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Managing Portfolios of Projects

THE THESIS

By

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ABSTRACT

This research was initiated a result of a proposition described by Cleland and King in 1983. They proposed that the management of a portfolio-of-projects could be achieved as a by-product of using a MIS containing project-management data. The hypothesis in this research takes their proposition further. It contends that the application of Pareto-based heuristics in the management of a portfolio-of-projects can improve on their approach.

The research has been undertaken in Hong Kong. However, a review of the literature defines Hong Kong as a 'city-state' construction industry that is shown to be similar to national industries elsewhere. On this basis, the research establishes its validity for the general-case.

Two qualitative surveys have been completed to identify the current methods used by Hong Kong contractors and by Hong Kong consultants for the management of their portfolios-of-projects. These elements of the research did not find evidence that in general, firms used a MIS that transformed project-level performance data to manage portfolios-of-projects. In this respect, there was no notable evidence of the adoption of the project-to-portfolio MIS data-pipeline described by Cleland and King. These surveys did not provide evidence that the commonly used 'individual review' or 'spreadsheet analysis' of multi-project data for portfolio management included prioritisation to identify projects of most significance to the outcome of the portfolio.

Empirical data from the public works element of the Hong Kong construction industry is used in simulations of portfolio management to test the hypothesis along with a longitudinal grounded case study of the implementation of a portfolio/project MIS within the Hong Kong Government (HKG SAR). This case study provided practical experimentation through the quantitative measurement of 'before' and 'after' effects of a change to project-based multi-project management techniques that fitted the Cleland and King model. A qualitative survey has been completed to assess the degree of success and User satisfaction with this practical experimentation. The

results of these elements of the research are taken to mean that the hypothesis is supported in principle.

The final element of the research uses the empirical data to investigate the effectiveness of basing success for the portfolio-of-projects largely on the outcome of the important projects within the portfolio. Monte Carlo techniques are used to simulate an achievable excellent performance for the projects deemed as significant within the portfolio whilst the outcome for the other projects is unchanged. The simulated improved performance for the significant projects is based upon a derived probability-distribution-function (PDF) that represents the top twenty percent of project achievement for the portfolio-of-projects. The simulated outcome provides evidence in support of the hypothesis. With the exception of one of the ten cases tested, the theoretical application of excellent outcomes for the significant twenty percent of the number of projects using Monte Carlo techniques results in a worthwhile improved outcome for the portfolio as a whole. In the exceptional case, the actual result was already in agreement with the theoretical proposition. All ten cases, thereby showed the hypothesis to be true within the specifics and constraints of this research.

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My wife, Sheila, and my daughter, Natalie, sighed deeply when I first mentioned to them my intention to undertake this personal odyssey. From that moment forward they have supported me in this endeavor and cared for me selflessly whereas in return I have been selfish with my time. I have missed being at leisure with them, but as a result I treasure moments together more than before, which is a very good thing.

I hear, and I forget.
I see, and I remember.
I do, and I understand.

Confucius

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Abbreviations

AACSB	means, the Architectural and Associated Consultants Selection Board of the HKG SAR who administer to the appointment of consultants who undertake building works.
CWRF	means, the Capital Works Reserve Fund of the HKG SAR, being the source of capital funds for the projects of the government.
EACSB	means, the Engineering and Associated Consultants Selection Board (EACSB) of the HKG SAR who review and delegate authority to appoint consultants for civil engineering works and associated services.
INFORM	means, the INFORMation MIS of the Architectural Services Department of the Government of the Hong Kong Special Administrative Region.
ITSD	means, the Information Technology Department of the Government of the Hong Kong Special Administrative Region of China.
HK	means the geographical entity administered by the HKG SAR.
HKG SAR	means, the Government of the Hong Kong Special Administrative Region of China, formally the British Crown Colony of Hong Kong. Otherwise abbreviated to HKG.
HKG	means the same as HKG SAR.
LAFIS	means, the Ledger-Accounting-Information-System the Government of the Hong Kong Special Administrative Region of China. LAFIS is a ledger accounting system used by the Treasury of the HKG SAR to record all accounting transactions.
Legco	means, the Legislative Council of Hong Kong, being it's law making body.
M.I.S.	means, Management-Information-System(s), usually a computer-based system of data analysis and reporting.
PDF	means probability distribution function.
PMIS	means, a project-management-information-system.
PRINCE	means, 'Project Management in a Controlled Environment'. It is highly regulated methodology for the project management of information technology projects. It was devised on behalf of the UK Government and is used as standard practice by ITSD.
PW_MS	means, the public works management system of HKG. It is an inter-department, multi-participant MIS serving as a project-level management tools and also an executive-level portfolio management tool.
PWP	means, the Public Works Programme of projects of the HKG. The range of public infrastructure capital works projects funded from the Government's Capital Works Reserve Fund.
PWSAU	means, the Public Works Systems Administration Unit, being the divison of the Works Bureau of the HKG SAR that supports the PW_MS.
PWSC	means, the Public Works Steering Committee, being a committee chaired by the Secretary for Works with the objective of facilitating public works capital projects.
RAS	means, the Resource Allocation System for prioritising capitial projects and allocating necessary resources for them to proceed to completion.
SSADM	means, 'Structured System Analysis and Design Methods'. It is a systemised methodology used for the analysis and documentation of a physical process that is then to be re-created within a computerised system.
WB	means, the Works Bureau of the HKG SAR and up to July 1997, formerly the Works Branch of the British Crown Colony of Hong Kong (HKG). It is the bureau of the policy-making Secretariat of the Government responsible for public works policies. The Secretary for Works is also responsible for the delivery of the PWP overall.

1 INTRODUCTION

1.1 Guide to the thesis

Each Chapter of this main volume of the Thesis is presented as a discrete element of research. They are laid out in the same sequence as the line of enquiry followed for the entire project. Each one starts with a brief introduction as a navigational aid and concludes with a summary. These are provided for those readers who do not require the greater detail provided within the main part of the text. Citations within each Chapter are cross-referenced by a superscript notation to a list of references at the end of the Chapter. A Bibliography is printed at the end of the Thesis. Appendices of data and additional supporting evidence are provided on CD-ROM for those readers that require further substantive argument or greater detail.

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

This chapter of the Thesis is to put the research into context. It describes:

- What the research is about (Section 1.2);
- The Hypothesis to be tested (Section 1.2.1.3);
- The practical application of the Hypothesis (Section 1.3); and,
- The relevance of this research to the construction industry in general (Section 1.4).

1.2 Purpose of the research

This research is about the management of a portfolio-of-projects: an action that arises whenever there is an interest in the combined outcome of more than one project.

Specifically, the research is to:

- identify the current practices for the management of portfolios-of-projects within the construction industry of Hong Kong,
- undertake practical experimentation by way of a 'before and after' longitudinal-grounded study of a project-management-information-system (PMIS0 that is used for the management of a portfolio-of-projects, and
- test, using empirical data, the hypothesis with a view to defining a heuristic that reduces the effort needed for the effective management of a portfolio-of-projects.

The management of a portfolio-of-projects is a common requirement for big or small, public or private-sector, construction firms. The objective is to gain maximum benefit from an optimum deployment of a pool of resources. The greater the number of projects, then the greater the difficulty in assessing competing priorities and in making appropriate allocations of resources. Management wants to achieve the best possible outcome for the firm, i.e., an optimum outcome for the portfolio-of-projects as a whole rather than for individual projects. There is a spectrum of possible outcomes for this ambition. The best possible outcome is achieved if all the projects have a perfect delivery. The converse is also true. Between these extremes are the more realistic possibilities of an outturn due to some projects performing well whilst others perform badly. If we contrive a situation where the projects that provide the most good, do well, whilst the projects that provide the least good do less well: then an overall result is achieved that tends to the more desirable outcome within the spectrum of possibilities. It is this approach that is the basis of the hypothesis tested in this research.

If the projects in the portfolio are perfectly identical, then they cannot be separated into 'those-that-provide-most-good' and vice versa but this is not true in the real world. There are always priorities to be satisfied that identify what is 'good' and what

is 'bad' for the portfolio. Knowing this makes it possible to separate the projects into the two categories. As the portfolio increases in size and diversity, then the differences between the projects becomes more obvious. Separation into the 'most good' and the 'least good' categories is then potentially easier. In practice, there are many attributes that are considered good or bad. They are not mutually exclusive. They can form combinations whose impact is difficult to measure. This research does not set out to investigate this aspect of project significance i.e., the possible permutations of 'most good' or 'least good' attributes although others have addressed this topic from a variety of stand points[1,2,3,4,5,6,7,8,9,10,11,12,13,14,15]. It does investigate the outcome that is achieved if the projects, which according to a commonplace attribute of what is good for the portfolio i.e., cost of work, are ensured success compared to the others. It examines the outcome derived from a 'project-significance' approach to the management of an empirical portfolio-of-projects compared to the outcome in practice, i.e., the 'actual' outcome.

The application of this principle in practice can vary with the nature of the portfolio-of-projects and the owner's criteria for success. The 'criteria of success' defines what projects are significant within the portfolio.

> The objective of this research is to demonstrate that this principle of 'project significance' is an efficient and effective method for the management of a portfolio-of-projects because it provides a reasonable approximation of the best possible outcome for the portfolio but is achieved at lesser managerial effort.

1.2.1 Stimulus for the research

1.2.1.1 The problem

The catalyst for this research was a description by Cleland and King published in 1983, of a functional specification for a project-management-information-system (PMIS) that also served as a tool for the management of a portfolio-of-projects[16]. They theorised that project-level data used to measure the performance of each project in a portfolio-of-projects could be used to provide aggregated measures of

performance for the entire group of projects. They saw this capability as a further benefit to be derived from the use of the information pipeline that would exist within computerised project management processes.

It is an intriguing concept. Analysis of each time-slice of aggregated project-data, provides an overview of the portfolio. Comparing the overview with the planned position would show the performance. Successive performance measurements would indicate a trend. Extrapolation of the trend provides a forecast of a likely outcome. On the basis of this, managing a portfolio-of-projects as a by-product of project-management appears to offer added-value to the use of a computerised PMIS. Advances in Information Technology (IT) since 1983 have increased the practicality of this proposition. Computerised systems are well suited to serving as 'information pipelines' that consolidate fine-detailed data into items of summary-information, but they suffer from two drawbacks that render them difficult to implement in practice. First, these systems are intensive users of project-level data that is costly to capture because they require the same range of detailed data, at the same frequency, from all the projects in the portfolio irrespective of their significance. Second, the aggregation of the fine-detailed data may indicate unsatisfactory performance overall, but it does not indicate the deviant projects among the many being viewed in aggregate. Data-warehousing techniques can solve the latter problem but not the former. What is intriguing about Cleland and King's proposition is that twenty-years-on, it is apparently not a commonplace approach adopted by the construction industry for the management of their portfolio-of-projects.

1.2.1.2 An alternate approach

An alternate to the Cleland and King proposition is to use Pareto heuristics such as the 80:20 rule to identify the significant projects within the portfolio and to ensure that their performance is excellent because they will dominate the results desired for the portfolio overall. This research sets out to prove that the satisfactory performance achieved by these lesser number of significant projects leads to a reasonable approximation of the optimum outcome for the portfolio overall, other things being equal.

Murray et al[17], Horner and Zakieh[18], Al-hajj and Horner[19], Munns and Al-Haimus[20], and Poh and Horner[21] have taken a similar approach with construction estimating. They propose heuristics based on the cost-significance of items within the Bill of Quantities that substantially reduce the overall estimating effort at the cost of a minor loss of accuracy overall.

1.2.1.3 The consequentially derived hypothesis

This Pareto-based approach to the management of a portfolio-of-projects provides the basis for the hypothesis to be empirically tested in this research, namely;

> **The outcome for a portfolio-of-projects is reasonably assured when a satisfactory outcome is achieved for those twenty percent, or thereabouts, of the projects in the portfolio that contribute eighty percent or thereabouts of the value of the portfolio.**

'Twenty percent' and 'eighty percent' are thresholds indicative of the probable contribution of the few high-value projects in the portfolio compared to the larger number of lower-value projects. This twenty:eighty heuristic is derived from Vilfredo Pareto[22]. 'Satisfactory' is taken to mean within +/- twenty percent of an ideal outcome. 'Reasonably' is taken to mean a fifty:fifty (evens) probability.

The value of this heuristic is that the paramount impact of the twenty-percent significant projects warrants detailed and frequent collection of project data: less so for the eighty-percent of less-significant projects. If true, then it is possible to revise the Cleland and King proposal to avoid the dependency on the collection and analysis of consistent data from all the projects in the portfolio.

1.3 Application of the alternate approach

The usefulness of a 'project significance' (Pareto-based) approach to the management of a portfolio-of-projects is a function of:

- Increased management effort applied to the twenty-percent significant projects;

- Reduction of data collection effort for the eighty-percent of less significant projects.

The practical issues in deploying this alternate approach are noted in the subsequent sub-sections 1.3.1 to 1.3.4 of this Chapter.

1.3.1 The presumption of the 80:20 heuristic.

In practice, the key to ensuring an optimal outcome for the portfolio-of-projects is to know in advance which projects are significant to the outcome for the portfolio and to give them more managerial attention than the other projects. If the portfolio is sufficiently large and contains a diverse population of projects, then statistical principles apply enabling use of the heuristic and the presumption that twenty-percent of the projects will have a major impact whilst about eighty percent will have a minor effect. In practice, this takes place within a portfolio-of-projects undergoing dynamic change. The application of the principle must be effective, timely, and cost-effective according to the rate of dynamic change inherent in a portfolio-of-projects.

1.3.2 Problems in practice due to dynamic change within a rolling-portfolio of projects

The challenge in this approach is to identify the projects that are significant at any moment in time within a diverse and dynamically changing portfolio-of-projects. This focus on significant projects must be as fast as the rate of change within the portfolio. The dynamic within the portfolio increases with the size of the portfolio, and with shorter rates of change or shorter average-duration of the projects. Each project within the portfolio is subject to dynamic change as it progresses through the development cycle until completion. In a rolling-programme, new projects are added as mature projects are completed thereby maintaining the diversity of the dynamic change within the portfolio. The dynamic is compounded by changes in the relative significance of the project as it evolves. A project that is significant to the portfolio at one stage of its development may be less significant at a later stage. In a well-managed project, adverse risks are greatest at the outset and diminish as action is taken to mitigate them during the development of the design. Similarly, risks in construction are dissipated as work progresses.

1.3.3 Performance measurement effort

There is an overhead cost in the measurement of the performance of the portfolio-of-projects: and it makes sense to minimise it. The method described by Cleland and King is a maximum effort for data maintenance as it is necessary to measure the performance of all the projects in the portfolio according to the finest level of detail required for the minimum level of reporting for the most sensitive project. These consistent inputs are then consolidated to a net effect to be used as the overall measure of performance. The effort expended in this timely collection of the data at frequent intervals, increases in proportion to the number of projects in the portfolio. The analysis of these data must be as fast as the rate of change within the portfolio. As the amount of data and the rate of dynamic change increases, then manual methods become less practical and data-processing with a computerised management-information-system (MIS) is necessary.

1.3.4 Dependency upon Project-Management-Information-Systems (PMIS)

The processing of the collected data can be crudely done using manual methods, or thoroughly by using a computerised information system. Computerised systems used in this manner form 'information pipelines'. They enable the consolidation of the fine-detailed data to become more generalised items of data. The stream of consistent fine-detailed data can be algorithmically processed to provide a summarised view of the portfolio as a whole, or subsets of it. They have two drawbacks, already noted, that make them difficult to implement in practice. None-the-less, except for portfolios of a few projects, the benefits of using a MIS for the processing and aggregation of project data exceed the disadvantages. The use of information technology for transmission of data, data processing, and communication of information appears to be a self-evident pre-requisite for the management of a portfolio-of-projects. This presumption is the subject of qualitative research on the management of portfolios-of-projects within the Hong Kong construction industry described in this Thesis.

1.4 Application of the research to the construction industry at large

This research has used audited data and casework taken from the construction industry of Hong Kong. This does not impose any extraordinary conditions on the research. The scale and the open-market environment of the Hong Kong construction industry and its general attributes are explained in Chapter 3, and are not unusual. For these reasons, the findings of the research are deemed applicable to the general case.

1.5 Summary of the Introduction

This research is about the management of a portfolio-of-projects: an action that arises whenever a participant has an interest in the combined outcome of more than one project. Specifically, the research is to identify the current practices for the management of portfolios-of-projects within the construction industry of Hong Kong. It includes practical experimentation by way of a 'before and after' longitudinal-grounded study of a PMIS that is used for the management of a portfolio-of-projects. And, to test, using empirical data, a hypothesis that applies Pareto-principles of project significance with a view to defining a heuristic that reduces the data-administration overhead for the effective management of a portfolio-of-projects using a PMIS. This research has used audited data and casework taken from the construction industry of Hong Kong. This does not impose any extraordinary conditions on the research: thus, the findings of the research are deemed applicable to the general case.

The subject area - management of a portfolio-of-projects - is a common requirement for big or small, public or private-sector, construction firms. The best possible outcome is achieved if all the projects each have a perfect delivery. The research investigates the outcome that is achieved if the projects, which according to the most commonplace attribute of what is good for the portfolio i.e., cost of work, are ensured success compared to the others. An objective of this research is to demonstrate that this principle of 'project significance' is an efficient and effective method for the management of a portfolio-of-projects because it provides a reasonable close-

approximation of the best possible outcome for the portfolio, at lesser managerial effort.

The catalyst for this research was a description by Cleland and King published in 1983, of a functional specification for a project-management-information-system (PMIS) that also served as a tool for the management of a portfolio-of-projects. They theorised that project-level data that is used to measure the performance of each project in a portfolio-of-projects could be used to provide aggregated measures of performance for the entire group of projects. They saw this capability as a further benefit to be derived from the use of the information pipeline that would exist within computerised project management processes. An alternate to the Cleland and King proposition is to identify the lesser number of significant projects within the portfolio and to ensure that their performance is excellent because they will dominate the results for the portfolio overall. This research sets out to prove that the satisfactory performance achieved by these lesser number significant projects is a reasonable approximation of the outcome for the portfolio overall, other things being equal. This Pareto-based approach to the management of a portfolio-of-projects provides the basis for the following hypothesis to be empirically tested in this research, namely;

> **The outcome for a portfolio-of-project is reasonably assured when a satisfactory outcome is achieved for those twenty percent, or thereabouts, of the projects in the portfolio that contribute eighty percent or thereabouts of the value of the portfolio.**

If the hypothesis is true, then it is possible to revise the Cleland and King proposal to avoid the dependency on the collection and analysis of consistent data from all the projects in the portfolio. This effort-saving approach is of potential benefit to many organisations but of particular relevance to the project-dominated construction industry.

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Chapter Two

2 Research Methodology

2.1 Introduction

This Chapter of the Thesis describes the order of the research and the methodologies used in each element of the work. With regard to methodology in general, Easterby-Smith et al[1], and Fellows and Liu[2] have been used as principal references on methodology throughout the research supplemented by others at specific instances of the work. Cited references with regard to methodology are provided as endnotes to this Chapter and included in the entire Bibliography at the end of this Volume. Table 2-1 below, is a quick-reference navigational aid to each element of the research. It states the objective of that item of research and a reference to the location of detailed information within this document.

Element of research *(Ref Figure 2-1)*	**Objective**	**Chapter**	**Page #**
(1) Literature review of the theory on the topic of research	• Consolidaton of existing theory to derive/validate the hypothesis	Chapter Four	76
(2) Literature review of research environment	• To relate specific context of the research to the general case	Chapter Three	61
(3) Survey of Hong Kong contractors	• Qualitative research of portfolio-management by the contractor element of the construction industry in Hong Kong	Chapter Five	89
(4) Survey of Hong Kong consultants	• Qualitative research of portfolio-management by the consultant element of the construction industry in Hong Kong	Chapter Six	127
(5) Case study	• Longitudinal-grounded case study of project/portfolio-management complying with principles stated by Cleland and King[3]	Chapter Seven	161
(6) User survey	• Qualitative research of the use of project/portfolio-management approach in the case study	Chapter Eight	195
(7) Simulation modeling	• Quantitative research using empirical data on an alternative approach to Cleland and King	Chapter Nine	212

Table 2-1 Locational guide to the research

2.2 Layout of the Thesis

Figure 2-1 shows each element of the research in terms of their interrelationship and approximate chronological order. The description of the methodologies used for each element of the work follows this sequence and numbering.

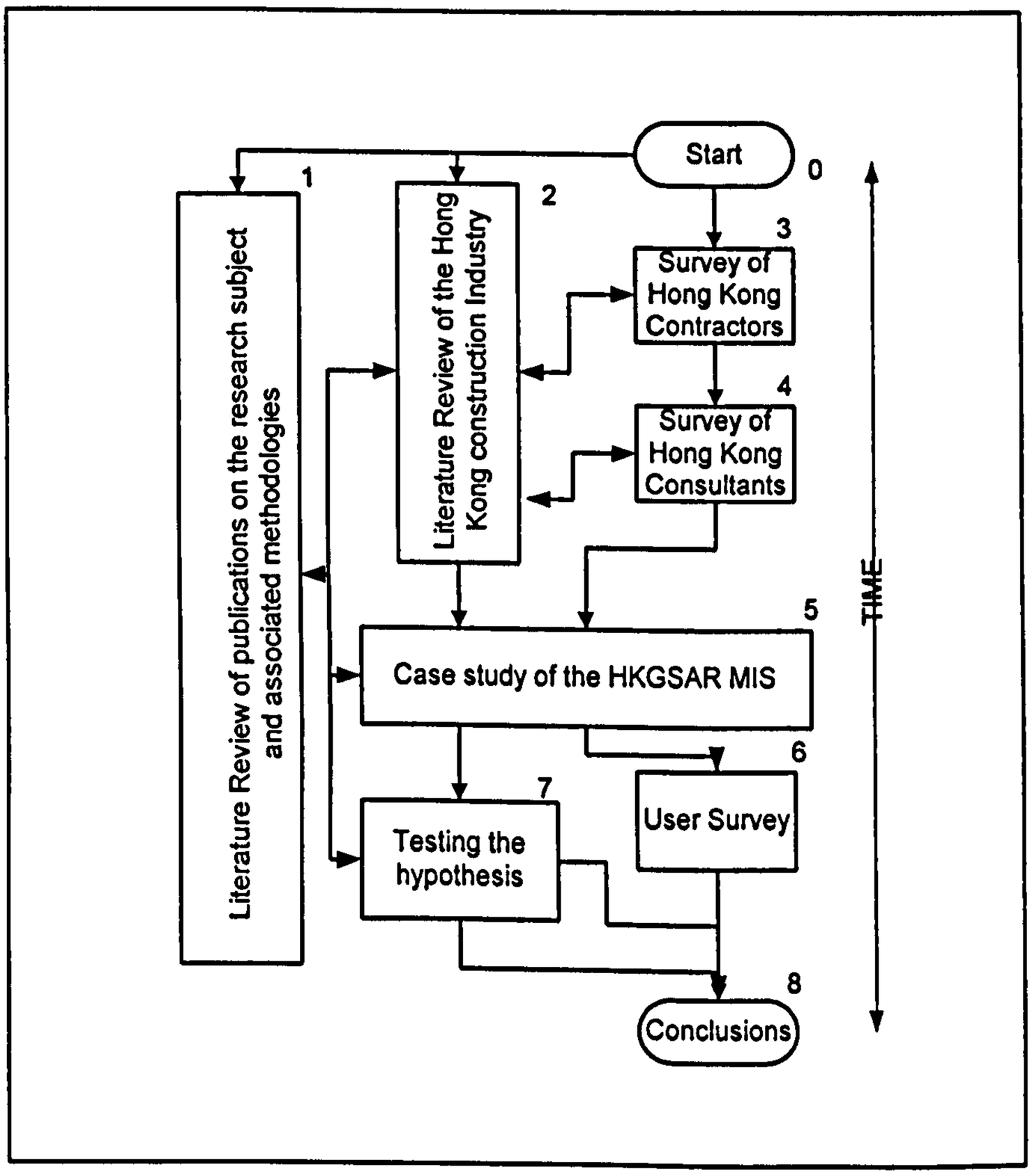

Figure 2-1 Chronologically ordered flowchart of the elements of the research

The overall logic of the stages of the research methodology was to address the following research questions. The results have been published in the series of papers listed in Section 10.4 :

- How do firms manage their project portfolios?
- How do they rationalise the trade-off between optimum project outcomes versus optimum portfolio outcome?
- How do they use IT to support these trade-offs?

- What are the problems with the implementation and the use of such IT systems and what factors lead to their success?

A literal description of the investigation is provided in the Abstract. Further detailed description of methodology is given within Section 2.3 of this Chapter, as follows:

- Section 2.3 Methodology – literature discovery;
- Section 2.4 Methodology – Hong Kong construction industry as a generic national industry;
- Section 2.5 Methodology – qualitative research into portfolio-management by Hong Kong Contractors;
- Section 2.6 Methodology – qualitative research into portfolio-management by Hong Kong Consultants;
- Section 2.7 Methodology – longitudinal-grounded case study of a portfolio-management-system in the model form of Cleland and King;
- Section 2.8 Methodology – qualitative research into the use of a portfolio-management-system in the model form of Cleland and King; and
- Section 2.9 Methodology – quantitative research into portfolio management based upon project significance according to Pareto-rules.

2.3 Methodology – literature discovery

Seminal works by Cleland and King[3], Horner and others[4,5,6], Turner[7], Turner and Speiser[8] are the fundamental references for this work because of their high degree of relevance. The 1996-2001 proceedings of the conferences of CIBW78: 'Construction Information Technology' has been a further source of published literature and also used as a forum for the publication of peer-reviewed papers generated by this research. These are cited within the Thesis. However, the depth and breadth of the literature discovery is predominantly the peer-reviewed research journals that encompass the topic of construction management and related technologies. These are described in Table 2-2. The 'breadth of the discovery' is this range of research periodicals. Whereas, the depth is the decade, or so, of the issues reviewed.

Title/Period	Stated audience	Pub.	Edit Board
Automation in Construction *Skibniewski, Ed. Reviewed from 1st issue in 1999*	'. . .an international journal for the publication of original research papers. . . . all aspects pertaining the use of IT in [AEC] . . . . Includes Management Information Systems.'	Elsevier	Yes
Construction Information Technology *Alshawi and Skitmore Ed. Reviewed from 1990*		Salford Univ	Yes
Construction Management and Economics *Bon and Hughes, Ed. Reviewed from 1990*	'. . .Is a bi-monthly international journal which serves all practitioners in the construction sector and researchers in academic and research organisations.'	E&FN Spon	Yes
Engineering Construction and Architectural Management *McCaffer and Thorpe. Ed. Reviewed from 1990*	'This journal publishes original research work and technical papers reporting innovative developments in construction and its management.'	Blackwell Science	Yes
International Journal of Project Management *Turner, Ed Reviewed from 1990*	A monthly journal that is 'devoted to the publication of papers which advance knowledge of the practical and theoretical aspects of project management. . .'	Pergam'n	Yes
International Journal of Computer Integrated Design and Construction *Anumba. Ed Reviewed from 1st edition 1999*	'Is a quarterly journal that publishes peer reviewed papers on Computer Integrated Design and Construction.	SETO	Yes
Journal of Construction Engineering and Management *Harris. Ed. Reviewed from 1990*	'. . . quality papers to advance the science of construction engineering. . . . Topics include, . . .production planning, specifications, scheduling, estimating, cost control, . . . construction management, . . .'	ASCE	Yes

Journal of Engineering and Technology Management *Reviewed from 1990*	'Is an international peer-reviewed journal which aims to promote the theory and practice of technology and engineering management. . . .planning, development, and implementation of technological capabilities to shape and accomplish strategic and operational objectives of an organisation.'	Elsevier	Yes
Journal of Management in Engineering *Russell, Ed. Reviewed from 1990*	'Is a publication of the Engineering Management Division of the ASCE, . . . areas of interest are: project management; department, branch and office management, finance management, marketing; computing systems management	ASCE	Yes

Table 2-2 Journals accessed for the literature review.

Although, the primary objective of the search is to ascertain prior work on the topic of multi-project management, the opportunity was also used to take note of research in other topics meaningful to this Thesis. Table 2-3 shows the primary keywords and corresponding research references extracted to assist in this work.

Keyword	Nos. Refs	Comment
Const-IT	26	• Information Technologies in construction with a portfolio/project management relevance
Hong Kong	34	• Attributes of the Hong Kong construction industry
Methodology	13	• Research methodologies relevant to this research
Monte Carlo	41	• Theory and example of the use of this technique
Multi projects	37	• Management of portfolios-of-projects
Multi-participant	10	• Participants in portfolio/project management
PIMS	84	• Project information management systems
PWP	5	• Public works programme of the HKG SAR
Significance	23	• Management by selectivity

Table 2-3 Results of 'discovery' by keywords

In this discovery process, 355 peer-reviewed journals, books and other references were accessed. 3,154 abstracts were reviewed and 274 papers extracted as a source of reference to this research. Table 2-4 shows the extent of this discovery in terms of the periodicals listed in Table 2-2.

Journal	Period	Issues	Abstracts	Noted
Automation in Construction	94-01	41	338	13
Construction Information Technology	98-01	5		5
Construction Management and Economics	90-01	71	603	73
Engineering Construction and Architectural Management	94-01	30	213	21
International Journal of Project Management	88-01	65	501	70
International Journal of Computer Integrated Design and Construction	99-00	6	31	2
Journal of Construction Engineering and Management	89-01	55	647	21
Journal of Engineering and Technology Management	95-01	16	84	1
Journal of Management in Engineering	89-01	60	356	13

Table 2-4 Sources of related research

A review of the literature on the topic of 'multi-projects' meaning the management of portfolios-of-projects is in Chapter Four. The other topics of literature discovery noted in Table 2-3 are used in Chapters of the Thesis as appropriate.

2.4 Methodology – Hong Kong construction industry as a generic national industry

Seminal works by Rowlinson and Walker[9], and Enright et al[10] are the fundamental references for this work because they comprehensively describe the nature of the Hong Kong construction industry. The journals listed in Table 2-2 have also been reviewed for publications on this subject. Statistical data on this topic is taken from the Hong Kong Annual Digest of Statistics, 1998 Edition. Data from these sources is used as evidence that it is acceptable to categorise the Hong Kong construction industry as comparable to a 'national' industry.

2.5 Methodology – qualitative research into portfolio-management by Hong Kong Contractors

Qualitative research in the form of a postal survey was used to assess the current methods used by Hong Kong contractors to manage their portfolio-of-projects[11]. The pilot interviews and the questionnaire survey were targeted at a representative sample of Hong Kong contractors. The postal survey covered three aspects of project/portfolio information management:

i) the use of information technology to assist in the flow of project information; it's aggregation into information that indicates the overall status of the portfolio-of-projects; and, the distribution of this information;

ii) the methods employed for drawing together project information to help manage the portfolio-of-projects; and

iii) the current methods used for the measurement of the performance of the portfolio-of-projects.

In addition, a self-assessment instrument that assesses the strategic use and management of IT was included in the questionnaire with the agreement of Betts.

2.5.1 Identification of questions

Three subject areas were identified as being of primary importance in this qualitative assessment:

Coms_Net – meaning the communications methods/network used to transfer items of project data from work-sites to the corporate-centre for consolidation into an indicator of corporate performance;

Proj_Data – meaning the items of data that are used as indicators of project performance that can be consolidated into an indicator of performance for the portfolio as a whole;

Portfolio_Method - meaning the method adopted for consolidating project data into an indicator of performance for the portfolio-of-projects. A subset of this aspect of the research is the baseline adopted for measuring performance. This requires knowledge of the owner's critical-success-factors for their portfolio-of-projects.

Other approaches used for similar research into the use of information technology in construction[12,13,14,15,16,17,18,19,20,21,22,23,24], were studied to identify useful concepts to be adopted in this questionnaire. Atkins et al[25,26,27,28] carried out a series of interviews and questionnaire surveys in 1996, 1997, and 1999 as part of a comprehensive benchmarking exercise to measure the extent that information technology is used by construction firms in Great Britain compared to other benchmark industries such as the automotive industry. Their line of questioning in these specific survey instruments is similar to this research. It is focused on the flow-of-work that is to be serviced by using information technology. Howard and Samuelson[29], and Samuelson[30] (1998), describe their investigations in Sweden on the same topic. Their objective is to measure the extent that information technology is used by the construction industry. Their questionnaire is targeted at industry in general and therefore contains questions to identify the attributes of each respondent company. The line of questioning on IT is precise: it asks the respondent to state the number of machines of various types, to name the software used, and so forth. This line of questioning was thought to be too onerous for the Hong Kong survey. It would probably result in a low response. Shen and Fong[31] did record a low response of sixteen percent in their postal survey of Hong Kong contractors. Similar to Samuelsson,

they asked for precise information regarding the numbers and types of hardware and software in use, along with the number of instances a task was carried out using information technology. Shen and Fong wanted quantitative measurement of the use of information technology by contractors, architectural firms, and quantity surveying firms. They used a questionnaire targeted at these types of firm.

Having considered this prior work, qualitative data drawn from a broad response was deemed a better approach rather than the precise approach of others. The mind-mapping techniques recommended by Buzan[32] were used to breakdown the area of investigation into a hierarchy of sub-topics, of increasing detail, until the specific questions for the questionnaire were identified.

The method developed Betts and Shafagi[33], for a self-assessment element of the questionnaire was included as the fourth element of the questionnaire. This self-assessment health check comprises twenty-eight, 'tick-the-box' questions that respondents can answer and then self-score to subjectively measure their strategic use and management of IT. These questions are grouped into three major categories:

- the position of IT within the competitive business strategy of the organisation;
- the overall role of IT within the organisation; and
- the current IT strategy within the company.

This part of the questionnaire is useful to the respondent and researcher alike as it gives the respondents quick feedback on the extent of their strategic use of IT compared to a benchmark standard developed in the UK for this purpose. It is also a basis for comparison with the same research exercise carried out in Great Britain by Betts and Shafagi, in Australia by Stewart[34], and Allen in South Africa. The questions in the health check are not precise, but they are useful as an indicator of the construction industry's self regard for their strategic use of IT.

2.5.2 Development of questionnaire

2.5.2.1 Development process

The review of comparable similar questionnaires introduced ideas for the postal survey but none-the-less the instrument was conceived as a fresh approach designed to encourage a rapid qualitative response. The questionnaire was developed through a process of mind-mapping techniques to breakdown the research topic into detailed questions. The draft questions were then tested in-house and revised again. Selected pilot interviews of the refined questions resulted in a final version of the questionnaire. The Secretary for Works reviewed this version before it was released by post to the survey population. Each stage of the development was sequential to allow continual improvement by revisions carried out at each feedback stage as depicted in Figure 2-2.

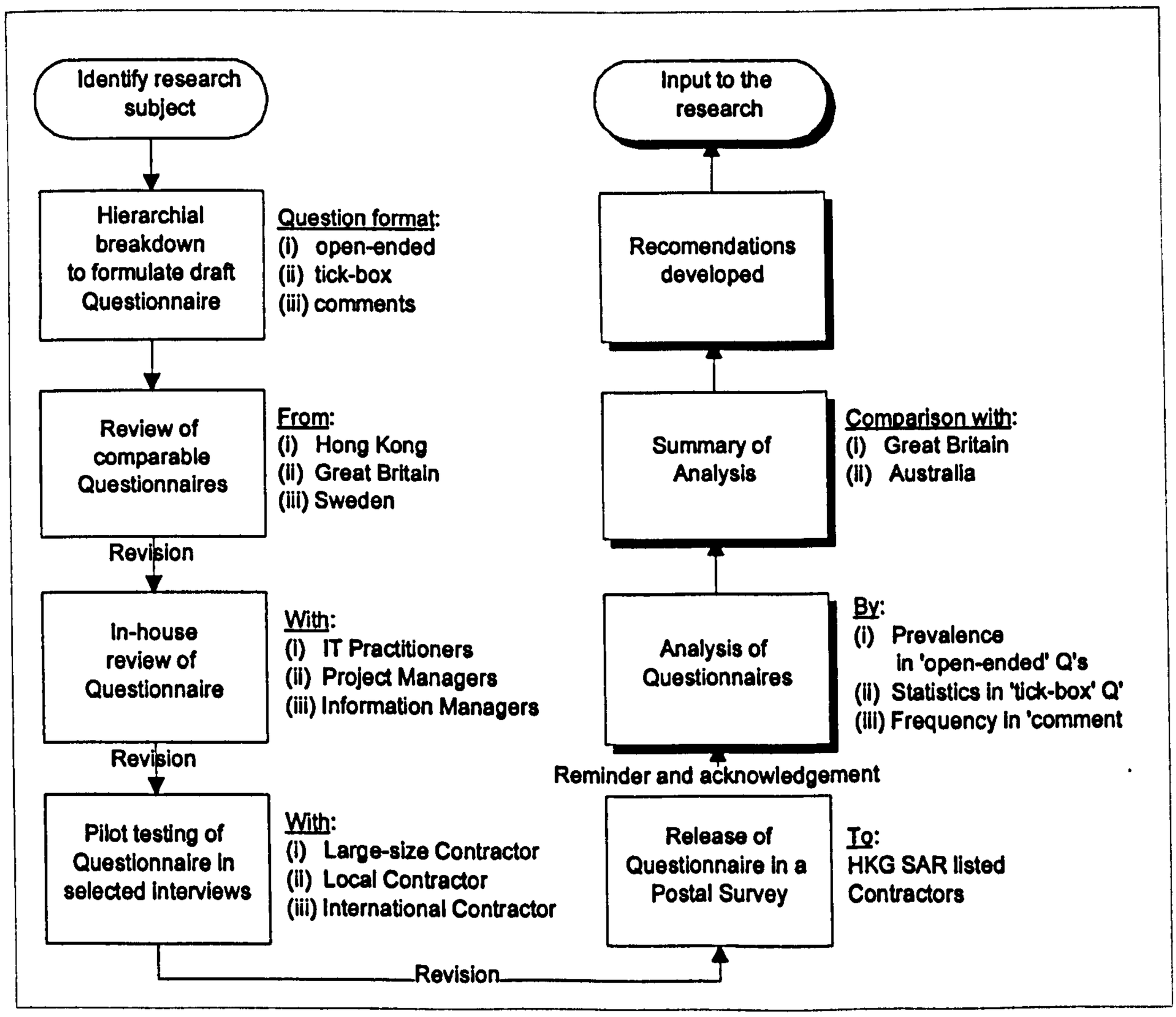

Figure 2-2 Development of a questionnaire survey of Hong Kong contractors.

The purpose of the process was to develop objective and succinct questions that are readily understood. Improvement was through a sequence of consultation and revision. It included: a comparison with questionnaires developed elsewhere for similar research purpose; consultation with in-house professionals; and pilot interviews where the questionnaire was validated, or amended, by selected contractors from the sample population. Questions were developed following guidelines proposed by Sinclair[35], Wright and Barnard[36], Oppenheim[37], and Hoinville[38]. They advise:

- Use simple English;
- Avoid biased questions
- Keep the questions short;
- Set out the questionnaire well;
- Use a self-explanatory questionnaire;
- Questions should be designed for easy analysis; and
- The questionnaire should be clear, unambiguous and easy to answer.

'Tick-the-box' types of questions were used where-ever possible because they best suited statistical analysis. 'Open-ended' or 'comment' responses were invited in the questionnaire when the opinion of the respondent was needed

2.5.2.2 Review of the questionnaire.

The questionnaire along with a commentary, that explained the rationale for the questionnaire, was validated by Dr Rowlinson, the Director of the Hong Kong Centre for Construct IT at the University of Hong Kong, and subject to academic critique by the Supervisor of this research. Upon their satisfaction, the revised questionnaire was tested within the Works Bureau of the HKG. They had agreed to lend their support to this element of the research. Three Works Bureau professional staff, responsible for data-maintenance, reports, and application-development of the Government's 'public works management system' (PW_MS) independently undertook a critique and agreed the questionnaire subject to some minor suggestions. They suggested, for the sake of completeness, that questions on the use of pager technology, Intranets, and the sums of money invested on IT, should be in the questionnaire. These ideas were not taken up. Pagers are a prelude to a two-way communication between participants. The use of

Intranets is included within the questionnaire. Querying the amounts of money spent on IT was unacceptable to the Works Bureau.

The questionnaire and the commentary was also reviewed by the Chief Assistant Secretary for Professional Services within the Works Bureau. This unit of the Works Bureau is responsible for the administration of the Contractor List for public works projects. They agreed to the questionnaire and provided the details of the survey population sample from their database of public works Contractors. This information was limited to non-commercial data. It includes all the approved contractors within the major groupings of tendered public works on the Government list. Details of the population sample are given in Chapter Five.

In a further stage of independent professional critique, the questionnaire was also passed to two independent IT consultants employed by the Highways Department of the HKG SAR. They found the questionnaire reasonable but recommended that it also include measurements of the use of IT to assist in the flow of information on construction-related issues such as safety, quality assurance, and the like; plus a measurement of the current practices for archiving of documents. This was done.

2.5.2.3 Pilot testing of the Questionnaire

The revised questionnaire was tested at two pilot interviews with Contractors from the HKG Contractor List, namely, Chevalier (Construction) Co. Ltd., and Gammon Construction Ltd. Pilot testing was by a process of question-by-question testing of the questionnaire with a panel from each Contractor on separate occasions. They pointed out instances of ambiguity, or a lack of clarity, and suggested changes to the order of questions to improve the logical flow of the inquiry. They confirmed that the questionnaire was adequate to the intended purpose, and that they found it a useful exercise. They confirmed that the results of the survey would be practical to them.

The Secretary for Works approved the final revised questionnaire, the draft of the covering letter, and agreed to sponsor the survey. The questionnaire was issued as a HKG document. Refer to Volume II, 'Appendices' Section 5.3 for further details. The contents of the letter followed the guidance given by the Hoinville et al, it:

- Explains the aim of the survey;
- Provides assurance of confidentiality;
- Confirms the importance of the survey;
- Confirms the importance of prompt response;
- Explains the mutual benefits arising from the survey; and
- Signature, in the name of the Secretary for Works, increases the probability of a response.

2.5.2.4 Postal release of the Questionnaire

The questionnaire was distributed to the sample population by postal distribution on Monday, March 2, 1998 following the guidance given by the Hoinville et al, it:

- Was accompanied by a self-explanatory covering letter;
- Included a clearly printed questionnaire with explicit instructions on the first page;
- Included an addressed, postage pre-paid, envelope for the return of the questionnaire
- The questionnaire and the return envelope were marked with the respondents unique reference code; and
- Sets of mailing labels were used to log the postal distribution, receipt of responses, reminders, and data transcription.

The response period was three weeks. The percent level of response was measured at the end of the period and a list of responses created. Reminders were then issued and the registration process repeated for the second round of responses. A second reminder letter was used but not a third, as further demands for a reply were more likely to induce a bias into the overall response.

The details of the survey questionnaire, the population-sample, and the results of the survey are provided in Chapter Five.

2.6 Methodology – qualitative research into portfolio-management by Hong Kong Consultants

This second element of the research is a qualitative postal survey to assess the current methods used by Hong Kong consultants to manage their portfolio-of-projects[39,40]. It closely follows the purpose and the methodology described for the postal survey of Hong Kong contractors described in Section 2.6 of this Chapter of the Thesis. It allows a comparison of contractor/consultant results and thus provides a pan-industry assessment of project/portfolio management methods used in practice. In this case, projects and assignments are used as synonymous terms. The survey covers the same three aspects of project information management identified in Section 2.5.1. As far as possible the questionnaire is kept the same to enable side-by-side comparison of results.

The population-sample for this survey is taken from the HKG SAR directory of companies considered for public works consultant services. These are the companies listed by the HKG SAR's two Boards constituted to select and appoint consultants for public works professional services. The Architectural and Associated Consultants Selection Board (AACSB) deals with building works. Whereas, the Engineering and Associated Consultants Selection Board (EACSB) deals with consultants for general civil engineering works and a wide range of special services.

2.6.1 Identification of questions

The purpose of the questionnaire is the same as the survey of contractors. Inappropriate questions from the previous questionnaire were amended to suit the case of consultants. This is done carefully to keep the original line of questioning. As before, the method developed by Betts and Shafagi, for a self-assessment of the strategic use of IT within the company, is included as part four of the questionnaire.

2.6.2 Development of the questionnaire

The process is the same as described in Section 2.5.2 for the survey of contractors. However, terms that are specific to the work of contractors are amended to terms appropriate to consultants. These interchanged terms are listed on Table 2-5.

Terms used in the questionnaire for Contractors	Terms used in the questionnaire for Consultants
• Supervisory staff	• Technical staff
• Labour	• Clerical/administrative staff
• Site offices	• Assignment locations (a definition of this term is provided on the front page of the questionnaire).
• Construction sites	• Assignment offices
• Head office	• Company office
• Construction projects	• Assignment projects

Table 2-5 Interchanged terms to adapt the Contractor questionnaire for a survey of Hong Kong consultants.

In addition, task-specific questions are altered to suit the data flow that applies to consultants. For example, the term 'lists of variations' is amended to 'changes in the scope of work'. The important thing to note is that the line of questioning remains the same in both surveys. The methodologies remain consistent in adhering to the guidelines proposed by Sinclair, Wright and Barnard, Oppenheim and Hoinville as cited in Section 2.5.2.

2.6.2.1 Development process

The mind-mapping approach used is explained in Section 2.5.1.

2.6.2.2 Review of the questionnaire.

The questionnaire was re-submitted to Dr Rowlinson of the University of Hong Kong and Professor Thorpe of the University of Loughborough for further academic critique due to

the subtle changes included to better suit a survey of consultants. They agreed it as fit for the purpose.

The endorsed questionnaire was then deemed suitable for a review within the host organisation. It was sent on March 8, 1998, with a commentary, to the Secretary of the AACSB and to his counterpart on the EACSB. Subject to agreed minor amendments they confirmed that the questionnaire was acceptable to them. The Secretaries of the two Boards provided the details of the survey population sample from their database of public works consultants. This information was limited to non-commercial data. It includes all the listed consultants on the AACSB and EACSB lists. Details of the population sample are given in Chapter Six. As before, the questionnaire was also passed for review to the two, independent IT consultants currently employed by the Highways Department of the HKG. They found the questionnaire fit for the purpose but recommended that the term 'electronic mail' should be made explicitly synonymous with 'Internet'. This was accepted. They also recommended that the questionnaire provide a measurement of the flow of information from the consultant to the client and to the contractor. This was also done. As a final stage in the internal review of the questionnaire, it was sent with the commentary in March, 1998, to the Director of Architectural Services and also to the Director of Civil Engineering. They confirmed that it was acceptable and agreed to its release to the sample population.

2.6.2.3 Pilot review of the Questionnaire

The revised questionnaire was tested at two pilot interviews with international consultants selected from the population sample, namely; Binnie Consultants Ltd and International Bechtel Inc. Binnie Consultants Ltd., suggested that the instructions on the questionnaire should make it clear that representative answers are required. This was done, along with other suggestions for improved wording of some of the questions. They confirmed that the questionnaire was straightforward and meaningful. In a similar manner the pilot test of the questionnaire with International Bechtel Inc resulted in some fine-tuning of the questionnaire otherwise it was deemed as fit for the purpose. On the

recommendation of these consultants, the Secretary for Works agreed to support this research. He gave formal approval to the final revised questionnaire and agreed to the draft of the covering letter to be issued under his letterhead. Refer to Volume II Section 6.2 for further details.

2.6.2.4 Postal release of the Questionnaire

The questionnaire was distributed to the sample population on 2nd March, 1998. As before, the postal distribution followed the guidance given by the Hoinville et al.

The response period was three weeks. At the end of the period, the percent level of response was measured and a list of responses created. Reminders were then issued and the registration process repeated for the second round of responses. A second reminder letter was permitted but not a third, as further demands for a reply may have induced a bias into the response.

The details of the survey questionnaire, the population-sample, and the results of the survey are provided in Chapter Six.

2.7 Methodology – longitudinal-grounded case study of a portfolio-management-system in the model form of Cleland and King

The third element of research is a longitudinal-grounded case study carried out to assess the impact of a PMIS, in the Cleland and King model-form, that was used by the Hong Kong SAR to manage their Public Works Programme (PWP) portfolio-of-projects.

> The PWP is . . . a complex and diverse rolling-programme of projects, which, according to the Government classification, includes up to seventy-two types of public infrastructure: from abattoirs to water-supply. These projects are carried out by the eight public works departments in response to requests from eleven Government Bureaus, or 'Ministries', and for other quasi-government organisations. The Bureaus are the 'Clients' for the projects with each project a . . . component of a Bureau's policy for . . .

the community. The Works Bureau . . . co-ordinate[s] the efforts of the Bureaus and the public works departments. . . . [The] delivery process, . . . depends on a highly diverse organisation in which each of the public works departments has different staffing levels, workloads, locations, and each undertake different types of work. They carry out between 1,200 to 1,500 PWP projects on behalf of a number of Clients.[41]

This PMIS was introduced as part of a change in working practice that started in 1993/94. The change included emphasis on a 'project management approach' to the delivery of the projects within the Public Works Programme of the HKG SAR. The PMIS was to support the project management approach at the project-level, and to provide corporate control for the PWP portfolio of projects as a whole. These two objectives broadly comply with the fourteen requirements for a project-management MIS as stated by Cleland and King in their seminal work in 1983. Table 2-6 lists them and comments on corresponding intentions for the PMIS deployed in this case for the management of the PWP.

This case study thus provides insight into the application of a MIS to manage a portfolio of projects. The research within the population samples of Hong Kong contractors and Hong Kong consultant firms showed that this approach is not generally adopted. In this sense, the PWP MIS provides a unique opportunity to record an uncommon practical experiment that follows the precepts stated in Table 2-6.

#	Cleland and King[3] Criteria	PW_MIS
1	Provide essential information on the cost-time-performance parameters of a project and on the interrelationships of these parameters.	Yes
2	Provide information in standardised form to enhance its usefulness to top management for multi-project control and long range planning.	Yes
3	Be decision-orientated, in that information reported should be focused toward the decisions required of the project manager and top management.	Yes
4	Provide for customer-reporting requirements.	Yes
5	Be exception-orientated. in that it will focus the manager's attention on those critical areas requiring attention rather than simply reporting on all areas and requiring the manager to devote attention to each	Yes
6	Fit into the organisation information system and strategic planning system.	Yes
7	Be prospective in nature rather than retrospective, in that it should give special attention to potential problem areas within the project; it should, in effect be an 'early warning' system for the project manager.	Yes
8	Incorporate both external and internal data to provide a capability for keeping track of evolving projects in the customer's organisation. In this fashion, the PMIS can interface with an organisational strategic management system.	No
9	Be consistent with existing project management guides and procedures.	Yes
10	Be consistent with policy documentation developed by the organisation.	Yes
11	Provide a capability for routine reporting, exception reporting, and special analyses (such as statistical analyses) which may be desired by the project manager or top management.	Yes
12	Provide for measurement of the critical project-functional interface, so that the project manager and functional manager will have data on which to base those decisions for which authority and responsibility are shared.	Yes
13	Provide a basic data requirement for functional managers to furnish to the project office and to facilitate in-house functional visibility.	Yes
14	Provide for project visibility during phases of a project life-cycle.	Yes

Table 2-6 Applicability of the Cleland and King requirements for a PIMS in the longitudinal-grounded case study.

Its suitability as a case study was reviewed following recommendations proposed by Eisenhardt[42], Easterby-Smith et al, Simister[43] and Fellows and Liu. It is a suitable case study of a practical experiment for the following reasons:

- The requirement for change and the implementation is documented in correspondence files that are made available to the researcher with the permission of the Secretary for Works of the HKG SAR. Cross-referenced documents in these files allow the triangulation of supporting statements to separate fact from opinion;

- The system has been in operation for five years. Long enough to become an established operational practice. The evidence and the user response to a questionnaire survey are thus based on norms of performance;

- There are records of PWP performance before and after the change that provide a measurement of the impact of the change;

- The user community of five hundred and ninety three registered users is large enough to form a population sample that provides statistically robust measures of user satisfaction;

- The PWP is made of individual projects whose impact on the portfolio overall is mutually exclusive. The lack of interrelationship between projects means that the performance of one project has no impact on others;

- The implementation was rapid, taking a 'big-bang' approach to replacing the predecessor process. There is no confusion due to overlapping processes or gradual introduction of change.

- It was universally introduced within a large organisation delivering typically fifteen-hundred varied projects within an overall portfolio-of-projects of known objective. The results are broad-based providing robust measurements of effect.

The demand for a change, and bringing about a change, in the management process was evolutionary over several years starting in 1992-93. A literature search through the correspondence files on this subject shows that the objectives were not clear-cut. They were determined over time. A definitive statement of objective is not available. The evolving process of change is described according to the sequence of events by making reference to the statements discovered in the search of the case files.

The research describes the attributes of the PWP portfolio-of-projects and of the participants involved in the process of project delivery. It also describes the legal and procedural requirements for the project delivery process. The attributes of the PWP are defined from statistics derived from PWP data published by the HKG. The legal and procedural requirements that delineate the PWP management process are taken from a number of authoritative documents produced by the HKG SAR for these purposes.

The management approach itself is described from reference to the HKG documents. This includes a description of the Public Works Management System (PW_MS) that is itself a critical-success-factor in the management of the PWP-portfolio-of-projects.

The pre-change, and the post-change performance in terms of project-delivery, is assessed using qualitative statements and quantitative measurement derived from the HKG published data on the public-works-programme of projects. From the facts presented, an alternate to the Cleland and King approach is formulated for the management of a portfolio-of-projects using project-level data.

2.8 Methodology – qualitative research into the use of a portfolio-management-system in the model form of Cleland and King

Qualitative research was carried out to assess the degree of satisfaction of the public works department with the PW_MS management information system that is used to help them to manage the HKG SAR portfolio of public works projects[44] as described in Section 2.7. This MIS started operations in 1994 and has been in use since then. In late 1998, the Secretary for Works, the client for the PW_MS, decided to stop further it's further development to determine, in the light of user experience and the advances of technology, short to longer-term proposals for an improved use of the system. The Secretary of Works sanctioned this survey as part of that investigative process.

This is the fourth element of data obtained for the thesis. It involves research carried out with a population-sample taken from the PW_MS user community within the public

works departments of the HKG SAR. The results provide a basis for the derivation of the proposed alternate approach to the management of a portfolio-of-projects.

The Cleland and King model (1983) of a project management MIS serves two categories of audience. One, it should meet the needs of the managers working at the project-level who provide the project data for the MIS. In general, they do not have a need for portfolio-wide information. Two, it should satisfy the information requirements of the executive-level audience that manages the portfolio but who are not concerned about the project detail unless adverse situations arise. Figure 2-3 shows this information flow in the case of the PW_MS, starting from the project manager's data and feeding to the executive-level audience.

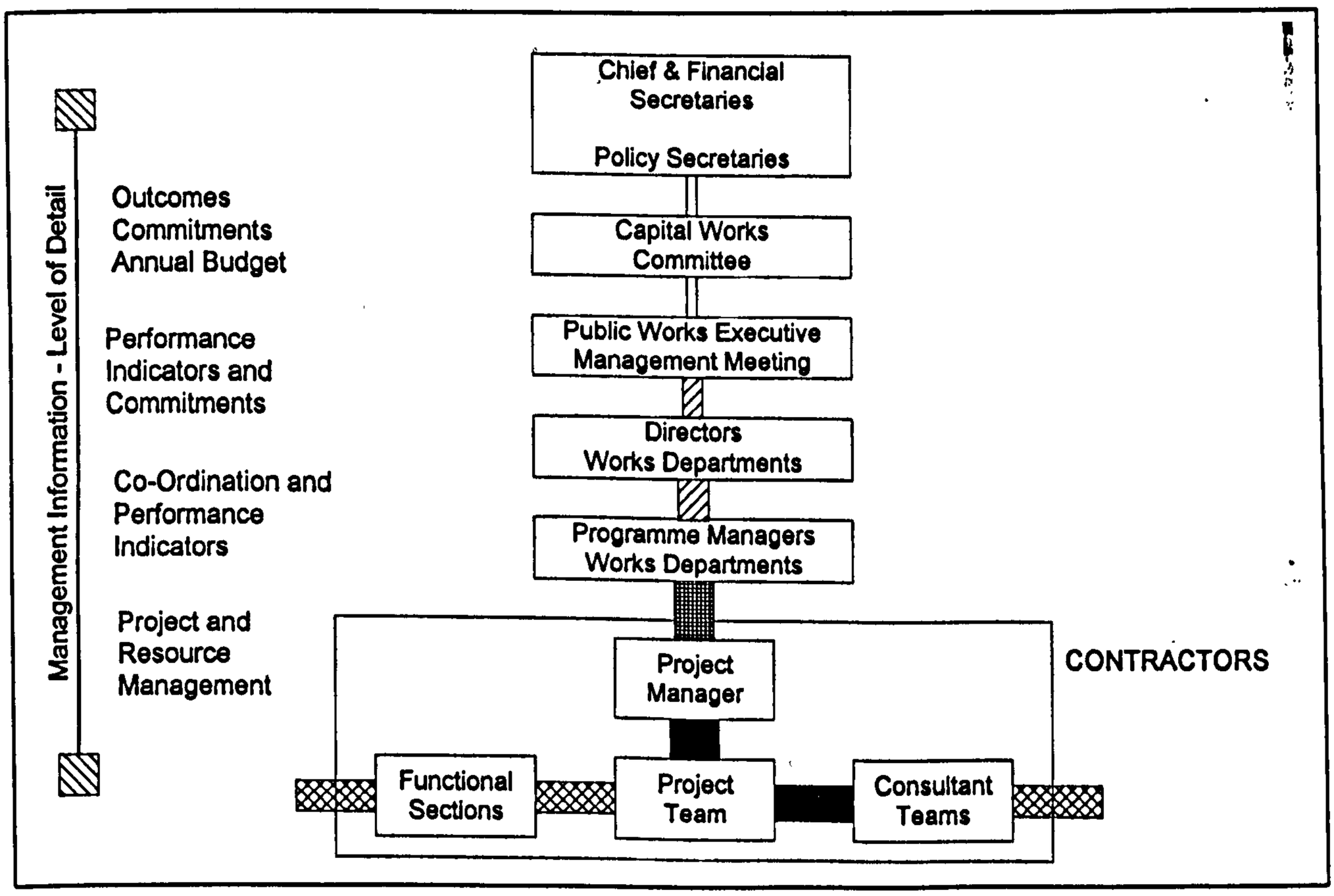

Figure 2-3 PW_MS information pipeline.

The burden in maintaining this information flow is unevenly carried. Project managers provide the raw data to serve the needs of higher-level management who gain insight at no data-capture effort. The project managers use the MIS as a project management tool to suit their project-level purposes, hence the primary benefit arising from the MIS is to be enjoyed by the project managers. A commonsense heuristic arising from this is that

the benefits to the project managers should outweigh their effort in using it. The benefit to the portfolio manager is without the overhead of data-capture and is therefore more likely to exceed their effort in using the system than the case for the project managers. This secondary benefit of the MIS is an added value enjoyed solely by the higher level of management. Providing benefit to the project managers is thus a critical-success-factor for the MIS as a whole. This element of the research is to measure the degree of satisfaction achieved at the project-level of the PW_MS information pipeline.

A postal survey was the method adopted in a systematic effort to acquire this knowledge from the user population. Questions were developed for the questionnaire survey according to four fundamental subject areas and the underlying research intent of the questioning. These are stated in Table 2-7.

	Stated objective	Underlying purpose
PM_Utility	• determine the extent that the PW_MS is used for the management of individual projects	• Measures the redundancy within the PW_MS.
Folio_Utility	• determine the extent that the PW_MS is used for the management of PWP portfolios-of-projects	• Measures the effectiveness of the PW_MS.
Other_Means	• What other means are used for PM_Utility and Folio_Utility functions	• Measures the need that is unsatisfied by the PW_MS.
MIS_ Functionality	• to identify the requirements for an improved MIS.	• Statement of the required Functional Specification.

Table 2-7 PMIS User survey fundamental areas of enquiry and purpose.

As previously described in Section 2.5.1, other questionnaires were examined for useful ideas that also set out to benchmark the use of information technology in construction. Their relevance to this survey are also cited in Section 2.5.1.

The Secretary for Works supported this survey provided that it involved minimal effort on the part of the respondents. Representatives of the PW_MS Users Committee kept a watching brief on the process on his behalf. To minimise the respondent effort, the survey was addressed to a pre-determined representative sample of the overall population. Although the population is from within the public works organisation of the

HKG SAR, it is also differentiated by specialisms and sentient attitudes. For example, there is a hierarchy in the project management role of the project delivery process that separates the responsibility for project management from the day-to-day reporting of project progress. The interface with the PW_MS is, in some instances, by staff at a junior level who are not the decision-makers. The departments are sentient: being organised around their engineering specialisms. This permeates further into the departments due to further specialisms at the Division and Unit level. These phenomena are accounted for in the population-sample, subject to the practicality of being able to achieve a statistically adequate level of response.

2.8.1 Population-sample

The population is taken from the list of authorised users registered within the PW_MS. An individual becomes an authorised user of the PW_MS after a period of training and formal registration within the PW_MS to grant log-in and access rights. This is provided to those individuals who have a functional role in the delivery of the public works projects. For example, project managers and their support staff, are trained for data-entry and the interactive use of the PW_MS to plan, monitor, and provide forecasts on their projects. Programme Managers are trained in the interactive use of the PW_MS to obtain status reports of projects, and of portfolios-of-projects.

The data on the population of authorised users of the PW_MS was provided by the Public Works Administration Unit, of the Works Bureau, in January 1999 after a validation check to ensure it was up-to-date.

The population can be separated into two user classes: programme managers, and project managers. The attributes of the population supplied by the Works Bureau are listed in Table 2-8.

Data attribute	Comment
User Class Code	Unique character code string for one of 24 types of user class. The combination number is made of: (a) prefix to denote role: HQ = works dept headquarters role PGM = programme manager role PJM = project manager role. (b) suffix to denote works department ARCHS = architectural services CED = civil engineering services DSD = drainage services EPD = environmental services HAD = home affairs HYD = highways TDD = territory development WSD = water supplies
Individual name	Full name
Initials	Given name initials
Dept/Div	Organisational address suitable for internal distribution of mail
Post	Organisational position/grade
Telephone	
Fax	

Table 2-8. Attributes of the population sample supplied by the PWSAU of the WB.

The numbers in each of the user classes are listed in Table 2-9.

Userclass	No	Userclass	No	Userclass	No
HQARCHS	1	PGMARCHS	2	PJMARCHS	13
HQCED	4	PGMCED	4	PJMCED	68
HQDSD	13	PGMDSD	5	PJMDSD	86
HQEPD	4	PGMEPD	5	PJMEPD	39
HQHAD	2	PGMHAD	0	PJMHAD	0
HQHYD	3	PGMHYD	9	PJMHYD	128
HQTDD	8	PGMTDD	2	PJMTDD	78
HQWSD	0	PGMWSD	1	PJMWSD	110

Table 2-9 The Population in terms of numbers in each Userclass.

The population for the survey is 584 unique authorised users of the PW_MS employed within the works departments of the public works organisation. A random selection from the population was used to form a population-sample for the postal questionnaire survey. The sample frame is constrained by the following criterion adopted by the members of the project assurance team:

- The sample-size should provide a 95% confidence limit that it is representative of the population;
- The sample size should include sufficient numbers of the 'HQ/PGM' class to provide a 95% confidence limit that it is representative of that strata of the population;
- The sample size should include at least 10% of numbers of each of the works department PJM stratum.

A stratified random sampling technique described by Hoinville[21], and by Sinclair is used to select the respondents from the HQ/PGM population strata and also the PJM population strata. Fellows and Liu, and Easterby et al advise how the population sample size can be calculated to achieve a desired level of confidence so that the results obtained from the population-sample are representative of the population. However, this assumes prior knowledge of the statistical parameters of the population. These are unknown in this case but Easterby et al, using Maxwell[45] (1970) suggests a heuristic in formula (1) for estimating the sample size needed to give a representative number of responses to a question, assuming well-balanced responses.

$$n = P(100-P)/E^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where:
n = is the sample size required.
P = is the percent occurrence of the state/condition.
E = is the maximum error required.

There is no prior work to establish the probable outcome for this survey, so a conservative 95% confidence level was adopted. Substituting an evens occurrence in (1) gives the greatest value for n. Using Easterby's suggested formula for 'finite population correction' (2), 'n' can be adjusted to account for the size of the population or population strata – as the case maybe.

$$n^1 = n/(1+(n/N)) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where:
n = is the sample size from (1).
N = is the total population size (63No. HQ/PGM strata; 521 No. PJM strata).
n^1 = is the sample size required.

From (2) the random sample to be taken from the HQ/PGM and the PJM stratum are thirty-eight numbers and eighty-four numbers respectively. This does not take into account any bias introduced by reduced response caused by staff changes, misdirected mailing or a reluctance to participate. An arbitrary fifty percent response rate was

assumed resulting in a proposed population sample comprising a census of the HQ/PGM strata and a random sample of one hundred and sixty eight of the PJM strata.

A random-sample of the PJM strata of the population was generated using the random number feature of Microsoft Excel software. The attributes of the derived population sample are listed in Table 2-10.

Population Strata	Numbers in population-sample
HQ/PGM	63 No. (100% of the population strata)
PJM	168 No. • ARCH = 5 No. (38% sub-strata) • CED = 20 No. (29% sub-strata) • DSD = 31 No.(36% sub-strata) • EPD = 14 No. (36% sub-strata) • HAD = 0 No. (no sub-strata) • HYD = 39 No. (30% sub-strata) • TDD = 27 No. (35% sub-strata) • WSD = 32 No. (29% sub-strata)

Table 2-10 Attributes of the population-sample

2.8.2 Development of questionnaire

The process is shown in Figure 2-4. The questionnaire was constructed using the mind-mapping and hierarchical breakdown analysis methods already described earlier in Section 2.5.1. The approach followed the guidelines already cited for the development of survey questionnaires, namely; Sinclair, Wright and Barnard, and Oppenheim and Hoinville. This was to ensure a consistent form of query, and consistency in the data so that it is suitable for statistical or frequency analysis. Each stage of development was sequential to allow continual improvement from specialists and expert practitioners.

The data gained from the questionnaire is used to separate the population sample into sectors according to their differentiation. Some of the sectoral information is obtained from the population sample mailing list obtained from the PW_MS. Other information is obtained from questionnaire questions regarding the 'identity', 'role', and 'activity' of the respondent. The number of population sectors was kept to a minimum to ensure

sufficient response within each sector (i.e., >15) for statistical analysis of the results that would highlight sectoral patterns of response.

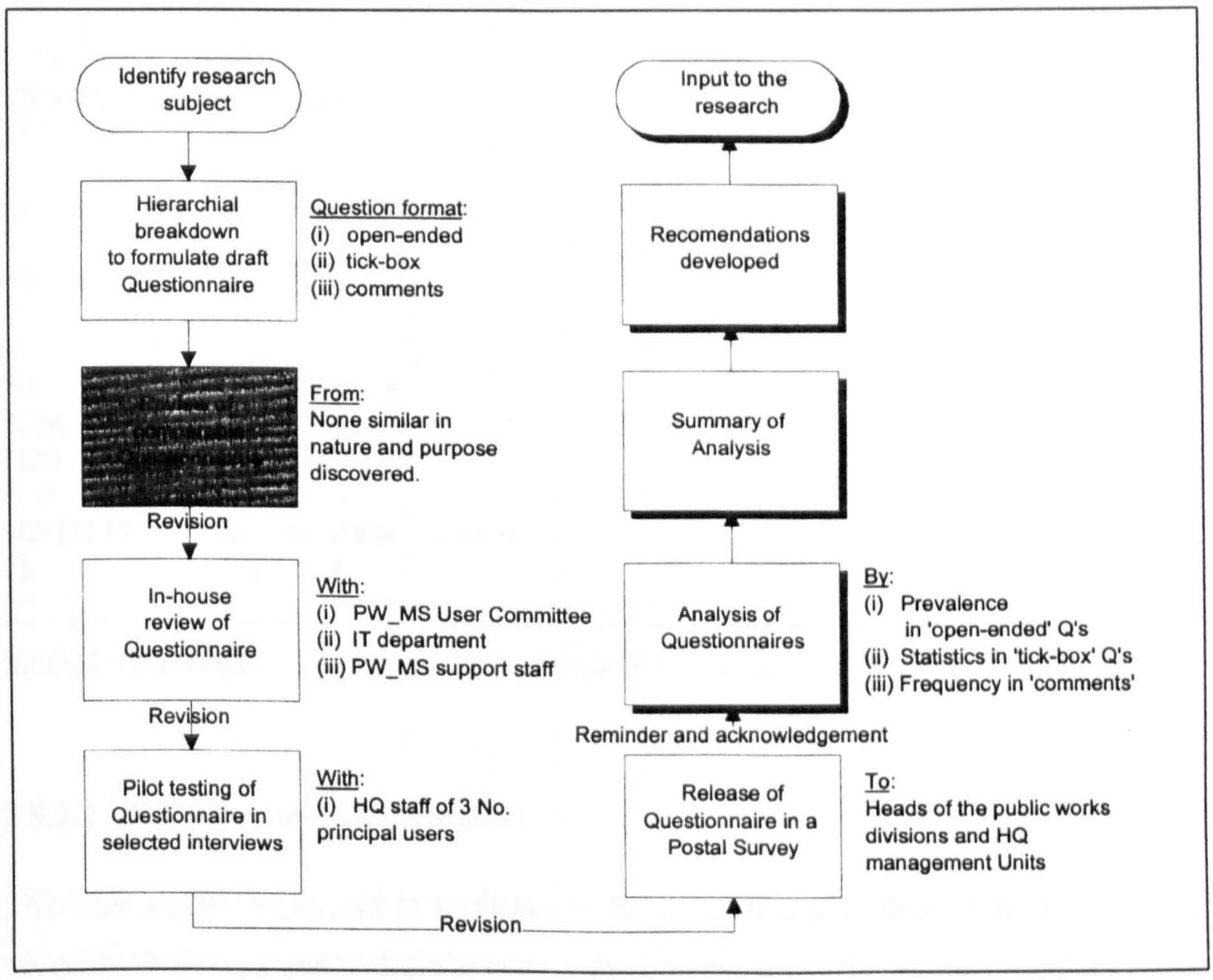

Figure 2-4 Development of a questionnaire for a PMIS user survey within the public works department

Table 2-11 shows the 'User-role' descriptions within the PW_MS. The items in grey-italic are external roles taken up by personnel not employed by the public works departments and not included in the population sample.

Role (abbr)	Description
APJM	Assistant Project Manager
CD	*Client Department Representative*
CLIREP	*Client Representative*
DIRECTOR	Director
EPD	*EPD [environment protection department] Representative*
FB	*Finance Branch Representative*
FM	Functional Manager
LD	*Lands Department Representative*
PAT	*Project Action Team Representative*
PB	*Policy Branch Representative*
PC	*Prime Contractors' Representative*
PD	Project Director
PGM	Works Department Programme Manager
PJM	Project Manager
SCR	*Sub-Contractor's Representative*
SUPPORT	General Support Person
TL	Team Leader
WD	*Works Department Representative*

Table 2-11 Designated project roles available from within the PW_MS.

