective management of services installations between the management contractor,
services contractors and building works contractor based on improved working
relationship, as ‘Differentiation’ between Main-contractor and M&E services
contractors had been greatly reduced. Breaking down of the traditional adversarial
barrier was conducive to integrating the builder and engineers for better coordinating
the building services. Most importantly, services would be planned adhead of
construction and then coordinated amongst M&E trades and between M&E trades and
other trades. Clashes or conflicts once identified would be resolved on site by the
relevant contractors. To improve the coordination process, the management contractor
and the consultants would also provide prompt attention to the conflicts/problems.
Details of Survey

a) Discussion with the building service engineer of the management contractor.
b) Information from the management contractor
c) Report from journals
d) Observation of services installations and construction of building
Project Number 17 – 25

These projects had been studied by the author but not as comprehensive as cases 1 – 16 owing to the fact that full details of these projects were not readily available as a result of their ages and incomplete members of the whole building team. However, the requisite aspects of the management of building services co-ordination in each project were available from the M&E services consultants and the M&E services contractors. The details given to the author were deemed to be adequate and reliable for deepening the understanding of the research subject in conjunction with the cases 1 – 16. Brief details are as shown below:

P.17 Project Number – 17 (TSKH)

An emergency hospital to be redeveloped and complex services were the requirements. Sufficient co-ordination details were provided by the consultant. The main-contractor’s building services coordinator co-ordinated all services installations with the nominated services sub-contractors by means of drawings, meetings and site controls. The overall performance was quite satisfactory and the working relationship was good. The project demonstrates the importance of proper design and good management of the co-ordination issues coupled with the selection of good contractors.

P.18 Project Number – 18 (POH)

This was an extension to an existing hospital. The main-contractor did not appreciate the importance of building services work carried out by three nominated services sub-contractors. Site management executed by all contractors was poor and this factor led to delay and poor project performance. This project result demonstrates the importance of managerial actions and quality of contractors.

P.19 Project Number – 19 (HB)

This was a large office building project. The procurement system was traditional path. The mechanical sub-contractor had a special relationship with the electrical sub-contractor and they both also had a good working relationship with the consultant and the client. The M&E services design was not very complex and all services contractors did very good site co-ordination work. All M&E services contractors also worked quite co-operatively with the main-contractor. The job was completed on time and the quality was good. This project indicates that team building is of paramount importance to project success.

P.20 Project Number – 20 (HI)

This was a large hotel building. The M&E services sub-contractor was fully responsible for most of the M&E services. The hotel was large and complex and spaces were tight. However, the services contractor did a good job and solved most of the co-ordination problems on site even complete co-ordination details were not available from the consultant. The services contractor also managed the services very efficiently with the main-contractor and the project was also completed on time. One important thing found was that the project participants had very good communication. There was a team spirit
amongst all members of the building and all provided a high degree of co-ordination even if they were traditional contracting and the project was comparatively large and complex. Again, this project demonstrated the importance of team building, good communication and the attitudes of the project participants.

P.21 Project Number – 21 (MTRC)

This was a large underground railway station M&E services project. The main-contractor was fully responsible for all M&E services with his own services contractors. Comprehensive co-ordination details were developed by the design team first and followed up again by the contractors. All the contractors provided comprehensive co-ordination and planning of M&E services installation with the building work. The building team worked quite co-operative and overcome many co-ordination problems on site. The job was completed on time and the quality was high. This project showed that the client was fully aware of the importance of building services co-ordination and allocated sufficient resources for both design and construction. The whole building team also gave very good managerial actions and controls throughout the design and construction stages. This project demonstrates the importance of complete design especially for sophisticated services and the need of good co-ordination on site.

P.22 Project Number – 22 (HKEC)

This was a large office building with normal M&E services. The main-contractor and all services sub-contractors cooperated efficiently and completed the job. Most co-ordination details were not seen from the consultant’s drawings but all services contractors (and the main-contractor) provided very good site communication. They planned their work ahead and solved many co-ordination problems on site. Again, this traditional contracting showed good co-ordination of services.

P.23 Project Number – 23 (CH)

This was a large high-rise hospital project. The design was considered very detailed but again complete co-ordination work was left to the main-contractor and his domestic sub-contractors. The main-contractor requested the HVAC contractor to carry out the co-ordination work under the supervision of his building services coordinator. The work had been planned ahead and sufficient co-ordination was carried out by the construction team and with back-up from the M&E services consultant. The work was completed to the satisfaction of the client. The consultant informed the author that the building services co-ordination work was handled very professionally by a team of experienced contractors who were all committed to do a good project for the sake of good name and future business. This project demonstrates that the effective co-operation of a group of people in activities that are directed towards a common goal is more advantageous from the viewpoint of good project performance.

P.24 Project Number – 24 (LTCH)

This was a new hospital using a traditional procurement path. The design was considered very detailed but building services co-ordination work was left to the main-contractor and all nominated services sub-contractors. The consultant knew the co-ordination problems
and requested the main-contractor to price all co-ordination work and the provision of a co-ordination team. The project result was very satisfactory as the consultant design was quite detailed and all contractors carried out the second co-ordination process on site very effectively. There were also good working relationships between all project participants. The project results demonstrate the importance of good design and the usefulness of the main-contractor’s building services co-ordination team as well as the quality of all project participants.

P.25 Project Number – 25 (SESH)

This was a hospital in UK using a D&B system. The data was given to the author by another researcher in Hong Kong. The D&B contractor was very experienced and all building services were also carefully co-ordinated by the contractor’s design and construction teams. There were good personal relationships amongst the project team members. High level of project management was a critical factor in the success of this project. The choice of the right contractor (not the cheapest) was also an important factor. Involvement of the services contractor in the design process at a point where he could contribute significantly to a potential buildability savings and the speed of completion also contributed to the success of this project. This project shows:

- D&B is seen to be providing the missing integration of the design and execution of a construction project
- An increased level of synergy in the D&B environment
- Communication was more informal
- The M&E consultant and the contractors seem to be greatly appreciated with greater involvement, increased satisfaction and significant improvement of their response time to request of information
- Interface between project participants is less problematic
- Less confrontational relationships in D&B