2.8.2.1 Review of the questionnaire

The draft questionnaire and an explanatory document that provided a commentary on the rationale for the questionnaire was sent to three members of the 'project assurance team' of the PW_MS. This is the PW_MS quality assurance standing committee set up under PRINCE methodology business rules. They critiqued the draft questionnaire as too long and too complex and recommended a re-ordering of the lines of enquiry to place more emphasis on the User recommendations for improving the system. A first revised draft questionnaire was produced to meet these requirements. A further two cycles of critique was completed to achieve their satisfaction. The members of the project assurance team approved the methodology for creating the representative population sample from the population of seven hundred and thirty authorised users (refer to Section 2.8.1). They also approved the issuance of the questionnaire accompanied by a covering letter (refer to the 'Appendices CD-ROM' Section 6.2) that followed the guidance previously used for the corresponding survey of contractors, namely Hoinville et al (1977).

After pilot review the final draft questionnaire was subsequently submitted to the project assurance team for their approval. The draft document and commentary was also forwarded to the Research Supervisor to ensure that the questionnaire was deemed adequate for the proposed postal survey of the users of a project-information-management-system. This endorsement was granted.

2.8.2.2 Pilot review of the Questionnaire

The draft questionnaire was piloted in the Architectural, the Civil Engineering, and the Highways Department out of the eight HKG SAR public works departments. The interviewees were selected for the pilot trials because of their Senior Engineer status and their responsibility for project planning and monitoring within their department. This meant that they had executive-level appreciation of the need for management of their portfolio-of-projects and were expert in the day-to-day business of project management of public works projects. They are also regular, hands-on users of the PW_MS. A series of pilot trials of the questionnaire was completed in the form of a structured interview following the wording of the questionnaire. Each interview lasted one hour. Each one resulted in minor revision to wording and the order of the questions. However, each pilot test of the questionnaire deemed it fit for the stated purpose.

2.8.2.3 Postal release of the Questionnaire

The questionnaire was distributed to the population-sample on Monday, January 23, 1999. As before, the postal distribution followed the guidance given by the Hoinville et al. The personally addressed letters and questionnaire were delivered to the respondents via the internal postal service of the HKG SAR. The response period was three weeks. At the end of the third week, the percent level of response was measured and a list of responses created. The on-going concern of the Secretary for Works to limit the degree of imposition on the public works staff did not allow the use of reminders to encourage a greater participation in the survey.

The details of the survey questionnaire, the population-sample, and the results of the survey are provided in Chapter Eight.

2.9 Methodology – quantitative research into portfolio management based upon project significance according to Pareto-rules

This fifth element of the research investigates the effectiveness of managing a portfolio-of-projects by basing success primarily on the outcome of the projects that have a high impact[46]. It tests the hypothesis stated in Section 1.2.1.3 using empirical data.

2.9.1 Empirical Data

The empirical data is taken from the audited accounts of the 'Category A projects' of the PWP of the HKG SAR over the ten-year period 1989-90 to 1998-99. 'Category A projects' are projects that are allocated funds and will incur 'actual' expenditures within the financial year. The PWP portfolio-of-projects each financial year is managed as a separate entity by the HKG SAR and used in that manner in this research i.e., as ten successive data-sets of consistent heritage. Some items listed in the PWP programme of projects are excluded from this research because they are subject to different processes that make them inherently different to the project-managed infrastructure/public-works projects. These are:

- Land procurement (listed under 'Land Acquisition - Head 701' in the PWP),
- IT procurement/implementation projects (listed under 'Capital Subventions and Major Systems and Equipment - Head 708' in the PWP), and
- 'Omnibus' items of expenditure to be spent on unascertained small elements of associated works that are bundled together into a 'block' item for accounting convenience.

The PWP is a good source of data because it is a large portfolio that contains a diverse range of public works. Look to Table 2-12 for an indication of the range of diversity in terms of general statistics for each of the ten data-sets used in this research. The diversity within each of the ten successive portfolios-of-projects is displayed in Table 2-13. The negligible extent of causal relationship in the data is checked through the measurement of

mutual exclusivity between the projects in each of the ten sequential data-sets used in the research.

	Portfolio statistics in terms of project planned expenditure ($ '000s)					
Year	Project Nos	Low Value	High Value	Mode Value	Mean Value	Median Value
89-90	1196	0	510,000	100	11,543	2,330
90-91	1286	0	484,415	1	14,035	2,615
91-92	1224	0	955,980	113	16,164	2,961
92-93	1143	0	1,482,000	11	18,550	2,310
93-94	1130	0	2,580,000	10	24,533	1,668
94-95	1131	0	2,838,000	10	23,075	1,604
95-96	1086	0	1,935,741	0	21,041	533
96-97	1096	0	1,777,380	10	26,012	1,929
97-98	1048	0	866,000	0	17,497	450
98-99	1082	0	818,299	10	22,902	2,684

Table 2-12 General statistics of each of the annual portfolios within the 1989-1999 period of this analysis.

The attributes of the data within each data-set were measured for a comparison of the representation and consistency within each of the ten data-sets. A good degree of representation exists within each, in terms of:

- 'Heads of Expenditure' – these are the sub-divisions of the PWP into broad groups of construction classification that correspond to the disciplines of each of the public works departments.

- 'Categories of work' – these signify the type of architectural/engineering work according to a HKG SAR classification-index of seventy-eight types of public works[47]. These are listed in Volume II, Chapter 2, Section 2.2.

Aspects of Diversity	Financial Years beginning . . .									
	89	90	91	92	93	94	95	96	97	98
By Heads of Expenditure										
	702 – Port & Airport Development									
• % of Nos	-	2	3	4	4	5	6	6	6	5
• % of planned exp	-	4	16	38	40	48	42	36	24	16
	703 – Buildings									
• % of Nos	23	24	24	21	22	22	35	37	36	36
• % of planned exp	28	29	22	15	31	14	23	30	28	32
	704 – Drainage									
• % of Nos	-	4	5	6	6	5	7	7	7	10
• % of planned exp	-	6	7	6	3	3	3	4	5	11
	705 – Civil Engineering									
• % of Nos	10	5	6	7	7	7	7	6	5	4
• % of planned exp	8	6	8	11	7	9	6	5	11	7
	706 – Highways									
• % of Nos	10	10	9	9	9	9	9	8	9	9
• % of planned exp	18	12	9	6	4	7	8	9	10	9
	707 – New Towns									
• % of Nos	49	47	46	47	44	43	27	28	27	25
• % of planned exp	40	38	32	21	11	13	13	11	14	13
	709 – Waterworks									
• % of Nos	7	7	7	7	8	8	8	8	8	7
• % of planned exp	6	5	5	4	5	5	5	4	3	3
	710 – Housing									
• % of Nos	-	-	-	-	-	<1	1	1	2	4
• % of planned exp	-	-	-	-	-	<1	1	1	4	10
By Categories of work										
• Nos of types	52	51	51	53	59	63	61	53	48	47
• % (of 78 types)	67	65	65	67	76	81	78	68	62	60

Table 2-13 Indicators of the diversity of projects within annual PWP portfolio of projects, 1989-1999.

Spearman Rank Correlation was used to identify the 'moderate-correlation' that exists between the value of the 'planned expenditure' and the 'outturn variance' as shown in Table 2-14. Spearman was also used to determine the 'negligible correlation' between the 'planned expenditure' and the 'percent outturn variance': also shown in the same Table.

Year	Correlation coefficients of 'Amended Estimate' Vs Outturn Variance	
	Outturn Variance	% Outturn Variance
1989-90	0.592	-0.017
1990-91	0.564	-0.034
1991-92	0.805	-0.016
1992-93	0.655	0.013
1993-94	0.640	0.031
1994-95	0.375	0.014
1995-96	0.548	0.024
1996-97	0.680	0.005
1997-98	0.563	-0.010
1998-99	0.540	-0.003

Table 2-14 Correlation Coefficients between values of Amended Estimate and Outturn Variance.

2.9.2 Testing a significance approach to the management of a portfolio-of-projects

The empirical data is extracted from two sets of related annual accounts. The forecast of intended expenditure on each of the PWP projects that is published as part of the HKG SAR budget each Spring is used to determine the 'planned expenditure' for the PWP projects. Whereas, the audited actual expenditure per project, which is published in the 'Annual Report of the Director of Accounting Services and the Accounts of Hong Kong for the year ended 31 March 19XX', states the 'actual expenditure'.

For the reasons explained in more detail in Chapter Nine, the expenditure of the budgeted funds for a project is a Client's measure of satisfactory project achievement. Projects are deemed significant in terms of their forecast of expenditure. Highest values of planned expenditure are the more significant. To measure the effect of the significance approach, the outcome for these projects is manipulated. The outcomes for the insignificant projects remains unchanged. In these terms, the 'outcome performance' for each project is the percent difference between the actual expenditure compared to the planned expenditure, i.e., it is an 'outturn variance' that is expressed as a percent of the planned expenditure, or as differential Hong Kong Dollars.

The mathematical validation of the significance approach is by a calculation of the effect when the projects that are significant to the portfolio, perfectly achieve the forecast budgeted expenditure. The stochastic validation of the approach reflects a real-life outcome. Both calculations are carried out for increasing numbers of projects in terms of percent of the portfolio.

2.9.3 Methodology

The portfolio management approach used by the HKG SAR is to project manage all of the projects so that each one achieves a close match with its spending target. The intention is that the total of all the spending, for all the projects, will be a close match with the overall budgeted expenditure for the portfolio. This element of the research is to calculate the effect of a more selective approach.

2.9.4 Mathematical validation of a significance approach

The outturn objective of the HKG SAR for the Category A PWP projects is to achieve a match with their published targets of expenditure. In this context, high-impact projects are defined as the ones with the greatest planned expenditure that financial year.

For a mathematical validation of the significance approach, the constituent projects in the portfolio-of-projects are ordered in descending value of planned expenditure. The effect is calculated of an increasing percentage of the highest value projects achieving zero outturn variance, whilst the outturn variance for the remainder is unchanged. The relationship between the percentage of high impact projects that achieves a perfect outcome, and the overall success for the portfolio, is then considered. This methodology is shown in the flow-chart at Figure 2-5.

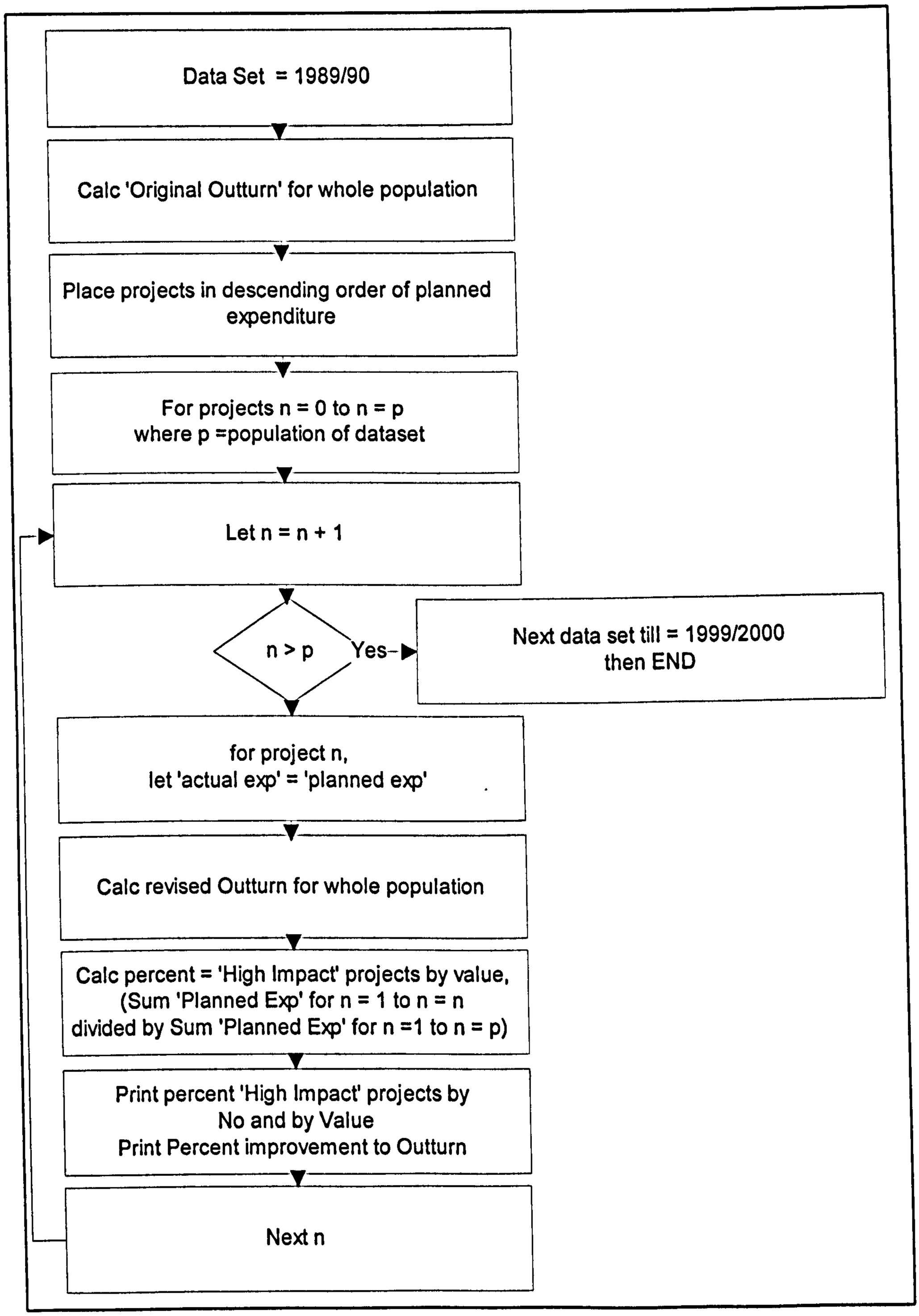

Figure 2-5 Flow-chart of mathematical method for evaluating the impact of project significance on portfolio outturn

2.9.5 Stochastic validation of a significance approach

The mathematical validation described in Section 2.9.4 is an idealistic approach. It is improbable that the many significant projects will all achieve a perfect outturn of zero-value outturn-variance. However, some of the projects within the portfolio do achieve a high standard of performance. The stochastic validation assumes that if the significant projects in the portfolio are given management attention then they can also achieve this premier performance. Each project-outcome within the empirical portfolios-of-projects is mutually exclusive, hence there is no causal relationship to confound this proposition. Using well established Monte Carlo methods[48,49,50,51,52,53,54,55,56,57,58,59] the stochastic outcome of each significant project can be derived from a PDF that represents the empirically-based, better project-performance found within that portfolio-of-projects. This PDF is derived from the frequency distribution of project 'outturn-variance' for the population of occurrences, i.e., for all the projects in that portfolio by a best-fitting to standard continuous PDFs. Table 2-15 lists the ten PDFs used for this exercise.

For the purposes of this research it is assumed that the significant projects can achieve the best twenty-percent outturn variance found within the empirical data set.

In the stochastic validation of the significance approach, the constituent projects in the portfolio-of-projects are ordered in descending value of planned expenditure. The effect is calculated, of an increasing percentage of the highest value projects achieving an actual expenditure within a PDF that best represents the likelihood of achieving the better performance found in the empirical data set. Whilst the outturn variance for the remainder of the projects is unchanged.

Continuous Probability Curve	Typical application (ref Sargent and Wainwright[26])
Triangular	• Simplistic: used if minimum, maximum and most likely values are known, assumed intermediary linear variation.
Weibull	• Complex: used to represent physical effects.
Normal	• Used to describe natural phenomena or uncertain variables.
Beta	• Used to represent variability over a fixed range.
Logistic	• Used to represent growth.
Extreme Value	• Used to describe the largest value of a response over a period of time i.e., flood flows.
Exponential	• Used to describe events recurring random in time.
Gamma	• Used to describe a wide range of physical quantities i.e., pollutant quantities.
Lognormal	• Used where values are positively skewed i.e., real estate valuation.
Uniform	• Simplistic: all values between the minimum and the maximum occur with equal likelihood.

Table 2-15 Continuous Probability Distributions used for best-fit comparison with the empirical frequency data.

The Crystal Ball™ software used for the Monte Carlo analyses includes a best-fit computation by choosing the values for the parameters of each PDF to best fit to the empirical data[60]. The results are tested using the standard goodness-of-fit methods described in Table 2-16[61,62,63].

Test of goodness-of-fit	Typical application (ref Sargent and Wainwright)
Chi-square	• Gauges the general accuracy of the fit. The test breaks down the distribution into areas of equal probability and compares the data points within each area to the number of expected data points. Generally, a *θ-value* greater than 0.5 indicates a close fit.
Kolmogorov-Smirnov	• Is essentially the largest vertical distance between the two cumulative distributions. Generally, a value less than 0.03 indicates a close fit.
Anderson-Darling	• Resembles Kolmogrov-Smirnov except that it weights the differences between the two distributions at their tails greater than at their mid-ranges. This method is used when a better fit is needed at the extreme tails of the distribution. Generally, a value less than 1.5 indicates a close fit

Table 2-16 Tests for degree of fit of empirical data to probability distributions.

Methodology for the selection of the PDF

The best-fit probability distribution (PDF) derived from this calculation is used in the Monte Carlo analysis to determine a stochastic variable that represents the degree of high-performance 'outturn variance' in the case of the significant projects in the portfolio. Hence,

- If, the curve-fitting of the empirical values of 'outturn variance' from each of the ten data-sets does provide a close fit to one of the continuous probability distributions. Particularly at the tail-end of the curve that relates to the higher-performance achieved by the projects within each portfolio i.e., within the range of zero to twenty percent 'outturn variance'. Then, this portion of the best-fit PDF is used in the Monte Carlo analysis to determine a value for the stochastic variable that represents the degree of high-performance 'outturn variance' in the case of the significant projects in the portfolio.

Otherwise,

- The curve-fitting exercise is repeated for the empirical values of 'outturn variance' within the range of zero to twenty percent.

Figure 2-6 is an example of a PDF derived from the 1989-1990 empirical dataset and used in the Monte Carlo analysis in this research.

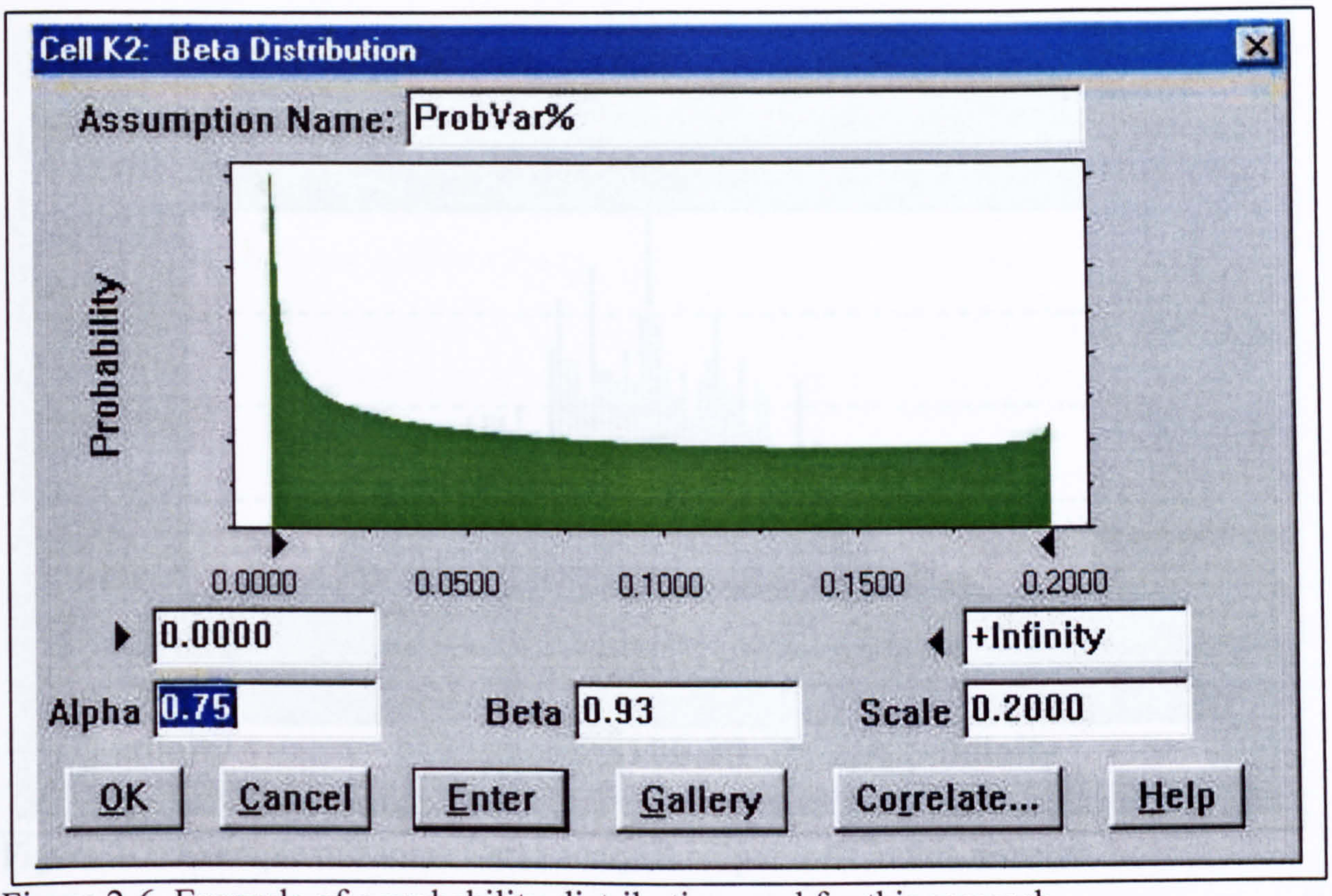

Figure 2-6 Example of a probability distribution used for this research.

The Monte Carlo simulation is performed by using the Crystal Ball™ Version 4.0 software by Decisioneering (www.decisioneering.com). This is an add-on software package that operates in conjunction with an Excel spreadsheet software. The software randomly assigns a value of outturn variance based upon the PDF for a percent number of significant projects in the spreadsheet. This occurs for each 'trial' carried out by the software. The number of 'trials' within each Monte Carlo analysis was set at one thousand to establish a well-defined output. The computer uses the results of these trials to compute a PDF of output values. Figure 2-7 shows an example of the PDF output derived from a Monte Carlo simulation following this methodology. From the PDF of outcomes, the percentile outcome for the portfolio outturn is determined.

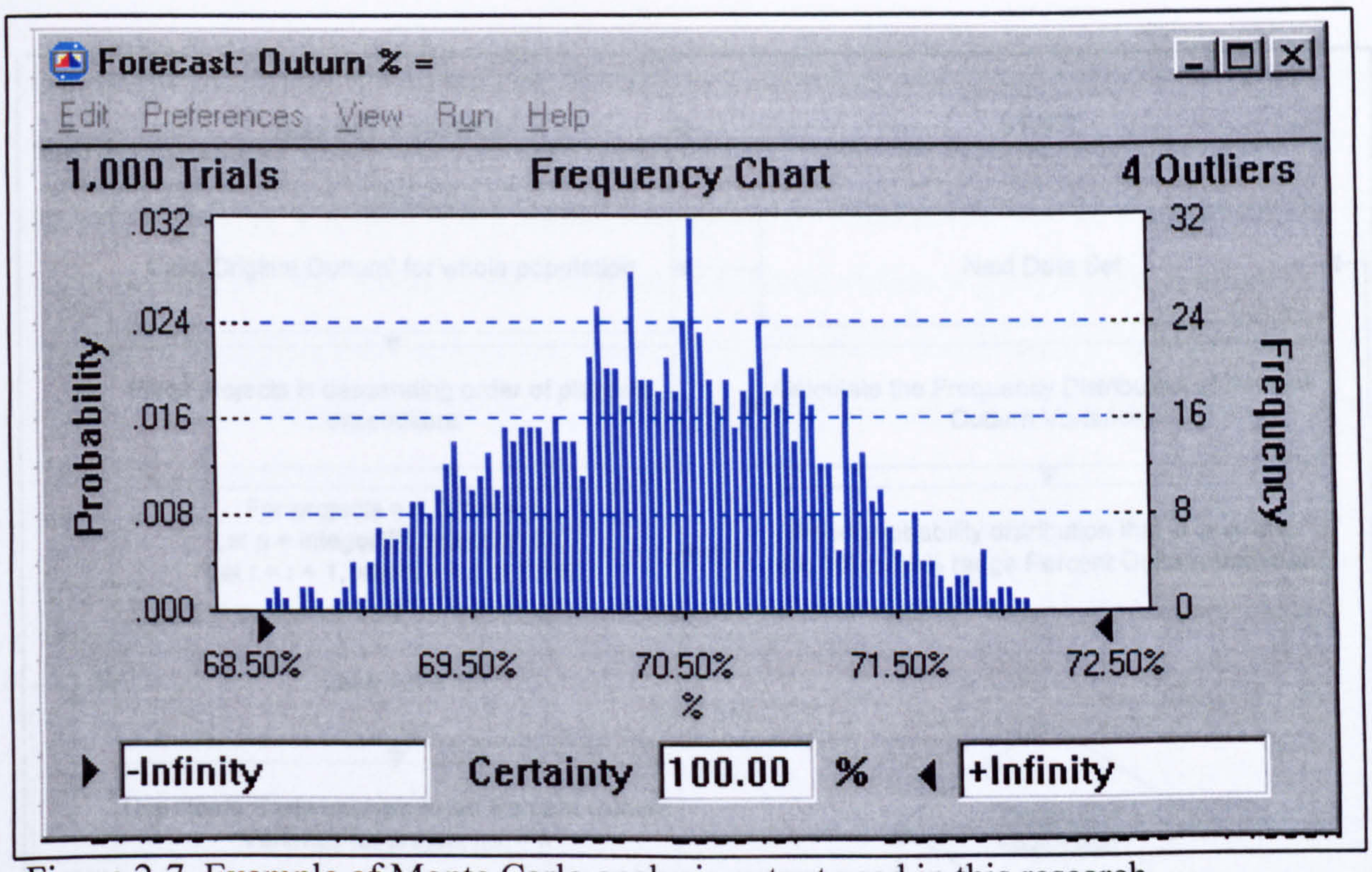

Figure 2-7 Example of Monte Carlo analysis output used in this research.

These results provide data for a comparison of actual outturn with the 'ideal' produced from the mathematical analysis, and the 'realistic' optimum from the stochastic analysis. The flow-chart in Figure 2-8 states the methodology followed. The results are tabulated to enable a comparative assessment and to assist in the formulation of heuristics for the general case.

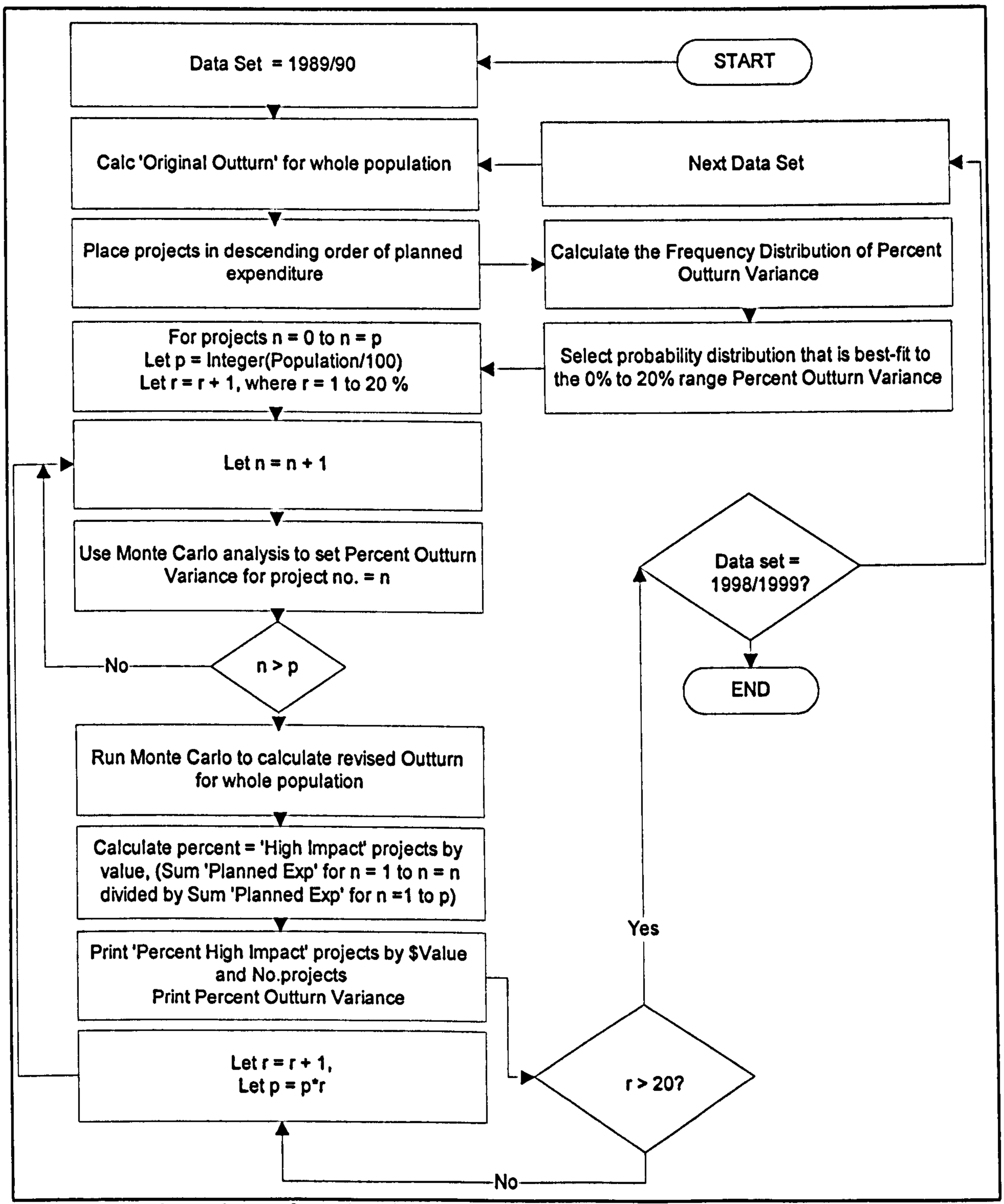

Figure 2-8 Flow-chart of stochastic method for evaluating the impact of project significance on portfolio outturn

Table 2-17 is an example of the results of this analysis for the 1989-90 data set. The table contains the actual results achieved by the empirical data, compared to the 'ideal' mathematical case results, and the 95%, 90%, 75% and 50% percentile outcome derived from the Monte Carlo analyses. The 'Ave-mean' is the average of the mean values per

project of outturn variance derived within the Monte Carlo simulation. The 'mean of the Ave-mean' outturn variance is the average of the twenty simulation cases, i.e., one percent to twenty percent of the significant projects in the portfolio. In the case of the 1989-90 data set, the mean of the 'Ave-mean outturn variance per project' derived in the Monte Carlo simulations is 8.9% compared to 0.0% if an 'ideal' outturn variance is assumed for the significant projects. The mean outturn variance actually achieved in the 1989-90 empirical data-set was 24.6%.

% No projects modified outturn	% Value	Outturn percent of target expenditure achieved						
		Actual %	Ideal %	Monte Carlo Percentiles				
				Ave-Mean outturn variance per project	95%	90%	75%	50%
1%	25%	75.4	80.6	8.84	79.51	79.36	79.86	78.92
2%	38%	75.4	82.5	8.94	80.21	80.04	79.76	79.52
3%	45%	75.4	83.4	8.91	80.29	80.20	79.97	79.71
4%	51%	75.4	84.0	8.98	80.44	80.29	80.01	79.78
5%	**55%**	**75.4**	**84.9**	**8.92**	**80.98**	**80.83**	**80.59**	**80.35**
6%	59%	75.4	85.6	8.94	81.33	81.18	80.96	80.74
7%	62%	75.4	86.2	8.97	81.68	81.53	81.23	81.00
8%	65%	75.4	86.5	8.90	81.73	81.57	81.33	81.07
9%	67%	75.4	87.2	8.92	82.28	82.14	81.39	81.67
10%	**69%**	**75.4**	**88.0**	**8.92**	**82.79**	**82.63**	**82.39**	**82.14**
11%	71%	75.4	88.7	8.91	81.13	83.02	82.82	82.59
12%	72%	75.4	89.0	8.95	83.60	83.42	83.18	82.93
13%	74%	75.4	89.4	8.92	83.95	83.71	83.49	83.22
14%	76%	75.4	89.7	8.91	84.09	83.37	83.57	83.32
15%	77%	75.4	90.1	8.94	84.37	84.17	83.88	83.50
16%	78%	75.4	90.5	8.94	84.51	84.37	84.14	83.29
17%	79%	75.4	90.9	8.93	84.84	84.70	84.46	84.15
18%	81%	75.4	91.3	8.92	85.13	84.96	84.69	84.95
19%	82%	75.4	91.6	8.92	85.16	85.05	84.82	84.28
20%	**83%**	**75.4**	**97.1**	**8.93**	**85.41**	**85.24**	**84.99**	**84.71**

Table 2-17 Comparison of the improved outtrun for the 1989-90 portfolio due to the impact of the outturn-variance for 1% to 20% significant projects according to 'actual', 'ideal' and 'stochastic' scenarios.

When deriving heuristics from this data, the 'evens' probability is used, i.e., the 50% percentile. This is because the difference between 95% and 50% percentile values in the case of ten percent and twenty percent of significant projects is small and 'evens' is a conservative norm value to adopt for the general case.

Using the results of the stochastic analyses, three heuristics are proposed corresponding to the twenty-percent, the ten-percent and the five percent levels of significant projects in the portfolio.

2.10 Conclusions drawn from the research

The outputs from each element of the research are woven together in the Conclusion to bring completeness to this thesis – to this stage of the research. It restates the constraints and the limits of the work done.

Kempner-Tregoe methodology is used to help define what the research 'is' and what it 'is-not'[64]. This provides the focus for a concluding commentary advising on the potential benefits of additional related research.

2.11 Summary of the research methodology

The methodologies used in the research are stated in this Chapter of the Thesis. The application of the methodologies are described subsequently at each stage of the research. The research undertaken builds upon a proposition stated by Cleland and King in 1983 whereby the management of a portfolio-of-projects could be achieved as a by-product of using an MIS containing project-management data. A literature review established that this topic was fertile ground for further research in so far as sparse literature has been discovered that describes the Cleland and King proposition applied in practice. The published work of Horner with others showed the potential benefits of Pareto-based heuristics to the management of a portfolio-of-projects. The hypothesis in this research was thus formulated by incorporating these concepts into the Cleland and King proposition

Methodologies used in qualitative surveys are described: these were used to measure the use of information-systems within the construction industry of Hong Kong for the management of portfolios-of-projects. These indicate that MIS are not used according to the Cleland and King proposition. Evidence is also provided through an extension of the literature review to indicate that the construction industry in Hong Kong is not unique but in the general sense is typical of national construction industries. On this basis it is proposed that the results of the qualitative surveys in particular and the research in general applies to the construction industry at large and is not limited to these local conditions.

The research has taken place within Hong Kong because of the availability of a rich source of data and the opportunity to use the implementation of a MIS within the public works department as full-scale experimentation to test the Cleland and King proposition. This latter part of the research is a longitudinal-grounded case study, but qualitative survey methods are also used to assess the user satisfaction with the MIS. This survey is based upon a representative population-sample that conforms to a predetermined sample frame. User comment from this survey indicates that the Cleland and King proposition as represented by the examined MIS is not a satisfactory model for the management of a portfolio-of-projects. An alternate approach that accords with the hypothesis is tested using quantitative methods and authenticated empirical data. The methodologies employed include best-fit curve fitting to determine an appropriate PDF and its subsequent use within Monte Carlo simulation techniques.

Fellows and Liu, along with Easterby-Smith et al have been used as the main references on research methodology. Other works are referenced as endnotes throughout this Chapter and listed at the end. A bibliography is also provided at the end of the Thesis.

Conclusions are drawn from all of these elements of research with regard to the hypothesis and to propose further lines of research.

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Chapter Three

3 Research Environment

3.1 Introduction

The research has been carried out within Hong Kong drawing on data taken from the construction industry in general and from the public works programme of the HKG SAR in particular. The purpose of this Chapter of the Thesis is to provide evidence that the Hong Kong construction industry is similar in fundamental respects to national construction industries elsewhere. Thereby supporting the contention that this research applies to the general case.

This Chapter of the Thesis does not include side-by-side comparisons of the Hong Kong construction industry with other countries – that would require extensive data comparisons beyond the constraints of this research. Instead the attributes for Hong Kong industry are taken from prior research on related topics and presented along with relevant commentary. The seminal research on this topic, is by Rowlinson and Walker[1], and Enright et al[2].

As a rule the data cited refers to expenditure in Hong Kong dollars. For consistency, this arrangement is continued. For conversion purposes it is worth noting that the Hong Kong dollar has been 'pegged' to the US dollar since the early 1980's within a narrow range around an exchange rate of HK$ 7.80 for US $ 1.00.

3.2 The scale of construction in Hong Kong

As in any country, the ability to afford construction is dictated by Gross Domestic Product (GDP). Enright et al make clear how well Hong Kong has prospered in these terms:

'. . .and achieved real annual growth in GDP of 6 percent from 1965 to 1975; 8.5 percent from 1975 to 1985; and 6.5 percent from 1985 to 1995. Between 1975 and 1995, real GDP quadrupled to more than US$140 billion and real per capita GDP tripled to US$23,200[3]. According to the World Bank, by 1994 Hong Kong's per capita GDP was the fourth highest in the world on a purchasing-power-parity basis, behind only Luxembourg, the United States, and Switzerland [refer toTable 3-1]. This sustained economic growth has been achieved with low unemployment, which peaked at around 3.5 percent in the late 1995, only to fall to less than 3 percent in 1996. According to the Institute of Management Development (IMD) *World Competitiveness Yearbook 1996*[4], Hong Kong has the world's third most competitive economy. The US-based Heritage foundation has ranked the Hong Kong economy as the freest in the world. Despite a population of only 6.3 million, Hong Kong is a leading exporter of commercial services.'

(Source Enright et al, p8)	US Dollars	
Country/Region	**1995**	**1994**
Luxembourg	29,000	28,189
United States	26,825	26,646
Switzerland	25,070	23,484
Hong Kong	**23,892**	**23,020**
Singapore	23,565	21,518
Canada	22,220	22,316
Japan	22,200	21,616

Table 3-1 1995 GDP per capita - purchasing-power-parity of selected economies.

For further evidence, Table 3-2 shows the percent contribution of construction to the GDP growth by main expenditure component from 1988 to 1998 (i.e., end of 1997 calendar year). The HKG SAR definitions of the 'Expenditure-based Gross Domestic Product (GDP) Main Components' stated by the Census and Statistics Department is provided in the Appendices CD-ROM within Section 3.2. 'Gross Domestic Fixed Capital Formation (GDFCF)' is defined as 'the gross value of investment expenditure on construction as well as machinery and equipment: real estate developers margin; and

transfer costs of land and buildings.' GDFCF is taken as a good approximation of the gross value of construction.

Main Expenditure Component	1988	1991	1993	1994	1995	1996	1997
			HK$ 1000 millions at Money-of-the-Day Market Prices				
Private consumption	254.68	391.10	514.24	592.67	654.50	722.10	802.72
Government consumption	30.01	51.47	72.62	83.66	94.24	104.39	114.16
GD fixed capital formation (GDFCF)	116.13	177.73	245.18	301.11	329.58	372.74	467.77
Changes in Inventories	14.13	4.10	2.30	21.26	45.66	10.32	1.59
Exports of Goods	493.07	765.89	1,046.25	1,170.01	1,344.13	1,397.92	1,455.95
Less imports of Goods	*501.17*	*782.04*	*1,075.71*	*1,254.43*	*1,495.71*	*1,539.85*	*1,619.47*
Exports of Services	110.98	161.09	215.58	240.67	265.64	292.76	293.37
Less imports of Services	*62.81*	*100.81*	*122.99*	*144.07*	*160.88*	*167.76*	*177.00*
Expenditure-based GDP	455.02	668.51	897.46	1,010.89	1,077.15	1,192.61	1,339.09
Per capita GDP ($)	80.86	116.22	152.09	167.49	174.97	188.97	205.95
GDFCF/GDP %	25.5%	26.6%	27.3%	29.8%	30.6%	31.3%	34.9%
			HK$ 1000 millions at Constant 1990 Market Prices				
Private consumption	302.39	359.02	415.62	443.57	450.45	471.77	503.35
Government consumption	39.00	46.62	53.94	56.057	57.86	60.15	61.62
GD fixed capital formation (GDFCF)	137.46	168.06	190.26	220.17	243.80	270.15	313.30
Changes in Inventories	14.32	4.08	2.22	20.06	40.10	9.61	3.70
Exports of Goods	527.74	750.68	1,021.02	1,127.28	1,262,52	1,322.95	1,404.12
Less imports of Goods	*531.86*	*767.80*	*1,057.54*	*1,206.01*	*1,371.85*	*1,430.86*	*1,533.71*
Exports of Services	134.27	148.95	177.98	189.60	198.75	215.65	214.25
Less imports of Services	*73.95*	*97.59*	*113.28*	*123.22*	*125.80*	*129.01*	*134.52*
Expenditure-based GDP	549.30	612.02	690.22	727.51	755.83	790.40	832.11
Per capita GDP ($)	97.61	106.40	116.97	120.54	122.78	125.24	127.98
GDFCF/GDP %	25.0%	27.5%	27.6%	30.3%	32.3%	34.1%	37.7%

Source: Hong Kong Annual Digest of Statistics, 1998 Edition[5]

Table 3-2 Gross Domestic Product (GDP) Estimates by Main Expenditure Component for 1988 to 1997

Table 3-2 concurs with the work of Rowlinson and Walker who argued that:

> '. . .contribution to GDP by sectors of the economy for 1992 as prepared by the Census and Statistics Department . . .[property and construction] is hidden within other sectors. When the statistics are disaggregated [Table 3-3]. . . . it can be seen that the property and construction sector is equivalent to the other major sector – the conglomerate wholesale, retail, import/export trades, restaurants and hotels sector – which is a reflection of its true significance. Its value is far greater than manufacturing.'

Contribution to GDP by conventional HKG SAR Census and Statistics 'economic sectors'	
Wholesale, retail and import and export trade, restaurant and hotels	24.0%
Financing, insurance, real estate and business services	21.5%
Others	16.7%
Community, social and personal services	14.6%
Manufacturing	14.3%
Transport, storage and communication	8.9%
Contribution to GDP by re-ordered 'economic sectors'	
Wholesale, retail and import and export trade, restaurant and hotels	24.0%
Real estate, property and construction	23.5%
Community, social and personal services	14.6%
Manufacturing	14.3%
Financing, insurance, and business services	13.6%
Others	10.0%
	Source: Rowlinson and Walker p14

Table 3-3 True significance of the 'real estate, property, and construction' economic sector in 1992

Rowlinson and Walker show that GDCFC '. . .has been running at this high level year after year. As property is a long-term fixed asset, with a life-span of normally at least 60 years, the significance of property [and thereby 'construction'] in terms of its percentage of accumulated total fixed assets (that is the capital value of Hong Kong) is enormous.'

Table 3-4 adds to this picture by showing the year-on-year growth in construction activity in terms of the key statistics produced by the HKG SAR that are used to indicate the scale and relative growth of the Hong Kong construction industry for the decade from 1988.

	1988	1991	1993	1994	1995	1996	1997
Construction output in nominal terms (HK$ Mill)	40,702	64,030	75,338	89,172	99,807	116,290	131,500
Private domestic units with consent to start work	34,324	36,981	19,160	12,536	19,750	22,113	40,962
Consideration of documents received for registration at the Land Registry (HK$ Billion)	106.41	318.56	424.33	505.50	283.23	517.77	937.81
• Agreement for sale and purchase of building units and land (HK$ Billion)	79.07	227.02	326.70	397.91	309.48	412.42	790.41
• Assignments of building units (thousands)	79.10	227.02	326.70	397.91	309.48	412.42	790.41
• Assignments of land (thousands)	32.41	41.07	81.79	80.98	49.66	38.10	93.75
Housing Authority rental flats completed (Nos)	39,518	21,190	19,848	24,440	14,559	14,946	17,917
Home Ownership Scheme residential units completed (Nos)	6,300	9,804	14,973	4,004	14,868	13,188	12,040

Source: Hong Kong Annual Digest of Statistics, 1998 Edition

Table 3-4 Land, building and Construction 'Key Statistics' for the decade 1988-1997

The Report of the Construction Industry Review Committee[6] provides data that reaffirms that the construction industry is 'one of the main pillars of Hong Kong's economy.' The following statements are extracted from the Report:

> 'In 1999, it [construction *per se*] accounted for 5.6% of the GDP and 40% of gross domestic fixed capital formation. Since 1990, the industry's contribution to GDP in percentage terms has been in the range of 4.9% to 6%. . . .Of the total fixed asset investment in 1999 (as measured by gross domestic fixed capital formation in GDP), about two-fifths was attributable to building and construction. . . . The gross value of construction work performed by main contractors . . .increased from

[HK]$44.7 billion to [HK]$102 billion between 1990 and 1998. . . . The number of employed persons in construction industry has increased since 1995, reaching a peak of 309,500 in 1998. In 1999, 9.2% of our workforce was employed by the construction industry. . .' (Tang, 2001)

Hong Kong has an enviable, successful economy that is underpinned by the 'real estate and construction industry' to a significant degree. Enright et al describe Hong Kong's economy as 'city-state' whereby the scale and intensity of this industry is on national-scale of endeavour. Fundamental attributes of this 'quasi-national' city-state industry are briefly described in Section 3.3 of this Chapter.

3.3 Attributes of the Hong Kong construction industry

3.3.1 Demand for construction

Strong markets exist in Hong Kong for building, civil engineering, and to a lesser degree maintenance and repair. Table 3-5 shows the percent contribution to GDP of these sub-sectors of the construction market. Rowlinson and Walker have researched this in some depth. They show a two-to-one split between private and public sector construction work and identify that the HKG SAR is the single largest client of the construction industry whereas developers predominate in the private sector. They state that, '. . . in 1993, the total market capitalisation of all property-related stocks is about 45 percent [of the market total]. . . .Of the top 20 % is companies listed, 11 are property and/or construction companies, or are consolidated enterprises heavily committed in property and construction'.

Sub-sector	Percent	Sub-total
Buildings		
• Housing	33.2 %	
• Private non-residential	26.7 %	
• Public non-residential	5.8 %	
		65.7 %
Civil Engineering		19.9 %
Maintenance and repair		14.4 %
Total output = HK$ 61.3 billion)		100 %

Source: Estimation of GDP (1966-1993), Survey of Building, Construction and Real Estate Sectors, Census and Statistics Department, Hong Kong Government

Table 3-5 Market share for types of construction work in Hong Kong in 1991 from Rowlinson and Walker.

High-levels of expenditure in real estate and construction is expected to continue into the near future. The Financial Secretary, Donald Tsang[7], in 1999, spoke of 'pushing ahead with a new phase of infrastructure development . . .spend[ing] US$30 billion on major road, rail, land formation, housing and port development projects, as well as numerous other smaller projects. . .The price tag is 50 percent more than the US$20 billion spent on the new airport and the nine supporting bridge and highway projects.'

There is an expectancy of a resurgence of private-sector development from the end of 2001 but this is subject to global economic factors.

3.3.2 Construction firms

The seminal work of Rowlinson and Walker along with Enright et al provide a substantive description of the composition of the Hong Kong construction industry. Whilst there is a range of large to small firms and speciality interests within them, Rowlinson and Walker point out the distinctive aspects of the local industry. Namely:

- A relatively small number of sophisticated large contractors;
- An extremely high-level of sub-contracting;
- A large number of overseas contractors;
- Many companies that are developers and contractors;
- Many construction companies that are an element within a Group that has a diverse range of commercial interests.

The high-level of small firms is borne out in the statistics published annually by the Census and Statistics Department in the annual Survey of Building, Construction and Real Estate Sectors. For example, Table 3-6 shows the situation in 1991.

Gross value of construction performed HK$m	No. of Establishments			Gross value of construction work done				No. of persons directly engaged			
	Est	% Ttl	CF %	GV HK$m	GV/ Est HK$m	% Ttl	CF %	N	N/ Est	% Ttl	CF %
Under 0.5	4,643	36.3	36	1,078	0.2	1.0	1	9,589	2.1	8.3	8
0.5 – 1.999	4,720	36.9	73	4,970	1.1	4.5	6	20,603	4.4	17.2	25
2 – 4.999	1,665	13	86	5,513	3.3	5.0	11	14,653	8.8	12.3	38
5 – 9.999	695	5.4	92	4,969	7.1	4.5	15	7,140	10.3	6.0	44
10 – 19.999	360	2.8	94	5,020	13.9	4.6	20	7,280	20.2	6.1	50
20 – 49.999	363	2.8	97	10,206	28.1	9.3	29	11,599	32.0	9.7	60
50 – 99.999	144	1.1	98	10,130	70.3	92.0	38	6,835	47.5	5.7	65
100 and over	199	1.6	100	67,995	341.7	61.9	100	41,500	208.5	34.7	100

Est: *No. of Establishment*
GV: *Gross Value of construction work done in HK$ millions*
N: *No. of persons directly engaged*
CF: *Cumulative frequencies*
Source: Survey of Building, construction and Real Estate Sectors. Census and Statistics Department

Table 3-6 Market share and company size by different gross value of construction work performed in 1991.

The Rowlinson and Walker analysis is picked up by Enright et al: they both lead to the same conclusion regarding the participation of firms in the Hong Kong construction industry. Namely:

- The large number of small firms indicates low barriers to entry – it merely requires the registration of a firm with the Company Registrar;
- Small and large firms are complementary – large firms tend to sub-contract to the smaller ones. This creates a tolerance and work sharing that enables small firms that are technologically and financially inferior to survive;
- Smaller firms cannot easily grow out of their niche due to selective tendering processes in private and public sectors – a 'catch 22' situation arises in that a prior track-record is needed before a firm can be pre-selected to bid for that type/scale of work – hence the smaller number of large firms;
- Small firms are more reactive to fluctuations in the market due to their lower overheads and resource deployment. Large firms are more likely to leave the market when workloads diminish.

Enright et al describe the Hong Kong economy as having '. . .unique combinations . . . . the balance between government and business, local and overseas firms, and between

entrepreneurship and management. . . .there are no government holding companies with stakes in leading firms in the economy. . .'. They also point out that Hong Kong is also one of the world's leading centres for overseas firms. Over 200 of the Fortune 500 companies have a presence in the territory. As of May 1996, nearly 4,500 overseas companies had established a place of business in Hong Kong under Part XI of the Companies Ordinance[8]. Professional services are a major interest of overseas firms. Nearly ten percent of regional headquarters of overseas firms in Hong Kong are active in finance and banking, another seven percent in transportation and related services, and nearly five percent in construction and architectural and civil engineering[9]. Hong Kong has around 1,400 firms engaged in a wide range of engineering and technical services, more than 500 firms active in real estate surveying, valuation, and consultancy, and around 400 architectural design firms. These three sectors as a whole employ an estimated 23,000 persons[10]. More than one hundred Hong Kong contractors have been certified under the ISO9000 quality management plans[11].

3.3.3 Subcontracting

Mention has already been made of the presence of a large number of small firms mostly occupied in the 'multi-layered' subcontracting found in Hong Kong. The recent report of the Construction Review Committee (Tang, 2001) expresses concern about:

- The lack of formal contracts with the main contractor at the lower tiers in the multi-tiered subcontracting chain – contributing to problems in direct control and supervision;
- Broker-type subcontracting that creates multiple layers in the project delivery team, complicates communication and reduces the profit margin at the lower end of the chain – tending to a cutting of corners at the expense of quality;
- No minimum requirement on the capital, managerial and technical competance, and the employment of direct labour; and
- Lack of sanctions for non-performers.

According to Rowlinson and Walker the value of subcontracted work is about half of the total work done by all contractors.

3.3.4 Construction costs

Tang shows that construction costs in Hong Kong are high compared to Singapore and the United States. Table 3-7 compares 'luxury' and 'good quality' high-rise residential costs whereas Table 3-8 compares high-rise office buildings.

	1996		1997		1998		1999	
	Tender prices in US$ per construction floor area in m^2							
Quality⇒	Luxury	Good	Luxury	Good	Luxury	Good	Luxury	Good
Hong Kong	1,210 – 1,740	1,070 – 1,240	1,420 – 1,920	1,280 – 1,460	1,460 – 1,900	1,310 – 1,490	1,390 – 1,790	1,260 – 1,400
Singapore	1,210 – 1,420	920 – 1,210	1,210 – 1,480	1,010 – 1,210	960 – 1,200	780 – 900	890 – 1,120	710 - 940
Los Angeles	1,190 – 1,350	1,080 – 1,190	1,240 – 1,400	1,080 – 1,240	1,350 – 1,460	1,080 – 1,300	1,400 – 1,620	1,130 – 1,350

NB: Los Angeles represents the United States as it is in the middle cost range among major US cities
Source: Levett and Bailey Chartered Quantity Surveyors

Table 3-7 Comparison of tender prices for construction of high-rise residential building in Hong Kong, Singapore and the United States.

	1996		1997		1998		1999	
	Tender prices in US$ per construction floor area in m^2							
Quality⇒	High	Good	High	Good	High	Good	High	Good
Hong Kong	1,290 – 1,730	1,110 – 1,370	1,510 – 1,960	1,250 – 1,520	1,550 – 1,980	1,260 – 1,520	1,490 – 1,890	1,210 – 1,440
Singapore	1,450 – 1,680	1,380 – 1,540	1,440 – 1,640	1,370 – 1,510	1,130 – 1,340	1,070 – 1,220	1,030 – 1,240	970 – 1,120
Los Angeles	1,730 – 1,890	1,510 – 1,730	1,670 – 1,890	1,460 – 1,670	1,730 – 1,940	1,510 – 1,730	1,830 – 2,050	1,670 – 1,830

NB: Los Angeles represents the United States as it is in the middle cost range among major US cities
Source: Levett and Bailey Chartered Quantity Surveyors

Table 3-8 Comparison of tender prices for construction of high-rise office buildings in Hong Kong, Singapore and the United States.

The steep terrain and need for deep piling as well as the challenging climatic conditions are factors that drive up the costs of high-rise construction but the Tang report identifies the following attributes of the costs of construction in Hong Kong:

- A fragmented approach to construction and a poor supply chain that contributes to low efficiency;
- Very short construction programmes driven by a need to achieve early occupation and income;
- A tendency to favour the lowest bid without regard to quality [in their view] leading to higher outturn price and life-cycle costs;
- Tolerance of contract variations;
- Non-value adding multi-layered subcontracting that reduces profit margins of the firms doing the work; Use of labour intensive, in-situ construction methods with higher supervisory costs and material wastage;
- Low-labour productivity and shortages of skilled labour supply;
- High-degree of regulatory imposition upon construction;
- Incomplete, or inaccurate, as-built records of underground utilities within the congested urban environment; and
- High-cost of material components.

3.3.5 Construction safety

Hong Kong's track record for the production of high-quality, leading-edge buildings and civil engineering is well documented in the professional and academic journals. Safety is a feature of the industry that has received attention for less salutary reasons.

Tang reports that in 1999, the accident rate per 1,000 employees in all industrial undertakings was 55.1, far below the overall construction-site accident rate. Table 3-9 shows the predominantly high rate of accidents in construction compared to other industrial sectors. Considerable effort has been expended on improving site-safety throughout the 1990's – these figures are for 1999 and indicate the current improved situation.

Industrial Sector	Percent of Industrial Accidents	Nos of workers employed
Construction	39.1%	71,000
Catering	34.9%	188,000
Manufacturing	15.3%	248,000

Table 3-9 Comparison of accidents per industrial sector in Hong Kong in 1999

The accident record is poor as construction-related accidents exceed the industrial manufacturing sector.

3.4 Summary of the research environment

This Chapter of the Thesis is to show that the Hong Kong construction industry is similar in nature to national construction industries elsewhere and that this research applies to the general case. To support this contention, attributes of the Hong Kong construction industry are presented with commentary cited from seminal research on this topic.

Hong Kong has an enviable, successful economy that is underpinned by the 'real estate and construction industry' to a significant degree. Enright et al describe Hong Kong's economy as 'city-state' whereby the scale and intensity of this industry is on national-scale of endeavour. 'Since 1990, the [Hong Kong construction] industry's contribution to GDP in percentage terms has been in the range of 4.9% to 6%. . . .Of the total fixed asset investment in 1999 (as measured by gross domestic fixed capital formation in GDP), about two-fifths was attributable to building and construction. . . . The gross value of construction work performed by main contractors . . .increased from [HK]$44.7 billion to [HK]$102 billion between 1990 and 1998. . . . The number of employed persons in the construction industry has increased since 1995, reaching a peak of 309,500 in 1998. In 1999, 9.2% of our workforce was employed by the construction industry. . .' (Tang, 2001)

Strong markets exist for building, civil engineering, and to a lesser degree maintenance and repair. A two-to-one split exists between private and public sector construction work. The government is the single largest client of the construction industry whereas developers predominate in the private sector. Rowlinson and Walker also argue that, '. . . in 1993, the total market capitalisation of all property-related stocks is about 45 percent [of the market total]. . . .Of the top 20 % companies listed, 11 are property and/or construction companies, or are consolidated enterprises heavily committed in property and construction'. According to the Financial Secretary (Tsang, 1999), high-levels of expenditure in real estate and construction is expected to continue into the near future.

Rowlinson and Walker point out the distinctive aspects of the local industry. Namely:

- a relatively small number of sophisticated large contractors;
- an extremely high-level of sub-contracting;
- a large number of overseas contractors;
- many companies that are developers and contractors;
- many construction companies that are an element of a Group with a diverse range of commercial interests.

The participation of firms in the Hong Kong construction industry is due to the:

- the low barriers to entry;
- small and large firms are complementary – large firms tend to sub-contract to the smaller ones;
- smaller firms cannot easily grow out of their niche due to selective tendering;
- small firms are more reactive to fluctuations in the market.

Hong Kong is one of the world's leading centres for overseas firms. Five percent of the overseas firms in Hong Kong are engaged in construction and architectural and civil engineering. Hong Kong has around 1,400 firms engaged in a wide range of engineering and technical services, more than 500 firms active in real estate surveying, valuation, and consultancy, and around 400 architectural design firms. These three sectors as a whole employ an estimated 23,000 persons. More than one hundred Hong Kong contractors have been certified under the ISO9000 quality management plans.

According to Rowlinson and Walker the value of subcontracted work is about half of the total work done by all contractors. A large number of small firms are mostly occupied in the 'multi-layered' subcontracting found in Hong Kong. The attributes of these arrangements are:

- the lack of formal contracts with the main contractor at the lower tiers in the multi-tiered subcontracting chain;
- 'broker-type' subcontracting that creates multiple layers in the project delivery team;
- no minimum requirement on the capital, managerial and technical competance; and
- the lack of sanctions for non-performers.

The steep terrain and need for deep piling as well as the challenging climatic conditions are factors that drive up the costs of high-rise construction, but there are other considerations that affect the cost of construction in Hong Kong. Such as, a fragmented

approach to construction and a poor supply chain. Also, short construction programmes, lowest-bid tendering, poor control of contract variations at the sub-contractor level, use of labour intensive, in-situ construction methods, and the need to import most construction materials. Construction safety has improved but the construction-industry still has an accident rate that exceeds industrial manufacturing.

Dense urban construction on the steep terrain and to accommodate a wide range of climatic conditions has resulted in the development of a technologically advanced industry. The cultural ethos of striving to deliver projects on-time is also a key factor in the industry's enviable reputation. However, these factors due not have any implications to this research. Hong Kong is not a centre for leading edge innovation: it employs technologies developed elsewhere. It's cultural propensity for hard work is found elsewhere: east or west.

3.5 References regarding the research environment

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Chapter Four

4 Literature Review

4.1 Introduction

The literature review is to ascertain the theory and the consequential findings of contemporary research on the topic of this Thesis - the management of portfolios of projects. In particular, the use of project-level data to aid portfolio-level management along with the use of Pareto-based principles of project significance when managing a diverse range of projects. For the purposes of this Thesis the term 'management of a portfolio-of-projects' is synonymous with 'programme management' or 'multi-project management'.

The methodology for this aspect of the research is described in Chapter Two, Section 2.3.

4.2 Multi-project management

The thirty-seven references on the subject of multi-project management extracted from the 3,155 abstracts reviewed provide definition and research background to the topic of multi-project management. None of them address the interelated topics inherent in this research, namely management of portfolios-of-projects using Pareto-based heuristics of project significance. A synopsis of this identified prior work is provided here as a theoretical foundation. It indicates the relevance of the research described in this Thesis.

Chinowsky and Meredith[1], citing Goodman[2], observed that existing literature and research reports provide fewer avenues for construction professionals to obtain this strategic management knowledge. Eskerod[3] says that most of the existing literature is about coordinating, scheduling and managing single projects. Evaristo and Fenema[4] also note that the literature is predominantly focussed on single projects. Turner[3] emphased

the dearth of literature on this topic suggesting that this is due to attention being focussed on large capital construction projects that constitute 10% of the issue.

The advantages of using a portfolio management as a fundamental business strategy was advised by Hedley[5] as long ago as 1977. Gareis[6] observed that 'the structures and processes of a 'project-performing-company' influence the success of each single project, hence the management of the company itself becomes an object of consideration'. The project-orientated company therefore has management demands imposed upon it that go beyond the project management of individual projects.

Turner[7] and later Ferns[8], also note the corporate advantage in adopting a portfolio approach by suggesting that the co-ordinated management of a portfolio-of-projects would deliver benefits not possible if they were managed independently. Turner provided three prerequisites for success in this. First, select the constituent projects in a portfolio so that they are, to some degree, in common. Aspects of commonality might be: objectives, resources or skill types, engineering or software technology, markets or products, or contractors. Second, manage the interfaces between the shared interests. Schmitz[9] provides a useful example of a PMIS used for this purpose on a portfolio of mega-projects to specifically deal with the scheduling, interface management and the resolution of conflicts. Third, assign priorities to projects as part of the managerial decision making process. For these reasons the management of a portfolio-of-projects occurs at a higher level of management than project management. There is a separation of role and, by implication, the need for information management of the enterprize. Ferns noted some of the practical difficulties arising from this as 'corporate standards for [PMIS] are rarely written to satisfy the diverse [PM] needs of all types of projects'. A dichotomy that is confirmed in the case study included in this Thesis.

Turner and Speiser[10], in what has been described as seminal reference on this topic, describe the information management requirements of portfolio management. They advocate the use of the deployment of resources 'on a priority basis' as the means of optimising the outcome. Gokhale and Bhatia[11] later set out to provide a PMIS in the

nature of the Turner and Speiser model but largely theorise about the needed functionality. Whereas, Scheinberg and Stretton[12] suggest the user-defined key portfolio parameters (indices) that are the most relevant to the portfolio of projects at any particular stage should be used in an algorithm to re-schedule projects to optimise the outturn variance in these attributes.

The challenge in providing a PMIS is made greater by the nature of construction. In this regard, Veshosky[13] emphasised the importance of 'patterns of decisions' with regard to personnel, technology, and business development activities for A/E firms. He suggested that the rational coordination of these critical issues required the adoption of the principles of portfolio management. The studies of Mitrovic et al[14] agreed with Veshosky. They identified that 'disintegrated processes [are]. . . a main industry weakness.' . . The reasons stem from the diversity of the industry, its distributed business environment, wide interfaces with all segments of society, and very little knowledge within the industry of what its business processes really are. The way a construction company will process customer requirements will be decided at its multi-project level. This is the level where the company's multi-project portfolio is managed, where, therefore, major opportunities for optimization exist and where the key competitive capabilities of a company reside'.

Van der Merwe[15] describes a programme in terms of a small number of projects to be managed concurrentl. The same management team is the common factor that defines the extent of the portfolio. He detailed a methodology on how to manage those projects whereas Turner and Speiser noted that portfolio diversity will include medium sized projects.

Williams[16] notes that much of the current research has focussed on individual project risk management that has the benefit of inherent flexibility. Whereas, if the project is being carried out by a consortium or community of companies there is a need for communication across the complex project structure. In his view the keyword in achieving this is 'formality' in the form of structural proforma for enquiring, reporting,

and instruction. Thereby providing a common currency for such communication and for ensuring monitoring and control. Hutchinson[17] identified five key steps for an IT integrated programme management approach that is predominantly about communication between multi-participants. These involve IT communication technologies employing: e-mail; interactive e-mail; e-conferencing; audio-videoconferencing; and hypermedia documentation. In the same multi-project management context, Kurbel[18] describes these as 'groupware' in reference to 'computer-based systems that support two or more users engaged on a commontask (or goal) and that provides an interface to shared environments. He is more explicit in his functional itemisation by naming software tools that focus on: electronic-mail systems; electronic conferencing; co-authoring systems; group based decision –support systems; group calendars; work-flow systems. He also describes differentiated levels of cooperation in the organisation such as the top level comprising strategic project planning with concerns for the choice of an adequate development strategy and a process model, the definition of major project stages, provisions for alternative subplans and so forth. On the middle level (tactical level), overall stages are subdivided into medium-range tasks and subtasks and are scheduled subject to temporal dependencies. On the operative level, subtasks are decomposed into detailed activities to be performed by the team members[19]. Hastings[20] suggests that most organisations underestimate the depth of change in attitude, skill, and systems required for 'management by projects' as opposed to traditional departmental or line working. He says that there is a requirement for information technology infrastructure in three broad areas: a) information systems; b) planning tools; c) groupware. The keynote here is simplicity, he cites a Managing Director of a large semi-conductor manufacturer in the States says that he is able to review 400 in-company projects in two hours using a very simple system based on key activity reviews and key milestones on a company network. Hastings agrees with others that the senior managers' requirements for information for widely differing types of projects are different from the information requirements of the project leader or team members. Any system has to be able to accommodate both these needs.

Dikbas et al[21] propose a PMIS as a solution to how best to manage multiple projects arguing that previously developed models accommodate general project management requirements. They suggest that the main problem in developing integrated automated information systems for construction management purposes is that the large number of different software packages used in the construction sector render the integration process quite complicated. The difficulty lies in formulating a process for collecting data from various software packages, accumulating this data in a multi-project environment, and formatting this data to create integrated reports. When this process is considered in the Web-environment, interface requirements create further complications. However, Mezher et al[22] describe the use of low-end technologies and ACCESS software used by the Near-East Telecommunications Installation Company to help in the management of telecommunication construction works. A much more comprehensive approach in practice, that is similar in many respects to the longitudinal ground case study included in this research, is provided by Kuprenas et al[23]. Their case study describes how the non-wastewater elements of the Bureau [of Engineering of the City of Los Angeles Department of Public Works] were organized into a program-based matrix organization with a Project Manager as the focus for project delivery with project conception-to-conclusion delivery. They mandated a dramatic shift to a 'project delivery' approach to multi-project management. Methods of reporting their 'lean project delivery system performance' center on a new project management control system (PMCS) that uses traditional measures of earned value.

Conversely, Gareiss[24] uses a case study to define the need for differentiated PM approaches within cost managing multi-projects. His description is in systems theory terms and concludes that the variety of projects in project-orientated companies requires differentiated project management techniques. Furthermore, appropriate planning and control techniques have to be selected for each specific project situation. Very little support is currently available in the way of computer based planning and control tools for the management of networks of projects. Whereas, Miller et al[25] focus upon a model that supports simultaneous use of multiple project delivery methods. The discussion and frameworks they provide are the result of a variety of research efforts at MIT but these

are more to do with procurement than program management but do incorporate the multi-participant roles within the multi-project coalition.

Many authors developed operational definitions of the management of portfolios-of-projects. Citing each other in the process. Angling[26] proposed seven aspects of this approach:

- the basic unit of the programme [portfolio] is the project, divided into activities when necessary;
- the resourcing and timing of each project may be aggregated to form a complete programme; however as each project is a component of the programme any change in one, will affect the other;
- the successful control of a multi-project programme depends on the successful control of each individual project;
- the person responsible for project management information on each project should be clearly identified;
- allocation of manpower to projects should be carried out on small groups of projects;
- when resources are insufficient, a means of ranking projects by priority is required; and
- communication must be sufficiently robust that information is coordinated with the minimum of delay for effective decision making.

Angling assigned 'significance and/or priority' by a marking scheme involving factors of 'purpose' and 'urgency'. The work of Angling is broadly in agreement with Cleland and King's proposition. It assumes that an optimum outcome overall is derived from an optimum outcome for all the constituent projects, even though his approach involves assigning resources according to prioritisation.

Reiss[27] addresses the planning (or scheduling) aspects of programme management. He proposes a model of the programme modeling processes that follows the management structure of the organisation. Seven stages in the planning of a portfolio-of-projects are identified:

- Planning - the process of planning each project in terms of time and resource requirements - this is similar to planning a single project;
- Transmission - the transmission of the individual project plans to a central point;
- Consolidation - The process of combining the many individual project plans into a programme plan;

- Evaluation - exposure of inter-project conflicts and identification of problems especially multi-resource over demands;
- Experimentation and decision making - The process of experimenting with alternative strategies to find optimal schedules for the future work load;
- Dissemination - the dissemination of decisions taken back to the individual project teams and the modification of the individual project plans;
- Achievement measurement - feedback via timesheet systems either to measure effort or to monitor progress.

Reiss notes the main strategies used currently for the purpose of programme management by practictioner organisations and says that these tend to follow the availability of software tools. The methods employed by these organisations to plan and monitor their workload do not represent a model of the organisations management. He says that such models are therefore structurally flawed and often inappropriate. Platje and Seidel[28] also observed that the concurrent management of the throughput times, resource allocations and costs of the projects is a complex process of balancing the (often-conflicting) interests of multiple participants. However, they are doubtful of the success of a simplistic approach to the management of a portfolio of projects. They argue that projects do not necessarily have common objectives except that of contributing to the overall profitability. Aggregating single projects into a portfolio of projects for management according to the principles of 'plan-do-check-action', in their view, does not work. Using large information systems and rigid planning and control procedures is not helpful in this context. Instead, they recommend that all the project management responsibilities are delegated to the lowest possible organisation level, that communication is made explicit, and the role of general management is restricted to setting priorities, authorizing the overall portfolio, and resolving bottlenecks which cannot be managed at the portfolio management level. Research by Tullett[29] pointed out that multi-project managers have an innovative thinking style and are less likely to be concerned with the attention to detail and the structured systematic approach required to plan and manage projects. The further work of Platje et al[30] suggested that portfolio management required the linking of the project breakdown structure and the OBS but does not give details.

Payne and Turner[31] attempt to resolve this dichotomy within their definition of unified PMIS that accommodates project-by-project tailoring of approach to suit project diversity. Payne[32] identified that 'inhomogenity adds complexity to programme management'. He found that where people used consistent procedures regardless of project type, size, and skill type, they reported less success than where people tailored their procedures. The Payne and Turner solution is to develop a strategic plan for every project based on the common approach, but to allow different projects to adopt different approaches at the detail of tactical level. Payne also noted that a major problem with multi-projects is that they can have an independent existence with separate goals and problems, and yet draw at least some resources from a common pool. They must be integrated into the management control and reporting systems of the owner of the resource-pool. Spuhler and Biagini[33] confirm that 'there is hardly a company to be found which does not launch more projects than it can master with the available resources . . . The size of a project normally determines its perceived importance. . .Commitment to the project is relative to it's perceived importance'. Frame[34] says that it is necessary to consider the effect of the integration of multiple projects into one big control systems. He also proposes that a special consideration in a portfolio of projects is that the 'optimization of the portfolio's performance will require sub-optimization of individual projects'. Payne's review reveals that most authors place emphasis on mechanistic methods of coping with the multi-projects. It looks at the problems associated with simultaneous multiple projects in terms of categories of capacity, complexity, conflict, and commitment and context but ignores issues such as small versus large projects.

Pellegrinelli[35] continues this theme of differentiation by suggesting that programme management has evolved a core set of actions, structural arrangements and approaches, which, when compared with project management, are distinct and address conceptually different issues. Pelleginelli and Bowman[36] advocate the use of the programme approach as a way of managing the interdependence between projects and the need to respond to changing circumstances associated with the implementation of the firms' strategy. They say that 'Programme management' is not the same as multi-project management nor the management of scarce resources, or the establishment of appropriate information

systems. They say that the term 'programme' has, for some time, been widely used to describe the organising structure and processes used to coordinate and direct related projects. In a multi-project environment, the management of resource conflicts is the key challenge facing the organisation. Evaristo and Fenema add to this debate by the introduction of a typology of 'new forms of project management' that differentiate between single-site versus multi-site projects, and single versus multiple projects. Shapira et al[37] state that in a multi-project environment projects are not delivered by project managers, but by teams composed of functionaries and specialists. Such teams are required for the making of integrative decisions and for there efficient execution. Other participants in the multi-project coalition are recognized by Johns[38] who describes serving the Clients' needs through project-management. He describes the portfolio/project method as a system for managing behaviours needed by people who work together in teams to satisfy the needs of their customers. Gray[39] adds to this theme of authority structures by noting that irrespective of a clear programme of projects, project work is unlikely to be successfully managed without the active involvement of very senior people to maintain the authority structure. The effective interchange of information requires the commitment of resource and the active ongoing support of senior people; to be successful it needs to be seen as the chosen way of handling programmes in the company. Not only do appropriate technology and skills need to be put in place to handle the mechanics of the information exchange, but the free input of information must be seen to have the active support of all concerned. Griffith and Headley[40] expand these issues into the management of small projects. They suggest that management must be exerted at two levels. One, is within the organisation of the works. Two, is the development of a framework and organisation which considers the implication of the works upon the organization's ongoing business. They say that the vehicle for establishing such an approach is a dynamic management system which considers clear goals and provides feedback on work across the organization's small works portfolio.'

4.3 Summary of the literature review

A small number of references (37 from 3,155 abstracts) have been extracted out of a broad and in-depth review of peer-reviewed journals that include the topic of the management of portfolios-of-project. This dearth of publications is noted by several of the authors cited.

The summary of the search of the literature on this topic describes the advantage of using portfolio management as a business strategy. It provides operational definition of portfolios and their management.

Authors stated the theoretical prerequisites for the management of a portfolio of projects. Also described are the basic functional requirements of a MIS that can assist in this management. Case study observations from research practice, and industry example are included in these references.

Several authors noted the need to prioritise projects and that 'resources allocated on a priority basis' was key to this process. In this context 'User-defined key portfolio parameters (indices) that are the most relevant to the portfolio of projects at any particular stage should be used in an algorithm to re-schedule projects to optimise the outturn variance' is specifically mentioned by Scheinberg and Stretton. Angling assigned 'significance and/or priority' by using marking scheme involving factors of 'purpose' and 'urgency'. The work of Angling is broadly in agreement with Cleland and King's proposition. It assumes that an optimum outcome is derived from an optimum outcome for all the constituent projects even though his approach involves assigning resources according to prioritisation.

Information management systems for the purpose of managing a portfolio-of-project were a stated requirement of these approaches. Descriptions were cited of the broad functional requirements for such systems. In some instances these included networked

information technologies and communications facilities primarily mentioned in the context of better integration of the portfolio participants.

None of these references undermine the proposition of Cleland and King and the basis for the hypothesis stated in this Thesis.

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Chapter Five

5 Assessing The Practices Of Hong Kong Contractors For Managing Portfolios-Of-Projects

5.1 Introduction

This chapter describes the research carried out to assess the current methods used by Hong Kong contractors to manage their portfolio-of-projects. It is the first element of data obtained for the thesis. The purpose of this research is to qualitatively assess the practices of the Hong Kong contractors for the management of their portfolios-of-projects. Specifically, it is to measure the extent that PMIS are used in the manner proposed by Cleland and King. It also caters to other related research interests of importance to the Secretary of Works of the HKG SAR who supported this work.

5.2 Chapter Outline

The scope of this element of the research and the methodology for the development, testing and validation of this questionnaire has been earlier described in Chapter Two, Section 2.5. The further details of this element of the research are set out as follows:

- Section 5.3 describes the conversion of the research topics into a questionnaire. A commentary on each question along with a copy of the survey instrument is provided in the 'Appendices CD-ROM' within Chapter Five;
- Section 5.4 gives the details of the population sample;
- Section 5.5 recounts the level of response received;
- Section 5.6 provides the analysis of the response to this questionnaire. Section 5.6.1 and 5.6.2 discusses the analysis of the 'tick-the-box' and the 'open-ended' questions respectively – refer to the Appendices CD-ROM for the detailed results and analysis of the responses;
- Section 5.7 details the results of the research and the points carried forward to subsequent studies; finally,
- Section 5.8 provides a summary of this element of the research.

5.3 Conversion of the research topics into questions

The three research topic areas to be surveyed are described in Table 5-1. A fourth topic is added for reasons described earlier in Section 2.5: this uses a survey questionnaire developed by Betts and Shafagi[1] called an 'IT healthcheck'. It provides a self-assessment of the strategic use of information technology for firms in the construction industry.

Coms_Net	• the communications network used to transfer items of project data for consolidation into a bigger indicator of performance
Proj_Data	• the items of data that are used as indicators of project performance, that can be consolidated into an indicator of performace for the portfolio as a whole.
Portfolio_method	• the method adopted for consolidating project data into an indicator of performance for the portfolio-of-projects. A subset of this aspect of the research is the baseline adopted for measuring performance. This requires knowledge of the owner's critical-success-factors for their portfolio-of-projects.
IT Health check	• 28 closed-questions that respondents answer to assess how they measure up against a best-practice benchmark.

Table 5-1 Four research topics included in the questionnaire survey of Hong Kong contractors

The first part of this survey, called Coms_Net, is to assess the use of information technology that enhances the process of communication between the human resources. The breakdown of Coms_Net into question topics, using mind-mapping techniques, is shown in Figure 5-1. For the purposes of this questionnaire, the term **'Communication'** is defined as the transfer of information; for example, from the company head office to a construction site and vice versa. It also means the transfer and receipt of information between project participants within these work-centres. **'Project participants'** means any person involved in a project. In this context, **'Information technology (IT)'** means all electronic devices for capturing, storing, re-using, and communicating data/information between project participants. The questions start with commonplace technologies, such as the telephone, and extend into the use of the Internet and entirely

electronic means of communication between project participants. Pagers are not included because they are viewed as a one-way communication.

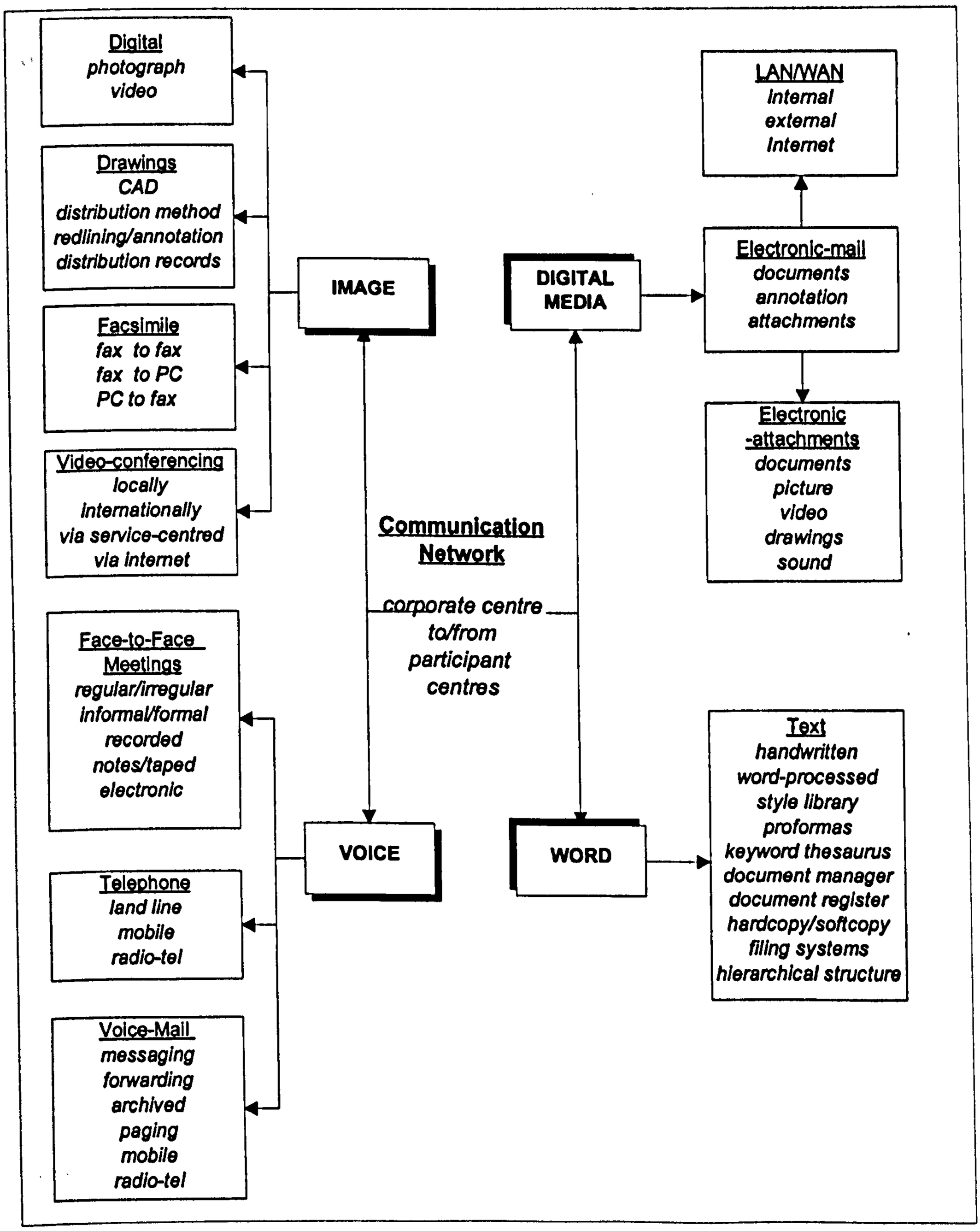


Figure 5-1 Development of Coms_Net into question topics.

The topic breakdown of the second part of the survey, called Proj_Data, into question topics, also by mind-mapping techniques, is shown in Figure 5-2. Early discussion with a number of the contractors indicated that project data flows were concentrated at the project site and did not flow to the corporate centres to a significant extent, except for a few key indicators. An approach is therefore adopted whereby the use of a few, commonplace, indicators of performance are measured. These are limited to traditional aspects of project-management; namely, scope-cost-time-resources.

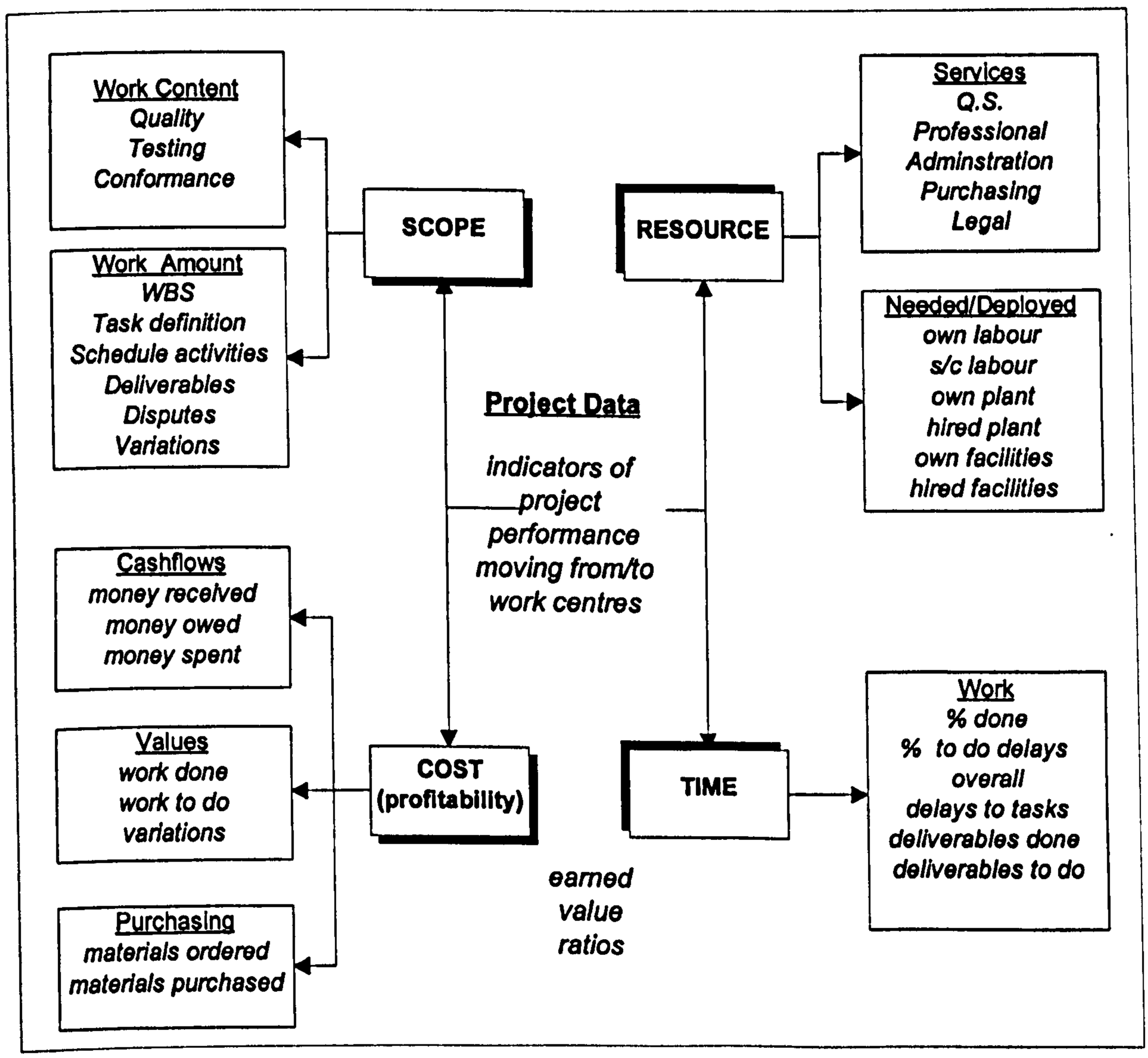


Figure 5-2 Development of Project_Data into Questionnaire topics.

The topic breakdown of the third part of the survey, called Portfolio-Data, into question topics is shown in Figure 5-3. The fundamental issues to be addressed are what process

of synthesis is possible, and what project information is fed into the process. It is assumed that this will be either,

- the human interpretation of the status of individual projects;
- the analysis of numeric, date and codified data using spreadsheets; or
- trend and exception reporting using the analytical and Boolean processes available in databases.

Cleland and King (1986) described this objective as obtaining a 'big picture from legitimate detail'. Accounts of recent MIS systems used on HKG projects that have achieved some of these aims are published elesewhere[2,3,4]. Others, also involved in Hong Kong construction portfolios-of-projects have similarly described the MIS methods and the benefits gained[5,6]. The questionnaire polls the population sample to identify the criterion that is used to assess overall performance in terms of scope, cost, time, and resources.

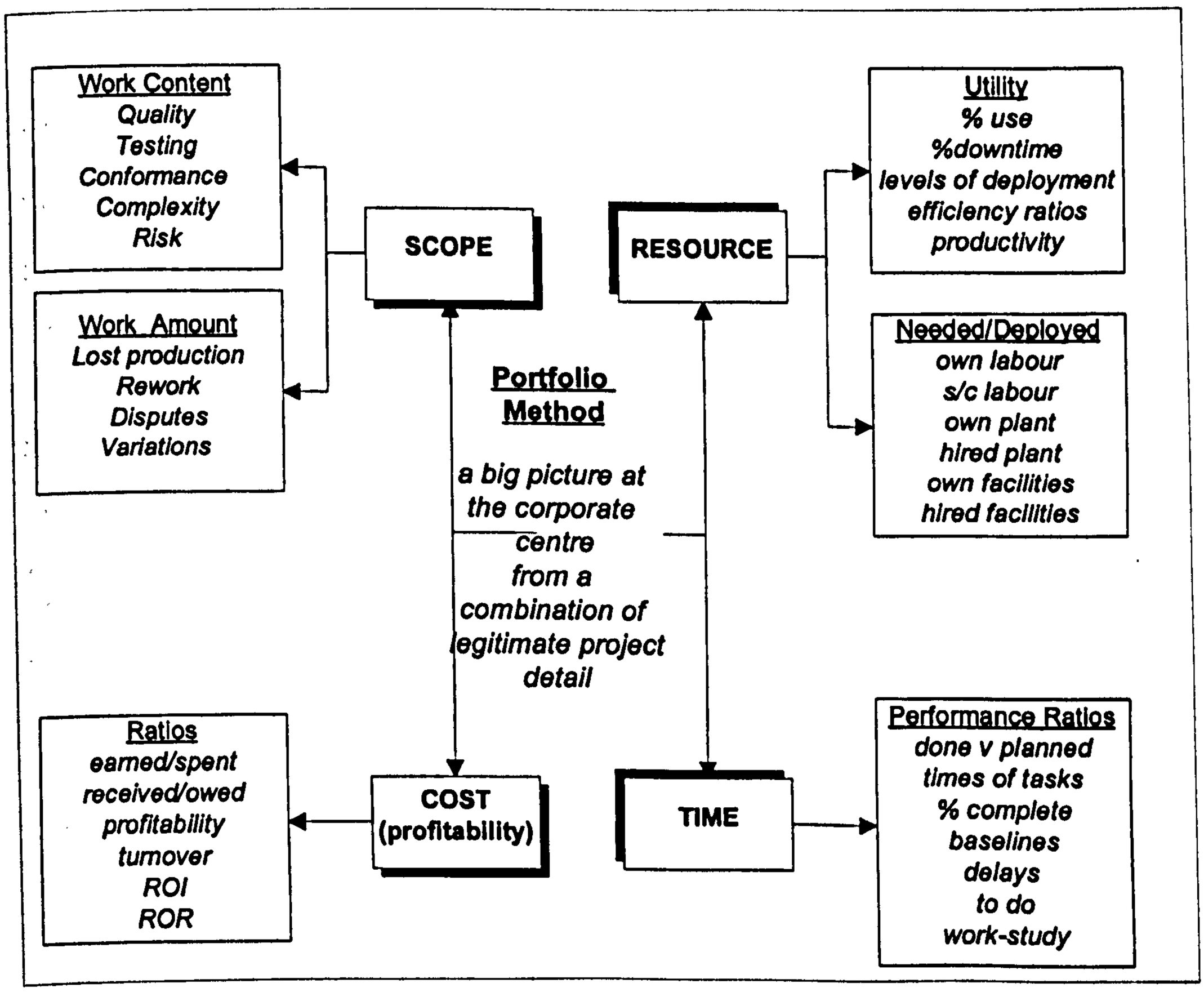


Figure 5-3 Development of Portfolio_Method into question topics.

The fourth part of the questionnaire, the 'IT healthcheck', comprises twenty-eight closed questions that companies answer and score to subjectively measure their use and management of IT. The questions are grouped into three major categories:

- the position of IT within the competitive business strategy of the organisation;
- the overall role of IT within the organisation; and
- the current IT strategy within the company.

It provides a comparison[7]. with the same research exercise carried out in Great Britain by Betts and Shafagi, (1997), and in Australia by Stewart (1997).

The resultant questionnaire, with the text of the covering letters used on the first, second, and third issue, are printed for reference in the 'Appendices' and at Section 5.2 of the CD-ROM.

5.4 Population Sample

The sample population is taken from the list of approved Contractors, kept by the Professional Services Unit of the Works Bureau of the Government of Hong Kong. Works Branch Technical Circular No 9/97[8] (1997) describes the HKG rules for admission to the list. The Contractors are placed into group A, B, or C according to their proven track record and their ability to finance construction. Each group corresponds to a range of value for public works contracts offered for tender. The current limits are stated in Table 5-2.

Group	Permitted Tender Value
Group A	• Contracts of value up to HK$ 20 million.
Group B	• Contracts of value up to HK$ 50 million
Group C	• Contracts of any value exceeding HK$ 50 million

Table 5-2 Group Tender Limits for HKG public works contractors.

The Contractors are approved within one or more, of five categories of public works, namely: buildings (BD); port works (PW); roads and drainage (RD), site formation (SF), and water works (WW). The suitability of a contractor for inclusion in one or more of

the categories and a particular group is assessed from the contractor's global business and construction activity in Hong Kong. The approval assessment considers financial criteria, technical and management capabilities, and general evidence of being suitable to tender for public works projects within a group and for certain categories. As a condition of admission, all applicants must be a business in Hong Kong as defined in the Business Registration Ordinance. They must also employ in Hong Kong, a minimum number of full time management and technical personnel with relevant experience and recognised qualification in engineering and project management. For example, a Group C contractor in the 'Buildings' category must have 'at least one member of the resident top management [with] . . . a minimum of five years local experience in managing a construction firm obtained in the past eight years'[1]. The minimum technical staff is 'at least two persons with a relevant degree from a Hong Kong University, or equivalent, with at least five years post-graduate experience in building works[1]." The minimum financial criteria for admission onto the list is changed from time to time to reflect the costs of public works and are currently set at the limits shown on Table 5-3.

	Minimum employed capital (HK$)	Minimum Working Capital (HK$)
Group A	2.1 million	2.1 million
Group B	5.3 million	5.3 million
Group C	9.0 million	9.0 million

Table 5-3 Financial criteria for Groups of Contractors on the HKG List.

In addition, there is a requirement to maintain minimum working capital to cover the operating costs of new and outstanding works. For Group A contractors, the working capital is the greater of the criteria in Table 5-3 or 20% of the combined annual value of the new contract and uncompleted works on other current Government contracts. For Group B, the percentage is 10%, and for Group C, it is 6%. A holding company and its subsidiaries shall be permitted to be included in the Contractors List, however they must give an undertaking that only one company will tender for one contract.

The Professional Services Unit of the Works Bureau of HKG provided spreadsheets of data taken from their Contractors List. This included data on 1,636 contractors in total

but including a large number of specialist firms within fields so narrow as to not compare to a General Contractor, these include Elevator Installations, Curtain Walling, or E&M and so forth. A tabulation of the extent of the data provided is listed in the 'Appendices CD-ROM' at Section 5.3, on Table 5.3. After the exclusion of the specialist firms a population of 317 contractor firms remains. The variables in this population sample of Hong Kong contractors are listed in Table 5-4. The attributes-in-common are listed in Table 5-5. Table 5-6 details the sub-sectors within the population sample.

File	Field data	Field attribute
Contractor *317 records*	CONTRACTOR_REF	Contractor's unique reference code
	CONTRACTOR_NAME	Contractor's name
	CONTRACTOR_ADS	Contractor's address in Hong Kong
	CONTRACTOR_PHONE	Contractor's telephone number
	CONTRACTOR_FAX	Contractor's fax number
	NATION_CODE	Nationality code
	BUS_STATUS	Business status (CO=corp. PT=partnership, PR=proprietorship)
ISO *125 records*	CONTRACTOR_REF	Contractor's unique reference code
	ISO_CERT	Y=yes
Contractor_list _cat _grp *317 records*	CONTRACTOR_REF	Contractor's unique reference code
	CAT_CODE	List category code (BD, PW, RD, SF, WW) (BD, PW, RD, SF, WW
	GRP_CODE	Group code (A, B, C)

Table 5-4 Variable data items within the Contractor population sample.

Common attribute
• Approved Contractor on the public works Contractor List of the HKG. • Not a joint-venture company. • Questionnaire sent to the Hong Kong registered company address. • General Contractor listed in one, or more, categories of works that includes: buildings (BD); port works (PW); roads and drainage (RD); site formation (SF); and water works WW).

Table 5-5 Attributes-in-common of the Contractor population sample.

Characteristics of the population sample
• Of the 317 Contractors in the population sample, 317 (100%) are listed in terms of Category and Group. • Of the 317 Contractors in the population sample, 125 (39%) have ISO 9000 certification. • Of the 129 Group C Contractors in the population sample, 103 (80%) have ISO 9000 certification. • Of the 88 Group B Contractors in the population sample, 15 (17%) have ISO 9000 certification. • Of the 100 Group A Contractors in the population sample, 7 (7%) have ISO 9000 certification. • Of the 129 Group C Contractors in the population sample, 21 (16%) are approved for all five Categories of public works. • *(2 Group B Contractors also have five Categories, 0 Contractors in Group A.)*

Table 5-6 Sub-sector attributes of the Contractor population sample.

The derived population sample is three hundred and seventeen contractors registered as Hong Kong companies. One hundred contractors are in Group A – these are the smaller firms. Eighty-eight contractors are in Group B, and one hundred and twenty-nine are in Group C. Thirty nine percent of the population sample, have ISO9000 certification. Eighty percent of the certificated companies are Group C contractors. Seventeen percent of the Group B contractors have ISO9000 certification. Seven percent of the Group A contractors are certificated.

5.5 Postal survey level of response

The questionnaire was mailed to the sample population of 317 contractors on February 27, 1998 so as to arrive on March 2, 1998. Table 5-7 lists the responses received at the first, second and final deadline. Two companies ceased trading during the postal survey and five companies pointed out that they were listed under two names. Two were joint venture companies using a single address and in other cases a company take-over had resulted in two companies operating from one address. These duplications are not included in the analysis.

Deadline date (Max possible) ⇒	Response (317)	Group A (100)		Group B (88)		Group C (129)		With ISO (125)	
	No (%)	No	%	No	%	No	%	No	%
March 20, 1998	91 (28%)	22	22%	29	33%	40	31%	42	34%
April 3, 1998	195 (62%)	50	50%	62	71%	83	64%	92	74%
April 17, 1998	224 (71%)	60	60%	71	81%	93	72%	99	79%
Later	239 (75%)	68	68%	72	74%	99	77%	105	84%

Table 5-7 Response from the postal survey of HKG's public works contractors.

The overall response of 75% is good. The response included 44% contractor companies who are ISO9000 certificated. Forty-one percent of the respondents are Group C contractors- the larger contractor firms, thirty-one percent are Group B, and sixteen percent are Group A firms.

Each respondent was asked to state the number of permanent employees in the Hong Kong operation. This is used as an indicator of the size of the company organisation. Overall scored response achieved by each respondent was compared to the number of permanent employees to see if there is a correlation. Negligible correlations were found. Table 5-8, presents the general statistics of the survey response. These are further divided into sample sectors based on the attributes of the respondent firm.

Sample sector	Sector Pop	High Value	Low Value	Median Value	Mode	Mean Value	SD
All	238	8000	1	30	20	16	651
Group A	68	100	2	15	20	20	20
Group B	72	600	3	36	20	66	91
Group C	99	8000	1	70	30	340	983
With ISO9000	105	8000	1	88	30	327	953
Without ISO9000	134	870	2	20	20	41	95
Group A + ISO9000	3	100	37	80	Nil	72	32
Group A – ISO9000	68	100	2	15	20	20	19
Group B + ISO9000	15	300	17	82	40	108	98
Group B – ISO9000	57	600	3	30	20	55	87
Group C + ISO9000	87	8000	1	90	30	374	1041
Group C – ISO9000	12	870	3	18	3	99	245

Table 5-8 Statistics on the size of Contractor organisation within the respondent groupings

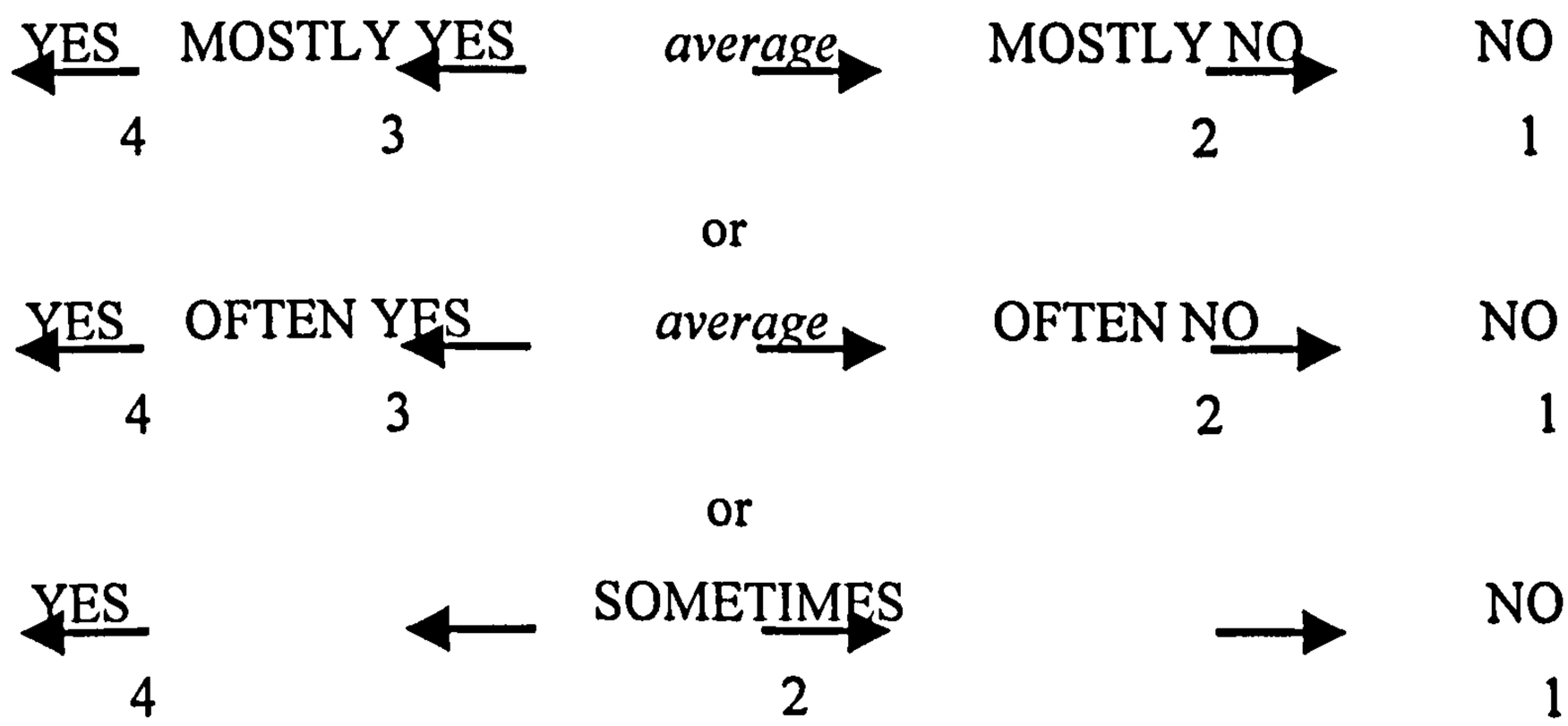
The significant sectors of the population are the first six listed in Table 5-8. Of the Group A and Group B sectors, most of the firms do not have an ISO9000 certification. The

opposite is true of Group C sector. The smaller sectors of the population do not provide an adequate response for statistical purposes.

5.6 Analysis of responses received

5.6.1 'Tick-the-box' questions

'Tick-the-box' questions predominate within the questionnaire because they permit a quick response from the respondent and thereby encourage participation in the survey. To further encourage participation the questions call for responses that will identify a trend rather than accurately measure a quantum. The selection of a response can be either the extreme of the spectrum of answers, i.e., 'yes' or 'no', or either side of the average, i.e., 'mostly yes' or 'mostly no'. The marks that are assigned to each response differentiate the options. The marks range from one mark for a 'no' answer, to four marks for a 'yes' answer. Marks for answers in-between are distributed in pro-rata fashion. Statistical methods are used to analyze the responses for each question, or the groups of questions. This arrangement is used throughout the questionnaire although there are slight differences in wording to better suit the questions as follows:



The marks for each section of Part 1 of the questionnaire are adjusted so that they each contribute the same total 'maximum possible marks' per section and are thus rendered of equal impact when the sections are combined for an overall mark. This is to avoid a bias

within Part One of the questionnaire when the marks are aggregated into a single measure. The adjustment factors, for each section of Part One, are listed in Table 5-9.

Section	Maximum Marks	Adjustment Factor	Adjusted Marks
1.1	68	1.47	100
1.2	20	5.00	100
1.3	36	2.77	100
1.4	20	5.00	100
1.5	80	1.25	100
1.6	60	1.66	100
1.7	165	0.61	100
Total	**449**		**700**

Table 5-9 Adjustment factors to remove bias from within Part 1 of the Contractor IT survey.

Adjustment is not needed in the other parts of the questionnaire because the marks regime does not introduce a bias.

5.6.2 Analysis methodology for the 'Open-ended' questions

The methodology for resolving the semantic differences and the derivation of the frequency of responses in the open-ended questions is shown in Figure 5-4. Dendrograms are used to present the consolidation of variations in words/phrases into standardised-format-responses. The open-ended questions asked for five responses in order of most importance. Frequency analysis of keywords and phrases was carried out to identify the most prevalent answers to the questions from the Contractors in general and within the Group A, B or C, and for Contractors with ISO9000 accreditation and for those without it. The rationalized responses were weighted from 1.0 to 0.2 to reflect the order of importance of each component of each response. The totals derived from the unweighted frequency analysis indicate the most frequent response in general, but the analysis using the weighted-frequency indicates the frequency of response in terms of greatest concern.

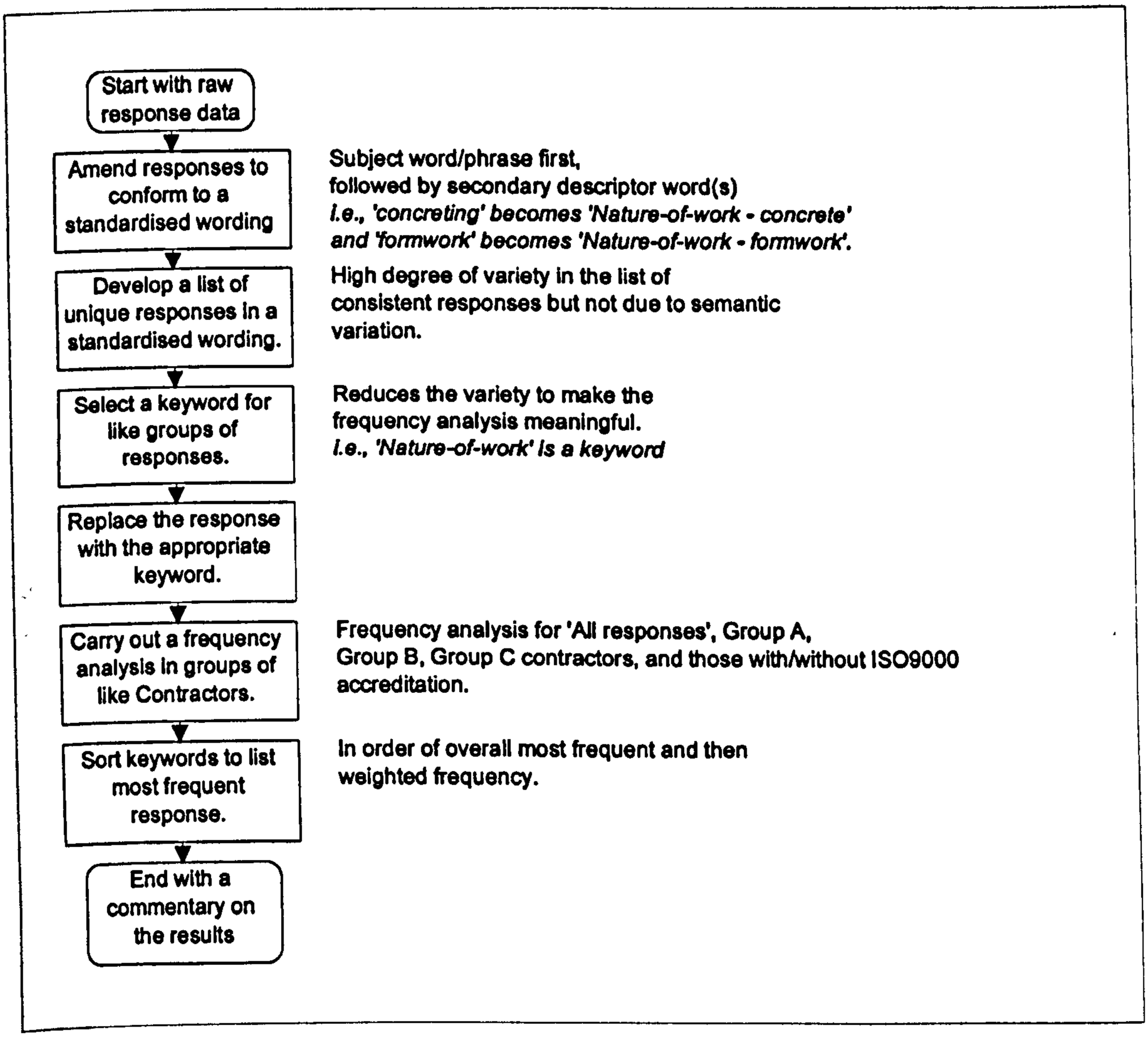


Figure 5-4 Frequency analysis process for open-ended questions.

For each open-ended question, the percent level of response is calculated. The number of unique standardised-format-responses is given as a percent of the population sample. This percent is an indicator of the variability in the responses received. A table of the most significant response keywords is provided in the order of their frequency and the weighted-frequency. The significant response keywords are taken as those that fall within the seventy-five percentile of most-frequent keyword responses. If the response has a low variability resulting in a list of response keywords of about twenty then the significant keywords carried forward for the research are the ten highest frequency items. If the variability is greater then the significant keywords carried forward for the research are taken to be the fifteen highest frequency items. Response keywords that relate to data/information in number or date format, and can be included in computer algorithms,

is printed in normal font. Response-keywords that relate to data/information that is usually in un-structured text or image format and therefore *cannot* be readily included in computer algorithms, is printed in italic font.

5.6.3 Analysis methodology for the IT Healthcare Check

Scoring for each question in this part is consistent with the method used by Betts and Shafagi[1] and Stewart[9] so that a comparison with the UK survey and the Australian healthcare survey is possible. Each of the 'tick-the-box' questions has four question-specific options that are coded 'D' to 'A'. The twenty-eight questions are grouped into three sections. Answers for each question are given a score of 1 for a 'D', 2 for a 'C', 3 for a 'B' and 4 for an 'A'. The statistical average score for the questions for the twenty-eight questions overall were calculated and graded for the purposes of comparative self-assessment as follows:

- An average score between 0 and 1 is graded overall as a 'D';
- An average score between 1 and 2 is considered a 'C';
- An average score between 2 and 3 is considered a 'B'; and
- An average score between 3 and 4 is considered an 'A'.

The questionnaire includes an interpretation of the comparative meaning of the overall grading of 'D' to 'A' based on the benchmarking best practices identified by Betts and Shafagi (refer to Table 5-19 for details).

A small number of participants were unable to complete all questions in the health check so their Part 4 response was completely removed from the statistical data analysis and the formulation of the 'IT Healthcheck' overall assessment for the survey population.

5.7 Results of the postal survey

A detailed question-by-question statistical analysis of the survey response and interpretative commentary is provided in the 'Appendices CD-ROM' at Section 5.4. The tabulated statistical attributes of the analysis of the response in terms of population strata of the population sample are within Section 5.5 of the Appendices.

The main points that are carried forward from this postal questionnaire survey of the HKG list of Contractors are briefly stated in the Section 5.7.1 to 5.7.4. herein.

5.7.1 Part 1 of the Questionnaire

This part of the survey is to establish the extent that project information is communicated between project participants located in the centres of information – typically between head-offices and construction sites. The attention of the construction site is focused on the project whereas the head-office needs to gather site information to gain a view on their portfolio-of-projects. The questionnaire probed the use of modes of communication used to meet these needs according to IT types i.e. from telephones, fax and so forth through to the Internet. The results are as follows:-

The <u>use of telephones for communication</u> between project participants is universal. Public telephone services are the most common service used. Leased line services and radio-telephones are also used but to a lesser extent. Seventy-five percent of the contractors provide mobile telephones to their managerial staff. Fifty-six percent provide them to professional staff, and thirty-five percent to supervisory staff. As expected, labourers are not given access to mobile telephones. Forty-six percent of the contractors use mobile telephone 'messaging' and fifty-four percent use 'call forwarding'. In general, it is not company policy for important telephone communications to be recorded. Twenty-two to twenty-seven percent of the respondents state that recording messages is

company policy. Hand-written notes are used for this purpose. Message recording devices are not generally used.

The use of facsimile machines is also prevalent among all contractors. More than ninety-five percent of the respondents use fax in their head offices. This falls to fifty percent in other company offices. The use is greater than eighty percent in site offices except for Group A contractors. Sixty percent respond that they deploy fax machines in their site offices. Faxes are not sent to PC's but PC's are used to send faxes to fax machines by seventy percent of respondents. Fifty percent of Group A contractors respond that they use this method.

The use of meetings for communication is nearly a one hundred percent affirmative response if the 'yes' and 'mostly yes' are taken together. The majority of the response is that company policy/instruction is for minutes/notes of meetings to be recorded. Hand-written methods are the prevalent means of recording meeting details. The use of tape-recorders, word-processors, or electronic-note boards is negligible.

Video-conferencing is not used for communication between participants within Hong Kong (92-94% of the respondents say 'no') nor internationally (95-93% of the respondents say 'no'). Where this method is used, then commercial hired services or company-owned facilities are rare. Using the Internet is more popular with six percent of respondents stating 'yes' to this mode of video-conferencing. The Group C contractors or those with ISO9000 certification are the sample sectors with the highest stated use of video-conferencing. However, Group A contractors, or those without ISO9000 certification, use the Internet for video-conferencing more than the other sample sectors.

The use of CAD in company head-offices is thirty percent 'yes' and twenty-eight percent 'mostly yes'. Group A contractors state a lesser use of this technology. They respond twenty-nine percent 'yes' and thirty-four percent 'mostly yes' to the use of manual drafting methods in their head-office. Group C contractors have less use of manual drafting methods. Hiring of CAD or manual drafting services is generally not done.

There is a greater use of manual drafting methods on site: thirty-two percent respond 'yes' and thirty-nine percent 'mostly yes'. More so for Group A contractors. Correspondingly the use of CAD on sites is less than in the head-offices. Fifty-three percent respond 'no'. Group C contractors and those with ISO9000 certification use CAD on site more than the other sample sectors.

In general, construction drawings are distributed as hardcopy (66-79% 'yes plus 1-24% 'mostly yes'). Distribution as electronic files on disk is 'no' or 'mostly no' for the response overall and for Group A, B and contractors without ISO9000 certification. Group C contractors, or those with ISO9000, have an increased tendency for distribution by electronic disk. (10% 'yes' plus 41% 'mostly yes' versus 24% 'mostly no' plus 26% 'no').

Distribution of construction drawings across a LAN received a 'no' response although Group C contractors and those with ISO9000 certification are the more positive of the sample sectors analyzed. Similarly, a 'no' response was received for the distribution of construction drawings via modems or the Internet. Group C contractors, or those with ISO9000, are the more positive of the sample sectors.

Transmittal of construction drawings is recorded manually in registers (72-7% 'yes') whereas electronic registers are infrequently used (7-9% 'yes' plus 8-16% 'mostly yes').

Construction drawings are not revised/checked in hardcopy form. Only six percent of the contractors said 'yes' and seventeen percent stated 'mostly yes' to this function.

Analogue photographs are used by contractors (54-71% 'yes' plus 18-22% 'mostly yes'). Digital photographs and video images are not used in general. Correspondingly, photographs are distributed in hardcopy form. Distribution of image by electronic means is not the norm. (59-78% 'no' plus 13-29% 'mostly no') However, Group C contractors or those with ISO9000 certification make a more positive response than the other sample sectors.

In general, contractors produce written documents according to company standards and in pre-determined document formats in head-offices and in site-offices. Printed proformas and forms are used frequently. Similarly, company procedures and instructions are used for the filing of written documents in an organised filing system in the head-office and also on site. Contractors use the same document filing system on all of their construction sites (44-52% 'yes' plus 35-45% 'mostly yes'). Filing systems are manual in head office and on site – electronic systems are infrequent. However, 'keywords' are used to identify the contents of written documents for ease of retrieval in head-offices but not in site-offices. Contractors employ staff to organise and maintain the filing systems in the head office and, to a lesser degree, on site. They do not employ an 'information manager' to organise and maintain the filing system of written documents and their contents, and also the distribution and use of documents.

E-mail via LANS, modems or the Internet, is not used in general, in company head-offices or on construction sites. Group C contractors and those with ISO9000 certification have the higher response for e-mail provision. Where e-mail is provided, then it is supplied to managerial and professional staff in head-offices and to a lesser degree to these personnel-types in site offices.

In general, Contractors do not employ staff to administer their IT in company head-offices nor on-site. The response varies within the sample sectors. Group A and Group B contractors responded negatively to this question whereas Group C contractors and those with ISO9000 certification have a response falling between a clear 'yes' or 'no', i.e., for the head office, 39% 'no' versus 35% 'yes'; or for the site office, 44% 'no' versus 20% 'yes'.

The most frequent highest level of management of IT in the company is:

- None 27%
- Part-time involvement of a Director 19%
- Full-time involvement of a Director 18%
- Part-time involvement of a Manager 11%

In general, a higher percent of the Group A contractors (37%) have no IT management than Group B (20%) or Group C (26%). Director-level IT management is at 42% for Group B and Group C, whereas Group A has thirty-six percent. The use of Manager-level personnel for the highest level of IT management in the firm is twelve percent for Group A, seventeen percent for Group B, and twenty-two percent for Group C.

Contractors in general do not use e-mail for sending written messages in company offices but Group C contractors do so to a greater extent than other sample sectors. E-mail is used to a lesser extent for: agreeing the text of written messages; for marking/amending messages; for attaching messages, digital images, sound-files, or delegating actions. The use of e-mail on sites is less than the corresponding use of e-mail in company head-offices.

Contractors, in general, do not have 'homepages' on the Internet (78-9% 'no'). They do not, in general, have their own Internet server. Nor do they provide their staff with access to the Internet. Group C contractors and those with ISO9000 certification respond more frequently than the other sample sectors that they provide Internet access to managers and professionals (32% 'no' versus 34% 'yes').

The conclusion drawn from this analysis and carried forward to the next stage of the research is that the survey of the Hong Kong contractors shows that:

- **Electronic transfer of digital information between construction-sites, head-office and to other participants is not a commonplace mode of communication:** and

- **Use of networked digital information systems by contractors is uncommon.**

5.7.2 Part 2 of the Questionnaire

This part of the survey measures the use of IT to communicate construction-related performance indicators to head-office from construction sites. It also measures the extent that commonplace work-related performance indicators are used by the head-office to gauge the well being of work in progress.

Telephones, facsimile and hardcopy documents are the most frequent communication modes used to transmit work-content, time, cost, and resource measures of project performance to the head-office. The use of e-mail is given a 'no' response overall by all sample sectors. However, Group C contractors or those with ISO9000 certification have a greater frequency of e-mail being used for these purposes than other sample sectors.

All sample sectors responded positively to questions on the use of work-content, time, cost, and resource indicators of project performance and progress. The percent positive response per sample sector is listed in Table 5-10.

Work-content indicators

% 'yes' + % 'mostly yes' response

Lists of:	All	Grp A	Grp B	Grp C	ISO	W/o ISO
'activities'	38+32%	42+22%	37+41%	36+33%	36+33%	39+32%
Items to be done	36+34%	40+25%	36+43%	32+33%	33+33%	37+34%
Variations	35+32%	39+24%	33+39%	34+33%	32+34%	37+30%
Disputes	34+27%	37+22%	27+36%	36+23%	31+29%	36+25%

Time-related indicators

% 'yes' + % 'mostly yes' response

Lists of:	All	Grp A	Grp B	Grp C	ISO	W/o ISO
'work schedule'	39+39%	39+33%	38+42%	40+39%	41+39%	38+38%
% work done	35+39%	38+30%	33+46%	36+40%	38+40%	34+38%
% work to be done	34+37%	38+26%	31+44%	34+38%	37+38%	33+35%
Replanned work	32+38%	38+26%	27+49%	33+38%	35+38%	31+38%

Cost-related indicators

% 'yes' + % 'mostly yes' response

Value of:	All	Grp A	Grp B	Grp C	ISO	W/o ISO
Work done	48+29%	45+27%	39+36%	57+26%	53+30%	44+29%
Work to be done	41+29%	43+25%	33+36%	45+26%	42+32%	41+26%
Materials delivered	42+31%	50+27%	39+33%	39+31%	41+31%	43+30%
Materials ordered	39+32%	48+30%	36+36%	36+31%	39+31%	40+33%
Variations	40+31%	46+25%	29+42%	45+28%	42+33%	39+30%
Disputes	33+33%	37+28%	22+43%	37+30%	34+34%	32+33%
Money received	44+24%	52+13%	28+37%	49+21%	48+24%	41+23%
Money owed	34+27%	37+22%	27+36%	36+23%	31+29%	36+25%

Resource-related indicators

% 'yes' + % 'mostly yes' response

	All	Grp A	Grp B	Grp C	ISO	W/o ISO
Labour deployed	33+36%	35+28%	29+47%	33+33%	35+33%	31+37%
Labour required	32+37%	35+32%	29+44%	30+35%	33+34%	31+40%
Plant deployed	32+33%	31+28%	31+38%	34+32%	35+30%	30+35%
Plant required	32+38%	32+34%	31+41%	32+38%	34+38%	31+38%
Sub-contractors hired	38+33%	38+34%	35+40%	39+29%	36+35%	40+33%
Purchasing required	41+32%	37+35%	47+32%	38+30%	39+33%	41+32%
QS required	30+39%	30+34%	26+44%	31+37%	30+38%	29+38%
Legal required	27+27%	25+21%	25+32%	30+26%	29+26%	26+27%
Management required	29+31%	27+24%	25+35%	33+33%	32+35%	27+28%
Admin required	29+36%	28+25%	25+40%	32+40%	32+39%	27+33%
Professional required	28+35%	30+28%	22+46%	31+32%	31+36%	26+35%

Table 5-10 Hong Kong contractors use of project performance indicators.

Respondents stated the five items of data/information that are the most important in their company for assessing the performance of a construction project. The response rate was equal to or greater than seventy-eight percent for all sample sectors and eighty percent overall. One hundred and forty-two unique responses were received indicating a variability of fifteen percent. Twenty-three keywords were derived from the unique responses. Table 5-10 lists the ten significant keywords for each of the sample groups in their order of frequency. There is consistency in the first nine keywords. Three alternate keywords are appended as the tenth keyword in some of the sample sectors. Based on the overall response the ten most important project performance data/information for Hong Kong contractors are listed in Table 5-11 with the frequency of response received from each of the sample sectors.

Project performance indicators

	All	Grp A	Grp B	Grp C	ISO	W/o ISO
[Total Response]	[954]	[262]	[301]	[391]	[425]	[529]
Value	229	70	75	84	94	135
Work-schedule	164	45	52	67	70	94
Financing	112	26	25	61	61	51
Resources	106	34	43	29	40	66
Quality	58	12	14	32	35	23
Safety	54	12	17	25	29	25
Cost-actuals	52	16	11	25	26	26
Variation	34	12	9	13	13	21
Employer feedback	*2*	*6*	*8*	*12*	*12*	*14*
Performance	17	3	6	8	9	8

Table 5-11 Frequency that Hong Kong contractors cite the ten most important project performance indicators

Risk analysis, *documentation*, and forecast are also introduced as variants of the tenth keyword in certain sample sectors. The keywords printed in italics are likely to be in the form of variable unstructured text not easily included in an algorithmic-based MIS.

Telephones, facsimile, and hardcopy are the most frequent modes used to communicate these measures of project performance. E-mail is not used although Group C contractors and those with ISO9000 certification use e-mail more frequently than the other sample sectors.

The conclusion drawn from this analysis and carried forward to the next stage of the research is that the survey of the Hong Kong contractors shows that:

- **Project performance data/information is communicated in analogue mode using voice, or written media;**
- **E-mail is not commonly used for the communication project performance data/information except in a minority of contracting companies; and**
- **The ten most important project performance indicators used are:** 'Value'; 'Work schedule'; 'Financing'; 'Resources'; 'Quality'; 'Safety'; 'Variation'; '*Employer feedback*'; and 'Performance'.

5.7.3 Part 3 of the Questionnaire

This part of the survey is to measure how project data is added together to provide an overall view of what is happening within a portfolio of projects. Specifically, the research measures whether 'individual review', 'spreadsheet analysis', or 'database analysis' is the more commonplace method of data combination for the principal project management data types of 'work-content', 'time', 'cost', and 'resource'. The questionnaire also sets out to identify what project data is fed into this process.

Individual review is the most common process adopted for combination of project data. Using spreadsheets is the second most common process. Database processes are not commonly used, although Group C contractors and those with ISO9000 certification have a more frequent use of databases than the other sample sectors. Table 5-12 displays the extent of the use of these processes.

Processes for combining work-content data

% 'yes' + % 'mostly yes' response

Process:	All	Grp A	Grp B	Grp C	ISO	W/o ISO
Individual review	39+39%	36+41%	32+44%	45+35%	41+39%	36+40%
Spreadsheet	29+42%	28+37%	25+42%	33+47%	30+49%	28+37%
Database	17+29%	18+29%	11+28%	20+31%	17+32%	17+28%

Processes for combining time data

% 'yes' + % 'mostly yes' response

Process:	All	Grp A	Grp B	Grp C	ISO	W/o ISO
Individual review	37+43%	33+42%	34+47%	41+41%	38+46%	36+41%
Spreadsheet	27+43%	24+36%	26+44%	28+48%	27+51%	26+38%
Database	15+28%	18+23%	11+29%	16+31%	13+30%	17+26%

Processes for combining cost data

% 'yes' + % 'mostly yes' response

Process:	All	Grp A	Grp B	Grp C	ISO	W/o ISO
Individual review	45+38%	46+40%	35+48%	52+31%	47+36%	44+40%
Spreadsheet	34+41%	29+37%	29+45%	40+42%	36+46%	32+38%
Database	17+29%	16+29%	13+29%	20+29%	16+32%	17+27%

Processes for combining resource data

% 'yes' + % 'mostly yes' response

Process:	All	Grp A	Grp B	Grp C	ISO	W/o ISO
Individual review	40+40%	38+42%	34+49%	46+34%	43+39%	38+42%
Spreadsheet	25+43%	25+33%	21+48%	28+48%	24+53%	26+36%
Database	14+30%	17+25%	10+34%	16+32%	12+35%	16+27%

Table 5-12 Hong Kong contractors preference for the means of combining project data for a view of portfolio performance

The priority order for the fifteen most important work-content related performance criterion used by Hong Kong contractors to assess the combined performance of several construction projects is stated in Table 5-13. There is consistency among the sample sectors with the first ten of these keywords but less so in the last five. A further five keywords are introduced to accommodate all the sample sectors. The level of response in all sample sectors was greater than fifty percent, with fifty-five percent response achieved overall. One hundred and eighty-two unique responses were listed. The variability in the unique responses was twenty-eight percent. Thirty-seven response keywords were derived from these. Table 5-13 lists the significant response-keywords for the overall sample population and the frequency that they are cited within each sample sector.

Work-content portfolio performance indicators

Response-keywords:	All	Grp A	Grp B	Grp C	ISO	W/o ISO
[Total Response]	[656]	[166]	[207]	[283]	[325]	[331]
Quality	69	22	16	31	34	35
Activity schedule	54	5	25	24	35	20
Variation	48	4	21	23	26	22
Performance	47	9	13	21	21	26
Safety	45	14	9	22	27	18
Construction-issues	*33*	*11*	*10*	*12*	*13*	*20*
Costs	33	18	7	8	11	22
Work schedule	30	5	10	15	19	11
Value	24	8	8	8	10	14
Disputes	23	2	10	11	14	9
Material use	19	3	8	8	10	9
Timing	19	9	2	8	8	11
Work achieved	19	5	8	6	7	12
Management of work	*18*	*5*	*4*	*9*	*9*	*9*
Quantity	17	3	4	10	9	8

Table 5-13 Frequency that Hong Kong contractors cite the fifteen most important work-content performance indicators

There is consistency in the top fifteen response-keywords in all groups except for Group A Contractors. They include response-keywords 'labour', 'resources', 'client-involvement', and 'profit' in the high frequency list instead of 'variations', 'disputes', and 'material-use'. Group B contractors include 'payments', 'labour', and 'resources'. Group C contractors and contractors with ISO9000 accreditation include 'client-involvement' instead of 'work achieved'. The response-keywords written in italic font indicate that the data/information is probably in the form of variable, unstructured text not easily included in an algorithmic-based MIS.

The priority order for the fifteen most important time-related performance criterion used by Hong Kong contractors to assess the combined performance of several construction projects is stated in Table 5-14. There is consistency among the sample sectors with the first five of these keywords but less so in the last ten. A further seven keywords are introduced to accommodate all the sample sectors. The level of response in all sample sectors was greater than forty-four percent, with fifty-one percent response achieved overall. Two hundred and sixty-six unique responses were listed. The variability in the unique responses was forty-four percent. Forty-three response keywords were derived

from these. Table 5-13 lists the significant response-keywords for the overall sample population and the frequency that they are cited within each sample sector.

Time-related portfolio performance indicators

Response-keywords:	All	Grp A	Grp B	Grp C	ISO	W/o ISO
[Total Response]	[606]	[167]	[166]	[273]	[312]	[294]
Work schedule	75	21	22	32	40	35
Percent progress	57	8	21	28	35	22
Progress	47	6	19	22	26	21
Progress vs schedule	33	9	7	17	18	15
End-date issues	*28*	*11*	*5*	*12*	*15*	*13*
Extension-of-time	27	7	5	15	17	10
Time management	22	9	4	9	10	12
Approvals	*21*	*7*	*4*	*10*	*10*	*11*
Material issues	*19*	*9*	*6*	*6*	*7*	*14*
Delays	*19*	*4*	*6*	*9*	*9*	*10*
Replanned work	*19*	*2*	*7*	*10*	*11*	*8*
Site-related issues	*18*	*8*	*6*	*5*	*7*	*12*
Valuation	17	5	2	11	12	
Project data	14	1	7	9	9	8
Labour issues	*14*	*4*	*3*	*7*	*7*	*7*

Table 5-14 Frequency that Hong Kong contractors cite the fifteen most important time-related performance indicators

There is consistency in the top fifteen response-keywords but substitutions and changed order occurs in all groups.

- Group A contractors include in the fifteen most frequent list: 'communication', 'performance', 'duration', and 'deliveries', but omit: 'delays', 're-planned work', 'project data' and 'labour issues.
- Group B contractors include in the fifteen most frequent list: 'management', 'variation' and 'deliveries', but omit : 'approvals', 'valuation' and 'labour issues'.
- Group C contractors include 'costs' in the fifteen most frequent list but omit 'site-related issues'.
- Contractors with ISO9000 include 'costs' in the fifteen most frequent list but omit 'materials issues'.
- Contractors without ISO9000 include 'deliveries' and 'management' in the fifteen most frequent list but omit 'valuation' and 'labour-issues'.

The response-keywords written in italic font indicate that the data/information is probably in the form of variable, unstructured text not easily included in an algorithmic-based MIS.

The priority order for the fifteen most important cost-related performance criterion used by Hong Kong contractors to assess the combined performance of several construction projects is stated in Table 5-15. There is consistency among the sample sectors with the first five of these keywords but less so in the last ten. A further seven keywords are introduced to accommodate all the sample sectors. The level of response in all sample sectors was greater than forty-six percent, with fifty-four percent response achieved overall. Two hundred and forty-seven unique responses were listed. The variability in the unique responses was thirty-eight percent. Forty response keywords were derived from these. Table 5-15 lists the significant response-keywords for the overall sample population and the frequency that they are cited within each sample sector.

Cost-related portfolio performance indicators

Response-keywords:	All	Grp A	Grp B	Grp C	ISO	W/o ISO
[Total Response]	[645]	[170]	[182]	[293]	[338]	[307]
Categories of value	126	27	45	54	70	5
Categories of cost	95	25	28	42	50	45
Payments	73	18	20	34	43	29
Management	*39*	*14*	*10*	*15*	*15*	*24*
Variation	*33*	*7*	*12*	*14*	*18*	*15*
Cost management	*28*	*9*	*5*	*14*	*13*	*15*
Cashflow	24	7	2	15	15	9
Material	*19*	*8*	*4*	*7*	*8*	*11*
Expenditure	*18*	*4*	*7*	*7*	*9*	*9*
Profit/loss	*18*	*4*	*3*	*11*	*12*	
Budget	*15*	*5*	*4*		*8*	*7*
Subcontractor	*14*	*3*	*6*	*5*	*6*	*8*
Overhead	13	4	3	7	9	5
Labour	12	4	4	4	5	7
Work schedule	*10*	*5*		*5*	*5*	*5*

Table 5-15 Frequency that Hong Kong contractors cite the fifteen most important cost-related performance indicators

There is consistency in the top fifteen response-keywords but substitutions and changed order occurs in all groups.

- Group A contractors includes 'time' in the fifteen most frequent list but omits 'subcontractor'.

- Group B contractors include in the fifteen most frequent list: 'resource', 'site', and 'finance', but omit : 'cashflow', 'profit/loss', and 'work-schedule'.
- Group C contractors include in the fifteen most frequent list: 'claims', 'quality', and 'safety, but omit 'subcontractor', 'labour' and 'work-schedule'.
- Contractors with ISO9000 include 'claims' in the fifteen most frequent list but omit 'work schedule'.
- Contractors without ISO9000 include 'resources' in the fifteen most frequent list but omit 'work schedule'.

The response-keywords written in italic font indicate that the data/information is probably in the form of variable, unstructured text not easily included in an algorithmic-based MIS.

The priority order for the ten most important resource-related performance criterion used by Hong Kong contractors to assess the combined performance of several construction projects is stated in Table 5-16. There is consistency among the sample sectors with the first five of these keywords but less so in the last five. A further four keywords are introduced to accommodate all the sample sectors. The level of response in all sample sectors was greater than forty-four percent, with fifty-two percent response achieved overall. Two hundred and thirty unique responses were listed. The variability in the unique responses was thirty-seven percent. Twenty-one response keywords were derived from these. Table 5-16 lists the significant response-keywords for the overall sample population and the frequency that they are cited within each sample sector.

Resource-related portfolio performance indicators

Response-keywords:	All	Grp A	Grp B	Grp C	ISO	W/o ISO
[Total Response]	[620]	[173]	[166]	[281]	[330]	[290]
Manpower resources	144	41	39	64	78	66
Plant	105	29	26	50	64	41
Management resources	80	14	26	40	43	37
Material resources	66	17	16	33	38	28
Subcontractor	61	13	19	29	33	28
Cost of resources	29	9	10	10	13	16
Resources	*20*	*6*	*2*	*12*	*11*	*9*
Information	*18*	*10*	*5*	*3*	*5*	*13*
QS	16	2	5	9	11	5
Production	14	6	2	6	6	8

Table 5-16 Frequency that Hong Kong contractors cite the ten most important resource-related performance indicators

There is consistency in the top ten response-keywords but substitutions and changed order occurs in all groups.

- Group A contractors includes 'finance' in the ten most frequent list but omit 'QS'.
- Group B contractors include 'work schedule' and 'reports' in the ten most frequent list but omit: 'resources' and 'production'.
- Group C contractors include 'value' in the ten most frequent list but omit 'information'.
- Contractors with ISO9000 include 'value' in the ten most frequent list but omit 'information'.
- Contractors without ISO9000 include 'work schedule' in the ten most frequent list but omit 'QS'.

The response-keywords written in italic font indicate that the data/information is probably in the form of variable, unstructured text not easily included in an algorithmic-based MIS.

The conclusion drawn from this analysis and carried forward to the next stage of the research is that the survey of the Hong Kong contractors shows that:

- **'Individual review" is the most common process adopted for combining together project data.**

- **'Using spreadsheets' is the second most common process.**

- **'Database processes' are not commonly used.**

- **The fifteen most important work-content project performance indicators used for assessing the well being of a portfolio-of-projects, are:** 'Quality'; 'Activity schedule'; 'Variation'; 'Performance'; 'Safety'; 'Construction-issues'; 'Costs'; 'Work schedule'; 'Value', 'Disputes', 'Material use', 'Timing', 'Work achieved', 'Management of work', and 'Quantity'.

- **The fifteen most important time-related project performance indicators used for assessing the well being of a portfolio-of-projects, are:** 'Work schedule'; 'Percent progress'; 'Progress'; 'Progress vs schedule'; 'End-date issues'; 'Extension-of-time'; 'Time management'; 'Approvals'; 'Material issues', 'Delays', 'Replanned work', 'Site related issues', 'Valuation', 'Project data', and 'Labour issues'.

- **The fifteen most important cost-related project performance indicators used for assessing the well being of a portfolio-of-projects, are:** 'Categories-of-value'; 'Categories-of-cost'; 'Payments'; 'Management'; 'Variation'; 'Cost management', 'Cashflow'; 'Material'; 'Expenditure', 'Profit/loss', 'Budget', 'Subcontractor', 'Overhead', 'Labour', and 'Work schedule'.

- **The ten most important resource-related project performance indicators used for assessing the well being of a portfolio-of-projects, are:** 'Manpower resources'; 'Plant'; 'Management resources'; 'Material resources'; 'Subcontractor', 'Cost of resources'; 'Resources'; 'Information', 'QS', and 'Production'.

5.7.4 Part 4 of the Questionnaire

The questions in the 'IT healthcheck' are grouped into three major categories:

- the position of IT within the competitive business strategy of the organisation;
- the overall role of IT within the organisation; and
- the current IT strategy within the company.

Table 5-17 states the response included in the analysis.

Pop sample	All	Grp A	Grp B	Grp C	ISO9000	W/o ISO
Nos. polled	317	100	88	129	125	192
Response Nos.	194	55	59	80	89	105
Response %	61%	55%	67%	62%	71%	55%

Table 5-17 Percent response included in the 'IT healthcheck' of Hong Kong contractors

Table 5-18 is the matrix achieved for the results overall. Whereas Table 5-19 shows the results in terms of the three major categories by sample sector. The classifications used in these tables are:

- A = IT innovator
- B = IT active
- C = IT aware
- D = IT unconcerned

IT Healthcheck Question	D	C	B	A
IT support of core competencies.			Yes	
How IT helps company compete.			Yes	
Impact of IT on goals and objectives			Yes	
Position of IT compared to others.			Yes	
Impact of IT on Clients.			Yes	
Belief that IT expertise wins work.			Yes	
Use of IT as part of strategic alliances.			Yes	
Current use of IT in the company.			Yes	
Relationship between IT and business strategy			Yes	
Participation of IT in forming business strategy		Yes		
Impact of IT on operational strategy.			Yes	
IT influence on marketing strategy		Yes		
Use of IT systems in company		Yes		
Objectives of IT strategy.		Yes		
Thrust of IT strategy			Yes	
Management of IT in the future			Yes	
CSF's for competitive advantage through IT			Yes	
Management of IT projects and innovation.			Yes	
Level of R&D in IT		Yes		
Nature of IT department.		Yes		
Importance of IT skills in company.		Yes		
Awareness of IT strategy.			Yes	
Involvement of Users in IT strategy.			Yes	
Risks associated with IT strategy.		Yes		
Periodic review of IT strategy.			Yes	
Measurement of IT performance.			Yes	
Characteristics of IT strategy.			Yes	
Who champions IT in the company?			Yes	

Table 5-18 Extent of strategic use of IT by Hong Kong contractors gauged by the IT 'healthcheck' questionnaire.

Classifications and nomenclature used in the table are:

IT classification

- A = IT innovator
- B = IT active
- C = IT aware
- D = IT unconcerned

Rating nomenclature

- R = maximum range possible;
- H = high rating achieved;
- L = low rating achieved;
- Md = Median achieved;
- M = Mode achieved; and
- Mn = Mean achieved.

Overall (194 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A	C-	B	B	B
Role of IT	D-A	A+	DC	CB	CB	B-
IT Strategy	D-A	A+	DC	CB	C+	B-
Overall	D-A	A+	C-	B-	B-	B-
Group A (55 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A	C-	B	B	B
Role of IT	D-A	A+	DC	CB	CB	CB
IT Strategy	D-A	A+	DC	C+	B-	CB
Overall	D-A	A	C-	CB	C-	B-
Group B (59 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A	C	B-	B-	B-
Role of IT	D-A	BA	DC	B-	B-	CB
IT Strategy	D-A	A-	C-	CB	B-	CB
Overall	D-A	A-	C-	B-	C+	B-
Group C (80 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A+	C-	B	B	B
Role of IT	D-A	A+	C-	B-	B-	B-
IT Strategy	D-A	A	DC	B-	C+	B-
Overall	D-A	A	C-	B-	B-	B-
With ISO9000 (89 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A+	C+	B	B	B
Role of IT	D-A	A	C	CB	CB	CB
IT Strategy	D-A	A	DC	B-	B-	B-
Overall	D-A	A-	C-	B-	B-	B-
W/o ISO9000 (105 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A+	C+	B	B	B
Role of IT	D-A	A+	DC	CB	CB	CB
IT Strategy	D-A	A+	DC	CB	B-	CB
Overall	D-A	A	C-	B-	C+	B-

Table 5-19 Hong Kong contractors classified in terms of their strategic use of IT

Section 5.4.11, in the 'Appendices CD-ROM', it shows the statistical results achieved by the sample sectors. Converting these back to the A, B, C, and D classifications of IT strategy in Table 5-18 and Table 5-19 leads to the following conclusions regarding the extent that IT is employed for strategic purpose by Hong Kong contractors:

- All the sample sectors are 'IT active' in the use of 'IT to improve competiton and for reasons of business strategy' although Group B contractors are rated overall at the lower end of this ranking.
- The 'role of IT' in all the sample sectors is at the threshold of 'IT aware' and 'IT active'. In this respect, Group C contractors are rated higher than the others.
- Group A contractors and Group B, are also rated as on the threshold between 'IT aware' and 'IT active' with regard to 'IT strategy'. Group C contractors were ranked higher, moving into the lower end of 'IT active'.

The results overall within each sample sector, show that:

- Group A contractors are mostly 'IT aware';
- Group B contractors are mostly at the lower end of 'IT active';
- Group C contractors are at the lower end of 'IT active';
- Contractors with ISO9000 certification are ranked at the lower end of 'IT active'; whereas,
- Contractors without ISO9000 are mostly at the threshold between 'IT aware' and 'IT active'.

There are contractor firms that are individually rated as 'IT innovators' but few that are rated as 'IT unconcerned'. An interpretation to be placed on these generalised ratings is that Hong Kong contractors are 'IT aware' and at the simpler stages of 'IT active'. For example, the earlier parts of the questionnaire show that networked information technology is not generally used and that the use of CAD is not universal.

Table 5-18 shows that the Hong Kong contractors are not 'IT active' with regard to:

- 'participation of IT in forming business strategy';
- 'use of IT systems in company';
- 'objectives and IT strategy';
- 'level of R&D in IT';
- 'nature of IT department';
- 'importance of IT skills in company'; and
- 'risks associated with IT strategy'.

The conclusion drawn from this analysis and carried forward to the next stage of the research is that the survey of the Hong Kong contractors shows that in general:

- **They are 'IT aware' and at the simpler stages of 'IT active'**
- **They are not 'IT active' with regard to the 'use of IT systems in [the] company'.**

5.8 Summary of the assessment of the portfolio management practices of Hong Kong contractors

This element of the research was carried out to qualitatively assess the current methods used by Hong Kong contractors to manage their portfolio-of-projects. A postal survey questionnaire was developed to query three aspects of project information management:

- the use of information technology to assist in the flow of project information; it's aggregation into information which indicates the overall status of the portfolio-of-projects; and, the distribution of this information;
- the methods employed for drawing together project information to help manage the portfolio-of-projects; and
- the current methods used for the measurement of the performance of the portfolio-of-projects.

The population sample comprised 317 Contractors pre-approved by the HKG SAR for the submission of tenders in competition with others for the construction of public works projects. The Contractors are placed into group A, B, or C according to their proven track record and ability to finance construction. Group A is the smaller firms eligible for the lower value contracts, whereas Group C contractors tend to be major firms of international repute.

In Chapter 3, Enright et al note that, 'Hong Kong has around 1,400 firms engaged in a wide range of engineering and technical services, more than 500 firms active in real estate surveying, valuation, and consultancy, and around 400 architectural design firms. Chan et al state that, 'More than one hundred Hong Kong contractors have been certified

under the ISO9000 quality management plans'. In the same Chapter, Rowlinson and Walker were cited as identifying that there is a two-to-one split between private and public sector construction work and identify that the government is the single largest client of the construction industry whereas developers predominate in the private sector. The population sample of 317-contractor-firms is therefore taken to be a significant proportion of the contracting industry of Hong Kong. The seventy-five percent overall response to the postal survey is good and taken as indicative for the population overall. This is supported for the Group A, B, C sub-strata as the response received include forty-four percent contractor companies who are ISO9000 certificated. The composition of the response is forty-one percent Group C contractors- (the larger contractor firms), thirty-one percent Group B, and sixteen percent Group A. The sub-strata results are also taken as indicative based on the good sub-strata response and the high representation of the sub-strata within the sample-population.

The conclusion drawn from the analysis of Part One of the Questionnaire of Hong Kong contractors is that the electronic transfer of digital information between construction-sites, head-office and to other participants is not a commonplace mode of communication, and the use of networked digital information systems by contractors is uncommon.

Part Two of the Questionnaire led to the conclusion that project performance data/information is communicated in analogue mode using voice, or written media. E-mail is not commonly used for the communication of project performance data/information except within a minority of contracting companies. The ten most important project performance indicators used are: 'value', 'work-schedule', 'financing', 'resources', 'quality', 'safety', 'variations', '*employer-feedback*', and performance'.

Part Three of the Questionnaire is to measure how project data is added together to provide an overall view of what is happening within a portfolio of projects. Specifically, the research measures whether 'individual review', 'spreadsheet analysis', or 'database analysis' is the more commonplace method of data combination for the principal project

management data types of 'work-content', 'time', 'cost', and 'resource'. From the survey results it is concluded that personal review by individuals is the most common process adopted for combining together project data. Using spreadsheets is the second most common process. Database processes are not commonly used. This element of the survey also identified the fifteen most important project-performance indicators used for assessing the well-being of a portfolio-of-projects in terms of work-content, time-related, costs-related, and resource-related aspects of the projects. These are listed on Table 5-20

Work-content	Time-related	Cost-related	Resource-related
• Quality	• Work schedule	• Categories-of-value	• Manpower resources
• Activity schedule	• Percent progress	• Categories-of-cost	• Plant
• Variation	• Progress	• Payments	• Management resources
• Performance	• Progress vs schedule	• Management	• Material resources
• Safety	• End-date issues	• Variation	• Subcontractor
• Construction-issues	• Extension-of-time	• Cost management	• Cost of resources
• Costs	• Time management	• Cashflow	• Resources
• Work schedule	• Approvals	• Material	• Information
• Value	• Material issues	• Expenditure	• QS
• Disputes	• Delays	• Profit/loss	• Production
• Material use	• Replanned work	• Budget	•
• Timing	• Site related issues	• Subcontractor	•
• Work achieved	• Valuation	• Overhead	•
• Management of work	• Project data	• Labour	•
• Quantity	• Labour issues	• Work schedule	•

Table 5-20 Summary of the fifteen project performance indicators of Hong Kong contractors for assessing the well-being of a portfolio-of-projects

These are broad descriptive terms of project data. They are derived from a series of open-ended questions within the questionnaire. The responses received vary in semantic form and phrasing. Dendrograms of these words and their derivatives from the responses received are exhibited in the 'Appendices CD-ROM', at Sections 5.7 to 5.11.

The fourth part of the Questionnaire concluded the Hong Kong contractors are 'IT aware' and at the simpler stages of 'IT active'. They are not 'IT active' with regard to the 'use

of IT systems in [the] company'. These results when compared with the outcome from the same exercise carried out in the UK[1] and Australia[9] place Hong Kong as much the same as these counterparts[7].

This element of the research did not find evidence of the general use of a MIS that used project-level performance data to manage portfolios-of-projects. In this respect there was no notable degree of adherence to the precepts of Cleland and King.

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Chapter Six

6 Assessing The Practices Of Hong Kong Consultants For Managing Portfolios-Of-Projects

6.1 Introduction

This element of the research is also a qualitative postal survey to assess the current methods used, in this case, by Hong Kong consultants to manage their portfolio-of-projects. It closely follows the purpose and the methodology described for the postal survey of Hong Kong contractors described in Chapter Five of the Thesis. This is to provide a pan-industry assessment of project/portfolio management methods used in practice.

6.2 Chapter Outline

The methodology for the development, testing and the validation of this questionnaire survey is described in Section 2.4 in Chapter Two. A commentary on each question along with a copy of the survey instrument for the survey of consultants is in the'Appendices' and also within Chapter Six of the Appendices CD-ROM.

For the purposes of easier navigation of the text please note that:

- Section 5.3. describes the conversion of the research topics into a questionnaire;
- Section 6.4 explains details of the population sample;
- Section 6.5 recounts the level of response received;
- Section 5.6 provides a summary of the analysis of the response to the survey - – refer to the Appendices CD-ROM for the detailed results and analysis of the responses;
- Section 6.7 details the results of the research and the points carried forward to subsequent studies; and finally,
- Section 6.8 provides a summary of this element of the research.

6.3 Conversion of the research topics into questions

There is no deviation from the questionnaire derived for the survey of contractors other than changes in semantics to suit consultant firms. These are described in Sections 2.6.1 and 2.6.2.

6.4 Population Sample

The sample population is taken from the directory of approved consultants kept by the AACSB and the EACSB of the HKG. Being listed on these directories means that these companies have expressed an interest in performing public works commissions of the HKG SAR. They are different in style and content. Each is designed to meet the needs of its separate constituency.

The AACSB directory contains 96 companies who have registered an interest in providing up to five categories of professional services. There is differentiation among these companies with most being registered in a single category. Only 6% of the companies are registered in two categories, and 3% in three categories. All of the companies in the directory are registered as companies in Hong Kong. The attributes of the AACSB information supplied by the Secretary to the AACSB are listed in Table 6-1. All of the AACSB companies are included in the consultant population sample.

Data attribute	Comment
Code	Unique 6 letter identifier
Company name	
Company address	Hong Kong addresses
Telephone	
Fax	
Companies in each category.	17 No. Building Services Co. 35 No. Architectural Co. 15 No. Quantity Surveying Co. 9 No. Landscaping Co. 32 No. Structural Engineering Co.
Percent of the companies in each category that are ISO9001 certificated. (77 companies in the population sample (80%) are certificated)	100% Building Services o. 83% Architectural Co. 100% Quantity Surveying Co. 33% Landscaping o. 75% Structural engineering Co.
No. of consultants providing for multiple services	0 No for 5 services 0 No for 4 services 3 No for 3 services 6 No for 2 services
Population sample from AACSB	96 companies

Table 6-1. Attributes of the population sample supplied by the AACSB.

The EACSB directory contains a profile of 347 companies who have registered an interest in providing up to 18 categories of professional service plus miscellaneous services which are placed in a 'catch-all' category, called 'other'. The EACSB directory includes companies registered in Hong Kong and companies operating from overseas. It includes a statement of the numbers of local staff, and overseas staff, who have expertise in the 18 categories of service included in the profile. Works Branch Technical Circular 16/95[1] explains that the directories are merely convenient technical registers that identify a broad list of consultants for initial consideration. Some organisations listed are not suitable for this survey because they fail the selection criteria listed in Table 6-2.

Selection rule
Must be a company practicing in Hong Kong i.e. must have a local address.
Can have a majority of staff located offshore as construction briefs are often transient in nature.
Must be companies whose primary business is providing a construction service.

Table 6-2. Selection rules for the population sample taken from the Engineering and Associated Consultants Selection Board.

Culling the EACSB list according to the criteria listed in Table 6-2 results in a population sample of 159 companies. The directory information supplied by the EACSB for this population-sample is shown within Table 6-3.

Data attribute	Comment
Company name	
Contact	
Company address	Hong Kong address
Telephone No	
Fax No	
NP	No. professional staff
NT	No. technical staff
NO	No. other staff
No Resident	No. staff with residency rights
No Registered	No. staff registered as professionals in Hong Kong
Registered	Company registered in Hong Kong
Companies in each category.	76 No. Civil engineering 67 No. Geotechnical 51 No. Public Health 56 No. Water engineering 67 No. Structural engineering 48 No. Marine engineering 42 No. Tunnel engineering 60 No. Traffic engineering 56 No. Highway engineering 41 No. Railway engineering 82 No. Environmental engineering 62 No. Urban Planning 61 No. E & M 92 No. Project Management 41 No. Quantity Surveying 30 No. Surveying 60 No. Information Technology 32 No. Materials 20 No. None
Percent of the companies in each category with ISO9000. *(61 companies are certificated, 38% of the population sample)*	47% Civil engineering 49% Geotechnical 51% Public Health 47% Water engineering 49% Structural engineering 58% Marine engineering 57% Tunnel engineering 45% Traffic engineering 46% Bridge engineering 50% Railway engineering 41% Environmental engineering

	45% Planning
	44% E & M
	42% Project Management
	61% Quantity Surveying
	47% Surveying
	48% Information Technology
	56% Materials
	20% Other
	2% None
Population No	162 companies

Table 6-3. Attributes of the population sample supplied by the EACSB.

The majority of the EACSB consultants are multi-discipline practices: 75% of the population sample register their expertise in two or more of the eighteen categories; 51% are in five or more categories; and 24% are in twelve or more categories. Their response to the questionnaire will reflect the broad nature of their multi-discipline practices and not the special procedures needed for specific professional services. For the purposes of this survey the EACSB consultants are placed in one multi-discipline category, '[civil] engineering'. The two populations are combined to form the resultant Consultant Population Sample of 207 companies as described in Table 6-4 and their attributes are listed in Table 6-5.

File	Field data	Field attribute
Consultant_	CONTRACTOR_REF	Company unique reference code
pop_sample	COMPANY	Name of company
207 records	NAME	Contact person
	CONTRACTOR_ADS	Contractor's address in Hong Kong
	CONTRACTOR_PHONE	Contractor's telephone number
	CONTRACTOR_FAX	Contractor's fax number
	BUILDING SERVICES	Category of professional service
	STRUCTURAL	Category of professional service
	ARCHITECTURAL	Category of professional service
	LANDSCAPE	Category of professional service
	QUANTITY SURVEY	Category of professional service
	ENGINEERING	Category of professional service
	ISO	Yes if certificated.

Table 6-4. Data items within the Consultants Population Sample.

Attribute of the population sample
• Of the 207 Consultants in the population sample, 154 (74%) are taken from the EACSB directory.
• Of the 154 EACSB Consultants in the population sample, 53 (39%) have ISO 9000 certification.
• Of the 96 AACSB Consultants in the population sample, 47 (49%) have ISO 9000 certification.
• Of the 207 Consultants in the population sample, 100 (48%) have ISO 9000 certification.

Table 6-5. Attributes of the Consultants Population Sample in general.

The population sample includes eight sample sectors, namely:

- 'architecture' (35 firms),
- 'building services' (17 firms),
- 'Civil engineering' (147 firms),
- 'landscape' (9 firms),
- 'structural [engineering]', (32 firms),
- 'quantity surveyors' (15 firms),
- 'consultants firms with ISO9000 certification' (100 firms), and
- 'consultant firms without ISO9000 certification' (107 firms).

The ISO9000 sample-sectors are mutually exclusive: the others are not. The 'landscape' sample sector cannot provide fifteen or more responses and is not taken as providing a statistically significant set of results.

6.5 Postal survey level of response

The questionnaire was distributed to the sample population on 2nd, March, 1998. As before, the postal distribution followed the guidance given by the Hoinville et al (1977). The response period was three weeks. At the end of this time, the percent level of response was measured and a list of responses created. Reminders were then issued and the registration process repeated for the second round of responses. A second reminder letter was permitted but not a third, as further demands for a reply may induce a bias into the response. Table 6-6 lists the responses received at the first, second and final deadline.

Deadline Date	Response Overall	
	No.	% pop. sample
Mar 24	5	2%
Apr 14	68	33%
May 8	148	71%
Later	n/a	n/a

Table 6-6 Response from the postal survey of HKG's public works Consultants.

The percent response within each sector of the population sample is representative as shown within Table 6-7.

Population Sector	No. response	% pop. Sector	% pop sample
Overall (207 firms)	148	Na	71%
Architectural (35 firms)	27	77%	13%
Building services (17 firms)	12	71%	6%
Civil (147 firms)	101	69%	49%
Landscaping (9 firms)	8	89%	4%
Structural (32 firms)	26	81%	13%
Quantity Surveying (15 firms)	15	100%	7%
ISO certification (100 firms)	86	86%	42%
W/o ISO certification (107 firms)	61	57%	29%

Table 6-7 Level of response for the population sectors within the population sample of Hong Kong consultants.

The 'Building Services', 'Landscaping', 'and 'Quantity Surveying' sample sectors are less than fourteen firms and not statistically large enough to support meaningful statistical analysis such as correlation. The coded results from the survey were compared to the number of permanent employees to see if there is a meaningful correlation. Negligible correlation was found.

6.6 Analysis of responses received

The method of analysis of these survey results is described in Section 5.6

6.7 Results of the postal survey

The following are the main points that are carried forward from this postal questionnaire survey of the HKG list of Contractors approved for public works.

6.7.1 Part 1 of the Questionnaire

The researcher set out to establish the extent that project information is communicated between project participants located in centres of information – typically between head-offices and the offices where the assignment work is done. The assignment team is focused on the project whereas head-office needs to gather progress information to gain a view on their portfolio-of-projects. The questionnaire probed the use of modes of communication according to IT types i.e. telephone, fax and through to the Internet. The analysis has been completed in terms of the sectors of the population but the results stated here are general to the whole response unless stated otherwise. Results of the sample sectors are provided in the 'Appendices CD-ROM' within Chapter Six.

The <u>use of telephones for communication</u> between project participants is universal. Public telephone services are the most common service used. Leased line services and radio telephone are also used but to a lesser extent. Fifty-two percent of the consultant firms provide mobile telephones to their managerial staff. Twenty-two percent provide them to professional staff. Others are not given access to mobile telephones. Thirty-eight percent of the consultants use mobile telephone 'messaging' and thirty-five percent use 'call forwarding'. In general, less than half of the respondents have a company policy that important telephone communications are recorded. Fifty to thirty-five percent of the respondents state that recording messages is company policy. Hand-written notes are used for this purpose. Message recording devices are not generally used.

The <u>use of facsimile machines is also prevalent</u> among all consultants. More than ninety-two percent of the respondents use fax in their head offices. This falls to more than seventy-one percent in other company offices. The use is greater than forty-three percent

in assignment offices except for Architectural and Building Services Consultants, more than eighty percent respond that they deploy fax machines in their assignment offices. Faxes are not sent to PC's and PC's are not used to send faxes to fax machines. Less than ten percent of the sample sectors use a PC to send faxes.

The use of meetings for communication is nearly universal: one hundred percent affirmative response if the 'yes' and 'mostly yes' are taken together. It is company policy/instruction that minutes/notes of meeting are recorded for the majority of the response. Hand-written methods are the prevalent means of recording meeting details. The use of tape-recorders, word-processors, or electronic-note boards is negligible.

Video-conferencing is not used for communication between participants within Hong Kong (72-95% 'no') nor internationally (63-87% 'no'). Where this method is used, then commercial hired services or company-owned facilities are rare. Using the Internet is more popular with three to seventeen percent of respondents stating 'yes' to this mode of video-conferencing.

The use of CAD in company head-offices is sixty-three percent 'yes' and nineteen percent 'mostly yes'. Quantity Surveyor firms and those without ISO9000 certification have a lesser use of CAD. Hiring of CAD or manual drafting services is generally not done. There is a lesser use of CAD in assignment offices: twenty percent respond 'no'. In general, construction drawings are distributed as hardcopy (27-97% 'yes plus 3-33% 'mostly yes'). Distribution as electronic files on disk is 'yes' or 'mostly yes' for the response overall and for the sample sectors. Distribution of construction drawings across a LAN received a 'no' response although Building Services and the Landscaping firms say 'yes'. A 'no' response was received for the distribution of construction drawings via modems. Conversely, a 'yes' response was given to the distribution of construction drawings via the Internet.

Transmittal of construction drawings is recorded manually in registers (70-100% 'yes') whereas electronic registers are infrequently used (14-24% 'yes' plus 14-30% 'mostly yes').

Construction drawings are revised/checked in hardcopy form.

Analogue photographs are used by contractors (27-62% 'yes plus 13-31% 'mostly yes'). Digital photographs and video images are not used in general. Correspondingly photographs are distributed in hardcopy form. Distribution of image by electronic means is not the norm.

In general, consultant firms produce written documents according to company standards and in pre-determined document formats in head-offices and in assignment-offices. Printed proformas and forms are frequently used. Similarly, company procedures and instructions are used for the filing of written documents in an organised filing system in the head-office and also on assignment. Consultants use the same document filing system on all of their assignments (31-54% 'yes' plus 27-46% 'mostly yes'). Filing systems are manual in head office and on assignment – electronic systems are infrequent. However, 'keywords' are used to identify the contents of written documents for ease of retrieval in head-offices but not in assignment-offices. Consultants employ staff to organise and maintain the filing systems in the head office and, to a lesser degree, on site. They do not employ an 'information manager' to organise and maintain the filing system of written documents and their contents, and also the distribution and use of documents.

E-mail via LANS, modems or the Internet, are used in a majority of cases, in company head-offices and to a lesser extent within assignment offices. Civil, Landscaping and Structural firms have the higher response for e-mail provision. Where e-mail is provided, then it is supplied to managerial, professional and supervisory staff in head-offices and to a lesser degree to these personnel-types in assignment offices.

In general, Consultants employ staff to administer their IT in company head-offices but not within assignment offices. The most frequent highest level of management of IT in the company is:

- Part-time involvement of a Director 35%
- Full-time involvement of a Director 15%
- Full-time involvement of a Manager 14%

In general, the Building Services, Civil, and Structural firms have a greater involvement of Director-level staff in IT management than the other sample sectors. The response received from the ISO9000 certificated firms is much the same as from firms without the certification.

Consultants in general, use e-mail for sending written messages in company offices. E-mail is used to a lesser extent for: agreeing the text of written messages; for marking/amending messages; and for attaching messages. E-mail is not used for attaching digital images, sound-files, or for the delegation of actions. The use of e-mail within assignment offices is less than the corresponding use of e-mail in company head-offices.

Consultants, in general, do not have 'homepages' on the Internet (83-54% 'no'). They do not, in general, have their own Internet server, but they provide some of their staff with access to the Internet. Managerial staff are given access to the Internet across all sample sectors. Professional staff are also given Internet access but the response is more varied across the sample sectors. Supervisory and clerical staff do not have access.

The conclusion drawn from this analysis and carried forward to the next stage of the research is that the survey of the Hong Kong consultants shows that:

- **The management of data and information is predominantly by traditional manual methods;**
- **Electronic transfer of digital information between assignment offices, head-office and to other participants is not a commonplace mode of communication:** and
- **Use of networked wide-area digital information systems by consultants is not uncommon.**

6.7.2 Part 2 of the Questionnaire

This part of the survey measures the use of IT to communicate project-related performance indicators to head-office from assignment location. It also measures the extent that commonplace work-related performance indicators are used by the head-office to gauge the well being of work in progress.

Telephones, facsimile, e-mail and hardcopy documents are the modes of communication that are used to transmit work, time, cost, resource, issue, company and project related items of information on project performance to the head-office. The use of e-mail is given a 'mostly yes' response overall for work and time related data flow. For other data types the response is less positive and varies as follows:

- Cost data receives a 'mostly no' response that varies for sample sectors.
- Resource data is not exchanged by e-mail overall.
- Issue data via e-mail is a 'mostly no' response except for civil, landscaping and firms without ISO9000 who state 'mostly yes'.
- Company related data via e-mail is 'mostly no'.
- Project related data via e-mail is also 'mostly no'.

All sample sectors responded positively to questions on the use of these stereotype indicators of project performance and progress. The percent positive response for significant sample sectors of the population are listed in Table 6-8. 'Significant' sample sectors are Architecture, Civil, Structural, Quantity Surveying, and firms with or without ISO9000 certification as they received a response from at least fifteen firms.

The abbreviation used in Table 6-8 to denote sample sectors of the population are:

- Arc = Architecture
- Civ = Civil sample
- Str = Structural
- QS = Quantity Surveyor
- ISO+ = with ISO9000 certification
- ISO- = without ISO9000 certification

Work-content indicators

	% 'yes' + % 'mostly yes' response						
Lists of:	**All**	**Arc**	**Civ**	**Str**	**QS**	**ISO+**	**ISO-**
Activities	**24+31%**	17+21%	**26+33%**	**23+31%**	27+20%	**23+31%**	**25+30%**
Deliverables	**22+30%**	14+28%	**23+33%**	**23+31%**	27+13%	**23+31%**	20+29%
Changes	19+30%	14+28%	**20+31%**	12+35%	27+20%	19+27%	**18+34%**
Disputes	16+26%	17+21%	16+27%	8+31%	20+20%	15+25%	18+27%

Time-related indicators

% 'yes' + % 'mostly yes' response

Lists of:	All	Arc	Civ	Str	QS	ISO+	ISO-
Work schedule	27+33%	28+31%	29+30%	15+38%	27+27%	27+35%	26+28%
% work done	20+35%	21+34%	20+34%	15+38%	27+13%	23+35%	15+34%
% work to be done	19+34%	21+28%	18+35%	12+38%	27+13%	21+34%	15+32%
Replanned work	19+38%	17+34%	19+39%	12+42%	33+20%	22+39%	15+36%

Cost-related indicators

% 'yes' + % 'mostly yes' response

Value of:	All	Arc	Civ	Str	QS	ISO+	ISO-
Work done	27+28%	24+14%	27+30%	27+27%	33+20%	28+31%	24+24%
Work to be done	25+29%	24+10%	22+33%	15+31%	33+20%	25+31%	24+26%
Expenditure	25+28%	17+28%	27+28%	19+19%	33+20%	26+28%	24+28%
Commitment	20+32%	14+31%	19+34%	15+27%	33+13%	22+32%	17+33%
Variations	22+30%	21+17%	19+33%	19+27%	40+13%	25+32%	17+26%
Disputes	18+29%	17+17%	16+32%	8+35%	27+20%	18+32%	17+24%
Money received	28+25%	28+14%	24+31%	23+23%	40+7%	33+20%	20+33%
Money outstanding	29+25%	28+14%	26+30%	27+19%	40+7%	34+20%	20+31%

Resource-related indicators

% 'yes' + % 'mostly yes' response

	All	Arc	Civ	Str	QS	ISO+	ISO-
Personnel deployed	20+29%	72+21%	19+31%	12+27%	27+20%	22+30%	17+28%
Personnel required	19+34%	21+34%	18+35%	15+27%	20+20%	22+35%	15+31%
Facilities employed	15+32%	10+41%	16+31%	8+27%	20+13%	16+35%	15+26%
Facilities required	16+32%	10+41%	17+32%	8+27%	20+7%	17+35%	15+26%
Sub-consultants hired	16+28%	10+41%	17+28%	12+31%	14+7%	15+30%	17+24%
Purchasing required	17+28%	18+32%	15+31%	12+19%	27+7	20+32%	11+23%
QS required	9+26%	7+32%	6+23%	0+23%	27+20%	9+28%	9+21%
Legal required	11+18%	11+18%	9+18%	0+27%	27+7%	10+20%	11+15%
Management req'd	9+24%	11+21%	7+27%	0+35%	20+7%	8+26%	11+21%
Admin required	9+26%	11+25%	9+26%	4+31%	13+20%	9+28%	9+23%
Out-sourced services required	9+26%	7+21%	9+29%	4+35%	13+7%	8+27%	9+23%

Issue-related indicators

% 'yes' + % 'mostly yes' response

Transmission of	All	Arc	Civ	Str	QS	ISO+	ISO-
Requests for info	38+40%	34+38%	33+44%	19+46%	53+20%	40+40%	34+41%
Variation quotes	32+33%	29+29%	29+34%	19+35%	53+20%	32+38%	31+26%
Change orders	31+33%	29+32%	28+33%	15+38%	47+13%	30+38%	33+25%
Approval requests	34+31%	36+32%	29+33%	19+35%	47+13%	38+29%	28+35%
Quality conformance	30+32%	36+29%	25+34%	19+27%	33+20%	32+31%	25+33%
Approvals given	32+32%	39+29%	26+36%	19+35%	40+13%	38+30%	24+36%

Company-related indicators

% 'yes' + % 'mostly yes' response

Transmission of	All	Arc	Civ	Str	QS	ISO+	ISO-
Names & addresses	40+32%	31+38%	43+29%	27+35%	40+20%	43+31%	37+33%
Files references	33+26%	36+25%	32+27%	15+35%	40+13%	33+31%	33+19%

Tel directories	**24+26%**	**25+21%**	**24+26%**	19+23%	**27+27%**	**24+31%**	24+17%
Shared facilities	15+17%	18+11%	14+16%	15+12%	20+20%	19+18%	9+15%
Info registers	21+21%	25+14%	17+21%	15+23%	**27+27%**	26+21%	13+22%

Project-related indicators

% 'yes' + % 'mostly yes' response

Transmission of	All	Arc	Civ	Str	QS	ISO+	ISO-
Specifications	**42+25%**	**45+10%**	**37+31%**	**38+31%**	**53+7%**	**45+24%**	**36+27%**
BoQ's	**31+18%**	28+7%	27+20%	**23+38%**	**60+7%**	**33+19%**	28+15%
Tender Drawings	**36+18%**	**41+10%**	**33+19%**	**38+27%**		**42+17%**	28+19%
Const. Drawings	**34+17%**	**41+10%**	30+17%	**38+27%**		**39+18%**	26+17%
As-built Drawings	**28+21%**	**34+24%**	24+20%	**35+38%**		**33+22%**	20+20%
Contract correspondence	**42+28%**	**52+10%**	**34+33%**	**31+35%**	**60+20%**	**45+28%**	**38+29%**
Routine correspondence	**44+34%**	**55+7%**	**36+41%**	**31+35%**	**60+20%**	**48+32%**	**38+36%**
Instructions	**41+31%**	**55+7%**	**34+41%**	**38+27%**		**43+29%**	**38+36%**
Monthly reports	**44+29%**	**52+10%**	**39+33%**	**38+31%**	**53+20%**	**48+26%**	**39+34%**
Method statements	**28+34%**	**31+24%**	**27+36%**	**35+27%**	20+27%	**30+33%**	**27+36%**
Quality conformance	**29+30%**	**34+24%**	**27+31%**	**31+23%**	27+13%	**31+31%**	**27+29%**
Manuals and Proc	**27+25%**	28+21%	**25+25%**	**19+42%**	33+13%	**27+32%**	27+14%
Cost reports	**28+28%**	**34+17%**	**19+32%**	**19+31%**	**60+20%**	**33+32%**	20+21%
Programmes/bar charts	**33+33%**	**45+14%**	**27+41%**	**27+35%**	**47+13%**	**39+30%**	**25+39%**

Table 6-8 Hong Kong consultants use of project performance indicators.

From Table 6-8, the extent of the transmission of the listed project performance indicators by the majority of the respondents, is:

- Half of the work-content indicators;
- All of the time-related indicators;
- All but one of the cost-related indicators;
- None except one of the resource-related indicators;
- All of the issue-related indicators;
- Three out five of the company-related indicators; and
- All but one of the project-related indicators.

The use of IT for the transmission of these indicators of project performance in terms of 'yes' and 'mostly yes' percent response is summarised in Table 6-9.

Indicator-type	Tel	Fax	e-mail	hardcopy
Work-content	**54+32%**	**59+32%**	**22+43%**	**66+26%**
Time-related	**48+27%**	**50+37%**	**21+36%**	**62+22%**
Cost-related	**33+30%**	**45+37%**	18+27%	**61+27%**
Resource-related	**41+37%**	**44+44%**	19+25%	**52+36%**
Issue-related	**62+48%**	**49+41%**	18+30%	**66+24%**
Company-related	**47+36%**	**49+38%**	16+30%	**57+31%**
Project-related	**40+32%**	**55+39%**	15+29%	**74+24%**

Table 6-9 Types of IT used to transmit project performance indicators

Respondents stated the five items of data/information that are the most important in their company for assessing the performance of a project. The response rate was equal to or greater than thirty-four percent for all sample sectors and forty-five percent overall. One hundred and ninety-five unique responses were received indicating a variability of forty-two percent. Twenty-four keywords were derived from the unique responses. Table 6-10 lists the ten significant keywords for each of the sample groups in their order of frequency. There is consistency in the first five keywords. Seven additional keywords are appended to cover the spectrum of ten most frequent keywords for all the sample sectors. Based on the overall response the ten most important project performance data/information for Hong Kong consultants are listed in Table 6-10, with the frequency of response received from each of the sample sectors.

Project performance indicators

	All	Arc	BS	Civ	Land	Str	QS	ISO+	ISO-
[Total Response]	[463]	[82]	[44]	[317]	[21]	[102]	[45]	[279]	[184]
Work controls	88	13	8	68	5	24	3	45	41
Costs	67	11	5	46	2	16	9	44	23
Value	62	9	3	46	4	14	5	36	26
Fees	37	5	6	24	0	6	7	27	10
Quality	29	7	4	20	0	4	3	19	10
Resources	25	4	2	17	1	8	2	17	8
Time	24	3	2	17	1	3	3	16	8
Client feedback	*21*	*3*	*1*	*17*	*0*	*2*	*2*	*6*	*15*
Man-power	17	3	0	11	1	1	3	11	6
Staffing	13	3	2	10	1	3	1	9	4
Drawings	6	4	1	0	0	2	0	6	0
Correspondence	*10*	*2*	*4*	*3*	*0*	*2*	*0*	*8*	*2*
Profit	10	1	3	7	0	4	3	7	3
Deliverables	3	1	0	3	2	0	0	0	3
Project attributes	*11*	*2*	*0*	*8*	*2*	*3*	*1*	*4*	*7*
Performance reports	*10*	*3*	*1*	*3*	*1*	*2*	*1*	*7*	*3*

Table 6-10 Frequency that Hong Kong consultants cite the ten most important project performance indicators

Drawings, *correspondence*, profit, deliverables, *project attributes and performance reports* are also introduced as variants of the keywords in certain sample sectors. The keywords printed in italic font are likely to take the form of variable unstructured text not easily included in an algorithmic-based MIS.

The transmission of issue-related, company-related, and project-related data/information was included in this part of the research. Telephones, facsimile, and hardcopy are the most frequent modes used to communicate these measures of project performance. E-mail is not used as frequently.

The conclusion drawn from this analysis and carried forward to the next stage of the research is that the survey of the Hong Kong consultants shows that:

- **Project performance data/information is predominantly communicated in analogue mode using voice, or written media;**
- **'Work', 'Time', 'Cost', 'Issue', 'Company' and 'Project' related project performance issues are transmitted to head office in the majority of instances but not 'Resource' related indicators to the same extent;**
- **E-mail is not used for the communication of project performance data/information except within a minority of consulting companies and mostly for work-content and time-related project performance indicators; and**
- **The ten most important project performance indicators used are:** 'Work controls'; 'Costs'; 'Values'; 'Fees'; 'Quality'; 'Resources'; 'Time'; *'Client feedback'*, 'Manpower' and 'Staffing'.

6.7.3 Part 3 of the Questionnaire

This third part of the questionnaire is to measure how project data is added together to provide an overall view of what is happening within a portfolio of projects. Specifically, the research measures whether 'individual review', 'spreadsheet analysis', or 'database analysis' is the more commonplace method of data combination for the principal project management data types of 'work-content', 'time', 'cost', and 'resource'. The questionnaire also sets out to identify what other project data is fed into this process.

Individual review and using spreadsheets are the most common processes adopted for combining together project data. Database processes are less commonly used, although this varies within sectors of the population-sample. Table 6-11 displays the response rate for the use of these processes for those sample sectors with fifteen or more responses i.e., 'All', 'Architecture', 'Civil', 'Structural', 'with ISO certification' and 'without ISO certification'.

Processes for combining work-content data						
	% 'yes' + % 'mostly yes' response					
Process:	**All**	**Arc**	**Civ**	**Str**	**ISO+**	**ISO-**
Individual review	**25+48%**	**24+48%**	**25+49%**	**88+12%**	**26+52%**	**23+42%**
Spreadsheet	**26+44%**	**31+34%**	**22+47%**	**31+46%**	**28+47%**	**23+38%**
Database	15+34%	14+34%	14+33%	**23+35%**	**15+41%**	15+23%
Processes for combining time-content data						
	% 'yes' + % 'mostly yes' response					
Process:	**All**	**Arc**	**Civ**	**Str**	**ISO+**	**ISO-**
Individual review	**27+40%**	**31+34%**	**26+40%**	12+27%	**28+45%**	**25+32%**
Spreadsheet	**23+43%**	**28+38%**	**19+46%**	**27+50%**	**25+45%**	**19+40%**
Database	12+33%	10+38%	12+30%	**19+42%**	11+38%	13+25%
Processes for combining cost-content data						
	% 'yes' + % 'mostly yes' response					
Process:	**All**	**Arc**	**Civ**	**Str**	**ISO+**	**ISO-**
Individual review	**28+42%**	**38+34%**	**24+46%**	8+31%	**33+44%**	**21+40%**
Spreadsheet	**28+42%**	**38+34%**	**25+44%**	**31+42%**	**31+45%**	**19+40%**
Database	18+31%	**24+34%**	15+32%	**15+38%**	**18+38%**	13+25%
Processes for combining resource-content data						
	% 'yes' + % 'mostly yes' response					
Process:	**All**	**Arc**	**Civ**	**Str**	**ISO+**	**ISO-**
Individual review	**26+43%**	**31+38%**	**21+44%**	**12+38%**	**31+43%**	**21+40%**
Spreadsheet	**23+39%**	**28+34%**	**21+39%**	**28+44%**	**26+42%**	**25+38%**
Database	14+30%	14+34%	13+28%	**16+36%**	14+32%	19+19%

Table 6-11 Hong Kong consultants preference for the means of combining project data for a view of portfolio performance

The priority order for the ten most important work-content related performance criterion used by Hong Kong consultants to assess the combined performance of several construction projects is stated in Table 6-12. There is varying degrees of consistency among the sample sectors. A further fourteen keywords are introduced to accommodate all the sample sectors. The level of response in all sample sectors was greater than nineteen percent, with thirty percent response achieved overall. Two hundred and twenty unique responses were listed. The variability in the unique responses was seventy percent. Twenty-eight response keywords were derived from them. Table 6-12 lists the significant response-keywords for the overall sample population and the frequency that they are cited within each sample sector.

Work-content portfolio performance indicators

Response keywords	All	Arc	BS	Civ	Land	Str	QS	ISO+	ISO-
[Total Response]	[310]	[52]	[38]	[216]	[12]	[98]	[33]	[210]	[100]
Quality	42	7	5	30	2	10	5	25	17
Project attributes	*27*	*2*	*1*	*22*	*3*	*10*	*1*	*14*	*13*
Work progress	24	7		17	1	10	1	16	8
Scope	21	2	6	15		8	1	13	8
Costs	17	5		9	1	2	5	12	5
Client issues	*15*	*4*	*2*	*9*	*1*	*3*	*2*	*11*	*4*
Management	*14*			*10*		*3*	*3*	*12*	*2*
Deliverables	13	1	4	8		3	2	11	2
Time	13	6		6		2	1	7	6
Documentation	*13*	*2*	*1*	*10*		*4*	*1*	*9*	*4*
Quantities	5	2	1	3		1	1	4	1
Manpower	3	2		1		2		3	
Claims/disputes	*13*	*2*	*5*	*8*		*4*	*2*	*10*	*3*
Activities	9	1	5	6		4	1	7	2
Design	8	1	1	6		5	1	6	2
Progress	8		1	8	2	5		6	2
Value	5	1	1	3	1		1	3	2
Approvals	*3*	*1*	*1*	*2*		*3*		*2*	*1*
Communication	*10*	*1*		*9*		*3*		*6*	*4*
Resources	6	1		3	1		3	3	3
Drawings	7	1	1	5		4		6	1
Information	*8*		*1*	*7*		*4*	*1*	*8*	
Variations	9	1	1	7		4		5	4
Correspondence	*2*					*1*	*1*	*2*	

Table 6-12 Frequency that Hong Kong consultants cite the ten most important work-content performance indicators

There is variation in the top ten response-keywords in all sample sectors however the ten most frequent keywords overall also occur in the sample sectors with an above average commonality for eight out of the ten keywords:

- 'quality' in 9/9 instances;
- *'project attributes'* in 7/9 instances;
- 'work progress' in 7/9 instances;
- 'scope' in 7/9 instances;
- 'costs' in 7/9 instances;
- *'client issues'* in 8/9 instances;
- *'management'* in 4/9 instances;
- 'deliverables' in 5/9 instances;
- 'time' in 3/9 instances; and
- *'documentation'* in 6/9 instances.

The response-keywords written in italics indicate that the data/information is probably in the form of variable, unstructured text not easily included in an algorithmic-based MIS. The priority order for the ten most important time-related performance criterion used by Hong Kong consultants to assess the combined performance of several construction projects is stated in Table 6-13. There is consistency among the sample sectors with the first five of these keywords but less so in the last five. A further fourteen keywords are introduced to accommodate all the sample sectors. The level of response in all sample sectors was greater than nine percent, with twenty-four percent response achieved overall. One hundred and seventy-three unique responses were listed. The variability in the unique responses was eighteen percent. Thirty-one response keywords were derived from these. Table 6-13 lists the significant response-keywords for the overall sample population and the frequency that they are cited within each sample sector.

Time-content portfolio performance indicators

Response keywords	All	Arc	BS	Civ	Land	Str	QS	ISO+	ISO-
[Total Response]	[252]	[34]	[27]	[178]	[4]	[81]	[27]	[165]	[87]
Work schedule	38	8	8	24		12	6	31	7
Work progress	21	2	6	14		7	3	17	4
Completion factors	16	1	1	12		4	2	9	7
Time	16	5		9		4	1	6	10
Information	*15*			*13*	*2*	*4*	*1*	*11*	*4*
Re-planning	15	4	3	8		6	1	8	7
Costs	9	2		6		1		3	6
Project factors	*9*			*8*		*2*	*1*	*6*	*3*
Milestone	8		2	7		5	2	6	2
Manhours	8			7		2	1	5	3
Duration	8	2	1	5		3	1	6	2
Delay	8	2	1	6		2		6	2
Drawing time	3	2	1	1		2		3	
Staff	7	2		5		4		3	4
Production	*7*	*1*		*5*		*2*		*3*	*4*
Critical actions	8		1	4		2	4	7	1
Participant performance	*7*	*1*	*1*	*4*		*1*	*1*	*5*	*2*
Quality	3		1	3		1		2	1
Scope	*3*	*1*	*1*	*2*		*1*		*1*	*2*
Timesheets	5			5	1	2		3	2
Deliverables	2			2	1			1	1
Design time	5			3		3		2	3
Resources	4			2		2	2	4	
Client actions	*3*			*1*		*1*	*1*	*1*	*2*

Table 6-13 Frequency that Hong Kong consultants cite the ten most important time-related performance indicators

There is variation in the top ten time-related, response-keywords in all sample sectors however the ten most frequent keywords overall also occur in the sample sectors with an above average commonality for seven out of the ten keywords:

- 'work schedule' in 8/9 instances;
- 'work progress' in 8/9 instances;
- 'completion' in 7/9 instances;
- 'time' in 7/9 instances;
- *'information'* in 6/9 instances;
- 're-planning' in 7/9 instances;
- 'costs' in 4/9 instances;
- *'project factors'* in 1/9 instances;
- 'milestones' in 6/9 instances; and
- 'manhours' in 3/9 instances.

The response-keywords written in italic font indicate that the data/information is probably in the form of variable, unstructured text not easily included in an algorithmic-based MIS.

The priority order for the ten most important cost-related performance criterion used by Hong Kong contractors to assess the combined performance of several construction projects is stated in Table 6-14. There is consistency among the sample sectors with the first five of these keywords but less so in the last five. A further eight keywords are introduced to accommodate all the sample sectors. The level of response in all sample sectors was greater than thirteen percent, with twenty-seven percent response achieved overall. One hundred and eight-four unique responses were listed. The variability in the unique responses was thirteen percent. Twenty-four response keywords were derived from these. Table 6-14 lists the significant response-keywords for the overall sample population and the frequency that they are cited within each sample sector.

Cost-related portfolio performance indicators

Response keywords	All	Arc	BS	Civ	Land	Str	QS	ISO+	ISO-
[Total Response]	[284]	[56]	[32]	[180]	[6]	[86]	[35]	[206]	[78]
Valuation	31	5	7	19	1	6	5	22	9
Management factors	*25*	*4*		*16*	*2*	*9*	*2*	*19*	*6*
Cost of work	21	5		15		6		13	8
Fees	20	3	3	11		12	3	13	7
Payments	20	4	7	11		6	4	17	3
Cost uncertainties	20	6	1	13		1		14	6
Budget	18	3	5	12		7	3	9	9
Profit	18	1	3	12	2	6	6	15	3
Expenditure	16	3	2	11		5	1	10	6
Cost of resources	14	3	1	10		3	1	11	3
Cost of overheads	11	3		5		4	3	11	
Cost management	3		2	3		1		3	
Quality	4		1	3		3		4	
Production factors	*5*	*2*		*3*	*1*	*1*		*4*	*1*
Work progress	12	2		9		6		7	5
Resources	10	2		6		3	2	9	1
Cashflow	3			1			2	2	1
Expenses	4			4		1		1	3

Table 6-14 Frequency that Hong Kong consultants cite the ten most important cost-related performance indicators

There is variation in the top ten cost-related, response-keywords in all sample sectors however the ten most frequent keywords overall also occur in the sample sectors with an above average commonality for all of the ten significant keywords:

- 'valuation' in 9/9 instances;
- *'management factors'* in 8/9 instances;
- 'cost of work' in 6/9 instances;
- 'fees' in 8/9 instances;
- 'payment' in 7/9 instances;
- 'cost uncertainties' in 6/9 instances;
- 'budget' in 8/9 instances;
- 'profit' in 7/9 instances;
- 'expenditure' in 7/9 instances; and
- 'cost of resources' in 7/9 instances.

The response-keywords written in italic font indicate that the data/information is probably in the form of variable, unstructured text not easily included in an algorithmic-based MIS.

The priority order for the ten most important resource-related performance criterion used by Hong Kong contractors to assess the combined performance of several construction projects is stated in Table 6-15. There is consistency among the sample sectors with the first five of these keywords but less so in the last five. A further nine keywords are introduced to accommodate all the sample sectors. The level of response in all sample sectors was within a range of nine to fifty-four percent, with twenty-seven percent response achieved overall. Two hundred and one unique responses were listed. The variability in the unique responses was twelve percent. Twenty-four response keywords were derived from these. Table 6-15 lists the significant response-keywords for the overall sample population and the frequency that they are cited within each sample sector.

Resource-related portfolio performance indicators

Response keywords	All	Arc	BS	Civ	Land	Str	QS	ISO+	ISO-
[Total Response]	[284]	[50]	[32]	[164]	[4]	[87]	[30]	[181]	[79]
Staffing	57	6	9	39		22	8	37	20
Facilities	*21*	*4*	*2*	*11*		*5*	*4*	*13*	*8*
IT	18	3		13	2	4	1	12	6
Resources	16	4	1	11	2	7	2	10	6
Management factors	16	6	5	7		4	2	13	3
Cost	15	4	5	9		5	2	12	3
Productivity	14	2		6		7	4	10	4
Specialist services	12	4	1	6		2	2	9	3
Competance	12	2	4	10		2		5	7
Manpower	8	2		4		5		8	
Manhours	8	4		4		1		8	
Time	5	2		1		2	2	5	
Sub-contractor	6		2	3		3		2	4
Communication	6	1	1	5		3		5	1
Abortive work	4	2	1	1		1	1	4	
Quality	4		1	4				3	1
Information	7			7		5		7	
Plant/equipment	6			5		3		3	3
Sub-consultant	8	1		6		2	1	4	4

Table 6-15 Frequency that Hong Kong consultants cite the ten most important resource-related performance indicators

There is variation in the top ten resource-related, response-keywords in all sample sectors however the ten most frequent keywords overall also occur in the sample sectors with an above average commonality for eight of the ten significant keywords:

- 'staffing' in 8/9 instances;
- *'facilities'* in 8/9 instances;
- 'IT' in 8/9 instances;
- 'resources' in 9/9 instances;
- 'management factors' in 7/9 instances;
- 'cost' in 8/9 instances;
- 'productivity' in 6/9 instances;
- 'specialist services' in 5/9 instances;
- 'competance' in 4/9 instances; and
- 'manpower' in 3/9 instances.

The response-keywords written in italic font indicate that the data/information is probably in the form of variable, unstructured text not easily included in an algorithmic-based MIS.

The conclusion drawn from this analysis and carried forward to the next stage of the research is that the survey of the Hong Kong consultants shows that:

- **Individual review and using spreadsheets are the most common processes adopted for combining together project data/information for assessing the performance of a portfolio of projects.**

- **Database processes are used less than the average: the degree of use varies within sectors of the population-sample.**

- **The ten most important work-content project performance indicators used for assessing the well being of a portfolio-of-projects, are:** 'quality'; 'project attributes'; 'work progress'; 'scope'; 'costs'; 'client issues'; 'management'; 'deliverables'; 'time', and 'documentation'.

- **The ten most important time-related project performance indicators used for assessing the well being of a portfolio-of-projects, are:** 'work schedule'; 'work progress'; 'completion factors'; 'time'; 'information'; 're-planning'; 'costs'; 'project factors'; 'milestones', and 'manhours'.

- **The ten most important cost-related project performance indicators used for assessing the well being of a portfolio-of-projects, are:** 'valuation'; 'management factors'; 'cost of work'; 'fees'; 'payments'; 'cost uncertainties', 'budget'; 'profit'; 'expenditure', and 'cost of resources'.

- **The ten most important resource-related project performance indicators used for assessing the well being of a portfolio-of-projects, are:** 'Staffing'; 'facilities'; 'IT'; 'resources'; 'management factors', 'cost'; 'productivity'; 'specialist services', 'competence', and 'manpower'.

6.7.4 Part 4 of the Questionnaire

The method of analysis of this section of the questionnaire is described in Section 5.6.3.

By May 8, 1998, 147 questionnaire responses were received. Incomplete responses to the health check survey reduced this to 126 (61%) for analysis. Average scores from each of the 28 questions, for the three major sections, and the responses overall were calculated. Table 6-16 states the level of response included in the analysis.

Pop sample	All	Arc	BS	Civ	Land	Str	QS	ISO+	ISO-
Nos polled	207	35	17	147	9	32	15	100	107
Response Nos	126	25	11	83	7	24	15	81	45
Response %	61%	71%	65%	56%	78%	75%	100%	81%	42%

Table 6-16 Percent response included in the 'IT healthcheck' of Hong Kong consultants

Table 6-17 contains the results of a check for correlation between the number of employees in the company and the results from the survey.

All Groups *(126 Consultants)*	Correlation	Comment
Competition and Business Strategy	0.24	Negligible correlation
Role of IT	0.12	Negligible correlation
IT Strategy	0.17	Negligible correlation
Overall	0.19	Negligible correlation

Table 6-17 Correlation between the number of employees in the consultant firm and the score on the IT 'healthcheck'.

There is agreement between the value of the mode and median achieved throughout the survey. Converting these back to the A, B, C, and D classifications provides a matrix that better indicates the extent that IT is employed for strategic purpose by the Hong Kong consultants.

Table 6-18 is the matrix achieved for the results overall. The classifications used in this table are:

- A = IT innovator
- B = IT active
- C = IT aware
- D = IT unconcerned

IT Healthcheck Question	D	C	B	A
IT support of core competencies.			Yes	
How IT helps company compete.			Yes	
Impact of IT on goals and objectives			Yes	
Position of IT compared to others.			Yes	
Impact of IT on Clients.				Yes
Belief that IT expertise wins work.			Yes	
Use of IT as part of strategic alliances.		Yes		
Current use of IT in the company.			Yes	
Relationship between IT and business strategy			Yes	
Participation of IT in forming business strategy		Yes		
Impact of IT on operational strategy.			Yes	
IT influence on marketing strategy		Yes		
Use of IT systems in company		Yes		
Objectives of IT strategy.		Yes		
Thrust of IT strategy			Yes	
Management of IT in the future		Yes		
CSF's for competitive advantage through IT		Yes		
Management of IT projects and innovation.			Yes	
Level of R&D in IT		Yes		
Nature of IT department.	Yes			
Importance of IT skills in company.		Yes		
Awareness of IT strategy.		Yes		
Involvement of Users in IT strategy.		Yes		
Risks associated with IT strategy.		Yes		
Periodic review of IT strategy.				Yes
Measurement of IT performance.			Yes	
Characteristics of IT strategy.				Yes
Who champions IT in the company?				Yes

Table 6-18 Extent of strategic use of IT by Hong Kong consultants gauged by the IT 'healthcheck' questionnaire.

Table 6-19 provides a broad statistical indication of the extent that IT is employed for strategic purpose by Hong Kong consultants in terms of the three major categories and by sample sector.

IT classification

- A = IT innovator
- B = IT active
- C = IT aware
- D = IT unconcerned
- Mn = Mean achieved.

Rating nomenclature

- R = maximum range possible;
- H = high rating achieved;
- L = low rating achieved;
- Md = Median achieved;
- M = Mode achieved

Overall (126 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A	CB	BA	B	BA
Role of IT	D-A	BA	DC	B	B	B+
IT Strategy	D-A	A+	C	B	B	B
Overall	D-A	A+	C	B+	B	B+
Architectural (25 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A+	CB	B+	B+	B+
Role of IT	D-A	A+	DC	CB	CB	C+
IT Strategy	D-A	A	C-	B-	B-	B-
Overall	D-A	A+	C+	B	A-	B
Civil (83 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A+	CB	BA	BA	BA
Role of IT	D-A	A+	D+	BA	B	B+
IT Strategy	D-A	A+	C	B	B	B
Overall	D-A	A+	C	B	A-	B
Structural (24 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A+	CB	BA	BA	BA
Role of IT	D-A	A+	DC	B	A-	B
IT Strategy	D-A	A	C	B	A	B
Overall	D-A	A	C	B+	B+	B
QS (15 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A	CB	B+	B+	B+
Role of IT	D-A	A-	DC	B-	CB	B-
IT Strategy	D-A	A	C	C+		B-
Overall	D-A	A	C	B	B	B
ISO9000+ (81 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A	C+	BA	B+	B+
Role of IT	D-A	A+	DC	B	B	B
IT Strategy	D-A	A+	C	B	B	B
Overall	D-A	A+	C	B-	B-	B
ISO9000- (45 No)	**R**	**H**	**L**	**Md**	**M**	**Mn**
Competition and Business Strategy	D-A	A+	CB	BA	BA	B+
Role of IT	D-A	A	C	B	B	B+
IT Strategy	D-A	A	C	B	B	B
Overall	D-A	A	C	B	BA	B

Table 6-19 Hong Kong consultants classified in terms of their strategic use of IT

All the sample sectors are 'IT active' in the use of 'IT to improve competition and for reasons of business strategy'. The 'role of IT' in all the sample sectors is 'IT active' except for the architectural sample sector at 'IT aware'. All sample sectors except QS are also rated at 'IT active' with regard to 'IT strategy'. The QS sector is at 'IT aware'.

The results overall within each sample sector, show that:

- Architectural consultants are mostly 'IT active' but have a mode of 'IT innovators';
- Civil consultants are mostly 'IT active' but have a mode of 'IT innovator';
- Structural consultants are mostly 'IT active';
- Quantity Surveyor consultants are mostly 'IT active';
- Consultant firms with ISO9000 certification are ranked at the lower end of 'IT active'; whereas,
- Contractors without ISO9000 are 'IT active' but with a bias towards the higher end of this range.

There are consultant firms that are individually rated as 'IT innovators' but few that are rated as 'IT unconcerned'. An interpretation to be placed on these generalised ratings is that Hong Kong consultants are 'IT active'. For example, the earlier parts of the questionnaire show that networked information technology is used by a large minority of the firms whereas CAD is used by a majority of the respondents.

Table 6-18 shows that they are not 'IT active' with regard to:

- 'Use of IT as part of strategic alliances';
- 'Participation of IT in forming business strategy';
- 'IT influence on marketing strategy';
- 'Use of IT systems in company';
- 'Objectives of IT strategy';
- 'Management of It in the future';
- 'CSF's for competitive advantage through IT';
- 'Level of R&D in IT';
- 'Importance of IT skills in the company';
- 'Awareness of IT strategy';
- 'Involvement of Users in IT strategy'; and
- 'risks associated with IT strategy'.

However, Hong Kong consultants are found to be 'IT innovators' with regard to:

- 'Impact of IT on clients';
- 'Periodic review of IT strategy';
- 'Characteristics of IT strategy'; and
- 'Who champions IT in the company'.

Hong Kong consultants are also 'IT unconcerned' about the 'nature of the IT department'.

The conclusion drawn from this analysis and carried forward to the next stage of the research is that the survey of the Hong Kong consultants shows that in general:

- **They are 'IT active'.**

6.8 Summary of the assessment of the portfolio management practices of Hong Kong consultants

This element of the research was carried out to qualitatively assess the current methods used by Hong Kong consultants to manage their portfolio-of-projects. The postal survey questionnaire described in Chapter Five was also similarly used in this case, but subject to minor changes of words that the adjusted the question to suit this sample population.

The sample population is taken from the directories of approved consultants kept by the ACSB and the EACSB of the HKG. The resultant population sample of 207 firms includes eight sample sectors, namely:

- 'architecture' (35 firms),
- 'building services' (17 firms),
- 'Civil engineering' (147 firms),
- 'landscape' (9 firms),
- 'structural [engineering]' (32 firms),
- 'quantity surveyors' (15 firms),
- 'consultants firms with ISO9000 certification' (100 firms), and
- 'consultant firms without ISO9000 certification' (107 firms).

In Chapter 3, Enright et al, note that, 'Hong Kong has around 1,400 firms engaged in a wide range of engineering and technical services, more than 500 firms active in real estate surveying, valuation, and consultancy, and around 400 architectural design firms. In the same Chapter, Rowlinson and Walker were cited as identifying that there is a two-to-one split between private and public sector construction work. They note that the government is the single largest client of the construction industry whereas developers predominate in the private sector. The population sample of 209 consultant-firms is therefore taken to be a significant proportion of the consulting industry of Hong Kong. The questionnaire was distributed to the sample population on 2nd, March, 1998. The seventy-one percent overall response to the postal survey is good and taken as indicative for the population overall. The sub-strata results are also taken as indicative based on the good sub-strata response and the high representation of the sub-strata within the sample-population. The response for the sample strata was not less than fifty-seven percent. The 'Building Services', 'Landscaping', 'and 'Quantity Surveying' sample sectors are not statistically large enough to support meaningful statistical analysis.

The conclusion drawn from Part One of the survey is that the Hong Kong consultants management of data and information is predominantly by traditional manual methods. The electronic transfer of digital information between assignment offices, head-office, and to other participants is not a commonplace mode of communication. The use of networked wide-area digital information systems by consultants is not uncommon. Whereas, the conclusion from Part Two of the survey is that project performance data/information is predominantly communicated in analogue mode using voice, or written media. 'Work', 'Time', 'Cost', 'Issue', 'Company' and 'Project' related project performance issues are transmitted to head office in the majority of instances but not 'Resource' related indicators to the same extent. E-mail is not used for the communication of project performance data/information except within a minority of consulting companies and mostly for work-content and time-related project performance indicators. The ten most important project performance indicators used are 'work-controls, costs, values, fees, quality, resources, time, *client-feedback*, manpower and staffing'.

Part Three of the Questionnaire is to measure how project data is added together to provide an overall view of what is happening within a portfolio of projects. Specifically, the research measures whether 'individual review', 'spreadsheet analysis', or 'database analysis' is the more commonplace method of data combination for the principal project management data types of 'work-content', 'time', 'cost', and 'resource'. From the survey results it is concluded that individual review and using spreadsheets are the most common processes adopted for combining together project data/information for assessing the performance of a portfolio of projects. Database processes are used less than the average: the degree of use varies within sectors of the population-sample. This element of the survey also identified the ten most important project-performance indicators used for assessing the well-being of a portfolio-of-projects in terms of work-content, time-related, costs-related, and resource-related aspects of the projects. These are listed on Table 6-20.

Work-content	Time-related	Cost-related	Resource-related
• quality	• work schedule	• valuation	• Staffing
• Project attributes	• work progress	• management factors	• facilities
• work progress	• completion factors	• cost of work	• IT
• Scope	• time	• fees	• resources
• costs	• information	• payments	• management factors
• client issues	• re-planning	• cost uncertainties	• cost
• management	• costs	• budget	• productivity
• deliverables	• project factors	• profit	• specialist services
• time	• milestones	• expenditure	• competence
• documentation	• manhours	• cost of resources	• manpower

Table 6-20 Summary of the ten project performance indicators of Hong Kong consultants for assessing the well-being of a portfolio-of-projects

These are in many cases broad descriptive terms of project date. They are derived from a series of open-ended questions within the questionnaire. The responses received vary in semantic form and phrasing. Dendrograms of these words and their derivatives from the responses received are exhibited in the 'Appendices CD-ROM' within Sections 6.7 to 6.11.

The fourth part of the Questionnaire concluded the Hong Kong consultants are 'IT active' and more advanced in the strategic use of I.T. than the contractor firms in the Hong Kong construction industry.

In general, this element of the research did not find evidence of the general use of a MIS that used project-level performance data to manage portfolios-of-projects. In this respect there was no notable degree of adherence to the precepts of Cleland and King.

6.9 References cited in the assessment of the portfolio management practices of Hong Kong consultants

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[1] Works Branch Technical Circular. 1995. WBTC 16/95. Selection and remuneration of Engineering and Associated Consultants. Works Bureau of the Government Secretariat of the Hong Kong Special Administrative Region of China.

Chapter Seven

7 A Longitudinal-grounded study of a Project-Management-Information-System (PMIS)

7.1 Introduction

This fifth element of the Thesis is a longitudinal-grounded case study of a change of working practice within the public works organisation of the HKG SAR that started in 1993/94. The change included an adjustment of working practices to place more emphasis on a project management approach to the delivery of the projects within the PWP. It included the introduction of a MIS that supported the project management approach and also provided for corporate control for the PWP portfolio of projects as a whole. These two objectives comply with the fourteen requirements for a project management MIS stated by Cleland and King. Refer to Table 2-6 where these requirements are listed with the corresponding ambitions of the HKG SAR for the MIS they deployed for the management of the PWP. By an examination of the before and after effects, the PWP MIS of the HKG SAR provides a unique opportunity to record an uncommon practical experiment that follows the precepts of Cleland and King. The suitability of this case study for the purposes of this research is previously described under Methodology in Section 2.7.

7.2 Chapter Outline

The research methodology is earlier described in Chapter Two, Section 2.7. Greater detail on this element of the research is provided in the 'Appendices CD-ROM' within Chapter Seven and cross-referenced to the text in this Chapter.

The layout of this Chapter is as follows:

- Section 7.3, of this Chapter describes the driver for a change in process that included the introduction of the MIS called the PW_MS;
- Section 7.4; describes the diversity within the PWP and thus the challenge inherent in it's management;
- Section 7.5 describes the procurement process of the HKG SAR for public works to be satisfied by the new approach;
- Section 7.6 summarises the chronological history of the management change with regard to the PW_MS;
- Section 7.7 describes the post implementation status of the PW_MS to establish its bona fides as a successful project/portfolio management tool;
- Section 7.8 compares the pre and the post implementation performances; and
- Section 7.9 provides a summary of this longitudinal grounded case-study.

7.3 Catalyst for improved management of the PWP

Consistent failure to match actual expenditure to the budgeted funds allocated for public works projects was the catalyst that caused a change to a more pro-active style of portfolio management of the PWP.

The Financial Secretary[1] stated in his 1994 budget speech, 'the objective measurement of success for the PWP is a match between actual CWRF expenditure and planned CWRF cashflow.' In 1992, he spoke of an eight billion Hong Kong dollar shortfall in expenditure due to underspending by the Government overall. He said that, 'The main reason for this shortfall in expenditure was an underspending of $5.6 billion [HK dollars] on public works'[2]. Examination of the Annual Report of the Director of Accounting Services[3,4,5,6,7,8] for the period 1987-1992 shows that expenditure on public works projects managed by the works departments was at least eighteen percent less than planned in each year. Table 7-1 shows the expenditure performance for the five years before the 1992 budget speech. The term 'Estimate' in the Table refers to the budgeted amounts published as part of the annual Appropriations Bill. During the financial year these may be updated to a 'Revised Estimate' to allow for new projects or for an increased scope of work. The data in the Table does not include spending on subvented

infrastructure projects or the many Category D public works items that cost less than $15 million Hong Kong dollars. The first section of the Table refers to year 1991-92 and includes, for illustration, the expenditure performance broken down to the Heads of Expenditure as well as for the overall expenditures. Thereafter, for brevity, only the overall expenditures are shown for 1990-91 to 1987-88. The greater detail is provided, if needed, in the 'Appendices CD-ROM' at Section 7.4.

Financial Year 1991-92	**Underspending (+ve)**	
PWP sub-heads ▼	Cf Estimate	Cf Revised Estimate
702 Port and Airport Development	48%	50%
703 Buildings	25%	36%
704 Drainage	25%	30%
705 Civil Engineering	38%	48%
706 Highways	13%	22%
707 New Towns and Public Housing not Housing Authority	34%	41%
709 Waterworks	42%	48%
Total for 1991-92 ⇒	**33%**	**40%**
Financial Year 1990-91	**Underspending (+ve)**	
	Cf Estimate	Cf Revised Estimate
Total for 1990-91⇒	**10%**	**29%**
Financial Year 1989-90	**Underspending (+ve)**	
	Cf Estimate	Cf Revised Estimate
Total for 1989-90 ⇒	**-15%**	**21%**
Financial Year 1988-89	**Underspending (+ve)**	
	Cf Estimate	Cf Revised Estimate
Total for 1988-89 ⇒	**-22%**	**18%**
Financial Year 1987-88	**Underspending (+ve)**	
	Cf Estimate	Cf Revised Estimate
Total for 1987-88 ⇒	**-18%**	**18%**

Table 7-1 PWP underspending in percent for per-PW_MS i.e., 1991-92 to 1987-88

In his 1993-94 Budget speech, the Financial Secretary[10] again commented upon the continued under-spending. He said that, "...half of the additional surplus is the result of capital under-spending. Members [of the Legislative Council] will not find this acceptable. Neither do I....It has to be faced the main under-spending is the result of slower progress with our capital works programme [the PWP] than we had planned".

Table 7-2 shows the extent of the percent PWP underspending within 1992-93 for each PWP head of expenditure.

Financial Year 1992-93	Underspending (+ve)	
PWP sub-heads ▼	Cf Estimate	Cf Revised Estimate
702 Port and Airport Development	19%	32%
703 Buildings	35%	43%
704 Drainage	36%	38%
705 Civil Engineering	34%	38%
706 Highways	17%	24%
707 New Towns and Public Housing not Housing Authority	19%	31%
709 Waterworks	27%	34%
Total for 1992-93 ⇒	**25%**	**34%**

Table 7-2 PWP underspending in 1992-93.

The Financial Secretary[20] announced an initiative to bring about an improvement in the delivery of the PWP. He told the Legislative Council of the need for,

- '. . .new measures to ensure that there is effective liaison between those who design projects, those who undertake land acquisition for them, those who monitor their environmental implications, and those who implement the works, and with the client Branches [now called Bureaus] or departments. This requires that overall management of public works becomes more unified.'

- '. . .So as to remove any doubt about where overall management responsibility lies, I have taken steps to place with the Secretary for Works overall responsibility for the implementation of the Public Works Programme.'

- '. . .To help fulfill his new responsibility for ensuring public works are delivered on time and within budget, the Secretary for Works will establish a more sophisticated, computer-based information and management system. This will link all the Works Departments and the relevant Branches. It should enable problems to be identified and solved at an earlier stage. And it will allow us to extend systems [scope-cost-time project control procedures] which have been used successfully in implementing the Airport Core Programme.'

- '. . .A new realism will characterise our estimates of project costs and progress in future.'

- '. . .we need . . .a thorough overhaul of public works procedures, practices and systems . . . to increase substantially our capacity to deliver projects on time and within budget.' '. . . I have asked the Secretary for Works to carry out an urgent review and to report to me by the end of June [1993].'

These demands were the driving force for change within the PWP process that included the fast-track implementation of the MIS in the form of the Cleland and King model. Given this mandate, the Secretary for Works appointed McKinsey Inc to undertake a review of the procedures, practices, and systems necessary to bring about the required improvement in the delivery of the PWP. The development of the MIS was an inextricable part of the Financial Secretary's demand for an improved approach to the management of the PWP. Nine months was the time allowed to bring about the changes demanded. It was thought not possible to implement in that brief a period of time a corporate MIS according to SSADM methodology or the SSADM/PRINCE[9] methodology of the HKG SAR Information Technology Department. Instead a rapid prototyping approach was to be adopted. Browning[10] of McKinsey and Co Inc.,and KPMG[11] have written guidelines for a rapid prototyping of a MIS to help bring about change within an established organisation. This did not allow for a SSADM analysis to define the functional requirements to be coded into the MIS. Instead the PW_MS was implemented in an ad hoc manner without a clear statement of the functional requirement. A literature search of the documents produced during the implementation is used to track the Owner's requirement for the PW_MS and their consequent inclusion in the prototype system, or not.

However, for the challenge to be understood it is first necessary to appreciate the scale and diversity inherent within the PWP and complexity of the PWP procurement process itself as these are unchanged by the new approach. These are described within the next two sections of this Chapter of the Thesis.

7.4 Scale and diversity of the PWP

A brief description of the PWP is provided in Chapter Two, Section 2.7. However, a discovery within the statutes and procedures of the HKG SAR described here establishes a useful operational-definition for the PWP and the responsibility for its management.

The Laws of Hong Kong Government, 'Interpretation and General Clauses Ordinance[12] provides the first mention of 'the Public Works Programme' (PWP). It appears in the subsidiary legislation to the Public Finance Ordinance[13] that was used to create the Capital Works Reserve Fund (CWRF) of the public finances of Hong Kong, for *inter alia* 'the purposes of the Government's public works programme'. When proposed in Legco it was stated that, '. . .the Financial Secretary may expend moneys from the [CWRF] Fund for the purposes of the Government's Public Works Programmme . . . '[14]. 'Public Works' are thus taken to mean 'engineering and building projects that are funded from the CWRF'. Whereas, Financial Circular No 8/90[15] states that the Public Works Programme (PWP) is, "a list of all public works projects of a non-recurrent nature and they are arranged according to . . . categories [of approved funding]". These categories are listed in Table 7-3.

PWP Category	Description of the category
D	• 'Projects estimated to cost up to the prevailing financial ceiling for Category D projects [currently HK$ 15 million) on which work may proceed and expenditure may be incurred, subject to availability of funds in the block votes provided for the purpose.'
C	• 'Projects which are accepted in principle [by the Chief Secretary's Committee] to enable client departments to plan their requirements.'
B	• 'Projects which are earmarked resources in the latest RAS exercise, or which have been chosen for a start in a previous Public Works Sub-Committee (PWSC) Annual Review but are not yet in Category A.'
A	• 'Projects which are ready in all respects for tenders to be invited and for construction works to proceed (save for projects directly injected in Category A), and which have approved project estimates.'

Table 7-3 Categories of PWP projects according to Financial Circular No 8/90.

To apportion accountability the PWP is also sub-divided into categories-of-cost called 'Heads of Expenditure'. Each one assigned a 'Controlling Officer'. This is defined in the Public Finance Ordinance. It states that the Controlling Officer is held responsible and personally accountable for the expenditure of the funds allocated to their Head of Expenditure or its derivatives called 'sub-heads'. These accountabilities are shown in Table 7-4, but there are complications that confound the clear assignment of responsibilities in some cases. For example:

- Several Directors are named as Controlling Officers in the case of Heads 702, 707, 708 and 711. Each will have responsibility for specific sub-heads within the Head;

- The roles and responsibilities of the Controlling Officers is not clear in all cases. For example, in Head 702 the Director of Territory Development is the Controlling Officer for 'tunnels and bridges' but in Head 711 the Director of Highways is Controlling Officer for 'transportation works', and for 'roads' in Head 702;.

- Head 710 ' Computerisation' does not fall within the definition of public works but these expenditures have a procurement cashflow similar to public works projects so they are included in the CWRF; and,

- Head 708 includes 'subvented' works projects that are funded by the HKG SAR from the CWRF for reasons of the public interest, albeit that they are for the purposes of quasi-HKG SAR organisations.

Head of Expenditure	Category-of-cost	Controlling Officer
701	• Land acquisition	• Director of Lands
702	• Port and Airport Development	• Director of Architectural Services • (food supply services) • Director of Civil Engineering (port works) • Director of Highways (roads) • Director, New Airport Projects Co-ordination Office (support) • Director of Territory Development (sewage treatment, land development, bridges and tunnels) • Director of Water Supplies (combined fresh/salt water supply)
703	• Buildings	• Director of Architectural Services
704	• Drainage	• Director of Drainage Services
705	• Civil Engineering	• Director of Civil Engineering
706	• Highways	• Director of Highways
707	• New Towns and Urban Area Development.	• Director of Territory Development • Director of Home Affairs (sewage treatment, roads and rural housing improvement)
708	• Capital Subventions and Major Systems and Equipment	• 31 Directors or equivalent officers are named with respective Controlling Officer responsibility for sub-categories-of-cost.
709	• Waterworks	• Director of Water Supplies
710	• Computerisation	• 24 Directors or equivalent officers are named with respective Controlling Officer responsibility for sub-categories-of-cost.

711	• Housing	• Secretary for Housing (block funds) • Director of Architectural Services • (building works) • Director of Civil Engineering (civil engineering works) • Director of Drainage Services (drainage works) • Director of Highways (transport works) • Director of Territory Development (territorial development works) • Director of Water Supplies (water supply works)

Source: Government of the Hong Kong Special Administrative Region, 1998[16]

Table 7-4 Capital Works Reserve Fund for the PWP divided in categories-of-cost called 'Heads of Expenditure'.

Table 7-5 shows the operational criteria used to determine which projects within the CWRF are recorded within the PW_MS for the purposes of the day-to-day management of the PWP.

Criteria for inclusion in the PWP MIS	Clarification
• CWRF funded project	• Excludes other Government owned Corporation works such as the mass transit railways.
• For clients within the HKG SAR	• Excludes subvented projects.
• For public works projects i.e., HKG SAR-funded engineering and building works	• Excludes land acquisition, equipment procurement and computerisation.
• Must be for specified projects	• Excludes catch-all items placed in a single 'block' item.

Table 7-5 Criteria for screening out non-construction elements of the CWRF.

The criterion in Table 7-5 screens out of the PWP all of the non-recurrent expenditure items within the following Head of Expenditure:

- Head 701 - Land acquisition transaction costs;
- Head 708 - Capital Subventions and Major Systems and Equipment; and
- Head 710 - Computerisation.

The projects within the PWP vary according to the policies of the HKG SAR and the consequent demand for infrastructure, but the scale of the portfolio is consistently large and has great diversity. Table 7-6 shows the high degree of diversity within the PWP at

March 31,1998. For further illustration if needed, Table 7-2 in the Appendices states the project diversity within the PWP for the period 1994-1999.

Diversity of projects	Statistics or frequency		
At 31 March, 1998 for the financial year 1998/1999	48 out of 72 categories of infrastructure		
	Statistics for frequency;		
	High	= 137	Nos
	Low	= 1	Nos
	Median	= 7	Nos
	Mode	= 1	Nos (6 instances)
	Mean	= 18	Nos
	SD	= 29	Nos
	10 most frequent categories of infrastructure		
	137	Nos	Civil Eng - Land development
	119	Nos	Roads
	78	Nos	Environment - sewerage
	62	Nos	Fresh water supply
	61	No	Secondary schools
	55	No	Primary schools
	36	No	Civil Eng - drainage and erosion
	33	No	Fresh/salt water supply
	27	No	Tertiary education
	25	No	Environment - refuse disposal

Table 7-6 Project diversity within the PWP for the 1998/99 financial year

7.5 The PWP procurement process

This Section of the Chapter is to describe the challenge inherent in the management of the PWP in terms of the procurement process. The process itself is delineated by the de jure allocation of authority for PWP-related decision making defined within the statutes of the HKG SAR. These define the decision-maker and the process.

The PWP of the HKG SAR is self-contained. The demand for public works stems from needs arising from the policies initiated by the Government. The funding of these policies, including the necessary public works, comes from the public funds administered by the HKG SAR according to the mandate stated in the Public Finance Ordinance. The needed public works are procured by the Works Departments of the Government. Other

government departments make essential inputs to the delivery of the public works. For example, land is supplied by the Lands Department, environmental approvals are granted by the Environmental Protection Department. Figure 7-1 shows this business arrangement in the form of a management triangle.

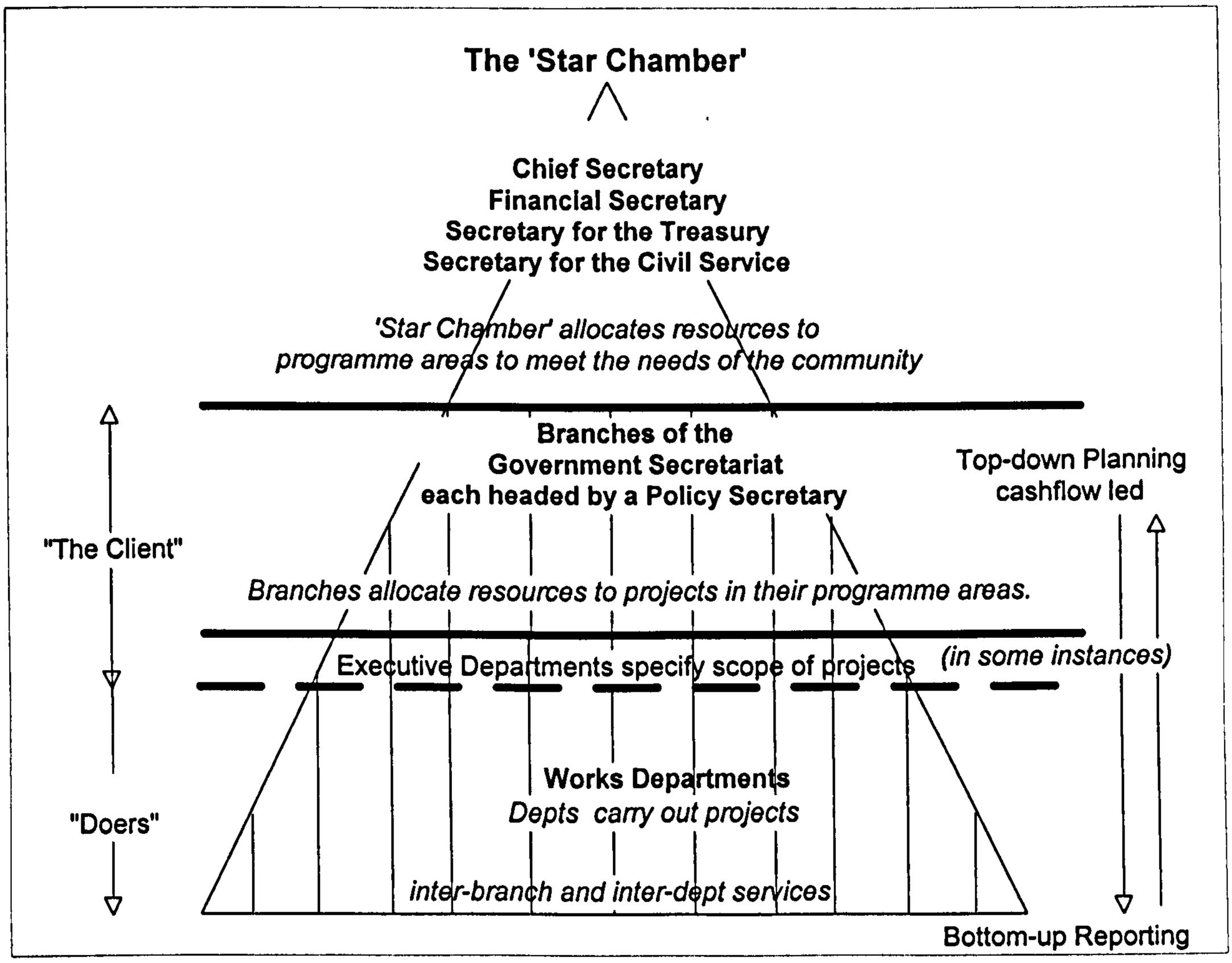

Figure 7-1 PWP management triangle, taken from the Public Works Project Controls Procedure 001[17].

The statutory framework for the PWP is founded on the Public Finance Ordinance[2] of the Laws of Hong Kong. This makes the Financial Secretary responsible for the management, supervision, control and direction of the financial affairs of the HKG SAR in keeping with the policies and the business of the HKG SAR. The setting of these business priorities, along with the allocation of the required resources, is the responsibility of the Chief Secretary's Committee. Colloquially known as the 'Star Chamber' it has a membership of the Chief Secretary, the Financial Secretary, the Secretary for the Treasury, and the Secretary for the Civil Service. Its role is to oversee

an annual Resource Allocation Exercise (RAE) that apportions the funds for recurrent and the capital expenditures of the HKG SAR that are needed to satisfy the policies approved by the Legislative Council (Legco). At six monthly intervals the Star Chamber reviews with the respective Policy Secretaries ('Ministers' in the English-model of government) the performance of, and the pressures on, their subordinate departments. This permits a readjustment of resource allocation and spending priorities where expedient[18]. Financial Circular No 8/90[4] describes this process of allocation of resources. It also introduces the main participants in the process and their responsibilities. Other procedures and documents published by the HKG SAR[19,20] further define the roles and responsibilities of the principal participants in the delivery of the PWP.

In 1996, it was explicitly stated that the Secretary for Works was formally held accountable to the Legco for the overall-delivery of the PWP[8]. The major participant roles identified in this statement of responsibilities and their mandate are laid out in Table 7-7.

Role	Mandate	Examples
CLIENTS	General Circular 8/90	Sec for Planning, Environment and Lands Sec for Transport Sec for Education and Manpower Sec for Economic Services Sec for Security Sec for Health and Welfare Sec for Works Sec for Home Affairs Sec for Housing Urban Council Regional Council
RESOURCE PROVIDERS	Public Finance Ordinance General Circular 3/98	Star Chamber Finance Bureau Finance Committee of the Legco
PROGRAMME MANAGER	Financial Circular 16/96	Sec for Works (for delivery of the PWP overall) Director of Architectural Services Director of Civil Engineering Director of Drainage Services Director of Environmental Protection Director of Home Affairs Director of Highways Director of Territory Development Director of Water Supply
PROJECT MANAGERS	PWP Technical Manual	Individual staff of the works departments assigned responsibility for delivery of specific projects
ENABLING AGENTS	PWP Technical Manual Civil Engineering Manual	Lands Department (for land supply) Housing Department (for squatter clearance)
STATUTORY CONTROLS	Civil Engineering Manual	Lands Department Planning Department Building Department Civil Engineering Department Environmental Protection Department

Table 7-7 Major participant roles in the PWP.

The data that flows between these principal participants is a function of their roles and their responsibilities. The results of an analysis of the physical process along with items such as the roles and responsibilities for data, is captured in the data-flow diagram in Figure 7-2.

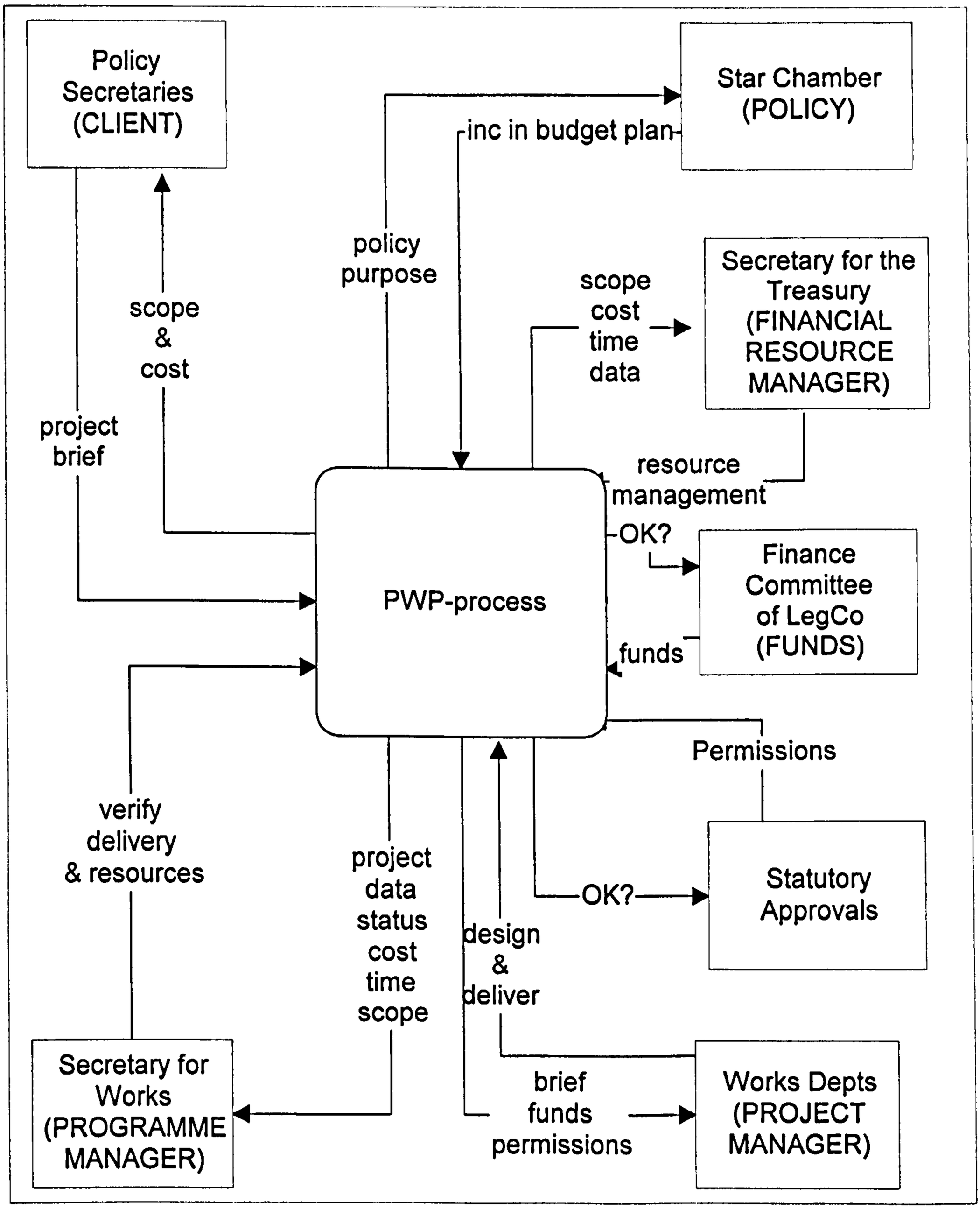

Figure 7-2 Data flow between the major participants in PWP delivery, taken from the Public Works Project Controls Procedure 001.

Whereas Figure 7-3, shows the integration of the principal roles in the use of the MIS introduced in 1994 for this purpose and named the 'Public Works Management System' (PW_MS).

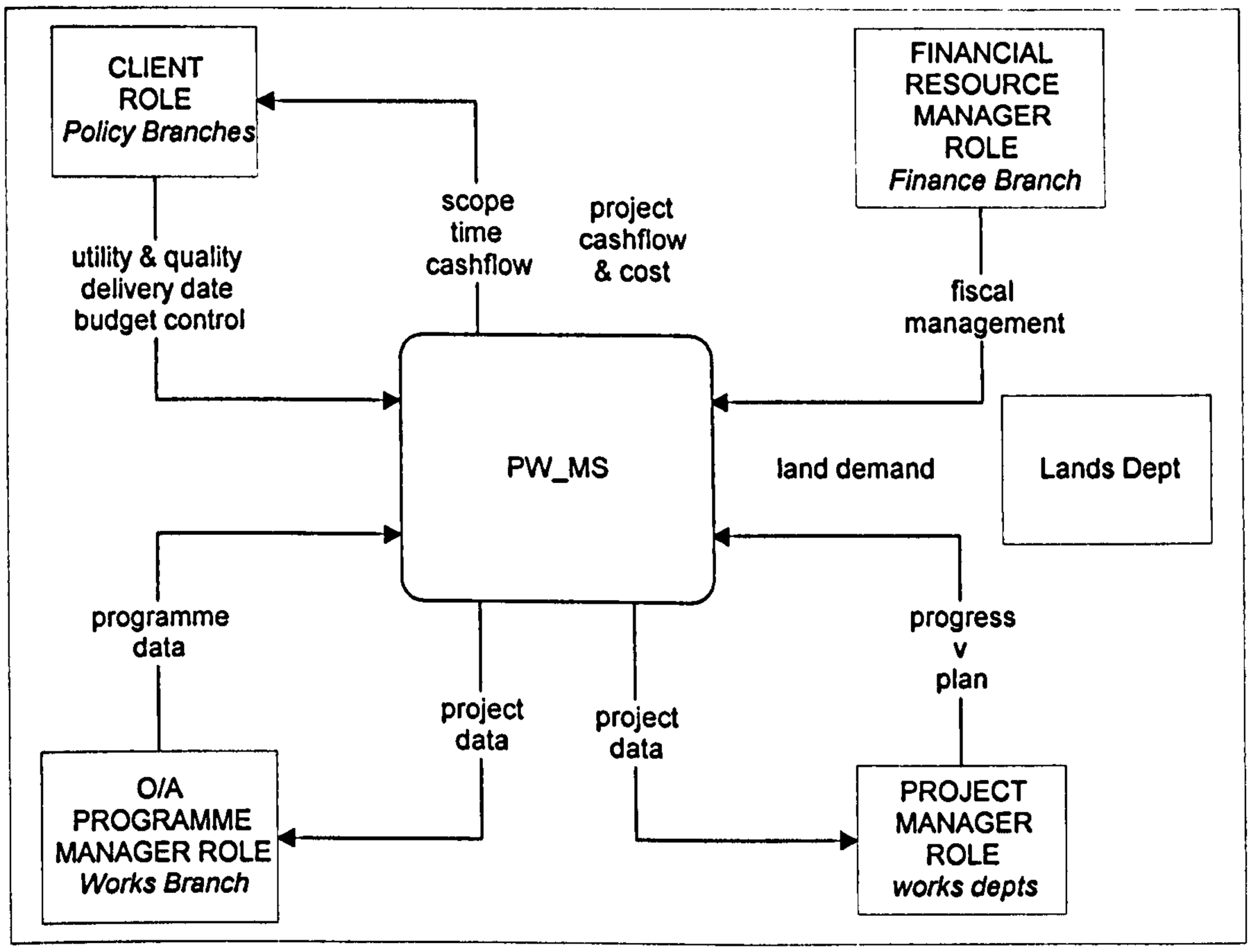

Figure 7-3 Integration of the major participants in PWP delivery via the MIS, taken from the Public Works Project Controls Procedure 001.

The responsibilities of these four 'generic' major-participants, the 'client-role', the 'Financial-resource Manager-role', the 'overall Programme Manager-role', and the 'Project Manager-role' are also defined within the Government procedures. They are further described in the 'Appendices CD-ROM' within Section 7.3 if needed to further assist in understanding the roles and responsibilities involved in the PWP procurement process.

7.6 Chronological history of the management change introduced within the PWP process

7.6.1 Longitudinal-grounded case study of the PW_MS

The Secretary for Works of the Government Secretariat gave permission for a discovery research-process within the files of the Works Bureau on the topic of the implementation

of the PW_MS. Different sources have been examined where possible to triangulate opinion found within the registry of files.

The purpose of this section of the research is to document the owner's requirements for the PW_MS and to measure the degree that they are provided in the PW_MS. This is difficult to do because a clear statement of the functional requirement for the PW_MS does not exist. A series of authoritative documents produced throughout the early history of the PW_MS contain statements of requirement. Some requirements were not pursued as presumably the perceived need faded away. Other requirements achieved greater importance over time. Some requirements were dropped because of time and cost constraints. In the absence of a final statement of functional requirement, and because the management debate during implementation reflects subjective attitudes toward the implemented system, the emerging requirement is traced in chronological order and audited against the physical system. The inception and early development of the PW_MS is recounted in terms of the decisions and objectives of the day to explain them in the context the evolution of the PW_MS. It also illustrates changes of intent dictated by the prevailing environmental circumstances.

The finer-details of this research is recounted in the 'Appendices CD-ROM' within Section 7.5. A synopsis of that work is provided here.

7.6.2 Implementation of the PW_MS

Using a systems approach of diagnostic analysis[21], the implementation of the PW_MS is seen to follow three fundamental stages of development: conception, inception and construction. Key decisions were made between these stages. These determined the nature of the system and how it was introduced into the public works organisation of the HKG SAR.

The key-decision that defined the end of the PW_MS conceptual work, was the public announcement by the Financial Secretary of the initiative for a 'project management

approach to delivery of the PWP'[20]. The characteristics of the earlier conceptual work on the PW_MS are identified as:

High degree of corporate leadership and commitment due to:

- Leadership and commitment to achieve an early implementation of a project/portfolio management information system called the PW_MS, was driven from the highest levels of authority within the HKG SAR;
- The PW_MS was publicly announced within the context of the 1993/94 budget as a major component of Government policy for effective management of the public works programme;
- Implementation was steered in a transparent fashion by high-ranking government officials at ministerial level, respected leaders of the construction industry, and by politicians with appropriate cognate experience;
- A powerful consensus of the Directors of the Works Departments had confirmed their support of the initiative; and,
- McKinsey Inc., were hired to assist in this undertaking.

Business drivers for change were paramount to all other considerations due to:

- The cost of the MIS was not an issue but the urgent need for a useable system was a predominant concern as the Financial Secretary had already stated that it would be in operation within nine months;
- Within this timeframe, the development of a customised MIS using SSADM and PRINCE methodologies was agreed as not practicable;
- The PW_MS was conceived as a critical-success-factor in the business of project/portfolio procurement. The information technology involved was a secondary consideration; and as a consequence,
- The project was lead as a business initiative by the business leaders with most to win from its success.

No apparent concern for detail due to:

- The functionality of the MIS was not clearly stated, other than it would serve as an aid to the project management of the public works projects and would thus enable the Secretary for works to manage the whole of the PWP so as to match actual expenditure to budgeted funding.

The decisions made within the inception stage of the implementation were founded on the objectives and the constraints announced earlier by the Financial Secretary. McKinsey Inc became the prime-movers for the fast-track implementation and imposed strategies that would fulfill the requirements of the conception. The identified characteristics of the inception stage of the PW_MS implementation are identified as:

Moderate degree of corporate leadership and commitment due to:

- The leadership and commitment from the highest levels of authority, evident at the conception stage to achieve an early implementation of the PW_MS, was now content to subordinate their authority to McKinsey Inc who had been appointed with responsibility for recommendation and implementation; and
- The tendency to delegate-down decisions on detail but retain a 'steering' authority on the 'big-picture' became irrelevant as the importance of the detail outweighed other considerations.

Business drivers for change were paramount to all other considerations due to:

- Definition using SSADM methods of a minimum set of functionality for the PW_MS was not achieved due to the Client's fixation on preserving the existing core-process of PWP procurement, some of which was enshrined in Hong Kong legislation;
- Selection of a UK-based proprietary software as the 'best-fit' solution that none-the-less required customisation to suit the Client's needs was a courageous decision that imposed managerial challenges in coordinating communications, understanding, and the production of software deliverables in the UK for issues arising in Hong Kong.

No apparent concern for detail due to;

- Implementation of the PW_MS using a rapid-prototyping approach was determined as essential to bring the MIS into operational service within a nine-month project period;
- Selection of a best-fit proprietary software solution was expedient and in keeping with the rapid prototyping, but it resulted in conforming the problem to fit the solution; and,
- Lack of consultation with the Users on the adoption of software and by default, the Functionality, caused a lack of 'ownership' from the User community with regard to the change in the PWP delivery process. Resistance to change at the middle-management level became an issue from this moment forward.

The award of a contract to develop the pilot system using a uniquely-customised version of Panorama© software without agreeing a detailed final specification of Functional Requirement was the second key decision. It delineated the end of inception and the start of the construction stage of the PW_MS implementation. It permitted a high-degree of flexibility in determining the 'minimum-core-requirements' of the initial PW_MS. The identified characteristics of the construction stage of the PW_MS implementation are:

Lesser degree of corporate leadership and commitment due to

- The leadership and commitment from the highest levels of authority evident at the conception stage to achieve an early implementation of the PW_MS was further reduced to the extent that decision-making on 'technical' issues was substantially delegated to the consultants.

Business drivers for change were NOT paramount to all other considerations due to:

- The functional specification for the PW_MS was dictated by what was possible within existing constraints rather than desirable, excepting for a 'core' minimum set of requirements.

No apparent concern for detail due to;

- Retrospective user-consultation showed dissatisfaction with the PW_MS functionality and performance; and,
- Retrospective SSADM analysis showed lack-of-fit between desired and delivered functionality.

In respect of the objectives of the implementation the PW_MS is considered a success. The ambition for operational service within nine-months, although challenging, was accomplished. It was understood from an early stage that post-implementation development would be needed to fully establish the innovative system within the established public works organisation. The technical system that was built is described in the 'Appendices CD-ROM within Chapter 7, Section 7.6' for a more detailed understanding of the PW_MS if needed. Greater descriptive detail on the project/portfolio management functionality is also provided in the CD-ROM in Section 7.7.

7.7 The functional status of the PW_MS at 5-years post-implementation

The following sub-sections provide a critique of the functionality found within the PW_MS compared to the objectives. The items shown in red text are functional objectives not met within the system at 5-years post-implementation.

7.7.1 Access to the PW_MS

McKinsey proposed, and the Steering Committee accepted, the following objectives for user-access to the PW_MS;

- 'The PW_MS is to link all the Works Departments and relevant Branches'[22]. . . Serving 3 constituencies: policy bureaus, works departments, and enabling departments[23].'
- Policy Secretaries [Clients] to have a terminal per bureau[29].
- Works department access to a terminal at every level down to engineers/architects[29].
- Recommended number of terminals is 256 by early 1995[29].

Currently the PW_MS has 168 terminals. Eight are dedicated to hands-on PW_MS training that takes place within a training version of the system. The remaining 160 terminals are for operational access to the PW_MS. The distribution of these terminals is shown in Table 7-8.

Location	Terminal	Comment
Works Bureau	30 No	Including training room, distribution in WB (PWSAU operations control, PMU, PAT, INCO, FU)
Finance Bureau	5 No	DptySec, and Works Div
PEL Bureau	1 No	One of the PWP client/policy bureau
Health and Welfare Bureau	1 No	One of the PWP client/policy bureau
Housing Bureau	1 No	One of the PWP client/policy bureau
Security Bureau	1 No	One of the PWP client/policy bureau
Education and Manpower Bureau	1 No	One of the PWP client/policy bureau
Economic Services Bureau	2 No	One of the PWP client/policy bureau. 1 assigned to port development
Transport Bureau	1 No	One of the PWP client/policy bureau
Audit Department	1 No	At their request – to review PWP projects
Lands Department	12 No	HQ and DLO's
Urban Services Department	1 No	At their request and at their cost.
Housing Department HQ	1 No.	At their request and at their cost.
Architectural Services	17 No	At HQ and Project Management Branch
Civil Engineering	16 No	Dispersed to Divisions
Drainage Services	15 No	Dispersed to Divisions
Environmental Protection	5 No	Dispersed into activity areas
Home Affairs Department	1 No	In works division
Highways Department	19 No	Dispersed to Divisions
Territory Development	21 No	Dispersed to Divisions
Water Supplies	16 No	Dispersed to Division

Table 7-8 Distribution of PW_MS terminals

Table 7-9 shows the terminal/project ratios for each of the departments measured in May, 1998.

Works Department	No. Terminals	No. PWP projects	Projects/Terminal
Architectural Services	17	548	42:1
Civil Engineering	16	64	4:1
Drainage Services	15	128	9:1
Environmental Protection	5	32	6:1
Home Affairs Department	1	41	41:1
Highways Department	19	149	8:1
Territory Development	21	355	17:1
Water Supplies	16	133	8:1

Table 7-9 Ratio of PWP projects to PW_MS terminals in the works departments

Although the objective for ease-of access to the PW_MS is not stated in quantifiable terms, the distribution and number of terminals in the Architectural Services Department is regarded as inadequate[24]. According to a written report produced in January, 1999[30] the accuracy of the timeplan, scope and diary data of Architectural Services projects, along with the timely updating of information, are a concern to the PWSAU. The same report indicates satisfactory performance by the other works departments. This is taken as evidence of adequate provision of PW_MS terminals distributed to the user community with the exception of the Architectural Services Department.

7.7.2 Ease-of-use of the PW_MS

The PW_MS meets the target requirements for a 'MS.Windows®' type operation that uses pull-down menus and selection-lists so that it can be 'mouse' driven as far as possible. However, the UNIX operating system does not allow an online help system to be provided with the software. This is a shortfall in the specified user requirement for the PWP MIS. Users of the PW_MS have at their meetings and in the SSADM interviews complained that it is difficult to use[25]. These complaints fall into two categories:

- The PW_MS is complicated and therefore difficult to use; and
- The PW_MS is slow and tedious to use compared to other PC software including the works department PC-databases used for project-management purposes.

These issues are further investigated in a qualitative survey of PW_MS users described in Chapter Eight.

In response to these complaints the PWSAU noted in its report to the Secretary for Works[26] that,

> 'the PW_MS is more difficult to use on a routine basis, compared to most PC-based word-processing or spreadsheet software. Its response is much slower than PC's and it uses a high degree of project management jargon. Further effort within the software is unlikely to increase the speed and the ease-of-use of the PW_MS'.

As a remedy, they proposed :

- increasing user skills within the software by training,
- increasing project management expertise by training,
- modifying the software to remove the lack-of-fit between the software and the functional needs; and
- modifying current practices so that the PW_MS is used as the single source of PWP data for RAE and Estimates purposes. Thereby stopping the frequent separate submission exercises in which ad hoc changes to project plans are proposed by works departments and accepted by policy bureau/finance bureau.

Some of these initiatives have been carried through. The PWSAU has developed two, User-training manuals: one on the PW_MS in general, the other is on the subject of project and programmme-area reports that are available from the PW_MS. They have also developed three User-training courses to suit categories of PW_MS users. Training records kept by the PWSAU show that since the start of PW_MS operations in 1994, four hundred and twenty two persons have received hands-on user training and one hundred and seventy-six other users have received executive user training. 'Train-the-trainer' teaching to create a number of persons suited to carry out in-house training resulted in thirty-seven individuals being prepared for this task. Only three carried out in-house training for a short period of time. This reluctance caused the 'train-the-trainer' classes to be discontinued by the PWSAU. A 1998 survey of demand for continued PW_MS training measured a requirement for the training of two hundred persons per annum with regard to 'hands-on user' and 'PW_MS reports' training, plus one hundred person per

annum for 'Executive User' training. Further assessment of User efficacy for the PW_MS is assessed in Chapter Eight.

7.7.3 Production of information from the PW_MS

The fundamental requirement of the PW_MS is that it must feed information to managers so that the PWP projects and the programme of projects is executed with efficiency and effectiveness. The Preliminary Functional Specification[29] accepted by the Steering Committee, states that 'customised reports should be [created] without programming [expertise]'. In practice, the PW_MS can provide information on the PWP and it's projects in three ways:

- From an inter-active use of the PW_MS when information is presented on the PW_MS screens;
- From the PW_MS reports; and
- From data taken from the PW_MS database and imported via a pre-programmed data download into other software for re-use.

There is a limited flexibility to improve the production of information from the PW_MS. The constraints are:

- Writing the PW_MS paper reports requires a high degree of knowledge of the PW_MS, expertise in computer programming, and detailed knowledge of the Oracle database;
- Writing PW_MS screen reports requires access to computer coding that is only possible technically and legally by PSCL;
- In some areas, particularly baseline date information, the data required for meaningful reports is not recorded within the PW_MS[25].

It is worth noting that the SSADM consultants recommended that an improvement in the flexibility of producing information was possible by a data-download into other report writing software. In 1998 the PWSAU implemented this solution with a limited data-download into a FoxPro™ database. The consultants[31] also recommended the introduction of data-warehouse techniques so that flexibility in report writing is also achieved, namely,

- Reports are more straightforward to produce by non-programmers and PW_MS users;

- The report is automated when produced so that the next time it is required a simple command produces the report;
- The reports are released to all users, so that reports written by the PWSAU can be created for the PW_MS community;
- It is free of the slow-response and hard-to-use aspects of the PW_MS;
- Other data sources can be married to the PW_MS data to produce reports hitherto impossible to achieve;
- It is an approach used elsewhere in the Government;
- The software is available using Government's bulk contracts administered by ITSD.

The Works Bureau has not agreed to implement a data-warehouse on the PW_MS network although the PWSAU has also recommended that it be done.

7.7.4 Use of information from the PW_MS

The PWSAU[26] intend that the PW_MS should provide useful information to:

- the works departments;
- the enabling departments;
- client bureaus; and
- the managers of the PWP – primarily the Secretary for Works and the Secretary for the Treasury.

It is also intended that the PW_MS should be the single source of bona-fide consistent data on the PWP and its projects. The Works Group of Directors[27] agreed in 1995 that the PW_MS should be used so as to be the source of PWP data by project and by programme. It is difficult to measure the degree of use of PW_MS information by the works departments and the enabling departments. PW_MS statistics given in the 'Appendices CD-ROM' within Section 7.8 measure the number of times a report is printed at user request. They show a high degree of use of project-level reports. User representatives state their acceptance of the data download facility but have asked for improvement and a greater range of data to be made available to them. The effectiveness of the PW_MS in this respect is more objectively measured by the post-implementation changes in the performance of PWP delivery described in Section 7.8, and by qualitative measurement of User satisfaction for the PW_MS as reported in Chapter Eight).

7.8 Results of the change in the PWP process

Public statements from Government officials regarding the change in PWP performance attributed in part to the PW_MS are stated in Section 7.8.1.

A comparison of PWP actual and budgeted expenditures and the consequent outturn performance for the PWP for five years before and after the PW_MS implementation is in Section 7.8.2.

7.8.1 Post-change performance measurement

On the 17th March, 1999, the Secretary for Works stated in his annual report to the Special Finance Committee Meeting of Legco[28];

> 'Last year, we successfully reduced under-expenditure from 36% in 1991/92 to about 6% in 1996/97. In this financial year [1998-97], we have further reduced the under-spending on PWP to around 5%. These figures exclude the purchase of properties and land. In the next financial year, we estimate that the expenditure on public works will be maintained at a level comparable to that of last year. We budget to spend about $22.8 billion and start 93 new PWP projects.'

This was queried further in a written/supplementary question to the Secretary for Works[29] when he was specifically asked,

> 'For project A002XZ [the PW_MS], comparing the actual expenditure with the original estimate, what were the percentages of underspending of the Public Works Programme in the past few years since the implementation of this system? Has the Government carried out any review to ascertain whether the system is cost-effective or not?'

The written reply by the Secretary for Works[35] provided the annual percent underspending excluding land acquisition and purchase of premises shown in Table 7-10.

Financial Year	Underspending %
1994-95	6.3
1995-96	9.1
1996-97	6.1
1997-98	3.4
1998-99	4.5 (estimated)

Table 7-10 Percent underspending on the PWP for the period 1994-95 to 1998-99. (Kwong, 1999b)

By the end of April 1999, provisional figures indicated an underspending on the PWP of 1.4%. This was the best performance achieved in ten years[30]. The record of the speaking notes of the Secretary for Works for the Special Meeting of the Finance Committee included a statement regarding the PW_MS, under the heading '. . . regular reviews of the on cost-effectiveness of the Public Works Management System':

> 'The system is an effective tool for project management. There has been a sustained trend of improvement in PWP spending (i.e. to a level below 5%) since implementation of the system. The output and benefits produced by the system are being monitored.'[34]

Table 7-11 gives more detail to this official message of satisfaction with the effectiveness of the PW_MS. The figures are taken from the annual reports on public expenditure[31,32,33,34,35,36] subsequent to the implementation of the PW_MS in 1992-93. More detailed breakdown of these figures, if needed, to show spending performance in terms of the Heads of Expenditure is provided in the 'Appendices CD-ROM' within Section 7-9.

Financial Year 1993-94	**Underspending (+ve)**	
Estimates	Cf Estimate	Cf Am'd Estimate
Total outturn for 1993-94 ⇒	**-3%**	**24%**
Financial Year 1994-95	**Underspending (+ve)**	
Estimates	Cf Estimate	Cf Am'd Estimate
Total outturn for 1994-95 ⇒	**6%**	**23%**
Financial Year 1995-96	**Underspending (+ve)**	
Estimates	Cf Estimate	Cf Am'd Estimate
Total for 1995-96 ⇒	**3%**	**27%**
Financial Year 1996-97	**Underspending (+ve)**	
Estimates	Cf Estimate	Cf Am'd Estimate
Total for 1996-97 ⇒	**12%**	**25%**
Financial Year 1997-98	**Underspending (+ve)**	
Estimates	Cf Estimate	Cf Am'd Estimate
Total for 1997-98 ⇒	**6%**	**21%**
Financial Year 1998-99	**Underspending (+ve)**	
Estimates	Cf Estimate	Cf Am'd Estimate
Total for 1998-99 ⇒		

Table 7-11 PWP underspend in percent for 1993-94 to 1998-99

7.8.2 Comparison of pre and post change measurement

The measure of improvement achieved over a five-year pre-implementation period and also the post-implementation period is shown in Table 7-12.

Year	Cf. Estimates	Annual Difference	Cf. Rev Estimates	Annual Difference
87-88	18%	-	18%	-
88-89	22%	4%	-18%	0%
89-90	15%	-7%	-21%	-3%
90-91	-10%	-25%	-29%	-8%
91-92	-33%	-23%	-40%	-11%
92-93	-25%	+8%	-34%	6%
93-94	3%	+28%	-24%	10%
94-95	-6%	-9%	-23%	1%
95-96	-3%	3%	-27%	4%
96-97	-12%	-9%	-25%	-2%
97-98	-6%	6%	-21%	4%

Table 7-12 Comparison of spending performance pre and post PW_MS implementation in 92-93.

Over the five-year pre-implementation period, 1987/88 – 1991/92, the outturn spending on the PWP overall, increased year-on-year, to peak at a 33% underspend of the target budget for public works stated in the published Estimates of the Hong Kong Government. For the same period, the outturn performance against the 'Amended Estimates' increased to a peak of 40% underspending. In 1992/93 the peak figures decreased to 25% and 34% underspending respectively.

Over the five-year post implementation period, 1993/94 – 1997/98, outturn spending compared to the published Estimates decreased to 3% overspending within one year and thereafter averaged 5.25% under-spend with a mode of 6% under-spend. The comparison of outturn spending to Revised Estimates shows a decreased under-spend from 34% to 24% underspending. The average underspending over the five-year period is 24% with the best performance of 21% underspending being achieved in 1997/98.

These figures provide quantitative measurements of an improved outturn performance after 1992/93 when the management approach for PWP spending was changed. Achieving at least a three-fold improvement in spending performance compared to the five-year period before 1992/93.

A similar improvement was not achieved for spending performance measured against the Revised Estimates. In this case the pre and the post implementation performance was poor. Revision to the published Estimates takes place throughout the financial year. The PWP management process and the PW_MS take the latest approval of the Finance Committee as an approved change to the baseline programme of the project even though they are too late in the year to be managed successfully. Hence, the outturn comparison for the financial year against the Revised Estimates is not a good indicator of satisfactory project management. Late changes in the Estimates can be due to the introduction of new projects into the programme to meet urgent policy needs, or revised scope, timing, and/or costs of existing projects due to changes in client requirement or problems with the projects themselves.

The figures in Table 7-12 indicate that the management of the PWP improved in the five year period after 1992/93, from the year that the Hong Kong Government imposed new practices and processes for the management of the PWP. There is no proof that this improvement is due to the PW_MS: although it is recognized that the PW_MS is an intrinsic and essential part of the new management approach.

7.9 Summary of the longitudinal-grounded study of a PMIS

This Chapter of the Thesis is a longitudinal-grounded case study of the implementation of a MIS within the public works organization of the HKG SAR. It has provided practical experimentation through the quantitative measurement of 'before' and 'after' effects of a change in management techniques that was substantially dependent upon the introduction of a novel MIS that conformed to the Cleland and King model for a portfolio-management-system.

It is a suitable case study of a working practice experiment for several reasons. One, the requirement for change and the subsequent implementation is documented in correspondence files that allow the triangulation of supporting statements. Two, the system has been in operation for five years, long enough to become an established operational practice so that the user response to a questionnaire survey are based on norms of performance. Three, there are quantitative records of PWP performance before and after the change that provide a measurement of the impact of the change. Four, there is a population sample of five hundred and ninety three registered users of the MIS. This sample size is large enough to provide statistically robust measures of user satisfaction. Five, the PWP is made of individual projects whose impact on the portfolio overall is mutually exclusive. The lack of interrelationship between projects means that the performance of one project has no impact on others. Finally, six, the change of management approach was rapid: in the form of a 'big-bang' change to replace the predecessor process. This reduces confusion due to the overlap of processes that would occur in a gradual introduction of change. The new approach was universally introduced

within a large organisation delivering more than fifteen hundred varied projects within an overall portfolio-of-projects of singular known objective. The results are consequently broad-based, thus providing robust measurement of effect.

The leadership for a change in approach in the management of the PWP was from the senior-levels of the HKG SAR. The need for change was driven by unacceptably high levels of under-spending of the funds allocated to public works. In his 1993-94 Budget speech, the Financial Secretary reported that he was no longer tolerant of the trend of continuing under-spending. He went on to announce the initiative for an improvement to the delivery of the PWP that included the PW_MS. Whilst the vision for the PW_MS was clear, the detail was unspecified. The functional requirements for the MIS developed over time. A triangulated-search of the case files held by the Works Bureau of the HKG SAR has been used to identify the evolving functional requirements for the PW_MS and their delivery. An audit of the implemented PW_MS against the specified functionality is used to measure the extent that the PW_MS meets the stated needs of the project/portfolio management system.

Due to time constraints a rapid prototyping implementation was used instead of more definitive SSADM methodologies. As a result, the PW_MS was implemented in an ad hoc pragmatic manner without a clear statement of the functional requirement. Table 7-13 shows the variation in the Owner's participation in the implementation.

Aspect ▼	Conception	Inception	Implementation
High level leadership and commitment	H	M	L
Business drivers are paramount	H	H	M
No apparent concern for detail	L	H	L

Table 7-13 Owner's involvment in the PW_MS implementation.

Proprietary software was selected that was the closest fit to the problem. Gaps in the functionality of the software were bridged with customised-coding of the product commissioned from the manufacturer. The pilot system implemented was a sub-set of the total ambition described in the Preliminary Technical Specification for the PW_MS. It comprised the core PW_MS functionality: 'baseline management and reduced scope

change; exception generation and corrective action planning; generic templates for work-scheduling; work progress tracing using timesheets; annual resource planning process using aggregates of resource demand and availability.' Other desirable functions were to be delivered in subsequent stages of development. This did not take place.

McKinsey Inc., completed their assignment on January 31, 1994 having managed the customisation of the core PW_MS software and the installation of a 50 terminal wide area network in a short period of time from November 1993 to the end of January 1994. The core-prototype PW_MS became operational in May 1994. However, the fifty-six terminals in the core-prototype PW_MS network were too few to provide enough access points for the regular update of project data. The system response was very slow, making it frustrating to use the software, and few people were trained in the operation of the PW_MS or the concepts of project management. To overcome some of these problems the core-prototype was rapidly expanded so that it would be equipped with a sufficient number of terminals distributed to system users so that data updates and report generation can take place quickly enough to produce timely progress reports and monitoring of projects. Adjustments to the software to remove the weaknesses recognised during prototyping were not fully implemented. This second stage of PW_MS implementation was carried out according to I.T. professional standards. ITSD appointed James Martin Ltd., information technology consultants, to this role. They were instructed to apply SSADM techniques as far as possible and work to PRINCE methodologies to provide an unbiased professional opinion on the 'weaknesses recognised during prototyping' and the status of the prototype PW_MS overall. The Final Report of 'Selected Business System Options'[25] identified the 'lack-of-fit' between the things the PW_MS could do, when compared to the things that needed to be done. These were the failings in the existing system that most threatened its viability in use. The IT contractor advised that, in the short term, these lack-of-fit' issues must be fixed to maintain an on-going service from the PW_MS. In the long term, the contractor recommended an early start to a fundamental re-development of the PW_MS. Irrespective of these detractions the PW_MS has remained in operational service, largely unchanged, since May 1994.

With regard to the management results obtained from PW_MS, the figures in Table 7-12 indicate that the management of the PWP has improved in the five-year post implementation period. In 1999, at the Special Meeting of the Finance Committee, the Secretary for Works said that there had been a sustained trend of improvement in PWP spending i.e., to a level below 5% since implementation of the system. After 1992/93, the management of PWP spending over a five-year period improved to the extent that the annual outturn was approximately 6% on target. At least a three-fold improvement in spending performance compared to the five-year period before 1992/93. There is no proof that this improvement is due to the PW_MS: although the PW_MS is an intrinsic and essential part of the new management approach.

7.10 References of the longitudinal-grounded study of a PMIS

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Chapter Eight

8 A qualitative survey of user satisfaction with the case-study PMIS

8.1 Introduction

The implementation of the PW_MS within the public works departments of the HKG SAR is deemed a success because of the overall improved performance achieved in the delivery of the PWP. There is no measure of the quantum of improvement attributable to the PW_MS. This element of the research is to assess the operational-value of the PW_MS in helping to deliver an improved overall performance for the PWP. Qualitative postal survey techniques were used to measure the User satisfaction with the PW_MS as a project/portfolio management MIS according to the proposition of Cleland and King.

Chapter Outline

This Chapter describes a qualitative postal survey of a representative population sample of the registered Users of the PW_MS. The methodology for the development, testing and the validation of this questionnaire survey is described in Section 2.8 in Chapter Two, whereas the derivation of the representative population-sample is described in Section 2.8.1. This Chapter is laid out as follows:

- Section 8.2 of this Chapter describes the conversion of the lines of enquiry into the questionnaire instrument. A commentary on the questions within the questionnaire is provided within the 'Appendices CD-ROM' in Chapter Eight. A copy of the questionnaire used is also appended;
- Section 8.3 describes the population sample;
- Section 8.4 of this Chapter states the response received;
- Section 8.6 refers to the analysis of the response;
- Section 8.6 details the results of the research and those points that will be primarily carried forward to subsequent studies; and
- Section 8.7 provides a summary of what has been found during the research.

8.2 Conversion of the research topics into questions

As explained in Section 2.8.2, there are four fundamental areas of investigation to be surveyed. These are repeated here in Table 8-1.

	Stated objective	Underlying purpose
PM_Utility	• Determine the extent that the PW_MS is used for the management of individual projects	• Measures the redundancy within the PW_MS.
Folio_Utility	• Determine the extent that the PW_MS is used for the management of PWP portfolios-of-projects	• Measures the effectiveness of the PW_MS.
Other_Means	• What other means are used for PM_Utility and Folio_Utility functions	• Measures the need that is unsatisfied by the PW_MS.
MIS_Functionality	• To identify the requirements for an improved MIS.	• Statement of Functional Specification for Folio MIS.

Table 8-1 Four topics of research to be included in the questionnaire of the HKG SAR public works departments.

8.2.1 Breakdown of Respondent_Attributes into Questionnaire topics.

The hierarchical breakdown of this element of the questionnaire into question topics is presented in Figure 8-1. Recording the role and activity of the respondent is important because of the diversity in these attributes within the population sample. Section 2.8.1 explains the methodology employed in the derivation of a representative sample-population and its sub-sectors.

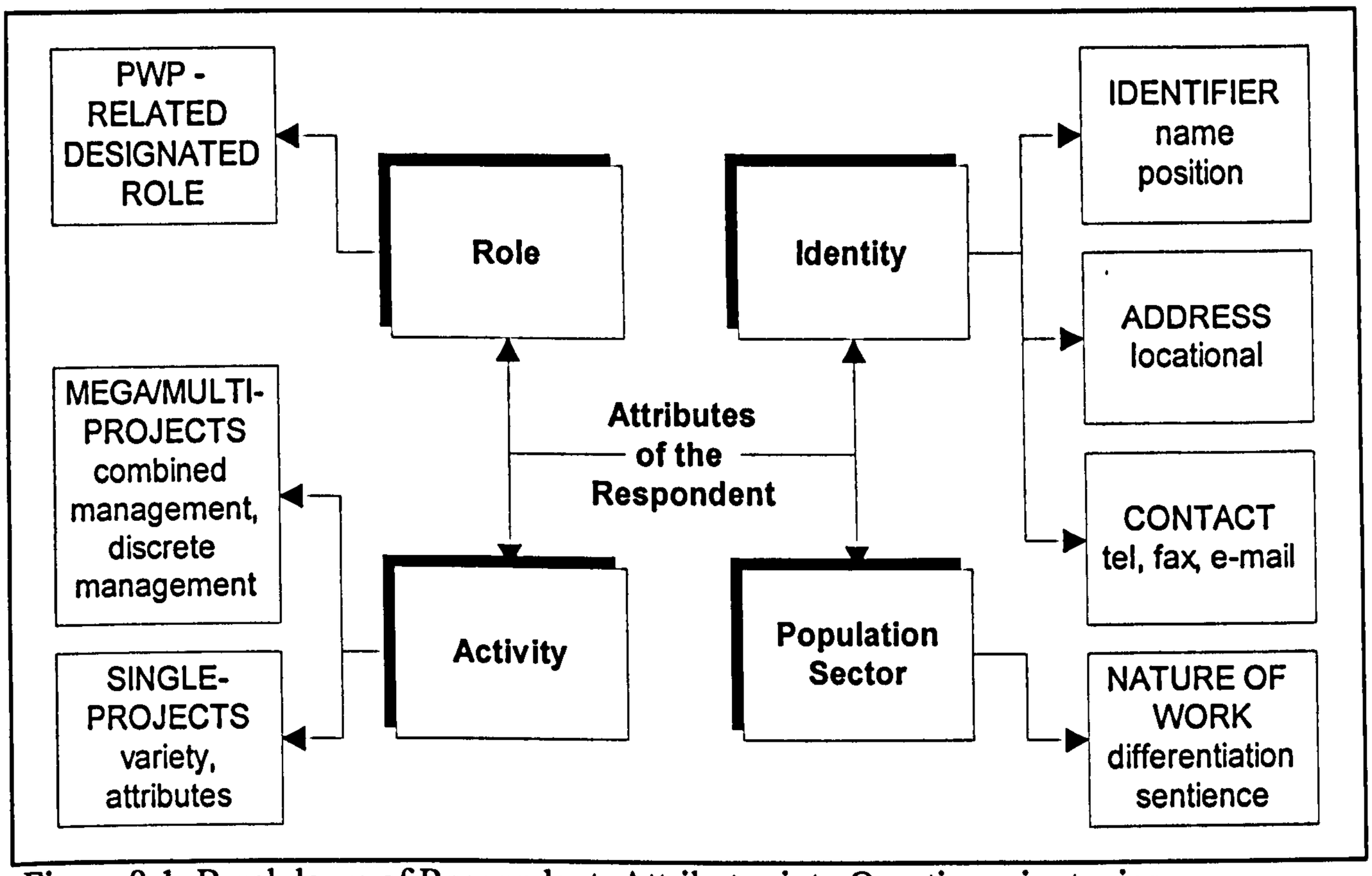

Figure 8-1 Breakdown of Respondent_Attributes into Questionnaire topics.

8.2.2 Breakdown of PM_Utility into Questionnaire topics

The breakdown of PM_Utility into question topics, after using mind-mapping techniques, is presented in Figure 8-2. The six questionnaire topics shown in Figure 8-2 address the major features of the PW_MS. These are developed into questions to measure the use, the appropriateness to actual projects, and the redundancy in project management practices of these aspects of the PW_MS. The PW_MS has not been configured to provide resource management utilities at the project-level nor for portfolio purposes. The need for this, to satisfy project management purposes at the project level, is included within the questionnaire.

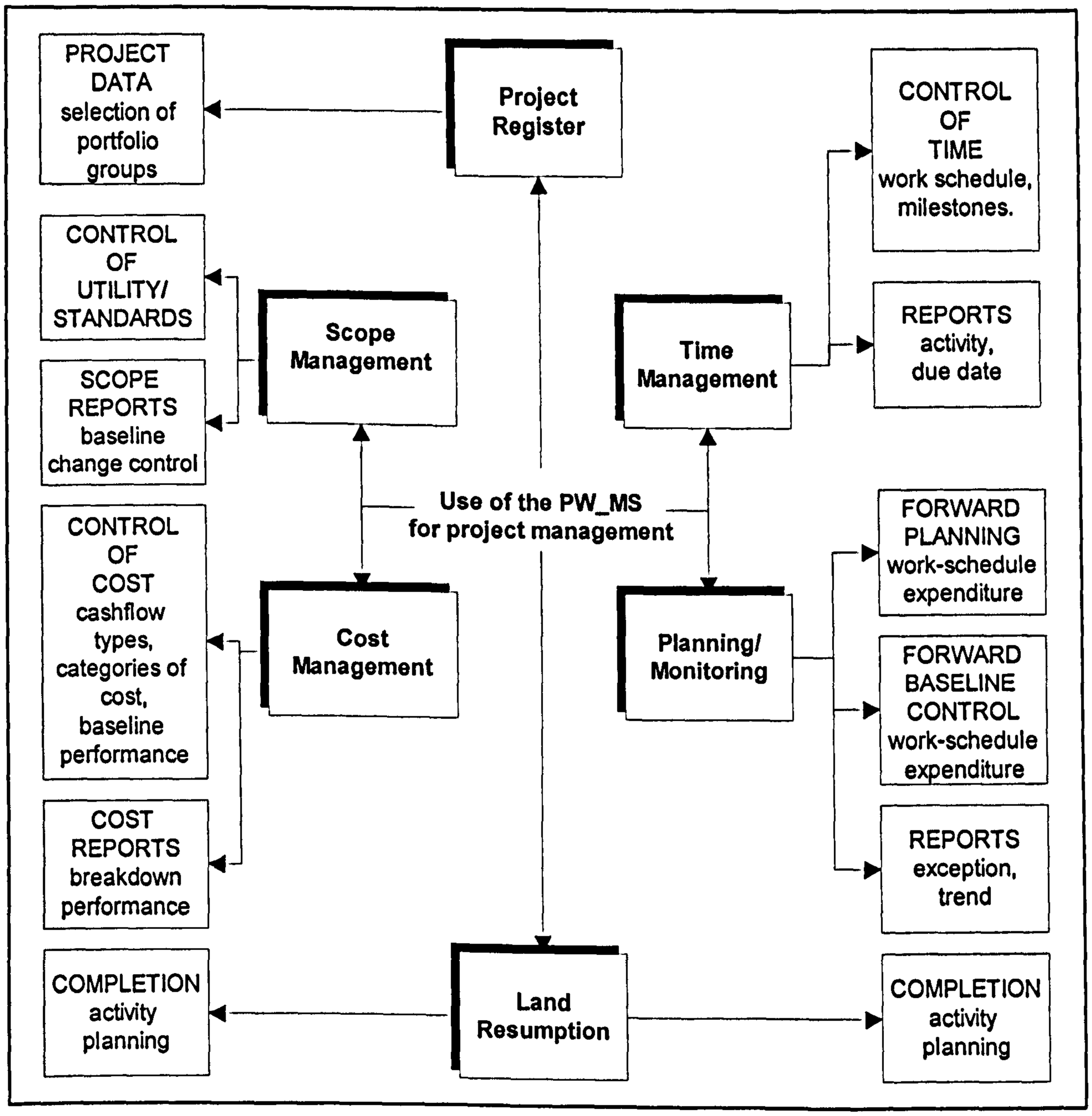

Figure 8-2 Breakdown of PM_Utility into Questionnaire topics.

8.2.3 Breakdown of Folio_Utility into Questionnaire topics

The hierarchical breakdown of this element of the questionnaire into question topics is presented in Figure 8-3.

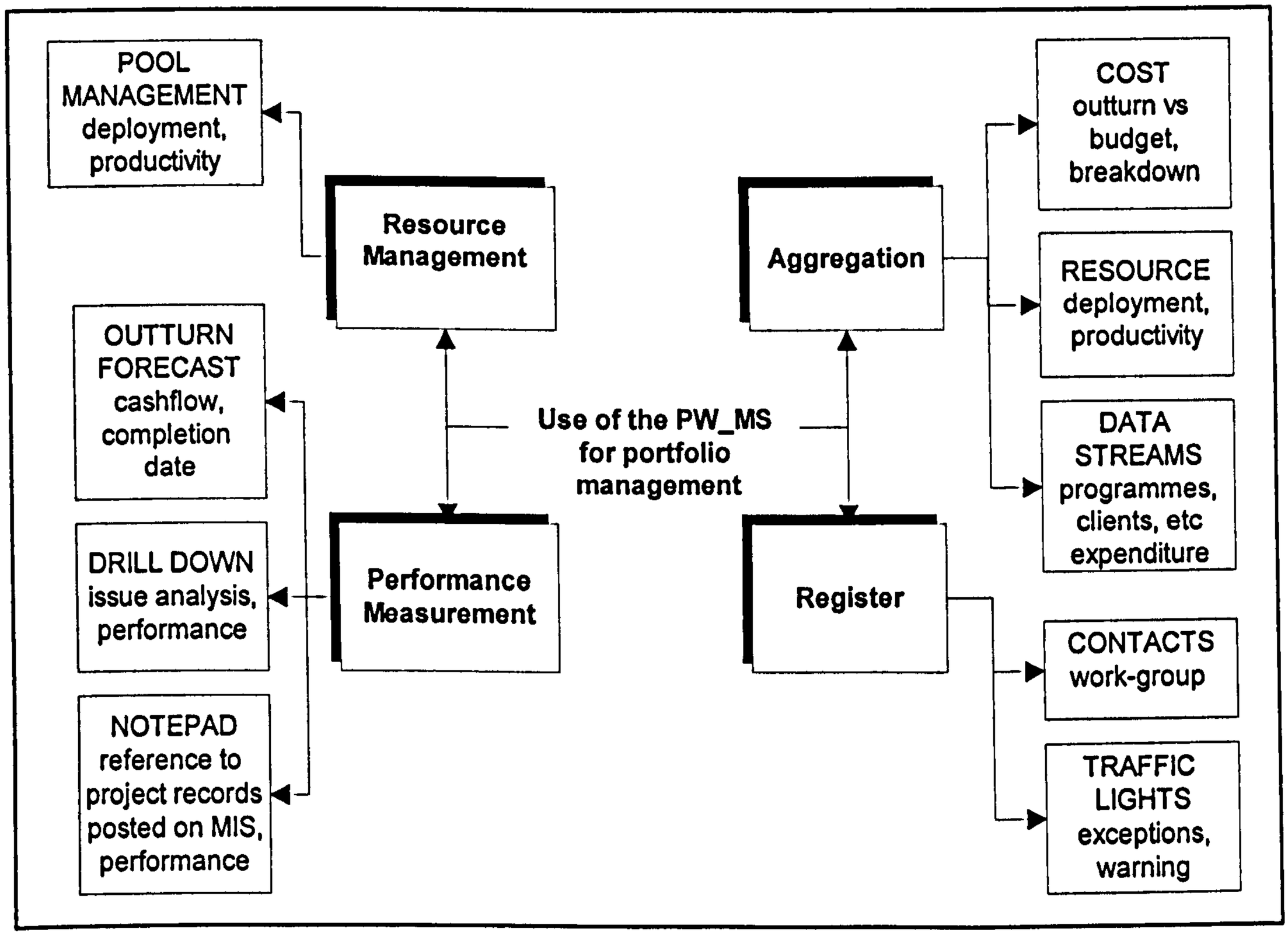

Figure 8-3 Breakdown of Folio_Utility in Questionnaire topics.

Use of a MIS for the management of a portfolio-of-projects relies on four fundamental methods of data-processing:

- aggregation of discrete data items into a single composite value in the same units;
- sorting of like items of data to find a match or an exception to a defined business-rule;
- selecting items of data according to a defined business-rule; and
- storing and retrieval of digital data.

The aggregation of data is possible if the data items are structured values that can be added together and vice versa. In practical terms these are numeric values that apply to measures of cost, quantity, and time. Sorting of data is also dependent on structured data

so that like-with-like comparisons can be made. These values can be alphanumeric providing they conform to the defined data structure. In practical terms these relate to identifiers of cost, time, quantity, and data items labeled by string-codes. The automated selection of data items is also reliant on the use of highly structured alphanumeric data items. These three fundamental methods of data-processing use arithmetic functions and Boolean logic in algorithmic processes coded into the software. In this respect the software is inherently inflexible as it is constrained to follow the logic of the software code. You cannot record unstructured data in such systems. The fourth fundamental data processing method – data storage and retrieval – overcomes this problem. It relies on some element of structured data to enable appropriate storage and retrieval of data items, but it can also include unstructured alpha numeric data that is stored and retrieved to be used verbatim. This creates an electronic notepad that can be configured as a diary, a register, a bulletin board and so forth.

Futcher and Thorpe[1] have observed that MIS in the construction environment are well received when they present data and information in a manner that is most easily assimilated by the human recipient. These four fundamental methods of data processing exist within the PW_MS for portfolio management purposes. This part of the questionnaire is to measure the extent that these portfolio management features are used at the public works department level and if other, non-PW_MS, means are employed because of deficiencies in the PW_MS.

8.2.4 Breakdown of Other_Means into Questionnaire topics

The hierarchical breakdown of this element of the questionnaire into question topics is shown in Figure 8-4. These question topics are to identify information management methods for project management and for portfolio management purposes used within the public works departments. These can be other MIS or non-IT systems. The questions are to measure their use and importance to the departments.

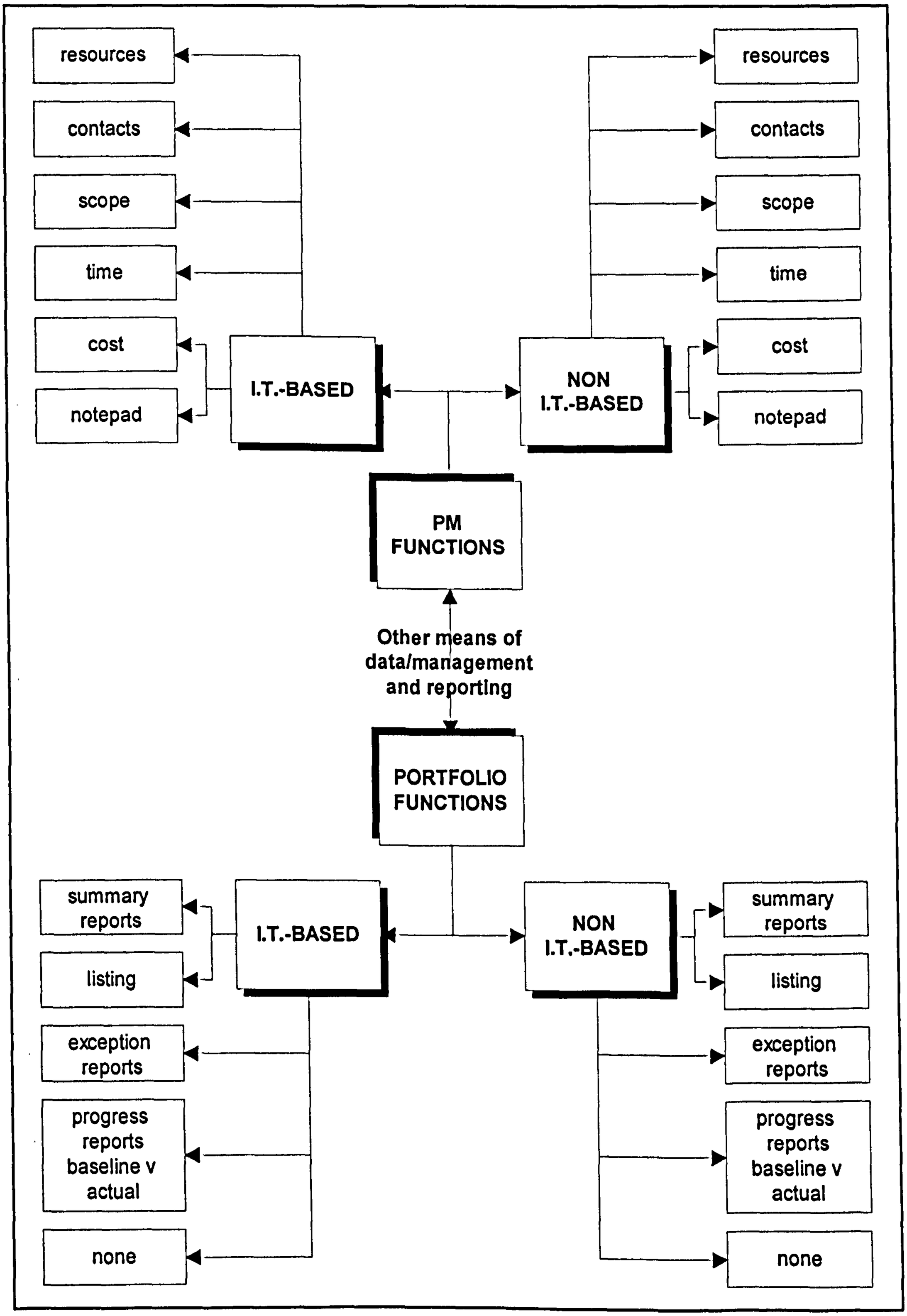

Figure 8-4 Breakdown of Other_Means into Questionnaire topics.

Further questions are included to identify the extent that PC computing is used that involves:

- spreadsheets;
- low-end relation data-bases without underlying business-rule algorithms;
- work-scheduling;
- financial management; and
- business-rule MIS.

8.2.5 Breakdown of MIS_Functionality into Questionnaire topics

The line of questioning in the final part of the questionnaire is to measure the extent that the requirements in the following list are unfulfilled within the PW_MS and the demand for them. Open-ended questions will be used to avoid self-evident and leading questions that may introduce a bias into the response to these questions.

From the point-of-view of a project manager, the basic requirements of a project management MIS are:

- it satisfies the information management and data processing needs of the traditional aspects of project control, i.e., scope, cost, and time;
- it serves as an efficient information filing system;
- it demands a minimum effort for data capture and data entry;
- it can provide added value that exceeds the effort required to maintain up-to-date data in a timely manner;
- it can provide routine and ad-hoc hardcopy, screen-displayed, and electronic reports with minimum effort in a point-and-click manner when used by project staff and management executives who are not IT professionals; and
- it provides a single-source of accurate data/information to the project participants in a trust-worthy manner thereby avoiding disputes caused by mis-information.

8.3 Population Sample

The population and the derived representative population sample are described in Section 2.8.1.

8.4 Postal survey level of response

The questionnaire was mailed to the sample population on January 22, 1999 under cover of an explanatory letter from the PWSAU of the Works Bureau – the sponsors of the survey. The deadline for response was February 16, 1999. Subsequent reminders and later deadlines were not set because the Works Bureau did not agree to a further imposition on the respondents. Table 8-2, lists the responses received at the deadline and beyond in terms of the two predominant population strata within the population-sample, i.e., HQ/PGM (portfolio-managers) and PJM (project-managers). The overall rate of response is 65% without a reminder being issued. A 35% response was achieved within the deadline.

Deadline Date	Response		HQ/PGM (portfolio managers)		PJM (project managers)	
	No	%	No	%	No	%
Feb 16	84	35%	20	28%	64	38%
Later	76	32%	26	37%	50	30%
Total	**160**	**67%**	**46**	**65%**	**114**	**68%**

Table 8-2 Rate of response from the postal survey of PW_MS Users.

All sample strata in the random population sample are well represented in terms of percent of each of the strata population. Please refer to the 'Appendices CD-ROM' within Section 8.4 for the details of sample-strata representation. The forty-seven numbers response for the HQ/PGM class exceeds the required minimum response required for representation of the population as calculated in Section 2.8.1. The one-hundred-and-fourteen response for the PJM class exceeds the minimum response of eighty-four numbers calculated in Section 2.8.1. The results of the questionnaire analysis for the HQ/PGM and for the PJM User classes are therefore taken as representation of the population overall.

8.5 Analysis of responses received

The 'Tick-the-box' questions were designed for a rapid response from the respondent to encourage completion of the questionnaire. 'Open-ended' questions are used to poll for user's ideas. To further encourage participation, the 'tick-the-box' questions called for responses that identified a trend rather than accurately measured a quantum. The response to the question, is, in general, either the extreme of the spectrum of answers, i.e., 'yes' or 'no', or 'keep' or 'change' with a further mid-range option such as, i.e., 'mostly' or 'sometimes'. The tick-the-box options used throughout the questionnaire are designed to be consistent throughout the instrument. The marks assigned to the options within each question are weighted to represent the relative importance of the answer: the higher values are assigned to a positive affirmation in favour of the PW_MS. The '*I don't know* ' or '*not used*' response available in many of the 'tick-the-box' style of questions is taken as a legitimate response that means the user is not familiar with that specific feature of the PW_MS. The survey also measures when a respondent cannot offer an opinion because of a lack of knowledge on that topic. In these instances the response is denoted by the code string 'na'. Statistical methods are used to analyze the responses for each question, or the groups of questions. The summary table of this analysis is printed in the 'Appendices CD-ROM' within Section 8.5.

The 'Open-ended questions' are the respondent's suggestions for improving the utility and quality of the PW_MS by the addition/deletion/change to its functionality. They invite the respondent to make five prioritized suggestions. They are also asked to select a verb prefix for each suggestion: these are, 'add', 'change', and 'delete'. In this manner the respondent is stating, in order of priority, up to five critiques of the PW_MS. Frequency analysis of keywords and phrases was carried out to identify the most prevalent answers to the questions from the respondents in general and according to their category of user class. The response to these questions falls below the minimum required to give a 95% confidence limit that they statistically represent the User population of the PW_MS, or minimum thirty-eight responses to represent the 'HQ and portfolio manager' or eighty-four responses from the 'project manager' sub-strata of the population. The

greatest response to any 'open-ended' question is twenty-two respondents of the 'HQ and portfolio manager' strata and thirty-eight respondents of the 'project manager' strata of the population sample. This is fifty-eight percent and forty-five percent of the minimum response needed for representation of the 'HQ and portfolio manager' and the 'project manager' strata. The summary table of this analysis is printed in the Appendices at Section 8.6. From these results it is taken as self-evident that the response for the population sample overall is not representative of the PW_MS User community. Furthermore, the nature of the response received is not uniform. Table 8-3 shows the numbers of suggestion and their distribution in the categories of 'change', 'add to' or 'delete from' the PW_MS.

Q. No.	Topic	No suggested amendments for Pop Sample o/a *(Max number possible = 5x231 = 1155/Q)*		
		Change	**Add**	**Delete**
1.1.3	Resource management	66	45	14
1.2.2	Resource management	na	Na	na
1.3.4	Effort in data capture/entry	36	35	14
1.4.3	Added value from PW_MS	19	35	12
1.5.3	Report writing and output	10	18	2
1.6.2	Centralised data	9	18	2
1.7.2	Effectiveness of PW_MS	4	6	0
1.8.3	Using the PW_MS	21	15	1
2.1.2	Project register	8	6	5
2.1.4	Project diary	13	3	9
2.1.6	Project contacts	1	0	2
2.1.8	Work-package register	0	2	10
2.1.10	Work-package diary	5	3	7
2.2.2	Project scope	3	2	0
2.3.2	Project cost	21	26	0
2.4.2	Time management/CPM	14	29	6
2.5.2	Change orders/baselines	8	7	0
2.6.2	Land delivery	1	12	7
2.7.2	Works contracts	1	8	1
3.1.2	Works contacts – multi projects	1	2	0
3.1.4	Traffic lights – multi projects	2	2	4
3.2.2	Data summation – multi proj	0	4	0
3.2.4	Cost summation – multi proj	0	5	0
3.3.2	Time deviation – multi proj	2	4	0
3.3.4	Cost comparison – multi proj	0	1	0
3.3.6	Identify poor performance – multi projects	0	5	0
3.3.8	Project diary – multi-projects	1	0	0

Table 8-3 The numbers of proposed alterations to improve the PW_MS received from the population sample of PW_MS Users.

This non-uniform, insignificant level of response does not provide adequate data for a frequency analysis of the response received. Examination of the pattern of the types of suggestion i.e., 'change', 'add', or 'delete, shows that for fifteen out of twenty-six questions the majority of suggestions of what should be done to the PW_MS are to 'add' to the existing elements of the software. This is taken to indicate a benign opinion towards the PW_MS. Eight of the twenty-six questions have a majority of suggestions that call for 'change' to the existing elements of PW_MS. This is taken as a middle-of-the road opinion that could be benign or adverse. Four of the twenty-six questions propose a deletion of existing features/functions. This is taken as an adverse opinion. In total the 'add' exceed 'change' and 'delete' propositions. This is taken as an indication that the respondents are generally in favour of positive reinforcement of the PW_MS.

The marks for each section or part of the questionnaire are mutually exclusive.

8.6 Results of the postal survey

The detailed question-by-question analysis of the results for the 'tick-it' questions are stated in the 'Appendices CD-ROM' within Section 8.7. A summary of these results are provided here in Sections 8.6.1 to 8.6.5.

8.6.1 Usage of the PW_MS

The conclusion drawn from the 'Preliminary' part of the postal survey of a population sample of the PW_MS Users shows that fifty-three percent of the PW_MS Users are managing five or less PWP projects. Forty-five percent of 'HQ and portfolio manager' strata of the User population manage ten or less PWP projects. Fifty-four percent of the user community does not personally log onto the PW_MS and thirty-one percent of the user community uses a proxy operator. The frequency of logging onto the PW_MS is rarely at a weekly interval, it is most often at monthly interval or, to lesser degree at the mandated quarterly interval.

8.6.2 Users recommendations for improving the PW_MS

The conclusion drawn from this analysis of Part 1 'Improving the PW_MS', shows that eighty percent of the population sample is qualified to express an opinion about the functions/features of the PW_MS. This further confirms that the results are representative of the population of PW_MS Users. There is no evidence that the features/functions of the PW_MS cited in Part 1 of the questionnaire are redundant. The 'scope statement' and the 'cashflow' features of the traditional project management aspect of the PW_MS should be kept as present. However, the 'work-schedule' and 'baseline dates' feature of traditional project management within the PW_MS should be changed or the requirement reduced. A 'staff resources' feature within the PW_MS that gives data on staff resource demands, capacity, and performance is not required by the Users.

The 'effort in data entry' to the PW_MS is not satisfactory. The procedural requirement for monthly updating of the PW_MS is not supported in general, but the 'HQ and portfolio' sub-strata of the population sample tend to a preference for a monthly updating of data. The frequency of updating of the data should be changed to reflect the differences between 'high impact' and other projects in the PW_MS database. Forty-five percent of the population-sample recommend a frequency of updating at 'monthly intervals for high impact projects and quarterly intervals for the others'.

The PW_MS is deemed 'sometimes useful' and that it is 'sometimes' worth keeping the data up to date. The specific features/functions of the PW_MS queried in the questionnaire should be kept the same – the response does not give a mandate to change or reduce the features/functions of the PW_MS.

The PW_MS reports are deemed 'useful' whether pre-formatted, on-screen or a hardcopy. The data supplied from the PW_MS are useful except for the 'FoxPro' data download. The PW_MS is deemed to be 'an effective, centralised, single-source of accurate PWP data/information'. The PW_MS 'is effective for the management of the

groups of projects in the hierarchical breakdown structures in the WBS, OBS, FRS, and the CRS' but these are under-utilized.

However, the response-time of the PW_MS is too slow. It should be as fast as using 'a stand-alone PC for word-processing' and it should be as easy to use as 'Microsoft Excel or Lotus 123 spreadsheet software'.

In overall terms, a majority of the user population deem the PW_MS as 'sometimes' satisfactory to use, or better. Although it should also be born in mind that twenty-four to thirty-nine percent of the positive participative response say that it is not satisfactory to use.

8.6.3 Use of the PW_MS for the management of projects

These conclusions are drawn from the analysis of Part 2 'Use of the PW_MS' for management of Category C, B, and A PWP projects' of the postal survey. There is no evidence that features/functions of the PW_MS used as the basis for the questions in Part 2 of the questionnaire are redundant. However, the 'land delivery' and the 'works contracts' features/function of the PW_MS are deemed to be 'severely under-utilized' in general. The 'cost functions' of the PW_MS are also 'severely under-utilized' by the 'HQ and Programme Manager' strata of the population sample. In addition, there is also 'under utilization' in using: the project diary, project contacts, work-package register, work-package diary, project scope, time planning functions, and the change order and baseline control functions.

The 'positive participative' assessment of the user population is that the PW_MS has the 'right amount' of data and functions, for the project register; project diary; work-package register; work-package diary; project scope; cost element; time plan element; change order and baseline control elements; land delivery element; and works contracts elements of the PW_MS.

No element of the PW_MS was deemed overall to be inadequate or excessive to requirements.

8.6.4 Use of the PW_MS for the management of portfolio-of-projects

These conclusions are drawn from the analysis of Part 3 'Use of the PW_MS' in the management of *groups* of Category C, B, and A PWP projects'. There is no evidence that features/functions of the PW_MS used as the basis for the questions in Part Three of the questionnaire are redundant. However, project contacts; screen traffic lights; summation information on groups of projects; cashflow performance; milestone variance; spending performance; poor performance identified; and quarterly reports diary data: group features/functions of the PW_MS are severely under-utilized. The data and the functionality are deemed as being the 'right amount' in all cases cited, but this is based on a 'positive participative' minority of the population sample. These results should not be taken as indicative that the cited features/functions are deemed adequate by the User Population overall.

This is taken to mean that the PW_MS is not meeting the needs of the majority of the User population for the purposes of managing more than one project.

8.6.5 Use of non-PW_MS methods for the management of projects

These conclusions are drawn from the analysis of Part 4 'Non-PW_MS' methods used for the management of Category C, B, and A PWP projects.' Non-PW_MS computer-based systems are 'sometimes' used for the project management of PWP projects. The percent 'not used' response ranges from 22% to 46%. Of the named types of software used for these purposes, 'spreadsheet' is the most commonplace response except in the case of 'project costs' where database software is the significant response. Manual methods are also 'sometimes' used for the project management of PWP project functions cited in the

questionnaire. The percent 'not used' response to these questions, ranges from 22% to 44%. However, 'staff resources', and manual work scheduling/CPM for the 'HQ and portfolio manager' sub/strata, are under utilized. 'Files' are the most commonplace manual record used for this purpose.

Forty-nine to seventy-two percent of the population sample/strata state that non-PW_MS computer-based systems are 'not used' for the management of groups of projects. The positive participant respondents 'sometimes' use computer-based systems for this purpose. The named types of software: 'database, spreadsheet, or package software', are all used for this purpose. Fifty-three to seventy-five percent of the population sample/strata respond that manual methods are 'not used' for the management of groups of projects. 'Files is the predominant type of records used for this purpose.

Non-PW_MS computer-based systems are 'sometimes' used for the project management of PWP projects. Non-PW_MS computer-based systems are 'not used' for the management of groups of projects.

8.7 Summary of the qualitative survey of user satisfaction with the case-study PMIS

The results of the questionnaire analysis for the HQ/PGM and for the PJM User classes are taken as representation of the population overall.

The lesser number of 'Open-ended questions' in the questionnaire are to poll the respondents for suggestions to improve the utility and quality of the PW_MS by the addition/deletion/change to its functionality. The inconsistent, insignificant level of response does not provide adequate data for a frequency analysis of the response received. The nature of these responses indicates that the respondents are generally in

favour of positive reinforcement of the PW_MS. However, the unrepresentative and indeterminate response does not provide a mandate for change in the PW_MS.

The overall conclusion carried forward from this postal survey of the degree of satisfaction of the public works department with the PW_MS, are:

- a majority of the user population deem the PW_MS as 'sometimes' satisfactory to use, or better. Although a twenty-four to thirty-nine percent of the positive participative response say that it is not satisfactory to use. However, the response-time is too slow. It should be as fast as using 'a stand-alone PC for word-processing' and it should be as easy to use 'Microsoft Excel or Lotus 123 spreadsheet software'.

- The project management features/functions of the PW_MS are not deemed by the Users to be redundant, inadequate or excessive. The response does not provide a mandate to change or reduce the features/functions of the PW_MS.

- The 'effort in data entry' to the PW_MS is not satisfactory. The procedural requirement for monthly updating of the PW_MS is not supported in general, but the 'HQ and portfolio' strata of the population sample tend towards a preference for a monthly updating of data. The frequency of updating of the data should be changed to reflect the differences between 'high impact' and other projects in the PW_MS database. Forty-five percent of the population-sample recommends that the frequency of updating should be at 'monthly intervals for high impact projects and quarterly intervals for the others'.

- The PW_MS is not meeting the needs of the majority of the User population for the purposes of managing more than one project.

8.8 References of the qualitative survey of user satisfaction with the case-study PMIS

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[1] Futcher, K., and Thorpe, T. 1998 The significance of data 'held in context' in project information management systems. Second Singapore International Conference on Construction Project Management, Singapore, February 19-20 1998.

Chapter Nine

9 Stochastic modeling of an alternate approach to portfolio management.

9.1 Introduction

A conclusion drawn from the postal survey of PW_MS Users is that the frequency of updating of the data should be changed to reflect the differences between 'high-impact-projects' and the others in the PW_MS database. This Chapter of the thesis investigates the outcome for a number of PWD portfolio-of-projects if the projects that have a high-impact, and are therefore significant, do very well – other things being equal.

A validation of this 'significance' approach using empirical data is possible by the mathematical calculation of the effect if the projects deemed as 'significant' perfectly achieve their forecast target-performance whilst the others are left unchanged. This is an idealistic scenario as it is unlikely that this perfection would be achieved in practice. Symbolic modeling[1] to better reflect a real-life outcome is also part of this element of the research. This involves using Monte Carlo techniques to introduce a range of possible good-outcomes for the significant-projects. These outcomes are randomly taken from a probability-distribution that represents the best twenty percent outturn-performance achieved by any of the projects in that empirical portfolio-of-projects. This is based on the premise that special management attention to the significant-projects will result in an outcome that also ranges from the good to excellent empirically achieved within the portfolio.

The empirical data used for these analyses is taken from the 'Annual Reports of the Director of Accounting Services and the Accounts of Hong Kong' for the ten year period from 1989-90 until 1998-99. These reports include the list of Category A PWP projects

and their planned and audited actual expenditures. The ten-year period is used to provide analyses of the five-years before and the five-years after the implementation of the PW_MS. A period of five-years is taken as the minimum period to provide a reasonable indication of a trend or pattern.

9.2 Chapter Outline

The methodology for the mathematical and stochastic modeling of a significance approach to project/portfolio management is described in Section 2.9 in Chapter Two. This Chapter is laid out as follows:

- Section 9.3 describes the empirical data used in the 1989-90 analysis. The empirical data for nine other analyses over the period 1990-91 to 1998-99 is provided in the 'Appendices CD-ROM' within Chapter Nine.
- Section 9.4 provides a comprehensive example of the mathematical and stochastic modeling for the 1989-90 empirical data. The repetition of these processes for financial years 1990-91 to 1998-99 is similarly provided in the 'Appendices CD-ROM'.
- Section 9.5 contains the results of the analyses of the empirical data and the results of the modeling analyses for the ten sets of empirical data used in this research.
- Section 9.6 states the summary of the conclusions drawn from this element of the work.

9.3 Empirical Data

A description of the source, diversity and attributes of the empirical data used in this research is in Section 2.9.1 and further examined in the context of the PWP in Sections 7.4 and 7.5.

9.3.1 1989-90 financial year

This data is taken from the 'Annual Report of the Director of Accounting Services and the Accounts for the year ended 31 March 1990[2]' published by the Hong Kong Government in 1990. Reference is also made to the earlier forecast of this spending programme taken from the 1989-90 Budget process, i.e., the 'Estimates for the year ending 31 March 1990: Volume III – Fund Accounts, Memorandum Notes, and Payments and Receipts[3]'.

The portfolio of Category A projects to be analyzed for this element of the research contains 1196 mutually exclusive projects. The 'Original Estimate' of expenditure on these projects was HK$ 9,370 million[1,2]. Approved revisions to the Original Estimate result in an 'Amended Estimate', which in this case was HK$ 13,805 million[1], whereas the audited 'actual' expenditure was HK$ 10,412 million[1]. This under-expenditure of 24.6% or of HK$ 3,393 million is the actual 'Outturn Variance' for this portfolio-of-projects.

The portfolio contains all of the PWP for 1989-1990 except for the exclusion of items listed in the Heads of Expenditure for 'Land Acquisition (Head 701 PWP Items)', 'Capital Subventions and Major Systems and Equipment (Head 708 PWP Items)'; and the 'omnibus' items defined in 2.9.1. Table 9-1 states the statistical attributes of the consequent data-set to be used in this analysis.

Expenditure	**No Projects**	**Statistics** *(Units are HK $ 000's)*					
		Low	**High**	**Mode**	**Mean**	**Median**	**S.D.**
Original est		0	510,000	0	7,834	1,300	26,986
Amended est	1196	0	510,000	100	11,543	2,330	35,298
Actual		-571	389,245	0	8,713	567	29,368
Outturn		0	427,033	100	2,837	799	13,617

Table 9-1 Statistical attributes of the portfolio of projects taken from the 1989-1990 Public Works Programme of projects.

As mentioned earlier, the PWP is sub-divided into broad groups of construction classification called the 'Heads of Expenditure' that correspond to the disciplines of the public works departments. The composition of the portfolio in these terms is displayed in Table 9-2.

Code	**Head of Expenditure**	**By No. Projects**		**By 'Amended Estimate' Value**	
		Nos	%	Value *HK$000's*	%
702	Port & Airport Development	Na	na	na	na-
703	Buildings	281	23%	3,920,040	28%
704	Drainage	Na	na	na	na-
705	Civil Engineering	120	10%	1,057,597	8%
706	Highways	120	10%	2,430,834	18%
707	New Towns & Public Housing (exc HK Housing Authority)	586	49%	5,558,373	40%
709	Waterworks	89	7%	838,719	6%

Table 9-2 Composition of the 1989-90 data set in terms of 'Heads of Expenditure'.

Heads of Expenditure '703 Buildings', and '707 New Towns and Public Housing' predominate in terms of the size and the total value of these sub-portfolios. Fifty-two out of seventy-eight official categories-of-works are represented in this empirical data set. This is taken to indicate a good degree of diversity (sixty-seven percent) of the total range of the types of HKG SAR infrastructure projects represented in the PWP. The significant representation of categories of public works within the data set is shown in Table 9-3. The categories-of-works listed comprise eighty-six percent by number and eighty-eight percent by value of the data set to be analyzed.

Category of public works	**ID**	**By Project No.**		**By Value (HK$ 000's)**	
		No	**%**	**Amended Est Value**	**%**
Civil engineering – land development	CL	173	14%	2,365,149	17%
Transport – roads	TH	144	12%	3,527,625	26%
Water supply - fresh water supplies	WF	74	6%	652,504	5%
Education – primary	EP	62	5%	198,359	1%
Recreation, culture and amenities – open spaces	RO	58	5%	189,022	1%
Environmental engineering – sewerage and sewage treatment	DS	55	5%	637,115	5%
Education – secondary	ES	53	4%	361,911	3%
Recreation, culture and amenities – sports facilities	RS	46	4%	191,545	1%
Law and order – police	LP	43	4%	416,769	3%
Social welfare and community building – community centres and halls	SC	41	3%	145,446	1%
Support - internal security	GF	36	3%	77,590	1%
Public safety - fire services	BF	29	2%	152,938	1%
Environmental engineering – refuse disposal	DR	29	2%	253,918	2%
Support – offices	GO	29	2%	971,323	7%
Transport – footbridges and pedestrian tunnels	TB	29	2%	57,757	0%
Air and sea communications – airport	AA	27	2%	219,283	2%
Health – hospitals	MH	24	2%	880,745	6%
Water supply – combined fresh/salt water supply projects	WC	19	2%	188,511	1%
Support – Government buildings	GG	18	2%	202,499	1%
Health – clinics	MC	18	2%	65,401	0%
Sub-totals			82%	$11,755,410	85%

Table 9-3 Categories of work that are greater than one percent of the 1989-90 PWP data set.

The predominant categories-of-work in the data set in terms of planned expenditure in the 1989-90 financial year, are:

- TH 'Transport – roads', 26% by value but 12% by number of projects;
- CL 'Civil engineering – land development', 17% by value but 14% by projects;
- GO 'Support – offices ', 7% by value but 2% by number of projects.

Table 9-4 shows the statistical attributes of these sub-portfolios of projects. The mode and the median values indicate that the majority of the project values are at the low-value end of the range.

Cat. of Work	No Projects	Statistical attributes in terms of 'Amended Estimate' *(HK$ 000's)*					
		Low	High	Mode	Mean	Median	SD
TH	144	0	409,110	2,000	24,497	3,935	57,646
CL	174	3	340,160	100	13,593	3,630	33,530
GO	29	50	286,770	-	33,494	11,920	33,530

Table 9-4 Statistical attributes of the dominant sub-portfolios in the 1989-90 dataset.

9.3.1.1 Planned expenditure variable

For the purposes of the modeling, the value of the planned expenditure per project is the 'Amended Estimate' variable in the data source. The statistical attributes of this variable within the data set for this analysis were stated earlier in Table 9-1. These indicate that the values of 'Amended Estimate' expenditure within the portfolio are mostly at the low-value end of the range of values. Table 9-5 shows that ninety-five percent of the number of projects contains forty-five percent of the total value of the planned expenditure on the projects.

Percentile (No Projects)	Thresh-hold Value of 'Amended Estimate of a project (HK $ 000's)	Cum Value (HK $ 000's)	Cum Value (%)
5%	30	675	0.005%
10%	100	6,035	0.04%
15%	177.75	12,477	0.1%
20%	300	29,774	0.2%
25%	460	48,382	0.4%
30%	605	79,428	0.6%
35%	952.75	124,870	0.9%
40%	1,300	191,792	1.4%
45%	1,852	281,902	2%
50%	2,330	407,128	3%
55%	3,000	579,628	4.2%
60%	3,920	776,061	5.6%
65%	5,000	1,049,123	7.6%
70%	6,290	1,379,313	10%
75%	8,000	1,835,110	13%
80%	11,500	2,387,095	17%
85%	15,450	3,187,572	23%
90%	23,127.5	4,271,401	31%
95%	47,110	6,191,718	45%

Table 9-5 Percentiles for 'Amended Estimate' variable in the 1989-90 data set

9.3.1.2 'Outturn variance' variable

The 'Outturn Variance' is the difference between the 'Amended Estimate' and 'Actual' expenditure. The statistical attributes of this variable within the data set for this analysis were also stated earlier in Table 9-1. These indicate that the values of 'Outturn' expenditure within the data-set are predominantly at the low-value end of the range of values. Table 9-6 shows that ninety-five percent of the number of projects contains fifty percent of the total outturn variance.

Percentile (No Projects)	Thresh-hold Value of 'Outturn variance' for a project (HK $ 000's)	Cum Value (HK $ 000's)	Cum Value (%)
5%	7	152	0.004%
10%	32.5	1,229	0.04%
15%	83	4,865	0.14%
20%	122	10,778	0.3%
25%	176	19,865	0.6%
30%	247.5	31,972	0.9%
35%	347.5	49,495	1.5%
40%	439	72,926	2%
45%	560.75	102,862	3%
50%	799	143,969	4%
55%	1,022	198,682	6%
60%	1,266	267,152	8%
65%	1,622	352,297	10%
70%	2,010	462,305	14%
75%	2,540	599,411	18%
80%	3,210	775,291	23%
85%	4,022	988,862	29%
90%	5,466	1,274,937	38%
95%	8785	1,681,500	50%

Table 9-6 Percentiles for 'Outturn variance' variable in the 1989-90 dataset.

9.3.1.3 Probability curve fitting

For the purpose of these modeling analyses, a PDF is to be selected that best represents the values of the percent Outturn Variance within the range of 0 to 0.2 based upon the actual performance achieved by the empirical data set. The two-step curve-fitting methodology for this is described in Section 2.9.5. In the first step, the curve-fitting range is for the values of percent 'Outturn Variance' from zero to two hundred percent. There are sixteen instances in the data set, out of 1196 data pairs, where this threshhold is exceeded. These are unrepresentative outliers and are not included in the frequency distribution shown in Figure 9-1. The statistical attributes of the data set within the zero to two hundred percent range of project Outturn Variance for this frequency distribution are listed in Table 9-7.

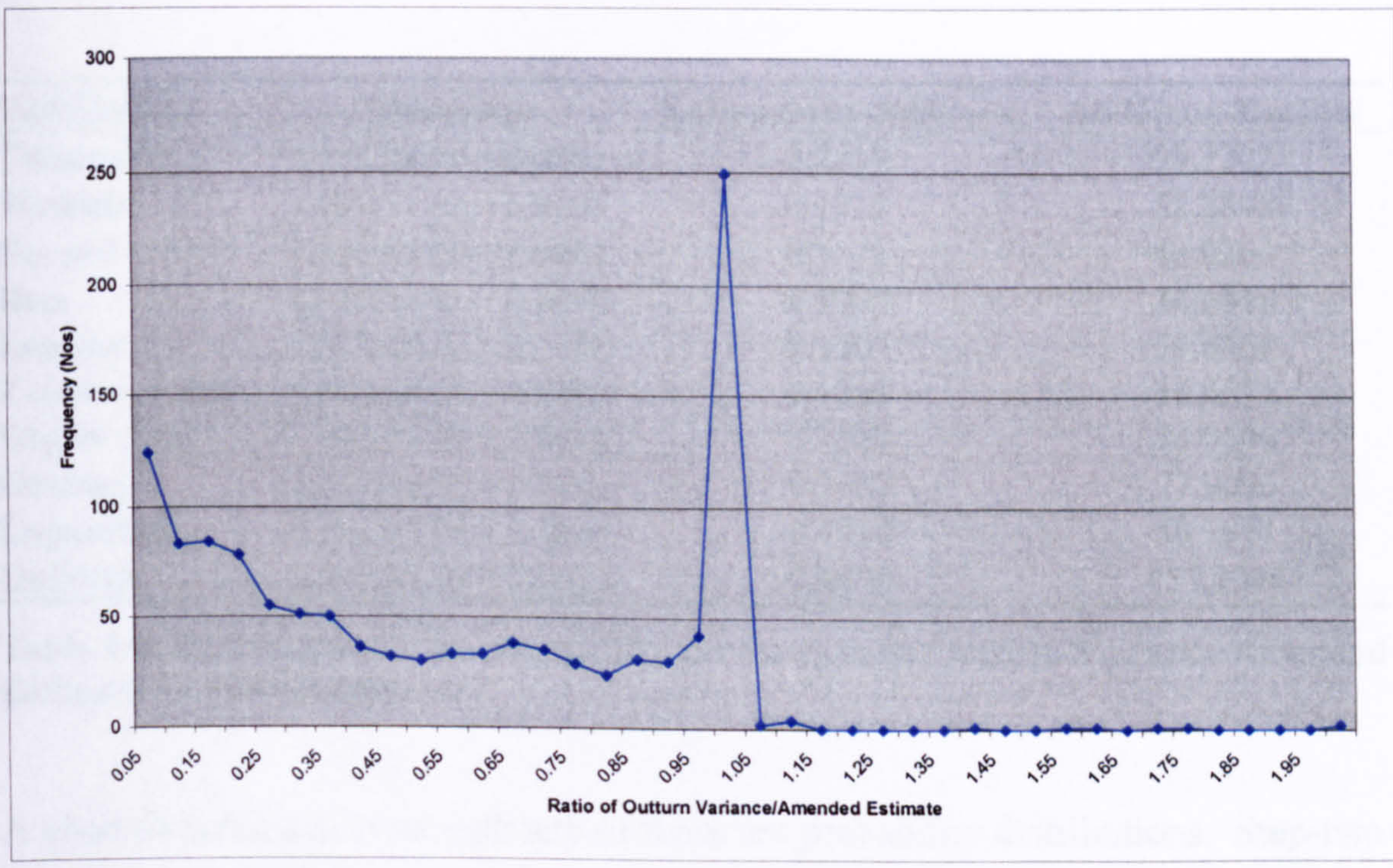

Figure 9-1 Frequency distribution of the ratio of Outturn Variance/Amended Estimate for 1989-90 dataset.

Attribute	Value
No data pairs	1180
Low Value	0.000
High Value	2.000
Mode Value	1.000
Mean Value	0.506
Median Value	0.442
Standard Deviation Value	0.376

Table 9-7 Statistical attributes of frequency distribution of 'Outturn Variance' ratio

Using the distribution fitting methods within the Crystal Ball software, ten standard PDF are fitted to the data array of 'Outturn Variance/Amended Estimate' shown in Figure 9-1 and described in Table 9-7. The results of the distribution fitting are tested using three goodness-of-fit methods: Chi-square; Kolmogorov-Smirnov; and Anderson-Darling. The resultant distribution fit for the ten probability distributions tested are shown in Table 9-8.

Distribution	Chi-square	Kolmogorov-Smirnov	Anderson-Darling
Triangular	1,492.28 (θ = 0.000)	0.2519	93.7262
Weibull	1,591.11 (θ = 0.000)	0.1225	52.2848
Normal	1,920.04 (θ = 0.000)	0.1175	42.9264
Beta	1,170.72 (θ = 0.000)	**0.1087**	**34.5316**
Logistic	1,872.16 (θ = 0.000)	0.1104	39.6368
Extreme Value	1,644.24 (θ = 0.000)	0.1203	38.0571
Exponential	1,484.33 (θ = 0.000)	0.1280	34.0136
Gamma	2,157.98 (θ = 0.000)	0.1467	77.9096
Lognormal	2,366.55 (θ = 0.000)	0.1719	50.1971
Uniform	2,340.04 (θ = 0.000)	0.4890	451.1946

Table 9-8 Distribution fit for probability curves against 'Outturn Variance/Amended Estimate' in 1990-91 data set

A good fit is not achieved with any of these ten probability distributions. Step-two of the curve fitting, within the x-axis range of 0 to 0.2 therefore applies as described in Section 2.9.1 of the methodology. If we constrain distribution fitting to the data pairs within the range of 0 to 0.2 then the statistical attributes of the data pairs are as shown in Table 9-9 and the probability histogram for this range is shown in Figure 9-2.

Attribute	Value
No data pairs	369
Low Value	0.000
High Value	0.200
Mode Value	0.000
Mean Value	0.090
Median Value	0.087
Standard Deviation Value	0.061

Table 9-9 Statistical attributes of frequency distribution of 'Outturn Variance' ratio for x-axis values of 0 to 0.2.

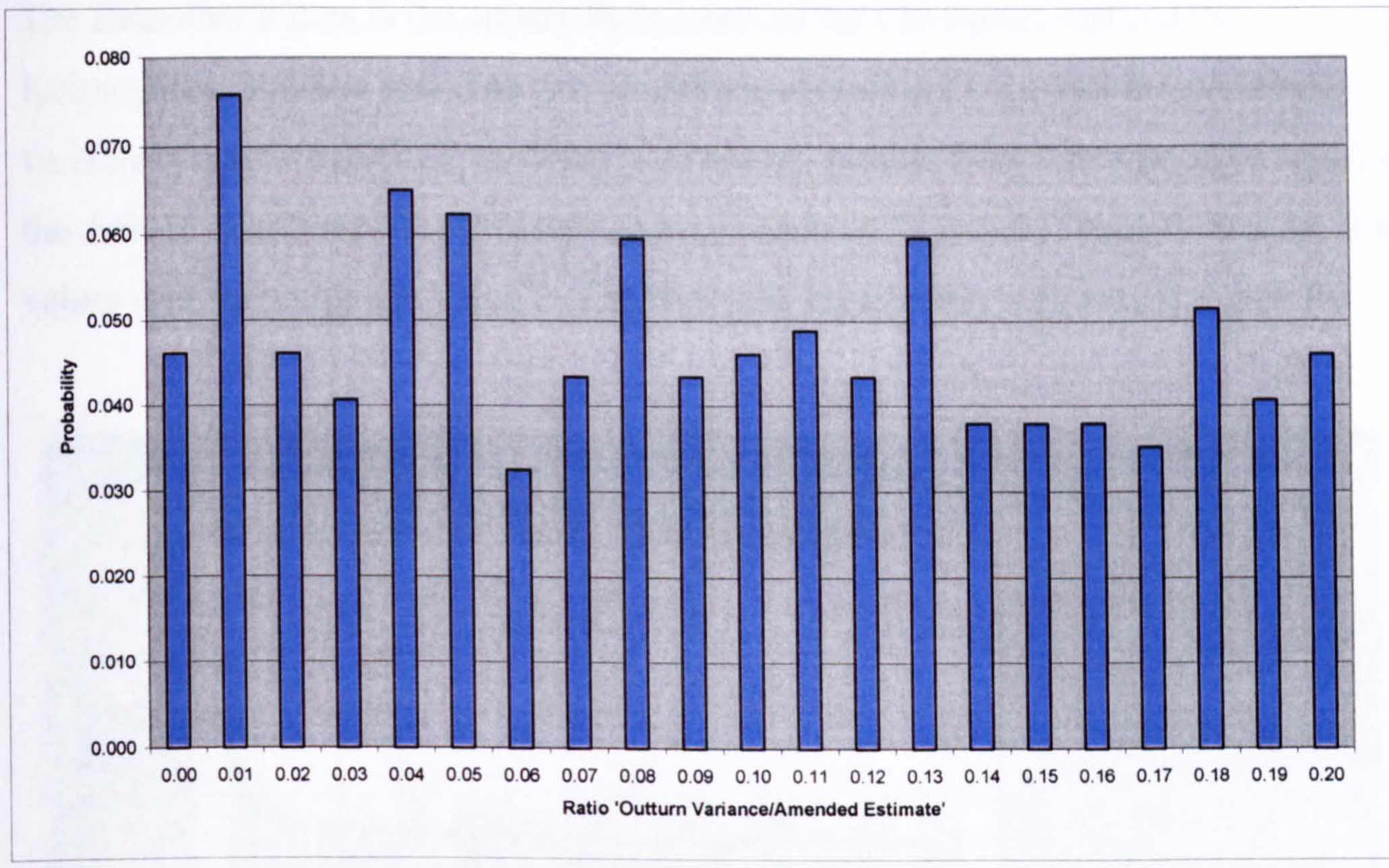

Figure 9-2 Probability histogram for Ratio of Outturn Variance/Amended Estimate within the ratio range of 0 - 0.2

The distribution fit of the frequency distribution shown in Figure 9-2 for the ten probability distributions tested is shown in Table 9-10.

Distribution	Chi-square	Kolmogorov-Smirnov	Anderson-Darling
Triangular	150.650 (θ = 0.000)	0.169	33.295
Weibull	133.919 (θ = 0.000)	0.090	11.765
Normal	100.227 (θ = 0.000)	0.082	**4.762**
Beta	**25.333 (θ = 0.0875)**	**0.047**	9.074
Logistic	132.667 (θ = 0.000)	0.086	4.795
Extreme Value	81.106 (θ = 0.000)	0.077	5.136
Exponential	147.463 (θ = 0.000)	0.133	20.911
Gamma	487.675 (θ = 0.000)	0.323	76.656
Lognormal	235.675 (θ = 0.000)	0.161	27.752
Uniform	44.000 (θ = 0.001)	0.087	9.199

Table 9-10 Distribution fit for probability curves against 'Outturn Variance/Amended Estimate' in the range x = 0 to 0.2 in the 1989-90 data set

The Beta-distribution is the closest fit in terms of the Chi-square test and the Kolmogorov-Smirnov test. The two conditions underlying it are that the probability variable (y-axis – uncertain variable) is a random number from 0 to a positive value, and the derived distribution is positively skewed (alpha (0.75)<(0.93) beta) with most of the values near the minimum value[4]. The fit to this distribution is shown in Figure 9-3.

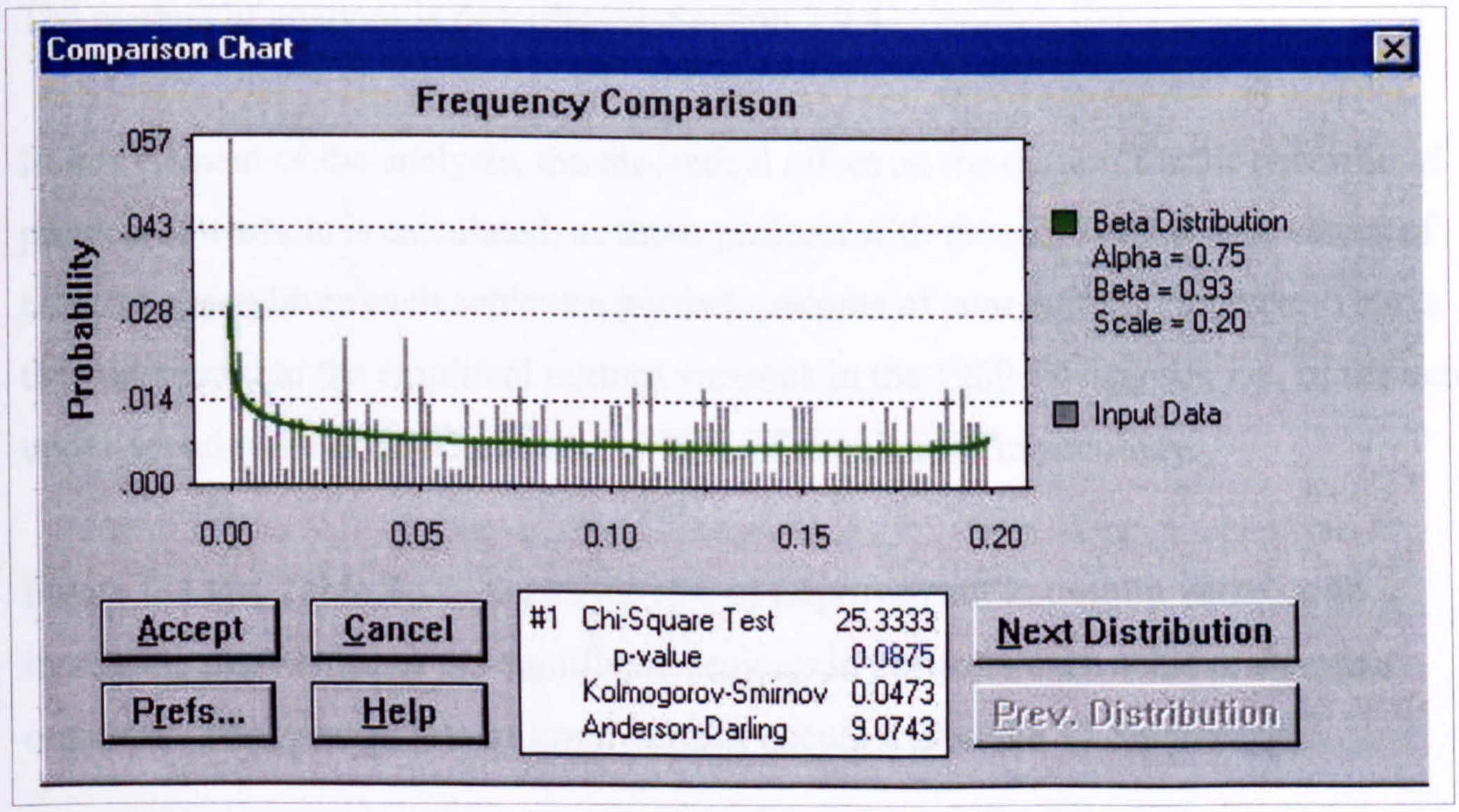

Figure 9-3 Showing the fit of to a Beta distribution for x-range of 0 to 0.2, 1989-90 data set.

It is reasonable to apply the Beta distribution because it is a flexible distribution used to represent variability over a fixed range. This is substantiated by other authors[5,6,7,8,9,10,11,12,13,14,15]. This distribution is used in the stochastic analysis described in Section 9.4.1.2.

9.3.2 1990-91 to 1998-99 financial years

The curve fitting for the subsequent data sets used in this research is a repetition of this process. These are reported in the 'Appendices CD-ROM' within Section 9.3. The results are reported in this Chapter at Section 9.5.

9.4 Modeling of the significance approach

9.4.1 1989-90 financial year

The attributes of the 1989-90 data set used in this analysis are described in Section 9.3.1.

9.4.1.1 Mathematical model

The method of analysis is described in Section 2.9.4.

In this element of the analysis, the theoretical effect on the outturn for the portfolio of projects as a whole is calculated, as those projects with the more significant values of planned expenditure each achieve a perfect outcome of zero outturn variance. This is then compared to the empirical outturn variance in the 1989-90 data set, i.e., of the actual under-spend of HK$ 3,393 million, or 25% of the planned expenditure.

Figure 9-4 and Table 9-11, shows the rate of improvement in outturn variance as increasing percentiles of the significant projects in portfolio each achieve a perfect outcome. The greatest rate of improvement occurs within the 17.5 percentile.

This analysis indicates that an ideal delivery for the significant value twenty percent of the projects in the data set will deliver an overall outturn for the portfolio that is ninety-two percent of the planned outcome – all other things being unchanged.

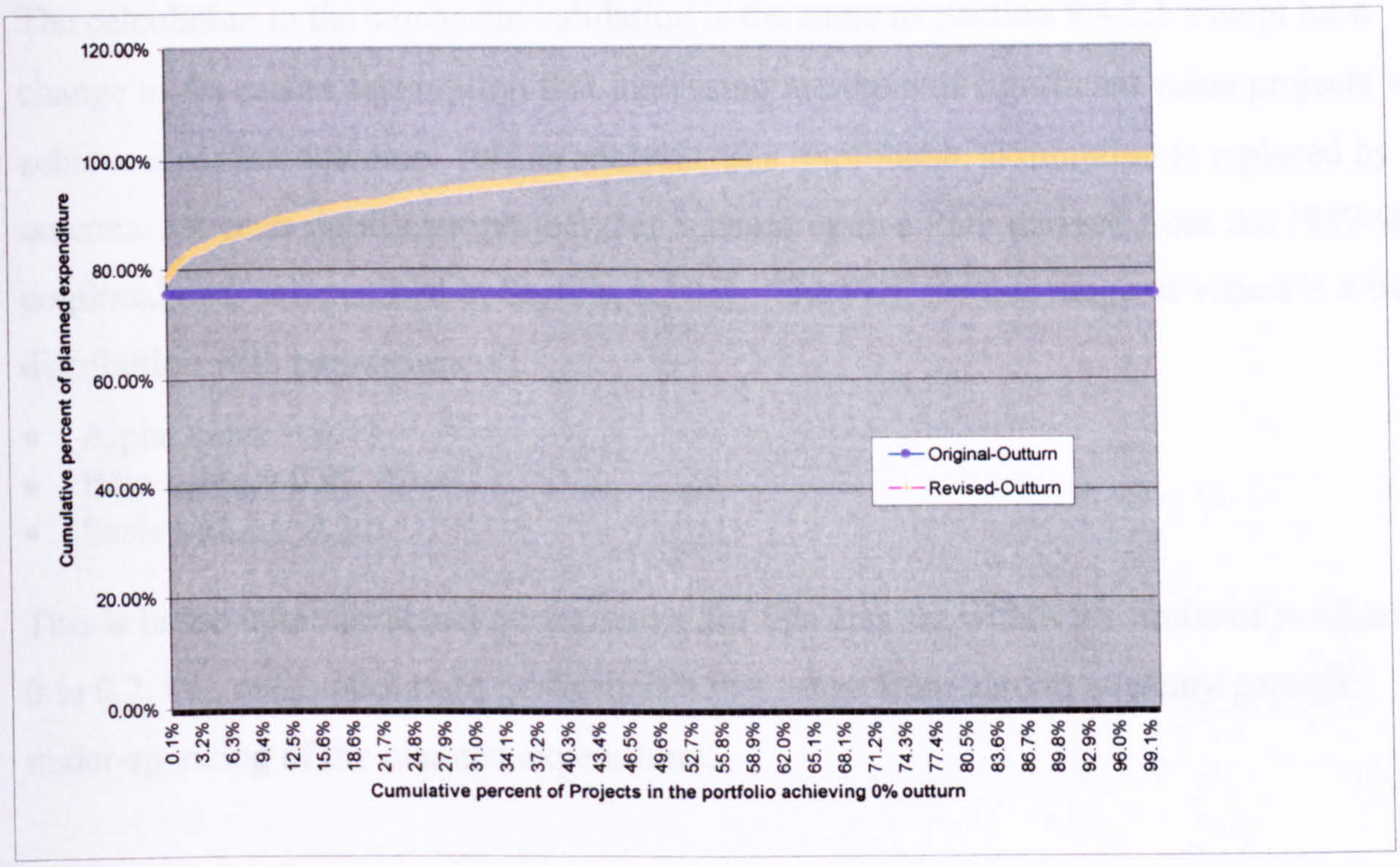

Figure 9-4 Improved outturn achieved in 1989-90 dataset as ideal outturn is achieved by significant projects

Percentile (Projects in dataset)	**Outturn Achieved**	**Diff to Actual Outturn**
2.5%	83%	8%
5%	85%	10%
7.5%	86%	11%
10%	88%	13%
12.5%	89%	14%
15%	90%	15%
17.5%	91%	16%
20%	**92%**	**16%**
22.5%	92%	17%
25%	93%	18%
27.5%	94%	19%
30%	95%	19%
35%	96%	20%
40%	97%	21%
50%	98%	23%

Table 9-11 Improved outturn achievement for 1989-90 dataset

9.4.1.2 Stochastic model

The calculation in the stochastic validation is the same as Section 9.4.1.1 except for a change to the earlier assumption that increasing numbers of significant value projects will achieve a perfect outcome. In this analysis, this improbable assumption is replaced by an outcome for each significant project that is based upon a PDF derived from the 1989-90 empirical data as described in Section 9.3.1.3. The PDF for this range of values is a Beta distribution with parameters of:

- Alpha value = 0.75
- Beta value = 0.93
- Scale value = 0.20

This is based upon the actual performance for this data set within the limits of x-values of 0 to 0.2, i.e., ratios of outturn performance that range from zero to a twenty percent under-spending of the planned expenditure.

Crystal Ball® software by Decisioneering Inc is used to perform Monte Carlo analysis on the variable 'Outturn variance/Amended Estimate', for one to twenty percent, by number, of the significant value projects within the 1989-90 data set of 1,196 projects. The Crystal Ball® analysis derives a frequency diagram for the consequential outturn variance for the data set in terms of total expenditure and also percent outturn. Figure 9-5, for example, shows the range of total expenditures for the data set whilst Figure 9-6 shows the corresponding outturn in terms of percent.

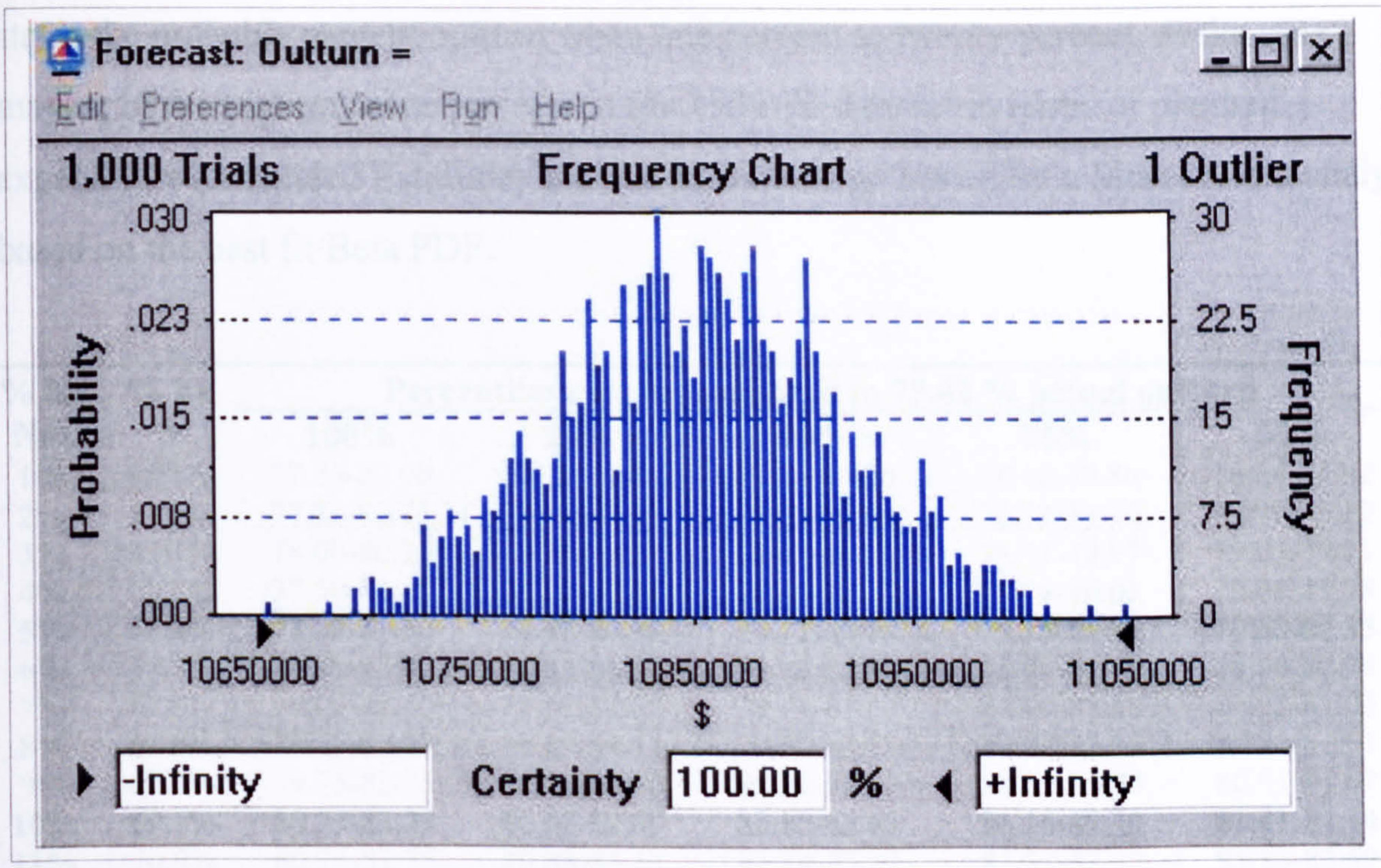

Figure 9-5 Frequency chart derived from Monte Carlo analysis of 1989-90 data set with one percent of significant projects subject to stochastic outturn

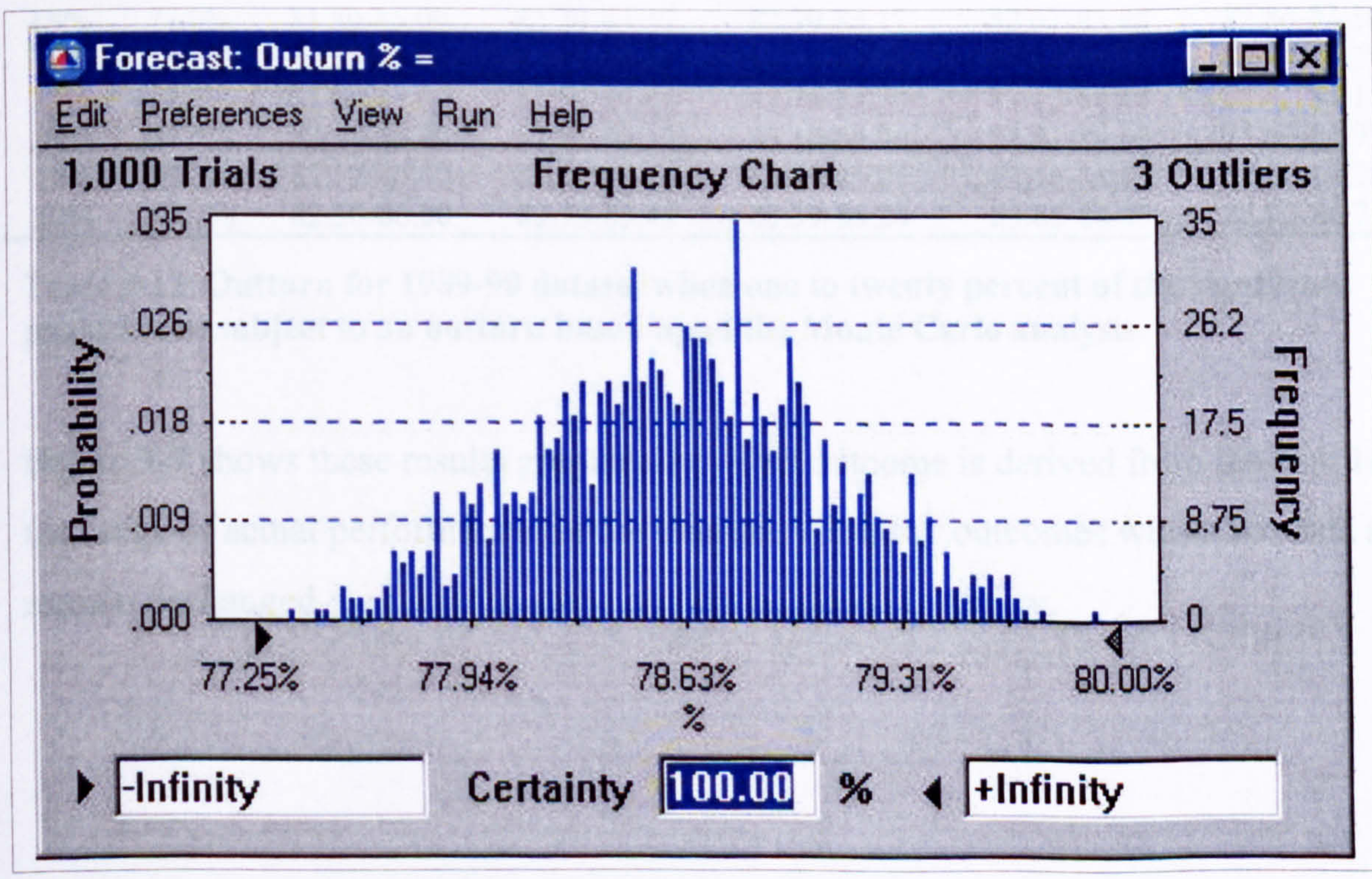

Figure 9-6 Frequency chart of outturn percent for 1989-90 data set when one percent of high impact projects are subject to stochastic analysis

Percentiles for the 100%, 95%, 90%, 75% and 50% ranges of probability are recorded in Table 9-12 for each frequency chart generated, as illustrated in Figure 9-6. Table 9-12

states the probable percent outturn when one percent to twenty percent, as the case maybe, of the highest value projects in the 1989-90 data set in terms of planned expenditure (Amended Estimate) achieve an outturn governed by a Monte Carlo analysis based on the best fit Beta PDF.

% by	% by	Percentiles results compared to 75.42 % actual outturn				
Nos	$	100%	95%	90%	75%	50%
1%	25.1%	77.25-80.00	77.77-79.51	77.86-79.36	78.12-79.86	78.34-78.92
2%	37.9%	77.75-80.75	78.14-80.21	78.28-80.04	78.52-79.76	78.79-79.52
3%	45.1%	78.00-80.75	78.20-80.29	78.41-80.20	78,71-79.97	79.03-79.71
4%	50.9%	77.50-81.00	78.20-80.44	78.41-80.29	78.74-80.01	79.04-79.78
5%	**55.2%**	**78.50-81.50**	**78.92-80.98**	**79.12-80.83**	**79.35-80.59**	**79.60-80.35**
6%	58.8%	78.50-82.00	78.94-81.33	79.34-81.18	79.65-80.96	80.00-80.74
7%	61.9%	79.00-82.50	79.57-81.68	79.74-81.53	80.00-81.23	80.25-81.00
8%	64.6%	79.25-82.25	79.59-81.73	79.80-81.57	80.06-81.33	80.32-81.07
9%	67.0%	79.75-82.75	80.10-82.28	80.28-82.14	80.63-81.89	80.91-81.67
10%	**69.1%**	**80.25-83.25**	**80.58-82.79**	**80.85-82.63**	**81.16-82.39**	**81.41-82.14**
11%	70.9%	80.75-83.75	80.88-83.13	81.18-83.02	81.53-82.82	81.83-82.59
12%	72.5%	81.00-84.00	81.46-83.60	81.63-83.42	81.87-83.18	82.13-82.93
13%	74.3%	81.00-84.50	81.70-83.95	81.91-83.77	82.19-83.49	82.46-83.22
14%	75.6%	81.00-84.50	81.87-84.09	82.03-83.37	82.29-83.57	82.53-83.32
15%	77.0%	81.50-85.00	82.20-84.37	82.39-84.17	82.61-83.88	82.86-83.50
16%	78.3%	82.00-85.00	82.39-84.51	82.56-84.37	82.84-84.14	83.14-83.29
17%	79.5%	82.00-85.50	82.50-84.84	82.78-84.70	83.12-84.46	83.41-84.15
18%	80.6%	82.50-86.00	82.93-85.13	83.10-84.96	83.41-84.69	83.69-84.95
19%	81.7%	82.50-86.00	82.92-85.16	83.19-85.05	83.16-84.82	83.86-84.28
20%	82.7%	82.50-86.00	83.75-85.41	83.39-85.24	83.65-84.99	83.93-84.71

Table 9-12 Outturn for 1989-90 dataset when one to twenty percent of the significant projects are subject to an outturn based upon the Monte Carlo analysis.

Figure 9-7 shows these results graphically. This outcome is derived from the best 10% of the range of actual performance for the data set. All other outcomes within the data set remain unchanged, i.e., remain at the outturn achieved in reality.

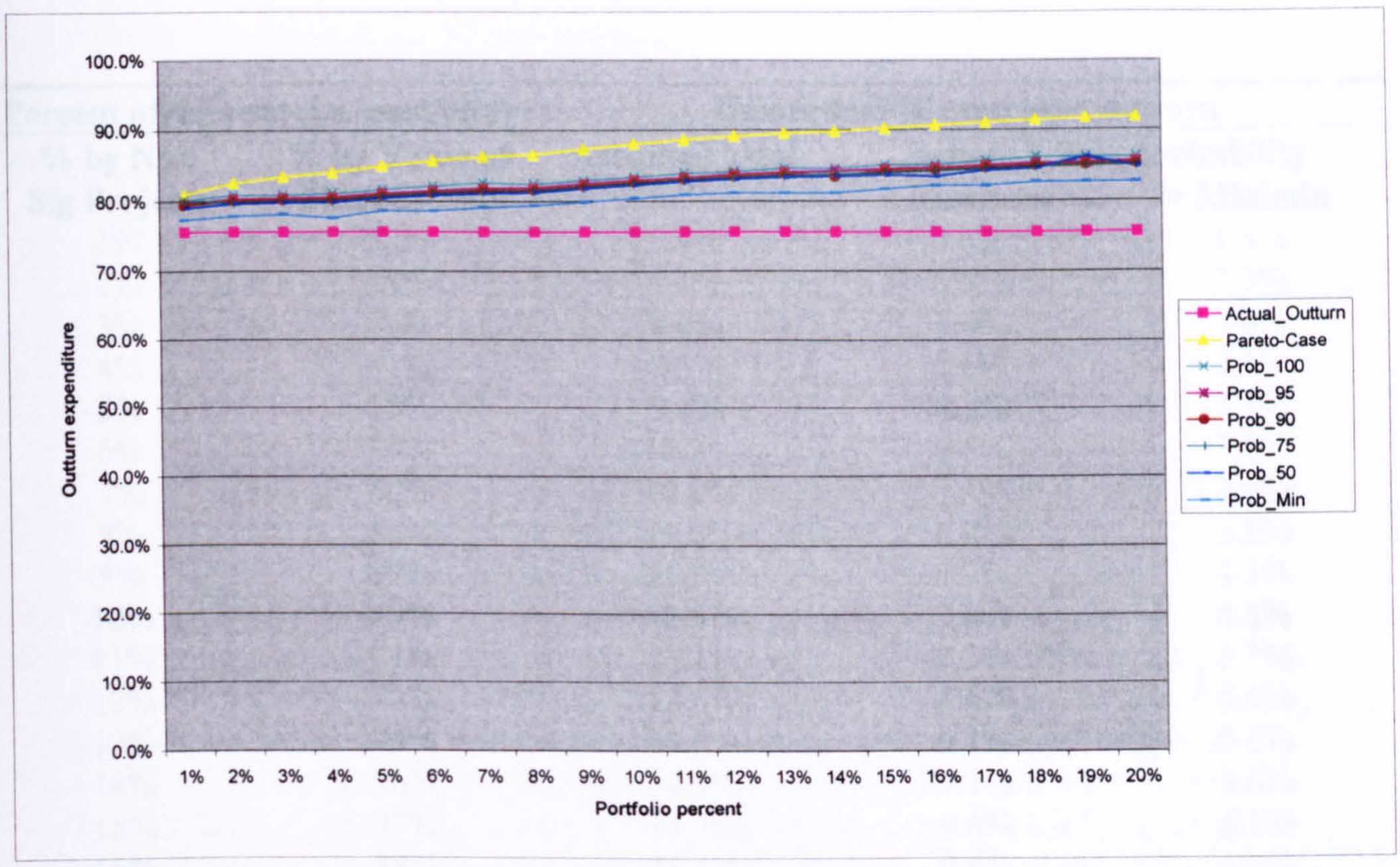

Figure 9-7 Variation in outturn expenditure 1989-90 dataset: comparison of actual outturn when significant projects achieve an ideal or probability-based ideal outcome.

The percent improvement over the actual performance achieved in 1989-90 for this data set, that could theoretically be achieved, based on the assumptions in the mathematical analysis in Section 9.4.1.1 and this stochastic analysis, are set out in Table 9-13.

Percent of data-set (i.e. portfolio)		Theoretical % improved outturn		
% by Nos. Sig Projects	% by Value of Planned Exp	Assumed ideal	assumed Beta probability < Maximax	> Minimin
1%	25%	5.4%	4.6%	1.8%
2%	38%	7.1%	5.3%	2.3%
3%	45%	8.0%	5.3%	2.6%
4%	51%	8.5%	5.6%	2.1%
5%	55%	9.4%	6.1%	3.1%
6%	59%	10.2%	6.6%	3.1%
7%	62%	10.8%	7.1%	3.6%
8%	65%	11.0%	6.8%	3.8%
9%	67%	11.8%	7.3%	4.3%
10%	69%	12.5%	7.8%	4.8%
11%	71%	13.1%	8.3%	5.3%
12%	73%	13.6%	8.6%	5.6%
13%	74%	14.0%	9.1%	5.6%
14%	76%	14.3%	9.1%	5.6%
15%	77%	14.7%	9.6%	6.1%
16%	78%	15.1%	9.6%	6.6%
17%	80%	15.5%	10.1%	6.6%
18%	81%	15.8%	10.6%	7.1%
19%	82%	16.2%	10.6%	7.1%
20%	83%	16.3%	10.6%	7.0%

Table 9-13 Theoretical relative outturn improvement in the outturn performance for the 1989-90 data set

The numbers of significant projects subject to the stochastic analysis ranges from twelve to two hundred and thirty-nine. Table 9-14 states the statistical attributes from each of the analyses. It shows the distribution of outcomes to be a consistent, normal distribution. This is reasonable as the Beta distribution used in the Monte Carlo analysis tends to a uniform distribution for the statistical reasons described by Raftery[16]. The range width is narrow: two to four percent in all cases. The kurtosis values are close to the value of 3.0 associated with a normal distribution[3]. The values of skewness are close to zero showing the distribution to be highly symmetrical. The values of the 'mean' and the 'median' are coincident due to the symmetry. The Beta distribution is continuous and does not lend itself to producing mode values. The Standard Deviation is also uniform.

Prop dataset	Range	Kurtosis	Skew	Mean	Median	Mode	SD	Sensitivity > 0.5
1%	2.95%	2.87	-0.15	78.7%	78.7%	-	0.5%	No (-0.48)
2%	3.30%	2.74	0.06	79.2%	79.1%	-	0.5%	No (-0.43)
3%	3.34%	2.86	-0.11	79.4%	79.4%	-	0.5%	No (-0.42)
4%	3.34%	2.93	-0.10	79.4%	79.4%	-	0.5%	No (-0.42)
5%	3.21%	2.87	-0.14	79.9%	79.9%	-	0.5%	No (-0.36)
6%	3.59%	3.10	-0.13	80.4%	80.4%	-	0.6%	No (-0.41)
7%	3.00%	2.73	0.07	80.6%	80.6%	-	0.5%	No (-0.36)
8%	3.47%	2.90	-0.10	80.7%	80.7%	-	0.6%	No (-0.37)
9%	3.39%	2.98	-0.05	81.3%	81.3%	-	0.6%	No (-0.40)
10%	3.34%	3.03	-0.04	81.8%	81.8%	-	0.5%	No (-0.38)
11%	3.10%	2.68	-0.20	82.2%	82.3%	-	0.6%	No (-0.40)
12%	3.60%	2.81	-0.05	82.5%	82.5%	-	0.6%	No (-0.38)
13%	3.67%	2.97	-0.05	82.8%	82.8%	-	0.6%	No (-0.44)
14%	3.56%	2.86	0.05	82.9%	82.9%	-	0.6%	No (-0.43)
15%	3.39%	2.82	0.12	83.2%	83.2%	-	0.5%	No (-0.41)
16%	3.03%	2.66	-0.04	83.5%	83.5%	-	0.5%	No (-0.38)
17%	3.34%	2.82	-0.04	83.8%	83.8%	-	0.6%	No (-0.43)
18%	3.72%	3.14	-0.01	84.1%	84.15	-	0.6%	No (-0.38)
19%	3.40%	2.94	-0.15	84.3%	84.3%	-	0.5%	No (-0.38)
20%	3.97%	2.97	0.11	84.3%	84.3%	-	0.6%	No (-0.37)

Table 9-14 Statistical attributes of the Monte Carlo analysis of the 1989-90 data set for cases 1% to 20% project significance

The CrystalBall® software calculates sensitivity during the Monte Carlo analysis by collecting assumption values and forecast values as they are produced. Correlation coefficients are computed for the pairs. At the end of the simulation, final sensitivity coefficients are calculated by averaging the coefficients of each pair. For the purpose of this analysis, correlation coefficients less than +/- 0.5 are taken to indicate a lack of sensitivity between the individual variables and the outcome. This is found to be true even when the number of variables is lowest and the potential for any one variable to affect the outcome is greatest. It is the effect of the significant group of projects that produces the overall outcome in these cases.

The Monte Carlo analysis generates the mean value for the percent outturn variance of each project out of the one thousand trials computed in the analysis. This ranges from zero to twenty percent according to the Beta PDF. Table 9-14 shows the statistical attributes for these mean values in each of the analysis scenarios: from one percent

significant projects to twenty percent in this case. The average-mean outturn-variance for the significant projects in the Monte Carlo analyses is 8.93% compared to the 0% assumed in the mathematical analyses in Section 9.4.1.1.

%Sig	Statistical Mean Values from 1000 Monte Carlo Trials						
	Nos	Low	High	Mode	Mean	Median	SD
1%	12	8.70%	9.01%	8.80%	8.84%	8.81%	0.09%
2%	24	8.68%	9.26%	8.96%	8.94%	8.96%	0.14%
3%	36	8.35%	9.23%	9.14%	8.91%	8.90%	0.19%
4%	48	8.625	9.29%	9.19%	8.98%	8.99%	0.17%
5%	60	8.56%	9.35%	8.78%	8.92%	8.91%	0.18%
6%	72	8.30%	9.58%	8.88%	8.94%	8.94%	0.23%
7%	84	8.44%	9.44%	8.88%	8.97%	8.98%	0.21%
8%	96	8.36%	9.24%	8.95%	8.90%	8.95%	0.17%
9%	108	8.56%	9.46%	8.57%	8.92%	8.91%	0.20%
10%	120	8.38%	9.72%	8.82%	8.92%	8.90%	0.22%
11%	131	8.48%	9.47%	8.81%	8.91%	8.90%	0.21%
12%	143	8.42%	9.50%	9.05%	8.95%	8.95%	0.18%
13%	156	8.48%	9.26%	8.82%	8.92%	8.92%	0.17%
14%	167	8.43%	9.29%	8.73%	8.91%	8.91%	0.19%
15%	179	8.17%	9.55%	8.76%	8.94%	8.93%	0.20%
16%	191	8.16%	9.53%	8.92%	8.94%	8.94%	0.20%
17%	203	8.01%	9.47%	8.95%	8.93%	8.94%	0.18%
18%	215	8.11%	9.48%	8.90%	8.92%	8.93%	0.19%
19%	227	8.36%	9.64%	8.96%	8.92%	8.93%	0.20%
20%	239	8.33%	9.47%	8.99%	8.93%	8.94%	0.20%

Table 9-15 Statistical attributes of mean values derived from Monte Carlo simulations of outturn performance for percents of project significance, 1989-90 portfolio.

For brevity in this thesis, the frequency diagrams are not reproduced here of all the analyses, however the results corresponding to percentiles are tabulated here.

9.4.1.3 1989-90 results

Table 9-16 lists the results of the analysis of the 1989-90 empirical data set. The table contains 'ideal' case results taken from Section 9.4.1.1 and the 'stochastic' results for percentiles of 95%, 90%, 75% and 50% probability taken from the Monte Carlo analyses in Section 9.4.1.2. The statistical attributes for the Monte Carlo values for each percent-significance are listed in Table 9-15. When deriving heuristics from this data, the 'evens' probability is used, i.e., the 50% percentile. This is because the difference between 95%

and 50% percentiles values in the case of ten percent and twenty percent of significant projects is less than 0.5% and is not significant.

% No projects modified outturn	% Value	Outturn percent of target expenditure achieved						
		Actual %	Ideal %	Monte Carlo Percentiles				
				Ave-Mean outturn variance per project	95%	90%	75%	50%
1%	25%	75.4	80.6	8.84	79.51	79.36	79.86	78.92
2%	38%	75.4	82.5	8.94	80.21	80.04	79.76	79.52
3%	45%	75.4	83.4	8.91	80.29	80.20	79.97	79.71
4%	51%	75.4	84.0	8.98	80.44	80.29	80.01	79.78
5%	**55%**	**75.4**	**84.9**	**8.92**	**80.98**	**80.83**	**80.59**	**80.35**
6%	59%	75.4	85.6	8.94	81.33	81.18	80.96	80.74
7%	62%	75.4	86.2	8.97	81.68	81.53	81.23	81.00
8%	65%	75.4	86.5	8.90	81.73	81.57	81.33	81.07
9%	67%	75.4	87.2	8.92	82.28	82.14	81.39	81.67
10%	**69%**	**75.4**	**88.0**	**8.92**	**82.79**	**82.63**	**82.39**	**82.14**
11%	71%	75.4	88.7	8.91	81.13	83.02	82.82	82.59
12%	72%	75.4	89.0	8.95	83.60	83.42	83.18	82.93
13%	74%	75.4	89.4	8.92	83.95	83.71	83.49	83.22
14%	76%	75.4	89.7	8.91	84.09	83.37	83.57	83.32
15%	77%	75.4	90.1	8.94	84.37	84.17	83.88	83.50
16%	78%	75.4	90.5	8.94	84.51	84.37	84.14	83.29
17%	79%	75.4	90.9	8.93	84.84	84.70	84.46	84.15
18%	81%	75.4	91.3	8.92	85.13	84.96	84.69	84.95
19%	82%	75.4	91.6	8.92	85.16	85.05	84.82	84.28
20%	**83%**	**75.4**	**97.1**	**8.93**	**85.41**	**85.24**	**84.99**	**84.71**

Table 9-16 Comparison of the improved outtrun for the 1989-90 portfolio due to the impact of the outturn-variance for 1% to 20% significant projects according to 'actual', 'ideal' and 'stochastic' scenarios.

Using the results shown in Table 9-16, three heuristics are proposed corresponding to the twenty-percent, the ten-percent and the five percent levels of significant projects in the portfolio.

- 80:20 rule case:

Twenty percent of the number of the projects in the 1989-90 portfolio contain eighty-three percent of the 'planned expenditure' of the portfolio. There is an evens probability of achieving an eighty-five percent spending performance for the portfolio overall *compared to the seventy-five percent outturn actually achieved.* This assumes that best endeavour management effort is applied to each of the twenty percent projects with greatest planned expenditure that year so that they each achieve an outturn variance that is within the range of zero to twenty percent. Other projects remain at actual performance levels.

- 60:10 rule case

Ten percent of the number of the projects in the 1989-90 portfolio contain sixty-nine percent of the 'planned expenditure' of the portfolio. There is an evens probability of achieving an eighty-two percent spending performance for the portfolio overall *compared to the seventy-five percent outturn actually achieved.* This assumes that best endeavour management effort is applied to each of the ten percent projects with greatest planned expenditure that year so that they each achieve an outturn variance that is within the range of zero to twenty percent. Other projects remain at actual performance levels.

- 50:5 rule case

Five percent of the number of the projects in the 1989-90 portfolio contain fifty-five percent of the 'planned expenditure' of the portfolio. There is an evens probability of achieving an eighty percent spending performance for the portfolio overall *compared to the seventy-five percent outturn actually achieved.* This assumes that best endeavour management effort is applied to each of the five percent projects with greatest planned expenditure that year so that they each achieve an outturn variance that is within the range of zero to twenty percent. Other projects remain at actual performance levels.

9.4.2 1990-91 to 1998-99 financial years

These analyses are a repetition of the analyses described in Section 9.4.1 and are reported in detail in the 'Appendices CD-ROM' in Section 9.4. All of the results are reported in this Chapter at Section 9.5 below.

9.5 Results

9.5.1.1 Attributes of the data

Section 2.9.1 provides a general description of the source of the audited, published data used in the year-by-year analysis for this ten-year period. A side-by-side comparison of the general statistics for each of the portfolios is given in Table 2-12.

The number of projects within each of the ten portfolios exceeded 1,048 in all cases. The mode and the median show that the majority of the projects have a value of planned expenditure at the lower end of the range. This is seen in the frequency graph at Figure 9-8 and in associated Table 9-17.

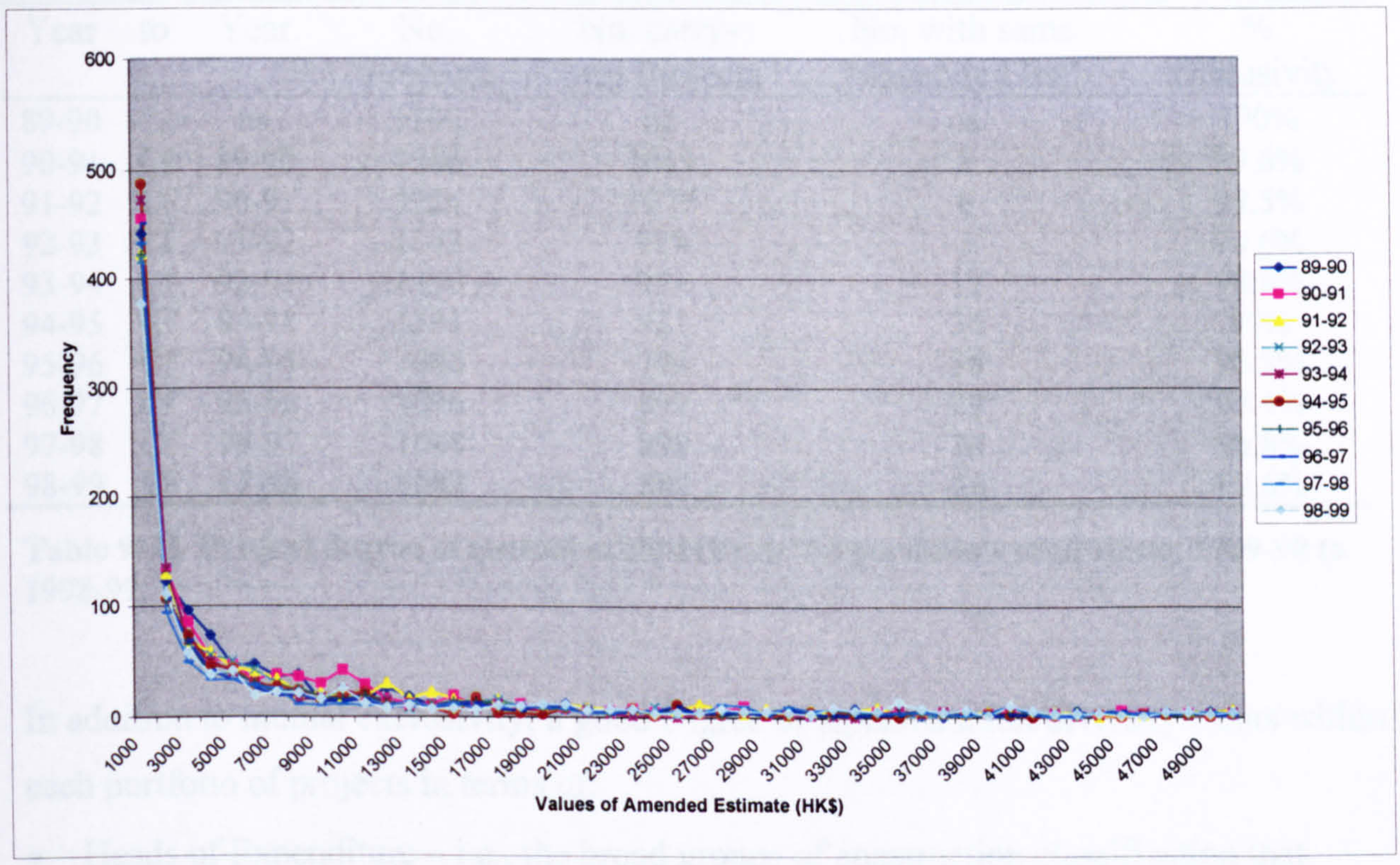

Figure 9-8 Frequency distribution for values of 'Amended Estimate' within $0 - $50,000

'Amended Estimate'	Financial Year beginning . . .									
> $50,000	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98
Nos of projects.	50	79	81	86	66	85	91	100	93	121
% of Total	2%	3%	3%	3%	3%	3%	4%	4%	4%	5%

Table 9-17 Proportion of projects within annual portfolios with a value of Amended Estimate > $50,000.

The projects within each annual portfolio have a lifecycle that spans several years. Consequently, a large proportion of them re-occur in successive portfolios-of-projects. However, the planned expenditure value for each project changes as the project progresses making the portfolios-of-projects mutually exclusive in successive years. The degree of this exclusivity in terms of planned expenditure is shown in Table 9-18.

Year	to	Year	No. Projects	No. carry-over Projects	No. with same 'Amended Est'	% exclusivity
89-90		na	1196	na	na	100%
90-91	Cf	89-90	1286	1019	5	99.6%
91-92	Cf	90-91	1224	1077	6	99.5%
92-93	Cf	91-92	1143	929	5	99.6%
93-94	Cf	92-93	1130	951	12	98.9%
94-95	Cf	93-94	1131	951	34	97%
95-96	Cf	94-95	1086	796	38	96.5%
96-97	Cf	95-96	1096	892	29	97.4%
97-98	Cf	96-97	1048	899	34	96.8%
98-99	Cf	97-98	1082	882	26	97.6%

Table 9-18 Percent degree of mutual exclusivity in the portfolio's of projects, 1989-90 to 1998-99.

In addition to mutual exclusivity, a good degree of representation/diversity exists within each portfolio of projects in terms of:

- Heads of Expenditure – i.e., the broad groups of construction classification that correspond to the disciplines of each the public works departments.
- Categories of work - the type of architectural/engineering work according to an index of seventy-eight types of public works.

The diversity within each of the ten successive portfolios-of-projects was displayed earlier in Table 2-13. It also shows that all the Heads of Expenditure are represented in each annual portfolio considered except for new Heads 702 and 710: these were introduced later within the ten year period of analysis. Diversity in terms of the categories-of-works exceeds sixty percent in all years. Table 9-19 shows the Pareto effect within each of the annual portfolio-of-projects in terms of the cumulative value of 'Amended Estimate' for the 5%, 10% and 20% of the number of highest value projects.

Year	Value of 'Amended Estimate' within		
	5% of Projects	10% of Projects	20% of Projects
1989-90	55%	69%	83%
1990-91	51%	66%	82%
1991-92	52%	67%	83%
1992-93	52%	67%	88%
1993-94	76%	85%	93%
1994-95	74%	83%	92%
1995-96	71%	82%	92%
1996-97	67%	80%	91%
1997-98	58%	73%	87%
1998-99	51%	66%	83%

Table 9-19 Values of 5%, 10% and 20% Pareto significance, 1989-1998.

The Pareto effect shown in Table 9-19 indicates that the performance of the lesser number significant projects within the portfolio may also have a significant effect on the Outturn Variance of the portfolio as a whole.

Table 9-20 shows that the annual overall Outturn Variance is an average value of thirty-three percent underspend for the five year period of 1989-1993: thereafter performance improves over five years to an annual, overall average of twenty-five percent under-spend of the planned expenditure. Less than two percent of the projects within any of the portfolios-of-projects have an Outturn Variance greater than two hundred percent. In these few cases, the projects realise an actual expenditure that greatly exceeds the relatively low value of planned expenditure. Figure 9-9 shows the Frequency of Variance achieved within a range of zero to two-hundred percent. Table 9-21 states the number of instances a greater than two-hundred percent variance is achieved and also shows the predominance of an Outturn Variance of one hundred percent. This peak, clearly shown in Figure 9-9, occurs when zero-value actual expenditure occurs. These twenty to thirty percent of the projects in each annual portfolio have made no progress in terms of spending performance. This is usually due to the late start of the spending profile and is coincident with low-value planned expenditure at the early stage of the cashflow 'S-curve'.

Year	Outturn Performance ($ millions)		
	Planned Expenditure	Actual Expenditure	Variance (%)
1989-90	13,805	10,412	25
1990-91	18,049	11,930	33
1991-92	19,784	10,744	46
1992-93	21,203	13,893	35
1993-94	27,722	20,958	24
1994-95	26,098	20,014	23
1995-96	31,312	22,850	27
1996-97	28,509	20,968	26
1997-98	23,650	18,337	22
1998-99	24,780	18,568	25

Table 9-20 Outturn performance for each of the annual portfolios within the 1989-1999 period of this analysis.

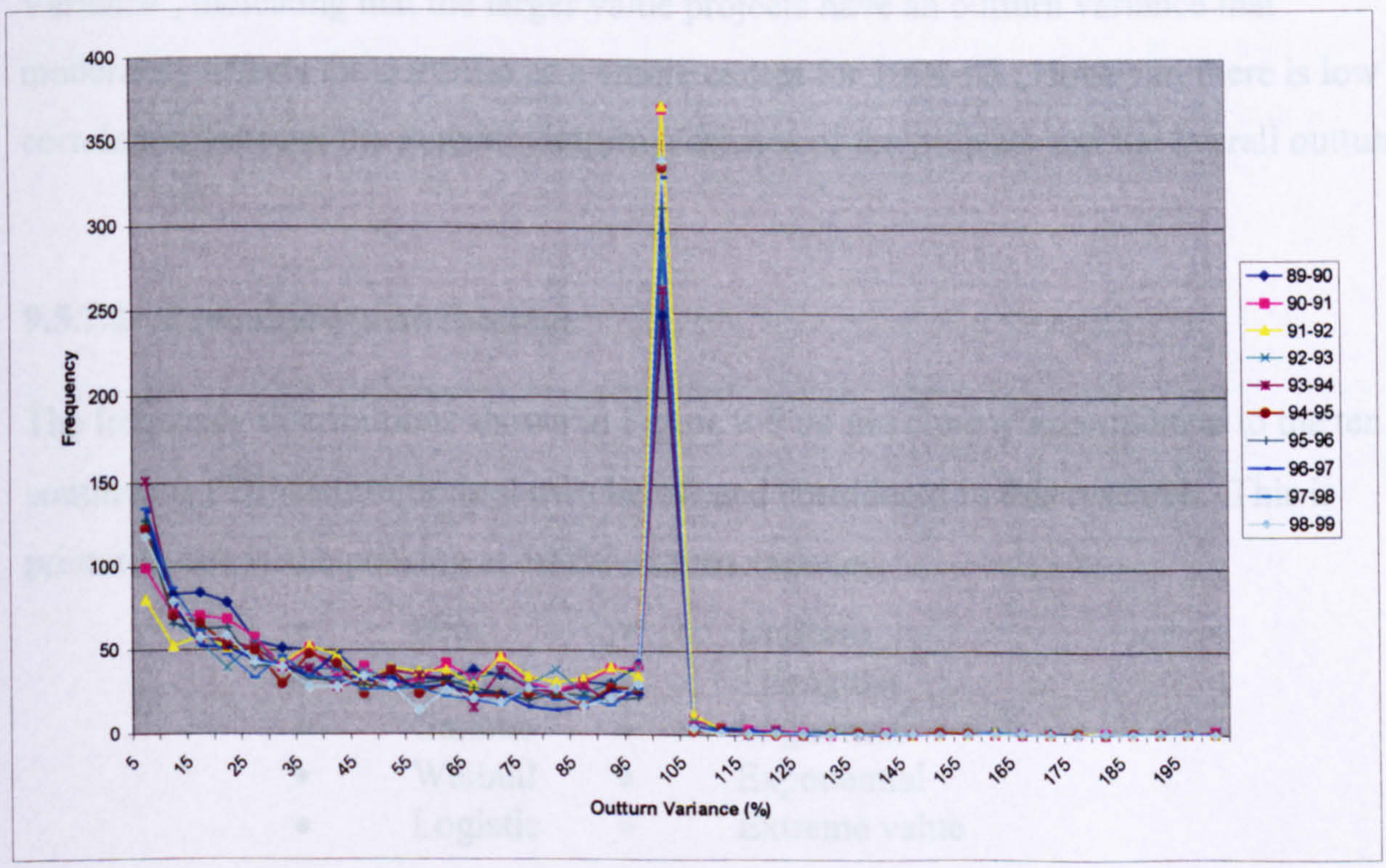

Figure 9-9 Frequency comparison of Outturn Variance, 1989-99

	Financial Year beginning . . .									
	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98
No projects > 200%	16	11	0	26	32	16	17	6	9	14
% of portfolio	1%	1%	0%	2%	3%	1%	2%	1%	1%	1%
% projects = 100%	21%	29%	30%	25%	23%	30%	29%	30%	28%	31%

Table 9-21 Proportion of projects with an Outturn Variance > 200% or equal to 100% in annual portfolios 1989-98.

Table 2-14 states the Spearman Rank Correlation Coefficients calculated for each annual portfolio in terms of the value of 'Amended Estimate' Vs the 'Outturn Variance', and also 'Amended Estimate' Vs the Percent Outturn Variance. These show a moderate positive correlation between the value of 'Amended Estimate' and the 'Outturn Variance', indicating that the larger value projects have an outturn variance that moderately affects the portfolio as a whole except for 1994-95. However, there is low correlation between the Percent Outturn Variance of the projects and the overall outturn.

9.5.1.2 Probability distributions

The frequency distributions shown in Figure 9-9 do not closely approximate to the ten continuous PDF distributions shown below and considered in this research. This is primarily due to the peaking at 100% outturn variance.

- Beta
- Normal
- Gamma
- Weibull
- Logistic
- Uniform
- Triangular
- Lognormal
- Exponential
- Extreme value

Curve fitting to any of the ten standard probability distributions does not give a good fit in itself: nor to the data of predominant interest in this research, namely within the x-axis range of 0 to 0.2. As stated earlier, the hypothesis tested in this research presupposes that management effort can be focused on the significant projects within a population to achieve the better performance found within an outturn PDF for the whole population. The best management effort is taken as the performance achieved in the range 0.0 – 0.2

ratio of 'Outturn Variance/Amended Estimate' i.e. the best ten percent of the zero to two-hundred percent range of outturn variance. For the purposes of this research the best fit to the empirical data within the x-range of 0 to 0.2 is required for each of the annual portfolio-of-projects within the period 1989-98.

In each financial year 1989-90 to 1998-99, a Beta PDF is found to be the closest fit to the empirical data. Table 9-22 shows the attributes of the Beta distributions and the second and third closest fit probability distributions. The results of the distribution fitting are tested using three goodness-of-fit methods[3]: Chi-square; Kolmogorov-Smirnov (K-S); and Anderson-Darling (A-D).

In terms of Chi-Square tests, 1994-95, 1995-96, and 1996-97 achieve a close fit to a Beta distribution with values of 'θ less than 0.5'. Kolmogrov-Smirnov tests show a close fit in 1995-1996 with a value of about 0.03, whilst Anderson-Darling does not achieve a close fit (values less than 1.5) but is closest in 1995-96 with a value of 5.244.

The attributes of the Beta distribution fitted to the empirical data from each of the financial-years analyzed varies in terms of α = **0.54 to 0.78, and** β = **0.81 to 1.06.** These values are used in the stochastic analyzes previously described in this research at Section 9.4.1.2 of the Thesis and in Section 9.4 of the Appendices.

Year	Probability Distribution		Test of Fit		
	Distribution	Attributes	Chi-Sq	K-S	A-D
1989	**1.Beta**	**α= 0.75, β=0.93, scale=0.2**	**25.33 (θ = 0.088)**	**0.047**	**9.074**
-	2. Uniform	Min=-0.00, Max=0.20	44.00 (θ = 0.001)	0.087	9.200
1990	3. Ext Value	Mode=0.06, Scale=0.05	81.11 (θ = 0.000)	0.077	5.136
1990	**1.Beta**	**α= 0.74, β=0.89, scale=0.2**	**30.79 (θ = 0.009)**	**0.068**	**16.779**
-	2. Uniform	Min=-0.00, Max=0.20	43.38 (θ = 0.000)	0.092	9.281
1991	3. Ext Value	Mode=0.06, Scale=0.05	90.51 (θ = 0.000)	0.087	6.105
1991	**1.Beta**	**α= 0.68, β=0.82, scale=0.2**	**28.21 (θ = 0.013)**	**0.086**	**20.810**
-	2. Uniform	Min=-0.00, Max=0.20	43.12 (θ = 0.000)	0.101	8.732
1992	3. Normal	Mean= 0.09, SD=0.06	73.80 (θ = 0.000)	0.093	3.860
1992	**1.Beta**	**α= 0.61, β=1.06, scale=0.2**	**31.73 (θ = 0.000)**	**0.077**	**19.913**
-	2. Triangular	Min=-0.00, Likliest0.0, Max=0.21	68.40 (θ = 0.000)	0.098	13.898
1993	3. Exponential	Rate=13.70	98.80 (θ = 0.000)	0.098	26.736
1993	**1.Beta**	**α= 0.54, β=0.92, scale=0.2**	**23.87 (θ = 0.092)**	**0.062**	**14.293**
-	2. Exponential	Rate=13.47	104.22 (θ = 0.000)	0.092	22.138
1994	3. Triangular	Min=-0.00, Likliest0.0, Max=0.21	111.26 (θ = 0.000)	0.105	17.897
1994	**1.Beta**	**α= 0.64, β=0.97, scale=0.2**	**15.17 (θ = 0.439)**	**0.061**	**13.364**
-	2. Uniform	Min=-0.00, Max=0.20	74.68 (θ = 0.000)	0.155	25.871
1995	3. Exponential	Rate=12.54	79.08 (θ = 0.000)	0.105	20.268
1995	**1.Beta**	**α= 0.65, β=0.91, scale=0.2**	**14.29 (θ = 0.577)**	**0.038**	**5.244**
-	2. Uniform	Min=-0.00, Max=0.20	55.43 (θ = 0.000)	0.155	17.240
1996	3. Exponential	Rate=11.98	85.21 (θ = 0.000)	0.109	11.178
1996	**1.Beta**	**α= 0.61, β=1.02, scale=0.2**	**14.13 (θ = 0.516)**	**0.054**	**10.676**
-	2. Weibull	Loc=-0.0,Scale=0.08,Shape=1.28	67.30 (θ = 0.000)	0.096	10.357
1997	3. Triangular	Min=-0.00, Likliest0.0, Max=0.21	67.42 (θ = 0.000)	0.090	10.701
1997	**1.Beta**	**α= 0.64, β=1.06, scale=0.2**	**26.12 (θ = 0.052)**	**0.046**	**8.109**
-	2. Exponential	Rate=13.13	71.94 (θ = 0.000)	0.086	13.905
1998	3. Triangular	Min=-0.00, Likliest0.0, Max=0.21	70.12 (θ = 0.000)	0.081	10.185
1998	**1.Beta**	**α= 0.67, β=0.99, scale=0.2**	**23.42 (θ = 0.076)**	**0.058**	**11.975**
-	2. Normal	Mean= 0.08, SD=0.06	87.73 (θ = 0.000)	0.090	5.435
1999	3. Exponential	Rate=12.50	93.212 (θ = 0.000)	0.100	18.996

Table 9-22 1st, 2nd, 3rd closest-fit continuous-probability distributions 1989-90 to 1998-1999.

9.5.1.3 Mathematical analysis for an Optimum Outturn

The methodology for the calculation of the theoretical 'Optimum Outturn' for the portfolio is described in Section 2.9.4 'Mathematical validation of a significance approach'. This 'ideal' outcome is compared to the actual outcome as shown in Table 9-20. Table 9-23 shows the overall improvement in the outturn for the portfolio as an increasing percent of the significant projects achieve the theoretical ideal outturn. Table 9-24 shows the corresponding positive differential improvement to the 'actual outturn' achieved in each of the financial years, 1989-90 to 1998-99.

	Financial year beginning . . .									
	89	90	91	92	93	94	95	96	97	98
No projects	1196	1286	1224	1143	1130	1131	1086	1096	1048	1082
Actual o/t cf	75%	66%	54%	65%	76%	77%	73%	74%	78%	75%
o/t @ 2.5%	83%	75%	71%	79%	90%	85%	85%	86%	84%	79%
o/t @ 5%	**85%**	**79%**	**76%**	**84%**	**92%**	**90%**	**89%**	**89%**	**87%**	**84%**
o/t @ 7.5%	86%	82%	80%	88%	93%	92%	91%	91%	88%	86%
o/t @ 10%	**88%**	**84%**	**82%**	**89%**	**94%**	**93%**	**93%**	**92%**	**90%**	**88%**
o/t @ 12.5%	89%	86%	85%	91%	95%	94%	94%	94%	91%	89%
o/t @ 15%	90%	87%	87%	92%	96%	95%	95%	95%	93%	91%
o/t @ 17.5%	91%	89%	89%	93%	96%	96%	95%	95%	94%	92%
o/t @ 20%	**92%**	**90%**	**90%**	**94%**	**97%**	**96%**	**96%**	**96%**	**95%**	**93%**
o/t @ 22.5%	92%	91%	91%	94%	97%	97%	97%	97%	96%	93%
o/t @ 25%	93%	92%	92%	95%	98%	97%	97%	97%	96%	94%
o/t @ 27.5%	94%	93%	93%	96%	98%	98%	98%	98%	97%	95%
o/t @ 30%	95%	94%	94%	96%	98%	98%	98%	98%	97%	96%
o/t @ 35%	96%	95%	96%	97%	99%	98%	98%	98%	98%	97%
o/t @ 40%	97%	97%	97%	98%	99%	99%	99%	99%	99%	98%
o/t @ 50%	98%	98%	98%	99%	99%	99%	99%	100%	99%	99%

Table 9-23 Improved portfolio-outturn achieved when increasing percentiles of significant value projects achieve a zero outturn variance, 1989-1998.

	Financial year beginning . . .									
	89	90	91	92	93	94	95	96	97	98
No projects	1196	1286	1224	1143	1130	1131	1086	1096	1048	1082
Actual o/t cf	75%	66%	54%	65%	76%	77%	73%	74%	78%	75%
o/t @ 2.5%	8%	9%	17%	13%	15%	8%	12%	13%	6%	4%
o/t @ 5%	**10%**	**13%**	**22%**	**19%**	**16%**	**13%**	**16%**	**16%**	**9%**	**9%**
o/t @ 7.5%	11%	16%	26%	22%	18%	15%	18%	17%	11%	11%
o/t @ 10%	**13%**	**18%**	**28%**	**24%**	**19%**	**17%**	**20%**	**19%**	**12%**	**13%**
o/t @ 12.5%	14%	20%	30%	25%	20%	18%	21%	20%	14%	14%
o/t @ 15%	15%	21%	33%	27%	21%	18%	22%	21%	15%	16%
o/t @ 17.5%	16%	23%	34%	27%	21%	19%	22%	22%	16%	17%
o/t @ 20%	**17%**	**24%**	**36%**	**28%**	**21%**	**20%**	**23%**	**22%**	**17%**	**18%**
o/t @ 22.5%	18%	25%	37%	29%	22%	20%	24%	23%	18%	19%
o/t @ 25%	19%	26%	38%	30%	22%	21%	24%	24%	19%	19%
o/t @ 27.5%	19%	27%	39%	30%	22%	21%	25%	24%	19%	20%
o/t @ 30%	19%	28%	40%	31%	23%	21%	25%	24%	20%	21%
o/t @ 35%	20%	29%	41%	32%	23%	22%	25%	25%	21%	22%
o/t @ 40%	21%	31%	43%	32%	23%	22%	26%	25%	21%	23%
o/t @ 50%	23%	32%	44%	33%	24%	23%	26%	26%	22%	24%

Table 9-24 Percent differential improvement in outturn for the portfolio when increasing percentiles of significant value projects achieve a zero outturn variance, 1989-1998.

These results are theoretical extremes that rely on achieving a perfect outcome for a large number of high-value projects. In the real world it is unrealistic to expect to achieve a perfect outcome for fifty or more significant projects within a portfolio of more than one-thousand projects. An improved outturn that is based upon better performance for the lesser number of significant projects within the large number of projects overall lies somewhere between the 'actual outcome' and the theoretical extreme identified here. The results of this stochastic analysis are stated below in Section 9.5.1.4

9.5.1.4 Stochastic outturn

The stochastic outturn is derived from analyzes of the effect on the outturn for the portfolio of projects as a whole when increasing percents of the significant projects within the portfolio achieve an outturn variance that falls within the best ten percent of the achievable range of performance. In this case, the range is from zero to two-hundred

percent outturn variance. The achievable range of performance is derived from empirical actual performance data for the portfolio.

The value of the outturn variance, falling within the best ten percent achievable range of performance, is determined by Monte Carlo stochastic analysis using the Beta PDF described in Section 9.5.1.2. The methodology is described in Section 2.9.5. The stochastic outcome is then compared to the actual outcome as shown in Table 9-20. CrystalBall® software by Decisioneering Inc., was used for the Monte Carlo analyses. Each variable in the stochastic model is mutually exclusive and therefore defined in the mathematical model as an independent probability variable with the Beta probability distribution characteristics calculated from the empirical data for that portfolio-of-projects. Each probability variable was subject to a one thousand run Monte Carlo analysis set at the default initial seed-value of zero. This ensured a consistent basis for analysis in each processing run of the model. The software produced distributions of outcome, the statistical attributes of these distributions, and also reported the impact sensitivity of the variables within each processing run of the model. The range of the statistical attributes from each of the analyses is shown in Table 9-25.

Statistical attributes of the distribution of outcomes	Extreme values from 200 No. Monte Carlo analyses	
	Low Value	High Value
Range	2.3%	7.08%
Kurtosis	2.56	3.26
Skew	-0.33	0.11
Mean	63.1%	89.2%
Median	63.1%	89.2%
Mode	-	-
Standard Deviation	0.5	1.1

Table 9-25 Range of statistical attributes of the distribution of outcomes from two-hundred Monte Carlo analyses.

The range width is narrow: two to seven percent in all cases. The kurtosis values fall within a range close to the value of 3.0 associated with a normal distribution[3]. The values of skewness are close to zero showing the distribution to be highly symmetrical. Whereas the values of the 'mean' and the 'median', are coincident due to the symmetry. The Beta distribution is continuous and does not lend itself to producing mode values.

The Standard Deviation is also uniform and within a narrow range. These attributes indicate that the distribution of outcomes is a consistent, normal distribution in all cases.

The CrystalBall® software calculates sensitivity during the Monte Carlo simulations by collecting assumption values and forecast values as they are produced. Correlation coefficients are computed for the pairs. At the end of the simulation, final sensitivity coefficients are calculated by averaging the coefficients of each pair. For the purpose of this analysis, correlation coefficients less than +/- 0.5 are taken to indicate a lack of sensitivity between the individual variables and the outcome. The correlation coefficients were generally less than this, and in any case did not exceed –0.63. It is the effect of the significant group of projects that produces the outcome.

There is no indication of a single project significantly influencing the outcome for the portfolio-of-projects as a whole.

The ten most sensitive variables were identified in each Monte Carlo simulation. To make the point, Table 9-26 summarizes the extent of sensitivities within the simulations.

	Financial year beginning . . .									
	89	90	91	92	93	94	95	96	97	98
No projects	1196	1286	1224	1143	1130	1131	1086	1096	1048	1082
	Instances of Sensitivities > +/- 0.5									
1 % Sig	Nil	Nil	Yes	Yes	Yes	Nil	Yes	Yes	Nil	Nil
2 % Sig	Nil	Nil	Yes	Yes	Yes	Nil	Nil	Nil	Nil	Nil
3 % Sig	Nil	Nil	Yes	Yes	Nil	Nil	Nil	Yes	Nil	Nil
4 % Sig	Nil	Nil	Yes	Yes	Nil	Nil	Nil	Nil	Nil	Nil
5 % Sig	Nil	Nil	Yes	Nil	Yes	Nil	Nil	Nil	Nil	Nil
6 % Sig	Nil	Nil	Yes	Yes	Yes	Nil	Nil	Nil	Nil	Nil
7 % Sig.	Nil	Nil	Yes	Yes	Nil	Nil	Nil	Nil	Nil	Nil
8 % Sig.	Nil	Nil	Yes	Yes	Yes	Nil	Nil	Nil	Nil	Nil
9 % Sig.	Nil	Nil	Yes	Yes	Yes	Nil	Nil	Nil	Nil	Nil
10 % Sig.	Nil	Nil	Yes	Yes	Nil	Nil	Nil	Nil	Nil	Nil
11 % Sig.	Nil	Nil	Yes	Yes	Yes	Nil	Yes	Nil	Nil	Nil
12 % Sig.	Nil	Nil	Yes	Yes	Nil	Nil	Yes	Nil	Nil	Nil
13 % Sig.	Nil	Nil	Yes	Nil	Yes	Nil	Nil	Nil	Nil	Nil
14 % Sig.	Nil	Nil	Yes	Yes	Yes	Nil	Nil	Nil	Nil	Nil
15 % Sig.	Nil	Nil	Yes	Yes	Yes	Nil	Nil	Nil	Nil	Nil
16 % Sig.	Nil	Nil	Yes	Yes	Yes	Nil	Nil	Nil	Nil	Nil
17 % Sig.	Nil	Nil	Yes	-	Yes	Nil	Nil	Nil	Nil	Nil
18 % Sig.	Nil	Nil	Yes	-	Nil	Nil	Nil	Nil	Nil	Nil
19 % Sig.	Nil	Nil	Yes	-	Nil	Nil	Nil	Nil	Nil	Nil
20 % Sig.	Nil	Nil	Yes	-	Yes	Nil	Nil	Nil	Nil	Nil
	Range of the highest sensitivity value for 1% to 20% project significance									
Low value	-0.36	-0.31	-0.50	-0.48	-0.48	-0.43	-0.46	-0.42	-0.30	-0.34
High value	-0.48	-0.48	-0.63	-0.63	-0.53	-0.49	-0.55	-0.50	-0.41	-0.47

Table 9-26 Comparision of sensitivity analysis within the 200 Monte Carlo simulations.

The Monte Carlo analysis generates the mean value of the one thousand instances, of the percent outturn variance of each significant project computed in each analysis. This value falls within the scale of zero to twenty percent Outturn Variance according to the Beta PDF. Bearing in mind the shape of the PDF, a mean value is expected that tends to the middle of the scale. Table 9-27 shows the average of the mean values for the two-hundred Monte Carlo analyses.

	Financial year beginning . . .									
	89	90	91	92	93	94	95	96	97	98
Alpha =	0.75	0.74	0.68	0.61	0.54	0.64	0.65	0.61	0.65	0.67
Beta =	0.93	0.89	0.82	1.06	0.92	0.97	0.91	1.02	1.06	0.99
No projects	1196	1286	1224	1143	1130	1131	1086	1096	1048	1082
Average of the 1000 Mean Values of project Outturn Variance each Monte Carlo analysis										
1 % Sig	8.84	9.08	9.06	7.25	7.34	7.88	8.33	7.44	7.57	8.02
2 % Sig	8.94	9.09	9.12	7.26	7.37	8.00	8.30	7.49	7.65	8.04
3 % Sig	8.91	9.08	9.11	7.29	7.44	7.90	8.30	7.52	7.64	8.07
4 % Sig	8.98	9.07	9.11	7.30	7.38	7.91	8.33	7.48	7.56	8.08
5 % Sig	8.92	9.06	9.03	7.37	7.41	7.92	8.35	7.52	7.58	8.05
6 % Sig	8.94	9.07	9.09	7.28	7.41	7.96	8.34	7.47	7.59	8.10
7 % Sig.	8.97	9.08	9.06	7.28	7.41	7.97	8.35	7.49	7.60	8.08
8 % Sig.	8.90	9.09	9.06	7.33	7.38	7.95	8.36	7.48	7.60	8.10
9 % Sig.	8.92	9.08	9.07	7.30	7.40	7.93	8.38	7.49	7.59	8.06
10 % Sig.	8.92	9.08	9.07	7.29	7.37	7.94	8.36	7.47	7.63	8.10
11 % Sig.	8.91	9.08	9.07	7.33	7.40	7.93	8.35	7.48	7.60	8.04
12 % Sig.	8.95	9.08	9.07	7.31	7.37	7.94	8.33	7.46	7.62	8.07
13 % Sig.	8.92	9.06	9.06	7.33	7.43	7.97	8.32	7.48	7.60	8.05
14 % Sig.	8.91	9.08	9.08	7.31	7.39	7.97	8.34	7.45	7.59	8.07
15 % Sig.	8.94	9.07	9.07	7.30	7.39	7.93	8.33	7.47	7.57	8.10
16 % Sig.	8.94	9.08	9.06	7.31	7.39	7.95	8.35	7.49	7.61	8.07
17 % Sig.	8.93	9.07	9.05	7.31	7.40	7.97	8.37	7.50	7.60	8.08
18 % Sig.	8.92	9.07	9.06	7.33	7.39	7.98	8.33	7.45	7.62	8.05
19 % Sig.	8.92	9.08	9.07	7.32	7.40	7.96	8.32	7.49	7.62	8.09
20 % Sig.	8.93	9.08	9.08	7.30	7.40	7.96	8.31	7.50	7.61	8.07
	Average of the Means									
1-20% Sig.	8.93	9.08	9.08	7.30	7.39	7.95	8.34	7.48	7.60	8.07

Table 9-27 Comparision of average-mean values of the Outturn Variance for the significant projects within the 200 Monte Carlo simulations.

9.6 Summary of the stochastic modeling of an alternate approach to portfolio management

The results from the idealistic mathematical validation of the significance approach described in Section 9.5.1.3 and the stochastic validation in Section 9.5.1.4, lead to the following generalisation for the 1989-1999 analyses:-

- The first benchmark is to be the actual outcome achieved;
- It is self-evident that there is a much lower expectancy of achieving an Outturn Variance of zero percent for the significant projects. However, this ideal scenario provides a second benchmark for comparing the outcome calculated in the stochastic validation.
- There is a reasonable expectancy of achieving an overall average Outturn Variance of seven to nine percent for the significant projects.

Taking the results obtained from the mathematical analysis in Section 9.5.1.2 as a whole, then the following statements are derived:-

- **At the 5% percentile,** a seventy-nine to ninety-two percent outturn variance is theoretically achieved for the portfolio as a whole when a zero outturn is achieved for the 51 to 64 projects with highest planned expenditure. This is a nine to twenty-two percent positive differential improvement compared to the actual outcome achieved in the ten years, 1989-90 to 1998-99.

- **At the 10% percentile,** an eighty-two to ninety-four percent outturn variance is theoretically achieved for the portfolio as a whole when a zero outturn is achieved for the 102 to 129 projects with highest planned expenditure. This is a twelve to twenty-eight percent positive differential improvement compared to the actual outcome achieved in the ten years, 1989-90 to 1998-99.

- **At the 20% percentile,** a ninety-two to ninety-seven percent outturn variance is theoretically achieved for the portfolio as a whole when a zero outturn is achieved for the 204 to 258 projects with highest planned expenditure. This is a seventeen to thirty-six percent positive differential improvement compared to the actual outcome achieved in the ten years, 1989-90 to 1998-99.

Using the results obtained from the stochastic analysis in Section 9.5.1.4; the net outturn for the portfolio-of-project is shown in Table 9-28 for percentiles of five, ten and twenty percent significant projects.

	Financial year beginning . . .									
	89	90	91	92	93	94	95	96	97	98
No projects	1196	1286	1224	1143	1130	1131	1086	1096	1048	1082
Actual o/t cf	75%	66%	54%	65%	76%	77%	73%	74%	78%	75%
100 percentile outturn overall (1 dp)										
o/t @ 5%	81.5	75.5	72.8	81.5	80.0	75.5	85.0	86.5	84.0	81.0
o/t @ 10%	83.3	79.3	78.0	86.0	91.0	79.0	88.0	88.5	86.0	83.8
o/t @ 20%	86.0	83.8	84.5	89.5	93.0	81.0	90.5	91.5	90.0	87.0
95 percentile outturn overall (1 dp)										
o/t @ 5%	81.0	75.2	72.1	80.8	88.1	74.9	83.9	85.5	83.3	80.5
o/t @ 10%	82.8	78.8	77.4	85.1	89.8	78.0	87.3	87.7	85.3	83.6
o/t @ 20%	85.4	83.2	83.7	88.7	91.7	80.1	90.0	90.5	89.4	86.7
90 percentile outturn overall (1 dp)										
o/t @ 5%	80.8	75.1	72.0	80.6	87.9	74.7	83.8	85.4	83.1	80.4
o/t @ 10%	82.6	78.7	77.3	84.9	89.5	77.8	87.1	87.6	85.2	83.5
o/t @ 20%	85.2	83.1	83.6	88.5	91.5	80.0	89.8	90.3	88.9	86.5
50 percentile outturn overall (1 dp)										
o/t @ 5%	80.4	74.6	71.5	80.3	87.2	74.1	83.1	84.7	82.4	79.9
o/t @ 10%	82.1	78.3	76.8	84.2	88.6	77.2	86.4	86.8	84.7	83.0
o/t @ 20%	84.7	82.6	83.1	87.9	90.7	79.4	89.0	89.7	88.7	86.1
0 percentile outturn overall (1 dp)										
o/t @ 5%	78.5	73.0	69.8	77.5	83.0	71.5	80.5	82.0	80.0	78.0
o/t @ 10%	80.3	76.5	74.5	81.5	84.0	74.5	83.5	84.0	82.5	81.0
o/t @ 20%	82.5	81.0	81.0	85.0	86.0	77.0	86.0	87.0	86.5	84.0

Table 9-28 Comparison of outturn variance achieved for the portfolio overall at 5%, 10% and 20% significance for 1989-90 to 1998-99.

The stochastic analysis results leads to the following statements:

At 5% project significance, for the:

- 100 percentile (maximax)….. the outturn ranges from 72.8% to 90%;
- 95 percentile…….. the outturn ranges from 72.1% to 88.1%;
- 90 percentile…….. the outturn ranges from 72.0% to 87.9%;
- 50 percentile…….. the outturn ranges from 71.5% to 87.2%; and
- 0 percentile (minimin) …….. the outturn ranges from 69.8% to 83.0%.

Leading to the generalisation over the ten-year period analyzed that if in each financial year, the **5% of projects with greatest planned-expenditure** achieve an outturn variance that is within the range of the best 10% of the range of performances achieved by the projects in the portfolio, then the outturn for the portfolio as a whole is greater than

70%, with an evens probability of an outturn variance of 71.5%, all other things being equal.

At 10% project significance, for the:

100 percentile (maximax)..... the outturn variance ranges from 78.0% to 91%;
95 percentile ..... the outturn variance ranges from 77.4% to 89.8%;
90 percentile ..... the outturn variance ranges from 77.3% to 87.1%;
50 percentile ..... the outturn variance ranges from 76.8% to 86.8%;
and
0 percentile (mimimin) .....the outturn variance ranges from 74.5% to 84.0%.

Leading to the generalisation over the ten-year period analyzed that if in each financial year, the **10% of projects with greatest planned-expenditure** achieve an outturn variance that is within the range of the best 10% of the range of performances achieved by the projects in the portfolio, then the outturn for the portfolio as a whole is greater than 75%, with an evens probability of an outturn variance greater than 77%, all other things being equal.

At 20% project significance, for the:

- 100 percentile (maximax) ..... the outturn ranges from 81.0% to 93.0%;
- 95 percentile .....the outturn ranges from 80.1% to 91.7%;
- 90 percentile .....the outturn ranges from 80.0% to 90.3%;
- 50 percentile .....the outturn ranges from 79.4% to 89.7%; and
- 0 percentile (mimimin) .....the outturn ranges from 77.5% to 87.0%.

Leading to the generalisation over the ten-year period analyzed that if in each financial year, the **20% of projects with greatest planned-expenditure** achieve an outturn variance that is within the range of the best 10% of the range of performances achieved by the projects in the portfolio, then the outturn for the portfolio as a whole is greater than 77.5%, with an evens probability of greater than 79.4%, all other things being equal.

Table 9-29 shows the differential improvements gained over the Actual Outturn. The stochastic analysis resulted in an improved outturn in nine of the ten financial years considered. In 1994, the actual outcome out-performed the theoretical stochastic approach. This is a substantiation of the presumption in the stochastic analysis: namely,

it is possible to achieve for the significant projects in the portfolio, the ten percent best performance of the range of performance for all the projects in the portfolio.

	Financial year beginning . . .									
	89	90	91	92	93	94	95	96	97	98
No projects	1196	1286	1224	1143	1130	1131	1086	1096	1048	1082
Actual o/t cf	75%	66%	54%	65%	76%	77%	73%	74%	78%	75%
Maximax percent (100 percentile) differential outturn overall (1 dp)										
o/t @ 1%	4.6	2.2	10.2	7.0	7.9	-9.7	5.5	8.4	2.0	1.8
o/t @ 2%	5.3	5.7	13.0	11.5	12.4	-5.2	7.5	9.9	3.7	2.1
o/t @ 3%	5.3	7.4	15.7	13.5	13.4	-3.7	10.5	11.5	5.0	3.1
o/t @ 4%	5.6	8.9	17.2	15.0	13.4	-2.2	11.5	12.0	5.5	5.1
o/t @ 5%	**6.1**	**9.6**	**18.5**	**16.0**	**14.4**	**-1.2**	**12.0**	**13.0**	**6.5**	**6.1**
o/t @ 6%	6.6	10.4	19.8	17.0	14.4	0.3	12.5	13.5	7.5	7.1
o/t @ 7%	7.1	11.2	21.5	18.5	14.4	0.8	13.5	13.5	7.5	7.3
o/t @ 8%	6.8	12.4	22.7	19.5	14.9	1.3	14.0	14.0	7.5	8.1
o/t @ 9%	7.3	12.9	23.2	20.0	15.4	1.8	14.5	14.5	8.0	8.8
o/t @ 10%	**7.8**	**13.2**	**23.7**	**20.5**	**15.4**	**2.3**	**15.0**	**15.0**	**8.5**	**8.8**
o/t @ 15%	9.6	15.7	27.7	23.0	17.4	3.3	17.0	17.0	10.5	11.1
o/t @ 20%	**10.6**	**17.7**	**30.2**	**24.0**	**17.4**	**4.3**	**17.5**	**18.0**	**12.5**	**12.1**
Minimin percent (0 percentile) differential outturn overall (1 dp)										
o/t @ 1%	1.8	0.2	7.3	3.0	1.9	-13.2	1.5	4.5	-0.8	-0.7
o/t @ 2%	2.3	3.4	10.1	7.5	5.4	-9.2	3.5	5.5	0.7	-0.7
o/t @ 3%	2.6	4.9	12.3	9.4	6.4	-7.7	6.0	7.0	2.0	0.3
o/t @ 4%	2.1	6.4	14.1	10.5	7.4	-6.2	7.5	7.0	1.5	2.3
o/t @ 5%	**3.1**	**6.9**	**15.2**	**12.0**	**7.4**	**-5.2**	**7.5**	**8.4**	**2.5**	**3.1**
o/t @ 6%	3.1	7.7	17.3	13.0	8.4	-3.7	8.0	8.9	3.5	4.3
o/t @ 7%	3.6	8.4	18.4	14.0	8.9	-3.2	8.5	8.9	4.0	4.6
o/t @ 8%	3.8	9.7	19.1	15.0	8.4	-2.7	9.5	9.4	4.0	5.1
o/t @ 9%	4.3	10.2	18.8	16.0	8.4	-2.7	10.0	9.9	4.5	5.1
o/t @ 10%	**4.8**	**10.4**	**20.5**	**16.0**	**8.4**	**-1.7**	**10.5**	**10.5**	**5.0**	**6.1**
o/t @ 15%	6.1	12.9	23.7	18.5	10.4	-0.7	12.5	12.5	7.0	8.1
o/t @ 20%	**7.0**	**14.9**	**26.8**	**19.5**	**10.4**	**0.3**	**13.0**	**13.5**	**9.0**	**9.1**

Table 9-29 Comparison of differential outturn variance achieved for the portfolio overall for 1989-90 to 1998-99.

At 5% project significance,

- 100 percentile (maximax), the differential change to the actual outturn ranges from –1.2% to 18.5%; and
- 0 percentile (minimin), the differential change to the actual outturn ranges from –5.2% to 15.2%.

At 10% project significance,

- 100 percentile (maximax), the differential change to the actual outturn ranges from 2.3% to 23.7%; and
- 0 percentile (minimin), the differential change to the actual outturn ranges from –1.7% to 20.5%.

At 20% project significance,

- 100 percentile (maximax), the differential change to the actual outturn ranges from 4.3% to 30.2%; and
- 0 percentile (minimin), the differential change to the actual outturn ranges from 0.3% to 26.8%.

The presumption, that if given management attention then the most significant twenty percent of the number of projects can achieve an outturn variance that falls within the probability curve of the highest ten percent of the empirical range of performance, is true in one instance out of the ten mutually exclusive cases examined in this research. With the exception of this one case, the theoretical application of probable outcomes for the most significant twenty percent of the number of projects using Monte Carlo methodologies results in a worthwhile improved outcome for the portfolio as a whole.

9.6.1.1 Derived heuristics

The argument for the hypothesis tested in this research is described in Section 1.2.1.3, namely:

> **The outcome for a portfolio-of-projects is reasonably assured when a satisfactory outcome is achieved for those twenty percent, or thereabouts, of the projects in the portfolio that contribute eighty percent or thereabouts of the value of the portfolio.**

'Twenty percent' and 'eighty percent' are thresholds indicative of the probable contribution of the few high-value projects in the portfolio compared to the larger number of lower-value projects. 'Satisfactory' is taken to mean within +/- twenty percent of an ideal outcome. 'Reasonably' is taken to mean a fifty:fifty (evens) probability.

With this hypothesis in mind, Table 9-30 exhibits the results of the stochastic analyses carried out in the ten mutually-exclusive, large and diverse portfolios-of-projects used as a source of validated empirical data for this research.

Portfolio	Actual Outturn	% No Projects	% Value	Evens outturn
89-90	75%	**20%**	83%	85%
		10%	69%	82%
		5%	55%	80%
90-91	66%	**20%**	82%	82%
		10%	66%	78%
		5%	51%	75%
91-92	66%	**20%**	83%	83%
		10%	67%	77%
		5%	52%	72%
92-93	66%	**20%**	88%	88%
		10%	76%	84%
		5%	62%	80%
93-94	75%	**20%**	93%	91%
		10%	85%	89%
		5%	76%	87%
94-95	77%	**20%**	92%	79%
		10%	83%	77%
		5%	74%	74%
95-96	73%	**20%**	92%	89%
		10%	82%	86%
		5%	71%	83%
96-97	74%	**20%**	91%	90%
		10%	80%	87%
		5%	67%	85%
97-98	76%	**20%**	87%	89%
		10%	73%	85%
		5%	58%	82%
98-99	75%	**20%**	83%	86%
		10%	66%	83%
		5%	51%	80%

Table 9-30 Stochastic results for 1989-90 to 1998-99 used to valid the hypothesis.

The hypothesis is proved in the case of the ten, mutually exclusive portfolios-of-projects considered in this research.

- At an 'evens' probability: if the **twenty** per cent of the most significant projects in the portfolio achieve an outturn per project that falls within a Beta PDF that represents the best fit the twenty per cent outturn empirically achieved for the portfolio, then the outturn variance for the portfolio is twenty percent or less.

This provides the basis for a 'triple-twenty' heuristic that states:

- If the **twenty** percent of projects within a portfolio that comprise the eighty percent of the planned expenditure for the portfolio, are managed to a performance that is within the zero to **twenty** percent range of the PDF for outturn variance, then there is an 'evens' probability that the overall outturn variance will be **twenty** percent or less.

Two further heuristics are proposed for the ten percent, and the five percent most significant projects within the portfolio, as follows,

- If the **ten** percent of projects within a portfolio that comprise the seventy percent of the planned expenditure for the portfolio, are managed to a performance that is within the zero to **twenty** percent range of the PDF for outturn variance, then there is an 'evens' probability that the overall outturn variance will be twenty-five percent or less; and,

- If the **five** percent of projects within a portfolio that comprise the eighty percent of the planned expenditure for the portfolio, are managed to a performance that is within the zero to **twenty** percent range of the PDF for outturn variance, then there is an 'evens' probability that the overall outturn variance will be thirty percent or less.

9.7 References of the stochastic modeling of an alternate approach to portfolio management

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Chapter Ten

10 Conclusions drawn from the research

10.1 Introduction

The outputs from each element of the research are woven together in Section 10.2 of this Chapter to bring completeness to this Thesis – and to end this stage of the research.

Kempner-Tregoe[1] methodology is used to help define what the research 'is' and what it 'is-not'. This provides the focus for a concluding commentary advising on the potential benefits of additional related research as advised in Section 10.3.

Section 10.4 cites the publications produced as part of the peer review of the principal elements of this research.

10.2 Research findings relative to the Hypothesis

The hypothesis that is the focus of this research is a Pareto-based approach to the management of a portfolio-of-projects, namely;

> **The outcome for a portfolio-of-projects is reasonably assured when a satisfactory outcome is achieved for those twenty percent, or thereabouts, of the projects in the portfolio that contribute eighty percent or thereabouts of the value of the portfolio. With 'Satisfactory' taken to mean within +/- twenty percent of an ideal outcome and 'reasonably' is taken to mean a fifty:fifty (evens) probability.**

The value of this heuristic is that, if true, then it is possible to revise the Cleland and King proposition to avoid a dependency on the collection and analysis of consistent data from all the projects in the portfolio.

10.2.1 Qualitative surveys of the existing practices of Hong Kong contractors and consultants

This research is reported in Chapter Five and Chapter Six.

The population sample of 317 contractor-firms that responded in this postal survey is deemed to be a significant proportion of the contracting industry of Hong Kong. The seventy-five percent overall response to the postal survey is good and taken as indicative for the population overall. It was found that the electronic transfer of digital information between construction-sites, head-office and to other participants is not a commonplace mode of communication, and the use of networked digital information systems by contractors is uncommon. The results showed that project performance data/information is communicated in analogue mode using voice, or written media. E-mail is not commonly used for the communication of project performance data/information except within a minority of contracting companies. The ten most important project performance indicators used are: 'value', 'work-schedule', 'financing', 'resources', 'quality', 'cost-actuals', 'safety', 'variations', '*employer-feed back*', and 'performance'. Personal review by individuals is the most common process adopted for combining together project data. Using spreadsheets is the second most common process. Database processes are not commonly used. Hong Kong contractors are graded as 'IT aware' and at the simpler stages of 'IT active'. They are not 'IT active' with regard to the 'use of IT <u>systems</u> in [the] company'. This taken as evidence of a lack of a general practice for the contractors to employ a project/portfolio MIS for the purposes of the portfolio management. This survey does not provide evidence either way that the 'personal review by individuals' involves the use of project prioritisation to identify projects of most significance to the outcome.

The population sample of 209-consultant-firms is also taken to be a significant proportion of the consulting industry of Hong Kong. The seventy-one percent overall response to the postal survey is good and taken as indicative for the population overall. With regard to Hong Kong consultants, management of data and information is predominantly by traditional manual methods. The electronic transfer of digital information between assignment offices, head-office and to other participants is not a commonplace mode of communication. The use of networked wide-area digital information systems by consultants is not uncommon. Project performance data/information is predominantly communicated in analogue mode using voice, or written media. 'Work', 'Time', 'Cost', 'Issue', 'Company' and 'Project' related project performance issues are transmitted to head office in the majority of instances but not 'Resource' related indicators to the same extent. E-mail is not used for the communication of project performance data/information except within a minority of consulting companies and mostly for work-content and time-related project performance indicators. The ten most important project performance indicators used are work-controls, costs, values, fees, quality, resources, time, *client-feedback*, manpower and staffing. From the survey results it is concluded that individual review and using spreadsheets are the most common processes adopted for combining together project data/information for assessing the performance of a portfolio of projects. Database processes are used less: the degree of use varies within sectors of the population-sample. This element of the survey also identified the ten most important project-performance indicators used for assessing the well-being of a portfolio-of-projects in terms of work-content, time-related, costs-related, and resource-related aspects of the projects. The survey concluded that the Hong Kong consultants are 'IT active' and more advanced in the strategic use of I.T. than the contractor firms in the Hong Kong construction industry. In general, this element of the research did not find evidence of the general use of a MIS that used project-level performance data to manage portfolios-of-projects. In this respect there was no notable degree of adherence to the precepts of Cleland and King. This survey does not provide evidence that the 'individual review or spreadsheet analysis' involves the use of some form of project prioritisation to identify projects of most significance to the outcome.

10.2.2 Longitudinal grounded case study of a PMIS

This element of the research is reported in Chapter Seven and Chapter Eight.

The longitudinal-grounded case study of the implementation of a MIS within the public works organization of the HKG SAR has provided practical experimentation through the quantitative measurement of 'before' and 'after' effects of a change in management techniques. This was substantially dependent upon the introduction of a novel MIS that conformed to the Cleland and King model for a portfolio-management-system. A portfolio-management approach that was found to be uncommon in the qualitative surveys of the Hong Kong contractors and consultants.

With regard to the management results obtained from PW_MS, the figures in Table 7-12 Comparison of spending performance pre and post PW_MS implementation in 92-93.' indicate that the management of the PWP has improved in the five-year post implementation period. In 1999, at the Special Meeting of the Finance Committee, the Secretary for Works said that there had been a sustained trend of improvement in PWP spending i.e., to a level below 5% since implementation of the system. After 1992/93, the management of PWP spending over a five-year period improved to the extent that the annual outturn was approximately 6% on target. At least a three-fold improvement in spending performance compared to the five-year period before 1992/93. This is supportive of the Cleland and King model for a project/portfolio MIS; but there is no proof that this improvement is entirely due to the PW_MS, although the PW_MS is an intrinsic and essential part of the new management approach.

A User satisfaction survey has been completed to gauge the efficacy of this PMIS. The results of the questionnaire analysis for the portfolio managers user class and for the project manager user classes is representative of the population overall. The nature of the responses to the open-ended questions is taken as an indication that the respondents are generally in favour of positive reinforcement of the PW_MS but is not a mandate for change in the PW_MS. The survey concludes that the PW_MS is deemed by the

majority to be 'sometimes' satisfactory or better. The project management features/functions of the PW_MS are not deemed by the Users to be redundant, inadequate or excessive. The majority is not seeking a change or to reduce the features/functions of the PW_MS. However, the administration overhead in the regular updating of project management data for all projects in the portfolio is not satisfactory to the users. They recommend that the updating of the data should be changed to reflect the differences between 'high impact' and other projects in the PW_MS database. Forty-five percent of the population-sample recommends that the frequency of updating should be at 'monthly intervals for high impact projects and quarterly intervals for the others'. The survey found that the PW_MS is not meeting the needs of the majority of the User population for the purposes of managing more than one project.

These results are taken to mean that the practical application of the hypothesis is supported in principle.

10.2.3 A significance-based alternate model

This research is reported in Chapter Nine.

The presumption that if given management attention, then the most significant twenty percent of the number of projects can achieve an outturn variance that falls within a PDF that represents the highest ten percent of the empirical range of project performance is empirically true in one instance out of the ten mutually exclusive cases examined in this research. Otherwise, the theoretical substitution of excellent, achievable outcomes for the most significant twenty percent of the number of projects using Monte Carlo methodologies results in a worthwhile improved outcome for the portfolio as a whole. Thereby showing the hypothesis to be true within the specifics and constraints of this research.

The result of the research is a proposition to be further tested for the general case, namely, a 'triple-twenty' heuristic that states:

- If the **twenty** percent of projects within a portfolio that comprise the eighty percent of the planned expenditure for the portfolio, are managed to a performance that is within the zero to **twenty** percent range of the PDF for outturn variance, then there is an 'evens' probability that the overall outturn variance will be **twenty** percent or less.

On the basis of this heuristic, there is a case to revise the use of the project data in information pipelines to avoid the previous dependency on the collection and analysis of consistent data from all the projects in the portfolio. This thesis contributes further to existing research on the subject of the management of portfolios of projects by confirming that a Pareto approach approximates to empirical practice and offers management advantage if deployed in an appropriate MIS.

10.3 Recommendations for further research

The environment, constraints and details of this research has been rigorously stated throughout this Thesis. These define the validity of the research conclusions within the specifics of those constraints. Kempner-Tregoe methodology has been used to define the attributes of these research constraints as shown in Figure 10-1. Table 10-1 is used to identify the corresponding areas that may be considered for further research to test the hypothesis and the 'triple-twenty' heuristic for the general case.

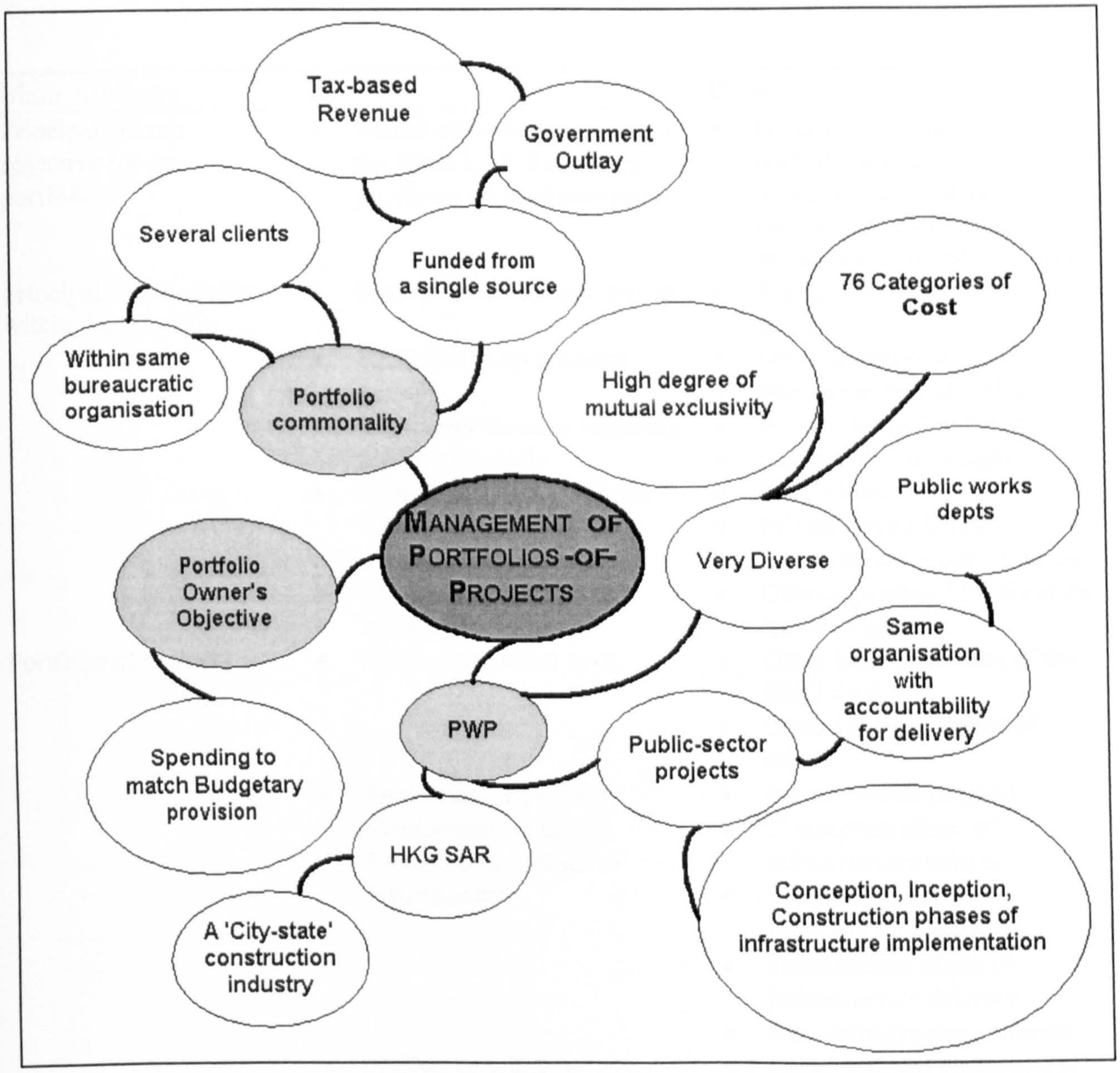

Figure 10-1 Mind-map of the attributes of the research constraints/limitations

Main Attribute	IS	IS NOT
Principal outturn objective for the portfolio	• Actual expenditure to match the HKG SAR Budgetary provision without exception.	• Other project management or portfolio management control or parameter such as: delivery on time, efficient use of resources, political priorities.
Principal commonality within the portfolio	• Funded from a single source	• Funded from disparate sources
	• HKG SAR Government outlay	• Other government outlay • Non-government outlay
	• Tax-based revenue requiring public over-sight	• Private sector financing • Confidential oversight
	• Many institutional Clients for the projects	• Single Client • Private-sector Clients • Single private-sector Clients
	• Clients governed by the same 'rules of game'	• Clients governed by disparate 'rules of game'
Portfolio of projects	• PWP of the HKG SAR	• Other large portfolios of the HKG SAR • Other large portfolios of others
	• Public-sector projects	• Private-sector projects
	• Conception-Inception-Construction phases of infrastructure	• Conception phase of infrastructure delivery • Inception phase of infrastructure delivery • Construction phase of infrastructure delivery • Non-infrastructure projects
	• Delivered within a 'city-state' construction industry	• Other national construction industry • Other non-national construction industry • Non-construction industry
	• Very diverse	• Non-diverse • Grouping of like projects
	• High degree (98%) of mutual exclusivity	• High degree of correlation
	• Large Nos (78) of category-of-cost.	• Less Nos of category-of-cost.
	• Same organisation with accountability for delivery	• Different organisations
	• Public-sector delivery	• Private sector delivery

Table 10-1 Dendrogram of the attributes of the research to indicate areas for further testing of the hypothesis.

All of the 'IS NOT' exceptions noted in Table 10-1 are aspects for further research on this topic. No particular recommendation is made to set priorities for this further work. However, the seminal work of Professor Horner on the subject of 'significant items' within a portfolio of many items has been important from the inception of this doctoral research. It is highly recommended that the methodology described by Al Hajj and Horner[2] be applied to the data sets to see if their heuristics are applicable in the case of the management of portfolios of projects.

10.4 Peer-reviewed publications produced within this research

Papers generated by this research have been published at conferences, notably CIB W78, for the purposes of peer review, dissemination of research, and collegial discussion on related topics. These are cited here for further reference if required.

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10.5 Summary references

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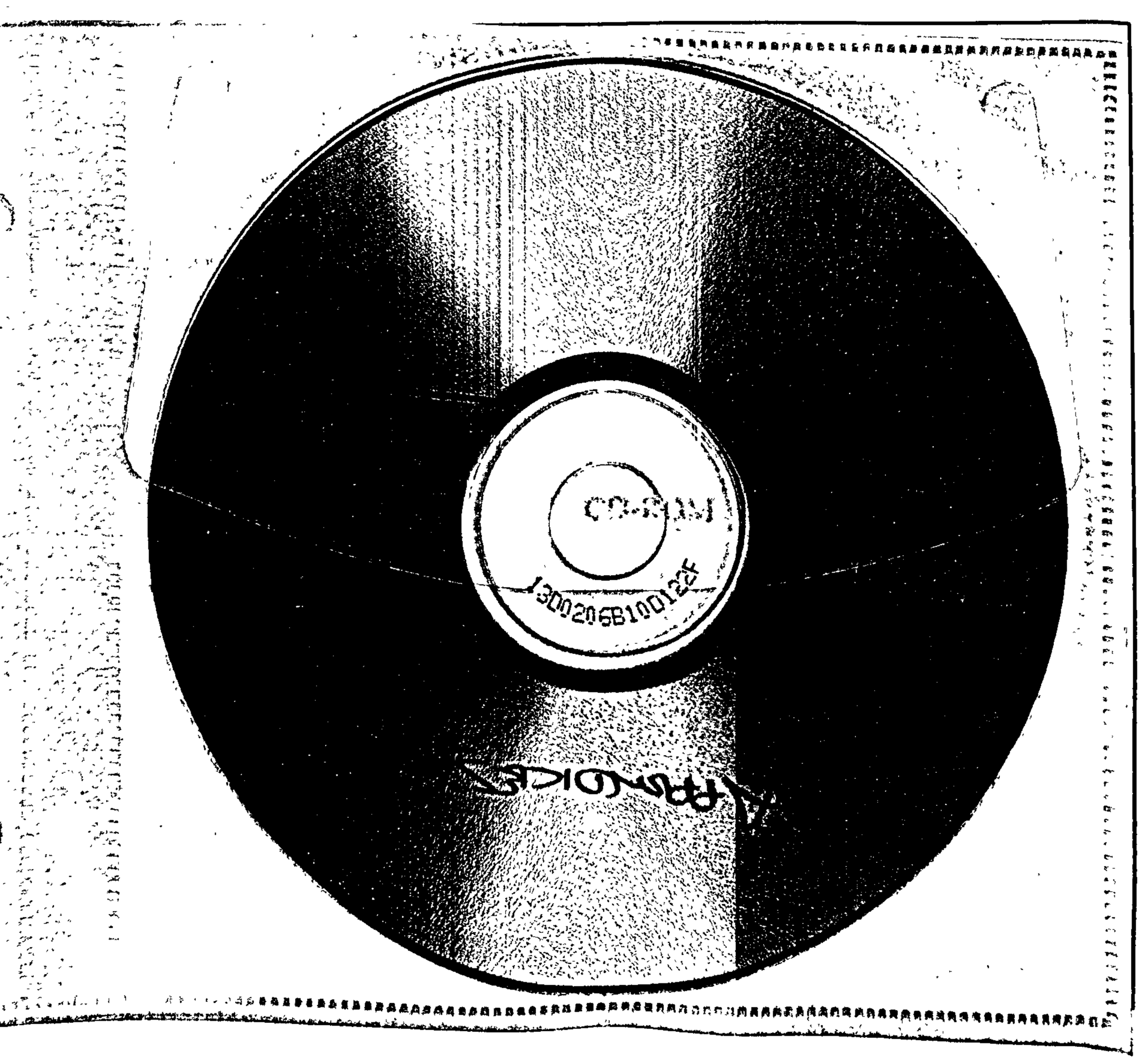
Appendices

Appendices of data and additional supporting evidence are provided in PDF files on the enclosed CD-ROM for those readers that require further substantive argument or greater detail. To access this information, open the files 'Appendices.pdf' and navigate using the hypertext provided within the e-document. Each Chapter of these e-appendices follows the layout of the Thesis and is presented as a discrete element of research. They are laid out in the same sequence as the line of enquiry followed for the entire project. Citations within each Chapter are cross-referenced by a superscript notation to a list of references at the end of the Chapter. A Bibliography is printed at the end of the Thesis.

Also bound in these Appendices are copies of the proforma postal survey questionnaires developed for and used in this research.



Instructions:

There are three different ways of answering the questions in this questionnaire

(a) Circle the appropriate answer;
(b) Put a [✓] check mark in the appropriate squared box provided;
(c) Write a brief answer in the space provided on the questionnaire.

Please answer the questions as fully as possible. If you think further comment or clarification is needed, then please add information in the margin of the page, next to the question.

Please complete and return the questionnaire by **March 20, 1998** addressed to:

Keith Futcher
Chief Assistant Secretary/Public Works Systems Administration,
Works Bureau,
10F, Murray Building,
Garden Road,
Central,
Hong Kong.

@ fax 2869 6095

PLEASE NOTE CAREFULLY THESE DEFINITIONS

'Information technology (IT)' means all electronic devices for capturing, storing, re-using, and communicating data/information between project participants.

'Project participants' means any person involved in a project. They can be from different companies. They can be involved for only a brief moment or purpose.

'Communication' means the transfer of information, for example from the company head office to a construction site and vice versa. It also means the transfer and receipt of information between project participants.

PLEASE FIX YOUR COMPANY NAME CARD IN THE SPACE PROVIDED.

Glue your name card here

PLEASE ANSWER THIS QUESTION FIRST, THEN ANSWER THE QUESTIONS ON THE FOLLOWING PAGES.

Please state the number of permanent employees, all grades of staff, in the company:	

Part 1 Use of information technology to assist project communication

1.1 Telephone communication

1.1.1 Does your company provide a telephone per person, or easy access to a telephone, for communication?
Ans: *(tick appropriate box for each part of the question)*

For managerial staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For professional staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For supervisory staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For labour?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.

1.1.2 Which telephone services does your company use?
Ans: *(tick appropriate box for each part of the question)*

Telephone company public services?	YES ☐, SOMETIMES ☐, NO ☐.
Telephone company leased line services?	YES ☐, SOMETIMES ☐, NO ☐.
Radio-telephone services?	YES ☐, SOMETIMES ☐, NO ☐.

1.1.3 Does your company provide/use mobile telephones for communication?
Ans: *(tick appropriate box for each part of the question)*

For managerial staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For professional staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For supervisory staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For labour?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.

1.1.4 Which special mobile telephone services does your company use?
Ans: *(tick appropriate box for each part of the question and add to the list, in order of importance, other services that are used, such as: user ID; paging; secretarial; info services.)*

Message services?	YES ☐, SOMETIMES ☐, NO ☐.
Call forwarding?	YES ☐, SOMETIMES ☐, NO ☐.

1) .....
2) .....
3) .....
4) .....
5) .....

1.1.5 Is it your company policy/instruction that important telephone communications are recorded?

Ans: *(tick appropriate box)*	YES ☐, SOMETIMES ☐, NO ☐.

1.1.6 How does your company make a record of important telephone communications?
Ans: *(tick appropriate box for each part of the question)*

Using message recording services/facilities?	YES ☐, SOMETIMES ☐, NO ☐.
Tape recording of the speaker-phone telephone call?	YES ☐, SOMETIMES ☐, NO ☐.
Making a written note of the communication?	YES ☐, SOMETIMES ☐, NO ☐.

1.2 Fax communication

1.2.1 Does your company use facsimile (fax) for communication?
Ans: *(tick appropriate box for each part of the question)*

In head office?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
In other company offices?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
In site offices?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

1.2.2 Does your company use facsimile (fax) to and from personal computers (PC's) for communication? Ans: *(tick appropriate box for each part of the question)*

Fax to PC's?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
PC's to fax?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

1.3 Meetings for communication

1.3.1 Does your company use formal, regular, face-to-face meetings for the communication of project information? Ans: *(tick appropriate box for each part of the question)*

In head office?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
In other company offices?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
In site offices?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Between site offices and other offices?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

1.3.2 Is it your company policy/instruction that minutes/notes of meetings are recorded?

Ans: *(tick appropriate box)*	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

1.3.3 How does your company record minutes/notes of meetings?
Ans: *(tick appropriate box for each part of the question)*

Hand-written notes/minutes?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Tape recordings?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Word-processor notes/minutes?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Electronic 'notice board'	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

1.4 Video-conferencing for communication

1.4.1 Does your company use video-conference facilities for communication?
Ans: *(tick appropriate box for each part of the question)*

Communication within Hong Kong?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For international communication?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.4.2 Which video-conference services does your company use?
Ans: *(tick appropriate box for each part of the question)*

Commercially hired video conferencing services?	YES ☐, SOMETIMES ☐, NO ☐.
Company-owned private services.	YES ☐, SOMETIMES ☐, NO ☐.
Using the Internet	YES ☐, SOMETIMES ☐, NO ☐.

1.5 Images used for communication

1.5.1 How does your company produce construction drawings?
Ans: *(tick appropriate box for each part of the question)*

Manual methods in the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
CAD systems in the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Hiring manual drafting services?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Hiring CAD drafting services?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Manual methods in site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
CAD systems in site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.2 How does your company distribute construction drawings?
Ans: *(tick appropriate box for each part of the question)*

As hardcopy?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files on disk?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files across an internal computer network (LAN)?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files, to other computers or LANS , using modems?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files, to others using an external computer network via the Internet?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.3 How does your company record the distribution of construction drawings
Ans: *(tick appropriate box for each part of the question)*

By hardcopy transmittal?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
By electronic database register of transmittal?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.4 How does your company check/revise construction drawings?
Ans: *(tick appropriate box for each part of the question)*

As hardcopy?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files, with amendments shown as red-lined?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.5 Does your company use picture images for communication?
Ans: *(tick appropriate box for each part of the question)*

Photographs?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Digital photographs?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Videos?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.6 How does your company distribute picture images for communication?
Ans: *(tick appropriate box for each part of the question)*

In original physical format?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic digital images?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6 Written communication

1.6.1 Does your company produce written documents according to company standards and pre-determined document formats?
Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.2 Does your company use printed proforma and forms for routine documents?
Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.3 Does your company have a procedure/instruction for the filing of all written documents in an organised filing system? Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.4 Is the same document filing system used on all construction sites?

Ans: *(tick appropriate box)*	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.5 Does your company use a computer-based document management system to record the location of filed written documents? Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.6 Does your company use a system of keywords to record the contents of written documents and to find them in the future? Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.7 Does your company employ staff to organise and maintain a filing system of written documents? Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.8 Does your company employ someone as an 'information manager' whose principal occupation is to organise and maintain the systematic use, distribution and storage of project information and documents?
Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6 Electronic communication

1.7.1 Does your company use electronic-mail for communication?
Ans: *(tick appropriate box for each part of the question)*

Within the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Within the site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
From company office, or site office(s), to other places using modems and telephone lines.	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Between the company offices and anywhere else, using the Internet?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.7.2 Does your company provide electronic-mail for communication?
Ans: *(tick appropriate box for each part of the question)*

For office-based managerial staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For office-based professional staff/	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For office-based supervisory staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For office-based clerical staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For site-based managerial staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For site-based professional staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For site-based supervisory staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For site-based clerical staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.7.3 Does your company employ staff to administer your information technology?
Ans: *(tick appropriate box for each part of the question)*

For the company's, office-based equipment and systems?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For the site-based equipment and systems?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.7.4 What is the highest level of management of information technology, in the company?
Ans: *(tick one appropriate box only)*

Director	FULL TIME ☐, PART TIME ☐.
Manager reporting to a Director.	FULL TIME ☐, PART TIME ☐.
Senior professional	FULL TIME ☐, PART TIME ☐.
IT professional	FULL TIME ☐, PART TIME ☐.
Operative	FULL TIME ☐, PART TIME ☐.
Sub-contracted	FULL TIME ☐, PART TIME ☐.
None	☐.

1.7.5 Does your company use electronic-mail in company offices for the following purposes? Ans: *(tick appropriate box for each part of the question)*

Sending written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Agreeing the drafting/text of written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Marking up and amending the written messages of others?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching other written documents to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching drawing files to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital photographs to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital video images to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital sound files to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Assigning/delegating an action?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.7.6 Does your company use electronic-mail on construction sites for the following purposes? Ans: *(tick appropriate box for each part of the question)*

Sending written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Agreeing the drafting/text of written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Marking up and amending the written messages of others?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching other written documents to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching drawing files to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital photographs to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital video images to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital sound files to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Assigning/delegating an action?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.7.7 Does your company have a homepage on the Internet?

Ans: *(tick appropriate box)*	YES ☐, NO ☐

1.7.8 Does your company have it's own Internet server?

Ans: *(tick appropriate box)*	YES ☐, NO ☐

1.7.9 Does your company provide an Internet service to the following categories of staff, for communication purposes?
Ans: *(tick appropriate box for each part of the question)*

For managerial staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
For professional staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
For supervisory staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Administrative, clerical and other staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

Part 2 Purpose of the information technology

2.1 What information technology does your company use to communicate/transmit to head office and vice versa, **work-content related** data/information?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic mail?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.2 Does your company communicate/transmit to head office and vice versa, using information technology, the following **work-content related** data/information?
Ans: *(tick appropriate box for each part of the question)*

Lists of activities?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Lists of items to be done?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Lists of variations and their status?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Lists of disputes and their status?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.3 What information technology does your company use to communicate/transmit to head office and vice versa, **time related** data/information? Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic mail?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.4 Does your company communicate/transmit to head office and vice versa, using information technology, the following list of **time related** data/information items?
Ans: *(tick appropriate box for each part of the question)*

Work schedule of activities?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
% work done?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
% work to be done?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Re-planned work?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.5 What information technology does your company use to communicate/transmit to head office and vice versa, **cost related** data/information?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail/	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.6 Does your company communicate/transmit to head office and vice versa, using information technology, the following **cost related** data/information items?
Ans: *(tick appropriate box for each part of the question)*

Value of work done?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Value of work to be done?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Value of materials delivered?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Value of materials ordered?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Value of variations?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Value of disputes?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Money received?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Money owed?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.7 What information technology does your company use to communicate/transmit to head office and vice versa, **resource related** data/information?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.8 Does your company communicate/transmit to head office and vice versa, using information technology, the following **resource related** data/information items?
Ans: *(tick appropriate box for each part of the question)*

Labour deployed?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Labour required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Plant deployed?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Plant required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Sub-contractors hired?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Purchasing services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
QS services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Legal services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Management services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Administrative services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Professional services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.9 What five items of data/information is most important in your company for assessing the performance of a construction project? *For example, 'value of work done to date'*
Ans: *(state briefly, in order of importance, five items of data/information in the space below)*
1) .....
2) .....
3) .....
4) .....
5) .....

2.10 What information technology does your company use to communicate/transmit to head office and vice versa, the five items of data/information stated in 2.9?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.11 Does your company communicate/transmit to head office and vice versa, using information technology, the following **issue related** data/information items?
Ans: *(tick appropriate box for each part of the question)*

Requests for information?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Variation quotations?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Change Order proposals?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Accident/Safety reports?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Quality conformance?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Approvals?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.12 What information technology does your company use to communicate/transmit to head office and vice versa, the **issue-related** items of data/information stated in 2.11?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.13 Does your company communicate/transmit to head office and vice versa, using information technology, the following **company-related** data/information items?
Ans: *(tick appropriate box for each part of the question)*

Names and addresses?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
File references?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Telephone directories?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Shared facilities e.g. Meeting Rooms?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Information registers?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.14 What information technology does your company use to communicate/transmit to head office and vice versa, the **company-related** items of data/information stated in 2.13?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Intranet	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

Part 3 Use of the information technology

3.1 How does your company use information technology **to combine together** data/information relating to the **work-content** of your construction projects, to get an overview of performance?
Ans: *(tick appropriate box for each part of the question)*

Review of individual reports?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Spreadsheets of numeric and date data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Database(s) of alpha-numeric data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

3.2 What five, **work-content related,** criteria are most important in your company for assessing the overall performance of several construction projects?
Ans: *(state briefly, in order of importance, five criteria in the space below)*
1) .....
2) .....
3) .....
4) .....
5) .....

3.3 How does your company use information technology **to combine together** data/information relating to the **time aspects** of your construction projects, to get an overview of performance? Ans: *(tick appropriate box for each part of the question)*

Review of individual reports?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Spreadsheets of numeric and date data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Database(s) of alpha-numeric data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

3.4 What five, **time-related,** criteria are most important in your company for assessing the overall performance of several construction projects?
Ans: *(state briefly, in order of importance, five criteria in the space below)*
1) .....
2) .....
3) .....
4) .....
5) .....

3.5 How does your company use information technology **to combine together** data/information relating to the **cost aspects** of your construction projects, to get an overview of performance? Ans: *(tick appropriate box for each part of the question)*

Review of individual reports?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Spreadsheets of numeric and date data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Database(s) of alpha-numeric data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

3.6 What **cost-related,** criteria are most important in your company for assessing the overall performance of several construction projects?
Ans: *(state briefly, in order of importance, five criteria in the space below)*
1) .....
2) .....
3) .....
4) .....
5) .....

3.7 How does your company use information technology **to combine together** data/information relating to the **resource aspects** of your construction projects, to get an overview of performance? Ans: *(tick appropriate box for each part of the question)*

Review of individual reports?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Spreadsheets of numeric and date data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Database(s) of alpha-numeric data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

3.8 What five, **resource-related,** criterion are most important in your company for assessing the overall performance of several construction projects?
Ans: *(state briefly, in order of importance, five criteria in the space below)*
1) .....
2) .....
3) .....
4) .....
5) .....

Part 4 Self assessment of your strategic use of information technology

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BACKGROUND

Analysis of the data collected from the UK industry resulted in over 200 propositions concerning the management of IT in construction organisations. Some of these propositions have been selected and translated into the following questions. We urge you to ask these questions of your business or businesses as a stimulus to your own debate about how you are using and managing IT. We hope it acts as a trigger to the ongoing debates about IT investment and management within your organisation.

Instructions – **Step 1:** -Select one of the scenarios, which is the closest fit to your company circumstances with regard to the use of IT. Mark your choice by circling the option selected.

4.1 Competition and business strategy

4.1.1 Does IT support your core capabilities?

IT does not support our capabilities.	IT offers some support to our capabilities.	IT is critical to our core capabilities.	Our core capabilities are our IT systems.
D	**C**	**B**	**A**

4.1.2 How do you think IT could help your company to compete?

Changing our competitive behaviour.	Changing our competitive behaviour and supporting our capabilities.	Changing competitive behaviour, supporting capabilities, and enabling strategic alliances with others.	Changing competitive behaviour, supporting capabilities, enabling strategic alliances with others, and achieving an unassailable market position.
D	**C**	**B**	**A**

4.1.3 What is the impact of IT on your corporate goals and objectives?

IT has no impact.	IT has some positive impact.	IT supports our corporate objectives through business efficiency and cost reduction.	IT is critical to business efficiency, financial gains, engineering excellence, R&D and innovation.
D	**C**	**B**	**A**

4.1.4 With regard to IT, what is your position compared to your competitors?

12 months behind other companies.	6 months behind other companies.	The same level as other companies.	Ahead of other companies.
D	**C**	**B**	**A**

4.1.5 What is the impact of your use of IT on your clients?

IT does not have any impact.	IT is important to some clients.	IT is good for presentation and communication to clients.	IT is essential for meeting clients requirements.
D	**C**	**B**	**A**

4.1.6 Do you think your company IT expertise will help it to win work?

IT has no influence on winning work.	IT is good for presentation.	IT an be instrumental in winning work.	IT is critical to winning work.
D	**C**	**B**	**A**

4.1.7 How is IT used as a part of strategic/business alliances?

Spreading the costs and risks.	Business efficiency.	Improving combined competitive behaviour.	To gain combined competitive behaviour.
D	**C**	**B**	**A**

4.2 The role of IT

4.2.1 How do you currently use IT in your company?

IT is not seen as an important part of the business.	We use IT but let the technology find its own way within the organisation.	Use IT after proven, and satisfactory results from others users and other companies.	Pro-actively seek to use IT as part of a well thought through strategy for achieving competitive advantage.
D	**C**	**B**	**A**

4.2.2 How would you describe the relationship between IT and your business strategy?

They are completely separate entities.	IT is indirectly addressed through its supportive role.	IT plays a central role in our business strategy.	IT is a critical success factor for local and overseas business strategies.
D	**C**	**B**	**A**

4.2.3 What is the level of participation of your IT people in the development of your overall business strategy?

No participation.	IT people simply informed of the business strategy.	Main Board IT Director responds to business strategy proposals.	Main Board IT Director has part of the responsibility to suggest new business strategies
D	**C**	**B**	**A**

4.2.4 Does IT have an impact on your operational strategy?

IT supports operational strategy.	IT helps to reduce costs through speed and efficiency.	IT assists us to improve quality to meet client's requirements within budget.	IT enables us to provide products and services that are better than anyone else.
D	**C**	**B**	**A**

4.2.5 Does IT have any influence on the delivery of your marketing?

IT has nothing to do with our marketing strategy.	IT has some impact on marketing strategy.	IT is important to the success of marketing strategy.	IT is critical to the success of our marketing strategy.
D	**C**	**B**	**A**

4.3 IT strategy

4.3.1 How would you describe the use of IT systems in your company?

Mainly functional applications.	Mainly functional applications with some integrated systems.	Mainly integrated systems.	Process support tools with full information sharing.
D	C	B	A

4.3.2 What are the objectives of your IT strategy

Business efficiency.	Business efficiency, improving quality and improving communications with internal and external stakeholders.	Providing support for business strategy.	Delivery of business strategy.
D	C	B	A

4.3.3 What is the thrust of your IT strategy?

Up-to-date IT facilities.	Competent IT skill level within the company and required IT facilities.	Support for business strategy and user participation and empowerment.	Exploiting IT for competitive advantage.
D	C	B	A

4.3.4 How do you intend to manage IT in the future?

Follow other companies after assessing their experience.	To do much the same as other companies at about the same time as them.	To experiment and develop the technology.	To have advanced technology developed as a key part of the business.
D	C	B	A

4.3.5 What are the critical success factors for sustainable competitive advantage achieved through IT in your company?

We do not seek a sustainable competitive advantage through IT.	Acquisition of the right technology.	To use the strategic and innovative IT opportunities that arise.	Continuous R&D programmes and seeking innovative solutions to construction problems.
D	C	B	A

4.3.6 How do you intend to manage IT projects and innovations?

We are not concerned with IT innovation.	Out-sourcing.	IT professionals and external facilitators.	IT professionals, appropriate management, user group committees, strategic alliances, internal and external facilitators.
D	C	B	A

4.3.7 What is the level of R&D regarding IT in your company?

No interest.	Planned R&D.	R&D focus aimed at new future markets.	R&D focus aimed at new, future, markets and the achievement of a sustainable competitive advantage
D	**C**	**B**	**A**

4.3.8 What is the nature of your IT department?

Small technical unit providing group technical services.	Large technical group providing group technical services.	Central technical support to individual business units.	Fully developed IT responsibility for strategy and business.
D	**C**	**B**	**A**

4.3.9 How much importance do you attach to IT skills within your company?

Low-cost IT training initiatives	Provide IT training when required.	Seeking and upgrading the quality of IT training in our company.	Develop intensive education and training programme for all IT users, including senior management.
D	**C**	**B**	**A**

4.3.10 Who is aware of your IT strategy?

Technical staff.	IT professionals and users.	Business managers.	All key internal and external personnel.
D	**C**	**B**	**A**

4.3.11 What is the extent and nature on involvement of IT users in the development and implementation of your IT?

There is no user involvement.	Involved when required	Involved at the early stages.	Involved throughout the whole process.
D	**C**	**B**	**A**

4.3.12 What do you consider to be the risks associated with the implementation of your IT strategy?

Financial risks.	Technological risks.	Business environment risks.	Strategic risks.
D	**C**	**B**	**A**

4.3.13 How often do you review your IT strategy

Every five years.	Every three years.	Every year.	IT strategy is reviewed continuously.
D	**C**	**B**	**A**

4.3.14 How do you measure the IT performance of your company?

Short-term payback.	Cost-reducing aspects of the IT.	Value adding properties of IT.	Strategic opportunities provided by IT.
D	**C**	**B**	**A**

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Data will not be disclosed. A summary report will be sent to all respondents
http://hkusury2.hku.hk/rec/cit.html

4.3.15 What are the characteristics of your IT strategy?

Financial issues dominate IT.	IT is driven from the bottom-up	IT is driven by middle-managers.	IT is managed from the top.
D	**C**	**B**	**A**

4.3.16 Who is the champion for IT projects in your company?

Technical staff.	Functional managers.	IT Director.	Senior Management.
D	**C**	**B**	**A**

Instructions – Step 2: -Transfer your choices to the answer matrix below to see which category contains the majority of the scenarios you regard as being appropriate to your company circumstances

	Question	D	C	B	A
Competition and business strategy					
	4.1.1				
	4.1.2				
	4.1.3				
	4.1.4				
	4.1.5				
	4.1.6				
	4.1.7				
The role of IT					
	4.2.1				
	4.2.2				
	4.2.3				
	4.2.4				
	4.2.5				
IT strategy					
	4.3.1				
	4.3.2				
	4.3.3				
	4.3.4				
	4.3.5				
	4.3.6				
	4.3.7				
	4.3.8				
	4.3.9				
	4.3.10				
	4.3.11				
	4.3.12				
	4.3.13				
	4.3.14				
	4.3.15				
	4.3.16				
Total					

Instructions – Step 3: -Review your score against the following descriptions of the interpretations that you might make of the alternative scenarios that arise from your response to the questions in part 4 of this questionnaire.

For your information, on the next page is a UK based, subjective, assessment of the answer matrix.

D If you have mainly ticked scenarios in this category you are clearly using IT as a support tool for operational efficiency. It appears that IT is not viewed as an important part of your business and IT applications are mainly directed at support and functional systems with very little in terms of integration. The financial justification for IT investments have stopped your company from developing a clear IT strategy in line with your business, market and industry requirements. You may need to analyse your current situation concerning various aspects of IT, including education and training programmes and to develop an IT strategy that would focus on long term objectives and goals with consideration to your existing market status within your industry sector. The seniority and profile of staff involved with managing IT may be too low. You need to rethink the way in which you intend to manage IT within your organisation. The supportive role of IT, the level of management commitment, low levels of IT skills and expertise, and the philosophy of following other companies concerning IT can no longer meet the needs of the dynamic and competitive environment of the 1990s.

C If your company can mainly relate to the scenarios in column 'C' of the matrix, you are aware of some of the strategic opportunities provided by IT, but, your bottom-up approach has formed a barrier to your progress. Whilst it is encouraging to learn that IT is used to reduce costs and increase the overall business efficiency, you are not fully benefiting from the opportunities provided by IT. However, in this respect, you are better than some companies in your sector but behind many others. Therefore, you may need to analyse your situation compared to that of your competitors. This requires the involvement of the IT people in the development of your business strategy, more focus on training and better awareness of IT as a competitive weapon. You may be beginning to plan to use IT strategically. But, your perception of the level of risks involved together with cost and the complexity of technology is forming a block that is influencing the awareness of strategic possibilities offered by IT in your company. As you have already benefited from some of the opportunities provided by IT, you need to improve your industry position within your sector. This is only possible through being innovative, investing in people and the required technology and finally to create an IT infrastructure and culture that would support your competitive strategy and corporate goals.

B If you have mainly placed your company in scenarios in column 'B' of the matrix, you are probably among the best practice companies when considering the use and management of IT. However, there is still room for improvement. Whilst you are benefiting from some of the strategic opportunities provided by IT: the conditional commitment of senior management; the limited involvement of IT users; the low levels of IT skills in some departments; and the partial commitment to R&D initiatives, may slow down the rate of progress of IT in your organisation. You may be planning to strategically exploit IT for efficiency gains and competitive advantage. Whilst you may be ahead of some of your competitors, you are operating in a similar environment to them. Therefore to improve your market status and industry position you need to plan to use IT more aggressively to combat the threat of competition.

A If you an relate to the majority of scenarios in column 'A' you are among the very few and best practice companies that are truly exploring IT for its strategic opportunities. You are also in a position to benefit from the IT culture you have developed and maintain IT on the urgent agenda of concern of top management. However, to maintain and improve your business growth and the prosperity of your organisation, you should continue to do what you have been doing and focus on new and profit generating activities through R&D initiatives. You appear to be truly planning to exploit IT for its strategic opportunities. You need to maintain, guard and improve your position and to capitalise from your capabilities and expertise.

<<<END>>>

Please immediately return the questionnaire to

Keith Futcher
Chief Assistant Secretary/Public Works Systems Administration,
Works Bureau,
10F, Murray Building,
Garden Road,
Central,
Hong Kong.

Thank you for your cooperation.

We will send you a copy of the summary report

*****

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Proforma questionaire for the postal survey of Hong Kong Consultants

Instructions:
There are three different ways of answering the questions in this questionnaire
(a) Circle the appropriate answer;
(b) Put a [✓] check mark in the appropriate squared box provided;
(c) Write a brief answer in the space provided on the questionnaire.
Please answer the questions as fully as possible. If you think further comment or clarification is needed, then please add information in the margin of the page, next to the question.

Answer the questions as they apply in general to your company

Please complete and return the questionnaire by **April 9, 1998** addressed to:

Keith Futcher
Chief Assistant Secretary/Public Works Systems Administration,
Works Bureau,
10F, Murray Building,
Garden Road,
Central,
Hong Kong.

PLEASE NOTE CAREFULLY THESE DEFINITIONS

'Information technology (IT)' means all electronic devices for capturing, storing, re-using, and communicating data/information between project participants.

'Project participants' means any person involved in a project. They can be from different companies. They can be involved for only a brief moment or purpose.

'Communication' means the transfer of information, for example from the company office to an assignment office and vice versa. It also means the transfer and receipt of information between project participants.

'Assignment office' means a location outside of company offices where the company has established a work team for design, construction supervision, or other related service.

PLEASE FIX YOUR COMPANY NAME CARD IN THE SPACE PROVIDED.

Glue your name card here

PLEASE ANSWER THIS QUESTION FIRST,
THEN ANSWER THE QUESTIONS ON THE FOLLOWING PAGES.

Please state the number of permanent employees, all grades of staff, in the Hong Kong company:	

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Data will not be disclosed. A summary report will be sent to all respondents
http://hkusury2.hku.hk/rec/cit.html

Part 1 Use of information technology to assist project communication

1.1 Telephone communication

1.1.1 Does your company provide a telephone per person, or easy access to a telephone, for communication?
Ans: *(tick appropriate box for each part of the question)*

For managerial staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For professional staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For technical staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For administrative/clerical staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.

1.1.2 Which telephone services does your company use?
Ans: *(tick appropriate box for each part of the question)*

Telephone company public services?	YES ☐, SOMETIMES ☐, NO ☐.
Telephone company leased line services?	YES ☐, SOMETIMES ☐, NO ☐.
Radio-telephone services?	YES ☐, SOMETIMES ☐, NO ☐.

1.1.3 Does your company provide/use mobile telephones for communication?
Ans: *(tick appropriate box for each part of the question)*

For managerial staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For professional staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For technical staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.
For administrative/clerical staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐.

1.1.4 Which special mobile telephone services does your company use?
Ans: *(tick appropriate box for each part of the question and add to the list, in order of importance, other services that are used, such as: user ID; paging; secretarial; info services.)*

Message services?	YES ☐, SOMETIMES ☐, NO ☐.
Call forwarding?	YES ☐, SOMETIMES ☐, NO ☐.

1) .....
2) .....
3) .....
4) .....
5) .....

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1.1.5 Is it your company policy/instruction that important telephone communications are recorded?

Ans: *(tick appropriate box)*	YES ☐, SOMETIMES ☐, NO ☐.

1.1.6 How does your company make a record of important telephone communications?
Ans: *(tick appropriate box for each part of the question)*

Using message recording services/facilities?	YES ☐, SOMETIMES ☐, NO ☐.
Tape recording of the speaker-phone telephone call?	YES ☐, SOMETIMES ☐, NO ☐.
Making a written note of the communication?	YES ☐, SOMETIMES ☐, NO ☐.

1.2 Fax communication

1.2.1 Does your company use facsimile (fax) for communication?
Ans: *(tick appropriate box for each part of the question)*

From the main company office?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
From other company offices?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
From assignment locations?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

1.2.2 Does your company use facsimile (fax) to and from personal computers (PC's) for communication? Ans: *(tick appropriate box for each part of the question)*

Fax to PC's?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
PC's to fax?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

1.3 Meetings for communication

1.3.1 Does your company use formal, regular, face-to-face meetings for the communication of project information? Ans: *(tick appropriate box for each part of the question)*

In company office?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
In other company offices?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
In assignment locations?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Between assignment locations and other offices?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

1.3.2 Is it your company policy/instruction that minutes/notes of meetings are recorded?

Ans: *(tick appropriate box)*	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

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1.3.3 How does your company record minutes/notes of meetings?
Ans: *(tick appropriate box for each part of the question)*

Hand-written notes/minutes?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Tape recordings?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Word-processor notes/minutes?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Electronic 'notice board'	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

1.4 Video-conferencing for communication

1.4.1 Does your company use video-conference facilities for communication?
Ans: *(tick appropriate box for each part of the question)*

Communication within Hong Kong?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
International communication?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.4.2 Which video-conference services does your company use?
Ans: *(tick appropriate box for each part of the question)*

Commercially hired video conferencing services?	YES ☐, SOMETIMES ☐, NO ☐.
Company-owned private services.	YES ☐, SOMETIMES ☐, NO ☐.
Using the Internet	YES ☐, SOMETIMES ☐, NO ☐.

1.5 Images used for communication

1.5.1 How does your company produce construction drawings?
Ans: *(tick appropriate box for each part of the question)*

Manual methods in the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
CAD systems in the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Hiring manual drafting services?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Hiring CAD drafting services?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Manual methods in assignment locations?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
CAD systems in assignment locations?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

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1.5.2 How does your company distribute construction drawings?
Ans: *(tick appropriate box for each part of the question)*

As hardcopy?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files on disk?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files across an internal computer network (LAN)?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files, to other computers or LANS , using modems?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files, to others using an external computer network via the Internet?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.3 How does your company record the distribution of construction drawings
Ans: *(tick appropriate box for each part of the question)*

By hardcopy transmittal?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
By electronic database register of transmittal?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.4 How does your company check/revise construction drawings?
Ans: *(tick appropriate box for each part of the question)*

As hardcopy?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files, with amendments shown as red-lined?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.5 Does your company use picture images for communication?
Ans: *(tick appropriate box for each part of the question)*

Photographs?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Digital photographs?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Videos?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.6 How does your company distribute picture images for communication?
Ans: *(tick appropriate box for each part of the question)*

In original physical format?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic digital images?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

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1.6 Written communication

1.6.1 Does your company produce written documents according to company standards and pre-determined document formats?
Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the assignment locations?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.2 Does your company use printed proforma and forms for routine documents?
Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the assignment locations?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.3 Does your company have a procedure/instruction for the filing of all written documents in an organised filing system? Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the assignment locations?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.4 Is the same document filing system used on all assignment locations?

Ans: *(tick appropriate box)*	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.5 Does your company use a computer-based document management system to record the location of filed written documents? Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the assignment locations?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.6 Does your company use a system of keywords to record the contents of written documents and to find them in the future? Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the assignment locations?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

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1.6.7 Does your company employ staff to organise and maintain a filing system of written documents? Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the assignment locations?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.6.8 Does your company employ someone as an 'information manager' whose principal occupation is to organise and maintain the systematic use, distribution and storage of project information and documents?
Ans: *(tick appropriate box for each part of the question)*

In the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
In the assignment locations?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.7 Electronic communication

1.7.1 Does your company use electronic-mail for communication?
Ans: *(tick appropriate box for each part of the question)*

Within the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Within the assignment locations?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
To other places via modems and telephone lines.	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Between the company offices and anywhere else, using the Internet?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.7.2 Does your company provide electronic-mail for communication?
Ans: *(tick appropriate box for each part of the question)*

For office-based managerial staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For office-based professional staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For office-based technical staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For office-based clerical staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For assignment-based managerial staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For assignment-based professional staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For assignment-based technical staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For assignment-based clerical staff?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

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1.7.3 Does your company employ staff to administer your information technology?
Ans: *(tick appropriate box for each part of the question)*

For the company's, office-based equipment and systems?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For the assignment-based equipment and systems?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.7.4 What is the highest level of management of information technology, in the company?
Ans: *(tick one appropriate box only)*

Director	FULL TIME ☐, PART TIME ☐.
Manager reporting to a Director.	FULL TIME ☐, PART TIME ☐.
Senior professional	FULL TIME ☐, PART TIME ☐.
IT professional	FULL TIME ☐, PART TIME ☐.
Operative	FULL TIME ☐, PART TIME ☐.
Sub-contracted	FULL TIME ☐, PART TIME ☐.
None	☐.

1.7.5 Does your company use electronic-mail in company offices for the following purposes? Ans: *(tick appropriate box for each part of the question)*

Sending written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Agreeing the drafting/text of written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Marking up and amending the written messages of others?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching other written documents to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching drawing files to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital photographs to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital video images to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital sound files to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Assigning/delegating an action?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

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1.7.6 Does your company use electronic-mail on assignment locations for the following purposes? Ans: *(tick appropriate box for each part of the question)*

Sending written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Agreeing the drafting/text of written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Marking up and amending the written messages of others?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching other written documents to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching drawing files to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital photographs to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital video images to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Attaching digital sound files to written messages?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Assigning/delegating an action?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.7.7 Does your company have a homepage on the Internet?

Ans: *(tick appropriate box)*	YES ☐, NO ☐

1.7.8 Does your company have it's own Internet server?

Ans: *(tick appropriate box)*	YES ☐, NO ☐

1.7.9 Does your company provide an Internet service to the following categories of staff, for communication purposes?
Ans: *(tick appropriate box for each part of the question)*

For managerial staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
For professional staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
For technical staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Administrative, clerical and other staff?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

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Part 2 Purpose of the information technology

2.1 Does your company communicate/transmit to company office and vice versa, using information technology, the following **work-content related** data/information?
Ans: *(tick appropriate box for each part of the question)*

Lists of activities?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Lists of deliverables?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Changes in scope/standards?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Lists of disputes and their status?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.2 What information technology does your company use to communicate/transmit to company office and vice versa, **work-content related** data/information?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic mail/Internet?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.3 Does your company communicate/transmit to company office and vice versa, using information technology, the following list of **time-related** data/information items?
Ans: *(tick appropriate box for each part of the question)*

Work schedule of activities?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
% work done?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
% work to be done?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Re-planned work?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.4 What information technology does your company use to communicate/transmit to company office and vice versa, **time-related** data/information?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic mail/Internet?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

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2.5 Does your company communicate/transmit to company office and vice versa, using information technology, the following **cost-related** data/information items?
Ans: *(tick appropriate box for each part of the question)*

Value of work done?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Value of work to be done?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Expenditure?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Commitment?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Value of variations?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Value of disputes?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Money received?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Money outstanding?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.6 What information technology does your company use to communicate/transmit to company office and vice versa, **cost-related** data/information?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail/Internet?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.7 Does your company communicate/transmit to company office and vice versa, using information technology, the following **resource related** data/information items?
Ans: *(tick appropriate box for each part of the question)*

Personnel deployed?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Personnel required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facilities employed?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facilities required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Sub-consultants hired?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

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Purchasing services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
QS services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Legal services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Management services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Administrative services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Other out-sourced services required?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.8 What information technology does your company use to communicate/transmit to company office and vice versa, **resource-related** data/information?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail/Internet?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.9 What five items of data/information is most important in your company for assessing the performance of an assignment? *For example, 'value of work done to date'*
Ans: *(state briefly, in order of importance, five items of data/information in the space below)*
1) .....
2) .....
3) .....
4) .....
5) .....

2.10 What information technology does your company use to communicate/transmit to company office and vice versa, the five items of data/information stated in 2.9?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail/Internet?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

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2.11 Does your company communicate/transmit to company office and vice versa, using information technology, the following **issue-related** data/information items?
Ans: *(tick appropriate box for each part of the question)*

Requests for information?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Variation quotations?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Change Order proposals?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Requests for approvals?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Quality conformance?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Approvals?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.12 What information technology does your company use to communicate/transmit to company office and vice versa, the **issue-related** items of data/information stated in 2.11?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail/Internet?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.13 Does your company communicate/transmit to company office and vice versa, using information technology, the following **company-related** data/information items?
Ans: *(tick appropriate box for each part of the question)*

Names and addresses?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
File references?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Telephone directories?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Shared facilities e.g. Meeting Rooms?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Information registers?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

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2.14 What information technology does your company use to communicate/transmit to company office and vice versa, the **company-related** items of data/information stated in 2.13? Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail/Internet?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Intranet	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.15 Does your company communicate/transmit to other **project participants**, such as the client or the contractors, and vice versa, using information technology, the following **project-related** data/information items? Ans: *(tick appropriate box for each part of the question)*

Specifications?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Bills of Quantities?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Tender drawings?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Construction drawings?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
'As built' drawings	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Contract correspondence?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Routine correspondence/	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Instructions?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Monthly and other reports?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Method statements?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Quality conformance statements?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Manuals and procedures?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Cost reports?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Programmes and bar charts?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

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2.16 What information technology does your company use to communicate/transmit to the **client and vice versa**, the **project-related** items of data/information stated in 2.15?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail/Internet?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

2.17 What information technology does your company use to communicate/transmit to the **contractors and vice versa**, the **project-related** items of data/information stated in 2.15?
Ans: *(tick appropriate box for each part of the question)*

Telephone?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Facsimile?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Electronic-mail/Internet?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Hardcopy, letter/report/form?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

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Part 3 Use of the information technology

3.1 How does your company use information technology **to combine together** data/information relating to the **work-content** of your assignment projects, to get an overview of the performance as a whole?
Ans: *(tick appropriate box for each part of the question)*

Review of individual reports?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Spreadsheets of numeric and date data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Database(s) of alpha-numeric data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

3.2 What five, **work-content related,** criteria are most important in your company for assessing the overall performance of several assignment projects?
Ans: *(state briefly, in order of importance, five criteria in the space below)*
1) .....
2) .....
3) .....
4) .....
5) .....

3.3 How does your company use information technology **to combine together** data/information relating to the **time aspects** of your assignment projects, to get an overview of the performance as a whole?
performance? Ans: *(tick appropriate box for each part of the question)*

Review of individual reports?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Spreadsheets of numeric and date data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Database(s) of alpha-numeric data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

3.4 What five, **time-related,** criteria are most important in your company for assessing the overall performance of several assignment projects?
Ans: *(state briefly, in order of importance, five criteria in the space below)*
1) .....
2) .....
3) .....
4) .....
5) .....

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3.5 How does your company use information technology **to combine together** data/information relating to the **cost aspects** of your assignment projects, to get an overview of the performance as a whole?
Ans: *(tick appropriate box for each part of the question)*

Review of individual reports?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Spreadsheets of numeric and date data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Database(s) of alpha-numeric data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

3.6 What **cost-related**, criteria are most important in your company for assessing the overall performance of several assignment projects?
Ans: *(state briefly, in order of importance, five criteria in the space below)*
1) .....
2) .....
3) .....
4) .....
5) .....

3.7 How does your company use information technology **to combine together** data/information relating to the **resource aspects** of your assignment projects, to get an overview of performance as a whole?
Ans: *(tick appropriate box for each part of the question)*

Review of individual reports?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Spreadsheets of numeric and date data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.
Database(s) of alpha-numeric data?	ALWAYS ☐, MOSTLY ☐, RARELY ☐, NEVER ☐.

3.8 What five, **resource-related**, criterion are most important in your company for assessing the overall performance of several assignment projects?
Ans: *(state briefly, in order of importance, five criteria in the space below)*
1) .....
2) .....
3) .....
4) .....
5) .....

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Part 4 Self assessment of your strategic use of information technology

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BACKGROUND

Analysis of the data collected from the UK industry resulted in over 200 propositions concerning the management of IT in construction organisations. Some of these propositions have been selected and translated into the following questions. We urge you to ask these questions of your business or businesses as a stimulus to your own debate about how you are using and managing IT. We hope it acts as a trigger to the ongoing debates about IT investment and management within your organisation.

Instructions – **Step 1:** -Select one of the scenarios, which is the closest fit to your company circumstances with regard to the use of IT. Mark your choice by circling the option selected.

4.1 Competition and business strategy

4.1.1 Does IT support your core capabilities?

IT does not support our capabilities.	IT offers some support to our capabilities.	IT is critical to our core capabilities.	Our core capabilities are our IT systems.
D	**C**	**B**	**A**

4.1.2 How do you think IT could help your company to compete?

Changing our competitive behaviour.	Changing our competitive behaviour and supporting our capabilities.	Changing competitive behaviour, supporting capabilities, and enabling strategic alliances with others.	Changing competitive behaviour, supporting capabilities, enabling strategic alliances with others, and achieving an unassailable market position.
D	**C**	**B**	**A**

4.1.3 What is the impact of IT on your corporate goals and objectives?

IT has no impact.	IT has some positive impact.	IT supports our corporate objectives through business efficiency and cost reduction.	IT is critical to business efficiency, financial gains, engineering excellence, R&D and innovation.
D	**C**	**B**	**A**

4.1.4 With regard to IT, what is your position compared to your competitors?

12 months behind other companies.	6 months behind other companies.	The same level as other companies.	Acompany of other companies.
D	**C**	**B**	**A**

4.1.5 What is the impact of your use of IT on your clients?

IT does not have any impact.	IT is important to some clients.	IT is good for presentation and communication to clients.	IT is essential for meeting clients requirements.
D	**C**	**B**	**A**

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4.1.6 Do you think your company IT expertise will help it to win work?

IT has no influence on winning work.	IT is good for presentation.	IT can be instrumental in winning work.	IT is critical to winning work.
D	C	B	A

4.1.7 How is IT used as a part of strategic/business alliances?

Spreading the costs and risks.	Business efficiency.	Improving combined competitive behaviour.	To gain combined competitive behaviour.
D	C	B	A

4.2 The role of IT

4.2.1 How do you currently use IT in your company?

IT is not seen as an important part of the business.	We use IT but let the technology find its own way within the organisation.	Use IT after proven, and satisfactory results from others users and other companies.	Pro-actively seek to use IT as part of a well thought through strategy for achieving competitive advantage.
D	C	B	A

4.2.2 How would you describe the relationship between IT and your business strategy?

They are completely separate entities.	IT is indirectly addressed through its supportive role.	IT plays a central role in our business strategy.	IT is a critical success factor for local and overseas business strategies.
D	C	B	A

4.2.3 What is the level of participation of your IT people in the development of your overall business strategy?

No participation.	IT people simply informed of the business strategy.	Main Board IT Director responds to business strategy proposals.	Main Board IT Director has part of the responsibility to suggest new business strategies
D	C	B	A

4.2.4 Does IT have an impact on your operational strategy?

IT supports operational strategy.	IT helps to reduce costs through speed and efficiency.	IT assists us to improve quality to meet client's requirements within budget.	IT enables us to provide products and services that are better than anyone else.
D	C	B	A

4.2.5 Does IT have any influence on the delivery of your marketing?

IT has nothing to do with our marketing strategy.	IT has some impact on marketing strategy.	IT is important to the success of marketing strategy.	IT is critical to the success of our marketing strategy.
D	C	B	A

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4.3 IT strategy

4.3.1 How would you describe the use of IT systems in your company?

Mainly functional applications.	Mainly functional applications with some integrated systems.	Mainly integrated systems.	Process support tools with full information sharing.
D	C	B	A

4.3.2 What are the objectives of your IT strategy

Business efficiency.	Business efficiency, improving quality and improving communications with internal and external stakeholders.	Providing support for business strategy.	Delivery of business strategy.
D	C	B	A

4.3.3 What is the thrust of your IT strategy?

Up-to-date IT facilities.	Competent IT skill level within the company and required IT facilities.	Support for business strategy and user participation and empowerment.	Exploiting IT for competitive advantage.
D	C	B	A

4.3.4 How do you intend to manage IT in the future?

Follow other companies after assessing their experience.	To do much the same as other companies at about the same time as them.	To experiment and develop the technology.	To have advanced technology developed as a key part of the business.
D	C	B	A

4.3.5 What are the critical success factors for sustainable competitive advantage achieved through IT in your company?

We do not seek a sustainable competitive advantage through IT.	Acquisition of the right technology.	To use the strategic and innovative IT opportunities that arise.	Continuous R&D programmes and seeking innovative solutions to construction problems.
D	C	B	A

4.3.6 How do you intend to manage IT projects and innovations?

We are not concerned with IT innovation.	Out-sourcing.	IT professionals and external facilitators.	IT professionals, appropriate management, user group committees, strategic alliances, internal and external facilitators.
D	C	B	A

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4.3.7 What is the level of R&D regarding IT in your company?

No interest.	Planned R&D.	R&D focus aimed at new future markets.	R&D focus aimed at new, future, markets and the achievement of a sustainable competitive advantage
D	C	B	A

4.3.8 What is the nature of your IT department?

Small technical unit providing group technical services.	Large technical group providing group technical services.	Central technical support to individual business units.	Fully developed IT responsibility for strategy and business.
D	C	B	A

4.3.9 How much importance do you attach to IT skills within your company?

Low-cost IT training initiatives	Provide IT training when required.	Seeking and upgrading the quality of IT training in our company.	Develop intensive education and training programme for all IT users, including senior management.
D	C	B	A

4.3.10 Who is aware of your IT strategy?

Technical staff.	IT professionals and users.	Business managers.	All key internal and external personnel.
D	C	B	A

4.3.11 What is the extent and nature on involvement of IT users in the development and implementation of your IT?

There is no user involvement.	Involved when required	Involved at the early stages.	Involved throughout the whole process.
D	C	B	A

4.3.12 What do you consider to be the risks associated with the implementation of your IT strategy?

Financial risks.	Technological risks.	Business environment risks.	Strategic risks.
D	C	B	A

4.3.13 How often do you review your IT strategy

Every five years.	Every three years.	Every year.	IT strategy is reviewed continuously.
D	C	B	A

4.3.14 How do you measure the IT performance of your company?

Short-term payback.	Cost-reducing aspects of the IT.	Value adding properties of IT.	Strategic opportunities provided by IT.
D	C	B	A

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4.3.15 What are the characteristics of your IT strategy?

Financial issues dominate IT.	IT is driven from the bottom-up	IT is driven by middle-managers.	IT is managed from the top.
D	**C**	**B**	**A**

4.3.16 Who is the champion for IT projects in your company?

Technical staff.	Functional managers.	IT Director.	Senior Management.
D	**C**	**B**	**A**

Instructions – Step 2: -Transfer your choices to the answer matrix below to see which category contains the majority of the scenarios you regard as being appropriate to your company circumstances

	Question	D	C	B	A
Competition and business strategy					
	4.1.1				
	4.1.2				
	4.1.3				
	4.1.4				
	4.1.5				
	4.1.6				
	4.1.7				
The role of IT					
	4.2.1				
	4.2.2				
	4.2.3				
	4.2.4				
	4.2.5				
IT strategy					
	4.3.1				
	4.3.2				
	4.3.3				
	4.3.4				
	4.3.5				
	4.3.6				
	4.3.7				
	4.3.8				
	4.3.9				
	4.3.10				
	4.3.11				
	4.3.12				
	4.3.13				
	4.3.14				
	4.3.15				
	4.3.16				
Total					

Instructions – Step 3: -Review your score against the following descriptions of the interpretations that you might make of the alternative scenarios that arise from your response to the questions in part 4 of this questionnaire.

For your information, on the next page is a UK based, subjective, assessment of the answer matrix.

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D If you have mainly ticked scenarios in this category you are clearly using IT as a support tool for operational efficiency. It appears that IT is not viewed as an important part of your business and IT applications are mainly directed at support and functional systems with very little in terms of integration. The financial justification for IT investments have stopped your company from developing a clear IT strategy in line with your business, market and industry requirements. You may need to analyse your current situation concerning various aspects of IT, including education and training programmes and to develop an IT strategy that would focus on long term objectives and goals with consideration to your existing market status within your industry sector. The seniority and profile of staff involved with managing IT may be too low. You need to rethink the way in which you intend to manage IT within your organisation. The supportive role of IT, the level of management commitment, low levels of IT skills and expertise, and the philosophy of following other companies concerning IT can no longer meet the needs of the dynamic and competitive environment of the 1990s.

C If your company can mainly relate to the scenarios in column 'C' of the matrix, you are aware of some of the strategic opportunities provided by IT, but, your bottom-up approach has formed a barrier to your progress. Whilst it is encouraging to learn that IT is used to reduce costs and increase the overall business efficiency, you are not fully benefiting from the opportunities provided by IT. However, in this respect, you are better than some companies in your sector but behind many others. Therefore, you may need to analyse your situation compared to that of your competitors. This requires the involvement of the IT people in the development of your business strategy, more focus on training and better awareness of IT as a competitive weapon. You may be beginning to plan to use IT strategically. But, your perception of the level of risks involved together with cost and the complexity of technology is forming a block that is influencing the awareness of strategic possibilities offered by IT in your company. As you have already benefited from some of the opportunities provided by IT, you need to improve your industry position within your sector. This is only possible through being innovative, investing in people and the required technology and finally to create an IT infrastructure and culture that would support your competitive strategy and corporate goals.

B If you have mainly placed your company in scenarios in column 'B' of the matrix, you are probably among the best practice companies when considering the use and management of IT. However, there is still room for improvement. Whilst you are benefiting from some of the strategic opportunities provided by IT: the conditional commitment of senior management; the limited involvement of IT users; the low levels of IT skills in some departments; and the partial commitment to R&D initiatives, may slow down the rate of progress of IT in your organisation. You may be planning to strategically exploit IT for efficiency gains and competitive advantage. Whilst you may be acompany of some of your competitors, you are operating in a similar environment to them. Therefore to improve your market status and industry position you need to plan to use IT more aggressively to combat the threat of competition.

A If you an relate to the majority of scenarios in column 'A' you are among the very few and best practice companies that are truly exploring IT for its strategic opportunities. You are also in a position to benefit from the IT culture you have developed and maintain IT on the urgent agenda of concern of top management. However, to maintain and improve your business growth and the prosperity of your organisation, you should continue to do what you have been doing and focus on new and profit generating activities through R&D initiatives. You appear to be truly planning to exploit IT for its strategic opportunities. You need to maintain, guard and improve your position and to capitalise from your capabilities and expertise.

<<<END>>>

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Please immediately return the questionnaire to

Keith Futcher
Chief Assistant Secretary/Public Works Systems Administration,
Works Bureau,
10F, Murray Building,
Garden Road,
Central,
Hong Kong.

Thank you for your cooperation.

We will send you a copy of the summary report

*****

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Proforma questionaire for the postal survey of the Users of the Public Works_Management System

PLEASE NOTE

You have been selected at random from the list of PW_MS Users to be part of 'a population sample of the PW_MS users'. Your knowledge and experience is needed in this survey of PWP participants so that we can determine how to improve the PW_MS to better meet user expectations. **Your response will be kept confidential.** It will be combined with the other responses to produce an overall assessment of the PW_MS and of user needs. Your response will then be destroyed.

Instructions:

- The questionnaire is designed to suit a wide range of works department staff who vary greatly in their knowledge of the PW_MS and in their experience of the delivery of single, or groups, of PWP projects.
- The questionnaire is divided into four parts and designed to make it easy to complete.
- Please answer all the questions as best you can.
- If the question is about a requirement that you do not use or need, or beyond your experience, then tick the box '*NOT USED*'.
- Some of the questions seek your advice and ideas. Please answer them concisely and mark the option that says how the idea is to be applied to the PW_MS i.e., '*Add/~~delete/change~~ data on xxxxxxxxxxx to yyyyyyyyyyyy*'.
- There are two ways of answering the questions in this questionnaire
  - (a) Put a [✓] check mark in the appropriate squared box provided; or
  - (b) Write a brief answer in the space provided on the questionnaire, **if you have no answer then write 'NONE'.**
- Please answer the questions as fully as possible. If you think further comment or clarification is needed, then add information in the margin of the page, next to the question. If necessary, telephone Mr Terrie Hung of the PWSAU at 2848 2920 if you need further advice on how to complete the questionnaire.
- Complete and return the questionnaire in confidence by February 12, 1999 addressed to:

Keith Futcher, Chief Assistant Secretary/Public Works Systems Administration,
Works Bureau, 10F, Murray Building,
Garden Road,
Central,
Hong Kong.
@ tel 28482437 or fax 2869 6095

PLEASE NOTE CAREFULLY THESE DEFINITIONS

'PW_MS' is the public works management information system.
'PROJECT PARTICIPANTS' are all the people working on the project from government departments or companies.
'MIS' means any management information system used for the project management of one or more PWP projects. **It can be a manual or a computer-based system.**
'GROUPS OF PROJECTS' means a number of projects that are grouped together for some common reason i.e., the same client or by the same works division.

PLEASE FIX YOUR NAME CARD IN THE SPACE PROVIDED OR FILL IN THE DETAILS IN CASE WE NEED TO CONTACT YOU FOR FURTHER INFORMATION.

Name: .....

Post.....

Dept/Div.....

Profession .....

Tel & Fax Nos .....

E-mail.....

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Your response will be kept confidential and used for the purposes of PW_MS planning

PRELIMINARIES

I.1 Participation in PWP project delivery. *Ans: (state numbers in the right hand box)*

(a) The number of Cat. A PWP projects I am currently involved with is =	Num.
(b) The number of Cat. B PWP projects I am currently involved with is =	Num.
(c) The number of Cat. C PWP projects I am currently involved with is =	Num.

I.2 How frequently do you use the PW_MS? *Ans: (tick appropriate box for each part of the question)*

(a) Logging on yourself	WEEKLY ☐ MONTHLY ☐ QUARTERLY ☐ NEVER ☐
(b) By other staff using the PW_MS for you?	WEEKLY ☐ MONTHLY ☐ QUARTERLY ☐ NEVER ☐

PART 1 IMPROVING THE PW_MS.

Explanation: This series of questions is to measure the adequacy of the PW_MS and to identify ideas to improve it.

1.1 The PW_MS used for traditional project control of scope, cost, and time

1.1.1 **Does the PW_MS satisfy** the traditional aspects of **project management** i.e., information management and control of the scope, the cost, and the time of a project?
Ans: *(tick appropriate box)*

ALWAYS ☐ MOSTLY ☐ SOMETIMES ☐ NEVER ☐ *NOT USED* ☐

1.1.2 Should the requirements of those features/functions/procedures of traditional **project management** listed below be **kept the same, reduced, or changed** in the PW_MS?
Ans: *(tick appropriate box for each part of the question)*

(a) Scope statement	KEEP ☐ REDUCE REQUIREMENT ☐ CHANGE ☐ *NOT USED* ☐
(b) Cashflows	KEEP ☐ REDUCE REQUIREMENT ☐ CHANGE ☐ *NOT USED* ☐
(c) Work-schedules and baseline dates	KEEP ☐ REDUCE REQUIREMENT ☐ CHANGE ☐ *NOT USED* ☐

1.1.3 What features/functions/procedures/requirements should be **added/changed/deleted** in the PW_MS to **better satisfy** the information management and data processing needs of the traditional aspects of **project management** i.e., scope, cost, and time management?
Ans: *(state briefly, in order of importance, five features/functions in the space below)*

1) *add/change/delete* .....
2) *add/change/delete* .....
3) *add/change/delete* .....
4) *add/change/delete* .....
5) *add/change/delete* .....

1.2 Resource Management

1.2.1 Do you want to **add a staff resources** element into the PW_MS to give you the data that you want on the **staff resource demands/capacity/performance?** Ans: *(tick appropriate box)*

YES ☐ NO ☐ *NOT USED BY ME* ☐

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Your response will be kept confidential and used for the purposes of PW_MS planning

1.2.2 What five items of data or function should be **included in an add staff resources** element of the PW_MS to give you the data that you want on **the staff resource demands/ capacity/performance** of a group of projects that you select?
Ans: *(state briefly, in order of importance, five items of data/function in the space below)*

1) .....
2) .....
3) .....
4) .....
5) .....

1.3 Effort in data capture and data entry

1.3.1 Is the **effort needed for data entry** into the PW_MS acceptable to you?
Ans: *(tick appropriate box)*

YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐.

1.3.2 In general, what should be the **frequency for regular updating of the PW_MS data** for the actions listed below? Ans: *(tick appropriate box for each part of the question)*

(a) Cost-forecast	3 MONTHS ☐ 1 MONTH ☐ WEEKLY ☐ AS DATA CHANGES ☐ *NOT USED* ☐
(b) Record actual expenditure	3 MONTHS ☐ 1 MONTH ☐ WEEKLY ☐ AS DATA CHANGES ☐ *NOT USED* ☐
(c) Progress/update of the timeplan	3 MONTHS ☐ 1 MONTH ☐ WEEKLY ☐ AS DATA CHANGES ☐ *NOT USED* ☐
(d) Record progress in the project diary	3 MONTHS ☐ 1 MONTH ☐ WEEKLY ☐ AS DATA CHANGES ☐ *NOT USED* ☐
(e) Record progress in the work-package diary	3 MONTHS ☐ 1 MONTH ☐ WEEKLY ☐ AS DATA CHANGES ☐ *NOT USED* ☐

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1.3.3 How does your company record minutes/notes of meetings?
Ans: *(tick appropriate box for each part of the question)*

Hand-written notes/minutes?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Tape recordings?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Word-processor notes/minutes?	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐
Electronic 'notice board'	YES ☐, MOSTLY YES ☐, MOSTLY NO ☐, NO ☐

1.4 Video-conferencing for communication

1.4.1 Does your company use video-conference facilities for communication?
Ans: *(tick appropriate box for each part of the question)*

Communication within Hong Kong?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
For international communication?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.4.2 Which video-conference services does your company use?
Ans: *(tick appropriate box for each part of the question)*

Commercially hired video conferencing services?	YES ☐, SOMETIMES ☐, NO ☐.
Company-owned private services.	YES ☐, SOMETIMES ☐, NO ☐.
Using the Internet	YES ☐, SOMETIMES ☐, NO ☐.

1.5 Images used for communication

1.5.1 How does your company produce construction drawings?
Ans: *(tick appropriate box for each part of the question)*

Manual methods in the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
CAD systems in the company offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Hiring manual drafting services?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Hiring CAD drafting services?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Manual methods in site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
CAD systems in site offices?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

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http://hkusury2.hku.hk/rec/cit.html

1.5.2 How does your company distribute construction drawings?
Ans: *(tick appropriate box for each part of the question)*

As hardcopy?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files on disk?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files across an internal computer network (LAN)?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files, to other computers or LANS , using modems?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files, to others using an external computer network via the Internet?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.3 How does your company record the distribution of construction drawings
Ans: *(tick appropriate box for each part of the question)*

By hardcopy transmittal?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
By electronic database register of transmittal?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.4 How does your company check/revise construction drawings?
Ans: *(tick appropriate box for each part of the question)*

As hardcopy?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic files, with amendments shown as red-lined?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.5 Does your company use picture images for communication?
Ans: *(tick appropriate box for each part of the question)*

Photographs?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Digital photographs?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
Videos?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.6 How does your company distribute picture images for communication?
Ans: *(tick appropriate box for each part of the question)*

In original physical format?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.
As electronic digital images?	YES ☐, OFTEN YES ☐, OFTEN NO ☐, NO ☐.

1.5.2 Are/would the PW_MS reports, or the supply of data listed below be useful to you? Ans: *(tick appropriate box for each part of the question)*

(a) Quarterly progress reports on high impact Cat A projects.	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(b) Quarterly progress reports on Cat B projects.	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(c) Any of the reports listed on the 'reports' menu within the PW_MS.	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(d) 'FoxPro' data download from the PW_MS.	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(e) Spreadsheet format data download from the PWSAU.	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(f) Use of SQL to access the PW_MS database	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐

1.5.3 What reports/features/functions should be changed/added/deleted to the PW_MS to better provide reports/supply of data to you?
Ans: *(state briefly, in order of importance, five features/functions in the space below)*

1) *add/change/delete* _____
2) *add/change/delete* _____
3) *add/change/delete* _____
4) *add/change/delete* _____
5) *add/change/delete* _____

1.6 Centralised, single source of data

1.6.1 Is the PW_MS an effective centralised, single source of accurate PWP data/information to project participants? Ans: *(tick the appropriate box)*

YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED BY ME* ☐

1.6.2 What features/functions should be changed/added/deleted in the PW_MS to make it a more effective centralised, single source of accurate PWP data/information to project participants. Ans: *(state briefly, in order of importance, five features/functions in the space below)*

1) *add/change/delete* _____
2) *add/change/delete* _____
3) *add/change/delete* _____
4) *add/change/delete* _____
5) *add/change/delete* _____

1.7 Effectiveness of the PW_MS

1.7.1 Is the PW_MS effective for the management of the groups of projects in the hierarchical breakdown-structures in the PW_MS, i.e. WBS OBS, FRS, CRS?
Ans: *(tick one appropriate box)*

YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED BY ME* ☐

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1.7.2 What features/functions/process/uses should be added/changed/deleted to the PW_MS to make it more effective for the management of the groups of projects in the hierarchical breakdown-structures in the PW_MS, i.e. WBS, OBS, FRS, CRS?
Ans: *(state briefly, in order of importance, five features functions in the space below)*

1) *add/change/delete* _____
2) *add/change/delete* _____
3) *add/change/delete* _____
4) *add/change/delete* _____
5) *add/change/delete* _____

1.8 Using the PW_MS

1.8.1 Is the performance of those features/functions/process/uses listed below satisfactory to you? Ans: *(tick one appropriate box for each part of the question)*

(a) Logging onto the PW_MS.	OK ☐ A BIT SLOW ☐ VERY SLOW ☐ *NOT USED* ☐
(b) Accessing project data	OK ☐ A BIT SLOW ☐ VERY SLOW ☐ *NOT USED* ☐
(c) Updating the project timeplan	OK ☐ A BIT SLOW ☐ VERY SLOW ☐ *NOT USED* ☐
(d) Recording expenditure	OK ☐ A BIT SLOW ☐ VERY SLOW ☐ *NOT USED* ☐
(e) Creation of a pending change order involving cashflow	OK ☐ A BIT SLOW ☐ VERY SLOW ☐ *NOT USED* ☐
(f) Writing an entry in the project or work package diary	OK ☐ A BIT SLOW ☐ VERY SLOW ☐ *NOT USED* ☐
(g) Updating the project contacts	OK ☐ A BIT SLOW ☐ VERY SLOW ☐ *NOT USED* ☐
(h) Obtaining and printing a report	OK ☐ A BIT SLOW ☐ VERY SLOW ☐ *NOT USED* ☐

1.8.2 In overall terms, is the PW_MS satisfactory to use? Ans: *(tick appropriate box)*

YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED BY ME* ☐

1.8.3 What features/functions should be added to, or changed in the PW_MS to make it perform better? Ans: *(state briefly, in order of importance, five features functions in the space below)*

1) *add/change/delete* _____
2) *add/change/delete* _____
3) *add/change/delete* _____
4) *add/change/delete* _____
5) *add/change/delete* _____

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1.8.4 How fast should the PW_MS be? Ans: *(tick appropriate box for each part of the question)*

Reasonably the PW_MS should as fast as..?	A STAND ALONE PC USED FOR WORD PROCESSING ☐ A BANK AUTOMATED TELLER MACHINE (ATM) i.e., ETC machine ☐ USING THE INTERNET/WORLD-WIDE-WEB (WWW) VIA A MODEM ☐ I DON'T KNOW ☐

1.9 Ease of use of the PW_MS

1.9.1 Ans: *(tick one appropriate box)*

The PW_MS should be as easy to use as?	MICROSOFT EXCEL OR LOTUS 123 SOFTWARE ☐ MICROSOFT WORD SOFTWARE ☐ FOXPRO DATABASE SOFTWARE ☐ WORK-SCHEDULING SOFTWARE ☐ I DON'T KNOW ☐

PART 2 USE OF THE PW_MS FOR MANAGEMENT OF CATEGORY C, B, AND A PWP PROJECTS

Explanation: This part of the questionnaire sets out to measure the extent that the PW_MS meets the need for a project management tool. It also asks for details of the shortfall and redundancy in these tools.

2.1 Project Register, Diary and Contacts

2.1.1 Does the **project register** in the PW_MS **contain** all the data that you want for your projects? Ans: *(tick one appropriate box)*

TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED BY ME* ☐

2.1.2 What features/functions should be **changed/added/deleted in the project register** to **better satisfy** the **project information** needs?

Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*

1) *add/change/delete* .....
2) *add/change/delete* .....
3) *add/change/delete* .....
4) *add/change/delete* .....
5) *add/change/delete* .....

2.1.3 Does the **project diary** in the PW_MS **contain** all the data that you want for your projects? Ans: *(tick appropriate box)*

TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED BY ME* ☐

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2.1.4 What features/functions should be **changed/added/deleted in the project diary** to **better satisfy your project information needs?**
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*
1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

2.1.5 Does the **project contacts** in the PW_MS **contain** all the data that you want for your projects? Ans: *(tick one appropriate box)*

TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED BY ME* ☐

2.1.6 What features/functions should be **changed/added/deleted in the project contacts** to **better satisfy your project information needs?**
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*
1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

2.1.7 Does the **work-package register** in the PW_MS contain all the data that you want for your projects? Ans: *(tick appropriate box)*

TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED BY ME* ☐

2.1.8 What features/functions should be **changed/added/deleted in the work-package register to better satisfy the project information needs?**
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*
1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

2.1.9 Does the **work-package diary** in the PW_MS **contain** all the data that you want for each project work-package? Ans: *(tick one appropriate box)*

TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED BY ME* ☐

2.1.10 What features/functions should be **changed/added/deleted in the work-package diary to better satisfy the project information needs?**
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*
1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

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2.2 Project Scope

2.2.1 Does the **scope** element of the PW_MS have all the data and functions that you want for your projects? Ans: *(tick one appropriate box)*

(a) Data is?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐
(b) Functions are?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐

2.2.2 What features/functions should be **changed/added/deleted in the scope** element to **better satisfy your project** needs? Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*

1) *add/change/delete* .....
2) *add/change/delete* .....
3) *add/change/delete* .....
4) *add/change/delete* .....
5) *add/change/delete* .....

2.3 Cost

2.3.1 Does the **cost** element of the PW_MS have all the data and functions that you want for your projects? Ans: *(tick one appropriate box)*

(a) Data is?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐
(b) Functions are?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐

2.3.2 What features/functions should be **changed/added/deleted in the cost** element to **better satisfy your project** needs? Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*

1) *add/change/delete* .....
2) *add/change/delete* .....
3) *add/change/delete* .....
4) *add/change/delete* .....
5) *add/change/delete* .....

2.4 Time management and work-scheduling

Does the **time plan** element of the PW_MS have all the data and functions that you want for your projects? Ans: *(tick one appropriate box)*

(a) Data is?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐
(b) Functions are?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐

2.4.2 What features/functions should be **changed/added/deleted in the time management and work-scheduling** element to **better satisfy your project** needs?
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*

1) *add/change/delete* .....
2) *add/change/delete* .....
3) *add/change/delete* .....
4) *add/change/delete* .....
5) *add/change/delete* .....

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2.5 Project planning and monitoring using change orders and baseline control

Does the **change orders and baseline** element of the PW_MS have all the data and functions that you want for your projects? Ans: *(tick one appropriate box)*

(a) Data is?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐
(b) Functions are?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐

2.5.2 What features/functions should be **changed/added/deleted in the project planning and monitoring using baseline functions to better satisfy your project** needs?
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*
1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

2.6 Land delivery

Does the **land delivery** element within the Project Register, in the land work-packages, and in the land reports in the PW_MS have all the data and functions that you want for your projects? Ans: *(tick one appropriate box)*

(a) Data is?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐
(b) Functions are?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐

2.6.2 What features/functions should be **changed/added/deleted in the land delivery functions to better satisfy your project** needs?
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*
1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

2.7 Works Contracts

Does the **works contracts** elements in the PW_MS have all the data and functions that you want for your projects? Ans: *(tick one appropriate box)*

(a) Data is?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐
(b) Functions are?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐

2.7.2 What features/functions should be **changed/added/deleted in the contracts element to better satisfy your project** needs?
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*
1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

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PART 3 USE OF THE PW_MS IN THE MANAGEMENT OF *GROUPS* OF CATEGORY C, B AND A FWP PROJECTS

Explanation: This series of questions is to measure the adequacy of the PW_MS for the purposes of the managing more than one project. It assumes the user has an interest in global performance, i.e., performance of a group of projects overall. This is certainly true for managers at the senior levels but it is an important aspect of the PW_MS and your views about it are needed.

3.1 Project Contacts

3.1.1 Does the **contacts** element of the PW_MS have all the data and functions that you want to enable you **to make effective rapid contact** with the project participants?

Ans: *(tick one appropriate box)*

(a) Data is?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐
(b) Functions are?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐

3.1.2 What features/functions should be **changed/added/deleted in the contacts to better satisfy your multi-project** needs?

Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*

1) *add/change/delete* .....
2) *add/change/delete* .....
3) *add/change/delete* .....
4) *add/change/delete* .....
5) *add/change/delete* .....

3.1.3 Does the **'traffic-lights'** element of the PW_MS screen display of projects show the data that you want, to **identify/warn** of the projects that are not progressing as planned?

Ans: *(tick one appropriate box)*

(a) Data is?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐
(b) Functions are?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐

3.1.4 What features/functions should be **changed/added/deleted in the traffic lights function to better satisfy your multi-project** needs?

Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*

1) *add/change/delete* .....
2) *add/change/delete* .....
3) *add/change/delete* .....
4) *add/change/delete* .....
5) *add/change/delete* .....

3.2 Summations of data for selected *groups* of projects

3.2.1 Does the PW_MS provide enough **information on *groups* of projects** that you select? Ans: *(tick one appropriate box)*

(a) Information on groups of projects is ..?	TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED* ☐

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3.2.2 What features/functions should be **changed/added/deleted to better satisfy your multi-project** needs? Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*

1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

3.2.3 Does the **addition of project costs** in the PW_MS give you the information that you want on the **cashflow performance** of a **group** of projects i.e., the RAS Graphics Reports or other Graphics Reports? Ans: *(tick one appropriate box)*

TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED BY ME* ☐

3.2.4 What features/functions should be **changed/added/deleted in the adding of costs function to better satisfy your multi-project** needs?
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*

1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

3.3 Progress Performance Measurement

3.3.1 Does the comparison of **baseline dates vs forecast dates and actual dates** in the 'Milestone Variance Report', give you the timing information that you want on the **performance of the projects in a *group*** that you select? Ans: *(tick one appropriate box)*

TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED BY ME* ☐

3.4.2 What features/functions should be **changed/added/deleted in the report of target and actual dates to better satisfy your multi-project** needs?
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*

1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

3.4.3 Does the comparison of **baseline costs compared to forecast and actual costs** in the 'Resource Allocation System Report', the 'Graphics Report for WBS, OBS, CRS, FRS Rollup-Data' give you the information that you want on the **spending performance of a *group* of projects** that you select? Ans: *(tick one appropriate box)*

TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED BY ME* ☐

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3.4.4 What features/functions should be **changed/added/deleted in the actual costs compared to baseline and forecast costs to better satisfy your multi-project needs?**
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*
1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

3.4.5 Does the PW_MS provide enough cost and time data/information to **identify the poorly performing** projects within a **group** of projects that you select?
Ans: *(tick appropriate box)*

TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED BY ME* ☐

3.4.6 What features/functions should be changed/added/deleted to better identify the poorly performing projects within a **group** of projects?
Ans: *(state briefly, in order of importance, five features/functions and the recommended change in the space below)*
1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

3.4.7 Does the PW_MS provide enough **data/information in the project diary** and used in the Quarterly Reports to help manage a **group** of projects? Ans: *(tick one appropriate box)*

TOO MUCH ☐ RIGHT AMOUNT ☐ TOO LITTLE ☐ *NOT USED BY ME* ☐

3.4.8 What features/functions should be **changed/added/deleted in the project diary to better support your management of a *group* of projects?**
Ans: *(state briefly, in order of importance, features/functions and the recommended change in the space below)*
1) *add/change/delete*
2) *add/change/delete*
3) *add/change/delete*
4) *add/change/delete*
5) *add/change/delete*

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PART 4 'NON-PW_MS' METHODS USED FOR THE MANAGEMENT OF CATEGORY C, B AND A PWP PROJECTS

Explanation: This series of questions measures the extent that other information technology and manual systems are used to manage PWP projects singly or in-groups. From this information we can determine the need to integrate the PW_MS with the other systems and to identify features that should be included in the PW_MS, or not.

4.1 Project management functions – computer-based

4.1.1 Do you use **'Non-PW_MS' computer-based systems** to record/process project data **for project management** purposes for the following items?

Ans: *(tick appropriate box for each part of the question)*

(a) Records of staff resources?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(b) Records of project contacts?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(c) Records of project scope?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(d) Records of project dates?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(e) Records of project costs?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(f) Records of works contracts?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(g) Records of project diary?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(h) Work scheduling/CPM	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐

4.1.2 What **information technology** do you use **for 'Non-PW_MS' systems** that are used to record/process project data **for project management** purposes?

Ans: *(tickone appropriate box and name the software for each part of the question)*

(a) Records of staff resources?	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF INFORMATION SYSTEM =*)
(b) Records of project contacts?	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF INFORMATION SYSTEM =*)
(c) Records of project scope?	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF INFORMATION SYSTEM =*)
(d) Records of project dates?	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF INFORMATION SYSTEM =*)
(e) Records of project costs?	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF INFORMATION SYSTEM =*)
(f) Records of works contracts?	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF INFORMATION SYSTEM =*)

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(g) Records of project diary?	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF INFORMATION SYSTEM =)*
(h) Work scheduling/CPM	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF INFORMATION SYSTEM =)*

4.2 Project management functions – Manual methods

4.2.1 Do you use **manual record systems** to record/process the following project data **for project management** purposes? Ans: *(tick appropriate box for each part of the question)*

(a) Records of staff resources?	NO ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(b) Records of project contacts?	NO ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(c) Records of project scope?	NO ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(d) Records of project dates?	NO ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(e) Records of project costs?	NO ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(f) Records of works contracts?	NO ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(g) Records of project diary?	NO ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(h) Work scheduling/CPM	NO ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐

4.2.2. What **manual records** do you **most use** to record/process project data **for project management** purposes? Ans: *(number the appropriate boxes in priority order for each part of the question)*

(a) Records of staff resources?	FORM ☐ DIARY ☐ FILE ☐ PERSONAL FILE ☐	NONE ☐
(b) Records of project contacts?	FORM ☐ DIARY ☐ FILE ☐ PERSONAL FILE ☐	NONE ☐
(c) Records of project scope?	FORM ☐ DIARY ☐ FILE ☐ PERSONAL FILE ☐	NONE ☐
(d) Records of project dates?	FORM ☐ DIARY ☐ FILE ☐ PERSONAL FILE ☐	NONE ☐
(e) Records of project costs?	FORM ☐ DIARY ☐ FILE ☐ PERSONAL FILE ☐	NONE ☐
(f) Records of works contracts?	FORM ☐ DIARY ☐ FILE ☐ PERSONAL FILE ☐	NONE ☐
(g) Records of project diary?	FORM ☐ DIARY ☐ FILE ☐ PERSONAL FILE ☐	NONE ☐
(h) Work scheduling/CPM	FORM ☐ DIARY ☐ FILE ☐ PERSONAL FILE ☐	NONE ☐

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4.3 Management of *groups* of projects – computer-based functions

4.3.1 Do you use **'Non-PW_MS' computer-based Management Information Systems** to record/process project data for management of ***groups*** **of projects?**
Ans: *(tick appropriate box for each part of the question)*

(a) Summary reports of progress?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(b) Lists of groups of projects?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(c) Exception reports?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(d) Progress reports?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐

4.3.2 What information technology do you use **for 'Non-PW_MS' Management Information Systems** that are used to record/process project data for management of ***groups*** **of projects?** Ans: *(tick appropriate box and name the software for each part of the question)*

(a) Summary reports of progress?	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF SYSTEM/PACKAGE =)*
(b) Lists of groups of projects?	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF SYSTEM/PACKAGE =)*
(c) Exception reports?	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF SYSTEM/PACKAGE =)*
(d) Progress reports?	DATABASE ☐ SPREADSHEET ☐ PACKAGE S'WARE ☐ NONE ☐ *(NAME OF SYSTEM/PACKAGE =)*

4.4 Management of *groups* of projects – Manual Methods

4.4.1 Do you use **manual methods** to record/process project data **for management of** ***groups*** **of projects?** Ans: *(tick appropriate box for each part of the question)*

(a) Summary reports of progress?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(b) Lists of groups of projects?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(c) Exception reports?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐
(d) Progress reports?	YES ☐ MOSTLY ☐ SOMETIMES ☐ NO ☐ *NOT USED* ☐

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4.4.2 What other **manual methods** are do you use to record/process project data **for management of *groups* of projects?** Ans: *(tick one appropriate box for each part of the question)*

(a) Summary reports of progress?	FORM ☐ DIARY ☐ FILES ☐ PERSONAL FILE ☐ NONE ☐
(b) Lists of groups of projects?	FORM ☐ DIARY ☐ FILES ☐ PERSONAL FILE ☐ NONE ☐
(c) Exception reports?	FORM ☐ DIARY ☐ FILES ☐ PERSONAL FILE ☐ NONE ☐
(d) Progress reports?	FORM ☐ DIARY ☐ FILES ☐ PERSONAL FILE ☐ NONE ☐

<<< Thank you for your cooperation>>>
Please immediately return the questionnaire in confidence to
Keith Futcher
Chief Assistant Secretary/Public Works Systems Administration,
Works Bureau,
10F, Murray Building,
Garden Road,
Central,
Hong Kong.
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Your response will be kept confidential and used for the purposes of PW_MS planning

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